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### **Are synthetic pheromone captures predictive of parasitoid densities as a kairomonal attracted tool?**

**Abstract** - Abundance of White Peach scale (WPS), *Pseudaulacaspis pentagona* (Targioni-Tozzetti) and San José scale (SJS), *Diaspidiotus perniciosus* (Comstock) (Hemiptera: Diaspididae) adult males and their attracted parasitoids were monitored using pheromone and sticky tape traps in an orchard of Budapest, Hungary, during 2010. In this study, we tried answer on the question raised whether synthetic commercial pheromones of WPS or SJS could work as a kairomonal stimulant and positively attract higher numbers of the specialized parasitoids. Although pheromone traps attracted a wide range of parasitoid species, most of them were accidentally. However, the parasitoid *Thomsonisca amathus* (Walker) (Hymenoptera: Encyrtidae) and the parasitoid *Encarsia perniciosi* (Tower) (Hymenoptera: Aphelinidae) significantly respond to the sex pheromones of WPS and SJS, respectively, suggesting that they may play an important role in host location.

**Riassunto** - *Le catture di un feromone sintetico possono fornire indicazioni sulla densità di un parassitoide agendo come uno strumento attrattivo kairomonale?*

La densità di maschi adulti di *Pseudaulacaspis pentagona* (WPS) (Targioni-Tozzetti) e di *Diaspidiotus perniciosus* (SIS) (Comstock) (Hemiptera: Diaspididae) e dei loro parassitoidi è stata monitorata nel corso del 2010, utilizzando feromoni e trappole collanti in un frutteto di Budapest (Ungheria). Scopom del lavoro è stato quello di rispondere alla questione se il feromone sintetico dei due Diaspini agisca come kairomone, attraendo un elevato numero di parassitoidi specializzati. Sebbene si verifici ciò, la maggior parte dei parassitoidi viene catturata occasionalmente. Tuttavia, l'Imenottero Encirtide *Thomsonisca amathus* (Walker) e l'Afelinide *Encarsia perniciosi* (Tower), rispondono in modo significativo al feromone sessuale, rispettivamente, di WPS e di SIS; ciò suggerisce che il feromone può svolgere un ruolo importante nell'individuazione dell'ospite.

**Key words:** *Thomsonisca amathus*, *Encarsia perniciosi*, *Pseudaulacaspis pentagona*, *Diaspidiotus perniciosus*, Europe.

## INTRODUCTION

The white peach scale (WPS), *Pseudaulacaspis pentagona* (Targioni-Tozzetti, 1880) (Hemiptera: Diaspididae) is one of the most important pest of ornamentals and fruit trees (about 380 host plant records) all over the world (Ben-Dov *et al.*, 2010; Koszarab and Kozár, 1988; Kozár, 2009; Saber *et al.*, 2010). The other important armored scale insect is the San José scale (SJS), *Diaspidiotus perniciosus* (Comstock, 1881) (Hemiptera: Diaspididae) which attacks at least 34 families of hosts (over 700 species) and it has become a cosmopolitan pest in deciduous fruit and nut orchards (Ben-Dov *et al.*, 2010; Konstantinova *et al.*, 1982).

Pheromones are one of the major components of ecologically based insect pest management (Kozár, 1997; Howse *et al.*, 1998). Effectively, the use of pheromones for monitoring, mass trapping, mating disruption, or lure-and-kill has been investigated or developed during recent decades (Smetnik, 1991; Kozár, 2009). Parasitoids often use chemical stimuli, called infochemicals (Mendel *et al.*, 2004; Franco *et al.*, 2008) when they are searching for their hosts, and these infochemicals can be associated to their host, such in the case with the host sex pheromone (reviewed in Godfray, 1994). Parasitoids can orientate towards these cues over a moderate distance that they associate in some way with the host.

Although pheromones are generally viewed as environmentally sound, some practical problems regarding their safety could arise from their kairomonal activity. This is of importance, as catching large numbers could affect negatively the densities of these beneficial insects, and potentially result in increases in pest populations. However, this aspect has not been studied in detail to date in scale insects. Matuhira and Kouzaki (2001) reported that *Thomsonisca typica* Mercet, 1920 was the only parasitoid attracted by the synthetic sex pheromone of *P. pentagona* in Japan. They found that a half of attracted female wasps had well developed ovaries, suggesting that they use the sex pheromone as a kairomone in order to find a host scale. On the other hand, when sex pheromones are used as a pest management strategy, the potential negative effects on the populations of natural enemies must take into consideration. As an alternative, using of pheromone lure alone in the infested trees, as an attractive kairomonal tool, could help to increase the efficiency of parasitoids in biocontrol rather than to reduce their populations. The attractively of parasitoids *T. amathus* was observed in the pheromone traps of WPS during 2009 (Kozár, personal observations).

The objective of this study was to evaluate the effectiveness of commercial pheromones of WSP and SJS for catching parasitoids as kairomonal stimulants.

## MATERIALS AND METHODS

The effect of baited traps with synthetic pheromone dispensers of *P. pentagona* (WSP) and *D. perniciosus* (SJS) as well as the non baited sticky traps on the numbers of captured males and parasitoids was studied in Budapest (Hungary) during 2010. The trees (*Prunus* sp., *Malus pumila* Mill., *Syringa vulgaris* L.) in surrounding area were



Fig. 1 - Hungarian tent trap with the pheromone dispenser (Photo Dr. I. Tóbiás).

infested with both scales. The traps were of the Hungarian tent trap design (10×10 cm, plastic square with plastic glue). Commercial pheromone dispensers of WSP and SJS were obtained from Biochemtech (Biochemtech Ltd. Kishinev, Moldavia) pheromone dispensers, with Soveurode (Witasek Pflanzenschutz GmbH, Austria) glue. The compound of the sex pheromone of WPS is (Z)-3,9-dimethyl-6-isopropenyl-3,9-decadien-1-yl propanoate (WPS-1) (Heath *et al.*, 1980). The compounds of SJS pheromone are: (Z)-3,7-dimethyl-2,7-octadien-1-yl propanoate (SJS-I; ca. 48%) and 7-methyl-3-methylene-7-octen-1-yl propanoate (SJS-II; ca. 47%) (Gieselmann *et al.*, 1979). The dispensers of both pheromones were left in the field for c. 4-8 weeks and then replaced according to Rice *et al.*, (1982). The pheromone dispenser was suspended c. 3-4 cm below the trap (Figure 1). The sticky tape trap squares were replaced every time the traps were inspected and the number of scale insect males and their attracted parasitoids were counted in the laboratory using stereo binocular microscope (Figure 2).

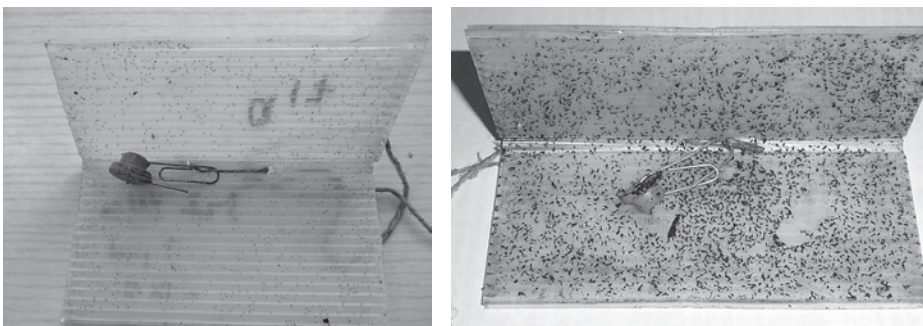


Fig. 2 - The males of *P. pentagona* (left) and the parasitoids (right) captured on the internal white plastic surfaces of the pheromone trap.

For each host, three pheromone traps (treatment) and three sticky traps (control) were monitored for each data as recommended by Rice *et al.* (1982). Traps were placed in the orchards on 1 June till 13 November 2010. The pheromone and sticky traps were located at minimum five trees from an orchard border and at a height of about 2 m from the ground (Rice *et al.*, 1982).

For each diaspidid host, the mean WSP and SJS males and their associated parasitoids captured in the three pheromone traps and the three associated sticky tape traps within each date of 2010 contributed for the regression analyses. Regression analyses were performed by using SPSS to determine the relationship between the WSP males and the parasitoid *Thomsonisca amathus* (Walker, 1838) as well as between SJS males and the parasitoid *Encarsia perniciosi* (Tower, 1832) captured in the pheromone traps during 2010. Data were analyzed by using One way ANOVA followed by post hoc Student-Newmann-Keul's multiple-range tests ( $\alpha = 0.05$ ) (CoStat, 2004). The WPS and SJS pheromones have relative volatiles, therefore to test the pheromone response of WPS and SJS males and the kairomonal response of *T. amathus* wasps for both pheromones, the data were analyzed using independent sample *t* test. Data were  $\ln(x + 1)$  transformed prior to analysis to normalize the residuals. Bars in the graphs were followed with mean numbers of catches prior to transformation.

## RESULTS

A wide and low range of WSP and SJS male densities were recorded in pheromone traps in the orchard monitored during the different periods of study. The highest number of WPS and SJS male catches was recorded during July. The *t* test revealed that there were significant differences in male catches of each diaspidid host between pheromone and sticky traps during different swarming periods. The statistical analysis showed that there were significant differences between parasitoid species captured in pheromone traps within each period of swarming, but not in sticky traps (Figures 3, 4). In addition, there was a significant difference between the mean numbers of WPS and SJS male catches by pheromone traps during the period of study ( $t=4.01$   $P<0.0001$ ) (Figure 5).

A wide range of specialized aphelinid parasitoid species was recorded in the traps baited with WPS or SJS pheromones. The endoparasitoid, *Encarsia berlese* (Howard, 1906) and ectoparasitoid *Aphytis proclia* (Walker, 1839) in WPS traps; and the endoparasitoid *E. perniciosi* and *A. proclia* in SJS traps were recorded in few numbers in both pheromone and sticky traps. On the other hand, the encyrtid endoparasitoid *T. amathus* was recorded in high numbers in sex pheromone traps of WPS, while the encyrtid endoparasitoid *Coccophagous* sp. was recorded in very few samples in traps of both host.

In the WPS and SJS pheromone traps, the parasitoids *T. amathus* and *E. perniciosi* were captured in significantly higher numbers than other species, respectively (Figure 3). There were significant differences in the number of *T. amathus* captures between pheromone and sticky traps of WPS ( $F= 189.44$ ,  $df= 3,11$ ,  $P < 0.001$ ) (Figure 4). In WPS pheromone traps, there were significant differences between parasitoid species captures

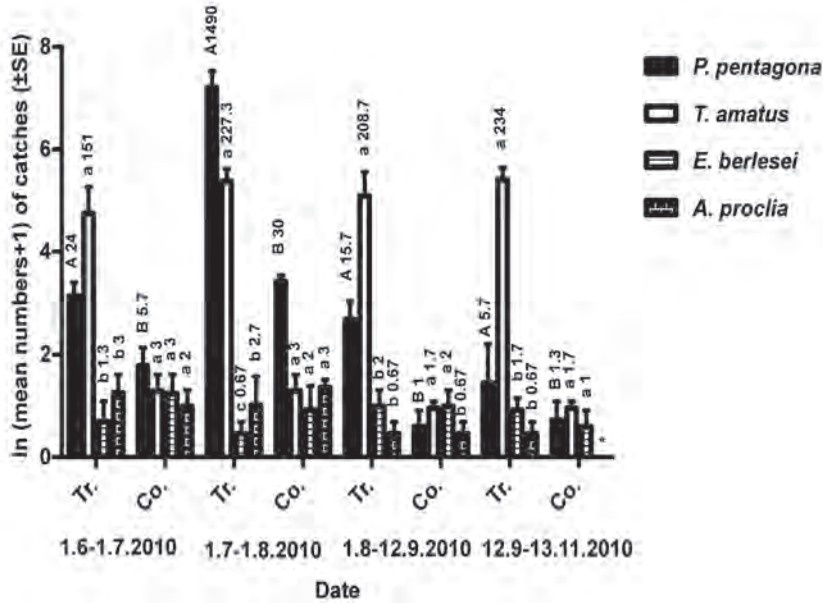


Fig. 3 - ln (mean numbers+1) of *P. pentagona* males and parasitoids captured in pheromone (treatment) and sticky (control) traps during the different swarming dates in 2010. Bars followed with the different small (between parasitoid species within each treatment or control) and capital (between treatment and control for each host species) letters (letters followed with mean numbers prior to transformation) within each date are significantly different at  $\alpha=0.05$ . \*Data equal to 0 and not statistically enough for comparison.

within each period of study, and the same significant differences were also performed in SJS pheromone traps (Figures 3, 4). The mean numbers of *T. amathus* wasps significantly differed between WPS and SJS pheromone traps ( $t= 13.19$ ,  $df= 1,11$ ,  $P< 0.001$ ; Figure 5), while there were no significant differentiation between sticky traps and SJS trap. This information shows that catches of *T. amathus* by SJS traps was accidentally.

There were no significant relationships between WPS males and *T. amathus* wasps ( $n= 12$ ,  $r= 0.20$ ,  $P> 0.05$ ) as well as between SJS males and *E. perniciosi* wasps ( $n= 12$ ,  $r= 0.42$ ;  $P> 0.05$ ) during the period of study.

## DISCUSSION AND CONCLUSIONS

The parasitoids *T. amathus* and *E. perniciosi* significantly respond to the sex pheromones of WPS and SJS compared with other species, suggesting that they may play a role in host location (Tashiro *et al.*, 1979). This kairomonal activity is previously demonstrated in insect parasitoids in Japan, where the parasitoid *T. amathus* responded

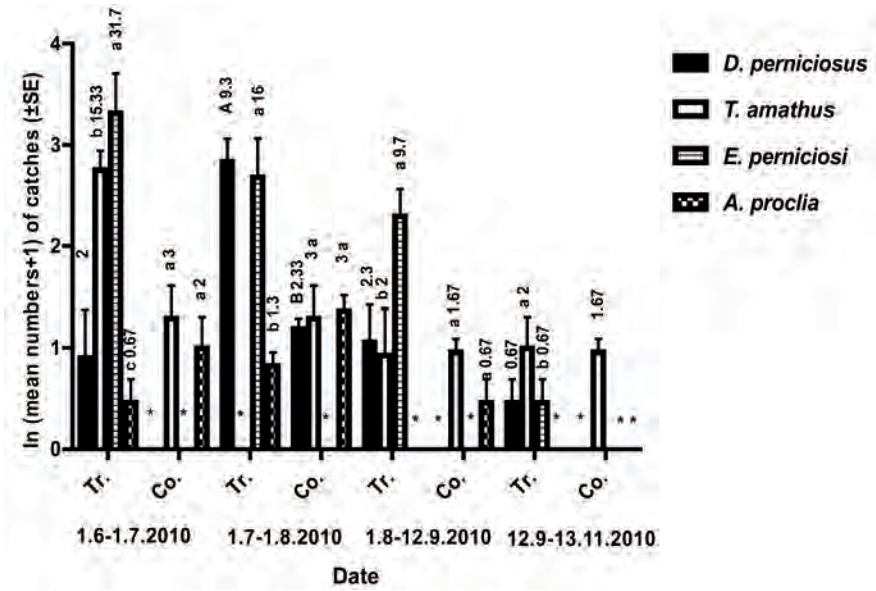


Fig. 4 - ln (numbers+1) of *D. perniciosus* males and their collected parasitoids captured in pheromone (treatment) and sticky (control) traps during the periods of activity in 2010. Bars followed with the different small (between parasitoid species within each treatment) and capital (between treatment and control for each host species) letters within each date are significantly differed at  $\alpha=0.05$ . \* Data equal to 0 and not statistically enough for comparison.

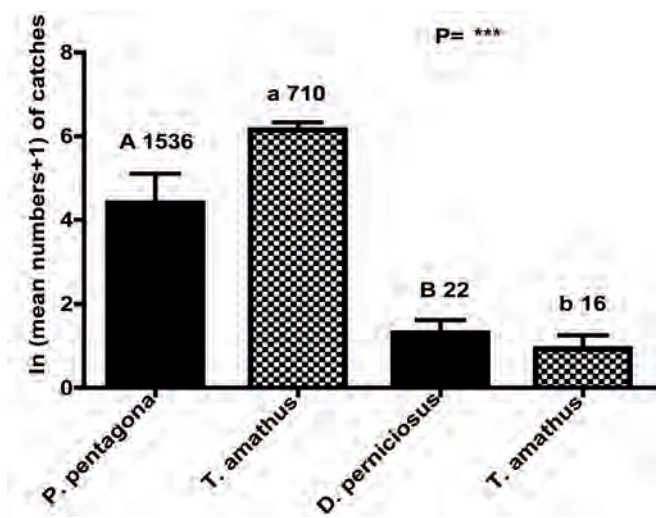


Fig. 5 - ln (mean numbers+1) ( $\pm$ SE) of *T. amathus* wasps captured in pheromone traps of *P. pentagona* and *D. perniciosus* during 2010. Bars followed with the different small (+ total catches) or capital letters (+ total catches in 2010) are significantly differed at  $\alpha=0.05$ .



to the WPS pheromone (Matuhira *et al.*, 2001). *T. amathus* is a common parasitoid of the diaspidid species, *Chionaspis salicis* (Linnaeus, 1758), *C. lepineyi* Balachowsky 1928, and *P. pentagona* in central Europe (Erdős, 1957; Kosztarab and Kozár, 1988; Zahradnik, 1972; Trjapitzin, 1978; Subba Rao, 1979). In this study, WPS pheromone seems to be a kairomone for *T. amathus*. This was because higher numbers of *T. amathus* wasps were attracted to WPS pheromone than SJS pheromone, since that there were significant differences between pheromone and sticky trap captures, while these differences were absent in case of SJS. Furthermore, the highest number of *T. amathus* wasps was recorded during July in WPS and SJS pheromone traps; however, there was high variation in its population in the pheromone traps of both hosts (Figures 3, 4). Therefore, it seems to be accidentally crossed to SJS pheromone traps during its swarming towards WPS pheromone. The WSP pheromone may be having a kairomonal function for attracting high numbers of *T. amathus*, and thus the effects of both functions may be may be antagonistic or synergistic.

In conclusion, our study provides insights on the kairomonal responses of parasitoids to synthetic sex pheromones. The synthetic WPS pheromone had a higher kairomonal effect on *T. amathus*; however, SJS pheromone had the same effect on *E. perniciosi*, suggesting that they may play a role in host location. Our results are the first to capture *T. amathus* using the synthetic pheromone of SJS, however this was thought accidentally.

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