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Population dynamics of *Euphyllura olivina* Costa, 1857 (Psyllidae: Hemiptera) in olive trees in the semi-arid region of Djelfa (Algeria)

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Abstract. We studied the population dynamics of the olive psyllid *Euphyllura olivina* Costa, 1857 in a semi-arid region (Djelfa, central Algeria) during a year, from December 2017 to November 2018. The visual control approach and the striking method were used to monitor the different stages of this pest. The species had two generations per year: a spring generation from March to June and a fall generation from September to November. The first generation of eggs is laid in March and continues through May. The second generation begins in late August and early September and continues through November. The statistical study of the impact of the researched climatic factors (minimum, maximum, and average temperatures; precipitation and frost) on the various stages differs from one stage to the next.

Keywords: *Euphyllura olivina*, population dynamics, *Olea europaea*, climatic factors, Algeria.

Introduction

Olive cultivation is gradually spreading throughout the world. Several non-Mediterranean countries have developed and tended to this crop in specific regions of their territory in recent years. From the Americas (California, Mexico, Brazil, Argentina, and Chile) to Australia and China, as well as Japan and South Africa, olive-growing worldwide is estimated to cover 8,600,000 hectares-95% of which are located in the Mediterranean basin (Chafaa, 2013).

Average production is 10 million tons a year; of which 92% is dedicated to oil extraction whilst the rest goes for table consumption (Zouiten *et al,.* 2001). Mediterranean countries constitute more than 95% of olive oil production and 90% of its consumption (FAO, 2003).

Recently, countries south of the Mediterranean have showed a significant interest in boosting their olive producing industry through improved yielding techniques.

In Tunisia, olive cultivation has a critical socioeconomic role. It covers an area of about 1.7 million hectares (one third of the total of fertile lands) with a population of 67 million trees, (Dibou *et al*., 2010). In Morocco, constituting 55% of the entirety of trees, the olive tree occupies a central role (MADRPM, 2008). The culture of olive growing occupies a vital and privileged status in Algerian agriculture, with the yield obtained during the last two years (2009-2010) amounting to 13.1 quintals per hectare for all varieties. Furthermore, olive groves cover an area of 178,000 hectares with a production of 300,000 tons per year (Mendil, 2009). The wilaya of Djelfa experienced, for some years, a tremendous rise in olive growing-with olive growing areas going from 150 ha in 2000 to 11000 ha in 2015) (DSA, 2016). Algerian olive growing is characterized by aging trees and / or a lack care for the majority of plantations. This renders the latter vulnerable to alternation-related issues and diseases. We cite the Verticillium (*Verticillum dahliae*), Tuberculosis (*Pseudomonassa vastanoi*). On a similar note, the devastating species that tend to lay havoc on olive wood, foliage, flowers and fruits are as follows: the Otiorhynchus (*Otiorhynchus cribricollis*: Curculionidae: Coleoptera), the Moth (*Praysoleae*; Plutellidae: Lepidoptera), the Olive Psyllid (*Euphyllura olivina*: Psyllidae: Hemiptera), the Olive Fly (*Bactrocera oleae*: Tephritidae: Diptera) and the Purple Scale (*Parlatoria oleae*: Diaspididae: Hemiptera) (Arambourg, 1986;Biche, 1987; Biche, 1988; Zerkhefaou, 1988; Jardak and Ksantini, 1996;11;Chafaa *et al.,* 2013; Chafaa *et al.,* 2017).

E. olivina is a pest found in all olive-growing countries. It preys on new stems and flower clusters. According to Chermiti (1992), an infestation rate of 5 larvae per flower cluster causes a 32% fall of inflorescences and a loss of 46 fruits per 100 clusters. Tajnari (1992) estimated that with a density of 30 larvae/flower cluster, production is entirely compromised. This particular species was first recorded by Costa in 1839 as *Thrips olivina* (Zouiten *et al.,* 2001). Following that, Balachowsky and Mensil (1935) discovered this species on Phyllirea. Arambourg (1985) reported, on the other hand, that *E. olivina* is closely linked to olive trees. However, *Euphyllura phyllirea*, a species extremely similar to *E. olivina*, appears to operate similarly. This makes it often confused with *E. olivina* (Zouiten *et al*., 2001). Several studies have been carried out on the biology and population dynamics of olive psyllids and their natural enemies, notably in Tunisia, Morocco, Algeria, Iran, Italy, the United States of America and Egypt (Chermiti, 1989; Zouiten *et al.,* 2001, Boukir and Mimoun, 2003; Khaghaninia, 2009; Percy *et al.,* 2012, Meftah *et al.,* 2014). These studies came to the conclusion that this biopest has 2 to 6 generations every year, with the ecological characteristics of different locations being the cause of this variation. In Algeria, studies on this pest are very limited- a study in Tizi-Ouzou by (Boukir and Mimoun, 2003) and in Batna (Chafaa *et al.,* 2017).With that said, and considering the olive tree's economic and social value, cultivation has been the subject of research and experimentation for some time, with the goal of improving output. The aim of this study is to investigate the psyllid's dynamics in order to determine the number of generations of this bio-aggressor in the semi-arid bioclimatic stage, as well as to emphasize the effect of climatic conditions on the population of this insect.

Materials and methods

Study area

The Wilaya of Djelfa is located in central Algeria, in the transition zone between the highlands and the Saharan Atlas. The region's climate is defined by cold, harsh winters on the one hand and scorching, dry summers on the other. The experimental orchard was created in 1999 on clay-limestone soil with a surface of 5 hectares that contain 800 relatively homogeneous trees (varieties: Chemlal and Sigoise). The tree heights ranged from 1.5 to 3 meters, with a planting density of 3 x 5 meters. During the study period, the study orchard received no phytosanitary treatment.

Sample collection

Two sampling techniques were used in this study: Visual control and Threshing. Visual control is the most widespread sampling method used in studying the population dynamics of the psyllid. The latter grows, depending on the season, on young shoots, flower buds, and leaves (Laoudi, 2012). It is a generally a non-destructive mean of control, which allows for the possibility of following the evolution of populations of auxiliaries and pests (Reboulet, 1986). Our work consists of making field trips every fifteen days in order to conduct sampling via taking a branch from each direction of the tree at human height with the aid of pruning shears. Our sample consists of 10 trees chosen randomly for each variety (Chemlala, Sigoise), covering the entire surface of the orchard. A total of 40 branches were taken, and were put in labeled paper bags, bearing the date, the direction, and the variety. Samples were taken between December 2017 and November 2018. In the laboratory, observations under a binocular magnifying glass are made in order to examine the different life stages of the insects, as well as their appearance dates, and their peak dates.

Threshing Method: According According to Mcgavin (2007), Frah *et al.* (2015) and Chafaa *et al.* (2017), threshing is a simple method that allows for the simultaneous estimation of pest population and the auxiliaries present on the tree or the branches, whether they are winged or not. In our work, we carried out a threshing on the same trees previously selected in the visual control method—during the same time period and with two trees for each variety. Using a stick, only from top to bottom, we strike a branch on each of the four directions in order recover psyllid adults (male and female). The latter fall on the canvas where they are easily observed and counted; they are then retrieved using a pair of pliers, and are then kept in plastic Petri dishes, labelled with all necessary information such as date, olive variety, and direction. The both methods will be counted together.

Statistical Analysis

Principal component analysis (PCA) was performed to decompose the original matrix into multiplication of loading (environmental factors) and scores (the abundance of the species' larval stages) matrices. PCA is an unsupervised method of model recognition in that no grouping of data is to be known prior to analysis. PCA method explains the maximal amount of variance in the data described by the observed variables based on linear combinations of those groups for the abundance of the species' larval stages samples. Analyses were performed using the software XLSTAT version 5. 03 (2014) for MS Windows.

Results

Population dynamics of Euphyllura olivina

Two generations are present annually, according to research on the dynamics of the *E. olivina* population. The first generation is a spring one that lasts from March to June, and the second is an autumn one that begins in September 2018 and lasts until late November 2018 or early December 2017.

The first generation's egg laying begins in March and lasts until May, whereas the second generation's oviposition begins in late August or early September and lasts until November (Fig. 1).

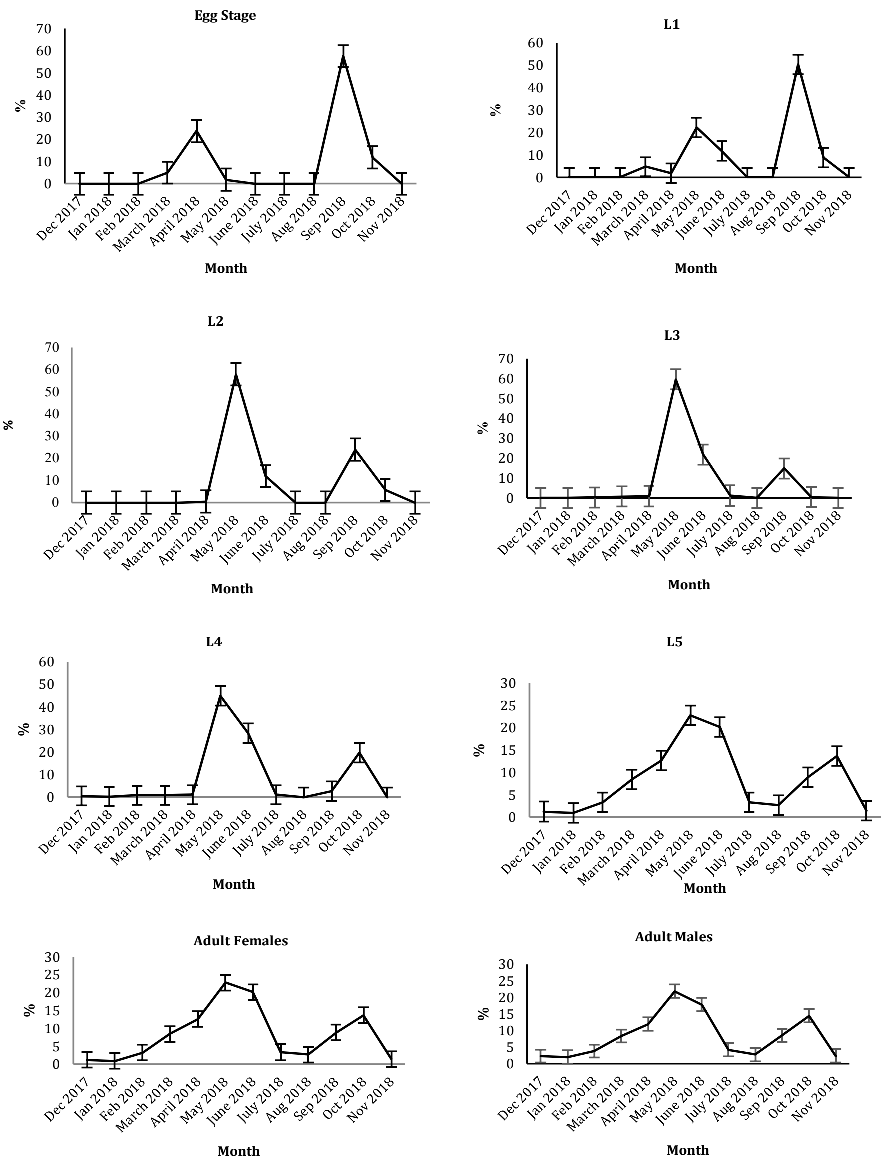

Figure 1. Evolution of the percentages of the different stages of *Euphyllura olivina* in an olive orchard of the semi-arid region Djelfa, Algeria

The first larval stage, for the spring generation takes place between April 2018 and May 2018 and between September 2018 and October 2018 for the fall generation. The second larval stage occurs between May 2018 and June 2018 for the first generation and between September 2018 and November 2018 for the second (Fig. 1). Between April and June for the first generation, and between September and October for the second generation, are when the third and fourth larval stages appear. Beginning in early May and lasting until the end of June for the first generation, and from September until the end of October for the second, the fifth larval stage is visible (Fig. 1). Although adult females are present all year round, they are most frequently seen between March and June for the first generation and beginning in September for the second generation. Between March and June, the males of the first generation leave. When it comes to the second generation, it is seen between September and October (Fig. 1).

The impact of climatic factors on the population dynamics of E. olivina

According to the results of the principal component analysis, the first two axes account for 75.0% of the variation in how climatic conditions affect the species' larval stages. The variance of the F1 axis is 50.96%, whereas that of the F2 axis is 24.03%. Two groups -groups 1 and 2- were determined using PCA. The factorial axes reveal that the eggs, L1, rainfalls (m/m), and T°C together created group 1 (cluster 1). (Mean, min and max) (Fig. 2).

As a result, the cluster records mean wind speed (m/s), as well as the rest of the species' larval stages and adults (L2, L3, L, L5, adult females and adult males). The effect of the climatic *variables considered on the number of different developmental stages of E. olivina* varies from one developmental stage to the next.

While rainfall and T°C had an impact on eggs and the L1 (Mean, min, and max), the influence of these factors was determined to be statistically significant ($r > 0.5$ for all). When other developmental stage phases (L2, L3, L4, L5, adult male, and adult female) are also involved, the effect of the mean wind speed is quite substantial ($r > 0.5$ and P 0.05 for all).

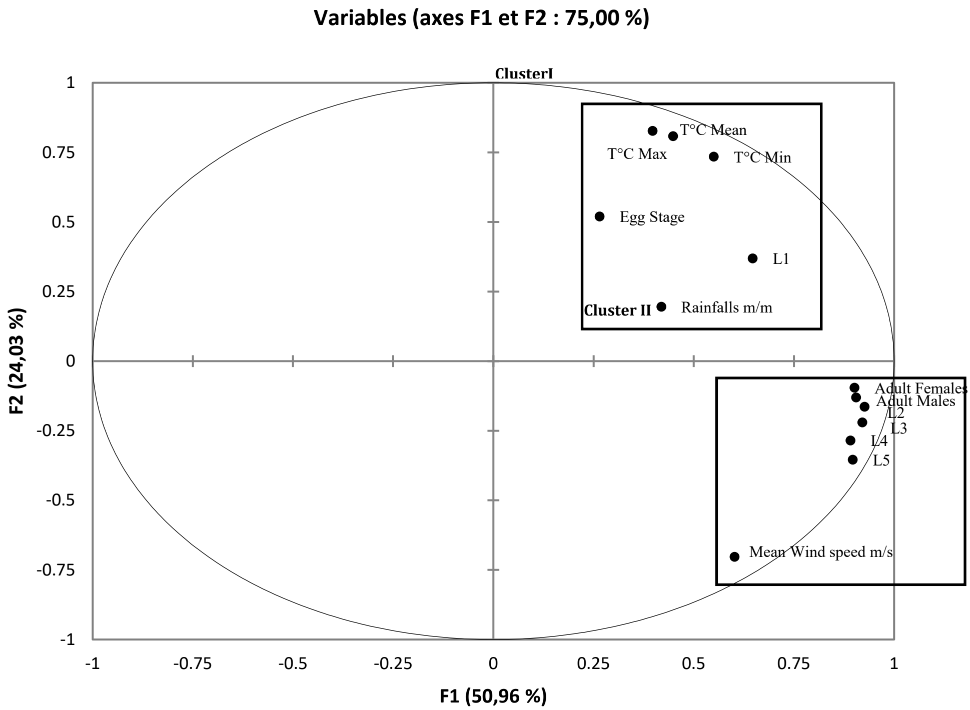

Figure 2. Principal Component Analysis (PCA) illustrating relationship between climatic factors and developmental stage phases

Discussion

This study focused on the question of how life-history traits respond to different climatic s facotrs in *E. olivine.* The *E. olivina* comes in two generations in the Djelfa region: spring and autumn. They hibernate as adult females and males throughout the winter, with larvae of various stages present in small numbers. Eggs are observed in March and September, while first stage larvae emerge in April and September. The first larval stage population peaks in May and September, while the second stage population peaks in late May and late September. The remaining larval stages (L3, L4 and L5) go through several successive molts and become adult females and males in May-June and in October-November.

The rainfalls and temperatures (Mean, min, and max) recorded during this period had an effect on the eggs and L1 stages (P 0.05). The mean wind speed, on the other hand, had a significant impact on the developmental stages of *E. olivina* (L2, L3, L, L5, adult females and adult males) with P 0.05.

These results are consistent with those of Chafaa *et al.* (2017), who claimed that this bio-pest develops in two annual generations in the Batna region (semi-arid climate of northeastern Algeria) and that this psyllid overwinters in several forms with low percentages.

Two generations were recorded by Tajnari (1992) in Morocco's El-Haouz region. The results are similar since this area, in particular, has numerous climatic similarities to Djelfa. The first generation begins to emerge in April and corresponds with the olive tree's budding cycle.Three recurring and one sporadic generations were observed in Tunisia's Sahel area of Sfax (Arambourg,1964;Chermiti,1983;Ksantini, 1997). Two spring generations and one sporadic were reported by Chermiti (1989) in the olive-growing region of the Côte d'Azur coast (France). In Jordan, two generations were recorded by Mustaph (1989).

Generally, three generations of psyllids tend to be the annual norm in many places in olive-growing countries. The first begins in March (Alford, 2014). The second in May, but enters an aestivation period as soon as temperatures exceed 27.2°C (Alford,2014;Johnson, 2009). The third of these generations appears in September and October (Zalom *et al,.* 2014).Our data , however, support the presence of just two generations. This might be explained by the Wilaya of Djelfa's climate, where summer highs reach 30 °C. Different rates are used by adult females to signal their presence throughout the year. Prophetou *et al.* (1976) in Greece, Meftah *et al.* (2014) in central Morocco, and Chafaa *et al.* (2017) in Batna, Algeria all made similar observations.The olive psyllid evolves on *Oleae europaea* in Djelfa throughout the course of a year-long study in two annual generations. Each region's climate has an impact on its dynamics.

Conclusions

The development of a monitoring and control system appears to require a complete understanding of the evolution of the olive psyllid in semi-arid regions of Algeria. In the Djelfa region, the olive psyllid has two generations per year, with oviposition starting in March and ending in June for the first generation. Egg laying for the second generation starts in the first week of September and ends by the end of October or the beginning of November.

The overwintering population is generally made up of adult females and a small proportion of the different stages.

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