

- Madsen, H. F., P. H. Westigard, and R. L. Sisson. 1963. Observations on the natural control of the pear psylla, *Psylla pyricola* Förster, in California. *Can. Ent.* 95: 837-844.
- Nickel, J. L., J. T. Shimizu, and T. Y. Wong. 1965. Studies on natural control of pear psylla in California. *J. Econ. Ent.* 58:970-976.
- Pickett, A. D. 1939. The mullein leaf bug, *Campylomma verbasci*, Meyer, as a pest of apple in Nova Scotia. *Rept. ent. Soc. Ont.*, (1938) 69:105-106.
- Putman, W. L. 1932. Chrysopids as a factor in the natural control of the oriental fruit moth. *Can. Ent.* 64:121-126.
- Ross, W. A., and L. Caesar. 1920. Insects of the Season in Ontario. *Rept. ent. Soc. Ont.*, (1919) 50:95-104.
- Slingerland, M. V. 1896. The pear psylla. *Bull. Cornell Univ. agric. Exp. Stn.* 108:69-81.
- Stewart, V. B., and M. D. Leonard. 1915. The role of sucking insects in the dissemination of fire blight bacteria. *Phytopathology* 5:117-123.
- Wilde, W. H. A. 1962. Bionomics of the pear psylla, *Psylla pyricola* Foerster, in pear orchards of the Kootenay Valley of British Columbia, 1960. *Can. Ent.* 94:845-849.
- Wilde, W. H. A., and T. K. Watson. 1963. Bionomics of the pear psylla, *Psylla pyricola* Foerster, in the Okanagan Valley of British Columbia. *Can. J. Zool.* 41:953-961.

CONE INSECTS OF GRAND FIR, *ABIES GRANDIS* (DOUGLAS) LINDLEY, IN BRITISH COLUMBIA

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ABSTRACT

Insects cause considerable seed loss in cones of grand fir, *Abies grandis* (Doug.) Lindl. on Vancouver Island. Three species of midge, a scale feeder, a gall former, and a seed-feeding midge; two species of seed chalcid, *Megastigmus pinus* Parf. and *M. rafni* Hoff.; and a cone maggot, *Earomyia abietum* McAlpine, were responsible for most of the damage. Coneworms were not important.

INTRODUCTION

Insects that destroy seed of grand fir, *Abies grandis* (Douglas) Lindley, have received little attention. Keen (1958) reported that insects, mainly chalcids and midges, destroyed 10 to 25% of the seed at Ashland, Oregon.

Information on insect species, and the type and extent of their damage was gathered on Vancouver Island in the summer of 1963. Cones collected weekly from 14 June to 19 August near Cowichan Bay contained midges, seed chalcids, cone maggots, and a few coneworms.

Grand fir flowers in spring and the cones mature by early September. Cones are erect, varying in length from 2.0 to 4.5 inches at maturity. In autumn they disintegrate.

LIFE HISTORY AND HABITS

Midges

Three species of midges, consistently present in cones, were distin-

guished by morphological characteristics and by their location in the cone (Fig. 1). Larvae of the scale midge feed on the inner surface of the cone scales, and have anal hooks which are absent in the cecidogenous midge and the seed midge. Morphological differences of the sternal spatulas of full-grown third instar larvae are compared in Fig. 2.

SCALE MIDGE. This is probably the insect which Keen (1958) refers to as the cone resin midge. The full-grown larva is orange and lives freely on the inner surface of the cone scale, often between the seed wing and scale, causing darkening of the scale at the feeding site. Larvae usually occur singly, but may be in clusters. Larvae are present throughout the summer; they averaged 28 per cone in eight cones dissected during June and July. In autumn the larvae drop to the ground to overwinter. The larvae do not affect the seeds directly so their damage is apparently light

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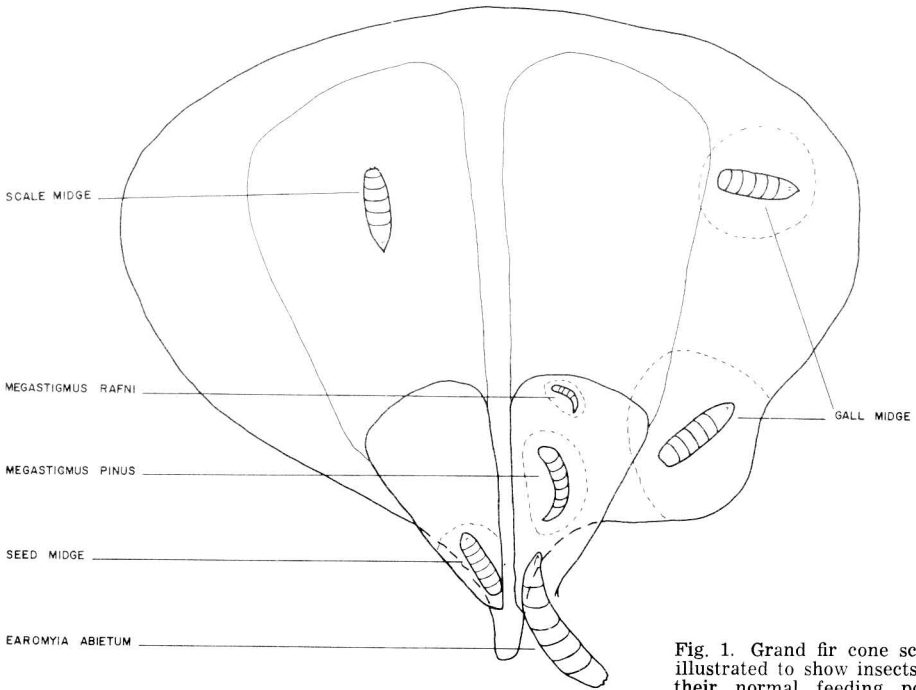


Fig. 1

Fig. 1. Grand fir cone scale illustrated to show insects in their normal feeding positions.

Fig. 2. Sternal spatulas of grand fir cone midges; (a) scale midge, (b) cecidogenous (gall) midge, (c) seed midge.

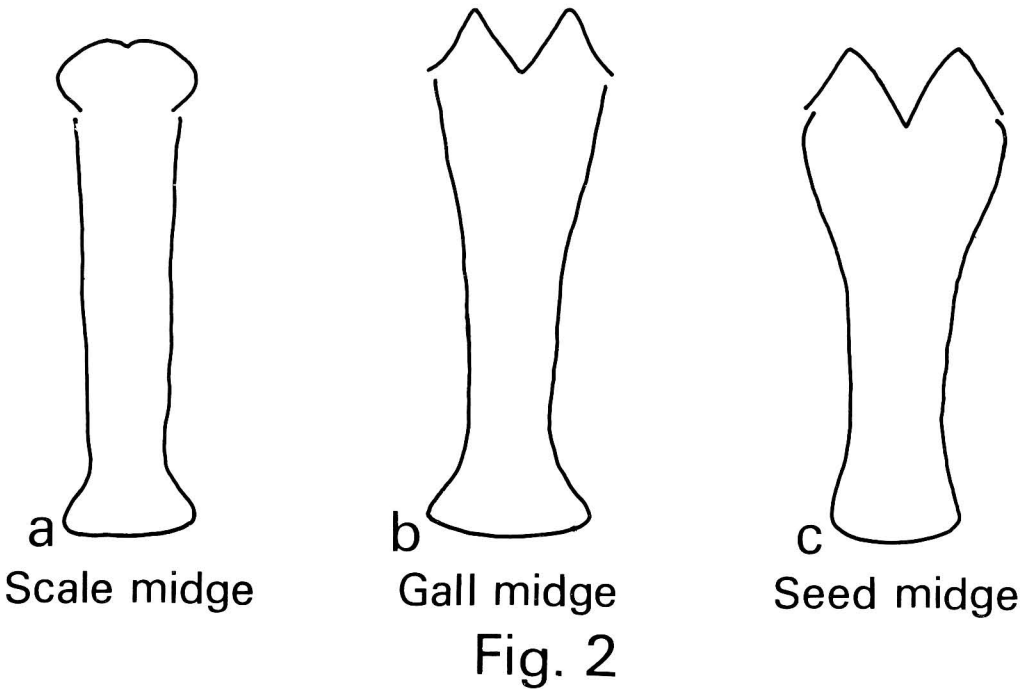


Fig. 2

in spite of large numbers.

CECIDOGENOUS MIDGE. The larva forms a gall in the cone scale, usually adjacent to the seed (Fig. 3), but is rarely found inside a seed. There is usually only one larva but two, separated by a thin wall, may be present in a single gall. The larva remains in the gall throughout the summer and drops with the cone scale in autumn to overwinter in the litter; pupation and emergence occur the following spring.

Seed loss results from fusion of the seed and cone scale. The eight cones examined were infested by an average of 13 larvae.

SEED MIDGE. Keen (1958) combines this species and the cecidogenous midge under the name "fir-seed gall midge", but the two are distinct species. The cecidogenous midge always forms a gall and rarely occurs inside the seed, whereas the seed midge does not form a gall and the larva occurs singly within a seed, near the micropylar end (Fig. 4).

Larvae occur in seeds throughout the summer and drop with the seeds when the cones mature. They overwinter in seeds on the ground, and pupate and emerge the following spring.

Nearly all infested seeds were aborted. Although the larvae occur singly in seeds, one was found with a seed chalcid larva and another with a cecidogenous midge larva. The eight cones were infested by an average of 6.6 seed midge larvae.

SEED CHALCIDS

Two species of *Megastigmus* are common in seeds of grand fir. Typically, the egg, larval, and pupal stages in this genus all occur within a seed.

Megastigmus pinus Parfitt. Adults are black with orange and yellow markings.

They emerged from seeds from 21 May to 11 June in 1958 (Hedlin, unpublished data), and during the last half of May in 1963. Thirty adult females and four males lived a maximum of 12 days and six days respec-

tively, when caged outdoors without food.

Although adults were observed ovipositing, eggs were not isolated. Larvae were observed first on 10 June, 1963, near the micropylar end of the seed which indicated that eggs were deposited in this region. They moved gradually throughout the length of the seed (Fig. 5) and when fully developed, almost filled it. When two are present in the same seed only one survives. Full-grown larvae are very active when disturbed and are easily distinguished from the sluggish *M. rafni*.

Eight cones contained an average of 25 larvae.

Megastigmus rafni Hoffmeyer. Adults are brownish yellow, with dark markings, similar in appearance to *M. spermotrophus* Wachtl which infests Douglas-fir seed.

Adults emerged from 9 to 19 June in 1958 (Hedlin, unpublished data) and during the first half of June in 1963, somewhere later than *M. pinus*.

The first larvae to be observed, on 2 July, were at the distal end of the seed feeding towards the micropylar end. The full grown larva reacts sluggishly when disturbed. When larvae of *M. rafni* and *M. pinus* occur within the same seed, the former is destroyed.

Eight cones contained an average of 3.4 larvae. The numbers of *M. rafni* are reduced by competition from *M. pinus*.

FIR CONE MAGGOTS

Earomyia abietum was the only species observed. Keen (1958) refers to this and other species of this group as "fir seed maggot". The name implies a seed feeder, and although the larva feeds on seeds it is also highly predacious, particularly in later instars. Thus I prefer the name "fir cone maggot" which does not imply specific feeding habits.

The opaque, white, sausage-shaped eggs are laid, usually singly, on the inner surface of the cone scale in May. Hatching occurs in late May and

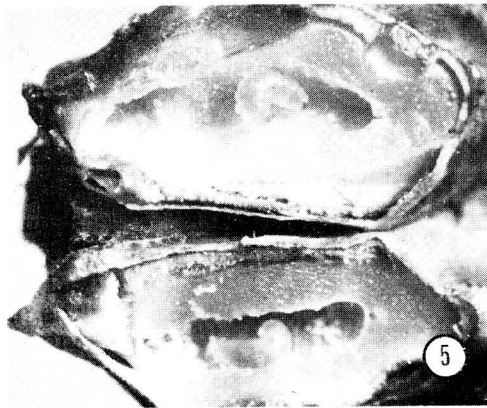
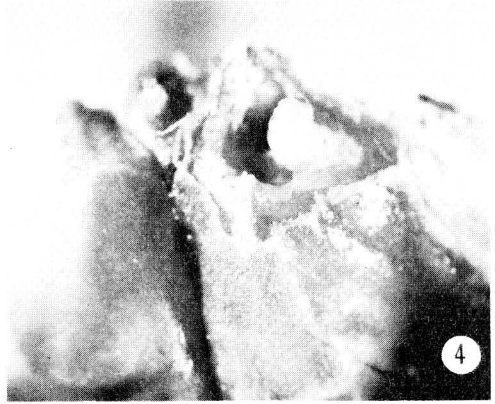
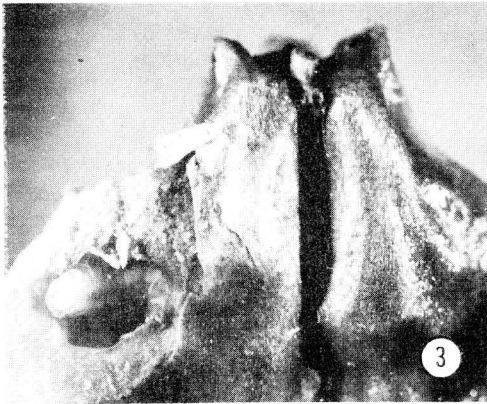


Fig. 3. Cecidogenous (gall) midge. Top of gall removed to expose larva.
Fig. 4. Seed midge. Seed opened to expose larva.
Fig. 5. *Megastigmus pinus*. Seeds sliced open to expose larvae in feeding tunnels.
Fig. 6. Entry holes of *E. abietum* in grand fir seeds.
Fig. 7. Puparia of *Earomyia abietum*.

TABLE I
Numbers of insects and numbers of seeds destroyed in grand fir cones,
Cowichan Bay, B.C., 1963 (Basis eight cones).

Insect	No. insects per cone	Seed loss	
		direct	indirect
Scale midge	28.0		7.0
Gall midge	13.0		13.0
Seed midge	6.6	6.6	
Megastigmus pinus	25.0	25.0	
Megastigmus rafni	3.4	3.4	
Earomyia abietum	1.3		5.0
Totals	77.3	35.0	25.0

early June and young larvae move down the scale to enter the seeds (Fig. 6). Early-instar larvae feed on endosperms, but later become predacious. One larva entered two seeds not infested by other insects and left without devouring the endosperm. Remains of a number of *Megastigmus* larvae and five cecidogenous midge larvae were observed following the ravages of *Earomyia* in seeds and galls.

In autumn, full-grown larvae drop on the ground, where they overwinter in puparia in the litter (Fig. 7).

An average of 1.5 *Earomyia* larvae occurred in cones examined.

CONEWORMS

Larvae of *Laspeyresia laricana* Busck and *Dioryctria* sp. were encountered but not in sufficient num-

bers to be considered important seed destroyers.

DISCUSSION

The average loss to all insects was 60 seeds per cone (Table 1). The direct loss was easily assessed by counting the actual seed eaten. Indirect losses were estimated, and resulted from (a) feeding which deprived the seed of nutrients (scale midge), (b) fusion of seed to the scale preventing separation (cecidogenous midge), and (c) damage to seeds by predacious larvae searching for insect prey (cone maggot).

Seed chalcids were the most important pests and were responsible for almost 50% of the insect-caused loss.

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References

- Hedlin, A. F. 1959. Studies on cone and seed insects in British Columbia. **Can. Dept. Agric. For. Bio. Lab. Victoria, B.C. Interim Rpt.** 1958: 12 pp.
Keen, F. P. 1958. Cone and seed insects of western forest trees. **U.S.D.A. Tech. Bull.** 1169, 168 pp.