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Mating disruption field trials to control the currant clearwing moth, *Synanthedon tipuliformis* Clerck: a three-year study

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Abstract: Mating disruption to control the currant clearwing moth, *Synanthedon tipuliformis* Clerck (Lepidoptera, Sesiidae) was applied for three consecutive years in a red currant plantation in Trentino, alpine Italian region. The major sex pheromone component (E,Z)-2,octadecadien-1-ol acetate was formulated in polyvinyl chloride (PVC) strings. Pheromone traps catches were reduced by 100% in the treated plot. The average number of larvae per metre decreased from 0.90 (prior to the treatment) to 0.25. Extensive sampling of pruned branches showed that a parasitoid wasp, *Macrocentrus marginator* Nees (Hymenoptera, Braconidae) killed from 38.8 to 55% of the larvae in the oldest wood.

Key words: mating disruption, *Synanthedon tipuliformis* (Lepidoptera, Sesiidae=Aegeriidae), sex pheromone (E,Z)-2,octadecadien-1-ol acetate, parasitisation, *Macrocentrus marginator* (Hymenoptera, Braconidae), red currant (*Ribes rubrum*).

Introduction

The Currant clearwing moth Synanthedon tipuliformis Clerck is a serious pest of both red and black currant. It is widely dispersed in Eurasia, where it is considered the key pest on Ribes crops. There is one generation per year. Adults emerge in May in the valleys and in June in uplands. Egg laying starts 10-15 days after emergence. Females lay eggs (35-50/female) on buds, stumps or bark wounds; two weeks later the larvae bore into the cane, where they feed and complete their development until the following spring.

Larvae complete their development in a tunnel within the pith, prior to creating 'exit windows' for the escape of adult moths. Pupation takes place within a loose silken cocoon in the cane near the 'exit window'. Feeding and tunnelling by larvae causes a depletion of the plant food reserves, weakening and breakage of canes, shoot dieback and uneven bud break in the damaged sections of canes. Indirect fruit yield losses accrue from larval feeding activity within canes.

Biological features and life behaviour make this pest difficult to control. The efficacy of chemical pesticides is limited by the short period when the larvae are not protected within the canes. Moreover, the emergence peak often coincides with the harvest period, when pesticide use is prohibited. Pesticide effectiveness is also limited by the scarcity of active ingredients registered for currant/gooseberry crops in Europe (Jörg, 1998).

Alternative control methods are hence necessary. Pheromones are used in mating disruption trials to control several lepidopterous species (Cardé & Minks, 1995). Here we present the results obtained when the mating disruption method was evaluated for three consecutive years. The effectiveness of mating disruption was assessed by male captures in pheromone traps and by measuring wood infestation levels before and after dispenser application.

Materials and methods

Plot selection and description. The trial was organised in a field (see map) of about 2000 sqm, selected in a typical productive area, at about 1000 m ASL. Red currant plants (cultivar Rovada) were 7 years old and trained in the linear system. Before application, more than 3 branches/plant were trained, but at the time of the first application, the grower started a rejuvenation plan, with the aim of reducing the size of the bushes to only 3 young branches/plant. This allowed us to collect and inspect a large number of pruned branches. The plantation was surrounded by grassland; the nearest trees and Ribes orchard were more than 300 m away. This area is particularly windy during the summer (prevalent north-north/east) direction, along the rows) and this could affect the efficacy of mating disruption. No insecticides were applied during the trial. Fungicides (copper oxychloride, dichlofluanide and copper sulphate) were applied 2-3 times each year.

Pheromone formulations. The major sex pheromone component (E,Z)-2,octadecadien-1-ol acetate [(E,Z)-2,13-18:Ac] was formulated in dispenser white polyvinyl chloride (PVC) tubular strings (Isomate CCM), supplied by Shin-Etsu Chemicals Co., Ltd, Tokyo, Japan. Catching traps were baited with a mixture of (E,Z)-2,13-18:Ac in proportion 100:3 with the sex attractant synergist (E,Z)-3,13-octadecadien-1-ol acetate [(E,Z)-3,13-18:Ac] as suggested by Szöcs *et al* (1991). Isagro Ricerche, Novara, Italy, supplied the mixture in small plastic vials.

Mating disruption. The pheromone dispensers were applied in May, before the emergence of adult moths. The distance between dispenser placement along each row was determined following the New Zealand formula (A+B)/(C*D), where A= length of row*number of rows (metres), B= length of block boundary (shelter) in metres, C= size of the block (ha), D= desired dispenser rate/ha. D ranges between 250 (maintenance levels), to 500 (high infestations). Due to the high pest infestation and to the negative features of the area, a range of rates from 599 (1996) to 406 (1998) dispenser/ha was used. Strings (20 cm long) were hung 1.6 m high on the plant. More strings were applied on the perimeter of the field. The pheromone release rate during the first year was empirically assessed in a sample of ten dispensers by recording the changing weight of the dispenser, and by measuring the length of the air bubble left after the diffusion of the volatile.

Table 1 Pheromone release rate from 10 dispensers during spring-summer 1996. Average pheromone content of about 37 mg/dispenser

Control date	mean dispenser weight (mg)	mean air content (cm)	n° days from previous control	daily weight decrease (mg)	daily air increase (cm)
02.05.96	815.6	2.74	-	-	-
21.05.96	814.8	3.56	19	0.04	0.043
04.07.96	808.8	6.28	45	0.13	0.060
17.07.96	805.9	7.15	13	0.22	0.067
31.07.96	804	8.02	14	0.13	0.062
21.08.96	798.9	9.09	21	0.24	0.051

Effectiveness assessment. Effectiveness of the technique on overwintering larval populations was assessed by sampling branches, and inspection before and after each application of dispensers. Pruned branches were collected in April and separated directly in the field into 3 classes: class A -the basal portion of the branch and connection portion with lateral canes (wood more than 3 years old); class B - the intermediate wood (2-3 years old), and class C - wood grown in the previous season.

Wood was measured; wood of class A was placed in emergence boxes in a warm room (25 °C - 70% R.H. – 17:7 LD photoperiod) to assess the number of adult moths and parasitoids emerging. After 5-6 months, rearing boxes were opened to collect adults that could not exit. Wood of classes B and C was opened in laboratory to extract the larvae.

Flight of male adult moths in the field was assessed using pheromonal traps; 1 trap was placed in the middle of the treated field. Two additional traps were set in the nearest red currant orchard (treated with malathion and carbaryl against Synanthedon tipuliformis).

Results and discussion

Trap catch

The total number of *Synanthedon tipuliformis* males captured in 1994 to 1997 in the traps placed outside the trial field is presented in figure 1. Data for the first two years precede the mating disruption trials, and data for 1998 are not available.

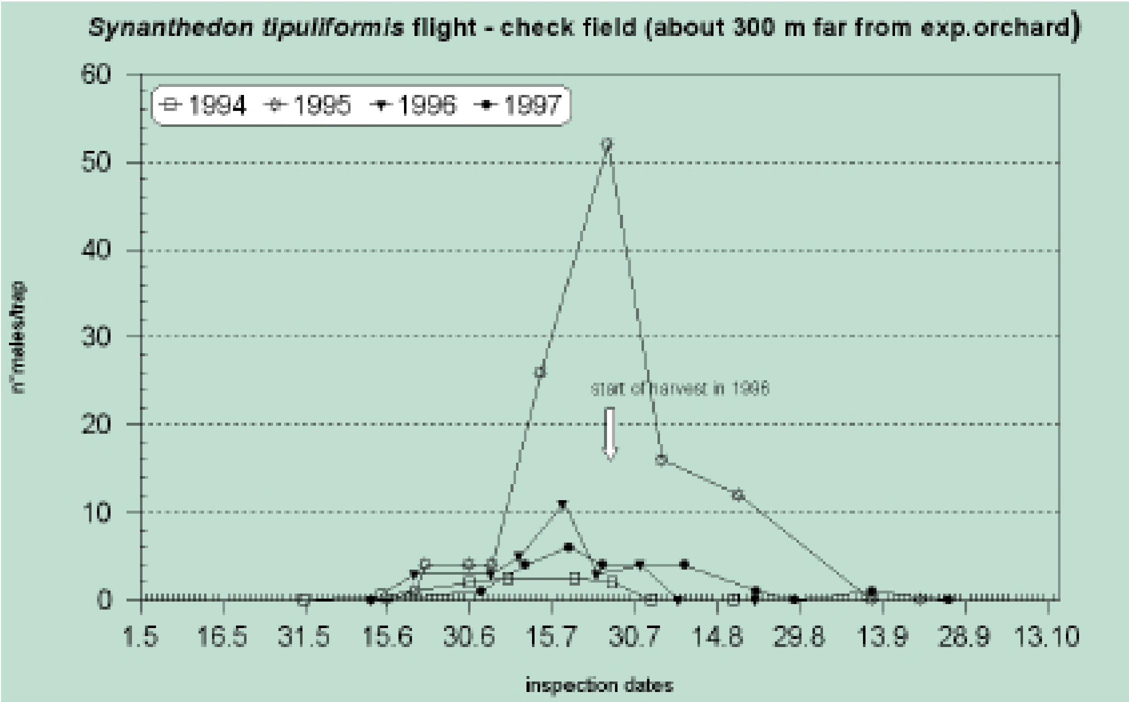

Figure 1. *Synanthedon tipuliformis* males flight development in the nearest red currant orchard.

Figure 1

The pattern of flight in the four years indicates a peak of emergence in July. The size of the population in 1995 is much bigger in comparison with the other years. Since there were no particular differences in chemical treatments, this increase may be explained by the biology of the insect. According to several authors (Zuccherelli, 1970; La_t_vka, 1983), clearwing moths may have different lengths of development depending on climatic and particularly on temperature conditions: 1-year development in warm, but 2-years development in cold conditions. Since the 1993-94 season was much colder than the following one, we can suppose that in 1995 our traps monitored the emergence of 1993 and 1994 larvae. On the other hand, the 1995 increase may be related to a cyclical fluctuation of *Synanthedon tipuliformis* populations.

No males were caught during the three years when a trap was placed in the experimental orchard. This indicates a good overall effect of mating disruption.

Mating disruption and parasitisation

The number of larvae/m of wood was drastically reduced during the three years of the mating disruption experiment (figure 2). The lowest infestation was reached after two years of application, although an increase was recorded after the third year. This increase may be the result of fewer dispensers being used in 1998. The trial site was particularly windy. In view of this, and the size of the plantation, a higher rate of dispensers would have been appropriate.

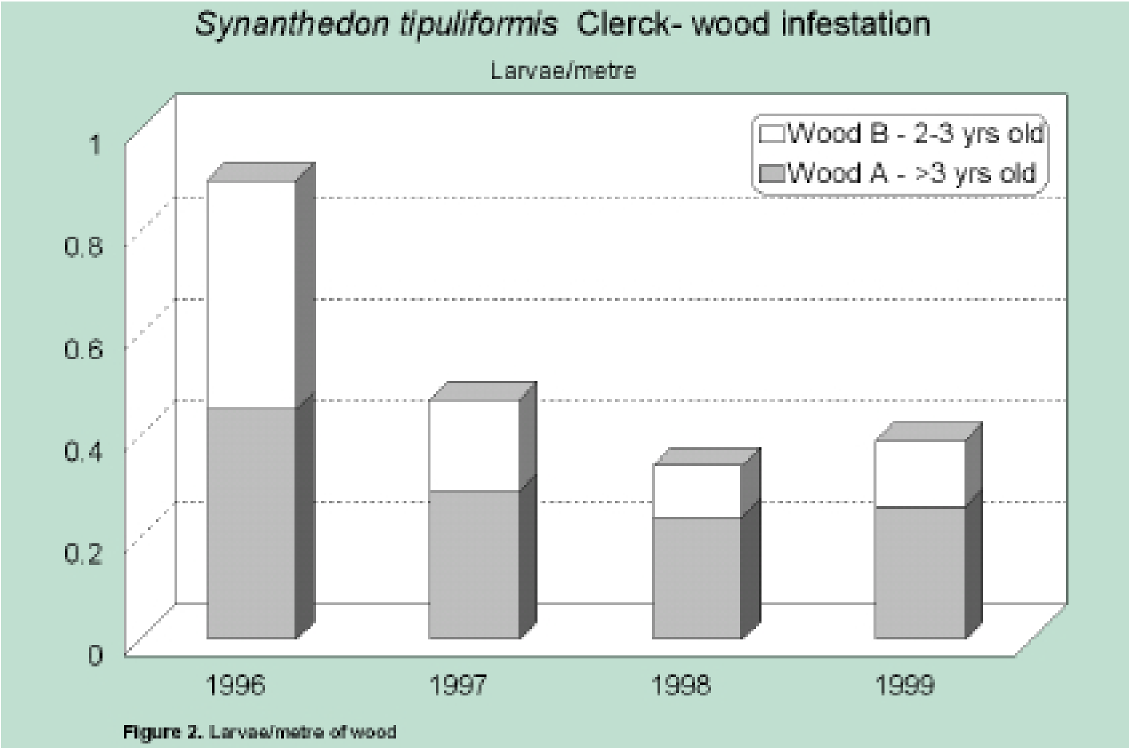

Figure 2

Interestingly, the highest percentage of decrease in the numbers of larvae was observed in wood of class B. It is possible that the covering effect of the pheromone was better on the youngest wood, since dispensers were hung on this portion of the branches. Moreover, wood of class A is more susceptible than the youngest wood to larval infestation.

The percentage of larvae infesting class A wood that were parasitised by Braconid wasps varied from 38.8% to 55% (Table 2). Larvae infesting wood of class B were also parasitised, but data have not been included, since many larvae on this wood were killed during the extraction.

Parasitoids, identified as *Macrocentrus marginator* Nees (Hymenoptera, Braconidae), started to emerge a few days after wood collection and storage in the warm room (Fig. 3).

The first parasitoid pupae were observed in mid-April on wood of class B. This suggests that they probably overwinter at the larval stage inside their host. Pupation occurs early in spring, when they kill their host emergence. Males emerged before females. Most of the adults collected were females.In the warm room, *Macrocentrus marginator* started to emerge about 17 days before *S. tipuliformis*. This indicates that the parasitoids are probably already active when *S. tipuliformis* starts to fly in the field.

Figure 3 shows two clear and separate peaks of emergence, probably depending on the larval stage of *S. tipuliformis* when parasitised. Adult wasps emerging in

June parasitised the last larvae of the previous season. Most of parasitisation probably occurs on the first *S. tipuliformis* larvae of the next generation.

Table 2. Summary data of *Synanthedon tipuliformis* mating disruption trial

	1st sampling	2nd sampling	3rd sampling	4th sampling
n° of old branches inspected (min. 3 ages of wood present)	325	302	309	214
% of old branches inspected on the total branches in the field	13%	12,30%	11,25%	8,30%
total length of wood of class A inspected	219,1	221,7	219,95	181,01
total length of wood of class B inspected	650,2	912,85	249	0
total length of wood of class C inspected	685,85	799,55	869,92	682,18
mean n° of larvae/metre of wood of class A [a]	0,45	0,29	0,24	0,26
mean n° of larvae/metre of wood of class B	0	0	0	0
mean n° of larvae/metre of wood of class C [b]	0,45	0,18	0,1	0,13
% of larvae parasitised on wood of class A	55%	39,30%	38,80%	47,90%

[a] Adults of *S.tipuliformis* emerged in warm room + parasites larvae (1 parasite means 1 S.tipuliformis larvae)

[b] Larvae of *S.tipuliformis* alive + larvae killed during extraction + parasitised larvae + parasites larvae or cocoons

This was confirmed by observations made during wood of class B inspections too. The major part of parasitoid pupae was found inside short tunnels, close to *S. tipuliformis* entrance holes below pruning cuts of the previous year. This suggest that parasitisation probably occurs early in the spring, when larvae are still young. Parasitised larvae continue to live and feed inside the wood, but always with less intensity and they remain alive over the winter.

Pheromone release from dispensers

The approximate empirical measurement method indicated that pheromone emission in the 1996 trial conditions was slow and prolonged (Table 1). About 20 mg of pheromone/dispenser (54% of its content) were still available on 21 August, after more than 3 months exposure.

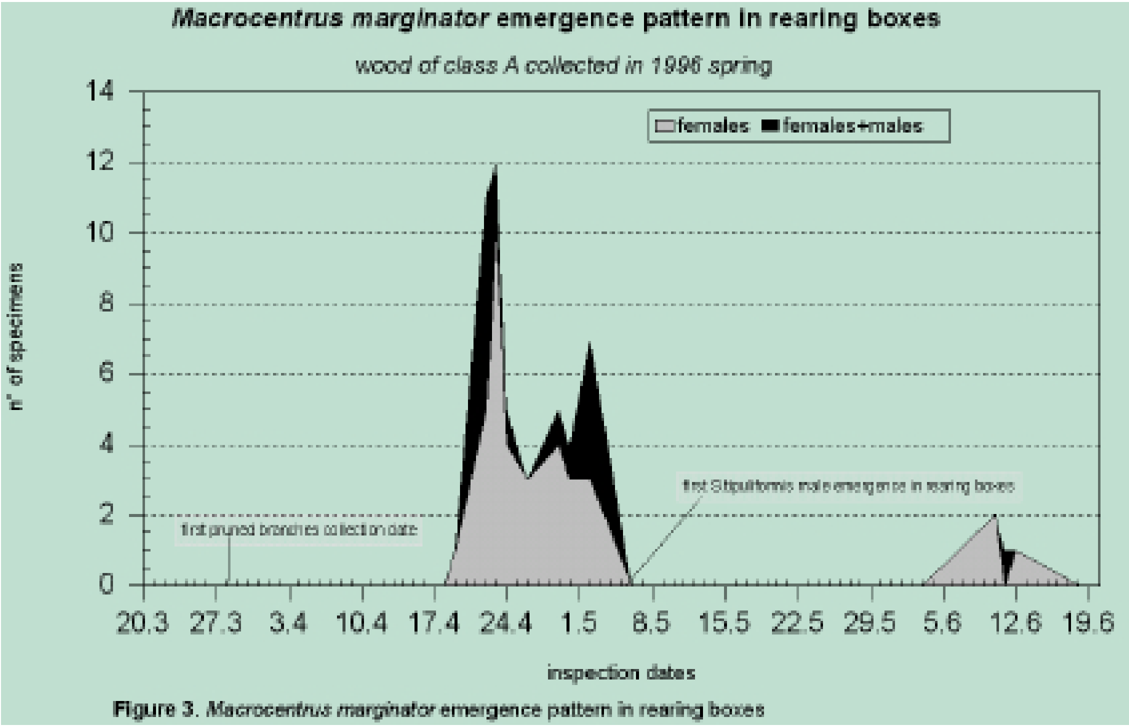

Figure 3

Maximum daily pheromone release rate from dispensers (0.24 mg) occurred during August, which is usually the hottest month of the summer in the region. It is equivalent to a theoretical release rate of 0.014 mg/sqm/day. Minimum threshold for *Synanthedon tipuliformis* mating disruption, fixed by Shin-Etsu to 0.2 µg/sqm, is supplied even when there is the minimum daily decrease of 0.04 mg during May, when pest flights have not yet started (0.04 mg/dispenser correspond to 0.23 µg/sqm/day).

Data suggest that a single application of dispensers theoretically guarantees an adequate covering during the whole *S. tipuliformis* flight period. If we assume that the larval infestation recorded after mating disruption applications results from mating between couples of *S. tipuliformis* inside the trial field, this probably occurred during windy days when the pheromone cloud was dispersed. In summer in this area, the wind blows with a speed ranging between 5 and 25 m/sec. (data collected by IASMA meteo-station placed at 1 Km from the trial field).

Conclusions

Results of this trial can be considered satisfactory. Larval infestation has been progressively reduced to tolerable levels by three consecutive years of mating disruption application. Parasitisation by *Macrocentrus marginator*, not disturbed by insecticide sprays, completed the control action.

Results are particularly interesting considering the main features of the trial site, which are typical of our region; small fields, windy sites and, normally, severe larval infestations. In addition, there are difficulties with chemical control, such as the availability of inadequate active materials (malathion, carbaryl, lambda-cyhalothrin and mineral oil), and the inability to apply sprays during the peak of adult emergence because it coincides with the fruit harvest period.

Larval infestations increased in the last year of application, when the number of dispensers was reduced to 406/ha: this suggests that a minimal application rate of 500-600 dispensers/ha should be used every year.

This trial indicates that mating disruption may be considered as an alternative low impact control method to reduce pest populations progressively in red currant fields. It should be integrated with monitoring, cultural practices, preventive measures application and *Macrocentrus marginator* exploitation (avoiding harmful treatments).

Uptake of the mating disruption method to control *Synanthedon tipuliformis* on red currant depends on the registration of Isomate CCM dispensers in Italy. Preliminary toxicological and eco-toxicological studies are not available for this product, and the costs of such studies could not be justified, given the limited potential acreage in Trentino. Use of data for registration of other similar dispensers and pheromones could be the only way to get an easier and faster registration.

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