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Diversity and abundance of soil arthropods in Jahangirnagar University campus, Dhaka, Bangladesh

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Abstract
Soil arthropods are an essential part of an ecosystem contributing significantly to maintaining biodiversity and ecosystem functioning. The present study was conducted to investigate the diversity and abundance of soil arthropods in selected habitats in Jahangirnagar University campus, Savar, Dhaka, Bangladesh. Sampling was conducted at three different habitats, *viz*., woodland (W), grassland with herbs (GH), and woodland with herbs (WH), from February 2022 to July 2022 using pitfall traps. A total of 9054 arthropods belonging to 19 different orders *viz*., Collembola, Diplura, Thysanoptera, Odonata, Orthoptera, Hemiptera, Blattodea, Coleoptera, Diptera, Hymenoptera, Isoptera, Lepidoptera, Acari, Araneae, Mesostigmata, Polydesmida, Isopoda, Scolopendrellida and Scolopendromorpha were collected. The most abundant order was Collembola (64.49%) followed by Diptera (12.89%), Hymenoptera (9.82%), Orthoptera (4.73%), Araneae (2.85%) and Coleoptera (1.38%), and the least abundant orders were Isoptera (0.17%), Scolopendrellida (0.13%), Thysanoptera (0.10%), Acai (0.09%), and Diplura (0.08%). Blattodea, Polydesmida, Lepidoptera and Isopoda represented 0.76%, 0.64%, 0.34% and 0.27% of the total captured individuals, respectively. The greatest number of individuals were collected from habitat-W (49.78%) followed by habitat-GH (28.32%) and habitat-WH (21.90%). The collembolans exhibited the highest abundance in all three habitats. Both the Shannon-Weiner index (H') and Pielou's evenness index. (J') showed the highest score in habitat-GH (H'=1.49, J'=0.5), whereas the least score in habitat-W (H'=1.04, (J'=0.36). Information revealed in this study is expected to contribute to developing baseline data of arthropod fauna in Jahangirnagr University campus. More importantly, this information would help us monitor any change in the abundance and diversity of soil-dwelling arthropods in Jahangirnagar University campus.

Keywords: Arthropods, soil, Bangladesh

Introduction
The phylum arthropoda, which includes insects, spiders, mites, and their relatives, is the most successful and diverse group of organisms on Earth [1]. Arthropod species make up more than 80% of all known species, with an estimated 1,170,000 species globally [2]. Arthropods are ubiquitously distributed on the earth's surface and their existence can be traced out even in the least inhabitable places *viz*., deserts or icecaps, trenches or mountains [3, 4].
Arthropods' responses to various interactions between habitat traits and environmental gradients are probably crucial indications of local community organization [5]. They have ecological significance and are significant study objects for examining the fundamental trends in biodiversity, abundance, and species richness [6]. However, due to their extensive environmental functions, they play a crucial role in the sustainability of ecosystems as pollinators and decomposers [7]. They also participate in nutrient cycling and energy transfer in the terrestrial or aquatic ecosystem as herbivores, detritivores, and predators [8]. They are present in all ecosystems, but their types and quantity vary depending on the type of habitat, the soil, and other abiotic conditions [9]. Groups of fauna, particularly those that live inside or on the soil's surface, are referred to as soil arthropods and constitute 23% of the total diversity of living organisms [10]. Despite extensive study on insect groups [11], there needs to be more knowledge about the functional groups in arthropod communities [12], particularly about soil fauna [13]. The spatial distribution of arthropods is sensitive to the kind of vegetation and environmental gradients. For researchers studying biodiversity, learning more about the composition of arthropod groups and how they react to vegetation remains a considerable

problem [14]. Arthropod β-diversity is, therefore likely aid in understanding how community composition alters along various environmental gradients [15]. (Since the diversity of arthropods is correlated with the viability of ecosystems, ecologists have always found the faunal distribution pattern of arthropods to be fascinating, especially in light of the fact that it is now known that arthropod diversity is declining as a result of the harsh environmental conditions [16]. Although each species reacts differently to varying climatic conditions, species distribution is mostly linked to eating patterns and local-scale habitat characteristics. Additionally, arthropod diversity changes have been observed due to temperature and precipitation conditions at soil fauna [17, 18].

Although Bangladesh is home to a wide variety of arthropods, including representatives of various insect groups, only a few studies on the abundance of soil arthropods [19, 18, 20, 21] have been undertaken till now, with the majority focusing on individual diversity and abundance of ants [22], butterflies [23], rice plant arthropods [24, 25], and spider [26]. So far, no research has been conducted on the diversity and abundance of soil arthropods in Jahangirnagar University (JU) campus. Therefore, the current study was carried out to document the diversity and abundance of soil arthropods in JU campus, Bangladesh.

Materials and Methods

Study area

The study was carried out in Jahangirnagar University campus, situated between 23.8671°-23.8977°E and 90.2588°-90.2731°N. The study area spanned 282.29 hectares of land and is located 32 km northwest away from the Dhaka city. The landscape pattern of this area is slightly undulating and composed of red lateritic soil. According to the meteorological data of WORLD® WEATHER ONLINE (www.worldweatheronline.com), recorded in the last 10 years, the monthly mean temperature fluctuates from 30°-41°C, 29°-32°C and 19°-25°C, rainfall ranges from 12.1-154.2 mm, 106.42 - 350.8 mm and 0-19.5 mm and humidity varies from 42-82%, 74-98% and 38-67% in summer, rainy and winter seasons, respectively prevail in the study area.

Sampling sites

Sampling was conducted in three distinct zones based on vegetation structure *viz*., woodland (W), grassland with herbs (GH) and woodland with herbs (WH).

Woodland (W)

This sampling site is dominated by woody plants. Few shrubs are also present on the periphery of the sampling sites. The most common woody plant species are Mahogany (*Swietenia mahagoni*), Palms (*Livistona sp.*), Elephant apple (*Dillenia indica*), Sal (*Shorea robusta*), Carambola (*Averrhoa carambola*), Indian gooseberry (*Phyllanthus emblica*), Opposite leaf Fig (*Ficus hispida*), Akashmoni (*Acacia auriculiformis*), Jhau (*Casuarina equisetifolia*), Debdaro (*Polyalthia longifolia*), various types of bamboo (*Bambusa* sp.), and shrubs etc. The ground layer of this sampling site is covered with a layer of decomposed and dried leaves. Scanty of herbs are also available on the lower canopy of the woodland (Fig. 1A).

Grassland with herbs (GH)

This area has a good composition of open grasslands with herbs. Grassland is dominated by *Cynodon* spp., *Axonopus compressus* and *Panicum maximum*. Predominant varieties of herbs available in this sampling location are Ban palang (*Sonchus wigtianus*), Latadeji (*Sphagneticola trilobata*), Marhatitiga (*Spilenthes acmella*), Kukurghiba (*Pseudelephantopus spicatus*), Gendaphul (*Tagetes erecta*), Kukshim (*Cyanthillium cinereum*), Assamlata (*Chromolaena odorata*), Ayapana (*Ayapana triplinervis*), Shealmotra (*Blumea lacera*), etc. There are also some planted trees such as Lychee (*Litchi chinensis*), Guajava (*Psidium guajava*), Mango (*Mangifera indica*), Amlaki (*Phyllanthus emblica*) etc. on the periphery of the sampling site (Fig. 1B).

Woodland with herbs (WH)

This area was home to a variety of trees and a few patches of herbaceous medicinal (*Adhatoda vasica*, *Centella asiatica*, *Ocimum sanctum* etc.) and wild plants. A heavy covering of dried leaves and sporadically existed grasses covered the ground (Fig. 1C).

Fig 1: Three different habitats selected in JU campus.

Pitfall trapping

An affordable pitfall trap technique that permits the quick and simple collection of invertebrates in the field has been widely utilized to estimate quantity, diversity and composition of ground dwelling arthropods [27]. In this study, soil arthropods were collected once a month from February 2022 to July 2022 arranging pitfall traps. Five pitfall traps were set at 10 meter intervals in each sampling site. So, a total of 15 traps were placed in three selected habitats. Plastic cups 11 cm wide and 5 cm deep were used for pitfall trapping. The holes in which the plastic cups were placed had been meticulously dug with little disruption to the soil and plants, and the top of each trap was placed at the same level as the surface of the soil. The traps were filled with 150 ml of water, and approximately 1 ml of liquid dishwashing soap was added to the water to prevent the escape of arthropods already fallen into the plastic

cups. Pitfall traps were installed every morning at 10.00 am and picked up on the following day at 10.00 am.

Sample processing and identification

Arthropods that had been trapped in the pitfall trap were put in a plastic jar (250 ml) marked with replication number and brought to the entomology laboratory of the Department of Zoology at Jahangirnagar University. A separate jar was used for each sample. The specimens in the plastic jar were rinsed with clean water and sieved using a strainer (Fisher Scientific, Mesh size 0.0098, USA) and finally preserved in the respective plastic jar using 70% ethanol for further investigation. Specimens were identified up to order following suitable taxonomic keys [28] and online resources. A stereo zoom microscope (AmScope FMA050) was used to record the number of individuals of each order.

Data analysis

Recorded data were incorporated in Microsoft Excel 2016 and subjected to analysis. Index of Shannon-Wiener Diversity (H') [29] and Pielou's evenness index (J') [30] were used to assess the diversity and evenness of soil arthropod orders, respectively.

Shannon-Wiener diversity index

The Shannon-Wiener formula can be used to figure out the order diversity index, which is:

$$H' = -\sum_{i=1}^{s} p_i (\ln p_i)$$

Where, H' is the Shannon-Wiener diversity index, pi is the proportion of the itch order in the whole sample, and in is the natural logarithm.

Pielou's measure of evenness

$$J' = H'/\ln(S)$$

Where, H' is Shannon-Weiner diversity and S is the total number of individuals in a sample, across all samples in the collection.

Relative Abundance

The relative abundance was determined using the following equation:

$$Ra = \left(\frac{Ts}{Tp}\right) * 100$$

Where, 'R_a' denotes the species' relative abundance (%)
'T_s' denotes total number of species in a given area
'T_p' denotes total population of all species in the area.

However, in this study, T_s considered as a total number of individuals from a single arthropod order instead of total number of species and T_p counted as a total number of individuals from all arthropod orders instead of total population of all species. So, R_a denotes the relative abundance of each arthropod order.

Results and Discussion

During the sampling period, a total of 9054 arthropods from 19 different orders, including Araneae, Acari, Mesostigmata, Collembola, Diplura, Thysanoptera, Blattodea, Diptera, Hemiptera, Coleoptera, Hymenoptera, Isoptera, Lepidoptera, Orthoptera, Odonata, Isopoda, Polydesmida, Scolopendrellida, and Scolopendromorpha were collected (Table 1). Out of 19 different orders, there were 12 orders from the class Insecta. Similar to our findings, soil arthropods were chiefly represented by the specimens under Arachnida, Chilopoda, Isopoda, Diplopoda, Insecta, Malacostraca, Pauropoda, Myriapoda, and Symphyla with the majority of insect fauna [31, 20, 32,]. Recently, [20] reported 10 orders of soil arthropods from Rajshahi University campus, Bangladesh. [19] Also reported only five orders from the same habitat. Compared to their study our study exhibited more diversified arthropods from the JU campus, which might be due to the availability of rich vegetation and arthropod-friendly soil and climatic conditions. Diversity and abundance of arthropods correlate with the type of habitat, soil, and other abiotic factors of the ecosystem [18, 9]. Moreover, habitat selection and timing of sampling could be another reason. A significant variation in the number of soil arthropods between habitats and sampling dates were observed by [33]. They also observed that undisturbed habitats host more soil arthropods than habitats with cultivated plants and grasslands. Selected habitat in this study was relatively undisturbed compared to other habitats of Jahangirnagar University campus.

Considering all of the sampling habitats, the most abundant order was Collembola (64.49%; Shanon-Weiner index H'= 0.28). However, individuals of collembolans were much greater in habitat-W than the habitat-GH and habitat-WH. In this study we did not measure the soil humidity and biomass. But, the ground layer of habitat-W was covered with thick leaf litter. Moreover, during the setting of the traps, we observed that habitat-W soil was moist compared to other habitats. Therefore, moist soil and thick leaf litter of the habitat-W might be a reason for the prolific number of Collembola. The numbers of Collembola were significantly higher in the moist soil with decomposed biomass compared to the poor humid soil [34, 35, ad 33]. In contrast to our findings, [19, 20] reported a very low density of Collembola in the Rajshahi University campus, Bangladesh.

Species of the order Diptera (12.89%), Hymenoptera (9.82%), Orthoptera (4.73%), Araneae (2.85%), and Coleoptera (1.38%) were also common in all sampling habitats (Table 1 and Table 2). The increased abundance of these groups could be interpreted as their ability to adapt and inhabit different habitats or might be due to the substantial amount of food availability in all selected habitats. Hymenoptera, Coleoptera and Arachnida were the dominant investigated groups [36, 19, 20]. The least number of individuals belonged to the order Isoptera (0.17%), Scolopendrellida (0.13%), Thysanoptera (0.10%), Acari (0.09%), and Diplura (0.08%) (Table 1). Blattodea, Polydesmida, Lepidoptera and Isopoda comprised 0.76%, 0.64%, 0.34% and 0.27% of the total captured individuals, respectively, resembling the findings of the previous study [37, 38].

Overall, insect fauna from 12 orders made up 91.62% of the collected arthropods. [19, 39, 20] also reported greater number of insect fauna than the non-insect arthropods. Araneae (spiders) was the dominant group among non-insect fauna. Members of the Araneae are frequent predators in terrestrial ecosystems that primarily predate insects and occasionally feed on other invertebrates, including spiders [32]. In this study, we have found a huge number of Collembola, gnat flies from Cecido

myiidae family and micro-hymenopterans, which could be interpreted as a higher number of spiders.

Species of the collected orders were more evenly distributed in habitat-GH (J' = 0.5) and habitat-WH (J' = 0.5) than habitat-W (J' = 0.3) even though the number of collected individuals were greater in habitat-W than the other two habitats (Fig. 2 and Table 2). The lower evenness of habitat-W is due to the enormous difference in the relative abundance from one order to another. Only Collembola makes up 74% of the arthropod community in habitat-W (Table 2). The values of Pielou's evenness index is between 0 and 1[30]. The value of Pielou's evenness index closer to 1 indicates that the arthropods in an ecosystem are equally distributed. The Shannon diversity index showed the highest value in habitat-GH (H'=1.49) compared to habitat-WH (H'=1.47) and habitat-W (H'=1.04), indicating a more diversified community. The difference in diversity between the three habitats could be due to the availability of food and the stability of the ecosystem. For instance, habitat-GH areas had a greater abundance of young grass, herbs, and shrubs.

Conclusion

The population abundance and diversity of soil-dwelling arthropods in Bangladesh have not been thoroughly studied yet. The present study was the first time effort to investigate the diversity and abundance of soil-dwelling arthropods in Jahangirnagar University campus. The information generated from this study would be helpful to make a partial baseline data of soil- living arthropod groups. In the future study, it is essential to conduct sampling over the year and identify the arthropods up to species level with the adoption of morphological and molecular techniques. Moreover, further study is required adding more parameters, including temperature, moisture, acidity, alkalinity and organic matters of the soil, and other abiotic factors such as temperature, humidity and rainfall to investigate how the population abundance and diversity of arthropods interact with environmental factors. All these biological and ecological data would help us develop a standard monitoring procedure to observe any change in the abundance and diversity of soil-dwelling arthropods and the habitat. Ultimately, the results of this study would help us in decision-making for the conservation practices of habitat, as arthropods are re-mark-able bio-indicators and indispensable parts of an ecosystem.

Table 1: Abundance and diversity of soil arthropods collected from different habitats of JU campus

Order	Number of individuals				RA (%)	H'
	Habitat-W	Habitat-GH	Habitat-WH	Total		
Acari	5	0	3	8	0.09	0.006
Araneae	72	115	71	258	2.85	0.101
Blattodea	11	35	23	69	0.76	0.037
Coleoptera	49	57	19	125	1.38	0.059
Collembola	3323	1424	1092	5839	64.49	0.283
Diplura	7	0	0	7	0.08	0.006
Diptera	481	415	271	1167	12.89	0.264
Hemiptera	6	6	10	22	0.24	0.015
Hymenoptera	332	286	271	889	9.82	0.228
Isopoda	24	0	0	24	0.27	0.016
Isoptera	0	3	12	15	0.17	0.011
Lepidoptera	8	8	15	31	0.34	0.019
Mesostigmata	19	3	0	22	0.24	0.015
Odonata	9	10	5	24	0.27	0.016
Orthoptera	110	148	170	428	4.73	0.144
Polydesmida	17	21	20	58	0.64	0.032
Scolopendrellida	6	5	1	12	0.13	0.009
Scolopendromorpha	23	24	0	47	0.52	0.027
Thysanoptera	5	4	0	9	0.10	0.007
Total	4507	2564	1983	9054	100.00	1.295

RA= Relative abundance, H'= Shanon-Wiener diversity index

Table 2: Diversity and abundance comparison of soil arthropods in different habitats of JU campus.

Order	Habitat-G			Habitat-GH			Habitat-WH		
	No. of individuals	RA (%)	H'	No. of individuals	RA (%)	H'	No. of individuals	RA (%)	H'
Acari	5	0.11	0.008	0	0	0.000	3	0.15	0.010
Araneae	72	1.60	0.066	115	4.49	0.139	71	3.58	0.119
Blattodea	11	0.24	0.015	35	1.37	0.059	23	1.16	0.052
Coleoptera	49	1.09	0.049	57	2.22	0.085	19	0.96	0.045
Collembola	3323	73.73	0.225	1424	55.54	0.327	1092	55.07	0.329
Diplura	7	0.16	0.010	0	0.00	0.000	0	0.00	0.000
Diptera	481	10.67	0.239	415	16.19	0.295	271	13.67	0.272
Hemiptera	6	0.13	0.009	6	0.23	0.014	10	0.50	0.027
Hymenoptera	332	7.37	0.192	286	11.15	0.245	271	13.67	0.272
Isopoda	24	0.53	0.028	0	0.00	0.000	0	0.00	0.000
Isoptera	0	0.00	0.000	3	0.12	0.008	12	0.61	0.031
Lepidoptera	8	0.18	0.011	8	0.31	0.018	15	0.76	0.037
Mesostigmata	19	0.42	0.023	3	0.12	0.008	0	0.00	0.000

Odonata	9	0.20	0.012	10	0.39	0.022	5	0.25	0.015
Orthoptera	110	2.44	0.091	148	5.77	0.165	170	8.57	0.211
Polydesmida	17	0.38	0.021	21	0.82	0.039	20	1.01	0.046
Scolopendrellida	6	0.13	0.009	5	0.20	0.012	1	0.05	0.004
Scolopendromorpha	23	0.51	0.027	24	0.94	0.044	0	0.00	0.000
Thysanoptera	5	0.11	0.008	4	0.16	0.010	0	0.00	0.000
Total	4507	100.00	1.042	2564	100.00	1.488	1983	100.00	1.468

RA= Relative abundance, H'= Shanon-Wiener diversity index

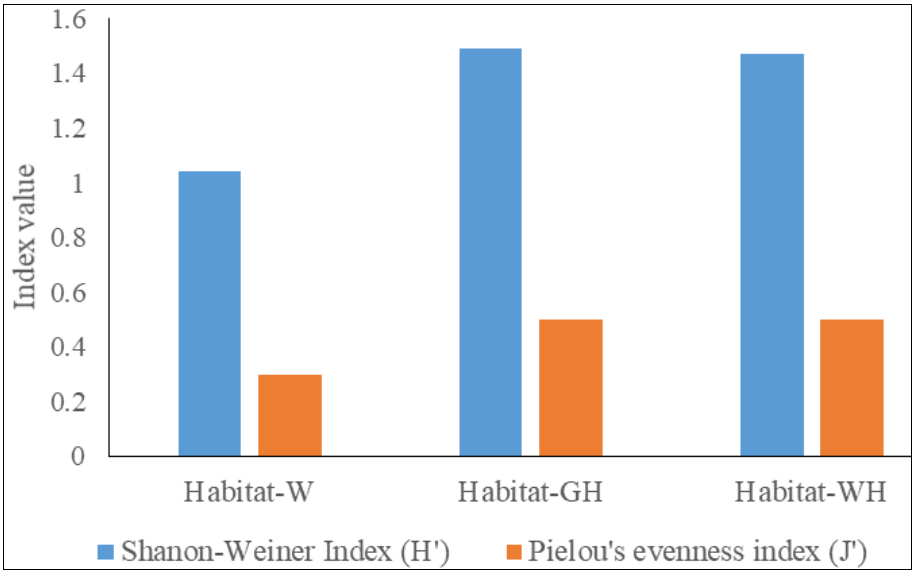

Fig 2: Diversity Indices of arthropods in different habitats of JU campus

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