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CARPENTERWORM MOTH

Insect Pest Management in Hybrid Poplars Series

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Carpenterworm Moth

Prionoxystus robiniae (Peck) (Lepidoptera: Cossidae)

Introduction

Carpenterworms are major pests of hybrid poplars in eastern Oregon and Washington. Larvae burrow into the boles of trees, weakening them and destroying heartwood. The objective of this pest sheet is to convey to professional pest managers a means to monitor moth populations and to suggest a male-trap-out strategy to control the population.

Taxonomy

Prionoxystus robiniae is an endemic North American species that is widely distributed throughout US and Canada (Solomon and Hay 1974). *Prionoxystus robiniae* is not the only Cossidae that attacks poplar. *Acossus centerensis* (Lintner) is named the “poplar carpenterworm” and can be found from Maine west to Montana, Nevada, Utah, Arizona, and Colorado in the US, and from Quebec west to Alberta in Canada (Carolin 1977; University of Alberta 2016). Another species, *Acossus populi* (Wik) is called the “aspen carpenterworm” and is found from coast to coast (Baker 1972). *Zeuzera pyrina* (L.), the leopard moth, is an invasive species from Massachusetts to Pennsylvania that has been in the US since 1909 (Howard and Crittenden 1909) and attacks poplar (Baker 1972).

Two burrowing Lepidoptera pests of poplar have the same species name: robiniae. These are the western poplar clearwing moth, *Paranthrene robiniae*, and the carpenterworm moth, *Prionoxystus robiniae*.

Hosts

Prionoxystus robiniae feeds on a variety of deciduous trees; including oak (*Quercus*), birch (*Betula*), ash (*Fraxinus*), black locust (*Robinia*), elm (*Ulmus*), maple (*Acer*), willow (*Salix*), cottonwood (*Populus*), pecan (*Carya*), and less commonly on fruit trees such as cherry (*Prunus*), peach (*Prunus*), apricot (*Prunus*), and pear (*Pyrus*) (Solomon and Hay 1974; Solomon 1988). *Prionoxystus robiniae* are primarily found in older, often previously damaged trees (USDA 1989).

Range

Carpenterworm moths (Figure 1) have a nationwide range, excluding New England and the northern central Great Plains states.

Figure 1. Adult female carpenterworm moth.
(Photo by E.R. Hannon.)

Life Stages

After hatching, larvae quickly grow and can reach a size of 2.5 cm within a month (Solomon 1967b). Burrowing galleries during larval development are the damaging portion of the life cycle. The larvae bore into the heartwood of the tree, pushing frass and detritus out of the entrance hole. The tunnels are formed in an upward direction and are enlarged steadily as the larva grows. Larvae have a minimum of seven instars, but can go through up to 30 instars (Solomon 1988). Unlike most Lepidoptera, *P. robiniae* larvae may undergo stationary molts until the correct environmental conditions trigger pupation.

The larvae pupate near the gallery exit, and the pupal exuvia may be found protruding from the exit hole. This species overwinters as larvae in various instars.

Larvae reach full length after seven instars (Solomon 1973). At room temperature (24°C) the pupal period lasts 11–20 days (Forschler and Nordin 1989). In the southern states, one to two years are required for the *P. robiniae* to go through its life cycle, while in the northern states it requires two to four years (USDA 1989). Sexual dimorphism exists (Figure 2).

Females have a much larger wingspan (6–8.5 cm) than males (4.3–6 cm), and the hind wings of males are orange with a black outer border. Sexual dimorphism also occurs in larvae (Figure 3); mature male larvae weigh 1.50 ± 0.03 g, while female larvae weigh 5.10 ± 0.08 g (Hannon 2006).

Figure 2. The larger female carpenterworm moth on the left and the smaller male carpenterworm moth on the right. Note the orange hind wings on the male moth. (Photo by J. Brown.)

Life History

The egg stage lasts 11–13 days at 22–26.6°C (Solomon 1967a). Larval development time in the laboratory (24°C), from hatch to eclosion, was approximately 300 days (Forschler and Nordin 1989). When reared at 20.6°C under laboratory conditions, the length of time between egg and adult took 330 days for males and 349 days for females (Hannon 2006). *P. robiniae* takes two to four years to develop in northern climates, but can complete its development in a single year in the southern part of its range (Hay 1968; Solomon and Hay 1974). Females completing development in one year have a smaller clutch size than those developing in two years, with approximately 500 eggs being laid for the former group compared to 800 eggs for the latter (Solomon and Neel 1974).

Under field conditions in the interior Pacific Northwest, wild *P. robiniae* require two years to complete their life cycle (Hannon 2006). In eastern Oregon and eastern Washington there is only one flight per year. Adults emerge between late April and early August, with the main emergence peak occurring in late June. The females mate shortly after emerging and live only a few days. Egg deposition occurs where mating takes place and studies indicate that they prefer rough bark (Solomon and Neel 1973). The greatest percentage of eggs laid is during the first day (Solomon and Neel 1974). Eggs are laid in several different clutches (2–6) and may contain anywhere between 100–200 eggs per clutch (Solomon and Neel 1974).

Larvae (Figure 3) are easily sexed (Leppla et al. 1979). *Prionoxystus robiniae* have a 1:1 sex ratio (Forschler and Nordin 1989), though long-term studies in populations that have both one- and two-year life cycles indicate that the sex ratio can be 5:1 (male: female) the first year and 1:2 (male: female) the second year (Solomon 1976).

Females usually mate once but can mate up to four times, and males are capable of mating several times (Solomon and Neel 1973). Male and female *P. robiniae* moths live only four to five days as adults (Forschler and Nordin 1989).

Figure 3. Female ultimate instar larva on the left is much larger than the male larva on the right. (Photo by E.R. Hannon.)

Damage

Larvae cause damage by boring into the wood, which results in discoloration and weakening of the trunk. The tree is weakened structurally by the large tunnels in the heartwood, and may snap off during windy conditions. Other insects and pathogens may gain entrance to the tree through the holes made by larvae and further weaken the tree. In trees grown for lumber, the quality of the resulting lumber is degraded by tunnels (Figures 4 and 5). In the southern United States, *P. robiniae* ranks among the most damaging species to oak timber production (Donely 1974; Morris 1977). In addition to the galleries, wood surrounding these galleries is often stained (Solomon and Toole 1971) and downgraded for paper pulp purposes.

Figure 4. Larval galleries in heavily infested bole of poplar tree. (Photo by E.R. Hannon.)

Figure 5. Gallery with a female carpenterworm larva (Photo by J. Brown) life. (Hymenoptera: Ichneumonidae).

Biological Control

Two species of entomophagous nematodes (*Steinernema carpocapsae* Weise and *S. feltiae* Bovien) have been reported to be effective control agents (Forschler and Nordin 1988) of *P. robiniae* larvae. Nematodes can be injected directly into the galleries. An ichneumonid parasitoid has been found attacking *P. robiniae* larvae in the interior Pacific Northwest, but the degree of suppression by this wasp is uncertain at this time. We formally submitted our parasitoid specimens to be identified by Dr. Robert W. Carlson, an ichneumonid specialist at the Smithsonian Institution/USDA. Dr. Carlson identified digital photographs of our adult specimens as *Lissonota* sp.

In 1915, Rohwer described a parasitoid species reared from *P. robiniae* in Virginia, and originally this species was designated *Amersibia prionoxysti* Rohwer. It was later moved into the genus *Lissonota* (Carlson 1979). It is likely that our specimens are *Lissonota prionoxysti* (Rohwer). There have been two reported hymenopterous parasitoids of *P. robiniae*.

These are *L. prionoxysti* (Rohwer) and *Pterocormus devinctor* (Say) (updated species reference within Solomon [1995] citing Carlson [1979]). At this point we do not know the distribution of these species. Thus, we do not know whether *P. devinctor* could occur in the plantations in Oregon and whether or not our specimens of *L. prionoxysti* are common in our area. The Hymenoptera catalog (Carlson 1979) only mentions their location as Virginia. We do know that this parasitoid species is also found in eastern Kentucky, where Hay and Morris (1970) reported that *L. prionoxysti* reduced carpenterworm moth emergence by 12%.

Monitoring

The sex pheromone of the female carpenterworm moth is a 9:1 ratio of Z3-E5-tetradodecenyl acetate and E3-E5-tetradodecenyl acetate (Solomon et al. 1972; Doolittle and Solomon 1986). The adult male *P. robiniae* flight season can be monitored by using bucket traps baited with 1 mg of synthetic sex pheromone, plus a toxicant strip (dichlorvos) in the bucket to kill captured moths (Hannon 2006).

Accumulated degree-day (ADD) calculations were made using two different methods to estimate the first male trap catch (i.e., biofix) and for peak trap catch during the flight season at the hybrid poplar plantations near Boardman, OR. The first degree-day calculating method used simple averaging: (max + min)/2 – 10°C, where “max” and “min” are the daily maximum and minimum temperature and 10°C was the lower developmental threshold temperature. The second calculating method used the single sine-wave method (Baskerville and Emin 1969).

For both methods, a lower developmental threshold of 10°C, as reported by Solomon and Neel (1972), was used. No upper threshold was used for either method as this information is unknown, but temperatures within the tree never exceeded 25°C (Hannon 2006). For the biofix calculations, ADD accumulations were initiated on January 1, as Solomon and Neel (1972) noted this start date gives the lowest variation between years and thus the greatest predictability. To obtain ADD values for the peak flight season, ADD accumulations were reset to zero at the biofix and allowed to once again accumulate. Solomon and Neel (1972) found the first adult emergence to occur at 610±31°F (~321±88°C) degree-day heat units in the state of Mississippi using the simple averaging method.

Management

Carpenterworm larvae feed within the non-living heartwood of the trees, so systemic insecticides are ineffective. Contact insecticides would have to target the adult moth population that flies between May through July, and, even if successful in one year, the effort would need to be repeated two more years because of the multiple year life cycle.

The cost of producing enough synthetic sex pheromone prohibits a mating disruption strategy, but sex pheromones can also be used to trap out males of a pest species. Theoretically, this would have the same effect as mating disruption; mating is either delayed (Knight 1997; Vickers 1997) or prevented when fewer males are in the area. Carpenterworm moths eclose and mate in June and July. Males can be captured in bucket traps baited with 1 mg of synthetic sex pheromone. Two publications have reported success in using a mass trapping strategy to control Cossidae (carpenterworm moth family). Faccioli et al. (1993) had success controlling *Cossus cossus* L., a pest of apple and forest in Europe, by placing ten pheromone baited traps per hectare (four/acre) in infested plantations. Hegazi et al. (2009) reported that a mass trapping effort caused a 90% decrease in active galleries of the leopard moth (*Zeuzera pyrina* L.), another Cossidae attacking olive trees (and poplar), and resulted in a significant increase in olive fruit production.

In eastern Oregon, 270 acre units were targeted for a carpenterworm male moth trap-out effort in 2010–2011. During two years of trapping out male carpenterworm moths, populations of *P. robiniae* were significantly reduced in both the treated fields and in untreated adjacent fields. Furthermore, populations of this pest were suppressed for at least three years in treated fields even after the trap-out effort had stopped, though in the untreated adjacent fields the populations did not remain suppressed (Rodstrom 2013).

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References

Baker, W.L. 1972. Eastern Forest Insects. USDA-FS, Misc. Publ. #1175 Vol. 116-1200, page 388.

Baskerville, G.L., and P. Emin. 1969. Rapid Estimation of Heat Unit Accumulation from Maximum and Minimum Temperatures. *Ecology* 50: 514–517.

Carlson, R.W. 1979. Ichneumonidae, Stephanidae, Evanioidae, Trigonaloidea. In Catalog of Hymenoptera in America north of Mexico: Vol. 1., Symphyta and Apocrita (Parasitica), K.V. Krombein, P.D. Hurd, Jr., D.R. Smith, and B.D. Banks, eds. Washington, DC: Smithsonian Institution Press: 315–741.

Carolin, V.M. 1977. Western Forest Insects. Volume 1339. Page 132.

Donely, D.D. 1974. Woodborer Losses in Appalachian Oak. *Southern Lumberman* 229: 115–116.

Doolittle, R.E., W.L. Roelofs, J.D. Solomon, R.T. Carde, and M. Beroza. 1976. (Z,E)- 3,5- Tetradecadien-1-ol Acetate Sex Attractant for the Carpenterworm Moth, *Prionoxystus robiniae* (Peck) (Lepidoptera: Cossidae). *Journal of Chemical Ecology* 2: 399–410.

Doolittle, R.E., and J.D. Solomon. 1986. Stereoselective Synthesis of (Z, E) –3,5- Tetradecadienyl Acetate: Sex Attractant for Carpenterworm Moth, *Prionoxystus robiniae* (Lepidoptera: Cossidae) and Effect of Isomers and Monounsaturated Acetates on Its Attractiveness. *Journal of Chemical Ecology* 12: 619–634.

Faccioli, G., E. Pasqualini, and P. Baronia. 1993. Optimal Trap Density in *Cossus cossus* (Lepidoptera: Cossidae) Mass-Trapping. *Journal of Economic Entomology* 86: 850–853.

Forschler, B.T., and G.L. Nordin. 1988. Suppression of Carpenterworm, *Prionoxystus robiniae* (Lepidoptera: Cossidae), with the Entomophagous Nematodes, *Steinernema feltiae* and *Steinernema bibionis*. *Journal of the Kansas Entomological Society* 61: 396–400.

Forschler, B.T., and G.L. Nordin. 1989. Techniques for Rearing the Wood Borers *Prionoxystus robiniae* Lepidoptera Cossidae and *Paranthrene dollii* Lepidoptera Sesiidae.

Florida Entomologist 72: 224–226.

Hannon, E.R. 2006. Developing an IPM Program to Control the Carpenterworm Moth and Poplar-and-Willow Borer in Irrigated Hybrid Poplars. Ph.D. dissertation, Department of Entomology, Washington State University.

Hay, C.J. 1968. Frass of Some Wood-Boring Insects in Living Oak (Coleoptera: Cerambycidae; Lepidoptera: Cossidae and Aegeriidae). *Annals of the Entomological Society of America* 61: 255–258.

Hay, C.J., and R.C. Morris 1970. Carpenterworm. Forest Pest Leaflet 64. Washington, DC: US. Department of Agriculture, Forest Service.

Hegazi, E., W.E. Khafagi, M. Konstantopoulou, D. Raptopoulos, H. Tawfik, G.M. Abd El-Aziz, S.M. Abd El-Rahman, A. Atwa, E. Aggamy, and S. Showeil. 2009. Efficient Mass-Trapping Method as an Alternative Tactic for Suppressing Populations of Leopard Moth (Lepidoptera: Cossidae). *Annals of the Entomological Society of America* 102: 809–818.

Howard, L.O., and F.H. Crittenden. 1909. The Leopard Moth. USDA Department of Entomology, Circular #109.

Knight, A.L. 1997. Delay of Mating of Coddling Moth in Pheromone Disrupted Orchards. IOBC/WPRS Bulletin 20: 203–206.

Leppla, N.C., J.D. Solomon, and W.J. Pons. 1979. Sexing Carpenterworm Larvae. *Journal of the Georgia Entomological Society* 14: 145–148.

Morris, R.C. 1977. Insect-Caused Degrade in Hardwood Lumber. *Southern Lumberman* 234: 19–20.

Rodstrom, R.A. 2013. Epigeal Insect Communities and Novel Pest Management Strategies in Pacific Northwest Hybrid Poplar Plantations. Ph.D. dissertation, Department of Entomology, Washington State University.

Rohwer, S.A. 1915. *Amersibia prionoxysti*. *Proceedings of the United States National Museum* 49: 224.

Solomon, J.D. 1967a. Carpenterworm Oviposition. *Journal of Economic Entomology* 60: 309.

Solomon, J.D. 1967b. Rearing the Carpenterworm, *Prionoxystus robiniae*, in the Forest (Lepidoptera: Cossidae). *Annals of the Entomological Society of America* 60: 283–285.

Solomon, J.D. 1973. Instars in the Carpenterworm, *Prionoxystus robiniae*. *Annals of the Entomological Society of America* 66: 1258–1260.

Solomon, J.D. 1976. Sex Ratio of the Carpenterworm Moth (*Prionoxystus robiniae*) (Lepidoptera: Cossidae). *The Canadian Entomologist* 108: 317–318.

Solomon, J.D. 1988. Influence of Host on Larval Survival, Feeding Habits, and Adult Fecundity of the Carpenterworm (Lepidoptera: Cossidae). *Journal of Economic Entomology* 81: 834–839.

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