

Seasonal phenology and relative preference of *Closterotomus (Calocoris) trivialis* (Hemiptera: Miridae) on olive, citrus and associated host plants in the field

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Abstract The seasonal appearance and population abundance of nymphs and adults of *Closterotomus trivialis* (Costa) were studied by weekly canopy shaking samplings in an olive and a citrus orchard in Chania, Greece, from January to May 2009. In addition, samples were taken from weeds referred to in the literature as alternative host plants for *C. trivialis*. Results showed that nymphal instars of *C. trivialis* were first recorded on weeds in mid-January. The first adult appearance was recorded on *Mercurialis annua* L. in early March in the citrus orchard, while in the olive orchard, it was recorded 13 days later. A significantly higher population of *C. trivialis* under field conditions was found on *M. annua* followed by *Urtica* sp., *Parietaria officinalis* L. and *Sinapis alba* L. Population density on olive (*Olea europaea* L.) and sweet orange (*Citrus sinensis* (L.) Osbeck) trees as well as on *Sonchus oleraceus* L. and *Malva sylvestris* L. was very low in general. Collected information on host plant preference of *C. trivialis* may be helpful for the prediction of its occurrence and movement among crop and non-crop host plants and therefore in the

development of appropriate control strategies, thus avoiding unnecessary insecticidal treatments.

Keywords *Closterotomus* (= *Calocoris*) *trivialis* · Host plant preference · Seasonal appearance · Population abundance

Introduction

The phytophagous plant bug *Closterotomus* (= *Calocoris*) *trivialis* (Costa) (Hemiptera, Miridae) is widely diffused in the Mediterranean region. It is a polyphagous species commonly recorded on olive (*Olea europaea* L.), citrus, apricot (*Prunus armeniaca* L.) and peach (*Prunus persica* (L.) Batsch), as well as on several weeds such as *Urtica* sp., *Parietaria officinalis* L., *Mercurialis annua* L., *Sonchus oleraceus* L., *Smyrnum olusatrum* L., *Sinapis alba* L., *Medicago sativa* L., etc. (Barbagallo 1970; Yamvrias 1998; Gerakaki et al. 2007).

Nymphs and adults of the insect prefer feeding on young shoots, buds and flowers of the host plants. On olive trees they prefer the inflorescence buds (between the 54th and 59th phenological growth stages, according to Sanz-Cortés et al. (2002), BBCH scale) and flowers, which results in premature dropping. On citrus they prefer feeding on the young stems, buds [51st–59th phenological growth stages according to Agusti et al. (1997), BBCH scale] and flowers, which may also lead to the abortion of damaged tissues.

The damage potential of *C. trivialis* on olive, orange and other *Citrus* spp. has been reported in Italy (Barbagallo 1970; Monaco 1975) as well as on olive in certain areas of central Greece, Corfu and the western Peloponnese, where it has been reported to cause reduced fruit setting on olive trees (Yamvrias 1998). However, the severity of the

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damage caused by this insect in Greece has not been clear. Drosopoulos (1993) investigated the damage potential of *C. trivialis* on olive and concluded that the damage to olive crops was insignificant. Perdakis et al. (2009) also demonstrated that while *C. trivialis* is capable of inducing damage on the fruit setting of olive trees, this did not cause significant damage in citrus (Perdakis et al. 2010).

Although high population densities for *C. trivialis* have been recorded in early and mid-spring in olive and citrus orchards in western Crete, damage of limited economic importance has been reported only locally and occasionally (Gerakaki et al. 2007). However, the presence of high numbers of *C. trivialis* in Cretan olive groves leads many growers to spray with organophosphate insecticides in the early spring.

The present study was instigated in order to investigate why the appearance dense populations of *C. trivialis* in olive and citrus orchards frequently does not result in significant economic damage and to provide more precise knowledge on the bioecology of *C. trivialis* in western Crete. The outcome will assist in the development of appropriate integrated pest management (IPM) control strategies against this insect and can be used to support efforts to avoid unnecessary insecticidal sprayings.

The objectives of this study were to investigate the seasonal appearance and abundance of *C. trivialis* nymphs and adults on olive, orange and associated host plants in the field, as well as to identify host plants with the highest abundance of the insect, in order to contribute to integrated management guidelines for this pest.

Materials and methods

This study was conducted in two orchards: one with olive trees and one with sweet orange trees [*Citrus sinensis* (L.) Osbeck] located in the Chrysopygi and Mody areas respectively, in the Chania prefecture of western Crete. The orchard in Chrysopygi consisted of 150 olive trees of the ‘Tsounati’ variety and 100 olive trees of the ‘Koroneiki’ variety. ‘Koroneiki’ is the most commonly cultivated variety in Greece, used for olive oil production and mainly planted at lower elevations, while ‘Tsounati’ is also an oil-producing variety mainly cultivated in the highlands of Chania, up to 750 m above sea level. The orchard in Mody consisted of 86 sweet orange trees cv. ‘Washington Navel.’ No insecticide sprayings were applied in the orchards during the study period.

In order to estimate the seasonal dynamics and population abundance of *C. trivialis*, 18 weekly samplings were taken between 8 January and 14 May 2009. In each sampling 15 trees were randomly selected, from ‘Washington Navel,’ ‘Koroneiki’ and ‘Tsounati’ trees. From each tree,

one twig, about 20 cm in length, containing ten shoots on average, was randomly selected and individually shaken above a rectangular plastic tray (50 cm × 40 cm). On each sample date, the number of *C. trivialis* on twigs, the developmental stages as well as the phenological growth stage of each twig were recorded. Samplings were made at the phenological growth stages of: bud, leaf and shoot development (BLSD), inflorescence emergence (IE) and flowering (F).

Additionally, in order to determine the population abundance of *C. trivialis* on various host plants, samples were taken from weeds referred to in the literature as being alternative hosts for *C. trivialis*. For this reason various weed species surrounding the citrus and olive orchard were surveyed in each sampling. Fifteen randomly selected plants per weed species, growing under the tree canopy, were collected and individually shaken above a plastic tray (50 cm × 40 cm), as described above. On each sample date, the number of *C. trivialis* on weed host plants, the developmental stages and the phenological growth stage of each plant (BLSD, IE and F) were recorded. Plants surveyed included *Urtica* sp., *P. officinalis*, *M. annua*, *S. oleaceus*, *Malva sylvestris* L. (Malvaceae) and *S. alba*.

The number of nymphs and adults per plant or twig recorded on olive, sweet orange and weeds from each orchard was analyzed using one-way analysis of variance (ANOVA), with the factor being plant species. Data were $\log(x + 0.5)$ transformed before the analysis. When significant variation was noted, the differences were identified by the Tukey–Kramer significant difference test. Analyses were conducted using the statistical package JMP 7.0.1 (SAS Institute 2007).

Results

Seasonal phenology and relative abundance of *C. trivialis* on olive trees and associated host plants in the field

Data on the seasonal appearance and abundance of *C. trivialis* nymphs and adults on olive and associated weeds during the sampling period are shown in Fig. 1.

Nymphs of first and second instars of *C. trivialis* were first observed on *M. annua* plants in mid-January in the olive grove (Fig. 1a). Hatching continued till the 2nd week of April, as nymphs of first and second instars were observed until then. Adults were first observed in mid-March on *M. annua* and *Urtica* sp. (Fig. 1b). On olives, *C. trivialis* nymphs were first observed in the 3rd week of February (Fig. 1a), while the first observation of adults was made in mid-April (Fig. 1b). The *C. trivialis* population gradually increased from early February and by mid-May

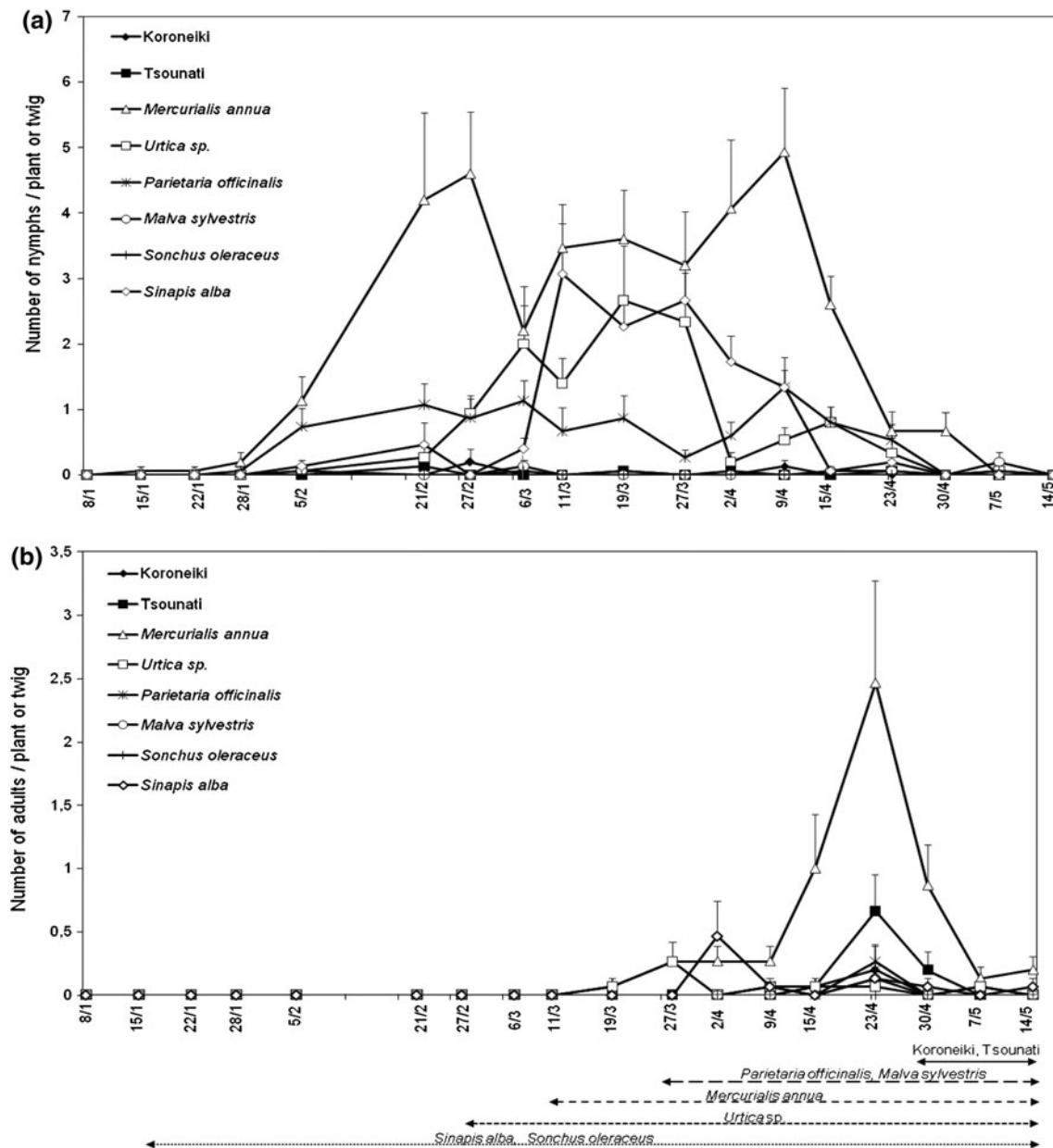


Fig. 1 Mean number ($\pm$ SE) (15 plants/host plant/week) of *C. trivialis* nymphs (a) and adults (b) recorded in samples from olive trees and different weed host plants in 2009 in Chrysopygi, Chania,

Greece. Dashed and solid lines show the flowering period of the host plants in the olive orchard

no individuals were observed on any of the host plants. Peak numbers of nymphs in the olive grove were observed at the end of February and mid-April, while the peak number of adults was observed in the 3rd week of April.

During the entire sampling period the highest populations of *C. trivialis* were found on *M. annua*. High numbers of nymphs and adults were also found on *S. alba*, *Urtica* sp. and *P. officinalis*, while relatively lower numbers of individuals were found on *S. oleraceus*, *M. sylvestris* and the 'Koroneiki' and 'Tsounati' olive trees. A significantly higher total number of *C. trivialis* nymphs and adults was

recorded on *M. annua* than on any other host (ANOVA nymphs, $F_{7,136} = 11.893$, $P < 0.001$; ANOVA adults, $F_{7,136} = 3.467$, $P < 0.001$) (Fig. 2).

Seasonal phenology and relative abundance of *Closterotomus trivialis* on orange trees and associated host plants in the field

Data on the seasonal appearance and abundance of *C. trivialis* nymphs and adults on sweet orange and on associated weeds in the citrus orchard are shown in Fig. 3.

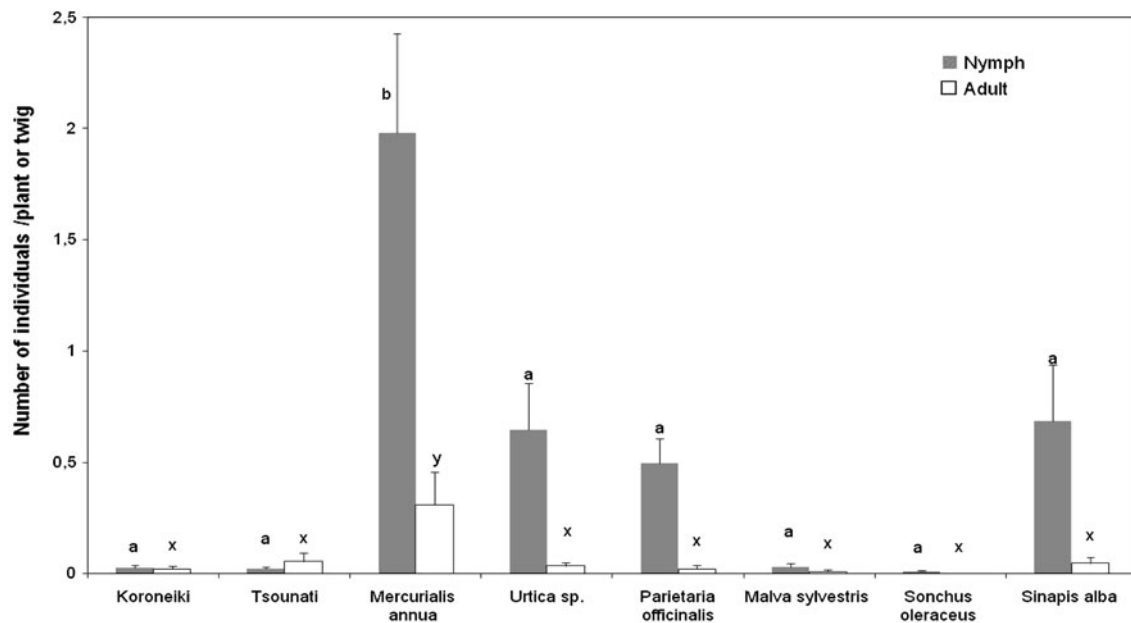


Fig. 2 Seasonal average number ($\pm$ SE) of *C. trivialis* nymphs and adults recorded in samples from olive trees and different weed host plants during 2009, in Chrysopygi, Chania, Greece. Value bars with

different letters within adult or nymph average are significantly different (Tukey–Kramer HSD $P < 0.001$)

In the citrus orchard, *C. trivialis* nymphs were first observed on *M. annua* in mid-January (Fig. 3a), while the first adult observation was made on *M. annua* in early March (Fig. 3b). In the orange tree canopy, nymphs were first observed in the 3rd week of February (Fig. 3a), while adults were first observed in mid-March (Fig. 3b). After mid-May, no individuals were observed in any of the host plants. In the citrus orchard, the *C. trivialis* population gradually increased from late January. Peak numbers of nymphs in the citrus orchard were observed in late January, mid-March and early April, while peak numbers of adults were observed in early April (Fig. 3a, b).

During the entire sampling period the highest populations of *C. trivialis* were found on *M. annua* and *Urtica* sp. High numbers of nymphs and adults were also found on *P. officinalis*, while relatively lower numbers of individuals were found on *S. alba*, *S. oleraceus*, *M. sylvestris* and orange trees. A significantly higher total number of *C. trivialis* nymphs were recorded on *M. annua* and *Urtica* sp. than on any other host plant, followed by *P. officinalis* (ANOVA, $F_{6,119} = 9.520$, $P < 0.001$), and significantly higher numbers of adults were recorded in *M. annua* compared with the other host plants (ANOVA, $F_{6,119} = 4.685$, $P < 0.001$) (Fig. 4).

Discussion

Results from this study show that *C. trivialis* nymphs and adults were found on all the weeds sampled (*M. annua*,

S. alba, *P. officinalis*, *Urtica* sp., *S. oleraceus* and *M. sylvestris*). This finding is in agreement with the results of previous studies describing this species as polyphagous (Barbagallo 1970; Pelekassis 1984; Tzanakakis 1998; Yamvriasis 1998; Gerakaki et al. 2007).

From the weekly samplings throughout January to May 2009, from olive, orange and the associated weeds, it is shown that *C. trivialis* began colonizing primarily *M. annua* in mid-January, while for *P. officinalis*, *Urtica* sp. and *S. alba*, colonization occurred 15 days later and continued until the middle of May. However, nymphs were first observed in the canopy of orange trees 1 month later (mid-February) and on olive trees 40 days later (end of February–early March), during the period when the inflorescence buds started to emerge. These results agree with the observations of other researchers showing that the first individuals of *C. trivialis* were present on weeds at the end of January in olive groves in the Chania prefecture (Gerakaki et al. 2007). Similarly, on the plains of Catania in Italy, hatching began in late January (Barbagallo 1970). However, in central Greece, the first nymphal instars were observed 1 month later, at the end of February (Drosopoulos 1993).

The first adult observation in both orchards was on *M. annua* in early March in the citrus orchard and 13 days later in the olive orchard, while on orange and olive trees, adults were first found in the last week of March and the 2nd week of April, respectively. These results agree with the observations of Gerakaki et al. (2007) about the first adults appearing at the end of February in the olive groves

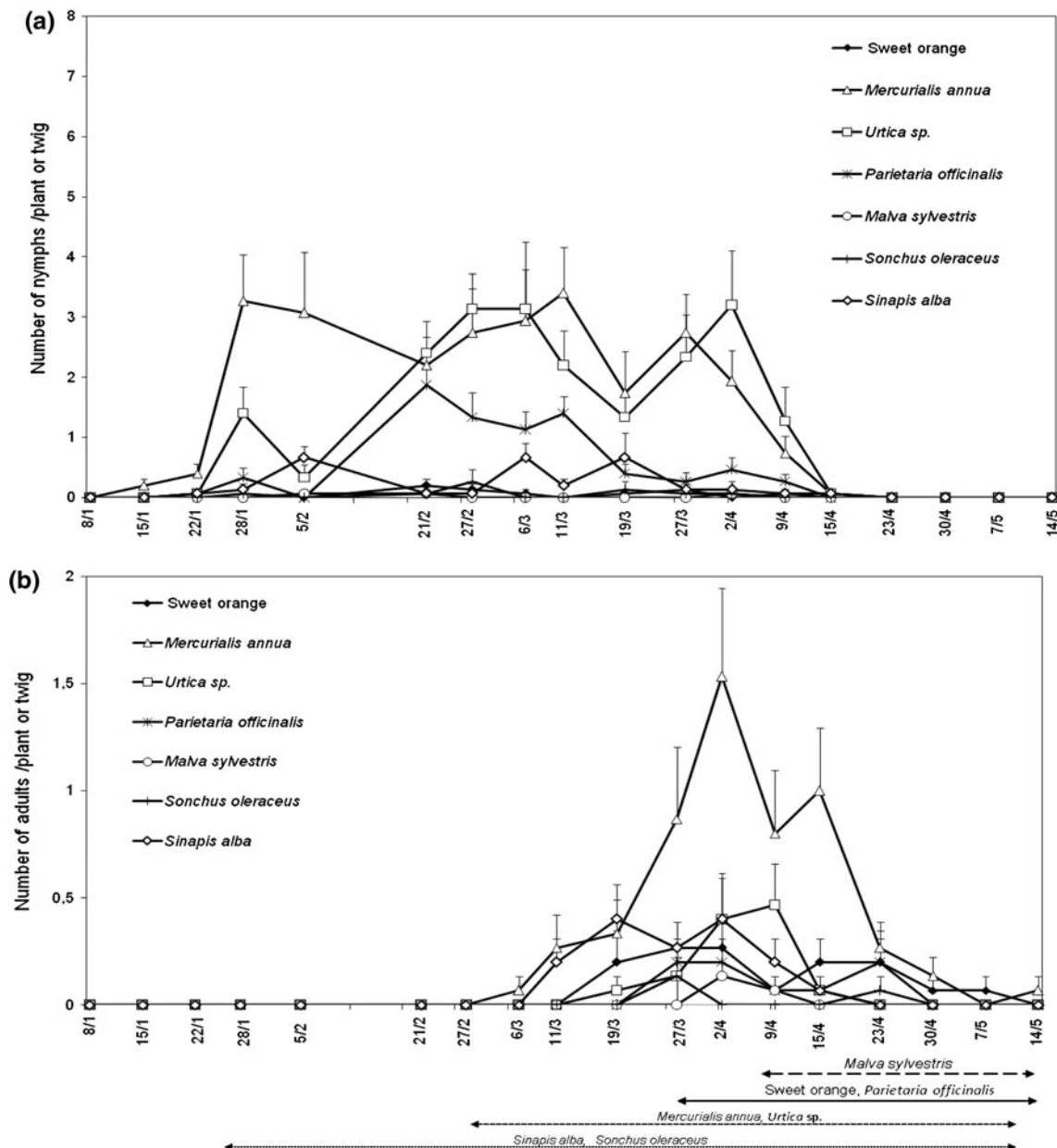


Fig. 3 Mean number ($\pm$ SE) (15 plants/host plant/week) of *C. trivialis* nymphs (a) and adults (b) recorded in samples from orange trees and different weed host plants during 2009 in Mody, Chania, Greece.

of Chania and with those of Barbagallo (1970), who observed the first adult appearance in late March on the plains of Catania.

Populations of *C. trivialis* on plants in the olive grove began to increase from early February, peaking at the end of February and in mid-April. In the citrus orchard, populations of *C. trivialis* started to increase from the end of January, peaking in late January, the middle of March and early April. After mid-May, no individuals were observed in any of the host plants in either orchard.

The results from this study show that the highest population of *C. trivialis* under field conditions was found on

Dashed and solid lines show the flowering period of the host plants in the citrus orchard

M. annua during the overall sampling period, followed by *Urtica sp.*, *P. officinalis* and *S. alba*. Although *M. annua* has not been previously reported by other researchers to be a preferred host for *C. trivialis* (Barbagallo 1970; Pelekassis 1984; Tzanakakis 1998; Yamvriasis 1998), in our study it was found to be a primary host for the insect. In other studies the weeds *Urtica sp.* and *P. officinalis* were reported to be the main hosts of the insect (Barbagallo 1970; Tzanakakis 1998; Perdakis et al. 2009). Olive and orange trees, as well as *S. oleraceus* and *M. sylvestris*, were found to be the least preferred hosts. Only a few individuals were collected from these plants throughout the sampling

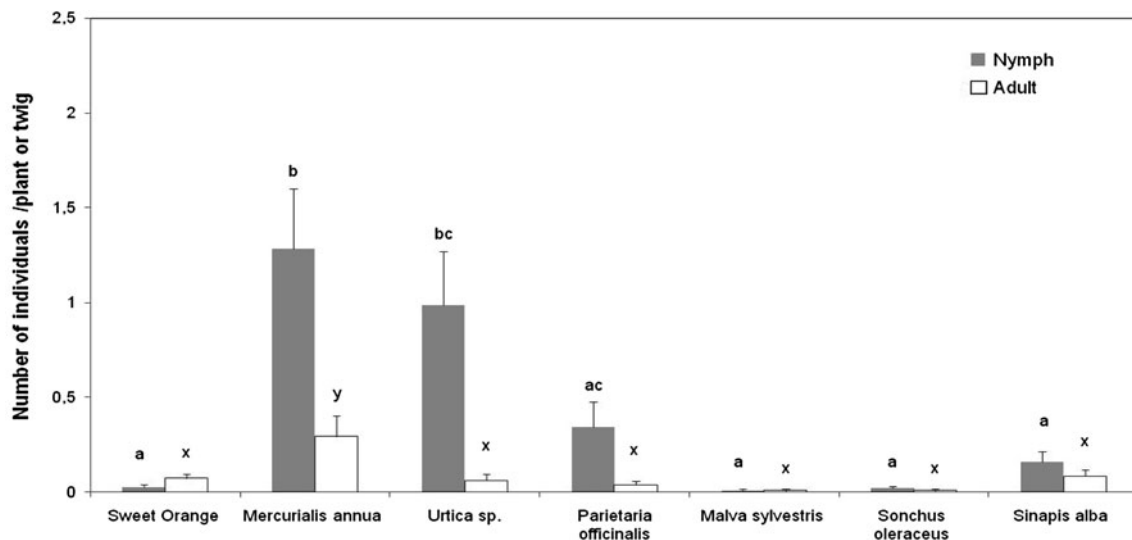


Fig. 4 Seasonal average number ($\pm$ SE) of *C. trivialis* nymphs and adults recorded in samples from orange trees and different weed host plants during 2009 in Mody, Chania, Greece. Value bars with

different letters within adult or nymph average are significantly different (Tukey–Kramer HSD $P < 0.001$)

period, indicating that these species might be less nutritiously suitable for the development of this insect.

Olive and citrus trees are more susceptible to the damage from *C. trivialis* from the early emergence of flower buds until the beginning of flowering period. In this study, such a critical period was observed from the end of February to the end of April in citrus and from early March to mid-May in olives. Within this period, the mean number of *C. trivialis* individuals on olive and citrus trees never exceeded 0.7 individuals per twig (maximum 2 individuals/twig), which was considered below the threshold to induce significant damage. Our preliminary studies showed that when 3, 6 or 12 *C. trivialis* nymphs were enclosed in muslin cages containing shoots of olive trees, only in the cages with 12 individuals did a high percentage of inflorescence buds drop (Kalaitzaki et al. unpublished data). Moreover, the presence of three or six individuals did not cause serious reduction in fruit setting of olive trees (Perdikis et al. 2009).

However, the presence of eight individuals of *C. trivialis* per shoot was capable of inducing damage on the fruit setting of olive trees (Perdikis et al. 2009), but this did not cause significant damage in citrus (Perdikis et al. 2010).

From the above results, it appears that *C. trivialis* prefers to feed and develop on weeds. It appears that may opportunistically feed on olive and citrus trees only when the surrounding weeds are non-hosts or less suitable hosts, or have begun to desiccate. This dispersive behavior has been previously observed in other mirids occurring in orchard–weed environments, as for example *Calocoris norvegicus* (Gmelin), which prefers weeds to pistachios (*Pistacia vera* L.) (Purcell and Welter 1990), *Lygus hesperus* (Knight)

(Hemiptera: Miridae) and other *Lygus* species, which prefer alfalfa (*Medicago sativa* L.), Russian thistle (*Salsola iberica* L.) and pigweed (*Amaranthus palmeri* L.) rather than cotton (*Gossypium* sp.) and sunflower (*Helianthus annuus* L.) (Barman et al. 2010).

The information collected on the host plant preference of *C. trivialis* may be helpful in predicting its occurrence and movement among crop and non-crop host plants. Olives and oranges were not found to be the preferred hosts for *C. trivialis*, at least in the presence of other hosts such as *M. annua*, *Urtica* sp., *P. officinalis* and *S. alba*. This knowledge could be essential for the development of appropriate control strategies against this widespread insect and could contribute to the effort to avoid unnecessary insecticidal treatments. However, further work is required to determine differences in *C. trivialis* population dynamics in those olive and citrus orchards where the surrounding weeds are only non-hosts or less suitable hosts.

In conclusion, the current study showed that despite the fact that *C. trivialis* was recorded in high numbers in the olive and citrus orchards, it preferred to feed on the inflorescence buds and flowers of weed host plants. The presence of *C. trivialis* in orchards during the critical period should not be considered as potentially damaging to fruit setting if there are weed host plants at the flowering or inflorescence emergence growth stages in the orchard. Aiming to optimize the control strategies of *C. trivialis*, it is advisable in integrated pest management programs to sustain the preferred weed host plant species in the orchards until the beginning of olive and citrus blooming. It is also advisable to perform beating-tray samplings at weekly intervals at critical periods and when dense populations

occur on the trees (upwards of 6 per twig) in the critical period should spraying be applied.

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