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DOES ORGANIC MANAGEMENT INFLUENCE THE VERTICAL DISTRIBUTION OF SOIL ORIBATID MITES?

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ABSTRACT

The main goal of the present study was to answer the question raised: Does organic management influence the vertical distribution of soil oribatid mites? To obtain answer of this question, two fields (three independently plots for each) were selected for this study. at a farm of Al-Fayoum, Egypt (290 19 12 N and 300 48 E). The conventional field (CMS) was chosen as a reference site. The second field was subjected to organically managed system (OMS). During sampling the two fields had the same vegetation cover (clover, Trifolium alexandrina). Fifteen random soil samples were collected from each plot at three depths (0-4 cm, 4-8 cm and 8-12 cm) every month. The experiment carried out on October 2013 to March 2014. The obtained results revealed that a species was not influenced to OMS e.g. *Rhysotritia ardua ardua*. Three other species had a negative response to OMS e.g. *Epilohmannia Cylindrica, Oppiella nova and Zygoribatula exarata* and other species had a positive response e.g. *Lohmannia loebli, Javacarus kuhneltii, Niloppia sticta, Tectocepheus velatus, Lamellobates h. aegyptica, Xylobates capucinus Galumna gharbiensis and Scheloribates laevigatus*. The mean number of total oribatid mite individuals was significantly higher in the OMS plots than in the CMS. In OMS, density of oribatid mites decreased with soil depth in most studied months except in March the density of mites concentrated in the middle soil layer (4-8 cm depth). While in CMS, oribatid mites prevailed in the middle layer (4-8 cm depth) and decreased in number with soil depth (8-12 cm depth). It was found that the total number of oribatid mites in OMS decreased with increasing soil depth. Oribatid mite species showed a different pattern of vertical distribution in the studied sites where the most species tend to be found in the upper most stratum in organically management system. Tis may be contributed to organic matter content, porosity of soil and Herbs create a favorable circumstances that enhance to the upward movements of mites into uppermost layer. However, in conventional management system, these species showed a downward migration into a mean depth range from 2.6 – 6.7cm due to herbicides application in CMS plot that makes mite individuals migrate into the deepest soil depth to avoid it. . It can be concluded that OMS had a marked influence on vertical distribution of soil oribatid species as compared with that of CMS.

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INTRODUCTION

Organic farming system (OFS) is the farming system that works in harmony with the nature without harming the natural environment or people who live or work in it. It creates a healthy balance between nature and farming, where crops and animals can grow, pests and weeds are to be controlled to an acceptable level for high yield benefits. Organic Farming system (OFS) is replacing conventional farming system (CFS) gradually due to increasing demands for organic food and growing environmental concerns. Studies reported that organic farming is able to increase the level of total nitrogen in soil and preventing nutrients leaching (Melero et al., 2006). However, conventional farming often gives many negative impacts such as soil erosion, nutrient runoff, loss of organic matter, impairment of environmental quality and pollution of natural water by agricultural chemicals (Diepeningen et al., 2006). Organic farming has the possibility of reducing the negative effects of conventional agriculture, because the system avoids or largely excludes applications of synthetic fertilizers and pesticides, relies on organic inputs and recycling for nutrient supply, livestock feed additives, and emphasizes cropping system design and biological processes for pest management (Rigby and Cáceres, 2001).

Soil microbes play a critical role in ecological processes such as recycling of nutrients, nutrients turnover, decomposition and transformation of organic materials (Marshall, 2000; Nannipieri et al., 2003). Microbial processes are important in organic farming system because a lot of organic matters are used in organic systems. Soil active microbial communities are vital in synchronizing nutrient release from organic matter and nutrient demands for plant growth in organic farming system. Also, it can suppress plant diseases caused by soil borne pathogens, mainly by antibiosis and competition for nutrients (Mazzola, 2002; Garbeva et al., 2004). Changes in microbial communities could be used to predict the effects of ecosystem perturbations by organic and conventional management practices (Bending et al., 2000; Poudel et al., 2002; Van Bruggen and Semenov, 2000). In addition, knowledge of the changes in soil microbial processes is important in order to understand how microarthropod abundances and density to be enhancement. Organic agriculture has triggered a controversial debate in the last decades, most importantly because it shed light on the darker sides of chemical-intensive conventional farming by offering an alternative. By now, there is a strong body of evidence showing that organic farming is more environmentally friendly: potential benefits from organic production arise from improved soil fertility, organic matter content and biological activity; better soil structure and reduced susceptibility to erosion; reduced pollution from nutrient leaching and pesticides; and improved plant and animal biodiversity (Kasperczyk and Knickel, 2006 and Sudhakaran et al., 2013).

Mites are a common and widespread arthropod occurring in soil throughout the world. They exist in different soil horizons in land with high species richness, abundance and diversity. As they are vulnerable to land use changes, the spatial distribution tendency of soil mites could be used as a significant mannar of soil functioning processes. Vertical distribution of oribatid mites in different habitates has been examined (Perdue and Crossley, 1990; Edsberg and Hagvar, 1999). However, a very few studies on vertical distribution of oribatid mites and the relationships between their population and abiotic environment in Egyptian plantations were undertaken (Wafa et al., 1965 and Abo- Korah, 1979) consequently the aim of the present study is to provide information on changes in the vertical distribution of oribatid mites associated with organically managed system.

MATERIALS AND METHODS

Study site

The present study was carried out on October 2013 to March 2014 at a farm of Al-Fayoum, Egypt (29^0 19 12 N and 30^0 48 E). Two fields (three independently plots for each) were selected for this study. The conventional field was chosen as a reference site and had been cultivated with annual crops clover, wheat and cotton for more than thirty years. The second field was subjected to organically managed system (OMS) with the same agronomic manner as the conventionally managed system (CMS). During sampling the two fields had the same vegetation cover (clover, *Trifolium alexandrina*).

Fifteen random soil samples were collected from each plot at three depths (0-4 cm, 4-8 cm and 8-12 cm) every month. The samples were taken randomly, the peripheral edges of each plot were excluded from the sampling scheme to minimize possible edge effects. Sampling was conducted by means of rectangular metal sampler (10 ×10× 4 cm depth) (5 sample × 3 depths × 3 plots × 6 months = 270 samples). Collected samples were extracted for four 3-5 days in the laboratory. The soil oribatid mites were extracted from the soil sampling using modified Berlese funnels as described by Bayoumi (1978). Oribatid mites were separated from other creature and were preserved and identified according to Al-Assiuty et al. (1993). Additional samples were collected at the same depths and transported to the laboratory in plastic bags and weighed, dried at 100^0 for 5 h and weighed again to determine soil moisture, soil pH and organic matter content (OMC) was determined as recommended by Jackson (1958).

Data analysis

Population fluctuation of oribatid mite species from each biotope were determined where population densities are expressed as mean / m^2 ± SE. Species diversity value were evaluated using Shannon Whiner index (H) and equitability (J) was calculated by Pielou (1984). Mean depth and depth deviation were estimated for each species of mites according to Usher's methods (1975). Differences among means were detected by students t- test. Results were considered significant at $p \leq 0.05$.

RESULTS

Physicochemical analysis

No significant difference in soil moisture content when comparing organically managed system (OMS) and conventionally managed system (CMS). Organic matter content varied between 4.65 ± 0.069 and 2.91 ± 0.078 in OMS and CMS, respectively. Soil pH was slightly to moderately- alkaline (7.1 – 7.5) in OMS plots and tend to be significantly higher in

CMS plots where pH value was in the range of 7.6 - 7.8. Nitrogen was 0.18 ± 0.01 and 0.13 ± 0.003 in OMS and CMS, respectively. Carbon was 1.73 ± 0.032 and 1.31 ± 0.01 in OMS and CMS, respectively.

Species composition and abundance

A total of 4838 oribatid individuals representing 13 species were recorded from organically managed system (OMS) and it reached a maximum mean density (2917 ind / m^2) at 0-4 cm depth (table 1) through all sampling period except on March. While in conventional managed system (CMS), number of 1834 oribatid individuals of 17 species were collected from it and a maximum mean density (866 ind / m^2) at 4-8 cm depth. It was found that the total number of oribatid mites decreased with increasing soil depth in OMS. In CMS large numbers (866 ind / m^2) of oribatid mites concentrated in the middle layer (4-8 cm) (table 1).

Table (1): Oribatid list and their abundance, species diversity and equitability throughout the period of study at Three soil depths in organically managed system (OMS) and conventionally managed system (CMS).

	OMS			CMS		
	Soil depth (cm)					
Species	**0 - 4**	**4 – 8**	**8 - 12**	**0 - 4**	**4 - 8**	**8 - 12**
Epilohmannia Cylindrica	26	7	4	30	39	27
Lohmannia loebli	11	11	13	2	5	5
Javacarus kuhneltii	2	9	3	1	0	5
Rhysotritia ardua ardua	48	35	10	27	49	21
Oppiella nova	31	13	4	30	43	28
Niloppia sticta	28	5	2	11	2	0
Tectocepheus velatus	549	216	32	9	10	5
Lamellobates h. aegyptica	788	524	54	16	15	12
Xylobates capucinus	9	23	35	12	14	24
Galumna gharbiensis	490	261	103	7	4	2
Scheloribates laevigatus	925	396	160	261	509	224
Scheloribates confundatus	-	-	-	14	36	16
Scheloribate spallidulus	-	-	-	20	45	19
Zygoribatula exarata	5	0	0	42	77	57
Zygoribatula niliaca	-	-	-	12	16	19
Striatoppia papillata	5	1	0	-	-	-
Multoppia wilsoni	-	-	-	3	1	2
Quadroppia michaeli	-	-	-	1	1	4
Total	2917 ± 310	1501 ± 250	420 ± 43	498 ± 66	866 ± 123	470 ± 16
Shannon diversity (H')	1.6	1.61	1.73	1.86	1.61	1.93
S	13	12	11	17	16	16
Equitability (J)	0.62	0.64	0.71	0.68	0.57	0.68

The mean number of total oribatid mite individuals was higher in the OMS plots than in the CMS (table 1). The difference was found to be statistically significant ($p \leq 0.05$). The population densities of soil oribatids varied widely (4838-1834 individuals) between the two managed ecological systems.

Vertical distribution:

The relative contributions of total oribatid mite species in each soil layer for each month from organically and conventional managed systems are represented in Fig (1). In OMS, density of oribatid mites decreased with soil depth in most studied months except in March the density of mites concentrated in the middle soil layer (4-8 cm depth). While in CMS, oribatid mites prevailed in the middle layer (4-8 cm depth)) and decreased in number with soil depth (8-12 cm depth). It was found that the total number of oribatid mites in OMS decreased with increasing soil depth. In total, at OMS 76.2 % of oribatid mites were presented in the top soil depth (0 - 4 cm) on February and 18.3 and 5.6 % at a depth of 4-8 and 8-12 cm, respectively. While, in CMS, 53.2 % of mites were recorded in the middle soil depth (4-8 cm) and 28.8 and 17.9 % at a depth of 4-8 and 8-12 cm, respectively on December (figure 1).

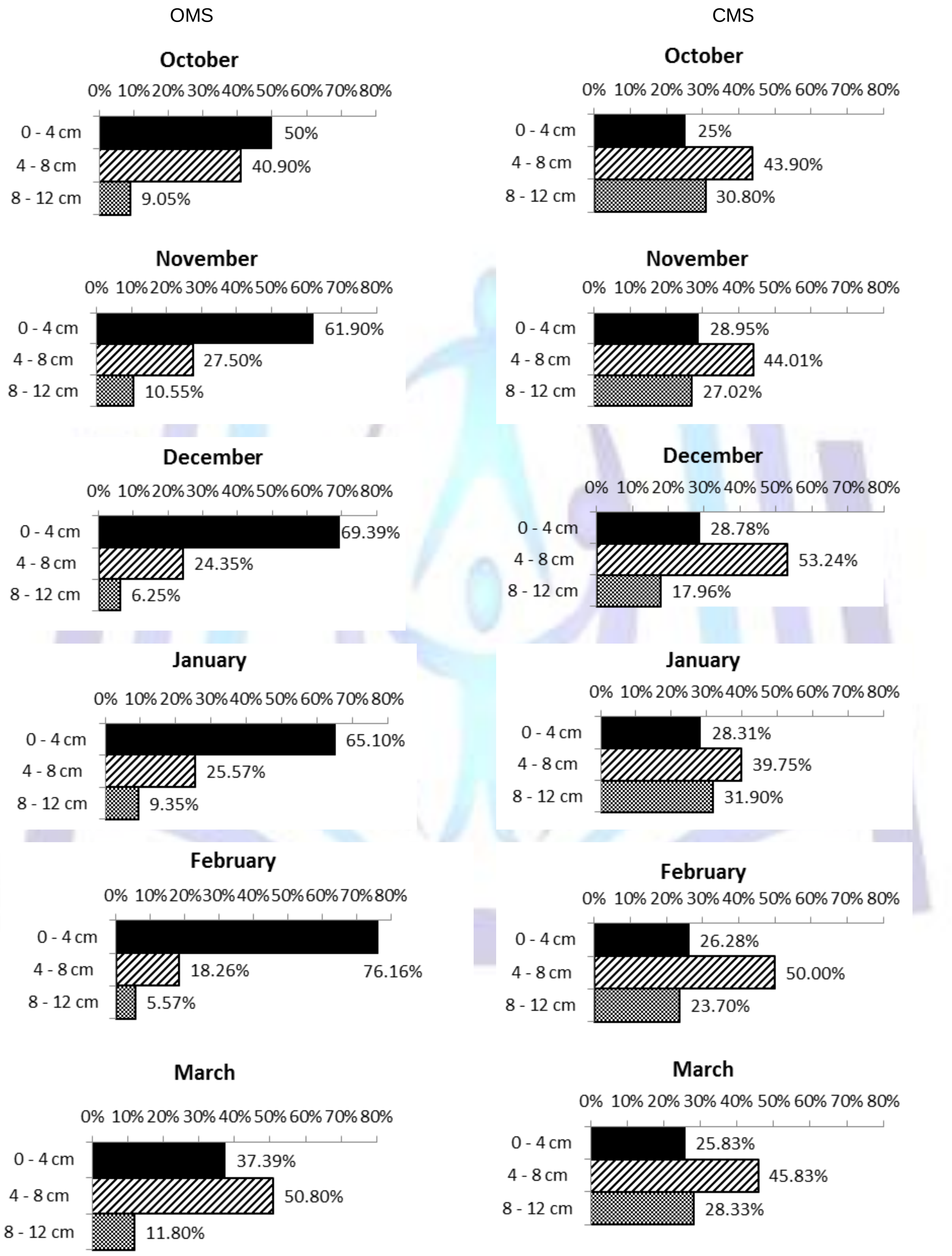

Figure (1): The vertical distribution pattern of total oribatid individuals throughout each month of studying period in organically managed system(OMS) and conventionally managed system (CMS).

Oribatid species *Tectocepheus velatus, Lamellobates h. aegyptica, Galumna gharbiensis* and *Scheloribates laevigatus* prevailed in the upper soil layer and decrease in number with soil depth in OMS and found in all tested soil depths. While in CMS, *Tectocepheus velatus Scheloribates laevigatus* found at middle layer in a large number (table 1).

Zygoribatula exarata was found only in the top layer (0-4 cm) in OMS. While it represents in three depths in CMS with large number in the middle layer. *Striatoppia papillata* found in OMS while it absent in CMS. *Scheloribates confundatus, Scheloribates pallidulus, Zygoribatula niliaca, Multoppia wilsoni and Quadroppia michaeli* were represented only in CMS but they absent in OMS (table 1).

On the base of change in the total density, oribatid mites could be grouped into three categories as shown in table (2).

1- Species not influenced by OMS viz:, *Rhysotritia ardua ardua.*

2- Species with a positive response towards OMS viz: *Lohmannia loebli, Javacarus kuhneltii, Niloppia sticta, Tectocepheus velatus, Lamellobates h. aegyptica, Xylobates capucinus Galumna gharbiensis* and *Scheloribates laevigatus.*

3- Species with a negative response to OMS viz: *Epilohmannia Cylindrica*, *Oppiella nova* and *Zygoribatula exarata.*

From table (2), it can be seen that OMS had a marked influence on vertical distribution of the some oribatid species as compared with that of CMS.

Table (2):Data of the oribatid mite species show the mean number of collected mites (N), mean depths (M) and depth deviations in organically managed system (OMS) and conventionally managed system (CMS).

	OMS			CMS		
Species	**N**	**M**	**S**	**N**	**M**	**S**
Epilohmannia Cylindrica	37	3.622	2.70	96	5.875	3.08
Lohmannia loebli	35	6.229	3.30	12	7	2.89
Javacarus kuhneltii	14	2866.	2.37	6	8.667	2.98
Rhysotritia ardua ardua	93	4.366	2.7	97	5.753	2.8
Oppiella nova	48	3.75	2.57	101	5.921	3.03
Niloppia sticta	35	3.029	2.21	13	2.615	1.44
Tectocepheus velatus	797	3.405	2.22	24	5.333	2.98
Lamellobates h. aegyptica	1366	3.851	2.29	43	5.628	3.21
Xylobates capucinus	67	7.552	2.85	50	6.96	3.26
Galumna gharbiensis	854	4.187	2.79	13	4.462	2.95
Scheloribates laevigatus	1481	3.934	2.73	994	5.85	2.79
Scheloribates confundatus	-	-	-	66	6.121	2.69
Scheloribates pallidulus	-	-	-	84	5.952	2.73
Zygoribatula exarata	5	2	0.00	176	6.341	2.98
Zygoribatula niliaca	-	-	-	47	6.596	3.19
Striatoppia papillata	6	2.667	1.49	-	-	-
Multoppia wilsoni	-	-	-	6	5.333	3.59
Quadroppia michaeli	-	-	-	6	8	3.06

From figure (2) it could be indicate that oribatid mite species showed a different pattern of vertical distribution in the studied sites where the most species tend to be found in the upper most stratum in organically management system. However, in conventional management system, these species showed a downward migration into a mean depth range from 2.6 – 6.7cm. The dynamic of vertical movements of common oribatid species in OMS and CMS cleared that *Xylobates capucinus* reached the deepest depth (7.55cm) in OMS. While *Zygoribatula exarata* reached the lowest depth (2 cm). In CMS, *Javacarus kuhneltii* arrived at a depth 8.66 cm in soil while, *Niloppia sticta* reached the lowest mean soil depth (2.6 cm).

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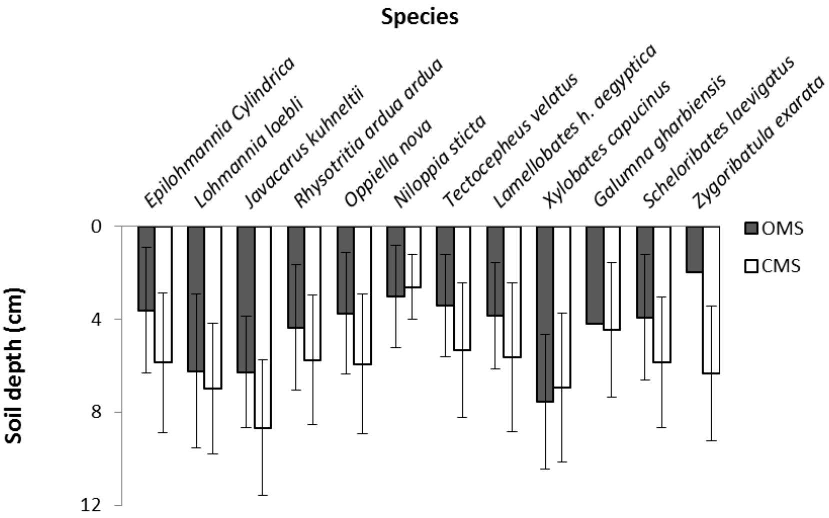

Fig (2): Mean depth (columns) and depth deviation (vertical bars) of common oribatid mite species in organically managed system

(OMS) and conventionally managed system (CMS).

Table (3) shows that the highest densities were observed in December in both types of managements (1088/15×100/m^2 in organic plots and 462/15×100/m^2 in conventional plots).

Table (3) : Data of the oribatid mites sampling show the total number of soil mites collected (N), mean depths (M) and depth deviations in organically managed system (OMS) and conventionally managed system (CMS). throughout the studying period

Month	OMS			CMS		
	N	M	S	N	M	S
October	674	4.36	2.59	396	6.2	2.98
November	701	3.9	2.7	259	5.9	2.99
December	1088	3.47	3.46	462	5.5	2.68
January	919	3.77	2.63	166	6.1	3.1
Febreuary	646	3.17	2.26	312	5.89	2.28
March	805	4.97	2.61	240	6.1	2.94

However, the lowest was 646/15×100 m^2 in February in organically managed system and 166/15×100 m^2 in January from CMS. The differences were statistically significant ($p \leq 0.05$). The mean depth remain the same and depth deviation is small in all studied month except in March in OMS (oribatid mites are concentrated in the upper soil horizon (0-4 cm). In CMS site, oribatid mite species are presented in the middle soil horizon since they are clustered into the center of second horizon (4-8 cm) in all studied months.

Diversity (H`) and equitability (J) provide another way to detect and evaluate the effect of organic system on soil oribatid mites. From the present data (table 1) it can be observed that the diversity values were high in CMS plots than in OMS plots. Diversity index (H`) value of oribatid communities in the three depths were 1.60, 1.61and 1.73, respectively in OMS. While diversity index in CMS were 1.86, 1.61 and 1.93 in the three depths, respectively. Evenness index (J`) value were 0.62, 0.64 and 0.71, respectively in three soil depths in OMS. While in CMS evenness value were 0.68, 0.57 and 0.68, respectively in CMS at three soil depths.

Discussion

The soil pH ranged from slightly to moderately alkaline (pH 7.1 - 7.5) in organically managed system and 7.6-7.8 in conventionally managed system from most sampling dates. This range appeared to be within tolerance of most species (Bedano et al., 2005), and due to plant cover that were favorable conditions for oribatid mites.

Soil organic matter content is usually beneficial for most soil animal groups (Noti et al., 2003) and that biodiversity is relatively strongly linked to available energy resources and essential nutrients. This agreement with several studies found correlation between organic matter content and the structure of oribatid communities (Bedano et al., 2005; Salmon et al., 2006). Peterson and Luxton (1982) observed that the presence of soil mites in a bimodal distribution was correlated with soil moisture and root biomass. Badejo (1990) found a significant positive correlation between percentage of moisture content and total mite numbers in the forest plot was not significant.

Fluctuation of population density in OMS throughout the period of study may be due to mechanical weed control and organic matter content was high at the upper most layer. December was more suitable for soil oribatid mites in OMS and CMS thus migration of mite species up and down in the soil was more noticeable. Low densities of oribatid mites during January in CMS could be attributed to high drop in population density of Scheloribates *laevigatus* was recorded in January.

The concentration of oribatid mite species in the top layer (0-4 cm) in OMS plot may be due to the green cover of the herbs that protect the fauna from unsuitable temperature and light and conditions are optimum at this level therefore migration to lower zones of the soil do not often occur. Herbs create a favorable circumstances that enhance to the upward movements of mites into uppermost layer. Al- Assiuty et al (1993) reported that soil mites reached maximum density in spring and winter and a minimum density in summer. Organic farming can lead to higher populations and species diversity of beneficial arthropods. Where the organic farming system enhanced the mean weight diameter of soil aggregates compared to conventional farming system. This may be due to the different way of use and frequency of cultivation techniques – cultivation techniques determine the presence of soil binding agents of soil particles, leading to the formation or decomposition of aggregates (Jiao et al., 2006). During March in OMS, the oribatid mites concentrated in the middle layer, this may be contributed to high temperatures have been reported to reduce or prevent egg- laying and cause mortality of the sperm of mites, thereby leading to a decrease in the size of mite populations (Badejo, 1990) or may be due to relatively low moisture on March. Soil moisture is one of the most decisive factors affecting the life of oribatid communities (Gregoes and Hufnagel, 2009). While in CMS plot, oribatid mite species are presented in the middle soil depth in all studied months. This may be due to herbicides application in CMS plot that makes mite individuals migrate into the deepest soil depth to avoid it.

Papadopoulos et al., (2014) demonstrated that organic soil management can substantially improve soil structural condition, especially in terms of organic matter level, soil aggregate stability (ability of soil to resist breakdown by forces associated with cultivation) and soil pore characteristics, but that the effects might be both scale and time – dependant. At all sites it was found a significant increase in soil pore measurement at the mesoscale associated with organic management. However, at the microscale, only the most recent conversion to organic farming had an enhanced pore network compared with conventional managed soil. Porosity of soil was greater in the organic than conventional management system that enable soil mites upwards migration easy.

This pattern of variability in different soil layers, principally related to seasonal environmental variations, may be a common feature in soil communities as suggested by the occurrence of vertical migration in diverse soil inhabiting taxa in different systems (Frouz et al., 2004). It is obvious that soil oribatids can avoid the effect of unsuitable conditions by the ability of vertical migration,. This interpreted the presence of some oribatids during the hottest period.

The vertical arrangement of oribatid mites in the soil profile was not permanently fixed. These changes may have been affected not only by the emergence of new forms and death of old ones, but also by the movement from one layer to another. Reduction in the abundance and aggregation of individuals in deeper layers may be due to less available of food sources and corresponding unfavorable microclimate condition. In fact, there were differences in diversity between the top layer on the others, with the former maintaining a higher diversity from the other levels, as previously indicated for Wafa et al., (1965) and Abo- Korah, (1979).

Hole et al. (2005) indicated that OMS contain a greater abundance and diversity of arthropods than CMS. The present data revealed that the average number of all adult oribatid mite individuals was higher in OMS than in CMS. Species diversity was higher in conventional plots than in organic plots. This is consistent with the finding of Minor and Norton (2004) who found that compost had a great effect on mite diversity than chemical fertilizer although both treatment reduced the diversity. The population dynamics of soil organisms in agricultural system depends on arrange of different factors such as soil characteristics, climate, type of farm management, crop, ploughing and use of pesticids (Debeljak et al., 2007).

Species diversity and abundance of orbatid mites decreased gradually with soil depth, as previously reported in other ecosystem. S. lavigatus, was found in the top layer (0-10 cm), during the time of sampling in search of fungal hyphae which formed a large part of food (Gulvik, 2007).

The management system methods associated with organic farming particularly organic inputs and effective crop rotations, induce the formation of an ameliorated soil structure, which is porous, better developed and has an increased a horizon depth, organic matter content and soil biota presence and activity. On the other hand, the management method associated with conventional farming, lack of organic inputs conventional tillage and monoculture, result in soil with a degraded, less porous, less developed structure, afflicted by compaction and erosion in which there is a reduced a horizon depth, organic matter content, porosity and soil biota presence and activity.

Generally, vertical distribution, the total number of species recorded and abundance noted in this study are difficult to compare with several other published studies because of different sampling.

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