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Predatory effect of *Coccinella septempunctata* on *Thrips tabaci* and *Trialeurodes vaporariorum*

P. N. Deligeorgidis, C. G. Ipsilandis, M. Vaiopoulou, G. Kaltsoudas and G. Sidiropoulos
Department of Crop Production, Technological Education Institute of Western Macedonia/Branch of Florina, Florina, Greece

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Abstract: The predatory effect of adult ladybird *Coccinella septempunctata* L. on adults of thrips, *Thrips tabaci* Lindeman, and whiteflies, *Trialeurodes vaporariorum* (Westwood), was examined in controlled environment chambers, on tomato leaves, in transparent small plastic cages at proportions of 1/(10 + 10), 1/(20 + 20), 1/(30 + 30) and 1/(40 + 40) predator/number of thrips and whiteflies. We conclude that *C. septempunctata* could be used with success for the biological control of thrips and whiteflies in greenhouse crops, with almost the same effectiveness as for aphids, at predator/prey proportions near 1 : 30. Additionally, it was found a prey preference for *T. tabaci* in comparison with *T. vaporariorum*. According to the model used, effective predation is correlated with predator/prey ratio rather than to prey preference.

Key words: *Coccinella septempunctata*, *Thrips tabaci*, *Trialeurodes vaporariorum*, predatory effect, prey preference

1 Introduction

Onion thrips, *Thrips tabaci* Lindeman (Thysan., Thripidae) and whiteflies, *Trialeurodes vaporariorum* (Westwood) (Hom., Aleyrodidae), are major pests of greenhouse crops worldwide, where they cause great damage (Broadbent et al., 1987; van Lenteren and Woets, 1988; Mandel and van de Vrie, 1988; Byrne et al., 1990). They can transmit tomato spotted wilt virus (Sakimura, 1969; Robb and Parrella, 1987; Cho et al., 1989; Martin et al., 1991; Parella et al., 1992). Both species were first recorded in Europe on greenhouse crops in early 1980 (Byrne and Bellows, 1991). *Thrips tabaci* and *T. vaporariorum* can be managed using predatory mites (Hansen Stengård, 1988, 1989; Gillespie, 1989; Onillon, 1990; Parella et al., 1992; Holmer et al., 1993) and other natural enemies such as spider beetles, anthocorids, coccinellids, chrysopids and hemerobiids (Onillon, 1990).

Coccinellids have been widely used in biological control for more than a century. Augmentative releases of several coccinellids species are well documented and effective; however, infectious species continue to be used because of easy collection. *Coccinella septempunctata* L. (Col., Coccinellidae) is an important coccinellid (Coleoptera) species, which have experimentally appraised and established throughout Europe in glasshouse crops such as tomato, sweet papers and cucumbers. It is predaceous usually on aphids, thrips, whiteflies, mites and lepidopteron eggs (Gordon, 1985; Hagen, 1987). Additionally, mass rearing of *C. septempunctata* is easily achieved by supplying the best food (Omkar and Srivastava, 2003; Kalushkov and Hodek, 2004). In this study a laboratory examination of the predatory effect of *C. septempunctata* on adults of *T. tabaci* and *T. vaporariorum* was conducted, with the aim of defining prey preference in relation to the predatory effect of *C. septempunctata* between the two species (*T. tabaci* and *T. vaporariorum*).

2 Materials and Methods

The predatory effect of *C. septempunctata* was studied in May 2002 on adult *T. tabaci* and *T. vaporariorum* using a series of experiments in small cages. The basic experimental unit was a single tomato leaf (approximately 20 cm^2) in a $15 \times 15 \times 10$ cm clear plastic cage. The cages had three openings, each of 3×2 cm, covered with dense material made of muslin (0.06 mm opening) for aeration. Each tomato leaf in the cage was held away from the upper internal part of the cage from the petiole, with sticky tape. Two-day-old females of *C. septempunctata* were used for all experiments and starved for 24 h before use by placing them on the tomato leaves in individual cages. Also, adults of *T. tabaci* and *T. vaporariorum* were collected from laboratory colonies reared on tomato leaves. After introduction of *T. tabaci* and *T. vaporariorum* individuals and *C. septempunctata*, cages were held in controlled environment chambers at a temperature of 24 ± 0.2°C, 60 ± 2% relative humidity (RH), with a 16 h light, 8 h dark photoperiod and intensity of light 9000 lx, after which the survivors of each species were counted.

Each female *C. septempunctata* corresponded to 10 + 10, 20 + 20, 30 + 30 and 40 + 40 thrips and whiteflies per cage. The experiment was replicated 10 times. The estimation of the predatory effect of *C. septempunctata* was based on the percentage (%) of thrips and whiteflies consumed by the predator to their initial (total) number before the introduction of the predator. Four more cages were used as control (check). In these cages, there were 10 + 10, 20 + 20, 30 + 30 or 40 + 40 thrips and whiteflies per cage but in the absence of the predator (no beetles). No mortality was found in the control after 24 h (100% survival of thrips and whiteflies).

For statistical analysis (ANOVA), the values were converted to degrees, according to the formula: $a^\circ = \arcsin\sqrt{\frac{\%\text{pred.effect}}{100}}$ (adaptation from SNEDECOR and COCHRAN, 1980).

3 Results

The predatory effect of *C. septempunctata* on mortality of adults of *T. tabaci* and *T. vaporariorum* is presented in table 1. The analysis of variance revealed that there were significant differences in the predatory effect of *C. septempunctata* between different proportions (initial number) of both prey species. *Coccinella septempunctata* was a more potential predator of *T. tabaci* than *T. vaporariorum* because, in all cases (different proportions), the predatory effect was greater on *T. tabaci*.

The relationship between the total number of prey (total number of insects, x) and percentage prey survived (insects escaped %, y) is presented in fig. 1. Equations describing the models of the predatory effect of *C. septempunctata*, on both species are also presented in fig. 1, according to the findings of DELIGEORGIDIS et al. (2005). These equations were similar for both species ($y = 0.078x^2 - 1.9x + 47.425$ for *T. vaporariorum* and $y = 0.082x^2 - 2.1x + 38.108$ for *T. tabaci*) and highly accurate ($R^2 = 1$). Predictions for this relationship according to the second-degree model are presented in fig. 2. Theoretical maximum linear models for *T. vaporariorum* and *T. tabaci* are included, compared with that for *Macrosiphum euphorbiae* L. (DELIGEORGIDIS et al., 2005). There were differences between species in the intercept values (a) of theoretical maximum linear models, and a-values of *T. tabaci* were lower than *T. vaporariorum* (fig. 2).

Table 1. *Predatory effect of the mean numbers (±SE) of* Coccinella septempunctata *on adults of* Thrips tabaci *and* Trialeurodes vaporariorum

Ratio of *C. septempunctata*/ no. *T. tabaci* & *T. vaporariorum*	*T. tabaci*	*T. vaporariorum*
1/(10 + 10)	74.67 ± 2.88 a	63.52 ± 1.99 a
1/(20 + 20)	72.81 ± 3.09 a	60.55 ± 2.85 a
1/(30 + 30)	51.37 ± 0.93 b	38.94 ± 1.55 b
1/(40 + 40)	16.94 ± 0.44 c	4.99 ± 0.45 c

Data followed by the same letter did not differ significantly at $P < 0.05$.

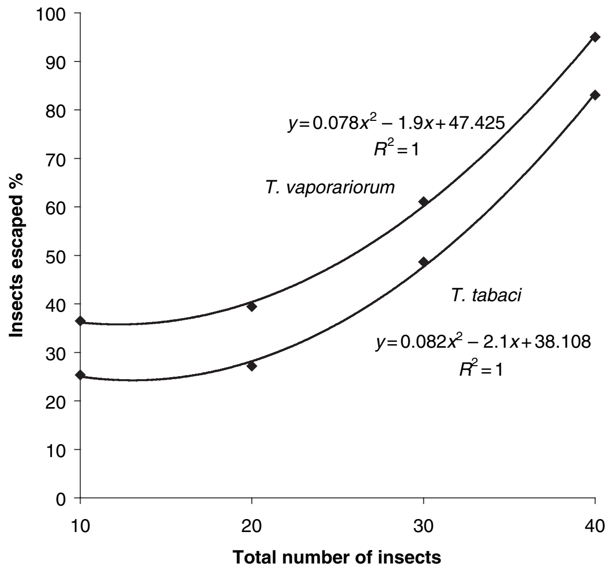

Fig. 1. *Relationship between the total number of insects for both* Trialeurodes vaporariorum *and* Thrips tabaci *in the experiment (total number of insects) and the percentage (%) of insects that survived (insects escaped %)*

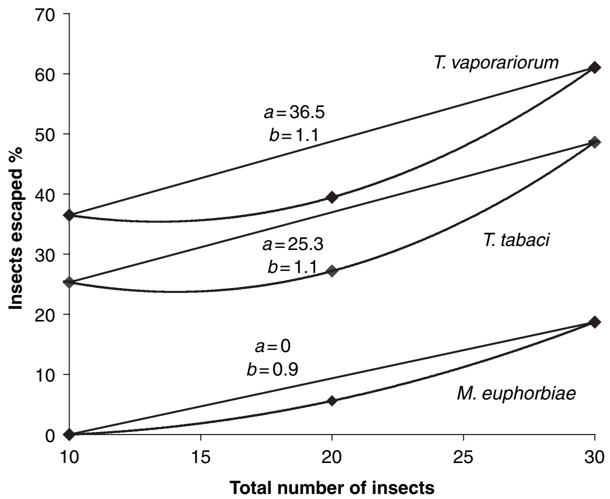

Fig. 2. *Predictions according to the second-degree model describing the relationship between the total number of insects (total number of insects) and the percentage (%) of insects that may survive (insects escaped %). Theoretical maximum linear models included for* Trialeurodes vaporariorum, Thrips tabaci *and* Macrosiphum euphorbiae *(data from* DELIGEORGIDIS *et al., 2005)*

4 Discussion

Female adults of *C. septempunctata* were found to be a potent predator of *T. tabaci* and *T. vaporariorum* on tomato leaves (in the cages). *Coccinella septempunctata* consumed more thrips insects than whiteflies. Perhaps the predatory ability and selective preying of *C. septempunctata* on *T. tabaci* is due to its easy capture or due to its smaller resistance compared with *T. vaporariorum* which has big wings and flies for a

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longer time than *T. tabaci* which does not move rapidly. Predacious coccinellids have been used in improved methods of biological control of thrips and whiteflies and, of course, aphids (Hagen, 1987; Gerling, 1990; Holmer et al., 1993) in greenhouses and are included in an integrated pest management. Nevertheless, researchers suggest other species for effective biological control of *T. tabaci*, such as *Verticillium lecanii* or *Amblyseius barkeri* (Hughes) (Binns et al., 1982; Hansen Stengård, 1989). Thus, there is not enough information about the actual predatory effect of *C. septempunctata* on *T. tabaci* and *T. vaporariorum*, but some related research works report that its active growth stages are capable of killing aphids (Hagen, 1962; Gordon, 1985; Omkar and Srivastava, 2003). Singh and Malhotra (1979) reported that the rate of feeding among different instars varied greatly in *C. septempunctata*. Similarly, Mahmood and Mahmood (1986) reported that aphid consumption increased with increasing age of its larval instars. The suitability of aphid species as the best food for *C. septempunctata* is a well-documented subject (Omkar and Srivastava, 2003; Kalushkov and Hodek, 2004) as effective predation depends (partly) on the food specificity of the predator.

Coccinella septempunctata has been proved, according to the results of this research, as an effective predator when used for the biological control (in controlled environments) of *T. tabaci* and *T. vaporariorum* at proportions near 1 : 30 (predator/total prey) where slope (*b*) of theoretical maximum linear model is near 1 (Deligeorgidis et al., 2005). At that predator/total prey proportion, hanger satiation and dropping away slow down the predation rate decreasing the efficiency of predation (Deligeorgidis et al., 2005). In greater pest densities, effective predation and successful biological control is difficult to achieve (Hansen Stengård, 1989; Deligeorgidis et al., 2005), requiring more predators to control pest. It can be concluded that *C. septempunctata* is a capable predator and can be used for the biological control of *T. tabaci* and *T. vaporariorum* in a greenhouse. Finally, the differences in the intercept (*a*) of theoretical maximum linear models can be used as an index of preference (prey preference) for some species during predation, and lower values of intercept (*a*) reveal greater prey preference, as less insects may escape predation. Direct comparison between data of this study and data from Deligeorgidis et al. (2005) for aphids cannot be made, due to differences in experimentation, especially the presence of two species simultaneously. By contrast, data indicate that there is a preference for *M. euphorbiae* in comparison with *T. tabaci* and *T. vaporariorum* (fig. 2), due to the great difference (distance) among the three second-degree models. Even if we consider predation on doubled total population of aphids (or half total population of both *T. tabaci* and *T. vaporariorum*), the model proposed by Deligeorgidis et al. (2005) reveals a slight preference for aphids of *M. euphorbiae* especially in lower pest densities where predation is more effective. Dixon et al. (1997) concluded that coccinelids, in general, have not proven effective in classical control programmes against aphids, even though *C. septempunctata* is considered a potent predator for many aphid species (Hagen, 1987; Omkar and Srivastava, 2003; Kalushkov and Hodek, 2004). According to the model used, effective predation is correlated with predator/prey ratio rather than with prey preference, although aphids are considered better food for *C. septempunctata* and data from this study show a clear preference for aphid *M. euphorbiae* in comparison with *T. tabaci* and, even more, *T. vaporariorum*. These two parameters (predator/prey ratio and prey preference) must be considered separately in experimental procedures and also the second-degree model proposed by Deligeorgidis et al. (2005) can provide an independent estimation of efficient predation by using the coefficients *b* (slope) and *a* (intercept).

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Author's address: P. N. Deligeorgidis (corresponding author), Department of Crop Production, Technological Education Institute of Western Macedonia/Branch of Florina, Terma Kontopoulou, 53100 Florina, Greece. E-mail: tm00078@kozani.teikoz.gr