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EFFECTIVENESS OF VISUAL TRAPS FOR DETECTION AND SURVEY OF CONE FLIES, *STROBILOMYIA* SPP. (DIPTERA: ANTHOMYIIDAE), INFESTING CONES OF EUROPEAN LARCH (*LARIX DECIDUA* MILL.) IN ROMANIA

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Abstract

Visual traps consisting in a set of horizontal yellow sheets and vertical sheets coloured in yellow with purple stripes were used to monitor *Strobilomyia* cone flies in a larch seed orchard in Romania. Three species, *S. laricicola* Karl, *S. melania* Ackland and *S. infrequens* Ackland were detected, and a total of 101 individuals were caught from late April to early June. *S. melania* was predominant, accounting for 50.5 % of the captures, whilst *S. laricicola* represented 39.6 %, and *S. infrequens* only 9.9% of the trapped insects. These captures overestimated the population density of *S. laricicola* relatively to these of the two other species. The trapping confirmed the existence of phenological differences in the flight period of the three *Strobilomyia* cone flies but these flight periods partially overlapped. The sex ratio of the trapped specimens varied largely among species, females and males being predominant in *S. laricicola* and *S. melania*, respectively. Both kinds of traps (horizontal and vertical) caught about the same number of cone flies per species regardless of sex, except for *S. melania* where females were significantly more trapped by the horizontal traps. The differences observed between the Alps and Romania in the response to visual traps of *S. laricicola* led to suggest the existence of geographical strains for that species.

Introduction

In Romania, twelve insect species are known to attack cones and seeds of European larch (*Larix decidua* Mill.). Among them three cone flies of genus *Strobilomyia* (Diptera: Anthomyiidae), *S. laricicola* Karl, *S. melania* Ackland, and *S. infrequens* Ackland, usually constitute the major pests (Olenici, 1998; Olenici, Olenici, 1999). Therefore, control tactics have been proposed to limit fly damage (Olenici, 1991; 1992; 1998) but such measures remained difficult to be applied because the estimation of damage level was only based on cone dissection; i.e., after the larvae have begun to damage the cones. The usefulness of visual traps to monitor *Strobilomyia* spp. has been shown in the Alps (Roques, 1986b) and China (Yao *et al.*, 1991; Roques *et al.*, 1995). Relying on the behaviour of cone flies, the trapping design mimics the reflectance contrast between cone and foliage of larch, which represents a visual cue for adults in search of mating and oviposition sites within a larch stand (Roques, 1986a). However, the response of cone flies appeared to differ significantly with species, sex, sexual maturation and location (Roques *et al.*, 1995). The main objective of our study was to assess the relative attractiveness of these visual traps for adults of both sexes of the three species of *Strobilomyia* present in Romania, and to compare the captures with specific cone damage in order to determine whether visual trapping can be used for survey and monitoring of cone fly populations in that region.

Materials and methods

The study was conducted in 1992 within a 5.6 ha-large seed orchard of European larch located at Hemeiusi - Bacau (46° 35' N, 26° 58' E, 180-200 m above sea level), north- eastern Romania. The trapping design consisted of a pair of yellow traps settled near three larch trees bearing cones on lower crown. Each pair consisted of 1- a plywood plate (20 by 20 by 1 cm) covered with a sheet of "Yellow A" (Pantone®), that was fixed in an horizontal position on a post 40 cm above ground, 2 m from the tree; 2- a similar plate covered with "Yellow A", on which were glued two vertical stripes (1 by 20 cm) of "Purple A" (Pantone®) at equal distances from either edge, and mounted vertically on a post 2 m above ground, 20 cm from the tree, the coloured design facing the external side of the tree. The traps respectively aimed at mimicking nutritional flower-type stimuli to attract immature flies searching for food (horizontal trap) and the natural cone-foliage reflectance contrast to attract sexually mature flies (vertical trap) (Roques, 1986b). The traps were settled so that they were sun-exposed from 10:00 am to 4:00 pm during the whole trapping period. A thin layer of Soveurode® was sprayed over each trap to catch alighting flies.

The trapping began on 15 April and lasted until 26 May (6 weeks). The colored sheets were replaced weekly to prevent significant alteration in the reflectance of color as a result of exposure to direct sunlight (Jenkins and Roques, 1993). All anthomyiid-like flies were then removed from the sheets at laboratory. In order to remove the glue, the flies were immediately put in methylcyclohexane for 10 min and then in alcohol 100^{o} for another 10 min. They were finally preserved in alcohol 70^{o}. After having been cleared in KOH 10% for several hours, the species were identified by examining the genitalia (Michelsen, 1988).

In order to compare the captures with the development of specific damage by *Strobilomyia* spp., 10 cones per tree were randomly sampled on 5 trees every week throughout the trapping period. At the end of the experiment, a total of 100 cones was finally collected on 10 trees in order to measure more precisely the final damage. All the sampled cones were immediately dissected, scale by scale, and the possible insect traces (egg, larva, damage) were referred to cone fly species using descriptions from Roques (1984).

The number of individuals captured per species and sex on each trap was transformed using logarithmic transformation ($\log_e[x+1]$) in order to stabilize variance, and then compared between horizontal and vertical traps using ANOVA tests ($\alpha < 0.05$).

Results and discussion

Species-specific response to trap colour and trap position

A total of 101 *Strobilomyia* cone flies were caught by the visual traps (Tab. 1). The most abundant species was *S. melania* (51 individuals; i.e., 50.5% of the total captures), followed by *S. laricicola* (40 individuals; i.e., 39.6%), a few number of *S. infrequens* having been trapped (10 individuals; i.e., 9.9%). However, the respective proportions of damaged cones were highly different. Taking into account that several species could be present in the same cone, maggots of *S. melania* were observed in 97.9 % of the sampled cones whereas these of *S. laricicola* and *S. infrequens* infested 35.0% and 45% of the cones, respectively. These data suggested that the trapping led to an overestimation of the population density of *S. laricicola* relatively to that of the two other species, the more as the female of *S. laricicola* tends to disperse the eggs on the larger number of cones as possible (usually one, more scarcely two eggs per cone; Roques *et al.*, 1984) whilst these of *S. melania* and *S. infrequens* concentrate egg-laying (several eggs per cone; *ibidem*). Previous trappings carried out with similar visual traps in the French and Italian Alps supplied opposite results, *S. laricicola* having been much less trapped comparatively to *S. melania* with respect to their relative damage in the stand (Roques, 1984; 1986b; Jenkins, Roques, 1993; Da Ros, 1997). In addition, Roques (1984) showed that French specimens of *S. laricicola* replied significantly more to white lures than to yellow ones in arena whereas the response of *S. melania* was opposite. Convergent observations were made in northeastern China where yellow traps largely underestimated the abundance of *S. laricicola* in comparison to that of a vicariant of *S. melania*, *S. melaniola* Fan (Roques *et al.*, 1995).

Table 1. Species- and sex-specific responses of *Strobilomyia* spp. to the different types of visual traps used in a larch seed orchard during April-May 1992 in Romania

Species	Sex	Horizontal trap*	Vertical trap*
S. laricicola	males**	1.33 (1.53)^{aA}	1.00 (1.00)^{aA}
	females	5.00 (5.29)^{aA}	6.00 (7.81)^{aA}
S. melania	males	5.33 (4.73)^{aA}	8.00 (4.58)^{aA}
	females	3.00 (4.36)^{aA}	0.67 (1.15)^{aB}
S. infrequens	males	1.00 (1.73)^{A}	0.00
	females	1.33 (1.15)^{aA}	1.00 (1.00)^{a}

*For each species, any two numbers from the same column followed by the same capital letter are not significantly different at P = 0.05 level (ANOVA test on data transformed using $\log_e (x+1)$ transformation).

** For each species, any two numbers from the same line followed by the same small letter are not significantly different at P = 0.05 level (ANOVA test on data transformed using $\log_e (x+1)$ transformation). Data sets not followed by letters were not subjected to statistical analysis

The trapping also confirmed the existence of phenological differences in the flight period of the three *Strobilomyia* cone flies (Fig. 1). *S. laricicola* was trapped earlier than the two other species. For this species, the major part of the captures was realized during the last week of April and the 1st week of May, and no more individuals were trapped after 13 May. Limited numbers of *S. melania* were caught in late April but the captures peaked from the 1st to the 3rd week of May and ended in early June. *S. infrequens* was trapped from the 2nd to the 4th week of May. A similar sequence including a more precocious emergence of *S. laricicola* has been noticed in the French Alps (Roques *et al.*, 1984), in the Italian Alps (Da Ros, 1997) and in China (Yao *et al.*, 1991; Roques *et al.*, 1995). However, the flight periods of the three species overlapped at least partially during the first two weeks of May in Romania whilst the flight period of *S. laricicola* is completed one week before the beginning of adult emergence of *S. melania* and *S. infrequens* in the French Alps (Roques *et al.*, 1984).

Sex-specific response to trap colour and trap position

The sex ratio of the trapped specimens varied largely among species of *Strobilomyia*. Females were predominant in *S. laricicola* (33 over 40; i.e., 82.5%) whilst the major part of the captures of *S. melania* corresponded to males (40:11). By contrast, Jenkins and Roques (1993) observed a sex ratio skewed in favour of males in trappings of *S. laricicola* in the French Alps. Regarding *S. melania*, similar results had been recorded in both the French and Italian Alps, males being significantly more trapped than females (Roques, 1986b; 1987; Jenkins, Roques, 1993; Da Ros, 1997).

Both kinds of traps (horizontal and vertical) caught about the same number of cone flies per species regardless of sex, except for *S. melania* where females were significantly more trapped by the horizontal traps (Tab. 1). However, the temporal development of fly captures revealed large differences according to species and sex (Fig. 1).

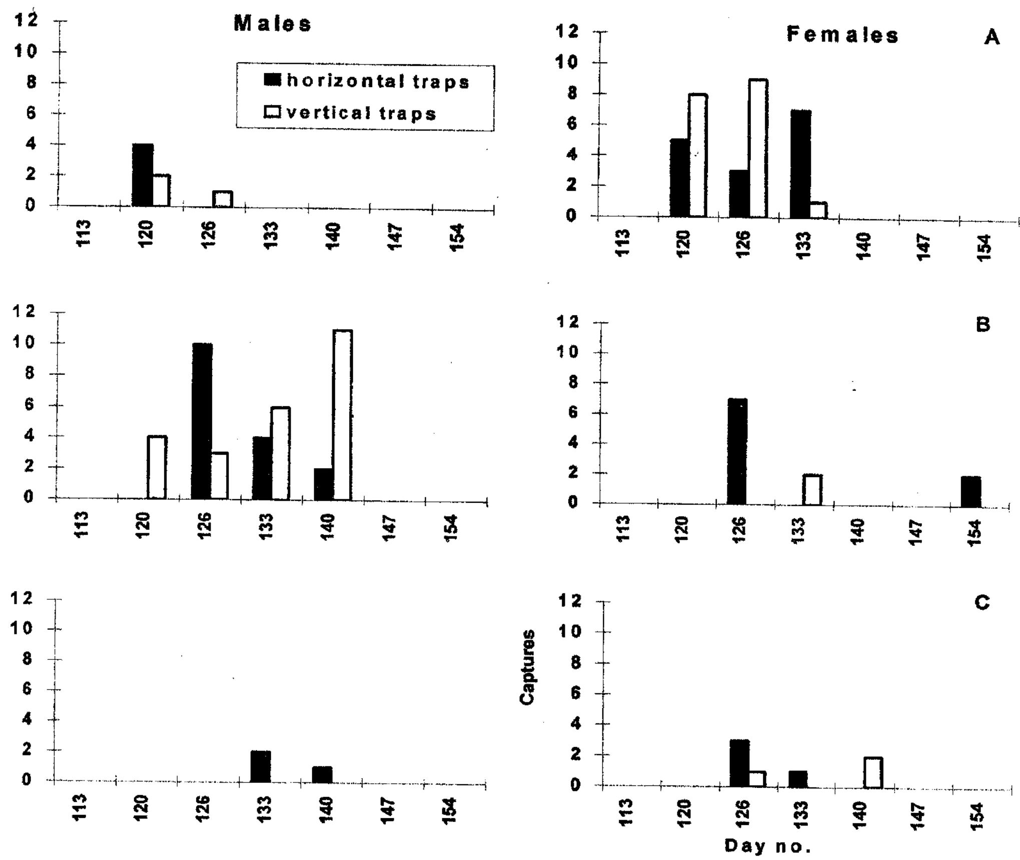

Figure 1. Temporal development of captures of *Strobilomyia* cone flies using visual traps in Romania during 1992; A - *S. laricicola*; B - *S. melania*; C - *S. infrequens*

The females of *S. laricicola* alighted more on vertical traps than on horizontal ones during late April- early May whilst the horizontal traps were more effective during the second week of May. The number of males of *S. melania* alighting on vertical traps increased quite regularly from late April to mid- May whereas it decreased on horizontal traps during the same period. Because of the limited number of captures, no conclusion could be drawn for the males of *S. laricicola*, the females of *S. melania*, and both sexes of *S. infrequens*. These results did not fit entirely the assumptions on which the trapping design relied. The horizontal yellow traps were supposed to attract flies searching for food in order to mature sexually, and thus to be more effective at the beginning of the emergence period, whilst the yellow/purple vertical traps should attract mature adults in search of mating and oviposition sites, and thus be more effective later during the flight period (Roques, 1986b; 1987). This was mostly true for males of *S. melania* but not at all for females of *S. laricicola* although the reasons remain unanswered Unfortunately, it has not been possible to dissect the captured specimens and relate their maturity status with the trap position and colour.

Finally, the differences observed in the specific and sex-specific response of *S. laricicola* according to geographical location may indicate the existence of different strains for that species as it has already been suggested by Da Ros (1997). It may reflect differences in foraging patterns, and has thus to be considered when defining monitoring programs for cone flies.

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