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Effect of type, color and location of sticky pheromone traps on male moth catches of *Cameraria ohridella*

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Abstract: The horse chestnut leaf miner, *Cameraria ohridella* Deschka & Dimic (Lepidoptera: Gracillariidae), is a new invasive pest that has spread all over the Europe over the last 25 years. This paper presents research aimed to: 1) compare the effectiveness of sticky pheromone traps of various types (sizes and colors), 2) determine the effect of a trap location on moth catches. Studies were conducted in Warsaw and Falenty near Warsaw. No trap color preference by male moths was found in tests of white, blue and green barrier traps. Barrier traps had the largest sticky area (32 dm^2) in comparison to PL-2 (5.625 dm^2) and delta PL-1 (3.4 dm^2) traps, thus they caught the highest total number of males, however PL-2 traps were the most effective (268-381 moths/dm^2). The results of the studies suggest that to make traps with the *C. ohridella* pheromone be more effective they should: a) be located on a stem below a tree crown or in its lower part for the first *C. ohridella* generation, and in crowns for the second and later insect generations, b) be placed in some distance from a tree stem, if located in crowns.

Keywords: horse chestnut leaf miner

INTRODUCTION

The horse chestnut leafminer *Cameraria ohridella* has become a serious pest of the white flowering horse chestnut *Aesculus hippocastanum* L. (Hippocastanaceae) in urban territories over the whole Europe since 1984 when it was observed in Macedonia for the first time [1]. It produces two to four generations per year, thus mining larvae cause heavy leaf damage throughout the season, and at high densities *C. ohridella* completely defoliates trees already in summer.

In 1999 Svatoš et al. [2] identified the pheromone of *C. ohridella* as (8E,10Z)-tetradeca-8,10-dienal. Later Hoskovec et al. [3] described its synthesis and Francke et al. [4] conducted the studies that confirmed pheromone structure, synthesis and biological activity. The pheromone may be used for different purposes, like monitoring, mass trapping, mating disruption, etc [5]. For monitoring and mass trapping lures are placed in traps of different types. The delta trap is usually used as a standard trap [6] to: a) determine a beginning of the flight period and terms of pest control e.g. using chitin synthesis inhibitors before hatching of larvae, b) detect the pest in new areas, c) evaluate efficacy of various control methods, etc. The major disadvantage of this trap type is that it becomes saturated very quickly, thus requiring replacement of a sticky insert [7, 8, 9, 10]. Other tested sticky traps, e.g. barrier traps of a small size (25 x 10 cm), showed similar effectiveness to those of delta traps. There was no significant effect of a color (yellow or blue) on number of moths on barrier traps mentioned above in comparison to white delta traps [8]. However Baranowski et al. [9] showed that 50 cm wide transparent sticky bands on tree stems were more effective than yellow ones. They also found out that sticky bands or barrier traps with pheromones caught significantly more leaf-miner moths and significantly less non-target insects than those without pheromones. To avoid saturation of a sticky surface a few non-sticky traps (funnel and tube traps) have been tested and proved to be a good alternative for delta and barrier sticky traps [7, 10].

Since sticky traps are used in practice most often for different purposes, our objectives were to: 1) compare the effectiveness of such traps, but of various types (shape and size) and colors, 2) determine the effect of trap location (a height above the ground and distance from a tree stem) on moth catches. The studies were conducted in 2003 using Camerariawit lures distributed in Poland by Fa. Interforst Polska (currently Inter Forst Polska Sp. z o.o., Marcinowice, Poland) and various types of sticky traps produced by WITASEK Pflanzenschutz GmbH, Feldkirchen, Austria (distributed by Fa. Interforst Polska), IPM Tech, Inc. (currently APTIV, Inc., Portland, OR, USA), and ZD Chemipan (Warsaw, Poland). The results allowed us to propose the way to increase an effectiveness of sticky traps with the highly attractive *C. ohridella* sex pheromone to be used in monitoring or integrated pest management system.

METHODS

Study areas

The study areas were located in the horse chestnut plantations: 1) along Szwoleżerów and Wołoska streets, and in the Łazienki Królewskie park in Warsaw, and 2) in a small park in Falenty near Warsaw. The effects of a trap type and color

on male moth catches were studied in 20-30 year old tree plantations along two streets in Warsaw (hereafter Szwoleżerów and Wołoska sites). The effect of trap location was studied in Falenty and the Łazienki Królewskie park with 70-80 year old trees (hereafter Falenty and Łazienki sites, respectively).

Testing traps of various colors

The experiment was set up at the Wołoska site on 9 July 2003, during the flight period of the second generation of *C. ohridella*. We tested 32 Witasek barrier sticky traps (Photo 1a) of two types – 16 blue and 16 green traps with the sticky area of 48 dm^2, and 6 white barrier traps with the sticky area of 32 dm^2 produced by ZD Chemipan. A half of traps of each type was baited with lures Camerariawit and another half was without lures. Traps were set up in the lower parts of crowns (1 trap per tree), at the height of 3-4 meters above the ground, in the following order: Bp→Gp→B→G→W→Wp→Bp→Gp→B→G→repeted two more times→ Bp→Gp→B→G→Bp→Gp→B→G (B – blue trap, G – green trap, W – white trap, p – pheromone). They were checked on 14 July 2003. One white trap without pheromone was damaged during the observation period.

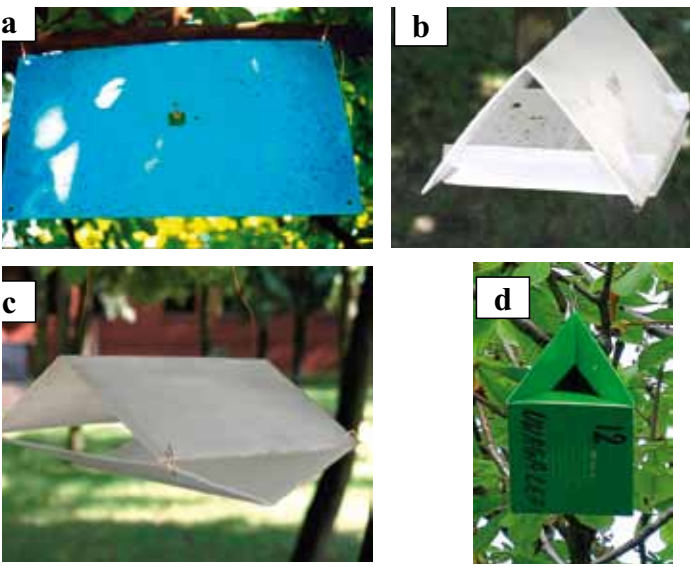

Photo 1. Trap types used in the studies: a) barrier sticky trap produced by WITASEK Pflanzenschutz GmbH (Feldkirchen, Austria), b) PL-1 sticky trap and c) PL-2 sticky trap by ZD Chemipan (Warsaw, Poland), d) delta sticky trap by IPM Tech, Inc. (currently APTIV, Inc., Portland, OR, USA).

Testing traps of various types

This experiment was set up at Szwoleżerów site on 1 July 2003, during the flight period of the *C. ohridella* second generation. We used 15 white sticky traps (ZD Chemipan) of three types: five delta PL-1 traps (Photo 1b) with the sticky area of 3.4 dm^2, five PL-2 traps (Photo 1c) with sticky area of 5.625 dm^2, and 5 barrier traps with the sticky area of 32 dm^2. Traps were baited with Camerariawit lures and set up in the following order repeated five times: PL-1→PL-2→barrier trap. Traps were checked on 3 July.

Effects of trap location on moth catches

The first experiment was set up at Falenty site on 8 May 2003 during the flight period of the first *C. ohridella*' generation. The IPM Tech delta sticky traps (Photo 1d) were established at the height of about 3, 5 and 8 m above the ground, in crowns of 60-80 years old trees. Each height variant was replicated 5 times. Traps were checked on 13 May.

The second experiment was set up at Falenty site on 9 July 2003 during the flight period of the second leaf miner's generation. We used 16 Witasek barrier sticky traps of 4 x 6 dm (Photo 1a) with Camerariawit lures. Eight traps were established in tree crowns at the height of 6-8 m above the ground and 1 m from a stem at least. The sticky area of these traps was 48 dm^2 each, which includes both sides of a trap. The remaining traps were attached to tree stems at the height of 1.5 m above the ground and in this case the sticky area was 24 dm^2 (one side of the trap). Traps were checked on 14 July.

The third experiment was set up at Łazienki site on 12 May 2003 on the first generation of *C. ohridella*. The IPM Tech delta sticky traps were established near the stems, in the middle and at the edge of crowns of 80 years old horse chestnut trees at the height of about 6 m above the ground (one trap per tree). Each variant was replicated three times. Traps were checked on 20 May.

Moth counting and data analyses

When moth catches in barrier traps were too high, counting of moths was done on four squares of 1x1 dm on each side of traps (taking into consideration the distribution of moths on sticky area). Then, numbers of moths on the whole sticky area of traps were calculated. The number of moths per 1 dm^2 or the total number of moths per trap was used as variables in further statistical analyses.

Moth catches were analyzed by *t*-test or one-way ANOVA followed by Tukey test for equal or unequal sample size. When required, data were transformed as $x' = \log_{10}(x)$ to correct for heterogeneity of variances before analysis. When assumptions for one-way ANOVA were not met, the Kruskal-Wallis test was used

followed by a post-hoc test for multiple comparisons of ranks [11]. All analyses were performed using Statistica 7.1 software package (StatSoft Inc. 2005).

RESULTS AND DISUSSION

Effect of trap color and type on moth catches

Numbers of moths per 1 dm^2 in barrier traps with the pheromone were significantly higher than in traps of a respective color without the lure (Figure 1). Total average catches in five day period were 1,055-1,328 and 18-97 moths per trap in traps with and without the pheromone, respectively. These results confirm the high attractiveness of the *C. ohridella* sex pheromone to males. White barrier traps were more effective (41.5 and 3.0 moths/dm^2 in traps with and without the pheromone, respectively) than traps of other colors. The lowest numbers of moths were in green traps (22.0 and 0.4 moths/dm^2 in traps with and without the pheromone, respectively), but the differences in catches between traps of different colors were not statistically significant (Figure 1). Our results confirm the conclusion of Baranowski and Gaczkowska [8] that the trap color has no significant effect on catches of male moths, although they tested only blue and yellow barrier traps that in addition were much lower (2.5 dm^2) in size.

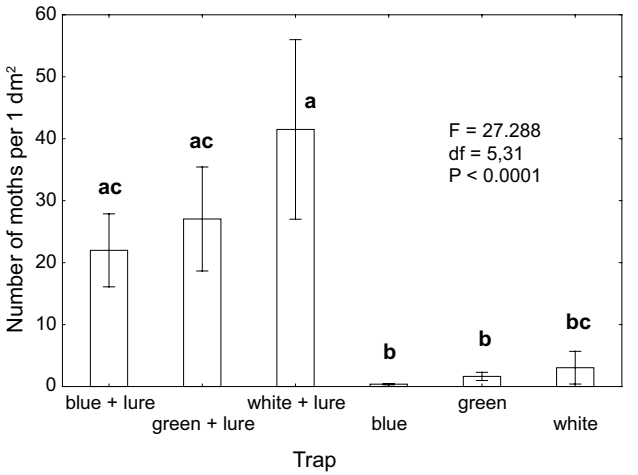

Figure 1. Mean numbers (±SE) of *Cameraria ohridella* moths per 1 dm^2 captured in the barrier sticky traps of different colors with and without lure in the period of 9-14 July 2003. Warsaw, Wołoska site. One-way ANOVA on log_{10}-transformed data followed by Tukey test for unequal sample size.

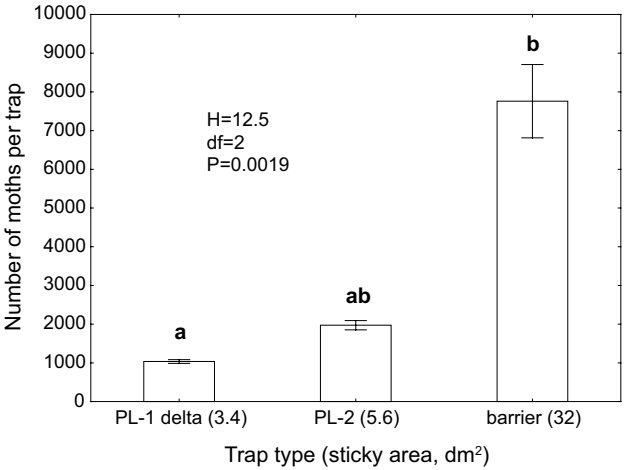

Figure 2. Mean numbers (±SE) of *Cameraria ohridella* moths per trap captured in PL-1 delta, PL-2 and barrier sticky traps (by ZD Chemipan) in the period of 1-3.07.2003. Szwoleżerów site, Warsaw. Kruskal-Wallis test followed by multiple comparisons of ranks.

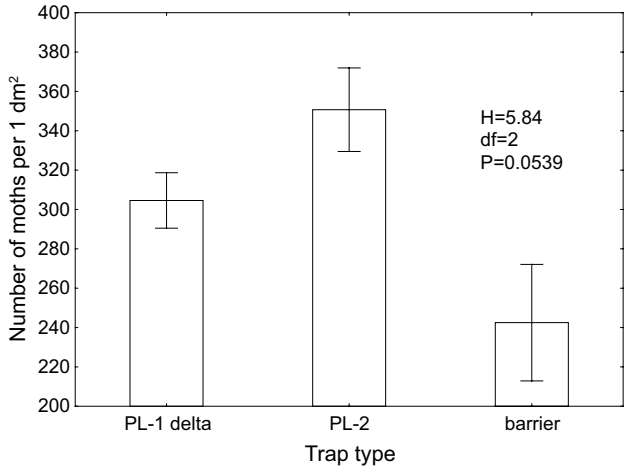

Figure 3. Mean numbers (±SE) of *Cameraria ohridella* moths per 1 dm^2 captured in PL-1 delta, PL-2 and barrier sticky traps (by ZD Chemipan) in the period of 1-3.07.2003. Szwoleżerów site, Warsaw. Kruskal-Wallis test followed by multiple comparisons of ranks.

Trap type had a significant effect on *C. ohridella* catches per trap in the experiment conducted at Szwoleżerów site (Figure 2). The larger was a sticky area, the higher were total moth catches per trap, but significant difference was

only between the highest mean number of moths in barrier traps (7760 moths/trap) and the lowest one in delta PL-1 traps (1036 moths/trap). However, when the numbers of moths per 1 dm^2 for each trap type were compared, the PL-2 trap appeared to be the most effective (351 moths/dm^2) and barrier traps were the least effective (242 moths/dm^2), although the difference was not significant at α=0.05 (Figure 3).

The highest total catches in barrier traps can be explained by their large sticky area, which, on another hand, makes traps more susceptible to wind causing their movement. This could be one of the reasons of the low effectiveness of barrier traps.

The effect of trap location on moth catches

In the experiment on the first generation of *C. ohridella* at Falenty site no significant differences in moth catches were revealed between IPM Tech traps established at the height of 3, 5 and 8 m above the ground. The mean number varied from 726 to 816 moths per trap.

In the experiment on the second generation at the same site we found out that the mean number of moths per 1 dm^2 of sticky area in Witasek barrier traps established in crowns at the height of 6-8 m above the ground was significantly higher than in those located on tree stems at the height of 1.5 m (Figure 4). The total number of moths captured in all traps established in crowns was 7.5 times higher than in traps located on stems (14,833 and 1,957 moths respectively).

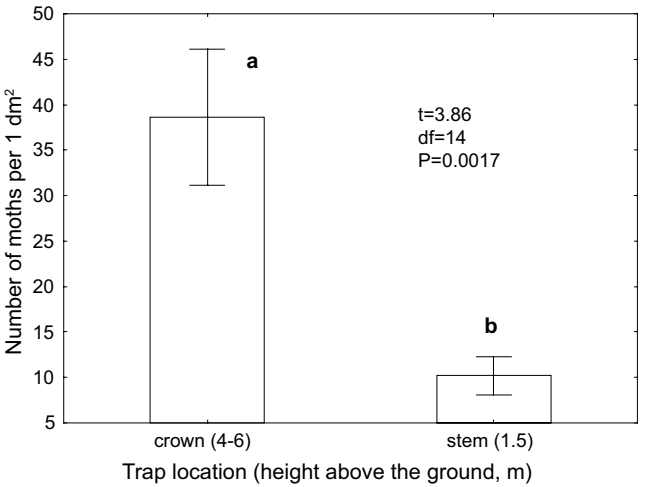

Figure 4. Mean numbers (±SE) of *Cameraria ohridella* moths per 1 dm^2 captured in the Witasek traps established in the crowns and on the stems of the horse chestnut trees (Falenty, 9-14.07.2003). Test t on log_{10}-transformed data.

Moths of the first generation, emerging from the litter, concentrate for mating rather in the lower part of tree stems. In our studies we tried to find out how males of *C. ohridella* are distributed in crowns. We did not find any significant difference in catches in traps established in crowns at 3, 5 and 8 m above the ground. This result suggests that male moths are distributed rather evenly in crowns and only a portion of the male population fly upward, probably, when the population in the lower part of a tree stem (below a crown) is overpopulated. During the flight of the second generation the catches in tree crowns were higher than on stems, suggesting that moths of later generations fly mainly in crowns.

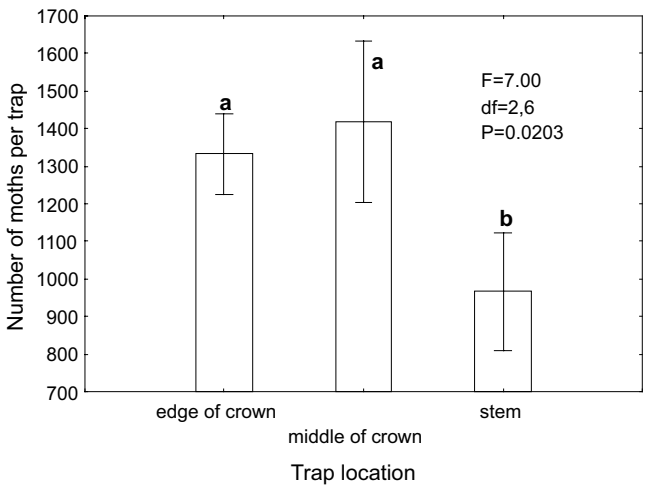

Figure 5. Mean numbers (±SE) of *Cameraria ohridella* moths captured in the IPM Tech traps established near stems, at the edge and in the middle of crowns of horse chestnut trees at about 6 m above the ground („Łazienki" site, 12-20.05.2003).

The location of IPM Tech delta traps at different distances from stems of the horse chestnut trees at Łazienki site resulted in low moth catches in traps located near tree stems and significantly higher catches in traps at the edge and in the middle of the crown radius (Figure 5). It seems that when traps are established just near stems, their effectiveness is limited, because it then depends on additional factors, like e.g., a wind direction.

CONCLUSIONS

1. We did not reveal any color preference of traps by *C. ohridella* male moths, although there was some bias towards white color traps.
2. Trap catches are highly influenced by the size of sticky area of traps. The number of moths in barrier traps with the largest sticky area was slightly higher than in PL-2 traps and significantly higher than in delta PL-1 traps. However, PL-2 traps were the most effective in comparison to other traps, when numbers of moths per 1 dm^2 were compared, although differences were not significant.
3. To increase the effectiveness of traps they should be placed: 1) on stems below a tree crown or in its lower part during the flight period of the *C. ohridella* first generation, 2) in crowns and in a distance from a tree stem during the flight period of the second and later generations.

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