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Relationship between soil diversity and inhabitant mites (Acari)

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ABSTRACT

Mites are important regulators of soil food webs in the ecosystem. Soil diversity, pH, electrical conductivity and organic matters are dominant disturbance factors on community composition of soil mites. Impacts of these factors were assessed on the species composition of soil mites at Dakahleia and Kafrelshikh governorates in six different sites. In total, 14 families, 30 genera, and 37 mite species belonging to the four sub-orders Gamasida, Actinedida, Oribatida and Acaridida were recorded. Mite abundance and diversity in the soil in Kafrelshikh was poor compared with Dakahleia sites. The effect of soil type on mite community composition was significant. PH and organic matters have been established as good indicators for soil fertility. Soil mites were affected by soil fertility as it was observed that soil mites population increased with increasing nutrients. This study provided important information on soil mite populations in cultivated soils and could provide baseline data for studies of bioindicators of soil quality. In conclusion soil mites responded to land type, pH, EC (ds/m) and organic matter level.

Key Words: Soil mites, Gamasida, Actinedida, Oribatida, Acaridida, Soil diversity, Organic matters, Soil fertility.

INTRODUCTION

The environment of soil organisms in managed ecosystems can be influenced by land use factors, such as tillage, pesticides and fertilizers application, soil compaction during harvest, and removal of plant biomass. The responses of soil communities to land management, quantified as changes in abundance, species richness and diversity indices, have generally been examined at habitat-wide scales (Vreeken-Buijs *et al.,* 1998). Soil tillage, application of biocides, reduction of vegetation cover and the consequent changes in microclimate have been reported to have negative effects on survival and reproduction of soil microarthropods in arable fields (Badejo and Straalen, 1993). Agricultural practices alter not only the abundance and dynamics of different organisms and nutrients in the soil, but also affect the structure and dynamics of the food webs (Moore, 1994). The soil microflora and fauna complement each other in commutation of litter, mineralization of essential plant nutrients and conservation of these nutrients within the soil system (Marshall, 2000). Soil mites are abundant soil organisms that are sensitive to soil perturbations in agricultural practices and their number and diversity often get reduced affecting their ecosystem services (Minor and Cianciolo, 2007). Several genera of soil mites are considered good bio-indicators of habitat and soil conditions (Behan-Pelletier, 1999). Several studies have been conducted to study the distribution and abundance of soil mites at different locations in Egypt (Kandeel, 1993; El-Moghazy, 2006 and El-Sharabasy, 2010).

The objective of this study was to determine the effect of soil diversity, soil water-table depth and fertilization in different sites in Dakahleia and Kafrelshikh governorates north of Nile Delta, on abundance and diversity of soil mites.

MATERIALS AND METHODS

Extraction and preparation of mite specimens:

The samples were taken from soil at six locations, three from Talkha district in Dakahleia and three from Motoubas district in Kafrelshikh governorates, Egypt, monthly during winter and spring seasons (December 2010 to May 2011). The samples in Dakahleia were taken from soil under potatoes, wheat and clover cultivars, while those in Kafrelshikh were taken from soil under guava trees orchard. Three soil samples were taken from (0-20 cm depth) by iron rectangle (6x6x8 inch), one Kg /sample, at each location then were put singly in tightly closed polyethylene bags. In the laboratory, mites were extracted from soil samples using Berlese-Tullgren funnel (Lasebikan, 1974). Receiving the extraction (mites and other arthropods) in aquatic medium that helped in purification and prohibit escaping mites. Extracted mites were then transferred to solution containing ethanol and acetic acid at 9: 1 ratio, sudden death solution, which quickly killed mites and stretched their bodies. After that, mites were transferred to clearing solution such as Nesbitt's solution or lactic acid for a period depending on mite species and its inflexible degree. Mite individuals were picked from clearing solution and singly mounted in Hoyer’s medium on glass slides and sample data were recorded on each side.

Mite identification:

Mites classification was defined according to Bregetova (1977), Krantz (1978) and Zaher (1986) as well as comparing them with those already identified in the Laboratory.

Soil analysis:

The soil sample (0-20 cm depth) was routinely analyzed according to Klute (1986) for physical properties; and according to Page *et al*., (1982) for chemical properties (EC, pH and soluble ions).

Available P, Fe, Mn, Zn and Cu were extracted according to the methods of Soltanpour (1991) by mixture solution of Diethylene Triamine pent acidic acid 97 % (DTPA) and ammonium bicarbonate with adjusting at pH 7.6, soil sample (20 gm) were shaken with 40 ml from the mixture solution to about 15 minutes then filtered. Determine of P, Fe, Mn, Zn and Cu was carried out in this extract using Inductively Coupled Plasma (ICP) spectrometry, (Ultima 2 JY plasma), potassium was determined by flame photometer and available nitrogen was determined by using Kjeldahl method according to Jackson (1973).

RESULTS AND DISCUSSION

Abundance and Diversity of the soil mites:

In total, 14 families of 30 genera, and 37 mite species were collected. The Gamasida (seven families) and Actinedida (five families) were the most-abundant taxa, followed by the Acaridida and Oribatida as one family for each were recorded.

Cheyletidae and Acaridae were the most diverse families, with five species for each, followed by Ascidae and Oppiidae with four species and Uropodidae & Cunaxidae with three species for each. Then other families followed with two or one species each (Tables 1 and 2).

Out of 37 species, six species were found in four sites. These were *Protogamasellus denticus* Nasr, *Hypoaspis bregetova* Shereef and Afifi, *Parasitus consanguineus* Oudemans and Voigts, *Uroobovella varians* Hirschmann, *Cheletomorpha lepidopterorum* (Shaw) and *Cunaxa setirostri* (Hermann). Site factors had remarkable effect on the diversity of soil mites. The overall structure of mite assemblages was significantly related to soil type.

These results were in agreement with that of Maraun and Scheu (2000) who observed that effect of soil type on community composition of both Oribatida and Mesostigmata was significant, confirming that species with different life history tactics were differently filtered from soil communities by land management practices

The relationship between PH, EC (ds/m) and organic matter in soils on community composition of soil mites:

Data on soil PH, EC (ds/m), organic matter content and statistics poll for each species/genus/family of soil mites extracted from the studied plots is presented in table (3). The abiotic conditions observed in soil at different sites in Dakahleia were suitable for the development of a high-diversity soil mite community as organic matters therein were relatively higher compared with those in Kafrelshikh, where soil organic matter contents as low as 0.5 % was recorded.

The highest community composition in soil was recorded in different sites in Dakahleia (Tables 1 and 2). From the obtained results, pH and organic matters have been established as good indicators for soil fertility and thereafter enhanced favorable conditions for soil mites flourish (Table 3).

These results are in agreement with Badejo and Ola-Adams (2000) who observed if data on PH and organic matter which have been established as good indicators of soil fertility show a trend of fertility decline in the plantations, it follows therefore that low cryptostigmatid mite density indicates low fertility. Organic matter is a source and a sink for nutrient elements in the soil. It has appreciable influence on many soil properties, hence its significance in maintenance of soil fertility (Swift & Woomer, 1993). The findings of Tian et *al.,* (1998) showed that microarthropods have a buffering effect in regulating leaf decomposition and nutrient release. Environmental factors such as high soil organic matter content and nearly neutral PH levels are favorable conditions for soil mite development. It is well known that high soil organic matter content is usually beneficial for most soil animal groups (Bandyopadhyaya *et al.,* 2002). Free-living soil gamasid mites are important regulators of decomposition processes in forest soil ecosystems and occupy a high trophic level in the soil decomposition food web (Schneider and Maraun, 2009). Consequently, the presence of gamasid mites may reflect overall physicochemical conditions of soil, including organic matter, microflora (fungi and bacteria), microfauna (nematodes), and mesofauna (collembolans, oribatids and other mites) (Walter *et al.,* 1988).

Table (1):- List of predaceous mites diversity at different sites

Mites	Dakahleia			Kafrelshikh		
	1	2	3	1	2	3
Gamasida						
Ascidae Voigts and Oudmans						
Protogamasellus denticus Nasr	+		+		+	+
Proctolaelaps pygmaeus (Műller)	++	+				
Lasioseius africanus Nasr	+		+			
L. aegypticus Afifi	+	+				
Laelapidae Berlese						
Laelaspis astronomicus (Koch)	+	++				
Hypoaspis bregetova Shereef and Afifi	+		+		+	+
Macrochelidae Vitzthum						
Macrocheles merdarius (Berlese)		+	+			+
Ologamasidae Ryke						
Gamasiphis parpulchellus Nasr and Mersal	+		+			
Parasitidae Oudemans						
Parasitus consanguineus Oudemans and Voigts	+				+	+
Uropodidae Berlese						
Urobovella varians Hirschmann	+	+	+			+
U. ovalis Hirschmann	+					
Uropoda sp.	+		++			
Actinedida						
Cheyletidae Leach						
Cheyletus trouessarti Oudemans	+++					+
C. aversor Rohdendorf		+	+			+
Acaropsellina sollers Rohdendorf	+		+			
Cheletomorpha lepidopterorum (Shaw)	+	++		+	+	
Cheletogenes ornatus (Can. and Fanz.)	+	+				
Cunaxidae Thor						
Cunaxa setirostris (Hermann)	++	+			+	+
Pulaeus glebulentus Den Heyer		+	+			
Pseudocunaxa sp.	+		+			
Raphignathidae Kramer						
Raphignathus gracilis (Rack)	++	+	+			
Raphignathus sp.		+				
Stigmaeidae Oudemans						
Apostigmaeus navicella Grandjean	+		++			
Stigmaeus sp.	+					

Table (2):- List of miscellaneous feeding mites diversity at different sites

Mites	Dakahleia			Kafrelshikh		
	1	2	3	1	2	3
Gamasida						
Ameroseiidae Evans						
Ameroseius ulmi (Berhard)		+			+	
Kleemannia plumosus (Oudemans)	+		+			
Actinedida						
Tarsonemidae Kramer						
Iponemus sp.	++					
Tarsonemus sp.	+	++				
Oribatida						
Oppiidae Grandjean						
Oppia concolor Koch	++	+				
O. sticta Popp	++		+	+		
Oppia sp.	+++					
Oppiella sp.						+
Acaridida						
Acaridae Leach						
Acarus siro L.	++	++			+	
Tyrophagus palmarum Oudemans		+	++			
T. putrescentiae (Schrank)	+					
Tyrolichus casei Oudemans	+	++	+			
Caloglyphus berlesei (Michael)		+				

+ = (<6) + + = (6-12) + + + = (>12) mite/sample

Table (3): Soil PH, EC (ds/m), organic matter and composition of mites in soil at different sites

Parameters	Dakahleia			Kafrelshikh		
	1	2	3	1	2	3
PH (1:2.5)	7.40	7.47	7.71	8.15	7.83	7.60
EC(ds/m)	0.52	0.40	0.61	3.2	1.12	0.52
Organic mater %	1.85	1.67	1.34	0.08	0.09	0.16
Family	13	12	12	2	5	9
Genus	25	19	17	2	6	8
Species	29	20	17	2	6	9

Table (4):- Some physical and chemical properties of investigated soil

Location	No.	Particle size distribution			Texture	SP	Soluble ions (meq/l)							
		Sand	Silt	Clay			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^-	HCO_3^-	SO_4^-	Cl^-
Dakahleia	1	10.0	10.7	79.3	Clay	45.5	1.20	0.60	1.27	1.40	-	2.17	1.10	1.30
	2	11.1	12.4	76.5	Clay	45.4	1.02	0.50	1.09	1.19	-	1.80	0.80	1.20
	3	11.9	12.5	75.6	Clay	45.8	1.60	0.90	0.67	2.10	-	1.90	2.10	1.36
Kafrelshikh	1	75.3	13.0	11.7	Sandy loam	37.50	7.51	9.55	14.43	0.49	-	1.50	4.58	25.90
	2	82.0	9.4	8.6	Sandy loam	36.50	2.00	3.55	5.41	0.22	-	0.50	1.18	9.50
	3	72.6	15.3	12.1	Sandy loam	36.2	1.20	0.81	1.32	1.11	-	2.2	1.10	1.32

Table (5):- Some nutrients content in the investigated soil sample

Location	No.	Macro-nutrients, available (ppm)			Micro-nutrients, available (ppm)			
		N	P	K	Fe	Mn	Zn	Cu
Dakahleia	1	85.81	1.10	54.60	18.57	1.27	0.59	5.14
	2	73.50	2.22	46.41	10.20	1.62	0.72	5.16
	3	183.75	3.24	81.90	25.07	2.35	1.64	6.78
Kafrelshikh	1	4.81	0.50	6.60	3.88	2.3	1.80	1.10
	2	6.40	0.42	7.14	2.99	2.14	1.72	0.86
	3	5.82	0.43	8.15	3.4	2.4	1.50	0.95

General effects of soil PH and salinity on community composition of soil mites:

Slightly alkaline soil PH in range from 7.0 to 8.15 occurred in Kafrelshikh locations that contain large amounts of naturally-occurring water sea. This high water sea may lead to change in soil PH. Irrigation of low quality waters also may cause this high soil PH change.

Salinity affects plant growth through ionic and osmotic effects as well as community composition of soil mites. Sometimes these effects are distinct from each other; while sometimes these effects overlap.

Based on the total salt concentration in soils extract; it is usually measured by electrical conductivity, EC in units of dS/m, where the brackets refer to the concentration in soil solution or the saturated paste extract. In slightly salinity soils, soil colloids disperse, disrupting soil structure and water physical change in soil structure has severe consequences on community composition of soil mites in addition to the direct effects of the slightly increase saline solutions. Slightly increase salts soil range (EC 0.52 to 3.20 dS/m) in locations of Kafrelshikh as it contains large amounts of naturally-occurring water sea. This high water sea may be due to change in soil extract EC. Irrigation low quality waters may be due to change high soil extract EC and also high soil water table. In salt-stressed plants, slightly increase saline-sodic conditions. Also this may affect plant nutrition, growth, water and ion transport in plants in addition to mites abundance, population densities and diversity in the soil. A major problem in slightly alkaline soils is reduced nutrient, and especially micronutrient, availability. Based on the above data of tables (3, 4 and 5) locations of Dakahleia contain large amounts of macronutrients and micronutrients and low salts soil range (EC 0.40 to 0.61 dS/m) and range PH 7.4 to 7.71; compared with locations of Kafrelshikh**.**

Finally, it can be concluded that low soil mites densities signify poor fertility in cultivated soils. The habitat fragmentation leads to fragmentation of the soil mites community and alteration of their diversity. PH and organic matter have been established as good indicators for soil fertility, as well as soil mites density. Type of vegetation cover and the resulting litter as well as intensive agriculture affect mite population densities and diversity in the soil. The difference in soil mites community is affected by natural salinity concentration and composition of the ions in solution.

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