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

BY P. PAPAIOANNOU-SOULIOTIS[1], A. TSAGKARAKOU[1] and M. NOMIKOU[2]

CITRUS
PHYTOSEIIDAE
ECO-ETHOLOGY
GREECE

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.

CITRUS
PHYTOSEIIDAE
ECO-ETHOLOGIE
GRÈCE

RÉSUMÉ : Une étude a été entreprise dans les vergers d'agrumes de trois régions de la Grèce, Aegeon, Preveza et Sparti, pour recenser les espèces d'acariens prédateurs associées aux agrumes et la fluctuation de leur population. Onze espèces de la famille des Phytoseiidae ont été récoltées: *Euseius stipulatus* Athias-Henriot, *Typhloseiulus amaliae* Ragusa, *Typhlodromus athenas* Swirski et 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) et *Phytoseiulus persimilis* Athias-Henriot. La population de prédateurs se compose surtout de *E. stipulatus* (plus de 80%). *E. stipulatus* est plus fréquente en Juin–Juillet dans les régions de Aegeon et Preveza, et en Août dans la région de Sparti. Aucun phénomène de diapause n'a été détecté et tous

[1] Benaki Phythopathological Institute, Ekalis 2, GR-145 61 Kifissia, Athens, Greece.
[2] University of Amsterdam, Krnislaan 320, 1098 SM Amsterdam, The Netherlands.

les stades du développement sont présents en hiver. Après *E. stipulatus*, l'espèce la plus fréquente est *T. amaliae* pour les régions de Aegeon et Sparti (avec 11% et 6% respectivement) tandis qu'à Preveza c'est l'espèce indigène *T. athenas* avec une fréquence de 9%. Les autres espèces peuvent être considérées comme rares. Une espèce d'acarien phytophage, *Tetranychus urticae* Koch, ne provoquant pas des dégâts importants, a été récoltée, ses populations étant limitées au maximum à 4 individus par feuille.

Introduction

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) eco-ethological 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 *Typhloseiulus 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 subsoleiger* Wainstein, *Typhlodromus cryptus* Athias-Henriot,

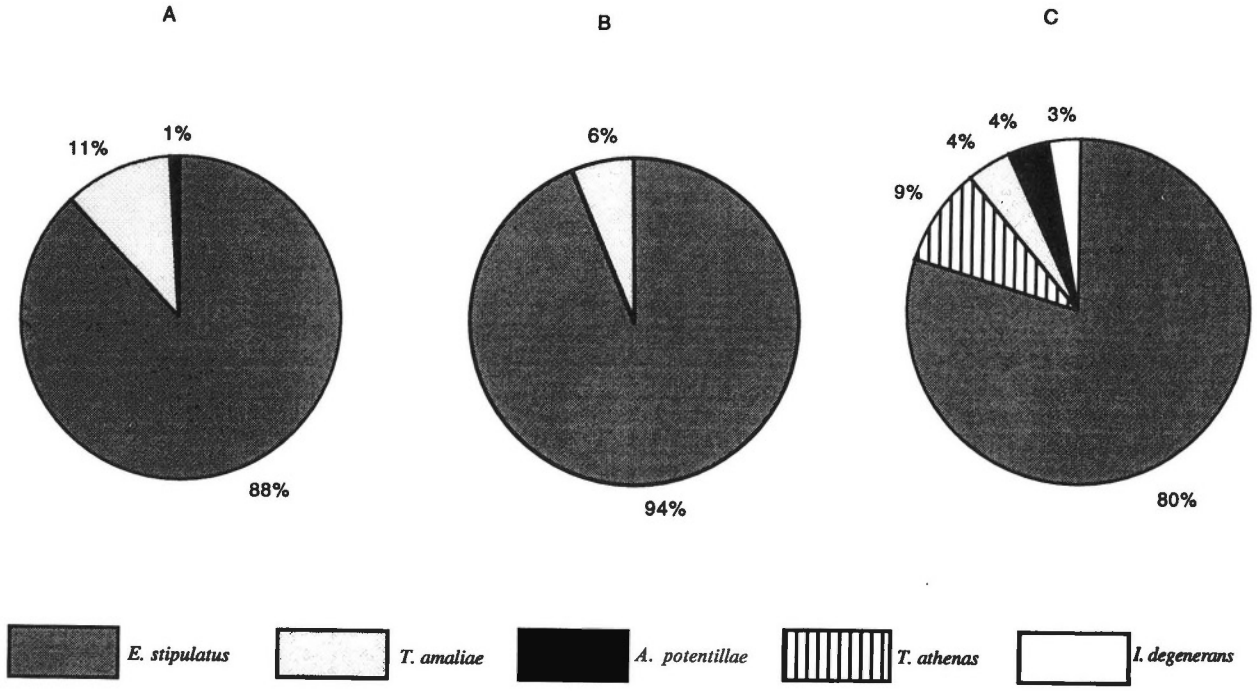

FIG. 1: Population composition of the most frequent phytoseiid species for the regions of Aegeon (A), Sparti (B) and Preveza (C).

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 (MIJUSKOVIC & 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 swirskii* 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).

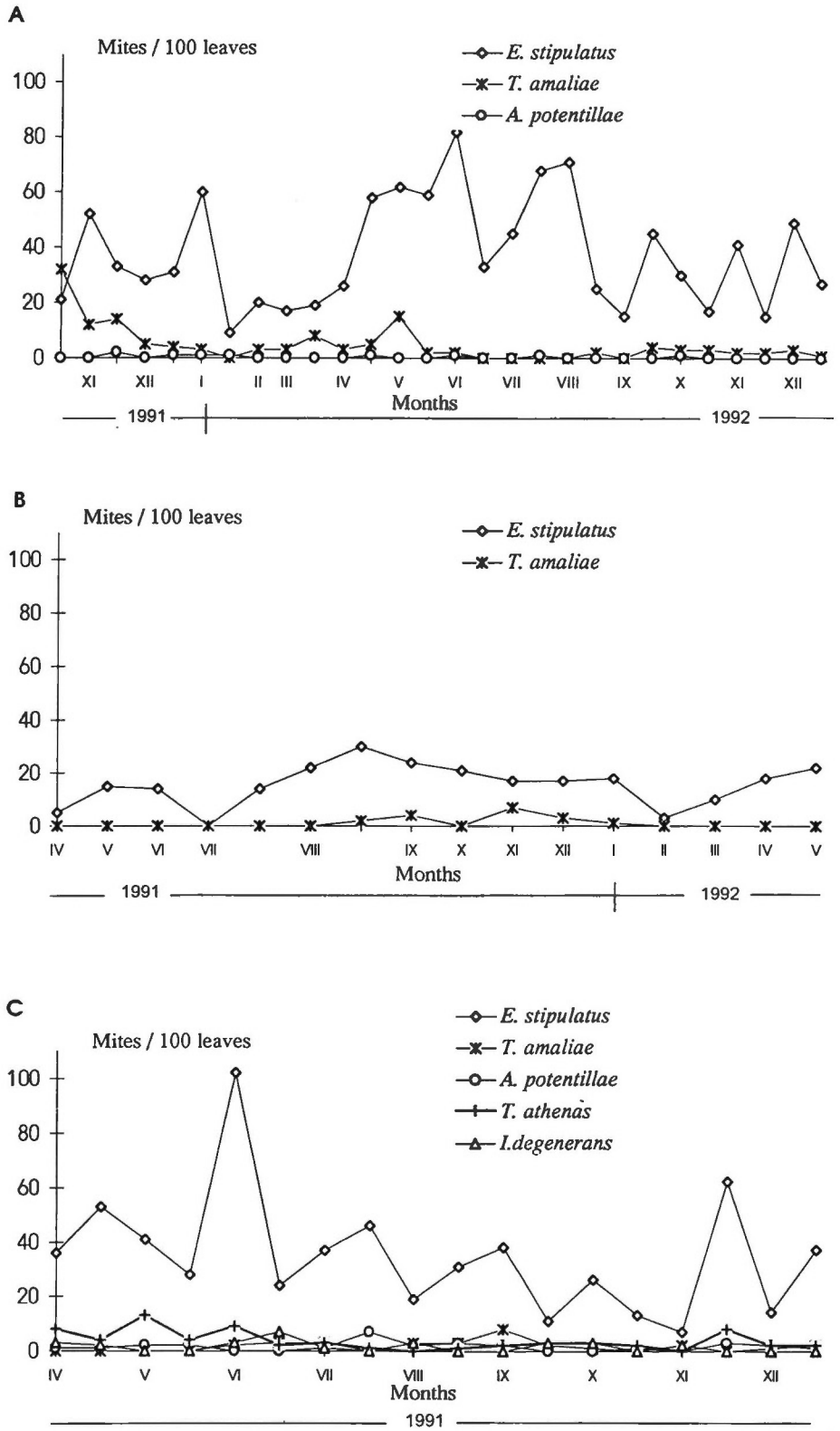

FIG. 2: Fluctuation of phytoseiid species populations for the regions of Aegeon (A), Sparti (B) and Preveza (C).

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. subsoleiger* 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 swirski* 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, well as young stages of insects, fungus etc. This

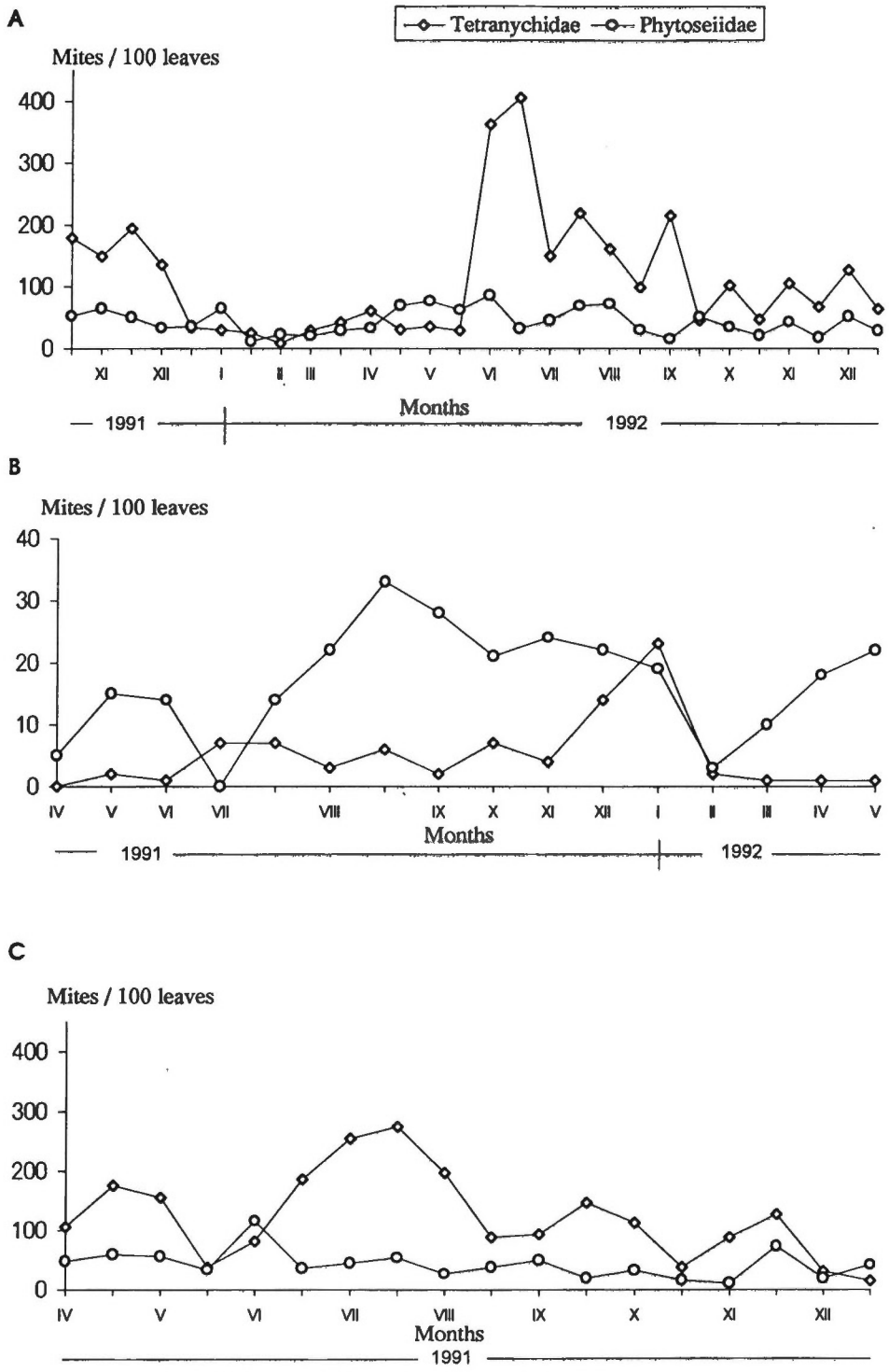

FIG. 3: Composition of the *E. stipulatus* population during the year for the regions of Aegeon (A) and Sparti (B).

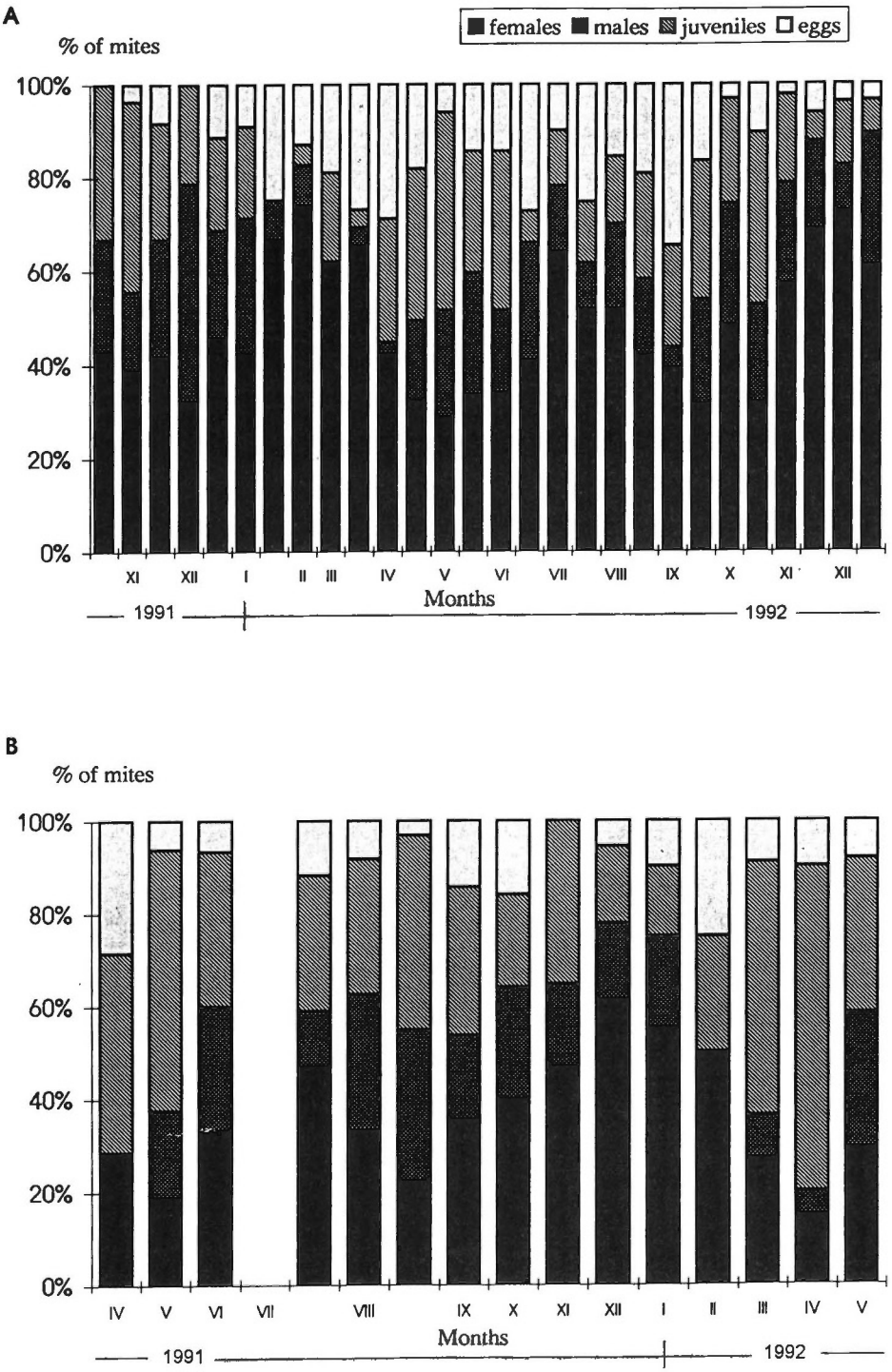

FIG. 4: Fluctuation of tetranychid and phytoseiid mite populations for the regions of Aegeon (A), Sparti (B) and Preveza (C).

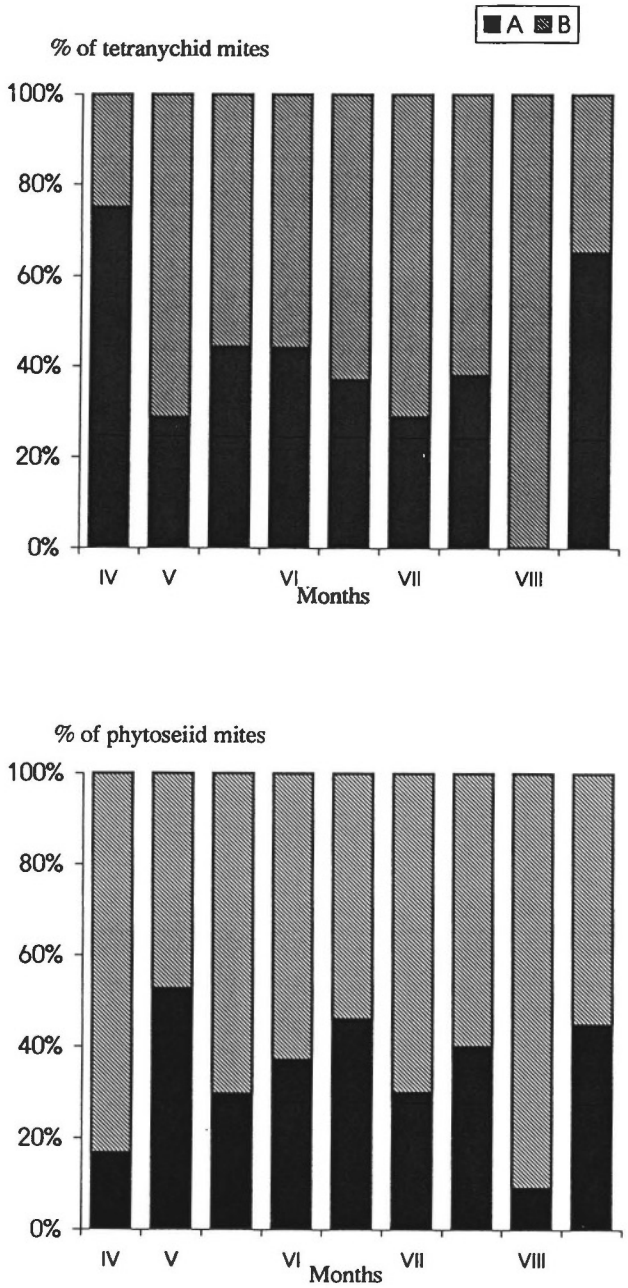

FIG. 5: Distribution of tetranychid and phytoseiid mites in the exterior (A) and interior (B) parts of the foliage for the locality of Aegeon.

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.

ACKNOWLEDGEMENTS

The authors are grateful to R. KARADIMA for her assistance in preparing this paper, and to S. ROOKER, whose comments improved the final version considerably.

REFERENCES

ATHIAS-HENRIOT (C.), 1960. — Nouveau *Amblyseius* d'Algérie. — Acarologia, **2** (3): 288-299.

DOSSE (G.), 1967. — Schadmilben des Libanos und ihre Pradatoren. 3 angav. — Z. angew. Ent., **59** (1): 16-48.

GARCIA-MARI (F.), SANTABELLA (E.), FERRAGUT (F.), MARZAL (C.), COLOMER (P.) & COSTA (J.), 1983. — El acarolojo *Panonychus citri* (McGregor): Incidencia en la problematica fitosanitaria de muestros agrios. — Bol. Serv. Playas, **9**: 191-218.

GARCIA-MARI (F.), FERRAGUT (F.), COSTA-COMELLES (J.) & MARZAL (C.), 1984. — Population dynamics of the citrus red mite *Panonychus citri* (McGregor) and its predators in Spanish citrus orchards. — Proc. Int. Soc. Citriculture, **1**: 459-462.

MCMURTRY (J. A.), HUFFAKER (C. B.) & VAN DE VRIE, 1970. — Ecology of tetranychid enemies. Their biological characters and the impact of spray practices. — Hilgardia, **40** (11): 331-390.

MCMURTRY (J. A.), 1977. — Some predaceous mites (Phytoseiidae) on citrus in the Mediterranean region. — Entomophaga, **22** (1): 19-30.

MCMURTRY (J. A.), 1982. — The use of phytoseiids for biological control: progress and future prospects, pp: 23-28. — In: Recent advances in knowledge of the Phytoseiidae. M. A. Hoy (ed.), University of California, Division of Agricultural Sciences. Berkeley, California.

MIJUSKOVIC (M.) & TOMASEVIC (C.), 1975. — The mites of the citrus trees on the Yugoslav littoral. — Soc. Sci. Art Montenegro, (nat. Sci.) **1**: 203 pp. (In Slavonic).

PAPAIOANNOU-SOULIOTIS (P.), 1981. — Predacious mites (Phytoseiidae) observed on various plants in Greece. — Annls Inst. Phytopath. Benaki, (N. S.) **13**: 36-58.

PAPAIOANNOU-SOULIOTIS (P.), 1989. — Preliminary results of the investigations on the fluctuations of Phytoseiidae mites in citrus-groves in Preveza (Greece). — Proc. Int. Symposium on Biological Control 27-30 November, Antalya-Turkey, 1989: 42-44.

PAPAIOANNOU-SOULIOTIS (P.), RAGUSA DE CHIARA (S.) & TSOLAKIS (C.), 1994. — Phytophagous mites and their predators observed on cultivated plants in Greece during 1975-1990. — Annls Inst. Phytopath. Benaki, (N. S.) **17**: 35-86.

PORATH (A.) & SWIRSKI (E.), 1965. — A survey of phytoseiid mites (Acarina: Phytoseiidae) on citrus with a description of one new species. — Israel J. Agr. Res., **15**: 85-100.

RAGUSA (S.), 1986. — A five year study on population fluctuations of phytoseiid mites in a citrus orchard in Sicily. — Acarologia, **27** (3): 193-201.

RASMY (A. H.), ZAHER (M. A.) & ALBAGOURY (E. M.), 1972. — Mites associated with citrus in the Nile Delta (U. A. R.). — Z. ang. Ent., **70**: 183-186.

SWIRSKI (E.) & RAGUSA (S.), 1976. — Notes on predacious mites of Greece with a description of five new species (Mesostigmata: Phytoseiidae). — Phytoparasitica, **42** (10): 101-122.

SWIRSKI (E.) & RAGUSA (S.), 1977. — Some predacious mites of Greece with description of one new species (Mesostigmata: Phytoseiidae). — Phytoparasitica, **5** (2): 75-84.

SWIRSKI (E.), GOKKES (M.) & AMITAI (S.), 1986. — Phenology and natural enemies of the citrus red mite, *Panonychus citri* (McGregor). — Israel J. Entomol., **20**: 37-44.

VACANTE (V.) & NUCIFORA (A.), 1987. — Gli Acari degli agrumi in Italia. — Boll. Zool. agr. Bachic. Ser.II, **19**: 145-184.

VIGGIANI (G.), 1982. — Effetti collateralli di fitofarmaci su Acari Fitoseiidi degli agrumi. — Atti Giornate Fitopatologiche Sanremo, **3**: 171-179.

WYSOKI (M.) & SWIRSKI (E.), 1971. — Studies on overwintering of predacious mites of genera *Amblyseius* Berlese, *Typhlodromus* Scheuten and *Iphiseius* Berlese in Israel. — Ent. Essays to Commemorate Retirement of Prof. K. Yasumatsu, 265-292.