Zimmerman Pine Moth Biology and Management

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Zimmerman pine moth (ZPM or a close relative) has been found feeding on main stems of true firs (*Abies* spp.) in Michigan and Wisconsin (Jill O'Donnell, personal communication). This damage appears similar to damage on the main stem of Douglas-firs throughout southern New England that made trees unsaleable (Fig. 1). These cankers, when extensive enough, cause the tops of affected trees to turn yellow and eventually die. The cause of this injury was revealed from samples containing caterpillars obtained in mid-summer. Younger larvae are a dirty spotted greenish color (Fig. 2), and fully developed larvae may be brick red. Larvae push frass (insect excrement) out of the galleries in the phloem under the surface of the bark where they feed. In 2017, I was able to rear out moths (Fig. 3) from these larvae and to identify them as most likely being ZPM, *(Dioryctria zimmermani (Grote)*, Lepidoptera: Pyralidae). Curiously, even though extension articles have been written about ZPM in Christmas trees (see: https://ento.psu.edu/extension/christmas-trees/information/pest-fact-sheets/zimmerman-pine-moth), these articles have focused on damage by ZPM to two-needle pines, such as Scotch and Austrian pines, and make no mention of damage to the trunks of Douglas-fir trees. The uncertainty regarding the identity of the insect is caused by the great diversity of similar, closely related moths that feed on conifers. Other species that appear to be close matches to *D. zimmermani* include *D. abietivorella* (the evergreen coneworm moth), *D. pseudotsugella, D. okaganella, D. delectella,* and *D. cambiicola* (western pine moth).

The species *D. pseudotsugella* and *D. cambiicola* are known to feed on Douglas fir phloem tissue (Roe et al. 2006), but neither previously have been reported east of the Rocky Mountains. Genetic methods have been published (Roe et al. 2006) for identification of these moth species, because there are so many look-alikes. Dr. Neil Schultes, a molecular biologist at the CAES, extracted and sequenced DNA from Connecticut moths. The closest match (only one of the 516 nucleotides in the sequence differed) was from a *D. cambiicola* specimen collected from British Columbia. It is easy to see how larvae feeding under the bark could have been transported with asymptomatic nursery stock from the Pacific Northwest to New England, where they completed development and reproduced. However, efforts to consistently distinguish species closely related to *D. zimmermani* via wing coloration and gene sequencing may not be reliable (Roe et al. 2011). It appears either that (1) there are fewer species than taxonomists have named and that interbreeding still occurs among groups, or (2) lepidopterists fail to properly sort specimens to species, and subsequent genetic sequencing perpetuates their errors. In some respects, lepidopterists have gotten species identification backwards: the moths identify conspecifics by scent and are reproductively isolated based upon the pheromones used by females to attract males for mating. Therefore,

Fig. 1. Damage to the main trunk of a Douglas-fir caused by tunneling by Zimmerman pine moth. Branches projecting outwards from or above the affected site turn yellow and may die. Check for the presence of frass (the reddish pellets) to confirm feeding activity by Zimmerman pine moth.

Fig. 2. Caterpillars of Zimmerman pine moth are a dirty greenish color and have small dark spots at the base of hairs on their back. The larvae can only be observed by carefully cutting away bark to expose the feeding tunnel.

Fig. 3. The adult Zimmerman pine moth is extremely well camouflaged against the background of the damaged tree trunk where it developed as a larva.

understanding the pheromone communication system, and not relying on wing coloration, will be critical to properly sort individuals to species, which then could untangle the genetic identification mess. It is important to determine whether the population of moths causing damage to true firs in the Midwest is a host race of *D. zimmermani*, and has shifted from its normal association with pine hosts, or has been misidentified and is an accidentally introduced fir specialist. Proper identification to species is a matter of practical importance, to allow this pest to eventually be managed via mating disruption with the moth's sex pheromones.

Life history and chemical control options – Zimmerman pine moths are about three-quarters of an inch long, with wings folded over their back while at rest. The adults would be very difficult to observe in a Christmas tree planting, as they actively fly at night. During the day we can expect them to hide on bark, where they are exquisitely camouflaged. Moths are expected to emerge from late August through October. They rely on sex-attractant pheromones produced by the females to find their mates. Eggs are laid on the bark, often near previously damaged areas. More than one year of damage may be necessary for tops of trees to turn yellow. Therefore, there can be many asymptomatic infested trees in a planting. Eggs hatch in the autumn, whereupon the young larva creates a shelter called a hibernaculum by spinning a silken protective covering on the bark. In the spring, larvae emerge and chew their way into the bark to feed in the phloem. Chemical control of ZPM thus has three difficult options: killing adults before they mate to lay eggs, killing caterpillars before they have a chance to burrow into the bark, or killing larvae as they feed within the phloem tissue. Killing adults would require a long-residual contact insecticide (e.g., bifenthrin), which if applied in a full foliar spray could disrupt beneficial predatory insects. Excising specimens from trees in mid-August revealed mid-stage larvae to pupae, and so the flight activity period of adults extends for so long that more than one spray per year would probably be required to be effective. Efforts to target larvae in the fall are claimed to not be effective. Targeting the larvae in the spring would require good spray coverage of the bark in the interior of the tree with a long-residual contact insecticide, which can be difficult to accomplish. Tests of systemic insecticides, such as imidacloprid or dinotefuran, to target newly hatched larvae as they start to feed have not been conducted. However, the fact that soil-applied imidacloprid is an effective treatment for Nantucket pine tip moth in pine seedlings suggests that basal bark sprays of this insecticide (an application method that reduces environmental risk) should be tested for preventing ZPM damage.

Fig. 4 Dioryctria spp. feeding on Fraser fir in Michigan. Photo Jill O'Donnell, MSU

Prospects for mating disruption – The sex-attractant pheromone claimed to be used by ZPM (Roe et al. 2011) has not attracted moths in infested Connecticut Christmas tree farms, which is further evidence that we are actually dealing with the western pine moth. I have been field-testing candidate pheromones to try and identify the pheromone of our pest moth, but cannot yet claim success. Mating disruption uses the concept that when sufficient numbers of pheromone dispensers distribute pheromone throughout a planting, it becomes impossible for a male to find the female moth. When the sexes cannot find each other, then the female will remain unmated and cannot lay viable eggs – thus breaking the life cycle. Such a strategy can only be effective when there are no previously mated females entering from outside the mating disruption area. Use of pheromones in mating disruption is an approach that only affects the targeted species and has no other environmental impact. Pheromones could be directly sprayed onto tree bark to disrupt mating, but this approach uses "large" quantities (1.5 gram per acre) of pheromone, which with ZPM would cost $180 per acre. An alternative could be to use multiple lures to disrupt mating. For fruit pests such as codling moth, this approach uses about 300 – 400 dispensers per acre. With our lures, this would be approximately $66 per acre for the cost of materials. A third and most economical method would be to combine attraction of the male to a pheromone point source (which necessitates fewer lures per acre than for mass disruption) with an insecticide applied to the zone where males will be visiting, such as individual trees where lures are placed.

References

Roe, A. D., Stein, J. D., Gillette, N. E., and Sperling, FAH. 2006. Identification of *Dioryctria* (Lepidoptera: Pyralidae) in a seed orchard at Chico, California. Ann. Entomol. Soc. Am. 99(3): 433 – 488.

Roe, A. D., Weller, D. R., and Weller, S. J. 2011. Complexity in *Dioryctria zimmermani* group: Incongruence between species limits and molecular diversity. Ann. Entomol. Soc. Am. 104(6): 1207 – 1220.