HOW SEEDBUGS REDUCE THE QUANTITY AND QUALITY OF PINE SEED YIELDS

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Abstract. --The seedbugs Tetyra bipunctata(H.-S.) and Leptoglossus corculus(Say) are sucking insects that reduce the yield of pine seed by inserting their stylets into a cone and secreting enzymes into an ovule or seed. L. corculus destroys first-year ovules, and the conelets are aborted. Second-year cones that are fed upon may yield fewer seed or greater numbers of non-viable seed. The problems involved in detecting these losses in seed orchards are discussed. Data for several major species of southern pines are presented to illustrate the damage potential of seedbugs.

Additional keywords: Leptoglossus corculus, Tetyra bipunctata, Pinus echinata, P. taeda.

Cone production is reaching operational levels in many of the South's pine seed orchards, and with it comes increasing concern over the quantity and quality of seed yields. Tree improvement workers are well aware of the serious threat insects pose to the success of the seed orchard concept (Zobel 1971). Both orchardists and forest entomologists acknowledge the coneworms, Dioryctria spp., as a major pest problem in seed orchards. Although a multitude of Insect species destroy the seeds and cones of southern pines, most orchard managers are familiar only with the more obvious types of losses. However, there are other insects which may have an equal or perhaps even greater effect upon seed production but go unnoticed because they operate in a more inconspicuous and subtle manner.

A shieldback bug, Tetyra bipunctata(H.-S.), and a leaf-footed bug, Leptoglossus corculus(Say), destroy pine seed but their mobility and the microscopic injury these sucking insects cause to attacked conelets and cones have hampered evaluations of their potential impact. This paper summarizes research devoted to answering the question of how seedbugs affect the quantity and quality of pine seed yields.

WHAT ARE SEEDBUGS?

Almost everyone recognizes at first meeting that T. bipunctata and L. corculus are stinkbugs. But to understand how these ubiquitous seedbugs limit seed yields of all the major species of southern pines, it is helpful to look at the differences between "true" bugs and the other, more familiar cone and seed insects. Seed orchardists frequently encounter damage caused by the larvae (immature stages) of moths, such *as* the seedworms, Laspeyresia spp. and the coneworms. Equipped with chewing mouthparts, these insects spend a large part of their life cycle within the cone, producing readily identifiable damage symptoms. In contrast, seedbugs feed externally, using hair-like sucking mouthparts called stylets to penetrate cones. Enzymes from the bug's salivary glands are secreted into an ovule or seed and the digested substrates are sucked up

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through the stylets. Consequently, the symptoms of damage are microscopic, and the seed losses are often attributed to causes other than insects.

Unlike most cone and seed insects, the seedbugs are hemimetabolous: they develop through five nymphal stages and then molt to the adult stage. There is no pupal (resting) stage, and the free-roaming nymphs are diminutive forms of the adult, lacking only the capabilities for reproduction and flight.

An important difference in the life histories of T. bipunctata and L. corculus greatly influences the relative damage potential of the two insects. Roth species overwinter in the adult stage, but T. bipunctata is not found actively feeding in seed orchards until midsummer. The overwintering adults apparently undergo an obligate diapause, which limits the species to a single generation each year. In contrast, L. corculus is active early in the year (February in north Florida and April in north Georgia), and several generations occur per year. As a result of this difference in biology, L. corculus destroys pine seed in all stages of seed development.

SEED LOSSES DURING THE FIRST YEAR OF CONE DEVELOPMENT

Conelet drop or abortion commonly occurs on longleaf, Pinus palustris Mill., shortleaf, P. echinata Mill., and loblolly, P. taeda L., pines. In the past, the phenomenon has been referred to by such colorful names as "poop out" and "physiological drop." A search for insects which might play a role in the problem of conelet abortion led to the discovery of L. corculus and T. bipunctata as seed orchard pests (DeBarr 1967).

Although we knew that L. corculus nymphs feed upon conelets and that circumstantial evidence suggested a link with the problem of conelet abortion, it was not until 1971 that we demonstrated the insect's innate capacity to induce conelet abortion (DeBarr and Ebel 1973). In April, individual clusters of conelets were enclosed in small screen-wire cages to prevent feeding by natural field populations of seedbugs. Twenty clusters were caged on each of nine shortleaf pine trees. Clusters chosen at random were then artificially infested with laboratory-reared L. corculus nymphs or adults for 1-week periods during the early (May-June), middle (July-August), or late (September-October) portions of the growing season.

Nearly all conelets subjected to nymphal feeding aborted: 100 percent in the early period, 98 percent in the middle period, and 94 percent in the late period. Most of the caged conelets exposed to adult bugs survived without noticeable external effects. In a similar experiment on loblolly pine, 73 percent of the conelets aborted when exposed to midseason feeding by nymphs and 61 percent aborted when exposed to late-season feeding. No check conelets protected by cages during the 1971 growing season aborted.

Our work demonstrated that L. corculus nymphs have the inherent capability of inducing conelets to abort. The insect stage, number of nymphs, and timing of feeding periods used in our experiments were realistic from the standpoint of the biology of natural field populations of bugs. Although we do not infer that all conelet abortion is caused by bugs, the problem can no longer be considered to lie solely in the scope of tree physiology.

In a follow-up study of the abortion phenomenon, we exposed conelets to L. corculus nymphs, then dissected and sectioned conelets to verify that the

nymphs feed directly on first-year ovules (DeBarr and Kormanik, unpublished data). Most of the ovules in aborting conelets were destroyed. Therefore, it seemed likely that conelets which were fed upon by bugs but which did not abort would yield fewer seed per cone at harvest. This theory turned out to be true. Cones protected for 2 years except for a 1-week exposure to an artificial infestation level of two nymphs per conelet during the first year of development yielded about half as many total seed per cone as did cones never exposed to seedbugs (table 1). Conelets exposed to natural field damage by seedbugs but protected with cages during the second year of development also produced significantly fewer filled and total seed per cone.

Table 1.--Mean seed yields from loblolly pine cones exposed to Leptoglossus corculus nymphs during the first year of strobili development (Clark County, Ga., 1972

Treatment	Filled (F)	Empty (En)	Total	Ratio of En:F+En
		- - Seed/cone		
Caged for 2 years; exposed to two second-instar nymphs per conelet for 1 week in 1971.	46.2a	21.8a	68.0a	0.32
Caged second year only; exposed to field population of seedbugs as conelets.	58.8a	26.1a	84.9a	.31
Check--caged for 2 years; never exposed to seedbugs.	85.1b	37.4b	122.5b	.31

1/ Means not followed by the same letter are significantly different at the 5-percent level by Duncan's new multiple-range test.

It should be pointed out that although ovule destruction during the first year of development reduced the number of seed extracted at cone maturity, the ratio of empty:total seed per cone did not change (table 1). The empty seed were due only to fertilization failure (incompatibility), or other physiological causes, which occurred the second year, hence this ratio was unaffected by the random feeding of bugs on conelets.

SEED LOSSES DURING THE SECOND YEAR OF CONE DEVELOPMENT

Seed with endosperms damaged but not completely destroyed by L. corculus and T. bipunctata can be detected on radiographs of mature seed (DeBarr 1970). Observations with this technique indicated that damage to seed harvested in seed orchards of slash pine, P. elliottii Engelm. var. elliottii, was as high as 20 percent (DeBarr et al. 1972). However, some seedbug-damaged seed cannot be differentiated on radiographs from aborted or empty seed resulting from other causes, such as fertilization failure, especially when damage occurs before seedcoat development is completed.

The effects of feeding by L. corculus on cones during the second year of strobili development were also studied (DeBarr and Ebel 1973). Cone clusters were enclosed during May, before appreciable feeding was likely to have occurred from overwintering field populations of L. corculus adults. Cages were installed upon each of five loblolly and eight shortleaf pine trees in Clarke County, Ga. Again, bugs were introduced into cages during the early, middle, and late portions of the growing season. Check clusters were caged for the entire growing season. In addition, a sample of cones exposed to the local bug population was also collected from each tree at harvest.

Cones exposed to natural bug populations for the entire growing season or to artificial infestations of bugs for 1 or 2 weeks early in the summer yielded significantly fewer seed than did cones exposed during the middle or late periods. Seed damaged early in the season, before the seed coats had hardened aborted; the net result was fewer seed per cone at harvest.

In contrast, the total numbers of seed produced by cones exposed only to insects later in the growing season did not differ significantly from those produced by cones never exposed. This similarity reflects the fact that seedcoat development had progressed to the point where bug-damaged seed was collected as defective seed at harvest but, nevertheless, did contribute to the total seed yield per cone.

Full seed yields from cones exposed to natural bug populations for the entire growing season and cones exposed to artificial infestation levels of one bug per cone for 1 or 2 weeks early in the summer were drastically reduced in comparison with those from check cones. Loblolly pine cones protected only for the second year of development yielded 2-1/2 times as many filled seed as did cones exposed to natural bug populations, and almost 6 times as many full seed as did cones exposed to 2 weeks of bug feeding in the early treatment. The increase in full seed yield was even more dramatic for shortleaf pine. Cones caged only during the second year of development yielded 12 times as many full seed as did uncaged cones on the same shortleaf trees. These differences in yields, supported by evidence from the artificial infestation experiments, strongly suggest that heavy seed losses naturally occur in the early season from the feeding of L. corculus, thereby reducing the yield of viable seed per cone.

Feeding by L. corculus adults early in the summer also apparently had a systemic effect on cones. When measured and weighed at maturity, cones which had been exposed to L. corculus early in the season either naturally or in artificial infestations were significantly shorter and weighed less than protected check cones. In the study on shortleaf pine, which produces smaller cones than loblolly pine, feeding by L. corculus early in the summer actually caused some of the cones to die or abort.

THE TOTAL IMPACT OF SEEDBUGS IN SEED ORCHARDS

Leptoglessus corculus and T. bpunctata have an impact on seed yields during the first and second year of female strobili development. The known effects of seedbug feeding can be summarized as follows:

First-year conelets

A1 = conelet abortion--extensive ovule damage; conelet withers and dies.

O1 ovule damage--conelet does not die; ovules are destroyed and seed are missing at harvest the following year.

Second year cones

A2 = cone abortion--extensive ovule damage; cone withers and dies.

02 = ovule damage--cone survives; ovules are destroyed and seed are missing at harvest; some may be extracted as flattened seed from mature cones.

E_b = empty seed resulting from seedbug feeding--seedcoat matures; seed produced is empty.

SB = seedbug-damaged seed--seed with damaged endosperm; can be detected on radiographs.

A sampling method for evaluating the total impact of seedbugs on orchard yields should account for all six categories of seed loss:

Total seedbug impact = Al + 01 + A2 + 02 + Eb + SB

However, conelet (Al) and cone (A2) abortion will only be detected by periodic observations on tagged sample clusters. Even then, an unequivocal link between seedbug feeding and conelet or cone abortion cannot be made because of the lack of characteristic symptoms. Ovule destruction during the first (01) and second (02) years of development is reflected only by reduced yields of seed per cone. Once the seedcoat has hardened, seedbug damage is evidenced by an increase in the number of defective seed (Eb + SB) per cone.

The Eastern Tree Seed Laboratory is currently conducting a Seed Orchard Survey (SOS) of admirable magnitude and scope to determine the quantity and quality of seed produced in State, Federal, and industrial orchards. One facet of SOS is to evaluate seed losses resulting from insects. Seedbug-damaged seed (SB) are determined on radiographs of samples of mature seed. However, we now know that a substantial proportion of the total seed loss caused by seedbugs is not apparent under natural conditions at the time of seed harvest, and is overlooked or attributed to causes other than insects. The real impact of seedbugs on yields can only be determined when a potential yield base is available for comparison. Yields from protected (caged) cones provide such a base (fig. 1). Although SOS may show the relative losses among orchards, it must be considered as a very conservative estimate of the actual impact of L. corculus and T. bipunctata on seed orchard yields.

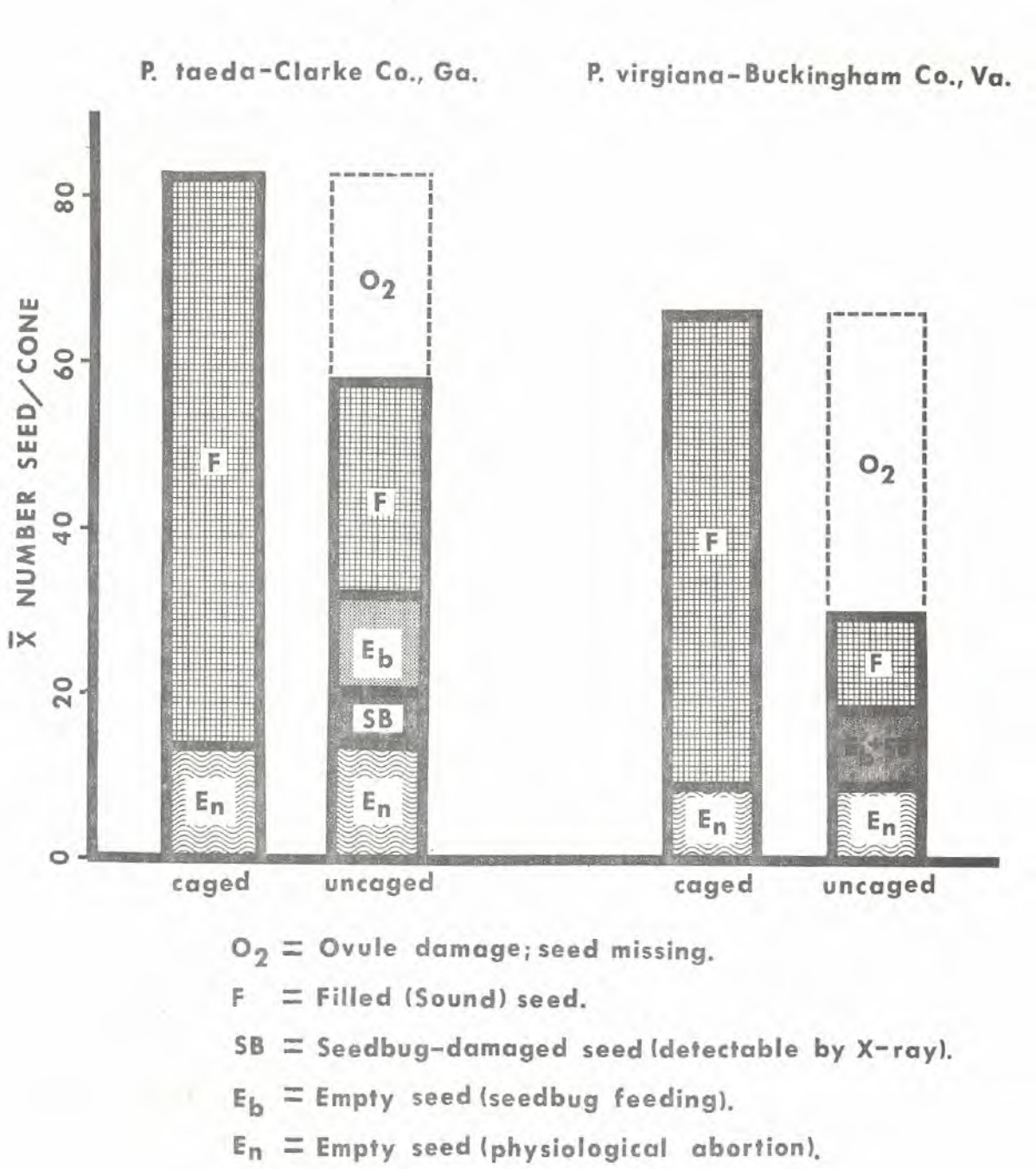

Figure 1.--Quantity and quality of seed harvested in 1971 from protected an unprotected cones on the same loblolly and Virginia pine trees: protected cones were caged second year only; unprotected cones were exposed to natur populations of seedbugs for 2 years. Data on loblolly pine adapted from DeBarr and Ebel (1973); data on Virginia pine adapted from Bramlett and Moyer (1973).

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