

COMPARATIVE ASSESSMENT OF BUTTERFLY SPECIES IN DURGAPUR CITY: A CASE STUDY

Sanchari Sarkar*, Rohit Shaw*, Moitreyee Chakrabarty*

* Durgapur Government College, Department of Conservation Biology, Durgapur, West Bengal, India

corresponding author: Moitreyee Chakrabarty, e-mail: mc_conb@durgapurgovtcollege.ac.in



This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/)

Professional paper
Received: April 20th, 2024
Accepted: June 17th, 2024
HAE-2437

<https://doi.org/10.33765/thate.15.3.2>

ABSTRACT

Butterflies, as charismatic and colourful insects, play a vital role in ecosystem health and serve as bio-indicators. In the context of Durgapur, West Bengal, India, a study was conducted to investigate the monthly diversity of butterflies in three different habitat types. These sites included dense vegetation with closed canopy cover, forest edges, and areas affected by human intervention. From November 2021 to May 2022, a total of 39 species of butterflies belonging to four families were recorded: Papilionidae, Pieridae, Nymphalidae, and Lycaenidae. The Nymphalidae family dominated with 44 % of observed species. The highest diversity and abundance were found in forest edge areas, while dense forests and human-influenced habitats showed lower butterfly diversity. The survival of these fragile, but necessary insects can be ensured if their ecological responsibilities are understood, and their diverse habitats preserved.

Keywords: butterfly, Durgapur, diversity, indicator

INTRODUCTION

Over 90 % of all insects in the world are recognized as butterflies. They are among the most popular insects. Consequently, much research has been conducted on their biology [1], making them possibly the most useful group of insects for studying patterns of terrestrial biotic diversity and distribution. According to Kocher and Williams [2], these stunning creatures are well-known for their excellent role as pollinators as well as bioindicators of anthropogenic disturbance and habitat quality. Numerous species of butterflies have strong seasonal preferences and are limited to specific types of habitats [3].

Three types of plants are necessary for the diversity and spread of butterflies: shade plants, nectarine plants, and larval host plants [4]. They serve as appropriate tools for studying biodiversity [5]. In addition, butterflies can serve as a model group for conservation efforts [6, 7]. The diversity of butterflies is a good indicator of the overall plant diversity in any ecosystem [8]. Because they rely on plants, butterflies are extremely vulnerable to changes in the environment [9, 10]. They are also affected by urbanisation [11 - 13]. As a result, they show the levels of stability and integrity of the ecosystem [8]. Due to the growing risks of human disturbance of biodiversity, biologists around the world are

faced with more difficult conservation difficulties [14]. Furthermore, it takes an almost unattainable amount of time and effort to conduct a comprehensive inventory of various species [15]. The best illustration of these difficulties are insects, which make up the largest part of animal species and range from 5 to 30 million [16]. As a result, insects are usually overlooked in conservation analyses and remain mostly unexplored [17]. In this sense, butterflies offer an opportunity because a large number of species can usually be quickly sampled, identified, and given an indication of their habitat or relevance for conservation [18].

Among the insect lineages that have been most extensively researched are the families of charismatic butterflies and odonates (damselfly and dragonfly) [19, 20]. Since they are easily identified, both groups are destined to serve as markers of changes in biodiversity in freshwater and terrestrial environments [21 - 23]. However, extrinsic extinction drivers, such as water scarcity and habitat fragmentation, have been extensively investigated for these groups [19, 20]. This is where butterflies present an opportunity, as many species can usually be quickly identified and sampled and can also provide information on habitat or conservation value [18]. There are 1501 species of butterflies in India out of the 19238 known species worldwide [24, 25]. Records from several regions of the Indian subcontinent confirm relationships between habitat and butterfly diversity [26, 27]. They are considered significant icons for the preservation of insects. The way they behave in relation to temperature, light, and habitat requirements has been quantitatively evaluated [28]. Because of their extreme sensitivity to even the smallest changes in environmental conditions, butterflies have been described as important indicator species. Their environment is a sign of robust ecology. According to Parikh et al. [29], butterflies show ecological fidelity and sensitivity to changes in the quality of their environment. These characteristics of butterflies led to the design of this study.

Several studies have noted the diversity of Odonata [30] in the Pashchim Bardhaman district of Durgapur, an industrial belt [31]. Only one order, Coleoptera, with a total of nine families of beetles, was investigated in Durgapur Steel City [32]. The Durgapur Government College Campus, located in an industrial area, is a home to more than 100 different species of birds [33]. The main subject of this study is the diversity of butterflies at three selected locations in Durgapur, as there is a lack of understanding of the diversity of this indicator group of insects.

METHODOLOGY

Study site

The research was conducted at three locations, i.e., Durgapur Government College Campus, Durgapur Barrage and Arjun Bandh, located in the “Steel City” Durgapur in West Bengal, Paschim Bardhaman district, India, as shown in Table 1 and Figure 1 made using ArcGIS.

Table 1. Geographic positions of the investigated places

Site	Geographic coordinates
Durgapur Government College Campus	23°32'33.77" N, 87°19'37.40" E
Durgapur Barrage	23°28'5.8" N, 87°18'6.8" E
Arjun Bandh	23°32'18.5" N, 87°19'38.60" E

Sampling

Durgapur is situated on the banks of the Damodar River and close to the main mining centre in Raniganj, West Bengal. The city covers an area of about 154.20 km² and has an average altitude of 65 m. This location has high summer temperatures, low to significant monsoon rains, and a dry winter [34].

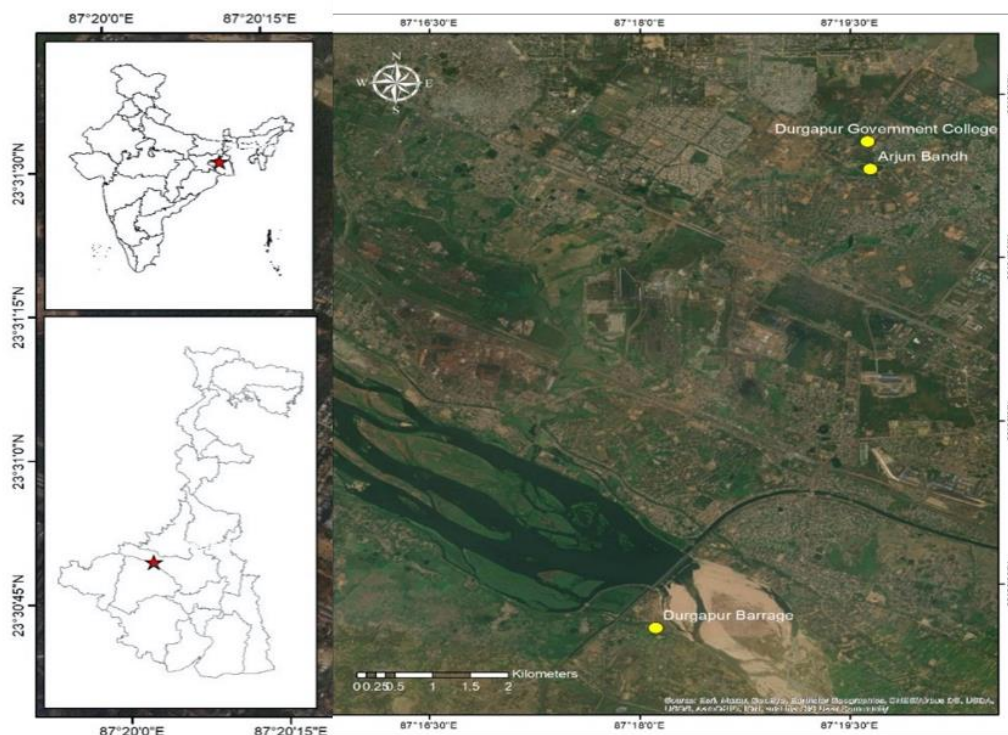


Figure 1. Locations of three research sites in Durgapur projected on a satellite image

The study was conducted from November 2021 to May 2022. Fieldwork was conducted every month, using random sampling method to ensure unbiased data collection, and data were collected for each study region.

Most of the study was limited to the period from 7:00 a.m. to 12:00 p.m. Butterflies were observed on leaves two meters on either side of the walking path. They were photographed and identified by comparing the morphological features of the butterflies with the published literature [35]. Since no specimens were taken or injured during the investigation, image identification was the only method used to identify each specimen.

Statistical analysis

The data were sorted and statistically analysed in the paleontological tool PAST 4.03 after processing in Microsoft Excel 2019 [36]. Popular ecological species indices, Simpson's Index (EH) to measure of diversity [37] and Shannon-Weiner Index (H) to estimate species diversity [38] were used to measure the species diversity. The Menhinick Index (D) to

compare the diversity of different communities [39] and Margalef Index (R) to calculate species richness [40] were used to generate the species richness index.

RESULTS

A total of 39 species of butterflies classified into four families, Papilionidae, Pieridae, Nymphalidae, and Lycaenidae, were identified (Table 2). All three investigated sites had significantly different family-wise distributions of the butterfly species, with Nymphalidae having the largest number of representative species, and Lycaenidae immediately following them (Figure 2). The monthly distribution shows that the highest abundance of butterflies was in March (17 %), followed by February. May had the lowest abundance (8 %) (Figure 3).

Throughout the year, papilionids were rarely seen, and nymphalids were much more common than any other family (Figure 4). Durgapur Government College Campus and Durgapur Barrage showed the highest

abundance of butterflies among the three locations during the study period (Figure 4). While butterfly abundance in Durgapur Barrage peaked in winter and declined in spring, it declined steadily in Durgapur Government College and Arjun Bandh region as the winter approached (Figure 5).

Table 2. List of butterfly species recorded in Durgapur city

No.	Common name	Scientific name	Family
1.	Common Gull	<i>Cepora nerissa</i>	Pieridae
2.	Common Crow	<i>Euploea core</i>	Nymphalidae
3.	Grey Pansy	<i>Junonia atlites</i>	Nymphalidae
4.	Common Lime	<i>Papilio demoleus</i>	Papilionidae
5.	Common Grass Blue	<i>Zizina labradus</i>	Lycaenidae
6.	Forget-Me-Not	<i>Catochrysops strabo</i>	Lycaenidae
7.	Lesser Gull	<i>Cepora nadina</i>	Pieridae
8.	Spotted Pierrot	<i>Tarucus callinara</i>	Lycaenidae
9.	Zebra Blue	<i>Leptotis plinius</i>	Lycaenidae
10.	Lemon Emigrant	<i>Catopsilia pomona</i>	Pieridae
11.	Tawny Coster	<i>Acraea terpicore</i>	Nymphalidae
12.	Tiny Grass Blue	<i>Zizula hylax</i>	Lycaenidae
13.	Commander	<i>Moduza procris</i>	Nymphalidae
14.	Common Sailor	<i>Neptis hylas</i>	Nymphalidae
15.	Common Pierrot	<i>Castalius rosimon</i>	Lycaenidae
16.	Three Spot Grass Yellow	<i>Eurema blanda</i>	Pieridae
17.	Common Grass Yellow	<i>Eurema hecabe</i>	Pieridae
18.	Plain Tiger	<i>Danaus chrysippus</i>	Nymphalidae
19.	Common Castor	<i>Ariadne merione</i>	Nymphalidae
20.	Chocolate Pansy	<i>Junonia iphita</i>	Nymphalidae
21.	Great Eggfly	<i>Hypolimnas bolina</i>	Nymphalidae
22.	Tytlar Bushbrown	<i>Mycalasis evansii</i>	Nymphalidae
23.	Dark Brand Bush Brown	<i>Mycalasis mineus</i>	Nymphalidae
24.	Common Evening Brown	<i>Melanitis leda</i>	Nymphalidae
25.	Common Mormon	<i>Papilio polytes</i>	Papilionidae
26.	Tailed Jay	<i>Graphium agamemnon</i>	Papilionidae
27.	Striped Tiger	<i>Danaus genutia</i>	Nymphalidae
28.	Glassy Tiger	<i>Parantica aglea</i>	Nymphalidae
29.	Orange Tip	<i>Anthocharis cardamines</i>	Pieridae
30.	Lemon Pansy	<i>Junonia lemonias</i>	Nymphalidae
31.	Blue Tiger	<i>Tirumala limniace</i>	Nymphalidae
32.	Common Cerulean	<i>Jamides celeno</i>	Lycaenidae
33.	Gram Blue	<i>Euchrysops cnejus</i>	Lycaenidae
34.	Common Albatross	<i>Appias albino</i>	Pieridae
35.	Mottled Emigrant	<i>Catopsilia pyranthe</i>	Pieridae
36.	Five-Bar swordtail	<i>Graphium antiphates</i>	Papilionidae
37.	Peacock Pansy	<i>Junonia almanac</i>	Nymphalidae
38.	Striped Albatross	<i>Appias olferna</i>	Pieridae
39.	Pale Grass Blue	<i>Pseudozizeeria maha</i>	Lycaenidae

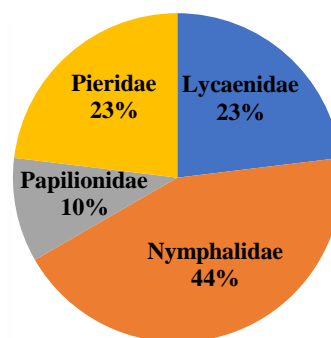


Figure 2. Distribution of butterfly diversity according to families

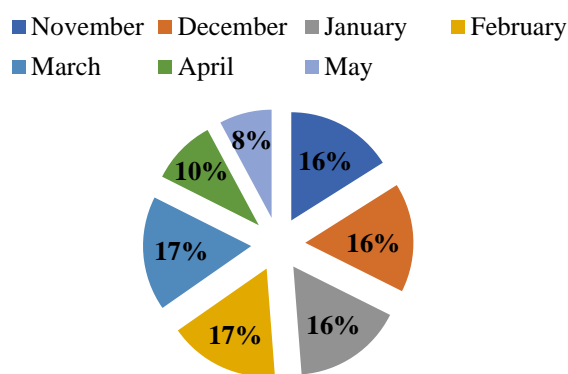


Figure 3. Percentage of occurrence of butterfly species in different months during the study period

Diversity indices showed that there was no variation in butterfly richness during the autumn, winter, and spring across the entire urban environment of Durgapur (which includes riverine habitats, undisturbed forest, and disturbed water body) (Table 3). In May, the number of individuals decreased, while at the same time dominance of certain species increased, as shown by Simpson's index (Table 3).

DISCUSSION

The diversity of butterflies in the tropics is very specific and mainly depends on forest vegetation [41, 42]. Kitahara and Fujii [43] predicted lower butterfly diversity in regions with high human disturbances. Accordingly, Blair and Launer [44] recorded fewer butterfly species and reduced overall abundance with

increasing urbanization in California. Extinction of species with more restricted distribution and therefore high conservation

values has often been shown to be the result of disturbances [45].

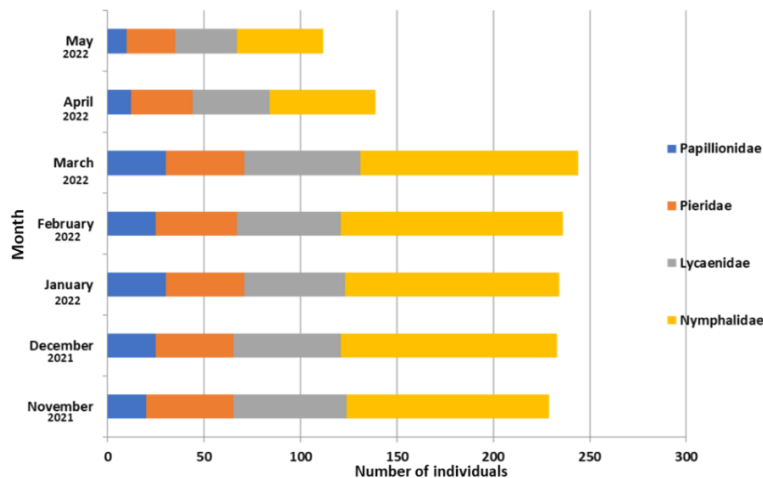


Figure 4. Occurrence of species in different butterfly families during the study period

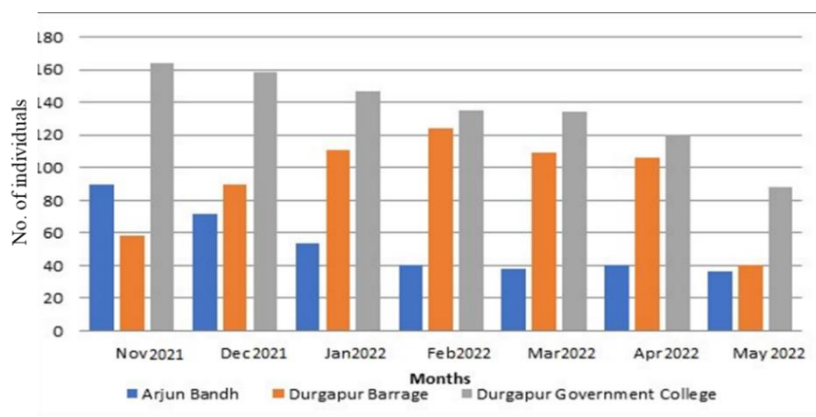


Figure 5. Comparison of butterfly abundance between the three study locations during the study period

Table 3. Monthly and seasonal estimates of different diversity indices indicating the overall status of butterfly diversity in the urban landscape of Durgapur

	Individuals	Simpson_1-D	Shannon_H	Evenness_e^H/S	Margalef	Equitability_J
November 2021	229	0.68	1.24	0.86	0.55	0.89
December 2021	233	0.67	1.24	0.86	0.55	0.89
Autumn	231 ± 2	0.67 ± 0.003	1.24 ± 0.0015	0.86 ± 0.00125	0.55 ± 0.008	0.89 ± 0.001
January 2022	234	0.68	1.26	0.88	0.55	0.91
February 2022	236	0.67	1.23	0.86	0.55	0.89
Winter	235 ± 1	0.67 ± 0.0056	1.24 ± 0.012	0.87 ± 0.0103	0.55 ± 0.004	0.98 ± 0.00855
March 2022	244	0.68	1.26	0.88	0.55	0.91
April 2022	139	0.70	1.28	0.89	0.61	0.92
May 2022	112	0.70	1.28	0.89	0.64	0.92
Spring	165 ± 40.26	0.69 ± 0.006	1.27 ± 0.0053	0.89 ± 0.0047	0.6 ± 0.0266	0.92 ± 0.0038

In the previous years, various similar studies on the butterflies of a particular region were carried out in other parts of the country. Roy et al. [46] recorded 30 species of butterflies from different habitats of Neora Valley National Park. Mukherjee et al. [47] observed 96 species belonging to five families from different areas of Kolkata, West Bengal. In the same year, Pal et al. [48] recorded a total of 91 species of butterflies belonging to 10 families from two different areas of North Bengal. In Berhampore Girls' College campus, 39 species of butterflies belonging to five families were found, more or less throughout the year, as reported by Saha et al. [49]. A total of 69 species of butterflies belonging to 54 genera and five families were recorded in Singur, Hooghly district by Dey et al. [50]. In another study from Midnapore city, Paschim Medinipur district, Biswas et al. [51] reported 82 species of butterflies belonging to six families.

During this study, it was observed that the largest number of recorded species belongs to the Nymphalidae family, which is in good agreement with previous studies [50, 51]. The highest number of species was recorded in Durgapur Government College, which suggests that the habitat of this place is still relatively intact, while the lower number of butterfly species at the other two places indicates that these two regions are affected by various anthropogenic disturbances. Seasonal variations indicate a sharp decline in numbers from April to May, which is not usually the case. The probable reason for such a result is the constant process of urbanization that leads to clearing of the plants for construction purposes and the disruption of plant-animal interactions. Another possible reason could be the delayed rain and increasing temperature on annual basis, creating a dry environment, and resulting in a decrease in the number of individuals.

Forest areas are being removed for housing, mining, and agricultural reasons due to growing industrialization and development, which in turn causes habitat degradation, modification, and fragmentation. Due to environmental pollution in that area, these

changes in the terrain make butterflies closer to human disturbances and more susceptible to them. There is an urgent need to address concerns from all aspects of society in order to preserve this unique ecoregion and the creatures that inhabit it. It is crucial to preserve the natural balance of the region, which has been disturbed for more than 200 years. The responsible authorities should restore those damaged coal mining sites and riverbanks under high anthropogenic pressure.

There is further opportunity to investigate site-specific occurrence and abundance of the butterflies in the present study area. More detailed research will certainly give some more insights into the state of butterflies in this region.

CONCLUSION

Amidst urbanization and environmental pressures, the presence of 39 recorded species of butterflies in the city of Durgapur is an example of nature's resilience. These delicate creatures, with their vibrant wings and intricate patterns, serve as bio-indicators, reflecting the health of ecosystems. Their resilience is reflected in their ability to adapt to different circumstances. Scattered wetlands, especially along the banks of the Damoder River, are essential for both butterflies and other wildlife, acting as breeding grounds and offering shelter. Long-term efforts such as butterfly gardening can improve biodiversity by attracting and maintaining butterfly populations. In addition to their intrinsic value, butterflies contribute to the economy through ecotourism. Local initiatives, such as raising awareness and involving citizens in monitoring butterflies, can play a vital role in protecting the environment.

REFERENCES

- [1] The Biology of Butterflies, eds.: R.I. Vane-Wright, P.R. Ackery, Symposium of the Royal Entomological Society of

- London, Number 11, Academic Press, 1984.
- [2] S.D. Kocher, E.H. Williams, The diversity and abundance of North American butterflies vary with habitat disturbance and geography, *Journal of Biogeography* 27(2000) 4, 785-794. <https://doi.org/10.1046/j.1365-2699.2000.00454.x>
- [3] K.J. Kunte, Seasonal patterns in butterfly abundance and species diversity in four tropical habitats in northern Western Ghats, *Journal of Biosciences* 22(1997), 593-603. <https://doi.org/10.1007/BF02703397>
- [4] F. Manzoor, H.B. Sadat, H. Farooq, Butterflies as indicator of climate change, *Zoo's Print* 28(2013) 2, 19-21.
- [5] J. Hortal, F. de Bello, J.A.F. Diniz-Filho, T.M. Lewinsohn, J.M. Lobo, R.J. Ladle, Seven shortfalls that beset large-scale knowledge of biodiversity, *Annual Review of Ecology, Evolution, and Systematics* 46(2015), 523-549. <https://doi.org/10.1146/annurev-ecolsys-112414-054400>
- [6] W.B. Watt, C.L. Boggs, Synthesis: butterflies as model systems in ecology and evolution - present and future, in: *Butterflies: Ecology and Evolution Taking Flight*, eds.: C.L. Boggs, W.B. Watt, P.R. Ehrlich, University of Chicago Press, Chicago, 2003, 603-614. <https://doi.org/10.7208/9780226063195-029>
- [7] On the Wings of Checkerspots: A Model System for Population Biology, eds.: P.R. Ehrlich, I. Hanski, Oxford University Press, Oxford, 2004. <https://doi.org/10.1093/oso/9780195158274.001.0001>
- [8] A.D. Padhye, N. Dahanukar, M. Paingankar, M. Deshpande, D. Deshpande, Season and landscape wise distribution of butterflies in Tamhini, Northern Western Ghats, India, *Zoos' Print Journal* 21(2006) 3, 2175-2181.
- [9] C. Parmesan, N. Ryrholm, C. Stefanescu, J.K. Hill, C.D. Thomas, H. Descimon, B. Huntley, L. Kaila, J. Kullberg, T. Tammaru, W.J. Tennent, J.A. Thomas, M. Warren, Poleward shifts in geographical ranges of butterfly species associated with regional warming, *Nature* 399(1999) 579-583. <https://doi.org/10.1038/21181>
- [10] T.H. Sparks, D.B. Roy, R.L.H. Dennis, The influence of temperature on migration of Lepidoptera into Britain, *Global Change Biology* 11(2005) 3, 507-514. <https://doi.org/10.1111/j.1365-2486.2005.00910.x>
- [11] P.B. Hardy, R.L.H. Dennis, The impact of urban development on butterflies within a city region, *Biodiversity & Conservation* 8(1999), 1261-1279. <https://doi.org/10.1023/A:1008984905413>
- [12] S. Jana, P.R. Pahari, T.K. Dutta, T. Baacharya, Diversity and community structure of aquatic insects in pond in Midnapore town, West Bengal, India, *Journal of Environmental Biology* 30(2009) 2, 283-287.
- [13] T. Kadlec, J. Benes, V. Jarosik, M. Konvicka, Revisiting urban refuges: Changes of butterfly and burnet fauna in Prague reserves over three decades, *Landscape and Urban Planning* 85(2008) 1, 1-11. <https://doi.org/10.1016/j.landurbplan.2007.07.007>
- [14] K.K. Islam, G.M. Mujibar Rahman, T. Fujiwara, N. Sato, People's participation in forest conservation and livelihoods improvement: experience from a forestry project in Bangladesh, *International Journal of Biodiversity Science, Ecosystem Services & Management* 9(2013) 1, 30-43. <https://doi.org/10.1080/21513732.2012.748692>
- [15] J.H. Lawton, D.E. Bignell, B. Bolton, G.F. Bloemers, P. Eggleton, P.M. Hammond, M. Hodda, R.D. Holt, T.B. Larsen, N.A. Mawdsley, N.E. Stork, D.S. Srivastava, A.D. Watt, Biodiversity inventories, indicator taxa and effects of habitat modification in tropical forest, *Nature* 391(1998), 72-76. <https://doi.org/10.1038/34166>
- [16] H.C.J. Godfray, O.T. Lewis, J. Memmott, Studying insect diversity in the tropics, *Philosophical Transactions of*

- the Royal Society of London, Series B, Biological Sciences 354(1999) 1391, 1811-1824.
<https://doi.org/10.1098/rstb.1999.0523>
- [17] Insect Sampling in Forest Ecosystems, ed.: S.R. Leather, Blackwell Publishing, Oxford, 2005.
- [18] K.S. Brown, R.W. Hutchings, Disturbance, fragmentation, and the dynamics of diversity in Amazonian Forest butterflies, in: Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities, eds.; W.F. Laurance, R.O. Bierregaard, University of Chicago Press, Chicago, 1997, 91-110.
- [19] V.J. Kalkman, J.-P. Boudot, R. Bernard, G. De Knijf, F. Suhling, T. Termaat, Diversity and conservation of European dragonflies and damselflies (Odonata), *Hydrobiologia* 811(2018), 269-282.
<https://doi.org/10.1007/s10750-017-3495-6>
- [20] O.T. Lewis, M.J.M. Senior, Assessing conservation status and trends for the world's butterflies: The sampled red list index approach, *Journal of Insect Conservation* 15(2011), 121-128.
<https://doi.org/10.1007/s10841-010-9329-8>
- [21] J.A. Thomas, Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups, *Philosophical transactions of the Royal Society of London, Series B, Biological sciences* 360(2005) 1454, 339-357.
<https://doi.org/10.1098/rstb.2004.1585>
- [22] A. Dolný, F. Harabiš, D. Bárta, S. Lhota, P. Drozd, Aquatic insects indicate terrestrial habitat degradation: changes in taxonomical structure and functional diversity of dragonflies in tropical rainforest of East Kalimantan, *Tropical Zoology* 25(2012) 3, 141-157.
<https://doi.org/10.1080/03946975.2012.717480>
- [23] T.B. Miguel, J.M.B. Oliveira-Junior, R. Ligeiro, L. Juen, Odonata (Insecta) as a tool for the biomonitoring of environmental quality, *Ecological Indicators* 81(2017), 555-566.
<https://doi.org/10.1016/j.ecolind.2017.06.010>
- [24] J. Heppner, Classification of Lepidoptera, Part I: Introduction, Association for Tropical Lepidoptera, 1998.
- [25] H. Gaonkar, Butterflies of the Western Ghats including Sri Lanka, A biodiversity assessment of a threatened mountain system, Centre for Ecological Sciences, Indian Institute of Science, Bangalore, India, Zoological Museum, Copenhagen, Denmark, The Natural History Museum, London, 1996.
- [26] T. Ramesh, K.J. Hussain, M. Selvanayagam, K.K. Satpathy, M.V.R. Prasad, Patterns of diversity, abundance and habitat associations of butterfly communities in heterogeneous landscapes of the department of atomic energy (DAE) campus at Kalpakkam, South India, *International Journal of Biodiversity and Conservation* 2(2010) 4, 75-85.
- [27] A.D. Tiple, A.M. Khurad, Butterfly species diversity, habitats and seasonal distribution in and around Nagpur City, central India, *World journal of Zoology* 4(2009) 3, 153-162.
- [28] P. Smetacek, Butterflies (Lepidoptera: Papilionoidea and Hesperoidea) and other protected fauna of Jones Estate, a dying watershed in the Kumaon Himalaya, Uttarakhand, India, *Journal of Threatened Taxa* 4(2012) 9, 2857-2874.
<https://doi.org/10.11609/JoTT.o3020.2857-74>
- [29] G. Parikh, D. Rawtani, N. Khatri, Insects as an indicator for environmental pollution, *Environmental Claims Journal* 33(2021) 2, 161-181.
<https://doi.org/10.1080/10406026.2020.1780698>
- [30] A.K. Nayak, U.S. Roy, An observation on the Odonata fauna of the Asansol-Durgapur industrial area, Burdwan, West Bengal, India, *Journal of Threatened Taxa* 8(2016) 2, 8503-8517.
<https://doi.org/10.11609/jott.2572.8.2.8503-8517>
- [31] State Industrial Profile of West Bengal 2018-19, Micro, Small & Medium

- Enterprises - Development Institute, Ministry of MSME, Government of India, 2019.
<http://www.msmedikolkata.gov.in/uploads/2021/03/SIP-2018-19.pdf>. Accessed: May 1, 2024.
- [32] M. Banerjee, Diversity and composition of beetles (order: Coleoptera) of Durgapur, West Bengal, India, *Psyche: A Journal of Entomology*, Volume 2014, 1-6. <https://doi.org/10.1155/2014/792746>
- [33] S. Adhurya, D. Gayen, M. Chakrabarty, U. Singha Roy, A study of avian diversity in Durgapur government college campus, West Bengal, India, *The Holistic Approach to Environment* 13(2023) 2, 48-62.
<https://doi.org/10.33765/thate.13.2.2>
- [34] D. Choudhury, K. Das, A. Das, Assessment of land use land cover changes and its impact on variations of land surface temperature in Asansol-Durgapur Development Region, *The Egyptian Journal of Remote Sensing and Space Science* 22(2019) 2, 203-218.
<https://doi.org/10.1016/j.ejrs.2018.05.004>
- [35] I. Kehimkar, *The Book of Indian Butterflies*, Bombay Natural History Society, Mumbai, India, 2008.
- [36] Ø. Hammer, D.A.T. Harper, P.D. Ryan, Past: paleontological statistics software package for education and data analysis, *Palaeontologia Electronica* 4(2001) 1, 1-9.
- [37] G.G. Simpson, *Biology and the Nature of Science: Unification of the sciences can be most meaningfully sought through study of the phenomena of life*, *Science* 139(1963) 3550, 81-88.
<https://doi.org/10.1126/science.139.3550.81>
- [38] C.E. Shannon, W. Weaver, *The Mathematical Theory of Communication*, The University of Illinois Press, Urbana, 1949.
- [39] E.F. Menhenick, A comparison of some species-individuals diversity indices applied to samples of field insects, *Ecology* 45(1964) 4, 859-861.
<https://doi.org/10.2307/1934933>
- [40] D.R. Margalef, Information theory in ecology, *General Systems* 3(1958), 36-71.
- [41] N.M. Collins, M.G. Morris, *Threatened swallowtail butterflies of the world: The IUCN Red Data Book*, IUCN, 1985.
- [42] S.L. Sutton, N.M. Collins, Insects and tropical forest conservation, in: *The Conservation of Insects and their Habitats*, eds.: N.M. Collins, J.A. Thomas, Academic Press, London, 1991, 405-424. <https://doi.org/10.1016/B978-0-12-181370-3.50021-X>
- [43] M. Kitahara, K. Fujii, Biodiversity and community structure of temperate butterfly species within a gradient of human disturbance: An analysis based on the concept of generalist vs. Specialist strategies, *Population Ecology* 36(1994) 2, 187-199.
<https://doi.org/10.1007/BF02514935>
- [44] R.B. Blair, A.E. Launer, Butterfly diversity and human land use: Species assemblages along an urban gradient, *Biological Conservation* 80(1997) 1, 113-125. [https://doi.org/10.1016/S0006-3207\(96\)00056-0](https://doi.org/10.1016/S0006-3207(96)00056-0)
- [45] W.R. Hill, M.G. Ryon, E.M. Schilling, Light limitation in a stream ecosystem: responses by primary producers and consumers, *Ecology* 76(1995) 4, 1297-1309. <https://doi.org/10.2307/1940936>
- [46] U.S. Roy, M. Mukherjee, S.K. Mukhopadhyay, Butterfly diversity and abundance with reference to habitat heterogeneity in and around Neora Valley National Park, West Bengal, India, *Our Nature* 10(2012) 1, 53-60.
<https://doi.org/10.3126/on.v10i1.7751>
- [47] S. Mukherjee, S. Banerjee, G.K. Saha, P. Basu, G. Aditya, Butterfly diversity in Kolkata, India: An appraisal for conservation management, *Journal of Asia-Pacific Biodiversity* 8(2015) 3, 210-221.
<https://doi.org/10.1016/j.japb.2015.08.001>
- [48] S. Pal, D. Das, A. Saha, K. Chakraborty, Holistic survey on butterfly diversity at two selected regions of the Northern parts of Bengal, India, *International*

Research Journal of Natural and Applied Science 2(2015) 4, 42-57.

- [49] M. Saha, I. Sarkar, L. Barik, R.P. Das, S.R. Dey, Butterfly diversity of Berhampore girls' college campus, Murshidabad, West Bengal, India: a preliminary assessment, The Beats of Natural Sciences 2(2015) 2, 1-12.
- [50] P.K. Dey, A. Pyra, K. Mondal, A study on butterfly diversity in Singur, West Bengal, India, E-planet 15(2017) 1, 73-77.
- [51] S.J. Biswas, D. Patra, S. Roy, S.K. Giri, S. Pal, A. Hossain, Butterfly diversity throughout Midnapore urban area in West Bengal, India, Journal of Threatened Taxa 11(2019) 14, 14816-14826.
<https://doi.org/10.11609/jott.4587.11.14.14816-14826>

Acknowledgements

The authors express their sincere gratitude to Dr. Debnath Palit, Principal of Durgapur Government College, for his constant support and kindness. We sincerely thank the members of the Department of Conservation Biology for their kind help during the field work.