International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 14-03-2025, Accepted: 13-04-2025, Published: 29-04-2025
Volume 10, Issue 4, 2025, Page No. 131-135

Diversity and abundance of aquatic insects in shrimp ponds of West Bengal, India

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Abstract
This study investigates the diversity and abundance of aquatic insects in shrimp ponds in Jogendranagar, South 24 Parganas, West Bengal, India, with a focus on understanding the ecological dynamics in shrimp aquaculture systems. Shrimp farming, particularly the cultivation of *Penaeus monodon*, is a prominent economic activity in the region, with approximately 60,000 hectares of brackish water aquaculture. Two ponds, pond-A and pond-B, were selected to represent different aquaculture practices and environmental conditions. Aquatic insects were sampled using standard collection methods such as D-frame nets, sweeping nets, and hand-picking. The specimens were identified to the lowest possible taxonomic level, focusing on four primary orders: Hemiptera, Coleoptera, Odonata, and Diptera. The study found that Hemiptera, particularly *Corixidae* (Water Boatman), The most abundant, accounting for 35.48% of the relative abundance (RA), followed by Coleoptera and Odonata. The results highlight the significance of aquatic insects in maintaining the ecological balance of shrimp ponds and emphasize the role of environmental factors such as vegetation and hydrological stability in shaping insect communities. This research contributes to the understanding of pond ecosystems and offers insights for improving shrimp pond management practices.

Keywords: Aquatic insects, shrimp farming, pond ecosystems, biodiversity, environmental factors, insect communities

Introduction

Aquatic insects constitute a vital component of freshwater and brackish water ecosystems, playing pivotal roles in nutrient cycling, energy flow, and serving as bioindicators of water quality (Ward, 1992) [19]. Their presence and diversity are indicative of the overall health and stability of aquatic environments (Priawandiputra *et al.*, 2018) [16]. Shrimp ponds, as managed ecosystems, present a unique environment where ecological dynamics are influenced by aquaculture practices (Semiun *et al.*, 2020) [17]. These practices include water management, feeding regimes, and the use of chemicals, which can significantly alter the aquatic insect communities (Pramudia *et al.*, 2022) [15]. Understanding the diversity and abundance of aquatic insects in shrimp ponds is crucial for assessing the ecological impacts of shrimp farming and developing sustainable aquaculture practices. Aquatic insects, with their diverse feeding habits and life cycles, are intricately linked to the food web dynamics within these ponds. Some species graze on algae and detritus, while others are predators, contributing to the control of other invertebrate populations. The composition of aquatic insect communities can also reflect the water quality conditions in shrimp ponds, with certain species being more tolerant of pollution than others. In recent years, shrimp aquaculture has grown to be important to the socio-economic development of certain coastal states in India (Naik *et al.*, 2020) [13]. However, it has also led to environmental issues like the destruction of mangroves and the salinization of ground water (Durai *et al.*, 2020) [5].

Sustainable shrimp farming needs a thorough understanding of the pond ecosystem, and aquatic insects are an important but commonly ignored element (Bachère, 2000) [1]. West Bengal, with its extensive coastal regions and brackish water ecosystems, is a major hub for shrimp aquaculture in India. The state's unique environmental conditions, characterized by monsoonal climate and tidal influence, create a complex interplay of factors that influence the ecology of shrimp ponds. Moreover, the integrated cultural practices involving fish and rice cultivation alongside shrimp farming contribute significantly to the local economy, generating substantial employment opportunities in rural areas (Guha, 2006) [8]. Therefore, investigating the diversity and abundance of aquatic insects in West Bengal's shrimp ponds is essential for gaining insights into the ecological functioning of these aquaculture systems and for formulating strategies for their sustainable management.

Shrimp farming is particularly prominent in the coastal regions of Bangladesh, where the low land gradient facilitates the creation of brackish water farms (Karim & Shah, 2000) [11]. Shrimp farming in areas like Banyuwangi has become essential for the people who live there, enhancing the region's economy (Wardhany *et al.*, 2020) [20]. The integration of rice and shrimp farming exemplifies an adaptive strategy employed by farmers to optimize resource utilization and mitigate risks associated with fluctuating yields and market demands (Kabir *et al.*, 2019) [10]. These integrated systems, prevalent in regions like southwest coastal Bangladesh, represent a synergistic approach to land and water management, promoting ecological balance and economic resilience (Islam *et al.*, 2018) [9]. The study of aquatic insects in these systems can provide valuable insights into the ecological sustainability of integrated farming practices.

Materials and Methods

Study Area: Jogendra Nagar is a locality in the South 24 Parganas district of West Bengal, India. While specific latitude and longitude coordinates for Jogendra Nagar are not readily available, the South 24 Parganas district is approximately situated at a latitude of 22.161970° N and a longitude of 88.431700° E. Shrimp farming, particularly the cultivation of tiger prawns (*Penaeus monodon*), is a significant economic activity in South 24 Parganas. The district has approximately 60,000 hectares dedicated to brackish water aquaculture, with many ponds measuring around 0.2 to 0.3 hectares. These ponds are primarily used for extensive and improved shrimp farming practices. However, the rapid expansion of shrimp farming has led to environmental concerns, including mangrove deforestation and social challenges such as land disputes and displacement of local communities. In response, some areas are adopting sustainable practices, integrating mangrove conservation with shrimp aquaculture to promote organic farming methods. (Fig:1& 2) Shrimp ponds A & B were selected to represent the range of aquaculture practices and environmental conditions prevalent in the region, with considerations given to pond age, management intensity, and proximity to natural water bodies.

Sample collection

Sampling points were established to account for spatial heterogeneity, ensuring a representative assessment of aquatic insect communities.

Collection and Identification

Aquatic insects were collected using standard methods, such as D-frame nets, sweeping nets, and hand-picking, targeting different microhabitats within the ponds. Samples were preserved in appropriate preservatives, such as 70% ethanol, to maintain specimen integrity for subsequent identification and analysis. Collected specimens were transported to the laboratory for identification to the lowest possible taxonomic level, typically genus or species, using taxonomic keys and references Aquatic Insect of India- A Field Guide" and "A Guide to the Study of freshwater biology" written by Subramanian & Sivaramakrishnan (2007) [18].

Fig 1: Showing Pond A

Fig 2: Showing Pond B

Table 1: Distribution and Relative Abundance (RA)

Order	Family	Species (Genus Name)	Pond-A	Pond-B	Total	RA (%)
Hemiptera	Notonectidae	*Notonecta* sp. (Back swimmer)	04	02	06	9.67%
	Corixidae	*Corixa* sp. (Water Boatman)	13	09	22	35.48%
	Hydrometridae	*Hydrometra* sp. (Water measure)	06	05	11	17.74%
	Mesoveliidae	*Mesovelia* sp. (Water treader)	03	01	04	4.83%
	Gerridae	*Limnogonnus* sp. (Water striders)	01	-	01	1.61%
		Gerris sp. (Water striders)	02	-	02	3.22%

Total Hemiptera			29	17	46	66.22%
Coleoptera	Gyrinidae	*Dineutus* sp. (Whirligig beetles)	02	01	03	4.83%
	Hygobiidae	*Hygrobia* sp. (Screech Beetles)	02	01	03	4.83%
	Hydrophilidae	*Hydrophilus* sp. (Aquatic beetle)	01	02	03	4.83%
		Berosus sp. (Scavenger beetles)	01	-	01	1.62%
Total Coleoptera			06	04	10	16.11%
Odonata	Libellulidae	*Diplocodes* sp. (Dragonflies)	03	01	04	6.45%
		Sympetrum sp. (Dragonflies)	01	-	01	1.62%
Total Odonata			04	01	05	8.07%
Diptera	Syrphidae	*Eristalis* (Droneflies)	02	-	02	3.22%
	Chironomidae	Chironomus Larvae (Non-Biting Midges)	03	01	04	6.45%
Total Diptera			05	01	06	9.67%
Grand Total			44	22	66	100%

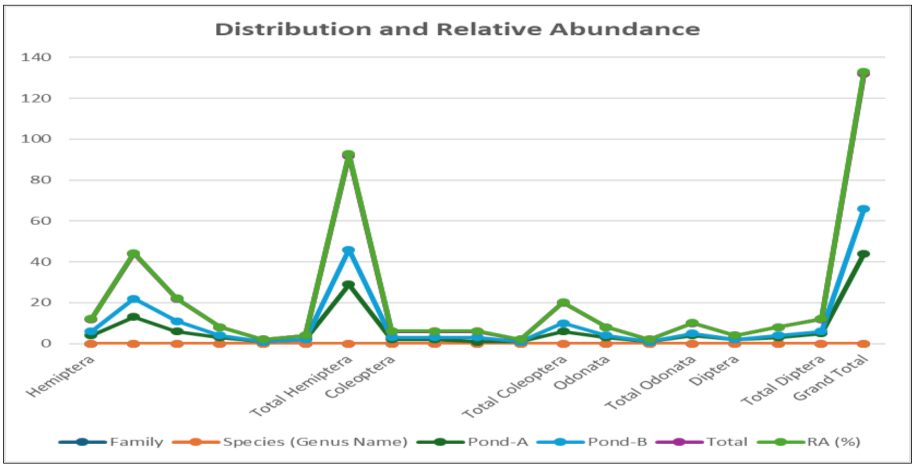

Fig 3: Showing Distribution and Relative Abundance

Fig 3: *Gerris* sp. (Water striders)

Results and Discussion

The table provided offers a detailed breakdown of species distribution and relative abundance (RA) across different families and orders, specifically in two distinct ponds (Pond-A and Pond-B). The species data are categorized under four orders: Hemiptera, Coleoptera, Odonata, and Diptera. Each order is represented by various families, with specific species listed along with their population counts in each pond and the total relative abundance for each species. Hemiptera: Notonectidae (Back swimmer) - 6 total species: 9.67% RA, Corixidae (Water Boatman) - 22 total species: 35.48% RA, Hydrometridae (Water measure) - 11 total species: 17.74% RA, Mesoveliidae (Water treader) - 4 total species: 4.83% RA, Gerridae (Water striders): Limnogonnus sp. and Gerris sp. - 3 total species: 4.83% RA combined With Hemiptera having the highest total abundance (66.22%), Corixidae stands out as the most dominant group in the ponds, accounting for over one-third of the species observed. Coleoptera: Gyrinidae (Whirligig beetles) - 3 total species: 4.83% RA, Hygobiidae (Screech Beetles) - 3 total species: 4.83% RA, Hydrophilidae (Aquatic beetles) - 3 total species: 4.83% RA, Berosus sp. (Scavenger beetles) - 1 total species: 1.62% RA, Though Coleoptera has a modest total RA (16.11%), these beetles, particularly Gyrinidae and Hydrophilidae, play an important role in aquatic ecosystems. Odonata, Libellulidae (Dragonflies) - 4 total species: 6.45% RA, Sympetrum sp. (Dragonflies) - 1 total species: 1.62% RA, Odonata, with an 8.07% RA, highlights the presence of dragonflies, which are often indicators of aquatic health. Diptera, Syrphidae (Droneflies) - 2 total species: 3.22% RA, Chironomidae (Non-Biting Midges) - 4 total species: 6.45% RA, with a combined RA of 9.67%, Diptera reflects the importance of Chironomidae in the pond's food web (Table:1 and Fig:3&4).

$$\text{Relative Abundance (RA\%)} = \left(\frac{\text{Number of individuals of a particular species}}{\text{Total Number of individuals of all species at the same place at the same time}}\right) \times 100$$

This result aligns with typical ecological studies where Hemiptera is often one of the dominant orders in aquatic ecosystems due to the diversity of species within families like *Corixidae* and *Hydrometridae*. Studies of freshwater ponds often show similar patterns of species dominance, with certain groups like Water Boatman (Corixidae) outnumbering others, contributing significantly to the overall species richness. The patterns observed in the pond study, particularly the dominance of Hemiptera and the significant presence of *Corixidae*, align with findings in other ecological studies of freshwater ponds (Fontanarrosa *et al*., 2012) [7]. Hemiptera Dominance observation that Hemiptera is the most abundant order, with Corixidae as the dominant family, is typical in many aquatic ecosystems (Fontanarrosa *et al*., 2012) [7]. Water boatmen are often highly adaptable and ecologically important in ponds. Coleoptera and Odonata were the presence of Whirligig beetles and dragonflies in the study also aligns with findings from other pond ecosystems. Beetles are significant predators, and dragonflies are essential for controlling pest populations and indicating water quality. These findings collectively highlight the biodiversity and ecological balance within pond ecosystems. Different insect groups contribute to various aspects of the ecosystem, from nutrient cycling to predation and serving as food sources for other organisms (Rajesh & Preethi, 2017). Studies on aquatic insects like Heteroptera and Coleoptera can be useful for environmental assessments in static water sites (Eyre & Foster, 1989) [6]. Some semi-aquatic bugs (Heteroptera: Nepomorpha) can even be used as bioindicators of the hydrological regime for permanent ponds (Olosutean & Ilie, 2013) [14]. Local environmental factors, such as vegetation cover and hydrological stability, play a crucial role in shaping the composition of aquatic insect communities (Deacon *et al*., 2018; Olosutean & Ilie, 2013) [14]. The ecological relevance of the study and contributes to a broader understanding of freshwater pond ecosystems (Rajesh & Preethi, 2017). Studies on aquatic insects like Heteroptera and Coleoptera can be useful for environmental assessments in static water sites (Eyre & Foster, 1989) [6]. Some semi-aquatic bugs (Heteroptera: Nepomorpha) can even be used as bioindicators of the hydrological regime for permanent ponds (Olosutean & Ilie, 2013) [14]. Keep in mind that local environmental factors, such as vegetation cover and hydrological stability, play a crucial role in shaping the composition of aquatic insect communities (Deacon *et al*., 2018; Olosutean & Ilie, 2013) [14].

Conclusion

This study provides valuable insights into the diversity and abundance of aquatic insects in shrimp ponds of West Bengal, India, shedding light on the ecological dynamics of these artificial ecosystems and their implications for shrimp pond management. The ecological balance observed in both ponds study mirrors broader trends in aquatic ecosystems. The diverse insect populations play a crucial role in the overall functioning of the pond, contributing to food webs, nutrient cycling, and maintaining biodiversity.

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