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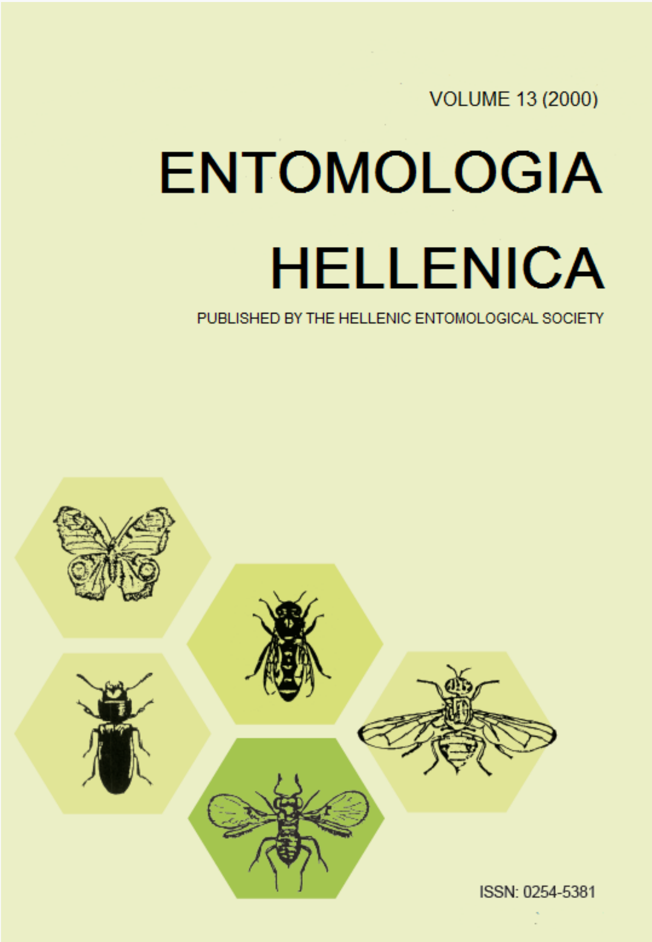

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The Effects of Natural Enemies on Aphid Populations on Processing Tomato in Central Greece[1]

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ABSTRACT

Two species of aphids, *Macrosiphum euphorbiae* (Thomas) and *Myzus persicae* (Sulzer) (Homoptera: Aphididae) were the only ones which developed populations on processing tomato in a two year study conducted in central Greece. The aphid population structure showed that *M. euphorbiae* was much more abundant than *M. persicae* in both years. The former species peaked in August whilst the latter did not show any particular peak over the two successive years. Some species of natural enemies were recorded. *Orius niger* Wolff was found in low numbers scattered over a long period but mainly towards the end of the growing season, and it did not correlate with the aphid population. The rate of parasitism of *M. euphorbiae* by *Aphelinus abdominalis* Dalman and *Praon volucre* (Haliday) was very low and it seemed that these two parasitoid species did not have any particular effect on the aphid population suppression. *Macrolophus pygmaeus* Rambur was the key natural enemy and the most abundant and effective among the predators found. Its highest numbers occurred towards the end of the growing season following the aphid population peak, suggesting a numerical response of this species to its prey. A proportion of the population of *M. pygmaeus* occurring on tomato plants after fruit harvesting, might be collected and subsequently released in crops such as tomato, pepper and eggplant to biologically control pests in greenhouses, like aphids and whiteflies, thus contributing to the production of healthy vegetable products.

Introduction

Several insect pests can attack tomatoes. They include whiteflies, leafminers, aphids, thrips and larvae of Lepidoptera (Lange and Bronson, 1981). Among aphid species, *Macrosiphum euphorbiae* (Thomas), *Myzus persicae* (Sulzer), *Aulacorthum solani* (Kaltenbach) and *Aphis* spp. can colonize tomato plants (Blackman and Eastop, 1985).

Previous studies have shown that *M. euphorbiae* (potato aphid) can develop large populations on processing and fresh market tomatoes in USA and Europe and sometimes cause economic losses (Walker et al., 1984; Walgenbach and Estes, 1992; Walgenbach et al., 1991; Lykouressis and Chalkia, 1994; Perdikis and Lykouressis, 1996). *M. euphorbiae* was more abundant than *M. persicae* in studies carried out in central Greece either on processing or fresh market tomatoes (Lykouressis and Chalkia, 1994; Perdikis and Lykouressis, 1996).

Aphids can attack both processing and fresh market tomatoes and cause direct and/or indirect damage. In processing tomatoes, aphids can damage the plant directly by sucking the plant sap, but also indirectly by virus transmission.

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This paper aimed at the study of species composition and abundance in aphid populations and how those populations are affected by the naturally occurring predators and parasitoids in fields of tomato.

Materials and Methods

This work was carried out in a processing tomato field (cv. H 30) located near Thiva, Co. Voiotia, central Greece, in 1992 and 1993. Aphid populations were estimated on samples taken at weekly intervals starting from the seedling stage until the end of fruit harvesting, May 25 until September 22 in 1992 and May 20 until September 30 in 1993.

Samples were taken from an experimental plot, of 0.2 ha, sited alongside a 2 ha tomato crop. The first sample was taken at the center of the plot and the others 38 m apart down the rows. In both years, on the first three sampling occasions, when the plants were still small, 100 seedlings were taken from the plot. From the fourth sampling onwards, two leaves, one young and one mature-old, both approximately of the same size, were taken from each plant, and hence a total of 100 young and 100 old leaves were collected at each sampling date. At the last sampling occasion in 1992 and at the last three sampling occasions in 1993 only young leaves were collected, since old ones were unsuitable for sampling due to very bad condition because of the late of the season.

Insecticides were not applied in the plot during the cultivation period. Plants were only sprayed by a mixture of the fungicide propineb "Antracol" and a foliar fertilizer (33-0-0) at recommended doses. Also, dusting of plants with sulphur was done in August. Harvesting of the largest amount of fruit took place in the first fortnight of September whilst the remaining fruits were collected in the second fortnight of the same month in both years.

Each leaf-sample was cut off after it had been carefully enclosed in a plastic bag, in order to avoid escaping of insects. Samples were examined under a binocular microscope. Live aphids were collected into preservative fluid (Eastop and van Emden, 1972) and separated into species. Also, aphid mummies were kept in plastic small vials for parasitoid emergence whereas predators were counted and kept for subsequent identification (Wagner, 1952a; Wagner, 1952b; Stichel, 1962; Starý, 1976; Ferrière, 1965; de V. Graham, 1976; Josifov, 1992). Regression analysis was conducted using the statistical package JMP (version 3, SAS Intsitute).

Results

Aphid species. Two aphid species, *M. euphorbiae* and *M. persicae*, were found developing populations on the tomato plants. The seasonal fluctuations are shown in Figs. 1 and 2 for 1992 and 1993, respectively. In both years, aphid population densities of *M. euphorbiae* and *M. persicae*, either for nymphs or adults, were much higher on young than on older leaves (Figs. 1 and 2).

M. euphorbiae was found at much higher population densities than *M. persicae* in both years. *M. euphorbiae* was found almost during the entire growing season and peaked in 1992 and 1993 in August, whilst lower numbers were present in July (Fig. 1).

M. persicae was also found to be present during almost the whole growing season, except September, with low numbers, and peaked in mid-July in 1992 and at the end of May in 1993 (Fig. 2).

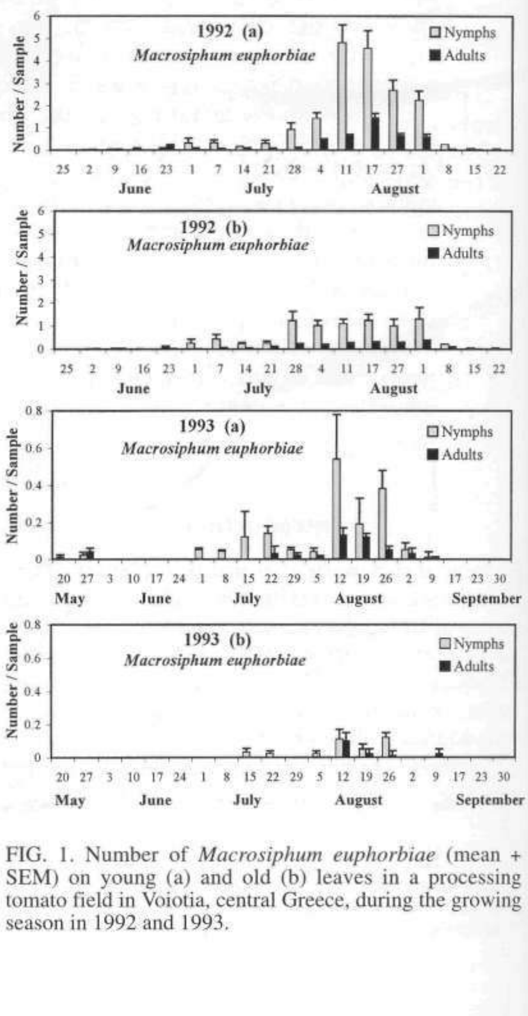

FIG. 1. Number of *Macrosiphum euphorbiae* (mean + SEM) on young (a) and old (b) leaves in a processing tomato field in Voiotia, central Greece, during the growing season in 1992 and 1993.

Natural enemies. The natural enemies found during this study were the predators *Macrolophus pygmaeus* Rambur (Hemiptera: Miridae) and *Orius niger* Wolff (Hemiptera: Anthocoridae). Also some eggs and larvae of Syrphidae and some eggs of Chrysopidae were recorded. The parasitoids, *Aphelinus abdominalis* Dalman (Hymenoptera: Aphelinidae) and *Praon volucre* (Haliday) (Hymenoptera: Aphidiidae) were found.

O. niger appeared in low numbers, mainly as adult, and particularly at the end of the growing season in both years (Fig. 3). A low number of eggs and larvae of Syrphidae was recorded mainly during August (Fig. 4) whilst only very few eggs (17 eggs in total) of Chrysopidae were found in 1992.

The number of mummies of *M. euphorbiae* parasitized by *A. abdominalis* and *P. volucre* was low and recorded mainly towards the end of

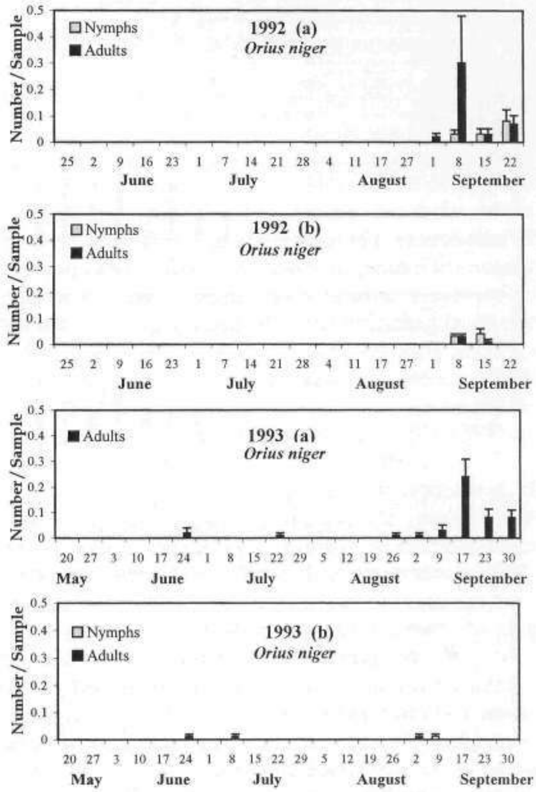

FIG. 3. Number of *Orius niger* (mean + SEM) on young (a) and old (b) leaves in a processing tomato field in Voiotia, central Greece, during the growing season in 1992 and 1993.

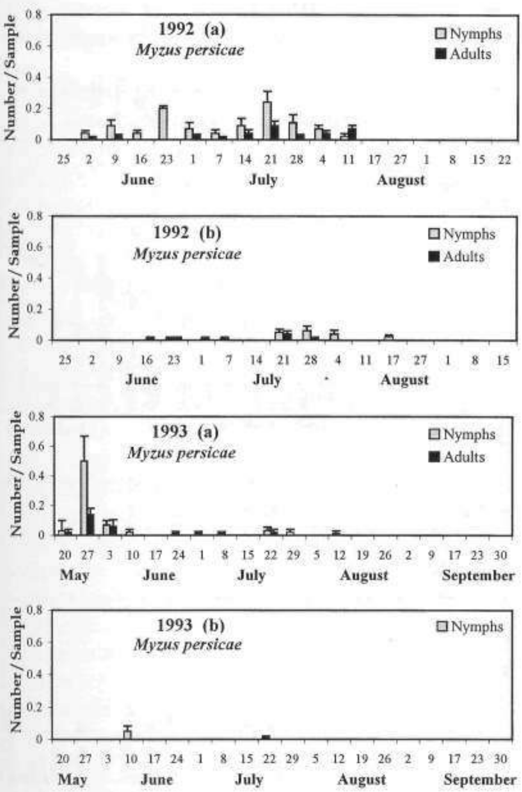

FIG. 2. Number of *Myzus persicae* (mean + SEM) on young (a) and old (b) leaves in a processing tomato field in Voiotia, central Greece, during the growing season in 1992 and 1993.

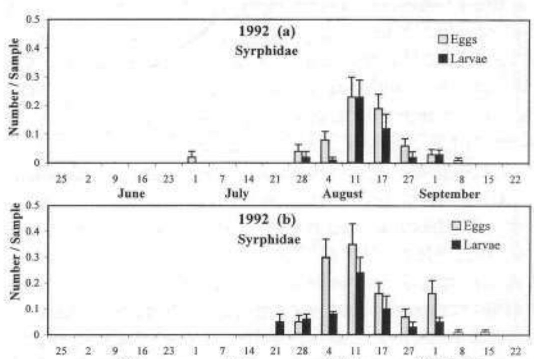

FIG. 4. Number of eggs and larvae of Syrphidae (mean + SEM) on young (a) and old (b) leaves in a processing tomato field in Voiotia, central Greece, during the growing season in 1992.

the growing season (Figs. 5 and 7).

M. pygmaeus was the most abundant predator in both years (Fig. 6). It was present, with very low numbers at the beginning, from almost the mid of the growing season in 1992 and in 1993. Its highest population densities were recorded during August and September and it peaked in September in both years (Fig. 8). Nymphs were

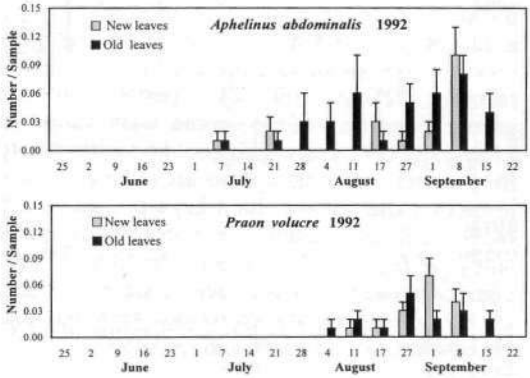

FIG. 5. Number of mummified *Macrosiphum euphorbiae* (mean + SEM) by *Aphelinus abdominalis* and *Praon volucre* on young and old leaves in a processing tomato field in Voiotia, central Greece, during the growing season in 1992.

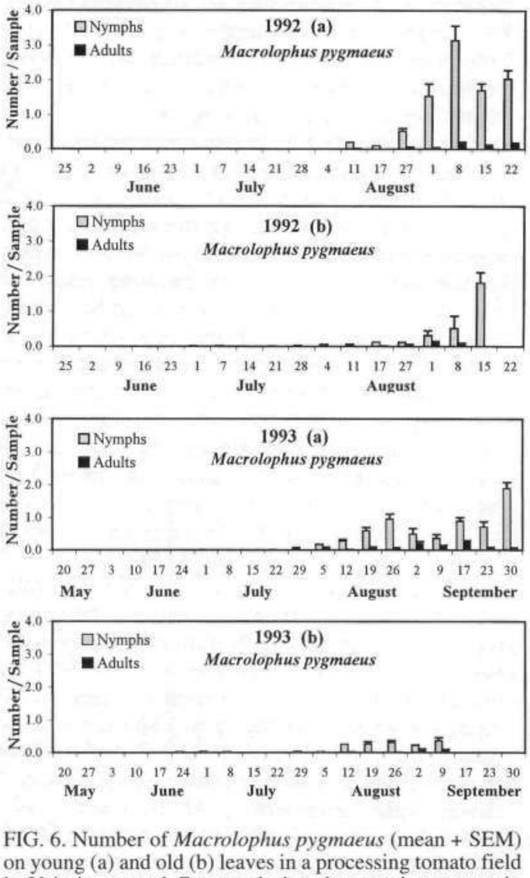

FIG. 6. Number of *Macrolophus pygmaeus* (mean + SEM) on young (a) and old (b) leaves in a processing tomato field in Voiotia, central Greece, during the growing season in 1992 and 1993.

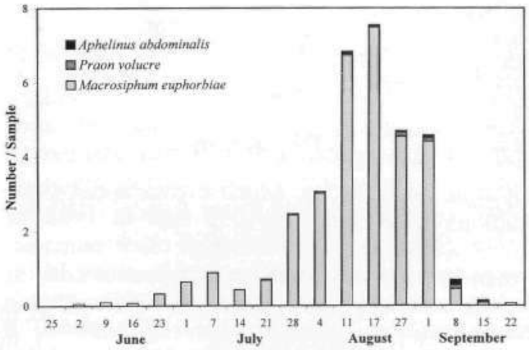

FIG. 7. Number of mummies of *Macrosiphum euphorbiae* per sample by *Aphelinus abdominalis* and *Praon volucre* in a processing tomato field in Voiotia, central Greece, in 1992.

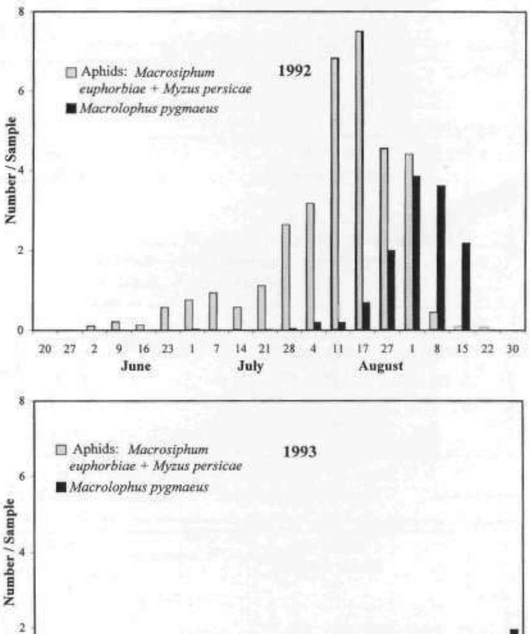

FIG. 8. Seasonal abundance of aphids and *Macrolophus pygmaeus* in a processing tomato field in Voiotia, central Greece, in 1992 and 1993.

always more numerous than adults either on young or old leaves, and the total population densities, of nymphs and adults, were again always higher on young than on old leaves.

Discussion

Aphid populations. Much higher aphid populations were found in 1992 than in 1993. *M. euphorbiae* was considerably more numerous than *M. persicae* in both years of the study. In a similar work by Perdikis and Lykouressis (1996), in a field of fresh market tomatoes (cv. Galill), in Akraifnio Voiotia, *M. euphorbiae* was found again in higher numbers than *M. persicae*, whilst Walker et al. (1984) have also found that *M. euphorbiae* showed large fluctuations on processing tomatoes in Ohio, USA which peaked in August. In this work, the population peak of the potato aphid occurred in August similar to the case on a fresh market tomato field (cv. Galli), near Akraifnio in Voiotia, in the work by Perdikis and Lykouressis (1996). Low numbers of *M. persicae* were recorded in both years whilst the peak did not occur at the same period in each year. Some of the *M. persicae* were alates immigrating into the crop whereas a few first instar nymphs were found. In an earlier work by Lykouressis et al. (1993), conducted in the same field, it was shown that there was not any correlation between alates of *M. persicae* immigrating into the crop caught in yellow water traps and aphid populations on the crop; however, the reverse was found for *M. euphorbiae*. As a consequence, the results of that study and the present one show that tomato plants are more suitable for the development and multiplication of *M. euphorbiae* than *M. persicae*.

Predators. *O. niger* appeared with low numbers mainly at the end of August and September. More individuals of *O. niger* were found on young than old leaves; a few nymphs, much fewer than adults, were recorded which suggests that reproduction and development of this species on processing tomato is very limited. In contrast to the case of *O. niger*, the number of nymphs of *M. pygmaeus* was much higher than that of adults, showing that this species can successfully reproduce and develop on processing tomato. In a work on fresh market tomato (Perdikis and Lykouressis, 1996), *M. pygmaeus* and *O. niger* were found at the same time and followed similar population trends as in the present study. Such predatory species were not found in the study of Walker et al. (1984) where the main biological control agents were parasitoids.

Low numbers of eggs and larvae of Syrphidae were found, yet most of them were recorded in August and this coincided with the peak of *M. euphorbiae* population suggesting a numerical response of Syrphids for oviposition when aphid numbers increase. Chrysopids do not seem to respond in a similar manner as quite a few eggs were recorded scattered over a wider period during the growing season and no larvae were found in samples in both years. This could be attributed to the fact that the tomato plants are not particularly attractive and suitable for Chrysopid species to oviposit. Similar results were obtained from the study on fresh market tomato (Perdikis and Lykouressis, 1996). No coccinellids were recorded, in either years, whilst such species were frequently present on tomato plants in the work of Walker et al. (1984).

Macrolophus pygmaeus. The development of sooty moulds on processing tomato fruits at harvest is considered not so serious as in the case of fresh market tomatoes. However, the development of high numbers of *M. pygmaeus* on processing tomato could greatly help in suppressing aphid populations on fresh market tomato as well as on other crops like eggplant, pepper and green beans since usually those crops grow in fields in close proximity to processing tomatoes in Greece.

The predator *M. pygmaeus* was the most important for suppressing *M. euphorbiae* and *M. persicae* populations among the natural enemies found. High populations of *M. pygmaeus* developed towards the end of the growing season of processing tomato, during August and September, and this seems to be a numerical response to the relatively high aphid population present in August, mainly of *M. euphorbiae*, as no other arthropod prey for this predator was available (Fig. 8). A significant relationship was found between population densities of *M. euphorbiae* and *M. pygmaeus* from the end of July until early September in 1992 when their numbers were relatively high ($r^2 = 0.98$, d.f. = 3, $P < 0.01$) (Fig. 9). That *M. pygmaeus* populations follow a numerical response, mainly to *M. euphorbiae*, is further supported by the fact that *M. euphorbiae* is a suitable prey for *M. pygmaeus* (Perdikis and Lykouressis, unpubl. data) and also that higher numbers of the predator were on young leaves where the largest part of the population of *M. euphorbiae* was found during August and September (Figs. 1 and 6). Even higher numbers of *M. pygmaeus* (10-15 individuals per leaf) were counted during October after fruit harvesting, in other fields of processing tomato in the same area, in both years. However,

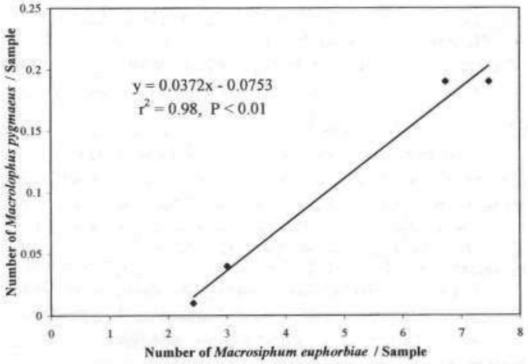

FIG. 9. Linear relationship between the number of *Macrosiphum euphorbiae* and the number of *Macrolophus pygmaeus*, at the period of their population increase, in a processing tomato field in Voiotia, central Greece, in 1992.

the predator did not cause any damage on the plant even when high numbers occurred on the plant.

Parasitoids. In the present study, as in that by Perdikis and Lykouressis (1996), only the parasitoids *A. abdominalis* and *P. volucre* were found to parasitise potato aphids. No *M. euphorbiae* parasitised by *Aphidius* were recorded either in the present work or the work by Perdikis and Lykouressis (1996) whereas in the work of Walker *et al.* (1984) *Aphidius* was one of the three major genera of parasitoids found, the other two being *Praon* and *Aphelinus*. The number of mummies we found was low and taking into account the fact that during August and September the number of *M. pygmaeus* was high, we might suppose that this was a result of interspecific competition between predators and parasitoids in favour of predators compared to the tiny parasitoids. Additionally, some already parasitised aphids could have been destroyed, sucked by *M. pygmaeus*, in this way lowering parasitism rates.

However, a slight difference seems to occur in favour of the mummies found on old than on young leaves in spite of the larger populations of aphids on young as compared to old leaves. A nearly similar situation has been reported by Walgenbach (1994) in which parasitism rates were higher in the middle compared with the upper plant strata. This behavioural characteristic, i.e. that mummification occurs in places other than the initial feeding site, has also been shown for other aphid species (van den Bosch et al., 1962; Powell, 1980; Lykouressis and van Emden, 1983; Messing, 1986; Lykouressis and Mentzos, 1995). Since the majority of predators are found on the upper leaves of tomato plants, the tendency that shows the parasitised aphids to move and mummify on lower leaves, might contribute to slightly higher aphid parasitism rates.

In conclusion, the high numbers of *M. pygmaeus*, occurring towards the end of the growing season, had a vast effect on aphid population suppression. These high numbers, apart from their considerable effect on aphid population management on tomato plants, could also contribute to the management of other pests on other crops. During late autumn and winter, crops of the family of Solanaceae such as tomato, pepper and eggplant are widely cultivated in greenhouses particularly in southern Greece. At that time pests like aphids and whiteflies are frequent on those crops in greenhouses. For the management of those pests the large populations of *M. pygmaeus* occurring either on processing or fresh market tomatoes in the field, a proportion of which will be lost during winter, could be collected by proper devices and maintained for future release into greenhouses. Previous work has shown that *M. pygmaeus* can successfully complete its development (Perdikis and Lykouressis, 1997; Perdikis and Lykouressis, 1999) and reproduce (Perdikis and Lykouressis, unpubl. data) on plants of the family Solanaceae referred to above and therefore *M. pygmaeus* could be transferred and established on those crops.

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KEY WORDS: *Macrosiphum euphorbiae*, *Myzus persicae*, *Macrolophus pygmaeus*, *Orius niger*, tomato, aphids, natural enemies.

Η Επίδραση των Φυσικών Εχθρών στους Πληθυσμούς των Αφίδων σε Καλλιέργεια Βιομηχανικής Τομάτας στην Κεντρική Ελλάδα

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ΠΕΡΙΛΗΨΗ

Στα πλαίσια της εργασίας αυτής μελετήθηκαν η σύνθεση και το ύψος των πληθυσμών των αφίδων και των φυσικών τους εχθρών σε καλλιέργεια βιομηχανικής τομάτας στην περιοχή Βάγια Βοιωτίας. Για το σκοπό αυτό λαμβάνονταν δείγματα νέων και ώριμων φύλλων από φυτεία βιομηχανικής τομάτας ποικιλίας Η 30 κατά τις καλλιεργητικές περιόδους των ετών 1992 και 1993. Τα αποτελέσματα έδειξαν ότι γενικά οι αριθμοί των αφίδων και των φυσικών εχθρών τους ήταν υψηλότεροι στα νέα από ότι στα ώριμα φύλλα. Τα είδη αφίδων που ανέπτυξαν πληθυσμούς επί των φυτών ήταν τα *Macrosiphum euphorbiae* (Thomas) και *Myzus persicae* (Sulzer). Οι πληθυσμοί του *M. euphorbiae* ήταν πολύ υψηλότεροι από αυτούς του *M. persicae* και κατά τα δύο έτη της μελέτης, παρουσιάζοντας μέγιστο κατά τη διάρκεια του Αυγούστου. Οι φυσικοί εχθροί που βρέθηκαν ήταν τα αρπακτικά *Macrolophus pygmaeus* Rambur (Hemiptera: Miridae) και *Orius niger* Wolff (Hemiptera: Anthocoridae), καθώς και είδη των οικογενειών Syrphidae και Chrysopidae. Επίσης, σημειώθηκαν τα παρασιτοειδή *Aphelinus abdominalis* Dalman (Hymenoptera: Aphelinidae) και *Praon volucre* (Haliday) (Hymenoptera: Aphidiidae). Ακμαία και νύμφες του αρπακτικού *M. pygmaeus* βρέθηκαν σε υψηλούς πληθυσμούς κυρίως κατά τη διάρκεια του Αυγούστου και του Σεπτεμβρίου, η δε ανάπτυξη του πληθυσμού του ακολούθησε αυτή των αφίδων γεγονός που υποδηλώνει την αριθμητική αντίδραση του αρπακτικού στην αύξηση της πληθυσμιακής πυκνότητας της λείας του. Το *O. niger* βρέθηκε σε πολύ μικρούς πληθυσμούς κυρίως προς το τέλος της καλλιεργητικής περιόδου ενώ το μεγαλύτερο ποσοστό του πληθυσμού του αποτελείτο από ακμαία. Πολύ μικρός αριθμός ωών και προνυμφών Syrphidae και Chrysopidae βρέθηκε κατά τη διάρκεια των δειγματοληψιών, κυρίως κατά τον Αύγουστο. Το *M. pygmaeus* φαίνεται να αποτελεί τον κυριότερο παράγοντα βιολογικής αντιμετώπισης των αφίδων επί της βιομηχανικής τομάτας στην περιοχή αυτή. Επειδή δε παρατηρήθηκαν υψηλοί πληθυσμοί του κατά το τέλος της καλλιεργητικής περιόδου θα μπορούσε, ίσως, ένα μέρος τους να συλλεγεί και να χρησιμοποιηθεί για αντιμετώπιση των αφίδων κυρίως σε καλλιέργειες υπό κάλυψη.