Compatibility of *Cheyletus eruditus* (Schrank) (*Acari: Cheyletidae*) **and** *Cephalonomia tarsalis* (Ashmead) (*Hymenoptera: Bethylidae*) **in Biological Control of Stored Grain Pests**

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Abstract

Žďárková E., Lukáš J., Horák P. (2003): **Compatibility of** *Cheyletus eruditus* (Schrank) (*Acari: Cheyletidae*) **and** *Cephalonomia tarsalis* (Ashmead) (*Hymenoptera: Bethylidae*) **in biological control of stored grain pests**. Plant Protect. Sci., **38**: 29–34.

A laboratory experiment was carried out on stored wheat infested by the stored product mite *Acarus siro* and beetle *Oryzaephilus surinamensis*. The initial infestation was 150 mites of *A. siro* and 15 beetles of *O. surinamensis* per 1 kg of wheat. The predatory mite *Cheyletus eruditus* and parasitoid *Cephalonomia tarsalis* were added in the ratio 1:20 and 1:12, repectively. Three combinations were tested: (1) mites and (2) beetles separately, and (3) mites and beetles together. The experiment ran for three months at 22°C and 75% RH. The pests were suppressed by their antagonists in all combinations. Synchronous application of both natural enemies resulted in better control of *O. surinamensis* through an enhanced effect of both antagonists.

Keywords: *Acarus siro*; *Oryzaephilus surinamensis*; *Cheyletus eruditus*; *Cephalonomia tarsalis*; stored wheat; biological control

Increasing demand by consumers on food quality and safety is reflected in changes of the protection measures used on stored products. The use of pesticides is minimised to an essential level, while that of alternative protective methods is maximised. Biological control plays an indispensable role in these programmes. Although there is a large spectrum of known biological control agents associated with stored pests (Žďárková 2001), only a small number is used in practice. It is known that stored wheat is in most cases infested by one or two pest species (Stejskal *et al*. 2002). Typically, one mite species is accompanied by a beetle species, as is the case by the severe pests of stored wheat *Acarus siro* L. and *Oryzaephilus surinamensis* L.

The biological control of stored product mites by the predatory mite *Cheyletus eruditus* Schrank is well known and it is used in practice preventively and repressively (Žďárková 1998; Žďárková & Fejt 1999). *Cephalonomia tarsalis* Ashmead is considered to be a promising biological control agent of *O. surinamensis* larvae and pupae. However, the influence of the interaction in a synchronous application of parasitoids/predators on the success of parasitation/predation has been largely ignored.

Powell (1938) found *C. tarsalis* to be a parasitoid of *O. surinamensis*. He concluded that *C. tarsalis* is not a suitable biological control agent due to its low parasitic rate. Other bethylid species, like *Cephalonomia gallicola* (Ashmead), parasitising on

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stored product pests are rather known as unusual causes of human allergy (Yamasaki 1982) than as bio-control agents (Kearns 1934). *Cephalonomia waterstoni* (Gahan) (Finlayson 1950; Flinn 1991; Flinn & Hagstrum 1995) and *Holepyris sylvanidis* (Brethes) (Ahmed *et al*. 1997) have also been poorly studied as natural antagonists. On the other hand, there is a well documented case of an applied biological control programme of the coffee berry borer *Phymastichus coffea* La Salle by the bethylid *Cephalonomia stephanoderis* Betrem in coffee groves (Perez-Lachaud *et al.* 2002; Damon & Valle 2002). Although *C. tarsalis* reportedly uses several different stored product beetles as its hosts, it appears to be primarily associated with the saw-toothed grain beetle, *O. surinamensis* (Howard *et al*. 1998). That paper reports on some of the sensory modalities that the female *C. tarsalis* uses to find, recognise and accept a host. It provides an ethogram sequence of the parasitoid behaviour from initial searching until the host is released in preparation for oviposition. The major host-recognition cues are chemical, primarily on the cuticle of the host and perceived through the antennae of the parasitoid, as well as movement by the host once contacted. Sedlacek *et al*. (1998) sampled shelled maize in metal grain storage bins between June and September 1990 in Kentucky to identify, enumerate, and determine the spatial distribution of pest and beneficial insects. Eight species of parasitoids were identified from the samples, among others *C. tarsalis*. Other experiments were conducted to determine the compatibility of *C. tarsalis* as ectoparasitoid and *Beauveria bassiana* (*Deuteromycotina, Hyphomycetes*) as entomogenous fungus, both being known as biological control agents of *O. surinamensis* (Lord 2001). He found that wasp larvae are susceptible to *B. bassiana*-infected host larvae and the adult wasp was also negatively affected by a higher dose of the entomopathogenic fungus. However, knowledge about synchronous control of mites and beetles by biological control means is missing.

The goal of this paper was to examine whether the predatory mite *C. eruditus* and the parasitoid *C. tarsalis* are suitable for synchronous application in biological control programs of pests in stored grains.

MATERIALS AND METHODS

Twelve cardboard barrels (22 cm in diameter, height 50 cm), each loaded with 7 kg of clean sterile wheat and 0.5 kg of oat flakes, were used to simulate a stored grain environment. The barrels were covered by cloth and left at 22°C and 75% RH for a week to balance the moisture content of the wheat. Pairs of barrels were infested with mites and beetles to give the following six combinations:

I a, b – 1000 mites *A. siro*
II a, b – 100 beetles *O. surinamensis*
III a, b – 1000 mites *A. siro* + 100 beetles *O. surinamensis*
IV a, b – 1000 mites *A. siro* + 50 predators *C. eruditus*
V a, b – 100 beetles *O. surinamensis* + 4 parasitoids *Cephalonomia tarsalis*
VI a, b – 1000 mites *A. siro* + 50 predators *C. eruditus* + 100 beetles *O. surinamensis* + 4 parasitoids *Cephalonomia tarsalis*.

The experiment lasted 3 months, samples (100–200 g) were taken at the end of each month. Berlese funnels were used to count the mites, and the beetles were sifted out and counted. At the end of the experiment all wheat from the barrels was sifted out and beetles and parasitoids were counted.

The mites and their predator came from cultures reared in the laboratory at 25°C and 75% RH on wheat germs, the predators were reared on lettuce seed with *A. siro* as prey. *O. surinamensis* beetles were reared in plastic boxes on a diet consisting of wheat germs, yeast and oat flakes in the ratio 10:2:10 and at 25°C and 75% RH. *C. tarsalis* was reared in clear plastic boxes with the last instar of *O. surinamensis* larvae and pupae and at 25°C and 75%RH.

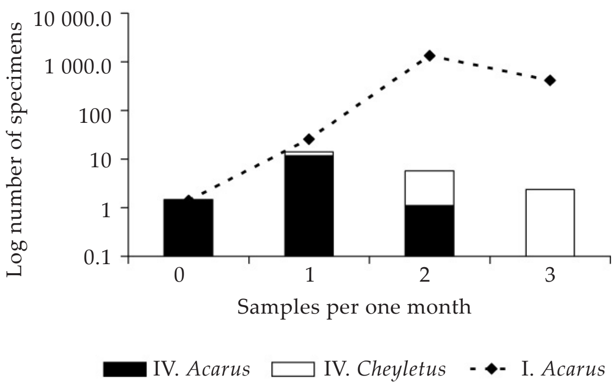

Figure 1. Changes of abundance of *Acarus siro* in the presence of *Cheyletus eruditus* compared to untreated control of *A. siro*

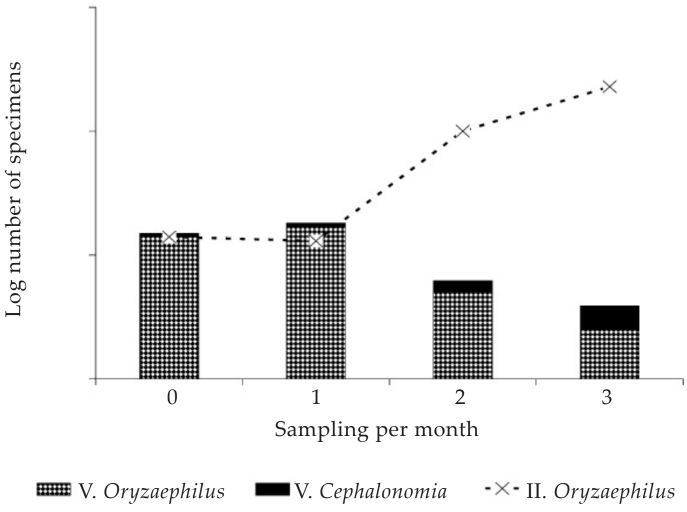

Figure 2. Changes of abundance of *Oryzaephilus surinamensis* in the presence of *Cephalonomia tarsalis* compared to untreated control of *O. surinamensis*

RESULTS AND DISCUSSION

Biological control of the storage mite *A. siro* by the predator *C. eruditus* was very efficient (Figure 1). Whereas the number of mites in the control surpassed 13 000 after 3 months, the predators eliminated the mites close to the zero level. Thereafter, the abundance of the predators decreased. The number of mites was re-calculated to 100 g of substrate.

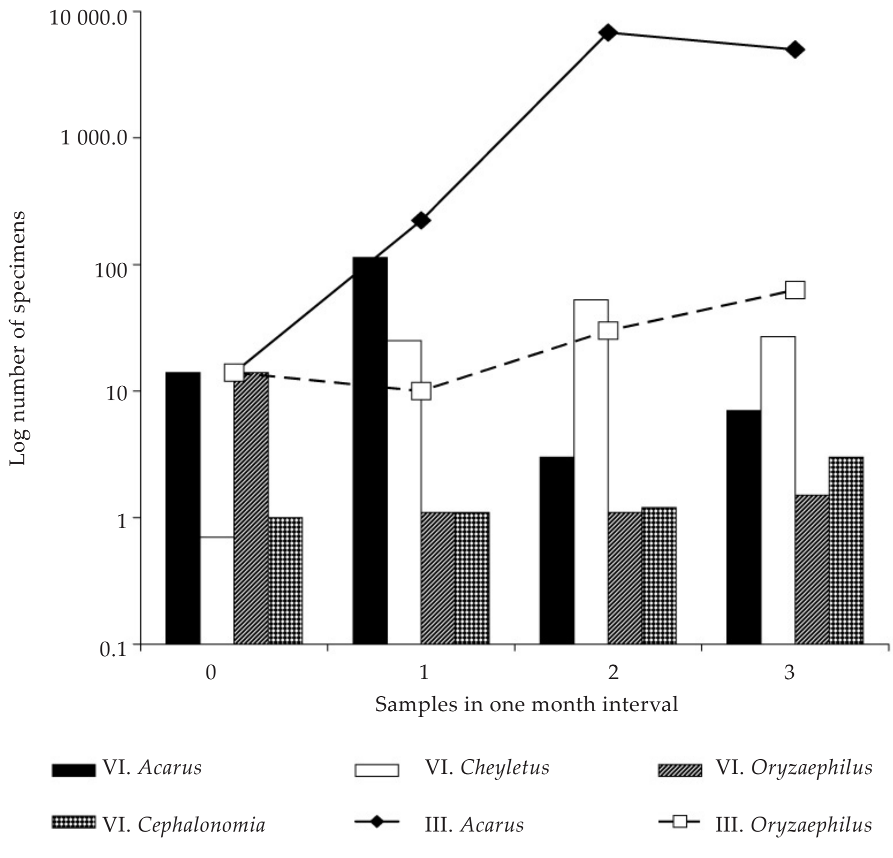

Figure 3. Changes of abundance of *Oryzaephilus surinamensis* (hatched filled bars) and *Acarus siro* when *Cephalonomia tarsalis* and *Cheyleus eruditus* are present concurrently, respectively, compared to untreated control of synchronous presence of *O. surinamensis* and *Acarus siro*

C. tarsalis was able to effectively control *O. surinamensis* (Figure 2). After a steady state of 1 month the abundance of the beetles declined. Its final population density was 1/10th of that without the presence of parasitoid. The number of beetles and parasitoids was re-calculated to 1 kg of substrate.

Surprisingly, synchronous application of both natural enemies resulted in more effective control of *O. surinamensis* than treatment with either biological agent alone; the number of beetles was only 1/40th of that in the control (Figure 3). The predator reduced *A. siro* to 7 specimens compared

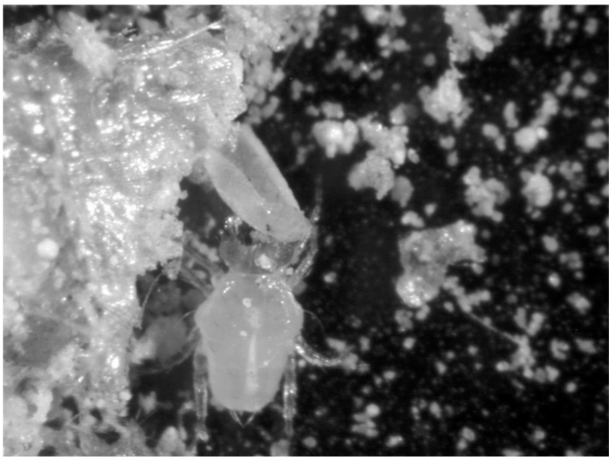

Figure 4. *Cheyletus eruditus* preying on egg of *Oryzaephilus surinamensis* (Photo Lukáš)

to 5000 in the control. The parasitoid multiplied from 4 to 21 specimens. The predatory mites were observed to prey on the eggs of beetles (Figure 4). The number of mites and insects was re-calculated to 100 g and 1 kg of substrate, respectively.

It was found that *C. eruditus* enhances the control of the population density of *O. surinamensis*. Eggs of the beetle can serve as an alternative source of food for *C. eruditus* when the main prey *A. siro* is scarce. Further research is needed to quantify this effect. Nevertheless, this finding leads to predict a higher stability of a biological control programme based on *C. eruditus*.

A number of studies (Helbig 1998; Sanon & Ouedraogo 1998; Schoeller 1999; Gauthier *et al.* 1999, and others) have dealt with the simultaneous release of two bio-agents to suppress one pest species, but the results varied. When the compatibility of *Cephalonomia tarsalis* and *Beauveria bassiana* as biological control agents of the saw-toothed grain beetle (*Oryzaephilus surinamensis*) was tested, the wasps in the experiment had an average mortality of 60% while in the control their mortality was only 1.7% (Lord 2001). Likewise, competition between the parasitoids *Anisopteromalus calandrae* (Howard) and *Choetospila elegans* Westwood exposed to immature rice weevils, *Sitophilus oryzae* (L.), had a negative effect on the populations of both species of parasitoids. Competition reduced their emergence (Wen & Brower 1995). Another example is the intraguild predation of *Phytoseiulus persimilis* Athias and *Neoseiulus californicus* McGregor, both predators of *Tetranychus cinnabarinus* Boisduval (*Tetranychidae*). Release of only *P. persimilis* led to most rapid suppression of the spider mite. Nonetheless, in perennial greenhouse-grown crops, *P. persimilis* and *N. californicus* could have complementary effects and a combination of the two predators could enhance the long-term biological control of spider mites under certain conditions, which have to be farther studied (Schausberger & Walzer 2001). When using two species of parasitoids or predators for application one should choose species that are not competitors; each one should prefer different pest species living in the same microhabitat. Thus, not only application and precise timing of biological agents but also their selection is very important in biological control management.

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Souhrn

Žďárková E., Lukáš J., Horák P. (2003): **Kompatibilita** *Cheyletus eruditus* (Schrank) (*Acari*: *Cheyletidae*) a *Cephalonomia tarsalis* (Ashmead) (*Hymenoptera*: *Bethylidae*) **v biologické regulaci škůdců skladovaného obilí**. Plant Protect. Sci., **39**: 29–34.

Provedli jsme laboratorní pokus na skladované pšenici, která byla napadena roztoči *Acarus siro* L. a brouky *Oryzaephilus surinamensis* (L.). Počáteční napadení bylo 150 roztočů a 15 brouků na 1 kg pšenice. Draví roztoči *Cheyletus eruditus* a parasitoidi *Cephalonomia tarsalis* byli přidáni v poměru 1 : 20 a 1 : 12. Testovali jsme tři kombinace: 1) roztoči 2) brouci odděleně, 3) roztoči a brouci společně. Pokus trval tři měsíce při 22 °C a 75% r. v. vzduchu.

Škůdci byli potlačeni svými přirozenými nepřáteli ve všech kombinacích. Synchronní aplikace obou antagonistů se projevila v účinnější regulaci *O. surinamensis* jako výsledek jejich zvýšeného působení.

Klíčová slova: *Acarus siro*; *Oryzaephilus surinamensis; Cheyletus eruditus*; *Cephalonomia tarsalis*; skladovaná pšenice; biologická ochrana

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