CONE AND SEED INSECTS OF SUBALPINE FIR DURING A YEAR OF LOW CONE PRODUCTION IN NORTHERN IDAHO[1]

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ABSTRACT

Cone and seed insects destroyed 29 percent of the seed crop of subalpine fir (**Abies lasiocarpa**) in the Freezeout Mountain area of northern Idaho in 1972 during a year of low cone production. Larvae of a coneworm, **Dioryctria abietivorella** destroyed 12 percent of the seed crop, accounting for 42 percent of the total insect damage. A newly discovered midge pest, a species of **Dasineura**, destroyed 11 percent of the seed crop, amounting to 40 percent of the total insect damage. The dipterans, **Hylemya abietis**, **Earoymia** sp., and **Asynapta keeni**, and the chalcid wasp, **Megastigmus lasiocarpae**, together destroyed 4 percent of the seed crop. Unknown causes accounted for 1.5 percent of the total seed destruction. X-ray was used to estimate seed lost to **M. lasiocarpae** and **Dasineura** sp. Regression equations are given relating cone length (mm), and the seeds on the axial surface, to total seeds. Sound and damaged seeds on the axial surface were highly correlated with the totals of sound and damaged seeds, respectively, in the cone.

INTRODUCTION

Insects inhabiting cones and seeds of subalpine fir, *Abies lasiocarpa* (Hook.) Nutt., have received little attention. Keen (1958) listed five species of insects that cause damage to subalpine fir cones: the fir coneworm, *Dioryctria abietella* (Denis and Schiffermueller) (= *D. abietivorella (Grote)*); a cone maggot, *Earomyia aquilonia* McAlpine; two species of seed chalcids in the genus *Megastigmus;* and a cone midge, *Asynapta keeni* (Foote). Hedlin (1974) states that *E. aquilonia* destroys most of the seeds in infested cones in British Columbia, and that the subalpine-fir chalcid, *Megastigmus lasiocarpae* Crosby, is not a serious pest. He constructed a key to the insects damaging cones in British Columbia. Moyer and Parker (1973), and Kulhavy, et al. (1975) presented a list of insects reared from these cones in Utah and Idaho. Kulhavy (1974) also constructed keys to the damage and to the insect pests of subalpine fir cones in Idaho.

Several methods are available to evaluate the damage within a cone and the impact on the seed crop. Cones can be halved longitudinally and counts made of insect-damaged, aborted, sound and the total seeds on the exposed axial surface (Winjum and Johnson 1960, McLemore 1961, and Bramlett and Hutchinson 1964). Seed-infesting insects may be detected by x-ray and dissections (Speers 1968, Fedde 1973). This paper reports on damage by cone and seed insects of subalpine fir in a year of very low cone production in northern Idaho, and on the reliability of estimating the damaged, sound, and the total numbers of seeds in cones.

METHODS

Subalpine fir cones were collected from early July through early September, 1972 from a 1.0 x 0.3 km. area in the Freezeout Mountain region of Shoshone County, Idaho. The collection area, primarily an *Abies lasiocarpa/ Xerophyllum tenax* habitat type (Daubenmire and Daubenmire 1968), has a slope of less than 10 percent to the southwest with an average elevation of 1800 m. From each of 15 cone bearing trees in the study area, 15 to 20 cones were collected for insect rearing and damage evaluation. These cones represented about 15 to 20 percent of the production in the area. The average height of the sampled trees was 9.3 m (range 3.1 to 13.7 m). The ages, taken at 1.3m height, averaged 27 years (range 20 to 40 years) and diameters averaged 20.0 cm (range 4.5 to 34.8 cm). Cones collected were placed either in one-gallon, single-light-source rearing cartons at 24°C, or dissected for insect damage. In the former case, the emerged adults were identified by specialists and included in a checklist (Kulhavy, et al. 1975), and in a key to damage (Kulhavy 1974).

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[3]An r^2 of 0.92 was obtained from a regression of seeds from one-half of a cone to total seeds within a cone.

From the 250 cone sample, 72 were completely disected within two weeks after collection for insect damage and seed estimation. These cones were cut in half lengthwise using a modified cone-knife cutter, and the numbers of insect-damaged seeds were counted on the exposed axial surface. Seeds were then hand extracted from one-half of each cone[3] (the half selected at random by the toss of a coin), counted and the seedwings removed. The seeds were then placed in plastic petri dishes and x-rayed for seed-infesting insects. The radiographs were made in Faxitron® Model 804 self-contained X-ray system at 15 kVP for 8 to 10 seconds using Polaroid® Type 52 Land film. The film was then developed for 10 to 15 seconds and coated with Polaroid print coater. The number of seed-infesting insects was counted and added to the damage caused by other insects. This value was regressed against the observed axial damage to estimate total insect damage.

The cone length (mm), width (mm), and axial seed count were regressed against the total number of seeds within one-half of a cone to obtain an estimate of the sound and total number of seeds within a cone. Observations on life history and behavior of the various species also were recorded.

RESULTS

Dioryctria abietivorella (Grote), fir coneworm

Larvae of this pyralid infested 20 percent of the examined cones and destroyed 45.7 percent of the seeds in the infested cones. It was the most destructive of all species, and caused 41.6 percent of the total insect damage, destroying 12.0 percent of the seed crop. Damage by *D. abietivorella* has been described by Keen (1958) and their feeding in subalpine fir cones is similar to that of related species in other trees species. The larvae often bore from one cone to another and through previously infested cones, leaving large masses of granular frass on the exterior of cones held together by webbing. Damaged cones turn brown and brittle by early August.

Larvae of *D. abietivorella* are behaviorally distinct from other lepidopteran pests of cones. When exposed, a mature larva immediately begins sealing its tunnel by spinning silk across the opeing, adding frass pellets to the lattice, then more silk. The behavior observed was similar to that seen in construction of pupal cells although the latter are lined with additional silk. A new species of parasitic Diptera in the genus *Lixophaga* (Tachinidae) was reared by us from larvae of *D. abielivorella*. The impact of this parasite is not known.

Dasineura sp., seed midge

Estimates of damage by the newly-discovered cecidomyiid pest of subalpine fir seeds were obtained from radiographs and seed dissections because the larvae feed internally in the seeds or underneath the seed coat. They destroyed 11.4 percent of the seed crop and accounted for 39.2 percent of the total insect damage. Mature larvae of this species are readily distinguished on radiographs from larvae of the seed chalcid, *Megastigmus lasiocarpae*. Late instar *M. lasiocarpae* larvae are distinclty "C" shaped and tapered at both ends, whereas larvae of *Dasineura* are straight or curved in the seeds, but not tapered.

This species overwinters as mature larvae but no pupae or adults were recovered. About 10 percent of the larvae were parasitized by a small, black, braconid wasp.

Asynapta keeni (Foote)

The larvae of this cecidomyiid were more abundant (700) then those of any other species. However, they accounted for only 1.2 percent of the total insect damage and destroyed 0.4 percent of the seed crop by resin exudation. The life cycle of the species in cones of subalpine fir is the same as it is in cones of grand fir, *Abies grandis* (Douglas) Lindley, (Kulhavy 1974). Adults emerge in late August or the following spring.

Hylemya abietis (Huckett)

One larva of this anthomyiid infested one subalpine fir cone and destroyed 32 seeds. This amounted to one percent of the insect-caused loss, or 0.3 percent of the seed crop. Larvae when removed from cones collected later became sluggish and constricted. They overwinter in puparia in the soil and adults emerge the following spring.

Earoymia sp.

Larvae of this lonchaeid caused 3.9 percent of the insect damage and destroyed 1.3 percent of the total seed crop in 1972. Seeds mined by the larvae become flat, resinous and dark brown. Only a very small amount of fine frass is produced. After the mature larvae leave a cone they move frantically until they find a suitable pupation site in the litter or soil. The larvae travel by three methods: (1) they wiggle the entire body, causing a rolling, twisting motion; (2) they alternately constrict and lengthen the body segments, resulting in a forward motion; and (3) they grasp fleshy areas near the posterior spiracles with one or both mouthhooks, which constricts the body into a "C" shape with the midbody segments flattened dorso-ventrally. When the mouthhooks are released, the larva is propelled for a distance of 8 to 15 cm. This snapping motion was stimulated in the laboratory and observed in the field, and has been reported previously for *E. aquilonia* by R. W. Reid as cited by McAlpine (1956).

TABLE 1. Summary of regression analyses for predicting total, filled, and damaged seeds in subalpine fir cones, northern Idaho, 1972 (n=72).

Dependent[1] Variables	Independent Variables	Intercept	Regression Coefficient	Standard error of estimate ($s_{y.x}$)	Coefficient of Determination (r^2)
Y_1	Length (mm.)	-50.4	2.09	19.6	.6055**
Y_1	Width (mm.)	-82.7	6.86	25.0	.3583**
Y_1	Length, Width	-62.2	1.96, 01.7	19.7	.6073**
Y_1	Axial seeds (Total)	-21.6	4.88	23.9	.4120**
Y_2	Axial sound seeds	14.0	3.47	28.0	.4668**
Y_3	Axial damaged seeds	9.2	2.55	15.5	.6777**

** Significantly different from zero at a=.01

1 Y_1=Total seed in one-half of a cone; Y2=total sound seeds in one-half of a cone; Y_3=total damaged seeds in one-half of a cone.

Megastigmus lasiocarpae Crosby

Larvae of this torymid destroyed 2.2 percent of the seed crop, which has 7.4 percent of the insect-caused seed loss. Damage by this seed-infesting chalcid was estimated from radiographs and seed dissections. Our observations agree with those of Keen (1958) who suggested that the species has a one year life cycle snychronized with cone development. The eggs are deposited in the seeds early in cone devlopment and the larvae feed singly. Only one larva develops if more than one egg is deposited within a seed. Overwintering occurs as mature larvae or pupae, and adults emerge the following spring. An undetermined portion of the population entered extended diapause in 1972 and emerged in 1974.

Unknown causes

These accounted for 1.5 percent of the total seed destruction.

Estimation of Seed Production and Damage

The number of seeds within subalpine fir cones can be reliably estimated (r^2=.6055, a=.01) from the cone length (Table 1). Neither cone width, nor the inclusion of both cone length and width improved the fit. Similarly, expressing the independent variables in logarithms, or fitting a second degree polynominal failed to significantly increase the fit.

The number of damaged seeds/cone also can be reliably estimated (r^2=.6777, a=.01) from counts of damaged seeds on an axial section (Table 1). However, the axial slice technique did not provide as good an estimate of the total number of seeds/cone (r^2=.4120), or the number of sound seeds/cone (r^2=.4668). Means and standard deviations for all variables are shown in Table 2.

DISCUSSION

Every cone dissected from the Freezeout Mountain area had at least one seed destroyed by insects. Insects destroyed 29.1 percent of the total seed crop during a year of very poor cone reproduction. This loss is magnified by the high percentage of aborted seeds, the naturally low viability of subalpine fir seeds (USDA

TABLE 2. Means and standard deviations for all variables for subalpine fir cones, northern Idaho, 1972.

Variable	Mean	Standard Deviation
Length (mm)	73.7	11.5
Width (mm)	28.7	2.7
Axial seeds (Total)	27.8	4.1
Axial sound seeds	7.1	7.7
Axial damaged seeds	9.1	8.7
Total sound seeds	37.2	38.0
Total damaged seeds	32.6	27.1
Total seeds	114.2	31.0

1974) and the cyclic nature of cone crops. Desiccation of the seeds adversely affects survival and seedling establishment during the first season of growth. In the Freezeout Mountain area, the establishment of seedlings was further hindered by the light intensity (USDA 1965) which exceeded 50 percent full sunlight. The similarity and proximity of the insect pests of grand fir cones (Kulhavy 1974, Kulhavy et al., 1975) indicate that the infestations probably were from overwintering or emigrating insects. The most destructive insect species, the coneworm, is an ubiquitous pest of cones and was also the most destructive pest of grand fir cones (Kulhavy 1974, Kulhavy and Schenk in press).

To obtain a reliable estimate of loss to cone and seed insects, damage by the insects feeding internally must be taken into account. Thus, a portion of the seeds should be examined by radiography or dissected to estimate the damage. Although reliable estimates were obtained of the total damage from the number of damaged seeds on the axial surface, and of total seeds per cone from the cone length, Kulhavy, (1974) has shown that there is high variability over the range of grand fir. Similar variability in subalpine fir is likely. Thus, the equation for predicting seeds in subalpine fir cones should be tested at different levels of cone production and insect populations and over a broader geographic range before applying it indiscriminately.

The loss of seeds to insects, coupled with the cyclic nature of cone crops and the generally poor germination of subalpine fir, are factors that should be considered before planning a timber harvest where natural regeneration is desired.

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