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COMMON INSECTS ON PINYON (PINUS EDULIS)

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While studying forest management of pinyon (*Pinus edulis*) in Arizona and New Mexico, Dr. Little made observations as to insect life on the foliage, in the bark, and in the cones and the large, edible seeds. He names and describes insect species observed on this tree and tells what sort of damage is known to be caused by individual species under usual and under exceptional conditions.

INTRODUCTION

Field work on *Pinus edulis* was centered at an experimental plot, named the Walnut Canyon Pinyon Plot, located in Sec. 30, T. 21 N., R. 9 E., about 12 miles east of Flagstaff on the Coconino National Forest in Coconino County, northern Arizona. The pinyon-juniper woodland here, at an elevation of 6,500 feet, is near its upper altitudinal limit. During the field seasons of 1938, 1940, and 1941 the author visited this plot at least once or twice weekly from April or May to September or October. Notes were recorded on the common insects found on various parts of the trees, and specimens[2] were collected. Further observations

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were made in field trips over New Mexico and Arizona during the pinyon nut harvests each fall. The Forest Service annual reports on insect control within the national forests of Arizona and New Mexico for the period from 1922 to 1940 have contributed data on insect epidemics on pinyon trees.

Because pinyons are of only slight importance for lumber, the insects attacking them have not attracted much attention. Blackman (*1*, p. 149) listed 11 species of bark beetles (10 of *Pityophthorus* and 1 of *Pityophilus*) on *Pinus edulis* and 4 species on the related single-leaf pinyon (*P. monophylla*). Keen (*5*, pp. 106–107) recorded 7 species of insects feeding on *P. monophylla*. Several insect species on *P. edulis* including some not collected by the author but cited here also were mentioned by Keen (*6*). As apparently no previous summary of the common and destructive insects on *P. edulis* has been published, the author's personal observations are presented here. It is realized that additional study of the insects of this host species over its entire range and over a longer period would be desirable. Insects which seem to be of slight importance might become epidemic and cause considerable damage at some future time. The insects observed on pinyon trees may be grouped for convenience in reference into three classes according to the parts of the host trees attacked: (1) insects on foilage; (2) insects in bark; and (3) insects in cones and seeds.

INSECTS ON FOLIAGE

The main insects on the foliage may be listed as follows: (1) pine tip moths; (2) scale insects; (3) aphids; (4) caterpillars; (5) gall makers; (6) cicadas; and (7) ants. A few insects of various other kinds occasionally are found on the foliage but apparently are not injurious or only slightly so, or else feed on other insects. In addition to the insects on the foliage discussed

of Forest Insect Investigations of that bureau kindly has handled the collection. The author is greatly indebted to the following specialists of the Division of Insect Identification for making the determinations: W. H. Anderson, H. G. Barber, M. W. Blackman, R. F. Blackwelder, L. L. Buchanan, E. A. Chapin, J. C. Crawford, R. A. Cushman, W. S. Fischer, C. T. Greene, A. B. Gurney, Carl Heinrich, P. W. Mason, H. Morrison, C. F. W. Muesebeck, P. W. Oman, and M. R. Smith. Helpful suggestions for the manuscript have been given by F. P. Keen and J. E. Patterson, of the Division of Forest Insect Investigations.

here, a pine louse (*Pineus coloradensis* Gill; Phylloxeridæ) has been reported on pinyon (*6*, p. 49) and a roundheaded borer (*Oeme costata* Lec.; Cerambycidæ) on twigs of pinyon (*6*, p. 37). A needle miner (*Recurvaria* sp., near *R. milleri* Busck; Gelechiidæ), which became epidemic on *Pinus monophylla* in California, may be looked for on *P. edulis*, according to J. E. Patterson.

Pine Tip Moths

Pine tip moths (*Dioryctria* sp.; Phycitidæ, known also as Pyralidæ) are common on pinyon trees and often abundant near the lower altitudinal limit. The whitish caterpillars become $\frac{3}{8}$ to $\frac{5}{8}$ inch long, and the gray adult moths have a length of less than $\frac{1}{2}$ inch. The larvæ, which are active mainly in May and June, kill leaders, other terminal shoots, and terminal buds in the upper parts of mature as well as smaller trees. Pine tip moths may tend to increase the branching and crooked limbs but the deformation caused is not conspicuous or very serious, as the low, spreading, much-branched pinyons seldom are used for lumber. There is a slight retardation in height growth when the leader is killed, but a shorter lateral shoot becomes a leader. Some indirect loss of cones is due to pine tip moths, because a few attacked shoots bear young cones.

J. E. Patterson suggests that another pine tip moth (*Rhyacionia neomexicana* Dyar; Eucosmidæ), which kills the tips, reduces the cone crops, and is very damaging to *Pinus monophylla*, might be found also on *P. edulis*.

Larvæ of pitch midges (*Retinodiplosis* sp., possibly *R. resinicola* O. S.; Itonididæ) were collected in masses of pitch on young shoots of the related species, Mexican pinyon (*Pinus cembroides* Zucc.), in the Patagonian Mountains, Coronado National Forest, southern Arizona.

Scale Insects

The pine needle scale (*Chionaspis pinifoliæ* (Fitch); Coccidæ), which is common and widely distributed on the foliage of pines and other conifers throughout the United States, apparently is relatively uncommon on pinyon needles. The mature scale is white and almost $\frac{1}{8}$ inch long. Heavily infested needles may die

and fall prematurely, or a few trees may be killed. Recorded from Cibola, Coconino, and Gila National Forests.

Another species, the pinyon needle scale (*Matsucoccus acalyptus* Herbert; Coccidæ) is generally infrequent on pinyon needles. The brownish or blackish body is about $\frac{1}{8}$ inch long, but the stage more often seen is dark brown and only about 1/64 inch in length. Needles of the current year become dotted with many small scales and turn yellow and brown as they are killed. In severe attacks the needles drop off after the first year, leaving thin foliage composed of only the needles of the current year.

A number of trees at their lower limit on the Coconino National Forest in this area were killed in 1940 by heavy infestations of this species. In 1924 pinyon trees of all sizes and ages in the vicinity of Fort Bayard, Gila National Forest, New Mexico, were killed by pinyon needle scales. Noted also on Cibola National Forest. Other hosts and localities recorded in literature include single-leaf pinyon in California (*2*, p. 376) and in southern Idaho (*3*, p. 270).

Two additional species, *Matsucoccus paucicatrices* Mor. and *M. monophyllæ* McK. have caused twig injury on *Pinus monophylla* and might be found also on *P. edulis*, according to J. E. Patterson.

Aphids

Bark aphids of two species infrequent on pinyon twigs probably cause only slight injury. Specimens of *Cinara atra* Gill. and Palm. (Aphididæ) were collected once feeding on new shoots at the Walnut Canyon plot. Associated with small black ants (*Liometopum apiculatum* subsp. *luctuosum* Whlr.), aphids of the species *Cinara terminalis* (Gill. and Palm.) were found on twigs on the Santa Fe National Forest, New Mexico. *Cinara edulis* Wilson has been recorded on pinyons in Colorado (*6*, p. 46).

Caterpillars

Caterpillars of several kinds, varying in length from $\frac{1}{2}$ to 1 inch or more, feed on the needles but usually are uncommon and attack only one or a few trees. Tent caterpillars, larvæ of tiger moths (*Halisidota ingens* Hy. Edw.; Arctidæ), were observed forming webs on the foliage of pinyons in September and October

at the Walnut Canyon plot and on the Cibola and Santa Fe National Forests. This species is also recorded (*6*, p. 68) from Colorado. Other caterpillars collected on pinyon needles include *Coloradia* sp. (*Saturniidæ*), at Walnut Canyon plot, and an undetermined one (Lasiocampidæ, presumably *Gloveria* sp.) from the Lincoln National Forest.

Sawfly larvæ or "false caterpillars" (*Neodiprion* sp.; Diprionidæ), which become $\frac{3}{4}$ to $\frac{7}{8}$ inch long, feed on the needles of pinyons. Infrequent on the Conconino and Kaibab National Forests. *Neodiprion rowheri* Midd. has been recorded (*2*, p. 338) on *Pinus edulis* in Colorado and *P. monophylla* in California, and on pinyons (*6*, p. 90) in New Mexico.

Gall Makers

Insect galls of a few kinds, formed mostly by gall midges (Cecidomyiidæ, known also as Itonididæ), are found on needles and twigs of pinyons. While these galls are widespread and common in Arizona and New Mexico, apparently the destruction of only a very small portion of the needles by the gall-forming insects is not serious.

Galls of three shapes occur on spur shoots and cause swelling of the bases of growing needles. One or more pink, orange, or white larvæ less than $\frac{1}{16}$ inch long develop inside a gall. At the end of the season the spur shoot with gall and dead needles is shed. Seldom are more than two or three spur shoots of a twig attacked, but many twigs have galls.

In the commonest type, caused by the gall midge identified doubtfully as *Janetiella coloradensis* Felt (?), the pair of needles produce at their base a spherical, hard, almost solid brown swelling about $\frac{3}{16}$ inch in diameter. Another kind is an oval-shaped gall similar to that described by Felt (*4*, p. 17; also *2*, p. 391) on *Pinus edulis* and *P. monophylla* caused by the gall midge, *Cecidomyia* sp. The swelling at the base of the pair of needles is elongate or cylindrical, soft, and hollow, and becomes pale green and sometimes reddish. It is $\frac{3}{8}$ to $\frac{1}{2}$ inch long and less than $\frac{3}{16}$ inch broad and contains several larvæ. The third type is a conical gall about $\frac{3}{8}$ inch long and $\frac{3}{16}$ inch wide, produced by an unidentified gall midge (probably a species of Cecidomyiidæ). In this type the needles do not elongate beyond the gall, and the

brown basal scales enlarge and cover the gall. Felt (*4*, p. 18; also *6*, p. 53) reported that another species of gall midge, *Thecodiplosis cockerelli* Felt, produces kidney-shaped enlargements at the base of pinyon needles in Colorado.

Tips of shoots occasionally may be deformed by spreading laterally instead of elongating. The spur shoots and needles are borne in a rosette-like cluster about ½ inch broad at the base and covered with brown scale leaves. These galls apparently are the same as those reported on *Pinus edulis* by Felt (*4*, p. 17; also *2*, p. 391) and caused by the gall midge, *Cecidomyia* sp. (Cecidomyiidæ).

Cicadas

Cicadas of two species are common in pinyon woodlands. The larger cicadas (*Okanagana magnifica* Davis; Cicadidæ) are commoner than the smaller ones, Putnam's cicada (*Platypedia putnami* var. *lutea* Davis; Cicadidæ). It is not known whether they injure the trees, but possibly the larvæ, which live underground several years, may feed upon the roots.

Adults of both species, which are active about a month, were observed on shrubs and pinyons at the Walnut Canyon plot in May and June, 1940 and 1941. Nymphs of Putnam's cicada emerge from the ground about the first or middle of May, depending upon the season, and those of the larger species appear about two weeks later. Numerous split skins of the larvæ are left on twigs and trunks of pinyons, where they were noticed at various localities.

Ants

Small black ants (*Liometopum apiculatum* subsp. *luctuosum* Whlr.; Formicidæ), about ⅛ inch long or larger, occasionally are common on the twigs and trunks and may be associated with aphids. Carpenter ants (*Camponotus* sp.; Formicidæ), large black ants about ½ inch long, are infrequent on the trunks and foliage of pinyon trees and may tunnel into the dead wood of living trees.

INSECTS IN BARK

Insects of several species are found in the bark of living and dead pinyon trees. Of all the insects on pinyons, bark beetles (Scolytidæ) have attracted the most attention among foresters.

F. P. Keen has written that he found the Black Hills beetle (*Dendroctonus ponderosæ* Hopk.) attacking *Pinus edulis* on the Kaibab National Forest during the epidemic of 1924 and 1925 and that *D. valens* Lec. and *D. barberi* Hopk. have been recorded on this host. Blackman (*1*, p. 149) listed these 11 additional species of bark beetles on *Pinus edulis* in New Mexico, Arizona, and Colorado: *Pityophthorus agnatus* Blackm., *P. comptus* Blackm., *P. deletus* Lec., *P. digestus* Lec., *P. immanis* Blackm., *P. infulatus* Blackm., *P. inquietus* Blackm., *P. mollis* Blackm., *P. ornatus* Blackm., *P. schwarzi* Blackm., and *Pityophilus barbatus* Blackm. However, four of these were not cited again for *P. edulis* in Blackman's list of hosts of these insect species on pages 153 to 156.

Bark Beetles

The commonest bark beetles attacking pinyons are known as Ips or engraver beetles (*Ips* spp.). In New Mexico and Arizona the principal species on pinyons probably is the Arizona five-spined engraver (*Ips lecontei* Sw.; Scolytidæ), collected on the Lincoln National Forest, New Mexico. Specimens collected at the Walnut Canyon plot were of a related species (*Ips* sp., near *Ips confusus* Lec., probably new variety or new species). These light to dark brown beetles less than $\frac{3}{16}$ inch long appear to be mainly secondary, as they attack weakened, injured, and dying pinyon trees, especially those affected by drought or on poor sites. Except in infrequent epidemics, only a few trees are attacked at a time, the loss is not great, and control measures are not needed.

Nearly all the references to insects on pinyons contained in the annual reports on insect control on the national forests of Arizona and New Mexico during the period 1922 to 1940 are about bark beetles, or Ips. In 1925 and 1926 there was a serious infestation of Ips, attributed partly to drought, on Chupadera Mesa, Cibola National Forest, New Mexico. From 10 to 50 per cent of the pinyon trees in different places were killed, but only a few died in 1927. Considerable numbers of trees were killed by Ips and drought on the Apache National Forest, New Mexico, in 1925 also, but by 1926 the infestation was not serious.

A severe epidemic of Ips, starting from blown-down timber, killed from 50 to 75 per cent of the pinyon trees in a large area

along the west slopes of the Sacramento Mountains, Lincoln National Forest, New Mexico, in 1925. Drought-weakened trees on the shallow-soiled, dry western slopes were attacked also. The great bulk of the trees turned brown during the last of June and July, but a few died later and in 1926. Slight infestation was reported on this forest again in 1928.

Some damage from Ips on pinyons was noted in 1930 in the Zuni Mountains, Cibola National Forest; in the dry year 1934 east of the Sandia Mountains, Cibola National Forest; and in 1937 on Coconino National Forest, where the bark beetles apparently had spread from nearby slash. Slight loss of pinyon trees already injured by smelter smoke was reported on an area of the Prescott National Forest, Ariz., in 1938 and 1940. Some bark beetle infestation, thought to have spread from clearing of a road, was noted on the Sitgreaves National Forest, Ariz., in 1939. A heavy infestation, thought to be of bark beetles, killed 10 per cent of the pinyons on ridges of a mountain on the Crook National Forest, Ariz., in 1940, where 10 per cent of the trees were killed. A few pinyon trees attacked by bark beetles were observed on the Kaibab National Forest in 1940, also.

Other Insects

Insects of several kinds, both larvæ and adults, are found in the bark of dying pinyon trees infested with bark beetles. These probably are secondary, do not cause death of the trees, and may not be injurious. Roundhead borers of two species (*Acanthocinus* sp., probably *A. spectabilis* Lec.; and *Monochamus* sp.; Cerambycidæ) were common in the bark of dying trees attacked by Ips at the Walnut Canyon plot. These large white grubs become $\frac{3}{4}$ to $1\frac{1}{4}$ inches long. Other white larvæ about $\frac{5}{8}$ inch long in the bark of these trees were ostomid beetles (*Temnochila* sp.), which may be beneficial in feeding upon bark beetles and other insects. Small adult beetles less than $\frac{1}{4}$ inch long found in the tunnels of bark beetles under the bark of the same trees were identified as: *Aulonium longum* Lec. (Colydiidæ); *Hypophloeus* sp. Tenebrionidæ); and *Platysoma punctigerum* Lec. (Histeridæ). Beetles of the last species feed on eggs and larvæ of bark beetles (*2*, p. 203). A flatheaded borer (*Melanophila pini-*

edulis Burke; Buprestidæ) has been reported on dead and dying pinyons in Colorado, Utah, and Arizona (*6*, p. 134).

INSECTS IN CONES AND SEEDS

While they do not kill the trees, the insects in the cones and seeds destroy large portions of the marketable crops of pinyon nuts each year. Fortunately, pinyon nuts are not attacked by insects after maturity and keep well for a few years, when stored in dry climates. It should be noted that many seeds die from other causes at various stages. Production of empty seeds, known as blighting or blasting, in cones not attacked by insects, sometimes is common.

Insects Feeding on Young Cones

The young cones emerging from the buds for pollination in June or May are soft and glandular for a few weeks until the cone scales form a hard surface. Miscellaneous insects feed upon these young cones and destroy a small portion. Though only a few scales may be eaten, the injured cone usually dies. A few June beetles (*Serica* sp., apparently undescribed; Scarabaeidæ) about $\frac{3}{8}$ inch long and an unidentified measuring worm (Geometridæ) about $\frac{1}{8}$ inch long were collected on the cones at this stage.

Larvæ in Cones, First Year

According to observations at the Walnut Canyon plot, there is a high mortality of pinyon cones from insects the first year, though the loss is much less conspicuous than that of the larger cones the second year. Destruction of cones the first year is caused principally by larvæ of unidentified gall midges (Cecidomyiidæ, known also as Itonididæ). The cones are attacked after pollination and killed when less than $\frac{1}{2}$ inch long. Eggs were found in a cone early in July. The white larvæ, less than $\frac{1}{8}$ inch long, are active in July and August but were found as late as September. They feed on the young seeds and soft tissues at the base of the cone scales. The infested cones usually die in August, shrivel slightly as they dry, and fall off when touched. When examined, they are usually hollow and show no evidence of insects.

A less common type of insect damage is that of abnormally swollen cones caused also by larvæ of gall midges (Cecidomyiidæ, known also as Itonididæ). In August or the last of July a few cone scales begin to grow more rapidly than the others and produce an asymmetrical cone with the larger scales protruding $\frac{1}{16}$ to $\frac{1}{8}$ inch. A whitish insect larva about $\frac{1}{16}$ inch long develops at the base of the enlarged scale and feeds upon the seed and scale.

Larvæ in Cones, Second Year

Great destruction of cones and seeds occurs the second year. Cones are killed both before and after they reach their full size of about $1\frac{1}{2}$ inches long early in July. Insect larvæ of four or five species of moths are especially active in the cones in June and destroy many cones and seeds in June, July, and August. These whitish to brown larvæ become $\frac{1}{4}$ to $\frac{3}{4}$ inch long. They bore into the green cones, and feed upon the soft tissues of the cone scales and upon the seeds.

A cone attacked by larvæ in June, when it is relatively soft, shrivels somewhat and turns brown. It may remain on the tree as a shrunken dead cone or may fall prematurely. The contents have been reduced to a powdery mass by the insect larvæ. Insect damage to cones attacked later in the season, as in July and August, may be less severe. At this time the tissues of the cone are becoming harder and the hard seed coats are forming. If most or all of the seeds are destroyed by the insect larvæ, the cone usually does not open at maturity but turns brown prematurely. Holes made by the larvæ and excessive secretions of resin are external evidences of insect work. If only part of the cone and seeds are destroyed, the cone may bear some normal seeds and open some scales at maturity.

For the most part these larvæ are caterpillars of pine cone moths (*Eucosma bobana* Kearf. (?); Olethreutidæ). A few cones collected from the trees at maturity in September on the Lincoln National Forest, Otero County, New Mexico, were found to contain, among the scales, brown pupa cases about $\frac{3}{8}$ inch long, when the seeds were extracted in the laboratory in November. The following May small gray moths about $\frac{3}{8}$ inch long emerged in the laboratory. A chrysalis was found in one cone early in July.

Caterpillars were collected of two or three additional species of pine cone moths (two species of *Dioryctria* and apparently a

third species of a different genus of the same family; Phycitidæ). To a certain extent these larvæ attack both tips of young shoots and the developing cones. The pine tip moth of pinyons is a species of *Dioryctria* also. In one instance where a bag was placed over a twig in cross-pollination studies, later examination showed that the tip of the twig and a second-year cone had been killed by the same larva.

Larvæ of small weevils (*Conotrachelus* sp.; Curculionidæ) are common and destructive in pinyon cones in June and July. Several small white maggots less than $\frac{1}{8}$ inch long (*Oscinella* sp.; Chloropidæ) were found in insect-infested cones in August and September. A few specimens of braconids (*Apanteles* sp.; Braconidæ), parasitic on lepidopterous larvæ, were found in infested cones. Eggs of assassin bugs of an undetermined species (Reduviidæ) were collected on scales of mature cones in September on the Lincoln National Forest.

Cone Beetles in Cones, Second Year

Pinyon cone beetles (*Conophthorus edulis* Hopk.; Scolytidæ) are very destructive to the cones the second year but apparently do not cause as much damage as the caterpillars. The adults, small dark brown beetles less than $\frac{1}{8}$ inch long, are active in the cones in June and July. They were observed to enter cones by boring into the stalk at the base. These beetles tunnel through the cone tissues and seeds and kill the cone. A cone with contents destroyed by pinyon cone beetles dies and turns brown early and does not open its scales in autumn. Usually work of pinyon cone beetles can be recognized by the presence of several small round holes about 1/32 inch in diameter formed on the outside of the cone when the beetles emerge. This species has been recorded on pinyon in Colorado, New Mexico, and Arizona (*2*, p. 115; *6*, p. 16).

Insects in Staminate Cones

The great numbers of staminate cones, or male cones, which produce enormous quantities of pollen each year, are infested by numerous insects also, though the damage is relatively unimportant. Some staminate cones, a small portion of the total, become transformed into insect galls, oval-shaped structures $\frac{1}{8}$ inch or more in length, each containing a white, undetermined

larva more than $\frac{1}{16}$ inch long. Larvæ were detected in buds as early as September, but the galls are not visible externally until the next spring, when the cones become exposed. The adult emerges a week or two before the time the staminate cones mature and shed pollen, about the middle of June at the Walnut Canyon plot. In a second unidentified species (possibly a gall midge; Cecidomyiidæ) forming galls from the staminate cones, the adult insect emerges earlier, about the last of May, when these cones and enclosing scales are less than $\frac{1}{8}$ inch long.

Numerous inconspicuous white larvæ, about $\frac{3}{16}$ inch long, of xyelid sawflies (*Xyelia* sp.; Xyelidæ) are found inside the staminate cones just before maturity. They feed upon the pollen without reducing the quantity noticeably. These larvæ crawled out of the staminate cones in large numbers when the twigs bearing clusters of these cones, collected for samples of pollen, were spread out to dry. The specimens exhibited evidence of attack by at least four species of parasites, two ichneumonids, a chalcidoid, and a dipteron. *Xyela minor* Nort. is said to feed on the staminate cones of pine (*2*, p. 341).

Western thrips (*Frankliniella occidentalis* (Perg.); Thripidæ), minute blackish insects about $\frac{1}{16}$ inch long, are common on the staminate cones at maturity, and apparently feed upon the pollen. A slightly larger, predaceous thrips (*Leptothryps* sp.; Phloeothripidæ) was collected on staminate cones also.

PRACTICAL ASPECTS

Aspects of insect infestation of pinyon that merit practical attention include damage caused, possibilities of control, and bearing on crop prediction.

Certain insects attacking the foliage, particularly scale insects, and bark beetles commonly kill a few trees and in occasional epidemics kill a considerable number of the trees over large areas of forest. Bark beetles normally destroy only a few weakened trees, which probably are not good bearers of nuts, and their epidemics usually subside within a year or two. It is doubtful that control of these insects would be practicable in most instances.

The greatest economic losses are caused by insects which attack the cones and seeds (but do not kill the trees). For such insects no feasible means of control has been devised, and in any event

it appears improbable that control operations would be economically justifiable under forest conditions. However, it is possible that, when the best pinyon nut producing woodlands have been placed under intensive management, practical measures will be developed for controlling such insects on small areas of woodland.

It does seem desirable to make some allowances for probable destruction of cones and seeds by insects, when predictions or estimates of the pinyon nut crop are made a few months or longer in advance. At least a few young cones are formed by some trees in a locality each year, though in most years a particular locality has no commercial pinyon nut crop. When only a few cones begin development, mortality is proportionately high and the cone crop at maturity is a failure. Insects kill nearly all the cones of a light cone crop and destroy a smaller proportion of a heavy cone crop. Thus, if it is poor at the end of the first year, the cone crop almost certainly will be a failure at maturity a year later because of insect damage and other losses, such as blighting of seeds. Obviously, a commercial pinyon nut crop is not produced unless the total number of cones beginning development has greatly exceeded the number destroyed by insects before maturity and the total number of nuts ripening has greatly exceeded that eaten or stored by rodents before the crop could be harvested by humans.

SUMMARY

The insects observed on pinyon (*Pinus edulis* Engelm.) in Arizona and New Mexico along with research on pinyons by the author from 1937 to 1941 are discussed. Field work was centered at an experimental plot about 12 miles east of Flagstaff in northern Arizona.

Among the more injurious insects on the foliage are two scale insects, the pinyon needle scale (*Matsucoccus acalyptus* Herbert) and the pine needle scale (*Chionaspis pinifoliæ* (Fitch)), which kill a few trees or more in epidemics.

Of the insects in the bark, the Arizona five-spined engraver (*Ips lecontei* Sw. and related species) is most destructive. Though generally only a few weakened trees are attacked, numbers of trees are killed over large areas in infrequent epidemics lasting only a year or two.

Insects in the cones and seeds of pinyons are, of course, those of greatest economic importance, even though they do not kill the trees, because the edible seeds or pinyon nuts are the most valuable product. Larvæ of unidentified gall midges (Cecidomyiidæ) kill many cones the first year, and caterpillars of pine cone moths (*Eucosma bobana* Kearf. (?) and two species of *Dioryctria*), larvæ of small weevils (*Conotrachelus* sp.), and pinyon cone beetles (*Conophthorus edulis* Hopk.) destroy numerous cones and seeds the second year. These insects together kill nearly all the cones of a light cone crop and destroy a smaller proportion of a heavy cone crop.

Control measures probably would not be economically justifiable under forest conditions, but it is possible that methods may be developed later for small areas under intensive management for pinyon nut production. As insects destroy a very high percentage of the cones when the number of cones is small, some allowances for probable losses should be made every year when advance estimates of the pinyon nut crop are made.

LITERATURE CITED

1. BLACKMAN, M. W. The genus Pityophthorus Eichh. in North America: A revisional study of the Pityophthori, with descriptions of two new genera and seventy-one new species. N. Y. State Col. Forestry, Syracuse Univ., Tech. Pub. 25: 1–183, illus. 1928.
2. DOANE, R. W., VAN DYKE, E. C., CHAMBERLIN, W. J., AND BURKE, H. E. 1936. Forest insects. 463 pp., illus. New York and London.
3. ESSIG, E. O. 1926. Insects of western North America. 1035 pp., illus. New York.
4. FELT, EPHRAIM PORTER. 1917. Key to American insect galls. N. Y. State Mus. Bul. 200. 310 pp., illus.
5. KEEN, F. P. 1928. Insect enemies of California pines and their control. Calif. Dept. Nat. Resources, Div. Forestry Bul. 7. 113 pp., illus.
6. ————. 1938. Insect enemies of western forests, U. S. Dept. Agr. Misc. Pub. 273. 209 pp., illus.