SEED CHALCIDS: NEW INSECT PESTS OF EASTERN WHITE PINE AND FRASER FIR SEEDS

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Abstract.--Seed chalcids are minute phytophagous insects whose larvae destroy seeds of various plant species by consuming the endosperm. Two species have recently been discovered in coniferous cones in North Carolina--Megastigmus specularis on Fraser fir and M. atedius on eastern white pine. This latter is the first record of chalcid attack on pine seeds in eastern North America.

Additional keywords: Megastigmus specularis, M. atedius, Abies fraseri, Pinus strobus.

Until recently there was little reason to be concerned about chalcids in the Southeastern United States because there was no record of their occurring in this region. During the past few years, however, they have been recovered from seeds of both eastern white pine, Pinus strobus L., and Fraser fir, Abies fraseri (Pursh) Poir. It is possible that these chalcids occur in other southeastern species as well, but as yet they have not been found in the major southern pine species during 15 years of intensive research on seed-destroying insects.

ROLE OF MEGASTIGMUS

From 1845 to about 1900, various views were expressed about the biology of species in the genus Megastigmus. Ratzeburg (1848) maintained that M. strobilobius Ratzeburg lived in spruce cones probably as a parasite of Laspeyresia, and that M. aculeatus Swederus was parasitic on a dipterous species that infested rose hips. Parfitt (1857) described a new species, M. pinus, which he collected from the cones of various California conifers and which he considered to be parasitic on a cynipid. Wachtl (1884) maintained that some Megastigmus were strictly phytophagous. The dispute continued and became particularly strenuous about 1900, with some workers persisting that all chalcids were parasitic on other insects. In 1893 Wachtl substantiated his former claim and described M. spermotrophus as a new phytophagous species which destroyed the seeds of Douglas-fir, Pseudotsuga menziesii (Mirb.) Franco. The fact that some Megastigmus are truly parasitic, some phytophagous, and others initially phytophagous and later parasitic partly accounts for the difficulties experienced by early investigators. When other species emerged from the same seed it was assumed that a true parasitic relationship existed.

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ECONOMIC IMPORTANCE OF *MEGASTIGMUS*

Losses caused by *Megastigmus* have varied widely from a few percent to an entire crop. Generally, losses in bumper crop years have been minimal, whereas in poor seed years almost the entire crop may have been destroyed. Losses in true firs and Douglas-fir have been particularly severe and sometimes approached 90 percent in the western United States and in plantations in the British Isles and Europe.

Fraser fir seed.--One of the more difficult trees on which to determine *Megastigmus* damage is Fraser fir because its seed is small, light-weight, and frequently filled with hardened resinous material. An infested seed weighs about as much as either resinous-filled or good seed. On wind separator seed cleaners infested seeds are often deposited with full ones or in the intermediate weight category.

In 1963 a bumper crop of Fraser fir cones was produced in the Southern Appalachians. In 1964, a poor seed year, cones were collected in September and air-dried, and the seeds were extracted in October. After extraction, numerous tiny insects were observed in flight near the seed. These were determined to be the parasite *Platymesopus* sp. (Hymenoptera: Pteromalidae).

Cutting tests revealed that many seeds still contained a hymenopterous larva. Ten samples of 100 seeds were taken at random from about 300 pounds of seed and dissected.

Infested seeds per sample ranged from 22 to 36 and averaged 29 percent (Speers 1968). The actual loss was much greater since infested light-weight and medium-weight seeds were rejected during cleaning and separation. When the adults emerged the following spring they were submitted to Washington, D.C. and identified as *Megastigmus specularis*

In the fall of 1965 a good crop of cones was produced and several hundred bushels were collected. These were cleaned, sampled, and examined as in the previous year. Losses due to *Megastigmus* ranged from 0 to 7 percent per sample and averaged 3.5 percent for the seed lot.

In 1967 fir seeds were collected from Pennsylvania, Virginia, and West Virginia. X-raying and inspection of radiographs indicated that *Megastigmus* was present at all collection points.

Seeds from 38 of 39 trees, kept separate by tree, contained *Megastigmus.* In West Virginia, where the cone crop was considered to be heavy, infestation varied from 2 to 31 percent per tree in about 1,000 seeds sampled on each of 10 trees (Speers 1969).

1/ Determined by B. D. Burks, Syst. Entomol. Lab., USDA Agric. Res. Serv., Washington, D. C.

Eastern white pine seed.--The extent of losses caused by Megastigmus to seed of this species are unknown. In good seed years the losses would be minimal and likely less than 1 percent. In poor seed years the damage caused by insect attack would be maximized.

RANGE

Megastigmus specularis.--This species was originally described by Walley (1932) from adults reared from balsam fir, Abies balsamea (L.) Mill., seed gathered in New Brunswick. Since then it has been collected from Saskatchewan to Nova Scotia. In the United States M. specularis has been reported from Minnesota to Maine and south through Massachusetts. Our collections extended the range through Pennsylvania, West Virginia, Virginia, North Carolina, and Tennessee (Speers 1969).

Megastigmus atedius.--Present literature indicates that the only chalcids collected from pine seed in America are M. albifrons Walker from ponderosa pine, P. ponderosa Laws., (Milliron 1949) in the Southwest and M. zwoelferi Schefer-Inmel from lodgepole pine, P. contorta Dougl., (Hussey 1967) in the state of Washington.

Megastigmus zwoelferi was described as a new species by Schefer-Immel (1957) from adults that infested eastern white pine seed in Germany. Several years later a shipment of lodgepole pine seed from the state of Washington was received in England by the British Forestry Commission. Hussey (1967) identified adults which emerged from this seed as M. zwoelferi. He concluded that this species occurred in the western United States as well as in Germany. In 1970 Boucek revised the West European species of Megastigmus and compared them with American forms. He contended that M. piceae Rohwer which infests spruce in both eastern and western America, M. zwoelferi, and M. atedius Walker in the Oxford University Collection and initially described in 1851, were synonymous. Since atedius had priority it was considered to be the type species.

We recently recleaned a shipment of eastern white pine seed received from Wisconsin. Medium-weight seeds were attacked by Megastigmus, probably atedius.

On the basis of nomenclature changes and the synonomy of species, it is evident that M. atedius attacks the seed of eastern white pine in North Carolina and probably in Wisconsin, lodgepole pine in Washington, and spruce in Ontario and the western United States. Thus, atedius occurs from at least North Carolina to Canada and from the Atlantic to the Pacific Ocean as well as in the British Isles and Europe.

LIFE HISTORY

Information for Megastigmus specularis is presented; it is probably similar to the life history of M. atedius. The life history of specularis was determined in Canada by Hedlin (1956). Our limited observations indicate that its life cycle in the Southeast is similar to that in Canada except that adults may emerge a week or two earlier in North Carolina.

The adults emerge in June through a small hole which they chew in the seedcoat. The minute wasps, about 3 mm long, fly to the new developing cones and oviposit in the seed embryo. Since their ovipositor is only a few nail long, the timing of their emergence for synchronizing with cone development is critical; the ovipositor must pass down through the soft cone, penetrate the seedcoat, and deposit the egg inside. After the egg hatches, the larva feed on the seed as it develops and consume the contents by the time the cone has matured. The larva over-winters in the seed on the ground. When the proper conditions for oviposition arrive, pupation occurs and adults emerge 3 weeks later. This cycle is repeated annually except that all of the population does not emerge the first year. Part of the larvae delay emergence for an additional year or more, presumably to preserve the species in case of crop failures.

The feeding of each larva is confined to the individual seed in which the egg was deposited. Infested seeds appear normal in shape and color and closely approximate good seed in weight. This maximizes seed cleaning problems which may be partially solved by the use of a gravity separation table.

OBSERVATIONS OF MEGASTIGMUS IN WHITE PINE SEED

According to an estimate based upon seedling production, over 1.5 billion eastern white pine seeds have been processed in the United States during the past 75 years— yet not a single chalcid was ever recovered.

In 1972 cones were collected from Transylvania County, N. C., stored until February 1973, when seeds were extracted. The seeds were cleaned with a Clipper laboratory model which had five categories into which the seed was deposited. The extra large and very small seeds were screened out mechanically along with the debris. The other three categories were separated by a fanning mill into heavy good seed, light-weight poor seed, and medium-weight seed which was a combination of the two.

The medium-weight seed was examined carefully to determine whether the force of the airdraft should be adjusted to provide a better separation of good and bad seed. During this examination several seeds apparently infested by Megastigmus were recognized. Some of these infested seeds were x-rayed and dissected under magnification, and recovered larvae were sent to Dr. B. D. Burks for identification. His report stated that the larvae were probably Megastigmus but that adults would be needed to make a positive identification.

Efforts to rear larvae to the adult stage for identification of the species were initiated immediately. Seeds were divided into lots. Part was stored at room temperature and the rest placed in refrigeration. This latter treatment prolonged the cold period in case the previous storage outside was not sufficient to break diapause.

1/ LeRoy Jones, U.S.D.A., Forest Service, Cooperative Forestry Division, Washington, D. C. Personal Communication.

Seeds kept at room temperature were examined weekly from April to November 1973, and although living larvae were recovered at each inspection none of the larvae broke diapause. The outside low temperatures from September to February were apparently too brief to cause transformation. This is difficult to understand since Schefer-Immel (1957) reported that he recovered larvae on November 24, pupae on December 5, and adults on January 2, 1956, all presumedly from seed collected in the fall of 1955.

In July one of the seedlots was transferred from refrigeration to room temperature. Of the 600 seeds examined in August, 35 contained larvae and 2 pupae. These pupae died after a few days apparently from injury during dissection. The larvae were observed for an additional 2 weeks but none broke diapause.

In October another lot was transferred from refrigeration to room temperature; however, the seeds in this lot were kept moist instead of dry. Between October and November many of the seeds germinated and were discarded. Seeds which did not germinate were dissected and 10 larvae, 3 pupae, and 2 dead adults were recovered. After transformation of the 3 pupae to adults, the 4 females and 1 male were submitted to Washington, D. C. for identification. All of the specimens were identified as Megastigmus atedius [1/].

Seed is still in refrigeration to determine how many years the larvae can remain in diapause before transforming to the adult stage. Several adults emerged in June 1974. Two years after egg deposition.

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