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Arthropoda associated to the olive crop in Southern Portugal (Algarve)

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Abstract: The main objective of this work was to study the abundance and diversity of arthropods associated with the olive crop (*Olea europea* L.), in southern Portugal. The trials were carried out in two different olive groves, one located in Olhão and the other located in Loulé, both in the integrated mode of production. The sampling techniques used in the trials consisted of pitfall traps, yellow sticky traps with and without sexual pheromone, delta pheromone traps (the pheromone lure in the trap attracts the adult moth) and sampling of leaves, flowers and fruits. The results obtained in the trials indicate that the arthropods associated with the olive crop belong to the following classes: Arachnida (order: Araneae), Chilopoda, Entognatha (order: Collembola) and Insecta. Among these groups, most specimens belonged to the class Insecta, followed by Arachnida, Entognatha and Chilopoda. Regarding to the Insecta class the orders and families that inhabit the olive ecosystem are: Diptera (Syrphidae and Tephritidae), Coleoptera (Carabidae, Chrysopidae, Curculionidae and Staphylinidae), Hemiptera (Anthocoridae and Miridae), Homoptera (Coccidae and Psyllidae), Hymenoptera (Braconidae, Encyrtidae, Eulophidae, Trichogrammatidae and Formicidae), Lepidoptera (Hyponomeutidae), Neuroptera (Chrysopidae) and Thysanoptera (Phlaeothripidae).

Key words: arthropods, diversity, olive crop

Introduction

The olive tree, *Olea europaea* L. (Fam.: Oleaceae) is an evergreen plant native to the Mediterranean, Asia and Africa. It is a plant from Asia Minor widely spread in the Mediterranean region through the Roman invasions and trade that occurred in this region. Today is widespread around the world and its cultivation has been expanded in the Americas, South Africa, Australia and Japan. This sturdy tree is one of the oldest cultivated plants in Mediterranean region. The olive's fruit, also called olive, is of major dietary and economic importance in the Mediterranean region as the source of olive oil. The olive's fruit are also used canned for human consumption (Gonçalves, 2014).

Among the arthropods associated with the olive trees, the class Insecta is the most studied group (Patanita & Reis, 2007). This is due to the fact that the class Insecta accommodates the most harmful organisms to the olive trees, i.e. the insect pests. There are several species of insects that can attack the olive tree, the most frequent being the olive fruit fly (*Bactrocera oleae* (Gmelin) (Diptera: Tephritidae) = *Dacus oleae*), the olive moth (*Prays oleae* (Bernard) (Lepidoptera: Hyponeumetidae)), the black scale (*Saissetia oleae*), the olive cotton (*Euphyllura olivina*), the weevil (*Phloeotribus scarabeoides*) and the olive thrips (*Liothrips oleae*). In the Mediterranean basin area the most important insect pests of the olive tree are the olive fruit fly, *B. oleae* and the olive moth, *P. oleae* (Alvarado *et al*., 1999;

Gonçalves & Andrade, 2010; Gonçalves & Andrade, 2012 a). However, it is also in the class Insecta that the greatest diversity of beneficial organisms of olive groves is included. This beneficial organisms are predators or parasitoids of the main olive pests (Gonçalves & Andrade, 2011). The beneficial arthropods whether in the Insecta class or in another class, are particularly important in natural control of the major pests of olive groves. However, a minimum human intervention in the olive groves is necessary for the natural enemies to be active.

The minimized or no tillage of the olive grove and the maintenance of the under canopy vegetation planted or spontaneous (natural meadow) retains more water available to plants (Pinheiro *et al.*, 2005; Gonçalves & Afonso, 2008). The cultural practice of maintaining the soil covered with vegetation improves the physical and chemical characteristics of the soil, resulting in the proper development of plant and contributes to the increase of their resistance to phytosanitary problems such as insect pests and diseases (Pinheiro *et al*., 2005; Gonçalves & Afonso, 2008; Gonçalves & Andrade, 2012 b).

This study took place in two olive groves both cultivated under integrated mode of production and aimed to increase our knowledge on the abundance and diversity of arthropods associated with the olive grove ecosystem in southern Portugal.

Material and methods

Our studies took place from April 2010 to April 2014 and were conducted in two olive groves, one located in Olhão and another located in Loulé. The olive grove of Olhão covers an area of 4 ha and olive grove of Loulé an area of 5 ha. Both olive groves are irrigated and under integrated production. In both olive groves, soil conservation is based on a permanent cover crop consisting of a mixture of grasses and leguminous plants. To identify and characterize the arthropods which naturally occur in the olive ecosystem several sampling techniques were used.

The sampling techniques consisted of pitfall traps buried in the ground but with the top of the trap at the level of the soil surface, yellow sticky traps, delta traps with sexual pheromone to capture adults of the olive moth and sampling of plant material (leaves, flowers and fruits). Regarding yellow sticky traps, they were used with sexual pheromone lures to capture adult males of the olive fruit fly and without pheromone lures to capture potential beneficial fauna. In each grove two yellow traps with only one surface adhesive were placed. Their adhesive surface was facing the ground, in the horizontal position, slightly above the soil surface aiming to capture specimens of Entognatha class. In each grove, two traps for each type were placed in the central part of the grove spaced 50 m apart from each other. All the traps were inspected every two weeks. The sexual pheromone capsules were replaced monthly or after six weeks depending on the weather conditions. The manipulation of the pheromone capsule was carried out with the help of a properly sterilized forceps. Each pitfall trap contained 125 ml of soapy water to keep the arthropods therein.

All samples were transferred to the laboratory for counting and identification of the arthropods captured. Moreover, samples of leaves, flowers and fruits were also collected, twice a month. These samples consisted of 100 flowers, leaves or fruits randomly collected from 10 trees in each olive grove. The samples were brought to the laboratory and placed in black boxes with a small circular opening in which was adjusted a test tube with a small drop of honey diluted and kept at T: 23 ± 2 °C and 12:12 (L:D). All arthropods captured in the field were taken to the laboratory for characterization, being kept in 70% alcohol. Also insects either emerged from the laboratory plant material placed in the black boxes or captured in

traps and removed from them with the aid of a drop of crude oil and brush and were placed in 70% alcohol. All specimens of the class Insecta were classified into orders and families. Our results have been subjected to statistical analysis by a Student's t test ($p \leq 0.05$) in Microsoft Excel.

Results and discussion

The percentage of each class of arthropods captured in Loulé olive grove in all types of traps and vegetable material collected during the four years of the study are shown in Figure 1. In that figure the domain of the class Insecta (74% of the individuals captured) on the remaining arthropod classes becomes clear. This class was followed in decreasing order by Arachnida (15%), Entognatha (8%) and Chilopoda (3%) classes. Regarding the olive grove of Olhão, it is also profound the predominance of class Insecta (69%), followed by Arachnida (20%), Entognatha (8%) and Chilopoda (3%) classes (Figure 2). These results show the importance of arthropods but furthermore the importance of the class Insecta in the agro-system of olive grove. The class Arachnida was represented exclusively by order Araneae (spiders), whose importance in agro-ecosystems is increasingly being recognized due to their predatory habits and subsequent importance as biological control agents of olive pests. Most spiders were captured in pitfall traps and at a much lower rate in the yellow sticky traps. Individuals of the order Collembola (springtails) whose activity is essential for the maintenance of soil fertility through their contribution in the decomposition of organic matter belonged in the Entognatha class. Although mostly captured in the yellow adhesive traps placed horizontally slightly above the soil surface, they were also captured in pitfall traps. Regarding the Chilopoda class centipedes were captured in pitfall traps. These arthropods are known to be carnivores (predators), so that its activity can be important in controlling insect pests which spend part of its life cycle in the soil, such as the olive fruit fly. This insect overwinters in pupal stage in the soil and thus can be a potential prey for centipedes.

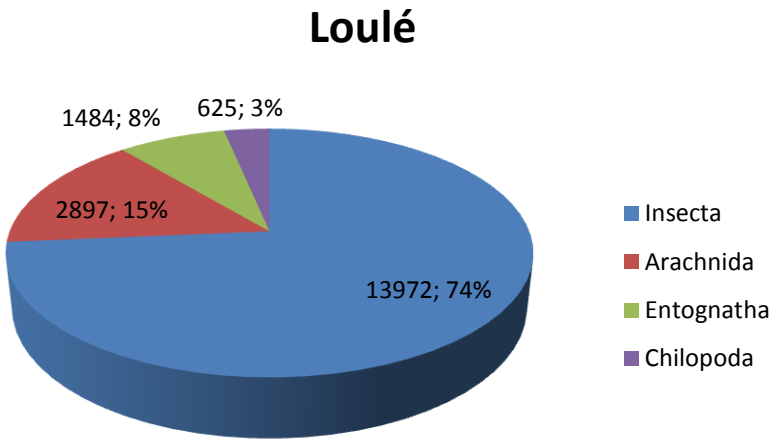

Figure 1. Percentage of total number of individuals that belonged to classes of arthropods captured in all the traps and plant material collected in the olive grove of Loulé, during the four years of the study (from April 2010 to April 2014).

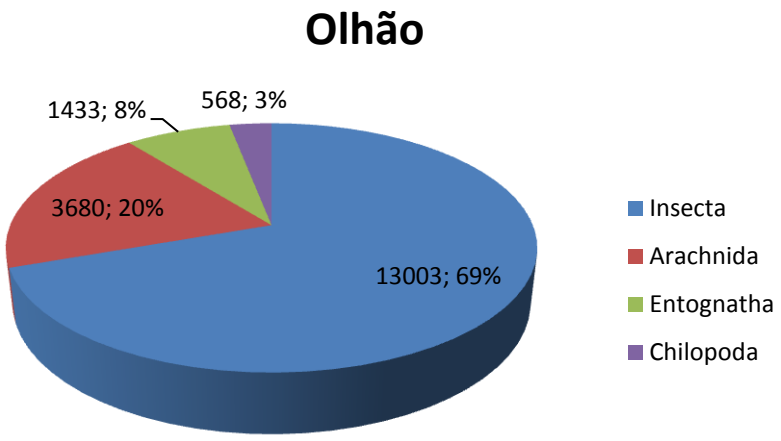

Figure 2. Percentage of total number of individuals that belonged to classes of arthropods captured in all the traps and plant material collected in the olive grove of Olhão during the four years of the study (from April 2010 to April 2014).

In Table 1 are indicated the total numbers of individuals of each order of the class Insecta, captured in the various traps and emerged in the laboratory from plant material collected in each olive grove, during the four years of the study.

Table 1. Total number of individuals (Mean ± SD), by order of the class Insecta captured in all the traps and emerged in the laboratory from plant material collected in each olive grove, during the four years of the study (from April 2010 to April 2014).

	Olive groves		
Order	**Loulé**	**Olhão**	Mean ± SD
Diptera	5,550	4,990	5,270 ± 280
Coleoptera	129	100	114.5 ± 14.5
Hemiptera	150	145	147.5 ± 2.5
Homoptera	1,020	899	959.5 ± 60.5
Hymenoptera	787	677	732 ± 55
Lepidoptera	3,543	3,089	3,316 ± 227
Neuroptera	1,700	1,545	1,622.5 ± 77.5
Thysanoptera	1,093	1,558	1,325.5 ± 232.5
Total	**13,972**	**13,003**	**-**

Taking into account the values shown in Table 1, although in the olive grove of Loulé more insects have been captured, the application of Student t- test revealed no significant differences between the two olive groves ($p = 0.15$). However, in both olive groves studied, it was verified that the most abundant insect orders were the Diptera and Lepidotera, followed by orders Neuroptera, Thysanoptera, Homoptera, Hymenoptera, Hemiptera and Coleoptera.

Regarding these insect orders, the specimens found belonged to the families Tephritidae and Syrphidae; Hyponomeutidae; Chrysopidae; Phlaeothripidae; Coccidae and Psyllidae; Braconidae, Encyrtidae, Eulophidae, Formicidae and Trichogrammatidae; Anthocoridae and Miridae; Carabidae, Curculionidae and Staphylinidae, in each order, respectively.

The main pests belonged to Tephritidae, Hyponomeutidae, Curculionidae, Coccidae, Psyllidae, and Phlaeothripidae families. In the following families belong very important auxiliaries in the biological control of the main pests of olive acting either as predators (Carabidae, Chrysopidae, Curculionidae, Staphylinidae; Formicidae; Anthocoridae and Miridae) or as parasitoids (Braconidae, Encyrtidae, Eulophidae and Trichogrammatidae) (Gonçalves & Andrade, 2012 b; Gonçalves, 2014).

The analysis of our results allows us to conclude that the integrated production mode together with the use of permanent cover crops contributes to high diversity of arthropods in the olive agro-ecosystem. Under the field conditions in which our studies were carried out we have found arthropod specimens of several classes, with those belonging to the class Insecta to be the most abundant. Regarding the Arachnida class in which exclusively spiders were recorded, it should be noted that the practice of soil cover crops either by natural meadow (weeds) or by seeded meadow (seed mixture of leguminous and grasses) and the practice of minimum tillage of soil particularly promote the populations of spiders in agricultural systems. These cultural practices may also be beneficial to the populations of springtails and centipedes which thus will find more food and shelters because the meadows attract a wide diversity of organisms either in the soil or on its surface. These meadows may also be attractive for auxiliary organisms of insect pests such as predators and parasitoids and also for insect pollinators.

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