REPRINTED FROM
Proceedings: Flowering and Seed Development in Trees: A Symposium.
USDA For. Serv., South. For. Exp. Stn., New Orleans.

IMPORTANCE OF THE SEEDBUGS *LEPTOGLOSSUS CORCULUS* (SAY) (HEMIPTERA: COREIDAE) AND *TETYRA BIPUNCTATA* (H.-S.) (HEMIPTERA: PENTATOMIDAE) AND THEIR CONTROL IN SOUTHERN PINE SEED ORCHARDS

Gary L. DeBarr
Principal Research Entomologist
USDA Forest Service
Southeastern Forest Experiment Station
Forestry Sciences Laboratory
Carlton Street
Athens, Georgia 30602
USA

SUMMARY

Seedbugs are major pests in the insect complex attacking pine seeds in the Southeastern United States. *Leptoglossus corculus* is the most important species, but *Tetyra bipunctata* also is very destructive in orchards established to provide genetically improved seeds. This paper reviews 10 years of research on these insects and discusses the prospects for their control using an integrated pest management system in pine seed orchards.

INTRODUCTION

In pine seed orchards of the Southeastern United States, seedbugs are key species in the insect complex which limits production (Ebel *et al.* 1975). *Leptoglossus corculus* (Say) is the predominant species, but *Tetyra bipunctata* (H.-S.) also destroys many seeds. In orchards established to provide genetically improved pine seeds, these insects abort ovules or conelets and kill seeds, often destroying over half of the annual crop. More than 10 years have passed since the recognition of these insects as seed pests (DeBarr 1967). This paper reviews research and discusses the prospects for an integrated pest management system aimed at seedbug control in pine seed orchards.

Keywords: insecticides, integrated control, *Pinus*.

BIOLOGY

Leptoglossus corculus (Say)

The southern pine seedbug occurs throughout the Eastern United States and is a major pest in southern pine seed orchards (Ebel *et al.* 1975). Hosts include *Pinus taeda* L., *P. echinata* Mill., *P. elliottii* Engelm. var. *elliottii*, *P. palustris* Mill., *P. virginiana* Mill., *P. strobus* L., *P. rigida* Mill., *P. pungens* Lamb., and *P. glabra* Walt. (Ebel 1977). Other native or introduced pine species in this region are also likely hosts. *Leptoglossus corculus* adults have a white zig-zag line across the wings and flattened, leaf-like hind tibiae (DeBarr 1967). They take flight with a loud buzzing sound when disturbed. Usually about 20 eggs are laid end to end in a line along a single needle. There are five nymphal stages, and several generations occur each year in the Southeastern United States. Adults overwinter in the duff and emerge to begin breeding in April. Nymphs and adults have piercing-sucking mouthparts that they insert into the conelets or cones to penetrate the ovules and seeds. Attacked cones show no external damage symptoms. In early stages, nymphs feed upon the needles and conelets. Third-, fourth-, and fifth-stage nymphs and adults feed primarily upon seeds developing within cones.

Tetyra bipunctata (H.-S.)

The shieldbacked pine seedbug attacks *P. taeda* L., *P. elliottii* Engelm. var. *elliottii*, *P. echinata* Mill., *P. palustris* Mill, *P. virginiana* Mill., *P. strobus* L., *P. banksiana* Lamb., *P. resinosa* Ait., and *P. clausa* (Chapm.) Vasey (Ebel *et al.* 1975, Gilbert *et al.* 1967). The adults and nymphs are oval shaped and have a humpbacked appearance (DeBarr 1967). Because of their shape and color, they are not readily noticed while feeding on nearly mature cones. About a dozen eggs are laid in two alternate rows along a single needle or in a group on a cone scale. Nymphs of all stages are gregarious. There is only one generation each year. Nymphs and adults have piercing-sucking mouthparts that they insert into cones to penetrate the seeds. Nymphs in the third stage and older, as well as adults, destroy seeds in cones.

DAMAGE AND IMPACT

Conelet Damage

The degeneration of pine conelets and ovules during the first year of development is a major problem in seed orchards. Because there are no obvious symptoms of damage by insects or diseases, such abortion was attributed entirely to physiological causes, usually lack of pollination or genetic problems. Although not all conelet abortion, particularly that occurring on *P. palustris* (White *et al.* 1977), is caused by insects, our studies demonstrate that feeding by second-stage nymphs of *L. corculus* induces abortion of *P. echinata* and *P. taeda* conelets (DeBarr 1974a; DeBarr and Ebel 1973, 1974). Little or no abortion occurs when conelets of these species are protected with screen wire cages.

Nymphs feed specifically upon ovules in conelets, rupturing the cells in the integuments and removing the contents of the nucellar cells (DeBarr and Kormanik 1975). Contrary to previous reports, the female strobili of pines, which botanists consider to be modified branches rather than leaves, undergo distinctive anatomical changes indicative of abscission zone formation. Aborting conelets fed upon by nymphs form an abscission layer in the cortex and pith at the base of the conelet stalk. Conelets fed upon in late summer abort, but do not drop, even though anatomical changes characteristic of an abscission zone can occur through the first growing season. Abscission and conelet drop occurs only in the spring when living cortical and pith cells make up most of the cross section of the stalk. Conelets aborting as a result of late summer feeding remain attached to the tree by the dead cells of the xylem.

Fungi isolated from aborting conelets and salivary gland extracts from *L. corculus* failed to promote conelet abortion when injected into healthy conelets (DeBarr 1974a). It appears that the most probable explanation of the physiological basis for conelet abortion following *L. corculus* feeding may be that ovule destruction by *L. corculus* simply promotes the natural physiological processes which occur when ovules degenerate and conelets abort in the absence of pollen.

We also found that subabortive levels of feeding on conelets by *L. corculus* nymphs cause first-year ovules in conelets to abort (DeBarr and Ebel 1973, 1974; DeBarr and Kormanik 1975). These seed losses are reflected by fewer seed per cone at harvest, and in the past were not attributed to insects. Although first-year ovule abortion reduces the number of seed extracted at cone maturity, it does not affect the ratio of empty:total seed/cone, since empty seeds are formed during the year following abortion. *Leptoglossus corculus* adults do little or no feeding on ovules in conelets and do not cause conelet abortion.

Cone Damage

The nature of the damage caused by *L. corculus* feeding in the second year of pine strobili varies with the stages of ovule development (DeBarr 1974a, DeBarr and Ebel 1974). Seedbug adults lower yields from *P. echinata* and *P. palustris* cones by aborting ovules during late May and early June. Immature *P. echinata* cones fed upon during this period are smaller than undamaged cones, since cone length and weight are positively correlated with the number of developing seeds. Losses through the rest of the growing season are reflected by increased numbers of nonviable seeds. During June, the integuments continue to develop but produce a hard, flattened, severely deteriorated or resin-filled seedcoat. Through July, feeding by seedbugs increases the numbers of empty seed. By late summer, nonviable seeds with gametophytes damaged by either *L. corculus* or *T. bipunctata* can be detected on radiographs (DeBarr 1970). Poor germination and moldy seed are associated with this gametophyte damage (Rowan and DeBarr 1974). Protected seeds from clonal orchards of *P. taeda* show almost no gametophyte damage (DeBarr 1974a).

Impact

Radiography has proven to be a useful technique for detecting seeds killed by seedbugs (DeBarr 1970). Millions of seeds have been radiographed to determine seedbug impact (Bramlett 1974a, DeBarr 1974b, DeBarr and Barber 1975, Ebel and Yates 1974, Goyer and Nachod 1976, Yates and Ebel 1978), evaluate the relative effectiveness of insecticides for seedbug control (DeBarr 1978, DeBarr and Merkel 1971, DeBarr *et al.* 1972, Merkel and DeBarr 1971, Merkel *et al.* 1976), and to examine the clonal variation in susceptibility to seedbugs (DeBarr *et al.* 1972). From 1971-1974, the U. S. Forest Service's Eastern Tree Seed Laboratory utilized radiography in an extensive Seed Orchard Survey (SOS) of production orchards. This survey showed that 9.9 percent of the loblolly pine seeds harvested from 297 clones located in 26 orchards and 15.0 percent of the slash pine seeds produced on 219 clones in 29 orchards were destroyed by seedbugs (Belcher and DeBarr 1975).

The usefulness of the radiographic technique is limited because damage by *T. bipunctata* and *L. corculus* cannot be separated on radiographs of mature seeds (DeBarr 1970). *Tetyra bipunctata* feeds mostly in the late summer and fall, causing seed losses that are usually detected on radiographs. In addition, radiography underestimates the impact of *L. corculus* because losses are also manifested by aborted conelets or cones, low seed yields, high numbers of empty seeds, poor seed viability, or mold in germination tests. *Leptoglossus corculus* is often the most important insect pest encountered in seed orchards when all these loss categories are considered.

The technique of radiographing mature seeds measures only one type of damage caused by *L. corculus*. Several types of damage are detected by cone analysis (Bramlett 1974, Bramlett *et al.* 1977). The total impact of *L. corculus* in orchards can best be estimated by comparing the quality and quantity of yields from cones protected by small screen-wire cages with those from unprotected cones on individual ramets (Bramlett and Moyer 1973; Bramlett, Lewis and DeBarr 1977; DeBarr 1974a; DeBarr and Ebel 1973, 1974).

Yields from clusters of *P. taeda* cones protected with cages in 15 orchards of the North Carolina State University Cooperative Tree Improvement Program (DeBarr 1974a) and *P. elliottii* Engelm. var. *elliottii* cones in seven orchards of the University of Florida Cooperative Tree Improvement Program (DeBarr *et al.* 1975b) were greatly increased, often doubled. Protected cones in a *P. echinata* orchard yielded 10 times the number of sound seeds produced by unprotected cones on the same trees (DeBarr and Ebel 1973). These yields demonstrated the potential for increased seed production with insecticidal control of seedbugs and importance of preventing seed destruction by *L. corculus* early in the growing season.

CHEMICAL CONTROL

Laboratory Screening of Insecticides

In 1974 we began laboratory tests to determine the relative toxicities of 34 insecticides to *L. corculus*. In addition to aiding us in selecting insecticides for field evaluation, these tests will provide a standard for detecting changes in tolerance (insect resistance) of *L. corculus* populations to chemicals applied in production orchards.

Second-stage nymphs were highly susceptible to most of the insecticides tested (DeBarr and Nord 1978). Twenty-six chemicals had LD_{50} (lethal dose for 50% mortality) values of less than 5 μg/g of body weight. Nine insecticides--aldicarb, aminocarb, azinphosmethyl, carbofuran, dicrotophos, FMC 45498, monocrotphos, propoxur, and SD 43775--had LD_{90} values of less than 1 μg/g of body weight.[1]

Twelve of the insecticides were also moderately to highly toxic to adult females of this seedbug (Nord and DeBarr, unpublished). Five insecticides--FMC 45498, carbofuran, SD 43775, aminocarb, and bioethanomethrin--were more toxic than the standard, azinphosmethyl. FMC 45498 was 29 times more toxic than azinphosmethyl. Five insecticides were tested on both males and females, and three were significantly more toxic to the females.

Other laboratory bioassays established LC_{90}'s (lethal concentrations for 90% mortality of *L. corculus* adults) for commercial formulations of insecticides applied to *P. taeda* foliage and evaluated the persistence of these foliar residues when subjected to simulated rain and aging (Nord, unpublished). Seven insecticides--azinphosmethyl, FMC 45498, malathion, permethrin, phosmet, propoxur, and SD 43775--had LC_{90}'s lower than 0.5% active ingredient. Phosmet and most of the pyrethroids were similar to azinphosmethyl in toxicity. FMC 45498 was 7.5 times as toxic as azinphosmethyl. The residues of propoxur and malathion were moderately toxic when compared to azinphosmethyl.

Permethrin, FMC 45498, SD 43775, bioethanomethrin, and malathion could be used in low-volume ground or aerial applications to reduce feeding by spring populations of *L. corculus* and thus prevent ovule and conelet abortion. Other insecticides (including azinphosmethyl, propoxur, fenthion, phosmet, and chlorpyrifos), applied primarily to control cone insects such as *Dioryctria* spp. or *Eucosma* spp., may also provide some control of seedbugs by residual contact as well as by direct contact with spray droplets. The systemic properties of aldicarb, carbofuran, dimethoate, dicrotophos, and monocrotophos make these insecticides particularly appealing for use in seed orchards. Carbofuran (formulated as 10G), propoxur, methomyl, permethrin, SD 43775, malathion, resmethrin, phosmet, and chlorpyrifos also offer the advantage of relatively low hazard of dermal exposure.

Field Tests

Results of our laboratory screening of insecticides for control of *L. corculus* agree closely with results of field tests. Several insecticides applied in field tests for control of the coneworms, *Dioryctria* spp. (Lepidoptera: Phycitidae), have also reduced losses caused by seedbugs. Of five insecticides previously evaluated in the field, the three best--azinphosmethyl, dicrotophos, and carbofuran--were also highly toxic to *L. corculus* in our topical tests.

---

[1]This paper reports research involving insecticides. It does not report recommendations for their use nor does it imply that any uses described here have been registered. All uses of insecticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

Azinphosmethyl controlled seedbugs on *P. elliottii* (Merkel *et al.* 1976), *P. taeda*, and *P. echinata* (DeBarr, unpublished). Trunk implantations of dicrotophos also reduced seedbug damage to *P. elliottii* seeds (Merkel and DeBarr 1971) and conelet abortion on *P. palustris* (DeBarr 1974a).

Carbofuran (Furadan® 10G), at rates of 4 to 32 oz. per inch of tree diameter (0.05 to 0.35 kg per cm), was tested on five species of pines growing in 30 seed orchards scattered throughout the Southern United States. No phytotoxic or human safety problems were observed, and control of seedbugs was excellent (DeBarr 1977, 1978). Individual ramets protected with carbofuran produced a higher number and percentage of filled seed/cone than control trees. One application of carbofuran in February often doubled the yield of filled seed per cone, even when the insecticide was applied only during the second year of the two-year development period.

Seedbug control was as good when all the carbofuran was applied at one time as when the material was divided among two or three application dates. Rates of more than 4 oz. (0.05 kg) generally increased the number of filled seed per cone but the increments were too small to be declared statistically significant. A single application of carbofuran enhanced seed yields the following year, apparently by reducing ovule abortion in protected conelets, but there was little or no direct control of seedbugs during the second year. Two successive annual applications of carbofuran increased cone crops, provided the highest filled seed yields, and reduced the variation associated with seed quality and yield per cone. There were no significant differences among band, drill, or broadcast application methods. In August 1976, the U. S. Environmental Protection Agency registered carbofuran for control of seedbugs in southern pine seed orchards.

Two insecticides which were poor in field tests, phorate and stirophos, were also relatively nontoxic to the *L. corculus* in laboratory tests. Seedbug control with soil applications of phorate was erratic (DeBarr *et al.* 1972, DeBarr 1978), and mist blower applications of stirophos[2] were ineffective.

TOWARD INTEGRATED CONTROL OF SEEDBUGS

An integrated approach to seedbug control in an Insect Pest Management (IPM) system for seed orchards will utilize the best alternatives available to achieve control with the least ecological disturbance. Insecticides will be used more effectively and in concert with natural controls.

---

[2]DeBarr, G. L. 1976. Analysis of data from the 1973 North Carolina Cooperative Gardona®-Thimet® Study. Unpublished Final Report FS-SE-2201-29(1), 10 pp. On file at Southeast. For. Exp. Stn., Athens, Ga.

Insecticides

Currently, insecticides are applied in seed orchards to protect the seed crop from anticipated attacks. Damage is monitored in operational orchards using Seed Orchard Survey evaluation tests or cone analysis. A decision to apply insecticides is based upon losses which occurred the previous year. Systemic insecticides, which take several weeks to reach lethal concentrations in the tree, are ideally suited to this preventative approach, but lend little flexibility to a pest management system.

Some limited steps can be taken to increase the effectiveness as well as minimize the costs and environmental problems associated with the two insecticides currently effective in controlling seedbugs in seed orchards. Spray coverage with azinphosmethyl can often be improved by simple equipment adjustments.[3] The inherent differences in susceptibility to seedbug damage among clones, apparent in almost all of our studies, can also be used to immediate advantage in an IPM system (DeBarr 1971). The most productive and most susceptible clones can be identified and azinphosmethyl or carbofuran can be applied only to these trees. Then, only 10 to 20 percent of the trees in many orchards would need to be treated in order to protect 80 to 90 percent of the seed crop. But, as long as we continue to apply insecticides solely on a preventative basis, little real progress will be made toward integrated control.

In an integrated pest management system, seedbug populations may be suppressed to low levels with sprays timed to control bugs only when populations reach an economic threshold. Using insecticides on other than a preventative basis will obviously require considerably greater understanding and sophistication. For example, unlike most agricultural pests, indigenous populations of seedbugs often exist in the natural forest stands and plantations surrounding seed orchards, and buffer strips around an orchard to prevent reinfestations would probably not be effective for any extended period of time. Thus, the problem of reinfestation, which is not serious when lethal residues are maintained on or in the trees, may become critical. Insecticides will undoubtedly remain important components of an integrated control program. However, because of their adverse effects on the environment, their use will probably be curtailed.

Natural Controls

Natural controls of the seedbugs have not been studied in detail, but I have observed a number of predators and parasites of the seedbugs. Several predaceous bugs, including the wheel bug, *Arilus cristatus* (Linnaeus) (Hemiptera: Reduviidae), prey upon seedbug nymphs. A tachinid fly, *Trichopoda pennipes* Fabr. (Diptera: Tachinidae), has also been found, on rare occasions, parasitizing *L. corculus* adults. In addition, several species of Hymenoptera, including a recently described species, *Ooencyrtus leptoglossi* Yoshimoto (Hymenoptera: Chalcidoidea, Encyrtidae) (Yoshimoto 1977), parasitize the eggs of seedbugs.

---

[3]Barber, L. R. 1976. Evaluation of spray coverage on the Beech Creek Seed Orchard, Tusquitee Ranger District, Nantahala National Forest. Report No. 76-1-26, State and Private Forestry, 6 p.

In an IPM system, the effectiveness of these parasites could be enhanced by using more selective insecticides, by modifying the orchard environment or management practices to favor these beneficial insects, by planting strips of agricultural crops which would serve as an insectary for populations of alternate host insects, or by the direct introduction of reared parasites.

Since several of these egg parasites appear to be very efficient in locating and destroying their hosts, they may offer real potential as biological control agents in an integrated control approach.

Sampling Seedbug Populations

Previous research has dealt with aspects of seedbug biology, damage, or chemical controls. Clearly, the development of an efficient and accurate population sampling technique is of crucial importance for progress toward an IPM system. Such a technique is essential for precisely timing chemical applications when populations reach economic thresholds or for evaluating control alternatives.

Sampling seedbug populations will be difficult. Our knowledge of the spatial distributions of seedbugs within orchards or within trees is rudimentary, but field observations show that on any given day the number of insects per tree is quite small (Chatelain 1976, Ebel 1977). Sampling individual branches is an unlikely approach, and simply observing and counting insects is too time consuming to be practical in seed orchards. Complications also arise because it will be difficult to obtain representative samples from trees averaging 10 to 20 meters in height. Within individual trees, seedbugs are often clumped; groups of nymphs feed on individual conelets or cone clusters. The distribution of adults appears to be more random. At harvest, seed damage varies significantly among individual cone clusters, but not among segments of the crown (upper and lower crown or quadrants) (DeBarr *et al.* 1975a).

We plan to evaluate two approaches to the sampling of seedbug populations. In the first, "whole tree" sampling, a quick knockdown pyrethroid insecticide would be applied, and the dead seedbugs would be tallied. This technique, in conjunction with a sequential sampling method, may offer some promise. For extremely low or high populations of seedbugs, only a few trees would be sampled before deciding if controls were necessary. At population levels close to some still-to-be defined economic threshold, more trees would be sampled to make the decision.

The second approach is attraction and trapping. Unlike most of the insect species important in seed orchards, seedbugs are not attracted to black light (Yates 1973). However, Aldrich *et al.* (1976) proposed that chemicals found in the males of a related species, *Leptoglossus phyllopus* (L.), may function as a long-range attractant of females. Research is underway to determine if such an attractant exists for *L. corculus*. Natural or synthetic attractants for the detection and surveillance of seedbug populations offer the obvious advantage of selectivity.

Perhaps the most difficult problem associated with whole tree-sampling, trap catches, or any other sampling scheme will be relating insect numbers to meaningful damage thresholds. The problem is complex because two insect species are involved, and the impact of each species upon seed production not only varies with insect numbers and stage, but also the phenological development of the pines.

During the past 10 years, we have progressed in our understanding of the importance of seedbugs and have developed practical chemical controls which have greatly increased the yields of genetically superior pine seeds. But much research lies between us and a truly integrated Insect Pest Management system for seedbug control in southern pine seed orchards.

LITERATURE CITED

Aldrich, J. R., M. S. Blum, S. S. Duffey and H. M. Fales. 1976. Male specific nature products in the bug, *Leptoglossus phyllopus*: chemistry and possible function. Insect Physiol. 22: 1201-1206.

Belcher, E. W. and G. L. DeBarr. 1975. Seed Orchard Survey (SOS): final report and sumamry of highlights. Proc. Thirteenth Southern Forest Tree Improvement Conference, pp. 145-152.

Bramlett, D. L. 1974a. Seasonal development and loss of Virginia pine ovules and seed. Seed Sci. and Tech. 2: 285-292.

____________ 1974b. Seed potential and seed efficiency, pp. 1-7. *In* John Kraus (ed.), Seed yield from southern pine seed orchards colloquium proceedings. Georgia Forest Research Council, Macon, Georgia.

____________, W. G. Lewis and G. L. DeBarr. 1977. Screen cages to protect control-pollinated pine cones from seedbugs. USDA Forest Service Tree Planters' Notes. 28(2): 25-29.

____________ and E. L. Moyer, Jr. 1973. Seed losses reduced in Virginia pine cones by screen wire cages. USDA Forest Service Research Note SE-192, 4 pp. Southeastern Forest Experiment Station, Asheville, North Carolina.

____________, E. W. Belcher, Jr., G. L. DeBarr and others. 1977. Cone analysis of southern pines: a guidebook. USDA Forest Service General Technical Report SE-13, 28 pp. Southeastern Forest Experiment Station, Asheville, North Carolina, and Southeastern Area, State and Private Forestry, Atlanta, Georgia.

Chatelain, M. P. 1976. Insects destructive to cones and seeds of loblolly pine *(Pinus taeda L.)* in Louisiana seed orchards. Master's Thesis, Louisiana State University, Baton Rouge. 54 pp.

DeBarr, G. L. 1967. Two new sucking insect pests of seed in southern pine seed orchards. USDA Forest Service Research Note SE-78, 3 pp. Southeastern Forest Experiment Station, Asheville, North Carolina.

__________ 1970. Characteristics and radiographic detection of seedbug damage to slash pine seed. Flor. Entomol. 53: 109-117.

__________ 1971. The value of insect control in seed orchards: some economic and biological considerations. Proc. Eleventh Southern Forest Tree Improvement Conference, pp. 178-185.

__________ 1974a. Conelet abortion, ovule abortion, and seed damage by *Leptoglossus corculus* (Say) in southern pine seed orchards. Ph.D. Dissertation, Department of Entomology, University of Georgia, Athens. 189 pp.

__________ 1974b. Quantifying the impact of seedbugs, pp. 34-41. *In* John Kraus (ed.), Seed yield from southern pine seed orchards colloquiem proceedings. Georgia Forest Research Council, Macon, Georgia.

__________ 1977. Registration and use of carbofuran (Furadan®) in southern pine orchards. Proc. 1976 Southeastern Area Forest Tree Nurserymen's Conferences, pp. 123-125.

__________ 1978. Southwide tests of carbofuran for seedbug control in pine seed orchards. USDA Forest Service Research Paper (In Press). Southeastern Forest Experiment Station, Asheville, North Carolina.

__________ and L. R. Barber. 1975. Mortality factors reducing the 1967-1969 slash pine seed crop in Baker County, Florida--a life table approach. USDA Forest Service Research Paper, SE-131, 16 pp. Southeastern Forest Experiment Station, Asheville, North Carolina.

__________, L. R. Barber, and R. C. Wilkinson. 1975a. Within-crown distribution of cone and seed insect damage to slash pine flowers, conelets, and cones. Flor. Entomol. 58: 281-288.

__________, D. L. Bramlett, and A. E. Squillace. 1975b. Impact of seed insects on control-pollinated slash pine cones. Proc. Thirteenth Southern Forest Tree Improvement Conference, pp. 177-181.

__________ and B. H. Ebel. 1973. How seedbugs reduce the quantity and quality of pine seed yields. Proc. Twelfth Southern Forest Tree Improvement Conference, pp. 97-103.

__________ and B. H. Ebel. 1974. Conelet abortion and seed damage of shortleaf and loblolly pines by a seedbug, *Leptoglossus corculus*. For. Sci. 20: 165-170.

__________ and P. P. Kormanik. 1975. Anatomical basis for conelet abortion following feeding by *Leptoglossus corculus* (Say) (Hemiptera: Coreidae). Can. Entomol. 107: 81-86.

__________, E. P. Merkel, C. H. O'Gwynn, and M. H. Zoerb, Jr. 1972. Differences in insect infestation in slash pine seed orchards due to phorate treatment and clonal variation. For. Sci. 18: 56-64.

__________ and J. C. Nord. 1978. Contact toxicity of 34 insecticides to second-stage numphs of *Leptoglossus corculus*. Can. Entomol. (In Press).

Ebel, B. H. 1977. *Leptoglossus corculus* (Say)--A study of its biology, life stages, and laboratory colonization. Ph.D. Dissertation, Department of Entomology, University of Georgia, Athens. 101 pp.

__________, T. H. Flavell, L. E. Drake, H. O. Yates III, and G. L. DeBarr. 1975. Seed and cone insects of southern pines. USDA Forest Service General Technical Report SE-8, 40 pp. Southeastern Forest Experiment Station, Asheville, North Carolina, and Southeastern Area, State and Private Forestry, Atlanta, Georgia.

__________ and H. O. Yates III. 1974. Insect-caused damage and mortality to conelets, cones, and seed of shortleaf pine. Entomol. 67: 222-226.

Gilbert, B. L., S. H. Barras, and D. M. Norris. 1967. Bionomics of *Tetyra bipunctata* (Hemiptera: Pentatomidae: Scutellerinae) as associated with Pinus banksiana in Wisconsin. Ann. Entomol. Soc. Amer. 60:698-701.

Goyer, R. A. and L. H. Nachod. 1976. Loblolly pine conelet, cone, and seed losses to insects and other factors in a Louisiana seed orchard. For. Sci. 22: 386-391.

Merkel, E. P. and G. L. DeBarr. 1971. Trunk implantations of discrotophos for cone insect control in slash pine production stands. J. Econ. Entomol. 64: 1295-1298.

__________ G. L. DeBarr, and C. H. O'Gwynn. 1976. Mist blower application of Guthion® for cone insect control in slash pine seed orchards. USDA Forest Service Research Paper SE-148, 8 pp. Southeastern Forest Experiment Station, Asheville, North Carolina.

Rowan, S. J. and G. L. DeBarr. 1974. Moldy seed and poor germination linked to seedbug damage in slash pine. USDA Forest Service Tree Planters' Notes, 25(1): 25-27.

White, T. L., H. G. Harris, Jr., and R. C. Kellison. 1977. Conelet abortion in longleaf pine. J. Can. For. Res. 7: 378-382.

Yates, H. O., III. 1973. Attraction of cone and seed insects to six fluorescent light sources. USDA Forest Service Research Note SE-184, 8 pp. Southeastern Forest Experiment Station, Asheville, North Carolina.

______________ and G. H. Ebel. 1978. Impact of insect damage on loblolly pine seed production. J. Econ. Entomol. 71: 345-349.

Yoshimoto, C. M. 1977. A new species *Ooencyrtus leptoglossi* (Hymenoptera: Chalcidoidea, Encyrtidae) reared from eggs of *Leptoglossus corculus* (Hemiptera: Coreidae). Can. Entomol. 109: 1009-1012.