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Research Article

IMPACT OF ANTHROPOGENIC PRESSURE UPON SPECIES DIVERSITY AND DENSITY OF BUTTERFLIES IN URBAN LANDSCAPE

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ABSTRACT
Urbanization, transportation, construction, and other human activities collectively contribute to anthropogenic pressure, leading to biodiversity loss. It has been demonstrated that anthropogenic pressure leads to the loss of biodiversity, and urbanisation, human activity, transportation, and building all contribute to this. However, more research is still needed to determine how it affects the taxonomic and functional variety of butterflies, particularly in urban settings where impact mechanisms need to be investigated. In order to find indicator species in various urban ecological gradient zones and investigate the effects of urbanisation and human pressure on their taxonomic and functional diversity, we employed butterflies as indicators. We conducted surveys of ten urban landscapes in Gaya and Patna City, Bihar, between January 2022 and December 2024.
In order to find differences between butterfly communities across urban ecological gradients, we first examined the effects of anthropogenic pressure on butterfly communities and pairwise compared various urban ecological gradients. Lastly, we looked into how different functional groups of butterflies responded to various urban ecological gradient areas and identified ecological indicative species. While present study find that the organisation of butterfly communities has become simpler as a result of urbanisation, yet there are also advantageous elements that contribute to individual butterfly survival. Butterfly communities and plant-feeding polyphagous butterfly groups have changed significantly as a result of urbanisation. The functional diversity of butterfly food and activity space groups has changed as a result of urbanisation. Ten eco-indicator species were found in various urban ecological gradients. The study's goal is to ascertain how different landscape management practices affect butterfly species' distribution and abundance. This study's goals were to evaluate butterfly populations and ascertain how disturbances affect butterfly individuals, species richness, and composition within selected sites of Gaya and Patna city in Bihar. However, the diversity and number of butterflies are negatively impacted in some areas that are bordered by anthropogenic activity. For effective butterfly conservation, it is crucial to preserve their habitats and ensure the availability of water during the dry season.

Keywords: *Butterfly diversity, Function diversity, Indicator species, Human conflict, Anthropogenic pressure*

INTRODUCTION
One of the most significant groups of colourful insects are butterflies. The group Macro Lepidoptera includes all butterflies as well as several bigger moths. Their variety is limited to certain seasons, and they have a preference for particular environments (Kunte, 1997 and Padhaye *et al.,*, 2006). Since the early 18th century, butterflies have been the subject of systematic research, and 19,238 species have been identified worldwide (Heppner, 1998). Butterflies are considered to be one of the most well researched groups of insects in the order Lepidoptera, both taxonomically and ecologically (Robbins and Opler, 1997; Mihoci *et al.,*, 2011). A certain set of habitats and host plants are preferred by butterflies in order to ensure their survival. They are considered to be potential indicator species of environmental quality and healthy ecosystems because of their sensitivity to temperature, humidity, and light levels as well as to disturbances and changes in habitat quality (Gunathilagaraj *et al.,*, 1998, Balmer and Erhardlt, 2000; Hogsden and Hutchinson, 2004 and Thomas, 2005). Butterflies, among other

insects, play an important role in ecosystems, and their diversity and abundance are regarded as reliable markers of the condition of any particular terrestrial biotope (Kunte 2000; Aluri and Rao 2002; Thomas 2005). In addition to creating extensive changes in the worldwide distribution of creatures, human impact on the environment has caused a mass extinction event that is significant on a geological time scale (Chapin *et al.,* 2000; Thomas *et al.,* 2004).

Rapid urbanisation is one of the main factors contributing to the reduction in urban biodiversity, and the effects of global environmental change are placing a great deal of strain on species survival (Grimm *et al.,* 2008). This is on top of the fragmentation of habitats and the deterioration of natural ecosystems brought about by urbanisation, which either directly or indirectly causes a decline in urban biodiversity by changing urban population densities, build-up densities, climate cycles, land-use patterns, and plant composition (Piano *et al.,* 2020, Tzortzakaki *et al.,* 2019, Uchida *et al.,* 2018, Kuussaari *et al.,* 2021). On the other hand, the process of urbanisation spreads from the centres of cities to the outskirts. Its effects extend beyond cities to rural areas, resulting in ecological zones with differing levels of quality (Van Nuland *et al.,* 2014, Li. Z. G. *et al.,* 2020). Significant differences in the distribution of biological species and populations are the outcome of this phenomena (Han *et al.,* 2021). While certain species or populations are able to adapt and thrive in highly urbanised surroundings, others are more susceptible and manage to live outside of urban centres or in high-quality urban areas. "Environmental stress" is implied by this phenomenon (Lexer *et al.,* 2005). Due to their short life cycles and vulnerability to ambient temperatures, butterflies—one of the most prevalent pollinating insects in urban areas (Dennis *et al.,* 2017) are extremely susceptible to environmental changes (Lewthwaite *et al.,* 2018). They co-evolve and become closely dependent on plants for life and reproduction. Butterfly and plant variety have been shown to positively correlate by Beirao and Soga *et al.,* (2021 and 2015). While urbanization has been highlighted as a significant contributor to the decline of biodiversity, research on its effects on biodiversity in numerous countries, particularly in developing nations, remains insufficient. As the largest developing country globally, India is undergoing swift urbanization as well as Bihar is also witnessing urbanization and development. Consequently, investigating how urbanization affects butterflies in Bihar is crucial.

MATERIALS AND METHODS

Sampling Criteria and Systematic Sampling Firstly, 50 m transects were established for green and construction landscapes using the Urban Biodiversity, which was based on anthropogenic activities. Up to 10 transects were selected for each location and evenly distributed within the selected location, with a minimum distance of more than 100 m between transects to reduce spatial autocorrelation.

The number of transects set up for each selected location were as follows:

The survey was conducted from January 1, 2022 to December 30, 2024. This corresponds to the most active period of butterfly activity in Bihar. Data collection for each park occurred on sunny days, with high visibility, low wind speeds and no precipitation. To maximize data accuracy, the survey was conducted from 9 a.m. to 12 p.m. and from 3:00 p.m. to 6:00 p.m., avoiding the midday period when butterflies tend to hide. Butterfly data collection has mainly occurred along the 50 m long, 4 m wide transects, and each transect was studied for a standard of 10 min until no new species has been observed. Three exams were held (January to December) and one round was held each month. This study was conducted primarily with three observers specialized training in the field of ecology, and had a broad understanding of butterflies, behavioural traits and plant habits. The photos were taken from various aspects using a GPS-based mobile camera. Based on the constant observation of butterfly species, it was listed in Table 1 as present and absent.

All the scientific name and identification of butterfly followed in the present study is referred from (Varshney,1983; Wynter- Blyth, 1957). The number of butterflies were recorded by direct watching and through the photographic confirmations. Sample collections are strictly avoided. No identifiable butterflies in this area were captured, but identifiable individuals were captured on a sweep net and identified using the appropriate key (Gay et al, 1992; Haribal, 1992; Kehimkar, 2008). The same was released to the same habitat of slight violations. The individuals observed were classified into different families as per the classification.

RESULTS AND DISCUSSION

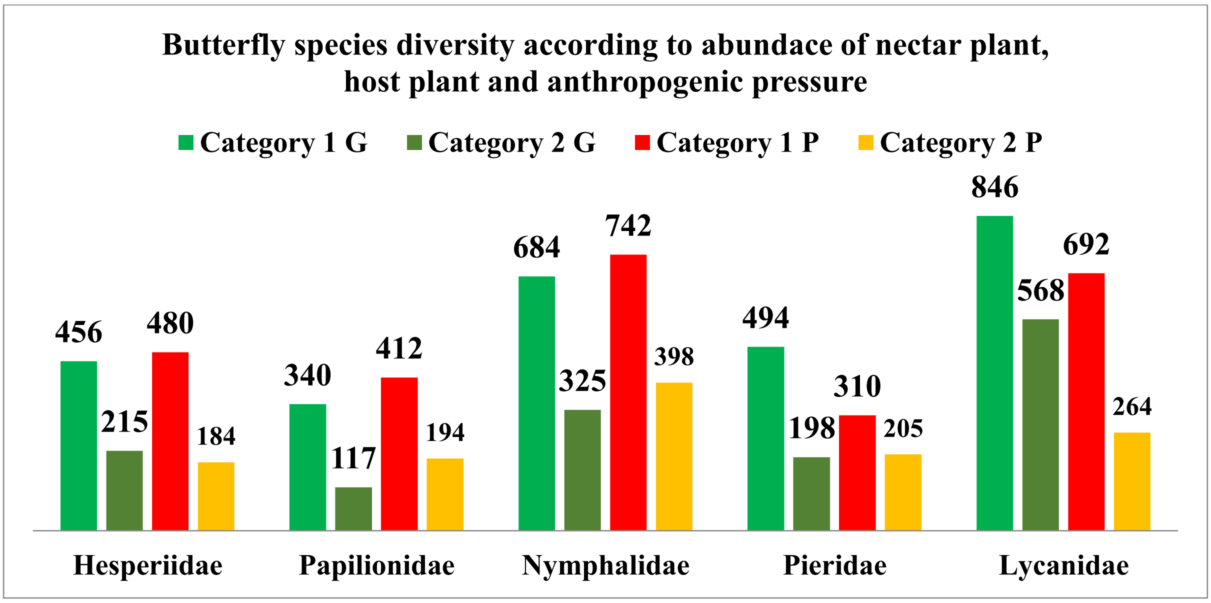
In the present study sites were selected under two categories in which category 1 represents naturally enriched flora and less human conflict and category 2 represents high anthropogenic pressure, high human conflict including habitat destruction, cutting down host plants in breeding season, pollution, dusting and burning weeds in farming landscape. One site under category 1 was selected in Gaya and Patna district while two sites under category 2/each were selected in both districts.

102 butterfly species belonging to five families were recorded in Site 1 including 2820 individuals and 2636 individuals were recorded from Patna under category 1 (site 4) belongs to 90 species. Under category 2 selected both sites represent an average of 1423 individuals belonging to 41 species and 42 species of butterflies respectively. While in Patna under category 2 both sites represent an average of 1245 individuals belonging to 48 and 39 species of butterflies respectively (Graph:1 & 2).

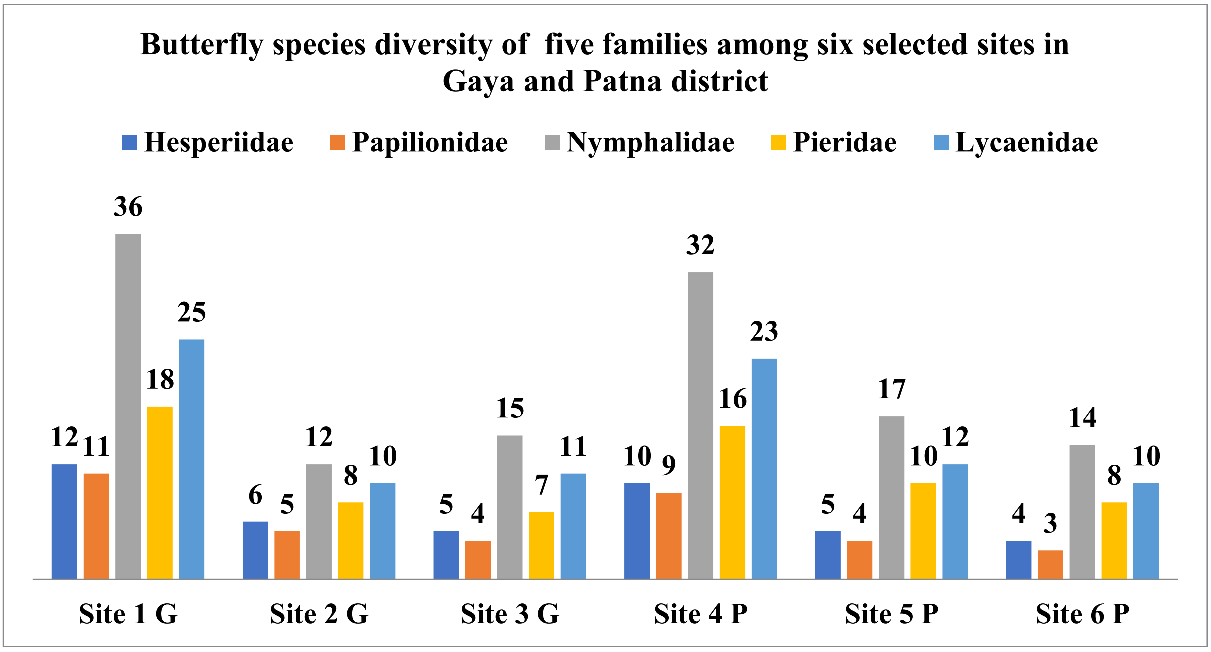
In Gaya Nymphalidae represents 35% of total recorded species followed by Lycaenidae 24%, Pieridae 18%, Hesperiidae 12% and Papilionidae 11%. While in Patna Nymphalidae represents 35% of the total population followed by Lycaenidae 26%, Pieridae 18%, Hesperiidae 11%and Papilionidae 10% (Graph:3).

Plain tiger, Common caster, Peacock pansy, Common emigrant, Lemon pansy Spotted Pierrot, Lime blue and Grass Yellow was very common in Category 1 and Category 2. While Pioneer, Painted Lady, Common Rose, Blue Mormon, Silverstreak blue, Monkey puzzle was not recorded in category 2 under highly anthropogenically pressured sites.

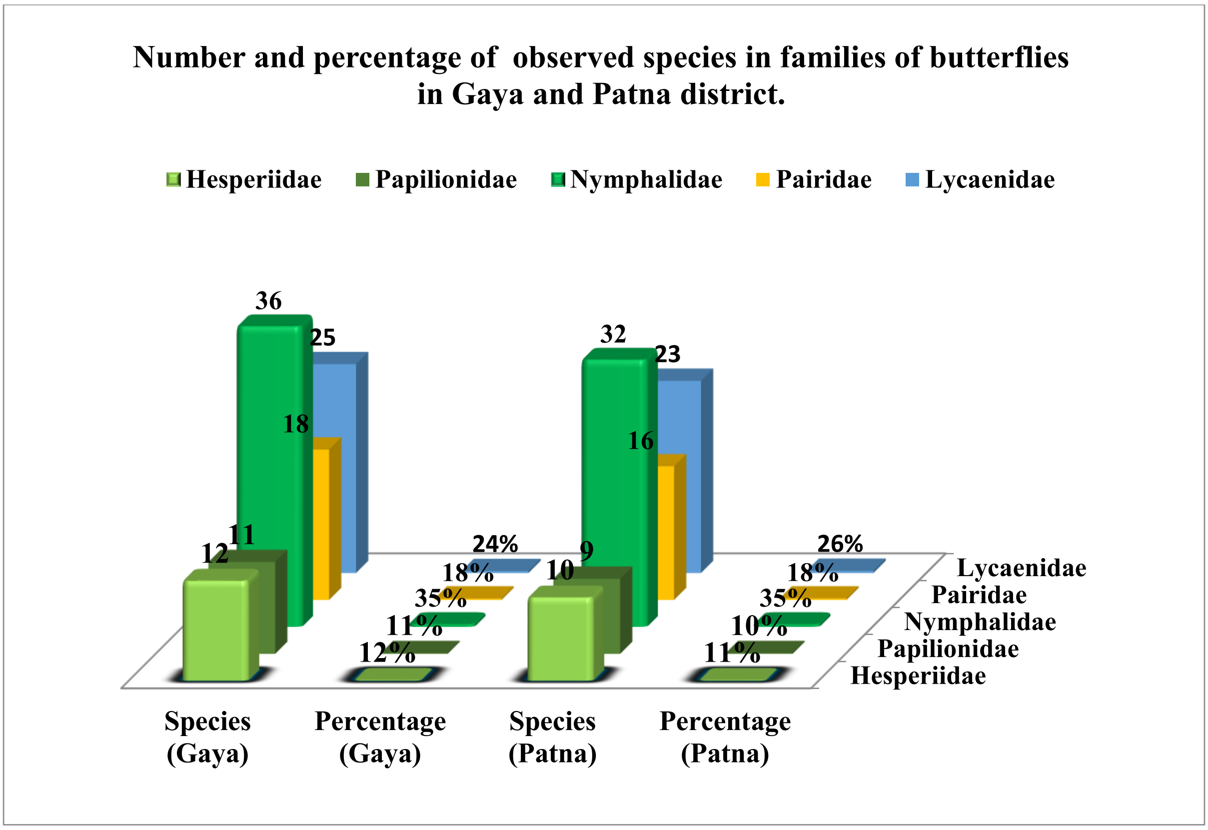
Image:1. Image showing human associated anthropogenic pressure on butterflies.



Graph: 1. Graphical representation showing number of individuals recorded in each site.



Graph: 2. Graphical representation showing butterfly species diversity.



Graph: 3. Graphical representation showing percentage of butterfly species diversity.

Table: 1. Showing the diversity of butterflies in all selected sites.

Serial no.	Common name	Scientific name	Site 1 G	Site 2 G	Site 3 G	Site 4 P	Site 5 P	Site 6 P
	Family: Hesperiidae							
1	Indian Palm Bob	*Saustus grenius* (Fabricius,1798)	*	*	*	*	*	–
2	Small Branded Swift	*Pelopidas mathias* (Fabricius, 1798)	*	–	–	*	*	*
3	Common Red Eye	*Matapa aria* (Moore, 1866)	*	*	–	–	–	–
4	Paint Brush Swift	*Baoris farri* (Moore, 1878)	*	–	–	–	–	–
5	Grass Demon	*Udaspes folus* (Cramer, 1775)	*	*	*	*	–	*
6	Contiguous Swift	*Polytremis lubricans* (Herrich-Schaffer,1869)	*	–	–	–	–	–
7	Rice Swift	*Barbo cinnara* (Wallace,1866)	*			*	*	*
8	Dark Palm Dart	*Telicota bambusae* (Moore, 1878)	*	*	*	*	*	*
9	Asian Grizzled Skipper	*Spialia galba* (Fabricius, 1793)	*	–	*	*	–	–

10	Common Palm Dart	*Telicota colon* (Fabricius, 1775)	*	*	–	*	*	–
11	Common Banded Awl	*Hasora chromus* (Cramer, [1780])	*	*	*	*	–	–
12	Brown Awl	*Badamia exclamationis* (Fabricius, 1775)	*	–	–	*	–	–
	Family: Papilionidae							
13	Common Mormon	*Papilio polytes* (Linnaeus, 1758)	*	*	*	*	*	*
14	Indian Common Mormon	*Papilio polytes romulus* Cramer, [1775]	*	–	–	–	*	–
15	Lime Butterfly	*Papilio demolus* (Linnaeus, 1758)	*	*	*	*	–	*
16	Common Jay	*Graphium doson* (C. & R. Fedler, 1864)	*	*	*	*	*	–
17	Tailed Jay	*Graphium agramemnon* (Linnaeus, 1758)	*	–	–	*	–	*
18	Common Rose	*Pachliopta aristolochiae* (Fabricius,1775)	*	–	–	*	–	–
19	Common Mime	*Papilio clytia* Linnaeus, 1758	*	–	–	*	*	*
20	Blue Mormon	*Papilio polymnestor* (Cramer, 1775)	*	–	–	*	–	–
21	Crimson Rose	*Pachliopta hector* (Linnaeus, 1758)	*	*	–	*	–	–
22	Common Bluebottle	*Graphium sarpedon* (Linnaeus, 1758)	*	*	*	–	–	–
23	Chain Swordtail	*Graphium aristeus* (Stoll, [1780])	*	–	–	*	–	–
	Family: Nymphalidae							
24	Gray Pansy	*Junonia atlites* (Linnaeus, 1763)	*	*	*	*	*	*
25	Peacock Pansy	*Junonia almana* (Linnaeus, 1758)	*	*	*	*	*	*
26	Chocolate Pansy	*Junonia iphita* (Cramer, 1779)	*	*	*	*	*	*
27	Lemon Pansy	*Junonia lemonias* (Linnaeus, 1758)	*	*	*	*	*	*
28	Yellow Pansy	*Junonia hierta* (Fabricius, 1798)	*	*	–	*	*	–
29	Blue Pansy	*Junonia orithya* (Linnaeus,1758)	*	–	–	*	*	–
30	Plain Tiger	*Danus chrysippus* (Linnaeus, 1758)	*	*	*	*	*	*
31	Striped Tiger	*Danus genutia* (Cramer, 1779)	*	–	–	*	*	–
32	Blue Tiger	*Trimula limniace* (Cramer,1775)	*	–	*	*	–	*
33	Common Baron	*Euthalia aconthea* (Cramer, 1777)	*	–	–	*	*	*

34	Gaudy Baron	*Euthalia lubentina* (Cramer, 1777)	*	–	–	*	–	–
35	Common Leopard	*Phalanta phalanta* (Drury, 1773)	*	–	*	*	–	*
36	Common Crow	*Euuploea core* (Cramer, 1780)	*	*	*	*	*	*
37	Common Evening Brown	*Melantis leda* (Linnaeus, 1758)	*	*	*	*	*	*
38	Dark Evening Brown	*Melantis phedima* (Cramer, [1780])	*	–	–	*	–	–
39	Common Three-ring	*Ypthima asterope* (Klug, 1832)	*	–	–	*	–	–
40	Common Four-ring	*Ypthima huebneri* Kirby, 1871	*	–	–	*	–	–
41	Common Bush Brown	*Mycalesis perseus* (Fabricius,1775)	*	*	*	*	*	–
42	Dark-branded Bush brown	*Mycalesis mineus* (Linnaeus, 1758)	*	–	–	*	–	–
43	Commander	*Moduza procris* (Cramer, 1777)	*	*	–	*	*	*
44	Great Eggfly	*Hypolimnas bolina* (Linnaeus, 1758)	*	–	*	*	*	*
45	Danaid Eggfly	*Hypolimnas misippus* (Linnaeus, 1764)	*	–	–	*	*	–
46	Common Castor	*Ariadne merione* (Cramer, 1777)	*	*	*	*	*	*
47	Tawny Castor	*Acraea terpsicore* (Fabricius,1793)	*	–	*	*	*	*
48	Angled Castor	*Ariadne ariadne* (Linnaeus, 1763)	*	–	–	*	–	–
49	Himalayan Yellow Coster	*Acraea issoria issoria* (Hubner, [1819])	*	–	–	–	–	–
50	Common Sailor	*Neptis hylas* (Linnaeus, 1758)	*	–	*	*	*	–
51	Short-banded Sailer	*Phaedyma columella* (Cramer, [1780])	*	–		*	–	–
52	Common Palmfly	*Elymnias hypermnestra* (Linnaeus,1763)	*	*	*	*	–	–
53	Baronet	*Symphaedra nais* Forster, 1771	*	–	–	*	–	–
54	Bamboo Tree Brown	*Lethe europa* (Fabricius, 1787)	*	–	–	–	–	–
55	Glassy Tiger	*Parantica aglea* (Stoll, [1782])	*	–	–	*	–	–
56	Bengal Spotted Palmfly	*Elymnias malelas malelas* (Hewitson, 1863)	*	–	–	–	–	–
57	White-line Bush brown	*Telinga malsara* (Moore, 1857)	*	–	–	–	–	–
58	Great Evening Brown	*Melantis zitenius* (Herbst, 1796)	*	–	–	*	–	–
59	Indian Nawab	*Charaxes bharata* C. & R. Fedler, [1867]	*	–	–	*	–	–

	Family: Pieridae							
60	Mottled Emigrant	*Catopsilia pyranthe* (Linnaeus,1758)	*	–	–	*	*	–
61	Common Emigrant	*Catopsilia pomana* (Fabricius, 1775)	*	*	*	*	*	*
62	Oriental Mottled Emigrant	*Catopsilia pyranthe pyranthe* (Linnaeus, 1758)	*	–	–	–	–	–
63	Yellow Orange Tip	*Ixias pyrene* Linnaeus, 1764	*	–	*	*	–	*
64	White Orange Tip	*Ixias marianne*(Cramer,1779)	*		–	*	*	–
65	Common Jezebel	*Delias eucharis* (Drury,1773)	*	*	*	*	*	*
66	Common Wanderer	*Pareronia hippia* (Cramer,1776)	*	*	–	*	*	–
67	Common Grass Yellow	*Eurema hesabe* (Linnaeus,1758)	*	*	*	*	*	*
68	Spotless Grass Yellow	*Eurema laeta* (Boisduval,1836)	*	–	–	*	*	*
69	Leser Gull	*Cepora nadia* (Lucas, 1852)	*	–	–	–		*
70	Common Gull	*Cepora nerissa* (Fabricius,1775)	*	*	*	*	*	–
71	Indian cabbage white	*Pieris canidia* (Sparrman, 1768)	*	*	–	*	*	–
72	Small Grass Yellow	*Eurema brigitta* (Stoll, [1780])	*	*	–	*	–	*
73	Psyche	*Leptosia nina*(Fabricius,1793)	*	*	*	*	*	*
74	Cabbage Butterfly	*Pieris rapae* (Linnaeus, 1758)	*	–	–	*	–	–
75	Three-spot Grass Yellow	*Eurema blanda* (Boisduval, 1836)	*	–	–	*	–	–
76	Pioneer	*Belenois aurota* (Fabricius, 1793)	*	–	–	*	–	–
77	Pale Clouded Yellow	*Colias erate* (Esper, 1805)	*	–	–	*	–	–
	Family: Lycaenidae							
78	Common Pierrot	*Castalius rosimon* (Fabricius,1775)	*	*	*	*	*	*
79	Common Silverline	*Cigaritis vulcanus* (Fabricius,1775)	*	–	–	*	*	–
80	Plains Cupid	*Chilades pandava* (Horsefield,1829)	*	*	*	*	*	*
81	Slate Flash	*Rapala manea* (Hewitson,1863)	*	–	*	*	*	–
82	Dark Grass Blue	*Zizeeria karsamdara* (Moore,1865)	*	*	*	*	*	*
83	Lesser Grass Blue	*Zizina otis* (Fabricius,1787)	*	*	*	*	*	*

84	Rounded Pierrot	*Tarucus nara* (Kollar,1884)	*	*	*	*	*	*
85	Common Guava Blue	*Virachola isocrates* (Fabricius,1793)	*	–	–	*	–	–
86	Lime Blue	*Chilades lajus* (Stoll, [1780])	*	*	*	*	–	*
87	Gram Blue	*Euchysops cnejus* (Fabricius,1798)	*	*	*	*	*	*
88	African Babul Blue	*Azanus jesous* (Guerin-Meneville,1849)	*	–	–	*	–	–
89	Pea Blue	*Lampidus boeticus* (Linnaeus,1767)	*	*	*	*	–	–
90	Apefly	*Spalgis epeus* (Westwood, 1851)	*	–	–	*	–	*
91	India sunbeam	*Curetis thetis* (Drury, [1773])	*	–	–	*	–	*
92	Saronis Sunbeam	*Curetis saronis* Moore,1877	*	–	*	*	–	–
93	Spotted Pierrot	*Taucus callinara* Butler,1886	*	–	*	*	*	–
94	Margined Hedge Blue	*Celatoxia marginata* (de Niceville, [1884])	*	–	–	*	–	–
95	Zebra Blue	*Leptosia plinius* (Fabricius,1793)	*	*	–	*	–	*
96	Lankan Oak Blue	*Arhopala amantes* (Hewitson, 1862)	*	–	–	*	–	–
97	Forget Me Not	*Ctochrysops strabo* Fbricius, 1793	*	–	–	*	*	–
98	Pale Grass Blue	*Pseudozizeeria maha* (Kollar, [1844])	*	–	–	*	–	–
99	Common Red Flash	*Rapala iarbus* (Fabricius, 1787)	*	–	–	*	–	–
100	Peacock Royal	*Tjuria jehana* Moore, [1884]	*	–	–	–	–	–
101	Silverstreak Blue	*Iraota timoleon* Stoll, 1790	*	–	–	–	–	–
102	Monkey Puzzle	*Rathinda amor* (Fabricius, 1775)	*	–	–	*	–	–

Recent studies show that about 100 out of 1,500 species found in India are one of the boundaries of the disappearance (Solman Raju & Rao (2002). Human activity has caused the extinction of some butterfly colonies, altering their environments beyond what the species can withstand. The presence of nectar plants and larval host plants, which are utilised by the majority of butterfly species, may be the cause of the diversity gap.

While the plantation and grassland sites receive lower scores for resource and vegetation complexity, the Garden site falls in the middle of these categories due to its diverse vegetation structures and large host plant and nectar supplies. The most significant disturbances occur in plantations and grasslands (buildings, human activity, and grass movement); in urban areas, many disturbances occur, mostly from human crowds and vehicle traffic, which disrupts the butterfly population. The elimination/destruction of human activity from natural nectar and the larval host, containing eggs, larvae and butterfly dolls, has a great influence on wealth, abundance and a variety of butterfly types. It is important to note that the variety of butterflies has also negatively influenced the cut of grass, subject to butterflies, their natural predators and unauthorized pasture and cutting plants for firewood (Image :1).

Destruction, degradation or fragmentation of biotopes are the most worrying cause of butterflies' species extinction. Hence control of the exploitation of natural biotopes for butterflies, including shrub, herb and trees, dried and green grasses would definitely help to maintain and increase the diversity of butterflies.

CONCLUSION

The conservation efforts should be collective and comprehensive, solving multifaceted tasks associated with the loss of the environment, climate change and other anthropogenic factors. Understanding and softening the drivers, the butterfly defaunation, we not only protect these delicate creatures, but also contribute to the prevention of the biodiversity and stability of the ecosystem of our planet. Understanding ecosystems has been found to support a wide range of butterflies and disturbed ecosystems, supporting migration, exclusion, and even the smallest number of populations and butterflies in the area. They are very good pollinators, and indirectly humanity, creating plants of various species that thrive without them. Training people, in particular the farmer, on the need and the importance of butterflies as a pollinator in various cultivated and wild plants to improve genetic changes. Understanding the impact of human activity, and seasonal differences on the diversity of species and the abundance of butterflies in the ecosystem are important to inform about preservation.
Present study shows that there is a significant difference in butterfly diversity, with abundance with low anthropogenic pressures and abundant natural fauna, including low human conflicts and adjacent farmlands with higher diversity where the land is free of artificial disability. The important and important differences between the types of butterflies and species communities explained by anthropogenic and environmental factors imply the need for planning to maintain natural habitats threatened by artificial offences. The types of butterflies specific to certain places can serve as an environmental indicator, as, by visible, use the environmental conditions of these places.
In future studies devoted to the study of how different individual types of butterflies depend on the available quality of the environment, will be necessary in the information that will be useful for determining the need for species necessary to improve the conversations of the butterfly community. Almost all human actions cause changes in a natural environment in more or less measure. It was impossible to observe human impact on biodiversity in a short period of training. There is no doubt that human civilization had a negative impact on biodiversity, especially after the Industrial Revolution. Destruction of housing by agriculture and growth of cities. Numerous animal and plant species have adjusted to the new stresses, food sources, predators, and dangers in urban and suburban settings, where they flourish alongside humans.

Conflicts of interests
The authors declare that there are no conflicts of interests.
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Ethical approval
The Animal ethical guidelines are followed in the study for species observation & identification.
Data and materials availability
All data associated with this study are present in the paper.

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