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Cone and Seed Insects of Southwestern White Pine

Daniel E. DePinte[1], Kristen M. Waring[2], and Monica L. Gaylord[3]

Introduction

Southwestern white pine, *Pinus strobiformis* Engelm. (SWWP), like other western pines, has a guild of insect species that feed on its cones and seeds. Those described here are the most commonly observed pests with a history of causing damage to SWWP cone and seed production. They are taxonomically diverse, and include species of Hemiptera, Diptera, Coleoptera, Lepidoptera, and Hymenoptera.

Host Distribution

Southwestern white pine is a five-needled pine found throughout mixed conifer forests of the American Southwest and Sierra Madre Occidental Mountains of Mexico (Figure 1). In the United States SWWP typically co-occurs with other species; very rarely occurring as a pure stand at elevations from 7,000 to 10,000 feet above sea level. It plays a critical role in early seral stages of forest succession and is a vital component of mixed conifer forest types. SWWP provides a variety of ecosystem services such as forest biodiversity and resiliency.

Figure 1. Distribution of southwestern white pine in U.S. and Mexico (Shirk et al 2018).

It is a major source of sustenance for wildlife with its relatively large, nutrient rich seeds. SWWP has been known to hybridize with limber pine (*P. flexilis*). SWWP is also susceptible to the non-native invasive pathogen, *Cronartium ribicola* (J. C. Fisch), which causes white pine blister rust. When a SWWP tree is approximately 15 years old it becomes reproductively mature. SWWP flowers in June; cones then begin to develop in July and continue

[1]*Forest Health Specialist, USDA Forest Service, Forest Health Protection, Southwest Region, Flagstaff, AZ*
[2]*Professor, School of Forestry, Northern Arizona University, Flagstaff, AZ*
[3]*Entomologist, USDA Forest Service, Forest Health Protection, Southwest Region, Flagstaff, AZ*

growth until reaching maturity in late August or early September of the second year when seeds are dispersed. Cones located on warmer sites and/or southerly aspects typically mature first. Seed dispersal lasts approximately four weeks for any given tree.

Lepidoptera

Fir Coneworm Distribution, Life Cycle, and Behavior

Dioryctria abietivorella (Groté) (Lepidoptera: Pyralidae), commonly called the fir coneworm, is the most abundant insect affecting SWWP cones. The geographic range of this species is quite extensive, ranging from interior northern Alaska and extending south to central Mexico. In Canada, it can be found from coast to coast. The behavior and life cycle of this moth are variable depending on geographic location.

Dioryctria abietivorella. *From top to bottom: Figure 2. Larva; Figure 3. Pupa; Figure 4. Adult.*

In the Southwest, on SWWP, fir coneworm larvae typically hatch in late spring/early summer and feed throughout the summer until early fall. The larvae typically bore into the second year cones, feed, and grow up to 18 mm in length. The first instar is a pale yellow, while later instars are a deep amber color with a darker brown head (Figure 2). Larval feeding consumes the seeds and internal tissue of the cone resulting in tunnels throughout the cone and copious amounts of frass on the outside of the cone. Once feeding is complete, the larvae emerge and pupate. The pupae are brown and measure about 10 mm long (Figure 3). The cocoon is attached directly to the cone and is camouflaged by reddish brown frass adhered to the outside. The adult moths (Figure 4) lay eggs shortly after emergence. The eggs are deposited near and/or on the cones where they over-winter to hatch in the spring. In the Southwest, coneworms complete one full generation per year. Occasionally, the insect enters a state of quiescence as a prepupae over the winter and emerges as an adult in the spring.

Fir Cone Looper Distribution, Life Cycle and Behavior

The fir cone looper, *Eupithecia spermaphaga* (Dyar) (Lepidoptera: Geometridae), is distributed from the lower coastal range of Alaska, south along the interior Rocky Mountains and continuing to the Sierra Madre Occidental mountain ranges of central Mexico. Fir cone looper eggs hatch in early spring and larvae quickly tunnel

Figure 5. Eupithecia spermaphaga *in adult form.*

into the second year cones. The larvae grow to 20 mm long. The first instar is a pale greenish to grey color. Later instars become a light green color with a brown head. Larvae consume the seeds and internal tissue of the cone throughout the spring and summer. In late summer, larvae will emerge to pupate prior to cone maturity and seed dispersal. The pupae are brown and about 11 mm in length. Generally, most moths pupate for about two months and emerge in September and October. Shortly after emergence, adults (Figure 5) mate and lay eggs. The eggs are laid near and/or on the cones where they diapause over winter and hatch in spring. Some fir cone loopers may pupate over winter and emerge as adults and lay eggs in spring.

Evidence of Infestation

The signs and symptoms of infestation are generally the same for fir coneworm and fir cone looper. Damaged cones typically do not fully develop, and damage is visible by the end of summer. Healthy SWWP cones are green or purple in color, only turning brown after release of seeds in the fall. Larval feeding causes part of the cone to turn brown during the summer and the entire cone typically fails to open in the fall (Figure 6). This is due to internal damage caused by the larvae consuming the internal tissue and seeds of the cone. The larvae can enter anywhere on the cone and entrance holes can be quite numerous. Frass and webbing present on the cone are additional evidence of larval presence (Figure 7).

Impacts

Under normal forest conditions, *D. abietivorella* and *E. spermaphaga* infestations cause low levels of damage relative to the abundance of healthy cones and seeds produced, particularly during mast years. However, they can have economic impacts in seed orchards. They can also impede natural regeneration and restoration efforts of SWWP. During non-mast years with low cone production, coneworms can destroy 10-50% of the total yield.

Management

Synthetic pheromones may be the best option to control damage caused by coneworms. Pheromones can be used to trap and kill the adults, or to disrupt the mating cycle. Research has shown the optimal trapping method for *D. abietivorella* uses a ratio of the two synthetic pheromones (200µg

Figure 6. External (left) and internal (right) damage caused by D. abietivorella *larval feeding on southwestern white pine cone.*

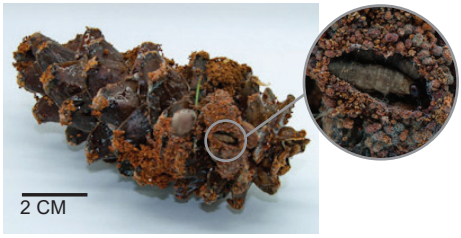

Figure 7. Frass and web covered southwestern white pine cone with D. abietivorella *larva starting to pupate.*

(Z)-9-11 E-14: Ac to 2000µg C25 pentaene and (Z)-9-Tetradecen-1-yl acetate) with a diamond-shaped sticky trap. Additional studies have shown that placing the traps higher in the crown will capture more adults than traps placed lower. When necessary, the use of insecticides is a possibility for seed orchards. Several broad spectrum insecticides such as permethrin, carbaryl, and dimethoate can be effective when application timing coincides with insect activity before larvae burrow into the cones after hatching. Monitoring for adults and larval hatch is necessary for proper timing of contact insecticide applications.

Cone Beetle Distribution, Life Cycle and Behavior

The western pine cone beetle, *Conophthorus ponderosae* (Hopkins) (Coleoptera: Curculionidae), can be found from the western coast of Canada to the southwestern United States, including the Rocky Mountains. *C. ponderosae* produce one generation per year. Adults are very small and brown to black in color (Figure 8). In late spring, a single adult female beetle will bore into the base of an immature cone. The female enters the cone approximately two millimeters from the stem of the cone. The beetle enters the cone and mines a tunnel down the entire length of the cone axis. Mating is believed to occur in the cone. The

Figure 8. Lateral view of adult Conophthorus ponderosae.

female deposits her eggs throughout the tunnel before exiting the cone. She can attack more than one cone. On average, the female will lay 12 eggs per cone. The larvae hatch and, during the summer, feed on the inner tissue and seeds of the cone. The larvae go through two instars before pupation occurs. Adults over-winter in stunted cones on the forest floor or in the canopy of the tree. Peak adult emergence occurs from early to mid-May. Adults attack cones within two to three days after emerging.

Evidence of Infestation

Visual detection of damage from *C. ponderosae* is difficult in the spring but becomes more evident as the summer continues. Infested cones fail to grow normally and are obviously stunted when compared to healthy cones, which are much longer. In the early spring, look for a single pitch tube with red frass located on the base of the cone (Figure 9). Additionally, the girdling of the cone axis by the beetle sometimes causes the cone to curl excessively (Figure 10). The infested cones will remain stunted, turn brown, and possibly drop to the forest floor as fall approaches. Dissecting infested cones should reveal small, c-shaped, pale, legless larvae, about 2-5 mm in length.

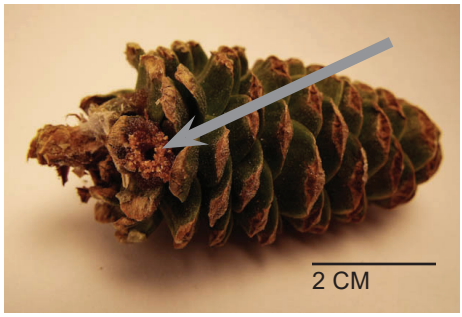

Figure 9. An immature southwestern white pine cone with arrow pointing to a cone beetle pitch tube located near stem

Figure 10. Conopthorus ponderosae *often girdle the cone axis causing cones to curl excessively.*

Impacts

Conopthorus ponderosae cause death of second year cones. The amount of mortality is variable, but in SWWP the average amount of mortality observed is usually 30%. In years of low cone production, up to 75% cone mortality can be observed. In western white pine seed orchards complete destruction of cone crops has been reported.

Management

Once presence of the cone beetles is detected, removal of infested cones is an effective way to reduce infestation rates the following year. Infested cones can be found on the ground from the fall to early spring. Mechanical removal of infested cones from the forest floor and canopy significantly reduces beetle incidence. Additionally, if the site and climatic conditions permit, a light ground fire is an option for reducing cone beetles overwintering in cones on the forest floor. Placing protective bags over developing second-year cones has been shown to be effective in protecting western white pines. Bags must be placed in early spring, prior to adult emergence. Aggregation pheromones can be used for flight monitoring in the spring; however, trap and kill methods to reduce populations are not currently effective. When warranted, contact insecticides such as pyrethroids can be used for seed orchard protection. Applications should occur when beetles are first caught in pheromone traps with a second application two weeks later.

Western Conifer Seed Bug Distribution, Life Cycle and Behavior

The western conifer seed bug, *Leptoglossus occidentalis* (Heidemann), is a serious pest of conifer seed production, especially pine species. This insect has been observed consuming the seeds of SWWP throughout Arizona and New Mexico. The native range of the western conifer seed bug extends from southwestern Canada throughout the western United States to northwest Mexico. Recently, the insect has been found in the Midwest, indicating its range is expanding.

The western conifer seed bug lays barrel shaped eggs from May until July. Eggs hatch into nymphs which feed on seeds in developing cones. They develop through five nymphal instars and reach maturity by late August and overwinter as adults. The insect produces one generation per year. The early instar nymphs are orange with two black dots on the dorsal portion of their abdomen (Figure 11). Later instars have well developed wing pads

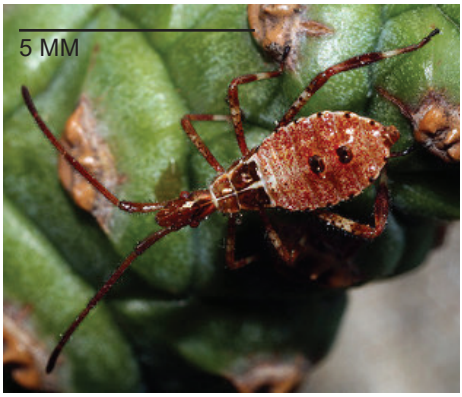

Figure 11. Second-instar nymph of the western conifer seed bug.

Figure 12. Adult western conifer seed bug.

and more of a reddish-brown color. Nymphs and adults will hide on the underside of foliage or cones when disturbed or jump to branches below to avoid being captured. Adults also readily fly away when disturbed and exude a foul-smelling odor to avoid predation. The adults are typically 15 to 18 mm long and 4 to 6 mm wide (Figure 12).

Impacts

The western conifer seed bug feeds on the seeds and ovules of cones. The long beak-like proboscis is comprised of several syringe-like stylets covered by a protective sheath and held under the body when not feeding. Adults overwinter and resume feeding in the spring, focusing on the first-year cones and the male conifer flowers. All stages of the western conifer seed bug will pierce the freshly developed pollen sacs and consume them, causing necrosis and reducing overall pollen production. In summer, adults and nymphs will penetrate both first-year conelets and maturing second-year cones, and consume the internal contents of ovules and seeds but leave little external evidence of damage. The cone continues to mature and only when the seed is exposed or internally evaluated can the damage be observed. Damage to seed crops on western white pines averages 26%.

Management

The western conifer seed bug is particularly difficult to observe, detect, and manage. The cryptic feeding leaves practically no observable damage on the cone. If feeding occurred during the early stages of cone development the seeds could appear undamaged to the naked eye. Radiographs can be used to detect if internal seed damage has occurred (Figure 13). If feeding occurred during the second year of cone development a tiny feeding scar is evident on the seed coats of the mature seeds. Staining techniques can also be used on cones to detect damaged seeds

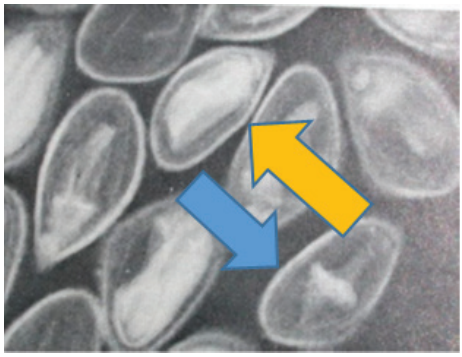

Figure 13. A comparison of damaged seeds (blue arrow) to healthy seeds (orange arrow) captured on a radiograph.

and estimate damage. Contact insecticides, such as permethrin, have been used successfully to control western conifer seed bugs in northern Idaho western white pine seed orchards. Caging individual cones with a mesh bag can be effective in protecting high value seeds from seed bug predation.

Assistance

Resource managers should contact their regional USDA Forest Service, Forest Health Protection (FHP) office for the most up to date information about the identification and management of seed and cone insects.

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