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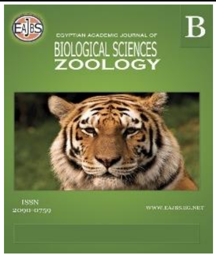

Abundance and Diversity of Soil Macroarthropods in Qena Governorate, Upper Egypt

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ABSTRACT

Soil arthropods represent a wide range of ecological functions, and their abundance and diversity can be used as an indicator of healthy soils. Thus, the species composition of soil macroarthropods at six different localities in Qena Governorate was carried out during one year extended from March 2021 to February 2022. The sites of collection differ in their soil structure, environmental factors and vegetation. The study revealed that the total number of soil macroarthropods collected was (7854 individuals) and could be attributed to four different classes (Insecta, Crustacea, Arachnida and Chilopoda), 13 orders, 36 families, 54 genera, 45 species and 3 unidentified taxa. The highest value of total abundance of macroarthropods was registered during spring and the lowest was in winter. Site IV (El-Taramsa) recorded the highest density of the collected specimens (3097 individuals), while the lowest value (392 indvs.) was recorded at site I (Nag Hammadi). Insecta was the dominant group; it represented about 63.13% of the total density followed by Crustacea (31.41%), Arachnida (5.20%) and Chilopoda (0.26 %). Taxa richness reached the highest peak (38 taxa) at sites III (SVU farm) and IV (El-Taramsa), while the lowest peak (20 taxa) was detected at site VI (Laqita). Shannon- Wiener's diversity index ranged between (1.328) at site VI and (2.393) at site III.

INTRODUCTION

Soil constitutes the most diverse and species-rich habitat within the terrestrial ecosystem (Decans *et al.*, 2006). Soil organisms play a crucial role in agricultural ecosystems, as their presence is essential for the maintenance of fertile and productive soils. Soil arthropods have significant roles within soil ecosystems, rendering them a highly integral component of various ecosystems, including agroecosystems. The decrease in soil arthropod diversity is expected to result in worse ecosystem functioning. Furthermore, there has been a growing interest in utilizing soil arthropods as biological markers for assessing habitat damage and land use (Andersen and Majer, 2004; Nakamura *et al.*, 2007).

Soil macroarthropods refer to soil-dwelling organisms of sufficient size to be individually examined as indicated by Callaham *et al.*, (2012). The category of macroarthropods encompasses several organisms such as millipedes, centipedes, numerous

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insect orders, certain crustaceans, and arachnids (Ishaya, 2019). Although certain types of soil macroarthropods are commonly regarded as pests (Jackson and Klein, 2006; Doğramaci and Tingey, 2009), they also play a crucial role in enhancing ecosystem processes through their substantial impact on the soil environment (Lavelle, 1997; Wolters, 2000). Ants, termites, millipedes, centipedes, woodlice, and beetles are significant contributors to macromixing and the creation of soil aggregates. They also aid in the mineralization of inorganic nutrients by activating microflora, as noted by Ruiz *et al.*, (2008). Additionally, they contribute to the development of macropores, which play a crucial role in soil aeration and water movement (Edwards and Bohlen, 1996).

The main objective of the present study is to provide an analysis of the soil macroarthropods community at different habitats in Qena Governorate, focusing on their distribution patterns, abundance and diversity.

MATERIALS AND METHODS

Collection:

To achieve the goal of the present study, samples were collected monthly for a period of one year, extending from March 2021 to February 2022. The collection sites are situated in Qena governorate, Upper Egypt (26°17'N and 32°70'E). Qena governorate is approximately 600 kilometers south of Cairo, 60 kilometers north of Luxor, and 260 kilometers west of the Red Sea. Samples were collected from six sites, the first site (referred to as site I) is situated in Nag Hammadi city (26°05'N and 32°23'E). It was a mango and bitter orange farm with sandy loamy soil. The second site (site II) is a farm located in Dishna city (26°12' N and 32°48' E), and planted with lime and fig in sandy loamy soil. The third site (site III) is situated at South Valley University (26°19' N and 32°73' E). It is an unmanagement experimental farm, with a loamy sand soil planted with many plants such as weeping fig, the flame of the forest, coastal sheoak, white mulberry and yellow bells. The fourth and fifth sites are characterized by their agricultural nature with different types of crops planted in sandy loam soils. The fourth site (site IV) is located in El-Taramsa village (26°14' N and 32°70' E), while the fifth site (site V) is situated in Qus city (25°95'N and 32°78'E). Site VI, the sixth site, is located in Laqita region (25°88'N and 33°12'E). This particular site is a newly reclaimed desert area with sandy soil. It is planted with roselle and alfalfa crops during all periods of investigation. The geographical positioning system (GPS) was utilized to identify and designate the specific locations where the collecting sites are situated. Fig. (1).

Fig.1: A map of Qena governorate showing sites of collection

Sampling:

Two methods of sampling were used for quantitative purposes. The first technique used a metal cube measuring 20×20×20 cm. Three random samples were collected from each site every month. The other method used Pitfall trapping which is a method of collecting epigenic invertebrate animals (Brussaard *et al.*, 2006). This method is a useful tool for estimating the abundance and composition of ground active invertebrate assemblages in an area (Harhash, 2003). A number of 48 plastic containers were used as pitfall traps; eight pitfall traps (13 cm. diameter and 8 cm. depth) for each site. The solution in the pitfall trap was soupy distilled water with some drops of absolute alcohol. The traps were set for one day and then collected (Southwood, 1978). The hand-picking technique was adopted to collect large macroarthropods (≥ 2 mm). The examination and enumeration of taxa were conducted using a stereomicroscope and the specimens were preserved in 70% ethanol.

All animal experiments were carried out in Institutional Animals Ethics Committee (Published by the faculty of Science, South valley university, Qena, Egypt under Code No. 014/12/22).

Identification of Soil Macroarthropods:

Most macroarthropod taxa were identified at the species level using different keys and only three taxa were identified at the family level. For Arachnida the following keys were used: El-Hennawy (1987, 1987, 1988, 1998, 2006, 2008, 2010), Hussien (2011, 2015), Batuwita and Benjamin (2014), Aboulnasr (2018) and El Masry (2020). Finally, species identification was confirmed by Mr. H. K. El-Hennawy an expert in spider identification in Egypt. Chilopoda was identified according to Ramzi (2015). Crustacea was identified according to Mahmoud (1990), Schmalfuss *et al.*, (2004) and Abd El-Wakeil (2005). Insecta was identified according to Scott and Stojanovish (1962), Mohamed *et al.*, (2001), Choate (2003, 2010), Ramzi (2015) and Hackston (2019). Insect identification was confirmed by the Insect Identification Unit at the Plant Protection Research Institute at the Agricultural Research Center in Cairo.

Data Analysis:

Species dominance structure was conducted by employing Engelmann's (1978) categorization, which categorizes species into subrecedent (less than 1.3%), recedent (1.3-

3.9%), subdominant (4-12.4%), dominant (12.5-39.9%), and eudominant (40–100%) groups. The Shannon-Wiener diversity index (H') was employed to assess the diversity of macroarthropods in the collected community. The Shannon-Wiener equation, $H' = -\Sigma$ pi (lnpi), was utilized for this purpose, where pi represents the proportion of individuals of each species. Also, the richness of soil macroarthropods in the community was quantified. The significance of differences in macroarthropod abundance in the six sites was measured by the statistical multivariate analysis of variance (MANOVA) using the SPSS software package (SYSTAT statistical program, version 23).

RESULTS

In the present study, a total of 7854 individual soil macroarthropods were collected from both sampling techniques. Pitfall traps accounted for 5882 individuals representing (74.89%), while 1972 (25.11%) were collected with the metal cube. The soil macroarthropods taxa gathered encompass four primary classes, namely Insecta (with 25 taxa), Arachnida (25 taxa), Crustacea (5 taxa) and Chilopoda (2 taxa). The total taxa were assigned to 13 orders, 36 families, 53 genera, 44 species, 9 unidentified species and 4 unidentified taxa from class Arachnida. The families varied in their numbers and frequencies of occurrence in the sites. The family with the highest abundance over the entire study period was Formicidae (Insecta), consisting of 3 species and a total of 4004 individuals represented (50.98 %). In contrast, the family with the lowest abundance was Scytodidae (Arachnida), which included only one species and a total of 2 individuals represented (0.02%) during the same study period, Table (1).

Table 1: The identified species from the six sites during the period of investigation

Class	Order	Family:	sp.	Class	Order	Family	sp.
Arachnida	Araneae	Dysderidae	*Dysdre crocata*	Insecta	Blattodea	Blattidae	*Blatella germanica*
		Gnaphosidae	*Berinda infumata*			Blaberidae	*Pycnoscelus surinamensis*
			Berlandina venatrix			Kalotermitidae	*Cryptotermes brevis*
			Marinarozelotes jaxartensis		Coleoptera	Carabidae	*Pterostichus barbarous*
			Setaphis subtilis			Scarabaeidae	*Rhyssemus schatzmayri*
			Synaphosus sp.				*Onthophagus* sp.
			Zelotes sp.			Elateridae	*Drasterius figuratus*
		Linyphiidae	*Mermessus denticulatus*			Tenebrionidae	*Ocnera hispida*
		Lycosidae	*Hogna ferox*				*Akis reflexa*
			Pardosa sp.				*Adesmia cothurnata*
			Arctosa sp.				*Gonocephalum rusticum*
			Wadicosa fidelis			Nitidulidae	*Carpophilus mutilates*
		Philodromidae	*Thanatus albini*			Curculionidae	*Hypera* sp.
		Pisauridae	unidentified species				*Sphenophorus coesifrons*
		Salticidae	*Plexippus* sp.				*Sitona lividipes*
			Bianor albobimaculatus			Staphylinidae	*Raphirus levicollis*
		Scytodidae	*Scytodes thoracica*		Dermaptera	Labiduridae	*Labidura riparia*
		Theridiidae	*Steatoda erigoniformis*			Anisolabididae	*Euborellia annulipes*
	Pseudoscorpionida	Atemnidae	unidentified species		Hemiptera	Reduviidae	*Oncocephalus notatus*
		Chernetidae	*Lamprochernes savignyi*			Lygaeidae	*Lethaeus fulvovarius*
		Geogarypidae	unidentified species			Cydnidae	*Aethus pilosulus*
		Olpiidae	*Olpium* sp		Hymenoptera	Formicidae	*Cataglyphis sinaitica*
	Scorpionida	Buthidae	*Androctonus amoreuxi*				*Camponotus thoracicus*
			Leiurus quinquestriatus				*Monomorium niloticum*
	Solpugida	Galeodidae	*Galeodes arabs*		Orthoptera	Gryllidae	*Gryllus domesticus*
Chilopoda	Lithobiomorpha	Lithobiidae	*Lithobius* sp.				
	Geophilomorpha	Geophilidae	*Necrophloeophagus longicornis*				
Crustacea	Isopoda	Aramadillidae	*Armadillidium vulgare*				
		Porcellionidae	*Leptotrichus naupliensis*				
			Porcellio laevis				
			Porcellionides pruinosus				
			Agabiformius lentus				

In all examined sites, Insecta was found to be the most prevalent group of soil macroarthropods, with a total of 4958 individuals represented (63.13%) of the total number. This was followed by Crustacea, which had a count of 2467 individuals representing (31.41%) of the total number. Arachnida ranked third group with 409 individuals representing (5.20%) of the total number, while Chilopoda had the lowest count of 20 individuals representing (0.26%) of the total number (Fig. 2). Upon analysis of the taxonomic composition of soil macroarthropods across all sites, it was observed that the highest abundance was recorded for *Camponotus thoracicus* (Family: Formicidae), with a total of 2676 individuals, accounting for 34.07% of the overall population. Conversely, *Scytodes thoracica* (Family: Scytodidae) exhibited the lowest species count, with only 2 individuals, representing a mere 0.02% of the total population (Table, 2).

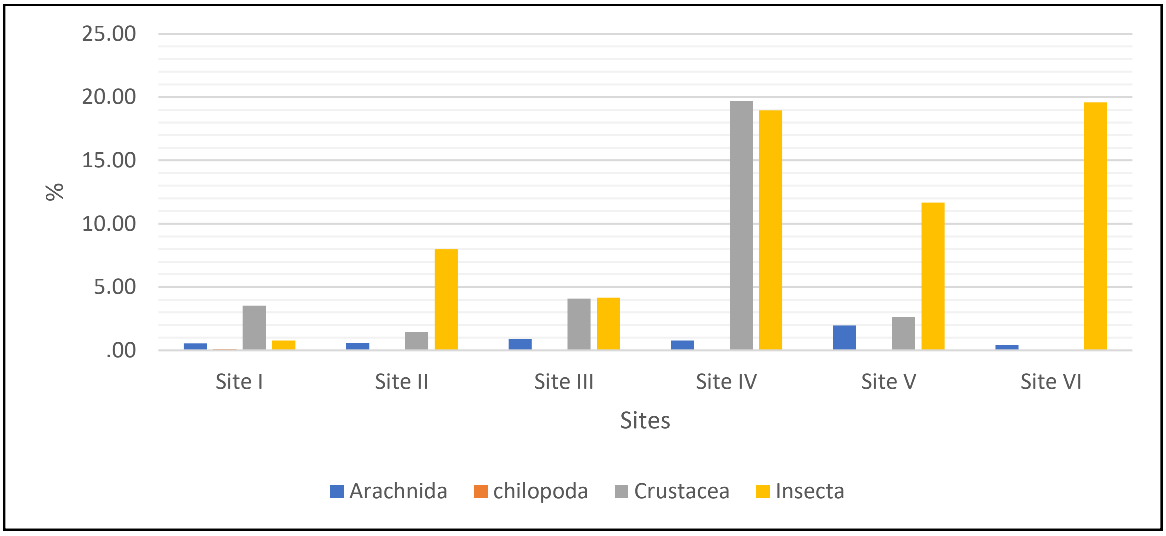

Fig. 2: The abundance of the collected soil macroarthropods (individuals) in the investigated sites.

Table 2: Total number and percentage of soil macroarthropods taxa collected from all sites during the period of investigation

Taxa	Sites							
	Site I	Site II	Site III	Site IV	Site V	Site VI	Total	%
Dysdre crocata	1	3	12	1	0	0	17	0.22
Brinda infumata	0	1	1	2	1	1	6	0.08
Berlandina venatrix	0	1	12	1	0	3	17	0.22
Mainarozelotes jaxartensis	1	2	5	3	1	0	12	0.15
Setaphis subtilis	0	0	3	0	0	0	3	0.04
Synaphosus sp.	0	1	7	1	0	0	9	0.11
Zelotes sp.	0	0	3	0	0	5	8	0.10
Mermessus denticulatus	0	7	1	3	1	1	13	0.16
Hogna ferox	29	20	13	19	70	4	155	1.97
Pardosa sp.	2	0	0	3	6	5	16	0.20
Arctosa sp.	7	0	1	0	9	0	17	0.22
Wadicosa fidelis	2	5	1	0	55	10	73	0.93
Thanatus albini	0	0	0	0	3	4	7	0.09
Pisauridae juvenile	0	0	1	2	0	0	3	0.04
Bianor albobimaculatus	0	0	1	1	2	0	4	0.05
Plexippus sp.	0	0	1	9	0	0	10	0.13
Scytodes thoracica	0	2	0	0	0	0	2	0.02
Steatoda erigoniformis	0	0	0	0	3	0	3	0.04
Order: Araneae	42	42	62	45	151	33	375	4.77
unidentified sp. of family: Atemnidae	1	2	6	11	3	0	23	0.29
Lamprochernes savignyi	0	0	1	2	0	0	3	0.04
unidentified sp. of family: Geogarypidae	0	0	3	0	0	0	3	0.04
Olpium sp.	0	1	0	4	0	0	5	0.06
Order: Pseudoscorpionida	1	3	10	17	3	0	34	0.43
Class: Arachnida	43	45	72	62	154	33	409	5.20
Lithobius sp.	9	2	0	1	2	0	14	0.18
Necrophloeophagus longicornis	1	2	2	0	1	0	6	0.08
Class: Chilopoda	10	4	2	1	3	0	20	0.26
Armadillidium vulgare	0	0	7	0	0	0	7	0.09
Leptotrichus naupliensis	4	5	2	35	55	0	101	1.29
Porcellio laevis	232	1	211	1425	3	0	1872	23.83
Porcellionides Pruinosus	39	101	66	87	146	0	439	5.59
Agabiformius lentus	2	7	36	0	3	0	48	0.61
Class: Crustacea, Order: Isopoda	277	114	322	1547	207	0	2467	31.41
Blatella germanica	8	10	136	6	7	0	167	2.12
Pycnoscelus surinamensis	10	11	22	44	14	0	101	1.29
Cryptotermes brevis	0	2	4	1	1	0	8	0.10
Order: Blatodea	18	23	162	51	22	0	276	3.51
Pterostichus barbarous	3	15	0	15	22	0	55	0.70
Hypera sp.	2	3	0	24	9	0	38	0.48
Sitona lividipes	1	0	1	38	4	0	44	0.56
Sphenophorus coesifrons	0	0	0	0	3	0	3	0.04
Drasterius figuratus	0	1	0	0	6	7	14	0.18
Carpophilus mutilates	1	0	0	2	0	0	3	0.04
Onthophagus sp.	0	2	1	2	10	4	19	0.24
Rhyssemus schatzmayri	0	2	2	3	9	2	18	0.23
Raphirus levicollis	2	9	4	3	7	0	25	0.32
Akis reflexa	0	0	0	3	0	0	3	0.04
Ocnera hispida	0	0	0	5	2	1	8	0.10
Gonocephalum rusticum	1	0	3	12	5	13	34	0.43
Adesmia cothurnata	0	0	0	0	0	29	29	0.37
Order: Coleoptera	10	32	11	107	77	56	293	3.73
Euborellia annulipes	25	18	44	33	10	0	130	1.66
Labidura riparia	2	14	0	35	14	80	145	1.85
Order: Dermaptera	27	32	44	68	24	80	275	3.51
Aethus pilosulus	0	1	3	2	3	0	9	0.12
Lethaeus fulvovarius	0	0	1	3	1	0	5	0.06
Oncocephalus notatus	0	0	6	7	0	1	14	0.18
Order: Hemiptera	0	1	10	12	4	1	28	0.36
Cataglyphis Sinaitica	0	0	3	0	0	617	620	7.90
Camponotus thoracicus	0	524	85	1232	766	69	2676	34.07
Monomorium niloticum	0	0	0	0	0	708	708	9.01
Order: Hymenoptera	0	524	88	1232	766	1394	4004	50.98
Order: Orthoptera, *Gryllus domesticus*	7	16	12	17	24	6	82	1.04
Class: Insecta	62	628	327	1487	917	1537	4958	63.13
Cube method	236	171	398	903	264	0	1972	25.11
Pitfall method	156	620	325	2194	1017	1570	5882	74.89
Total	392	791	723	3097	1281	1570	7854	100.00

Regarding monthly variations in the abundance of soil macroarthropods across all surveyed locations, the findings indicated that the greatest quantity was observed in June, with a collection of 1134 specimens accounting for 14.44% of the overall count. Conversely, the lowest quantity was recorded in January, with a collection of 257 specimens, constituting 3.27% of the total count. Site IV was found to be the most abundant site, as it yielded the maximum number of specimens (3097), representing 39.43% of the overall number. In contrast, site I recorded the lowest number, with 392 specimens, accounting for 4.99% of the total number. Table (3).

Table 3: Monthly total number of soil macroarthropods taxa collected from all sites during the period of investigation.

	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Total	%
site I	61	59	48	24	52	50	24	26	20	19	6	3	392	4.99
site II	137	60	109	30	62	157	29	36	72	31	24	44	791	10.07
site III	56	86	146	41	98	39	37	56	24	66	25	49	723	9.21
site IV	288	142	282	834	188	374	142	124	230	242	127	124	3097	39.43
site V	30	104	183	178	54	224	113	159	59	117	29	31	1281	16.31
site VI	313	507	34	27	3	95	112	8	89	279	46	57	1570	19.99
Total	885	958	802	1134	457	939	457	409	494	754	257	308	7854	100
%	11.27	12.20	10.21	14.44	5.82	11.95	5.82	5.21	6.29	9.60	3.27	3.92	100	

Regarding the seasonal variations observed throughout the six locations, it was found that the highest number of samples was collected during spring, accounting for 33.68% of the total number (2645 individuals.). Conversely, the lowest number of samples was collected during winter, accounting for 16.79% of the total number (1319 individuals.) (Fig. 3).

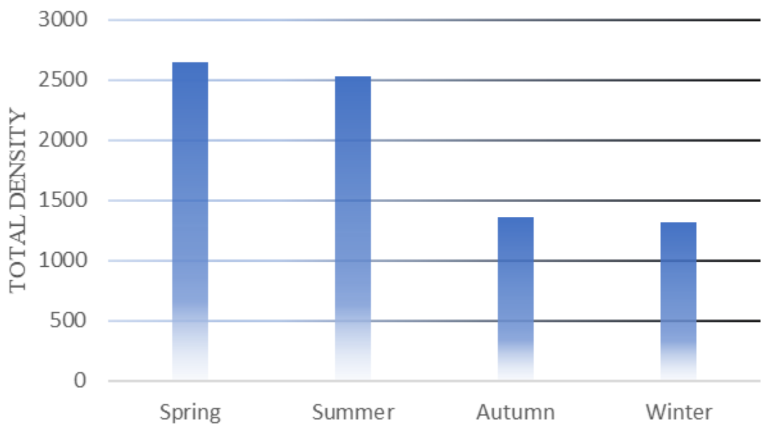

Fig. 3: Seasonal abundance of the total density of soil macroarthropods during the period of study.

The analysis of monthly fluctuations revealed that there were nine eudominant species of the collected species. The most eudominant species was *Porcellionides pruinosus* (73.15%) while *Blatella germanica* (44.44 %) was the least eudominant species. The other dominance structures are illustrated in Table (4).

Table 4: frequency, percentage (F. %) and dominancy of the soil macroarthropods taxa during the period of investigation.

Taxa	Site I		Site II		Site III		Site IV		Site V		Site VI		Total		
	F.	%	F.	%	F.	%	F.	%	F.	%	F.	%	Total	%	Dominancy
Dysdre crocata	1	8.3	3	22.2	8	66.7	1	8.3	0	0.0	0	0.0	13	17.59	Dominant
Brinda infumata	0	0.0	1	8.3	1	8.3	1	8.3	1	8.3	1	8.3	5	6.94	Subdominant
Berlandina venatrix	0	0.0	1	8.3	5	41.7	1	8.3	0	0.0	2	16.7	9	12.50	Dominant
Mainarozelotes jaxartensis	1	8.3	2	16.7	5	41.7	2	16.7	1	8.3	0	0.0	11	15.28	Dominant
Setaphis subtilis	0	0.0	0	0.0	3	27.8	0	0.0	0	0.0	0	0.0	3	4.63	Subdominant
Synaphosus sp.	0	0.0	1	8.3	6	47.2	1	8.3	0	0.0	0	0.0	8	10.65	Subdominant
Zelotes sp.	0	0.0	0	0.0	1	8.3	0	0.0	0	0.0	1	8.3	2	2.78	Recedent
Mermessus denticulatus	0	0.0	5	44.4	1	8.3	1	8.3	1	8.3	1	8.3	9	12.96	Dominant
Hogna ferox	12	100.0	9	75.0	6	47.2	8	66.7	11	94.4	2	16.7	48	66.67	Eudominant
Pardosa sp.	1	8.3	0	0.0	0	0.0	1	8.3	2	16.7	3	25.0	7	9.72	Subdominant
Arctosa sp.	4	33.3	0	0.0	1	5.6	0	0.0	1	8.3	0	0.0	6	7.87	Subdominant
Wadicosa fidelis	0	0.0	3	25.0	1	8.3	0	0.0	7	58.3	3	25.0	14	19.44	Dominant
Thanatus albini	0	0.0	0	0.0	0	0.0	1	8.3	3	25.0	1	8.3	5	6.94	Subdominant
Pisauridae juvenile	2	16.7	0	0.0	1	8.3	0	0.0	0	0.0	0	0.0	3	4.17	Subdominant
Bianor albobimaculatus	0	0.0	0	0.0	1	8.3	1	8.3	2	13.9	0	0.0	4	5.09	Subdominant
Plexippus sp.	0	0.0	0	0.0	1	8.3	3	25.0	0	0.0	0	0.0	4	5.56	Subdominant
Scytodes thoracica	0	0.0	2	13.9	0	0.0	0	0.0	0	0.0	0	0.0	2	2.78	Recedent
Steatoda erigoniformis	0	0.0	0	0.0	0	0.0	0	0.0	3	22.2	0	0.0	3	3.70	Recedent
unidentified sp. of family: Atemnidae	1	8.3	2	16.7	5	41.7	7	58.3	3	25.0	0	0.0	18	25.00	Dominant
Lamprochernes savignyi	0	0.0	0	0.0	1	8.3	2	16.7	0	0.0	0	0.0	3	4.17	Subdominant
Unidentified sp. of family: Geogarypidae	0	0.0	0	0.0	3	25.0	0	0.0	0	0.0	0	0.0	3	4.17	Subdominant
Olpium sp.	0	0.0	1	8.3	0	0.0	2	16.7	0	0.0	0	0.0	3	4.17	Subdominant
Lithobius sp.	7	58.3	2	16.7	0	0.0	1	5.6	2	16.7	0	0.0	12	16.20	Dominant
Necrophloeophagus longicornis	1	8.3	2	16.7	2	16.7	0	0.0	1	8.3	0	0.0	6	8.33	Subdominant
Armadillidium vulgare	0	0.0	0	0.0	7	58.3	0	0.0	0	0.0	0	0.0	7	9.72	Subdominant
Leptotrichus naupliensis	4	33.3	5	41.7	2	16.7	9	75.0	12	102.8	0	0.0	32	44.91	Eudominant
Porcellio laevis	12	100.0	1	8.3	11	91.7	12	100.0	3	27.8	0	0.0	39	54.63	Eudominant
Porcellionides Pruinosus	12	100.0	12	97.2	6	50.0	11	91.7	12	100.0	0	0.0	53	73.15	Eudominant
Agabiformius lentus	2	16.7	4	30.6	10	83.3	0	0.0	2	16.7	0	0.0	18	24.54	Dominant
Blatella germanica	6	50.0	5	41.7	12	100.0	4	33.3	5	41.7	0	0.0	32	44.44	Eudominant
Pycnoscelus surinamensis	6	50.0	6	50.0	11	91.7	11	88.9	7	58.3	0	0.0	41	56.48	Eudominant
Cryptotermes brevis	0	0.0	2	13.9	4	33.3	1	8.3	1	8.3	0	0.0	8	10.65	Subdominant
Pterostichus barbarous	2	16.7	7	58.3	0	0.0	6	50.0	7	58.3	0	0.0	22	30.56	Dominant
Hypera sp.	2	16.7	2	16.7	0	0.0	5	41.7	4	33.3	0	0.0	13	18.06	Dominant
Sitona lividipes	1	8.3	0	0.0	1	8.3	4	36.1	3	25.0	0	0.0	9	12.96	Dominant
Sphenophorus coesifrons	0	0.0	0	0.0	0	0.0	0	0.0	3	25.0	0	0.0	3	4.17	Subdominant
Drasterius figuratus	0	0.0	1	8.3	0	0.0	0	0.0	4	33.3	4	33.3	9	12.50	Dominant
Carpophilus mutilates	0	0.0	0	0.0	0	0.0	2	19.4	0	0.0	0	0.0	2	2.78	Recedent
Onthophagus sp.	1	8.3	2	16.7	1	8.3	2	16.7	2	16.7	1	8.3	9	12.50	Dominant
Rhyssemus schatzmayri	0	0.0	1	8.3	1	8.3	2	16.7	4	33.3	2	16.7	10	13.89	Dominant
Raphirus levicollis	2	16.7	5	41.7	3	25.0	2	16.7	4	33.3	0	0.0	16	22.22	Dominant
Akis reflexa	0	0.0	0	0.0	0	0.0	3	25.0	0	0.0	0	0.0	3	4.17	Subdominant
Ocnera hispida	0	0.0	0	0.0	0	0.0	4	33.3	2	16.7	1	8.3	7	9.72	Subdominant
Gonocephalum rusticum	0	0.0	0	0.0	3	22.2	3	25.0	3	25.0	5	41.7	14	18.98	Dominant
Adesmia cothurnata	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	33.3	4	5.56	Subdominant
Euborellia annulipes	9	75.0	11	91.7	11	91.7	12	100.0	8	69.4	0	0.0	51	71.30	Eudominant
Labidura riparia	1	8.3	3	25.0	0	0.0	7	58.3	5	41.7	9	75.0	25	34.72	Dominant
Aethus pilosulus	0	0.0	1	5.6	2	16.7	2	16.7	3	22.2	0	0.0	8	11.11	Subdominant
Lethaeus fulvovarius	0	0.0	0	0.0	1	8.3	2	16.7	1	8.3	0	0.0	4	5.56	Subdominant
Oncocephalus notatus	0	0.0	0	0.0	5	41.7	4	33.3	0	0.0	1	8.3	10	13.89	Dominant
Cataglyphis Sinaitica	0	0.0	0	0.0	3	25.0	0	0.0	0	0.0	6	50.0	9	12.50	Dominant
Camponotus thoracicus	0	0.0	11	91.7	10	83.3	12	100.0	12	100.0	5	41.7	50	69.44	Eudominant
Monomorium niloticum	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	9	75.0	9	12.50	Dominant
Gryllus domesticus	5	41.7	6	50.0	6	50.0	8	66.7	7	58.3	2	16.7	34	47.22	Eudominant

By applying MANOVA test using sites as independent factor and abundance of soil macroarthropods taxa as dependent factors, it was indicated that no significant differences in the taxa between sites except for *Dysdre crocata*, *Setaphis subtilis*, *Synaphosus* sp., *Hogna ferox*, *Wadicosa fidelis*, unidentified taxa of family: Atemnidae and family: Geogarypidae, *Lithobius* sp., *Armadillidium vulgare*, *Leptotrichus naupliensis*, *Porcellio laevis*, *Agabiformius lentus*, *Blatella germanica*, *Sitona lividipes*, *Sphenophorus coesifrons*, *Akis reflexa*, *Ocnera hispida*, *Adesmia cothurnata*, *Euborellia annulipes*, *Labidura riparia*, *Cataglyphis sinaitica* and *Monomorium niloticum* which they were highly significant ($p<0.01$). While, *Berlandina venatrix*, *Plexippus* sp., *Steatoda erigoniformis*, *Porcellionides pruinosus*, *Pterostichus barbarous*, *Drasterius figuratus*, and *Gonocephalum rusticum* showed significant difference ($p<0.05$).

Taxa richness and Shannon-Wiener diversity index:

The locations under investigation exhibited varying levels of diversity as measured by the Shannon-Wiener diversity index. Site III displayed the highest diversity value (2.393), whereas site VI exhibited the lowest diversity value (1.328). The highest richness value was recorded at sites III and IV (38), while the lowest value was recorded at site VI (20). (Fig.4).

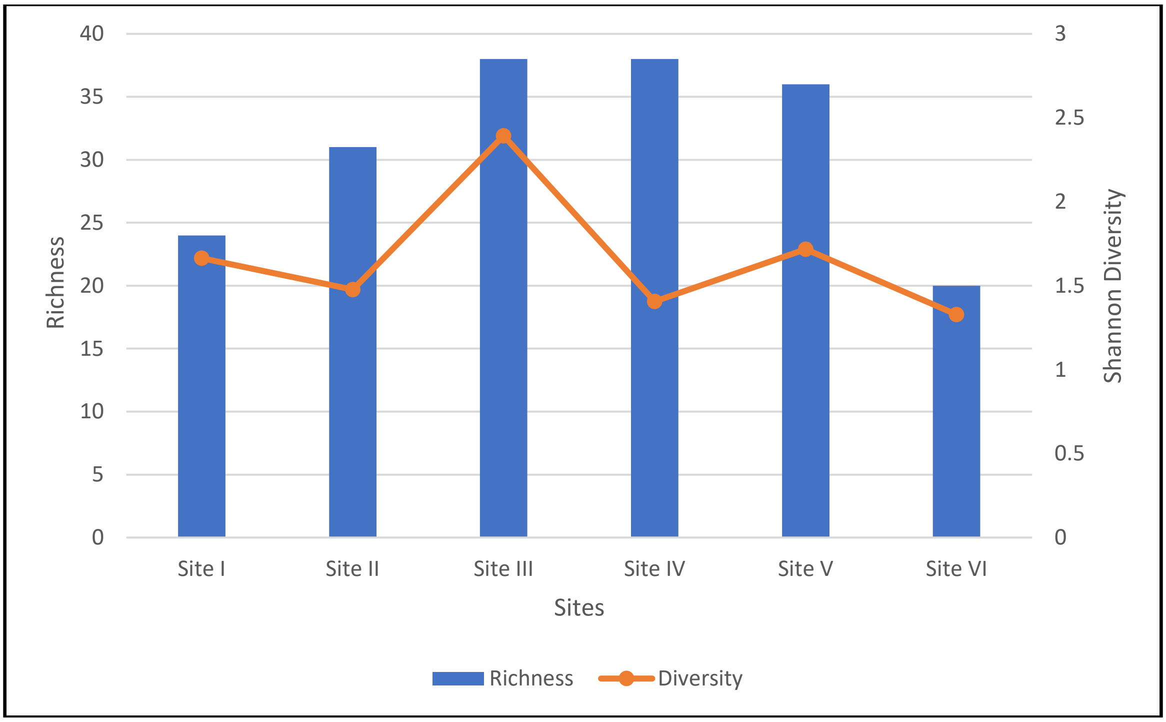

Fig. 4: Taxa richness and Shannon-wiener diversity index of the total soil macroarthropods at all sites during the period of investigation.

Table 5: MANOVA for the abundance of soil macroarthropods collected from six sites during the period of investigation

Source	Dependent variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
site	*Dysdre crocata*	8.916	5	1.783	5.35	0.001
	Brinda infumata	0.157	5	0.031	0.283	0.92
	Berlandina venatrix	8.916	5	1.783	2.675	0.033
	Mainarozelotes jaxartensis	1.472	5	0.294	1.949	0.103
	Setaphis subtilis	0.624	5	0.125	4.493	0.002
	Synaphosus sp.	3.133	5	0.627	8.803	0
	Zelotes sp.	1.938	5	0.388	0.821	0.541
	Mermessus denticulatus	2.737	5	0.547	2.318	0.058
	Hogna ferox	224.716	5	44.943	3.944	0.004
	Pardosa sp.	2.157	5	0.431	0.706	0.622
	Arctosa sp.	7.032	5	1.406	1.113	0.366
	Wadicosa fidelis	145.658	5	29.132	4.162	0.003
	Thanatus albini	1.383	5	0.277	0.943	0.462
	Pisauridae juvenile	0.291	5	0.058	1.396	0.243
	Bianor albobimaculatus	0.232	5	0.046	0.811	0.548
	Plexippus sp.	6.756	5	1.351	2.883	0.024
	Scytodes thoracica	0.277	5	0.055	1.997	0.096
	Steatoda erigoniformis	0.456	5	0.091	2.627	0.035
	unidentified sp. of family: Atemnidae	5.895	5	1.179	3.651	0.007
	Lamprochernes savignyi	0.401	5	0.08	2.1	0.082
	unidentified sp. of family: Geogarypidae	0.624	5	0.125	4.493	0.002
	Olpium sp.	0.978	5	0.196	1.761	0.139
	Lithobius sp.	4.762	5	0.952	4.898	0.001
	Necrophloeophagus longicornis	0.329	5	0.066	0.774	0.573
	Armadillidium vulgare	3.398	5	0.68	24.463	0
	Leptotrichus naupliensis	213.598	5	42.72	4.509	0.002
	Porcellio laevis	123949.66	5	24789.932	18.013	0
	Porcellionides Pruinosus	1068.242	5	213.648	3.075	0.017
	Agabiformius lentus	81.429	5	16.286	9.297	0
	Blatella germanica	1171.521	5	234.304	41.641	0
	Pycnoscelus surinamensis	79.449	5	15.89	2.072	0.085
	Cryptotermes brevis	0.935	5	0.187	1.994	0.096
	Pterostichus barbarous	34.966	5	6.993	2.664	0.033
	Hypera sp.	30.579	5	6.116	1.293	0.283
	Sitona lividipes	180.456	5	36.091	5.315	0.001
	Sphenophorus coesifrons	0.552	5	0.11	3.739	0.006
	Drasterius figuratus	4.165	5	0.833	2.552	0.04
	Carpophilus mutilates	0.252	5	0.05	1.815	0.128
	Onthophagus sp.	3.449	5	0.69	0.63	0.678
	Rhyssemus schatzmayri	3.501	5	0.7	1.569	0.187
	Raphirus levicollis	4.179	5	0.836	1.823	0.126
	Akis reflexa	0.772	5	0.154	4.042	0.004
	Ocnera hispida	2.457	5	0.491	7.45	0
	Gonocephalum rusticum	16.242	5	3.248	2.933	0.022
	Adesmia cothurnata	58.316	5	11.663	4.157	0.003
	Euborellia annulipes	111.172	5	22.234	8.538	0
	Labidura riparia	359.25	5	71.85	3.81	0.005
	Aethus pilosulus	0.74	5	0.148	1.053	0.398
	Lethaeus fulvovarius	0.704	5	0.141	1.503	0.207
	Oncocephalus notatus	3.683	5	0.737	2.132	0.078
	Cataglyphis Sinaitica	106598.67	5	21319.734	8.704	0
	Camponotus thoracicus	26346.102	5	5269.22	1.636	0.169
	Monomorium niloticum	34758.045	5	6951.609	3.863	0.005
	Gryllus domesticus	28.774	5	5.755	1.78	0.135

DISCUSSION

In the present investigation, two methods were used for collecting soil macroarthropod samples; the pitfall traps method which represented the highest percentage (74.89%) of the total density, while the metal cube method represented the lowest (25.11%).

Ombugadu *et al.*, (2017) demonstrated that catches by pitfall traps may be influenced by timing and placement of the traps. Ishaya *et al.*, (2018) stated that the high variation between a pitfall and hand-picking techniques in favour of pitfall may probably be connected with the time the traps were left to stand. It may also be due to that the trap works throughout the time it stands, the number of catches may exceed that of the handpicking or it may possibly be that some of the soil macroarthropods are more active at night when it is difficult for them to detect the traps. On the contrary, the study of Mwansat *et al.,* (2012) recorded no variation between macroarthropods collected by pitfall trap and hand capture techniques.

Based on the present research findings, the overall densities of soil macroarthropods peaked in spring and declined in winter. This finding is consistent with the research conducted by Liu *et al.,* (2013), which studied the seasonal distribution and diversity of ground arthropods in microhabitats in China. Liu's study showed that the community indices of ground arthropods exhibited a decreasing trend from spring through summer and eventually to autumn. Ghiglieno (2020) conducted a study on the arthropod community's response to soil characteristics and management in Italy. The findings of the study revealed that the majority of the samples, specifically 85%, were gathered during spring.

In relation to taxonomic groups, the group Insecta had the highest level of dominance, accounting for a total density of 63.13%. This finding aligns with the research conducted by Moco *et al.,* (2009) and Araujo *et al.,* (2010) in Brazil. Also, several studies have been conducted in different regions throughout the world. Liu (2013) conducted research in China, Ramzy (2015) focused on Assiut Governorate in Egypt, Hamdy, *et al.,* (2017) investigated the Suez Canal region in Egypt, Zodinpuii *et al.,* (2019) conducted their study in India, López *et al.,* (2019) focused on Mexico, Ishaya *et al.,* (2019) conducted research in Nigeria, and Ghiglieno (2020) conducted a study in Italy. The analysis revealed a notable rise in insect density, making class Insecta the most diverse among all animal groups (Ishaya, 2019). Blower & Wallwork (1971) indicated that Arthropoda was a group of soil animals, which generally showed the highest dominance among the organisms making up the community.

The findings of the present investigation indicated that Hymenoptera, namely the family Formicidae, had the highest prevalence, comprising 50.98% of the total catch. This finding is consistent with the research conducted by Hamdy *et al.,* (2017) in the Suez Canal region of Egypt, and López *et al.,* (2019). In a similar vein, the prevalence of Hymenoptera, specifically Formicidae, aligns with the observations made by Frouz and Ali (2004), who identified Formicidae as the primary category of soil-dwelling macroarthropods in highland ecosystems in Florida. The observed behaviour is likely attributed to the species' burrowing behaviour, which serves as means of evading natural predators and mitigating the impact of pesticides. The aforementioned observation aligns with the research conducted by Hickman *et al.,* (2001), where a significant population of Formicidae ants was identified in an Aldabra rainforest in India. The researchers established a correlation between the ants' dominance and their foraging and feeding behaviours. However, the findings presented here contradict the findings of Araujo *et al.,* (2010) in Brazil, who reported that Isoptera is the prevailing order, as well as the research undertaken by Liu (2013) in China, which identified Coleoptera as the dominant order.

Class Crustacea (Isopods) exhibited the highest numerical value during summer, as observed in the present investigation. This finding is in accordance with that of Abdulgabar (2019) in Assiut Governorate. Brigića *et al.,* (2019) showed that the isopod *Ligidium germanicum* exhibited its highest densities of seasonal activity during spring and early summer. However, it contradicts the observations made by Bedair (1991), Kayed *et al.,* (1991) in Ismalia region, Egypt and Abd El-Wakeil (2005) in Assiut Governorate, Egypt who reported the highest abundance of *Porcellio laevis* during the spring season. During the present investigation, *Porcellionides pruinosus* emerged as the most eudominant species (accounting for 73.15%) of the observed populations, while *Porcellio laevis* exhibited the highest population density (23.84 %). These findings align with the studies conducted by Abd El-Wakeil (2005) and Abdulgabar (2019) in Assiut Governorate. They indicated that *Porcellionides pruinosus* was commonly observed as the most frequent isopod species, while *Porcellio laevis* was recognized as the most abundant species, and this may be attributed to the organisms' capacity to thrive and adapt in many environmental circumstances and habitats.

The taxonomic group Arachnida exhibited the highest numerical value during summer throughout the designated time of study. This finding aligns with the research conducted by Khan and Zaman (2015) on the spider fauna in pir Baba, Pakistan. They observed a decrease in spider population from summer to winter, with a notable decline in December. However, it contradicts the findings of Obuid-Allah *et al.,* (2015), who concluded that the highest number of spiders was actually collected during autumn. On the other hand, the populations of spiders observed in the current study exhibited their lowest levels during winter. This finding aligns with the outcomes reported by Obuid-Allah *et al.,* (2015). During hibernation, activity is typically minimized, with the exception of warm days when certain species may exhibit movement on dead leaves and herbs. However, even during these periods, there is a paucity of evidence indicating predatory behaviour. In addition, hibernation can be described as a collective phenomenon when spiders undergo a migratory process towards lower regions (Weese, 1924). Mukherjee *et al.,* (2010), indicated that the abundance of spiders throughout winter and early spring is comparatively lower than that observed during late spring, summer, and autumn.

Hogna ferox, a member of the Lycosidae family, emerged as the dominating species within the arachnida group during the investigated time. This finding aligns with previous studies conducted by Zaher (2016), Hassan (2017), Aboulnasr (2018), and Zaki (2019), which similarly identified Lycosidae as the most prevalent family. According to Jogar *et al.,* (2004), it was shown that wolf spiders exhibit active wandering behaviour at ground level, resulting in a significant capture of spiders through the use of pitfall traps.

Chilopoda had the lowest level of dominance, as indicated by its total density accounting for only 0.26%. This finding aligns with the observations made by Ramzy (2015) in Assiut Governorate and Ishaya *et al.,* (2019) in Nigeria. In the realm of Chilopoda, the species *Lithobius* sp. exhibited dominance, whereas *Necrophloeophagus longicornis* assumed a subdominant role. This finding contradicts the assertions made by Ramzi (2015). The current study showed that the soil macroarthropod populations at the study sites clearly differ in terms of abundance. According to Hughes *et al.,* (2000), different ecosystems have a different effect on species abundance. According to research by Njila *et al.,* (2013), an ecosystem's biodiversity-that is, the variety and number of its species—is a key indicator of how healthy it is. According to the available data, site IV (the agricultural area in El Taramsa) had the maximum richness and abundance of soil macroarthropods. This might be because the land was an alluvial soil from the Nile Valley, which had abundant food resources. According to Seastedt & Crossley (2004), arthropod populations can increase geometrically or exponentially in the presence of plentiful supplies. According to the chemical characteristics of the soil and the conversion of natural habitat to agricultural land, agricultural operations have either beneficial or negative effects on the diversity, abundance, and activity of soil fauna.

Indicators of Shannon-Wiener diversity (H') varied between 2.393 and 1.328 at the several sites analyzed during the period of the study. According to McDonald (2003) and Ishaya *et al.,* (2019), the value of (H') has been observed to vary between (1.5) and (3.5) in natural systems. Also, the present finding matches with the values of Fauzi *et al.,* (2023), whereas below 1 was low diversity, between 1-3 the diversity was moderate and above 3 was high diversity. Site III (the farm at SVU), where there was a lot of litter and many plant species were seen, had the highest value (2.393) between sites, thus classified as a moderate diversity site. While there was no litter or variety of plants at site VI (a restored desert area), the diversity value was the lowest (1.328). Soil arthropod's diversity is very much determined by the vegetation above it. Previous research has demonstrated that abundant species and high-quality litter can give soil macroarthropods a plentiful food supply and comfortable living conditions for soil macroarthropods (García-Palacios, 2013). Land use can have a significant impact on the total abundance, diversity and community makeup of soil organisms, as demonstrated by research by Barrios *et al.,* (2005). In contrast to agricultural or reclaimed desert areas, Hanna *et al.,* (2012) found that the sites with the highest values of soil fauna diversity are those that are dominated by natural vegetation. According to Triyogo *et al.,* (2017), diversified flora can broaden the variety of soil organisms.

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ARABIC SUMMARY

وفرة و تنوع مفصليات التربة كبيرة الحجم في محافظة قنا ، صعيد مصر

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تقوم مفصليات التربة بمجموعة كبيرة من الوظائف البيئية، والتي يمكن استخدام وفرتها وتنوعها كمؤشر على صحة التربة. ولهذا تهدف الدراسة لمعرفة الأنواع المختلفة من مفصليات التربة الكبيرة في ستة مواقع مختلفة فى محافظة قنا خلال عام واحد يمتد من مارس 2021 ، وحتى فبراير 2022. وتختلف مواقع التجميع في تركيب التربة والعوامل البيئية والغطاء النباتي . وأظهرت الدراسة أن إجمالي عدد مفصليات التربة الكبيرة التي تم تجميعها يكون (7854 فرداً) ويمكن تقسيمها إلى أربع طوائف مختلفة (الحشرات و القشريات و العنكبيات و مئوية الارجل) ، متضمنين 13 رتبة، و36 فصيلة، و54 جنساً، و 45 نوع و 3 أنواع غير محددة. تم تسجيل أعلى قيمة للوفرة الكلية لمفصليات التربة الكبيرة خلال فصل الربيع ، والاقل كانت فى فصل الشتاء، وقد سجل الموقع الرابع (الترامسة) أعلى كثافة للعينات المجمعة (3097 فردا)، بينما سجلت أقل قيمة (392 فردا) في الموقع الأول (نجع حمادي). طائفة الحشرات هي المجموعة المهيمنة ، والتي تمثل حوالي 63.13% من الكثافة الكلية تليها القشريات (31.41%) ثم العنكبيات (5.20%) وأخيرا مئوية الارجل (0.26%). وقد بلغت أعلي قيمة لعدد الأنواع (38 صنف) في الموقعين الثالث (مزرعة الجامعة) ، والرابع (الترامسة)، بينما أقل قيمة (20 صنف) في الموقع السادس (اللقيطة). وقد اتضح من الدراسة والتحليلات الاحصائية أن مؤشر شانون وينر للتنوع تراوح بين (1.328) في الموقع السادس و(2.393) في الموقع الثالث.