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Diversity and abundance of aquatic insects of the natural ponds at the Jahangirnagar University Campus, Dhaka, Bangladesh

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Abstract
The investigation into the diversity and abundance of aquatic insects encompassed five ponds within Jahangirnagar University, Dhaka, Bangladesh, spanning from in the rainy month June 2023 to January 2024. A comprehensive tally revealed 4134 insects across 18 genera, distributed among 15 families and 5 orders. Predominant orders included Hemiptera (74.41%), Coleoptera (9.58%), and Odonata (8.08%), with non-Insect Orders represented by Acarina (3.97%) and Araneae (3.97%). Peak insect abundance occurred in July 2023, contrasting with the lowest count observed in January 2024. Among the species, Back swimmers (*Notonecta*) exhibited the highest relative abundance at 58.11%, while Riffle (*Velia sp.*) displayed the lowest at 0.83%. Correlation analysis unveiled positive associations in June between insect population and environmental factors such as temperature (31.5℃), water pH (7.51), and dissolved oxygen levels (17.01mg/L). Notably, Hemipteran (34.33%) and Coleopteran (5.64%) insects dominated, indicative of lower pollutant levels within the surveyed pond areas. The study underscores the dynamic nature of aquatic insect populations, influenced by seasonal fluctuations and temperature variations. These findings offer insights into the intricate ecological dynamics within aquatic ecosystems, emphasizing the sensitivity of insect communities to environmental changes.

Keywords: Abundance, aquatic insects, diversity, temperature, ph

Introduction
Aquatic insects are indispensable within freshwater ecosystems, fulfilling diverse ecological roles and acting as reliable indicators of environmental health and water quality (Merritt *et al*., 2008). Their diversity and abundance serve as barometers of the ecological condition of aquatic habitats, rendering them crucial subjects for ecological studies and biomonitoring endeavors (Barbour *et al*., 1999; Rosenberg *et al*., 1999) [6, 36]. Contributing significantly to nutrient cycling, energy transfer, and the dynamics of food webs within aquatic environments, aquatic insects play pivotal roles (Merritt and Cummins, 1996; Merritt *et al*., 2008). Consequently, understanding the composition, distribution, and abundance patterns of aquatic insects is paramount for effective ecosystem management and conservation efforts (Resh and Rosenberg, 1996; Dudgeon *et al*., 2006) [35, 14]. In recent decades, numerous studies have illuminated the taxonomic richness and functional diversity of aquatic insects across diverse freshwater habitats globally (Balian *et al*., 2008; Heino, 2011; Sanchez-Fernandez *et al*., 2012) [5, 20, 37]. These investigations have underscored the remarkable adaptability of aquatic insects to varied environmental conditions, spanning from pristine streams to heavily polluted urban water bodies (Fenoglio *et al*., 2015; Cereghino *et al*., 2018) [17, 11]. Moreover, advancements in molecular techniques and bioinformatics have facilitated the identification of cryptic species, shedding light on their ecological roles within aquatic ecosystems (Zhou *et al*., 2016; Elbrecht *et al*., 2017) [44, 16]. However, significant knowledge gaps persist, particularly concerning the drivers of community structure and the responses of aquatic insects to anthropogenic disturbances (Durance and Ormerod, 2007; Bonada *et al*., 2012) [15, 9]. Addressing these gaps is essential, considering the threats posed by factors such as climate change, habitat alteration, pollution, and invasive species. Further research is needed to comprehensively understand the resilience and vulnerability of aquatic insect communities in the face of these challenges.

Climate change, habitat alteration, pollution, and invasive species pose significant threats to aquatic insect communities, highlighting the pressing need for further research to uncover their ecological resilience and vulnerability (Stewart *et al*., 2017; Lancaster *et al*., 2019) [40, 26]. Additionally, integrating traditional ecological knowledge with modern scientific approaches can yield valuable insights into the cultural significance and traditional management practices associated with aquatic insects across different regions (Narchi *et al*., 2020) [33]. For example, a study by Smith *et al*. (2023) [39] revealed that urbanization substantially diminished the diversity and abundance of aquatic insects in streams, impacting ecosystem functioning and services. Similarly, research by Johnson *et al*. (2022) [23] showcased the detrimental effects of pesticide contamination on aquatic insect populations, triggering cascading effects on higher trophic levels and ecosystem processes. Moreover, recent advancements in molecular techniques have deepened our understanding of the genetic diversity and population dynamics of aquatic insects, elucidating their evolutionary history and adaptation to changing environmental conditions (Jones *et al*., 2024) [24]. The integration of molecular approaches with traditional ecological methods holds promise for studying the responses of aquatic insect communities to environmental stressors and predicting future trends. In recent years, significant progress has been made in unraveling the intricate relationships between aquatic insects and their environments. This review synthesizes the latest research findings from 2020 to 2024, offering insights into the current state of knowledge regarding the diversity and abundance of aquatic insects. Recent studies have employed advanced sampling techniques, such as environmental DNA (eDNA) metabarcoding and high-resolution imaging, to comprehensively assess the taxonomic composition and spatial distribution of aquatic insect communities (Ficetola *et al*., 2021; Jacobus *et al*., 2023) [18, 21]. These innovative approaches have unveiled previously unknown species and provided valuable insights into the factors influencing community structure and dynamics. Moreover, research focusing on the ecological roles of aquatic insects has underscored their multifaceted interactions with other organisms and their responses to environmental changes. For example, investigations into the impacts of climate change have documented shifts in the phenology and distribution of aquatic insect species, carrying implications for ecosystem functioning and services (Beche *et al*., 2022; Patino *et al*., 2024) [7, 34]. Furthermore, recent efforts have underscored the importance of considering anthropogenic stressors, such as pollution and habitat alteration, in assessments of aquatic insect communities. Studies have illustrated the sensitivity of certain taxa to specific pollutants and provided evidence of their potential as bioindicators for water quality monitoring programs (Menezes *et al*., 2020; Wang *et al*., 2023) [28, 43]. Jahangirnagar University Campus, situated in Dhaka, Bangladesh, encompasses a variety of aquatic habitats, including ponds, lakes, and streams. Despite its urban setting, these water bodies support diverse aquatic insect communities due to their varied habitats and surrounding vegetation (Hassan *et al*., 2015) [19]. Ponds are a vital component of the water ecosystem, constituting a major proportion of the world's inland waters. Biggs *et al*. (2005) [8] defined ponds as water bodies between one square meter and a couple of hectares in size, which can be permanent or seasonal, natural or synthetic. De Meester *et al*. (2005) [12] emphasized the high conservation value of ponds due to their distinctive and variable species composition. Additionally, Cereghino *et al*. (2008) [10] indicated that ponds harbor greater insect population diversity compared to rivers, lakes, wetlands, and other water body types. Several analyses have been previously conducted on aquatic and semi-aquatic insects in the Asian region. Ameen and Chowdhury (1972) [3] listed only four aquatic bugs from Dhaka city. Munira *et al*. (2014) conducted research on aquatic insects, listing 32 genera in Chittagong University Campus. Ameen and Nessa (1985) [2] documented twenty-three species of Hemiptera from Dhaka city. Alam *et al*. (1986) [1] recorded an inventory of fourteen species of aquatic and semi-aquatic insects from Chittagong University campus. While numerous research works are available on aquatic insects from various dimensions, notable recent contributions include those of Motta RL, Jacob *et al*. (2008) [22], Terence Andrew Bellingan (2010) [41], Annika *et al*. (2010) [4], Vincent H. Resh (2010) [42], Dinakaran *et al*. (2007) [43], Mariola *et al*. (2012) [27], and Joydeb *et al*. (2013) [25]. However, there is a dearth of comprehensive studies focusing on the diversity and abundance of aquatic insects within the Jahangirnagar University Campus. Understanding the composition and distribution of aquatic insect communities within this campus is essential for effectively managing and conserving its aquatic ecosystems. Furthermore, such studies can offer valuable insights into the overall ecological health of urban aquatic habitats in Bangladesh. This research aims to investigate the diversity and abundance of aquatic insects within the Jahangirnagar University Campus, Dhaka, Bangladesh. Through the utilization of standardized sampling methods and taxonomic identification, this study seeks to enhance our understanding of the aquatic insect fauna in urban freshwater ecosystems. It can help to provide baseline data for future ecological assessments and conservation initiatives. The study encompasses evaluating the structure, diversity, and group composition of aquatic insect communities in different ponds. Additionally, it assesses the relative abundance of each aquatic insect species and examine diversity in relation to key water parameters such as Dissolved Oxygen (DO), Temperature, pH, etc.

Materials and Methods

Methods for collection and identification of insects: Aquatic insects were collected from five ponds at Jahangirnagar University campus between June 2023 and January 2024, located at 30° 16″ N latitude and 90° 52″ E longitude, approximately 32 km northwest of Dhaka city. The collection process involved the use of mosquito nets, 75% ethanol, a DO meter (Model: DO-5509), a pH meter (Model: HI-98107), plastic bags, and other necessary materials. Sampling occurred at 15-day intervals between 7:00 AM and 10:00 AM local time.

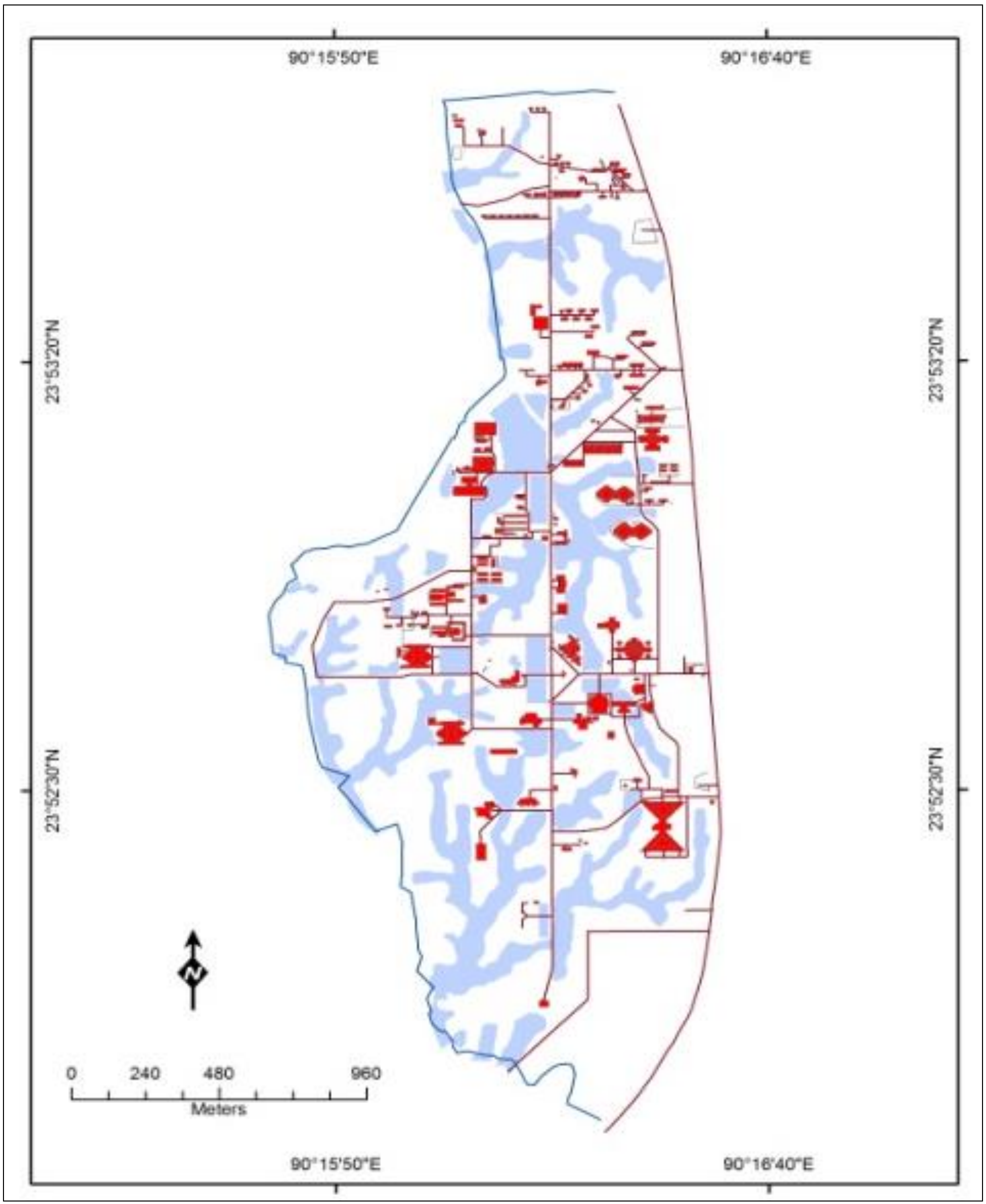

Fig 1: Map of Jahangirnagar University Campus

Samples were collected either from four corners of the pond within a 5m² area if vegetation was evenly distributed on all sides, or from four different vegetated areas of a pond. Collection involved dipping a 40 cm diameter circular net with a mesh size of 60 µm. Nets were hauled 10 times at each spot (5m² area) for approximately one minute. Aerial sweeping was not conducted, and only larvae or nymphs were included in the count, while adult flying aquatic insects were avoided. Hard-bodied insect specimens were desiccated, pinned, and preserved in dry conditions, while soft-bodied insects were preserved in 75% ethanol.

Insect examination and identification were conducted using a microscope (Model: [insert model]). Identification was carried out up to the lowest taxonomic category following the standard keys of insect identification described in the Encyclopedia of Animals by the Asiatic Society of Bangladesh.

Relative species abundance and species richness are two key elements describing biodiversity findings.

Relative species abundance refers to how common or rare a species is relative to other species in a given location or community which was calculated by the formula-

$$\text{Relative Abundance (RA)} = \frac{\text{Number of individuals of a particular species (or genus or group)}}{\text{Total Number of individuals of all species (or genus or group) found at the same place at the same time}}$$

Frequency is the number of the occurrences of a repeating event per unit of time. It is also referred as temporal frequency, which emphasizes the contrast to spatial frequency and angular frequency, and it was calculated by the formula:

$$\text{Frequency} = \frac{\text{Number of individuals of a particular species (or genus or group) in a particular time}}{\text{Total Number of the same species (or genus or group) found at the same place at the total time of collection}}$$

Monthly, Seasonal, and pond wise variations were analyzed by using ANOVA techniques in MS-Excel.

Results and Discussion

A comprehensive survey resulted in the collection and identification of 4134 aquatic insects, including water spiders and water mites, categorized under 18 genera, 15 families, and 5 orders (refer to Table 1 and 2). Notably, the count encompassed dragonfly and damselfly nymphs, treated as separate taxonomic entities. Interestingly, major aquatic insect taxa such as Ephemeroptera, Diptera, Plecoptera, and Trichoptera were notably absent from the studied ponds. Conversely, species richness and abundance were pronounced among insects of the orders Hemiptera, Odonata, and Coleoptera.

The relative abundance of various aquatic insects exhibited monthly variations, with Back swimmers consistently dominating except in January 2024. In June 2023, Back swimmers attained the highest relative abundance at 58.11, while Riffle insects displayed the lowest at 0.83. Additionally, Damselflies exhibited a notable relative abundance of 57.69, contrasting with Pond skaters, which recorded a relative abundance of 5.68. These fluctuations underscore the dynamic nature of aquatic insect populations, influenced by environmental factors and seasonal changes.

In July 2023, the relative abundance of the Back swimmer remained consistently high at 52.74, indicating its dominance within the aquatic insect community. Conversely, the lowest relative abundance was observed for another insect, the Water measurer, which recorded a mere 0.22 in this month. Additionally, the relative abundance of the Dragonfly nymph was noted at 7.79, contributing to the overall diversity of the insect population.

Moving to August 2023, the Back swimmer maintained its position as the most abundant species with a relative abundance of 47.16. However, there was a slight decrease in its abundance compared to the previous month. Interestingly, three aquatic insects the Water treader, Water measurer, and Whirligig beetle showed zero relative abundance, indicating either a decline in their population or their absence from the sampled areas. On the other hand, the relative abundance of the Pond skater increased substantially to 19.51 compared to July's 23.

In September 2023, Back swimmers were back again dominating the insect community, reaching a relative abundance peak of 44.56. Conversely, the Lesser water boatman recorded the lowest relative abundance during this month. Additionally, the relative abundance of the Pond skater decreased to 9.37 compared to the previous month, indicating potential fluctuations in its population dynamics. These findings highlight the dynamic nature of aquatic insect communities and the importance of monitoring their abundance over time.

In October 2023, the highest relative abundance of aquatic insects was recorded for the Back swimmer, reaching 47.85%. Conversely, the Riffle insect exhibited the lowest relative abundance during this period. Additionally, the Water skater demonstrated a relative abundance of 12.78%, while the Pond skater exhibited a relative abundance of 6.20% in the same month.

Moving to November 2023, the Back swimmer retained its dominance in terms of relative abundance, albeit at a decreased level compared to October. In this month, the highest relative abundance observed was 20.12%. Meanwhile, the Water skater displayed a relative abundance of 11.83%, and both the Water Mite and Riffle insects were obtained with a relative abundance of 7.69%.

Transitioning to January 2024, the highest relative abundance was recorded for the Pond skater, with the Back swimmer following closely behind with a relative abundance of 30.48%.

Table 1: A table of aquatic insects found in the ponds of JU campus

Order	Family	Common name	Scientific name
Hemiptera	Notonectidae	Back swimmer	*Notonecta sp.*
	Gerridae	Pond skater	*Gerris inolae*
		Water skater	*Gerris remigis*
		Water strider	*Limnogonnus sp.*
	Mesovelidae	Water treader	*Mesovelia vittigera*
	Hydrometridae	Water measure	*Hydrometra sp.*
	Nepidae	Water scorpion	*Ranatra sp.*
	Corixidae	Lesser water boatman	*Micronecta sp.*
		Greater water boatman	*Corixa sp.*
	Veliidae	Riffle	*Velia sp.*
	Velisae	Water cricket	*Velia caprai*
Coleoptera	Hydrophilidae	Aquatic beetle	*Hydrophilus sp.*
	Hygrobiidae	Screech	*Hygrobia sp.*
	Gyrinidae	Whirligig beetle	*Gelastocorpis sp.*
	Dytiscidae	Diving beetle	*Thermonectus sp.*
Araneae	Agelenidae	Water spider	*Argyronecta aquatic*
Odonata		Dragonfly nymph	*Sympetrum sp.*
		Damselfly nymph	*Ischmura sp.*
Acarina	Hydrachenellae	Water mite	*Hydrachna sp.*

Table 2: Number of individual and relative abundance collected during months of the year 2023-2024 from pond of JU campus.

Species (Scientific Name)	Order	Months													
		June 2023		July 2023		Aug 2023		Sep 2023		Oct 2023		Nov 2023		Jan 2024	
		NI	RA	NI	RA	NI	RA	NI	RA	NI	RA	NI	RA	NI	RA
Back swimmer (*Notonecta* sp.)		85	58.11	69	52.74	38	47.16	39	44.56	31	47.85	7	20.12	2	30.48
Pond skater (*Gerris inolae*)		19	5.68	16	4.39	51	19.51	30	9.37	14	6.20	2	2.96	7	40.00
Water skater (*Gerris remigis*)		9	3.31	9	2.19	5	3.38	4	3.93	23	12.78	2	11.83	0	1.90
Water strider (*Limnogonnus* sp.)		2	1.78	0	1.64	4	4.61	0	0.45	1	0.89	0	0.00	0	0.00
Water treader (*Mesovelia vittigera*)		4	1.30	1	1.21	0	0.00	2	2.87	1	1.01	0	0.00	0	0.00
Water measure (*Hydrometra* sp.)	Hemiptera	1	1.18	0	0.22	0	0.00	1	1.21	0	0.76	0	0.00	1	0.95
Water scorpion (*Ranatra* sp.)		4	1.66	9	3.18	3	2.15	8	2.72	2	0.89	0	1.18	0	0.95
Greater water boatman (*Corixa* sp.)		1	1.42	3	2.19	2	0.77	2	1.81	2	1.01	1	1.78	0	0.95
Lesser water boatman (*Micronecta sp.*)		3	0.95	16	2.96	0	2.46	0	0.00	0	1.14	0	0.59	0	0.00
Water cricket (*Velia caprai*)		1	1.89	5	1.54	1	1.23	3	1.81	2	2.03	5	7.69	0	0.00
Riffle (*Velia* sp.)		0	0.83	3	0.66	0	0.77	0	0.45	0	0.00	4	7.69	0	0.00
Aquatic beetle (*Hydrophilus* sp.)		8	2.72	8	2.19	2	1.54	8	6.34	6	2.78	1	5.92	0	0.00
Whirligig beetle (*Gelastocorpis* sp.)	Coleoptera	1	1.54	1	0.77	0	0.00	0	2.27	0	0.51	1	1.18	1	0.95
Screech (*Hygrobia* sp.)		2	1.66	4	1.86	0	0.61	1	0.76	2	0.76	1	0.59	1	1.90
Diving beetle (*Thermonectus* sp.)		1	1.30	8	4.50	9	4.92	6	3.63	8	4.30	9	17.16	3	6.67
Water spider (*Argyronecta aquatic*)	Araneae	5	3.91	8	4.06	3	3.07	7	3.78	10	4.05	1	4.14	1	9.52
Dragonfly nymph (*Sympetrum* sp.)	Odonata	7	1.89	6	1.43	4	1.38	2	3.32	9	4.30	1	3.55	0	0.00
Damselfly nymph (*Ischmura* sp.)		46	7.69	39	7.79	2	2.15	6	7.10	8	4.30	1	1.78	0	0.00
Water mite (*Hydrachna* sp.)	Acarina	2	1.18	6	4.50	8	4.30	1	3.63	7	4.43	6	11.83	0	5.71
N.B: NI=Number of Individuals of a species caught, RA=Relative Abundance															

Seasonal variation in Relative Abundance (RA)

During the summer season (June 23 to October 23), the Back swimmer exhibited the highest relative abundance, reaching 50.57. However, during the winter season (November 23 to January 24), their average abundance decreased significantly to 25.3. Conversely, the Riffle showed the lowest relative abundance, recorded at 0.83 in June, increasing to 7.69 in November, but entirely absent by January 24.

In summer, the Pond skater displayed an average relative abundance of 9.03. However, during winter, their abundance notably increased to 21.48. Similarly, the Water strider exhibited a relative abundance of 1.87 up to October, but during winter, their abundance dropped to zero, with Water striders entirely absent during this season.

On November 23, Dragonfly nymphs, Damselfly nymphs, Aquatic beetles, Water measurers, and lesser water boatmen were observed in comparatively high numbers, with abundance levels considered satisfactory. However, by January 24, these species had completely disappeared, with their abundance recorded at zero.

Monthly fluctuations of the Number of Species of the five water bodies: Number of Species (NS) (Table 2) of the aquatic insects varied from month to month. Among those, the highest monthly number of species was observed and that is 211 in number in July 2023 and the lowest in number is 16 in January 2024. However, species diversity fluctuated from 120-136 in during rest of the months of August 2023-October 2023.

Table 3: Physical parameters of pond water at Jahangirnagar University Campus

Parameter	Pond No.	June 2023	July 2023	Aug 2023	Sep 2023	Oct 2023	Nov 2023	Jan 2024
pH (mole/L)	P_1	7.40	7.32	7.35	7.10	6.85	6.50	6.30
	P_2	7.62	7.66	7.33	7.10	6.89	6.60	6.30
	P_3	7.44	7.44	7.45	7.20	6.60	6.60	6.40
	P_4	7.58	7.54	7.20	7.00	7.10	7.10	7.00
	P_5	7.51	7.49	7.40	7.35	7.05	6.70	6.30
DO (mg/L)	P_1	16.06	16.30	17.75	17.15	14.65	14.40	14.30
	P_2	17.06	17.42	18.05	17.25	16.30	16.20	16.10
	P_3	17.03	17.00	16.10	15.30	14.25	13.90	13.70
	P_4	16.08	16.96	15.80	15.50	14.40	14.20	14.00
	P_5	17.01	16.92	16.55	16.85	16.25	15.10	14.80
Temperature (ºC)	P_1	30.80	30.20	31.25	28.50	27.50	23.50	21.00
	P_2	32.20	32.80	30.25	27.00	27.00	22.75	21.75
	P_3	32.30	31.90	32.25	29.00	28.00	24.25	22.00
	P_4	30.70	32.10	31.00	28.25	27.25	23.00	20.00
	P_5	31.50	32.00	31.50	28.75	27.75	24.00	20.25
N.B: P_1= Pond 1; P_2= Pond 2; P_3= Pond 3; P_4= Pond 4; P_5= Pond 5								

Fig 2: (a) Back swimmer (*Notonecta* sp.) (b) Pond skater (*Gerris* inolae) (c) Dragonfly nymph (*Sympetrum* sp.) (d) Damselfly nymph (*Ischmura* sp.) (e)Water strider (*Limnogonnus* sp.) F Aquatic beetle (*Hydrophilus* sp.).

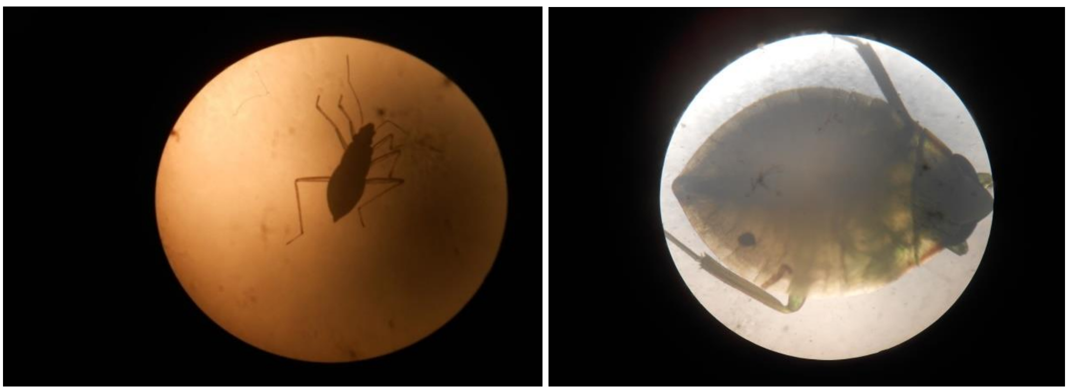

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Fig 3: (g) Water treader (*Mesovelia vittigera*) (h) Water mite (*Hydrachna* sp.) (i) Water spider (*Argyronecta aquatica*) (j) Water scorpion (*Ranatra* sp.) (k) Diving beetle (*Thermonectus* sp.).

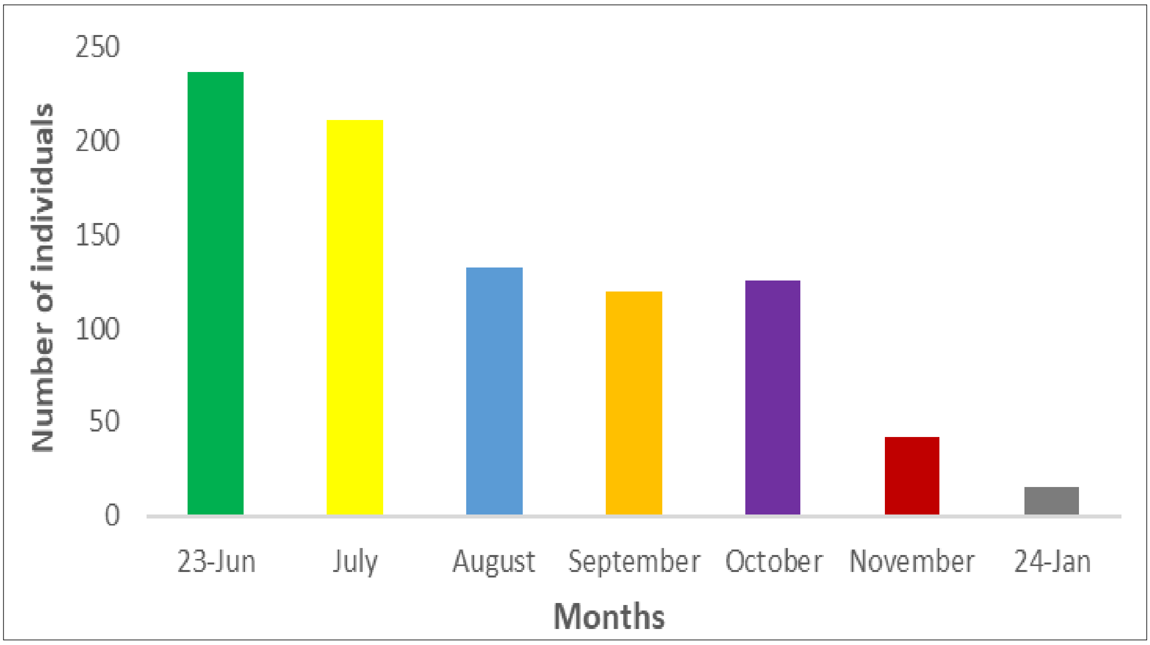

Fig 4: Monthly variation of number of aquatic insect of JU Campus

A quantitative analysis of the temperature data would involve the development of a way of characterizing the rate of change of temperature at each site, providing a repeatedly measurable variable that can be related to the macroinvertebrate community. Extensive studies to that end have been undertaken. Studies have shown the significance of "maximum temperature" as a variable for accounting for increasing aquatic diversity. The strongest positive correlation was found between abundance of the number of species and the external average environmental temperature. They were positively correlated and the value was r_S= 0.947803.

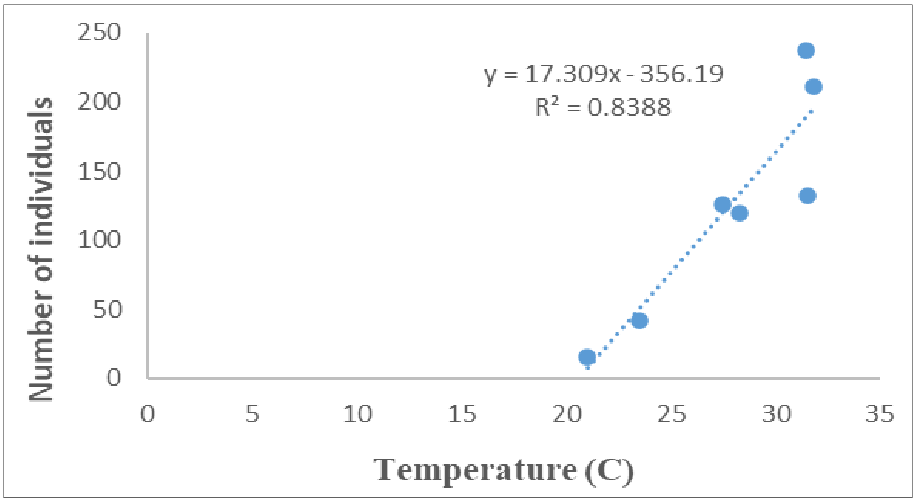

Fig 5: Relationship of Aquatic insect availability with changes of water temperature

Aquatic insects of five ponds total number indicates that they prefer 7-7.6 pH value, it means insects preferable pH is neutral water not acidic nor basic. A number of species and water pH value was positively correlated with each other and that value was, r_s= 0.951323.

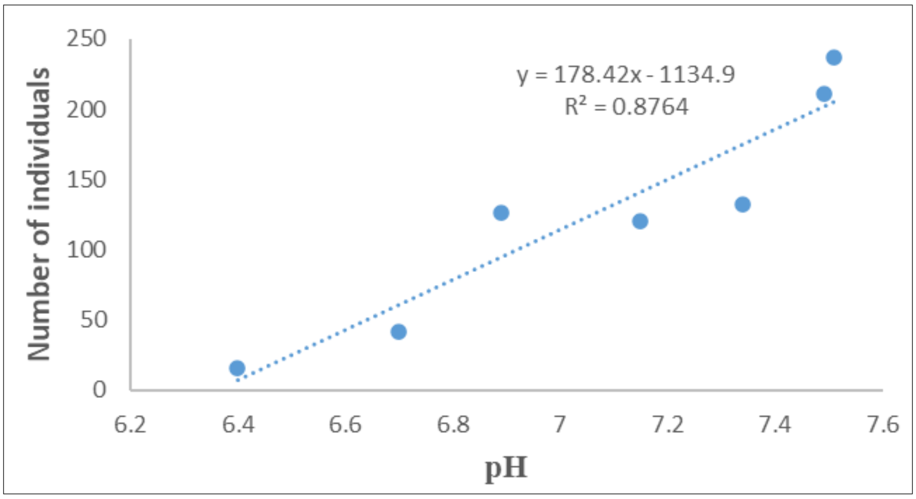

Fig 6: Relationship of Aquatic insect occurrence with water pH

Considering the value of dissolve oxygen changed and for the aquatic insect, they prefer the dissolved oxygen level about 16-17 mg/L. A number of species were positively correlated with the dissolved oxygen (DO) and that was r_s= 0.880073.

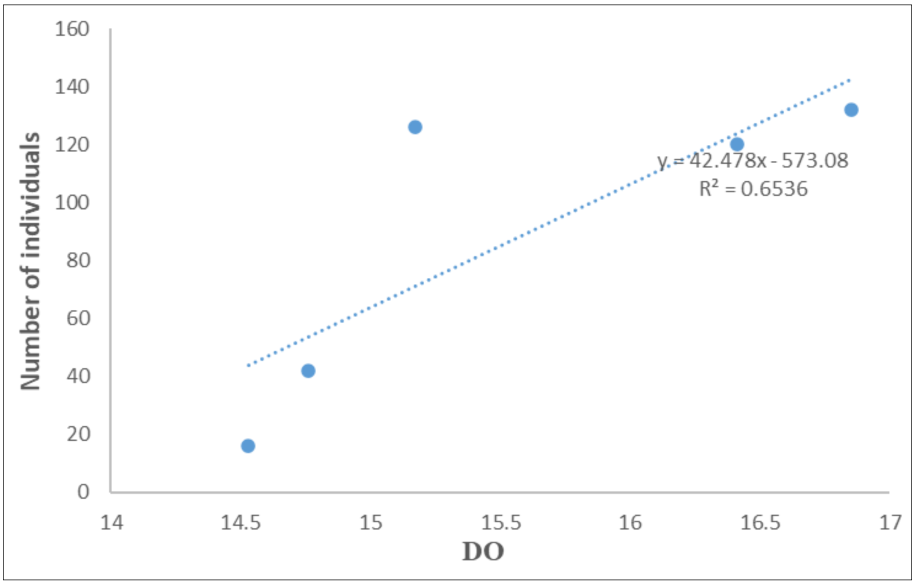

Fig 7: Relationship of Aquatic insect occurrence with Dissolved Oxygen in water

The present study draws a line to focus that the number of species which are fluctuated with the temperature, pH and DO of the water body. In future, we can compare the water quality with the number of species and also try to detect that which species is the highest indicator of the water quality.

Conclusion

The study revealed that the highest number of aquatic insects belonged to the order Hemiptera, with the most abundant family being Gerridae. This finding underscores the significant role played by aquatic insects in shaping the ecological structure and functioning of freshwater ponds. Aquatic insects are known to be highly sensitive to changes in pollutant levels in water, making them valuable indicators of ecosystem health. The absence of the order Diptera and the presence of pollution-sensitive taxa such as dragonfly and damselfly nymphs highlight the importance of maintaining pristine conditions in freshwater ponds. Moreover, insects serve as crucial test subjects for hierarchical bio-geographical reconstruction, offering insights into ecological patterns and processes. The analysis of aquatic insect diversity and water quality in the freshwater ponds of Jahangirnagar University, Dhaka, Bangladesh, using ordination methods, presents intriguing findings. These findings could pave the way for further research and contribute to a deeper understanding of aquatic ecosystems.

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