

Observing population changes of thrips (*Thysanoptera*) species damaging forced pepper and their natural enemies

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Summary: By the strengthening of environmental protection and food safety efforts in Hungary, integrated and especially biological pest control methods should increasingly put forward, for which a solid knowledge on the life course and efficiency of natural enemies applied against certain pests is necessary. Pepper has distinguished significance in domestic vegetable forcing, and the profitability of production is determined primarily by the efficiency of the control of thrips pests. This is why we attached great importance to study what results may be expected by introducing arthropod predators (*Amblyseius cucumeris*, *Orius laevigatus*) to control thrips species under domestic conditions on rock wool in a long vegetation period pepper culture. We also liked to find out what kind of role the cultivars play in the change of phytophagous and zoophagous populations. The *A. cucumeris* predatory mite introduced in late January proved to be effective in controlling thrips pests until mid-April. Despite repeated introductions, the predatory bug *O. laevigatus* (Heteroptera: Anthocoridae) did not proliferate. Among the three pepper cultivars (Hó, Keceli, Titán) grown at Ráckeve, thrips species proliferated in the highest number on cultivar 'Hó', while the population of predatory mites was lowest on the cultivar 'Titán', compared to the other two cultivars.

Key words: *Frankliniella occidentalis*, *Frankliniella intonsa*, *Thrips tabaci*, *Amblyseius cucumeris*, *Orius laevigatus*, biological pest control, cultivar susceptibility

Introduction

According to the latest statistical data, the size of area utilized for vegetable forcing attains 5770ha in Hungary. A significant proportion of this area, 2100ha is used for pepper growing. Based on preliminary data from 2007, production of around 173 thousand tons is forecast for the year 2008 (FruitVeB, 2007). A large part of the crop is exported to Western Europe, which gives a further emphasis of the significance of forced pepper. Beside the continuous growth of production costs and stagnation of market prices, producers are also detrimentally affected by the tightening of the rules of pesticide use. Thus, production in the future can only turn out profitable with a change in technology and the introduction of integrated (and especially biological) pest control (Zentai, 2007).

The western flower thrips (*Frankliniella occidentalis*) is one of the most important pests of forced pepper, and it spread quickly following its introduction to Hungary. According to the national survey conducted between 2002 and 2004 by the Central Agricultural Office, on 87% of the sample sites infected with thrips species, the western flower thrips (*Frankliniella occidentalis*) has been present. There have been two other prevalent thrips species: the onion thrips (*Thrips tabaci*) and the flower thrips (*Frankliniella intonsa*) (Vasziné et al. 2006). Thrips species not only cause damages directly by sucking, but also indirectly, by spreading viral

diseases of which the tomato spotted wilt virus (TSWV, *Tospovirus*, *Bunyaviridae*) has become one of the most important diseases of pepper. The most significant vector of the disease is *Frankliniella occidentalis* (Wijkamp et al., 1995), however Inoue et al. (2004) pointed out that *Frankliniella intonsa* can also spread the disease with the same efficacy. Numerous authors have already recorded the problems of chemical control of western flower thrips; the hidden life-cycle of the pest and its resistance against pesticides has been mentioned among the main reasons (Immaraju et al., 1992; Brodsgaard et al., 1994; Parrella et al., 1996). Conversely, the arthropod predators applied during the biological control of the pest, primarily *Amblyseius cucumeris* (*Phytoseiidae*), a predatory mite and *Orius laevigatus* (*Anthocoridae*), a flower bug efficiently inhibited the proliferation of the pest (Tavella et al., 1996; Shipp et al., 1996). Biological control has become widespread; more than 80 useful organisms have been marketed across Europe at the end of the last century (van Lenteren et al., 1997).

Amblyseius cucumeris is applied around the world in a wide range against thrips species in biological control (Shipp et al. 1996). Beside the western flower thrips, the mite also feeds properly on onion thrips (van Lenteren et al., 1997). In case of forced pepper, *Amblyseius cucumeris* is the most effective among the predatory mite species, in lack of thrips, the mite can also breed on pollen (van Houten, 1995).

However, it is very susceptible to low humidity: a relative humidity of above 70% is considered optimal for breeding (Williams, 2004). Phyllis et al. (2007) examined how the number of individuals of *Amblyseius cucumeris* is distributed among the pepper flowers and the lower, middle and upper leaves. They pointed out that the mites can be found in the greatest number inside the flowers, which verifies that the collection of flowers is an appropriate method to track the changes in the number of individuals. *Amblyseius cucumeris* can only feed on first larval thrips instars; it does not affect any of the other life stages (egg, second larval instar, prepupa, pupa and adult) directly. The efficacy of predatory mites against thrips species is affected by temperature and humidity, but the role of humidity is more significant (Shipp, 1996). Beside predatory mites, flower bugs belonging to the *Orius* genus are very frequently applied in the biological control of thrips, since these feed on both larvae and adults (Wittmann et al., 1996; Skirvin et al., 2005). Similarly to the predatory mites, these also breed on pollen as well. According to Cocuzza et al. (1997a) the lifespan of *Orius laevigatus* adults fed exclusively on pollen is equal to the lifespan of those fed on the eggs of Mediterranean flour moth (*Ephestia kuehniella*), however females fed on pollen produced 60% less eggs. Several authors emphasize the significance of this species, given that it seems to be the most effective in the biological control of thrips species (Tavella et al., 1996; Cocuzza et al., 1997b; Tommasini et al., 2001). The species adapts well to high temperatures in the summer; its development is significantly protracted at 15°C, while a new generation develops in 13 days at 30°C (Aluzet et al., 1994). Shipp et al. (1992) – similarly to predatory mites – found that the collection of flowers is an appropriate method to track the population of *Orius* species.

The success of biological pest control does not only depend on the efficacy of the introduced natural enemy, but also on whether the necessary conditions for its establishment can be provided in the greenhouse or not (Bale, 2005). Biological pest control is most economical in the so-called long-period forcing, when a growing period might last up to 8–10 months (Forray et al., 2006). Some of the domestic pepper growers already changed to soilless, nutrient solution cultures as a consequence of the infection of the soils, salt deposits and higher yield expectations (Izbéki et al., 2006). The almost exclusively used cultivar in this technology is the conical, white-fleshed 'Hó F1'. This is the most favourite cultivar type in Hungary, which – as our former examinations revealed – may suffer the most severe damage from western flower thrips. Until the beginning of summer, the tapered-hot type is also much demanded, the planting of which should be started at the earliest possible (November–December) period (Gyúró, 2007). Environmental conditions in Hungary greatly differ from those in Western European countries, where biological pest control practices had been introduced long ago. This is why we attached great importance to examine what kind of results might be expected under domestic conditions, in long-culture pepper on rock wool by introducing arthropod predators

(*Amblyseius cucumeris*, *Orius laevigatus*). We also liked to find out what kind of role the pepper cultivars play in the change of phytophagous and zoophagous arthropod populations.

Materials and methods

Conditions of the examination. Sample collections have been made at Ráckeve in high-roof greenhouses, where conical white-fleshed 'Hó F1' (2300 m²), green tapered-hot 'Titán F1' (430 m²) and 'Keceli F1' (215 m²) cultivars were grown on rock wool medium in long culture. Planting was done on 1st December, 2006. *Amblyseius cucumeris* (Biobest) predatory mites have been released on 24th January in 0.58 pack/m² density. *Orius laevigatus* (Biobest) predatory bugs have been released three times, on 21st and 28th February and 24th April in densities of 0.66 and 0.5–0.5 packs/m² respectively.

Collection of predatory mites, predatory bugs and sample processing. During the period of 27th February to 30th August, in every two weeks (a total of 13 occasions) 50 flowers of each cultivar were collected into phials containing 70% ethyl-alcohol. Flowers were collected randomly, from the entire area planted with the given cultivar. From the samples, mites and thrips were prepared in a laboratory with stereomicroscope onto separate slides for each flower. Predatory mites were identified based on the key of Karg (1993), and thrips species were identified using the key of Moritz et al. (2001). L1 and L2 stages of thrips larvae, and males and females were also distinguished. Adults of collected bugs were identified by the guide book of Péricart (1972).

Statistical analysis. Individual numbers per flowers of *Amblyseius cucumeris*, predatory bugs (*Anthocoridae*) and thrips species (*Thysanoptera*) have been compared by several different aspects. First, by summing up the data of all collections and then by the separate collection dates we examined if there were differences between the pepper cultivars in the number of arthropods per flowers. Then, by summing up the measured values of the three cultivars, we studied how the average number of individuals of introduced natural enemies and thrips species per flowers changed during the vegetation period. Statistical analysis has been conducted. At each analysis, the homogeneity of variances was checked with LEVENE test, and means were compared by using the Games-Howell test.

Results

Collection of predatory mites, predatory bugs and thrips species and the processing of samples. On the 13 occasions, a total of 6604 individuals have been collected, of which 6509 have been identified. 5588 individuals have been identified on species level, and 921 have been identified on family or genus level. Table 1 shows the results of collections.

Table 1: Results of collections in 2007, in forced pepper vegetation

<i>Amblyseius cucumeris</i> (Oudemans)	Acarina: Phytoseiidae	female	3599	4712
		male	606	
		juvenile	507	
<i>Thrips tabaci</i> Lindeman	<i>Thysanoptera: Thripidae</i>	female	378	378
<i>Frankliniella intonsa</i> Trybom	<i>Thysanoptera: Thripidae</i>	female	371	461
		male	90	
<i>Thrips flavus</i> Schrank	<i>Thysanoptera: Thripidae</i>	female	1	1
<i>Aelothrips intermedius</i> Bagnall	<i>Thysanoptera: Aelothripidae</i>	female	5	5
<i>Haplothrips aculeatus</i> (Fabricius)	<i>Thysanoptera: Phlaeothripidae</i>	female	2	2
Thripidae larva	<i>Thysanoptera</i>	L1 female	480	828
		L1 male	163	
		L2 female	134	
		L2 male	51	
<i>Aelothrips</i> larva	<i>Thysanoptera: Aelothripidae</i>		21	21
<i>Orius niger</i> (Wolff)	<i>Heteroptera: Anthocoridae</i>	female	1	27
		male	26	
<i>Orius minutus</i> (Linnaeus) or <i>vicinus</i> (Ribaut)	<i>Heteroptera: Anthocoridae</i>	female	2	2
<i>Orius minutus</i> (Linnaeus)	<i>Heteroptera: Anthocoridae</i>	male	2	2
<i>Orius</i> larva	<i>Heteroptera: Anthocoridae</i>		70	70

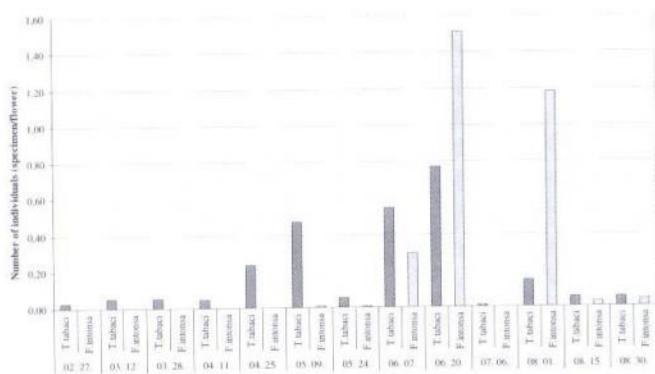


Figure 1: Number of *Thrips tabaci* and *Frankliniella intonsa* adults in the flower samples

More than 98% of the collected mites were identified as *Amblyseius cucumeris*, while 72 individuals could not be identified. During the processing of the samples, all the 847 thrips adults have been identified, and 378 individuals were *Thrips tabaci*, 461 *Frankliniella intonsa*, 1 female *Thrips flavus*, 5 *Aelothrips intermedius* and 2 female *Haplothrips aculeatus*. The most dangerous pest of forced pepper, the western flower thrips was not present at the examined site. More than 97% of the collected 849 thrips larvae belonged to *Thripidae* family in accordance with the species distribution of adults. Figure 1 shows the changes in the number of adults of the two thrips species with the highest number of individuals.

The figure shows that onion thrips appeared first in the greenhouse, and then from the second half of June, the mass immigration of *Frankliniella intonsa* took place.

During the period of the study, a total of 70 larvae and 31 adults of predatory bugs have been collected, however none of the adult individuals belonged to the introduced *Orius laevigatus* species.

Statistical evaluation. Examining the effect of cultivars on the number of thrips species and their natural enemies (Table 2) significant difference was found between the number of *Amblyseius cucumeris* predatory mite collected in the flowers of 'Keceli' and 'Titán' cultivars. As for the number of thrips individuals, cultivar 'Hó' proved to be somewhat more susceptible compared to the other two cultivars. *Orius spp.* bugs were present only in very low numbers in the flowers of all the three cultivars. Results are shown in Figure 2.

However, differences between cultivars at given collection dates were not uniform, as Table 3 shows. Difference in the mean number of individual predatory mites per flower can be pointed out at dates 1., 2., 3., 5., 6. and 9., while differences in the number of thrips individuals can be observed only at dates 4., 5., 8. and 9. Though the population of predatory mites can be considered equal on 'Hó' and 'Keceli' cultivars, almost twice

as many mites were found on cultivar 'Hó' at the first collection. Since the mite introduction was uniform the reason for this difference may be that mites proliferate slower on the pollen of 'Keceli'. At the second collection, when the highest number of mites were measured in the flowers, these two cultivars did not differ from each other, but the population of mites was significantly lower on 'Titán'. At the collection at 20th June, when the highest thrips numbers per flower were measured, there were significantly more individuals on cultivar 'Hó' than on the other two cultivars, which points out the susceptibility of this cultivar.

Table 2: Comparison of mean number of *Amblyseius cucumeris*, thrips species (*Thysanoptera*), and *Orius spp.* per flower on the three cultivars.

	Keceli		Hó		Titán	
	mean number of individuals per flower	95% confidence interval	mean number of individuals per flower	95% confidence interval	mean number of individuals per flower	95% confidence interval
<i>Amblyseius cucumeris</i>	2,66 a	± 0,392,65	2,65 ab	± 0,412,05	2,05 b	± 0,31
<i>Thysanoptera</i>	0,6 b	± 0,11,24	1,24 a	± 0,280,8	0,8 b	± 0,16
<i>Orius spp.</i>	0,07 a	± 0,020,04	0,04 a	± 0,020,05	0,05 a	± 0,02

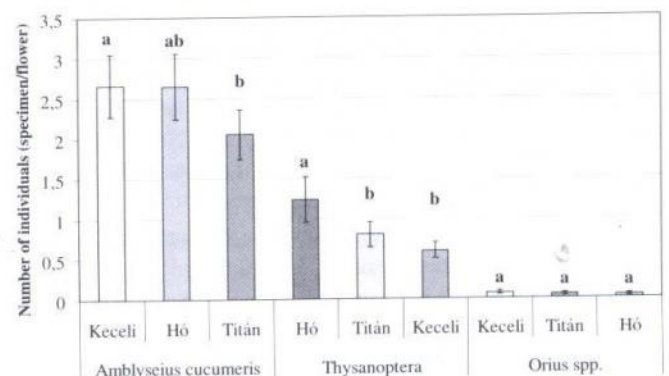


Figure 2: Effect of cultivars on the number of thrips species and their natural enemies

Table 3: Mean number of individual thrips per flower and their natural enemies in the given collection dates on 'Hó', 'Keceli' and 'Titán' cultivars

	Date of Collection	Hó	Keceli	Titán
		Mean	Mean	Mean
<i>Amblyseius cucumeris</i>	02.27.	10,96 a	5,52 b	5,72 b
<i>Thysanoptera</i>		0,04	0,08	0,02
<i>Orius spp.</i>		0	0	0
<i>Amblyseius cucumeris</i>	03.12.	11,4 ab	13,54 a	8,96 b
<i>Thysanoptera</i>		0,04 ab	0a	0,12 b
<i>Orius spp.</i>		0,04	0,02	0,12
<i>Amblyseius cucumeris</i>	03.28.	2,02 a	4,62 b	2,62 ab
<i>Thysanoptera</i>		0,06	0,02	0,12
<i>Orius spp.</i>		0	0,06	0
<i>Amblyseius cucumeris</i>	04.11.	0,76	0,74	0,5
<i>Thysanoptera</i>		0,14 ab	0,02 a	0,3 b
<i>Orius spp.</i>		0	0	0
<i>Amblyseius cucumeris</i>	04.25.	1,02 a	1,82 b	1,12 ab
<i>Thysanoptera</i>		0,24 a	0,32 ab	0,64 b
<i>Orius spp.</i>		0	0,04	0
<i>Amblyseius cucumeris</i>	05.09.	2,08 a	1,94 a	0,72 b
<i>Thysanoptera</i>		1,26	0,94	1,38
<i>Orius spp.</i>		0,08	0	0,04
<i>Amblyseius cucumeris</i>	05.24.	1,8	3,06	2,2
<i>Thysanoptera</i>		0,14	0,08	0,04
<i>Orius spp.</i>		0	0	0
<i>Amblyseius cucumeris</i>	06.07.	2,96	2,84	3,66
<i>Thysanoptera</i>		2,66 a	2,14 a	0,42 b
<i>Orius spp.</i>		0,04	0,04	0
<i>Amblyseius cucumeris</i>	06.20.	1,24 a	0,52 b	1 ab
<i>Thysanoptera</i>		8,68 a	1,72 b	3,86 c
<i>Orius spp.</i>		0,08	0,18	0,08
<i>Amblyseius cucumeris</i>	07.06.	0	0,02	0,02
<i>Thysanoptera</i>		0,24	0,04	0,16
<i>Orius spp.</i>		0	0	0
<i>Amblyseius cucumeris</i>	08.01.	0,16	0	0,08
<i>Thysanoptera</i>		1,94	2	2,9
<i>Orius spp.</i>		0,02 a	0,16 b	0,16 ab
<i>Amblyseius cucumeris</i>	08.15.	0	0	0,04
<i>Thysanoptera</i>		0,4	0,26	0,32
<i>Orius spp.</i>		0,14	0,1	0,06
<i>Amblyseius cucumeris</i>	08.30.	0	0	0,04
<i>Thysanoptera</i>		0,22	0,22	0,18
<i>Orius spp.</i>		0,12	0,3	0,14

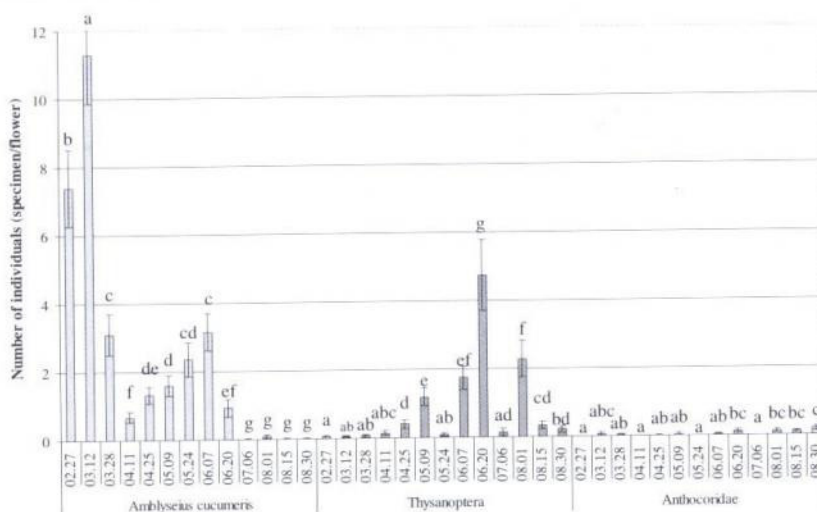


Figure 3 Fluctuation in the mean number of predatory mites, thrips and flower bugs in pepper flowers during the cultivation period.

Figure 3 shows the fluctuation of mean numbers of the studied arthropods during the vegetation period. The introduced *Amblyseius cucumeris* predatory mite established

quickly in the greenhouse right after its introduction (24th January). At the first collection at 27th February, 7.4 individuals per flower was found on average. This increased to 11.3 in two weeks, and then decreased drastically: at 11th April we found only 0.67 individuals per flower on average. Later the number of individuals increased at a small rate, but following 20th June predatory mites almost completely disappeared from the forced pepper vegetation. The number of thrips individuals increased significantly at the two collections following 11th April: at 9th May the mean individual number per flower exceeded one.

As a consequence of the decrease in the population of predatory mites and the unsuccessful introduction of *Orius laevigatus*, application of insecticides was needed to control the infestation of thrips species. Since there has been also a severe aphid infestation in the greenhouse, Mospilan 20 SP containing acetamiprid was sprayed at 14th May. To control the worsening thrips infestation, the vegetation was treated with Unifosz 50 EC containing dichlorphos at 25th June and 3rd August. As can be seen on the chart, significantly more mites could be found in the flowers following the acetamiprid treatment than before, but after the dichlorphos treatment predatory mites disappeared from the greenhouse.

Conclusions

As a consequence of the mild winter in 2007 and the extremely warm weather in early spring, the presence of onion thrips was observed as soon as at the first collection (27th February) in the greenhouse. Their mass proliferation has been prevented by the introduced *Amblyseius cucumeris* predatory mite until mid-April. However, in early April, the population of the predatory mites decreased significantly, and despite the following small increase until 7th June, this decreased population could not suppress the thrips population settling intensively into the greenhouse from outside.

Orius laevigatus has been introduced three times, with the doses recommended by the distributor. Despite the repeated introduction attempts, this species did not proliferate: not a single adult could be collected from the pepper flowers. In the lack of natural enemies, the number of thrips individuals increased significantly, and thus, in order to avoid massive economic loss, application of chemical treatments became inevitable. Since the biological control of aphids also turned out

unsuccessful, the first chemical treatment was directed against this pest. The acetamiprid active substance sprayed out at 14th May significantly reduced the number of thrips individuals, but it did not harm the predatory mites. It can be supposed however, that this treatment eradicated the predatory bugs introduced at 24th April, since according to the study of *Angeli et al.* (2004) the imidacloprid active substance – which belongs to the neonicotinoids, like acetamiprid – has 100% contact toxicity to *Orius laevigatus*. The following two chemical treatments were directed decidedly against the thrips species. As a result of the treatment with dichlorophos, predatory mites almost completely disappeared from the greenhouse. The *Orius* species collected during the vegetation period settled in the greenhouse from the natural fauna.

Frankliniella occidentalis is the most dangerous thrips pest in Hungary, but it was not observed at the examined site. *Frankliniella intonsa* is also a prevalent flower thrips species; we collected the first adult at 9th May and in the samples collected at 20th June it ousted the onion thrips from the pepper flowers which had been dominant until then. According to the observation of *Jenser* (1973), mass flight of *Frankliniella intonsa* begins in the second half of August in Hungary. Based on the results of our study, this started as early as in the second half of June in 2007.

The effect of cultivars on the *Amblyseius cucumeris* predatory mite and the number of thrips individuals were also studied. There was significant difference in the mean individual number of mites per flower between 'Keceli' and 'Titán', and it seems that mites proliferate faster on 'Hó' than on 'Keceli' cultivar. The cultivar 'Hó' proved to be more susceptible to thrips species than the other two cultivars. This difference was most marked at the time when the highest thrips numbers per flower were recorded. *Studies of Gerin et al.* (1999) pointed out that flowers play a decisive role in the case of *Frankliniella occidentalis*, since the thrips population can not proliferate in the lack of flowers. This is why the majority of adults reside in the flowers. At the time when the increased susceptibility of cultivar 'Hó' had been shown most markedly, the *F. intonsa* was dominant in the flowers. Flowers are supposedly as important for this species as they are for the western flower thrips. Further studies are needed to verify the influence of cultivars on the individual numbers of thrips species and their natural enemies.

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