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Data on biology and ecology of *Pseudaulacaspis pentagona* (Targioni Tozzetti) (Hemiptera: Diaspididae) on fruit trees in the Peloponnese

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Abstract. The study was conducted in Kalamata, Messinia, province of the Peloponnese, where infestations of *Pseudaulacaspis pentagona* (Targioni Tozzetti) (Hemiptera: Diaspididae) were found on kiwi trees *Actinidia deliciosa* (Actinidiaceae), peach trees *Prunus persica* (Rosaceae) and mulberry trees *Morus alba* (Moraceae). Data on biology and ecology of the scale were recorded by samplings of infested branches of mulberry trees and by examining them in the laboratory, during the years 2016—2018. *Pseudaulacaspis pentagona* is an oviparous and amphigonic species. The fecundity of the scale fluctuated between 97 and 133 eggs per female. In the area of Kalamata it completed 3 generations per year and overwintered as mated pre-ovipositing female. The main natural enemies of *P. pentagona* recorded in the area of Kalamata are the coccinellid predators: *Chilocorus bipustulatus* (L.) and *Rhyzobius lophanthae* Blaisdell.

Keywords: fecundity, natural enemies, predators, *Pseudaulacaspis pentagona*

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Introduction

The scale insect *Pseudaulacaspis pentagona* (Targioni Tozzetti) (Hemiptera: Diaspididae) is a polyphagous species, which originated from Asia (Japan or China) and it is widespread worldwide. It has been recorded in 110 countries on 221 host plant species, belonging to 85 plant families. In many regions of the world, such as in the

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United States of America: Florida, Carolina, Virginia, in Mediterranean coast and adjacent areas, in Asia: Taiwan, it is considered as one of the main insect pests of fruit trees and ornamental plants, causing serious economic damage [1]. It completes 2 to 4 generations per year in several countries, depending on the climatic conditions and the host plant species. Regarding the phenology of *P. pentagona*, the scale completes 2 generations per year in Switzerland [2], 4 generations in northern Florida [3], 3 in Virginia and 3 in Maryland [4], 4-5 in Bermuda [5], 3 in the Mediterranean part of France and Italy [1, 6], 3 in Romania [1], 3-4 in Turkey [1, 7]; 3 in Russia [8] and 3 in Japan [9].

Many natural enemies of *P. pentagona* have been recorded in several regions of the world, such as Hymenoptera of the families Aphelinidae, Encyrtidae, Eulophidae, Halictidae, Signiphoridae, Trichogrammatidae, Diptera of the family Cecidomyiidae, Neuroptera of the family Chrysopidae, Lepidoptera of the families Noctuidae and Arctiidae, Coleoptera of the family Coccinellidae, mites of the families Hemisarcoptidae and Tetranychidae and entomopathogenic fungus of the family Cordycipitaceae [1].

The presence of *P. pentagona* has been recorded in Greece by Balachowsky [10], Paloukis and Mentzelos [11], Paloukis [12, 13] and Argyriou *et al.* [14]. The phenology of the scale has been studied in Northern Greece, in Central Macedonia on peach trees, where 3 generations were recorded per year, according to the male flight monitoring, using sex pheromone traps [15]. The records of the scale in Northern Greece according to the above mentioned studies are presented in figure 1.

Due to the impact of *P. pentagona* as insect pest of fruit trees in many countries, and due to the lack of information on its ecology in Messinia province, Southern Greece (fig. 1), where serious damages were recorded by the scale on several fruit trees, such as on *Actinidiadeliciosa*, *Prunuspersica* and *Morus alba*, it was considered significant to study its phenology, biology and ecology in this area. The knowledge of the above characteristics of any harmful insect is very important to plan an effective Integrated Control Program.

Materials and methods

The study was made on the population of the scale insect *Pseudaulacaspis pentagona* (Targioni Tozzetti) (Hemiptera: Diaspididae) infesting *Morus alba* (Moraceae) in Kalamata, Messinia, province of the Peloponnese, during January 2016 — December 2018.

For the study of the phenology, samples of infested shoots were collected from trees every two weeks and were transferred in plastic bags to the laboratory. The samples were consisted of 10...15 infested shoots having a length of about 10 cm. The samples were examined under the stereoscope and the number of each developmental stage of the scale and the numbers of parasitized and predated scales were recorded.

The total number of each developmental stage and the numbers of parasitized and predated scales were expressed as the percentage,%, of the total number of the scale found per each sampling. As for parasitized, scales containing larvae and nymphs of parasitoids and scales with exit holes of parasitoids were counted. As for predated, scales having damaged scale cover were counted.

The fecundity was studied by counting the total number of eggs found under the scale cover of 25 ovipositing female adults on 20/9/2017.



Fig. 1. Records of *Pseudaulacaspis pentagona*: + – in the provinces of Northern Greece; X – in Messinia province (Southern Greece), during the present study

Results

Pseudaulacaspis pentagona was found in the area of Kalamata infesting kiwi trees *Actinidia deliciosa* (Actinidiaceae), peach trees *Prunus persica* (Rosaceae) and mulberry trees *Morus alba* (Moraceae). It is an oviparous biparental species.

The phenology of *P. pentagona* on *M. alba* in Kalamata during the two year study is presented in fig. 2. As it seems in this figure, the scale completed 3 generations per year, in both years of the study. The peaks of the numbers of the crawlers appeared by the end of April, the beginning of July and the middle of September, in both years (fig. 2a). Later, appeared the settled 1st instar nymphs and the 2nd instar nymphs (fig. 2b). Fig. 2c shows the fluctuation both of the male nymphs of the scale developed under their scale cover and the pre-ovipositing female adults. In fig. 2d, are seemed the three peaks of the ovipositing female adults.

The number of eggs laid per female fluctuated between 97 and 133 eggs and the average fecundity was estimated to 118.5 ± 25.7 eggs per female.

In fig. 3 the percentage of parasitized and predated scales are presented. The parasitism rate reached to 21 % in July of 2016 and to 18 % in August of 2017. It was not possible to identify the ectoparasite species found on the samples. The percentage of predated scales reached to 35 % on 2/8/2016 and to 28 % on 4/7/2017. Individuals of larvae and adults of the coccinellid predators *Chilocorus bipustulatus* (L.) and *Rhyzobius lophanthae* Blaisdell were observed on the examined infested samples during June and September in both years of the study.

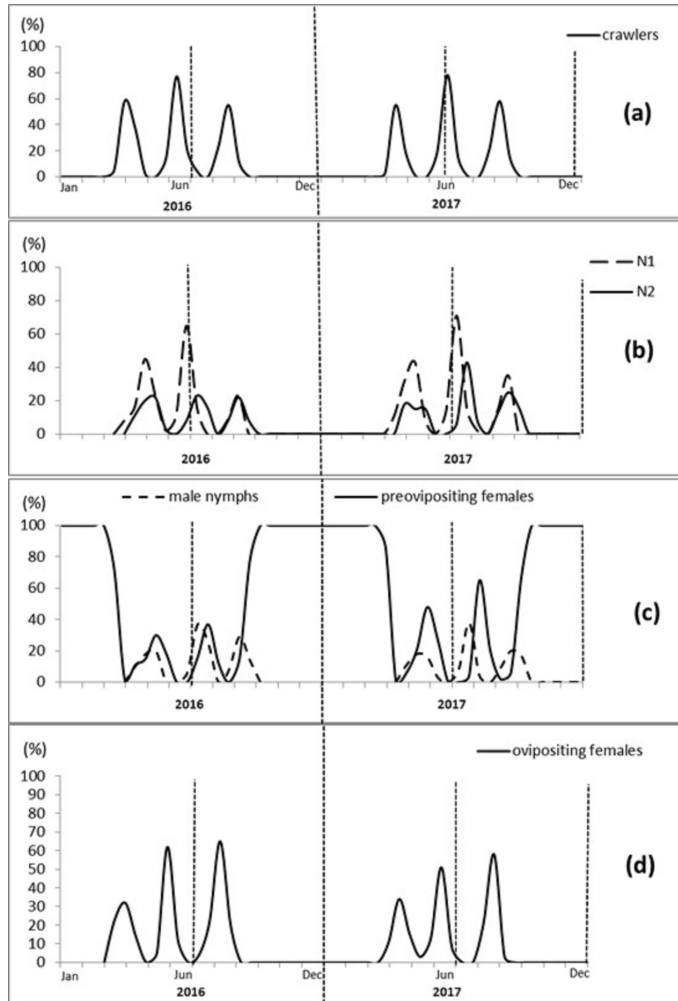


Fig. 2. Percentage of developmental stages of *Pseudaulacaspis pentagona* on *Morus alba* in Kalamata during 2016–2017

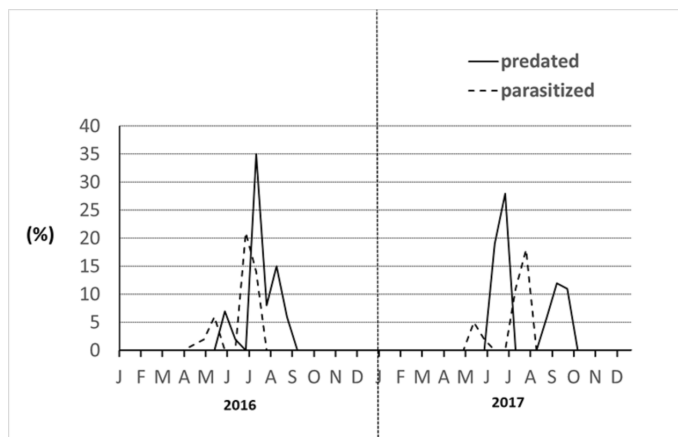


Fig. 3. Parasitized and predated *Pseudaulacaspis pentagona*, %, on *Morus alba* in Kalamata during 2016–2017

Discussion

Pseudaulacaspis pentagona on *Morus alba* completed 3 generations per year in Kalamata during 2016 and 2017. Similar results are referred to other studies of the scale in several countries. In Northern Greece on peach trees [15], in Virginia and in Maryland [4], in the Mediterranean part of France, in Italy and in Romania [1, 6], in Russia [8] and in Japan [9], *P. pentagona* is referred that it completed 3 generations per year. Nevertheless, 2 generations per year referred to in Switzerland [2] and 3–4 generations in Turkey. The above differences in the number of generations per year completed by *P. pentagona* could be attributed to differences in climatic conditions in the areas where the scale was studied. Beardsley & Gonzalez [16] refer that in particular species, the rate of development and the number of generations per year may vary substantially in different regions. Climatic conditions, particularly temperature, humidity, and rainfall, appear to be the principal controlling factors.

As it seems in fig. 2c, the peaks of male nymphs appeared some days earlier than the appearance of preovipositing female adults to all generations of the scale. In the present study the flights of males were not recorded. But the earlier appearance of male nymphs in comparison to the female adults could indicate that male flights (after their development under the scale covers) occurred at the same time as the female adults' appearance. The presence of males in mid-September to mid-October, followed by the presence of adult females in both years of the study, indicates that the scale overwintered as mated female adult. The same way of overwintering (as mated female) is also reported to other countries as well, such as in Japan: Murakami [9] referred that males of the last generation appeared in early November to mate with the females which overwintered.

As far as it concerns the fecundity of *P. pentagona*, Danzing [17, 18] refers that each female lays about 140 eggs and Varga [18, 19] noted that 80...100 eggs were laid per female. The average number of eggs laid per female on *M. alba* in Kalamata found 118.5 ± 25.7 . The number of eggs recorded in the present study, could be considered only indicative of the fecundity. It represents only the number of eggs found under the scales lifting the scale covers at the specific moment of the examination of the samples and not the total number of eggs that the females could give during their whole longevity. To measure the total fecundity of a scale, the females should be examined isolated during their whole longevity, using the micro-cage technique, under controlled conditions in the laboratory [20].

The parasitism of *P. pentagona* recorded to the present study was attributed to an unidentified ectoparasite. Argyriou, et al. [14] recorded the endoparasite *Prospaltella berleseii* Howard (Hymenoptera: Aphelinidae) as natural enemy of *P. pentagona* in Northern Greece. In the bibliography, many endoparasite and ectoparasites of the family Aphelinidae are referred in several countries as the natural enemies of the scale [1]. The predators of the scale found in Kalamata in this study, were the coccinelids *C. bipustilatus* and *R. lophanthae*. These species are referred as natural enemies of *P. pentagona* in other countries as well [1]. In Northern Greece, the predatory species *Chilocoru ssp.* and *Rhyzobius (Lindorus) lophanthae* are referred as predators of *P. pentagona* [14].

The knowledge of biology, phenology and natural enemies of the scales is necessary to plan an effective program of their Integrated Control. The above characteristics

compose the ecology of the scale in a region and they could vary according to the climatic conditions and the host plant species. The present study held in Southern Greece on *M. alba*, gives some additional information about *P. pentagona* that could be useful to control of the scale in the region of Messinia, Peloponnese.

Conclusions

Pseudaulacaspis pentagona infesting *Morus alba* (Moraceae) in Southern Greece (Kalamata) was found to be an oviparous biparental species, completing 3 generations per year. The peaks in crawler numbers of the three generations were recorded at the end of April, beginning of July and middle of September. The differences in voltinism of the scale recorded in other countries (2-4 generations per year) could be attributed to the differences of the climatic conditions of the countries where the scale was studied.

The mean number of eggs of the scale found under the females in September of 2017 was 118.5 ± 25.7 . This number could be considered as an indicative number of the total fecundity of the scale.

The parasitism rate of *P. pentagona* in Kalamata occurred due to the action of an unidentified ectoparasite species reaching to 21 %. No endoparasite was found on *P. pentagona* in Kalamata, as it was found in Northern Greece. In Kalamata, the main natural enemies of the scale were the coccinellid predators *C. bipustulatus* and *R. lophantae*, reaching a percentage of predated scales up to 35 %.

The data presented in this study, concerning phenology and ecology of *P. pentagona*, could attribute to the application of an effective Integrated Control program of the scale in Southern Greece.

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Особенности биологии и экологии *Pseudaulacaspis pentagona* (Targioni Tozzetti) (Hemiptera: Diaspididae), поражающей плодовые деревья на Пелопоннесе

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Аннотация. Исследования были проведены в Каламате (Мессения, провинция Пелопоннес), где были обнаружены поражения тутовой щитовкой *Pseudaulacaspis pentagona* (Targioni Tozzetti) (отряда Hemiptera, семейства Diaspididae) деревьев киви *Actinidia deliciosa* (Actinidiaceae), персика *Prunus persica*

(Rosaceae) и шелковицы *Morus alba* (Moraceae). Данные по биологии и экологии щитовки были собраны путем отбора проб зараженных ветвей тутовых деревьев и исследования их в лаборатории в 2016—2018 гг. Размножается *Pseudaulacaspis pentagona* половым путем, после чего каждая самка откладывает от 97 до 133 яиц. В области Каламата за год развивается 3 поколения *Pseudaulacaspis pentagona*, зимуют оплодотворенные самки. В данном районе основными естественными врагами *P. pentagona* являются хищные кокциnellиды: *Chilocorus bipustulatus* (L.) и *Rhyzobius lophanthae* Blaisdell.

Ключевые слова: плодовитость, естественные враги, хищники, *Pseudaulacaspis pentagona*, тутовая щитовка

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