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COMMUNITY STRUCTURE OF ISOPODS (ONISCIDEA) AT DIFFERENT ORCHARDS IN ASSIUT, EGYPT

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Terrestrial isopods provide many important services for the ecosystem such as litter decomposition, nutrient mineralization. The present study aimed to make a survey of the distribution of isopods as leaf litter decomposers; in five different orchards during winter and summer and effects of some ecological factors on them. Isopod samples were collected by a tin quadrate sampler (20 X 20 cm.). Some of ecological factors were measured, air and soil temperature, humidity, pH, conductivity, soil water content and organic matter content. In the present study, five isopod species were recorded. *Porcellio laevis* and *Porcellionides pruinosus* were eudominant while the other three species were subdominant. *P. laevis* recorded the highest value of total isopods mean and standard deviation (SD) and that was in site 1. In addition, ANOVA and Duncan comparison showed that total abundance of isopods had no significant difference with the studied seasons but they significantly varied with sites during the whole period of investigation. Species richness and Shannon diversity index recorded their highest values in site 3, then in site 2. The clusters analysis of isopods abundance according to the five studied sites showed that: (a) *Leptotrichus naupliensis* and *Chaetophiloscia hastata* were the most similar species in the cluster of isopods abundance. (b) *P. laevis* was similar to *P. pruinosus*. Canonical Corresponding Analysis (CCA) of Isopoda and ecological factors revealed that: *P. laevi s*had positive correlation with air temperature followed by soil water content and soil temperature. Thus, *P. laevis* and *P. pruinosus* were the most dominant and abundant species and they both have the ability to live and acclimate with different conditions of the arable fields; of Assiut governorate more than the others.

INTRODUCTION

Soil biota performs practical roles in any ecosystem processes (Menta, 2012).The community of terrestrial fauna is an important component of soil ecosystem for the essential roles that plays as driving force in soil processes such as litter decomposition, nutrient mineralization, and the change of soil physical structure (Wu 2006; Huhta 2007 and Carlesso *et al.*, 2019). They also provide many other important services for the ecosystem such as: solubilization, decomposition of soil organic matter, immobilization, nitrogen fixation which are important for plant growth and nutrient cycling (Brussaard

1998; Lavelle *et al*., 2006 and Bigler *et al*., 2012). These creatures include isopods, earthworms, lumbricids, diplopods, dipteran larvae, and termites (Wood *et al*., 2012). Pont and Nentwig (2005) concluded that isopods are among the most important species of detritophagous soil macrofauna.

Isopods are a marine group but have colonized not only freshwater but also terrestrial habitats. Moreover, they inhabit land more successfully than any other crustacean taxon (Zimmer *et al*., 2002). Terrestrial isopods have sustainability features make them appropriate organisms to study many topics related to the soil fauna. They are very widespread and in many temperate habitats, isopods considered from a dominant component of the soil arthropod macrodecomposer community. In addition, they are key system regulators of the ecosystem functions of decomposition and nutrient recycling since they feed on dead organic materials (Paoletti and Hassall 1999).

Isopods as a decomposer play essential role in the process of leaf litter decomposition (Wolters 2000; David and Handa 2010 and Pey 2019) by breaking down litter and make them easier to colonize by soil microorganisms (David 2014) which in turns represents a major part of the nutrient cycles and energy flow of soil ecosystems (Chew 1974; Swift and Anderson 1989). This process is carried out by the combined action between decomposer animals such as isopods and between microorganisms like fungi and Bacteria. (Swift *et al*., 1979; Magill and Aber 2000 and El-Wakeil 2015). By degrading leaf litter, microorganisms improve its food quality for terrestrial isopods (Hassall and Rushton 1984; Swift and Boddy 1984).

The present study was designed to make a survey and study the abundance of isopods as leaf litter decomposers; in five different orchards in Assiut, Egypt during two different seasons (winter and summer). Besides, it aimed to study the effects of some ecological factors on them and it also aimedto compare between the state of isopods in Assiut in the previous studies and the current one.

MATERIALS AND METHODS

Sampling locations:

Isopod samples were collected from five different orchards during two seasons; winter and summer 2015; in Assiut Governorate, Egypt (Lying between 27º 14¯ N and 31º 11¯ E). Four of the studied orchards (Sites 1, 2, 3 and 4) locate in the experimental farm of Assiut University and the fifth one locates in El-Wasta in Assiut city.

Site 1, represented Berry orchard (Morusalba); site 2, represented Apple orchard (Pyrusmalus); site 3, represented Orange orchard (Citrus sinensis) and sites 4 and 5, represented Mango orchard (Mangiferaindica).

Collection and identification

Three random samples were collected from each orchard. Isopod samples were collected by a tin quadrate sampler (20 X 20 cm.). Some of ecological factors were measured, using a portable multiprobe apparatus, which are: air and soil temperature, air humidity and soil pH and soil conductivity. Other soil analysis also were determined: Soil water content and soil organic matter content.

In the laboratory, to isolate isopod samples, the soil samples were sieved; through 1 mm mesh sieves. Large specimens can be picked by hand and animals from each site were counted and recorded.

Identification of samples:

Isopods identification were done according to: Schmalfuss and Ferrara, (1978); Mahmoud, (1990); Bedair, (1991), Kayed, *et al*., (1991); Abd El-Wakeil, (2001 and 2005) and Hussein, *et al*., (2002 a, b and c).

Samples treatment:

Classification of Engelmann (Engelmann, 1978) was applied for the collected taxa to estimate dominance structure where: eudominant (40-100%), dominant (12.5-39.9%), subdominant (4-12.4%), resident (1.3-3.9%) and subresident (bellow 1.3%); cited in (Hassan *et al*., 2014).

Statistical analysis:

Statistical analysis of the present data using SPSS software package (version 20) was applied. One way and multiple ANOVA besides Duncan test were used. Also species richness and Shannon diversity index of Isopoda were calculated. In addition, Primer 5 for Windows (version 5.2.0, 2001) software and Canonical Corresponding Analysis (CCA) were also used.

RESULTS

Mean and standard deviations of measured ecological factors were: Air temperature (At., 25.8±9.40oC); soil temperature (St. 21.1±8.97oC); relative humidity (Rh. 45.30±15.26%); hydrogen ion concentration (pH 8.52±0.29); soil water content (SWC 35.63±13.44%); soil organic matter content (OMC7.63±5.22%) and conductivity (cond. 1371.9±1745.65µs.) (Table1).

Five isopod species were recorded in the investigated sites during the period of collection. They were *Chaetophiloscia hastate*, *Leptotrichus naupliensis*, *Porcellio laevis*, *Porcellionides pruinosus* and *Proporcellio quadriseriatus*. Referring to (Table2), two of isopod species were eudominant: *P. laevis* and *P. pruinosus* while the other three species were subdominant.

The highest value of total mean and standard deviation (SD) of isopods (11.83±5.56) collected from 0.2 m2 of soil was in site 1. The highest isopods abundance was recorded in summer but no significant differences appeared between the total abundance of isopods and the two studied seasons (Fig.1). However, the total abundance of isopods at the five investigated sites significantly varied during the whole period of investigation (Fig.2).

P. laevis recorded the highest mean value of isopods taxa (10.00±4.24) collected from 0.2 m2 of soil and that was in site 1 (Fig. 3). *P. pruinosus* recorded the second highest mean value.

Species richness and Shannon diversity index recorded their highest values in site 3 and the second high values of them recorded in site 2. The other sites were equal in their values of species richness and Shannon diversity index (Fig. 4).

The clusters analysis of Isopods abundance at the five sites showed that: *L. naupliensis* and *C. hastata* were the most similar species in the cluster of isopods abundance. Besides, it also showed that *P. laevis* was similar to *P. pruinosus* (Fig.5).

Canonical Corresponding Analysis (CCA) was applied to study the relation between Isopoda and ecological factors (Fig. 6).

Discussion

In the present study, the mean value of pH levels showed that it was in the alkaline side which is favorable for terrestrial isopods. Previous studies found that acidification in the field will cause a decrease in population density of *Porcellio scaber* and come to the conclusion that soil acidification has negative effect on the nutrition of plants, as well as the feeding of saprophagous animals (Ullrich *et al*., 1991 and Zimmer and Topp 1997).

The present investigation found that the most abundant isopod species recorded was *P. laevis*, followed by *P. pruinosus*. Thus, the results of the present study were so much similar to the previous studies of Abd El-Wakeil (2001 and 2005) who studied the abundance of terrestrial isopods species in different habitats in Assiut, Egypt. These studies illustrated that the most abundance species in Assiut governorate are *P. laevis* and *P. pruinosus*.

In the present investigation, in spite of no significant differences appeared between the total abundance of isopods in the two studied seasons, the highest isopods abundance were recorded in summer. Bedair (1991), Kayed *et al*., (1991) and Abd El-Wakeil (2005) recorded the greatest number of *P. laevis* or others during spring, while the smallest number was noticed during winter. The first and second previously mentioned studies were carried out in Ismalia region and the last one was in Assiut governorate. Brigića *et al*., (2019) indicated that the most seasonal activity of the isopod L. germanicum occurred in spring and early summer.

To understand the isopods occurrence results, a comparison should be made between the present isopods frequency results with the previous mentioned ones of the year 2005 made by Abd El-Wakeil. Applying the classification of Engelmann (1978) on the previous author's results: *P. pruinosus* (92.5%), *L. naupliensis* (60%) and *P. quadriseriatus* (47.5%) were eudominant species. Whereas *P. laevis* (30%) was a dominant species and C. hastate was a subdominant species and it was the least frequent one (10%). In the present investigation, each of *P. laevis* (47%) and *P. pruinosus* (40%) were eudominant. The rest three recorded species were subdominant; C. hastate and *P. quadriseriatus* each of them achieves (10%) and *L. naupliensis* (7%) which was the least frequent one.

In the previous study of the year 2005 by Abd El-Wakeil; random isopod samples were collected from 40 different locations in Assiut governorate but the present study more concentrated on the orchards that locate in the experimental farm of Assiut University and only one orchard locate in El-Wasta. Thus, and from both studies one can conclude that: First, in Assiut governorate as a whole *P. pruinosus* is considered as the most frequent isopod species but *P. laevis* is considered as the most abundant one. Second, in the experimental farm of Assiut University *P. laevis* is not only considered as the most abundant isopod species, but it is also the most frequent one.

The process of decomposition may effect by the conditions at the edges of arable fields (Carlesso *et al*., 2019). Zagatto *et al*., (2019) found that soil invertebrates in natural systems exist in higher diversity than in agricultural systems. Terrestrial isopods can be used as bioindicators to intensive agriculture and how the habitat may modify responding to that (Paoletti 1999). Intensive crop production decreases the diversity of soil biota (Tsiafouli *et al*., 2015). Those studies explained why five species only occurred in experimental farm of Assiut University, three of them rarely occurred and if they did, they were in small numbers. So, one can elucidate the dominant and abundant of the other two species *P. laevis* and *P. pruinosus* that they have more ability to live and acclimate with a wide range of different conditions and habitat (ex., the arable fields) of Assiut governorate.

In the present study, species richness and Shannon diversity index of isopods recorded their highest values in site 3 Citrus orchardfollowed by site 2 Pyrus orchard. Abd El-Wakeil 2005 found that *P. laevis* was more abundant in Citrus orchard than other sites and he explained that may be due to that Citrus leaf litter are smaller and softer than other leaf at another sites..

The clusters analysis of Isopods abundance at the five sites showed that *P. laevis* was much similar to *P. pruinosus* because they were the most dominant and abundant species. They occurred in all studied sites and each of them generally, recorded high density values. However, *L. naupliensis* and *C. hastata* were the most similar species because they were both rare in their occurrence.

Canonical Corresponding Analysis (CCA) applied on Isopoda and ecological factors, revealed that: the main isopod species were: *P. laevis* and *P. pruinosus*. *P. laevis* had positive correlation with air and soil temperature and with soil water content. In addition, air temperature had the strongest effect on *P. laevis* than the two other previously mentioned factors. Soil properties and climate affect the soil biota activity which in turn affect plant decomposition (Castro-Huerta *et al*., 2015). In spatial and temporal scales, it is important to understand effects of the factors on soil biodiversitys (Decaëns 2010). Thus, favorable soil properties make better chance for soil fauna to occupy the habitat. Air temperature is considered as an important ecological factor affects isopods. In the present study, it had a positive effect on isopods abundance but the reverse could be expected in extreme hot days (air temperature could also had a negative effect). Thus recently, there were some studies on the global warming and global changes and their effects on isopoda and other soil creatures. These studies such as: David and Handa (2010); Dixie *et al*., (2015); Coyle *et al*., (2017) and Leclercq-Dransart *et al*., (2019).

Moreover, distribution of soil macroinvertebrates influence by changes in soil physicochemical properties, for example soil moisture (Savin *et al*., 2007). Leaf litter that cover soil makes soil moisture higher and soil temperature lower (Achat *et al*., 2015). Sensitivity of isopods to environmental changes, particularly soil moisture, may make them used as bioindicators (Wolters and Ekschmitt, 1997; Paoletti and Hassall, 1999). Their favorable habitats depend on a certain range of moisture (Warburg *et al*., 1984). This agreed with the result of the present investigation that P. leaves correlated positively with soil water content.

In conclusion, five species were recorded from the five investigated orchards. The most abundant isopod species were: *P. laevis* and *P. pruinosus*. Theywere more similar to each other than to the other three species; they were eudominant and the most abundant species and that may be due to their ability to live and acclimate with different conditions and habitat; such as the arable fields; of Assiut governorate. The highest isopods abundance value achieved in site 1. However, the highest value of diversity recorded in site 3 then in site 2. *P. laevis* was the most abundant species and it correlated positively with air temperature, followed by soil water content and soil temperature.

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TABLES

Table (1): Mean and standard deviations of ecological factors (Air temperature, soil temperature, relative humidity; hydrogen ion concentration; soil water content); soil organic matter content and conductivity); during the year of investigation 2015.

	At. °C	St. °C	Rh %	pH	SWC %	OMC %	Cond. μs
Mean ± SD	25.8 ± 9.40	21.1 ± 8.97	45.30 ± 15.26	8.52 ± 0.29	35.63 ± 13.44	7.63 ± 5.22	1371.9 ± 1745.65

Table (2): Frequency percentage and dominance of different isopods species, collected from the five investigated sites during the period of collection.

No.	Taxa	F%	Dominance
Isopoda			
1	*Porcellio laevis*	47	Eudominant
2	*Porcellionides pruinosus*	40	Eudominant
3	*Leptotrichus naupliensis*	7	Subdominant
4	*Chaetophiloscia hastata*	10	Subdominant
5	*Proporcellio quadriseriatus*	10	Subdominant

FIGURES

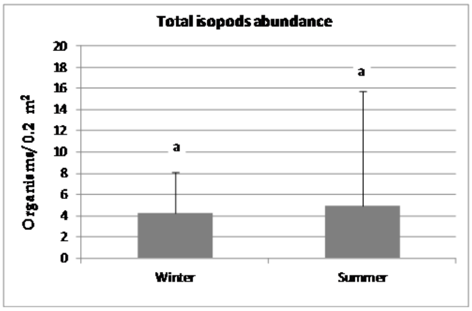

Fig.(1): Mean and standard divisions of total isopod species through winter and summer seasons (The similar characters show no (significant difference).

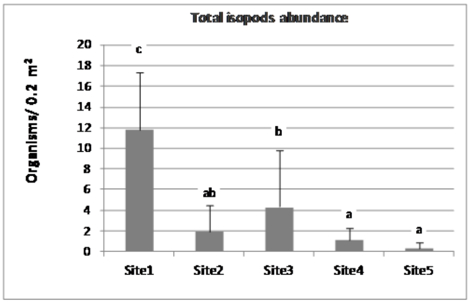

Fig.(2): Mean and standard divisions of the total abundance of isopods, at each of the five studded sites (The similar characters show no significant difference).

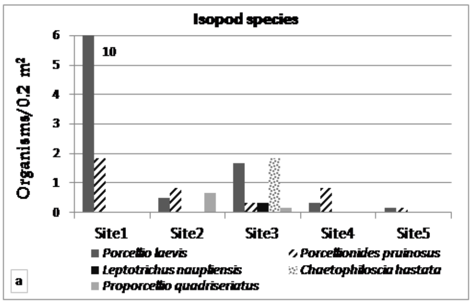

Fig.(3): Mean values of each isopods species at the five investigated sites.

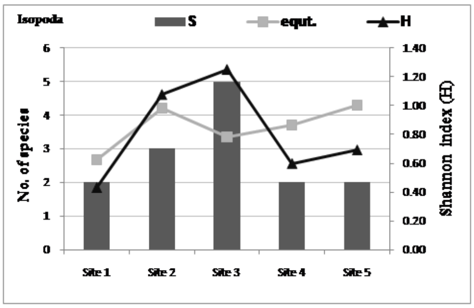

Fig (4): Species richness (S), equitability (equt.) and Shannon diversity index (H) for the abundance of soil isopods species, at the five investigated sites.

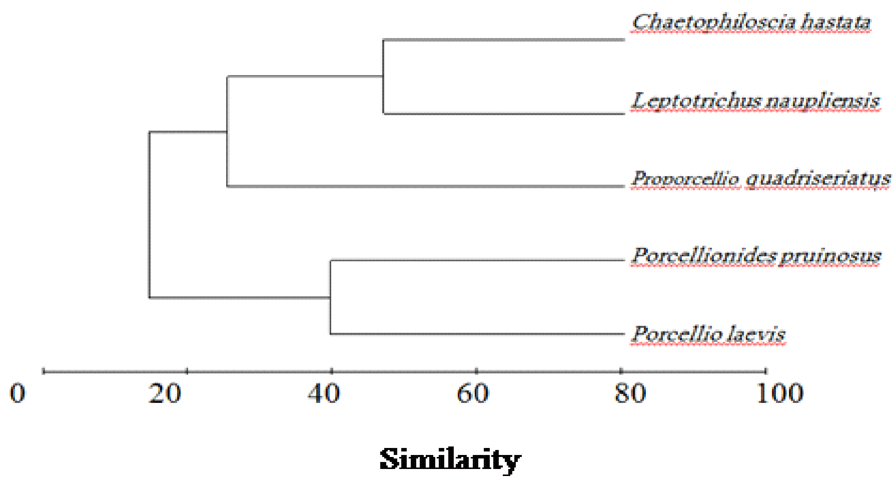

Fig (5): Dendrogram showing the clusters of isopods species identified from the Bray-Curtis similarity matrix of log10 (x+1) transformed isopods abundance data at the five investigated sites.

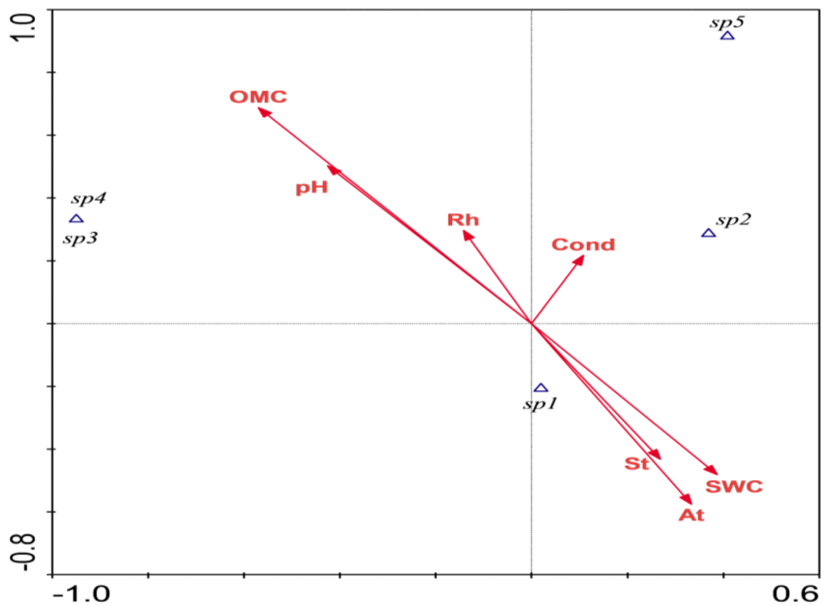

Fig. (6): Canonical Corresponding Analysis (CCA) of Isopoda species abundance and studied ecological factors. Isopoda species notation: sp1: *Porcellio laevis*, sp2: *Porcellionides pruinosus*, sp3: *Leptotrichus naupliensis*, Sp4: *Chaetophiloscia hastata*, sp5: *Proporcellio quadriseriatus*. Ecological factors notation: air and soil temperature (At., St.^{o}C, respectively) air humidity (Rh. %), soil hydrogen ion concentration (pH), soil organic matter content (OMC%), soil water content (SWC %) and soil conductivity (Cond. µs.) .

التركيب المجتمعي لمتشابهة الأقدام في بساتين فاكهة مختلفة في ,مصر محافظة أسيوط

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تعتبر متشابهة الأقدام الأرضية من أهم كائنات التربة ، لدورها المهم في العديد من العمليات الحيوية (مثل: تحلل المواد العضوية و التمعدن ....الخ) والتي تثري النظام البيئي للتربة وتحافظ على توازنه. تهدف الدراسة الحالية إلى حصر لمتشابهة الأقدام الأرضية - ككائنات محللة لأوراق الأشجار المتساقطة- في خمسة من بساتين الفاكهة خلال موسمي الشتاء ، و الصيف ، في محافظة أسيوط ، مصر. كما أنها تهدف إلى دراسة تأثير العوامل البيئية المختلفة على هذه الكائنات. بالإضافة إلى عمل مقارنة بين حالة هذه الكائنات في الوضع الراهن وفي الأعوام السابقة، في محافظة أسيوط . وقد تم تجميع العينات الحيوانية و تعريف الأنواع المختلفة لمتشابهة الأقدام الأرضية. كما تم قياس بعض العوامل البيئية وهي: درجة حرارة الهواء والتربة ، تركيز الأس الهيدروجيني ، الرطوبة النسبية للهواء ، والمحتوى المائي ، والمادة العضوية ، و معامل التوصيل للتربة . وقد تم حصرخمسة أنواع من متشابهة الأقدام الأرضية في المواقع قيد الدراسة من أصل ثمانية كانت قد عرفت في الدراسات السابقة في هذه المحافظة. وكان النوعين *Porcellio laevis* و *Porcellionides pruinosus* ، هما الأكثر تشابهاً ، سيادة، و وفرة . لم يكن هناك فرق معنوي بين الموسمين ، لكن وجد فرق معنوي بين المواقع من حيث وفرة متشابهة الأقدام الأرضية.

النوع *P. leavis* كان الأكثر سيادة و وفرة. و وجد أنه تأثر إيجاباً، وعلى التوالي بكل من: حرارة الهواء ، والمحتوى المائي للتربة ، و حرارة التربة. وخلصت الدراسة إلى أن سيادة و وفرة النوعين المذكورين يرجع لكونهما الأكثر تأقلماً مع الظروف البيئية ، والبيئات المختلفة ، خاصة بيئة الأراضي الزراعية. و قد تم مناقشة كل هذا مفصلاً في الدراسة الحالية.