THE PEA LEAF WEEVIL

an introduced pest of legumes in the Pacific Northwest

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THE PEA LEAF WEEVIL

an introduced pest of legumes in the Pacific Northwest

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The pea leaf weevil (*Sitona lineata* (L.)), long known as a pest of legumes in Europe, was first found in North America in 1936 by W. Downes (*5*) [3] on the southern end of Vancouver Island, British Columbia. The insect's life history and habits were studied by Jackson (*8*) in Great Britain, Baranov (*3*) and Grossheĭm (*7*) in Russia, and Andersen (*1*) in Germany. Several other members of this genus, including the clover root curculio (*S. hispidula* (F.)) and the sweetclover weevil (*S. cylindricollis* Fahr.), are economically important pests of legumes in North America.

SPREAD OF THE WEEVIL IN NORTH AMERICA

The pea leaf weevil is restricted in North America to the humid coastal area west of the Cascade mountain range in Oregon and Washington and to the western end of the Fraser River Valley in British Columbia. In 1937 it was widespread and abundant in the Victoria district, and growers reported that it was damaging seedling peas. In 1940 the weevil was found on the adjacent San Juan Islands of Washington, where heavy infestations were reported to be injuring peas and vetch. In 1941 it was discovered to the south on neighboring Whidbey Island. In 1942 it was found in several mainland areas bordering Puget Sound from Vancouver south and west in Washington to and including the northern extremity of the Olympic Peninsula.

Timber-covered mountain ranges and other ecological barriers tended to confine the natural spread of the weevil to the leguminous crops in the readily accessible valley areas of southwestern British Columbia and of western Washington and Oregon. In British Columbia the area immediately exposed to infestation included a 70-mile stretch of the Fraser River Valley from Vancouver to Agassiz, where cannery peas and clover are economically important legume crops. In Washington and Oregon the major areas were those cultivated valleys extending from the British Columbia boundary southward approximately 370 miles between the parallel Coast and Cascade mountain ranges. In

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[1] Retired in 1951.

[2] Most of the information on the early phases of this study was obtained from an unpublished 1942 report by the late L. P. Rockwood of the former Bureau of Entomology and Plant Quarantine. C. F. Doucette and W. W. Baker of that Bureau also contributed to the early studies.

[3] Italic numbers in parentheses refer to Literature Cited, p. 12.

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Oregon these areas included the Willamette River Valley from its confluence with the Columbia River southward to Eugene—a distance of over 100 miles. In the spring of 1958 the infestation, after progressing southward for 22 years at an average rate of 15 miles a year, attained this southern extremity, beyond which it cannot appreciably extend without crossing interposing natural barriers.

HOST PLANTS

Plants of the family Leguminosae constitute the major food of the adult weevils and the exclusive food of the larvae. In the Pacific Northwest peas and vetch are the principal hosts, but the adults feed heavily at times on alfalfa (*Medicago sativa*) and red clover (*Trifolium pratense*). The weevils feed lightly on many other legume species. None were observed feeding on several other species of *Trifolium* or on black medic (*Medicago lupulina*), lupine (*Lupinus* spp.), black locust (*Robinia pseudoacacia*), goldenchain (*Laburnum anagyroides*), and Scotch-broom (*Cytisus scoparius*).

The frequent mention in the European literature of severe damage to beans refers to the broadbean (*Vicia faba*) of the vetch genus, and not to *Phaseolus vulgaris*, from which are derived many common cultivated varieties known as beans in America. The latter are not attacked to any great extent by either adults or larvae.

The adult weevils feed heavily on the buds and bloom of birdsfoot trefoil (*Lotus corniculatus*). When leguminous crops are harvested or drying up, weevils may feed for awhile on certain nonleguminous plants. These include particularly members of the family Rosaceae, such as strawberry, raspberry, blackberry, apple, and rose. Severe feeding damage from overwintered weevils, amounting to almost complete defoliation, was noted in dwarf roses in western Oregon. A few weed varieties such as prostrate knotweed (*Polygonum aviculare*) are also occasionally attacked.

DAMAGE

The initial feeding damage by the adult is characteristic. It consists of subcircular notches in the leaf margins, typically cut in close sequence and producing a scalloped effect (fig. 1). Damage frequently progresses to the point of severe ragging of the leaves or even to complete defoliation of plants. Mid-March to mid-April is a critical period for seedling plants subjected to feeding damage from overwintered adults, but by late April the plants are usually large enough to withstand the attack without serious injury.

In the Willamette Valley seedling red clover or alfalfa is often eaten off to the ground in July and early August by the new-generation adults that have recently emerged from the soil of pea stands in which the clover or alfalfa had been seeded as a succession crop. When the peas are mowed or begin to dry up, the weevils attack the clover or alfalfa as their second preference, sometimes destroying entire plantings. If there is no succession crop, they may migrate to any adjoining field of mature clover or alfalfa and strip the plants to the bare stems along a 20- to 30-foot margin.

The newly forming buds of birdsfoot trefoil also are subject to attack in July by the new adults. Severe losses result where this plant is raised primarily for seed. How-

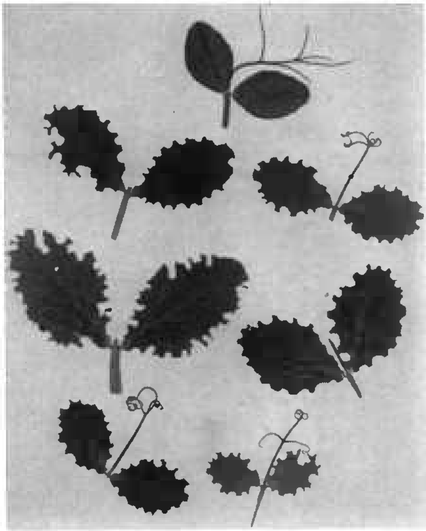

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FIGURE 1.—Feeding notches made by overwintered adults of the pea leaf weevil in leaf margins of Austrian field peas.

ever, the weevils do not feed on the foliage to any great extent, and few are found on the plant except during the bud and bloom stage.

Less obvious than the aboveground damage from the adults is that caused by the larvae. They feed underground on the nitrogen root nodules, which they penetrate as newly hatched larvae. They feed on the inner contents, leaving only the outer skin. The small larvae leave no visible mark where they enter the nodules, and their presence can be determined only by nodule dissection. As feeding continues, the damage finally results in recognizable discoloration and abnormal appearance of the external surface. Every year in the Willamette Valley the larvae destroy a large proportion of the root nodules in all the pea fields, and in many fields destruction is virtually complete.

There are several references in the European literature to destruction of plants in seedings of peas, broadbeans, and vetches because of feeding by the overwintered adults. Baranov (*3*) stated that from 60 to 75 percent of pea plants were destroyed by adult weevils in May. The Great Britain Board of Agriculture and Fisheries (*6*) reported that in many places the pea leaf weevil completely destroyed crops of peas and beans in Britain in 1917. Ulashkevich (*12*) noted that damaged plants were shorter and produced fewer seeds. Belyaev (*4*) reported that the vetch crop, after recovery when watered, was reduced 62 percent when plants were completely defoliated and 44 percent when they lost half of their leaf surface. Turaev (*11*) noted that the feeding of the larvae on the nodules decreased the yields of seed and straw in direct proportion to the degree of infestation and the resultant decrease of nitrogen in the soil, and also reduced seed and straw quality by lowering the protein content.

LIFE STAGES

The eggs (fig. 2) have a smooth, glossy surface, are subspherical, and are about 0.36 mm. in their greatest diameter. They are milky white when first laid, but after 24 to 48 hours they turn jet black.

The larva (fig. 3) is a light milky color, has a dark-brown head, and measures from 6 to 7 mm. long when full grown. It is curved in repose, legless, cylindrical, soft and fleshy, with long setae protruding vertically from the bulge of each segment.

The pupa (fig. 4) when newly formed is a glistening white throughout, but its eyes gradually turn light brown, then dark brown, and finally black, and its abdomen darkens to a less degree. Several

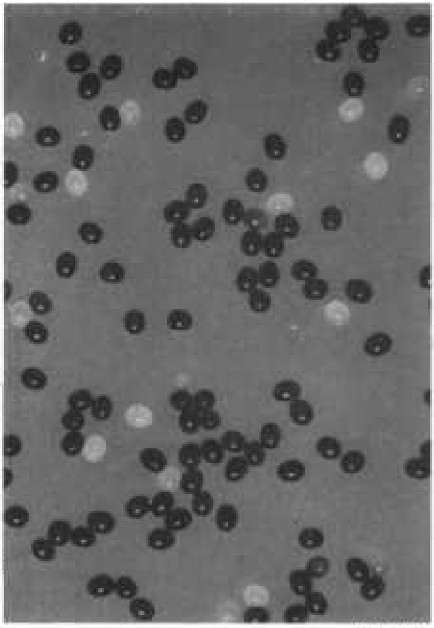

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FIGURE 2.—Eggs of the pea leaf weevil. X 16.

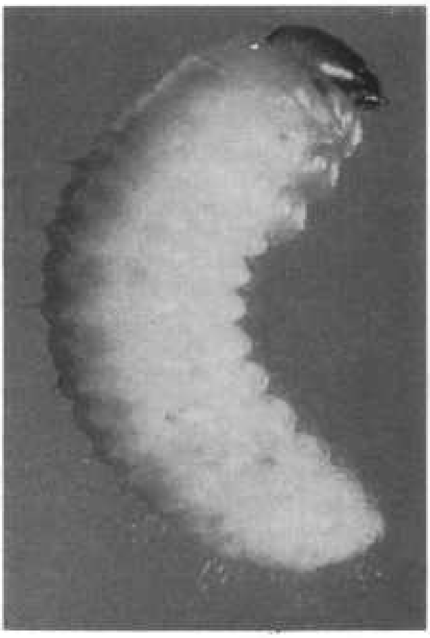

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FIGURE 3.—Full-grown larva of the pea leaf weevil. X 30.

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FIGURE 4.—Pupa of the pea leaf weevil. X 35.

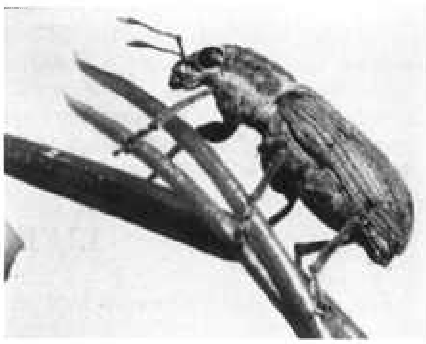

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FIGURE 5.—Adult of the pea leaf weevil. X 25.

pairs of fleshy setae project from the head and thorax, resembling miniature horns.

The adult (fig. 5) is slender, about 4.5 mm. long, and grayish brown. Three light, inconspicuous stripes, one central and two lateral, run lengthwise on the thorax, tending to extend onto the elytra. The elytra are marked lengthwise by parallel striations, and their bristles lie relatively flat against the elytral surface. In this respect this weevil is readily distinguishable from the clover root curculio, with which it is usually associated in clover and which has semierect elytral bristles. The weevil has large inner wings and is a strong flier.

SEASONAL HISTORY

The coastal region of the Pacific Northwest has milder winters than many countries of northern Europe because of its proximity to the Japanese Current. Consequently, the development of the weevil's life stages, the activity of the overwintered adults, and the host-plant development are from 1 to 2 months earlier than those described in much of the European literature.

The pea leaf weevil has a single generation annually. Overwintered adults start flying usually about the middle of March, when maximum temperatures reach 57° F. or higher. At this time those that have overwintered in stubble fields, roadsides, or other locations devoid of suitable hosts—probably an appreciable percentage of the population—fly to preferred legume species. In this migration more weevils are attracted to fields of alfalfa and clover, because of their more abundant foliage, than to seedling peas and vetch, which are comparatively barren at this time. By the end of March, when temperatures have increased to occasional maximums of 70°, flying is greatly accelerated, and there is a general migration of the weevils from alfalfa and clover to peas and vetch for oviposition.

The following tabulation of sweep counts for successive dates in 1958 taken in an alfalfa field and an adjacent pea field near Sheridan, Oreg., shows the correlation between the spring decline in weevil numbers in alfalfa and their simultaneous buildup in peas. During the last part of May the overwintered weevil population declines rapidly from normal mortality.

	Number of weevils per 20 sweeps in fields of—	
Date	*Alfalfa*	*Peas*
March 18	260	(1)
April 22	37	219
April 28	20	272
May 15	8	207
May 30	0	40

[1] Peas too short to sweep.

Studies conducted by Jackson (*8*) in Great Britain indicate that the sexual organs of the weevils do not mature until spring after the hibernation period. However, our studies show that hibernation is not obligatory in the milder climate of the Pacific Northwest and that in this region sexual maturation and egg laying begin much earlier. During the mild open winter of 1958 mating began as early as January 13 and egg laying started about February 7. However, in the winter of 1959, which was probably more normal, the first mating was noted on February 10 and egg laying started on February 16. Egg laying is greatly accelerated after the middle of March, reaches a peak in April, and declines rapidly after the middle of May. The eggs are scattered singly, occasionally on the plants, but mostly on the soil surface near the plant base or, in dry weather, on the moist undersurface of clods.

The females deposit a large number of eggs over an extended period. In Germany Andersen (*1*) recorded an average of 1,148 eggs per female for 24 females in laboratory cages in three seasons, 1928–30. Jackson (*8*) recorded from 354 to 1,655 eggs per female in Great Britain.

The data of European investigators show a wide range in the incubation period, evidently depending on temperature variations between different latitudes or in the same latitude from early to late in the egg-laying season. In the San Juan Islands off the coast of Washington, eggs kept at outside May temperatures hatched in 16 days. The normal incubation period during the peak of the egg-laying period in April is about 18 days.

The minute newly hatched larvae infiltrate the soil through pores and crevices until they come in contact with the root nodules of the host plants. As the larva grows, it eventually eats a hole through one end of the nodule, from which it sometimes partially protrudes, and finally emerges before pupation. The contents of many of the smaller nodules are completely consumed before the larvae in them attain full size. In this event they may leave the nodules and pupate as undersized larvae. However, occasionally large larvae are found with their heads inserted in partly eaten nodules. Apparently after consuming the first nodule, they may feed on others, at least those that are readily accessible. To what extent they actually search in the soil for additional nodules has not been determined.

Some European writers, including Ripper (*10*), Grossheĭm (*7*), and Baranov (*3*), reported that the older larvae attack the roots as well as the root nodules. However, Jackson (*8*) did not mention any feeding except on the nodules. Several larvae were observed through the glass sides of root cages to determine whether they would feed on the root. Serious damage was confined to the nodules, though a few of the small rootlets were damaged incidental to attack on the nodules. As a result of heavy infestations in some fields on the San Juan Islands, most of the nodules in the upper part of the soil were consumed, and larvae were found as deep as 11 inches. In sample collections from soil under fall-sown legumes, the smaller, younger larvae were found in nodules deepest in the ground when all the nodules in the upper strata had been destroyed by the larger, older larvae. Jackson (*8*) and Baranov (*3*) noted that there is a high mortality of the newly hatched larvae, because a large proportion are unable to find nodules.

The findings of Andersen (*1*) indicated that the mortality of late-hatching larvae would be heavy also because of higher temperatures and reduced humidity. He concluded from his experiments that the newly hatched larvae could detect root nodules at a distance of 2 or 3 yards, probably by smell. He found that such larvae at 48° F. and 100-percent relative humidity could survive 5½ days, but at the same humidity and at 79°, survival time was reduced to 1½ days. It was shortened to a few hours when the relative humidity dropped below 100 percent and the temperature was from 48° to 79°, but survival time was shortest at the higher temperature.

These observations are consistent with what takes place in the relatively cool, humid period when weevils in the Pacific Northwest oviposit on peas and vetch, and they suggest that the chance of survival rapidly diminishes for larvae hatching from eggs laid after April.

The effect of rising temperatures and declining humidity causes marked differences in the severity of infestations between fall-sown and spring-sown annual legumes. On the San Juan and Lopez Islands, Wash., soil samples 1 square foot in area and 10 inches deep were taken in vetch and pea fields in June and July, when only a few adults had emerged. The average number of larvae, pupae, and callow adults in each square-foot sample were as follows: On San Juan—257 for fall-sown common vetch, 106 for early spring-sown purple vetch, and 49 for late spring-sown purple vetch seeded in May; on Lopez—128 for fall-sown common vetch, 132 for fall-sown field peas, and 64 for Canadian field peas seeded on April 30.

The soil samples showed that most of the larvae were in the upper 3 or 4 inches. Samples taken on the San Juan Islands under early spring-sown vetch showed the vertical distribution of the larvae to be as follows:

Depth of soil sample (inches)	*Percent of larvae*
1–3	51
3–6	27
6–9	22

Because of the opacity of its contents, the gut appears elongate and dark through the semitransparent integument while the larva is feeding. When the larva becomes full grown, ceases feeding, and leaves the nodule, the gut clears and the larva becomes a uniform white throughout. Shortly thereafter it forms a cell in the upper 2 or 3 inches of the soil and pupates. The pupal stage in June lasts from 15 to 17 days. The pupae begin appearing in the soil late in May and reach peak abundance in the middle of June. By the middle of July most of them have transformed to adults.

The approximate total developmental period from egg to adult under optimum conditions is as follows:

Stage	*Days*
Egg	18
Larva	35
Pupa	15
Total	68

The beginning, peak, and termination of these three stages and of the adult are shown in figure 6. The emergence of new adults from the soil of pea and vetch fields begins early in June, reaches a peak about June 25, and is completed about July 15.

The new adults fly intensively for several weeks beginning early in July. Heavy flying was observed on July 3, 1959, near Lafa-

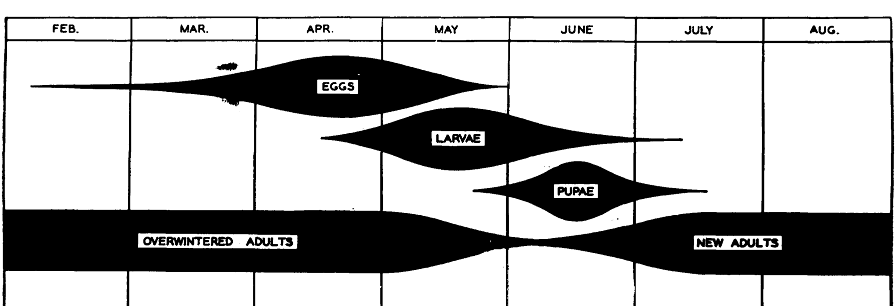

FIGURE 6.—Seasonal sequence of life stages of the pea leaf weevil.

yette, Oreg., from an Austrian pea field that was beginning to dry up. It was midday, clear, with a faint breeze and a temperature of 95° F. The weevils were climbing to the tips of the stems of volunteer grain plants, which were scattered throughout the peas. Nearly every tip had from two to five weevils that were making frequent gestures, such as assuming poised positions and buzzing their wings, as if about to take flight. Every now and then one would take off and ascend steeply into the air. The air overhead, as high as one could see, was full of flying weevils milling about or drifting slowly with the breeze.

In this manner, as well as on foot, weevils disperse widely in search of the still-succulent perennial legume crops, chiefly alfalfa and red clover. They feed avidly on these crops for several weeks. Where such perennial legumes as red clover are seeded with peas as a succession crop—a common practice in the Willamette Valley—the former are susceptible to extreme damage from the new brood of weevils.

The weevils tend to bypass the clover as long as the peas are green and succulent. However, when the pea vines are mowed or dry in the field, the weevils transfer to the clover. If at this time the clover plants are still very small with no more than four to six trifoliolate leaves, even a moderate weevil population sometimes does severe damage, and often entire plantings are destroyed.

The new adults estivate from late summer throughout most of the fall. In preparation for estivation they disperse widely, thereby greatly thinning out their populations in clover and alfalfa fields. They seek the shelter of sun-exposed areas, such as grass clumps and vegetative litter of roadsides, fence rows, and stubble fields. On warm days in February or early March while it is still too cool and seasonally early for flight, the weevils crawl up on grass and weed stems and can be swept from most any low vegetation. At this time net sweeps yield about as many weevils from old stubble or from green winter grain as from clover or alfalfa.

Estivation begins with an abrupt cessation of feeding coinciding with the disappearance of the weevils around mid-August. In areas of low winter temperatures such as northern Europe, the estivation period evidently extends without interruption into a period of true winter hibernation lasting until spring.

In Oregon those weevils that had estivated in legume fields ended their estivation and resumed a moderate amount of feeding during warmer periods of 50° to 60° F., beginning by mid-October and continuing throughout the winter. Fresh feeding notches appeared on the new foliage of fall-seeded peas and vetch and on red clover. Although feeding at this season is not intense, its cumulative effect after 2 or 3 winter months on seedling plants when their growth rate is most retarded is often severe (fig. 7). From December to March, the

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FIGURE 7.—Cumulative damage by the pea leaf weevil to Austrian field pea seedling. X 3.

greatest damage occurs around the borders of fields, where the weevils move in on foot from fence row or roadside plant trash in which they have estivated throughout late summer and early fall.

FACTORS AFFECTING FURTHER SPREAD

The flying capacity of the weevil and transportation by human conveyance favor spread of this pest. Weevils not only fly extensively when conditions are favorable but in the summer attain considerable altitudes with the aid of convection currents. They then descend apparently indiscriminately, and many alight on moving conveyances. They also settle on grainfields being harvested. They have been found mixed with grain in combine tanks and on harvested grain being hauled in trucks to grain elevators for ultimate shipment. However, these weevils are almost entirely the immature adults that would not mate until the following spring.

A more definite hazard is the possibility of weevils being transported in the winter or early spring in bulk materials, such as straw or baled hay. Such materials constitute ideal hibernating media for the weevils, which at that time of year are sexually mature or nearly so. Since at the lower temperatures the weevils are likely to be dormant, they can survive for long periods without succulent food. Active weevils have a high water requirement, and in the laboratory at room temperature they will perish in 24 to 36 hours if their food is low in water content.

Since its appearance in North America in 1936, the weevil has not crossed any major ecological barriers to establish new infestations. It has spread gradually throughout its present area from the original infestation. No isolated infestations have been found to indicate that the weevil has been carried appreciable distances by air currents or by vehicular conveyances.

The pea leaf weevil has occupied nearly all major parts of its habitat west of the Cascade mountain range within ready access. Major ecological barriers are interposed between the present area of infestation and other economically important agricultural areas constituting favorable habitats. Such barriers include the immediately surrounding timbered mountain ranges. The Cascade mountain range separates the humid western one-third of Oregon and Washington from the comparatively dry eastern two-thirds of these States. This drier climate might considerably reduce the survival and multiplication of any weevils introduced into the large cannery pea-producing areas, such as the Walla Walla-Milton-Freewater and the Columbia River basin areas.

Andersen (*2*) stated that "the areas of permanent injury by *S. lineata* occur in those regions of Europe where clover, peas, beans (*Vicia faba*), and vetches are largely grown and where the climate is moist and temperate." The North American region where the pea leaf weevil occurs is similar, but the surrounding region is not.

Another condition conducive to the buildup of heavy infestations is the production of both annual legumes, such as peas and vetches, and perennial legumes, such as alfalfa and clover, in the same locality, particularly in close proximity. This fact is frequently mentioned in the European literature and has been amply confirmed by observations in Oregon and Washington. The annual legumes are the almost exclusive hosts of the larvae. The perennial legumes constitute the principal food of the adults from the time the annual legumes dry up in the summer until new perennial legumes become available again in the spring.

BIOLOGICAL CONTROL

Adult weevils killed by the fungus *Beauveria globulifera* were found in small numbers at all times. European writers record *B. bassiana* as the causative agent of a fungus disease of some economic importance, but it is likely that this fungus is the same as that usually recorded as *B. globulifera* in America (Petch *9*). Three species of braconids were reared from adult weevils by Jackson (*8*) in England and Scotland; the most common species was *Perilitus rutilis* (Nees). Grossheĭm (*7*) reared the egg parasite *Anaphes* from eggs of these weevils and three braconids from adult weevils in Russia. The braconids were of the same genera as those found by Jackson.

On the San Juan Islands a species of *Cerceris* was found to be provisioning its nest with adults of the pea leaf weevil in August 1942. The number of cells provisioned by each female was not determined, but probably about 15 weevils are required for each cell. Nests of what was possibly the same wasp in some locations contained about a 50–50 mixture of *S. lineata* and *S. scissifrons* Say. The first wasps observed were collected when alfalfa was swept on August 12. The soil was searched for them, and their burrows were located. Both sexes of the wasp frequented the flowers of wild carrot (*Daucus carota*) and goldenrod (*Solidago* spp.). By the end of the first week in September adult wasps were very difficult to find and those collected had very ragged wings, an indication that they were almost through flying for the season.

CULTURAL CONTROL

Peas and vetch should be planted as far away from alfalfa and clover as possible. However, if clover or alfalfa is seeded with peas or vetch as succession crops, measures should be taken to promote growth of the perennials before the weevils attack these crops. Rapid growth and size are major factors in enabling plants to overcome or to withstand weevil damage. The timely use of irrigation and fertilizers to bring plants through the highly vulnerable seedling stage is economically important.

Many European writers recommend that pea and vetch fields should be plowed up soon after harvest to destroy any larvae or pupae in the soil, but only if harvesting is completed before most of the new adults have emerged.

CHEMICAL CONTROL

The advisability of chemical control depends on whether the infestation is severe enough to reduce harvest yields. In areas of the Pacific Northwest where spring rain is abundant, many growers have reduced or completely abandoned chemical controls, because they discovered that pea stands in seasons of normal precipitation have a remarkable capacity to recover from extreme foliar damage. However, more research is needed to provide reliable criteria by which to estimate losses resulting from both underground and aboveground damage.

In experiments in the Willamette

Valley, where large acreages of hairy vetch and Austrian field peas are planted exclusively for seed, heptachlor dust or granules applied at 1½ to 2 pounds of active ingredient per acre gave the best control. Aldrin and endrin dusts or granules at equivalent rates were fairly satisfactory. When the materials were applied just after the weevils had started intensive spring migration into the crops—usually from about mid-March to early April—control of adults was adequate to carry the plants through their early growth period. Two treatments—early in March and early in April—were required to obtain good subsequent control of larvae infesting root nodules. Further information must be obtained on these insecticides before they can be recommended for use on these crops.

Growers who dust peas and vetch with DDT to control the pea weevil (*Bruchus pisorum* (L.)) and the vetch bruchid (*Bruchus brachialis* Fahr.) occasionally use this insecticide on cannery peas to control the pea leaf weevil. Fairly satisfactory control with 1 to 1¼ pounds of DDT dust per acre is usually obtained for 2 or 3 weeks. However, crops treated with DDT should not be fed to poultry, dairy animals, or animals being finished for slaughter.

On peas and vetch to be used for forage, weevils can be reduced fairly satisfactorily with a spray containing methoxychlor at 1 to 1¼ pounds per acre. If applied to the borders, this insecticide should control weevils that have migrated into margins of alfalfa or clover stands from adjacent recently cut pea and vetch fields. Crops sprayed with this amount of methoxychlor should not be cut or pastured for 7 days after treatment.

SUMMARY

The pea leaf weevil (*Sitona lineata* (L.)) was found on Vancouver Island, British Columbia, in 1936. It has since spread on the coastal mainland of Washington and Oregon, where it has caused severe damage to peas, vetch, alfalfa, and red clover. The most noticeable damage results from adult feeding on plants in the seedling stage. However, the larvae severely damage and often totally destroy the nitrogen root nodules of peas and vetch.

The weevil has a single annual generation. The adults emerge from the soil of pea and vetch fields throughout June and early July, when they severely damage both seedling and mature perennial legumes, such as alfalfa and red clover. They move into these perennial legumes after their preferred annual legumes have dried up or have been harvested. Damage ceases when the weevils estivate in mid-August, but it is renewed again the following spring when the overwintered weevils migrate into new crops of seedling peas and vetch to feed and oviposit.

Temperate and humid climatic conditions favor survival and development of all the weevil's life stages.

Controls consist in avoidance of the production of annual host legumes in close proximity to perennial host legumes, appropriate utilization of irrigation and fertilizers to get plants rapidly through the vulnerable seedling stage, plowing pea and vetch soil promptly after crop harvest to destroy larvae and pupae in the soil, and insecticide applications to control adult weevils.

LITERATURE CITED

(1) ANDERSEN, K. T.
1931. REIZPHYSIOLOGISCHES VERHALTEN UND BIOLOGIE DER SITONA LINEATA-LARVE. Ztschr. f. Vergleich. Physiol. 15: 749–783. [In German.]

(2) ———
1933. ANALYSE DES SCHADENS UND DES MASSENWECHSELS DES LINIERTEN BLATTRANDKÄFERS (SITONA LINEATA L.). SEINE BEKÄMPFUNG UND ABWEHR. Landw. Jahrb. 78: 55–79. [In German.]

(3) BARANOV, A. D.
1914. [PESTS OF FIELD CROPS.] *In* [Materials for the Study of the Injurious Insects of the Govt. of Moscow]. V, pp. 112–130. Moscow. [In Russian.]

(4) [BELYAEV, I. M.]
1934. [PEA WEEVILS.] Moskov. Selsk. Khoz. Oblastn. Opytn. Sta. Polevod. Bul. 2, pp. 3–44. [In Russian. German summary.]

(5) DOWNES, W.
1938. THE OCCURRENCE OF SITONA LINEATUS L. IN BRITISH COLUMBIA. Canad. Ent. 70: 22.

(6) [GREAT BRITAIN] BOARD OF AGRICULTURE AND FISHERIES.
1918. REPORT OF INSECT AND FUNGUS PESTS OF PLANTS IN ENGLAND AND WALES, 1917. [Gt. Brit.] Bd. Agr. and Fisheries Misc. Pub. 21, 32 pp.

(7) [GROSSHEĬM, N. A.]
1928. [DATA FOR THE STUDY OF THE GENUS SITONA, GERM.] Mleev Hort. Expt. Sta. Bul. 17, 57 pp. [In Russian.]

(8) JACKSON, D. J.
1920. BIONOMICS OF WEEVILS OF THE GENUS SITONES INJURIOUS TO LEGUMINOUS CROPS IN BRITAIN. Ann. Appl. Biol. 7: 269–298.

(9) PETCH, T.
1926. STUDIES IN ENTOMOGENOUS FUNGI. VIII. NOTES ON BEAUVERIA. Brit. Mycol. Soc. Trans. 10: 245–271.

(10) RIPPER, W.
1937. SCHADEN UND BEKÄMPFUNG DER BLATTRANDKÄFER (VORLÄUFIGE MITTEILUNG). Neuheit. auf dem Geb. des Pflanzenschultz. 30 (2): 55–58.

(11) TURAEV, N. S.
1939. [THE EFFECT OF THE FEEDING OF THE LARVAE OF THE PEA WEEVILS (SITONA LINEATA, L. AND SITONA CRINITA, HBST.) ON THE CONTENT OF NITROGEN IN THE ROOT SYSTEM OF PEAS AND VETCHES, AS WELL AS ON THE GENERAL BALANCE OF THE BIOLOGICALLY BOUND NITROGEN IN THE SOIL.] *In* [Reports of the Scientific Meetings of the Leningrad Institute of Agriculture]. 5 Nos. Leningrad.

(12) [ULASHKEVICH, M. I.]
1935. [NODULE WEEVILS OF THE SPECIES SITONA LINEATA L. AND SITONA CRINITA HBST.] [Vinnitza Region. Agr. Expt. Sta.] No. 23, 75 pp. [In Ukrainian.]

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