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Seedworm (*Cydia piperana* complex) Monitoring in Ponderosa Pine at Plains Tree Improvement Area

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Introduction

Seedworms, *Cydia (=Laspeyresia) piperana* Kearfott and *C. miscitata* (Heinrich) are reported pests of ponderosa pine seed (*Pinus ponderosa*). From 1934-1936, *C. miscitata* was reared from ponderosa pine cones from 10 plots near Coeur d'Alene, Idaho causing an average seed loss of 28.5% (Rust 1937). *Cydia piperana* damaged up to 50% (average of 25-30%) of ponderosa pine seed in British Columbia (Hedlin 1967). Both *C. miscitata* and *C. piperana*, were collected from Idaho, Montana, and Washington from 1967-69 causing seed loss up to 26-50% (Dale & Schenk 1978, 1979). More recently, these two species were grouped with *C. injectiva* (Heinrich) in the *Cydia piperana* complex because of difficulty in distinguishing them on the basis of existing descriptions (Stevens et al. 1985, Sartwell et al. 1985).

In 2015, we found seedworms in the *C. piperana* complex for the first time in ponderosa pine cones at Plains Tree Improvement Area (TIA). They were identified by the habits of larvae (in webbed tunnels and in the pith late in the season) (figure 1) and moths reared from infested cones (figure 2). At the end of that season, seedworms had damaged 2% of 714 seed extracted from 40 cones as determined by examining radiographs of the extracted seed. Seedworm damaged seed is full of the insect's frass and easily detected (figure 3). Other types of seed damage found included seed predation by seed bugs, *Leptoglossus occidentalis*, and empty seed which could be caused by seed bugs, lack of pollination, or other physiological causes.

Seedworm damage appeared to increase in 2016 at Plains TIA and multiple larvae were found in several individual cones sampled in late July. In autumn, seedworm larvae were found in the pith of 70% of 249 cones examined after seed extraction. Seed yield per bushel from Plains was about half that of wild ponderosa pine cones collected from two other Northern Region forests (average at Plains=0.56, Bitterroot=1.14, Custer=1.1 (data from Coeur d'Alene Nursery)). Monitoring methods were needed to detect moths before larvae caused damage but no commercial pheromones were available.

In 1977, seedworms in the *Cydia piperana* complex were caught serendipitously in sticky traps during a test to determine optimum blends of synthetic chemicals for trapping Rhyacionia and Eucosma shoot moths. A 70:30 blend of (E)-9- and (Z)-9-dodecenyl acetate formulated in 1.4 mg pellets caught the most seedworm moths at two locations in Washington and Oregon, and was recommended for future studies (Sartwell et al. 1985).

The objectives of our study were to test different experimental doses of a 70:30 acetate blend at Plains TIA to determine if baited traps would catch Cydia moths in Montana, and to determine their flight period for the purpose of monitoring and timing of insecticide treatments in the future. An additional objective for this report was to describe an experimental treatment attempted at Plains TIA and to discuss possible management options for Cydia.

Life History and Habits of Seedworms as Reported in the Literature

Cydia miscitata moths began emerging from cones on May 20 in 1935 and May 9 in 1936 when daily high temperatures reached 80^{o} F. Emergence continued until June 11 (Rust 1937). Dale and Schenk (1979) observed similar emergence from early May through early June at elevations from 2,000-3,000 feet, but found that *C. piperana* emerged later—from late May through late June at 3,000 feet elevation. However, Hedlin (1967) reported *C. piperana* emergence from May 10-25 in British Columbia. *Cydia miscitata* moths were active during daylight hours and observed in the field from 2-6 p.m. (Dale & Schenk 1979).

Dale & Schenk (1979) found that after mating, female moths of *C. miscitata* laid eggs most often in clusters (ave. 5.5 eggs/cluster) in crevices between cone scales, on the tips of scales, or in the papery scales of the cone peduncle. Larvae entered the cone between cone scales. A small globule of pitch may exude from the tiny larval entry hole, but there are no other external signs of infestation. Infested cones appear normal. Newly hatched 1st instar larvae made their way to a developing seed and remained in the first seed encountered through development to 3rd instar. Movement to subsequent seed occurred in July and feeding was most intense that month. Cydia *miscitata* was reported to have 5 larval instars. Damage after August 7 was insignificant. In late July or early August, larvae move to the cone axis where they make extensive tunnels and overwinter. There can be several larvae in one cone. Pupae were present by mid-March at 2200-2500 feet elevation. *Cydia piperana* pupae were observed April 2-May 16 in British Columbia (Hedlin 1967).

Not all moths emerge in the spring after cone damage occurs. Some remain in diapause and emerge two years after cones are attacked. For *C. miscitata* in Idaho in 1935, 46% of larvae remained in cones for two years (Rust 1937). In 1969, the percent of larvae in diapause for more than a year varied from 1-70% (average 18%) over 15 sites in Idaho, Washington, and Montana (Dale & Schenk 1979). In British Columbia, 44-80% of *C. piperana* remained in diapause for more than a year (Hedlin 1967).

Several parasites have been reported from *Cydia* spp. (Rust 1937, Dale & Schenk 1979, Hedlin 1967), but their effect on seedworm populations has not been quantified.

Unusually severe winter temperatures (-40^{o} F) during the winter of 1968-69 killed 100% of overwintering larvae in cones on the ground without snow cover and 50% of larvae in cones covered by 18 inches of snow (Dale & Schenk 1979).

Figure 1. Left: *Cydia* larva in cone with tunnels in pith. Right: close-up of larva showing webbing in tunnel.

Figure 2. *Cydia* moths reared from ponderosa pine cones from Plains TIA showing a variety of mottled or banded brownish gray wing markings, and one empty pupal case.



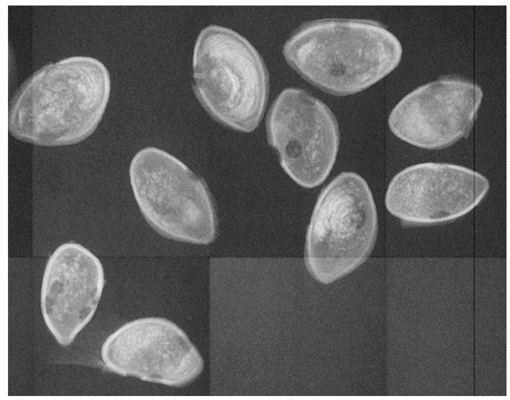

Figure 3. Left: Normal bisected cone on left showing mostly filled seed and *Cydia* damaged cone on right showing frass filled seed and larvae in pith. Upper Right: close up of normal filled seed on top and frass filled seed on bottom. Lower Right: radiograph of frass filled seed.

Methods

The study was conducted at the Forest Service Plains TIA, located three miles northwest of the town of Plains, Montana, on State Highway 200, in the north half of Section 16, T20N, R26W, south of Lynch Creek, at 2465 feet elevation. Genetically superior Douglas-fir, western larch, lodgepole, whitebark, and ponderosa pines are grown on site for seed production, genetic analysis, and protection and storage of genetic material.

We tested lure dosages of 1 mg, 3 mg, or 5 mg of a 70:30 blend of (E)-9- and (Z)-9-dodecenyl acetate supplied by Chemtica International. Ten Pherocon II® sticky traps baited with each lure (30 total) were randomly placed about 20 meters apart (same as Sartwell et. al 1985) in a 4.4 acre Montana mid-elevation ponderosa pine block. Baited traps were placed on April 24, 2017 and monitored weekly or biweekly until they were removed on August 19.

Results

A total of 27 Cydia moths were caught from June 9-August 3, 2017 and 102 western pine shoot borers (*Eucopina* (=*Eucosma*) *sonomana*) were caught from April 28-May 25 (figures 4 & 5). *Eucopina sonomana* flight ended before any Cydia were caught. Most of the Cydia moths were caught on June 9, but that was 15 days after the previous trap check on May 25 and some may have been caught earlier.

Figure 4. Moths caught in sticky traps, left: *Cydia* sp. shown next to rubber septa lure and right: *Eucopina sonomana*.

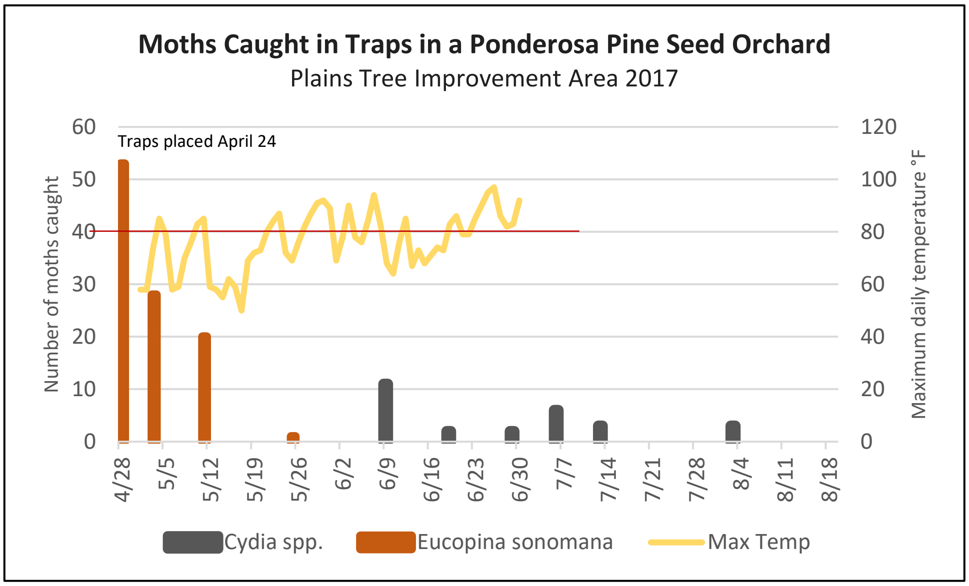

Figure 5. Number of *Cydia* spp. and *Eucopina sonomana* caught and daily maximum temperature by date. The red horizontal line is the 80º threshold when *Cydia miscitata* emerged in May in the 1930's.

Similar numbers of Cydia moths were caught in traps with each lure dose: 1 mg baited traps caught eight moths, 3 mg caught ten moths, and 5 mg caught nine moths. The 5 mg baited traps were most consistent in catching moths nearly every week from June 9-July 13 (figure 6).

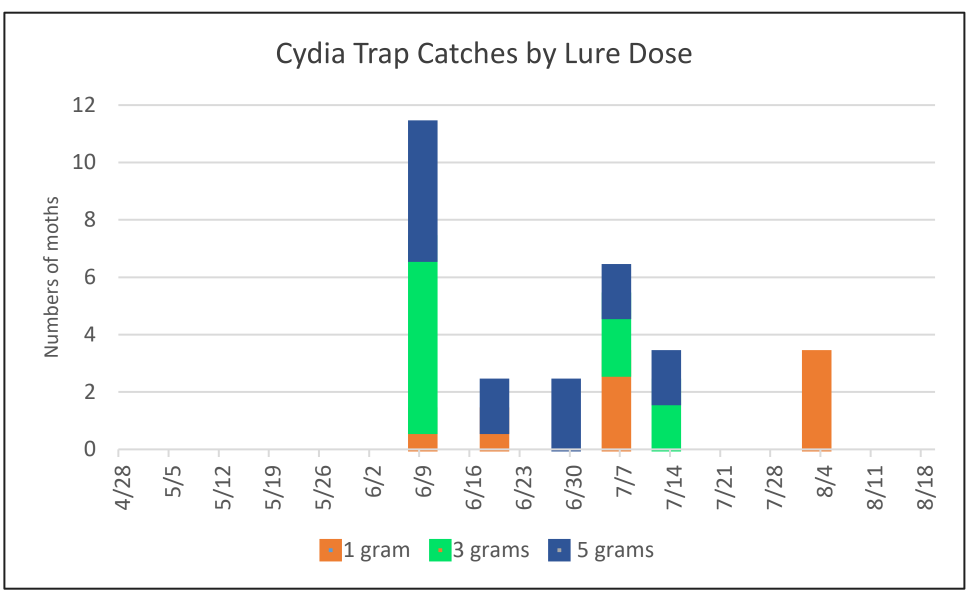

Figure 6. Numbers of *Cydia* spp. caught by lure dose.

Discussion

The flight period of Cydia moths caught in our traps was greatly extended from that reported in the literature. We caught several moths in early June, as was reported for *C. piperana* (Dale & Schenk 1979), but trap catches at Plains TIA continued into July and the last moths were caught in early August. Emergence of *C. miscitata* in Idaho began in May 1935-1936 when maximum air temperature was 80° F (Rust 1937). Daily maximum temperatures at Plains TIA were $\geq$ 80° F for 11 days in May 2017, including three days in the first half of the month, and over 90° F at the end of the month (Figure 5). It is possible that our traps caught *C. piperana,* and for some reason it has an extended flight period at this site in Montana; or perhaps we caught more than one species of Cydia, but could not differentiate them in the sticky traps.

The three tested lure doses caught nearly identical total numbers of Cydia moths. The 5 mg lure consistently caught moths throughout the flight period and could be used to time insecticide applications. Life cycles of *Cydia* spp. have been described, but with the difficulty of differentiating species within the genus, studies of the species present at Plains TIA and their life cycles would be worth further investigation. A better understanding of the timing of different life stages and number of species present could lead to more precise management options.

It was not unexpected to trap so many *Eucopina sonomana,* since we were using a lure that was developed for catching them. Their appearance is distinct and they are easily differentiated from Cydia.

Seedworm Management Options

Since seedworms overwinter as larvae in cones, removing or burning all cones that are not harvested would reduce on-site populations. However, that would not prevent immigration of moths from ponderosa pine stands surrounding the TIA.

In an attempt to reduce damage from seedworms at Plains TIA in 2016, the systemic insecticide, imidacloprid, was applied to the Montana mid-elevation ponderosa pine block as an injected soil drench in mid-May (figure 7). In foliage samples analyzed June 26, imidacloprid was "present at less than reporting limit" in one of three samples from the treated block. It was not detected in the other two samples, indicating soil application in mid-May was too late to reach tree crowns and potentially have an effect on cone and seed feeding insects that season. However, imidacloprid was detected in all foliage samples collected October 12, 2016. It is unknown if imidacloprid stayed in the foliage or reached developing 2nd year cones in 2017, but seedworm larvae were found in 16 of 20 cones sampled in August 2017.

Imidacloprid injected into ponderosa pine boles in May 2011 at a different seed orchard (Grouse Creek TIA in Idaho) reduced damage from coneworms (*Dioryctria* sp.) but not to a great extent compared to controls (37% infested imidacloprid treated cones versus 45% infested control cones). Imidacloprid injected in October had no effect on coneworms the following summer (Cook et al. 2013). It is unknown if injected imidacloprid would have an effect on Cydia.

Using pheromone traps to time topical contact insecticide applications aimed at Dioryctria moths and eggs has been successful in reducing damage at Bigfork TIA. Synthetic pyrethroid insecticide applications began 7 days after moths were first caught and again 2 or 3 weeks later. A similar treatment regime would be worth investigating for Cydia at Plains TIA.

Figure 7. Imidacloprid soil injection around tree boles at Plains TIA.

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