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Distribution and Composition of Soil Invertebrates in some Agricultural Fields in Al-Madaain District South Baghdad- Iraq

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Abstract

Soil invertebrates play an important role in the soil biota community; they are responsible for decomposing, aerating, recycling nutrients, and increasing agricultural products. This study aims to investigate the community of soil invertebrates in the fields of Al-Madaain district in south Baghdad, as well as their correlation with various soil physical and chemical properties. Each field received four randomly selected samples each month. We isolated the invertebrate samples from the soil using two methods: the direct method for large soil invertebrates and the indirect method for small invertebrates. In this study, we included the physical and chemical factors in the soil to determine them (Temperature, Salinity, pH, Organic matter, Humidity, and total calcium). The temperature ranged from 7 to 35 °C, salinity ranged from 0.10 to 6.80 %, pH ranged from 6.8 to 8.1, soil organic matter ranged from 0.31 to 7.39%, and total calcium ranged from 50 to 212. The number of isolated invertebrates in the study area was 8407; it belongs to 9 taxa; the most common was terrestrial isopoda (41% of total isolated invertebrates), followed by insects (24%), gastropods (17%), and nematodes (8% of total isolated invertebrates), in addition to earthworms, arachnida, chilopoda, and diplopoda. This study used biological indices such as Shannon-Wiener, uniformity, Jaccard, and richness, as well as the LSD test, to calculate significant differences.

Keywords: Soil invertebrates, Agricultural Fields, Biological indices, Physical and chemical parameters.

1. Introduction

Small animals known as soil invertebrates are extremely diverse in form, differ greatly in size and abundance, and often cluster in horizontal and vertical distribution, with the main groups based on their sizes [1]. Macroinvertebrates are big invertebrates, including oligochaetes, isopoda, spiders, diplopoda, chilopoda, and some insects such as beetles. They are bigger than 2 mm and can create their own living spaces in the soil. Mesoinvertebrates have an intermediate size (0.1–2 mm) and live in air-filled pore spaces in soils, including springtails and mites [2]. Microinvertebrates are <0.1 mm. They live in the water that is present around soil particles, including nematoda. Soil invertebrates feed on dead plants, fungi, bacteria, or other soil invertebrate. So the soil Invertebrates play an important role in agriculture and they are considered good indicators for detectives of the impacts of such environmental changes [3]. For example, oligochaetes and insects carry out decomposition, soil aeration enables water to drain through the soil more efficiently [4], and soil gastropoda spend most of their time in the leaf litter layer. There, they consume the dead and decaying vegetation, helping to decompose it. The snails dine on a diet of limestone rock containing lichens, a mixture of nitrogen-containing fungi and algae, and return the nutrient to the soil in their feces, contributing 11% of the nitrogen released into the soil each year. Large invertebrates play an important role in the fragmentation of organic matter and its incorporation into the soil, which creates suitable conditions for the microorganism decomposition process to ocIt also has an impact on the health of surface plant communities, shielding the plants from pests and diseases and hastening the decomposition of dead plants through various biological, physical, and chemical activities [7-9]. Invertebrates are widely regarded as powerful indicators and monitoring tools in environmental management because of their great abundance, diversity, and functional importance. They are resident organisms, relatively stable, and thus suitable for clarifying spatial differences. Many of them have relatively long life cycles, making them suitable for clarifying temporal differences [2]. Preserving this biodiversity is beneficial to the biological communities above and below the soil surface; any decrease in the biodiversity of soil invertebrates has a negative impact on the ecosystem [10, 11]. Some soil microinvertebrates, including nematodes and collembola [12], and mites are regarded as biological indicators to assess the chemical contamination of the soil. Where soil microinvertebrates were used as an indicator for polycyclic aromatic hydrocarbon (PAH) pollution, their results showed that nematodes are better indicators of PAH pollution in soil than microarthropods. Microarthropods are used as a better indicator of decomposition than nematodes, and numerous studies have confirmed that polycyclic aromatic hydrocarbons have an impact on the microbial population and the soil invertebrate community, including collembolans, earthworms, diptera larvae, and nematodes [13, 14]. Mites [15] are a useful biological indicator for estimating the environmental impact of soil chemical pollution [16] because of the role of their species in the basic ecological processes in the soil, including nutrient cycling and decomposition pGiven the significance of soil invertebrates, their crucial role in the environment, and the scarcity of research on them in Iraq, we selected them for the current study. This study aimed to determine the correlation between the diversity and existence of soil invertebrates, the type of soil, and the type of plants present. We selected various fields within Al-Madaen, provided that the relevant districts have a high level of agricultural activity. Counting Agriculture is the most prominent activity in the city and employs most of its population. Al-Madaen is well-known for its various fruit crops, including citrus fruits and dates, which are abundant in the region, raising sheep, cows, etc.

2. Materials and Methods

2.1. Study Area

Samples were collected from the Al-Madaen district, south of Baghdad, between the latitudes 33° 9’ 5.583” and 44° 33’ 32.277” (**Figure 1**). The district is small and located on the eastern bank of the Tigris River. Al-Madaen district is about 35 kilometers from Baghdad. Collected soil samples were taken monthly from Al-Madaen district, south of Baghdad, with four replications of Five sites randomly distributed for the period from October 2021 to June 2022.The selected sites represented a variety of agricultural fields, as follows: The first site (Alfalfa Field) is characterized by being evergreen throughout the study period, and the plant is relatively short and has high activity. The second site represents a palm tree field, while the third site represents a field for growing seasonal crops (eggplant, cauliflower, and tomato). The citrus field, characterized by the presence of orange and orange trees, represents the fourth site. For the fifth site, we chose a site that symbolizes the presence of wild plants on any land where humans have not interfered.

Figure 1. Study area shows the chosen fields.

2.2. Soil Fauna Samples

The present study was carried out in five agricultural fields from October 2021 to June 2022. The soil invertebrates' samples were collected using the soil core, which had a length of 10 cm and a diameter of 5 cm. The samples were collected randomly, and five replicates were taken from each study field. The Tullgren funnel, with an electric light bulb, is used to extract invertebrates from samples of soil or leaf litter [17, 18]. The samples were kept in 70% alcohol until the next sorting process [19]. Taxa identification and counting were undertaken using a disscting microscope, and the species classification was made using the published identification keys [20, 21]

2.3. Environmental Variables

Ecological factors were investigated: soil temperature (Ts) (◦C), soil acidity (pH), and salinity were measured in the field using portable meters [22]. While the soil moisture and organic matters follow the procedure of [23]. The Statistical Analysis System (SAS) program was used in the statistical analysis [24] to compare the physical and chemical properties and to identify the existence of significant differences by using the LSD test. The percentages of the components were extracted, and the rates, graphs, and standard deviation were calculated. Environmental indicators were used to find out the diversity of invertebrates in the orchards of Al-Madaen district, as follows: Biological Diversity Indices (2012) [25, 26].

2.4. Biological Diversity Indices

2.4.1. Species Richness Index (D)

This indicator is calculated monthly according to the formula stated by [27].

$$\mathbf{D} = \frac{S-1}{\log N}$$

As: S = the number of species.
N = the total number of individuals.

2.4.2. Jaccard Coefficient of Similarity (ICj)

This indicator is calculated according to [28].

$$ICj = \frac{C}{A+B-C} \times 100$$

As: A=Number of species at site A.

B = Number of species at site B.

C= Number of species found in both sites A and B.

2.4.3. Shannon-Weaver Diversity Index (H)

The values of this indicator were calculated monthly for all group samples by using the equations of Shannon and Weiner according to [28]

$$H = - \sum nx/n \log nx/n$$

As:

nx = the number of species individuals.

n = the total number of individuals.

2.4.4. The Species Uniformity Index (E)

The species uniformity index is measured according to the formula (1) contained in [29].

$$E = \frac{H}{lnS} \quad (1)$$

As:

LnS=H max

H= Shannon–Weiner index value.

S = Number of species on the site.

The station Analysis of variance (ANOVA) One-way classification was used and less significant difference (LSD) to determine the differences between parameters means at significance of ($P \leq 0.05$). All statistics were carried out using the Statistical Analysis System (SAS) Program [24].

3. Results and Discussion

This study looked at 8407 invertebrate soil samples from all 9 taxonomic groups. We identified 27 taxa from these groups: Nematoda (2 species), Lumbricidae (4 species), Arachnida (2 taxa), Isopoda (4 species), Chilopoda, Diplopoda, Insecta (5 taxa), and Gastropoda (5 species). Isopoda had the highest density, at 3405 ind/m^2, and made up 41% of all the soil invertebrates (**Figure 2**). They eat dead animals, leaves, straw, and wood that have gone bad. This explains the presence of isopods in citrus fields because the field contains a large amount of fruit and fallen leaves, which makes it a suitable environment for the presence of isopods. Site 5 (wild field) revealed large quantities of insects, with a total density of 1414 ind/m^2 (24%). This may be due to the soil's fragility, the ease with which insects can dig into it, and their lack of exposure to other invertebrates [30]. In addition to their total density of 135 ind/m^2 (17%), soil gastropoda also consume, decompose, and disintegrate plant leaves, serving as an important source of organic matter. This explains the presence of gastropoda species in sites 2 (palm fields), 3 (seasonal fields), and 4 (citrus fields), because these fields are full of leaves, fallen plants, and fruits [31, 32]. While the total density of Nematoda reached 658 ind/m^2 (8%), two species of nematodes appeared in Site-1 Alfalfa Field. The study period characterized the fields and plants as short, evergreen, and home to a high diversity of invertebrates [33]. Therefore, the total density of earthworms reached 513 ind/m^2 (7%). Earthworms derive energy to carry out various vital activities through their consumption of food, plant leaves, animal dung, fungi, bacteria, and the remains of dead animals that inhibit the soil [6]. We recorded the lowest density of chilopoda, diplopoda, spiders, and mites at 1109, 125, 119, and 28 ind/m^2, respectively. The current study also showed that the highest density of soil invertebrates reached its maximum (5152, 2373) ind/m^2 in sites 1 and 2, respectively, while the minimum was 924 ind/m2 in field 5. While the total density was slightly close at sites 3 and 4, it reached 1795 and 1163, respectively (**Table 1**).

Table 1. total density of soil invertebrates collected at the five sites during the study period

TAXA	Station					TOTAL	No. specifications
	ST1	ST2	ST3	ST4	ST5		
Nematoda	658	0	0	0	0	658	2
earthwormes	191	15	99	208	0	513	5
spider	19	10	15	27	48	119	1
Arachnida-mites	6	3	0	7	12	28	1
Isopod	1159	305	335	1606	0	3405	3
Chilopoda	20	34	39	16	0	109	1
Diplopoda	30	55	40	0	0	125	1
Insecta	20	326	761	132	797	2036	9
Gastropoda	49	415	506	377	67	1414	5
Total	2152	1163	1795	2373	924	8407	28
species	24	24	27	27	12		

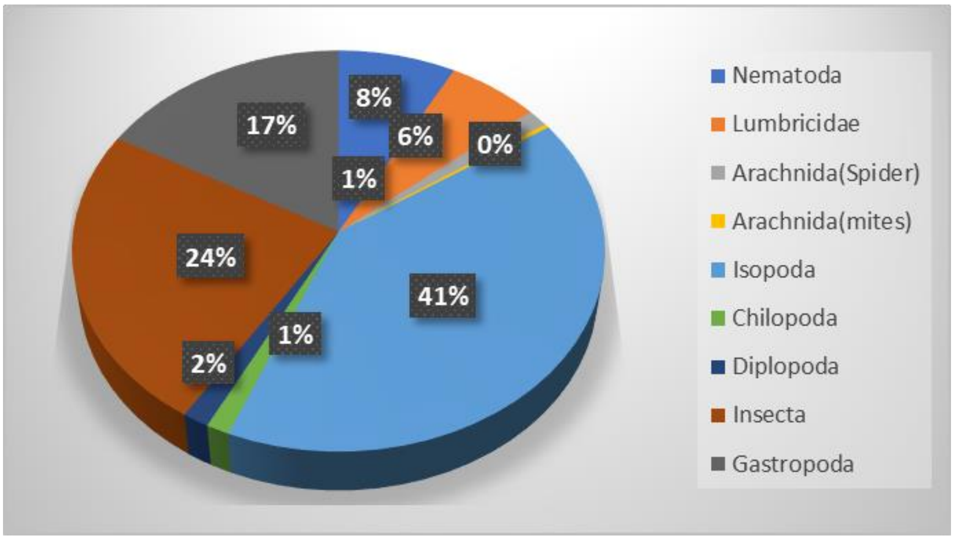

Figure 2. Percentages of different groups of soil invertebrates isolated from orchards in Al-Madaen district / Baghdad during the period from October 2021 to June.

Table 2 displays the temperature and salinity values for the study area. The temperature ranged from 7 in November 2021 to 35 in July 2022, with the lowest salinity value of 0.10 in February 2022 and the highest value of 6.8 in July 2022. The pH values ranged between 6.9 and 8.1 throughout the study period; the highest value was in March 2022, and the lowest value was in November 2021. The percentage of organic matter in soil during the study period ranged between 0.31 in December 2021 and 7.39 in October 2021.

Table 2. Range of physico-chemical and characteristics of each studied site during the studied period from February 2020 until February 2021.

Characteristics	Site 1	Site 2	Site 3	Site 4	Site 5	LSD
Temperature	7-28 19.61 ±6.77	12-29 20.44±6.09	19-26 22.28 ± 2.39	15-26 20.89 ± 3.41	22-35 26.44 ±3.97	6.028 NS
pH	7.1-7.60 7.34 ±0.19	7.1-8.1 7.36 ±0.32	7.2-8.1 7.52 ±0.32	7.1-7.6 7.30 ±0.19	6.8-7.50 7.09 ±0.22	0.592 NS
Salinity	0.52-0.94 0.73 ±0.17 a	0.55-6.80 4.72±5.44 a	0.10-5.58 2.13 ± 1.76 b	0.66-4.27 1.27±1.21 b	1.59-5.88 1.45±2.73 b	2.071 *
Organic matter	0.91-4.89 2.04 ±1.25	1.70-7.39 5.44 ±4.72	0.31-5.59 2.84 ±1.90	1.43-6.30 4.08 ±1.82	1.92-4.01 2.66 ±0.70	2.59 NS
Total Calcium	130-212 178±26.21 a	100-188 167.44±26.88 a	88-200 170.22±35.92 a	50-132 79±24.16 b	98-198 172.67±31.22 a	42.81*
Soil Moisture	20.67-28.87 24.51±3.04	20.67-28.87 24.51±3.04	20.67-28.87 24.51±3.04	20.67-28.87 24.51±3.04	20.67-28.87 24.51±3.04	3.91NS

The results of the current study (**Table 2**) revealed clear and significant differences in the environmental factors studied between the different study sites, with the exception of soil temperature, which was close. This may be due to the fact that the study sites are located in the same city and the measurement period was conducted at the same time. The pH values of the soil at sites 1 and 4 tended to be neutral throughout the study, ranging between 7.1 and 7.6. The two sites also showed neutral values, tending towards the basic, reaching the highest pH value of 8.1. During some months of the study, the acidity ranged between 6.9 and 7.5; this could be attributed to differences in the nature of the fields, the type of crops, and the presence of monolithic organisms, as reflected in the varying values. The statistical analysis revealed distinct variations in salinity values, with site 1 registering lower salinity values (0.455–0.94) than the other sites. This was due to the river's ability to provide permanent drainage, preventing salt accumulation in the soil [34]. Site 2 recorded the highest salinity values, ranging from 6.25 to 0.55. This was followed by the fifth site, which had the highest value at 5.88 and the lowest value at 1.59, due to its irrigation from undesirable wastewater and its poor natural drainage [35]. The second site had high soil salinity values, with the highest value reaching 5.58 and the lowest value being 0.47. On the other hand, the fourth site's soil salinity values ranged between 0.74-0.186, which were somewhat similar to the first site [36]. This could be attributed to factors such as excessive irrigation, poor soil drainage, high temperatures, and summer evaporation [37].

According to the Shannon-Weiner index, sites 1, 2, and 3 have a high level of diversity (**Figure 3**). The diversity index indicates the number of species in the population and the distribution of individuals between these species [38]. The Shannon-Weiner index's higher values indicate greater diversity [39]. As for environmental evidence, The Shannon Weiner values for invertebrates in this study ranged from 4.36 bits per person in June at the second site, the palm field, to 1.39 bits per person in April at the fifth site, the wilderness field. In this study, Shannon's index values show that the jet field, the palm field, and the seasonal field all have high diversity. This is because biodiversity indicators look at the number of species in the sample and how individuals are distributed within these species [38], and high values of the Shannon Wiener Index mean high diversity [39]. Furthermore, the high Shannon-Winner index values are only evidence of the field's high diversity [40]. The high biodiversity values in the three sites are due to the nature of the soil and water quality, as well as the suitability of environmental conditions such as good ventilation, light intensity, and high oxygen concentration, all of which are conducive to the presence and abundance of invertebrates.

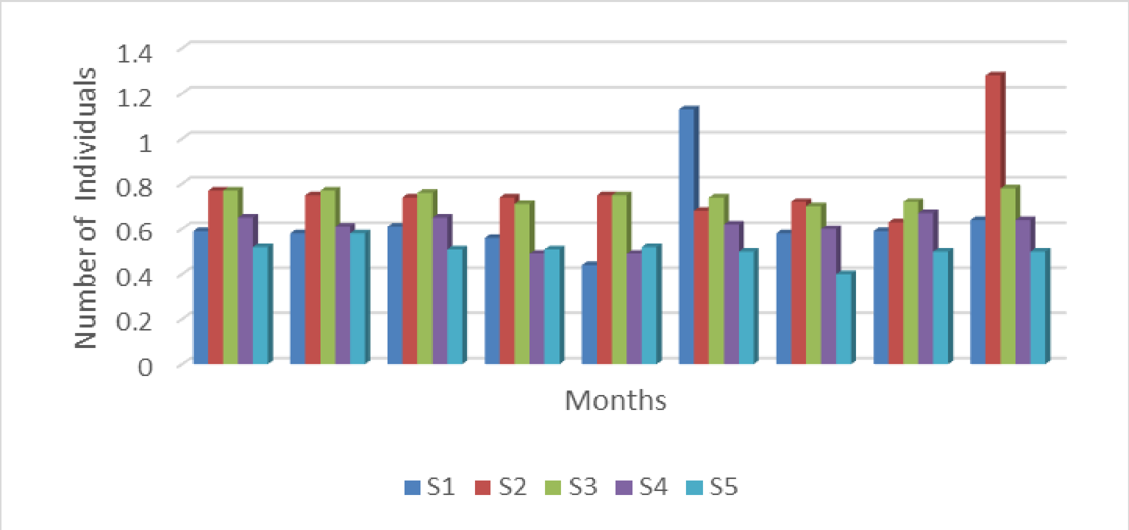

Figure 3. Shannon- Weaver diversity index (H).

The emergence of species is a crucial environmental indicator, as it signifies the proximity of the number of individuals returning to each species in the environment, as well as the pattern and distribution of individuals among the species (**Figure 4**). A low value indicates the presence of one or more dominant species, which exerts the strongest influence on the ecosystem's functions. The homogeneity index ranges from 0 to 1, with high readings indicating the absence of environmental burden and the stability of environmental habitats [28].

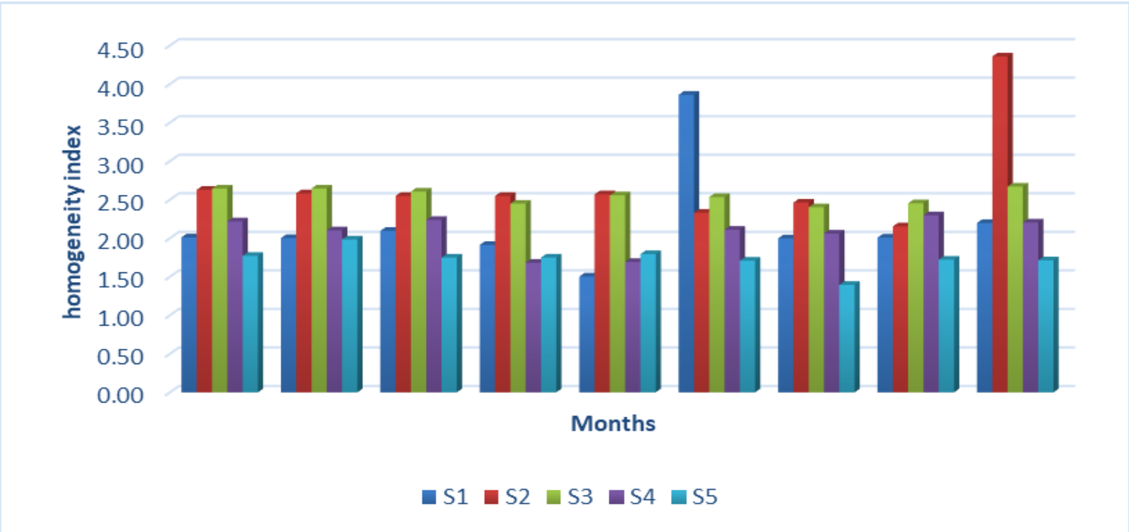

Figure 4. The monthly changes of the homogeneity index of species appearance Species Uniformity Index in the study sites in Al-Madaen district - south of Baghdad for the period from October 2021 to June 2022.

The calculation of the Jacquard similarity index Jaccard Presence-Community values revealed that the two sites, ST 3 and ST 4, had the strongest similarity relationship, with a score of 86. This was followed by the similarity between the second site and the third and fourth sites, with a percentage of 82. Conversely, the first site and the fifth site had the lowest percentage, with scores of 20 and 50, 44 and 39, respectively.

4. Conclusion

Soil invertebrates can be found in a variety of agricultural fields and have a wide range of physical and chemical characteristics; they are also thought to be a good indicator for detecting the effects of such environmental change.

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Conflict of Interest

There is no conflict of interest.

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