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**Population dynamics of Psyllidae on pistachio (*Pistacia vera*)
Bioecological data on *Agonoscena pistaciae* Burck. & Laut.
(Homop. Sternorrhyncha)**

Abstract - Among the pests of pistachio orchards in Greece - *Agonoscena pistaciae* Burck. & Laut., *A. cisti* (Puton), *A. targionii* (Licht.) and *Megagonoscena gallicola* (Burck. & Laut.) - the first is economically the most important. *A. pistaciae* appears on the leaves of pistachio from mid April and remains during the whole growing season until the fall of the leaves at the end of November. From mid August onwards the population density increases rapidly causing severe problems in this culture. *A. cisti* appears at the same time as the above mentioned one and remains on the pistachio leaves in small to medium sized populations until the end of July while, in small numbers too, *M. gallicola* is observed from mid July until the end of August. Finally, in the Avlona area (Attica) *A. targionii* was found in one sample only. At the beginning of May the presence of *Chrysoperla carnea* Steph. and *Anthocoris nemoralis* F. and of the parasitoid *Psylleaephagus pistaciae* Ferriere is noteworthy. They are found in satisfactory numbers between the beginning of August and mid-November and play a part in reducing the populations of *A. pistaciae* that is on the point of hibernating.

Riassunto - *Dinamica di popolazione delle Psille del pistacchio (Pistacia vera). Dati bioecologici su Agonoscena pistaciae Burck. & Laut. (Homop. Sternorrhyncha).*

Nei pistacchetti della Grecia, dopo il 1996 si è insediato un nuovo insetto della famiglia Psyllidae, precisamente *Agonoscena pistaciae* Burck. & Laut., mentre erano già noti *A. cisti* (Puton), *A. targionii* (Licht.), *Megagonoscena gallicola* (Burck. & Laut). Tra tutte, grande interesse economico riveste *A. pistaciae*, che si rinviene in natura a metà di aprile, attacca il fogliame restandovi per tutto il periodo di coltivazione, fino alla caduta delle foglie alla fine di novembre; è da notare che dopo la metà di agosto la popolazione aumenta bruscamente provocando seri danni. *A. cisti* è attivo nello stesso periodo e si mantiene nel fogliame in piccole o medie popolazioni sino alla fine di luglio; in ristrette popolazioni, nel periodo metà luglio-metà agosto si osserva pure *M. gallicola*. Inoltre ad Avlona, in Attica, in un solo campione si è trovata ai primi di maggio anche *A. targionii*. Intorno agli Psyllidae del pistacchio è interessante la presenza di predatori, quali *Chrysoperla carnea* Steph., *Anthocoris nemoralis* F. e specialmente del parassita

toide *Psyllaephagus pistaciae* Ferriere, che dai primi di agosto fino alla metà di novembre si trovano in popolazioni soddisfacenti, contribuendo alla diminuzione di *A. pistaciae*, che si avvia allo svernamento.

Key words: *Pistacia vera*, *Agonoscena pistaciae*, *Agonoscena cisti*, *Agonoscena targionii*, *Megagonoscena gallicola*.

INTRODUCTION

Pistachio (*Pistacia vera*) was first cultivated in Greece in 1860 in Attica and later it was established on in the island of Aegina, where it has become one of the main cultures because of the favorable growing conditions it has met there.

Today pistachio is cultivated in many parts of eastern continental and insular Greece. Improvements have been introduced into the culture continually, both concerning its varieties as well as the tending of the crop, to guarantee a high quality produce, since it is a profitable crop with satisfactory yield (Anagnostopoulos, 1935; Boursouvanas, 1980).

The main phytophagous insects in this culture are *Thyrostoma guerini* Stait (Lepid.: Helionidae), *Megastigmus pistaciae* Walker (Hym. Torymidae) and *Eurytoma plotnikovii* Nikolskaia (Hym.: Eurytomidae). *E. plotnikovii* is the most widely spread of the above species (Tzanakakis & Katsogiannos, 1998), as its infestation of the fruit may amount up to 95% of the yield (Anagnostopoulos, 1935). Since 1996 severe infestations caused by insects of the Psyllidae family (Homop.: Sternorrhyncha), have occurred in pistachio orchards in Greece. Poor development of twigs and flower buds, premature falling of the leaves and the production of honeydew on fruits and leaves are characteristic symptoms of this pest (Balachowsky & Mesnil, 1935; Bonnemaison, 1953). Especially in pistachio severe infestations by psyllids may cause a decrease in the yield and in the fruit quality, not only in the year of infestation, but also in the next year (Navrozidis *et al.* 1999; Zartaloudis *et al.* 1996).

As far as the Psyllidae infesting pistachio in Greece are concerned, it is not known which species are most abundant in each region. *Agonoscena targionii* (Licht.) was recently reported as a new pest, as it is considered to cause great damages in North Greece (Zartaloudis *et al.* 1996), where *Agonoscena pistaciae* Burck. & Laut. and *A. cisti* (Puton) have also been found in large numbers (Lauterer *et al.* 1998); *A. pistaciae* and *A. targionii* are very alike (Burckhardt & Lauterer, 1989). Because of their similarity the identification of these species may not have been completely successful (Tzanakakis & Katsogiannos, 1998) and it is thus possible that *A. pistaciae* has been reported as *A. targionii* by several authors (Burckhardt & Lauterer, 1989). Finally, the occurrence of Psyllidae of the genus *Megagonoscena* in pistachio in Greece is likely (Lauterer *et al.* 1998), as is supported by the recent record of *Megagonoscena gallicola* (Burck. & Laut.) on pistachio in central Greece (Souliotis & Tsourgianni, 1999). However, the identity of the Psyllidae occurring on pistachio seems to be equally unclear in other parts of the world, such as in Turkey, where the most common species

is *Agonoscena viridis* Bajava. Apart from that species *A. cisti* has also been found in Turkey on turpentine (*P. terebinthus*) and *A. succinata* Heefer, but it is not clear if the latter really infests pistachio in Turkey (Lodos & Onucar, 1985). In Iraq *A. targionii* is the most frequent species, where it has successive generations from mid May until the end of October (Mahammet, 1989). The same species is also in Sicily (Rapisarda, 1985).

The role of the above psyllid species has not been clarified yet.

The present work started in 1998 and is part of the program "Study on the biology and control of the pistachio psyllid (*A. pistaciae*)" that is financed by the Ministry of Agriculture. The aim of this study is the recording of the species that make up the populations of Psyllidae on pistachio, their population dynamics, biology and behaviour, in order to draw up a program for integrated control of the above pest.

MATERIALS AND METHODS

The survey was carried out in the years 1998-1999 in a pistachio orchard of 450 trees in the area of Anavissos (Attica), characterized by a warm and dry climate, as northern winds prevail during summer and rainfall is scarce. In 1999 the survey was extended to an orchard with 250 trees in the Avlona area, in the north of Attica, characterized by a continental climate with high relative humidity. In both biotopes the trees were 10-12 years old and were well tended (irrigated, fertilized and soil tilled) but no pesticides were applied. The population dynamics of the psyllids was monitored by weekly sampling from the beginning of April until the end of November. The sampling method based on the techniques usually applied in orchards was:

a) the knocking the adults out of the trees by the "frappage" ("beating") method (Burts & Brunner, 1981): 10 trees about the same stage of growth were randomly selected in each biotope and 4 branches per tree ($4 \times 10 = 40$ branches) were sampled. These branches were given two blunt beatings with a stick wrapped in foam rubber and the adults, that fell down on a piece of cloth, 50 x 50 cm, were collected;

b) the recording of eggs and juvenile stages by ocular check. This was done on ten randomly selected trees as well. Four twigs of 15-20 cm ($10 \times 4 = 40$ twigs) were cut per tree, covered in plastic bags and taken to the laboratory, where they were examined under stereo-microscope and eggs and juveniles were counted.

RESULTS AND DISCUSSION

A. pistaciae, *A. cisti* and *M. gallicola* occur in the pistachio orchards in Anavissos and Avlona; in addition, in Avlona *A. targionii* was also found.

In the Anavissos area, more specifically, the population dynamics of the species *A. pistaciae* and *A. cisti*, as measured by the respective numbers of adults, proceeded in a rather similar pattern in both years of the survey (Fig. 1). The adults of both species appear almost at the same time on the new vegetation of the trees early in spring (beginning of April). However, in the growing season the dynamics of their

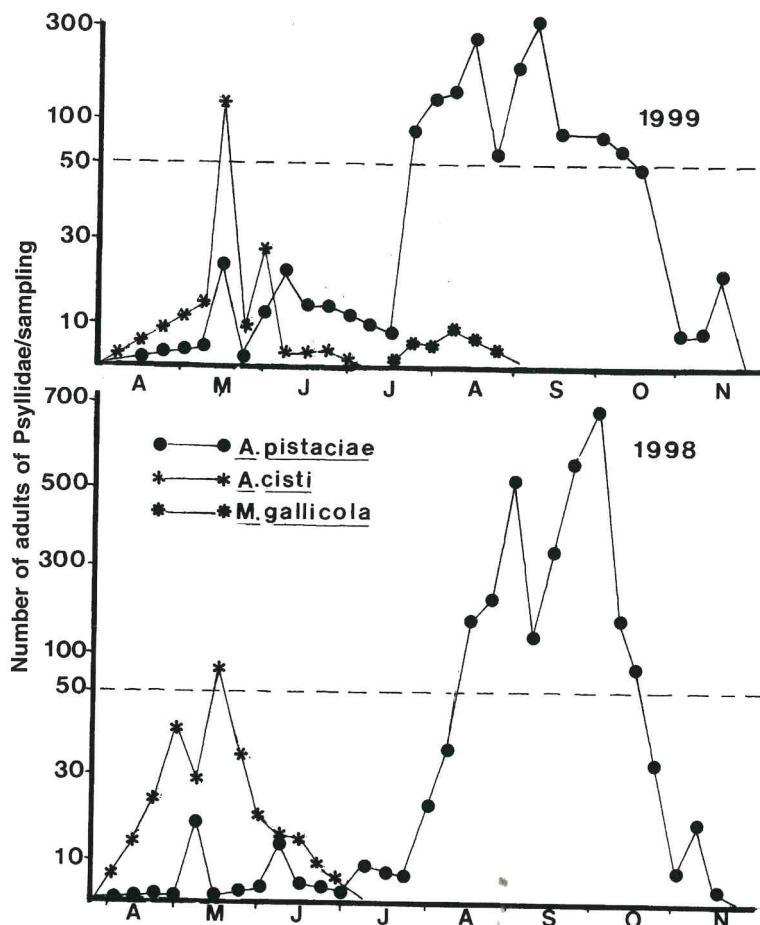


Fig. 1 - Population fluctuation of Psyllidae adults on pistachio, in the area of Anavissos (Attica), during 1998-1999.

populations clearly differ, in such a way that *A. cisti* shows a rapid increase in spring and peaks at the end of May. The insect is present during the whole month of June, its numbers gradually reducing, until disappears completely at the beginning of July. *A. pistaciae*, on the other hand, seems to be able to complete four generations during the growing season, which relate to the four peaks that can be seen in the same figure (Fig. 1). The first two generations develop between begin-April and mid-June, even if in both years of the survey the population density remains rather low during that period. The number of adults subsequently increases rapidly and remains at high levels until mid October, followed by a rapid decrease. At the end of November adults have disappeared at the same time as when the leaves fall in autumn. The adults attributed

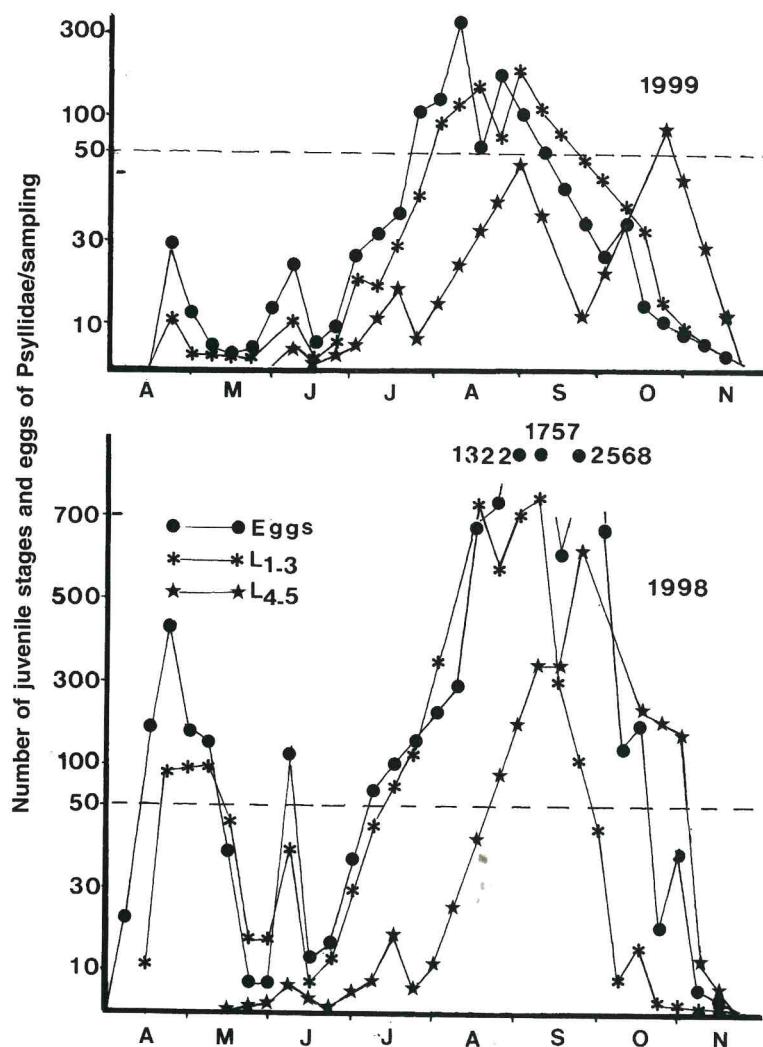


Fig. 2 - Population fluctuation of Psyllidae juvenile stages (nymphs L₁₋₃ and L₄₋₅) and eggs on pistachio, in the area Anavissos (Attica), during 1998-1999.

to the third generation appear when the population density of *A. pistaciae* is high, between the end of July and mid September, while the adults recorded after mid September are attributed to the fourth and last generation. It is likely, that shortly before pistachio sheds its leaves, *A. pistaciae* tries to develop a fifth generation that, however, is not completed. As far as *M. gallicola* is concerned, this was found on pistachio only in 1999. Adults were first observed in mid July and disappeared at the

end of August, their numbers are too low for further comments.

With regard to the densities of nymphs and eggs (Fig.2) the total number of post-embryonic stages (L_{1-3} and L_{4-5}) and eggs collected are considered, because is very difficult the classification of the above mentioned species in those stages.

This figure shows the large concentrations of psyllid eggs on pistachio in the area of Anavissos occurring in spring and in summer, from the end of April until mid May and between the end of July and mid October respectively, while the last egg deposits have been observed late in autumn at the end of November.

The nymphs L_{1-3} begin to appear on the leaves of new vegetation in mid April, about 15 days after the first egg deposits have been made, while during the whole growing season their density follows approximately the same fluctuation as adults and eggs, showing two peaks, the first at the beginning of August and the second at the end of the same month.

The nymphs L_{4-5} appear on the leaves nearly two months after the first egg deposits have been made and show from then onwards a continuously growing density, peaking at the end of September.

Furthermore, Figure 2 shows the exceedingly slow development of the juvenile stages since in spring as well as in summer and autumn the development from egg into nymph L_{1-3} takes at least 15 days and from nymph L_{1-3} into nymph L_{4-5} one to two months, according to the season.

The rapid increase of the population of Psyllidae in the period of August - October is to be attributed exclusively to the species *A. pistaciae*, being the only psyllid remaining on the trees from the end of August onwards (Fig. 1). In that period its female/male ratio highly exceeds 2:1 (Fig. 3).

In 1999 the dynamics of the Psyllidae populations in the Avlona biotope are very

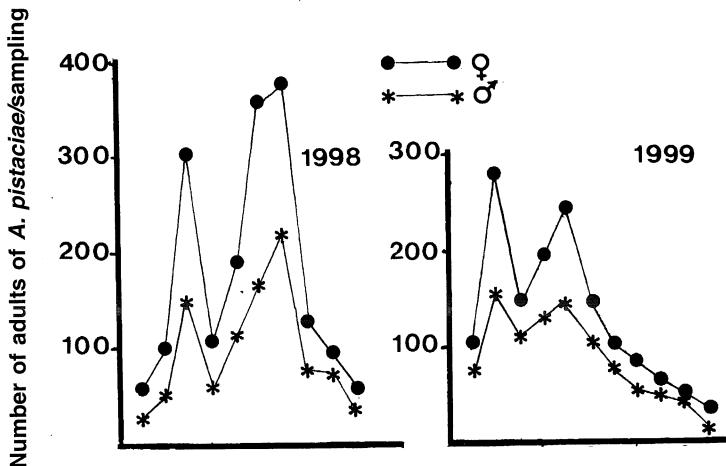


Fig. 3 - Males/females ratio of *A. pistaciae* in the area of Anavissos (Attica) from August till October, during 1998-1999.

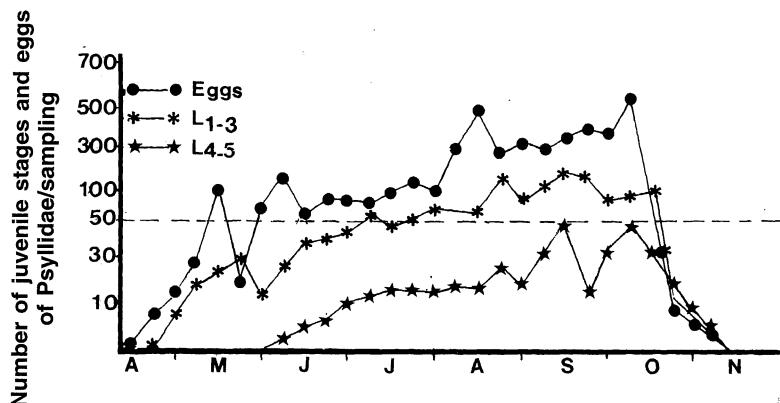


Fig. 4 - Population fluctuation of Psyllidae adults in the area of Avlona (Attica), during 1999.

similar to the previous area, thus confirming the population fluctuation of adults (Fig. 4) as well as of nymphs and eggs (Fig. 5). Contrary to this general impression, it should perhaps be noted that *A. cisti* in the first place and *A. pistaciae* secondly appear in the Avlona area in April - July in lower density as compared to the previous biotope. It is also worth mentioning that, at the beginning of May one more species appeared in the Avlona biotope, *A. targionii*, of which in total 7 adults were found (3 males and 4 females).

As far as nymphs L₁₋₃ and L_{4.5} and eggs are concerned, again no significant differences are apparent between Anavissos and Avlona (Fig. 5), since the first eggs were observed at the beginning of April, the first nymphs (L₁₋₃) at the end of the same

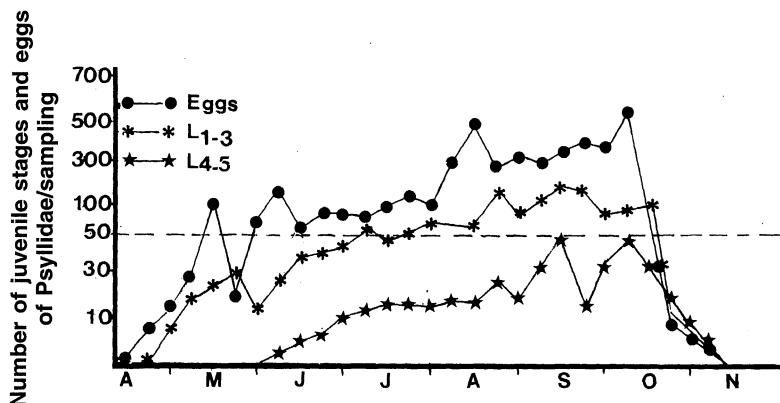


Fig. 5 - Population fluctuation of Psyllidae juvenile stages (nymphs L₁₋₃ and L_{4.5}) and eggs on pistachio, in the area of Avlona (Attica), during 1999.

month and the last nymphs (L_{4-5}) two months later than the first egg deposited by the adults.

From what has been stated it becomes obvious that *A. pistaciae*, as the main factor of this pest, is economically the most important. It should be mentioned, that the presence of insects, occurring in high densities in the pistachio orchards during the period of August - October, plays an important part in the population dynamics of the psyllid.

More specifically *Chrysoperla carnea* Steph. (Neur.: Chrysopidae) and *Anthocoris nemoralis* F (Heter.: Anthocoridae) are concerned as well as a few lady birds (Coccinellidae) while also the endoparasitoid *Psyllaephagus pistaciae* Ferriere (Hym.: Encyrtidae) occurs in considerable numbers. *C. carnea* appears in satisfactory density from the middle of August on, peaking a month later, while it can be encountered until the end of November, when only a few specimens are still found (Fig. 6). *A. nemoralis* appears a few days later than *C. carnea* in equally considerable numbers, being most frequent at the beginning of September. It keeps up high density levels until the end of October, while it disappears a little later in mid November. The Coccinellidae of pistachio probably need not be mentioned specifically, since these occurred in very small numbers and their role in the insect community on pistachio is not yet known.

Finally, *P. pistaciae* in the period between April and July it is not observed at all, while it appears suddenly in great numbers after the first ten days of August, remaining on pistachio until the end of November. *P. pistaciae* seems to have the ability to parasitize a high proportion of the psyllid nymphs occurring on the leaves (Fig. 7). As shown in the same figure, this parasitoid is so highly active after the first days of November, that the ratio of parasitized and survived nymphs of *A. pistaciae* is 1:1. This fact contributes significantly (in addition to the predators already mentioned) to the limitation of the population of *A. pistaciae*, that will go into hibernation.

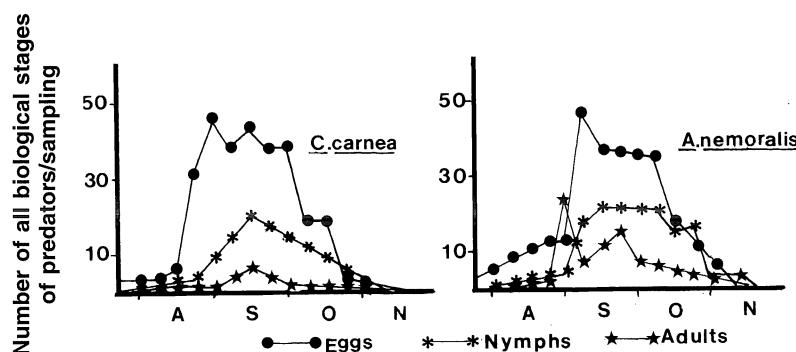


Fig. 6 - Population fluctuation of the predators *C. carnea* and *A. nemoralis* in the period August-November 1999, in the area of Anavissos (Attica).

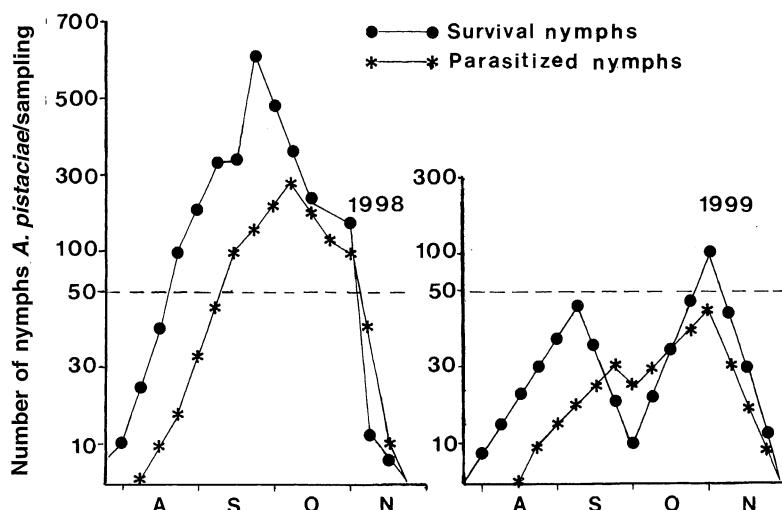


Fig. 7 - Populations fluctuation of *A. pistaciae* nymphs L₄₋₅ and parasitized nymphs by *P. pistaciae*, in the period August-November 1999, in the area of Anavissos (Attica).

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