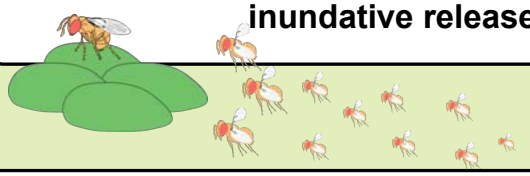
Parisitism of *Choristoneura rosaceana* Harris sentinel egg masses following inundative releases of *Trichogramma minutum* in apple orchards



Pelletier, F., Cormier, D., Chouinard, G., Bellerose, S.

Research and Development Institute for the Agri-Environment (IRDA)

3300 Sicotte, St-Hyacinthe (Qc), Canada J2S 7B8

Introduction

In Quebec, some populations of obliquebanded leafroller (OBLR), *Choristoneura rosaceana* Harris developed resistance to pyrethroid and organophosphate insecticides (Carrière *et al.* 1994) making OBLR control difficult. Repeated inundative releases of *Trichogramma* sp. may be an appropriate reduced-risk strategy to achieve adequate control of this pest. However, limited dispersal of parasitoids may affect the success of biological control by *Trichogramma* (McGregor *et al.* 2000). Dispersal and pattern of attack may be influenced by the dimensional volume of the crop and the complexity of the environment (Smith 1996; Smith 1988). In 2003, a local strain of *Trichogramma minutum* Riley was released weekly in plots of dwarf and semi-dwarf orchard to control OBLR populations. The purpose of this study was to evaluate the parasitism of OBLR egg masses located on release and non-release trees and in adjacent plots in order to compare parasitoid dispersal in the two types of orchards .

Materials and methods

Release sites and experimental design :

- 3 plots of 0,25 ha (release plot, upwind adjacent plot, downwind adjacent plot)
- Split plot design in 4 commercial orchards (2 dwarf and 2 semi-dwarf)

Parasitoid releases :

- *T. minutum* strain collected in 2002 in a Quebec orchard and reared on *Ephestia kuehniella* (Zeller) eggs
- Parasitized eggs glued on folded cardboard (trichocards) containing mixed-aged parasitoids (two cohorts) (Fig. 1)
- Eleven weekly releases (from June 16th to August 25th) at a rate of 1,0 to 1,3 millions of parasitoids/ ha/ week (except week 1 and 2 : 0,3 and 0,6 M/ha)
- 40 release trees evenly distributed in the release plot equivalent to 160 release trees/ ha (Fig.2) (ca. 4000 females/ release tree)

Figure 1 Trichocard

Parasitism measurements:

- OBLR sentinel egg masses placed on 5 trees in the middle of the release plot and renewed every 3-4 days (Fig. 3)
- Eggs recovered incubated at 22°C before being assessed for parasitism
- *Comparison within the release plots* : egg masses placed either on a release tree or at mid-distance between two release trees
- *Comparison with adjacent plots* : an identical layout of 5 egg masses established in the two adjacent plots (upwind and downwind) (Fig. 4)

Statistical analysis:

- 2-way ANOVAs (rootstock and plot) and (rootstock and release tree) with a split plot design, assigning 'rootstock' as the whole plot factor
- Parameters : occurrence of parasitism, mean number of parasitized eggs/ egg mass and mean number of parasitized eggs/ parasitized egg mass

Fig. 3 OBLR sentinel egg mass

Results

Comparison within the release plots :

- Sentinel egg masses in trees in which *Trichogramma* were released were not more frequently parasitized than those placed at mid-distance between two release trees ($F_{1,2}$ = 5,28 ; P = 0,1484) (Fig. 5a)
- In dwarf orchards, females parasitized significantly fewer eggs per egg mass on non-release trees as compared to release trees ($F_{1,2}$ =28,69 ; P = 0,0331) (Fig. 5b)
- A significant interaction between 'rootstock' and 'release tree' also observed when parasitism rate is calculated from parasitized masses only ($F_{1,2}$ = 26,83 ; P = 0,0353) (Fig. 5c)

Comparison with adjacent plots :

- For all parameters, interactions between 'rootstock' and 'plot' were not significant (ANOVA ; df= 2,4 ; P > 0,05), thus pooled data for dwarf and semi-dwarf orchards are presented (Table 1)
- Occurrence of parasitism ($F_{2,4}$=13,32 ; P=0,0171) and number of parasitized eggs / mass ($F_{2,4}$ = 14,35 ; P = 0,0150) were higher in the release plot than in adjacent plots
- Parasitized egg masses from the release plots were not more heavily parasitized than those in adjacent plots ($F_{2,4}$ = 4,49 ; P = 0,0950)

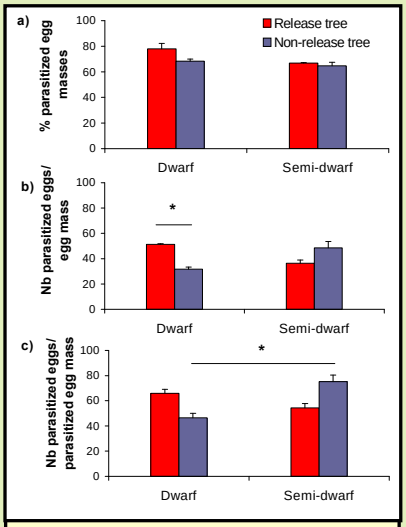


Figure 5 Occurence of parasitism (a), number of parasitized eggs on each OBLR egg mass (b) and on parasitized egg mass only (c) located on release tree and at mid-distance between two release trees. * indicates significant differences (ANOVA, a=0.05). Means ± SE. Data were arcsin or square root transformed when required.

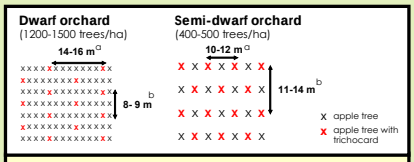


Figure 2 General arrangement of release trees in dwarf and semi-dwarf orchards and mean distances between two release trees within[a] and between[b] rows.

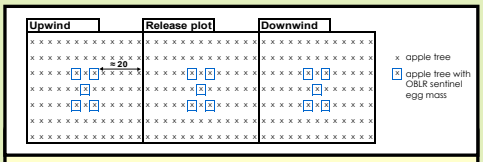


Figure 4 General arrangement of sentinel egg masses in the release plot and in the adjacent plots.

Table 1 Occurrence of parasitism and number of eggs parasitized in each OBLR sentinel egg mass in plots receiving repeated inundative releases of *T. minutum* and in adjacent plots. Different letters within each column indicate significant differences (ANOVA, a=0.05)

Plots	% parasitized egg masses (mean ± SE)	Nb parasitized eggs/ egg mass (mean ± SE)	Nb parasitized eggs/ parasitized egg mass (mean ± SE)
Release plot	70.1 ± 2.5 a	42.5 ± 0.8 a	60.8 ± 1.1 a
Upwind adjacent plot	42.3 ± 6.0 b	29.5 ± 5.7 b	69.9 ± 8.3 a
Downwind adjacent plot	33.7 ± 5.6 b	19.2 ± 3.2 b	57.1 ± 1.6 a

Data were arcsin or square root transformed when required.

Discussion

Parisitism observed on release and non-release trees of dwarf and semi-dwarf plots suggest that the size and density of apple trees influence the dispersal of *T. minutum*. Parasitoids usually avoid open aera (Smith 1996) and semi-dwarf orchard may offer greater protection from wind than dwarf orchards. In our experimental dwarf orchards, the closest release tree from a mass placed on a non-release tree was located on an adjacent row rather than on the same row (Fig. 1). Thus, the significant lower number of eggs parasitized on non-release trees in the dwarf orchards suggests that *Trichogramma* dispersal is lower between rows than within row, as observed by McDougall and Mills (1997) and Smith (1996). **Our results illustrated the need for more release trees in dwarf orchard and the importance of releasing parasitoids on each row to achieve uniform parasitism in the orchard.**

OBLR egg masses usually contain more than 200 eggs, thus **only partial parasitism generally occurs, even on release trees where approximately 4 000 female parasitoids emerged.** Effect of previous parasitism by conspecifics or interference between females (McGregor *et al.* 2000; Lawson *et al.* 1997; McDougall and Mills 1997) may explain partial parasitism in the release plot. Furthermore, **although sentinel egg masses in adjacent plots were less frequently localized than those in the release plot, similar number of eggs were laid in the masses visited by at least one female.** This suggest that each ovipositing female that reached an egg mass in the non-release plots may have deposited more eggs than each female that found a mass close to her emerging site. Also, greater urge to lay eggs of older females (Godfray 1994) which traveled up to 20 m may explain their greater propensity to deplete their egg supply when they encountered a host.

Many studies report the distance a trichogram disperse from a release point rarely exceeds 20 m in orchards (McDougall and Mills 1997; Yu *et al.* 1984) and dispersal is significantly affected by wind direction (Cossentine and Jensen 2000; Glenn and Hoffman 1997). **The activity of parasitoids detected in the adjacent plots, even up-wind, indicates that under repetitive releases with high release rate, many parasitoids traveled more than 20 m.**

Literature cited

Carrière, Y., J.P. Deland and D.A. Roff. 1996. Obliquebanded leafroller (Lepidoptera: Tortricidae) resistance to insecticides: among-orchard variation and cross-resistance. J Econ. Entomol. 89 : 577-582.

Cossentine, J.E., and B.M. Jensen. 2000. Releases of *Trichogramma platneri* (Hymenoptera: Trichogrammatidae) in apple orchards under sterile moth release program. Biological Control 18 : 179-186.

Glenn, D.C., and A.A. Hoffman. 1997. Developing a commercially viable system for biological control of light brown apple moth (Lepidoptera: Tortricidae) in grapes using endemic *Trichogramma* (Hymenoptera: Trichogrammatidae). J.Econ. Entomol. 90 : 370-382.

Godfray, H.C.J. 1994. Parasitoids : Behavioral and Evolutionary Ecology. Princeton University Press, Princeton, NJ.

Lawson, D.S., J.P. Nyrop and W.H. Reissig. 1997. Assays with commercially produced *Trichogramma* (Hymenoptera : Trichogrammatidae) to determine suitability for obliquebanded leafroller (Lepidoptera : Tortricidae) control. Environ. Entomol. 26 : 684-693.

McDougall, S.J. and N.J. Mills. 1997. Dispersal of *Trichogramma platneri* Nagarkatti (Hym., Trichogrammatidae) from point-source releases in an apple orchard in California. J. Appl. Ent. 121: 205-209.

McGregor, R., G. Caddick and D. Henderson. 2000. Egg loads and egg masses : Parasitism of *Choristoneura rosaceana* eggs by *Trichogramma minutum* after inundative release in commercial blueberry field. Biocontrol 45: 257-268.

Smith, S.M. 1996. Biological control with *Trichogramma* : advances, success and potential of their use. Annu. Rev. Entomol. 41: 375-406.

Smith, S.M. 1988. Pattern of attack on spruce budworm egg masses by *Trichogramma minutum* (Hymenoptera : Trichogrammatidae) released in forest stands. Environ. Entomol. 17 : 1009-1015.

Yu, D.S.K., J.E. Laing and A.C. Hagley. 1984. Dispersal of *Trichogramma* spp. (Hymenoptera : Trichogrammatidae) in an apple orchard after inundative releases. Environ. Entomol. 13 : 371-374.

Acknowledgements

We thank F. Vanoosthuyse, C. Carrière and P. Meunier (technical assistance), M. Laroche and R. Joannin (agronomic expertise), P. Lacroix, J. Lauzon, J.M. Denis, and F. Rochon (access to orchard plots).