A Bucket-Type Emergence Trap for Detecting Overwintered Dasineura oxycoccana (Diptera: Cecidomyiidae) and Its Parasitoids in Cranberry

Authors: Fitzpatrick, Sheila M., Wong, Warren H.L., Matthews, Kieryn, Mathur, Snehlata, Elsby, Miranda, et al.

Source: Florida Entomologist, 101(4) : 695-698

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.101.0410

A bucket-type emergence trap for detecting overwintered *Dasineura oxycoccana* (Diptera: Cecidomyiidae) and its parasitoids in cranberry

Sheila M. Fitzpatrick[1,], Warren H.L. Wong[2], Kieryn Matthews[2], Snehlata Mathur[1], Miranda Elsby[3], Kaitlyn Schurmann[4], and Lindsay N. Craig[2]*

Dasineura oxycoccana Johnson (Diptera: Cecidomyiidae) is an economically significant pest of cranberry, *Vaccinium macrocarpon* Aiton (Ericaceae), and highbush blueberry species, including *V. corymbosum* L., *V. corymbosum* L. × *V. darrowi* Camp., and *V. virgatum* Aiton (all Ericaceae) (Dernisky et al. 2005; Fitzpatrick 2009; Liburd & Averill 2016; Rhodes et al. 2014). Host-associated populations of *D. oxycoccana* from cranberry (cranberry tipworm) and blueberry (blueberry gall midge) (Cook et al. 2012) are genetically distinct (Mathur et al. 2012), produce different pheromones (Fitzpatrick et al. 2013) and do not interbreed (Cook et al. 2011). The overwintering stage of cecidomyiids is usually the full-grown larva that uses a spatula structure on the prothorax to dig into soil before entering diapause (Gagne 1989). Cranberry tipworm larvae overwinter in leaf litter and soil below the mat of cranberry vines (Eck 1990). Pupation is presumed to occur in early spring before adults emerge, mate, and lay eggs in the apex of growing cranberry shoots. Oviposition begins as cranberry shoots elongate in early spring (Cockfield & Mahr 1994) and increases steadily until mid- or late Jul when fruit have formed and plants are setting buds for the following year (Cook et al. 2012). Eggs laid in early spring are progeny of overwintered individuals. It is not known if eggs laid later in the season are progeny of overwintered or subsequent generations. If cranberry tipworm adults have a prolonged period of emergence from overwintering, as do adults of the swede midge, *Contarinia nasturtii* (Kieffer) (Diptera: Cecidomyiidae) (Des Marteaux et al. 2015), then a proportion of eggs laid throughout the growing season would originate from overwintered females.

To test the hypothesis that overwintered cranberry tipworms emerge as adults during a prolonged period through spring and summer, we designed an emergence trap similar to the bucket traps evaluated in blueberries (Roubos & Liburd 2010; Hahn & Isaacs 2012; Rhodes et al. 2014), but with some notable differences. Our bucket-type emergence trap can be seated snugly onto the soil without damaging the mat of intertwined woody cranberry vines while allowing penetration of rain and irrigation water. Here we describe trap design, report seasonal emergence of overwintered cranberry tipworms, and compare temperature inside and outside the trap during the growing season. In addition, we discovered that our emergence trap detected overwintered hymenopteran parasitoids from the soil beneath infested cranberry plants.

The emergence trap was constructed from 2 white 2.3 L buckets of high density polyethylene (Snap on Lid Pails; Pro-Western Plastics Ltd., St. Albert, Alberta, Canada) (Fig. 1). In order to create a cylinder 16 cm high, the bottom of 1 bucket (the support bucket) was removed with a power saw. The lower edge of the support bucket was fitted with 3 pegs (15 cm long) of plastic-coated wire (0.3 cm diam) spaced equidistantly and attached with cable ties through holes 2.5 cm above the lower rim. A pleated skirt (15 cm long) of black landscape fabric (Vigoro Polyethylene Weed Barrier; Home Depot Inc., Chilliwack, British Columbia, Canada) was attached with weatherproof sealant and black weatherproof electrical tape to the outer surface of the support bucket, 2.5 cm above the lower rim. The second (inner) bucket was cut to create a bottomless cylinder 10 cm high. A circular opening (10 cm diam) was cut in the center of the lid (16 cm diam) of the inner bucket. The opening was covered with a circle (13 cm diam) of white no-see-um mesh (7250NSW; BioQuip Products, Rancho Dominguez, California, USA) glued at the perimeter to the underside of the lid. To hold a double-sided yellow sticky card trap (Silvalure Catch-It Yellow; Terra-Link, Abbotsford, British Columbia, Canada) inside the inner bucket, a length of wooden dowel (0.5 diam × 16.5 cm long) was positioned 1 cm below the top rim and glued at the ends into holes (0.5 cm) cut into the plastic. A 2.5 cm foldback binder clip (Lyreco; Grand & Toy, Vaughan, Ontario, Canada) was clipped around the dowel and oriented so that the handles could be gripped through the no-see-um mesh to attach or release the yellow sticky card.

The trap was assembled by sliding the inner bucket, with the yellow sticky card attached to the clip on the dowel in the lid, into the support bucket (Fig. 1). The trap (20 cm high, 16 cm diam [top], 13 cm diam [bottom]) was seated into the cranberry field by pushing the 3 pegs on the support bucket into soil exposed by parting the cranberry vines, then pushing square-top landscape staples into the fabric skirt to seal the lower rim of the support bucket to the soil. The circular lower rim of the trap enclosed 135 cm^2 of soil. Traps were checked weekly by sliding the inner bucket out of the support bucket and squeezing the clip handles to release the used yellow sticky card before installing a fresh one.

[1]Agassiz Research and Development Centre, Agriculture and Agri-Food Canada PO Box 1000, Agassiz, British Columbia, Canada V0M 1A0; E-mails: Sheila.Fitzpatrick@AGR.GC.CA (S. M. F.); Snehlata.Mathur@AGR.GC.CA (S. M.)
[2]Simon Fraser University, Departments of Biological Sciences (W. H. L. W., L. N. C.), and Environmental Science (K. M.), 8888 University Drive, Burnaby, British Columbia, Canada V5A 1S6; E-mails: whw1@sfu.ca (W. H. L. W.); lncraig@sfu.ca (L. N. C.); kierynm@sfu.ca (K. M.)
[3]Ocean Spray of Canada Ltd., 5700 Dhillon Way, Richmond, British Columbia, Canada V6V 3A2; E-mail: miranda.elsby@gmail.com (M. E.)
[4]University of Alberta, Department of Renewable Resources, Edmonton, Alberta, Canada T6G 2H1; E-mail: kschurma@ualberta.ca (K. S.)
*Corresponding author; E-mail: Sheila.Fitzpatrick@AGR.GC.CA

Fig. 1. Bucket-type emergence trap seated into cranberry field. Inner bucket with mesh lid is descending into support bucket.

Emergence traps were tested in 2015 on 6 cranberry farms in Pitt Meadows (49.3833°N, 122.2333°W) and Langley (49.2666°N, 122.8166°W), British Columbia, Canada. On each farm, 10 emergence traps were placed 10 to 20 m apart along 1 field edge, where cranberry plants had cupped leaves characteristic of tipworm damage from the previous year. Yellow sticky cards in the traps were retrieved weekly and examined under 20 × magnification to count cranberry tipworms and parasitoids that emerged from pupation sites in the soil.

To determine if emergence of overwintered tipworms might be accelerated by warmer temperatures inside traps, hourly temperatures inside and outside 4 traps (1 in each of 4 fields) on 1 Pitt Meadows farm were measured using HOBO Pro v2 (U23-001) temperature loggers (Onset Computer Corporation, Bourne, Massachusetts, USA) in 2016. Loggers were mounted vertically on bamboo stakes with the sensor end 5 cm above soil surface and a UV protective cap over the communication window. We recognize the limitations of using temperature loggers in this way (Terando et al. 2017). Temperature data were downloaded weekly using the HOBO Waterproof Shuttle and HOBOware (Onset Computer Corporation, Bourne, Massachusetts, USA). In 2016, we also monitored emerged tipworms in 20 traps (5 per field) on this farm (see below).

During the 17-wk test period in 2015, a total of 161 overwintered cranberry tipworms were detected in emergence traps on the 6 farms (Fig. 2). The total non-zero number of tipworms per trap per wk ranged from 1 to 7, but zero was the most frequent weekly count; thus, data distribution was non-normal (Shapiro-Wilk = 0.306; N = 919; $P = 0.000$; SYSTAT 13) (SYSTAT Software Inc. 2013). Emergence began in early May and continued until mid Aug (Fig. 2). More females (101) than males (61) were detected (Pearson chi-square = 9.9; df = 1; $P = 0.002$; SYSTAT 13). Overwintered tipworms of both sexes were detected most wk.

In 2016, 20 traps on the farm where 43% of overwintered tipworms emerged in 2015 yielded only 5 overwintered tipworms in 17 wk: 3 (0.15 per trap) in May; 1 (0.05 per trap) in early Jun; and 1 (0.05 per trap) in early Jul. This result is not due to failure of emergence traps. It is due probably to the lethal effects of post-bloom application in 2015 of registered insecticide on larvae that would have otherwise overwintered.

In both years, 2 other cecidomyiid species were detected in emergence traps. Identification to species has not been possible, but 1 is in the subfamily Porricondylinae (S.M.F. unpublished data) and probably is mycetophagous in decaying woody substrates in cranberry fields. Mean daily temperatures increased from 30 Mar to 18 Jul 2016 (Julian dates 90 to 200), ranging from 8.6 ± 0.4 to 23.1 ± 1.7 °C inside ($y = 5.26 + 0.07x$; $r^2 = 0.45$) and 7.7 ± 0.4 to 21.6 ± 1.7 °C outside ($y = 5.18 + 0.07x$; $r^2 = 0.42$) emergence traps. The daily difference in mean temperature (inside minus outside) ranged from 0.9 ± 0.2 to 1.8 ± 1.7 °C and increased ($y = 0.07 + 0.005x$; $r^2 = 0.19$; SYSTAT 13) during the season. It is probable that tipworm pupae under emergence traps developed slightly faster than those outside traps.

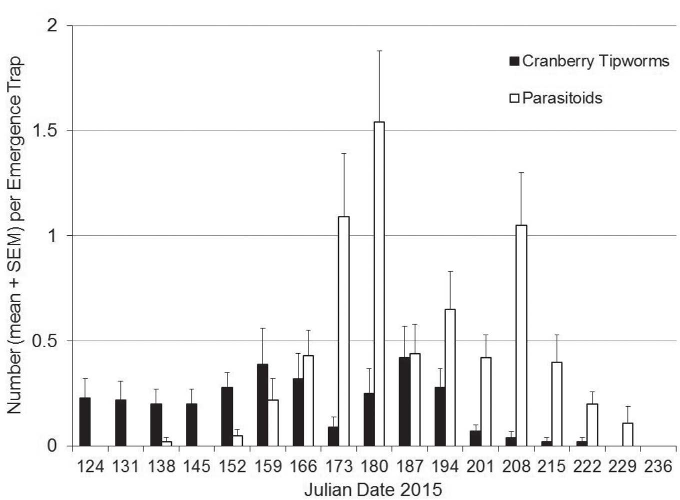

Fig. 2. Number (mean + SEM) of overwintered cranberry tipworms and parasitoids detected per emergence trap per wk in 2015. Julian Date 124 = 4 May; 152 = 1 Jun; 187 = 6 Jul; 215 = 3 Aug. Number of traps per wk was 30, 50, 59, 60, 60, 46, 56, 57, 57, 57, 57, 57, 57, 57, 57, 51, 51, respectively, for the 17 wk.

In 2015, overwintered parasitoids (Hymenoptera) of 4 genera were detected in emergence traps: 3 *Aprostocetus* sp. Westwood (near *Aprostocetus marylandensis* [Girault]) (Eulophidae); 365 *Ceraphron* sp. (Ceraphronidae); 2 *Inostemma* sp. (Platygastridae); and 4 *Platygaster* sp. Latreille (Platygastridae). Parasitoids in the genera *Aprostocetus* and *Playtgaster* are known previously from cranberry (Peach et al. 2012). In related studies, parasitoids in the genera *Ceraphron* and *Inostemma* have emerged in the laboratory from field-collected cranberry shoots harboring parasitized cranberry tipworm larvae; identification to species has not been possible (S.M.F. unpublished data). *Ceraphron*, in particular, might parasitize other cecidomyiids detected in emergence traps. The total non-zero number of parasitoids per trap per wk ranged from 1 to 12, but zero was the most frequent weekly count, thus data distribution was non-normal (Shapiro-Wilk = 0.38; N = 923; $P = 0.000$; SYSTAT 13). Emergence of parasitoids began in the third wk of May and continued every wk until mid-Aug (Fig. 2).

Our results from 2015 and 2016 support the hypothesis that overwintered cranberry tipworms emerge as adults during a prolonged period through spring and summer. Overwintered tipworms add offspring to the field population even after insecticide has been applied in spring. Recently, in British Columbia, spring applications have been discontinued because post-bloom application so effectively kills larvae that would otherwise overwinter. Nevertheless, it is important to understand the potential contribution of overwintered tipworms to the pest population in general.

Summary

An emergence trap was developed to test the hypothesis that *Dasineura oxycoccana* Johnson (Diptera: Cecidomyiidae) adults in cranberry, *Vaccinium macrocarpon* Aiton (Ericaceae), emerge from overwintering as larvae in soil throughout the spring and summer. The trap was constructed from 2 white plastic cylinders made from buckets, with the inner bucket telescoping into the support bucket. A mesh lid allowed penetration of rain and irrigation water. Wire support pegs and a skirt of landscape cloth anchored the trap to soil to prevent escape of target insects and ingress of others without damaging the mat of woody cranberry vines. Overwintered cranberry tipworms and their parasitoids were trapped on a yellow sticky card suspended inside the emergence trap. In the first year of testing, the trap detected overwintered tipworms every wk from early May to mid Aug, and overwintered parasitoids of 4 genera most wk from late May to mid Aug. It is probable that overwintered insects inside the traps emerged slightly ahead of those outside because temperatures inside traps were warmer than outside. We found that overwintered cranberry tipworms, and their parasitoids, emerge and add to the field population throughout the growing season in British Columbia, Canada.

Key Words: integrated pest management; small fruit crop; population dynamics; biological control

Sumario

Se desarrolló una trampa de emergencia para probar la hipótesis de que los adultos *Dasineura oxycoccana* Johnson (Diptera: Cecidomyiidae) en el arándano rojo, *Vaccinium macrocarpon* Aiton (Ericaceae), emergen

de invernar como larvas en del suelo durante la primavera y el verano. Se construyó la trampa de 2 cilindros de plástico blanco hechos de cubos, con la parte superior del cubo interior abriendo hacia adentro del cubo de soporte. Una tapa de malla permitió la penetración de la lluvia y el agua de riego. Se usaron clavijas de alambre y una tela de campo para anclar la trampa al suelo para evitar el escape de los insectos objetivo y la entrada de otros sin dañar la mata de vides de arándanos leñosos. Se atraparon larvas de las puntas de arándano que invernaron y sus parasitoides en una tarjeta pegajosa amarilla suspendida dentro de la trampa de emergencia. En el primer año de pruebas, la trampa detectó larvas de las puntas cada semana, desde el principio de mayo hasta el medio de agosto y 4 géneros de parasitoides que invernaron la mayoría de las semanas desde el final de mayo hasta el medio de agosto. Es probable que los insectos que invernaron dentro de las trampas emergieran un poco antes de los que estaban afuera porque las temperaturas dentro de las trampas eran más cálidas que en el exterior. Descubrimos que larvas de las puntas de arándano que invernaron y sus parasitoides emergen y se agregan a la población de campo a lo largo de la temporada de crecimiento en Columbia Británica, Canadá.

Palabras clave: manejo integrado de plagas; cultivos de fruto pequeño; dinámica poblacional; control biológico

References Cited

Cockfield SD, Mahr DL. 1994. Phenology of oviposition of *Dasyneura oxycoccana* (Diptera: Cecidomyiidae) in relation to cranberry plant growth and flowering. Great Lakes Entomologist 27: 185–188.

Cook MA, Fitzpatrick SM, Roitberg BD. 2012. Phenology of *Dasineura oxycoccana* (Diptera: Cecidomyiidae) on cranberry and blueberry indicates potential for gene flow. Journal of Economic Entomology 105: 1205–1213.

Cook MA, Ozeroff SN, Fitzpatrick SM, Roitberg BD. 2011. Host-associated differentiation in reproductive behaviour of cecidomyiid midges on cranberry and blueberry. Entomologia Experimentalis et Applicata 141: 8–14.

Dernisky AK, Evans RC, Liburd OE, MacKenzie K. 2005. Characterization of early floral damage by cranberry tipworm (*Dasineura oxycoccana* Johnson) as a precursor to reduced fruit set in rabbiteye blueberry (*Vaccinium ashei* Reade). International Journal of Pest Management 51: 143–148.

Des Marteaux LE, Schmidt JM, Habash MB, Hallett RH. 2015. Patterns of diapause frequency and emergence in swede midges of southern Ontario. Agricultural and Forest Entomology 17: 77–89.

Eck P. 1990. The American Cranberry. Rutgers University Press, New Brunswick, New Jersey, USA.

Fitzpatrick SM. 2009. Insect life histories in fruit, shoot and root environments of cranberry and blueberry. Acta Horticulturae 810: 231–250.

Fitzpatrick SM, Gries R, Khaskin G, Peach DAH, Iwanski J, Gries G. 2013. Populations of the gall midge *Dasineura oxycoccana* on cranberry and blueberry produce and respond to different sex pheromones. Journal of Chemical Ecology 39: 37–49.

Gagne RJ. 1989. The Plant-Feeding Gall Midges of North America. Cornell University Press, Ithaca, New York, USA.

Hahn NG, Isaacs R. 2012. Distribution and phenology of *Dasineura oxycoccana* (Diptera: Cecidomyiidae) in Michigan blueberries. Environmental Entomology 41: 455–462.

Liburd OE, Averill AL. 2016. Blueberry gall midge (cranberry tipworm), pp. 160–161 *In* Polashock JJ, Caruso FL, Averill AL, Schilder AL [eds.], Compendium of Blueberry, Cranberry and Lingonberry Diseases and Pests, Second Edition. APS Press, St. Paul, Minnesota, USA.

Mathur S, Cook MA, Sinclair BJ, Fitzpatrick SM. 2012. DNA barcodes suggest cryptic speciation in *Dasineura oxycoccana* (Diptera: Cecidomyiidae) on cranberry, *Vaccinium macrocarpon*, and blueberry, *V. corymbosum*. Florida Entomologist 95: 387–394.

Peach DAP, Huber JT, Fitzpatrick SM. 2012. Hymenopterous parasitoids of cranberry tipworm (Diptera: Cecidomyiidae) in British Columbia, Canada. The Canadian Entomologist 144: 487–490.

Rhodes EM, Benda ND, Liburd OE. 2014. Field distribution of *Dasineura oxycoccana* (Diptera: Cecidomyiidae) adults, larvae, pupae, and parasitoids and evaluation of monitoring trap designs in Florida. Journal of Economic Entomology 107: 310–318.

Roubos CR, Liburd OE. 2010. Evaluation of emergence traps for monitoring blueberry gall midge (Diptera: Cecidomyiidae) adults and within field distribution of midge infestation. Journal of Economic Entomology 103: 1258–1267.

SYSTAT Software Inc. 2013. SYSTAT, San Jose, California, USA.

Terando AJ, Youngsteadt E, Meineke EK, Prado SG. 2017. Ad hoc instrumentation methods in ecological studies produce highly biased temperature measurements. Ecology and Evolution 7: 9890–9904.