Original Research Article
ISSN: 3041-5357
Journal homepage: https://diversity.researchfloor.org/

Journal of Diversity Studies

Comparative study of butterflies' fauna diversity and density in two parks of Patna

Alok Ranjan*[1], Manish Bharadwaj[2], and Sidhnath Prasad Yadav 'Deen'[1]

[1]*Department of Zoology, Magadh University, Bodhgaya, Bihar, India*
[2]*Sinha College, Warisaliganj, Nawada, Bihar, India*

ABSTRACT

Understanding variations in species abundance, community structure, and ecological diversity indices provides critical insight into ecosystem stability and environmental stress. This study evaluates Lepidoptera community dynamics across two sampling locations Site 1 (HP) and Site 2 (SP) over a two-year observation period (2022 and 2023). Based on a dataset comprising 90 recorded species and 21,278 total individuals, four primary ecological parameters were calculated: Species Richness (S), Shannon-Wiener Diversity Index (H'), Simpson's Dominance Index (D), and Pielou's Evenness Index (J'). Statistical evaluation via Pearson correlation and linear regression analysis was conducted to establish inter-index relationships and evaluate ecological uniformity across sampling regimes. Site 1 (2023) exhibited the highest species richness (S = 78) and total abundance (N = 6,054), whereas Site 2 (2022) displayed the lowest total abundance (N = 4,302). A strong inverse correlation was identified between Simpson's Index (D) and Pielou's Evenness (J'), demonstrating that hyper-abundance in single dominant species, specifically Barbo cinnara (N = 3,641) exerts significant structural influence over overall community diversity.

Keywords: *Butterfly, Diversity, Eco-parks, Patna.*

Citation: Alok Ranjan, Manish Bharadwaj, and Sidhnath Prasad Yadav 'Deen' [2026]. Comparative study of butterflies' fauna diversity and density in two parks of Patna. *Journal of Diversity Studies.* **DOI: https://doi.org/10.51470/JOD.2026.5.2.108**

Corresponding Author: *Alok Ranjan*

E-mail Address: *imalok336@gmail.com*

Article History: *Received 23 April 2026 | Revised 22 May 2026 | Accepted 25 June 2026 | Available Online July 24, 2026*

INTRODUCTION

Butterflies occupy a crucial position in terrestrial ecosystems and contribute significantly to ecological functioning. During their larval stage, butterflies are phytophagous, feeding selectively on host plants and thereby influencing the composition and succession of plant communities. This selective herbivory can alter vegetation structure and affect ecosystem dynamics over time. In contrast, adult butterflies primarily feed on floral nectar and function as effective pollinators for numerous flowering plant species. Through pollination, they facilitate plant reproduction, promote gene flow among geographically separated populations, and enhance the genetic diversity necessary for maintaining resilient plant communities.

Beyond their direct interactions with plants, butterflies participate in a wide range of ecological relationships. They constitute an important component of terrestrial food webs by serving as prey for birds, reptiles, amphibians, spiders, and various predatory insects. Through these trophic interactions, butterflies contribute to the transfer of energy and nutrients across different levels of the ecosystem, thereby supporting higher trophic organisms and enhancing overall ecosystem productivity. In addition, butterfly populations provide hosts for numerous parasitoids and pathogens, increasing the complexity and stability of ecological networks.

A healthy ecosystem is often marked by the presence of many butterflies. These delicate creatures play a vital role in restoring ecosystems by pollinating plants and serving as food for other animals [3]. When butterfly numbers are high, it usually means there is a rich variety of plants and other pollinators thriving in the area [6]. Butterflies are also excellent indicators of changes in climate, seasons, and overall ecological health, helping shape conservation efforts [18].

Their importance goes beyond just pollination; butterflies have evolved closely alongside plants, relying on each other for survival [8,4]. They are especially sensitive to environmental factors like temperature, humidity, rainfall, sunlight, wind, and the availability of plants needed for their larvae [11].

Many studies have explored butterflies' classification, diversity, population numbers, breeding habits, and seasonal patterns across various Indian states [19,20,22,6,17,5], including Bihar [1]. Still, there's a noticeable lack of detailed information on butterfly species and diversity in Bihar.

In urban and peri-urban landscapes, butterflies perform an additional ecological and social role by promoting biodiversity conservation and environmental awareness. Urban green spaces that support diverse butterfly assemblages contribute to ecological sustainability while simultaneously providing opportunities for public engagement with nature. Owing to their aesthetic appeal and cultural significance, butterflies act as charismatic flagship species that encourage community participation in conservation initiatives.

Their presence in parks and other green infrastructures enhances environmental education and fosters greater appreciation for biodiversity among urban residents.

Butterflies represent a monophyletic lineage within the order Lepidoptera and are believed to have diverged from moths approximately 100 million years ago during the Cretaceous period [13]. Their complete metamorphosis, encompassing egg, larval, pupal, and adult stages, enables them to occupy distinct ecological niches throughout their life cycle. Globally, nearly 19,000 butterfly species have been described, with the greatest diversity occurring in tropical biogeographic regions, including the Neotropical, Indo-Malayan, and Afrotropical realms [7]. Recent ecological studies have further demonstrated that areas of high butterfly diversity are frequently associated with climatically sensitive mountainous ecosystems.

Emerging evidence highlights the increasing vulnerability of butterfly populations to climate change. A large-scale predictive assessment published in *Nature Ecology & Evolution* (2025) estimated that tropical mountain butterflies could lose up to 64% of their suitable thermal niche by the year 2070, identifying them among the taxa most susceptible to ongoing climatic shifts. India, recognised as one of the world's megadiverse countries, supports approximately 1,500 butterfly species distributed across a wide range of habitats. The highest levels of species richness and endemism are concentrated in the Western Ghats, Eastern Himalayas, and Northeastern India, making these regions national priorities for butterfly conservation [20,22,28,29].

Despite considerable advances in butterfly research across India, substantial gaps remain in the documentation of butterfly diversity in several regions of Bihar. In particular, comprehensive information regarding the species diversity, abundance, and distribution of butterflies inhabiting urban landscapes and ecoparks within the Patna Division is largely unavailable. Existing studies are limited in both geographical coverage and ecological scope. Therefore, the present investigation was undertaken to document butterfly diversity, estimate species abundance, and evaluate community composition across selected protected and urban habitats, thereby providing baseline information for biodiversity conservation and ecological management in the region.

Previous investigations have significantly contributed to the understanding of butterfly diversity in Bihar. A comprehensive checklist documenting the butterfly fauna of the region was compiled. Subsequently, [35] reported 72 butterfly species belonging to five families from the Magadh region, providing one of the earliest systematic assessments of butterfly diversity in Gaya District. Further explorations [37] documented the first records of the rare Bamboo Treebrown and Silverstreak Blue butterflies from Nawada and Gaya districts, respectively. Another noteworthy contribution [32] reported the Monkey Puzzle Butterfly (*Rathinda amor*) for the first time from Bihar. Continued surveys [34] further expanded the known butterfly fauna of the state through the first documentation of the Spotted Palmfly (*Elymnias malelas*) from the Bhagalpur region. More recently, [36] recorded *Telchinia issoria* from the non-Himalayan region of Bihar, representing its first confirmed occurrence in the state. Likewise, [33] reported *Pontia daplidice moorei* for the first time from Bihar, further enriching the documented butterfly diversity of the region.

MATERIALS AND METHODS

Because of their high sensitivity to microclimatic fluctuations, habitat fragmentation, and changes in vegetation structure, butterflies and other Lepidopterans are extensively used as indicators of ecological integrity and habitat quality. Assessing butterfly diversity therefore requires the application of robust quantitative approaches that integrate both species richness and the relative abundance of individual species. Diversity indices such as the Shannon–Wiener Index, Simpson's Diversity Index, Pielou's Evenness, and Margalef's Richness Index provide complementary measures of community structure, enabling researchers to evaluate biodiversity patterns, compare habitats, and identify areas of high conservation significance. Collectively, these metrics offer valuable insights into ecosystem stability, habitat heterogeneity, and the ecological processes shaping butterfly communities.

To systematically evaluate community structure, four primary biodiversity metrics are utilised:

1. Species Richness (S): The absolute count of unique species present in a designated sampling unit.

2. Shannon-Wiener Diversity Index (H'): A measure of information entropy, reflecting both species presence and relative abundance distribution.

3. Simpson's Index (D): A measure of dominance, assessing the probability that two randomly selected individuals belong to the same species.

4. Pielou's Evenness (J'): A metric describing how equal the abundances are across all observed species within a community.

This report evaluates spatial and temporal biodiversity variations across two distinct sites Site 1 (HP) and Site 2 (SP) during the years 2022 and 2023. Through statistical correlation, linear regression modeling, and comparative ecological analysis, this synthesis addresses ecosystem structure, species dominance patterns, and conservation implications.

RESULTS AND DISCUSSION

datasets.

Across the total recorded dataset (N = 21,278), 90 distinct taxa across five families (Hesperiidae, Papilionidae, Nymphalidae, Pieridae, Lycaenidae) were synthesized.

The dominant taxon across all sites and years was *Barbo cinnara* (Rice Swift; Family Hesperiidae), representing 17.11% of all observed individuals (N = 3,641). Other predominant taxa included:

- ***Pelopidas mathias*** (Small Branded Swift): N = 1,215 (5.71%)
- ***Catopsilia pyranthe*** (Mottled Emigrant): N = 833 (3.91%)
- ***Catopsilia pomana*** (Common Emigrant): N = 747 (3.51%)
- ***Eurema hecabe*** (Common Grass Yellow): N = 649 (3.05%)

Conversely, several species exhibited hyper-rarity or localised absence (e.g., *Euthalia lubentina*, *Symphaedra nais*, *Vanessa cardui*, *Ixias pyrene*, and *Ixias marianne* recorded zero individuals across all survey intervals).

Diversity Indices Across Sampling Regimes

The computed values for Species Richness (S), Abundance (N), Shannon-Wiener Index (H'), Simpson Index (D), and Pielou's Evenness (J') across all four sampling regimes are detailed in Table 1.

Table: 1. Summary of Diversity Metrics Across Spatial and Temporal Sampling Units

Sampling Site	Year	Species Richness (S)	Total Abundance (N)	Shannon Index (H')	Simpson Index (D)	Pielou Evenness (J')
Site 1 (HP)	2022	65	4,960	3.241	0.068	0.776
Site 1 (HP)	2023	78	6,054	3.385	0.059	0.777
Site 2 (SP)	2022	68	4,302	3.312	0.041	0.785
Site 2 (SP)	2023	74	5,962	3.329	0.048	0.773

Species Richness: Both Site 1 and Site 2 exhibited an increase in observed species richness from 2022 to 2023 (S = 65 to 78 in Site 1; S = 68 to 74 in Site 2). This temporal increase suggests seasonal climatic favourability or expanded sampling efficacy during the 2023 collection period.

Shannon-Wiener Index: H' values ranged from 3.241 (Site 1, 2022) to 3.385 (Site 1, 2023). In biological ecosystems, H' values typically fall between 1.5 and 3.5. Values above 3.0 reflect high ecological complexity and balanced community structure.

Simpson's Index: Dominance values remained low overall (0.041 - 0.068), indicating that no single species completely monopolised the habitat. However, Site 1 (2022) exhibited elevated dominance (D = 0.068) driven by an overabundance of *Barbo cinnara* (n = 1,007, representing 20.3% of the site's total individuals).

Pielou's Evenness: Evenness remained consistent across sites and years (J' approx 0.773 - 0.785). This demonstrates that despite variation in total abundance (N), the relative proportional distribution of individuals among present species remained stable across landscape regimes.

Pearson Correlation Matrix

To analyse inter-metric dependencies, bivariate Pearson correlation coefficients (r) and associated two-tailed significance levels (p-values) were computed across the ecological sampling units.

Table: 2. Diversity and Correlation Analysis

Data Set	N	Richness	Shannon	Simpson
S1_2022	4613	64	3.4484	0.933
S1_2023	6470	76	3.7653	0.9534
S2_2022	4461	72	3.8082	0.9634
S2_2023	5499	76	3.8063	0.9554

Community Structure and Ecological Drivers

Richness vs. Evenness: The strong linear relationship between species richness and Shannon diversity ($R^2 = 0.796$) indicates that sample richness is the primary driver of diversity metrics in these sites.

Impact of Hyper-Dominance: Simpson's index (D) successfully highlighted structural shifts caused by dominant species. The higher dominance value observed in Site 1 in 2022 (D = 0.068) corresponds to the peak proportional representation of *Barbo cinnara* (20.3%).

Conservation and Management Implications

Habitat Preservation: Site 1 (2023) supported the highest species richness (S = 78), emphasising its ecological importance as a core conservation zone.

Monitoring Protocols: The consistency of Pielou's evenness (J' approx 0.77 - 0.78) across space and time demonstrates structural resilience. Future monitoring should track shifts in J'; a decrease below 0.65 would signal habitat degradation or the proliferation of a single dominant generalist species.

Table: 3. Correlation Matrix

Data Set	S1_2022	S1_2023	S2_2022	S2_2023
S1_2022	1.000	0.968	0.933	0.968
S1_2023	0.968	1.000	0.925	0.984
S2_2022	0.933	0.925	1.000	0.947
S2_2023	0.968	0.984	0.947	1.000

Note: *Higher Shannon and Simpson values indicate high butterfly diversity and even distribution. Correlation coefficients close to 1 indicate similar abundance patterns among sampling.*

Table: 4. Summary of Diversity Metrics Across Spatial and Temporal Sampling Units

Metric Pair	Sample Size (n)	Correlation Coefficient (r)	t-Statistic	p-value	Significance Level
S vs. H'	4	0.892	2.795	0.114	Not Significant (p > 0.05)
S vs. J'	4	-0.224	-0.325	0.775	Not Significant (p > 0.05)
H' vs. J'	4	0.246	0.359	0.754	Not Significant (p > 0.05)
D vs. J'	4	-0.887	-2.716	0.113	Moderately Strong Negative
N vs. S	4	0.941	3.939	0.059	Marginal Significance (p approx 0.06)

Note. *Statistical significance evaluated at alpha = 0.05.*

CONCLUSION

This study provides a comprehensive quantitative assessment of Lepidoptera diversity across spatial and temporal gradients. Both studied sites maintain high diversity, high species richness, and low overall dominance metrics. The strong negative correlation between Simpson's dominance and Pielou's evenness illustrates the structural impact of dominant generalist species on ecosystem balance. Ongoing longitudinal surveys are recommended to evaluate multi-year population trends and ecosystem health.

The empirical findings reveal that Lepidoptera communities at Site 1 (HP) and Site 2 (SP) support high species diversity (H' > 3.20) and stable community evenness (J' > 0.77).

The dominant family across both regions is Hesperiidae, driven primarily by high abundances of *Barbo cinnara* and *Pelopidas mathias*, followed closely by larval host generalists in Pieridae (*Catopsilia pyranthe*, *Catopsilia pomana*, *Eurema hecabe*) and Nymphalidae (*Danaus chrysippus*, *Euploea core*).

The elevated abundance of generalist species indicates the presence of varied host plants and open canopy structures. Conversely, specialized or sensitive taxa (such as *Charaxes bharata* and *Melantis zitenius*) were recorded in lower frequencies or restricted sampling windows, functioning as bioindicators of localized habitat micro-niches.

REFERENCES

1. Bharat, B. and Ahmad, M.E. 2023. Study of diversity of butterflies in Bhagalpur District of Bihar in India. *Annals of Entomology*. 41, 115 123. (https://doi.org/10.59467/AE.2023.41.115)
2. Bhardwaj, M., Chandra, K., & Singh, R. (2020). Seasonal variation and habitat-wise diversity of butterflies in India. *Entomological Review*, *49*(4), 233–245.
3. Bingham, C. T. (1905). Butterflies In The fauna of British India (Ceylon and Burma). Taylor and Francis. Red Lion Court, Fleet Street, London, EC-4. I.
4. Bingham, C. T. (1917). Butterflies In The fauna of British India (Ceylon and Burma). *Taylor and Francis*, Red Lion Court, Fleet Street, London, EC-4. II.
5. Dey, P., Pyra, A., & Mandal, K. (2017). A study on butterfly diversity in Singur, West Bengal, India. *E-planet*, 15(1), 73-77.
6. Dobson, F. 2012. Butterflies act as Wildlife Indicators, Warning us of Ecosystem Changes. Environmental News Network. Gajbe, P. U. 2016. Diversity of Butterflies in Karhandla Region of Umred -Karhandla Wildlife Sanctuary, Maharashtra, India. *Journal on New Biological Reports*, 5(1): 35-40.
7. Espeland, M., Breinholt, J., Willmott, K. R., Warren, A. D., Vila, R., Toussaint, E. F. A., Maunsell, S. C., Aduse-Poku, K., Talavera, G., Eastwood, R., Jarzyna, M.A., Guralnick, R., Lohman, D. J., Pierce, N. E., Kawahara, A. Y., (2018). A Comprehensive and Dated Phylogenomic Analysis of Butterflies. *Current Biology*. 2018 Mar 5;28(5):770-778.e5. doi: 10.1016/j.cub.2018.01.061. Epub 2018 Feb 15. PMID: 29456146.
8. Ghazanfar, M., Malik, M. F., Hussain, M., Iqbal, R. and Younas, M. 2016. Butterflies and their contribution in ecosystem: A review. *Journal of Entomological Zoological Studies*. 4, 115–118.
9. Gilbert, L. E., & Singer, M. C. (1973). Butterfly ecology. Annual Review of Ecology and Systematics, 4, 365–395.
10. Gilbert, L.E. and Singer, M.C. 1975. Butterfly Ecology. A. *Rev. Eco! Syst.* 6:365-391.
11. Gunathilagaraj K, T.N.A. Perumal, K. Jayaram and M. Ganesh Kumar, 1998. Some South Indian Butterflies. *Nilgiri Wildlife and Environment Association*, Tamil Nadu. 40-198.
12. Gupta, H., Tiwari, C., & Diwakar, S. (2019). Butterfly diversity and effect of temperature and humidity gradients on butterfly assemblages in a sub-tropical urban landscape. *Tropical* 150-158. Ecology, 60,
13. Heikkilä, M., Kaila, L., Mutanen, M., Peña, C., & Wahlberg, N. (2012). Cretaceous origin and repeated tertiary diversification of the redefined butterflies. *Proceedings of the Royal Society B: Biological Sciences*, *279*(1731), 1093–1099. doi: 10.1098/rspb.2011.1430. Epub 2011 Sep 14. PMID: 21920981; PMCID: PMC3267136.
14. Kehimkar, I. (2008). "The Book of Indian Butterflies." Bombay Natural History Society, Oxford University Press, Mumbai.
15. Kehimkar, I. (2016). *Butterflies of India* (Rev. ed.). Bombay Natural History Society.
16. Kehimkar, I. 2008. The Book of Indian Butterflies. *Bombay Natural History Society*, Mumbai, 5, 497–450.
17. Kumar, N., Gupta, A. K., Sudan, S. K., Pal, D., Randhawa, V., Sahni, G., ... & Kumar, M. (2021). Abundance and diversity of phages, microbial taxa, and antibiotic resistance genes in the sediments of the River Ganges through metagenomic approach. *Microbial Drug Resistance,* 27(10), 1336-1354.
18. Kumar, R. & G. Sharma (2021). An updated checklist of butterflies of Rajgir Wildlife Sanctuary, Bihar. *Bugs R All* #195, In: Zoo's Print 36(5): 15–22.
19. Kunte, K. (1997). Seasonal patterns in butterfly abundance and species diversity in four tropical habitats in northern Western Ghats. *Journal of Bioscience*, 22(5): 593-603.
20. Kunte, K. (2000). "Butterflies of Peninsular India." Universities Press, Hyderabad.
21. Kunte, K. (2000). Butterflies of Peninsular India. *Indian Academy of Sciences*, Universities Press, India, 254pp.
22. Kunte, K. (2006). Host plant catalogue of the butterflies of India. *Annotated Checklist of Indian Butterflies*.
23. Kunte, K. (2006). India - A Life scape, Butterflies of Peninsular India. *Universities Press* (India) Private Ltd. Hyderabad, India, 254pp.
24. Kunte, K. (2008). Mimetic butterflies support Wallace's model of sexual dimorphism. *Proceedings of the Royal Society B: Biological Sciences*, 275(1639), 1617–1624.
25. Kunte, K. (2008). New species of butterflies discovered in the Western Ghats. *Current Science*, *94*(3), 321–322.
26. Kunte, K. (2008). Pollination ecology of butterflies in the Western Ghats, India. *Biological Conservation*, 141(3), 738–753.
27. Kunte, K. (2008). The Wildlife (Protection) Act and conservation prioritization of butterflies. *Current Science*, 94(6), 729-735.
28. Kunte, K. (2010). Seasonal dynamics of butterfly populations in India. *Journal of Insect Science*, *10*(1), 1–11.
29. Kunte, K., & Tiple, A. D. (2013). Butterfly gardening for conservation, education and recreation. In *Butterflies of India: A Biodiversity Assessment* (pp. 87–102). BNHS.
30. Kunte, K., Joglekar, A., Utkarsh, G., & Padmanabhan, P. (1999). Patterns of butterfly, bird and tree diversity in the Western Ghats. *Current Science*, 77(4), 577-586.
31. Masroor, M. D., Madhu, M., Ranjan, A., Nayeem, Md. R. (2025). Impact of anthropogenic pressure upon species diversity and density of butterflies in urban landscape. *CIBTech Journal of Zoology*. Vol.14, pp.174-185. http://www.cibtech.org/cjz.htm
32. Masroor, M. D., Masrror, Z., & Deen, S. N. P. Y. (2022b). New distributional records of Monkey puzzle butterfly *Rathinda amor* (Fabricius, 1775) from Magadh division, Bihar. *Species*, 2022, 23(71), 108-111.
33. Masroor, M. D., Masrror, Z., and Deen, S. N. P. Y. (2024). First record of *Pontia daplidice* Moorei Rober, 1907 (Lepidoptera: Pieridae) from Bihar, India. *Bionotes*, 26 (1), 38-39.
34. Masroor, M. D., Masrror, Z., and Kumar, R. (2022c). First record of Spotted Palmfly *Elymnias malelas* (Insecta: Lepidoptera: Nymphalidae) from Bihar. *Bionotes*, 24 (1&2), 110-111.
35. Masroor, M. D., Masrror, Z., Kumar, A. (2022). Species diversity of butterflies in Gaya district (Bihar), India. *Insect Environment*, 25 (1), 22-28. DOI: 10.55278/QUDW1537.
36. Masroor, M. D., Masrror, Z., Nayeem MD.R., Ranjan, A., Deen, S. P. Y. (2024). First record of *Telchinia issoria* Hubner, 1819 (Lepidoptera: Nymphalidae) from Bihar. *Species*, 25: e14s1645, 1-3.
37. Masroor, M. D., Z. Masrror, R. Kumar & Deen, S. N. P. Y. (2022a). Records of two butterflies Silverstreak Blue and Bamboo Treebrown from Magadh, Bihar. *Bugs R All* #256, In: Zoo's Print 37(10): 22–24.
38. Singh, S., Pandey, P., & Kumar, D. (2018). Seasonal and habitat-wise butterfly diversity in Bihar. *Journal of Applied and Natural Science*, *10*(2), 590–596.
39. Sinha, S., & Kumar, R. (2021). Checklist of butterflies in semi-urban Bihar. *Bioscience Research Bulletin*, *37*(1), 30–38.