Egyptian Journal of Zoology (EJZ)
Publisher: The Zoological Society of A. R. Egypt
DOI: 10.21608/ejz.2025.346370.1127

p-ISSN: 1110-6344
e-ISSN: 2682-3160

RESEARCH ARTICLE

THE FACTORS AFFECTING THE SPATIAL AND SEASONAL DISTRIBUTION OF SOIL MACROARTHROPODS IN QENA GOVERNORATE, EGYPT

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Article History:
Received: 21 December 2024
Accepted: 12 January 2025
Published Online:
19 January 2025

Keywords:
Distribution
Ecological factors
Macroarthropods
Qena governorate
Soil

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ABSTRACT

Soil macroarthropods are an important component of terrestrial ecosystems due to their main regulators of crucial processes; their abundance and diversity can be used as an indicator of healthy soils. The present study assessed the effect of some ecological factors on soil macroarthropod functional groups at six different localities in Qena Governorate during one year from March 2021 to February 2022. The study revealed that a total of 54 macroarthropod taxa were identified. The Insecta were the dominant group as numerically represented with 25 taxa, followed by Arachnida with 22 taxa, then Crustacea with 5 taxa, and finally Chilopoda, which was represented by 2 taxa. The results from multivariate analysis of variance (MANOVA) conducted that all of air and soil temperature, soil moisture, pH, total dissolved solids (TDS) and organic matter exhibited highly-significant differences ($P<0.01$) between the studied sites. Air temperature and TDS were found to be the most effective factors on the total density of soil macroarthropods using Pearson correlation coefficients and linear regression analysis. The Arachnida, Crustacea, and Insecta groups showed positive correlations with air temperature; while Chilopoda was positively correlated with soil moisture.

INTRODUCTION

Soil contains a highly diverse range of organisms, including microorganisms, small and large invertebrates, and small mammals[1]. However, more than 85% of the species richness of the soil fauna is comprised of edaphic arthropods[2]. Soil arthropods encompass groups of fauna, particularly those inhabiting inside or upper surface of the soil. Nonetheless, they are omnipresent in any ecosystem; their types and abundance fluctuate based on soil conditions, habitat types, and abiotic factors[3]. Soil arthropods are crucial in agricultural and plantation ecosystems, since they regulate nutrient dynamics and soil quality, exert pressures on soil biodiversity and degradation, and serve as biological markers of ecosystem conditions[4]. Soil arthropods constitute a highly sensitive component, with their community structure affected by environmental conditions, vegetation cover, climate, habitat disturbances, and soil management practices[5-7]. The distribution and abundance of soil arthropods are profoundly affected by the chemical and physical properties of the soil, as evidenced by numerous studies[8-11].

The impact of climate variables (i.e., precipitation and air temperature) and soil moisture/temperature on soil arthropods has been assessed across different habitats[12,13]. Soil moisture and temperature have emerged as the most important determinants of arthropod distribution[14-18], but the response of soil arthropods to these factors differs among taxa[19,20]. Soil texture, soil organic matter content, and pH significantly have a major impact on soil biota[8,21-24]. The significance of factors influencing soil arthropod diversity and abundance in agroecosystems remains far from being understood. Thus, the primary aim of the present study is to provide an analysis of the relationship between the distribution patterns and abundance of soil macro-arthropods and ecological parameters across different habitats in Qena governorate.

MATERIAL AND METHODS

Study sites

Collections of arthropods samples were carried out from six different sites in Qena governorate (26º7'N, 32º70'E) as illustrated in Figure (1). Samples were quantitatively collected every month over one year from March 2021 to February 2022. The sites of collection are: Nag-Hammadi city (site I; 26º05'N, 32º23'E), Dishna city (site II; 26º12'N, 32º48'E), South Valley University farm in Qena city (site III; 26º19'N, 32º73'E), El-Taramsa village (site IV; 26º14'N, 32º70'E), Qus city (site V; 25º95'N, 32º78'E), and El-Laqita region (site VI; 25º88'N, 33º12'E). Sites I and II are fruit farms, site III is a semi-desert farm, sites IV and V are agricultural regions, and site VI is a reclaimed desert area.

Sampling

Two methods of sampling were used for collecting samples of soil with macro-arthropods. The first technique was the metal cube (20×20×20 cm) and the second method was the Pitfall trapping; where eight pitfall traps (13 cm diameter and 8 cm depth) were used for each site. The examination and enumeration of macroarthropod taxa were conducted using a stereomicroscope and the specimens were preserved in 70% ethanol. Identification of soil macroarthropod taxa was carried out using different keys[25-27]. The experimental design and sampling were carried out according to the Institutional Animals Ethics Committee (Faculty of Science, South Valley University, Qena, Egypt; ethical reference number: 004/11/24).

Ecological factors

Physical and chemical parameters in each sampling station were assessed. Air and soil temperature (ºC) were measured using a thermometer. Relative humidity (%) was obtained from South Valley University-meteorological research station. Soil moisture (%) was evaluated by adding a sample of 20 g of fresh soil in an oven at 110ºC for 24 hours to dry[28]. The loss in weight represents the amount of water in the sample. The percentage of the soil water content was estimated by relating the water loss to the dry weight of the soil sample. Soil pH was determined using pH meter model AD 32 (Adwa, Szeged, Hungary). Soil salinity (mg/L) was measured using total dissolved solids (TDS) meter model AD 32 (Adwa); by making a solution of soil (1.0 soil: 5 distilled water). Soil organic matter content (%) was quantified by burning 20 g of dried soil in microwave oven at 600ºC for 8 hours[28]. The percentage of organic matter = [(Mass of unburned soil – Mass of burned soil) / Mass of unburned soil × 100].

Statistical analysis

The recorded data were summarized and analyzed using SPSS software (Version 23). The multivariate analysis of variance (MANOVA) was employed to determine the monthly variation of soil macroarthropod groups and physicochemical parameters of the investigated locations. Pearson correlation coefficients and multiple regressions were applied for evaluating the effects of ecological factors on soil macroarthropods community structure. The stepwise multiple regressions were used to select the affected variable and calculate regression equations[29].

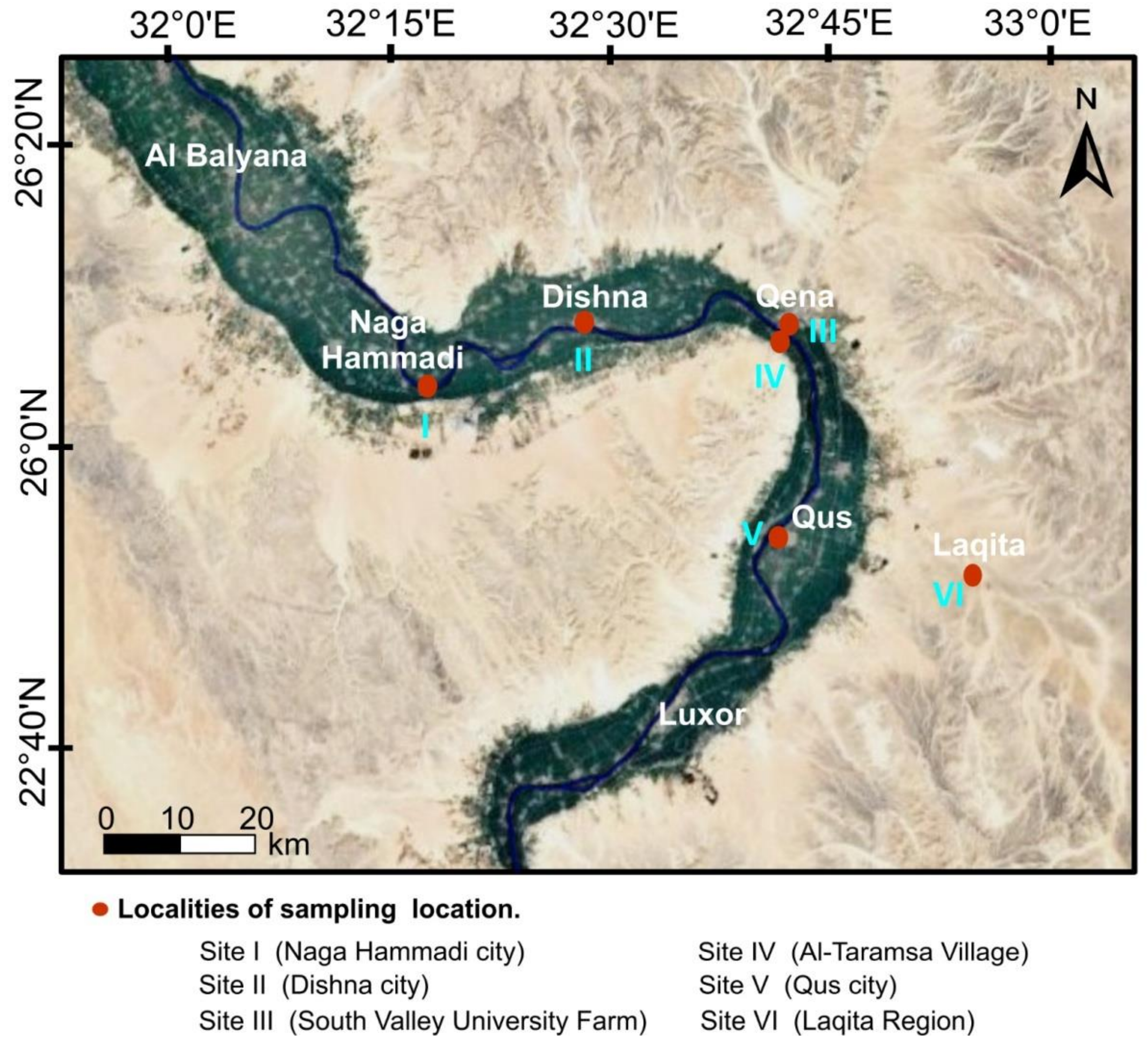

Figure 1: A map of Qena governorate showing the sites of collection during the study period.

RESULTS

Physicochemical parameters of soil macroarthropods in Qena governorate

The physicochemical results during the period of study are presented in Table (1). The recorded air temperature ranged from 9.4ºC (site I) to 41.7ºC (site IV). Soil temperature varied from 8ºC (sites V and VI) to 33ºC (site VI). The recorded soil moisture ranged from 1.2% (site VI) to 34.7% (site I). The pH values varied from 6.5 (site I) to 8.7 (site III). The TDS values ranged from 70 (site I) to 9260 (site IV). Organic matter content ranged from 3.2% (site VI) to 28.2% (site IV).

By applying MANOVA test between sites (Table 2), it was concluded that all of air temperature, soil temperature, moisture, pH, TDS, and organic matter exhibited highly-significant differences ($P<0.01$), while relative humidity (R.H.) was insignificant. Using seasons as independent variables in the above-mentioned test resulted in highly-significant differences ($P<0.01$) for air and soil temperatures, R.H., moisture, pH, TDS, and organic matter. In case of the interaction between sites and seasons, all of soil temperatures, moisture, pH, TDS, and organic matter gave highly-significant differences ($P<0.01$), while the air temperature and R.H. were insignificant.

Macroarthropods community of soil in Qena governorate

During the period of the research, a total of 54 macroarthropod taxa were identified (Table 3). Insecta were the dominant group

Table 1: Minimum, maximum, mean, and standard deviation (SD) of physicochemical parameters during the study period.

		Air temperature	Soil temperature	R.H.	Moisture (%)	pH	TDS	Organic matter (%)
Site I	Min	9.4	10	18.9	13.1	6.5	70	7.1
	Max	32.6	24	50.2	34.7	8.2	1930	14.3
	Mean	23.1	17.7	32.3	24.8	7.3	673.3	10.7
	±SD	±8.0	±6.0	±10.0	±6.2	±0.5	±501.4	±2.2
Site II	Min	11.6	11	18.9	10.8	7.3	140	8.3
	Max	34.9	26	50.2	24.4	8.5	1800	12.8
	Mean	25.4	19.5	32.3	18.8	7.9	584.2	10.1
	±SD	±8.0	±6.0	±10.0	±4.4	±0.4	±500.4	±1.4
Site III	Min	14.0	11	18.9	4.1	7.7	120	6.4
	Max	37.3	27	50.2	21.0	8.7	1360	16.4
	Mean	27.8	22.0	32.3	12.1	8.3	685.8	12.8
	±SD	±8.0	±5.4	±10.0	±4.8	±0.3	±356.2	±2.9
Site IV	Min	19.5	10	18.9	15.6	7.1	410	7.6
	Max	41.7	29	50.2	33.2	8.2	9260	28.2
	Mean	33.6	22.2	32.3	25.3	7.9	3297.5	13.4
	±SD	±7.7	±6.7	±10.0	±4.8	±0.3	±2612.6	±5.3
Site V	Min	18.5	8	18.9	2.8	7.2	200	7.3
	Max	41.1	32	50.2	27.4	8.6	3310	16.1
	Mean	32.8	22.4	32.3	18.5	8.1	740.0	10.4
	±SD	±7.6	±7.6	±10.0	±7.3	±0.5	±842.8	±2.1
Site VI	Min	17.5	8	18.9	1.2	7.5	260	3.2
	Max	40.2	33	50.2	10.7	8.5	8070	7.2
	Mean	31.5	24.1	32.3	5.1	8.1	1729.2	5.4
	±SD	±7.8	±8.0	±10.0	±3.4	±0.3	±2454.7	±1.1

R.H.: Relative humidity; TDS: total dissolved solids.

as numerically represented with 25 taxa, followed by Arachnida with 22 taxa, then Crustacea with 5 taxa, and finally Chilopoda, which represented by 2 taxa. Sites III and IV showed the greatest diversity of macroarthropod taxa (38 taxa), followed by site V (36 taxa), then site II (31 taxa), site I (24 taxa), and the lowest diversity was noticed at site VI (20 taxa). Insecta formed the majority of the macroarthropod population at the studied sites during the period of investigation. Crustacea comprised the second group of soil macroarthropods, Arachnida constituted the third class, while Chilopoda were poorly represented as shown in Figure (2).

Soil macroarthropod groups showed seasonal fluctuations during the period of the research (Figure 3). Insecta exhibited its peak density during spring (38.14%); whereas, the lowest density was observed in autumn (14.28%). Crustacea, Arachnida, and Chilopoda showed their maximal densities during summer (33%, 35.7%, and 45%, respectively), while the minimal densities of Crustacea and Arachnida were recorded during winter (19.62% and 7.58%, respectively) and during autumn (10%) for Chilopoda.

Correlation between factors and abundance of soil macroarthropods in Qena governorate

By applying the Pearson Correlation Coefficients analysis (Table 4), it was concluded that the abundance of Arachnida was positively correlated with air temperature ($r = 0.42$) and soil temperature

Table 2: Statistical results of two-way multivariate analysis of variance (MANOVA) for ecological factors between the studied sites and seasons.

	Dependent variable	Type III sum of cubes	Df	Mean cube	F value	Significance
Sites	Air temperature	3279.2	5	655.8	54.6	0
	Soil temperature	955.0	5	191.0	28.2	0
	R.H.	0	5	0	0	1
	Moisture	10788.6	5	2157.7	129.5	0
	pH	19.1	5	3.8	47.5	0
	TDS	207675700	5	41535140	25.0	0
	Organic matter (%)	1436.7	5	287.3	43.0	0
Seasons	Air temperature	10684.6	3	3561.5	296.6	0
	Soil temperature	7104.3	3	2368.1	349.6	0
	R.H.	18735.4	3	6245.1	546.5	0
	Moisture	559.4	3	186.5	11.2	0
	pH	8.7	3	2.9	35.8	0
	TDS	53622800	3	17874266.7	10.7	0
	Organic matter (%)	140.9	3	47.0	7.0	0
Sites and Seasons	Air temperature	15.1	15	1.0	0.1	1
	Soil temperature	969.9	15	64.7	9.5	0
	R.H.	0	15	0	0	1
	Moisture	2152.4	15	143.5	8.6	0
	pH	9.6	15	0.6	7.9	0
	TDS	123448900	15	8229926.7	4.9	0
	Organic matter (%)	283.2	15	18.9	2.8	0.001
Error	Air temperature	2305.7	192	12.0		
	Soil temperature	1300.5	192	6.773		
	R.H.	2194.1	192	11.428		
	Moisture	3197.9	192	16.656		
	pH	15.5	192	0.081		
	TDS	319587200	192	1664516.667		
	Organic matter (%)	1284.1	192	6.688		

Df: Degrees of freedom; R.H.: relative humidity; TDS: total dissolved solids.

(r = 0.34), while negatively correlated with R.H. (r = 0.36). Chilopoda group showed a positive correlation with moisture (r = 0.29). The abundance of Crustacea community was positively correlated with air temperature (r = 0.24), moisture (r = 0.39), TDS (r = 0.31), and organic matter (r = 0.28). Finally, Insecta group had a positive correlation with air temperature (r = 0.32), soil temperature (r = 0.31) and TDS (r = 0.24), but it was negatively correlated with R.H. (r = 0.23).

Table 3: Occurrence of soil macroarthropod taxa at the study sites during the study period.

Taxa	Sites					
	Site I	Site II	Site III	Site IV	Site V	Site VI
Dysdrea crocata	+	+	+	+	-	-
Brinda infumata	-	+	+	+	+	+
Berlandina venatrix	-	+	+	+	-	+
Mainarozelotes jaxartensis	+	+	+	+	+	-
Setaphis subtilis	-	-	+	-	-	-
Synaphosus sp.	-	+	+	+	-	-
Zelotes sp.	-	-	+	-	-	+
Mermessus denticulatus	-	+	+	+	+	+
Hogna ferox	+	+	+	+	+	+
Pardosa sp.	+	-	-	+	+	+
Arctosa sp.	+	-	+	-	+	-
Wadicosa fidelis	+	+	+	-	+	+
Thanatus albini	-	-	-	-	+	+
Pisauridae juvenile	-	-	+	+	-	-
Bianor albobimaculatus	-	-	+	+	+	-
Plexippus sp.	-	-	+	+	-	-
Scytodes thoracica	-	+	-	-	-	-
Steatoda erigoniformis	+	-	-	-	+	-
unidentified sp. of family: Atemnidae	+	+	+	+	+	-
Lamprochernes savignyi	-	-	+	+	-	-
unidentified sp. of family: Geogarypida	-	-	+	-	-	-
Olpium sp.	-	+	-	+	-	-
Class: Arachnida	8	11	17	14	11	8
Lithobius sp.	+	+	-	+	+	-
Necrophloeophagus longicornis	+	+	+	-	+	-
Class: Chilopoda	2	2	1	1	2	0
Armadillidium vulgare	-	-	+	-	-	-
Leptotrichus naupliensis	+	+	+	+	+	-
Porcellio laevis	+	+	+	+	+	-
Porcellionides pruinosus	+	+	+	+	+	-
Agabiformius lentus	+	+	+	-	+	-
Class: Crustacea, Order: Isopoda	4	4	5	3	4	0
Blatella germanica	+	+	+	+	+	-
Pycnoscelus surinamensis	+	+	+	+	+	-
Cryptotermes brevis	-	+	+	+	+	-
Pterostichus barbarous	+	+	-	+	+	-
Hypera sp.	+	+	-	+	+	-
Sitona lividipes	+	-	+	+	+	-
Sphenophorus coesifrons	-	-	-	-	+	-
Drasterius figuratus	-	+	-	-	+	+
Carpophilus mutilates	+	-	-	+	-	-
Onthophagus sp.	-	+	+	+	+	+
Rhyssemus schatzmayri	-	+	+	+	+	+
Raphirus levicollis	+	+	+	+	+	-
Akis reflexa	-	-	-	+	-	-
Ocnera hispida	-	-	-	+	+	+
Gonocephalum rusticum	+	-	+	+	+	+
Adesmia cothurnata	-	-	-	-	-	+
Euborellia annulipes	+	+	+	+	+	-
Labidura riparia	+	+	-	+	+	+
Aethus pilosulus	-	+	+	+	+	-
Lethaeus fulvovarius	-	-	+	+	+	-
Oncocephalus notatus	-	-	+	+	-	+
Cataglyphis sinaitica	-	-	+	-	-	+
Camponotus thoracicus	-	+	+	+	+	+
Monomorium niloticum	-	-	-	-	-	+
Order: Orthoptera, *Gryllusdomesticus*	+	+	+	+	+	+
Class: Insecta	11	14	15	12	19	12
Total	24	31	38	38	36	20

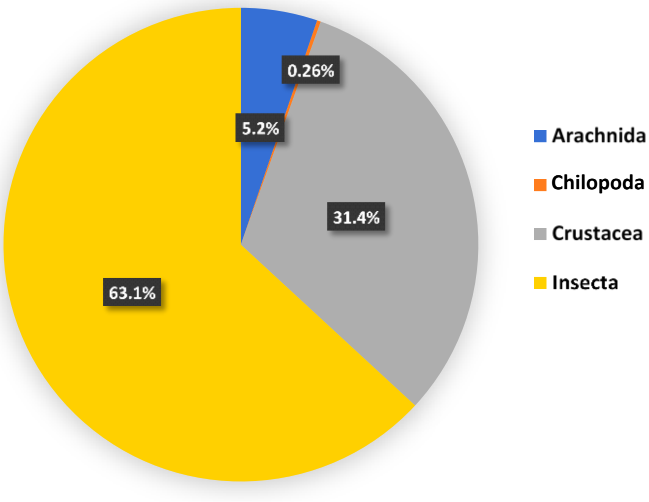

Figure 2: The total abundance percentage of the macroarthropod classes.

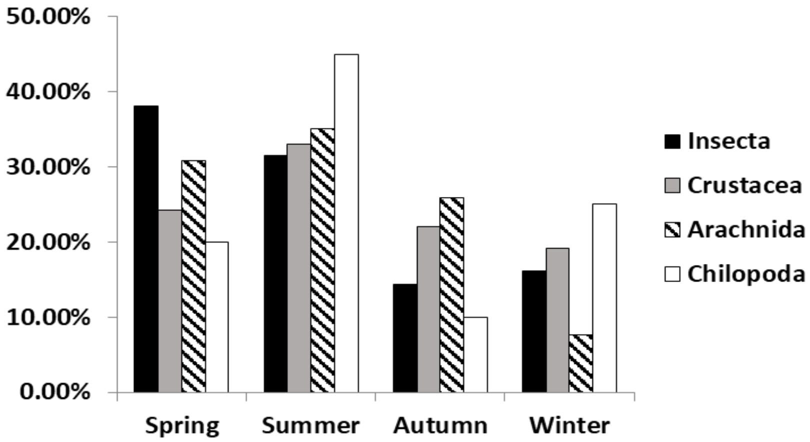

Figure 3: Seasonal occurrence percentages of soil macroarthropod classes of all sites collectively during the study period.

Table 4: Correlation between physicochemical factors and soil macroarthropod groups at the study sites.

	Soil temp	R.H.	M (%)	pH	TDS	OM (%)	A	Ch	Cr	I
Air temp	0.85**	–0.77**	–0.13	0.25*	0.17	0.03	0.42**	–0.08	0.24*	0.32**
Soil temp		–0.66**	–0.29*	0.18	0.14	0.004	0.34**	–0.09	0.09	0.31**
R.H.			0.12	0.06	–0.10	–0.04	–0.36**	–0.07	–0.09	–0.23*
M (%)				–0.23*	0.06	0.32**	–0.04	0.29*	0.39**	–0.21
pH					–0.28*	–0.07	–0.09	–0.21	–0.05	–0.01
TDS						0.13	–0.13	–0.15	0.31**	0.24*
OM (%)							0.10	0.05	0.28*	–0.10
A								–0.01	0.07	0.16
Ch									–0.03	–0.20
Cr										0.36**

A: Arachnida; Ch: Chilopoda; Cr: Crustacea; I: Insecta; M: moister; OM: organic matter; R.H.: relative humidity; Temp: temperature; TDS: total dissolved solids.

Linear regression analysis between soil macroarthropods and ecological factors in Qena governorate

The stepwise multiple regression analysis exhibits a good fit to the data, as it applied to select a model in which all variables were significant, and the models adequately describe the change in abundance of soil macroarthropod groups (Table 5). The total density of Arachnida was affected by air temperature (R= 0.42, *P*<0.01); the model equation = –3.48 + 0.32 air temperature. Chilopoda was impacted with moisture (R = 0.29, *P*<0.01); the model equation = –0.08 + 0.02 moisture). Crustacea was influenced by moisture, air temperature, and TDS (R = 0.54, *P*<0.01); the model equation = –66.44 + 2.61 moisture + 1.61 air temperature + 0.01 TDS. Insecta was affected by air temperature (R = 0.32, *P*<0.01); the model equation = –32.57 + 3.49 air temperature. The total density of all soil macroarthropods was impacted with air temperature and TDS (R = 0.44, *P*<0.01); the model equation = –50.81 + 4.72 air temperature + 0.02 TDS.

Table 5: Stepwise multiple regression between soil macroarthropod and ecological factors at the studied sites.

DV	SV	R	R2	SE of the Estimate	Unstandardized Coefficients		Standardized Coefficients	*t* value	Significance
					B	SE	Beta		
A	Constant Air temp	0.42	0.18	6.01	–3.48 0.32	2.47 0.08	 0.42	–1.41 3.87	0.16 0.00
Ch	Constant Moisture	0.29	0.09	0.61	–0.08 0.02	0.16 0.001	 0.29	–0.52 2.54	0.61 0.01
Cr	Constant Moisture Air temp TDS	0.54	0.30	47.80	–66.44 2.1 1.61 0.01	23.90 0.66 0.67 0.003	 0.41 0.25 0.25	–2.78 3.96 2.42 2.36	0.01 0.00 0.02 0.02
I	Constant Air temp	0.32	0.10	92.54	–32.57 3.49	38.06 1.26	 0.32	0.86 2.78	0.40 0.01
T	Constant Air temp TDS	0.44	0.19	117.63	–50.81 4.72 0.02	48.42 1.62 0.01	 0.32 0.25	–1.05 2.92 2.28	0.30 0.01 0.03

A: Arachnida; Ch: Chilopoda; Cr: Crustacea; DV: dependent variables; I: Insecta; OM: organic matter; R: correlation coefficient; SE: standard error; SV: selected variables; T: total; Temp: temperature; TDS: total dissolved solids.

DISCUSSION

The current study indicated that the sites I, II, and III exhibited the lowest soil temperature values, probably attributable to the extensive vegetative cover of long trees creating shade. Conversely, the sites IV, V, and VI exhibited the highest soil temperature, perhaps due to their agricultural and barren characteristics. Vegetation functions as a thermal insulation and rapidly absorbs heat during the warm season[30]. Soil moisture gave high significant differences between sites (Table 2). Malik and Shukla[31] stated that the geographical and temporal variability of soil moisture is influenced by differences in soil texture, terrain, crop cover, irrigation techniques, and groundwater depth. Site VI exhibited the lowest value of soil moisture (5.1 ± 3.4), likely attributable to its minimal organic matter content and sandy soil composition. Whereas site IV showed the highest value of soil moisture (25.3 ± 4.8); this perhaps due to its elevated organic matter content, as it is located adjacent to the Nile River. Nwogwu *et al*.[32] asserted that the organic matter composition of soil affects its water holding capacity in Nigeria.

The soil pH exhibited high significant variations among the examined sites (Table 2). Fabian[33] and Slessarev *et al*.[34] stated that soil pH is a crucial regulator of soil, inherently influenced by several soil-forming variables. Prior research indicates that the determinants of soil pH change are location- and scale-dependent[34,35]. Farmers should keep soil pH at an alkaline level to affect macroarthropods abundance in vegetable plots and ensure optimal productivity[36]. On a worldwide scale, soils collected from various climates have distinct soil pH[37]. In our study, sites III and VI recorded the highest values of pH (8.3 ± 0.3 and 8.1 ± 0.3, respectively, Table 1), where the lowest values of moisture and organic matter were noticed at these locations. The cultivation of plants in newly reclaimed soils encountered several challenges, including insufficient accessible nutrient levels, low organic matter content, and inadequate hydrophilicity[38]. There was a negative correlation between organic matter and pH in the current study; thus the lower organic matter the higher pH. The lowest values of pH in this research were showed at site I (7.3 ± 0.5) and site IV (7.9 ± 0.3), which may be attributed to the highest moisture levels. Brady and Weil[39] indicated that soils from arid areas are commonly alkaline with a high soil pH. Conversely, soils in humid climates are typically acidic, exhibiting a low soil pH.

Soil organic matter gave high significant differences between the investigated sites. The highest value of organic matter was seen at site IV (13.4 ± 5.3), which may be attributed to the presence of high amount of humus in this agricultural rich region with a high density of individuals, resulting in high amount of feces. Coulis *et al*.[40] and David[41] stated that both millipedes and isopods play important roles in converting leaf litter into feces, hence influencing organic matter dynamics and their distribution in the soil. In contrast, the minimum value of soil organic matter at site VI (5.4 ± 1.1) was seen in a reclaimed desert area with the least amount of leaf litter. TDS exhibited high significant differences between the present sites. The maximum value of TDS was observed at site IV (3297.5 ± 2612.6); as there is a lack of sewer system (wastewater treatment) at this area, resulting in sanitary wastewater under the agricultural area. Sangare *et al*.[42] stated that improper management of sanitary products (i.e., toilet compost, urine, and greywater) could lead to elevated soil salinity and sodium accumulation.

The present findings also indicated that the most ecological factors influencing the total density of soil macroarthropods at the examined sites were air temperature and TDS, as they correlated positively. This result agreed with Blackburn *et al*.[43] who concluded that the greater abundance of soil macrofauna exists in warmer regions compared to colder ones. Also, Mwansat *et al*.[44] recorded that temperature was strongly correlated with the abundance of soil arthropods, but Shakir and Ahmed[22] stated that excessive temperatures in colder areas had negative effects upon soil arthropods. Obuid-Allah *et al*.[45] reported high positive correlation between temperature and density of soil macroinvertebrates, with elevated densities recorded in summer and spring. Kudureti *et al*.[46] reported that warming could positively influence the density and diversity of soil fauna. On the other hand, Crozier and Dwyer[47] and Estay *et al*.[48] predicted the general positive global warming effect on population densities of ectotherms at high latitudes. Bos *et al*.[49] stated that higher temperature and low relative humidity caused a reduction of macroarthropods diversity in the humid tropics. Deutsch *et al*.[50] reported negative correlation between temperature and ectotherms in the tropics. While, Jabin[51] stated that extreme temperatures have no influence on abundance of macroarthropods.

In general, the total dissolved solids in soil significantly affected the distribution of soil creatures[46,52]. The positive correlation between TDS and densities of soil macroarthropods in the present study was in accordance with Butt and Briones[53] who indicated that the majority of soil arthropods, except collembolans, are more abundant in the salinization areas. The present results exhibited a positive correlation between air and soil temperature and Arachnida. Obuid-Allah *et al*.[54] concluded that the abundance of spider species was affected by air temperature. Hegazy *et al*.[55] studied arthropod fauna in the Egyptian Western Desert; they concluded that temperature and relative humidity had a crucial effect on the non-insect activity. Abdelhafez *et al*.[56] also revealed that the spider abundance was mostly related to humidity then air/soil temperature.

The most effective parameter on soil Chilopoda was soil moisture, which exhibited a positive correlation. Chilipoda preferred a damp habitat; residing in leaf litter and soil or located under stones and bark[57]. Due to their fragile epicuticular wax layer on the epidermis, they are especially susceptible to drying[58], leading them to be buried or sheltered in the soils[59]. Also, Kicaj[60] stated that Chilopods live a hidden life, avoiding daylight and dry locations. Our study showed positive correlation between soil moisture, air temperature, and TDS with the densities of isopods. Soil isopods are typically located beneath stones, logs, in leaf litter, amid meadow grasses, and on shrubs and tree canopies, primarily exhibiting nocturnal activity to avoid desiccation[61]. Species of terrestrial isopods from the suborder Oniscidea predominantly inhabit settings characterized by elevated humidity, with moisture serving as a critical limiting factor in their distribution[2]. Abdulgabar *et al*.[62] asserted that air temperature is a significant ecological factor influencing isopods, positively affecting their abundance, while the opposite may occur during extreme heat events. They also concluded that *Porcellio leaves* correlated positively with soil water content.

The most effective ecological factor on soil insects in our study was air temperature, which was correlated positively with their abundance. Bale *et al*.[63] and Menéndez[64] found that insects are poikilothermic organisms that visibly alter their activity in response to ambient temperature variations. Raising temperature to the thermal optimum accelerates insect metabolism, hence directly affecting their activity[65]. Winter temperature can enhance insect longevity, but very low temperatures typically result in elevated mortality rates within the population. Nevertheless, numerous species cannot complete their embryonic cycle or sustain eating in spring without an adequate number of low-temperature days [66,67].

In conclusion, the present study provides relevant knowledge on the effects of ecological conditions in the soil ecosystem on different macroarthropod groups, which supports the comprehension of how arthropod communities respond to the complexity of interaction factors and considered the best evidence for soil quality.

CONFLICT OF INTEREST

There are no conflicts of interest.

FUNDING SOURCES DISCLOSURE

This study didn’t receive any fund.

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العوامل المؤثرة على التوزيع المكاني والموسمي لمفصليات الأرجل كبيرة الحجم في التربة، في محافظة قنا، مصر

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تعد مفصليات الأرجل كبيرة الحجم في التربة عنصرًا مهمًا في النظم البيئية الأرضية نظرًا لتنظيمها للعمليات الحيوية المختلفة؛ ويمكن استخدام وفرتها وتنوعها كمؤشر على صحة التربة. وقد قيمت الدراسة الحالية تأثير بعض العوامل البيئية على المجموعات الرئيسية لمفصليات الأرجل في التربة في ستة مواقع مختلفة بمحافظة قنا خلال عام واحد من مارس 2021م إلى فبراير 2022م. وكشفت الدراسة عن تحديد إجمالي 54 نوعًا من مفصليات الأرجل كبيرة الحجم. وكانت الحشرات هي المجموعة المهيمنة حيث تم تمثيلها بعدد 25 نوعًا، تليها العنكبيات بعدد 22 نوعًا، ثم القشريات بعدد 5 أنواع، وأخيرا مئوية الأرجل التي تمثلت بنوعين. وأظهرت نتائج تحليل التباين متعدد المتغيرات (MANOVA) أن كل من درجة حرارة الهواء والتربة، ورطوبة التربة، والرقم الهيدروجيني، والمواد الصلبة الذائبة الكُلية، والمواد العضوية اختلافات كبيرة للغاية ($P<0.01$) بين المواقع تحت الدراسة. ووجد أن درجة حرارة الهواء والمواد الصلبة الذائبة هي العوامل الأكثر فعالية علي الكثافة الكُلية لمفصليات الأرجل كبيرة الحجم باستخدام تحليل معاملات ارتباط بيرسون وتحليل الانحدارالخطي. وأظهرت مجموعات العنكبيات والقشريات والحشرات ارتباطات إيجابية مع درجة حرارة الهواء، في حين كانت مئوية الأرجل مرتبطة بشكل إيجابي مع رطوبة التربة.