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Aquatic Entomofaunal Diversity in Raiwada Reservoir, Anakapalli District, Andhra Pradesh, India

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Abstract: *The present investigation on aquatic entomofauna was undertaken to assess the diversity and distribution patterns in Raiwada Reservoir over a two year period from February 2022 to January 2024. A total of 2,986 individuals were recorded, encompassing 32 taxa distributed across seven orders and 22 families, reflecting considerable taxonomic diversity within the reservoir ecosystem. The family level composition revealed distinct proportional representation among insect orders, with* Hemiptera *contributing the highest share (36.36%), followed by* Odonata *(18.18%). The orders* Coleoptera *and* Ephemeroptera *each accounted for 13.64%, while* Diptera *contributed 9.09% of the total families. At the taxonomic level,* Hemiptera *again dominated the assemblage, comprising 37.50% of the total taxa, followed by* Odonata *(28.12%).* Coleoptera *and* Ephemeroptera *contributed 12.50% and 9.37%, respectively, whereas* Diptera *represented 6.25% of the total taxa. Seasonal and monthly variations in entomofaunal density were analyzed using the Shannon Wiener diversity index (H'), with values consistently exceeding 0.69 across all seasons. These results indicate a stable, moderately diverse community structure and suggest favorable ecological conditions prevailing within the reservoir.*

Key Words: : *Entomofauna, Aquatic insects, Habitat, Shannon -Wiener diversity, Seasonal diversity, Evenness.*

1. INTRODUCTION:

India is globally acknowledged as one of the megadiverse nations, encompassing an extensive spectrum of aquatic ecosystems that collectively span approximately 3.16 million km². This remarkable ecological heterogeneity is governed by pronounced spatial variations in precipitation regimes, altitudinal gradients, latitudinal positioning, and complex physiographic features, which together sustain highly diverse and productive biological assemblages. Within these systems, a substantial proportion of insect taxa are adapted to freshwater environments including swamps, ponds, lakes, springs, streams, and rivers and are collectively designated as aquatic insects. Current estimates indicate the presence of approximately 8,600 aquatic insect species in India, distributed across 12 orders and 150 families, inhabiting a wide array of freshwater habitats (Sumanlata Saket and Gupta, 2023). Insects constitute the most speciose and evolutionarily successful faunal group, with nearly 751,000 described species worldwide, representing approximately three-fourths of all known animal taxa. Although the majority of insect species are terrestrial, a significant fraction has successfully radiated into aquatic environments, exhibiting remarkable adaptive diversification across varied ecological niches (Westfall and Tennessen, 1996; Anne et al., 2010). Aquatic insects are extensively employed as reliable bioindicators in environmental monitoring and ecological assessments owing to their pronounced sensitivity to physicochemical fluctuations and habitat perturbations. Functionally, they occupy pivotal roles in ecosystem processes, particularly in mediating energy transfer and nutrient cycling. By facilitating the breakdown and assimilation of organic matter, they enhance nutrient turnover and establish critical trophic linkages between aquatic and adjacent terrestrial ecosystems. Moreover, they form an indispensable component of the diet for fish, amphibians, and other aquatic and semi-aquatic organisms, thereby underpinning the secondary productivity of freshwater ecosystems. The larval stages of aquatic insects represent a dominant fraction of freshwater biota and serve as primary trophic resources for ichthyofaunal communities (Minshall, 2003; Tachet et al., 2003). In lotic ecosystems, such as streams and rivers, immature insect forms frequently constitute over 95% of total organismal abundance. Their spatial distribution, community structure, and population dynamics are profoundly influenced by environmental variables, among which substratum composition is a critical determinant. Additionally, many taxa exhibit stringent ecological preferences related to water quality parameters, nutrient availability, macrophyte cover, and habitat complexity. Inland wetlands of India are estimated to support nearly 5,000 species of aquatic insects (Subramanian and Sivaramakrishnan, 2007), underscoring their substantial ecological and taxonomic diversity.

Despite their recognized ecological significance, comprehensive studies on aquatic insect diversity in Andhra Pradesh remain relatively scarce, primarily due to limitations in taxonomic resolution and inadequate systematic surveys. Existing research has largely emphasized higher taxonomic categories, resulting in a paucity of species-level documentation. In this context, the present investigation seeks to generate a detailed inventory of aquatic insect diversity in Raiwada Reservoir, thereby establishing critical baseline data to support biodiversity evaluation, conservation prioritization, and the sustainable management of freshwater ecosystems.

2. LITERATURE REVIEW:

The diverse ichthyofaunal assemblages influenced by physicochemical parameters, hydrology, and anthropogenic activities. In this context, the study conducted by Sharmila Sree J and U. Shameem (2026) provides significant insights into fish biodiversity in the Meghadrigedda Reservoir located in Visakhapatnam.

The diversity and distribution of macrophyte flora are often influenced by seasonal variations, water quality, and anthropogenic disturbances. In this regard, the study carried out by Jaya P, K. Rama Rao, P. Tulasi, K. Devi, and B. Divya Sri (2024) provides a comprehensive account of aquatic macrophyte diversity in the Meghadrigedda Reservoir situated in Visakhapatnam.

The composition and abundance are highly sensitive to environmental factors such as temperature, light, nutrient availability, and hydrological conditions. In this context, the study conducted by Jyothi Kaparapu and Mohan Narasimha Rao Geddada (2015) provides significant insights into the seasonal dynamics of phytoplankton and their relationship with environmental parameters in the Meghadrigedda Reservoir located in Visakhapatnam.

Analysis of food and feeding habits provides insights into species interactions, resource utilization, and ecological niche partitioning. In this context, the study conducted by Karri Rama Rao, S. Nickhil Vardhan, Lakshmi Komali, and B. Karthik Priyatham (2022), published in the World Journal of Pharmaceutical and Life Sciences, examined the food and feeding habits of Securicula gora (Hamilton, 1822) in the Meghadrigedda Reservoir at Visakhapatnam.

3. OBJECTIVES:

- To assess the diversity and taxonomic composition of aquatic entomofauna in Raiwada Reservoir over a two-year period (February 2022 to January 2024).
- To analyze the distribution patterns and relative abundance of different insect orders, families, and taxa within the reservoir ecosystem.
- To evaluate seasonal and monthly variations in entomofaunal density using the Shannon–Wiener diversity index (H′) to understand community stability.
- To develop a comprehensive baseline database on aquatic insect diversity to support biodiversity conservation, ecological assessment, and sustainable management of freshwater resources.

4. MATERIALS AND METHODS:

i. Study area:

Aquatic insect samples were systematically collected from the Raiwada Reservoir at three designated monitoring stations at fortnightly intervals over a two year period, from February 2022 to January 2024. The selected sampling locations included the Raiwada Dam site (18.008145° N, 82.965750° E; S1), Velagalapadu (18.023196° N, 82.951529° E; S2), and Lovamukundapuram (18.022511° N, 82.996830° E; S3). These sites were strategically chosen to represent spatial heterogeneity within the reservoir system. Detailed geographic positions and site characteristics are illustrated in Figures 1, 2, and 3.



Fig 1, 2 & 3 Raiwada Reservoir

ii. Methodology

Aquatic insect samples were systematically collected from multiple zones of the dam using a nylon pond net, following the standard protocol outlined by Subramanian and Sivarama Krishnan (2007). Sampling was conducted during early daylight hours, between 06:30 h and 11:00 h, at fortnightly intervals over a two year period from February 2022 to January 2024.Collected specimens were carefully sorted, enumerated, and subsequently subjected to taxonomic identification using established diagnostic keys and reference manuals (Thirumalai, 1999; Jessup et al., 2003; Bahl and Basu, 2004; Gupta and Chaturvedi, 2008; Epler, 2006). For identification purposes, only a limited number of representative specimens (two to three individuals per taxon) were preserved and examined in detail, while the remaining individuals were released back into the reservoir after enumeration to minimize ecological disturbance.

Shannon-Wiener Index denoted by **H = -SUM [(p_i) × ln(p_i)]**

SUM = summation

p_i = proportion of total sample represented by species *i*

Divide no. of individuals of species *i* by total number of samples

S = number of species, = species richness

H_{max} **= ln(S)** Maximum diversity possible

E = Evenness = H/H_{max}

5. RESULTS AND DISCUSSIONS:

The present investigation documented the diversity and composition of aquatic insect fauna in Raiwada Reservoir over a two-year period from February 2022 to January 2024. A total of 29,867 individuals were recorded, encompassing 32 taxa distributed across 22 families and seven orders, indicating substantial taxonomic richness and community complexity within the reservoir ecosystem.

Among the recorded groups, the order *Hemiptera* exhibited the highest representation, comprising eight families Belostomatidae, Gerridae, Helotrephidae, Pleidae, Naucoridae, Nepidae, Notonectidae, and Microveliidae and accounting for the maximum diversity with 12 taxa. This dominance reflects the adaptive versatility of hemipterans to a wide range of aquatic microhabitats. The order *Odonata* constituted the second most dominant group, represented by four families Coenagrionidae, Libellulidae, Gomphidae, and Corduliidae with a total of nine taxa. Members of this order are well known for their ecological significance as predators and indicators of water quality. *Coleoptera* was represented by three families, namely Dytiscidae, Elmidae, and Hydrophilidae, contributing four taxa to the overall assemblage. Similarly, the order *Ephemeroptera* included three families Baetidae, Ephemerellidae, and Leptophlebiidae with three taxa recorded. The order *Diptera* was represented by two families, Chironomidae and Sciomyzidae, comprising two taxa. In contrast, the orders *Megaloptera* and *Trichoptera* showed minimal representation, each contributing a single family Corydalidae and Leptoceridae, respectively with one taxon each. Overall, the observed taxonomic composition highlights the predominance of Hemiptera and Odonata, while the relatively lower representation of other orders suggests variations in habitat suitability and ecological preferences across the reservoir system (Table 1).

Table 1. Identified order, family and taxa in Lower Manair Dam

Order	Family	Sl. no	Nymphs/Adults	Taxa
I. Coleoptera	Dytiscidae	1	Predaceous diving beetles	*Cybister sp.*
		2	Diving beetles	*Hydroporus sp.*
	Elmidae	3	Riffle beetles	*Stenelmis sp.*
	Hydrophilidae	4	Water scavenger beetles	*Helochares sp.*
II. Diptera	Chironomidae	5	Bloodworms nymph	*Chironomus sp.*
	Sciomyzidae	6	Marsh flies	*Sepedon sp.*
III. Ephemeroptera	Baetidae	7	Small minnow mayflies	*Baetis sp.*
	Ephemerellidae	8	Spiny crawler mayflie	*Ephemerella sp.*
	Leptophlebiidae	9	Mayflie	*Habrophlebiodes sp.*
IV. Hemiptera	Belostomatidae	10	Giant water bugs	*Belostoma sp.*
		11	Toe-biter	*Spherodema sp.*
	Gerridae	12	Water striders	*Gerris sp.*
	Helotrephidae	13	Water scorpions	*Nanotrephes sp.*
		14	Hemispherical backswimmers	*Helotrephes sp.*
	Pleidae	15	Pygmy backswimmers	*Paraplea sp.*
		16	Pygmy backswimmers	*Neoplea sp.*
	Naucoridae	17	Saucer bugs	*Naucoris sp.*
	Nepidae	18	Water stick-insects	*Ranatra sp.*
		19	Water scorpions	*Laccotrephes sp.*
	Micronectidae	20	Pygmy water boatmen	*Micronecta sp.*
	Veliidae	21	Water crickets	*Microvelia sp.*
V. Megaloptera	Corylladidae	22	Dobson flies	*Corydalus sp.*
VI. Odonata	Coenagrionidae	23	Forktails or bluetails	*Ischnura sp.*
	Libellulidae	24	Pygmyflies	*Nannophya sp.*
		25	Skimmers	*Hydrobasileus sp.*
		26	Baskers	*Urothemis sp.*
	Gomphidae	27	Clubtails	*Melligomphus sp.*
		28	Dragonflies	*Heliogomphus sp.*
		29	Hooktails	*Paragomphus sp.*
	Corduliidae	30	Striped emeralds	*Somatochlora sp.*
		31	Baskettails	*Epitheca sp.*
IV. Trichoptera	Leptoceridae	32	Long-horned caddisflies	*Leptocerus sp.*

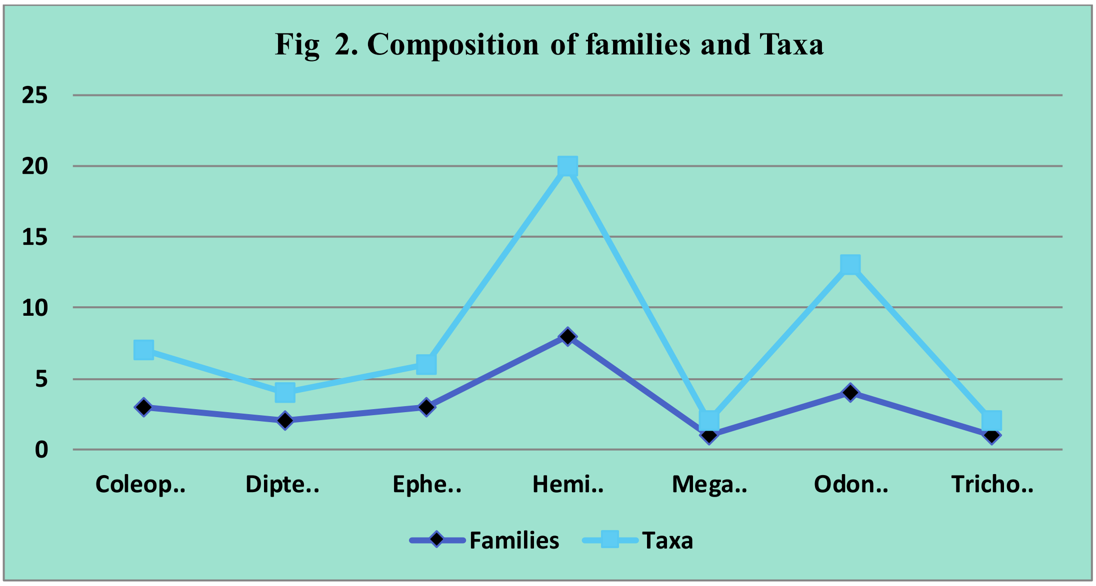
Comparable observations have been reported in earlier investigations on aquatic insect diversity across diverse freshwater ecosystems in India. Rama Rao et al. (2020) documented 37 taxa belonging to 22 families and seven orders from the Lower Manair Dam, demonstrating a taxonomic composition broadly consistent with the present findings. A comprehensive review by Anamika et al. (2021), covering studies conducted between 2011 and 2021, provided an extensive database on the distribution and diversity of aquatic insects across different regions of India. The review highlighted that the majority of aquatic insect assemblages are typically distributed among ten principal taxonomic orders, reflecting the wide ecological amplitude of these groups. Similarly, Bijita and Gupta (2015) reported 21 species of aquatic insects representing 14 families and seven orders from the Bakuamari Stream, indicating moderate diversity within lotic ecosystems. In contrast, Abhijna et al. (2013) recorded a comparatively higher diversity, identifying 60 species distributed across 37 families and eight orders in Vellayani Lake, suggesting that lentic ecosystems may support richer and more complex insect assemblages under favorable environmental conditions. Anjana Choudhary and Janakahi (2015) documented aquatic insect fauna from Sagar Lake, comprising 12 species under 12 genera, 10 families, and four orders, reflecting relatively lower taxonomic diversity. Furthermore, studies on freshwater lakes in Ajmer revealed the presence of more than 18 families of aquatic insects, including Dytiscidae, Helonidae, Hydraenidae, Hydrophilidae, Psephenidae, Corixidae, Gerridae, Nepidae, Notonectidae, and Veliidae, as reported by Rashmi Sharma (2015) and Amaravathi et al., (2018). Collectively, these studies corroborate the variability in aquatic insect diversity across different freshwater habitats, influenced by ecological conditions, habitat heterogeneity, and regional environmental factors, thereby supporting the findings of the present investigation.

A total of 22 families recorded from Raiwada Reservoir exhibited distinct proportional representation across different insect orders. The order *Hemiptera* contributed the highest share, accounting for 36.36% of the total families, followed by *Odonata* with 18.18%. The orders *Coleoptera* and *Ephemeroptera* each represented 13.64%, while *Diptera* contributed 9.09%. In contrast, *Trichoptera* and *Megaloptera* showed minimal representation, each comprising 4.55% of the total family composition. In terms of taxonomic richness, *Hemiptera* again dominated the assemblage with 37.50% of the total taxa, followed by *Odonata* at 28.12%. *Coleoptera* contributed 12.50%, while *Ephemeroptera* accounted for 9.37%. The order *Diptera* represented 6.25% of the total taxa, whereas *Trichoptera* and *Megaloptera* exhibited the lowest contribution, each comprising 3.12% of the total population. These patterns clearly indicate the predominance of hemipteran taxa in both family composition and species richness, followed by odonate groups, reflecting their ecological adaptability and successful colonization within the reservoir ecosystem (Table 2; Fig. 2).

Table: 2. Number and percent composition of families and Taxa of insects under various orders

S. no	Orders	% of families in an order	% of taxa in an order
1	Coleoptera	13.63	12.50
2	Diptera	09.09	06.25
3	Ephemeroptera	13.62	09.37
4	Hemiptera	36.36	37.50
5	Megaloptera	04.54	03.12
6	Odonata	18.18	28.12
7	Trichoptera	04.54	03.12

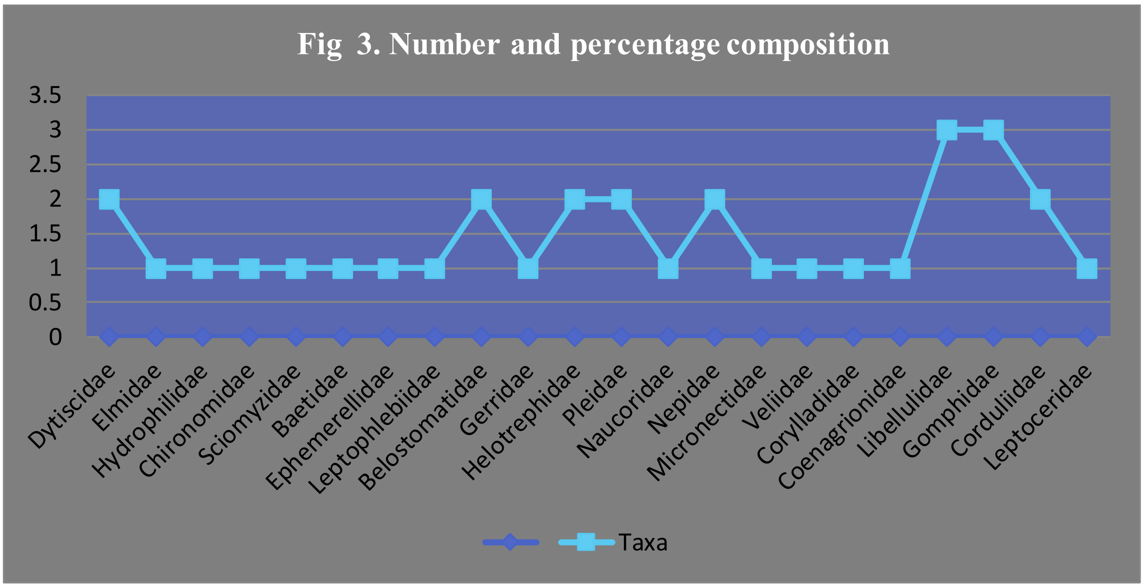
Comparable patterns of taxonomic dominance have been reported in earlier studies on aquatic insect assemblages. Rama Rao et al. (2020) observed that *Hemiptera* contributed 37.84% of the total taxa in the Lower Manair Dam, followed by *Odonata* (27.03%) and *Coleoptera* (16.22%), indicating a similar hierarchical distribution to that recorded in the present study. Likewise, Amaravathi et al., (2018) reported *Hemiptera* as the dominant order, comprising 10 families and contributing 37.04% of the total taxa. This was followed by *Coleoptera*, *Ephemeroptera*, and *Odonata*, each contributing 14.82%, while *Diptera* and *Trichoptera* accounted for 7.41% each, and *Megaloptera* represented the least with 3.70%. Studies from the Sothuparai Reservoir further corroborate the predominance of hemipteran taxa, where families such as Hydrometridae, Notonectidae, Nepidae, Ranatridae, Belostomatidae, Corixidae, and Naucoridae were reported as dominant components of the aquatic insect community (Medona Mary et al., 2015; Arimoro et al., 2007). Additionally, Rama Rao et al., (2020) documented that *Hemiptera* dominated with eight families contributing 36.36%, followed by *Odonata* at 18.18% in the Lower Manair Dam ecosystem. Collectively, these findings consistently highlight the ecological predominance of hemipteran insects across freshwater habitats, reinforcing the results of the present study and suggesting their strong adaptive capacity and ecological resilience in lentic environments.



In the present investigation the family wise composition of aquatic insects in Raiwada Reservoir revealed distinct patterns of relative abundance. Among the recorded families, *Libellulidae* and *Gomphidae* exhibited the highest contribution, each accounting for 9.38% of the total taxa. This was followed by *Dytiscidae*, *Belostomatidae*, *Helotrephidae*, *Pleidae*, *Nepidae*, and *Corduliidae*, each contributing 6.25% to the overall assemblage, indicating moderate representation within the community structure. In contrast, several families showed comparatively lower representation, each contributing 3.12% of the total taxa. These included *Elmidae*, *Hydrophilidae*, *Chironomidae*, *Sciomyzidae*, *Baetidae*, *Ephemerellidae*, *Leptophlebiidae*, *Gerridae*, *Naucoridae*, *Micronectidae*, *Veliidae*, *Corydalidae*, *Coenagrionidae*, and *Leptoceridae*. Overall, the family-level distribution underscores the dominance of odonate families, particularly *Libellulidae* and *Gomphidae*, while a larger number of families exhibited relatively low proportional representation, reflecting a diverse yet uneven community structure within the reservoir ecosystem (Table 3; Fig. 3).

Table: 3. Number and percentage composition of genera and species under various families

S.no	Families	% of Taxa in a family	S.no	Families	% of Taxa in a family
1	Dytiscidae	06.25	12	Pleidae	06.25
2	Elmidae	03.12	13	Naucoridae	03.12
3	Hydrophilidae	03.12	14	Nepidae	06.25
4	Chironomidae	03.12	15	Micronectidae	03.12
5	Sciomyzidae	03.12	16	Veliidae	03.12
6	Baetidae	03.12	17	Corylladidae	03.12
7	Ephemerellidae	03.12	18	Coenagrionidae	03.12
8	Leptophlebiidae	03.12	19	Libellulidae	09.38
9	Belostomatidae	06.25	20	Gomphidae	09.38
10	Gerridae	03.12	21	Corduliidae	06.25
11	Helotrephidae	06.25	22	Leptoceridae	03.12

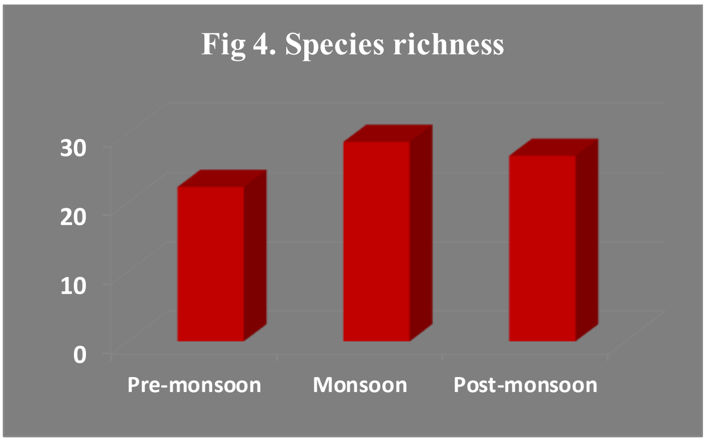


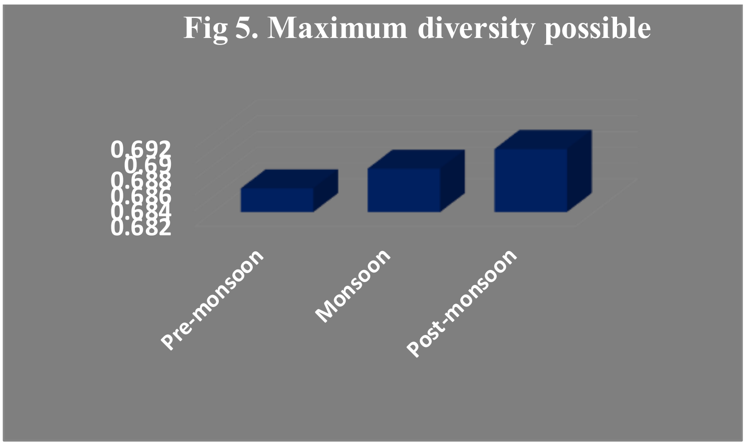
Similar trends in family level composition and dominance have been documented in earlier studies across diverse freshwater ecosystems. Amaravathi et al., (2018) reported that the family *Hydrophilidae* was the most dominant in Kondakarla Lake, contributing 46% of the total taxa, followed by representatives of the order *Coleoptera* (22%), indicating a strong prevalence of coleopteran taxa in that system. Investigations on the diversity of aquatic insects in the Karamana River, located in the southern Western Ghats of India, as reported by Bismi and Madhusoodanan (2016) and Malmqvist (2002), further emphasize the ecological variability and richness of aquatic insect communities across different habitat types. Additionally, Dharitri Choudhury and Susmita Gupta (2015) documented 31 species belonging to 18 families under five orders, reflecting moderate diversity within their study area. In Deepor Beel, Assam, the order *Hemiptera* was identified as the most dominant group, comprising 17 species across eight families, followed by *Coleoptera*, which included seven species distributed among five families. Collectively, these findings reinforce the variability in taxonomic composition and dominance patterns of aquatic insects across freshwater ecosystems, while consistently highlighting the ecological prominence of hemipteran and coleopteran groups, thereby supporting the observations of the present study.

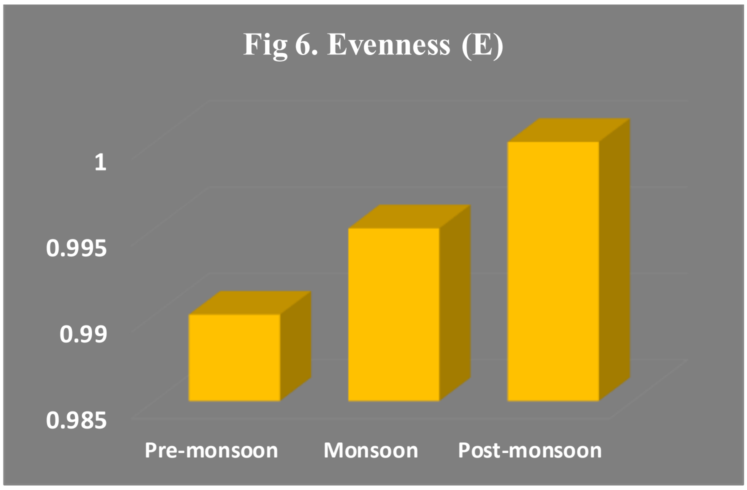
In the present investigation, species richness varied between 21 and 30 across different seasons, with the highest values recorded during the monsoon period (36.98%), followed by the post-monsoon season (34.40%), and the lowest during the pre monsoon phase (28.61%) (Fig 4). This seasonal variation reflects the influence of hydrological conditions and habitat availability on aquatic insect assemblages. The Shannon Wiener diversity index (H′) values were consistently greater than 0.69 across all seasons, indicating relatively unpolluted conditions and good water quality throughout the reservoir (Fig 5). Such values suggest a stable and moderately diverse aquatic community structure. Furthermore, the evenness index values ranged between 0.98 and 1.00, demonstrating a highly uniform distribution of individuals among the recorded taxa (Fig 6). This high degree of evenness (E) indicates the absence of pronounced dominance by any single species and reflects a well balanced and ecologically stable insect community across all sampling locations within the reservoir (Tab 4).

Table: 4. Insects Population Diversity Index from 2022-24

Season	Pre-monsoon				Monsoon				Post-monsoon			
Month	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Species richness	24	22	22	21	28	28	29	30	28	27	27	25
H_{max}	0.69	0.69	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.69	0.69
Evenness **E**	1.0	1.0	0.98	0.98	1.0	0.98	1.0	1.0	1.0	1.0	1.0	1.0







Comparable seasonal patterns of species richness and diversity have been reported by several investigators in different freshwater ecosystems. Rama Rao et al., (2020) observed that species richness in the Lower Manair Dam ranged from 31 to 34, with the highest values during the monsoon season (35%), followed by pre-monsoon (34%), and the lowest during the post-monsoon period (31%), which is broadly consistent with the seasonal trends recorded in the present study. Similarly, Joydeb Majumder et al., (2013) reported that the orders *Hemiptera* (32.26%) and *Odonata* (32.25%) exhibited higher species richness in urban freshwater lakes, followed by *Coleoptera* (25.81%) and *Diptera* (9.68%), indicating the dominance of hemipteran and odonate taxa across varied aquatic habitats. Several researchers, including Popoola and Otalekor (2011) and Turkmen and Kazanci (2010), have emphasized the importance of aquatic insects and benthic macroinvertebrates as reliable indicators for assessing biodiversity patterns and ecological health in aquatic ecosystems through the application of diversity indices. The observed patterns of species evenness in the present study are also in agreement with findings by Bismi and Madhusoodanan Pillai (2013), who reported high evenness values for aquatic insect communities in the Karamana River, Southern Western Ghats, suggesting stable and well-balanced community structures.

Furthermore, Balachandran et al., (2012) documented similar trends in the diversity and distribution of aquatic insects in the Aghanashini River of the Central Western Ghats, reinforcing the consistency of these ecological patterns across geographically distinct freshwater systems.

6. CONCLUSION:

The present study reveals that Raiwada Reservoir supports a rich and diverse assemblage of 32 taxa, 22 families, and seven orders of aquatic insects. The dominance of *Hemiptera* and *Odonata* in terms of both taxonomic composition and relative abundance highlights their strong ecological adaptability and significant role in freshwater ecosystems. Family level analysis further demonstrated the predominance of odonate families such as *Libellulidae* and *Gomphidae*, along with a wide representation of other families with moderate to low abundance, suggesting a structurally complex but evenly distributed community. Seasonal analysis indicated that species richness was highest during the monsoon and post monsoon periods, reflecting the influence of hydrological conditions and habitat heterogeneity on community dynamics. The consistently high Shannon Wiener diversity index values (>0.69) and near perfect evenness (0.98–1.00) across all sampling sites indicate good water quality, ecological stability, and a well-balanced distribution of taxa within the reservoir. Overall, the findings establish Raiwada Reservoir as a biologically productive and ecologically stable freshwater system. The study provides essential baseline data on aquatic insect diversity, which can serve as a valuable reference for future biodiversity assessments, environmental monitoring, and sustainable management of freshwater resources.

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1. **ETHICAL APPROVAL:**

This study was conducted according to international ethical standards set by the Institutional Animal Care and Use Committee (Vet CU 8/03/2022 /429)

2. **CONFLICT OF INTEREST**

There are no conflicts of interest to declare.

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