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Seasonal Variations in Odonata Assemblages: A Comparative Study of Rural and Urban Agroecosystems in Gaya, Bihar

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ABSTRACT

This study investigates the diversity, abundance, and seasonal variation of Odonata (dragonflies and damselflies) in rural and urban agroecosystems in Gaya district, Bihar, India. Data were collected from Manpur (rural) and Gaya urban belts, revealing distinct patterns in Odonata assemblages influenced by habitat type, seasonal factors, and environmental variables. A total of 16 Odonata species across three families (Aeshnida, Libellulidae, and Coenagrionidae) were recorded in Manpur, whereas only nine species were documented in Gaya urban. The Shannon diversity index (H) was significantly higher in Manpur (2.85) than in Gaya urban (2.1), indicating greater species richness and evenness in the rural ecosystem. Community composition differed notably between the sites: Anisoptera (dragonflies) dominated in Manpur (77% of the assemblage), while Zygoptera (damselflies) were more abundant in Gaya urban (75%). Exclusive species were observed at both sites, with *Anaciaeschnajaspidea, Neurothemisfulvia*, and *Rhodothemisrufa* recorded only in Manpur, and *Anaxguttatus*and *Brachydiplaxchalybea* unique to Gaya urban. Family-level analysis showed Libellulidae as the most dominant family at both sites, with relative abundances of 74.1% (Manpur) and 74.0% (Gaya urban). Coenagrionidae had a slightly higher abundance in rural areas (25.2%) compared to urban areas (22.9%). Seasonal patterns revealed that Odonata abundance peaked during the monsoon season in both ecosystems, with key species such as *Pantalaflavescens* and *Orthetrumsabina* showing significant increases in population during this period. Statistical analysis using ANOVA and Kruskal-Wallis tests revealed significant seasonal variations in Odonata abundance in Manpur ($p < 0.001$), underscoring the influence of climatic factors on species dynamics. This study highlights the greater ecological stability and diversity in rural agroecosystems compared to urban areas and emphasizes the need for conservation strategies tailored to habitat-specific dynamics.

INTRODUCTION

Odonata, an order of insects comprising dragonflies (suborder Anisoptera) and damselflies (suborder Zygoptera), are significant indicators of aquatic ecosystem health due to their dependence on water bodies for reproduction and their sensitivity to environmental changes (Corbet, 1999). These insects play a pivotal role in maintaining ecosystem balance, acting as both predators and prey within their habitats (Subramanian, 2009). Understanding their distribution and abundance provides insights into habitat quality, biodiversity conservation, and the ecological impacts of land use changes.

In recent years, rapid urbanization has led to significant habitat alterations, especially in developing regions like India. Changes in land use, water pollution, and loss of vegetative cover have influenced Odonata populations, leading to a shift in species composition and community structure (Kumar & Prasad, 2020). Studies comparing Odonata diversity between urban and rural areas are essential to assess the impact of urbanization on local biodiversity. Such assessments are particularly relevant in regions like Bihar, India, where agriculture dominates rural landscapes, while urban areas face significant anthropogenic pressures (Mishra et al., 2021).

This study focuses on the Gaya district of Bihar, encompassing a comparative analysis of Odonata assemblages between rural (Manpur) and urban (Gaya urban belt) agroecosystems. While rural agroecosystems are characterized by natural and semi natural habitats with diverse water bodies, urban areas feature fragmented green spaces with highly modified environments. By examining seasonal variations in species composition, diversity indices, and relative abundance, this research aims to address the following objectives:

a) To evaluate the diversity and abundance of Odonata in rural and urban agroecosystems.
b) To investigate seasonal patterns in Odonata populations across different habitats.
c) To assess the impact of urbanization on Odonata community structure using diversity metrics and statistical analyses.

This study contributes to the growing body of literature on urban biodiversity and provides baseline data for conservation efforts in the Gaya region. By integrating ecological and statistical approaches, it highlights the critical need for sustainable urban planning and habitat restoration to mitigate biodiversity loss.

Materials and Methods

Study Area

The study was conducted in two distinct agroecosystems in Gaya district, Bihar, India.

Manpur (Rural): A semi rural area characterized by agricultural fields interspersed with wetlands, small water bodies, and natural vegetation.

Gaya Urban Belt (Urban): A densely populated area with fragmented green spaces, concrete structures, and limited water bodies primarily influenced by human activities.

Sampling Design: The survey was carried out over a year (January to December), encompassing three seasons: Pre-Monsoon (March–May), Monsoon (June–September), Post Monsoon (October–February). At each site, sampling was conducted twice a month. Sampling locations included ponds, canals, and vegetative areas near water bodies.

Odonata Sampling& Identification: Odonata species were observed and identified using standard entomological methods. A sweep net was employed to collect individuals when necessary. Identification was conducted in the field using field guides (Fraser, 1933,1936; Subramanian & Nair, 2014) and photographic documentation. Species abundance was recorded as the number of individuals observed during a fixed survey time (9:00 AM to 4:00 PM).

Diversity and Abundance Metrics: The Shannon diversity index (H), Equitability index (J), and Dominance index (D) were calculated using standard formulas. Relative Abundance (RA): The proportion of individuals belonging to each species or family was computed to compare community composition between the sites.

Statistical Analysis

a) Sørensen's Similarity Index (S) was used to quantify similarity between rural and urban Odonata communities.
b) Seasonal Variation: One way ANOVA was applied to test differences in species abundance across seasons in Manpur. Additionally, the KruskalWallis test was used to confirm the results for nonnormal data.
c) Levene's Test: Assessed the homogeneity of variances among groups.
d) Software Tools: All statistical analyses were performed using R software (v.4.1.2).

Results:

The study recorded a diverse assemblage of Odonata species in Manpur (Gaya rural) and Gaya urban agroecosystems, with notable differences in species richness, composition, and ecological indices.

Species Diversity and Composition: In total 26 species were recorded from the Gaya region during the study period (2022-24). Manpur (Gaya rural) harbored 23Odonata species across three families (Aeshnidae, Libellulidae, and Coenagrionidae), while Gaya urban recorded only 15 species. The Shannon diversity index (H') was higher in Manpur (2.85) than in Gaya urban (2.1), indicating greater species richness and evenness in the rural ecosystem. Evenness (J) was slightly higher in Manpur (0.91) compared to Gaya urban (0.87), while the dominance index (D) was higher in Gaya urban (0.14) than Manpur (0.07). (Table-1 & Fig-1)

Suborder and Family Composition: The suborder Anisoptera (dragonflies) was represented by 15 species, predominantly in Manpur, while Zygoptera (damselflies) was more evenly distributed across the two sites. Libellulidae was the most abundant family at both locations, contributing 74.1% and 74.0% of the assemblage in Manpur and Gaya urban, respectively. Coenagrionidae had higher relative abundance in Manpur (25.2%) compared to Gaya urban (22.9%). (Table-2& Fig-2)

Seasonal Abundance: Odonata abundance varied significantly with seasons. Both sites showed peak abundance during the monsoon (23.45 ± 2.35 in Manpur, 21.92 ± 2.01 in Gaya urban), followed by lower populations in the pre-monsoon and post-monsoon seasons (Table-3). Key species such as*Pantalaflavescens* and *Ceriagrioncoromandelianum* showed maximum abundance during monsoon, correlating with higher water availability. Beside this species such as *Pantalaflavescens* and *Orthetrumsabina*which showed significant seasonal variation, exhibited with higher populations during monsoon in both rural and urban sites.It was also observed that selected species exhibited unique seasonal patterns in both sites. For example, at Manpur (Gaya Rural) *Pantalaflavescens*showed a peak abundance of 80.5 ± 7.29 individuals during the monsoon, declining significantly post-monsoonand at Gaya urban *Brachydiplaxchalybea*was observed only during the monsoon and post-monsoon periods, with highest abundance during monsoon (5.25 ± 1.1 individuals). (Fig-3)

Statistical Analyses:ANOVA and Welch F-tests revealed significant differences in Odonata abundance between the two sites (Gaya rural (Manpur): F = 14.41, p = 6.43×10^{-6},Gaya urban: F = 12.88, p = 3.79×10^{-5}, Levene's test confirmed significant differences in variance (Manpur: p = 8.65×10^{-6}, Gaya urban: p = 9.54×10^{-5}. The Kruskal-Wallis test (H = 25.85, p = 2.44×10^{-6} further corroborated these findings. In summary, it is observed that both ANOVA and Kruskal Wallis tests indicated significant seasonal differences in Odonata abundance in Manpur ($p < 0.001$), reflecting the strong influence of climatic factors on species dynamics. (Table-4&5)

Species Overlap:Sørensen's similarity index (S = 0.571) indicated moderate overlap in species composition between the two sites, reflecting differences in habitat preferences and ecological dynamics.

Key Observations: Species such as *Anaciaeschnajaspidea, Neurothemisfulvia* , and*Rhodothemisrufa* were exclusive to Manpur, while *Anaxguttatus* and*Brachydiplaxchalybea* were unique to Gaya urban. Seasonal fluctuations highlighted the ecological importance of the monsoon season for Odonata populations in both ecosystems.

The findings underscore the significant ecological differences between rural and urban agroecosystems and highlight the need for targeted conservation strategies.

Charts and Table:

Table-1:

Metric	Gaya Rural(Manpur)	Gaya Urban
Shannon Index (H')	2.85	2.1
Evenness (J)	0.91	0.87
Dominance Index (D)	0.07	0.14

Table 2: Relative Abundance of Odonata families at both sites

Family	RA (%) Gaya Rural(Manpur)	RA (%) Gaya Urban
Aeshnidae	0.7	3.1
Libellulidae	74.1	74
Coenagrionidae	25.2	22.9

Table 3: Seasonal Abundance (Mean ± S.E.) of Odonata

Season	Gaya Rural(Manpur)	Gaya Urban
Pre-Monsoon	5.37 ± 1.12	4.85 ± 1.01
Monsoon	23.45 ± 2.35	21.92 ± 2.01
Post-Monsoon	6.72 ± 1.08	5.37 ± 0.93

Table-4: One way ANOVA: Manpur (Gaya rural)

Test	Statistic	Value	p Value	Remark
ANOVA	F	14.41	6.43×10^{-6}	Significant difference between groups
Permutation Test	-	-	2×10^{-5}	Significant difference between groups
Variance Components	Group	83.5521	-	Between-group variance
Levene's Test (Means)	-	-	8.65×10^{-6}	Variances are significantly different
Welch F Test	F	8.427	0.0008991	Significant difference between groups
Bayes Factor	-	2906	-	Decisive evidence for unequal means

Table-5 :One way ANOVA: Gaya Urban

Test	Statistic	Value	p Value	Remark
ANOVA	F	12.88	3.79×10^{-5}	Significant difference between groups
Permutation Test	-	-	1×10^{-5}	Significant difference between groups
Variance Components	ICC	0.426	-	Moderate intraclass correlation
Levene's Test (Means)	-	-	9.54×10^{-5}	Variances are significantly different
Welch F Test	F	8.123	0.002093	Significant difference between groups
Bayes Factor	-	630.4	-	Decisive evidence for unequal means

- One way ANOVA showed significant differences in seasonal abundance in Manpur(Gaya urban) ($F = 14.41$, $p = 6.43\times10^{-6}$).
- The Kruskal Wallis test confirmed significant differences in medians ($H = 25.85$, $p = 2.44\times10^{-6}$).
- Sørensen's similarity index ($S = 0.571$) indicated moderate overlap in species between the two sites.

Fig-1: **Different Diversity Indices** at Gaya rural (Manpur) and Gaya urban

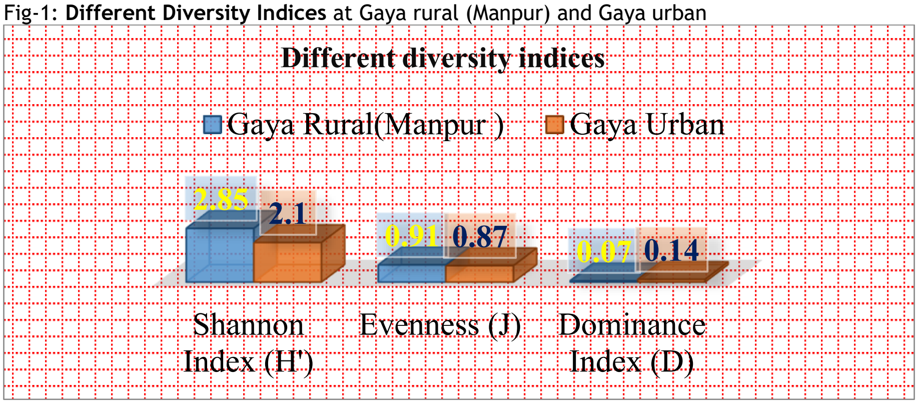


Fig-2: Family level composition at Manpur and Gaya urban.

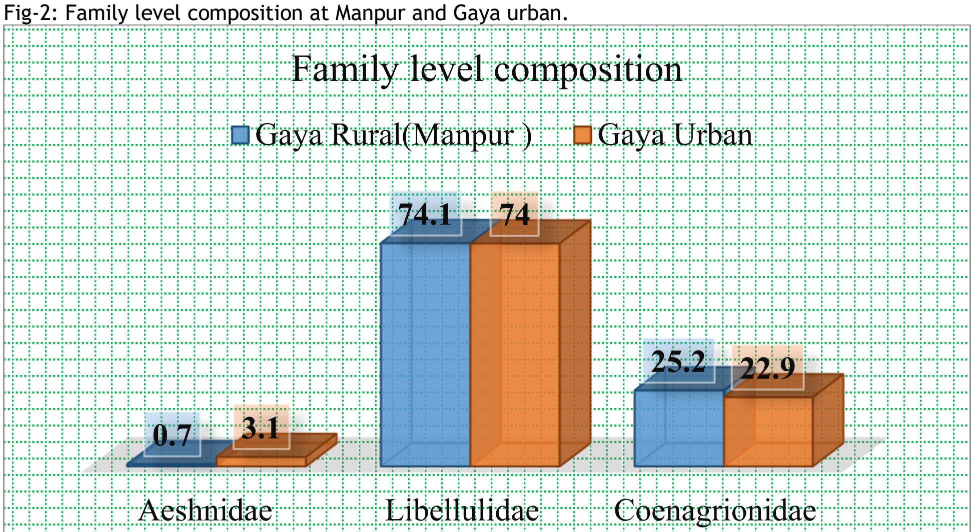
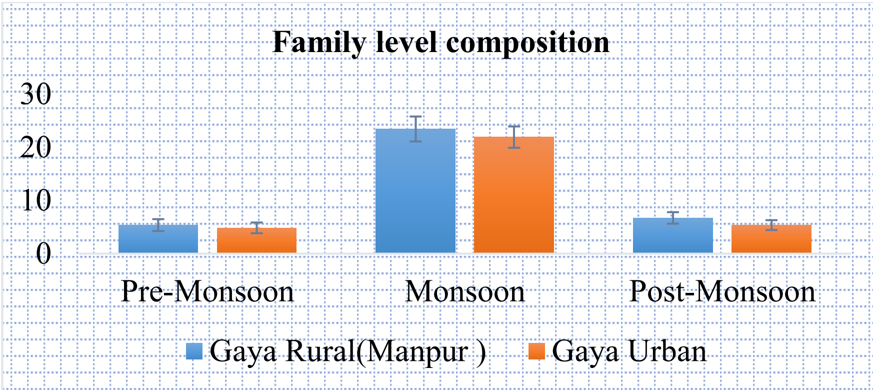


Fig-3: Seasonal total abundances at Manpur and Gaya urban.



DISCUSSION

The study highlights significant differences in Odonata diversity, abundance, and community structure between rural (Manpur) and urban (Gaya urban) agroecosystems in Gaya district, Bihar. The observed patterns underscore the influence of habitat heterogeneity, anthropogenic pressures, and seasonal variations on Odonata assemblages.The Shannon diversity index was higher in Manpur (H = 2.85) compared to Gaya urban (H = 2.1), indicating greater species richness and evenness in the rural ecosystem. This aligns with studies showing that rural habitats, characterized by less pollution and greater vegetation cover, tend to support more diverse Odonata communities (Korkeamäki&Suhonen, 2002; Prasad et al., 2019). In contrast, urban ecosystems are often dominated by tolerant species due to habitat fragmentation and water quality degradation (Samways et al., 2010).

The dominance index (D = 0.14) in Gaya urban was higher than in Manpur (D = 0.07), indicating that a few species, such as Brachydiplaxchalybea and Pantalaflavescens , dominate urban habitats. Such dominance patterns are consistent with findings from urban landscapes globally, where generalist and opportunistic species thrive in disturbed environments (Villalobos Jiménez et al., 2016).

Manpur'sOdonata community was dominated by Anisoptera (77%), while Zygoptera constituted the majority (75%) in Gaya urban. The higher proportion of Zygoptera in urban areas reflects their ability to survive in lentic water bodies often found in urban parks and reservoirs (Subramanian, 2009). However, the reduced abundance of Anisoptera in urban settings may indicate their sensitivity to water pollution and loss of emergent vegetation (Clausnitzer et al., 2009).

Within families, Libellulidae was the most dominant family at both sites, accounting for over 74% of the total abundance. This aligns with prior studies that report the adaptability of Libellulidae to diverse habitats, including anthropogenically altered environments (Kalkman et al., 2008). The relatively higher abundance of Aeshnidae in urban areas (3.1%) compared to rural areas (0.7%) is noteworthy, as it suggests a potential niche adaptation or urban resilience in this family (Corbet, 1999).

Seasonal variations in Odonata abundance were evident in both ecosystems, with the monsoon season showing peak populations. This pattern is consistent with the increased availability of breeding sites and resources during monsoon rains (Corbet, 1999). For instance, Pantalaflavescens , a highly migratory species, exhibited significant monsoon abundance in both rural (80.5 ± 7.29 individuals) and urban (71.25 ± 5.67 individuals) areas. Similarly, Orthetrumsabina , a widespread generalist, showed its highest abundance during the monsoon across both sites, indicating the importance of seasonal water bodies in sustaining populations. Odonata abundance peaked during the monsoon season at both sites, driven by increased water availability and emergent vegetation, which provide breeding habitats and prey resources (Subramanian &Sivaramakrishnan, 2005). Species such as Pantalaflavescens and Ceriagrioncoromandelianum were particularly abundant during the monsoon, corroborating previous studies on their migratory behavior and reproductive activities during this season (Anderson, 2009; Kalkman et al., 2010).

The relative reduction in abundance during the pre and post monsoon periods suggests the seasonal dependency of most species on favorable climatic and hydrological conditions for reproduction. Species such as Neurothemisfulvia and Ceriagrioncoromandelianum , which showed significant declines post monsoon, underscore the reliance on water availability for larval development.

The significant seasonal differences in species abundance, confirmed by ANOVA (F = 14.41, p = 6.43E 06), reflect the temporal dynamics of resource availability. Similar trends have been reported in tropical and subtropical regions, where monsoon rains substantially influence aquatic insect populations (Villanueva &Mohagan, 2010).

The moderate Sørensen's similarity index (S = 0.571) between Manpur and Gaya urban indicates some overlap in species composition but also highlights the distinct ecological pressures shaping these communities. Urban areas often exhibit lower diversity due to habitat homogenization, pollution, and reduced connectivity among green spaces (Suárez Rodríguez et al., 2017). The findings are consistent with research indicating that urban ecosystems tend to favor a subset of generalist and pollution tolerant species while excluding specialists (Samways, 2005).

Urban planning efforts must focus on preserving and restoring natural water bodies, creating green corridors, and reducing pollution to mitigate biodiversity loss. Studies from other Indian cities, such as Bengaluru and Pune, have demonstrated that urban green spaces with well maintained water bodies can support diverse Odonata communities (Bhatt et al., 2013; Mathur&Sundar, 2018).

CONCLUSION

By providing baseline data on Odonata diversity and their ecological roles, this research contributes to our understanding of how urbanization and seasonal dynamics impact biodiversity. The findings serve as a call to action for sustainable urban planning and rural habitat conservation in Gaya and similar regions. Future studies should focus on long term monitoring, incorporate additional environmental variables, and expand the spatial scope to provide deeper insights into Odonata ecology and their role as bioindicators.

REFERENCES

- Anderson, R. C. (2009). "Do dragonflies migrate across the western Indian Ocean?" Journal of Tropical Ecology , 25(4), 347 358.
- Bhatt, P. J., Koli, D., &Tandel, H. (2013). "Odonata diversity in urban landscapes of India." Biodiversity and Conservation , 22(3), 789 802.
- Clausnitzer, V., et al. (2009). "Odonata enter the biodiversity crisis debate." Biological Conservation , 142(4), 684 689.
- Corbet, P. S. (1999). Dragonflies: Behavior and Ecology of Odonata . Cornell University Press.
- Fraser, F. C. (1933 1936). The Fauna of British India, Including Ceylon and Burma: Odonata . Taylor and Francis.

- Kalkman, V. J., et al. (2008). "Global diversity of dragonflies in freshwater." Hydrobiologia , 595(1), 351 363.
- Korkeamäki, E., &Suhonen, J. (2002). "Distribution and habitat specialization of species affect local extinction in dragonfly Odonata populations." Ecography , 25(3), 459 465.
- Kumar, A., & Prasad, M. (2020). "Impact of urbanization on insect diversity in North India." Journal of Biodiversity and Conservation , 12(2), 45 56.
- McKinney, M. L. (2006). Urbanization as a major cause of biotic homogenization. Biological Conservation , 127(3), 247 260.
- Mishra, R., Singh, V., & Sharma, K. (2021). "Aquatic biodiversity in Bihar: Current trends and future prospects." Indian Journal of Ecology , 48(3), 345 354.
- Prasad, M., Sharma, K., & Mishra, R. (2019). "Freshwater biodiversity in Bihar: A comparative study of urban and rural landscapes." Journal of Ecology and Environment , 47(2), 201 213.
- Samways, M. J. (2005). "Dragonflies and damselflies: Model organisms for ecological and evolutionary research." Annual Review of Entomology , 50, 47 71.
- Samways, M. J., McGeoch, M. A., & New, T. R. (2010). Insect Conservation: A Handbook of Approaches and Methods . Oxford University Press.
- Simaika, J. P., &Samways, M. J. (2009). Odonata as indicators of freshwater ecosystem health . Insect Conservation and Diversity , 2(1), 93 102.
- Suárez Rodríguez, M., et al. (2017). "Urban biodiversity: Patterns and processes." Trends in Ecology & Evolution , 32(9), 645 659.
- Subramanian, K. A. (2009). Dragonflies of India: A Field Guide . Zoological Survey of India.
- Subramanian, K. A., & Nair, M. V. (2014). A checklist of Odonata (Insecta) of India. Zoological Survey of India .
- Subramanian, K. A., &Sivaramakrishnan, K. G. (2005). "Habitat and microhabitat distribution of stream insect communities of the Western Ghats." Current Science , 89(6), 976 987.
- Villalobos Jiménez, G., Dunn, A. M., & Hassall, C. (2016). "Dragonflies and damselflies (Odonata) in urban ecosystems." Journal of Insect Conservation , 20(5), 479 495.
- Villanueva, R. J. T., &Mohagan, A. B. (2010). "Diversity and status of Odonata across habitats in Mt. Hamiguitan Wildlife Sanctuary." Asian Journal of Biodiversity , 1(1), 25 35.