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The Snowy Tree Cricket

Its Injury to Prunes and Methods of Combating It

By

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THE SNOWY TREE CRICKET

ITS INJURY TO PRUNES AND METHODS OF COMBATING IT

CLAUDE WAKELAND

Summary

The snowy tree cricket is known to have been damaging prunes in Idaho since 1912. For a number of years loss from it was confined almost entirely to two small localities, but in 1921 it attracted considerable attention in the Boise-Payette valleys and during the years 1923-1924 it was the chief insect enemy of prunes in southern Idaho.

Adult crickets deposit their eggs in the bark of prune limbs in the late summer and fall. About June 1 the following year, eggs hatch and nymphs feed on prune leaves and green cover crops in the orchard. The adult stage is reached from July 20 to September 1. Injury to leaves becomes easily noticeable about the middle of July and the crickets continue to feed on the leaves until about August 1. After that date they begin to attack the fruit and direct loss of prunes often becomes very heavy. Indirect loss due to lowering of commercial grades, expense of sorting out damaged fruits, fruit spoiled in storage or in transit to market and lessened demand for fresh prunes is often so heavy as to render profitable production impossible.

Injury to leaves is of slight importance and is caused mainly by nymphs, but both nymphs and adults cause damage to the fruit.

The snowy tree cricket lives on a number of cultivated trees and shrubs and on wild shrubs, herbaceous plants and weeds. It is a pest of prune and not of apple, probably because of a difference in the bark of the two species—the bark of prune affording a favorable place to deposit eggs—and because the repeated applications of arsenical sprays to apple trees doubtless prevents it from surviving in large numbers.

Another species that attacks prunes in Idaho is known as the four-spotted tree cricket. It is of relatively small importance and can be readily distinguished from the snowy tree cricket by a difference in color, marking, egg laying and song.

Crickets feed on leaves before they attack the fruit and they destroy a large area of leaf surface in proportion to the material consumed. They can be controlled at reasonable expense by applications of lead arsenate spray or calcium arsenate dust after injury to leaves becomes freely apparent. Choice of spraying or dusting depends on

area to be treated and machinery available. One poison application, properly timed, will almost completely eradicate the tree crickets from a prune orchard and will prevent loss entirely for the season. The insects increase slowly and control measures probably will not have to be repeated for a period of several years.

Economic Importance of Tree Crickets

An exhaustive study of tree crickets has been made by P. J. Parrot and B. B. Fulton of the New York Agricultural Experiment Station and their findings are published in Bulletin No. 388, "Tree Crickets Injurious to Orchard and Garden Fruits." Concerning economic importance they say:

"The tree crickets derive their economic importance largely from their predatory habits, in subsisting upon other forms of insect life, and from their injurious work upon various cultivated crops. They are also suspected of acting as carriers of various plant diseases. Many writers upon these insects have commented upon their carniverous tendencies, and from this standpoint alone some have concluded that the tree crickets are beneficial rather than inimical to the farmer. The fondness of various species of these insects for plant lice is well known, and when these occur in abundant numbers they constitute an important item in the diet of the crickets. Bruner has noted the predaceous habits of *latipennis* and states that it feeds on saw-flies, leaf hoppers and tingitids. Conspicuous constituents in the food of tree-inhabiting species, as *niveus* and *angustipennis*, are scale insects. An examination of the crop contents of a number of specimens of *niveus* from an apple orchard infested with San Jose scale has revealed the presence of varying numbers of pygidia of this coccid which were intermingled with numerous fragments of plant tissues and bristles, pieces of chitin, etc., of larger insects. Unquestionably many other kinds of insects aside from those mentioned fall as prey to these crickets. The actual importance of tree crickets in this role deserves more careful consideration, but on the basis of our studies it appears that their beneficial services have, in the main, been over-rated because of their relatively small numbers in comparison with other groups of predaceous and parasitic insects.

"Their status as depredators on cultivated plants is more clearly understood. . . . Certain species have attained some distinction because of their depredations on various fruits. Garman has observed *niveus* and *angustipennis* feeding on ripening plums and peaches (Fig. 1) and *latipennis* on grape clusters. The attacks of the latter species were considered especially injurious, as the rupturing of the epidermis of the fruits apparently facilitated the spread of black rot. Wounds in the

other fruits also became centers of infection with brown rot. Saunders of Canada has likewise noted the destructive capacities of these insects in a similar role. Mally of Cape Town, South Africa, states that an apparently indigenous species, *capensis* Sauss., has become quite troublesome in peach orchards because of the small, round, surface wounds in peaches especially grown for exportation..... Both *niveus* and *angustipennis* have also been observed to feed on the foliage of apple trees, but the consumption of leaf tissues appeared to be small and unimportant."

Mr. T. D. Urbahns reported heavy loss to a crop of peaches in the Sacramento Valley by the snowy tree cricket eating holes in the ripe peaches and causing infection by brown rot. (1)

Economic Importance in Idaho

The snowy tree cricket, *Œcanthus niveus* DeG., is believed to have been causing damage to prunes in southwestern Idaho since 1910 when reports of reliable growers indicate that effects of its feeding were observed. Mention of the insect on prunes in the vicinities of Parma, Payette, and Weiser was made in 1914 in the notes of T. H. Parks at that time extension entomologist for the University of Idaho. Alvin A. Steel, in charge of a large prune orchard at Parma, was the first to associate the injury with the insects he found frequently in his orchard and to have the insects determined by a specialist.

During the period from 1912 to 1924 the snowy tree cricket is known to have been generally distributed in prune orchards in many localities of southwestern Idaho, but prior to 1922 it was of little economic importance except in the Steel orchard and in the Coble orchard near Weiser. In 1920 slight injury was caused to prunes near Boise and Meridian and specimens of the insect were collected in those localities by the writer. The amount of injury caused in 1922, to many orchards in the Boise and Payette valleys and in the Weiser locality, attracted considerable attention. The pest became epidemic throughout the prune growing districts of southwestern Idaho in 1923 and 1924, and in 1923 injury was so widespread and severe that it forced the state Department of Agriculture to make a change in its grading rules for prunes.

Since the publication of the New York bulletin, occasional reference to injury by tree crickets has been made in entomological literature, but in general the damage caused by them has been considered of slight economic importance. Bulletin No. 87 of the Idaho Agricultural Experiment Station, published in 1916, states that young snowy tree

(1) Mo. Bul. Calif. Dept. Agr. 12, 362, 1923.

crickets feed on the leaves of prunes and that adults often eat holes in the fruit. This probably is the first published record of the snowy tree cricket injuring prunes.

Mr. Steel kept careful record in his orchard during the 12-year period mentioned. He estimated that his annual loss averaged 10 percent and that during certain seasons it reached 25 percent. At first the serious injury was confined to this orchard, but in 1923 the insect suddenly became the most injurious enemy of prunes in Idaho. During 1923 and 1924 it was the direct cause of extremely heavy loss to prune growers throughout the infested district. Inspection reports of the Bureau of Plant Industry, state Department of Agriculture, indicate that in 1923 more than 90 percent of all insect damage to prunes was caused by the snowy tree cricket, and Harry Sabin, chief field inspector for the bureau, estimated that the actual loss of commercial fruit in certain orchards exceeded 35 percent.

Loss from snowy tree cricket injury reached its maximum in 1924. Damage was pronounced in nearly all prune orchards in the district mentioned. On August 8, 33 percent of the prunes in one orchard near Boise had been damaged, and conditions grew much worse in the same orchard later in the season. When growers became generally acquainted with the work of the insect many of them recalled injury that had caused them considerable loss and annoyance during former years.

Idaho Italian prunes are of unusually high quality when fresh and are known to "stand up" in shipment better than those from most other districts in the West. For this reason, most of them are shipped as "blue plums" instead of being dried. Statistics gathered by the Idaho Prune Growers' Association showed that three-fourths of all prunes grown and shipped fresh in the United States in 1923 were produced in a district comprising southeastern Oregon and southwestern Idaho.

Kinds and Descriptions of Losses

Losses may be classified generally as direct and indirect. Direct loss results when prunes cannot be placed on the market because of damage from the insect. Indirect loss is due to increased cost of handling, losses in transportation and less advantageous marketing possibilities.

Direct Loss: Prunes that are damaged to the extent that they ripen and fall prematurely or that have to be sorted out and thrown away after picking, must be considered as lost directly through injury by the snowy tree cricket. The percentage of fruits thrown away is frequently very high. The percentage that drops due to cricket injury is often heavy also, but there is no way of obtaining accurate data

since it is impossible to differentiate always between the effects of insect injury and those of drouth, excessive heat, etc. Generally speaking, direct loss is of less importance to the grower than indirect.

Indirect Loss: The cost of sorting out damaged fruits is prohibitive if the extent of injury is very great, and rather than try to grade the prunes so that they may be shipped fresh the entire crop is often taken to the drier. This usually means a much smaller return per ton. Instances are on record where cricket bites have caused a crop of prunes, which could have been shipped fresh at an additional net return to the grower of $15.00 per ton, to be sent to the drier.

The cost of sorting out even a small percentage of cricket-bitten prunes may easily exceed all of the other labor charges of packing. This is also chargeable to indirect loss.

Probably the greatest loss is occasioned by injured prunes which are included in containers destined for distant markets. The inspection laws of the state permit a tolerance of 5 percent in grading prunes. This tolerance is allowed to make grading of farm products practicable for the grower and the shipper. In orchards heavily infested with the snowy tree cricket it is impossible, under commercial conditions, to sort prunes so closely that packed crates will conform with inspection requirements. This fact often throws the entire crop of an orchard into No. 2 grade which must be marketed at a much lower price than the No. 1 grade.

Many punctures, so tiny that they escape the eyes of the sorters, are large enough to admit destructive organisms. For years growers have been forced to accept a reduced price or have taken a loss on prunes that, to their belief, were in good condition when shipped. Commonly they receive word from their brokers or commission firms that fruit has broken down in shipment, and adjustments have to be made when such damaged fruit is received on the market. Buyers likewise have sustained losses on prunes in shipment and have become accustomed to avoiding purchasing the crop from certain localities. In many instances there have been strained business relations and a mutual lack of confidence between buyer and producer when both may have been acting in entire good faith. The knowledge that a shipment contains even less than 5 percent of injured prunes often prevents the grower from shipping to distant markets where he might obtain a better price.

To obtain data on the effect of tree cricket injury to prunes in transit, two "suitcases" (local name for small boxes) were selected at random from a pile of boxes that were ready to be shipped. These were placed in cold storage where they were kept at a temperature of

43 degrees F. for 18 days. They were examined at the end of that time and the data in Table 1 obtained.

TABLE 1.—Percentages of Cricket-Injured Prunes Packed Under Commercial Conditions and Placed in Cold Storage 18 Days.

Box No.	Total Prun's	Cricket Injured		Cricket Injured Developing Mold		Healed Injuries		Soft	
		No.	%	No.	%	No.	%	No.	%
1	335	26	7.76	6	1.79	20	5.97	1	0.29
2	327	62	18.96	35	10.75	27	8.25	20	6.11
Total and Average	662	88	13.35	41	6.27	47	7.11	21	3.20

Prunes designated in Table 1 as "cricket injured" showed damage from slight to extremely severe. Those considered as "developing mold" included all those having cricket punctures in which mold could be discerned. Those designated as "healed" showed cricket bites over which scar tissue had formed and in which no mold was discernible. "Soft" prunes were moldy, unfit for food, and in many cases the tissue was broken down and the juice exuding. Different degrees of injury are illustrated in Fig. 2. It was impossible to tell whether decomposition had started from cricket bites—although there is no doubt that most of it had—so soft prunes are not given as cricket injured.

Time and temperature of this storage approximated those of prunes in iced cars bound for district markets. Of 662 prunes in the suitcases 13.35 percent were cricket injured, 7.11 percent had been bitten but the punctures had healed, 6.27 percent were developing mold in skin punctures, and 3.20 percent were so soft that they were partially or entirely broken down and were spreading disease to other fruits in contact with them. This offers an explanation of why prunes that growers believe to be of good quality often arrive on the market in a damaged condition. Loss of quality has injured the reputation of Idaho prunes and has lessened the demand. This is one reason why buyers have become very careful and may sometimes appear to be overcautious in their purchases.

Hosts and Distribution in Idaho

The snowy tree cricket is generally distributed throughout southern and southwestern Idaho. It occurs, as a pest of the prune, in the Twin Falls district and in the Boise, Payette, Snake River and Weiser valleys. It has been collected on wild vegetation at an elevation of 3,200 feet in Adams County and 50 miles distant from commercial prune orchards. It occurs in greatest numbers on prune trees

but has been collected from apple, grape, Virginia creeper, and raspberry, and from wild rose, choke cherry, and other wild shrubs. In addition, it has been heard chirping in tall poplar trees and in low growing, herbaceous plants. It apparently is capable of existing under a wide range of conditions and on numerous hosts. It has been very abundant and of economic importance only on prunes but it appears likely that it might also affect plums.

Time of Emergence of Nymphs

Authentic dates of hatching of eggs and emergence of nymphs (young crickets) in the Steel orchard were obtained in 1923 with the aid of Mr. Steel. The method was to inclose a prune branch, known to contain numerous live tree cricket eggs, with very fine silk gauze. The gauze did not interfere with natural conditions but it prevented crickets that emerged from escaping and allowed clear vision for the observer. Cages were placed on trees May 20 and examined daily. The first nymphs emerged June 2. In addition to orchard observations, quantities of large prune limbs were cut and placed in cages under out-of-door conditions. In these the first egg hatched June 1 and emergence of nymphs ceased after June 11. Numerous orchard observations in 1924 showed that emergence of nymphs took place the last week of May and the first week of June. Occasional nymphs in the fourth instar period were collected, however, as late as August 27, indicating that a few eggs probably did not hatch until late in July.

Time of Appearance of Adults

A record of the first appearance of adults in orchards was not obtained in 1923, but none was shaken from trees or swept from alfalfa beneath trees prior to August 2. The first adult was observed in 1924 on July 10 and adults were frequently observed by the 25th. It is evident from observations that varying seasonal conditions may cause considerable difference in the dates of transformation of nymphs to adults. The nymphal instars and the adult are illustrated in Fig. 3.

Oviposition

Oviposition takes place, for the most part, from August 20 to September 15 but continues to some extent until late in October or early in November—possibly later during some years—when the last females succumb to cold weather. Eggs are inserted in the soft bark of the larger branches almost entirely on the under side (Fig. 4), and most of the oviposition occurs at night. Egg punctures extend into the bark in a direction diagonal to the surface, and rarely enter the wood.

Females in the act of oviposition were readily observed at night by the use of artificial light. On September 6, 1924, 24 females were observed ovipositing between 8:00 and 9:30 o'clock p. m. Of these, 22 were in a position facing upward and all were on the lower sides of the limbs (Fig. 7). One female observed completed the entire process of oviposition in 15 minutes but others remained immovable with their ovipositors in the bark for a much longer time. Usually the female first chewed in the bark a small, shallow hole the diameter of which was little larger than that of an egg puncture. After the surface was broken she changed her position, extended her ovipositor until it came in contact with the bark, and then moved it around until she found the chewed area. By working the ovipositor and entire abdomen up and down with a twisting motion, she gradually forced her ovipositor its full length into the bark. Usually following this operation, which often appeared to be very difficult, she rested with her ovipositor in place before depositing the egg, which feat was finally accomplished by a series of muscular contractions of the abdomen. After the egg was placed in the bark, she appeared to rest again and then rapidly withdrew her ovipositor. Frequently she was observed to extend it forward beneath her body and clean it off with her mouth parts. After oviposition the females gnawed small bits of bark from the limb at the edge of the puncture and forced them into the opening until it was full. This operation usually required several minutes and was performed with a great deal of care.

Appearance of Egg Punctures in the Bark

Recent egg punctures may be easily distinguished in the fall. They appear then as small, reddish-brown spots (Fig. 5) somewhat raised from the surface of the bark and they present a roughened, "sawdust" appearance caused by the bits of chewed bark that were forced into the egg punctures. Thirty-five newly made egg punctures have been observed in one square inch of bark. During the winter the raised appearance of the punctures is lost, the color becomes darker, and by the time hatching takes place the following spring it is difficult to distinguish between punctures made the preceding fall and those of earlier date. When the bark is scraped lightly, however, exposing the tissue immediately beneath the surface, the punctures of the previous fall are readily distinguished by their fresh appearance and by the narrower, discolored area surrounding them in the bark. New egg punctures are freely interspersed with those of former years or they may be made directly in old ones. The bark becomes depressed and curled around old punctures and the lower sides of limbs in orchards that have been infested for years have a very rough, unsightly appear-

ance (Fig. 6). It has been suspected that the insect may be the means of transmitting disease, providing an entrance for disease organisms through punctures in the bark, but to date no evidence has been collected that appears to lend weight to the suspicion.

Reasons for Abundance in Prune Orchards

It appears that, compared with apple, the prune is a favorite host for the snowy tree cricket because of a difference in the bark of the two trees and a difference in spray practices. The surface layer of apple tree bark is smooth, hard, and thick, and it becomes harder with age. Comparative thickness of bark of the two trees is shown in Fig. 8. The bark on the smaller limbs of the prune is compartively thin and it also offers no suitable place for oviposition unless eggs are inserted into the wood or the pith. The snowy tree cricket is known to deposit eggs but rarely in this manner. The bark on larger limbs of the prune assumes a spongy texture as it becomes older and the surface layer is thinner and much more easily pierced than that of apple. In addition, it is so thick that the egg may be placed in it without coming in contact with the woody tissue. Another factor influencing the comparative populations in apple and prune orchards is the difference in spraying practices. The only spray applied to prune orchards, as a general thing, is the dormant application for control of San Jose scale or peach twig borer while apple orchards receive repeated, heavy applications of lead arsenate which are necessary for control of the codling moth.

Feeding Habits

Definite information concerning the food of very young nymphs has not been obtained in Idaho. They feed to some extent on alfalfa and weeds in the orchard and have eaten alfalfa in cages in laboratory. During June and early July they occur abundantly on cover crops in prune orchards and the population on trees may then be comparatively small. Practically no feeding injury has been discerned on prune leaves before July 15. Injury increases rapidly after that date and the relative abundance of the insects on trees and cover crops becomes reversed.

Adults attack the leaves to a limited extent. An adult is shown feeding in Fig. 9. Most of the feeding on foliage is done by nymphs, and leaf injury is very charactertistic. Nymphs work industriously. First they make a small hole in the epidermis. Apparently it is difficult for them to pierce the epidermis for they return time after time to the same leaf and enlarge the injured area by chewing on the leaf tissue around the edges of it. Nearly all feeding is done on the upper

surface of the leaf where tissue is eaten until the veins are exposed. Feeding areas rarely extend to the lower epidermis.

Feeding was freely observed at night by the aid of an electric lantern. Usually the rear legs of the nymph are extended backward and the abdomen is elevated as shown in Fig. 10. Antennæ move and jerk continuously as the crickets pull and tear at bits of leaf tissue. They feed for short periods of time, remaining motionless at intervals to rest. An eaten area is enlarged from time to time and adjacent areas may be increased in size until they often coalesce (Figs. 11 and 12) and the resulting area covers as much as one-third of the leaf surface. The injury of the snowy tree cricket on prune leaves is readily distinguished from that of the pear slug since the slug makes a smooth, parchment-like area.

Newly injured areas are a lighter green than normal leaf epidermis but soon turn light brown and then dark brown. The remaining tissue in the dark spots becomes brittle and in time cracks and drops out, leaving ragged holes in the leaves. Adults feeding in late summer occasionally cut holes entirely thru the leaves.

Feeding is generally confined to the leaves until the prunes begin to show color or until a few ripen prematurely. The date of this change varies from about July 25 to August 10, depending on seasonal conditions. After crickets start to attack fruit they cease to feed on leaf tissue nearly altogether. A small hole is first eaten thru the skin of the prune, as shown in Fig. 13, and a cavity is dug out beneath. This cavity is frequently enlarged while the skin puncture remains small. When the prune begins to soften it is attacked and eaten freely as illustrated in Figs. 14 and 15. Eaten areas are sometimes extended until they comprise as much as one-fourth of the surface of the prune. Nymphs feed on the prunes to some extent but the maximum injury occurs after most of the crickets have reached the adult stage.

Time of Feeding

Feeding, for the most part, takes place from sundown until about 10 o'clock during the warm nights of late July, August, and early September, and is resumed on warm mornings during that time from shortly after daybreak until sunlight strikes the foliage. During cool or cloudy periods of weather or in the late fall crickets may feed throughout the day. The insects were observed feeding freely on fruit and foliage in the daytime during the warm weather of early August, 1924, when severe injury was at its height, but this is unusual.

Amount of Injury

The injury to leaves is so slight that it is of no economic importance but the fact that leaves are attacked before injury to prunes takes place has important bearing on possible control measures. Examinations of leaves were made in a few infested orchards in the Boise-Meridian district on August 8, 1924, and it was found that from 5 percent to 50 percent had been injured to a greater or less extent at that time. In the same orchards from 14.74 percent to 33 percent of the fruits had been damaged more or less severely. It has been observed that injury usually is greatest on foliage near the outer portion of the tree.

Examinations of prunes at picking time are not truly indicative of the percentage of injury since those damaged early ripen prematurely and drop before harvest time. Data in Table II are of value, however, since they give some indication of the amount of work involved in sorting and grading fruit to meet commercial standards.

TABLE II.—Percentages of Injury to Prunes in Commercial Orchards at Picking Time, 1924.

Date	Orchard	Location	Number Prunes Examined	Percent Cricket Injured
Sept. 2	Paulson	Wilder	2000	6.55
Sept. 9	Hume	"	2000	10.20
Sept. 15	Clayvel	Boise	1500	18.26
Sept. 15	Huistrum	"	1000	1.50 (1)
Sept. 15	Otto Johnson	"	1000	9.30 (2)
Sept. 15	Lafe Boone	"	1000	7.80 (3)
Sept. 15	Noyburg	"	1000	14.70
Sept. 16	McBirney	"	1000	19.60 (4)

(1) Sprayed by the owner in May.

(2) Unpoisoned, nearly all injury recent.

(3) Dusted experimentally. Injury all old, 14.74 percent of the fruit damaged before control was undertaken.

(4) McBirney-Randell orchard. Sprayed with lead arsenate August 5. Cricket bites all healed, no fresh injury.

Number of Crickets per Tree

In estimating numbers of crickets per tree the practice was to spread a large sheet beneath a branch and shake the branch until no more crickets could be dislodged. Those dislodged were counted, the percentage of the tree shaken was estimated and from these data the population per tree calculated. This method is in error because a few crickets are dislodged from other parts of the tree than the branch which is shaken. It is often impossible also to shake a branch vigorously enough to dislodge all the crickets on it. Data presented in this bulletin in relation to control experiments indicate that estimates of tree populations were conservative. Estimated numbers of crickets per tree are given in Table III.

LEGENDS FOR ILLUSTRATIONS

Fig. 1. Tree Cricket Injury: Brown-rot infection of peaches following feeding of a tree cricket *(nigricornis)*. H. Garman, Ky. Exp. Sta. Bul. 116.

Fig. 2. Tree Cricket Injury: Prunes taken from commercially packed prunes after being in cold storage 18 days, in various stages of decomposition due to disease organisms entering fruit thru skin punctures made by snowy tree crickets.

Fig. 3. Life Stages of the Snowy Tree Cricket. Nymphal instars and adult. B. B. Fulton, N. Y. Agr. Exp. Sta. Bul. 388.

Fig. 4. Snowy Tree Cricket Egg. Drawing of an egg in position in the bark showing the puncture as plugged by the female cricket. B. B. Fulton, N. Y. Agr. Exp. Sta. Bul. 388.

Fig. 5. Egg Punctures of Snowy Tree Cricket in Prune Bark. Photograph taken a few days after the punctures were made.

Fig. 6. Egg Punctures in Prune Bark. Photograph made a year or more after punctures were made and showing the scars formed around the old egg punctures.

Fig. 7. Snowy Tree Cricket. Female in act of depositing eggs in bark. B. B. Fulton, N. Y. Agr. Exp. Sta. Bul. 388.

Fig. 8. Bark of Apple and Prune. Cross section showing the greater thickness of prune bark than that of apple on limbs of the same diameter. (a) Apple. (b) Prune.

Fig. 9. Snowy Tree Cricket Feeding. Flashlight photograph in a prune orchard at night. An adult female feeding on a leaf.

Fig. 10. Snowy Tree Cricket Feeding. Flashlight photograph in a prune orchard at night. Characteristic feeding posture of nymph.

Fig. 11. Feeding Injury to Leaf. Small eaten area on leaf surface.

Fig. 12. Feeding Injury to Leaf. Photograph showing eaten areas in the epidermis enlarged until they coalesce.

Fig. 13. Feeding Injury to Prune. Hole eaten thru the skin by a snowy tree cricket with the tissue surrounding beginning to break down.

Fig. 14. Feeding Injury to Prune. Eaten area enlarged after prune has begun to ripen or has become soft.

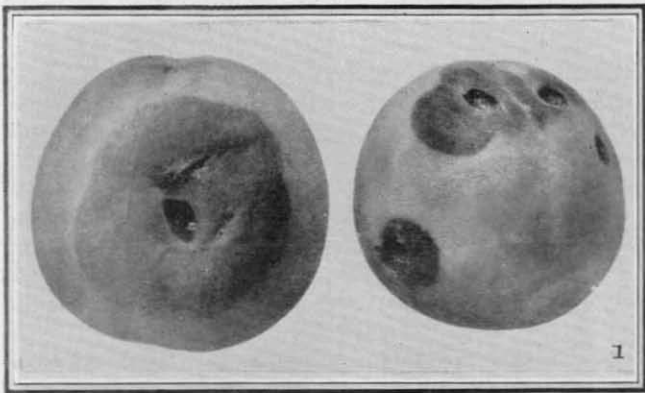
Fig. 15. Feeding Injury to Prune. Fruit shriveled as the result of tree cricket attack.

Fig. 16. Basal Antennal Segments of Tree Crickets Inhabiting Prune Trees. (a) Snowy tree cricket *Œ. niveus.* (b) Four spotted tree cricket *Œ. quadripunctatus.*

Fig. 17. Egg Punctures of the Four Spotted Tree Cricket in Prune Twig. Longitudinal section of year-old growth showing eggs deposited in a series and extending into the central pith.

Fig. 18. Controlling Snowy Tree Cricket. Dusting prune trees with calcium arsenate.

Fig. 19. Controlling Snowy Tree Cricket. Eleven hundred fifty-three dead crickets collected beneath one prune tree five days after dust application. At the expiration of six days 1386 dead crickets had been collected, at which time the orchard was irrigated, preventing further counts.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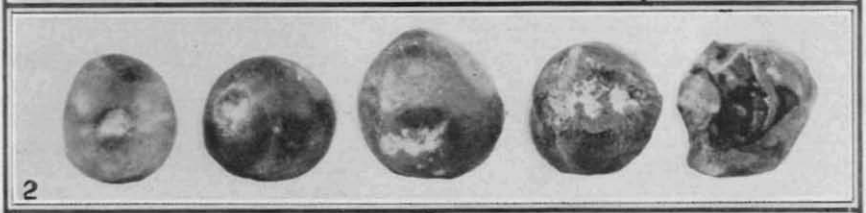
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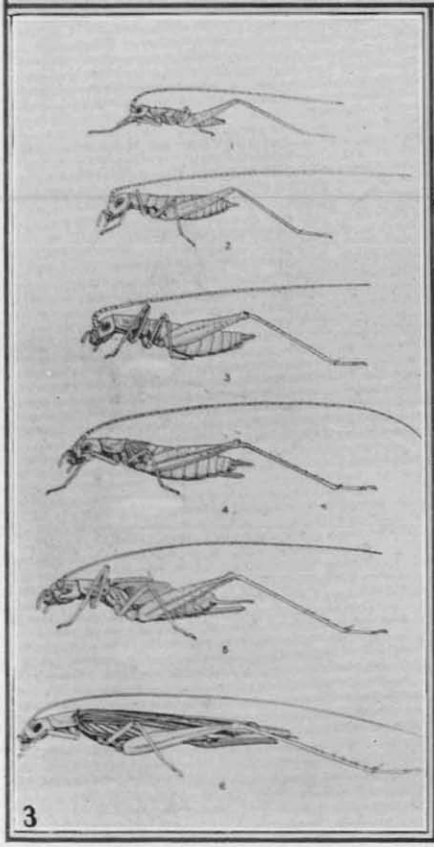
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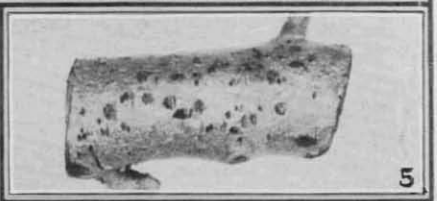
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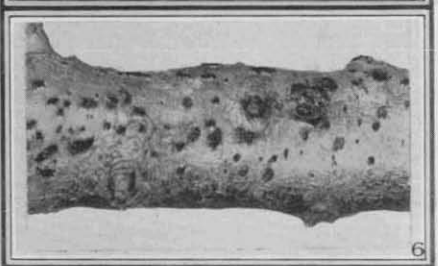
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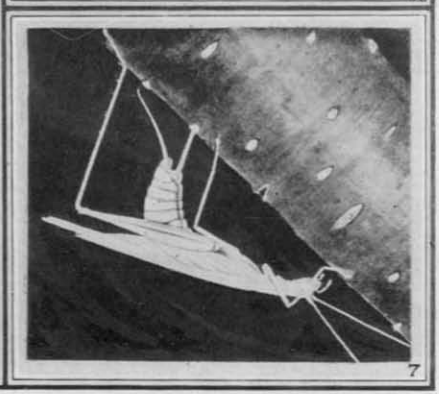
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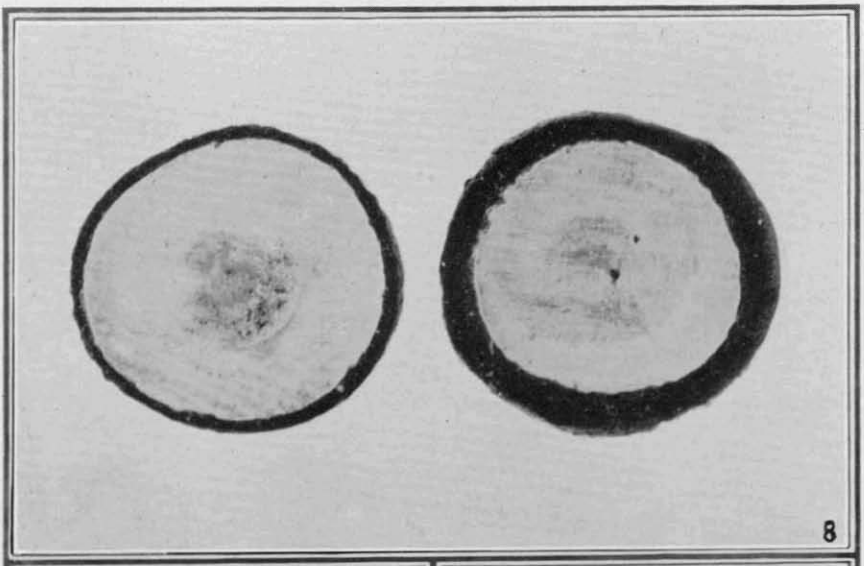

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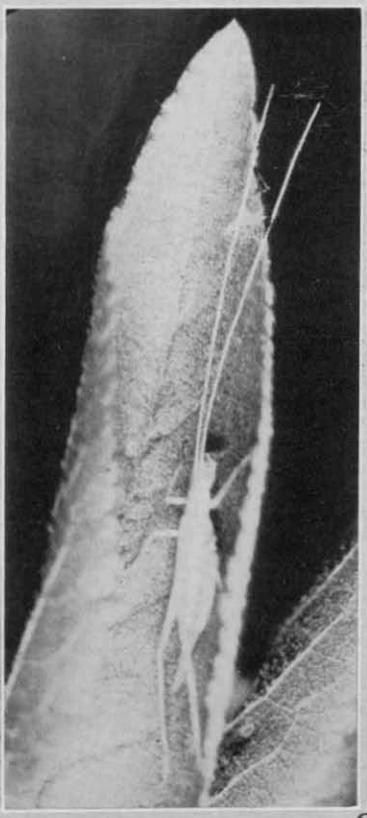

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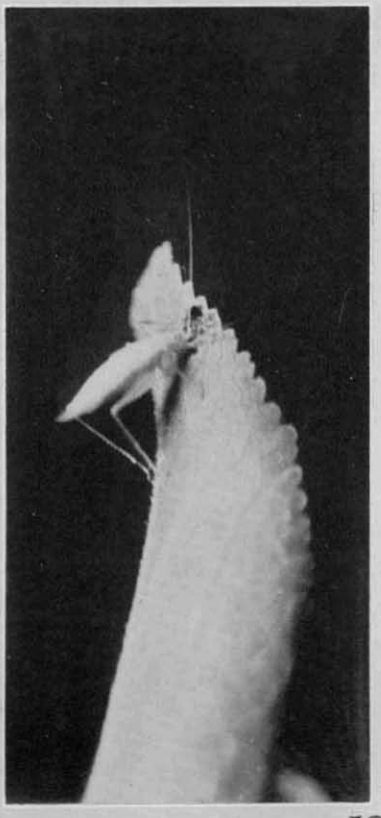

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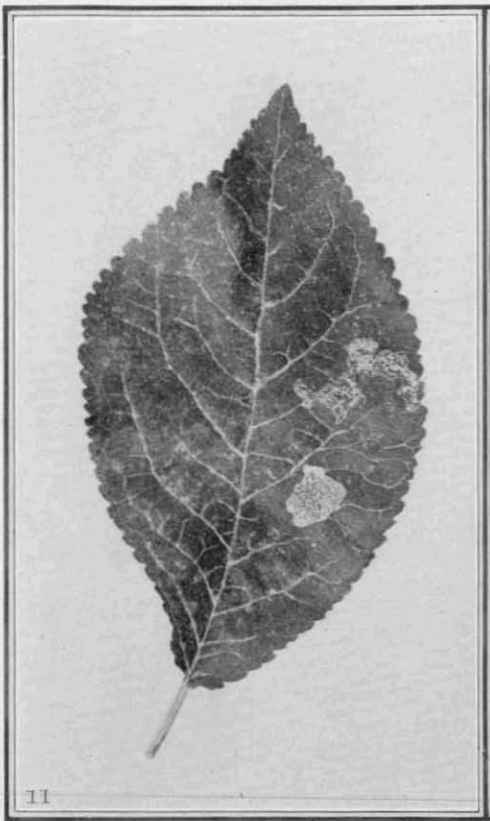

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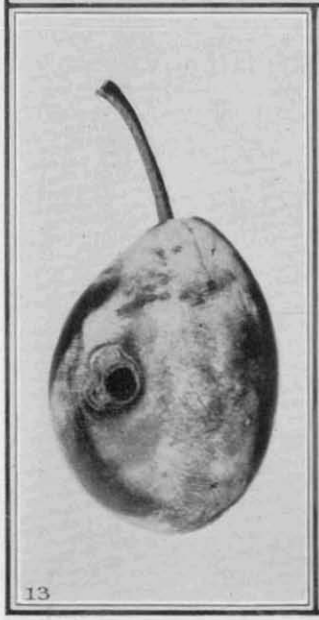

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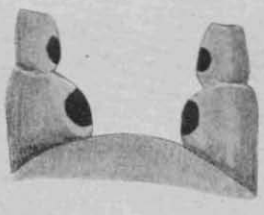

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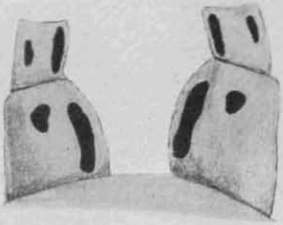

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TABLE III.—Number of Snowy Tree Crickets Per Tree Estimated from Counts Made in Prune Orchards in 1923 and 1924.

Date	Orchard	Location	Estimated Portion of Tree	Number Crickets Dislodged	Estimated No. Crickets Per Tree
Aug. 2, 1923	Idanha	Nyssa, Ore.	1/15	57	855
			1/13	50	650
			1/15	26	390
			1/13	34	442
			1/20	16	320
July 8, 1924	Gavin	Meridian, Ida.			100
					150
July 11, 1924	Humes	Wilder, Ida.			150
					200
July 10, 1924	Paulson	Wilder, Ida.			150
					200
Aug. 8, 1924	Schmitger	Meridian, Ida.	1/7	50	350
Aug. 9, 1924	Boone	Boise, Idaho	1/7	30	210
			1/6	66	396

Species in Prune Orchards

Two species of tree crickets deposit their eggs in prune trees and feed on the fruit and foliage. Feeding injury and control measures are identical but there is a marked difference in range of distribution, in oviposition habits, and in their song, as well as a difference taxonomically. *Œcanthus niveus* is about equally abundant in all parts of an infested orchard while *Œcanthus quadripunctatus* (the four-spotted tree cricket) inhabits prune trees in numbers only where they are adjacent to willows, underbrush and weeds, which grow along ditches, fence rows or on waste land.

Eggs of *niveus* are deposited singly in the bark of large limbs and rarely extend into the wood or penetrate the pith of the smaller twigs. Eggs of *quadripunctatus* are laid in a series with the row usually extending longitudinally although rows are observed occasionally which twist around the twig in a partial spiral. *Quadripunctatus* oviposits in small twigs, for the most part in growth of the previous season, although a few eggs are inserted in the new growth. Egg punctures of this species extend through the bark into the central pith.

There is a distinct difference in the song of the two species. Quoting from New York Experiment Station Bulletin No. 388: "The song of *niveus* is one of the most conspicuous and musical of the insect sounds commonly noted in the late summer and autumn. It can be heard from the time insects commence to mature until they succumb to the frosts of late October or early November. The song begins at the approach of darkness and continues until morning. Occasionally a few of the insects may be heard during the middle of the day when the weather is very cloudy. The song consists of a monotonous series of clear, high-pitched trills rhythmically repeated for an indefinite length

of time. The quality is that of a clear, mellow whistle and has been best described by the words, *treat-treat-treat.* The pitch varies somewhat with the temperature but on an ordinary summer evening it is about C, two octaves above middle C, or on a warm evening it may reach as high as D. The rapidity of the notes is directly dependent on the temperature. On a very warm night we counted 155 beats per minute, while on a cool night the number was only 64.

"The song of different individuals may vary also in quality, intensity, pitch and rapidity of notes. There is, however, a tendency for the insects in a restricted site—as a raspberry plantation, clump of bushes or a single tree or a small clump of trees—to sing in unison in one synchronous movement."

The above description also applies to the song of *niveus* in Idaho with the exception that singing abates partly or entirely after about 10 or 11 o'clock at night, even during August. This difference is due probably to the fact that the nights are cooler in Idaho. It was determined that the pitch of the song of *niveus* in southwestern Idaho ranges from C-sharp to D, two octaves above middle C. The frequency of notes varied, during the early evening of August 18, 1924, from 127 to 141 chirps per minute and gradually became less until at 10:30 chirping had nearly ceased and notes came at very long intervals in a low, toneless rasp. The "song" of the tree cricket is produced by the mature males and is made by elevating the front wings vertically and rapidly rasping them together from side to side.

The song of *quadripunctatus* consists of a continuous whir that ceases only at long intervals, and in pitch it is from two to three halftones higher than that of *niveus.* The four-spotted tree cricket sings in the daytime more than the snowy tree cricket, but like the latter insect it also sings at night more than during the day. Orchardists who have had no damage from snowy tree crickets may determine whether they are present in the their orchards in small numbers by listening for their song on warm nights in the late summer.

Means of Distinguishing Species of Tree Crickets Infesting Prune Trees

A. Snowy Tree Cricket (*Œ. niveus* De Geer):

1. *Antennæ:* Basal segments of antennæ with a swelling on the front and inner side. First and second segments each with a single black mark. (Fig. 16a.) General color light cream, sometimes light brown at tip.
2. *Legs:* Cream colored or pale yellow.
3. *Egg Punctures:* Made singly in the bark, mostly on under sides of larger limbs. (Fig. 5.)
4. *Song:* High-pitched trill, rhythmically repeated.

B. Four-Spotted Tree Cricket (*Œ. quadripunctatus* Beut.):

1. *Antennæ:* Basal segment of antennæ without a swelling on the front and inner side. First and second segments each with two black marks (Fig. 16b). General color light brown.
2. *Legs:* Light brown, tarsi dark brown.
3. *Egg Punctures:* Made in rows mostly in year-old wood and small twigs. (Fig. 17.) Punctures extend through bark and into the pith.
4. *Song:* Continuous whir, pitched higher than chirps of *niveus*.

Control Experiments, 1923

Experiments in control of the snowy tree cricket were undertaken in a restricted way in 1923. Fifteen cages were prepared and kept in an out-door insectary and 20 tree crickets were placed in each cage. Insects in each cage were allowed their choice between poisoned and unpoisoned prunes and prune leaves. Results of these experiments are shown in Table IV.

TABLE IV.—Results of Poison Tests for Snowy Tree Crickets in Cage Experiments, 1923.

Poison Used	Cage No.	No. Crickets Dead										Total
		No. Days After Poisoning										
		1	2	3	4	5	6	7	8	9	10	
Dusted with calcium arsenate, undiluted	1	4	6	10								20
	12	2	5	3	0	8	2					20
Dusted with lead arsenate, undiluted	2	3	4	4	0	9						20
	10	0	1	2	3	2	3	4	5			20
Sprayed with calcium arsenate 4 pounds in 100 gallons water	3	4	1	9	3	3						20
	13	0	3	0	2	8	7					20
Sprayed with lead arsenate 4 pounds in 100 gallons water	4	0	2	7	1	8	2					20
	11	1	4	2	1	3	1	1	2	4	1	20
Sprayed with calcium arsenate 4 pounds in 100 gallons water Sweetened with sugar beet molasses	14	4	5	6	4	1						20
Sprayed with lead arsenate 4 pounds in 100 gallons water Sweetened with sugar beet molasses	15	3	1	1	3	7	4	1				20
Unpoisoned Used as checks	6	2	0	5	0	0	0	0	0	0	0	7
	7	3	3	7	0	0	0	0	0	0	0	13
	8	2	3	3	1	0	0	0	0	0	0	9
	9	4	3	4	1	0	0	0	0	0	0	12
	16	0	1	2	0	1	1	0	0	1	3	9

Cages 1-4 inclusive poisoned August 7.
Cages 10-15 inclusive poisoned August 20.

Interpreting Table IV., we note the following results for the different treatments:

Calcium arsenate dust:
Cage 1. Crickets dead after three days....100% Check 40.87%
Cage 12. Crickets dead after six days.....100% Check 25%

Calcium arsenate spray:
Cage 3. Crickets dead after five days.....100% Check 41.12%
Cage 13. Crickets dead after six days.....100% Check 25%

Calcium arsenate spray, plus molasses:
Cage 14. Crickets dead after five days.....100% Check 20%

Lead arsenate dust:
Cage 2. Crickets dead after five days.....100% Check 41.12%
Cage 10. Crickets dead after eight days....100% Check 25%

Lead arsenate spray:
Cage 4. Crickets dead after six days.....100% Check 41.25%
Cage 11. Crickets dead after ten days.....100% Check 45%

Lead arsenate spray, plus molasses:
Cage 15. Crickets dead after seven days....100% Check 25%

Both of the arsenicals tested were effective in killing the snowy tree cricket under laboratory conditions but calcium arsenate produced results more quickly. Likewise each of the arsenicals produced a more complete kill when used as a dust than as a spray although experiments were not extensive enough to justify definite conclusions. The high death rate of crickets in the check cages which contained no poison is explained by the fact that they are extremely cannibalistic, and numbers cannot long be kept alive under laboratory conditions unless they are caged separately.

In the orchard one tree was dusted with undiluted calcium arsenate by means of a hand duster on August 2, 1923. A light breeze from the north carried some of the dust to the foliage of an adjacent tree. After a lapse of three days 68 dead crickets were collected beneath the dusted tree and 44 were collected under one-half of the tree adjacent. This test gave evidence that dusting might be effective under orchard conditions and that numerous crickets might succumb to the effects of dust that drifts with the breeze. Examinations following dust applications were made but once daily and doubtless there were many more dead crickets than those actually counted, since large numbers of ants in the orchard were quick to find the dead insects and to devour them or carry them away. The experiment was repeated August 10, using calcium arsenate dust on tree No. 1 and lead arsenate on tree No. 2. Tree No. 3 was selected as a check at some distance from

the dusted trees and was not dusted. The effect of arsenical dusts under orchard conditions is shown in Table V.

TABLE V.—Results of Poison Tests for Snowy Tree Cricket in Orchard Experiments, 1923.

Date Dusted	Date Examined	Number of Dead Crickets		
		Tree 1	Tree 2	Tree 3
August 10	August 12	12	5	1
	13	24	5	0
	14	12	1	1
	15	5	5	2
	16	3	8	2
	17	4	4	2
	18	0	4	0
	19	0	0	0
	Total	60	32	8
		Number of Live Crickets		
Trees shaken August 20		2	4	57

Results of preliminary experiments under orchard conditions indicated that arsenicals were effective and that calcium arsenate dust was more effective than lead arsenate dust.

Control Experiments, 1924

Results of preliminary experiments in 1923 led to the belief that arsenicals might be used successfully in the control of the snowy tree cricket after it had begun to feed on the leaves and before it attacked the prunes. Extensive tests were made in the use of dusts and liquids in the Paulson and Hume orchards at Wilder in 1924. The degree of infestation was about equal in both orchards but the Hume orchard was in clean cultivation while the Paulson orchard was in dense alfalfa cover crop. There is evidence that tree crickets live on green plants beneath the trees and it was thought possible that prunes, when ripening, might be injured by crickets which migrate from the cover crop after poisoning has killed those feeding on the leaves. Duplicate experiments were made in the two orchards in order to determine this point. Plots were so large that the effect of "drift" of dust was eliminated on the trees selected as count trees.

Dust applications were made with a Dosch crop duster driven by a Cushman four-horsepower engine. Dust was distributed in a continuous "stream" through a 4-inch delivery tube. One man acted as driver and one held the delivery tube and directed the dust stream as shown in Fig. 18. The team was driven at a steady pace and the dust applied to two sides of each row. Trees in these orchards are spaced 20 feet apart. Atmospheric conditions were nearly ideal but, even so, the drift of calcium arsenate was easily discernible four rows away

from the one to which application was made. A careful record as shown in Table VI was kept, from which calculations of costs of dust applications were later made.

TABLE VI.—Kinds and Amounts of Material Used, Number of Trees Dusted, and Time Consumed in Orchard Dusting Experiments July 24-30, 1924.

Material Used	Plot No.		Trees	Pounds Poison Used	Minutes Consumed in Dusting
	Clean Culture	Cover Crop			
Dow calcium arsenate undiluted	1		117	62.56	59
Double application		4	189	136.61	115
Dow calcium arsenate undiluted	4		149	30.69	38
Single application		3	710	254.89	218
Dow calcium arsenate 50%	2		543	133.00	96
Hydrated lime 50%		2	535	119.50	117
Dow calcium arsenate 20%	3		396	58.50	80
Hydrated lime 80%		1	509	63.60	150
	9		451		
Checks, untreated		9	104		
		10	223		

Other plots were sprayed with lead arsenate and with nicotine sulfate as shown in Table VII. A Bean Duplex sprayer was used with one lead of hose equipped with a Myers spray gun. A pressure of 200 pounds was maintained.

TABLE VII.—Kinds and amounts of materials used and number of trees sprayed in orchard spraying experiments in Paulson and Hume orchards July 24-30, 1924.

Material Used	Plot Number		Trees
	Clean Culture	Cover Crop	
"Blackleaf 40" 1 quart, laundry soap 4 lbs.,	5		45
in 200 gallons water, foliage drenched		7	47
Grasselli lead arsenate, 8 lbs.,	6		45
water 200 gallons		5	43
Grasselli lead arsenate, 4 lbs.,	7		45
water 200 gallons		6	38
Grasselli lead arsenate 4 lbs., sugar beet molasses 2 gallons, water 198 gallons. Coarse spray applied lightly to outside leaves	8		45
Grasselli lead arsenate ½ lb., sugar beet molasses 2 gallons, water 20 gallons. Spray applied in coarse drops at 20 lbs. pressure, team walking continuously at slow pace		8	19
	9		451
Checks, unsprayed		9	104
		10	223

It was not possible on August 8 to find live tree crickets in any of the plots sprayed with arsenicals. Doubtless there were a few, but owing to their scarcity they could not be observed or shaken from the

trees after continued effort. Their absence was further shown by the fact that, with a single exception, no males were heard singing at night in any of these plots while numbers of them were chirping in the check plots and in those sprayed with nicotine sulfate.

Table VIII gives the percentages of sound fruits in the dusted and sprayed plots at picking time.

TABLE VIII.—Percentages of sound fruits in the dusted and sprayed plots at picking time. Paulson and Hume orchards. Examinations made September 1-12, 1924.

Plot No.		No. Prunes Examined	Prunes Injured				Percent Prunes Sound
			Healed Injured		Recent Injured		
Clean Culture	Cover Crop		No.	%	No.	%	
1		2000	10	0.50	0	0	99.50
	4	2000	3	0.15	0	0	99.85
2		2000	6	0.30	0	0	99.70
	2	2000	9	0.45	0	0	99.55
3		2000	0	0.00	0	0	100.00
	1	2000	21	1.05	0	0	98.95
4		2000	4	0.20	2	0.10	99.70
	3	2000	8	0.40	0	0	99.60
9	Check	2000	56	2.80	148	7.40	89.80
Check	10	2000	105	5.25	26	1.30	93.55
Check	9	2000	40	2.00	87	4.35	93.65
5		2000	27	1.35	40	2.00	96.65
	7	2000	32	1.60	18	0.90	97.50
6		2000	8	0.40	2	0.10	99.50
	5	2000	6	0.30	0	0	99.70
7		2000	12	0.60	12	0.60	98.80
	6	2000	12	0.60	1	0.05	99.35
8		2000	12	0.60	0	0	99.40
	8	2000	18	0.90	19	0.95	98.15
Row 11		2000	18	0.90	0	0	99.10
Row 30		2000	0	0.00	0	0	100.00
Row 44		2000	3	0.30	1	0.10	99.60

Rows No. 11 and No. 30 were not poisoned but the adjacent rows on both sides were included in dusted plots. Row No. 44 was adjacent to a check plot and was two rows removed from a dusted plot. The only poison these rows received drifted from the plots dusted with calcium arsenate yet the control of tree crickets was as satisfactory as on most of the plots given heavy dust applications.

The orchards mentioned above were believed to be infested to about the same extent as others examined near Boise and Meridian and were chosen because they could be visited oftener and given closer attention. As indicated by data on the check plots, injury did not become extremely severe in the experimental orchards, but reports from the

Boise-Meridian district were that damage was being done to an alarming extent. In company with M. L. Dean and Leonard Fenn of the state Department of Agriculture, the writer made a trip of inspection to those districts. A survey showed that injury was much more severe and the number of crickets per tree much greater than at Wilder. Damage had been done to 14.74 percent of the prunes in the Lafe Boone orchard and insects were still eating leaves freely as was indicated by the fact that of the feeding areas on the leaves examined 18 percent were very recent. The estimated population per tree ranged from 210 to 396. Even though severe injury had already been done there was opportunity for testing the effects of arsenicals under extreme conditions. The dusting machine was rushed to the Boone orchard and applications of calcium arsenate dust were made on August 10 and 11, about 20 days too late to afford complete protection to the crop. Trees were 35 years old, very large, and had at least twice the leaf surface of those dusted at Wilder. One thousand and eight trees were dusted with 350 pounds of calcium arsenate, an average of 0.347 pound per tree. Following the dust application the dead tree crickets were collected from beneath three of the poisoned trees. Table IX shows the numbers killed per tree.

TABLE IX.—Numbers of crickets killed per tree in dusting experiments in the Boone orchard, 1924.

Tree No.	Poison Used	Date Examined	No. Dead Crickets Collected on Ground Beneath Tree	Total Dead
1	Calcium arsenate undiluted	Aug. 13	306	505
		Aug. 14	100	
		Aug. 15	43	
		Aug. 16	25	
		Aug. 17	20	
		Aug. 18	11	
2*	Lead arsenate spray 8 lbs. 200 gallons water	Aug. 14	337	337
3	Calcium arsenate dust undiluted	Aug. 15	1153	1386
		Aug. 16	233	

* Part of the orchard in which tree No. 2 was located was sprayed by the owner August 5 upon the suggestion of the Experiment Station.

Dead crickets were very abundant beneath all trees in the orchard after dusting, and count trees were selected at random. The orchard was in clean cultivation and the soil had been recently packed by irrigation so that crickets were readily observed on the surface. Many which were destroyed by ants and birds and dried up in the heat, were doubtless not included in the count, but even so the number per tree (See Fig. 19) was determined to be greater than had been estimated from counts of crickets shaken from limbs. Destruction of tree

crickets in the Boone orchard was so nearly complete that none could be shaken from the trees 10 days after dust applications were made and no singing whatever was heard at night. These results were accomplished after many of the crickets had reached the adult stage.

Comparative Costs, Spraying and Dusting

The operation of a power spray machine with two leads of hose or of a power duster requires the labor of two men and one team. Under practical field conditions, taking into consideration the time lost in filling the dust hopper, 2,000 prune trees may be dusted from two sides or 4,000 from one side in a 10-hour day. About 500 trees are usually sprayed in the same length of time. Figures in Table X are based on this calculation, with man labor worth $3 per day, team labor $2 per day, calcium arsenate 17c per pound, lead arsenate 24c per pound, and hydrated lime 2c per pound. (1924 prices.)

TABLE X.—Costs of dusting and spraying calculated from data collected in orchard experiments, 1924.

Material Used	Pounds Material Used Per Tree			Cost Per 100 Trees		
	Calcium Arsenate	Lead Arsenate	Hydrated Lime	Material	Labor	Total
Calcium arsenate, undiluted, double application	0.628	0	0	$10.676	$0.375	$11.051
Calcium arsenate, undiluted, single application	0.282	0	0	4.79	0.375	5.169
Calcium arsenate, undiluted, single application to but one side of row	0.141	0	0	2.397	0.187	2.584
Calcium arsenate, 50% Hydrated lime, 50%	0.234	0	0.234	4.446	0.375	4.821
Calcium arsenate, 20% Hydrated lime, 80%	0.136	0	0.540	3.392	0.375	3.767
Lead arsenate, 4 lbs. in 100 gals. water; 5 gals. spray per tree		0.10		2.400	2.65	5.05
Lead arsenate, 4 lbs. in 100 gals. water; 3 gals. spray per tree		0.06		1.440	1.59	3.03
Lead arsenate, 8 lbs. in 100 gals. water; 3 gals. spray per tree		0.12		2.880	1.40	4.28
Lead arsenate, 8 lbs. in 100 gals. water; 5 gals. spray per tree		0.20		4.800	2.69	7.45

Choice of Dusting and Spraying

Selection of the best method of control under practical field conditions depends upon a number of factors. Tests of dusting indicate that dispersion of dust is sufficient for effective control where the dust

is directed into a tree from but one side and results of extensive commercial dusting have shown that this method is entirely effective. In dusting, the labor cost is small but in spraying that item comprises the major portion of the expense. A power duster costs less than a power sprayer, is more simple to operate, will last much longer and will protect as many acres of prunes as eight spray machines. Another factor that argues in favor of dusting is that almost all of the cricket injury on prune leaves is on the upper surfaces and the insects eat more freely on the foliage on the outside of the trees than in the centers. The natural habit of the tree cricket, then, is to feed where it is easiest to put the poison dust.

Dusting is the preferable method of control when machinery has to be purchased expressly for combating tree crickets and also when control has to be practiced over an extensive area. Uniformity of dust application is not so important as it is in the control of most orchard insects and it doubtless will be found practical, where the acreage to be treated is small, to mount a good hand duster on a tower which can be hauled through the orchard. By stopping a few minutes at each tree and operating the hand duster, effective application of dust may be obtained at minimum expense.

Spraying is effective in controlling the snowy tree cricket and the cost of material per tree is about the same as when dusting is done. When a spray machine is already owned and the acreage to be treated is not extensive, it is practical to apply poison in the liquid form.

Frequency of Control

Increase of the snowy tree cricket has been slow in the prune orchards of southwestern Idaho and it is probable that after an orchard has been thoroughly dusted or sprayed it will not become heavily infested again for several years. Oviposition in the fall of 1924 was very heavy and normally the season of 1925 would have been one of extremely severe tree cricket damage. December, 1924, however, was the coldest on record in the state and mortality of cricket eggs from effects of extreme temperatures was very high. In the spring of 1925 it was determined that but five eggs out of 553 examined were alive, a death rate of 99.1 percent. Due to the heavy winter mortality throughout the infested area there was almost no damage from the insects in 1925. In 1926 populations of tree crickets in a few orchards had increased again until, in a few cases, they caused 15 percent injury and doubtless they will continue to increase until artificial control will again become necessary.

Recommendations for Control

In commercial dusting for the snowy tree cricket, more poison per tree than is necessary has been used. An emergency existed and it was more important to the grower to obtain good control than it was to limit the expense. Experiments were conducted to determine the minimum effective dosage and it was learned that good results may be obtained with not more than 0.14 pound of calcium arsenate per tree. The optimum dosage, however, was not learned. It appears likely that less dust than the amount given will prove effective but further experimental work must be done before optimum dosage is determined.

It is recommended that infested prune orchards be dusted with calcium arsenate or sprayed with lead arsenate after crickets begin to eat the leaves freely and before they attack the fruit. Poison applications should generally be begun and completed between July 20 and August 1. When dusting is employed, until further data are obtained, pure calcium arsenate should be applied at the rate of about 0.14 pounds per tree for 12-15 year old prune trees. When spraying is done, lead arsenate should be used at the rate of 4 pounds per 200 gallons of water.

Warning

Calcium arsenate dust settles on foliage beneath dusted trees quite as abundantly as on the tree foliage. The dust may drift to adjoining fields in even a light breeze. Caution needs to be exercised in pasturing live stock in dusted orchards or in fields adjacent until after considerable time has elapsed following dusting, or until after a rain.

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