Assessment of Interactions between the Predatory Bug *Orius insidiosus* and the Predatory Mite *Phytoseiulus persimilis* in Biological Control on Greenhouse Cucumber*

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Abstract

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The predatory mite *Phytoseiulus persimilis* and the predatory bug *Orius insidiosus* are now jointly used in the biological control on greenhouse cucumber. *P. persimilis* is a specific predator of the two-spotted spider mite, *Tetranychus urticae*. Compared to *P. persimilis*, *O. insidiosus* is a large and polyphagous predator and used to control thrips, but it could prey also on *P. persimilis* and *T. urticae*. The possible interactions between the predatory bug, the predatory mite, *T. urticae*, and the western flower thrips, *Frankliniella occidentalis*, were monitored on individual leaves of five marked cucumber plants grown under commercial greenhouse conditions. General linear models were used to test whether the simultaneous introduction of the predatory bug and the predatory mite had an influence on biological control. During two growing seasons, no statistical associations of the efficiency of biological control related to the simultaneous use of *P. persimilis* and *O. insidiosus* were revealed. Both the spider mites and the thrips were efficiently regulated by their predators. However, during both growing seasons the introduced predatory bug *O. insidius* was gradually replaced by its related native species *O. majusculus*.

Key words: *Orius insidiosus; O. majusculus; Frankliniella occidentalis; Phytoseiulus persimilis; Tetranychus urticae; Cucumis sativus;* biological control

Control of one of the most serious pest of greenhouse crops, the two-spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae), is obtained by the introduction of the predatory mite *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae) (OSBORNE *et al.* 1985; VRIE 1985; HUSSEY & SCOPES 1985; JAROŠÍK 1990; JAROŠÍK & PLÍVA 1990). However, pest management programmes in central Europe must now be expanded to include formerly less important thrips pests, particularly the western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) (SCHLIEPHAKE 1988; JENSER & TUSNADI 1989; PELIKÁN 1989; JAROŠÍK 1991; JAROŠÍK *et al.* 1997; JAROŠÍK & LAPCHIN 1998).

Thrips are difficult to control because they are resistant to many insecticides (IMMARAJU *et al.* 1992) and the few that are effective are not suitable for use with biological control agents. Attempts to use the predatory mites *Amblyseius barkeri* (Hughes) (= *A. mckenziei* Schuster & Pritchard) and *A. cucumeris* (Oudemans) (Acari: Phytoseiidae) to control thrips have not always been successful (RAVENSBERG & ALTENA 1987; HANSEN & GEYTI 1987; HANSEN 1988, 1989; PLÍVA & JAROŠÍK 1991; JAROŠÍK & PLÍVA 1995). Polyphagous predatory bugs (*Orius* spp. [Heteroptera: Thripidae]) appear the most promising control agents (GILKESON *et al.* 1990; PLÍVA & JAROŠÍK 1991; MALAIS & RAVENSBERG 1992; HIGGINS 1992; VEIRE & DEGHEELE 1992). However, as the bugs are polyphagous and large compared to the predatory mite, they might disturb the efficiency of biological control of the two-spotted spider mite by preying on the predatory mite. Conversely, the predatory bug can also prey on the two-spotted spider mite, and thus positively influence the efficiency of spider mite control.

We verified whether the efficiency of biological control of the two-spotted spider mite is actually influenced by the introduction of the predatory bug *Orius insidius* (Say) (Heteroptera: Anthociridae) on greenhouse cucumber under commercial conditions.

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MATERIAL AND METHODS

Studies were conducted within a two year period (1993–1994) in a heated greenhouse (1000 m^2) in Czech Republic where cucumber crops *Cucumis sativus* L. cv. Sandra were grown in soil. Temperatures ranged from 16 to 29°C in 1993, and from 17 to 34°C in 1994, and humidities ranged between 51 and 77% in 1993 and between 43 and 72% in 1994. Chemical treatments were restricted to the use of the fungicides a.i. propamocarb and a.i. benomyl in the first 2 weeks of cultivation.

The introduction of the predatory mite *Phytoseiulus persimilis* was carried out by the non-inundative method "after pest", i.e., by introducing the predator to natural foci of the two-spotted spider mite, *Tetranychus urticae*, after the first occurrence of the pest (JAROŠÍK 1990; JAROŠÍK & PLÍVA 1990). Segments of bean leaves with five to eight individuals of "mobile stages" (larvae, nymphs and adults) of *P. persimilis* were applied, keeping an approximate predator-prey ration of 1:80. Predatory mites were introduced on May 12th, June 4th and June 19th in 1993, and on June 12th in 1994.

The introduction of the predatory bug *Orius insidiosus* was made by use of the commercial product Thripor® after the first occurrence of the western flower thrips, *Frankliniella occidentalis*. The predators were distributed in bran on several leaves of each plant (approximately one individual per square meter, i.e., 1.6 individuals per plant). The introduction was made on May 14 and June 26 in 1993, and on June 6 in 1994.

In both season dynamics population were monitored on five randomly selected marked plants each, avoiding end plants and guard rows. The numbers of nymphs and adults were counted by examining individual leaves with the aid of a 12× hand lens. The numbers of predators, spider mites and thrips on 20 leaves (ranked in ascending order from the oldest to the youngest on the central stem of each experimental plant) were recorded separately. Censuses were made approximately weekly, that is, a total of ten times in 1993 (May 12–July 29), and seven times in 1994 (May 18–July 18). Species composition was monitored by taking samples of adult thrips and bugs collected on randomly chosen cucumber leaves and flowers at each census. The samples were determined under a stereo-microscope in the laboratory.

The data were evaluated by analysis of covariance (ANCOVA) with Poisson errors, using general linear modelling in GLIM® v. 4 (FRANCIS *et al.* 1994). The response variable was in turn number of thrips, spider mites, bugs, and predatory mites. Marked plants and date of observation were factors, and the 20 numbered leaves of each marked plant a covariate. The analyses were made separately for both seasons. The aim of each analysis was to determine the minimal adequate model. In this model, all parameters were significantly ($p < 0.05$) different from zero and from one another. This was achieved by a stepwise process of model simplification, beginning with the maximal model (containing all factors, interactions and covariates that might be of interest), then proceeding by the elimination of non-significant terms (using deletion tests from the maximal model), and the retention of significant terms (CRAWLEY 1993). MCCULLAGH and NELDER'S (1989) correction for over-dispersion was used. In this procedure, the data were rescaled using a dispersion factor which was calculated by dividing Pearson's chi-square by the residual degrees of freedom.

RESULTS

The biological control of the two-spotted spider mite *Tetranychus urticae*, using three introductions of the predatory mite *Phytoseiulus persimilis*, appeared quite successful in 1993. The predatory mite followed the increase of the spider mite and caused a rapid decrease of its population (Fig. 1). The control was less efficient with only one introduction in 1994. The predator arrested the growth of the pest but did not cause a notable decrease of its population before the end of the growing season (Fig. 2).

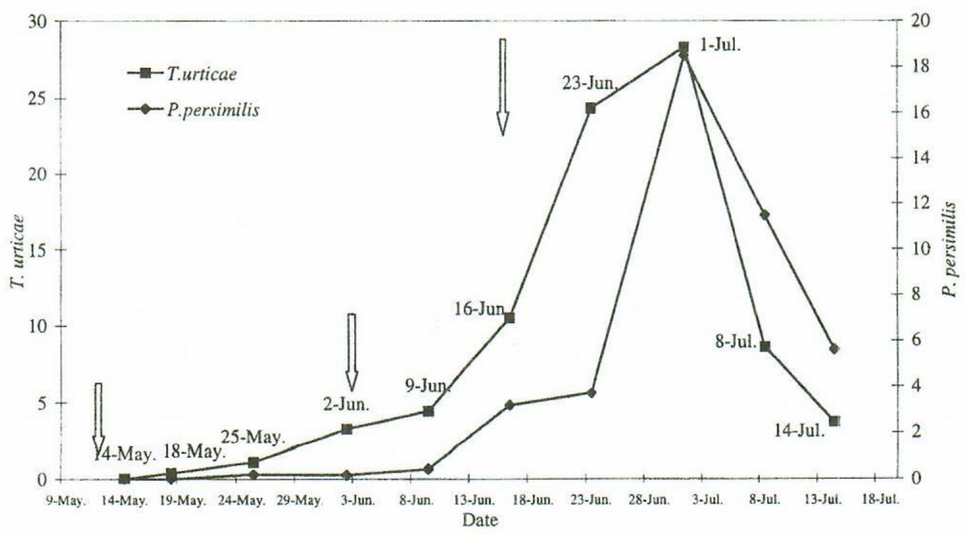

Fig. 1. Population dynamics (mean numbers per leaf) of the two-spotted spider mite, *Tetranychus urticae*, and the predatory mite, *Phytoseiulus persimilis*, on five marked plants in 1993. Arrows indicate applications of the predatory mite

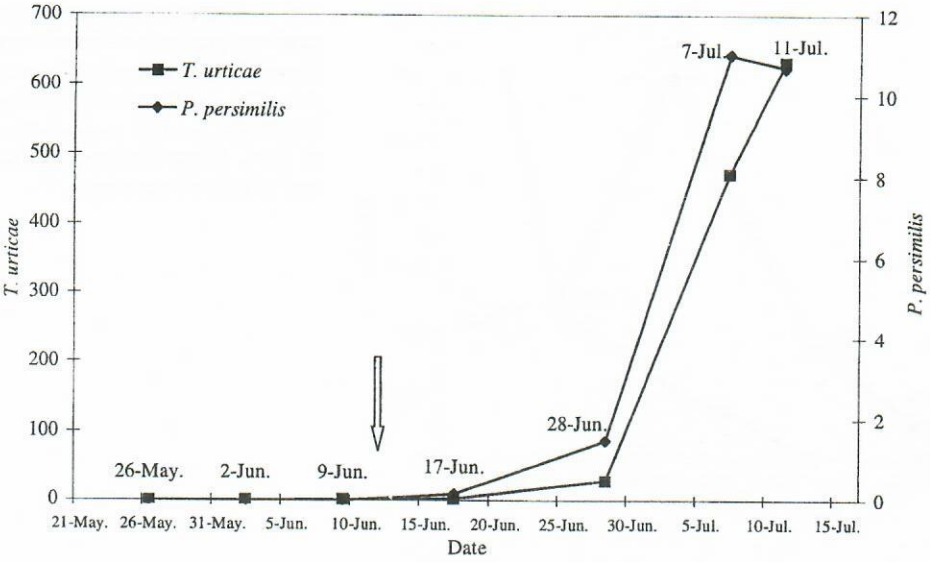

Fig. 2. Population dynamics (mean numbers per leaf) of the two-spotted spider mite, *Tetranychus urticae*, and the predatory mite, *Phytoseiulus persimilis*, on five mark-ed plants in 1994. Arrow indicates application of the predatory mite

Frankliniella occidentalis made up > 95% of the weekly random samples of adult thrips throughout the whole growing season. In both seasons, the random samples of predatory bugs indicated that the introduced species *Orius insidiosus* was gradually replaced by its related native species *O. majusculus* (Reuter) (Heteroptera: Anthocoridae).

The predatory bugs *Orius* spp. effectively controlled the populations of the western flower thrips *F. occidentalis* in both seasons. In 1993, the predators ended the growth of thrips already in early June after the first introduction. The second introduction caused a further decrease of the thrips population, followed by a decrease of the predators at the end of the growing season (Fig. 3). In 1994, the only introduction caused a later decrease of thrips population than in the previous year, and a continuous increase of the predators by the end of the growing season (Fig. 4).

The interactions between *Orius* spp., *P. persimilis*, *F. occidentalis* and *T. urticae* varied in strength within each season, but did not change between seasons. The results of ANCOVA did not reveal any statistically significant interaction between *Orius* spp. and *P. Persimilis*, nor between *Orius* spp. and *T. urticae*. The nonsignificant ($p > 0.05$) results are not shown. Therefore, no evidence for preying of *Orius* spp. on *P. persimilis*, or of *Orius* spp. on *T. urticae* was found. The only significant interactions were *P. persimilis*–*T. urticae* and *Orius* spp.–*F. occidentalis*, caused by the predators as they followed the populations of their preys. The results thus did not indicate any influence of the simultaneous introduction of *P. persimilis* and *O. insidiosus* on efficiency of biological control of spider mites and thrips.

DISCUSSION

Efficient biological control of two key pests of greenhouse cucumber in central Europe, namely the two-spotted spider mite *Tetranychus urticae* by the predatory mite *Phytoseiulus persimilis*, and the glasshouse whitefly *Trialeurodes vaporariorum* Westwood (Homoptera: Aley-

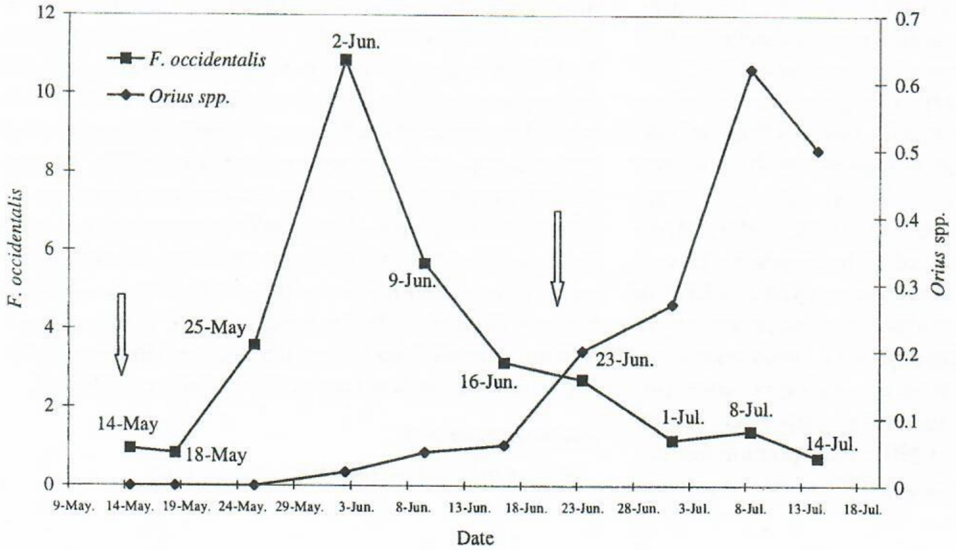

Fig. 3. Population dynamics (mean numbers per leaf) of the western flower thrips, *Frankliniella occidentalis*, and the predatory bugs, *Orius* spp., on five marked plants in 1993. Arrows indicate applications of the predatory bug

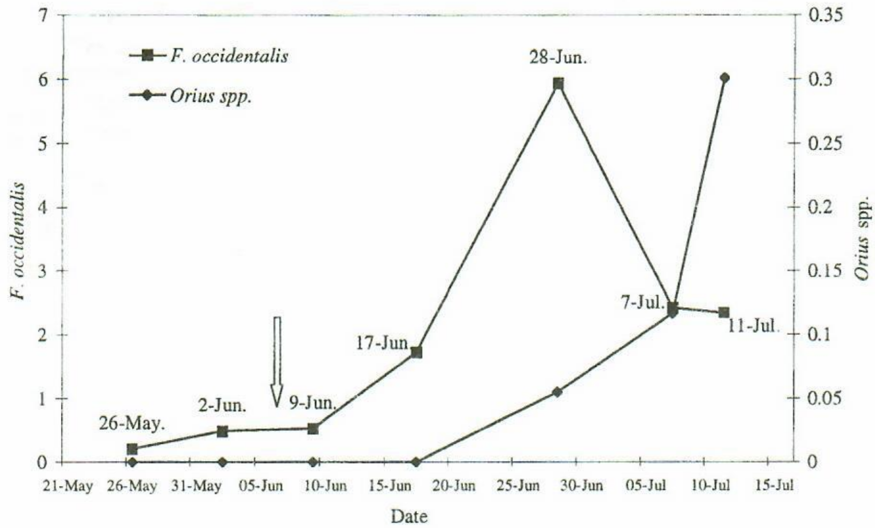

Fig. 4. Population dynamics (mean numbers per leaf) of the western flower thrips, *Frankliniella occidentalis*, and the predatory bugs, *Orius* spp., on five marked plants in 1994. Arrow indicates application of the predatory bug

rodidae) by the parasitic wasp *Encarsia formosa* Gahan (Hymenoptera: Chalcidoidea), enabled the spread of formerly less important greenhouse pests, in particular thrips (PARKER *et al.* 1995). Moreover, the onion thrips, *Thrips tabaci* Lindeman, that dominated in greenhouses of central Europe until the late eighties, was suddenly replaced by the western flower thrips *Frankliniella occidentalis* (SCHLIEPHAKE 1988; JENSER & TUSNADI 1989; PELIKÁN 1989; JAROŠÍK 1991). Observations in cucumber greenhouses under biological control in central Bohemia in 1987–1990 revealed that *F. occidentalis* has infested some crops since 1989. At the beginning of each season, *T. tabaci* and *F. occidentalis* usually occurred together, but during the season either *T. tabaci* or *F. occidentalis* predominated (JAROŠÍK & PLÍVA 1995). In 1990–1992 *F. occidentalis* already made up >95% of the species composition (JAROŠÍK *et al.* 1997). This proportion corresponds to results of our study made in 1993–1994. The reasons for replacement of *T. tabaci* by *F. occidentalis* remain unknown (RIJN *et al.* 1995).

Efficient biological control also made it possible to either eliminate or strongly restrict the use of insecticides. It enhanced a spontaneous spread of natural enemies that migrate into greenhouses from the open. Several anthocorid bugs from the genus *Orius* migrate into cucumber greenhouses (PLÍVA & JAROŠÍK 1991; VEIRE & DEGHEELE 1992). The spontaneous spread of *Orius majusculus* observed in this study is known also from dutch greenhouses (SCHREUDER & RAMAKERS 1989). However, the gradual replacement of *O. insidiosus* by *O. majusculus* is not observed everywhere (MEIRACKER & RAMAKERS 1991). This replacement does not argue against the artificial introduction of *O. insidiosus*. Control of thrips must start early in the season because fruit quality is initially high and declines steadily as the season progresses (WELTER *et al.* 1990). The spontaneous occurrence of *O. majusculus* is usually too late to prevent economic losses.

The lower efficiency of biological control of the two-spotted spider mite in 1994 than in 1993 can be attributed to the lower doses of the introduced predatory mites, and to less favourable abiotic conditions for the predator. A spatially density-dependent aggregative response of the predatory mite, related to the predictability of prey occurrence and searching efficiency of the predator, appear crucial for spider mite control on cucumber (JAROŠÍK 1990). These crucial factors are strongly related to the number of introduced predators (JAROŠÍK & PLÍVA 1990). Temperatures >30°C that are coupled with low relative humidity were more frequent in 1994 than in 1993. This combination is detrimental for development of the predatory mite (SABELIS 1981), but remains suitable for spider mites (HUSSEY, SCOPES 1985).

Compared to the use of the predatory mites *Amblyseius barkeri* and *A. cucumeris* (HANSEN 1988, 1989; JAROŠÍK & PLÍVA 1995) to control thrips, the number of introduced predatory bugs *Orius insidiosus* was low, and their efficiency high. Surprisingly, no influence of *Orius* spp. on two-spotted spider mite was found, even though the predatory bugs can be important predators of *T. urticae* (OATMAN & MCMURTRY 1966). The reason is probably low numerical response to increasing prey density that is a consequence of their polyphagy (HASSELL 1976). *Orius* spp. also appeared inefficient to control thrips in other systems, e.g., apple orchards (NIEMCZYK 1978). The statistically insignificant interactions between *Orius* spp.–*T. urticae* and *Orius* spp.–*P. persimilis*, however, do not mean that predators bugs do not prey on *T. urticae* or *P. persimilis*. This predation is very likely at high *Orius* densities towards the end of the growing seasons. Yet these interactions were difficult to reveal as the growing was probably terminated before they could be fully established.

Acknowledgements

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Souhrn

FEJT R., JAROŠÍK V. (2000): **Odhad interakcí mezi dravou ploštici** *Orius insidiosus* **a dravým roztočem** *Phytoseiulus persimilis* **při biologické regulaci na skleníkové okurce.** Plant Protect. Sci., **36**: 85–90.

Dravý roztoč *Phytoseiulus persimilis* a dravá ploštice *Orius insidiosus* jsou běžně využíváni při biologické regulaci na skleníkových okurkách. *P. persimilis* je predátor specializovaný na svilušku chmelovou (*Tetranychus urticae*). Ve srovnání s ním je *O. insidiosus* používaný proti třásněnkám velký a polyfágní druh, který může lovit i dravé roztoče a svilušky. Zkoumali jsme proto možné interakce mezi dravou ploštici, dravým roztočem, sviluškou a třásněnkou západní (*Frankliniella occidentalis*). Výzkum byl prováděn na jednotlivých listech pěti značených rostlin v produkčním skleníku během dvou pěstebních sezon. Pomocí zobecnělých lineárních modelů jsme zjišťovali, zda současná introdukce dravé ploštice a dravého roztoče má nějaký vliv na biologickou regulaci. Nebyla prokázána žádná souvislost účinnosti biologické regulace se společnou introdukcí dravé ploštice a dravého roztoče. Jak svilušky, tak třásněnky byly účinně regulovány. V průběhu sezony však byla introdukovaná ploštice *O. insidius* spontálně nahrazována příbuzným domácím druhem *O. majusculus*.

Klíčová slova: *Orius insidiosus*; *O. majusculus*; *Frankliniella occidentalis*; *Phytoseiulus persimilis*; *Tetranychus urticae*; *Cucumis sativus*; biologická regulace

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