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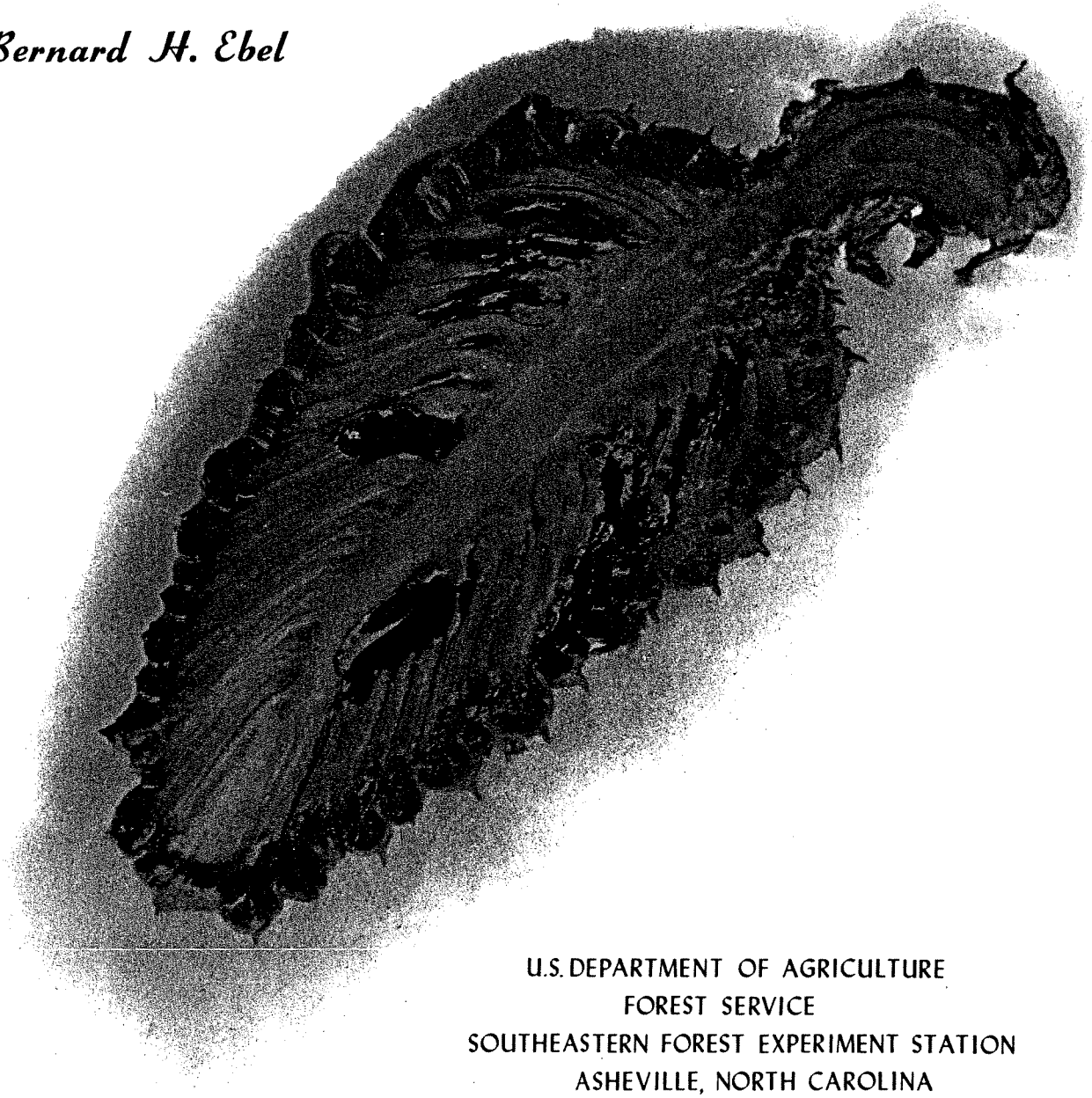
INSECTS AFFECTING SEED PRODUCTION OF SLASH AND LONGLEAF PINES

Their Identification and Biological Annotation

by

Bernard H. Ebel



U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
SOUTHEASTERN FOREST EXPERIMENT STATION
ASHEVILLE, NORTH CAROLINA

COVER PHOTO:
Second-year slash pine cone with multiple insect injury. Maggots, Itonididae, infested the cone base, while a coneworm, Dioryctria amatella, made the larger galleries in the midcone area.

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INTRODUCTION

Tree planting rates in the South have rocketed over the past three decades, and the area now leads the nation in plantation establishment. During 1960 over a half-million acres were planted in the states of Georgia and Florida alone. Such extensive planting, mainly of pines, has brought in its train a need for more seed and better seed. Each year the demand intensifies for seed from trees of known geographical origin with proven or inheritable desirable traits such as superior growth rates, superior form, disease resistance, or gum-producing capability. This demand in turn has led government and industry to establish extensive seed production areas and seed orchards composed of selected trees. Seed losses to date have been very heavy, and it is plain that natural losses of developing cones must be reduced if we are to harvest quantity seed yields from such trees. Most damage is done by insects.

For these reasons, a three-phase research program was started during 1956 in northern Florida to study insect damage to flowers, cones, and seed of slash pine (Pinus elliottii Engelm.) and longleaf pine (Pinus palustris Mill.). The first phase has been the identification of the insects and of their injury; the second is to study their biology; and the third is developing means for their control. The present paper is a summary of the first, or identification, phase, with biological annotation.

A review of published information showed that little was known about insects attacking slash, longleaf, or other southern pines. Wakeley (1931) had reported instances of insect-caused losses to longleaf pine flowers and cones, and also specific damage by a coneworm, Dioryctria amatella (Hulst), to the cones. Wahlenberg (1946) had also stated that in several southern states this coneworm destroyed flowers and cones of longleaf pine, and that another coneworm, D. abietella (D. & S.), destroyed cones and shoots. Knight (1952) reported damage to loblolly pine (Pinus taeda L.) cones by D. amatella and seed destruction by a seedworm, Laspeyresia toreuta Grote.

THE PRESENT STUDY

During 1957 and early 1958 many collections of obviously attacked flowers and cones were made. These were examined to determine the cause of the injury. Immature insects found were, where possible, reared. Guided by the information from these preliminary rearings, researchers started systematic collections of both slash and longleaf pine material in April 1958. The collections included flowers, cones, and also other pine material which might serve as an alternate habitat for insects that reduce the seed crop of the two pines. For a 1-year period collections were usually made at 2-week intervals, and then at monthly intervals during a second year. In March 1959, cankers of fusiform rust, Cronartium fusiforme (Pk.) Hedgc. & Hunt, on slash pine were included among the items collected. These cankers were collected bimonthly for 1 year and monthly thereafter. All collections, except of fusiform cankers, were stopped in May 1960. The canker collections are being continued to follow the biology of Dioryctria spp. coneworms in this habitat. Table 1 shows the number of collections made of various sorts of host material and the total number of each kind collected.

Table 1.--Slash and longleaf pine material collected for information about cone and seed insects, north Florida, 1958-60

Material collected	Slash pine		Longleaf pine	
	Items	Collections	Items	Collections
	Number			
First-year cones	--	38	--	38
Clusters	806	--	760	--
Individual cones	2,971	--	2,668	--
Second-year cones	2,536	26	2,460	28
Female flower clusters	783	11	466	6
Male flower clusters	813	12	665	10
Rust-infected first-year cones 1/	569	16	17	3
Vegetative buds, shoots	3,340	35	3,095	36
Fusiform cankers (through March 1962)	453	30	0	0

1/ Infected by Cronartium strobilinum (Arth.) Hedgc. and Hahn.

The number of each item included in a collection varied with its availability in the collection area. From 25 to 100 samples of an item were obtained if reasonably available, except for fusiform rust cankers. From 10 to 20 fusiform rust cankers comprised a collection of this type of material. Workers collected all other items either from live or freshly felled trees. Such trees were sufficiently mature to be producing regular flower and cone crops. Fusiform cankers were collected from the stems or branches, usually of saplings, adjacent to or intermingled with more mature, cone-bearing trees.

Cut ends of the collected material were waxed to retard desiccation. The material was then stored in the insectary in various containers. After about 1 week, it was examined for evidence of insect infestation such as frass, obvious external injury, and the presence of insects. Delaying this first examination allowed external signs of insect attack to become more apparent, enhancing the chances of observing small immature forms. Infested material was handled in several ways. Adult insects were associated with damage caused, if any, and then pinned or preserved. Where immature forms were found, some were preserved and others kept in rearing. Immature insects attacking individually or in small numbers were usually isolated for rearing. In cases of general infestation of a particular material, e.g., Dioryctria spp. in rust-infected cones, only a part of the larvae were placed in isolated rearing, the remainder being mass-reared from the host material. In instances where dissection of host material was apt to injure the immature forms present, some infested items were isolated intact. Fusiform rust cankers were not dissected. They were checked frequently for adult insect emergence, and waxed cones or buds added as food material for larvae as the cankers dried out. Some of the larvae entering these added food cones were preserved, some were isolated for rearing, and others mass-reared in the containers of cankers.

A second detailed examination was made of the collected material, except cankers, about one month after the first examination. Again infested material was removed and immature insects found were preserved or placed in rearing. In addition, at least part of the apparently uninfested material was cut open to check for strictly internal insects. Where such forms were present, the type of material infested was retained in rearing if there was any possibility of obtaining adults. Otherwise, these insects were looked for in later collections and reared out when they became sufficiently mature.

During the period of storage in the insectary, the containers of collected material were also frequently checked for the emergence of adult insects between scheduled examinations.

Series of adult insects found or reared were submitted to the United States National Museum for identification. 1/

1/ Appreciation is expressed to Dr. W. H. Anderson, of the Agricultural Research Service, and to the National Museum staff for identification of the various insects submitted. In addition, thanks are due to Dr. D. J. Burdick, Fresno State College, for specific identifications of Xyela spp. sawflies.

RESULTS

The rearings made in this study have yielded information on a number of insects present in the collected material. Some were found to be primary, a few primary in one material and secondary in others, and others strictly secondary. The present paper summarizes the results of the rearings as follows:

A. Habitat list of the insects found in the collected slash and longleaf pine host material.

B. Annotated list of the insects found in slash and longleaf pine material.

C. Key to common insect damage to flowers and cones of slash and longleaf pines.

A. Habitat List of Insects Found in Collected Slash and Longleaf Pine Host Material

Numbers in parentheses refer to the annotated list of insect species, Part B of this paper. Insects seldom occurring on a material are omitted or indicated as rare.

Female flower clusters:

Primary insects: Dioryctria amatella (11b), Dioryctria clarioralis (11c), Gnophothrips piniphilus (20) (slash pine only), Nepytia semiclusaria (15) (slash pine only), Rhyacionia subtropica (17) (rare, slash pine only).

Secondary insects: Holcocera lepidophaga (12).

Male flower clusters:

Primary insects: Dioryctria abietella (11a) (rare), Dioryctria amatella (11b), Dioryctria clarioralis (11c), Frankliniella spp. (19), Holcocera lepidophaga (12), Itonididae (5), Lepidopsallus australis (6), Lytta n. sp. (2), Satronia tantilla (18), Xyela spp. (9).

First-year cones:

Primary insects: Dioryctria abietella (11a), Dioryctria amatella (11b), Dioryctria clarioralis (11c), Itonididae (5), Toumeyella spp. (7).

Secondary insects: Battaristis vittella (10), Ernobius granulatus (1), Holcocera lepidophaga (12), Moodna ostrinella (14), Pityophthorus pulicarius (3).

Second-year cones:

Primary insects: Dioryctria abietella (11a), Dioryctria amatella (11b), Dioryctria clarioralis (11c), Itonididae (5), Laspeyresia spp. (13), Toumeyella spp. (7).

Secondary insects: Battaristis vittella (10), Ernobius granulatus (1), Holcocera lepidophaga (12), Pityophthorus pulicarius (3).

First-year cones infected by Cronartium strobilinum:

Primary insects (developing in live succulent diseased cones): Dioryctria abietella (11a), Dioryctria amatella (11b), Dioryctria clarioralis (11c), Itonididae (5), Moodna ostrinella (14), Satronia tantilla (18).

Secondary insects: Pyroderces rileyi (16).

Vegetative buds, shoots:

Primary insects: Dioryctria abietella (11a) (rare), Dioryctria amatella (11b), Dioryctria clarioralis (11c), Rhyacionia subtropica (17) (rare, slash pine only).

Secondary insects: Ernobius granulatus (1), Holcocera lepidophaga (12), Pityophthorus pulicarius (3).

Fusiform rust cankers:[2/]

Dioryctria abietella (11a), Dioryctria amatella (11b), Dioryctria clarioralis (11c) (rare), Moodna ostrinella (14), Satronia tantilla (18) (rare).

B. Annotated List of Insects Found in Slash and Longleaf Pine Material [3/]

COLEOPTERA

1. Ernobius granulatus LeConte--Anobiidae

Larvae of this beetle infested various dead, dry material, including first- and second-year cones and shoots. They were most frequently observed in aborted first-year longleaf pine cones. The cone abortion was apparently caused by some undetermined factor such as insufficient pollination or inadequate nutrient supply; Ernobius infestation occurred only after the cones had died and dried out.

2. Lytta n. sp.--Meloidae

A single instance of this large blister-beetle feeding on slash pine male flowers was observed. The flowers were stripped to their axes. Other meloids could be expected to feed on slash and longleaf pine flowers, for example, Pomphopoea polita (Say), which Allen and Coyne (1956) reported as destroying the male flowers of a shortleaf pine, Pinus echinata Mill., in Mississippi.

2/ Fusiform rust cankers were collected to determine which flower and cone insects, particularly Dioryctria spp., occurred in this habitat. Only such insects are listed here.

3/ Foliage-feeding and incidental insects are not considered in this listing.

3. Pityophthorus pulicarius (Zimm.)--Scolytidae

Adults of these small scolytids were often found boring into shoots or cones. Such attacks were apparently secondary, made either on material collected from felled trees or even by beetles attracted to material stored in coarsely screened cages. Instances of field infestation of shoots previously damaged by Dioryctria spp. coneworms were observed. Cone attacks on a lightning-struck tree also were noted. As compared to those of Ernobius, the Pityophthorus attacks were limited to dying rather than dry, dead host material.

4. Miscellaneous Coleoptera--

Surface feeding injury to buds, shoots, and cone stalks was sometimes noted. This was attributable to adults of Buprestidae, Cerambycidae, and Curculionidae. A cerambycid, Eupogonius tomentosus (Hald); a buprestid, Chalcophora sp., and a weevil, Pachylobius picivorus (Germ.), were seen on shoots or buds. Also several miscellaneous pollen-feeding Coleoptera, including curculionids and nitidulids, were seen among maturing male flowers.

DIPTERA

5. Cone midges--Itonididae[4/] (Cecidomyiidae)

Larvae of this group of flies were found as both primary and secondary inhabitants of first- and second-year cones. Several species, as yet unidentified, were reared.

One species, or group of species, caused injury to first- and second-year cones, including rust-infected cones. The yellow to orange-colored larvae fed within the cones on the inner surfaces of cone scales and on succulent seed causing typical cavities within the attacked cones (fig. 1). These cones or affected cone parts died. However, the incidence of such cones in the collections was low. They most often occurred in the spring or early summer or were associated with Dioryctria spp. coneworm injury.

Another species occurred in maturing male flowers where the larvae fed on the pollen.

Two other species were decidedly secondary in their occurrence. One of these was common between the cone scales of opening second-year cones. The other occurred in resin exuded on the cone surface. It was more frequent on the resinous cones of longleaf pine.

HEMIPTERA

6. Lepidopsallus australis Blatchley--Miridae

Developing nymphs and later adults of this bug were regularly found among the male flower buds of slash pine. Here they apparently fed into buds or bud stems, but no obvious injury was seen. Possibly this lack of injury can be attributed to the relatively few bugs which were ordinarily present in any one infested flower cluster.

4/ Reared adults of this group are being studied by Dr. R. H. Foote, of the U. S. National Museum.

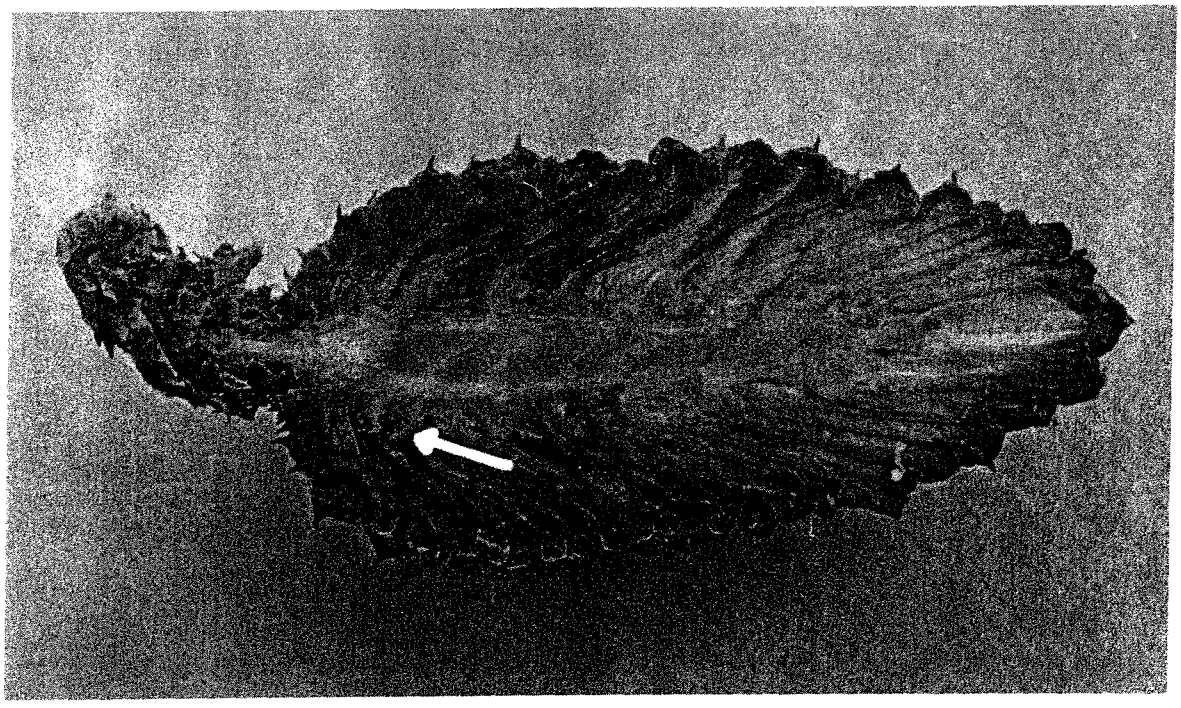


Figure 1. --Itonididae. Cavities between the scales of this second-year slash pine cone were caused by groups of these small fly larvae. Arrow indicates a single larva.

HOMOPTERA

7. Toumeyella spp.--Coccidae

These tortoise-shell scales infested the stalks of first-year and early second-year cones. Longleaf pine cones were more frequently infested than those of slash pine, but the scales were not abundant on either pine host. Several predators and parasites apparently limited the numbers of scales reaching maturity. No distinct injury to the infested cones was seen.

On a basis of the presence of the crawler stage under matured females, we would judge that each year at least two generations of these scales occurred. The first generation was present on first-year cone stalks in the spring and summer; reinfestation occurred on similar cones in the fall, and this generation of scales overwintered.

Two species were found in the collections. One, identified as Toumeyella near corrugatum neglectum (Pettit and McDaniel), was on both pine hosts. The other, identified only as another distinct Toumeyella sp., was on slash pine.

8. Miscellaneous scale insects--Coccidae

Several other coccids were infrequently found on cones or cone stalks. These included: Aspidiotus sp. near bumeliae Ferris but distinct; Chrysomphalus (Acutaspis) perseae (Comst.); Matsucoccus sp., possibly alabamae Morr.; Pseudococcus acutis Lobdell, and P. nr. aciculus Ferris, and Pseudophilippia quaintancii (Ckll.).

Figure 2. --Xyela spp. sawfly larvae leaving a maturing male flower of slash pine.

HYMENOPTERA

9. Xyela spp.--Xyelidae

The larvae of these sawflies were often abundant in the male flower buds, especially of longleaf pine. These small, white, grub-like larvae fed on the developing pollen within the buds. Some infested buds were flecked with small, white spots of dried resin and often obviously distorted; others appeared quite normal externally. As infested flowers matured and the scales opened up and released the pollen, the larvae wriggled out (fig. 2). They have, therefore, often been noticed in pollen extracted for breeding work.

Three species were reared. Of these, two, Xyela bakeri Konow and X. minor Norton, occurred in both slash and longleaf pine. The third, X. pini Rohwer, was reared from slash pine only.

LEPIDOPTERA

10. Battaristis vittella (Busck)--Gelechiidae

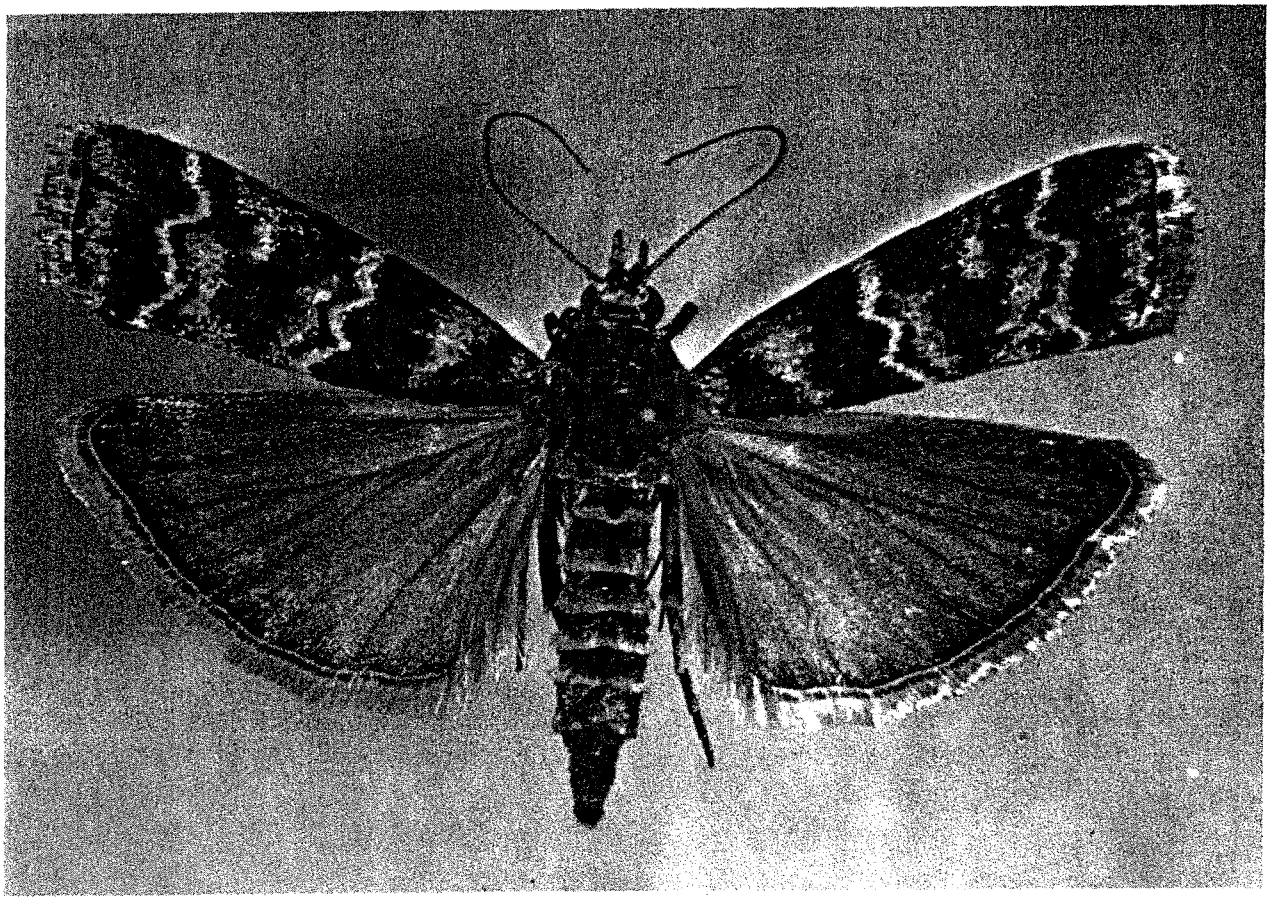
Specimens of this small moth and of a possible new species were reared from translucent greyish-white larvae found in dead cones and in a fusiform rust canker. Larval galleries were lined with silk.

In a single instance a larva was reared from an egg found on an overwintering live slash pine cone. However, in no case were larvae collected within live cones.

11. Dioryctria spp.--Phycitidae

These coneworms were generally the most injurious insects attacking cones of slash and longleaf pines. Commonly the larvae were found in flowers and cones and also in most other host material collected. These relatively large larvae (5/8 inch to 1 inch long) tunnelled extensively in the host material, usually extruding frass and often resin to the surface of the infested material. Several generations of each of the three species found in the collections developed annually. Figures 3, 4, and 5 show the adults of these coneworms. These species were as follows:

Figure 3. --Dioryctria amatella, adult of a common coneworm.



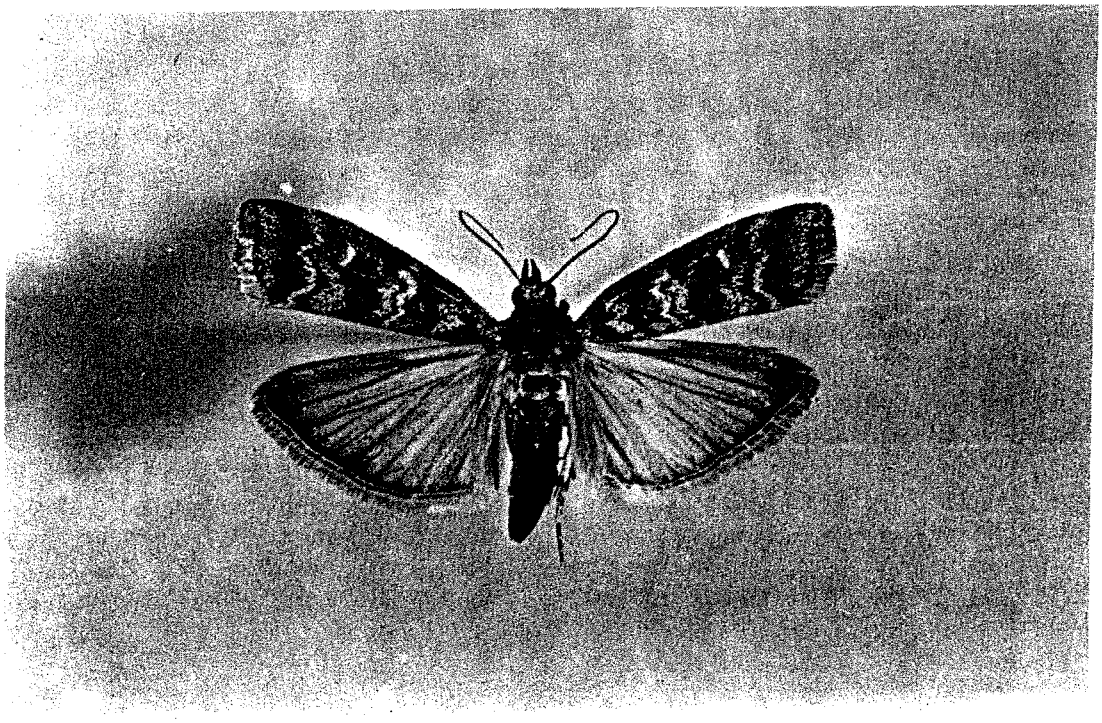


Figure 4. --Dioryctria abietella, adult of another common coneworm.

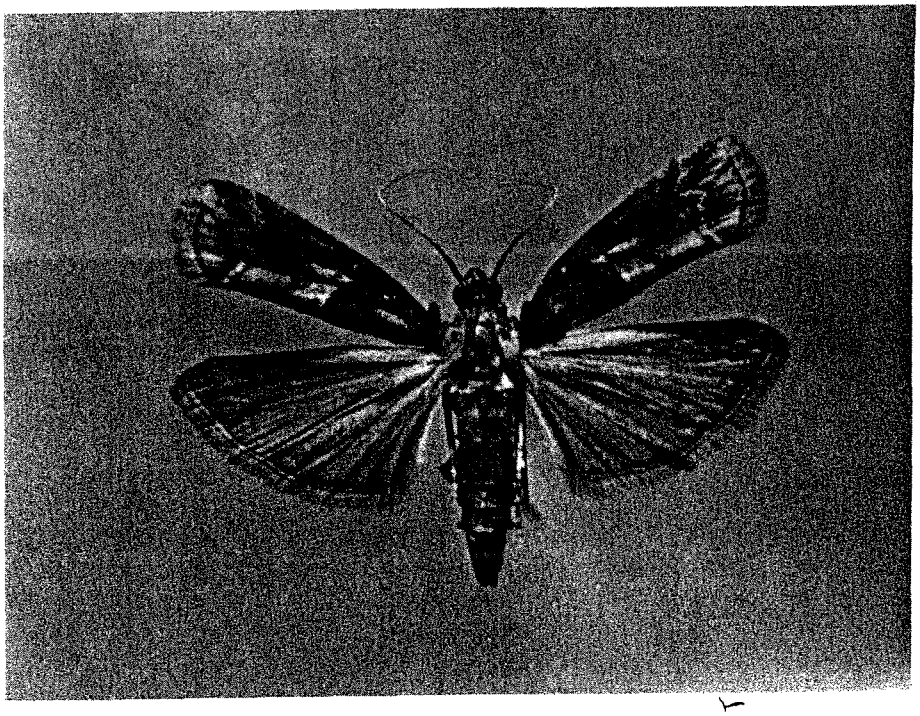


Figure 5. --Dioryctria clarioralis, adult of a less frequently found coneworm.

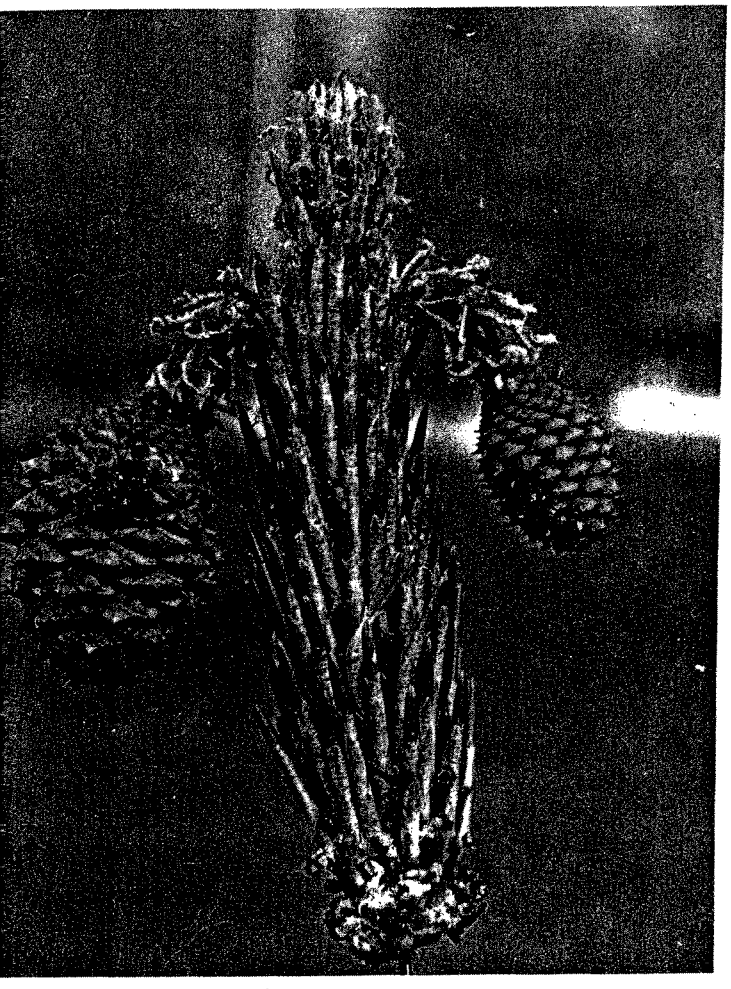


Figure 6. --Dioryctria abietella. Larval frass on the surface of a rust-infected cone (left). Right-hand cone is a normal first-year cone.

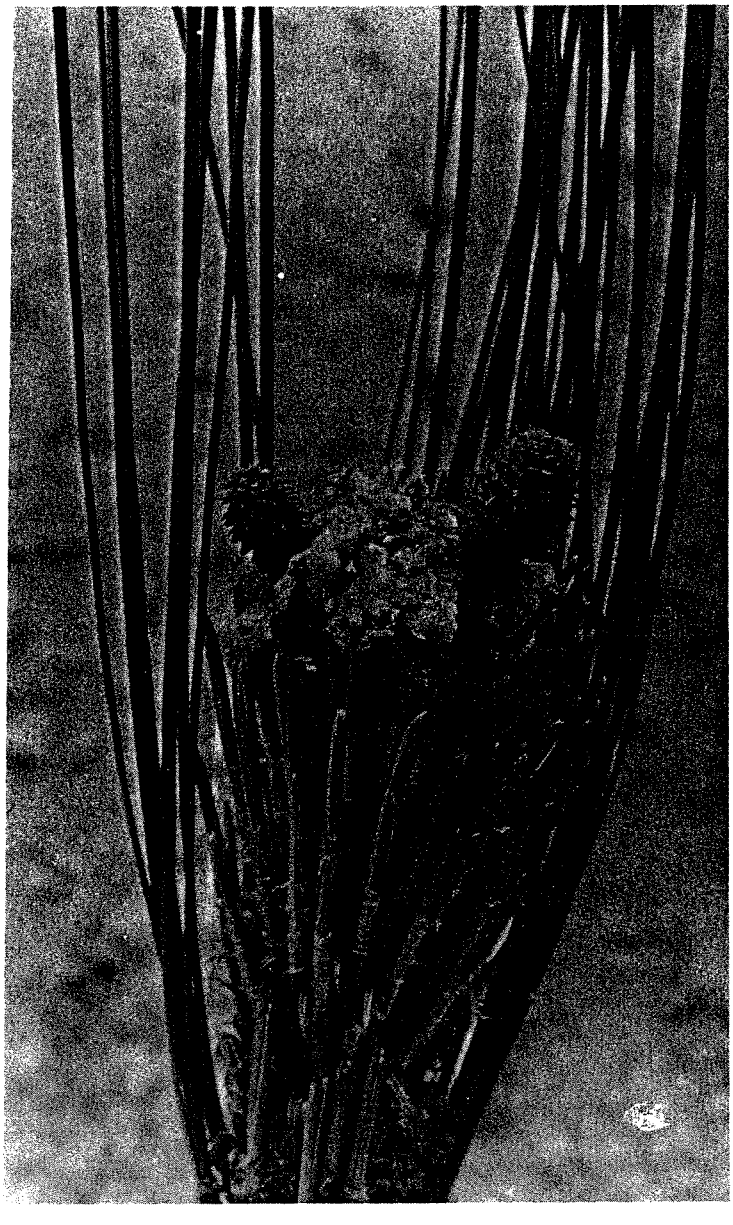


Figure 7.--Dioryctria amatella larva first killed a female flower (left), then entered the shoot, killing the entire cluster of young longleaf pine cones.

11a. Dioryctria abietella (D. & S.) [5/]

This coneworm was abundant in rust-infected cones (fig. 6) and in second-year cones. It was also found in fusiform rust cankers and occasionally in first-year cones. Rarely it infested male flower clusters and longleaf pine overwintering buds. Mature larvae were purple to brown in color and about 5/8 inch to 3/4 inch long. Often only frass was present on the surface of infested material.

11b. Dioryctria amatella (Hulst)

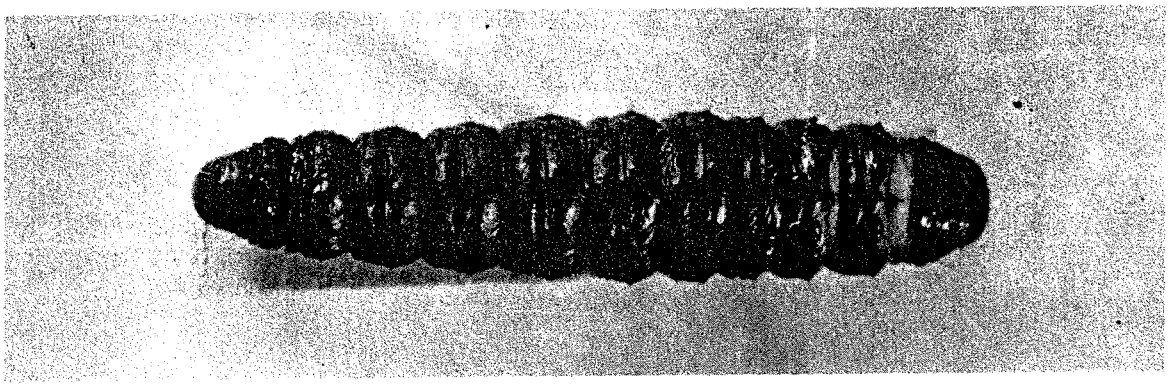
This species, the largest coneworm encountered, commonly infested the widest variety of the pine material collected. It was prevalent in buds, flowers, and shoots (especially of longleaf pine) (fig. 7) and in second-year cones, fusiform rust cankers, and rust-infected cones. It also occurred in wounded, or sometimes apparently normal, tree trunks, and around the graft unions of pines established in seed orchards. Attacks on first-year cones, except as related to flower and shoot infestations, were rare. Mature larvae (fig. 8) were usually dull purple to dark purple-brown, often with green suffusions, and about an inch long. Attacks were usually marked by a mass of mixed frass and resin on the surface of the host (fig. 9). This was the only species of coneworm found which regularly pupated within the infested material.

11c. Dioryctria clarioralis (Wlk.)

This coneworm was much less abundant in the collections than the previous two species. It was, however, quite regularly found in longleaf pine material and less frequently in slash pine collections. First-year cones (fig. 10), vegetative buds and male bud clusters were most commonly attacked; occasional female flower buds and some collections of rust-infected cones were also infested. Second-year cones and fusiform rust cankers were very rarely attacked. Mature larvae were usually colored yellow-brown to orange-brown, often heavily suffused with grey. They were about 3/4 inch long. A very characteristic blister of resin-coated silk was constructed over entry holes by these coneworms (fig. 11). Ejected frass accumulated inside these blisters.

5/ This species was based on European specimens. Monroe (1959) in Canada considered North American specimens which he examined as a distinct species, Dioryctria abietivorella (Grote). However, U. S. National Museum taxonomists follow Heinrich (1956), who included such specimens under D. abietella.

Figure 8. --Dioryctria amatella larva. Actual length is about 1 inch. Conspicuous tubercles distinguish this larva from two other Dioryctria species found in north Florida.



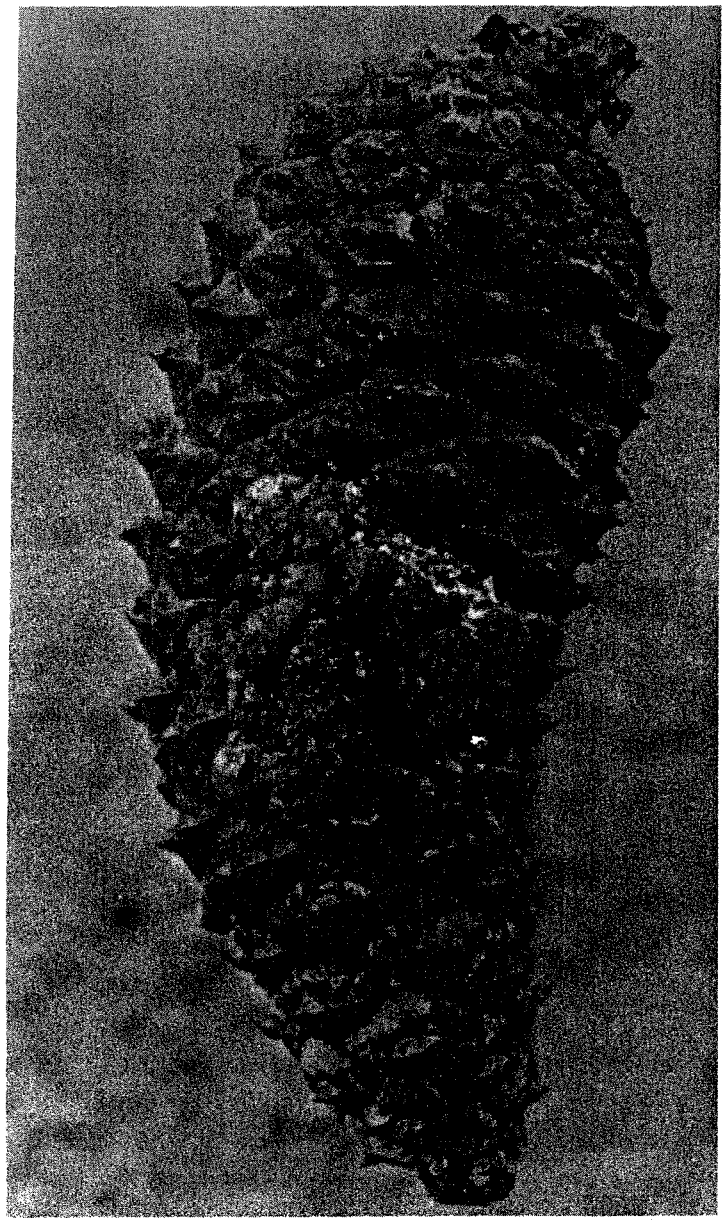


Figure 9. --Dioryctria amatella larval attack into second-year longleaf pine cone is marked with typical accumulation of frass and pitch.

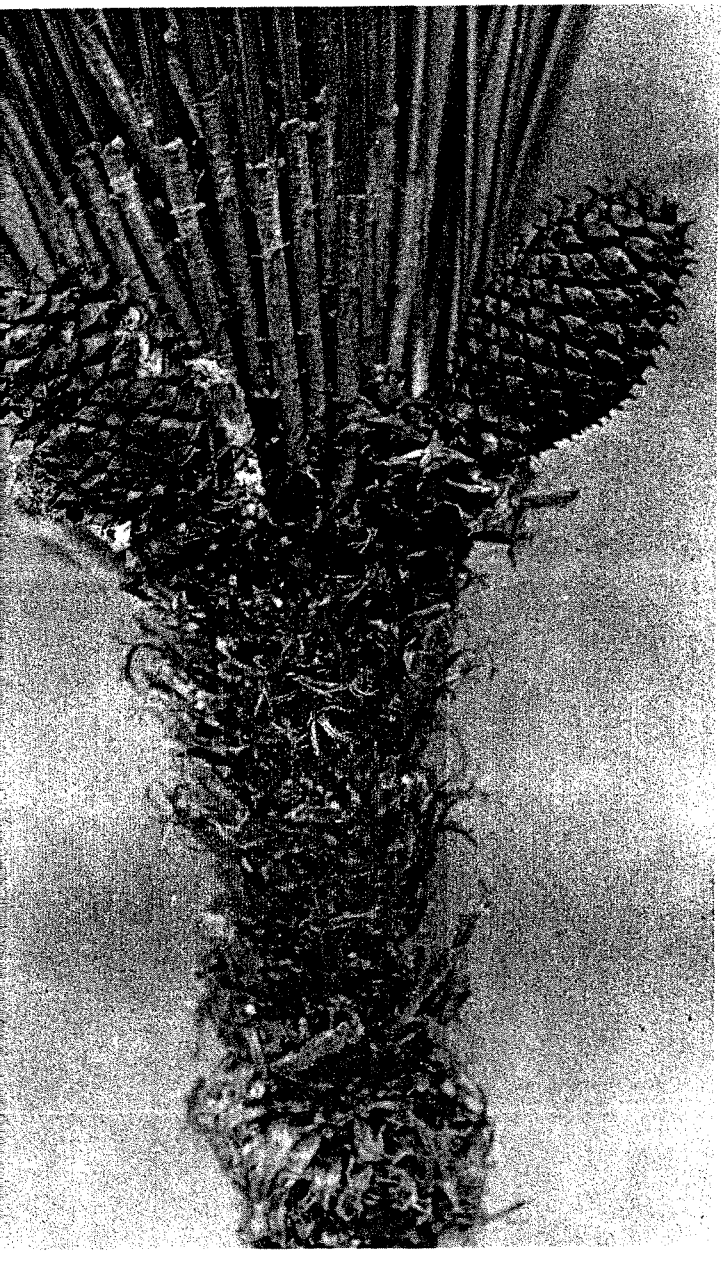


Figure 10. - - Dioryctria clarioralis larva riddled the first-year longleaf pine cone to the left. Resin blister is partly shown on cone base. Cone to the right is normal.

Figure 11. --Dioryctria clarioralis attack on terminal bud of longleaf pine shoot is marked by typical resin blister. Larva probably first fed on male flower buds now spent and dry.

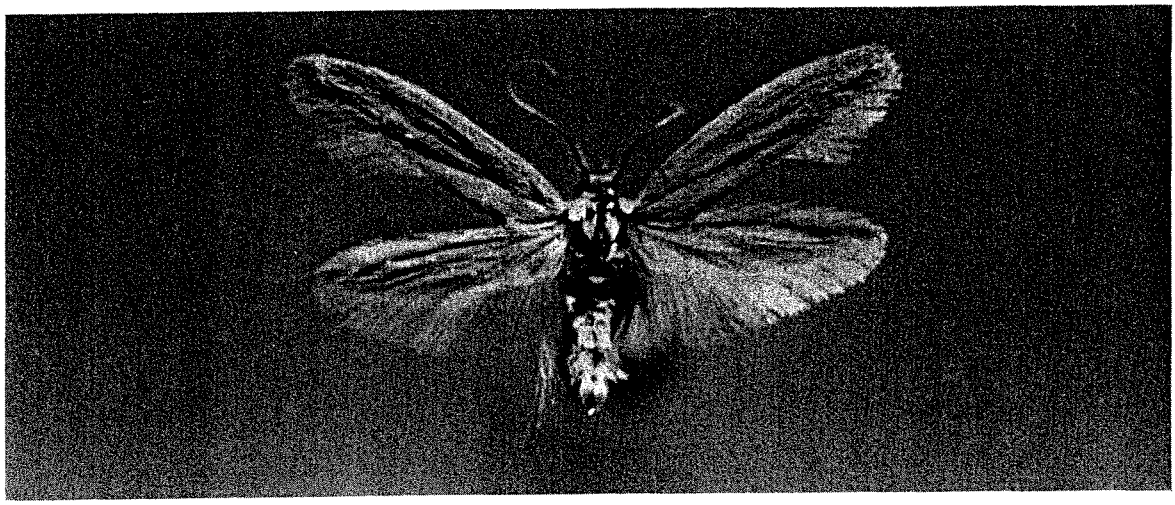
12. Holcocera lepidophaga Clarke--Blastobasidae

The purple-brown larvae of this small glossy tan moth (fig. 12) commonly fed into male flower buds of both pines. They constructed protective silken tubes among the buds. Frass and fine webbing were often obvious among the infested flower clusters.

Larvae were also common as secondary feeders on the dry scale leaves of buds, shoots, and cone stalks, and in rust-infected cones or material deteriorating following attacks by other insects. Occasionally they were found preying on Toumeyella scales on cone stalks. Several generations occur yearly.

The larvae resemble Dioryctria abietella in color and could be mistaken for the smaller larval forms of this coneworm. However, the prothorax of Holcocera larvae is obviously constricted in comparison to the head and remainder of the thorax; in D. abietella the prothorax is about the same width as these adjoining structures.

Figure 12. --Holcocera lepidophaga moth. The larva of this species commonly occurs among dry scale leaves of buds and cone stalks and seasonally on male flower buds.



13. Laspeyresia spp.--Olethreutidae

The white, grub-like larvae of these moths fed only in the seed of second-year cones. Eggs were laid on the cones in the spring. Larvae fed from seed to seed during the summer and, in the fall, entered the cone axis. Here they overwintered, pupating and emerging as adults in the spring. Cones containing Laspeyresia spp. larvae showed no external evidence of attack while still green. Hollowed seed, packed with frass, or the overwintering tunnels in the cone axis were obvious in cut-open cones (fig. 13). Also the hollowed seeds tended to remain in opened mature cones and were additional evidence of attack. Two species of these seedworms were found in the collections as follows:

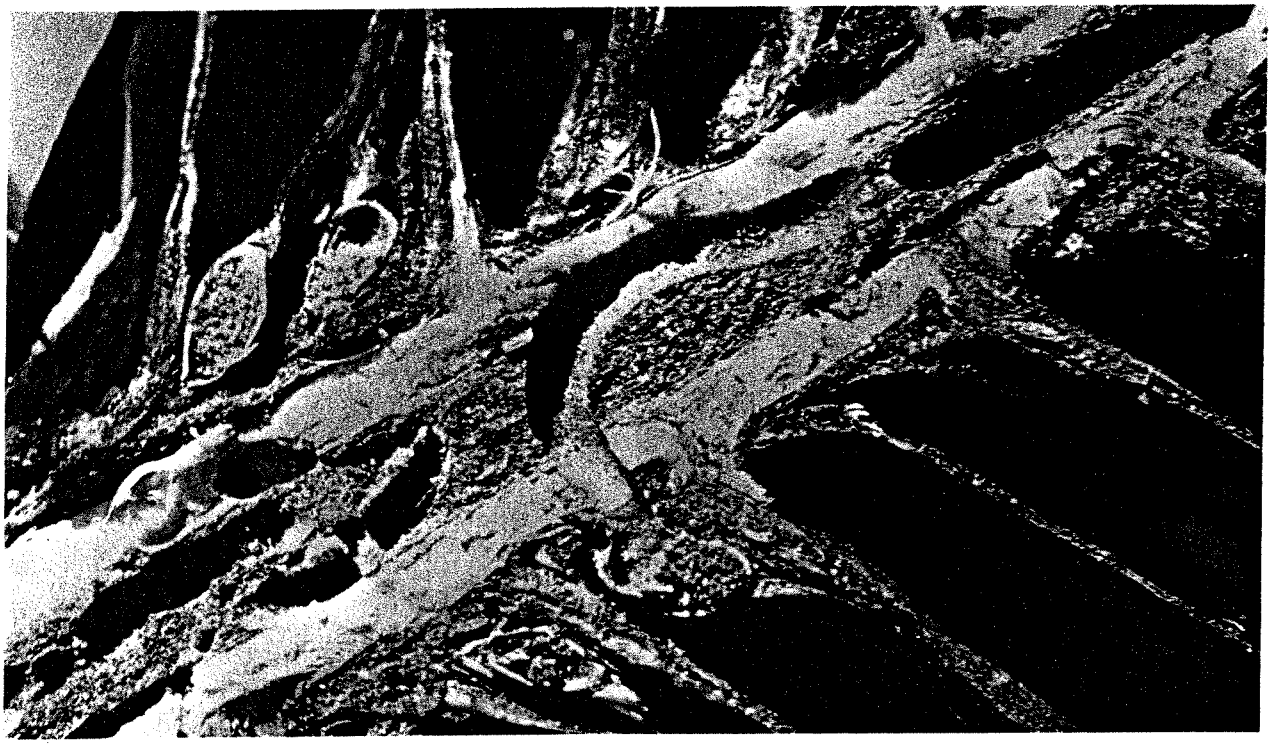


Figure 13. --Laspeyresia anaranjada. Several frass-filled seeds destroyed by the larvae of this moth remained in this open slash pine cone. A hibernation gallery constructed from the last infested seed is shown in the center of the photograph.

13a. Laspeyresia anaranjada Miller

This species commonly infested slash pine cones. It was very rarely found in cones of longleaf pine. The adult moth is a bright golden-orange with silvery-white markings (fig. 14).

13b. Laspeyresia ingens Heinrich

This seedworm was found in cones of both slash and longleaf pine but was much more abundant in those of longleaf. The adult moths (fig. 15) were grey-brown with silvery-white markings, the more usual color of Laspeyresia spp.

14. Moodna ostrinella (Clem.)--Phycitidae

Larvae of this moth were regularly found in rust-infected first-year cones. They also were reared from dead cones and from fusiform rust cankers.

The larvae occur with those of Dioryctria abietella in rusted cones and might be confused with these coneworms. The more robust larvae of M. ostrinella, however, have bright yellow-brown to orange-brown head capsules compared to the duller brown heads of D. abietella larvae.

15. Nepytia semiclusaria (Wlk.)--Geometridae

Early instar larvae of this looper were occasionally found feeding on the female flowers of slash pine. These larvae completed their development on new-growth needles and pupated there in a coarse meshwork of silk fibers. A single generation occurred each year, the larvae developing from late January through April. The species probably holds over in the egg stage as suggested by Hetrick (1960) in his observations of this insect on sand pine, Pinus clausa (Chapm.) Vasey, where it fed on old rather than new-growth needles.

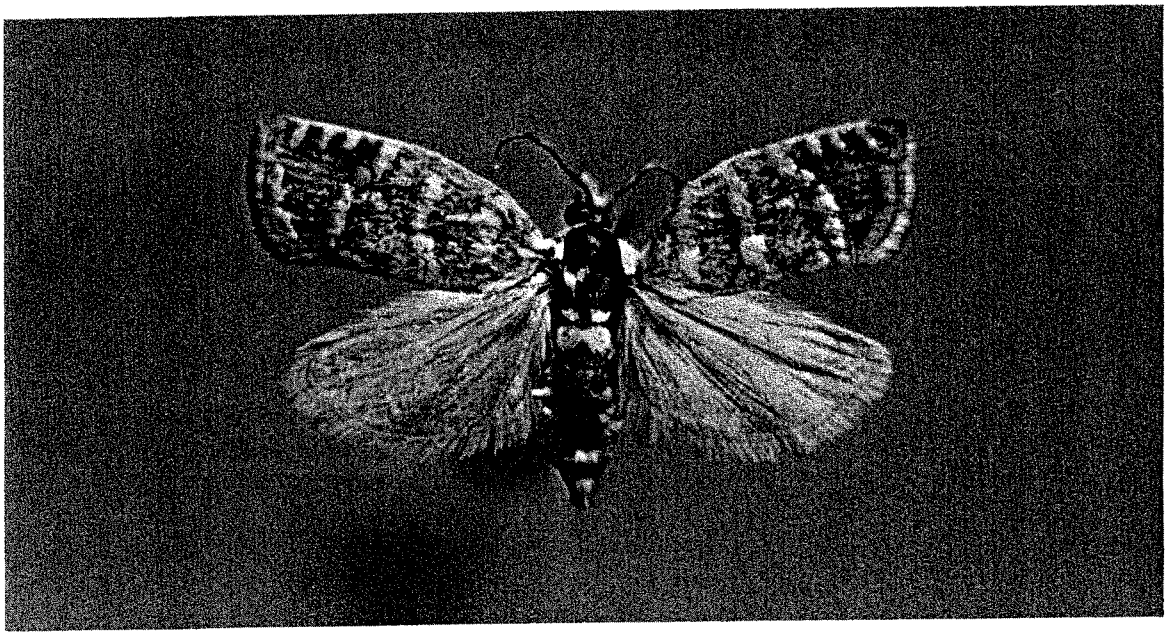
16. Pyroderces rileyi (Wlshm.)--Cosmopterygidae

This small moth was reared from rusted cones in late stages of development. It apparently was a secondary invader of the dying galled cones.

17. Rhyacionia subtropica Miller--Olethreutidae

Larvae of this tip moth were collected rarely in overwintering slash pine buds including in one instance a female flower bud. This is the common tip moth species found in the buds and shoots of young slash and loblolly pines in north Florida. It has frequently damaged grafted scions of slash pine in the propagation of selected genetic stock.

Figure 14. --Laspeyresia anaranjada moth. This species was common in slash pine cones.



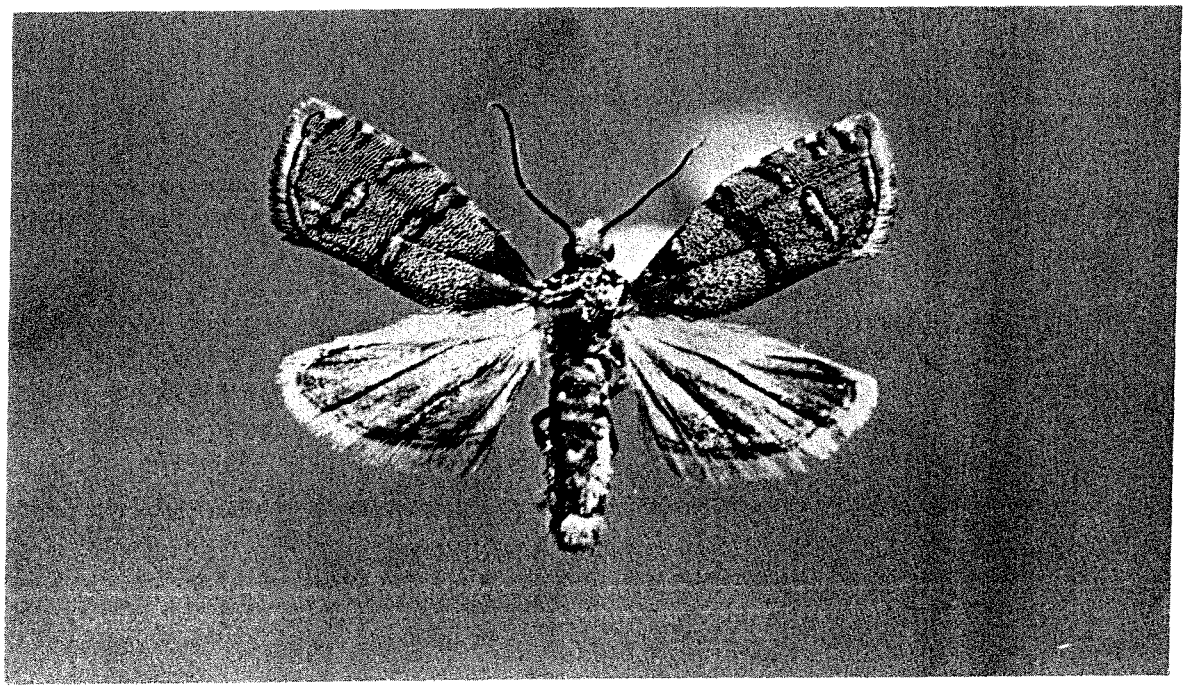


Figure 15. --Laspeyresia ingens moth. This species occurred regularly in longleaf pine cones and to a lesser extent in those of slash pine.

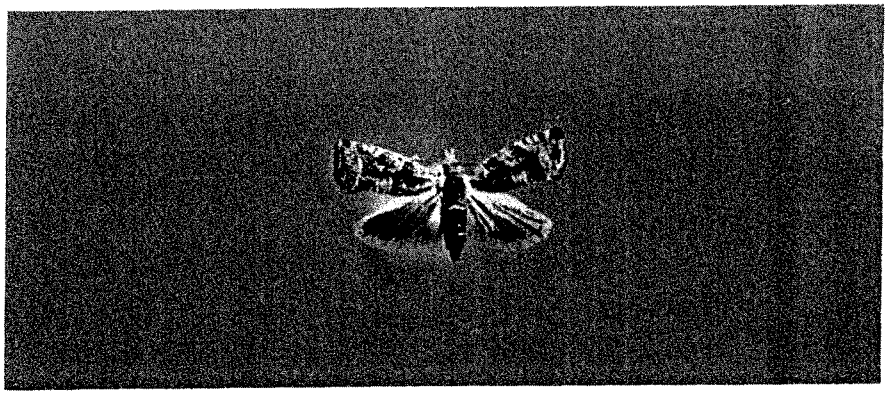


Figure 16. --Satronia tantilla. The larvae of this moth were abundant in longleaf pine male flowers.

18. Satronia tantilla Heinrich--Olethreutidae

The small, white larvae of this moth (fig. 16) bored within the male flower buds. Longleaf pine flowers were often heavily infested, while those of slash pine were comparatively lightly attacked. Eggs were laid upon the bud scales of the expanding flower clusters. Larvae extruded fine frass to the flower surface. Pupation occurred within the attacked flowers, often in the base of the shriveled remains of spent flowers.

A second generation of this moth developed in rust-infected first-year cones. Occasional adults have also been reared from fall collections of fusiform rust cankers, indicating that at least three generations of this moth can occur each year.

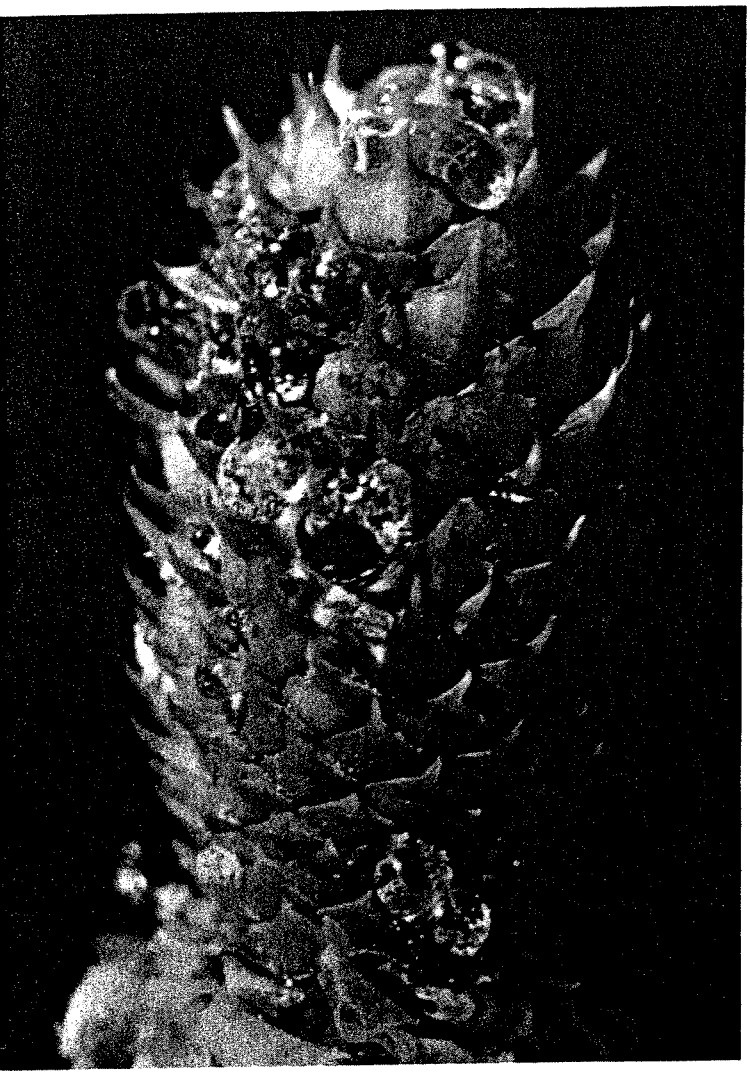


Figure 17. --Gnophothrips piniphilus adults on a young slash pine cone.

Figure 18. -- Gnophothrips piniphilus adult. Both the short-winged form shown and fully winged adults occurred in this thrips species. (Actual length about 1/16 inch.)

THYSANOPTERA

19. Frankliniella tritici (Fitch); Frankliniella spp.--Thripidae

These minute flower thrips were common in the pollen of opening male flowers. They have been noticed often in extracted pollen, from which they are difficult to remove because of their small size.

A single specimen of F. bispinosa (Morg.) was identified from a young cone. This was quite possibly an incidental occurrence since this thrips group was not ordinarily noticed on female flowers or cones.

20. Gnophothrips piniphilus Cwfd.--Phloeothripidae

Adults of this thrips were regularly found feeding on the female flower buds and young cones of slash pine (figures 17 and 18). Flower injury and often death were caused by the surface scraping of the scales and bracts by these small brownish-black insects. Beads of resin were conspicuous on injured flowers (fig. 19). Infestations seemed to be more prevalent on the flowers of open-grown trees than on those in forest stands. Attack by this thrips was the most common cause of slash pine female flower mortality.

From spring through fall this thrips was found widely dispersed on slash pine reproduction. In this habitat both adults and immature forms were observed but no obvious injury was noticed, probably because of the small numbers present on individual trees. It also was found on shoots of Pinus taeda.

21. Oxythrips sp. (pallidiventris Hd. ?)--Thripidae

Adults of this thrips were found in mature male flowers.

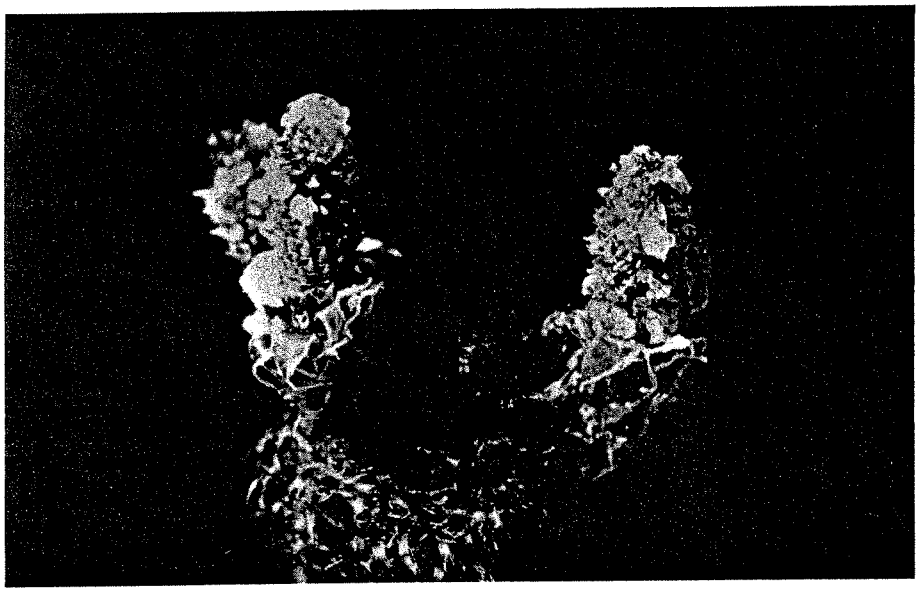


Figure 19.--Gnophothrips piniphilus feeding injury caused the typical beaded resinosus on these dying young slash pine cones.

C. A Key to Common Insect Damage to Flowers and Cones of Slash and Longleaf Pines

1.	Female flowers attacked[6/]	2
1a.	Male flowers or developing cones attacked[6/] . . .	5
2. (1)	Surface feeding (scraping) on scales and bracts, distinct beads of resin (fig. 19) forming on injured flower surfaces (slash pine only)	Gnophothrips piniphilus
2a.	Flowers externally gouged (bitten into), or bored into and internally injured, resin if present mainly in irregular droplets or masses	3
3. (2a)	Flowers gouged; small looper caterpillars may be present (slash pine only)	Nepytia semiclusaria
3a.	Flowers bored into; larvae, if present, not loopers	4
4. (3a)	Resin blister present at base of flowers; flower usually completely hollowed out	Dioryctria clarioralis
4a.	Pitch flow, or frass only, on flower; feeding often limited to the axis of the flower	Dioryctria amatella
5. (1a)	Attacks on male flowers	6
5a.	Attacks on cones	12
6. (5)	Frass absent; injury by adult or nymphal feeding	7
6a.	Frass present on or in the flowers; injury by larval feeding	8
7. (6)	No distinct injury observed, nymphs (orange-red) or adults (brown) of a true bug present among flower bases (slash pine only)	Lepidopsallus australis

6/ For simplicity the terms, "male flowers," "female flowers," and "cones" are used in this key. Their equivalents in more restricted botanical terms would be: male flowers = male strobili; female flowers = female strobili through the receptive stage; cones = female strobili in their period of development following receptivity until seedfall, a period of two growing seasons.

7a.	Flowers stripped to axis; adult beetles may be observed (slash pine only)	Lytta sp. (Meloidae)
8. (6a)	External evidence of attack limited to varying degrees of distortion and to small resin spots on the flowers. Small, creamy white, grub-like larvae (fig. 1) often seen in extracted pollen . . .	Xyela spp.
8a.	External evidence of attack more noticeable, frass, webbing, etc.; larvae, if found, typical caterpillars seldom seen in extracted pollen . . .	9
9. (8a)	Fine yellow frass inconspicuously webbed together on flower surface; small ($\frac{1}{4}$ inch), white caterpillars, with distinct anal comb 7/ at the end of the abdomen behind the anal prolegs, present inside flower buds	Satronia tantilla
9a.	Frass of various colors, loose, or with webbing distinct to the unaided eye; larvae without anal comb structure, in or on flower buds	10
10. (9a)	Webbing tunnels and conspicuous frass present among flower buds. Very elusive brown to purple larvae, with prothorax constricted, present among or in the flowers	Holcocera lepidophaga
10a.	Webbing coated with pitch to form a blister-like structure, or absent, frass usually not obvious; larvae, with prothorax as wide or wider than the head or remainder of thorax, in flower buds	11
11. (10a)	Webbing coated with pitch forms a blister over attacked buds (fig. 11). Larvae usually yellow to brown	Dioryctria clarioralis
11a.	Flower attack marked by fine frass only. Larvae most often creamy white to pale amber, with obvious raised setal bases on the top and sides of the abdomen (fig. 8)	Dioryctria amatella (young larvae)

7/ Peterson (1948, p. 169) illustrates this structure.

12. (5a)	Attacks on live cones	13
12a.	Attacks on dead cones[8/]	17
13. (12)	Superficial feeding on scale-leaves of the cone stalks; larvae in webbing tunnels	Holcocera lepidophaga
13a.	Definite feeding injury into or within cones	14
14. (13a)	Obvious external evidence of injury present in the form of frass, holes; or pitch masses . . .	15
14a.	Cones externally intact	16
15. (14)	A definite pitch blister present over injury; usually on first-year cones (fig. 10)	Dioryctria clarioralis
15a.	Frass and resin masses, or frass only over injury; usually on second-year cones (fig. 9) . . .	Dioryctria amatella, or D. abietella
16. (14a)	Seeds only attacked, in second-year cones. Frass packed in destroyed seeds. White larvae hibernate over winter in galleries in cone axis (fig. 13)	Laspeyresia spp.
16a.	Cavities formed between cone scales, involving both scale surfaces and developing seed structures (fig. 1). Small yellowish to bright orange larvae often present	Itonididae (Cecidomyiidae)
17. (12a)	Fine boring dust pushed from small hole in cone; attacks on dying, yet succulent, cones, especially those on felled trees or cones stored in coarsely screened cages. Small beetles, of the bark beetle type, usually present. Larvae grub-like and legless	Pityophthorus pulicarius
17a.	Pellets of granular frass pushed to cone surface or packed within cone. Larvae with definite legs	18

8/ If a dead cone is deformed, or has an obvious accumulation of resin on the surface or in insect galleries, consider it alive when attacked and go to couplet 13.

18. (17a) Short galleries, packed with fine, dry, granular frass without webbing, in dead, dry cones, often in the stalk or cone base. White, heavy-bodied, grub-like larvae often present . . . . . Ernobius granulatus

18a. Larval galleries wandering throughout the cones, webbing sometimes noticeable, and frass irregularly present. Larvae are elongate caterpillars with abdominal legs. Several lepidopterous larvae, commonly Battaristis vittella, Moodna ostrinella, and Holcocera lepidophaga

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