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FIELD OBSERVATIONS
ON SOME ECO-ETHOLOGICAL ASPECTS OF PHYTOSEIID MITES
IN GREEK CITRUS GROVES

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ABSTRACT: A study was carried out in citrus orchards situated in three regions of Greece—Aegeon, Sparti and Preveza—in order to ascertain the species of predatory mites associated with citrus trees and their population fluctuations. Eleven species of predatory mites (Phytoseiidae) were recorded: *Euseius stipulatus* Athias-Henriot, *Typhloseiulus amaliae* Ragusa, *Typhlodromus athenas* Swirski and Ragusa, *Amblyseius potentillae* Garman = *andersoni* (Chant), *Iphiseius degenerans* Berlese, *Paraseiulus soleiger* Ribaga, *Paraseiulus subsoleiger* Wainstein, *Typhlodromus cryptus* Athias-Henriot, *Kampimodromus aberrans* (Oudemans), *Euseius finlandicus* (Oudemans) and *Phytoseiulus persimilis* Athias-Henriot. The population consisted mainly of the species *E. stipulatus* (more than 80%). The population of *E. stipulatus* showed peaks in June–July for the regions of Aegeon and Preveza and in August for the region of Sparti. It did not exhibit the phenomenon of diapause and all of its developmental stages were represented during the winter. In Aegeon and Sparti the second most frequent species was *T. amaliae*, with 11% and 6% respectively, but in Preveza it was *T. athenas*, with 9% frequency. The other species could be considered as scarce. One species of phytophagous mite, *Tetranychus urticae* Koch, was found. It did not cause extensive damage, since its populations reached a maximum level of 4 mites per leaf.

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The phytophagous mites *Tetranychus urticae* Koch and *Panonychus citri* (Koch) are among the most important pests of citrus in Greece and are, to date, controlled by chemical compounds. In many cases, especially where intensive chemical control is used, the failure of these compounds to maintain the pest population at low levels is due to the development of resistance in phytophagous mites as well as to the reduction in populations of their predators.

The integrated approach to the control of pest populations is based on the application of selective chemicals when the population reaches an economic threshold, combined with the influence of predators, parasites, pathogen micro-organisms, traps, pheromones, etc. Among these, the presence of natural enemies constitutes one of the most important factors in their control.

The species of the family Phytoseiidae are the most important group of natural enemies of injurious mites (McMurtry et al., 1970, McMurtry, 1982). The natural population of predaceous mites together with laboratory reared ones which have been released into the environment, are capable of maintaining a biological balance, especially if selective compounds are chosen for treatments.

Although there are studies concerning the association of phytoseiid mites with citrus trees in Greece (Swirski & Ragusa, 1976, 1977; McMurtry, 1977; Papaioannou-Souliotis, 1981, 1989), little is known about their population fluctuations throughout the year. To improve the integrated pest control program for citrus groves, this study has been undertaken in order to ascertain the following points: a) the species of phytoseiid mites inhabiting citrus-groves; b) ecological aspects and population dynamics of phytoseiid mites, in particular *A. stipulatus*; and c) the relationship between the population fluctuations of predaceous and phytophagous mites.

**MATERIALS AND METHODS**

Mites were collected from three citrus-groves (lemon tree, var. Magglini and Karistini mix) located in the regions of Aegeon, Sparti and Preveza (hereafter abbreviated with the letters A, B and C respectively), in central, southern and north-west Greece respectively. The trees were 20-24 years old and had not been exposed to treatment for at least 8 years.

In each citrus orchard, samples were collected twice a month from 10 randomly chosen trees distributed all over the field. A hundred leaves (10 leaves per tree) were transferred to the laboratory, where mites were preserved in 70% alcohol, cleared in Nesbitt's, mounted in Hoyer's liquid and identified under a phase contrast microscope. All post-embryonic stages were taken into account to define the population composition. Females were checked to ascertain the presence of eggs inside their bodies.

Studies were carried out from 1991 to 1993.

**RESULTS AND DISCUSSION**

The population of phytoseiid mites found in the Greek citrus orchards in this study consisted principally of five species, with *Euseius stipulatus* Athias-Henriot being the dominant, followed by *Typhlodromus amaliae* Ragusa, *Typhlodromus athenas* Swirski and Ragusa, *Amblyseius potentillae* Garman = *andersoni* (Chant) and *Iphiseius degenerans* Berlese, whose frequencies were much lower. Only a few individuals of *Paraseiulus soleiger* Ribaga, *Paraseiulus subssoleiger* Wainstein, *Typhlodromus cryptus* Athias-Henriot,
Kampimodromus aberrans (Oudemans), Euseius finlandicus (Oudemans) and Phytoseiulus persimilis Athias-Henriot were found, and their presence may be considered as accidental.

The *E. stipulatus* population reached levels of 88%, 94% and 80% of the total of phytoseiid mites found during our study for the regions A, B and C, respectively (Fig. 1). This observation together with results of studies carried out in other Mediterranean countries such as Spain (GARCIA MARI et al., 1983, 1984), Italy (RAGUSA, 1986; VACANTE, 1984, 1987), Turkey (MCMURTRY, 1977), Yugoslavia (MUTUSKOVIC & TOMASENIC, 1979) and Algeria (ATHIAS-HENRIOT, 1960), confirm the characterisation of this species as "a predator of warm Mediterranean countries". In Israel, Lebanon and Egypt this species has not yet been observed in natural populations (PORATH & SWIRSKI, 1965; SWIRSKI et al., 1986; DOSSE, 1967; RASMY, 1971; RASMY et al., 1972). Moreover, *E. stipulatus*, imported from Sicily in 1985, has been mass-reared and released in various orchards in Israel, without yet being recovered. In Israel Amblyseius swirskei Athias-Henriot is the most abundant phytoseiid mite, particularly in the coastal plain (PORATH & SWIRSKI, 1965).

In the case of the species *T. amaliae*, although observed on many different plants (PAPAIOANNOU-SOULIOTIS et al., 1994), it seemed to be more abundant in the citrus groves. In the regions A and B its population reached 11% and 6% respectively, whereas in region C it did not exceed 4% and was less abundant than *T. athenas*, which had a frequency of 9%; the latter did not reach 1% in the other two regions.

*A. potentillae* populations showed low relative population densities levels of 0.11% in region B, 1% in region A, and only in region C did it reach 4%. These results are similar to those observed in citrus orchards in Italy (Sicily, Calabria) (RAGUSA, 1986; VACANTE & NUCIFORA, 1987) with the exception of the region of Campagna where this species presented populations equal to those of *E. stipulatus* (VIGGIANI, 1982). On the other hand, *A. potentillae* in peach and apple orchards in northern Greece can be considered as the most abundant and widespread phytoseiid species, where it seems to be important in controlling the populations of the phytophagous *T. urticae* Koch and *Aculus cornutus* Keifer (PAPAIOANNOU-SOULIOTIS, unpublished data).

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**Fig. 1:** Population composition of the most frequent phytoseiid species for the regions of Aegeon (A), Sparti (B) and Preveza (C).
Fig. 2: Fluctuation of phytoseiid species populations for the regions of Argeon (A), Sparti (B) and Preveza (C).
I. degenerans, considered as a common species in the Mediterranean area, reached just 3% in region C and in the other two regions very few specimens were found (Fig. 1). Although RAGUSA (1986) found this species in Sicily at low levels, PARATH & SWIRSKI (1964) reported that in Israel it is much more frequent in the coastal areas than in the interior.

K. aberrans and E. finlandicus, together with the predator Phytoseius finitimus Ribaga, constitute the most important natural enemies of T. urticae in vineyards of region C. Some individuals were found in citrus-orchards of this region, but were not observed in the other two regions. Few individuals of the species P. soleiger, P. subssoleiger and T. cryptus were collected, with more in area C than A.

P. persimilis was found sporadically, despite being artificially released in greenhouses of regions B and C to control T. urticae. Moreover, as far as the citrus-orchards in region A are concerned, we released populations of P. persimilis mass-reared in the laboratory, which have not yet been recovered.

The monthly population fluctuations of the species E. stipulatus, T. amaliae, T. athenas, A. andersoni and I. degenerans, are presented in Fig. 2. Throughout the years of our study only the first species was constantly present. Its populations were always higher than those of the other four, the only exception being in region A where in October 1991 T. amaliae was predominant. Among the three regions the E. stipulatus population in region B was the lowest (0.3 mites per leaf) but most constant throughout the year. A strong storm in July 1991 may be the reason for the significant decrease in its population size; a few days later it started increasing again. Although in the regions A and B this species was more abundant during spring and summer, when it reached levels of 0.8 and 1 mite per leaf respectively, its population never declined to low numbers throughout the rest of the year. The inconsistent population densities observed in the regions A and C are probably due to the frequent rainfall in this part of Greece during spring and summer. It is already known that not only the frequency but also the quantity of rain affect mite populations negatively.

In general, the population fluctuations of this species in Greece do not differ from other Mediterranean countries where it has been studied (RAGUSA, 1986; GARCIA MARI et al., 1984).

As far as the other species are concerned, T. amaliae was more abundant from October to December 1991 and March to May 1992 in region A; from August to December 1991 in region B; and during September 1991 in region C. T. athenas was observed mainly in region C and was more frequent in May, June and mid November. In region C, A. andersoni showed a peak in July and I. degenerans in mid-June.

Since E. stipulatus is the predominant species in our citrus orchards, a study of its population composition was also carried out for regions A and B (Fig. 3). It shows that E. stipulatus seems to be active during the winter as adults of both sexes and young in various developmental stages were found. The largest percentage of juveniles occurs in spring, mainly in May, and in autumn (October–November). In addition, ripe eggs were found in females during the winter months.

Absence of overwintering in E. stipulatus has also been observed in Italy (RAGUSA, 1986). In this respect it behaves like other phytoseiid species of warm countries, such as Euseius hibisci Chant, Amblyseius swirsksi Athias-Henriot, Euseius rubini Swirski and Amitai and Typhlodromus athiasae Porath and Swirski (WYSOKI & SWIRSKI, 1971).

Moreover, in winter we found adult females and males and a few young stages of T. amaliae and A. andersoni in area A, and T. athenas in area C. According to WYSOKI & SWIRSKI (1971), I. degenerans together with T. cryptus are apparently active throughout the year.

The population of the phytophagous T. urticae was maintained at low levels throughout the year (Fig. 5) reaching in mid-June just 4.06 and 2.75 individuals per leaf, respectively, in the regions A and C. In region B its population was kept during the whole year at lower levels than E. stipulatus, with the highest density in January 1992, when it reached 0.33 individuals per leaf. In the three regions, all the developmental stages were found during the winter.

The constant presence of E. stipulatus on the citrus trees even when phytophagous mites densities are low, especially in regions A and B, suggests that this species can use alternative food sources, such as mites belonging to the families Tydeidae and Stigmaeidae, as well as young stages of insects, fungus etc. This
FIG. 3: Composition of the *E. stipulatus* population during the year for the regions of Aegaeon (A) and Sparti (B).
Fig. 4: Fluctuation of tetranychid and phytoseiid mite populations for the regions of Aegeon (A), Sparti (B) and Preveza (C).
may not aid the fecundity of the species, but most likely helps its survival until phytophagous mites are present. This is an important observation as its constant presence on citrus trees renders it a good biological control agent.

Furthermore, we have studied the behaviour of *E. stipulatus* and phytophagous species regarding their preference for the interior or the exterior parts of the foliage. Both pest and predator were found mostly on the interior, at least during the summer period and especially during the warm hours (11.00-13.00) when sampling was undertaken.

**Conclusions**

The results of our study on citrus groves in three regions of Greece can be summarised as follows:
Eleven phytoseiid species were found inhabiting citrus trees. Among them, the most frequent was *E. stipulatus*, with a population consistently higher than those of the other species. *E. stipulatus* has no diapause and during the winter is an active species as all of its biological stages were present. Its highest population densities occur during the warm months (June–August).

Although phytophagous mites were always collected, their low population frequencies throughout the year could be explained by the constant presence of *E. stipulatus* on trees.

These results should aid further investigations concerning the use of *E. stipulatus* in the control of phytophagous mites in citrus orchards.

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