

INSECT PESTS
AFFECTING CLOVER IN OREGON

by

ERNEST CLIFFORD ANDERSON

A THESIS

submitted to the
OREGON STATE COLLEGE

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

May 1942

APPROVED:



Head of Department of Entomology

In Charge of Major



Chairman of School Graduate Committee



Chairman of State College Graduate Council

ACKNOWLEDGMENTS

The writer wishes to express his sincere appreciation to Professor Don C. Mote, under whose direction this work was carried out, for his kindly interest in the work and for many helpful suggestions and criticisms during the course of the thesis.

To Mr. L. P. Rockwood of the U.S.D.A. Bureau of Entomology the writer is extremely grateful for his many contributions of data and information used in this paper.

The writer wishes to thank Kenneth Gray, Associate Professor of Entomology, for his help with some of the experiments carried on in connection with this thesis and especially for his aid with the photographic work. The writer wishes also to thank Dr. Herman Scullen, Associate Professor of Entomology and Mr. R. G. Rosenstiel of Oregon State College Experiment Station for their assistance.

The writer is grateful to his wife, Idon Anderson, for her valuable help in the preparation and typing of this thesis.

CONTENTS

PART I MAJOR INSECT PESTS OF CLOVER

	Page
Introduction	i
Clover Root Borer.	1
Economic history and distribution	2
Type of injury and importance	2
Life history and habits	4
Host plants	5
Control.	6
Clover Flower Midge.	9
Economic history and distribution	9
Type of injury and importance	10
Life history and habits	11
Host plants.	12
Control	13
Clover Seed Chalcid.	15
Economic history and distribution	15
Type of injury and importance	16
Life history and habits	16
Host plants	18
Control	18
Clover Leaf Weevil	20
Economic history and distribution	20

Type of injury and importance	20
Life history and habits	21
Host plants	27
Control	27
Clover Root Curculio	29
Economic history and distribution	29
Type of injury and importance	30
Life history and habits	34
Host plants	38
Control	38

PART II MINOR INSECT PESTS OF CLOVER

Lesser Clover Weevil	40
Economic history and distribution	40
Type of injury and importance	41
Life history and habits	44
Host plants	45
Control	45
Alfalfa Weevil	46
Grasshoppers	49
Slugs.	54
Cutworms	56
Strawberry Fruit Worm.	59
Tree Hoppers	61
Green Clover Tree Hopper.	61

Dark-Colored Tree Hopper.	62
Buffalo Tree Hopper	63
Wireworms.	66
Seed Caterpillar	70
Clover Head Thrips	72
Aphids	73
Pea Aphid	73
Clover Aphids	76
Bibliography	105

PHOTOGRAPHS

Photo I. Clover Root Borer.	79
Photo II. Clover Flower Midge	80
Photo III. Clover Seed Chalcid.	81
Photo IV. Clover Leaf Weevil.	82
Photo V. Clover Root Curculio	83
Photo VI. Lesser Clover Weevil.	84
Photo VII. Alfalfa Weevil.	85

PLATES

Plate I. Clover Root Borer Injury	86
Plate II. Clover Root Borer Larva	87
Plate III. Clover Flower Midge Injury	88
Plate IV. Clover Flower Midge Larva	89
Plate V. Clover Seed Chalcid Injury	90
Plate VI. Clover Seed Chalcid Larva	91

Plate VII. Clover Leaf Weevil Injury.	92
Plate VIII. Clover Leaf Weevil Larva.	93
Plate IX. Experiment Emergence Cages.	94
Plate X. Experiment Lamp Chimneys	95
Plate XI. Fungus Attack on Clover Leaf Weevil . . .	96
Plate XII. Clover Root Curculio Injury.	97
Plate XIII. Clover Root Curculio Larva.	98
Plate XIV. Lesser Clover Weevil Injury.	99
Plate XV. Lesser Clover Weevil Larva.	100
Plate XVI. Alfalfa Weevil Larva	101
Plate XVII. Strawberry Fruit Worm Injury.	102

FIGURES

Fig. 1. Clover Root Borer Generation Chart.	103
Fig. 2. Emergence Chart for <u>Hypera punctata</u>	24
Fig. 3. Comparison Emergence Chart	25
Fig. 4. Table I, Root Injury by <u>Sitona hispidula</u> . .	33
Fig. 5. Emergence Chart for adult <u>Sitona hispidula</u> . .	35
Fig. 6. Egg Laying Record for <u>Sitona hispidula</u> . . .	36
Fig. 7. Lesser Clover Weevil Counts from Sweeps . .	43

INTRODUCTION

Hay and forage crops are of major importance in Oregon. They constitute with the pasture lands the basis of dairy and live stock industries of the state and have offered an exportable surplus of hay and seed. One of the most important of our cultivated legumes is clover, which, aside from its great forage value, is of primary importance in soil fertility and seed production. Although the Oregon farmers use clover for hay, fertilizer, and pasture, the greatest value comes from seed production. During 1940 Oregon raised 800 acres of small white clover seed, 23,000 acres of alsike seed, 4,500 acres of ladino clover seed, 14,000 acres of red clover seed, 1,200 acres of crimson clover seed, 300 acres of sweet clover seed and 400 acres of strawberry clover seed, making a total of 44,200 acres. The yield from this acreage was 7,915,000 pounds which brought a cash farm income of \$924,700.00 for the clover growers of Oregon.⁵⁰

It is a matter of common observation that it is becoming more difficult to grow good crops of clover, especially red clover and alsike in some sections of Oregon

which formerly grew it extensively. The writer was told last summer (1941) by a majority of the clover growers in Deschutes County, Oregon that they could no longer grow a good stand of clover from their clover plantings after the first year. The total production of clover seed in Oregon in 1925 was approximately one-tenth of that produced in 1916.^{48A} Clover insect pests are apparently partly responsible for this reduction. These pests attack all parts of the clover plants, roots, leaves, blossoms, and seeds. They take a toll of the clover crop every year and sometimes cause large losses. The seed grower has to contend with the insects that attack the seed itself or the sexual parts of the flower in which the seed is formed. Of these the more important are the clover flower midge and the clover seed chalcid. The clover aphid could also be considered as a seed pest. In addition to these there are those insects which are destructive to other parts of the plant such as the clover root borer and clover root curculio which feed on the roots; the clover leaf weevil and lesser clover weevil which feed on the leaves and stems. Grasshoppers, cutworms and caterpillars may enter a field in such large numbers that they will completely destroy the clover crop.

It is the purpose of this report to discuss these clover insect pests with the purpose of throwing some light

upon their distribution, type of injury, biology and habits, their importance to clover producers of Oregon, and some of the latest control measures. It is hoped that this information which has been obtained from literature and experiments performed by the writer during the last year will be of value to those in the future who study the insects in greater detail. It is quite apparent that many of these clover insects which are now considered as minor pests will at some future date become pests of major importance and need further investigation and study.

INSECT PESTS
AFFECTING CLOVER IN OREGON

PART I

MAJOR INSECT PESTS OF CLOVER

* * * * *

CLOVER ROOT BORER

Hylastinus obscurus Marsham

The clover root borer is a small dark brown Scolytid (Photo I) which mines and breeds in roots of herbaceous leguminous plants, thus differing from its bark inhabiting relatives. The species was first described by Marsham as Ips obscurus in 1802. Since then it has had the following names: Bostrichus trifolii Muller, 1807, Hylesinus trifolii Muller (Schmitt) 1844, Hylastes trifolii Muller (Chapuis) 1873, Hylesinus trifolii Muller (Riley) 1879, Hylastes trifolii Muller (Eichhoff) 1881, Hylastinus obscurus Marsham (Bedd) 1888, Hylastes obscurus Marsham (Davis) 1894, Hylastes trifolii Mul. (Hagedorn) 1910, Hylastinus trifolii Muller (del Guercio) 1915, Hylastinus obscurus Marsham

(Reitter) 1916, Hylastinus obscurus Marsham (Swaine) 1918. Hylastinus obscurus is the only representative of its genus known in America.⁴⁴

ECONOMIC HISTORY AND DISTRIBUTION. The clover root borer is a foreign insect of European origin. Muller reports serious injury to red clover fields by the insect in Mainz in Europe as early as 1803 at which time it destroyed all of the clover crops in some areas. The clover root borer was first noted as a pest in United States in 1878 in western New York. Henry reported that in 1880 the insect had taken the clover in portions of Genesee County, New York. It soon spread westward reaching Oregon in 1895, first reported by Cordley. It now occurs in most clover raising areas of Oregon, however the writer failed to find it in Crook county during his work on the clover insects in the summer of 1941.

IMPORTANCE AND INJURY. The clover root borer is the insect that is most destructive to mature stands of clover in Oregon.⁴⁶ In the Willamette Valley this insect is responsible for the fact that as a general rule more than one crop of clover after seeding is no longer profitable. In 1926 Rockwood reports a fifty percent loss of a second season crop of red clover in Washington County, Oregon. Cases of complete destruction of clover stands have been reported from states of Indiana, Ohio, and New York.

During 1926 E. B. Watson and E. C. Echman performed some experiments in Washington County, Oregon to determine how many borers a clover plant would tolerate. Their results show that on the average twenty-five to thirty borers usually cause the death of the plant.

The greatest damage is done to the roots of the clover plants by feeding and oviposition of the beetles. An examination of the roots of a plant that has died will show girdling on the surface of the root and numerous burrows running through them where the adults and larvae have been feeding. (Plate I). These burrows cut off the circulation to the plant which turns brown, wilts, and dies, generally having the appearance of suffering from some disease. It is for this reason that quite often the presence of the beetles is not detected until they have done great damage to the clover crop.

Usually the overwintering adults are not numerous enough to cause immediate death of the plants, but later on in the summer when the eggs hatch and the young larvae begin feeding, the plants soon die out unless there is an abundance of water present to enable the plants to survive in spite of the damage being done by the beetles.

A fungus disease caused by Sclerotinia trifoliorum, sometimes quite prevalent in Oregon, may easily be mistaken for root borer injury. An examination of plants

affected by fungus will show discoloration of the stems and often a thin whitish fungus growth.⁴⁴ The injury caused by this fungus also differs from that of the root borer in that several stems of the diseased clover plant usually wilt at different times whereas in case of injury by root borers all the stems die at the same time.

LIFE HISTORY AND HABITS. Clover root borers usually pass the winter as adults in the roots of the clover plants on which they fed as larvae. Occasionally some of the adults may get separated from the root and hibernate in the soil. In the spring when the soil begins to warm up, the adults become active and work up through the roots to the crown of the plant. Here they remain until the temperature reaches 55° to 60° Fahrenheit when they leave the crowns of the plants, walk around, and mate. Usually the beetles remain in the same clover from which they emerge; however if this field has been plowed, they migrate to new clover fields. Some have been observed to fly as far as two miles.

Rockwood suggests that flight is the principal means of dissemination of the root borers here in Oregon. His experiments with flight screens conducted near Forest Grove, Oregon in 1917 indicated that maximum flight took place May 13. Of those collected during the early days of flight about ninety-five percent were females. During

this same year E. E. Cowin performed similar experiments near Wapato, Washington. He found the maximum flight on May 12.

Shortly after the spring flight the females bore into the clover roots and construct egg galleries where they deposit their eggs. Usually the male and female are found together in such galleries and it is believed that the females are fertilized more than once during their reproductive period which lasts about three months. When the female has finished laying, the gallery is plugged with frass, cemented together with a sticky material and the beetles enter superficial burrows in the crown of the plant where they feed for several weeks before dying. Newly hatched larvae (Plate II) feed on the roots and pupate in the burrows after molting three to five times. In approximately ten days the adults emerge. There is only one generation a year in Oregon. (Figure I)

HOST PLANTS. Common red clover Trifolium pratense and mammoth clover Trifolium medium are the preferred host plants of the clover root borer. Alsike clover is attacked and may be severely injured in some sections. In Yakima Valley, Washington clover root borer adults have been observed attacking alfalfa and sweet clover. Vassiliev lists this insect as a pest of lucerne in Russia.⁴⁴ In the Willamette Valley alfalfa roots have been

examined at different times but no borers found on them. C. W. Creel reports the borers on vetch near Junction City, Oregon. A. L. Lovett of Oregon State Experiment Station reports that garden peas were damaged by this insect in Marion County, Oregon. In 1922 Max M. Reeher at Forest Grove found the clover root borer feeding inside the stem of Scotch broom Cytisus scaparius. Mote, 1941, reports finding the adults of the clover root borer doing damage to vetch roots near Monroe, Oregon. Swaine recorded the occurrence of this species on white Dutch clover. This insect is listed by Rockwood to have been found in the crowns of lupin, Lupinus sp. near Albany, Oregon 1919.⁴⁴ Root borer adults are usually most numerous on host plants adjacent to fields of abandoned clover that have been heavily infested with this insect.

CONTROL. Natural Enemies. Very few natural enemies of the clover root borer are recorded in literature. Riley records a soldier beetle, cantharis bilineatus, as being predaceous on the clover root borer⁴⁴, and also that a telephorid larva probably Telephorus bilineatus preys on the larva.⁶

In Oregon the most important natural enemy observed to attack the borer in the roots and on the ground is the well-known entomogenous fungus (Sporotrichum) Beauverii globulifera determined by L. P. Rockwood. Root borer

adults are exposed to the infection while above ground moving from root to root, mating, and starting burrows. The disease is most prevalent in the fall and spring at which time it often becomes of economic importance in root borer control. The fungus is parasitic on the adults, larvae, and pupae of these insects. Low, wet, poorly drained land is conducive to the growth of the disease.

The following birds of Oregon have been listed as predators of the clover root borers: streaked horned lark, brewer blackbird, Oregon vesper sparrow, Townsend sparrow, golden crown sparrow, cliff sparrow, northern violet-green sparrow, meadows, and Pacific house wren.

Cultural Control. As yet no chemical control has been successfully used against these insects. Davis of Michigan Agricultural Experiment Station found that fertilizing the clover plants had no apparent effect on the root borers.⁴⁴

Rockwood suggests the following cultural control:

(a) Adopt a one-crop system of clover culture throughout the community. This system consists of plowing the clover field after the first hay crop has been removed. (b) Follow a system of rotation in which clover is maintained for only one crop year. (c) Plow and harrow badly infested clover sod after the hay crop has been removed in late June or July. (d) Never plow badly infested clover sod in early

spring as severe damage may be caused to neighboring clover by migrating beetles. (e) In case of an early infestation by the root borers cut clover early for hay in order that the second crop may mature before being attacked.⁴⁴

In western Oregon farmers have found clover and wheat crop rotation successful.

CLOVER FLOWER MIDGE

Dasyneura leuminicola Lintner

The clover flower midge is a small mosquito-like fly (Photo II) which lays its eggs in the young clover heads. It belongs to the family Cecidomyiidae and has been referred to in literature by the following scientific names: Lintner (1879) called it Cecidomyia trifolii. Later in the same year (1879) he changed this name to Cecidomyia leguminicola. Aldrich (1905) called the midge Dasyneura leguminicola, the name by which it is now generally known. The clover flower midge has had many common names such as clover seed fly, clover fly, American seed midge, seed midge, clover flower midge, clover head midge, and flower midge. Most writers speak of it as the clover flower midge.⁶¹

ECONOMIC HISTORY AND DISTRIBUTION. Although the clover flower midge did not attract more than local attention until 1878 and was not described until a year later, there is considerable evidence indicating that it was injurious to clover in New England at least thirty years prior to these dates.

It was reported as destructive in Iowa in the early nineties, being called by Gossard (1893) "our most formidable insect." Weed (1885) and Forbes (1889) report the

midge as having done serious injury in northern Illinois.⁶¹ Rockwood reports that the clover flower midge has caused alarming reduction in seed yields in the Pacific Northwest since 1913. In Oregon it is found west of the Cascades and in Malheur County and quite likely it is in other irrigated sections east of the Cascades. In America it now probably occurs wherever mammoth, crimson, white, or the common red clovers are grown.⁴⁵

Apparently it does not occur in Europe.

TYPE OF INJURY AND IMPORTANCE. The flower midge is injurious only in its larva or maggot stage. As the name implies, it works in the flower (Plate III) feeding upon those parts which normally would develop into seed. Although one maggot prevents the formation of only one seed, nevertheless when great numbers of maggots are present, they make serious inroads on the seed crop. From observation it has been found that the forage value of red clover is not impaired by midge infestation and the insect, therefore, is of economic importance only in seed growing districts. Throughout the United States the infestation varies from none to eighty-five percent. Folsom in 1909 reports fifty to seventy percent damage to the clover seed in several sections of New York.⁶¹ The midge is an important pest of red clover in Willamette Valley.²³

During oviposition the female rests quietly on the clover head while she inserts her long ovipositor into the florets where the eggs are deposited singly or in clusters and attached to the hairs of the calyx of the blossom. These pale yellow elongate eggs hatch in about twenty-eight hours and the young maggots work their way into the florets sucking the sap and destroying almost completely that part of the flower which gives rise to the seeds.

In about one month the pale yellow larvae mature within the seed and drop to the ground to pupate as soon as there is sufficient rain to thoroughly moisten the clover heads and surface of the ground. Oregon reports indicate that often larvae are forced to wait two or three weeks for favorable conditions.⁴⁶

The larvae pupate below the surface of the ground in silken cocoons. Adults emerge in two or three weeks usually during the first part of July and begin laying eggs for the second generation thus completing two generations a year in Oregon.⁴¹

HOST PLANTS. Red clover is apparently the favorite food of the clover flower midge. Authorities differ when listing other clovers as food plants of this insect. Folsom (1909) reared midges from alsike clover and found alsike clover infested.⁶¹ Metcalf and Flint report that this midge has been found in small numbers on mammoth,

crimson, white and sweet clover, but it is of no importance on these crops.³¹

CONTROL. Natural Enemies. In 1880 Comstock reported a hymenopterous parasite Platygaster error Fitch of the family Platygasteridae, emerging from the cocoon of the clover flower midge. In Delaware Sanderson (1900) reared from the flower midge the parasite Tetrastichus carinatus. In 1886 Pergande suggests that thrips may feed on the eggs of the clover flower midge. The flower bug Triphleps insidiosus Say is an energetic enemy.¹⁴ How much value these natural enemies are in control of the clover flower midge has not been determined. Wehrle states that parasitism of the clover midge larvae was about seven percent or more.⁶¹

Cultural Control. The following control measures have been suggested for Oregon: (a) Pasture the red clover previous to starting a seed crop. This will keep down the volunteer heads in which the midge would otherwise secure a foothold in the field the first season. In case the pasturing has not been close enough to get all the heads, a mower should be run over the field shortly after the stock have been removed. (b) A majority of the clover growers have found success in the practice of early cutting of the hay crop. This method destroys the first brood of midge maggots by cutting off and drying up their

food supply. On account of seasonal and climatic variations affecting life history of the midge it is hard to set down any general rules telling when the clover should be cut; however if the clover is cut about June 1 the maggots of the spring generation will be destroyed. (c) It is also possible to escape the midge infestation by clipping the clover between May 10 and May 25 so that the clover will not produce heads until after the adults of the spring generation are gone. These heads will be far enough advanced by July 1 to be immune from attack by any of the adults of the summer generation.⁴⁵

CLOVER SEED CHALCID

Bruchophagus funnebris Howard

The clover seed chalcid is a very small wasp-like hymenopterous insect belonging to the family Chalcididae. (Photo III). This abundant and energetic chalcid formerly presumed to be an enemy of the clover seed midge and thus a good friend of the farmer is now considered to be one of the worst pests of clover. Instead of being a beneficial parasite as early entomologists thought, it eats into the clover seeds and reduces the crop materially.

ECONOMIC HISTORY AND DISTRIBUTION. It was not until 1896 when Hopkins made a study of this chalcid that we received much information about the damage it caused.²³

At present the clover seed chalcid occurs to a greater or less extent in practically every locality where either red clover or alfalfa seed is produced. It seems to reach its greatest numbers in irrigated sections in the Western and Southwestern States. It also occurs in large alfalfa growing areas in the Mid-Western States. Although it has been found in Germany, Chile, Turkey and Siberia, it seems possible that this chalcid is a native of the United States as it was originally described from this country by Howard. The spread of the insect has been hastened by shipments of infested seed from one district to another. The insect being a strong flier often ascends high in the air and is

windblown to neighboring fields. This may be a principle means of local spreading.⁶³

The clover seed chalcid, as far as we know, occurs in all Oregon clover seed districts, both east and west of the Cascade Mountains.

TYPE OF INJURY AND IMPORTANCE. The young larvae cause the most damage to the clover heads when they begin feeding on the albumen of the cotyledons in the seeds. Thus many of the seeds are broken or cracked open and by threshing time little is left of them but empty shells which often contain the matured chalcids. (Plate V).

In Oregon infestation of ten to thirty percent of the seed is common and counts of over fifty percent of infested seed have been recorded. Other states have reported forty to eighty-five percent infestation of the clover heads, making the growing of the clover seed unprofitable in many areas.¹³

LIFE HISTORY AND HABITS. The insect usually passes the winter as a full grown larva (Plate VI) in clover seeds shattered out in the fields at harvest time, in seeds around clover strawstacks, or in seeds of roadside clover. In the spring the adults emerge from the seeds and fly to the clover fields. In the Willamette Valley this occurs after the middle of May about the time the clover heads are maturing.⁴⁶ As soon as the female arrives

in the clover field she explores the clover heads for seeds that are not yet completely hardened. Inside the seed coat in the semifluid albumen of a developing seed she lays a small, pale green egg by bending the abdomen forward under her body and pushing down the long needle-like ovipositor through the calyx of the clover blossom until its tip has entered the young seed. The ovipositor is withdrawn to its normal position before the laying of the next egg. The entire operation takes from three to twelve minutes. Eggs are usually laid on warm sunny days when the chalcids are most active. Under normal conditions the egg laying period lasts about one month although this may be greatly altered by weather conditions. The eggs hatch in from three to twelve days, depending on the temperature.

The white maggot-like larvae feed and develop within the seed. When mature they transform to the pupal stage and emerge as adults in from five to forty days depending on moisture and weather conditions. In Willamette Valley emergence of the adults from the seeds of the first crop of clover usually begins early in July and may continue until the middle of August. These chalcids lay eggs for the second brood some of which may complete their cycle and emerge as adults in the fall or overwinter in the seeds as larvae. Thus there may be two generations in

Oregon each year.⁴⁶

The adults are often active from May to October and spread rapidly from their place of origin throughout the fields.

HOST PLANTS. As far as is known the clover seed chalcid is restricted to alfalfa and clover plants, the chief host being red clover. It also feeds on crimson, often on bur, and mammoth clover and Essig states that wild clovers may act as breeding places.¹³

CONTROL. Natural Enemies. Of the natural enemies the only parasite reported is tetrastichus bruchophagi which R. L. Webster saw emerge from the body of the seed chalcid. As yet we have not any evidence as to the value of this parasite in the control of the clover seed chalcid.¹⁴

Cultural Control. The controlling of the clover seed chalcid is difficult due to varying conditions under which the insect is encountered, its widespread distribution, its habits of development, and its remarkable ability to maintain itself. Fortunately, however, several relatively successful methods have been developed: (a) killing of the chalcids by cutting the clover early and removing the hay from the field before the seed has had time to mature; (b) destroying the volunteer clover in the field; (c) by plowing under of the clover crop and planting a crop that

requires frequent stirring of the soil; (d) purchasing seed that is free from the chalcid larvae; (e) and burning all infested seeds which come from the recleaner at hulling time.⁶³

Because of the rapid spread of the chalcids from the place of their origin through the seed fields, cooperation in a campaign of repression on the part of all the seed growers in a district is important for maximum reduction of injury by this pest. The larvae in the stored seed can be killed by fumigating with chloroform or bisulfide of carbon.

CLOVER LEAF WEEVIL

Hypera punctata Fab.

The clover leaf weevil is a widely distributed beetle of European origin belonging to the family Curculionidae. (Photo IV). It was first described by Fabricius in 1775 as Curculio punctatus. It is now known by the name Hypera punctata.

ECONOMIC HISTORY AND DISTRIBUTION: Hypera punctata has long been known throughout Europe, Asia, China, Africa and Egypt. Apparently this is the only species of Hypera that has reached the United States. The first record of this insect in the United States was in 1881 when a severe outbreak occurred in Barrington, New York. Likely the insect was present several years before it was recognized as a pest of clover crops here because a specimen was taken in Canada as early as 1850 and identified by Le Conte as the clover leaf weevil. It had spread from New York to Michigan and Iowa by 1892 and it probably reached the west coast about 1908. Hypera punctata is now distributed over most of the United States and Canada. In Oregon it occurs in all parts of the state where red clover is grown.⁴⁶

TYPE OF INJURY AND IMPORTANCE. The clover leaf weevil can hardly be looked upon as a pest of first importance because ordinarily its numbers are held in check by

a fungus disease, Empusa sphaerasperma. However in the absence of this fungus the clover leaf weevil becomes very destructive. Because of its large size and ravenous feeding habits this insect when present in large numbers may completely destroy a clover crop. C. V. Riley says that acres of clover were destroyed by this beetle during its early history in New York.²¹ During last summer (1941) the writer observed a ten-acre field of red clover which was eaten up by the feeding of the larvae of this beetle.

Both the adults and the larvae feed on the plants. The larvae while young eat small round holes in the leaves. Later when they become larger they eat large notches in the stems and leaves thus giving a ragged appearance to the foliage (Plate VII). The adults feed voraciously on the leaves and main stems of the plant often completely devouring all the plant above the ground. As far as is known these beetles do not feed on the roots.

LIFE HISTORY AND HABITS. A study of the life history and habits was made by the writer during the summer of 1941 in Deschutes County, Oregon.

The clover leaf beetles over-winter as larvae in the clover fields or near by under rubbish on the ground or between bases of the clover stems. Early in the spring as soon as the clover begins growing, the clover leaf weevil larvae become active. During the night they leave their

hiding places at the base of the plants and crawl up and feed on the leaves.

From each night sweepings numbers of larvae were collected from the tops of the clover plants. Close examination shows that they are footless, have brown heads, green bodies with a white or pale yellow strips along the middle of the back. (Plate VIII). During the daytime these larvae can be found under the leaves and rubbish at the base of the plants. In May and June the larvae spin brownish green cocoons in the debris at the base of the plants or beneath the surface of the ground and pupate. These cocoons can easily be found at the last of May or fore part of June by digging just below the surface of the ground under the clover plants.

After the pupal period which lasts from ten to twenty days, depending on the weather conditions, the adults emerge. To determine the height of emergence of adult beetles in Deschutes County, Oregon, the writer set out fifteen emergence cages placing a few in each field. These cages (Plate IX) were three feet square at the base, tapering to a small three inch hole at the top where a screen trap was placed to catch the emerging adults. They were set out June 11. Of the fifteen cages five were set over clover in the center of the fields, five were placed on the ditch banks adjoining the clover fields and the

other five were placed a short distance outside of the fields on waste land. Each week during the spring and summer the emerging beetles were collected from the traps, taken into the laboratory, counted and recorded. Although the writer was unable to get the emergence cages set out early enough in the spring to obtain complete information still he received some interesting data which should be recorded. Counts showing the peak of emergence of the adult clover leaf weevil in Deschutes County are recorded in the following graph. (Figure 2). The results show the peak of emergence to be about July 8. This agrees quite closely with the results obtained by Tower and Fenton of Indiana who found the peak of emergence of the Hypera punctata to be July 1. The graph in figure 3 shows a comparison of the number of beetles emerging from the center of the field, the ditch banks and the waste land located a short distance from the immediate clover fields. Results show that the greatest number of beetles emerged from those cages placed along the ditch banks adjoining the clover fields.

The adults feed on the leaves and stems of the clover throughout the summer. Usually the beetles hide at the base of the plant during the day and feed during the evenings and at night. In the fall these beetles mate and start laying.

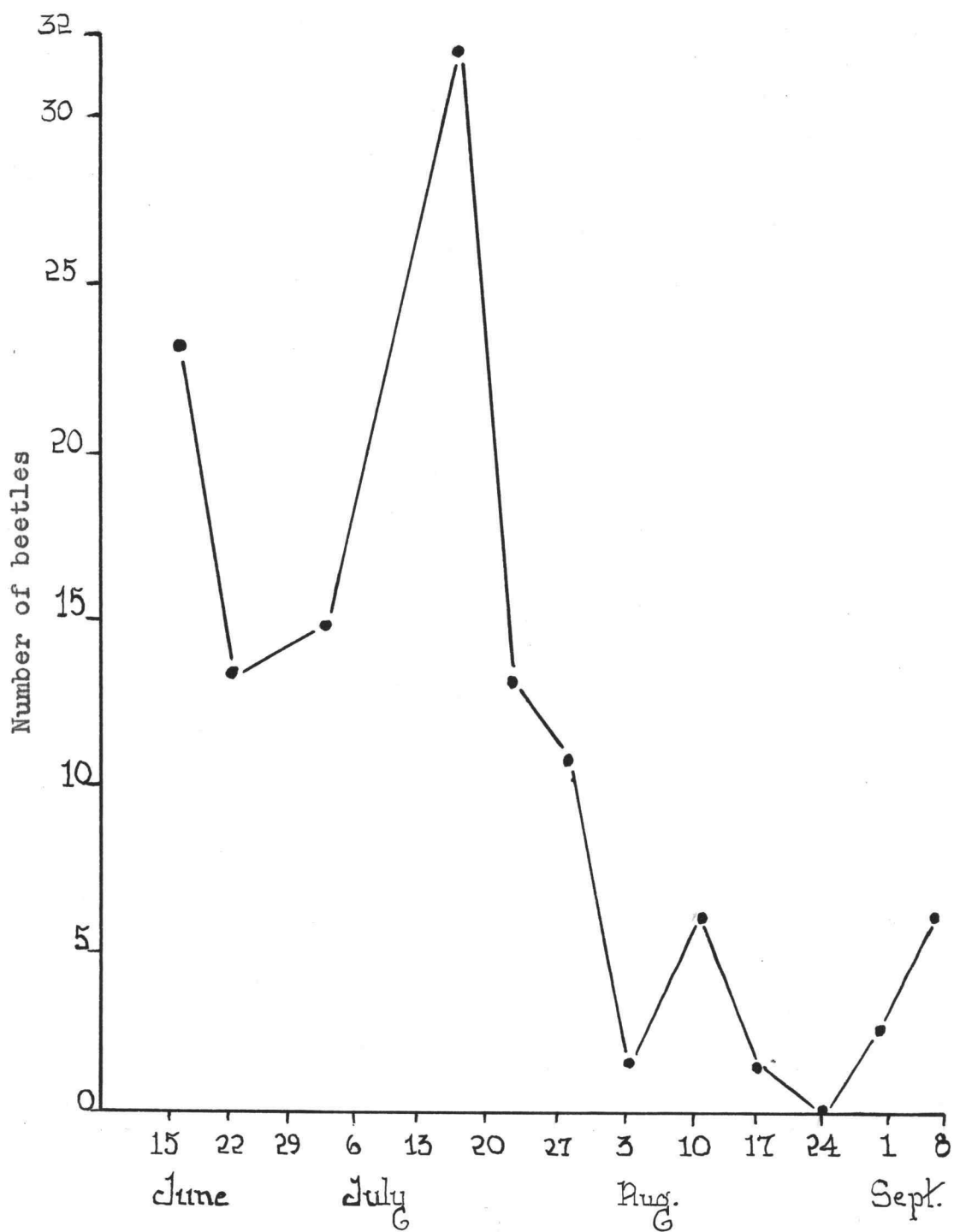


Figure 2. Emergence of adult Hypera punctata in Deschutes County, Oregon, 1941.

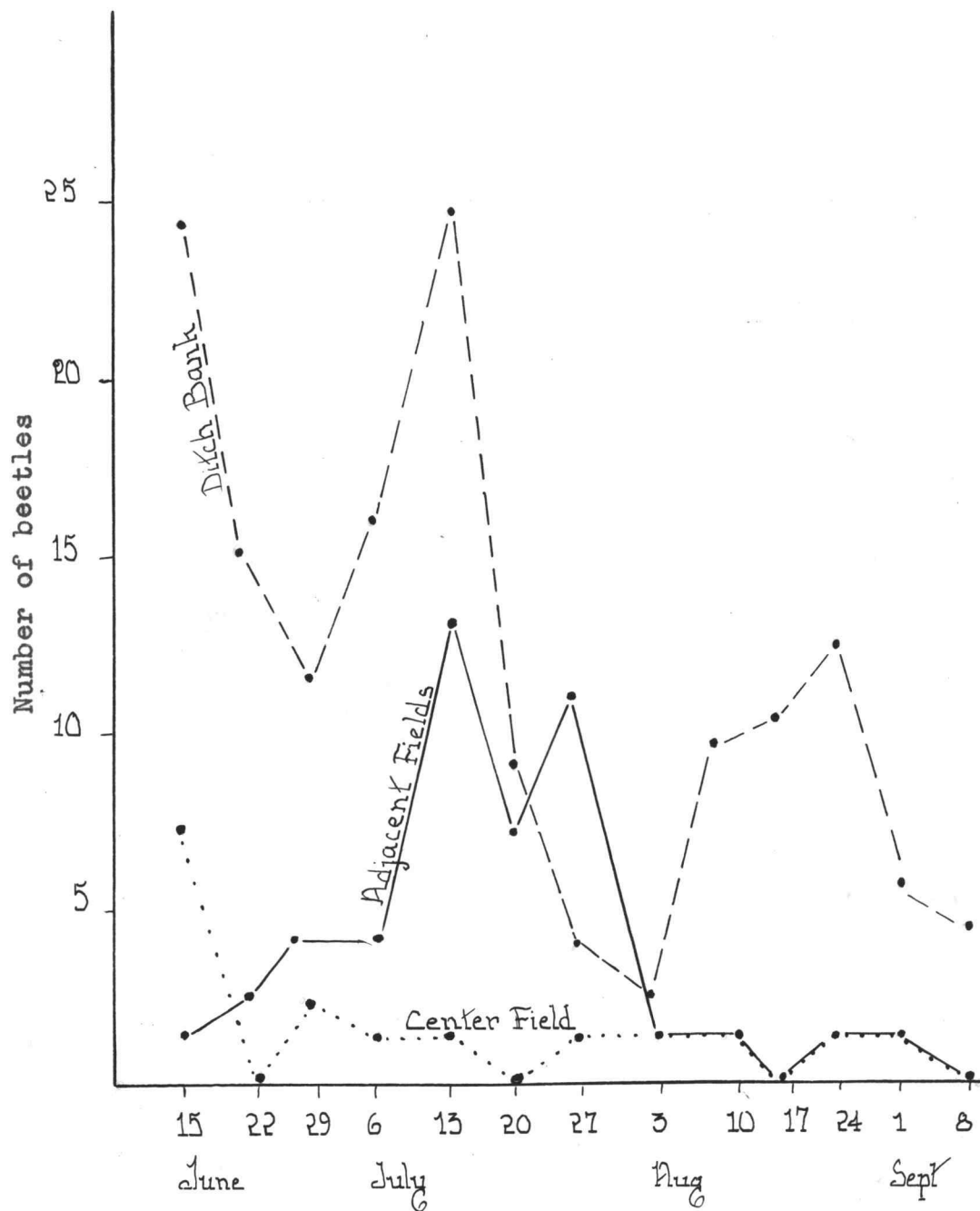


Figure 3. Number of adult Hypera punctata emerging from ditch bank, adjacent field, and center of clover field cages in Deschutes County, Oregon. 1941.

To determine the life cycle of the clover leaf weevil the writer collected one hundred adult beetles on Aug. 1 and put them in lamp chimneys (Plate X) where they were fed and observed until January 1. To make the feeding natural the top of a clover plant was put in the lamp chimney with its stem extending through a black muslin cloth stretched across the bottom of the chimney and into a small vial of water. The lamp chimney stood on an elevated board over a small round hole from which the vial was suspended. By this method the clover plant could be placed inside the lamp chimney in a natural position and would remain fresh for four or five days.

On Aug. 14 a pair of beetles was seen copulating. The first deposition of eggs was noted on Aug. 16 and the latest on November 23. The greatest activity in egg laying was during the months of September and October although many beetles continued actively to deposit eggs through most of November. The beetles deposited the eggs in cavities they made in the stems or in masses on the outside of the stems and leaves, and occasionally laid them promiscuously on the sides and bottom of the lamp chimney. When the lamp chimney was sufficiently shaded, eggs were sometimes laid during the day; normally they are laid at night.

The conspicuous yellow elongate eggs hatch in from thirteen to forty days depending on the type of weather and when laid. Eggs that were laid early in the fall usually hatched in about fifteen days whereas those laid later took from twenty-five to forty days to hatch. Herrick and Hadley of New York reported that some eggs that were laid late in the fall did not hatch until the following spring.⁴⁴

The young larvae feed on the tender leaves until cold weather when they hibernate in the clover sod until the following spring. There is only one generation a year in Oregon.

HOST PLANTS. The clover leaf weevil feeds on red clover, white clover, mammoth clover, sweet clover, alsike and alfalfa. The adults and larvae have also been observed feeding on beans, corn, timothy, burdock, soybean, and the flowers of goldenrod.²¹ The writer found several beetles on potato vines in Deschutes County, Oregon.

CONTROL. Natural Enemies. Very few parasites have been reported as important in the control of the clover leaf weevil. According to Riley the larva of a small beetle Collops quadrimaculatus Fab. feeds on the eggs of this weevil and one of the tiger beetles probably preys on the larvae.

Turkeys, chickens and a large number of our common birds are valuable and important natural checks on this insect.

The most important check on the abundance of Hypera punctata is the fungus disease Empusa sphaerosperma Fres. which kills the larvae in vast numbers during the spring and late fall. This disease is epidemic and being very contagious spreads so rapidly that often in two or three weeks most of the larvae in a field have been destroyed.

The sick larvae crawl up on herbage at night as high as possible and coil themselves in a horizontal position (Plate XI) around the stem of the plant. If not disturbed they die in this position in about twenty-four hours leaving only a black and shriveled mass covered with powdered whitish spores. The fungus attacks by sending mycelia from the germinating spores through the body of the larvae. This mycelia absorbs the body fluids and may even form rhizoids which attach the larvae securely to its support.⁵³

Cultural Control. The most practical method of dealing with outbreaks of this insect is to either cut the clover back in May or use it for pasture in the spring.²¹ Clipping and plowing under clover at the end of the second season have been quite successfully used by some growers.

CLOVER ROOT CURCULIO

Sitona hispidula

The clover root curculio is a root boring beetle of European origin belonging to the family Curculionidae. (Photo V). It was originally described by Fabricius as Curculio hispidula in 1776. Later Germar (1824) put it in the genus Sitona by which it is known today.⁶⁴ About twenty-five species have been described from the United States, most of them by Casey from California.³ The following species have been taken in Oregon and determined by Van Dyke: Sitona hispidula, S. scissifrons, and S. flavescens. The Key to Species of Sitona in Oregon follows:³

- A. Setae of elytral intervals very distinct.
 - B. Scales of upper surface dark gray and cupreous; setae long, erect.
. hispidula.
- AA. Setae wholly wanting or very minute.
 - C. Color nearly uniform brown; vesiture fine, hair-like, setae wholly wanting; length 4.5 - 5.5 mm. flavescens.
 - CC. Color steel-gray, elytra usually with paler stripes; vesiture of scales, setae minute; length 3 - 4.5 mm.
. scissifrons.

ECONOMIC HISTORY AND DISTRIBUTION. Although the distribution of the clover root borer has been common and

widespread in Europe and England since the middle of the last century, it apparently was not introduced into the United States until 1876. At about this time Le Conte collected some Sitonas feeding on the roots of grass grown on sand dunes at Long Branch, New Jersey. In 1891 the beetles were reported by D. F. H. Chittenden as feeding on clover on the grounds of the Department of Agriculture, Washington, D. C. In Corning, New York during the year 1906 the beetles were very numerous and it was reported that from one-half to two-thirds of the clover crop was taken by these beetles. During the summer of 1909 curculio beetles were found by J. H. Hyslop feeding in an alfalfa field near Pullman, Washington.⁶⁴

In Oregon Sitona hispidula and S. scissifrons occur generally throughout the State. Sitona flavescens occurs mostly in the coastal region; however it is found in lesser numbers generally throughout the State.⁴⁶

TYPE OF INJURY AND IMPORTANCE. These beetles work in such a way that their injury is not readily noticed. The small white larvae feed on the roots of the clover plant, cutting off the fine feeding roots and eating into and destroying the nodules and often girdling the tap roots. (Plate XII). Quite often large cavities are eaten along the main roots. This feeding by the larvae slowly kills the plant. The writer found that a plant attacked by these

beetles first turns a yellowish green color. Later the plant turns yellow and dries up. An examination of such plants shows that the roots are often almost completely eaten up and are girdled so badly that the water supply is cut off from the plant. It was also found by the writer that the damage affected the plants most when the soil was dry.

The adults feed on the leaves, eating out irregular patches from the margins of the leaves. (Plate XII).

This insect is of comparatively recent importance as an injurious species. In 1909 Folsom writes that the clover curculio has rarely been reported as injurious in this country but needs to be watched, nevertheless.¹⁴ In Europe at different times it has done great damage to clover fields. During 1910 Parks reported considerable damage being done in western Ohio by this insect.³⁷

It is quite evident that the clover root curculio is of economic importance to the clover growers of Oregon especially in Crook and Deschutes Counties. The writer was told last summer (1941) by a majority of the clover growers in Deschutes County, Oregon that they could no longer grow a good stand of clover from their clover plantings after the first year. These farmers further said that early in the spring their clover would grow luxuriantly for two or three weeks, then it would turn a yellowish

green color and stop growing. Upon examining the plants they found white grubs in the soil about the roots which were badly girdled. This destruction of the clover usually occurred around or shortly after the middle of May. As the writer did not have the opportunity of being in Deschutes County until the middle of June he was unable to check on these maggots. However in Mr. McFalls clover field he found on July 19, two of these small maggots which Mr. McFalls claimed were the kind that were numerous on his clover roots earlier in the season. These larvae were taken to the laboratory and reared to adults. They were of the species Sitona hispidula.

On July 24 the writer examined the roots of a twenty acre field of alsike clover in Deschutes County. According to Mr. McFalls, the owner of the field, the clover had been severely damaged earlier in the season by small white maggots that he had observed in the soil about the roots. Of the twenty-five square foot samples of roots taken at random throughout the field and examined by the writer eighty-six percent showed injury. (Table I, Figure IV). The injured roots were girdled on the outside and had tunnels running through the centers which were typical of beetle injury. Nematode injury was also found on the roots. This was confirmed by Dr. C. E. Owens, Professor of Botany and Plant Pathology, Oregon State College.

TABLE I

Fig. IV. Counts of root injury of alsike clover plants sampled at random in McFalls' field in Deschutes County, Oregon, July 24, 1941.

Sample	Injured roots	Uninjured roots	Percent of injury
1	15	0	100
2	40	2	95
3	43	9	82
4	24	4	85
5	9	1	90
6	15	1	94
7	21	3	87
8	23	3	88
9	24	2	92
10	19	3	86
11	18	6	75
12	19	4	83
13	15	3	83
14	20	3	87
15	11	2	85
16	6	0	100
17	11	3	79
18	12	0	100
19	15	3	83
20	16	5	76
21	17	1	94
22	15	3	83
23	13	3	72
24	17	7	71
25	18	3	78
Total	456	78	86

LIFE HISTORY AND HABITS: The life history of the clover root curculio is quite complicated and has considerable variation.

On June 11 the writer set out fifteen emergence cages in different clover fields in Deschutes County, Oregon. The clover root curculio beetles were collected from these cages at weekly intervals during the remainder of the summer. All beetles thus obtained from the cages were taken into the laboratory, counted, recorded and put into rearing lamp chimneys for the egg laying record. From these collections, as shown in Figure V, the peak of emergence was on July 20. The writer believes that at this time the adults of the new brood were emerging. On June 14 the first group of beetles were put in lamp chimneys. These beetles began laying eggs June 18 and continued to lay a few eggs now and then for about one week. Egg laying started again in the laboratory Aug. 15 and continued until Nov. 23. The peak of egg deposition was Aug. 30. (Figure VI). Rockwood states that the clover root curculio will lay eggs from late fall until June and they may even lay during the winter season when temperature is about 48° or above.⁴⁶

In the lamp chimneys the females laid some eggs promiscuously on the leaves and sides of the chimneys but most of the eggs were laid on the muslin at the bottom of

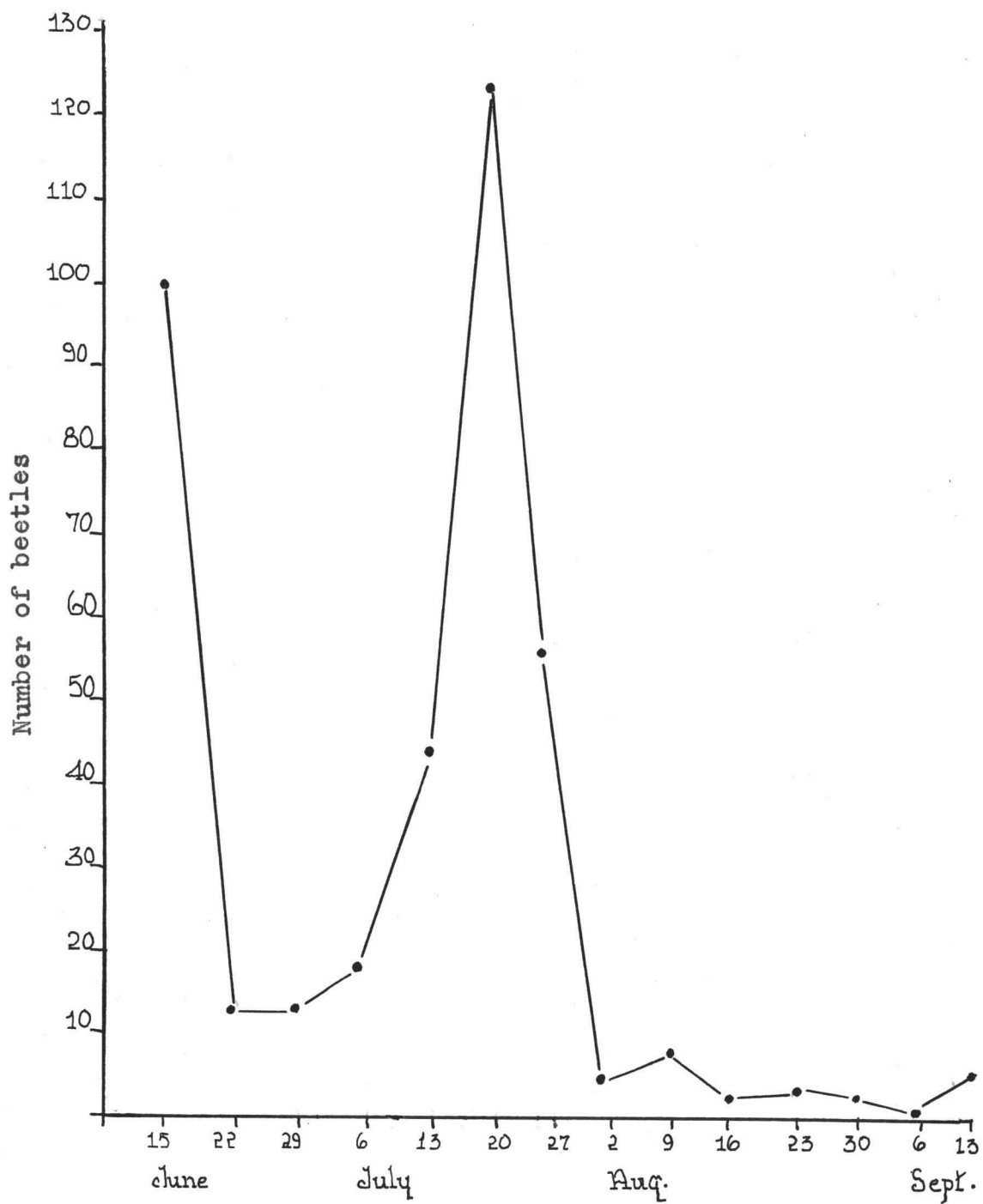


Figure 5. Emergence of adult *Sitona hispidula* in Deschutes County, Oregon, 1941.

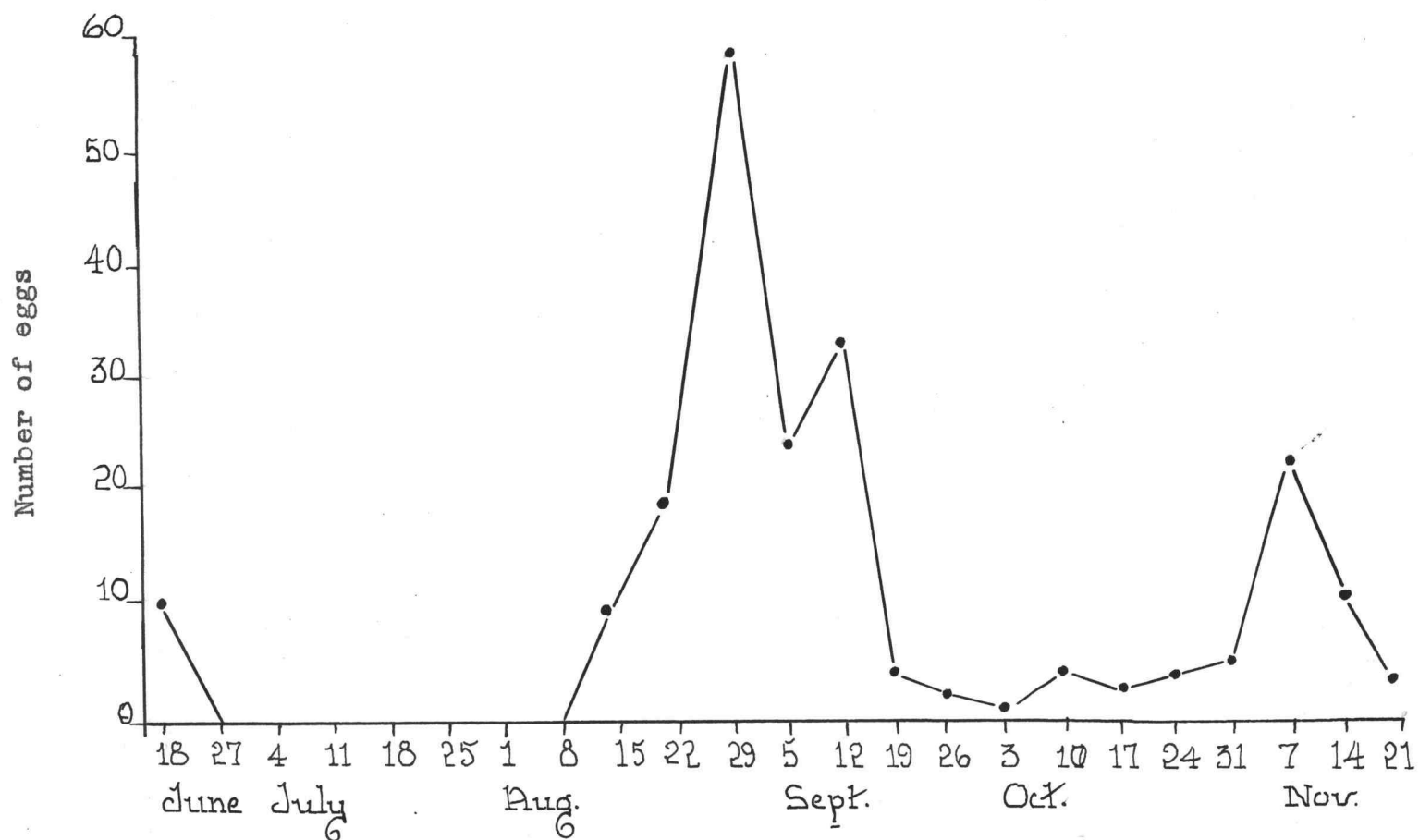


Figure 6. Egg laying record of Sitona hispidula in laboratory at Redmond, Ore., 1941.

the chimney which makes it seem very probable that in the field the eggs are usually deposited at or near the surface of the ground. Folsom states that the females lay the eggs on the ground at the base of the clover plants and he has observed cases where the female burrowed down to the roots and deposited eggs on the roots of the plants.¹⁴ In the laboratory the writer observed that those beetles which were placed on clover plants in flower pots laid eggs on the soil.

The beetles seem to lay eggs at irregular intervals extending over a long period of time. According to Rockwood the average number of eggs per female in cages is three hundred twenty-two and that copulation occurs repeatedly, apparently at intervals of three or four days.⁴⁶

The small, yellowish white eggs usually hatch in from fifteen to twenty days and immediately after hatching the larvae (Plate XIII) go down into the ground and begin feeding on the tender roots. Dorothy Jackson who has studied the curculio extensively states that those eggs laid late in the fall do not hatch until the following spring.^{24A} This is also the situation here in Oregon.⁴⁶

In the laboratory the larval period varies from twenty to forty days and the pupal period lasts from ten to fourteen days. The writer brought two larvae in from the field and reared them in salve boxes. The lengths of

their pupal periods were twelve and thirteen days. According to Rockwood the adult beetles are active during the early part of the season and when it gets hot they estivate until the early part of September when they become active again.⁴⁶

HOST PLANTS. The clover root curculio feeds on red clover, alsike, crimson and white clovers, and alfalfa.¹⁴ Other plants upon which it has occasionally been found are: soybeans, and cowpeas.³¹ Le Conte (1876) reports it as feeding on the roots of grasses growing on sand dunes. Wildermuth (1908) found the clover root curculio beetles feeding on blue-grass roots. The writer (1941) collected Sitona hispidula beetles from potato plants in Redmond, Oregon. Rockwood reports it feeding on vetch and lupin.⁴⁶

CONTROL. Natural Enemies. The larvae are sometimes diseased with the attack of nematodes of the genus Diplogaster. This causes the larvae to dry up. In Kansas one of every six curculio larvae were diseased.² One staphylinid beetle, Stenus sp. was reported feeding on eggs of curculio in Illinois. The larvae and adults are attacked by an entomophthorae fungus. Many of our common birds, especially the chimney swifts and song sparrows, feed on the adults of the curculio.

Cultural Control. In Deschutes and Crook Counties the clover growers have found the most successful control to be crop rotation. They suggest following a clover crop with wheat.

Some success has been reached with plowing the clover land late in the fall or early in the spring and thus destroying the overwintering beetles.³¹

Adopt any agricultural practice that makes for a healthy, rapidly growing root system, such as good seed, providing a good seed bed and maintaining in the soil the elements required for optimum growth of the plant.⁴⁴

INSECT PESTS
AFFECTING CLOVER IN OREGON

PART II

MINOR INSECT PESTS OF CLOVER

* * * * *

LESSER CLOVER WEEVIL

Phytonomus nigrirostris Fab.

The lesser clover weevil is a brilliant green beetle with brown legs and black snout belonging to the family Curculionidae. (Photo VI). It was first taken from Germany and described by Fabricius in 1775 as Curculio nigrirostris. Since then it has had the following names: Curculio variabilis Fab., Phynchaenus nigrirostris Fab., Hypera nigrirostris Germ., and at present it is known as Phytonomus nigrirostris Fab.

ECONOMIC HISTORY AND DISTRIBUTION. The lesser clover weevil is one of the common generally diffused insects of Europe, being found from Scandinavia southward into Egypt and Asia Minor. The technical literature of this species

runs back into the latter part of the eighteenth century. Kaltenbach (1874) says with reference to this species that it was found by F. Hoffman on Bupthalmum salicifolium in the flower heads on which the larvae live. Just when the species was introduced into America is not exactly known, but there are good reasons to believe that it first gained a foothold in New York and the New England states about 1881 probably coming from eastern Canada. In 1899 Dr. Fernald stated that the Phytonomus nigrirostris was very common on the Massachusetts Agricultural College farm at Amherst, Massachusetts and quite destructive to the clover growing there. In 1890 Dr. Fletcher stated that he had frequently found the larvae feeding on the heads of clover in eastern United States.

The lesser clover weevil was first found in the Pacific Northwest in 1916 at Olympia, Washington. In 1918 it appeared at Forest Grove, Oregon and was noted doing damage to clover near Forest Grove in 1921. It is now quite generally distributed over the state.⁴⁶

TYPE OF INJURY AND IMPORTANCE. Since about 1910 the lesser clover weevil has been very destructive to the red clover in the Mid-Western States. In 1919 Parks reported that there were heavy losses in western Ohio due to the feedings of this insect. The infestation is during dry weather. In greatest draught seasons the injury has at

times run as high as ninety to ninety-eight percent of all the plants in the field. In Oregon as far as we know the lesser clover weevil has not as yet been abundant enough to cause serious damage to clover crops, although it is generally distributed throughout the state and can always be found in moderate numbers in almost any clover field. During the summer of 1941 the writer made weekly sweepings with an insect net of the clover fields in Deschutes County. The fields were swept at random with fifty samples of twenty-five sweeps per sample. This was done for a period of three months from June to September. Results as recorded in Figure 7 on the following page show one beetle per fifty sweeps.

Both the larvae and adults feed on the clover plant, making holes in the leaves and also feeding on the stems, often cutting into them so that the plant falls over. (Plate XIV). As a result of this feeding the plants show a deadening of the leaves and general growth of the plant is checked. In addition to leaf and stem feeding larvae feed on the heads, causing them to become stunted and misshapen. Thus damage to the heads is of the greatest importance to the clover growers.

Note: Samples were taken at random over clover fields in the evening when the beetles were most active.

Date of collection	Number of samples	Number of sweeps per sample	Number of bugs
June 25	50	25	64
July 2	50	25	90
July 9	50	25	12
July 16	50	25	9
July 23	50	25	33
July 30	50	25	18
Aug. 7	50	25	14
Aug. 14	50	25	30
Aug. 21	50	25	17
Aug. 28	50	25	11
Sept 5	50	25	9
Totals	550	Sweeps 13,750	307

Figure 7. Counts of lesser clover weevils collected from sweepings on clover fields in Deschutes County, Oregon, 1941. Calculations show one beetle per fifty sweeps.

LIFE HISTORY AND HABITS. The lesser clover weevil passes the winter in the adult stage around the base of the clover plants, in leaves, in wood lots or under the grass along the ditch banks. In the spring when the weather becomes warm and the clover starts growing these adults leave their hibernation quarters and enter the clover fields where they mate and feed on the clover leaves for a few days before oviposition begins. Mr. Hyslop reported that the female laid her eggs interepidermally in the cavity between the upper and lower epidermis along the sides of the midrib of the leaf. Later Mr. Wildermuth (1911) examined hundreds of leaves without finding a single egg on the leaf itself, while he had no difficulty in finding where they had been laid under the epidermis of the basal leaf sheaths.⁵⁹ Since then other authorities have confirmed Wildermuth's findings.

Egg laying extends over a period of about one month and each female will lay on an average of two to three hundred eggs. The eggs hatch in from seven to ten days and the young white larvae (Plate XV) begin feeding in the folds of the small tender leaves. Later they attack the heads and stems of the plants. The larval period varies from seventeen to twenty days during which time the larva passes through three molts. When mature the larva spins a cocoon on the ground near the base of the plant and

transforms to the adult in from six to eight days. The entire life cycle takes thirty-five to forty days.

The writer found that in Deschutes County, Oregon the greatest emergence of adults was between the last of June and the first of July. Through close observations of the feeding habits of the larvae and adults and also by net sweeping during different periods of the day and night, the writer found that both the adults and larvae preferred to feed in the evening from 8:00 P.M. to 10:00 P.M. and that during the day most of the weevil were under the leaves at the base of the plants.

HOST PLANTS. The lesser clover weevil prefers red clover but feeds on alsike, sweet clover, alfalfa, and all other common species of clover.³¹

CONTROL. Natural Enemies. Webster states that two parasites have been reared from the larvae of the P. nigrirostris, a small fly determined by C. H. T. Townsend as Anisia sp., near variabilis coq. and a hymenopterous parasite determined by J. C. Crawford as Bracon sp. Webster also says that the pupae are destroyed by the fungus Empusa sphaerosperma which when present will be sufficient to hold the beetle in check.⁵⁹

The vulnerability of the lesser clover weevil to this fungus is likely one of the main reasons why it has not become a pest of economic importance.

ALFALFA WEEVIL

Hypera posticus Gyll.

The alfalfa weevil is a brown snout beetle (Photo VII) belonging to the family Curculionidae and has often been mistaken for the Phytonomus nigrirostris. Key, Pg. 104.)

This pest was first reported on the outskirts of Salt Lake City, Utah in the spring of 1904.⁵⁶ The actual manner of introduction is not known but it is thought to have come from Europe where it has been common since about 1813.⁴⁹

The alfalfa weevil was first introduced into southwestern Oregon near Medford in 1929. Because of its importance in this area as a pest of alfalfa, the Bureau of Entomology and Plant Quarantine established a laboratory at Medford, Oregon to study this insect in 1933.

The larvae (Plate XVI) feed in the growing tips of the host plants eating off the leaves and skeletonizing or shredding the young stems. In heavily infested fields the plants are stunted and the green part of the leaves is eaten out to such an extent that the fields appear to be suffering from severe frost injury.

Alfalfa is the most important food plant and is probably the only crop on which the alfalfa weevil is of economic importance. However Webster states that

occasionally bur clover is thoroughly stripped by the larvae of this beetle. Other occasional host plants are white sweet clover, yellow sweet clover, alsike clover, and crimson clover.⁵⁶

As far as is known, actual loss to the clover crops of Oregon by this pest is of minor importance.

The beetles pass the winter in the adult stage hidden away among the matted grass or other vegetation where they will be protected from the weather. In the spring these adults become active diffusing themselves over the alfalfa fields where they feed on any part of the plants that is green. They soon mate and the female deposits her eggs in the old, dead, overwintering stems of alfalfa plants.

The eggs hatch in from seven to sixteen days and the young larvae feed on the tender tips of the growing alfalfa for about twenty days when they spin a silken cocoon in the ground and pupate. The pupal period usually lasts only three or four days. There is one generation per year.⁵⁶

In 1934, Bathplectes curculionis, a small wasp-like parasite of the alfalfa weevil was liberated in Jackson County, Oregon by the Bureau of Entomology and Plant Quarantine. This parasite is now abundant in many alfalfa growing sections of Oregon and shows promise of becoming an important factor in weevil control. The alfalfa station

at Medford suggests the following control measures: (a) Early cutting when the majority of the plants are in the bud stage and before new shoots of the succeeding crop appear is a successful control measure. (b) Spraying plants with calcium arsenate as soon as the larvae start feeding is also recommended. This should be applied at the rate of two pounds of calcium arsenate to one hundred gallons of water per acre. The cost per acre is estimated at \$1.25. Chemical analysis shows that hay treated with calcium arsenate has no harmful effect on livestock. (c) Calcium arsenate may also be applied as a dust. This dust may be applied more easily and quickly than the spray but it gives lower kills. However it has been used successfully. Two to three pounds of calcium arsenate to the acre is recommended.³⁵

GRASSHOPPERS

During some years an enormous amount of damage is done by grasshoppers to the clover crops in Oregon both to the young clover during the first year of its growth and to the seed crop. When the grasshoppers show up in the seed fields at the time they are in full bloom, they not only trim off the leaves but also seriously reduce the seed yields by feeding on flowers of the clover either destroying the head or preventing the setting of the seed.

The Camnula pellucida is the most destructive and widespread species in Oregon. This commonly called "warrior grasshopper" is semi-migratory. Its normal habitat appears to be marshy areas, mountain meadows of various sizes and the large marshes in old lake beds in various parts of southcentral Oregon.

In the spring around May 15 as soon as the temperature has attained maxima of 70° or more for several days, the eggs hatch and the young black hoppers are seen gathered together in sunny areas during the warmer parts of the day. Soon after hatching the hoppers begin moving away from the egg beds and travel together in well defined bands. These bands appear to move steadily in the middle hours of sunny days but quit for feeding after 2:30 P.M. or 3:00 P.M. Why they all follow one course of direction in

their migration is not known.

After maturity the winged adults migrate, predominately in one direction, in a steady streaming flight at various heights above the ground during the warmer hours of the day. There are records in Oregon of swarms of Camnula traveling eight miles and it is believed that this species may move further than that.

Camnula pellucida begins to breed in July and continues until early October. There is no indication that vegetation or the soil influences the choice of bed areas although usually populous egg beds are found in pure mats of salt grass, in mat-like areas of *Juncus* and in other areas of nearly pure *Carex*. As to types of soil, eggs have been found in abundance in hard gumbo, sand, nearly pure peat, and gravel.

When grasshoppers are once in a stand of blossoming clover, there is little that can be done to combat them. The grasshoppers stay up in the tops of the plants and poison bait on the ground in the shade under the plants will do little good. However when the poison bait is used when the grasshoppers are small and before they have left their egg beds to enter the fields, they can be successfully controlled.

Dr. Don C. Mote has recommended the following poison-bran bait as the standard remedy for the control of

grasshoppers in Oregon:

Coarse bran - - - - - 100 pounds.

Sawdust - - - - - equal in bulk to
300 pounds bran.

Sodium arsenite (4# material) - 2 gallons.

Water - - - - - 10-40 gallons.

Note: Enough water should be used to moisten
the bait but not enough to cause the
flakes to stick together.

The best time to apply the bait is in the spring while the young grasshoppers are still in great numbers around their hatching ground. At this time a very small amount of bait is required to kill them if it is spread right where the grasshoppers are. The bait should be spread thinly and thoroughly to eliminate any danger of poisoning livestock, poultry, and birds. The bait is broadcast by hand from a bucket except where large areas are to be baited when power driven machines for this purpose are more convenient. Twenty pounds of bait per acre gives excellent results.

The bait should be spread when the grasshoppers do their greatest feeding. This generally occurs between 6:00 P.M. and 10:00 P.M. on mornings of bright and reasonably warm days. Later when the weather becomes quite hot,

best results will be secured by spreading bait very early, sometimes at day-break or before.³²

The most effective natural enemies seem to be egg predators, notably the Bombyliids, Systoechus creas and Aphobantus sp. and the carabid Amara obesa which feed on eggs both as adults and larvae. Anthomyiid Hylemyia silicrura and the Therevid Psilocephala aldrichi have been reared from Camnula pellucida egg pods. Grasshopper nymphs are occasionally parasitized by Sarcophaga atlantis or by the tachinid Acemyia tibialis. Toads, ground squirrels, mice, badgers, and coyotes have been observed feeding on this insect. There are of course several birds that are helpful at times in ridding fields of this pest.⁴⁶

The following is Rockwood's special report on grasshopper research conducted in Oregon by the Forest Grove Experiment Station showing the locations where they have occurred in damaging numbers:

Melanoplus atlantis: Hermiston, La Grande, Baker, Prairie City, Wheeler County, Dillard and Marion County.

Melanoplus devastator: Dillard County.

Melanoplus femur-rubrum: Forest Grove, Independence, Yamhill.

Melanoplus bivittatus: Lake County.

Aulocara elliotti: Lake County.

Camnula pellucida: Canyon, Weston, Lakeview, Paisley,
Summer Lake, Klamath Falls, Langell's Valley,
Keno, Malin, Silver Lake, Jefferson County,
Crook County.

Dissosteira carolina: Tule Lake.

Steiroxys sp.: Gilliam County.⁴⁶

SLUGS

Slugs belong to the phylum Mollusca of the animal kingdom along with snails, clams and oysters. The three species of slugs of economic importance in Oregon are the grey garden slug Agriolimax agrestis, the greenhouse slug Milax gagates and the reticulated slug Prophysaon andersoni. Practically all the damage done to clover is by the grey garden slug.

The grey garden slug has been known to be a pest of garden and truck crops in the Willamette Valley for many years but it did not receive much attention as a serious pest until the fall of 1940. During March 1942 B. G. Thompson of the Oregon State Experiment Station and H. T. Rainwater of the Bureau of Entomology and Plant Quarantine, made a survey and biological observations of the grey garden slug in the Willamette Valley, Oregon. Information obtained in this survey and information from the farmers in the infested area indicates that one third of the total acreage of leguminous crops was destroyed or damaged by the grey garden slug in 1941. They also found that crimson clover was the most seriously damaged crop. Other clovers affected were red clover and ladino clover. It is reported that during 1940 and 1941 thousands of acres of clover, vetch and peas in the Willamette Valley

were destroyed by this pest.⁵¹ The slug does its greatest damage to seedlings just pushing through the ground. Small seeds such as those of crimson clover, ladino clover and red clover are often completely destroyed. When the plants get larger, irregular holes are eaten in the leaves.

Slugs have soft bodies covered with a sensitive, moist skin, provided with minute glands from which they expel a mucous slime. They thrive best under moist conditions and are most active at night. During the day they hide in dark places such as weed patches, old clover fields, under boards or in the soil. If the day is cloudy and rather dark they may feed throughout the day.

Slugs are bisexual; every individual is capable of laying eggs. Slug eggs are laid in cracks, in the soil, or under boards and debris. They soon hatch. The period of development from egg to adult varies but it is usually about three months. Eggs are laid at all seasons of the year.

The most effective means of controlling slugs is a metaldehyde calcium arsenate bait:

Metaldehyde	1½ pounds.
Calcium arsenate	5 pounds.
Wheat bran100 pounds.

These ingredients should be thoroughly mixed.

The bait is used both as loose bran and in pellet form. Both give good results but it was found that better distribution of the bait was obtained with the pellet form. The bait is broadcast by hand or with a horn seeder. If a horn seeder is used, the screen is removed from the spout and part of the opening is closed with a cork.

The bait should be applied after the seed is planted and before it has had time to sprout. Four or five pounds of bait per acre has been recommended.⁵²

CUTWORMS

The cutworms that quite often do great damage to cultivated crops are the larvae of fairly large moths belonging to the family Noctuidae. There are several species of cutworms in Oregon, the more important being the variegated cutworm, Lycophotia margaritosa Hubn., the olive green cutworm, Neuria procincta Grote, the greasy cutworm, Agrotis ypsilon Rott., spotted cutworm, Agrotis c-nigrum L., yellow-striped army worm, Prodenia praefica Grote. Of these the variegated cutworm is probably the most destructive on clovers in Oregon.⁴¹

Cutworms, while not as mobile as most other insects, sometimes occur in such great numbers that they greatly reduce the hay and seed crops of clover. The cutworms normally feed at night, cutting off the younger plants near the surface of the soil and climbing up and feeding on the foliage of the older plants. When the clover is in bloom these cutworms do great damage to the seed crop by feeding on the clover heads.

Most of the cutworms spend the winter as half grown larvae in the soil. Early in the spring they become active and reach maturity during April and May when they enter the soil and pupate in earthen cells. The adults emerge during May and June. Soon after the adults

emerge they mate and the female begins laying eggs. The eggs are usually deposited in the field on or near the food plants of the larvae. The eggs hatch in a few days into another generation of worms.

There are two generations in Oregon a year.

Poison bran mash is the most successful control. The Oregon State Experiment Station has recommended the following bait:

Coarse wheat bran	5 pounds
White arsenic or paris green	3 ounces
(or Sodium fluoride	5 ounces)
Molasses or sirup	1 pint
Water to make a crumbly mash	2-3 quarts.

The dry ingredients are first thoroughly mixed and then the water and syrup added.^{33A}

The poison bait should be broadcast over the infested area at the rate of twelve to fifteen pounds per acre as soon as the first cutworm injury is noticed.⁵¹

STRAWBERRY FRUIT WORM

Cnephasia longana Haw.

The strawberry fruit worm is a small grayish brown moth belonging to the family Tortricidae. It was first reported in Oregon in 1929 by J. J. Inskeep who found it feeding on strawberries. The insect is now known to be scattered almost over the entire Willamette Valley. As yet it has not been reported west of the Coast Range Mountains or east of the Cascade Mountains.

In some localities in the Willamette Valley, the small creamy-brown larvae of this insect have been found numerous upon the blossoms of alsike, white, crimson, and red clovers. The feeding causes little damage except in the case of seed production which may be reduced by the destruction of the blossoms. During 1941 a field of scarlet clover in Polk County was severely damaged by the larvae of the strawberry fruit worm. (Plate XVII)

The life history and habits of this insect are not very well known yet. Usually the eggs are laid during May and June in crevices of cedar fence posts, telephone poles, rough tree bark and on the sides of shingle buildings. The eggs hatch in from twelve to eighteen days and the young larvae crawl over the plants in search of tender leaves which they may feed upon.

At the end of approximately eleven months the mature larvae webs a portion of the petals, leaves, or other plant material around itself and pupates. Adults emerge in from twelve to fifteen days. There is only one generation a year in Oregon.¹¹

As yet no satisfactory control has been worked out. In some cases it has been helpful to pick and destroy the blossoms before the larvae and pupae leave the host. In cases where hand picking is impractical due to seasonal development or expense, cleaning up adjacent fields and fence rows of wild flower hosts and thorough cultivation of the crops may prove of value.¹¹

TREEHOPPERS

In recent years considerable damage has been done to the young orchards and nursery trees of Oregon by various membracids known as treehoppers. The normal feed of the nymphs of these hoppers is certain leguminous crops, one of them being clover, used as cover crops in orchards. Upon these treehoppers pass their nymphal stage.

Of the treehoppers belonging to the family Membracidae those doing the most damage to clover are: Strictocephala inermis, the green clover tree hopper, Ceresa basalis, dark-colored tree hopper and Ceresa bubalus, the buffalo tree hopper.

GREEN CLOVER TREE HOPPER

Stictocephala inermis

This green clover tree hopper is a small homopterous insect. The adults are a brilliant green to yellowish in color and are found throughout the apple and pear orchards of Oregon wherever clover and alfalfa are grown as cover crops. It is commonly found on sweet clover and red clover.

The nymphs of this insect cause injury to the clover by sucking out the plant juices giving the clover plant stems a girdled appearance. According to the damage done as stated by Yothers this insect in the Northwest is

comparatively unimportant.⁶⁵

The green clover treehopper hibernates in the egg stage in the bark of fruit trees. These eggs hatch in early spring; the nymphs mature by early summer; and the adults lay their eggs during the middle and latter part of the summer.

There is one generation a year in Oregon.

Mortality of eggs ranges in instances from eleven percent to twenty-two percent when the eggs are excessively crowded by growing and swelling bark and wood. A few of the living eggs are grown over by new wood tissue in early spring before hatching. In such cases nymphs are unable to escape and so perish.

DARK-COLORED TREE HOPPER

Ceresa basalis Walk

The first reference to C. basalis, the dark-colored tree hopper in the Pacific Northwest was made by Wilson when he recorded it in Oregon in 1915.

The C. basalis is similar in habits, appearance and its feeding to the aforementioned S. inermis. The only known food plants of this species in the Pacific Northwest are alfalfa and sweet clover. It makes use of trees, mainly apple, peach, pear, willow, locust, and prune for oviposition purposes only.

The egg is the only stage in which this insect survives the winter. Eggs are laid in August or September and hatch during the fore part of May. Nymphal stage lasts about two months causing adults to appear about the second week in July completing one generation a year in Oregon.

This insect is its own worst enemy. The incisions it makes in the bark where it deposits its eggs usually kill the twig on which they are cut. A high mortality of eggs results because few of them are able to withstand the shrinking, withering effect of the drying wood.

BUFFALO TREE HOPPER

Ceresa bubalus Fab.

The occurrence of the buffalo tree hopper is rare when its numbers are compared to those of S. inermis and C. basalis; however it is the most widely distributed of all the membracids. It is readily distinguished from S. inermis and C. basalis by its larger size and large pronotal horns.

Although this species is the largest of the three tree hoppers mentioned and its injury generally is more severe, it is so scarce in most localities that it is of less economic importance than the S. inermis or C. basalis.

This insect has been little studied; however according to Yothers their chief food plant probably is alfalfa and they may also feed on sweet clover.⁶⁵ Funkhouse reports their feeding on sweet clover as common.⁶⁵ Yothers also has listed Ceresa albidosparsa Star of this family as feeding on sweet clover.⁶⁵

Most natural control for all of these species is similar. There is a high egg mortality especially of the eggs of C. basalis as previously mentioned. In dropping from trees many nymphs fall or are blown on utterly barren ground and are unable to reach suitable food plants; many fall in irrigation ditches and are lost. Of the many thousands of nymphs hatching few reach maturity.

Parasites are so few as to effect little control. But there are some that are known to be harmful to the tree hoppers, namely: Nymphs are devoured by some species of spiders; also certain species of mites, at least two of coccinellids, ants and toads prey upon the membracid nymphs.

Lubricating oil emulsions at four percent of actual oil used as a spray showed a mortality of ninety to one hundred percent of eggs and it may be applied to either dormant or hatching eggs with full effectiveness. Contact sprays are used against nymphs.

Where clover and alfalfa can be done away with as cover crops or around orchards tree hoppers soon die out. In light attacks by these insects pruning out of infested twigs is suggested as a means of control.

WIREWORMS

Several very different insects have received the name of wireworm, but to entomologists the ones known as wireworms are the larvae of some species of click-beetles belonging to the family Elateridae. The larvae of these beetles are considered to be among the worst pests of American agriculture as they feed on about all cultivated crops and are among the most difficult insects to control.

The larvae are white or yellow, cylindrical, and have hard shiny bodies. The presence of three pairs of jointed legs will distinguish them from true worms. They damage crops by destroying seed, by cutting off small underground stems, and by boring holes in the larger stems, roots, and tubers. Typical wire worm damage can be detected in the field when plants suddenly wither and turn yellow while the outer leaves remain green. Crops planted in recently plowed pasture lands suffer severe damage because wireworms that naturally feed on the roots of pasture grasses then must concentrate on the cultivated crop.²⁹

Wireworms are omnivorous in their feeding habits and are often found doing damage to native grasses, field forage, garden and truck crops.

Generally the adults emerge from the soil in the spring during April, May and June. After mating the

females burrow into the soil and lay their eggs on the roots or in the soil near the roots of the growing plants. The eggs hatch in from a few days to a few weeks and the larvae spend from two to six years in the soil feeding on the underground parts of the plants. Their depth in the soil will depend on the amount of moisture present in the soil.¹⁶

The more important species of wireworms in Oregon are: Great Basin wireworm Ludins noxius Hyslop, dry land wireworm Ludins inflatus Say., Puget Sound wireworm Ludius suckleyi Lec., Oregon wireworm Melanotus oregonensis Lec., sugarbeet wireworm Limonius (Pheletes) californicus Mann., and western field wireworm Limonius infuscatus Mots.

Great Basin Wireworm Ludius noxius Hyslop. This species is found in eastern Oregon. It feeds on native grasses and wheat. It is controlled by practicing clean summer fallow methods and by planting enough extra seed in the spring to allow for thinning by wireworms.

Dry Land Wireworm Ludius inflatus Say. This species is found in western Oregon as well as at higher elevations in eastern Oregon where precipitation is above fifteen inches annually. It feeds on the roots of grasses, perennial plants, cereal and forage crops. Little is known of control of this species but summer fallowing helps to keep down their numbers.

Puget Sound Wireworm Ludius suckleyi Lec., The habitat of this species is in western Oregon especially on the higher well drained prairies and timbered areas. It feeds upon grass roots, general field and garden crops.

Oregon Wireworm Melanotus oregonensis Lec. This species is fairly well distributed over the entire Northwest and it too feeds upon grass roots, general field and garden crops.

Sugar Beet Wireworm Limonius (Pheletes) californicus Mann. This wireworm is especially abundant and injurious in the irrigated lands of the drier portions of Oregon. Its food plants are the seeds, stems, roots, bulbs and tubers of the more succulent plants grown on the more fertile soils, especially corn, potatoes, onions, melons, bulbs, etc. Fumigation with carbon disulphide or naphthalene is an effective but expensive control. Flooding in hot weather will eradicate them and drying the soil by not irrigating growing alfalfa or wheat once in four or five years will help to keep down their numbers.

Western Field Wireworm Limonius infuscatus Mots. This species has a fairly general distribution on the loam soils where good soil moisture is uniform throughout the year; it is especially abundant in the Willamette Valley on river bottom soils.

False Wireworms. The false wireworms are the larvae of the darkling ground beetles which belong to the family Tenebrionidae. The larvae are often cylindrical and shining, somewhat resembling wireworms, hence the name "false wireworm." These larvae are chiefly nocturnal in habit and feed on many of our cultivated plants. The most important species in Oregon is Eleodes hispilabris imitabilis Blais. It is found in eastern Oregon and feeds on native grass roots and young sprouting grain.

SEED CATERPILLAR

Grapholitha conversana Wlsm.

This seed caterpillar is a moth belonging to the family Olethrutidae, and is not the common clover seed caterpillar Laspeyresia interstinctana as found in the East and Mid-Western sections of the United States. The Grapholitha conversana was first described in 1879 by Lord Walsingham from camp Watson on John Day's River, Oregon, now known as Wheeler County.

The seed caterpillar occurs in California, Oregon, Washington, British Columbia, and Idaho. Rockwood reports collecting this species from native clover Trifolium invalucrotum near the coast in Tillamook and Clatsop Counties, Oregon.

The larvae eat into the base of the florets consuming the ovules and the young seed pods. Sometimes they pass from one floret to another forming tunnels. This feeding on the florets causes the clover heads to dry up and turn brown prematurely. Some years when the caterpillars are numerous, a seed crop of clover is almost completely destroyed.

The seed caterpillars pass the winter in the pupal state in cocoons which are concealed in the debris beneath the host plants. In May and June the adult moths emerge

and mate. The female then deposits eggs on the underside of the involucre or around the base of the flower heads. Eggs may be laid singly or in small batches. They hatch in about twelve days and the young larvae feed on the clover plants. There is only one generation a year in Oregon.

L. P. Rockwood of the Forest Grove Experiment Station list the following host plants: native clover Trifolium involucreatum, red clover, alsike clover, and two species of native clover, Trifolium dangleasii and Trifolium plumosum.

Two species of hymenopterous parasites have been reared from the seed caterpillar larvae Orgilus mellipses and Microbracon hyslopi.

CLOVER HEAD THRIPS

Phloeothrips niger Osborn

This small, slender, black thrips belonging to the family Phloeothripidae is a European species now found in Oregon, California, Utah, British Columbia and Montana.

The adult thrips feed on the clover heads sucking sap from the plants causing the plant to lose vitality and interfering with the developing of the seeds.⁹ The thrips has been reported as destructive to the red clover seed crop in Montana and Idaho.¹³

The clover head thrips infests yarrow, corn, chrysanthemum, rudbeckia, red clover, apple, plum, tomato, rutabaga, grasses, alsike clover, ladino clover, strawberry clover and spirea.

Dr. Scullen in his 1940 survey of insects affecting clover seed in eastern Oregon reports finding from 800 up to 1600 thrips for forty clover heads. The thrips were more abundant on the clover during the early part of July. Most thrips were found on red and alsike clover.

It would seem reasonable to assume that the tremendous number of thrips found on the clover heads would have an important bearing on the clover seed production but as yet there have been few studies made of thrips on clover so at the present time the amount of damage can not be estimated.

APHIDS

Aphids are small brownish green plant lice belonging to the family Aphidae. These aphids occur throughout the clover seed districts of the Pacific Northwest and have occasionally caused severe losses to the growers of red and alsike clover seed in certain districts. The more important species of aphids on clover in Oregon are the clover aphids, Anuraphis bakeri Cowen and Anuraphis helichrysi Kalt.; pea aphid, Macrosiphum pisi Kalt.

PEA APHIS

Macrosiphum pisi Kalt.

This big, green, long-legged plant-louse has ruined millions of dollars worth of field peas and a great deal of red clover. It was probably introduced into this country about 1899 from Europe where it occurred on peas and clover.

The first mention of the pea aphid in Oregon was in 1914 when it was observed feeding on red clover. By 1915 these aphids had become quite abundant on red clover and by 1918 there were numerous records of severe infestations by this insect. The pea aphid is now generally distributed throughout Oregon.

In the spring when the clover begins to grow the young aphids begin feeding on the tender leaves and shoots sucking the sap from the plant and giving a whitish appearance to the plants. The leaves thus attacked wither and die. As the aphids mature they may eventually infest the entire plant.

According to Rockwood's reports the pea aphid rarely causes severe damage to clover because of natural checks on the aphids and because clover plants are quite resistant to their injury.⁴⁶

In the Willamette Valley and coast sections of Oregon the pea aphid overwinters in viviparous form on several legumes. The primary one is vetch. Others which serve as supplementary hosts are garden peas, sweetpeas, alfalfa, sweet clover, red clover and native clovers. Scotch broom is an all-year-round host with oviporous females and both alate and apterous males appearing in September. In eastern Oregon the pea aphid overwinters in the egg stage on alfalfa and sweet clover. Early in the spring the eggs hatch and the young nymphs feed until alates appear. These forms migrate to other crops. There are several generations a year.

The pea aphid feeds on a large number of hosts, the more common clover crops being sweet clover, red clover, crimson clover, white clover, yellow clover, and several

of the native clovers, Trifolium fimbriatum and T. eriocephalum being the most common.⁴⁶

The most important natural control of the pea aphid is a fungus disease, Entomophthora (Empusa) amphidis, which usually occurs early in the season, especially if wet. At times this disease is very abundant and acts as an important factor in holding these insects in check. Rockwood has listed the following predators of the pea aphid: Coccinella trifasciata subversa, Hippodamia convergens, H. ambigua, H. parenthesis, H. sinuata spuria, H. 13-punctata (tibialis), H. apicalis, Cycloneda sanguinea polita, Adalia bipunctata, A. frigida and Cleis (Harmonia) picta. Of the ones working on the pea aphid in the Willamette Valley C. trifasciata var. is the earliest efficient worker. H. convergens, C. polita, H. ambigua and H. sinuata spuria are helpful at times. Of more importance even than the coccinellids are the syrphids. Syrphus pyraustri and S. opinator are commonly found in Oregon.⁴⁶

For controlling the pea aphid in the field on peas dust of .75% rotenone and soyabean oil 3% has given very good results. This dust is applied at the rate of thirty-five pounds per acre.¹⁸

CLOVER APHIDS

Anuraphis bakeri Cowen

Anuraphis helichrysi Kalt.

For many years the clover seed growers of the Willamette Valley have suffered frequent losses from what they call "sticky seed." This is caused by small brownish green plant lice commonly known as clover aphids.

These aphids occur throughout the clover seed districts of the Pacific Northwest and occasionally have caused severe losses to the growers of both red and alsike clover seed. The most noticeable damage done by this insect is a result of honey-dew, secretions causing a sticky seed condition. This interferes with the hulling and may make it necessary to wash the seed before it can be sold in the seed markets. Rockwood reports finding sacks of sticky seed clover in the Willamette Valley, Oregon hardened so that they could not be used.⁴⁶

When numerous, the aphids may cause a sickening of the foliage and an imperfect development of the blossoms. Red clover and alsike clover fields which become infested with aphids early in the growing period usually suffer a marked reduction in the average number of stems and branches per plant. This destruction of the branches in their early stage of development results in a reduction of the

average number of blossoms causing low seed yields.⁴⁸

These aphids have fruit trees as alternate food plants. They pass the fall, winter, and spring months on the trees. In Oregon they become winged and migrate to clover fields during the latter part of May. On the clover the females multiply throughout the summer.⁴⁶ Smith reports as high as twenty-three generations of aphids on clover during the summer season.⁴⁸

During August and September these summer migrant females give rise to both males and females which migrate to the fruit trees. After mating the females lay eggs about the buds and in crevices of the bark on fruit spurs and branches of the trees. The winter is passed in the egg stage.⁴⁸

Coccinellidae or lady beetles have been the most important enemies in destroying the aphids in the later stages of infestation. Fifteen different species of these beetles have been taken on clover plants infested with clover aphids. Of this number the Hippodamia sinuata Muls. is the most important species. Five species of Hemiptera, Triphleps tristicolor, triphleps insidiosus, Melanophthalmus americanus, Charips sp., and Aphelinus lapisligni have been observed feeding on aphids. Of the syrphids the most important species working on the aphids in the clover fields are: Leucopis griseola Fall.,

Sphaerophoria sulphuripes Thom., Eupeodes volucris O. S., and Paragus tibialis Fall. Aphelinus lapsiligni Howard is by far the most important Hymenoptera attacking the clover aphids. This small chalcid accounts for about ninety-seven percent of all the aphids parasitized by Hymenoptera. Some species of spiders and Chrysopids have been found preying on aphids.⁴⁸

Early cutting of the hay crop reduces the amount of sticky seed in the Willamette Valley because the clover heads mature before the aphids have reached their maximum abundance. It has been observed that early cut fields of red clover are often comparatively free from sticky seed. Close pasturing of the first crop, until the first of June, is usually effective in keeping down the aphids.⁴⁶ In Idaho the aphids were successfully controlled on the fruit trees by spraying the trees just after green tips appeared on the blossom buds, using nicotine sulfate alone at the rate of three-fourths pint to one hundred gallons of spray, or using nicotine in combination with lime-sulphur.⁴⁸

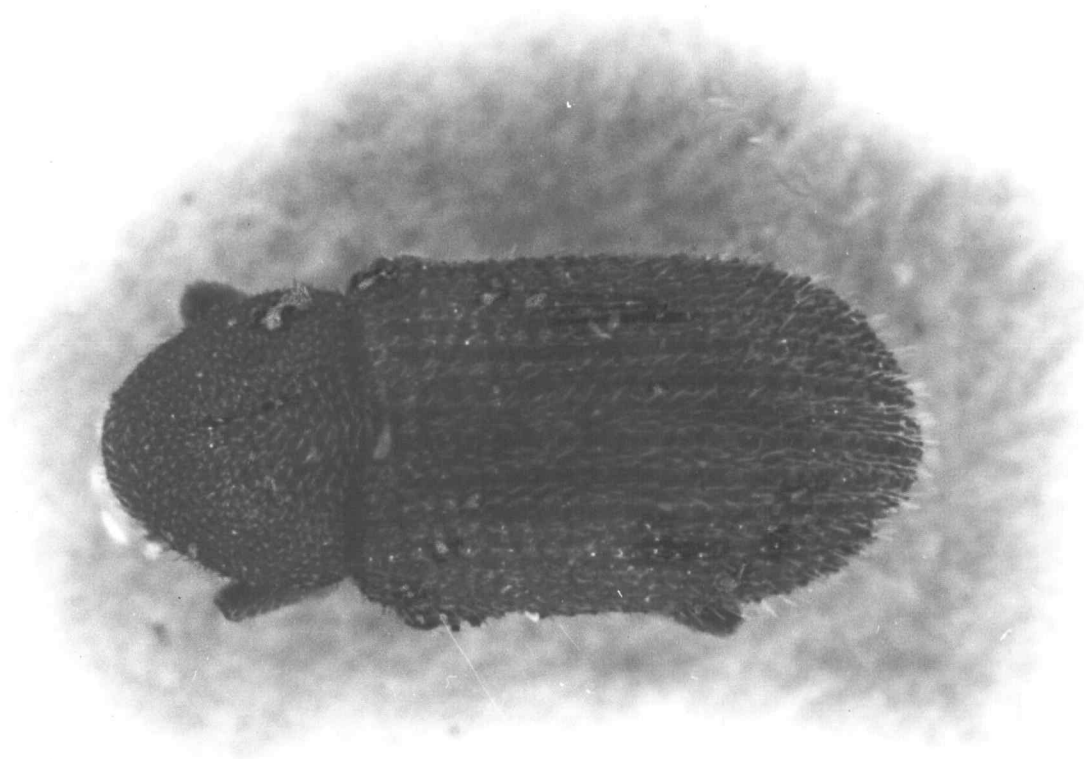


Photo I. Adult Clover Root Borer.

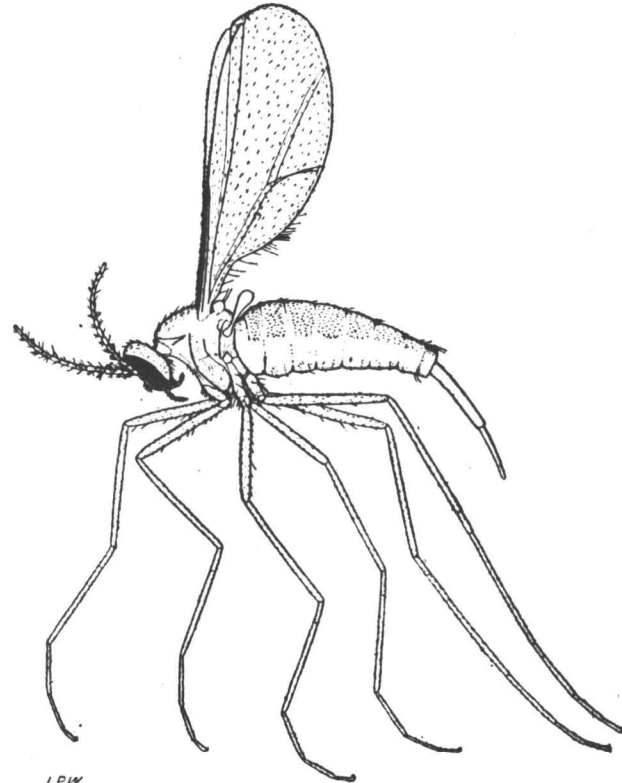
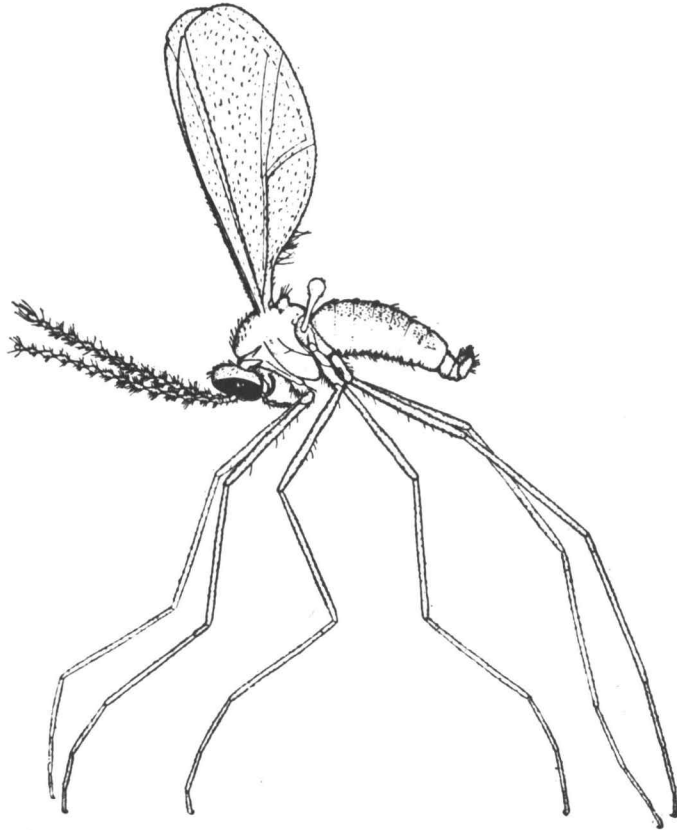


Photo II. Adult Clover Flower Midge. Male and Female.



Photo III. Adult Clover Seed Chalcid.

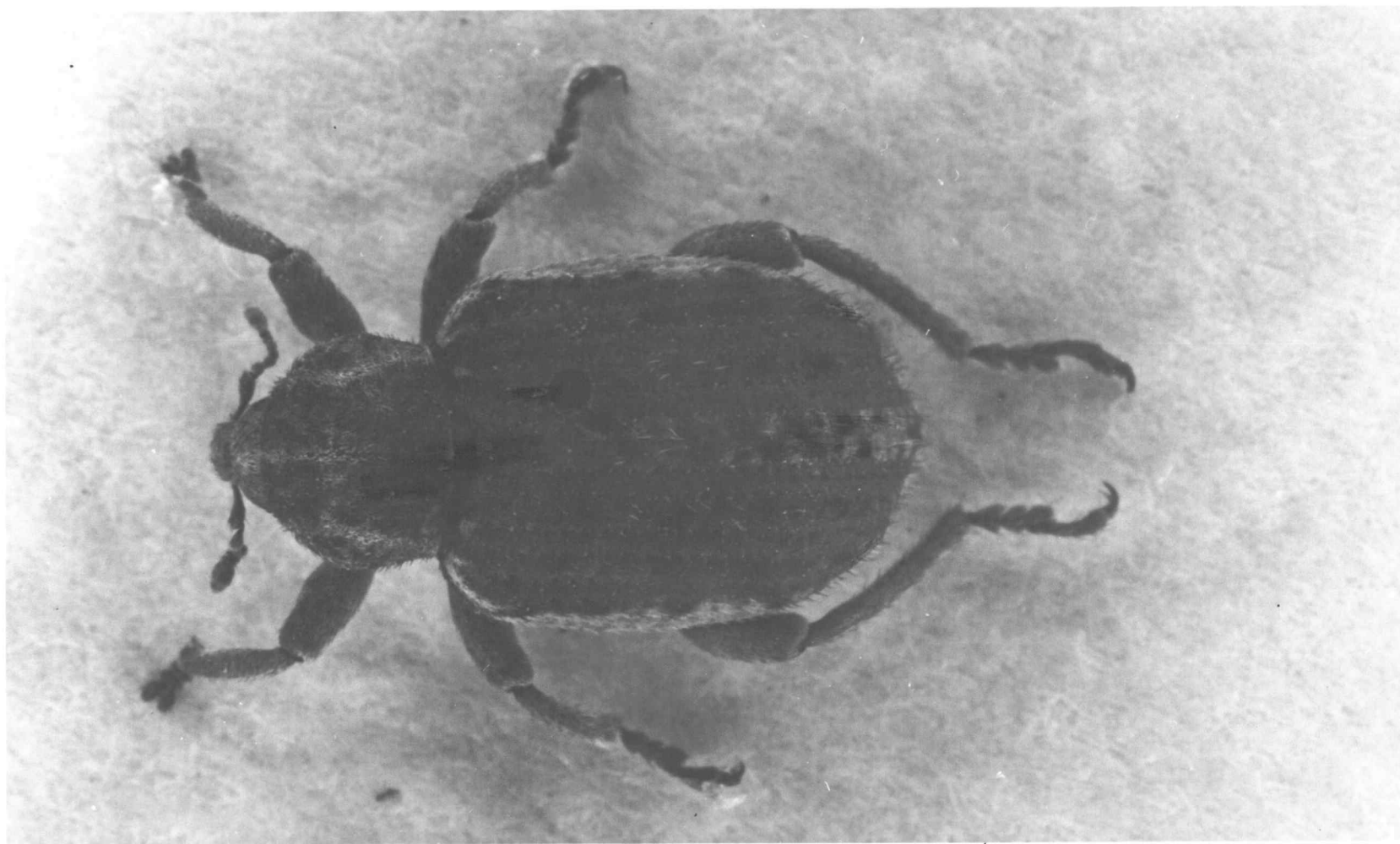


Photo IV. Adult Clover Leaf Weevil.

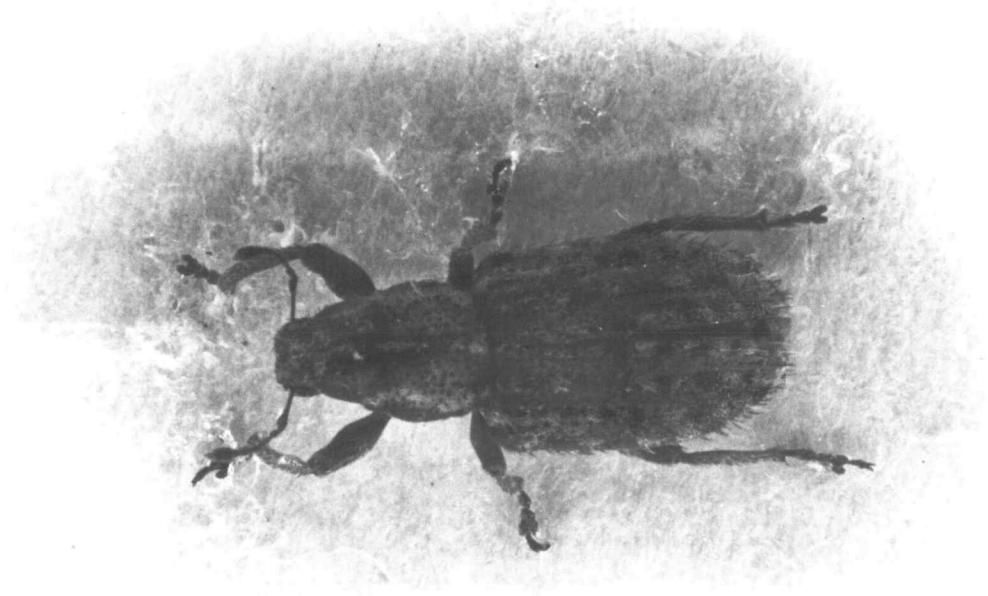


Photo V. Adult Clover Root Curculio.

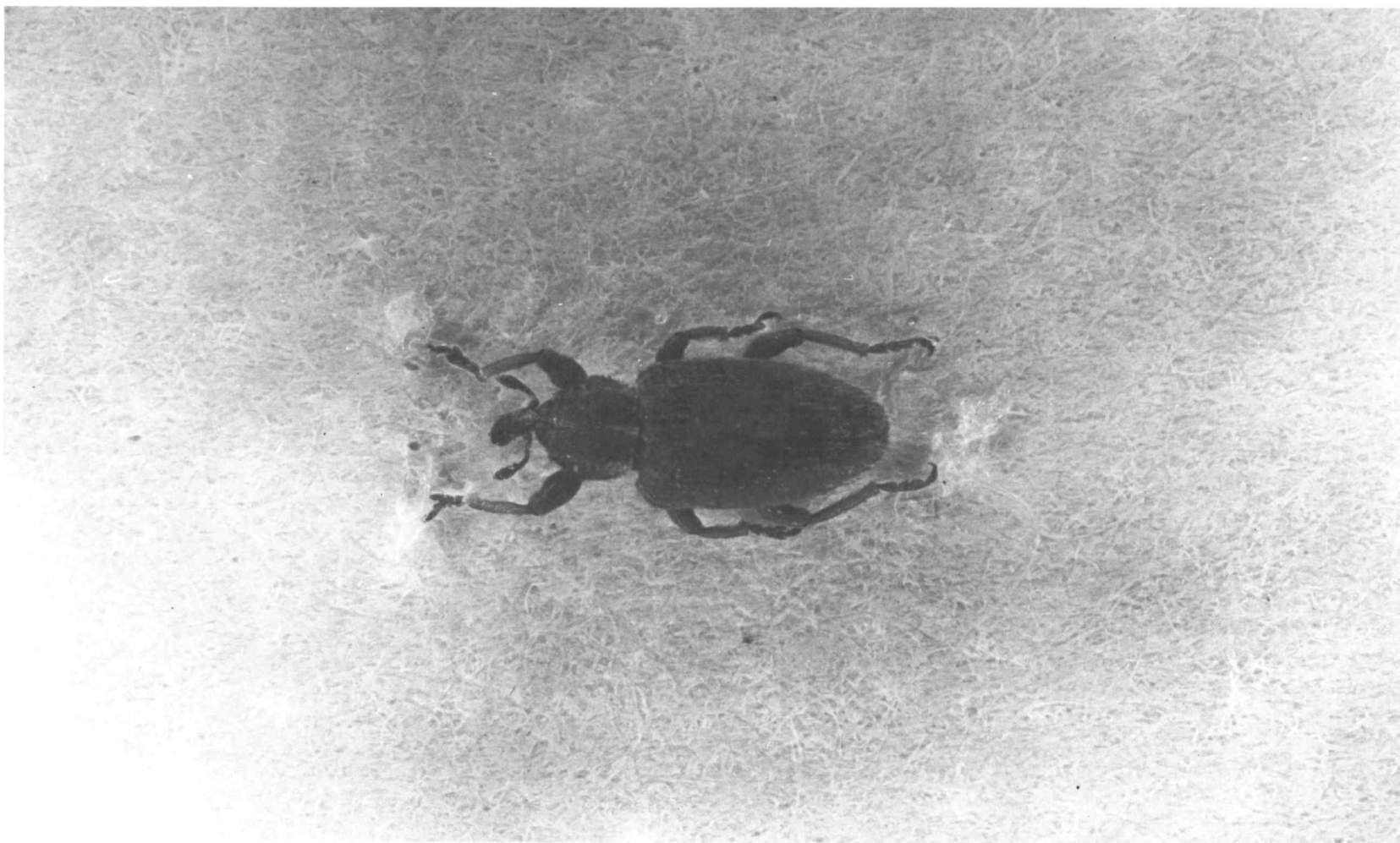


Photo VI. Adult Lesser Clover Weevil.



Photo VII. Adult Alfalfa Weevil.

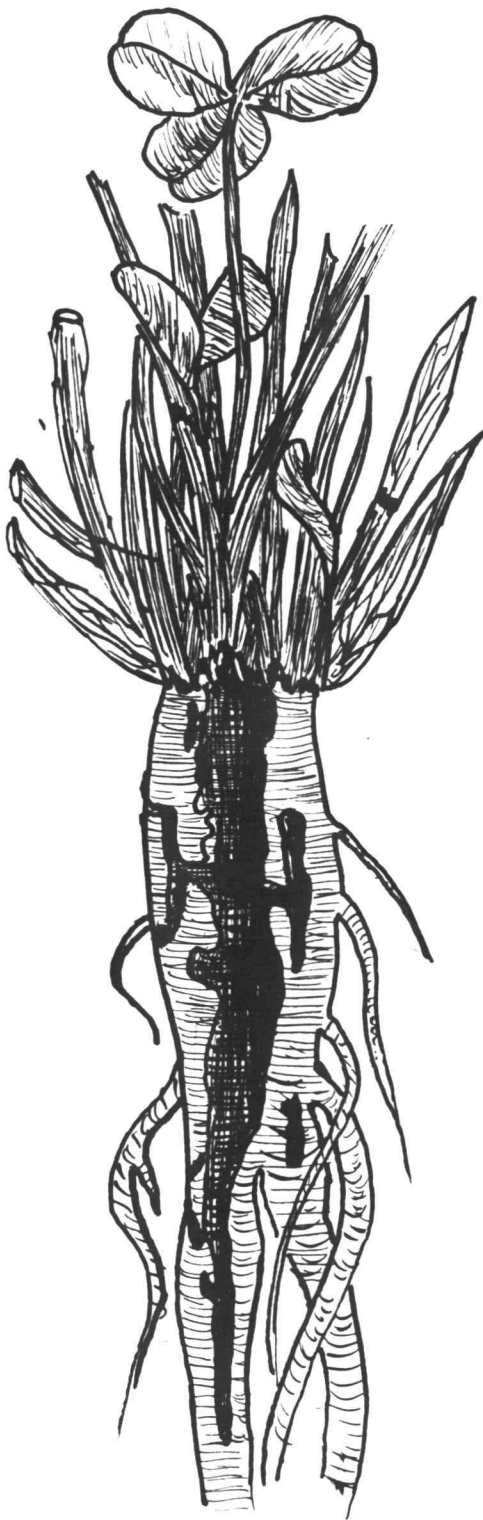


Plate I. Clover Root Borer Injury to Clover Roots.
(From Webster, U.S.D.A.)

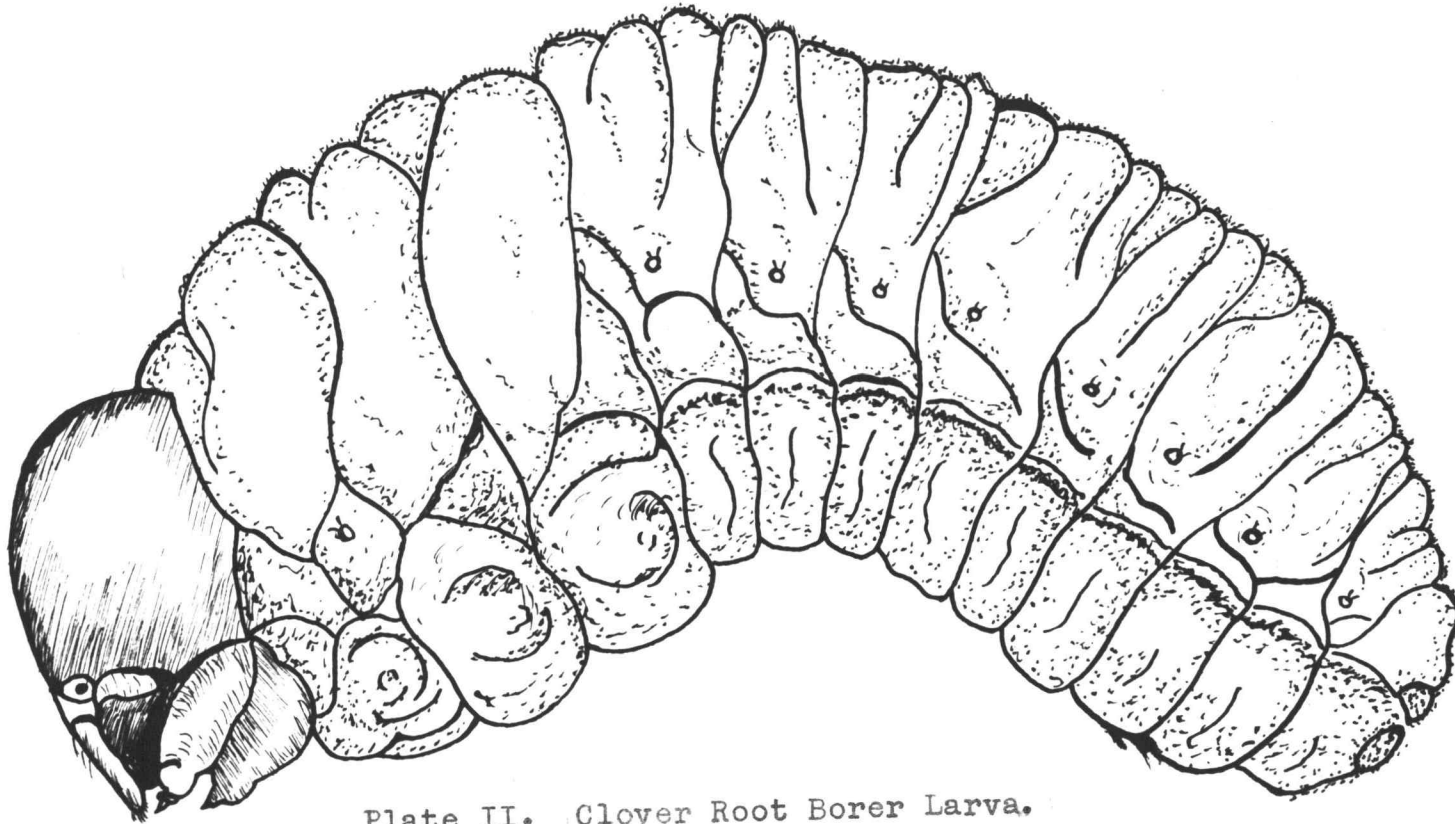


Plate II. Clover Root Borer Larva.
(From Rockwood, U.S.D.A.)



Plate III. Head of Red Clover Infested by Clover
Flower Midge.
(From L.P. Wehrle, Cornell Bull. 481.)

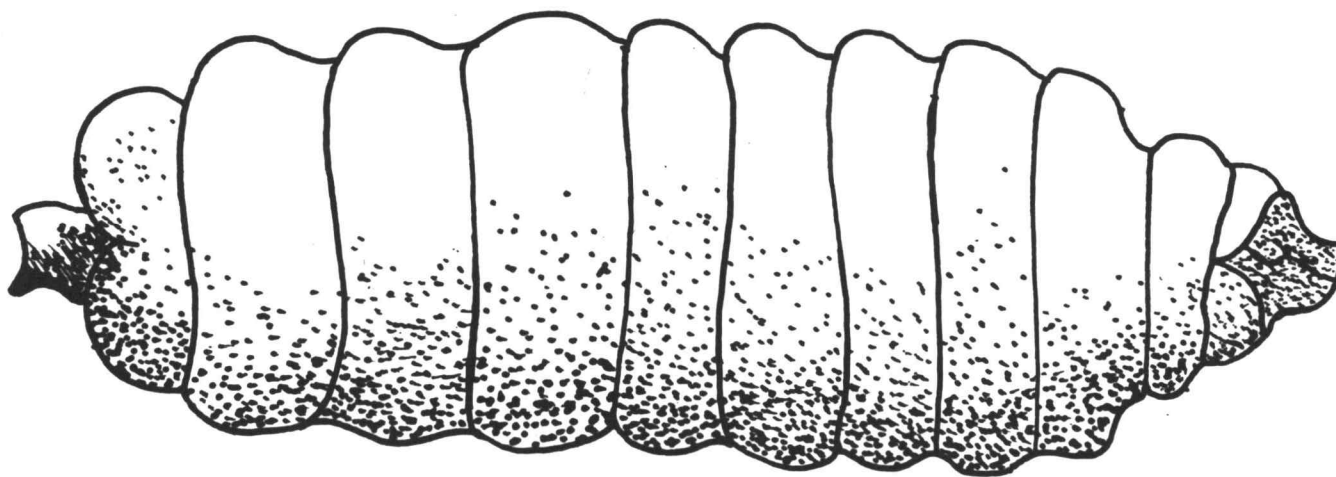


Plate IV. Clover Flower Midge Larva.
(From Moznette, OSC Ext. Bull. 203.)

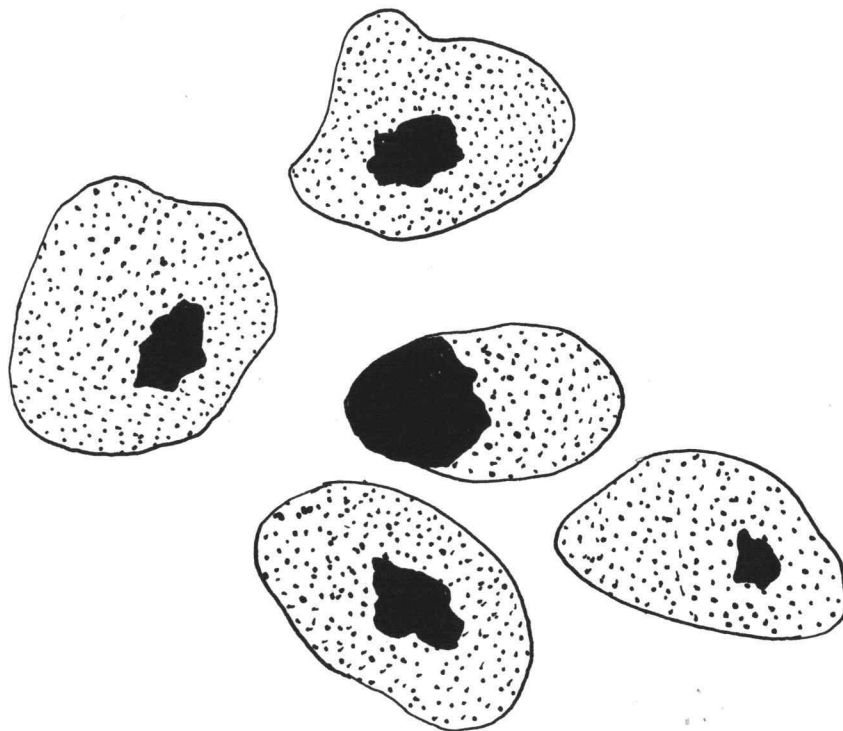


Plate V. Holes showing emergence of clover seed
chalcid from clover seeds.
(Wildermuth, U.S.D.A.)

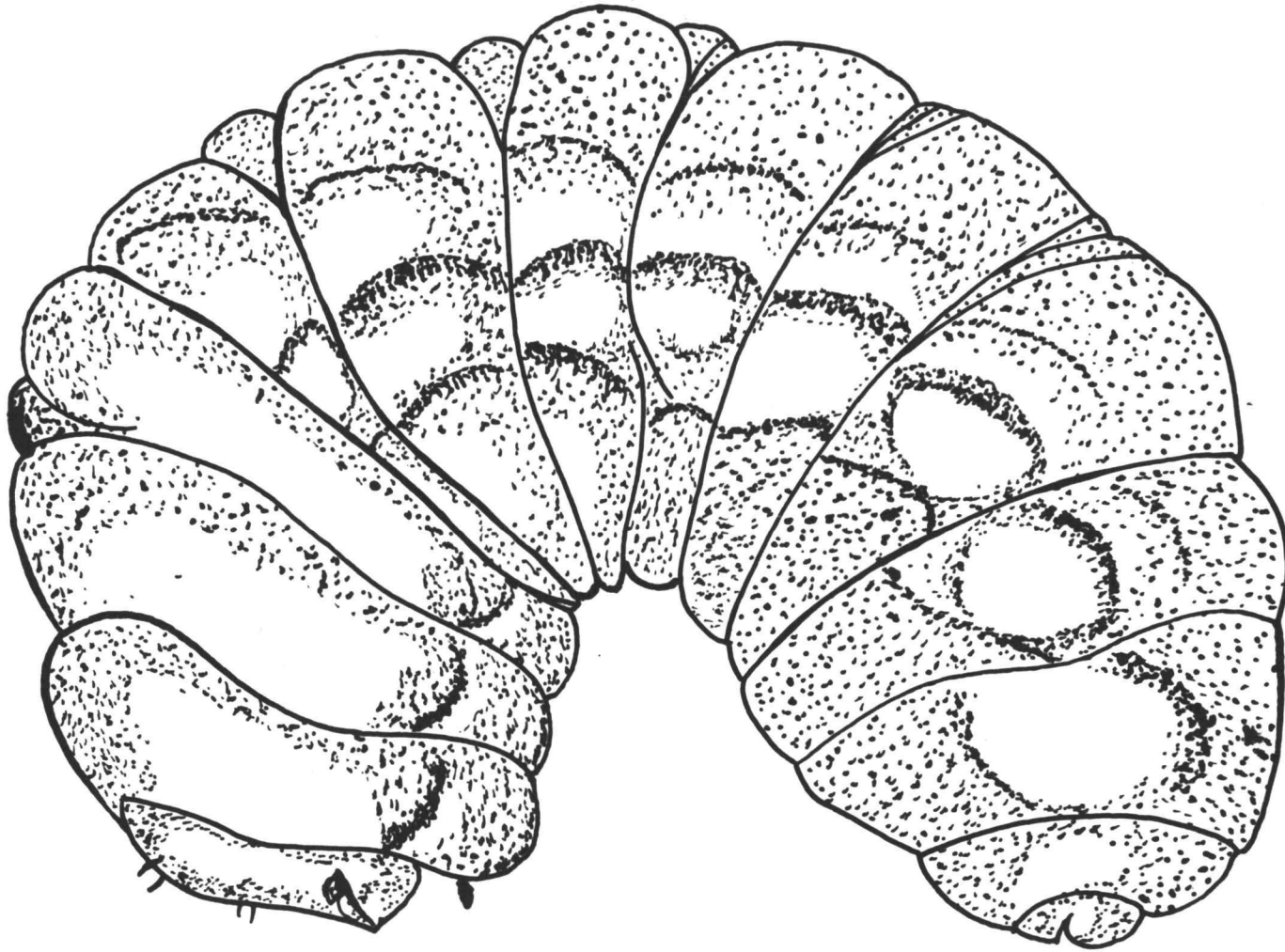


Plate VI. Clover Seed Chalcid Larva.
(From Urbahns, U.S.D.A.)



Plate VII. Leaf and stem injury of clover plant by clover leaf weevil.

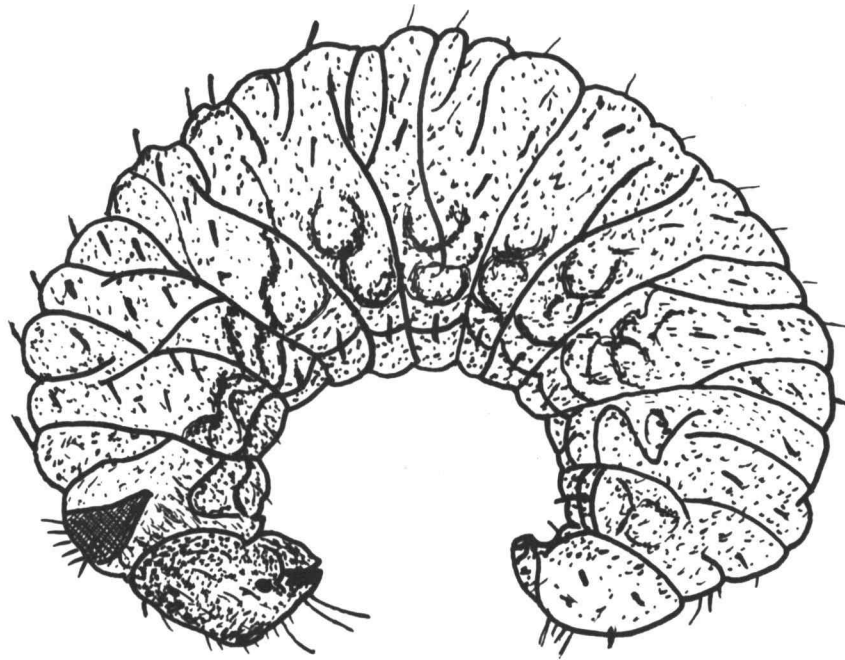


Plate VIII. Clover Leaf Weevil Larva.
From Tower, U.S.D.A.)



Plate IX. Field showing emergence cages used for clover leaf weevil.



Plate X. Rearing lamp chimneys used in studying life cycle of clover leaf weevil.

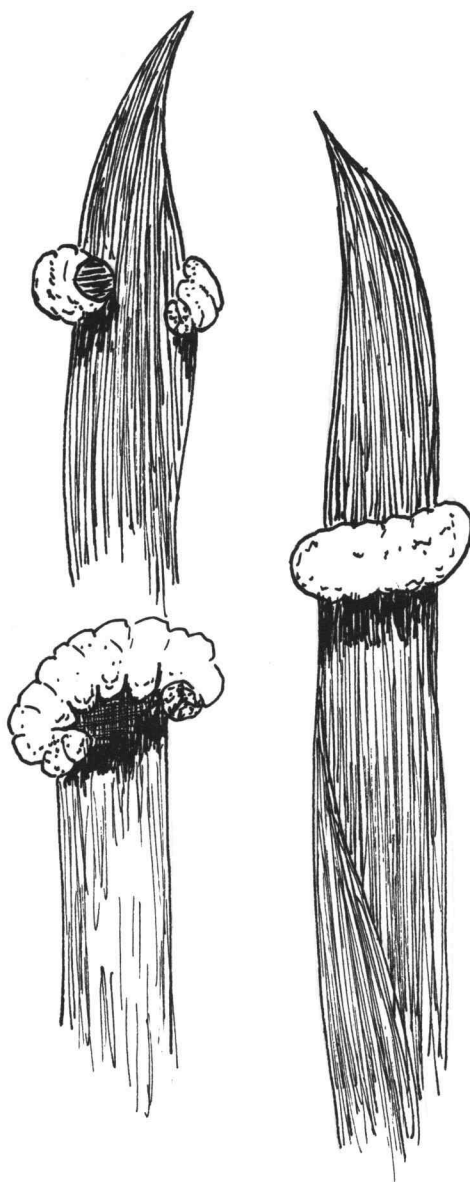


Plate XI. Clover leaf larva attacked by the
fungus, Empusa Spaerosperma.
(From Herrick, Cornell Bull. 411.)

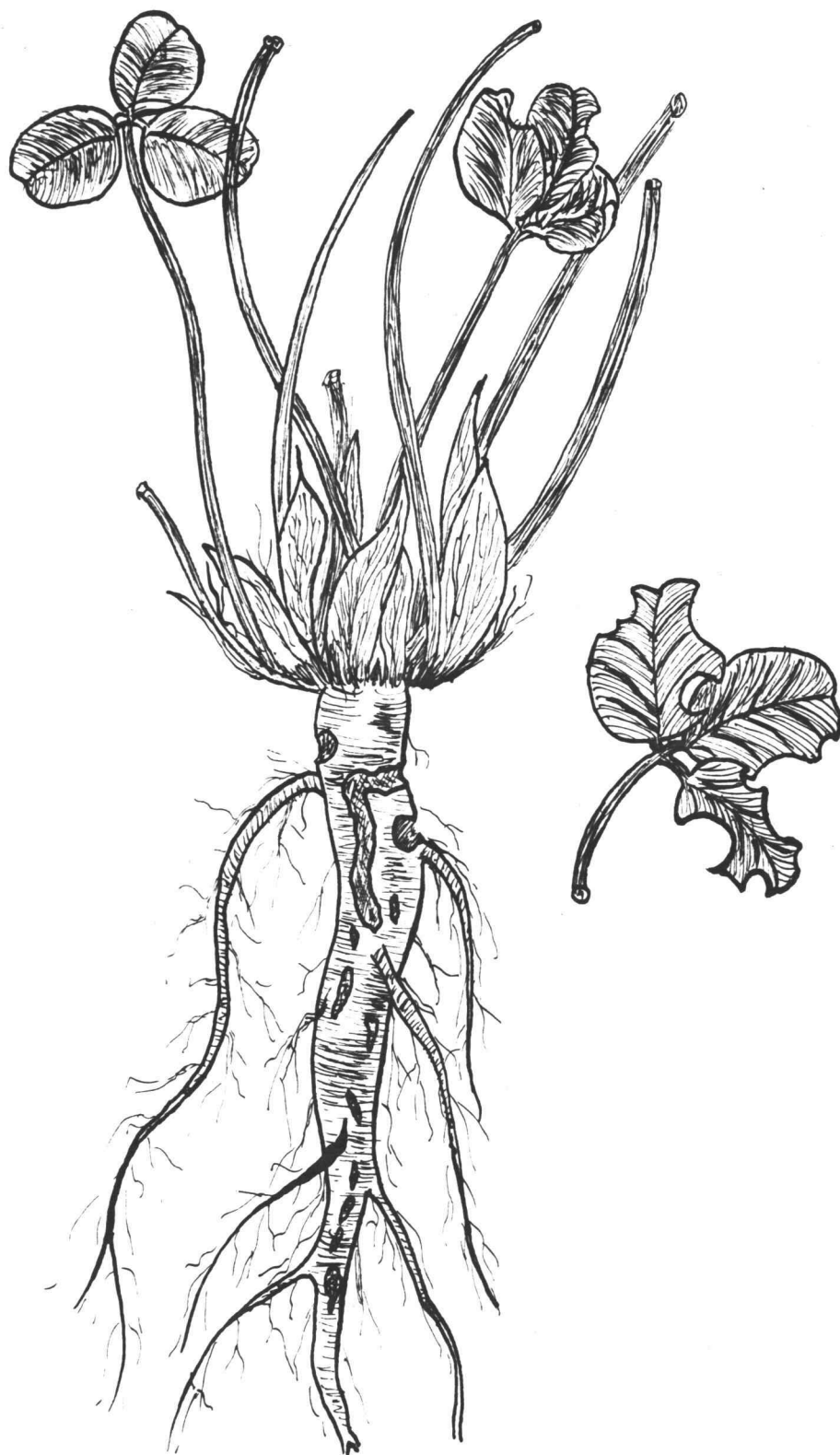


Plate XII. Work of clover root curculio on clover root and leaf. (From Wildermuth, U.S.D.A.)

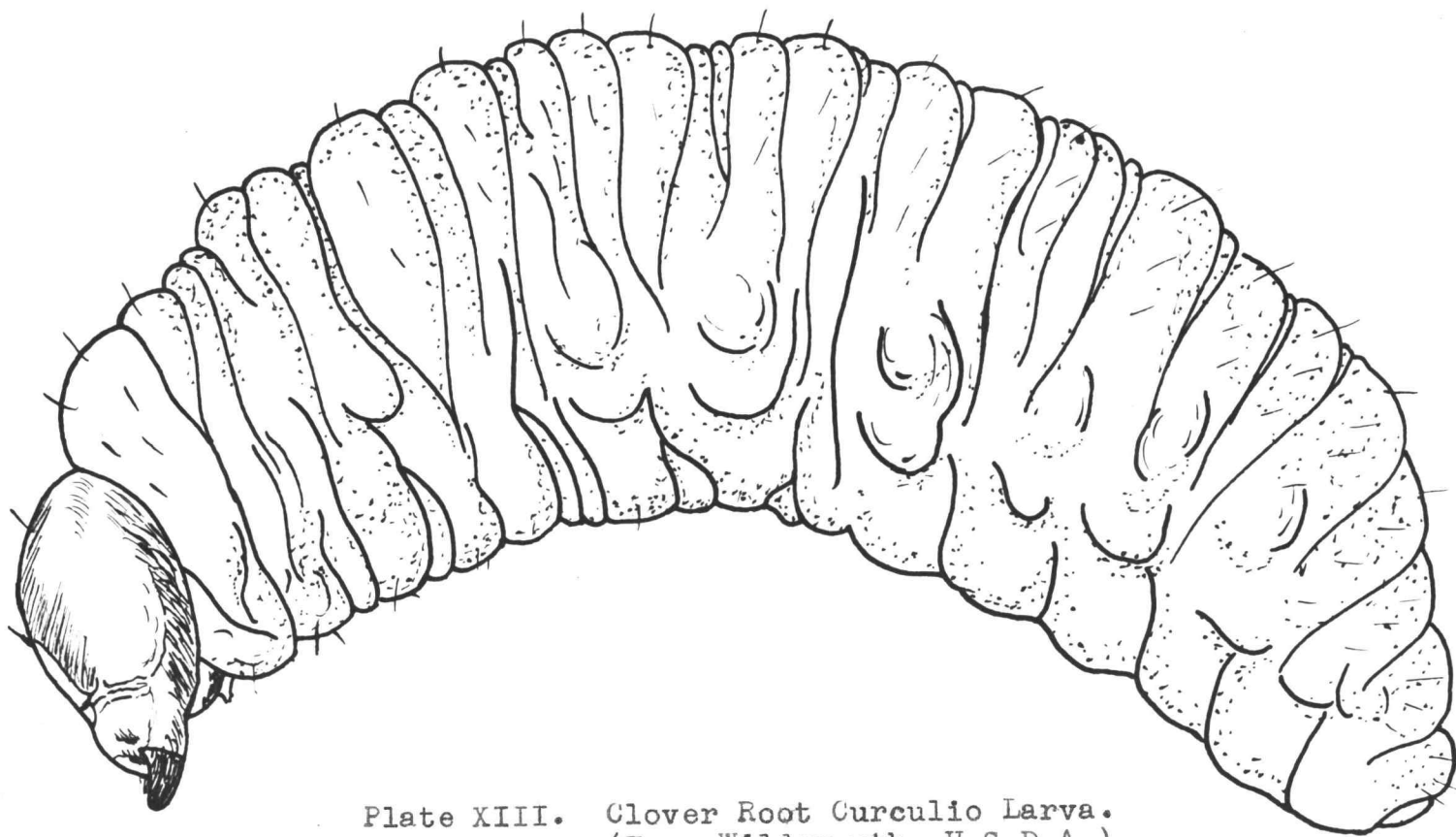


Plate XIII. Clover Root Curculio Larva.
(From Wildermuth, U.S.D.A.)



Plate XIV. Leaf injury by lesser clover weevil.

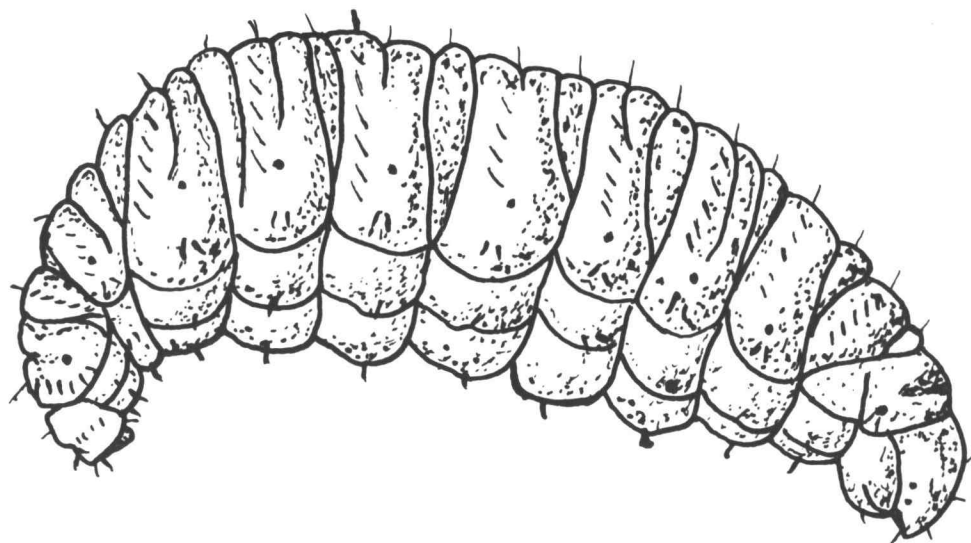


Plate XV. Lesser Clover Weevil Larva.
(From Detwiler, Cornell Bull. 420.)

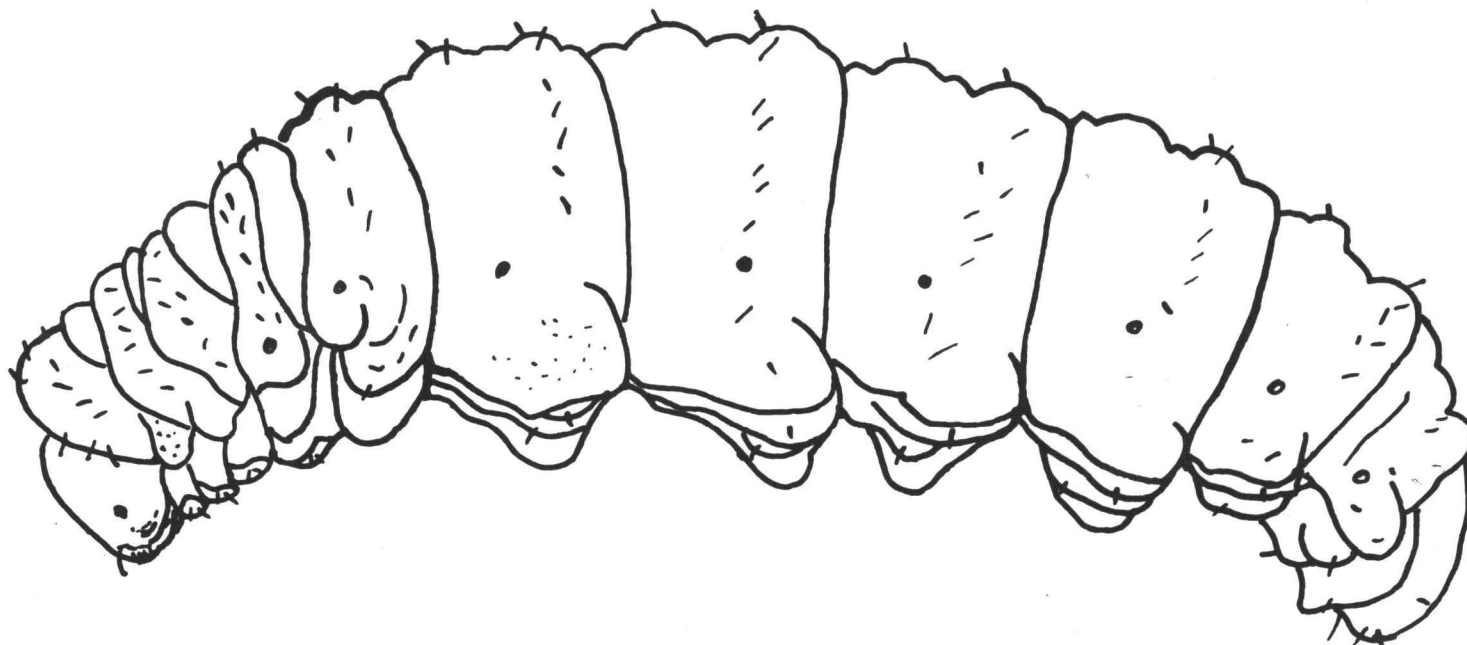


Plate XVI. Alfalfa Weevil Larva.
(From Titus, Utah Bull. 110.)



Plate XVII. Scarlet clover injury by strawberry fruit worm.

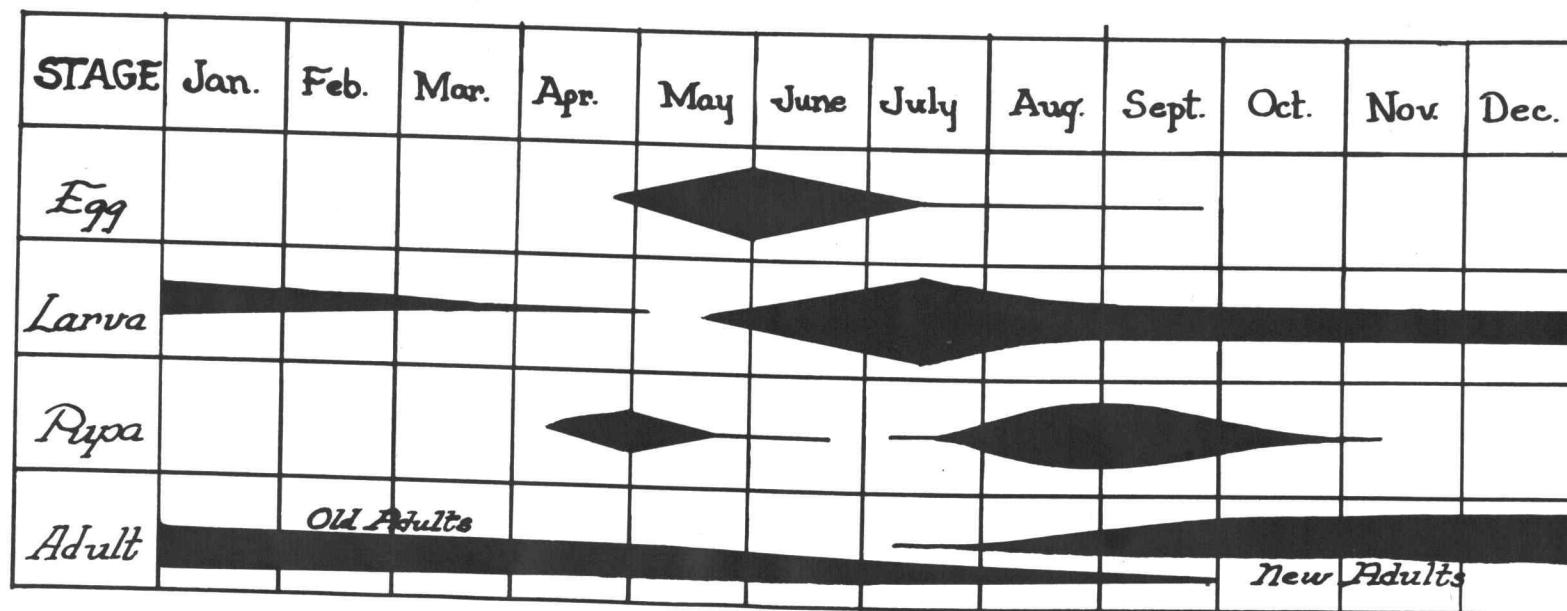


Figure 1. Life history chart of clover root borer in the Pacific Northwest.
(From Rockwood, U.S.D.A.)

KEY DIFFERENTIATING BETWEEN

Hypera punctata, Phytonomus posticus
and Phytonomus nigristrois

Beak stout, never longer than prothorax.

Large robust species, beak shorter than prothorax;
hairs of prothorax and elytra long and slender;
scales striate, narrowed toward tip, emarginate
without processes, concave rounded at base . .

. Hypera punctata

Beak more slender, always longer than prothorax.

Front between the eyes narrower than eye at widest
part, usually slightly concave.

Prothorax not wider than long, species rather
narrow, elongate; hairs on dorsum long,
fine, pointed. Phytonomus nigrir-
ostris.

Prothorax almost as wide as long; hairs on dor-
sum, especially on posterior part of ely-
tra, semi-decumbent, long and pointed. . .

. Phytonomus posticus

(From Titus)

BIBLIOGRAPHY

1. Aldrich, J. M. Grasshopper and Cricket Outbreaks. Univ. of Idaho Ag. Exp. Sta. Bull. 41. 1904.
2. Bigger, J. H. Clover Root Curculio. Journ. of Econ. Ent. 23:334. 1930.
3. Blatchley, W. S. and Leng, C. W. Rhynchophora or Weevils of North Eastern America. pp. 137-179. Nature Publishing Co. Indianapolis. 1916.
4. Bouquet, A. G. B. Clover Aphis. Ore. Sta. Coll. Circ. of Infor. 37. 1930.
5. Burrill, A. C. Clover Aphis. Idaho Exp. Sta. Ann. Report. Bull. 104. pp. 26-28. Dec. 31, 1917.
6. Butcher, F. Gray. Grasshopper Eggs, Their Destruction and Other Aids in Control. No. Dak. Ag. Ext. Serv. Circ. 157. 1937.
7. Crosby, C. R. and Blauvelt, W. E. Hypera nigrirostris. Journ. Econ. Ent. 23:882. Oct. 1930.
8. Daten, Samuel Bradford. Grasshoppers in Alfalfa Fields. Univ. of Nev. Ag. Exp. Sta. Bull. 57. 1904.
9. Davis, G. C. Insects of the Clover Field. Mich. Sta. Ag. Coll. Exp. Sta. Farm and Chem. Dept. Bull. 116. 1894.
10. Detwiler, J. D. Three Little Known Clover Insects. New York Cornell Bull. 420. May 1923.
11. Edwards, W. D., Gray, Kenneth, and Mote, Don C. Observations On the Life Habits of Cnephasia longana Haw. Cal. Dept. of Ag. Monthly Bull. Vol. XXIII. Nos. 10-11. Oct.-Nov. 1934.
12. Edwards, W. D. and Mote, Don C. Omnivorous Leaf Tier, Cnephasia longana. Journ. Econ. Ent. 29: 1118-1123. 1936.
13. Essig, E. O. Insects of Western North America. Pub. by Macmillan Co. New York. 1929.

14. Folsom, J. W. Insect Pests of Clover and Alfalfa.
Univ. Ill. Ag. Exp. Sta. Bull. 134. 1909.
15. French, H. T. Clover Insect Pests. Ore. Sta. Coll.
Bull. 35. 1895.
16. Garman, H. Some Common Pests of the Farm and Garden.
Ken. State Coll. Ag. Exp. Sta. Bull. 40. Mar. 1892.
17. Gillette, C. P. and Taylor, E. P. Orchard Plant Lice.
Col. State Coll. Exp. Sta. Bull. 133. 1908.
18. Gray, Ken and Schuh, Joe. Pea Aphid Control in Ore-
gon. Ore. State Coll. Ag. Exp. Sta. Bull. 389.
1941.
19. Haseman, Leonard. Pests of Field Crops. Univ. of Mo.
State Ag. Exp. Sta. Bull. 134. June 1915.
20. Henderson, W. W. Crickets and Grasshoppers in Utah.
Utah Ag. Coll. State Exp. Sta. Circ. 96. Nov. 1931
21. Herrick, Glenn W, and Hadley, C. H. Jr. Clover Leaf
Weevil. Cornell Univ. Ag. Exp. Sta. Bull. 411.
Ithaca, New York. July, 1922.
22. Hervey, G. E. R. European Nitidulid, Brachypterolus
pulicarius. Journ. Econ. Ent. 20:809. Dec. 1927.
23. Hopkins, A. O. U.S.D.A. Div. of Ent. Bull. 17. p.23.
24. Hunter, Bryon. Forage Crops in Western Oregon. Ore.
State Coll. Bull. 91. 1906.
- 24A. Jackson, Dorothy J. Weevils of the genus Sitona.
Ann. of App. Biol. Vol. IX No. 2. pp. 93-115.
June, 1922.
25. Lane, M. C. Control of Wireworms on Irrigated Lands
in the Pacific Northwest. U.S.D.A. Bur. of Ent.
and Plant Quar. E-320. Feb. 1937.
26. Langford, Geo. S. Some Factors Relating to the Feed-
ing Habits of Grasshoppers. Col. Ag. Coll. Exp.
Sta. Bull. 354. Jan. 1930.
27. Litner, J. A. Dasyneura leguminicola Lit. Can. Ent.
Vol. XI. pp. 44-45, 121-124. July, 1879.

28. Lovett, A. L. and Black, A. B. Grey Garden Slug.
Ore. State Coll. Ag. Exp. Sta. Bull. 170. Je. 1920.
29. Mail, G. Allen. The Wireworm. Univ. of Minn. Ag.
Ext. Div. Circ. 29. Oct. 1928.
30. Marshall, Edward. Clover Root Curculio. Journ. of
Econ. Ent. Vol. 27:807. 1934.
31. Metcalf, C. L., and Flint, W. P. Destructive and
Useful Insects. Second Edit. Published by McGraw-
Hill Book Co. Inc. New York. 1939.
32. Mote, Don C. How to Combat Grasshoppers. Ore. State
Coll. Ext. Circ. 326. 1939.
33. Mote, Don C. Control Measures for Aphids. Ore. Sta.
Coll. Exp. Sta. Circ. of Infor. 146. March 1936.
- 33A. Mote, Don C. and Thompson, B. G. Vegetable-Garden
Insect-Pest Control. Ore. State Coll. Ext. Bull.
551. March 1941.
34. Moznette, G. F. Three Insects Affecting Clover Seed
Production. Ore. State Coll. Ag. Ext. Bull. 203.
1917.
35. Newton, R. C., Gentner, L. G., Fowler, R. G., and
Bunn, R. W. Control of the Alfalfa Weevil in South-
western Oregon. Ore. State Coll. Ag. Exp. Sta. and
Bur. of Ent. and Plant Quarantine and the Bur. of
Plant Industry, U.S.D.A. and Ore. State Coll. Ext.
Service. Circ. of Infor. 182. April 1938.
36. Osborn, H. and Gossard, H. A. The Clover Seed Midge.
Iowa Bull. 13. May 1891.
37. Parks, H. T. Some Insects Injurious To Red Clover.
Ohio U. Ag. Coll. and U.S.D.A. Vol. 16. No. 10. 1914.
38. Piper, Charles V. Bur Clover. U.S.D.A. Farmers'
Bull. 693. 1915.
39. Reeves, Geo. I., Miles, Philip B., Chamberlain, Thom-
as, R., Snow, Sterling J., and Bower, Luther J.
The Alfalfa Weevil and Methods of Controlling It.
U.S.D.A. Farmers' Bull. 741. July, 1916.
40. Riley, C. V. Report of the Entomologist. Rept.
U.S.D.A. 1881-1882. pp. 61-214.

41. Rockwood, L. P. Alfalfa and Clover Insects in the North Pacific Region. The Columbia Port Digest. U.S.D.A. Bur. of Ent. Aug. 1926.
42. Rockwood, L. P. Controlling the Clover Flower Midge in the Pacific Northwest. U.S.D.A. Farmers' Bull. 942. April, 1918.
43. Rockwood, L. P. Hypera nigrirostris in Pacific Northwest. U.S.D.A. Bur. of Ent. Can. Ent. 52: 38-39. 1920.
44. Rockwood, L. P. The Clover Root Borer. U.S.D.A. Dept. Bull. 1426. 1926.
- 44A. Rockwood, L. P. The Seed Caterpillar. Journ. of Ag. Res. 43:57-65. No. 1. 1931.
- 44B. Rockwood, L. P. and Chamberlain, T. R. A Seed Caterpillar. U.S.D.A. Bur. of Ent. Ent. News 43:180-181. 1932.
45. Rockwood, L. P., Creel, C. W. The Control of the Clover Flower Midge. U.S.D.A. Farmers' Bull. 971. 1918.
46. Rockwood's unpublished material.
47. Saunders, W. Insects Injurious to Clover. Twelfth Ann. Rept. Entomological Soc. of Ontario. pp. 37-47. 1881.
48. Smith, Ralph H. Clover Aphis. Univ. of Idaho. Ag. Exp. Sta. Research Bull. 3. Jan., 1923.
- 48A. Strong, J. C. Price Current Grain Reporter Yr. Bk. 1926.
49. Titus, E. G. The Genera Hypera and Phytonomus in America. North of Mexico Ann. of Ent. Soc. in Amer. 4:383-473. 1911.
50. Thomas, M. D., Breithaupt, Nielson, N. I. Forest Seed Crops - 1940. Ore. State Coll. Ext. Circ. 375. 1941.
51. Thompson, B. G. and Rainwater, H. T. Survey and Biological Observations of the Grey Garden Slug in the Willamette Valley, Oregon. 1942. Not pub. yet.

52. Thompson, B. G. The Garden Slug and Its Control. Oregon State Coll. Circ. 258. 1942.
53. Thompson, B. G., Control of Cutworms in Ore. Ore. State Coll. Ag. Exp. Sta. Circ. 111. 1935.
- 53A. Thompson, B. G., Cutworm Control in Oregon. Ore. State Coll. Ag. Exp. Sta. Circ. 70. 1926.
- 53B. Tower, D. G., and Fenton, F. A. Clover Leaf Weevil. U.S.D.A. Bull. 922. 1920.
54. Urbahns, Theodore D. The Chalcis Fly in Alfalfa Seed. U.S.D.A. Farmers' Bull. 636. Dec. 31, 1914.
55. Washburn, W. L. Clover Mite. Oregon State Coll. Bull. 33. 1894.
56. Webster, F. M. Preliminary Report on the Alfalfa Weevil. U.S.D.A. Bur. of Ent. Bull. 112. May, 1912.
57. Webster, F. M. Some Destructive Insects. Ohio Ag. Exp. Sta. Bull. 68. 1896.
58. Webster, F. M. The Clover Root Borer. Ohio Ag. Exp. Sta. Bull. 112. 1899.
59. Webster, F. M. The Lesser Clover Leaf Weevil. U.S. D.A. Bur. of Ent. Bull. 85. Part I. 1909.
60. Webster, F. M. The Lesser Clover Leaf Weevil. U.S. D.A. Bur. of Ent. Bull. 85. 1911.
61. Wehrle, Lawrence Paul. Clover Flower Midge. Cornell Univ. Ag. Exp. Sta. Bull. 481. Ithaca, N. Y. 1929.
62. Wehrle, Lawrence Paul. The Clover Seed Caterpillar. Cornell Univ. Ag. Exp. Sta. Bull. 428. Ithaca, New York. June, 1924.
63. Wildermuth, V. L. Chalcid Control. U.S.D.A. Farmers' Bull. 1642. 1931.
64. Wildermuth, V. L. The Clover Root Curculio. U.S. D.A. Bur. of Ent. Bull. 85. 1910.
65. Yothers, M. A. Biology and Control of Tree Hoppers Injurious to Fruit Trees in the Pacific Northwest. U.S.D.A. Tch. Bull. 402. 1934.