Rearing the cranberry girdler *Chrysoteuchia topiaria* (Lepidoptera: Pyralidae) on reed canary grass *Phalaris arundinacea* (Festucoideae: Panicoideae)

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ABSTRACT

We report a method of rearing cranberry girdler *Chrysoteuchia topiaria* (Zeller), a pyralid that is a serious pest of cranberry *Vaccinium macrocarpon* Aiton. Fertile eggs from field-caught females were scattered on reed canary grass *Phalaris arundinacea* L. planted in greenhouse flats (50 eggs/flat) kept under fluorescent lights at 16L:8D and temperatures of 22-30°C (day): 19-24°C (night). Under these conditions, survival from egg to adult was 28%. Progeny of these adults entered diapause after exposure to low light (ca. 0.5 lux) as larvae. Diapause was broken by placing insects in the dark at 4.5-5.5°C for ca. 3 months, but survival was very poor (8% from egg to adult).

Key words: laboratory colony, laboratory rearing, turfgrass, *Vaccinium macrocarpon* Aiton, integrated pest management, subterranean webworm, sod webworm, diapause

INTRODUCTION

Cranberry girdler *Chrysoteuchia topiaria* (Zeller) is a serious pest of cranberries, *Vaccinium macrocarpon* Aiton in North America (Smith 1903). It is also recognized as a pest of grasses (Ainslie 1916) and coniferous seedlings (Kamm *et al.* 1983). Cranberry girdler belongs to the group of grass-infesting crambids (Pyralidae) commonly called sod webworms, and is also known as the subterranean webworm (Tashiro 1987). This pest overwinters as diapausing prepupae in the soil, and moths emerge from late May through early August (Kamm *et al.* 1990). Mated females deposit several hundred eggs (Scammell 1917, Kamm 1973b) singly or in groups at the soil surface. Neonate larvae are fragile, remaining near the surface where they feed on succulent tissue. Older larvae feed on crowns and roots, often severing them. Cranberry girdler is usually reported to be univoltine (e.g., Kamm *et al.* 1990), although moths observed flying in late August or September may represent a second generation (Smith 1903, Fitzpatrick unpublished).

Most studies of biology, chemical ecology and integrated pest management of cranberry girdler (summarized in Kamm *et al.* 1990) have been done in the field or have used insects gathered directly from the field (e.g., McDonough and Kamm 1979), because cranberry girdler is notoriously difficult to rear in the laboratory. The only report of successful rearing from egg to adult comes from Roberts and Mahr (1986), who obtained at best 17% survival from egg to adult on pinto bean diet at 16L:8D and 21°C.

Scammell (1917) complained that "some species of Crambinae defy all attempts to rear the larvae", noting that cranberry girdler was one of these. Our initial attempts to rear this insect

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(Fitzpatrick unpublished) almost led us to conclude that he was right. Under our conditions, girdler larvae did not survive on southwestern corn borer diet (Bioserve #F9763B; Bioserve, Frenchtown, NJ), sod webworm diet (Bioserve #F954B) or on pinto bean diet (modified from Shorey and Hale 1965) made in our laboratory. Only one of 200 larvae survived to the adult stage on general insect diet (Bioserve #F9004). We also tried five species of grass reported to be attractive to girdler larvae (Roland 1990): reed canary grass *Phalaris arundinacea* L., meadow foxtail *Alopecurus pratensis* L., red top *Agrostis alba* L., hard fescue *Festuca ovina* var. Duriuscula (L.) Koch., and creeping red fescue *Festuca rubra* L. Of these species, only reed canary grass sustained enough larvae for a colony. Here we report our method of rearing cranberry girdler on reed canary grass.

MATERIALS AND METHODS

Source of insects. A modified handheld vacuum (Bioquip, Gardena, CA) was used to collect mated female moths from commercial cranberry farms in Richmond and Pitt Meadows, British Columbia, in June and July 2000. Female moths were placed in plexiglass cages (0.3 x 0.3 x 0.3 m) in the laboratory at 16L:8D with temperatures ranging from 22-30°C (day): 19-24°C (night). Eggs, which are simply released from the ovipositor and dropped, were collected on sheets of wax paper or aluminum foil. If fertile, eggs changed colour from yellow to orange within 5-8 days of oviposition.

Rearing Conditions. Reed canary grass *Phalaris arundinacea* L. was seeded into a 50:50 mixture of potting soil and vermiculite in greenhouse flats (53 cm x 27.5 cm x 6.5 cm deep). The grass was watered, fertilized with 15-30-15 (N-P-K) as required, and maintained under fluorescent lights at 16L:8D in the laboratory or in the greenhouse, depending on which site was available. (At the time of this study, we had limited facilities.) In the laboratory, temperatures ranged from 22-30°C (day): 19-24°C (night). In the greenhouse, temperatures ranged from a high of 23°C during the day to a low of 15°C at night. All temperatures were recorded by Hobo® dataloggers (Onset Computer Corp., Bourne, MA). The reed canary grass grew for 10-60 days before fertile eggs were scattered onto the flats, and was kept trimmed to ca. 5-7 cm tall. Patches of grass killed by girdler larvae were reseeded. Girdler prepupae in cocoons were usually left in flats, which were placed in cages of various dimensions to contain emerging moths. Cages were made from screen (0.5 mm mesh) and PVC irrigation pipe, or plexiglass with screened openings. Flats from one rearing were placed in small controlled-environment chambers at 16L:8D with temperatures ranging from 21.5-24.5°C (day): 15-16.5°C (night). Light intensity, measured with a Hobo® datalogger, was 28-60 lux in the controlled-environment chambers. Light intensity in the laboratory and greenhouse was not measured.

We maintained some mature larvae and prepupae individually to produce unmated moths for fecundity studies (reported elsewhere). Mature larvae and prepupae in cocoons were removed from flats of reed canary grass and placed individually in 30-ml clear plastic cups containing a small amount of the moistened soil:vermiculite mixture and, if larvae were still feeding, a plug of reed canary grass. Insects in plastic cups were placed in small controlled-environment chambers under the conditions described above.

Statistics. Some moths were weighed on the day of emergence using a Sartorius microbalance (Sartorius Canada Inc., Mississauga, ON). To compare weights of adults, t-tests were performed on raw data (Systat 8.0 1998). Weights are given as mean ± standard error.

RESULTS

In mid-July 2000, a subset of 1550 fertile eggs from 131 field-collected females were scattered on 31 flats (50 eggs/flat) of reed canary grass in the laboratory. About 3 weeks later, small patches of dead grass could be lifted to reveal larvae feeding on the crowns and roots. As feeding and larval development progressed, some larvae crawled out of flats containing only dead grass. Most of these larvae were collected by hand and placed in flats containing live grass. Most larvae finished feeding by the third week of August. From 21-30 August, an uncounted number of girdler cocoons were removed from the flats and placed individually in 30-ml clear plastic cups containing the soil:vermiculite mixture. Cocoons recovered from the flats were left unopened to promote survival of the prepupa or pupa within. Cups containing cocoons were placed in the small controlled-environment chambers. Because we could not be sure that we had recovered all cocoons from the flats of grass, the flats were saved and maintained in the laboratory.

From 1 September to 27 October 2000, 268 males and 192 females emerged from the cups and flats. These individuals completed development without diapause. A subset of 60 unmated males and 60 unmated females was weighed. Males weighed 12.0±0.3 mg; females weighed 21.6±0.6 mg (t=13.72, df=118, P<0.001). From 8 September through 8 November 2000, a subset of 1900 fertile eggs from females used in fecundity studies was scattered on 19 flats of reed canary grass (100 eggs/flat) kept in the greenhouse. After 8-12 weeks, all larvae that could be found in the flats (570 larvae) were placed individually in 30-ml clear plastic cups with a plug of reed canary grass rooted in soil. All cups were placed in empty flats stacked (because space was very limited) in small chambers and repositioned every few days. In the previous rearing, cups were not tightly stacked because there were fewer cups and more space. The flats containing soil, dead grass and unrecovered cocoons were saved and also maintained in small chambers.

By early January 2001, only 32 adults had emerged. Several cocoons were opened to reveal diapausing prepupae. The measured light intensity reaching larvae inside cups in stacked flats was ca. 0.5 lux, which was so low that larvae probably did not experience the 16-h photoperiod as daylight. The light intensity experienced by larvae in cups at the top of the stack would have been close to the measured light intensity in the small chambers: 28-60 lux. We speculated that some larvae received enough light to continue their development without diapausing, but the majority did not. To break diapause, we exposed the cups containing cocoons and flats containing the remaining soil to simulated winter conditions of 4.5-5.5°C and total darkness in the small chambers from 5 January until 16 April 2001. On 17 April, photoperiod was set to 16L:8D and cups were arranged so that each received adequate light. Over the next 10 days, temperatures were gradually stepped up to 22:16°C. The flats containing the remaining soil were brought into the laboratory on April 17 (because there was insufficient space in the small chambers) and exposed to 16L:8D and approximately 22:16°C. From 4 May to 11 June 2001, 70 males and 61 females emerged from the flats of soil. No moths emerged from the cups. Males weighed less than those of the previous generation (9.7±0.2 mg; t=5.47, df=128, P<0.001), as did females (18.1±0.7 mg; t=3.88, df=119, P<0.001). At least 90% of these moths were unmated at the time of weighing. Of the individuals that never emerged from cups, 60 were pupae, 140 were prepupae, and the rest died as larvae.

DISCUSSION

When reared on reed canary grass *P. arundinacea* in greenhouse flats under fluorescent lights at a photoperiod of 16L:8D and temperatures of 22-30°C (day): 19-24°C (night), girdlers developed from egg to adult without diapause in 6-10 weeks. Roberts and Mahr (1986) reported developmental times of 10.4 weeks at 21°C and 7.6 weeks at 24°C for cranberry girdler reared through one generation without diapause on pinto bean diet.

Earlier observations in 1999 showed that this insect can be reared on reed canary grass under the above conditions through two generations without diapause (Fitzpatrick, unpublished). However, in late 2000, most of the progeny of non-diapausing girdlers entered diapause after larvae were reared at 15-23°C for the first 8-12 weeks, then exposed to low light intensity (ca. 0.5 lux) at 16L:8D and 15-24.5°C. Roberts and Mahr (1986) reared larvae at 16°C and at 21°C without triggering diapause. Our results suggest that diapause is triggered by photophase experienced by larvae, and is facultative. The only other report on photoperiod in relation to diapause in cranberry girdler comes from Kamm (1973a), who found that diapausing prepupae developed more slowly under a 12-h than a 16-h photophase.

In our study, 28% of non-diapausing cranberry girdlers survived from egg to adult. We did not quantify stage-specific mortality but we observed that late instars often crawled out of flats that had been overwatered or were very dry or were full of dying grass. These mobile larvae sometimes drowned under flats or escaped to corners of the laboratory and died. In the field, late instars may be a dispersing stage.

The survival of diapausing girdlers was very low, only about 8% from egg to adult. We suspect that the main reason for the additional mortality of diapausing girdlers was inadequate moisture in the soil, particularly in the 30-ml cups, during the 3-month simulated winter. It is also possible that larvae did not receive adequate food during development.

In both diapausing and non-diapausing groups, the average weight of newly emerged females was at least 80% greater than that of males. Adults that emerged after ca. 3 months in diapause weighed on average 17-20% less than adults of the previous, non-diapausing generation. This difference in weight may represent a physiological cost of diapause or may have resulted from insufficient food during larval development or dessication due to inadequate moisture in the soil during diapause.

In conclusion, cranberry girdler can be reared without diapause in greenhouse flats planted with reed canary grass (50 eggs/flat) and maintained under fluorescent lights at 16L:8D and temperatures of 22-30°C (day): 19-24°C (night). Late instars and prepupae in cocoons can be removed from soil in the flats and maintained individually until adult emergence.

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REFERENCES

Ainslie, G.G. 1916. Notes on crambids. Journal of Economic Entomology 9: 115-118.

Kamm, J.A. 1973a. Role of environment during diapause on the phenology of *Chrysoteuchia topiaria* (Lepidoptera: Pyralidae). Entomologia Experimentalis et Applicata 16: 407-413.

Kamm, J.A. 1973b. Biotic factors that affect sod webworms in grass seed fields in Oregon. Environmental Entomology 2: 94-96.

Kamm, J.A., G.C. Fisher, L. M. McDonough and C.H. Shanks, Jr. 1990. Cranberry girdler as a pest of grass seed, cranberry and nursery tree production in the Pacific Northwest, pp. 141-150. In: N.J. Bostanian, L.T. Wilson and T.J. Dennehy (Eds.). Monitoring and Integrated Management of Arthropod Pests of Small Fruit Crops. Intercept Ltd., Andover, Hampshire, United Kingdom.

Kamm, J.A., P.D. Morgan, D.L. Overhulser, L.M. McDonough, M. Triebwasser and L. N. Kline. 1983. Management practices for cranberry girdler (Lepidoptera: Pyralidae) in Douglas-Fir nursery stock. Journal of Economic Entomology 76: 923-926.

McDonough, L.M. and J. A. Kamm. 1979. Sex pheromone of the cranberry girdler, *Chrysoteuchia topiaria*

(Zeller) (Lepidoptera: Pyralidae). Journal of Chemical Ecology 5: 211-219.

Roberts, S.L. and D.L. Mahr. 1986. Development of cranberry girdler, *Chrysoteuchia topiaria* (Lepidoptera: Pyralidae) in relation to temperature. The Great Lakes Entomologist 19: 85-90.

Roland, J. 1990. Use of alternative plant species as a monitoring tool for the cranberry girdler (Lepidoptera: Pyralidae). Environmental Entomology 19: 721-724.

Scammell, H.B. 1917. The cranberry girdler. United States Department of Agriculture Bulletin No. 554.

Shorey, H.H. and R.L. Hale. 1965. Mass rearing of nine noctuid species on a simple artificial medium. Journal of Economic Entomology 58: 587-594.

Smith, J.B. 1903. Insects injurious in cranberry culture. United States Department of Agriculture Farmer's Bulletin No. 178.

Systat 8.0. 1998. SPSS Science Marketing Department, SPSS Inc., 233 South Wacker Drive, 11th Floor, Chicago, IL 60606-6307.

Tashiro, H. 1987. Lepidopteran pests: Family Pyralidae, pp. 70-90. In: H. Tashiro. Turfgrass Insects of the United States and Canada. Cornell Unversity Press, Ithaca, New York.