

A 9.6:95/pt.5

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 95, Part V.

L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON CEREAL AND FORAGE INSECTS.

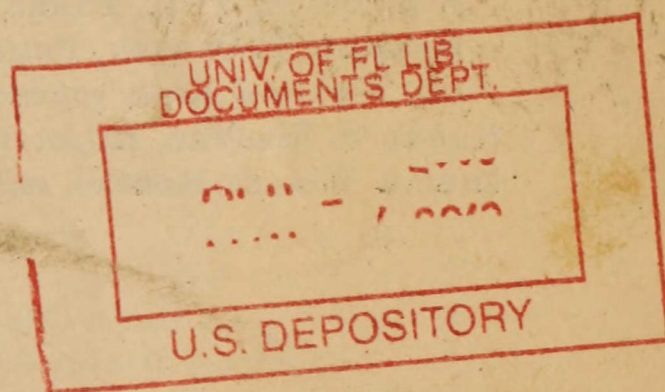
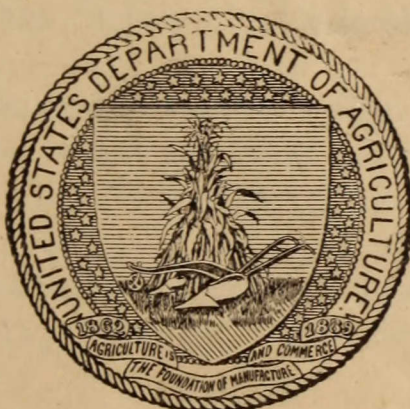
THE FALSE WIREWORMS OF THE
PACIFIC NORTHWEST.

BY

JAMES A. HYSLOP,

Agent and Expert, Cereal and Forage Insect Investigations.

ISSUED APRIL 22, 1912.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, *Entomologist and Chief of Bureau.*

C. L. MARLATT, *Entomologist and Acting Chief in Absence of Chief.*

R. S. CLIFTON, *Executive Assistant.*

W. F. TASTET, *Chief Clerk.*

F. H. CHITTENDEN, *in charge of truck crop and stored product insect investigations.*

A. D. HOPKINS, *in charge of forest insect investigations.*

W. D. HUNTER, *in charge of southern field crop insect investigations.*

F. M. WEBSTER, *in charge of cereal and forage insect investigations.*

A. L. QUAINANCE, *in charge of deciduous fruit insect investigations.*

E. F. PHILLIPS, *in charge of bee culture.*

D. M. ROGERS, *in charge of preventing spread of moths, field work.*

ROLLA P. CURRIE, *in charge of editorial work.*

MABEL COLCORD, *in charge of library.*

CEREAL AND FORAGE INSECT INVESTIGATIONS.

F. M. WEBSTER, *in charge.*

GEO. I. REEVES, W. J. PHILLIPS, C. N. AINSLIE, E. O. G. KELLY, T. D. URBAHNS,
HARRY S. SMITH, GEO. G. AINSLIE, J. A. HYSLOP, W. R. WALTON, J. T. MONELL,
J. J. DAVIS, T. H. PARKS, R. A. VICKERY, V. L. WILDERMUTH, E. G. SMYTH,
HERBERT T. OSBORN, PHILIP LUGINBILL, C. W. CREEL, E. J. VOSLER, R. N. WIL-
SON, VERNON KING, *entomological assistants.*

NETTIE S. KLOPPER, ELLEN DASHIELL, *preparators.*

MIRIAM WELLES REEVES, *collaborator.*

CONTENTS.

	Page.
Introduction.....	73
Historical.....	73
Distribution.....	75
The work in the Big Bend region of Washington.....	76
Descriptions.....	78
<i>Eleodes letcheri vandykei</i> Blaisd.....	78
The egg.....	78
The larva.....	78
The pupa.....	79
The adult.....	80
<i>Eleodes pimelioides</i> Mann.....	80
The egg.....	80
The larva.....	80
The pupa.....	81
The adult.....	81
Food substances.....	82
Seasonal history.....	83
Natural enemies and parasites.....	84
Remedial and preventive measures.....	86

ILLUSTRATIONS.

	Page.
FIG. 22. False wireworm, <i>Eleodes letcheri vandykei</i> : Adults in characteristic attitudes.....	73
23. False wireworm, <i>Eleodes letcheri vandykei</i> : Egg.....	78
24. False wireworm, <i>Eleodes letcheri vandykei</i> : Larva and details.....	79
25. False wireworm, <i>Eleodes letcheri vandykei</i> : Pupa, dorsal and ventral aspects.....	79
26. False wireworm, <i>Eleodes letcheri vandykei</i> : Adult.....	80
27. False wireworm, <i>Eleodes pimelioides</i> : Adult, details of larva.....	81

PAPERS ON CEREAL AND FORAGE INSECTS.

THE FALSE WIREWORMS OF THE PACIFIC NORTHWEST.

By JAMES A. HYSLOP,

Agent and Expert, Cereal and Forage Insect Investigations.

INTRODUCTION.

Up to within the past five years, except for a few scattering notices, the species of *Eleodes* have been considered of only incidental, if of any, economic importance. The Tenebrionidæ, to which this genus belongs, are sometimes saprophagous, feeding on dead vegetable matter in the soil, and occasionally on dead animal tissue as well as on stored grain and other food products.

Superficially the larvæ resemble the true wireworms (elaterid larvæ), and on account of this resemblance and the similarity of their

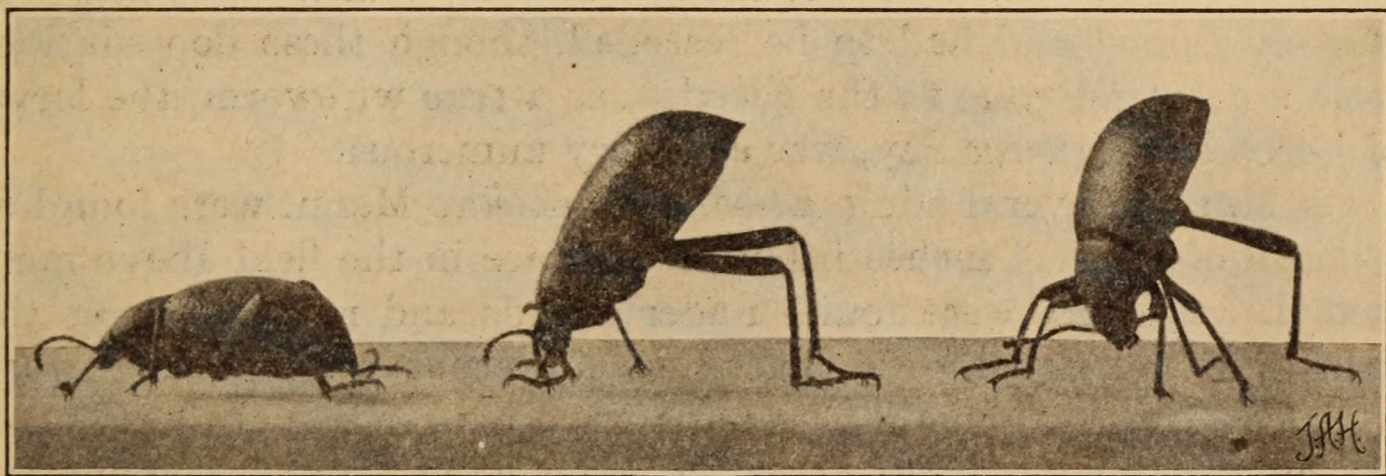


FIG. 22.—The false wireworm, *Eleodes letcheri vandykei*: Adults in characteristic attitudes. Somewhat enlarged. (Original.)

depredations in the grain fields the two are often confused. On closer examination, however, *Eleodes* larvæ can be easily recognized; the antennæ are rather long and very conspicuously clavate, the body is not flattened, and the forelegs are long and stout. These larvæ can move with great rapidity as compared with true wireworms.

The confusion of *Eleodes* with the true wireworms is unfortunate, as the preventive and remedial measures for the two pests are quite distinct, what is efficient treatment in one case being quite useless in the other.

HISTORICAL.

Among the earliest references to the economic importance of these beetles in this country is a note by Prof. Lawrence Bruner,¹ in which the species *Eleodes tricostata* Say is recorded as attacking cabbage

¹ Bul. 26 (old series), Div. Ent., U. S. Dept. Agr., pp. 11-12, 1892.

plants at Lincoln, Nebr., doing even more damage than the cutworms. It was also said to have attacked other garden crops, but these are not definitely recorded.

In 1895 Prof. C. V. Piper published an article in the Northwest Horticulturalist in which he refers to *Eleodes* larvæ attacking garden crops.

In 1898 Mr. Theo. Pergande¹ notes having received from McPherson, Kans., two larvæ of a tenebrionid with the statement that they do serious damage to wheat in Salina County, Kans., by attacking the grain when it becomes softened, destroying the germ. From one of these larvæ an adult was reared which proved to be *Eleodes suturalis* Say. In the autumn of 1911 Mr. E. O. G. Kelly, of this office, found the wheat in southern Kansas attacked by an *Eleodes* larva which may prove to belong to this latter species.

In 1908 Mr. Myron Swenk,² assistant State entomologist of Nebraska, reported *Eleodes opaca* Say as doing very serious damage to wheat in Nebraska, in some instances 60 per cent of the seed having been destroyed.

The larvæ were first found by the author in enormous numbers in May, 1909, in a wheat field south of Pullman, Wash. The field was entirely ruined and had to be reseeded, though these depredations were not entirely due to the *Eleodes*, as a true wireworm, the larvæ of *Corymbites inflatus* Say, was also very numerous.

On May 12 several adult *Eleodes pimelioides* Mann. were found at a depth of about 4 inches below the surface in the field above mentioned, and more were found under boards and rubbish about the fields. Many larvæ were placed in flowerpot rearing cages with wheat as food, and on July 3 a pupa was found in one of these cages. On July 20 an adult *Eleodes pimelioides* emerged. Later examination of several collections very clearly indicates that this species is far the more predominant in the Palouse country.

Other species known to occur in this region are *Eleodes obscura* Say var. *sulcipennis* Mann., *Eleodes hispilabris* Say var. *lævis* Blaisd., *Eleodes extricata* Say, *Eleodes manni* Blaisd., *Eleodes humeralis* Lec., *Eleodes schwarzii* Blaisd., and *Eleodes nigrina* Lec.

In the spring of 1909, on examining an oat field at Govan, Wash., that had been almost completely destroyed, many tenebrionid larvæ, *Eleodes letcheri* Blaisd. var. *vandykei* Blaisd., were found crawling over the surface of the field. They had evidently been forced to leave the ground by a heavy rain which fell the day before. On digging in this field many more larvæ were found about ready to pupate.

In the spring of 1910 the adults were found in enormous numbers on the roadsides in the Big Bend region and in the middle of the

summer they were found under the grain shocks in large numbers. In this region the species in enormous preponderance is *Eleodes letcheri vandykei*. *Eleodes pimelioides*, *Eleodes nigrina*, *Eleodes hispilabris* var. *lævis*, and *Eleodes obscura* var. *sulcipennis* also occur; the first one rarely, the last three quite commonly.

The results of three seasons' work in the Pacific Northwest demonstrate quite conclusively that the false wireworms are among the most destructive insects to recently planted wheat and corn in this region. They rank second only to the true wireworms (elaterid larvæ).

False wireworms are native and not introduced forms; the climatic conditions of the country are, therefore, ideal for their existence. The converting of enormous areas of the scantily verdured sagebrush prairie into wheat ranches has afforded them a new and increased food supply and the destruction of the sage hen, badger, and horned toad has removed their normal foes.

DISTRIBUTION.

The genus *Eleodes*, to which the beetles treated in this paper belong, is very closely confined to the Upper and Lower Sonoran Zones. These beetles do not fly and are therefore more restricted in their distribution than insects which have a more active means of dissemination. The mass of the species occur in the Southwest, while several occur in the arid and semiarid regions of California, Oregon, Washington, and Idaho. A few species extend into the Carolinian Zone in Kansas, Nebraska, and Iowa, *Eleodes tricolorata* having been collected as far east as Independence, Iowa.

Eleodes pimelioides, however, seems to be an exception to this general rule, and is very nearly confined to the northwestern portion of the Transition Zone, only occasionally being found in the Sonoran where this zone merges into the Transition. Specimens have been collected in the very humid coastal region of Washington, as well as in semiarid regions of this State, of Idaho, and of Oregon; in the Rocky Mountains at Helena, Mont., as well as at very nearly sea level on Vancouver Island. The species is predominant in the semiarid Transition of Washington and Idaho, the region commonly known as the Palouse country. The southernmost records of this species are Lake County, Cal.; Elko, Nev.; Wasatch, Utah; and Garland, Colo. It extends east to the middle of Colorado and north to Vancouver, British Columbia.

Eleodes letcheri vandykei has been collected at The Dalles, Oreg., by Messrs. Hubbard and Schwarz. Dr. E. C. Van Dyke has taken this species in Modoc County, Cal., and we have found it to be the predominant species in the Big Bend region of Washington. All of these localities are well within the Upper Sonoran Zone.

Eleodes opaca is apparently confined to the Plains region east of the Rocky Mountains, specimens having been collected in central and eastern Colorado, western Kansas and Oklahoma, northern Texas, all of Nebraska, and southern and eastern South Dakota.

Eleodes suturalis occurs over about the same region as *E. opaca*, with its variety *texana* Lec. extending southward into New Mexico and southern Texas.

THE WORK IN THE BIG BEND REGION OF WASHINGTON.

On May 28, 1909, an oat field at Govan, Wash., was examined. This field had been almost completely destroyed by true wireworms; besides these, many larvæ of *Eleodesletcheri vandykei* were found on the surface of the ground, evidently forced out by the unusually late heavy rains of the preceding day. These latter were by far too few in numbers to have destroyed the oats. Bluebirds (*Sialia mexicana occidentalis*) were noticed feeding in the fields in large numbers on the exposed *Eleodes* larvæ. Many of the larvæ were also found in the ground at a depth of from 3 to 5 inches, in small spherical cells, wherein they lay in a curled position. These were considerably softer and paler colored than those found in an active condition.

The work in 1910 started early in April when the false wireworms were to be found scatteringly throughout the grain fields, the grain having just sprouted.

Adults were first observed in 1911 on April 17, the day being quite hot, but the weather up to this time having been very cool. The beetles were to be seen at about 3 o'clock in the afternoon in great numbers along all the roadsides, where they were either awkwardly hurrying over the ground or nibbling at the foliage of the very young *Polygonum littorale*, which is very abundant in this region.

Adults of the larger species, *Eleodes obscura sulcipennis*, were usually to be found in or about the burrows of the ground squirrel (*Citellus townsendi*) and the badger.

When disturbed, the species of *Eleodes* have the ludicrous habit of standing still and elevating the abdomen so that the long axis of the body approaches the perpendicular instead of the nearly horizontal position it normally maintains while walking or at rest. The two beetles to the right in figure 22 are in this attitude. Thus they will remain motionless for several minutes and finally, if they are not further disturbed, they walk off. If one places the finger near the insect, an oily liquid is excreted from the anal aperture, which flows down over the elytra and abdomen. This liquid is pale yellow in color and makes a dark-brown stain; it has a very characteristic, strong, astringent, and offensive odor, and is evidently protective in

function. Mr. Carl F. Gissler¹ describes this secretion and the glands from which it is secreted.

Many pairs were in coitu on the 17th of April, and on the 21st a female that was confined in a pill box laid four eggs. Between the 21st and 23d, when the female died, she laid 10 more eggs, which, however, failed to incubate. Females dissected in the laboratory were found to contain from 92 to 199 eggs. The eggs were found to lie on the ventral side of the abdomen and to extend upward and over part of the viscera, filling all the interstices about the alimentary canal. The eggs were so crowded in the abdomen that they were quite distorted. Anteriorly the eggs were smaller and were fastened to the anterior abdominal sclerite by fine filaments.

The mating season lasted about two weeks, but the adults were in evidence throughout May and June. Well-grown larvæ were also to be found at this time. Many of the adults in the rearing cages, as well as two individuals observed in the field, were seen to burrow into the ground. This is accomplished by digging with the front tibiae, which are expanded and armed with spines for the purpose, the tarsi being folded back out of the way. The loose dirt is conveyed backward by the middle legs and piled up behind the beetle by the hind legs. When about one-fourth of an inch of dirt has accumulated the beetle backs out of the hole, pushing the earth out with the abdomen, the hind legs assisting in this process by keeping the earth piled behind the abdomen. On examining these burrows two or three eggs were found in each. The burrows are filled with earth after the beetles come out and are from 4 to 8 inches deep.

Rearing cages were established by sinking barrels to the surface level, filling them with earth, and fitting vertically onto the top a galvanized-iron cylinder 10 inches in height and the diameter of the inside of the barrel top, the open upper end being covered with wire mosquito bar, with an introduction hole made in the wire screen and corked.

On April 20 about 30 pairs of mated *Eleodes letcheri vandykei* were placed in this cage, which had previously been seeded with wheat and planted to *Polygonum littorale*.

By June 25 the beetles were all dead in the cage, probably due to abnormal conditions as well as age, though no living beetles could be found in the fields at that time. Small larvæ 4 to 5 mm. (about three-sixteenths inch) in length were then to be found in the cage.

On examining the cage on November 14 the larvæ were found to be about 14 mm. (nine-sixteenths inch) in length and at about a depth of 12 to 24 inches below the surface. The soil in the rearing cage was as dry as powder to a depth of nearly 2 feet, but the desiccation did not seem to affect the larvæ.

¹ Psyche, vol. 2, no. 58, 1879, p. 209.

July 4, 1911, the cage was again examined and the larvæ were found to be about $1\frac{1}{4}$ inches long. From early in July to the middle of August it became necessary to be away from Govan, where this experiment was in progress. On returning, August 16, the root cage was examined and two adults found about 6 inches below the surface. They were hard and had evidently emerged some days before this date. When the boards which had been placed over the barrel to protect it during the winter were removed in the spring, a number of adults was found that had hibernated under this shelter. On the above date and at a depth of about 20 inches a very young false wireworm (3.5 mm. long) was found; it was pure white and had evidently but very recently hatched. This larva was undoubtedly the young of one of these accidentally introduced beetles.

The soil at this time was dry to a depth of 4 inches. On June 25 a pupa was found in the field, placed in a pill box with dirt, and on the 30th an adult *Eleodes letcheri vandykei* emerged. In the fields, where a farmer was plowing his summer-fallow—and it may be remarked that this is exceptionally late for working the summer-fallow in this country—pupæ were found turned out by the plow. A little flock of Brewer's blackbirds (*Euphagus cyanocephalus*) were walking in the furrow a few yards behind the plow and picking up the upturned insects.

From the middle of July until the grain is harvested adults are to be found in large numbers under the grain shocks and bundles as they stand in the field, and also under grain sacks. Most of the beetles are quite soft early in the season, but later become hard.

DESCRIPTIONS.

Eleodes letcheri vandykei Blaisd.

The egg (fig. 23).—The egg is bluntly oval in longitudinal section and circular in cross section; it measures 1.1 mm. in length and 0.62 mm. in diameter; it is of a pure glistening white color and absolutely without sculpturing. Ovarian eggs measured 1.17 mm. in length and 0.74 mm. in diameter.

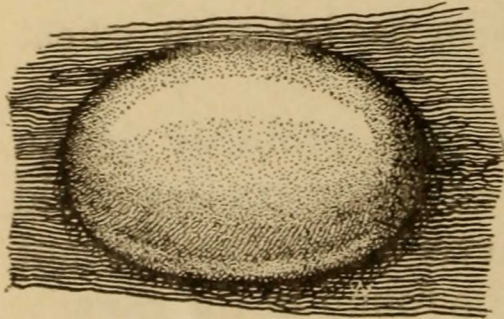


FIG. 23.—False wireworm, *Eleodes letcheri vandykei*: Egg. Greatly enlarged. (Original.)

The larva (fig. 24).—Elongate, subcylindrical, convex dorsally, flattened ventrally. Yellowish, ventral surface paler, anterior and posterior margins of first thoracic and posterior margins of succeeding segments brown; head slightly brown, edge of mandibles black, base of mandibles brown; claws, spines on legs, and caudal segment dark brown; antennæ pale yellow. Anterior and posterior margins of first and posterior margins of succeeding segments with striate marginal bands; band on anterior margin of first segment broader and more coarsely striate. Caudal segment scutelliform, flattened dorsally and convex ventrally, bearing 18 stout spines on its margin—4 on each lateral margin and 10 on terminal margin; a slight space equal to that occupied by one spine separates the lateral from the terminal spines. Several long hairs and a basal row

of short hairs on caudal segment. Head subquadrate, very convex, distance from base to labrum equal to one-half width of head, sides converging anteriorly, posterior angles rounded; two stout hairs on lateral dorsal surface; two oblong black eye-spots on lateral anterior part, a large one at base of antennæ, and a smaller one posterior and dorsad of this. Suture arising at base of each mandible flexed laterally and converging posteriorly to unite with the median suture at a distance from base of head equal to one-fourth distance from base to labrum; mouthparts usually directed ventrally. Labrum large, basal joint trapeziform, terminal joint rounded, bearing several hairs on margin, both joints margined anteriorly. Mandibles large, visible from above. Labium not covering mandibles, ligula broader than palpifer; labial palpi cylindrical, two-jointed, second joint papilliform; mentum larger than palpifer, submentum larger than mentum, all quadrangular and narrower at base than at anterior margin. Maxillæ larger than labium, stipes directed laterally; palpifer elongate and directed antero-medially; maxillary palpi at about middle of palpifer, three-jointed, first and second joints about equal in length, first stouter, third papilliform. Thoracic legs stout; first pair longer than width of thorax, second and third pairs one-third shorter; first pair very heavy, terminal hook as long as fourth joint, second joint bearing 2 stout short spines on inner distal margin, third joint bearing 3 marginal spines and fourth joint bearing 4 such spines.

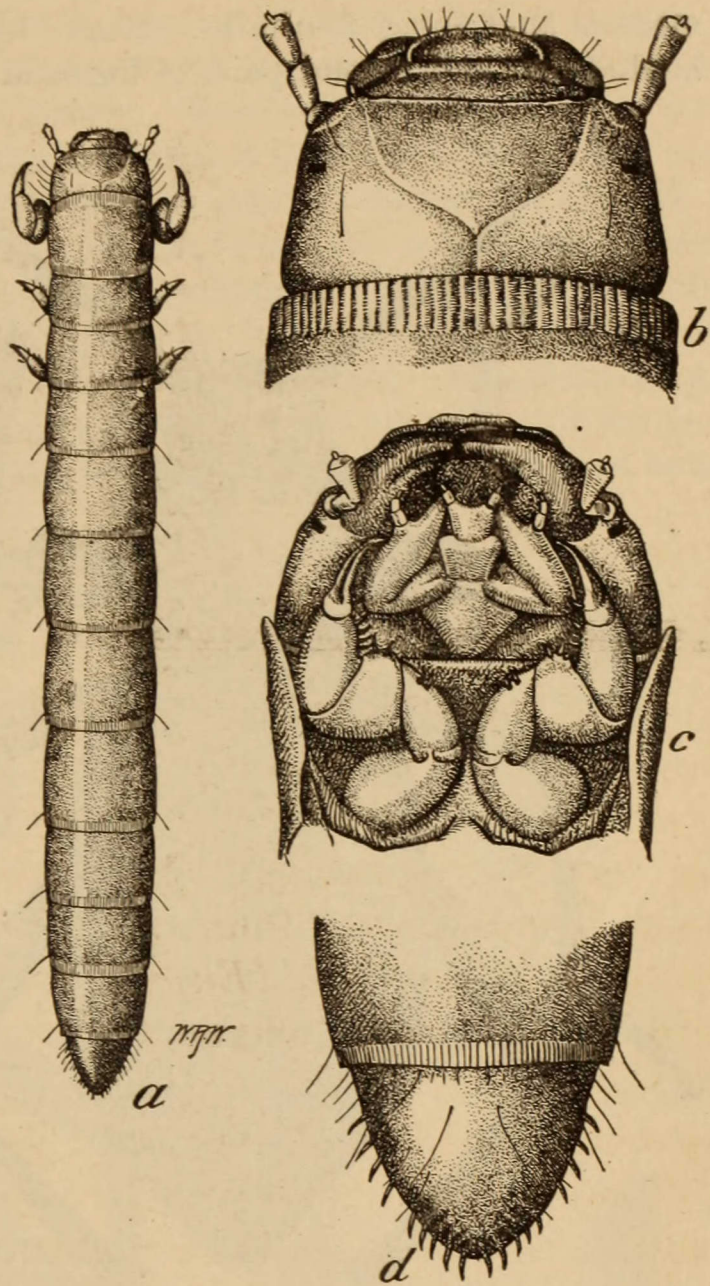


FIG. 24.—False wireworm, *Eleodesletcheri vandykei*. a, Larva, dorsal aspect; b, head, dorsal aspect; c, head, ventral aspect; d, caudal segment, dorsal aspect. a, Much enlarged; b, c, d, more enlarged. (Original.)

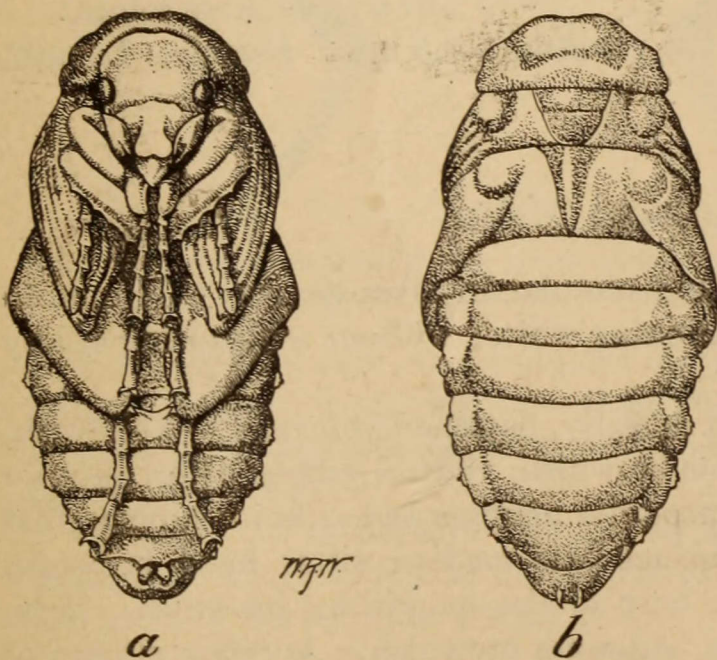


FIG. 25.—False wireworm, *Eleodesletcheri vandykei*. a, Pupa, ventral aspect; b, same, dorsal aspect. Much enlarged. (Original.)

The pupa (fig. 25).—Length 11 mm., width 5.3 mm., arcuate dorsally, flattened to slightly concave ventrally. Entirely white when first pupated but eyes soon become black followed by tips of mandibles; just prior to emerging the elytra and dorsum of thorax become black. Head pressed to the prosternum. Pronotum very broad and protruding anterior to the head, making the latter invisible from above. Mesonotum very narrow and scutelliform, with indistinct transverse sulcus slightly anterior to middle. Metanotum sagittiform, about as broad at anterior margin as mesonotum. At the base of each elytron and of each secondary wing pad is a rounded swelling. Seven abdominal plates visible dorsally. Between dorsal and pleural abdominal

plates is a distinct depression forming a submarginal groove. The caudal segment bears a pair of posteriorly directed spines near posterior margin dorsally and a pair of median anal lobes ventrally. Head, legs, and antennæ free. Antennæ passing behind first and second pairs of legs and over wing pads. Elytra folded ventrally

over the posterior legs. Eyes conspicuous. Pleural margin of abdominal segments bearing mammiform tubercles. Body without hairs or bristles.

*The adult*¹ (fig. 26).—More or less shining, elytra not pubescent. Antennæ with the third joint scarcely as long as the next two combined, fourth joint a little longer than the fifth, the latter slightly longer than the sixth, the latter and the seventh equal.

Pronotum usually widest at the middle, frequently widest just in front of the middle.

Elytra irregularly and quite densely muricately punctate, very minutely so on the dorsum, coarser on the sides and apex; from each puncture arises a rather short, stiff, curved, inconspicuous and semirecumbent seta. These are not evident on the inflexed sides.

Otherwise as in *letcheri*, but a little more robust.

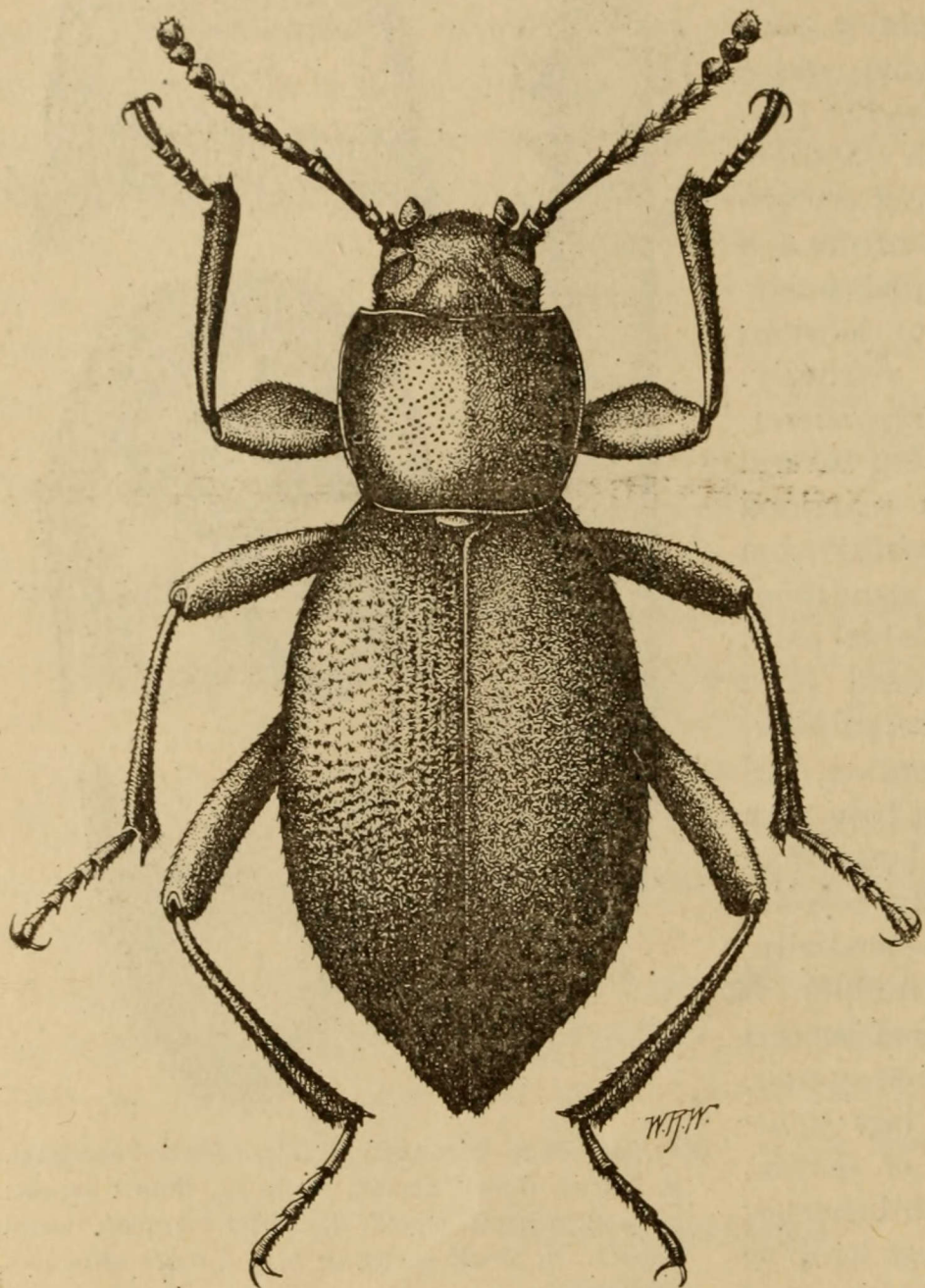


FIG. 26.—False wireworm, *Eleodes letcheri vandykei*: Adult, dorsal aspect. Much enlarged. (Original.)

Measurements.—Males: Length, 14.5–16 mm.; width, 5–6.5 mm. Females: Length, 15–16 mm.; width, 7.5 mm.

Genital characters as in *letcheri*.

Eleodes pimelioides Mann.

The egg.—Oval in longitudinal section and circular in cross-section; 1.34 mm. in length and 0.85 mm. in diameter; pure glistening white; without sculpturing of any kind.

The larva.—Elongate, cylindrical, convex dorsally, flattened ventrally. Yellowish, first thoracic and eighth abdominal segments brownish, ventral surface paler, anterior and posterior margins of first thoracic and posterior margins and anterior submarginal areas of succeeding segments brown, a distinct pale median vitta; head brownish posteriorly, edge of the mandibles black, base of the mandibles brownish; claws, spines on legs, and caudal segment brown; antennæ brownish. Anterior margin of first thoracic segment excavated, posterior margins on all segments except caudal

¹ The description of the adult given herewith is taken from "A Monographic Revision of the Coleoptera, belonging to the Tenebrionide Tribe Eleodiini, inhabiting the United States, Lower California, and Adjacent Islands," by Frank E. Blaisdell, Sr. Bul. 63, U. S. Nat. Mus., p. 136, 1909.

depressed, faintly striate. Caudal segment scutelliform, slightly convex dorsally, margined laterally, tip curved slightly upward, bearing 18 acute spines on margin—4 groups of 2 spines each on each lateral margin and 2 spines at tip. A number of hairs on dorsal surface and many on ventral surface. Head subquadrate, very convex, sides converging anteriorly, posterior angles rounded, 2 hairs on lateral dorsal and several hairs on ventral surface; 2 black eye spots on lateral anterior part of head, a large oblong one at the base of antennæ, and a smaller square one posterior and dorsal of this. Suture arising at the base of each mandible flexed laterally and converging posteriorly to unite with median suture near base of the head. Basal joint of labrum trapeziform, terminal joint rounded, trilobed, hairs on margin. Mandibles large, visible from above. Ligula broader than palpifer, labial palpi cylindrical, 2-jointed, second joint papilliform, mentum larger than palpifer, submentum larger than men-

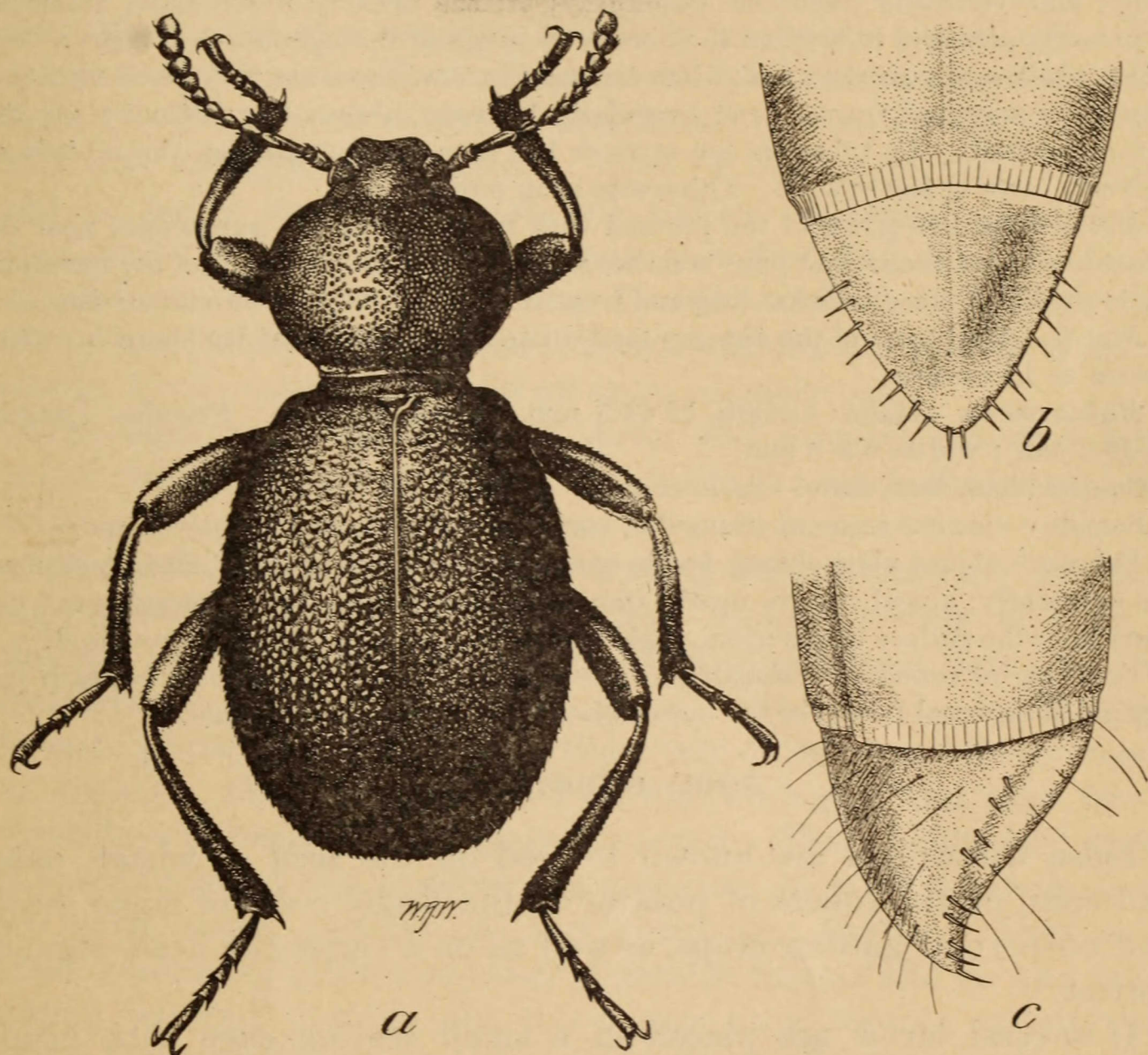


FIG. 27.—False wireworm, *Eleodes pimelioides*: a, Adult, dorsal aspect; b, caudal segment of larva, dorsal aspect; c, caudal segment of larva, lateral aspect. a, Much enlarged; b, c, more enlarged. (Original.)

tum. Legs 4-jointed. Second joint of anterior legs with 2 short stout spines on inner anterior margin; third joint of anterior legs with 3 longer spines on inner margin, and fourth joint with 3 still longer, stout spines; 2 spines on inner side and 1 spine on outer side of base of claw.

The pupa.—The pupa of this species is very similar to that of *Eleodesletcheri vandykei*, from which it can be distinguished, however, by a pair of rather stout spines at the apex of the secondary wing pads.

The adult (Fig. 27).¹—The following description is from page 384 Dr. Blaisdell's monograph previously mentioned in this paper:

Moderately robust, ovate, feebly shining to opaque, about twice as long as wide; prothorax more or less strongly constricted at base, densely rugoso-punctate; elytra

¹ Originally described in Bul. Soc. Nat. Moscou, vol. 16, p. 274, 1843.

sculptured with small tubercles, which may be rounded or reclinate and more or less piliferous. Head densely punctate, antennæ somewhat slender, ninth joint triangulo-orbicular to transversely oval, tenth more or less transversely oval.

Pronotum subcordate to transversely suboval, widest near the middle, a fourth to scarcely a half wider than long; sides evenly and quite strongly arcuate to basal seventh, or subangulate at middle, rounded in front and quite rapidly converging posteriorly and sinuate at basal fourth, thence in each instance quite straight and parallel to the basal angles; base equal to the length or in some males shorter than the length; apical angles obtuse, frequently not in the least rounded, at other times more or less so.

Elytra quite broadly oval to subquadrate, widest at or behind the middle, a fourth to a third longer than wide; disc more or less deplanate on the dorsum, strongly, arcuately, and vertically declivous posteriorly; surface densely tuberculate, tubercles apparently arranged in rows on the dorsum or irregular throughout; each bears a very short, black seta near the apex; when arranged in rows there are very small muricate punctures scattered sparsely and irregularly between, always less distinct along the suture centrally; the tubercles are more or less rounded and shining, the interstices between more or less opaque. Otherwise as in *cordata*.

Male.—First two joints of the protarsi with tuft of yellowish pubescence near tip beneath; that of the second joint is rather small; tuft on the first joint of the mesotarsi quite small. Tufts somewhat long and truncate at tips. Otherwise as in *cordata*.

Female.—First joint of the anterior tarsi distinctly thickened at tip beneath. Otherwise as in *cordata*.

Measurements.—Males: Length, 12–14.5 mm.; width, 6–7 mm. Females: Length, 13–15.2 mm.; width, 6.5–8 mm.

Genital characters, male.—As in *cordata*.

Female.—Genital segment triangular, surface quite plain and slightly setose.

Valvula.—Dorsal plate oblong, feeble or scarcely narrowed apically, slightly explanate externally; apical margin nearly transverse to feebly oblique, inwardly not defined from the surface of the apex, angle obtuse and more or less feebly rounded.

Ventrolateral surfaces.—Submarginal groove distinct and well defined beneath the expanded external border of the dorsal plate. Otherwise as in *cordata*.

FOOD SUBSTANCES.

- False wireworms are known to feed on the seed of wheat, oats, and corn, on the tubers of potato, on the fleshy roots of sugar beet, and on several garden crops, as well as on a variety of dead organic matter.

If several larvæ are placed in a small rearing cage with insufficient food they invariably prey upon one another until there is but a single survivor. Mr Swenk¹ observed that in cages where larvæ died of a disease their more fortunate survivors ate the dead individuals.

The adult beetles have been observed feeding on the seed of wheat and corn, on the leaves of corn, on *Polygonum littorale* and other weed leaves, and on decaying vegetable matter. An adult beetle was kept alive for several months in our laboratory. It was fed on wheat and occasionally drank from a piece of wet cotton.

¹ Journ. Econ. Ent., vol. 2, p. 336, 1909.

SEASONAL HISTORY.

The following life history was worked out for *Eleodes letcheri vandykei* at Govan, in the Big Bend region of Washington, and unless otherwise indicated the data refer to this species.

The adults emerge from hibernation in the early spring, about the middle of April, and after feeding for a short time on the leaves of various weeds, principally *Polygonum littorale*, mate and start oviposition. The eggs are deposited a few at a time in the ground, the adult female burrowing down through the soft dust to the moist soil below, usually to a depth of from 2 to 4 inches. The average number of eggs laid by one female is probably about 150. Five specimens of female *Eleodes letcheri vandykei* that were collected on April 30, 1911, were dissected and found to contain 199, 138, 161, 157, and 92 eggs, respectively. Most of these eggs were full-sized and probably mature, though one female contained 45 eggs and another 91 eggs which were about one-third full size. A female *Eleodes pimelioides*, collected May 1, 1911, at Pullman, Wash., was found to contain 167 eggs and 2 females of *Eleodes nigrina* collected late in April contained 96 and 58 eggs, respectively.

The eggs hatch in about 18 days, the recently emerged larvæ being cream-white, but rapidly assuming the normal amber-yellow color.

The larvæ feed throughout the ensuing summer, usually on decaying vegetable matter, hibernate, and resume feeding as soon as the soil becomes warm enough the following spring, but this time disastrously to the spring-sown grain. In June the larvæ transform to pupæ, and early in July the newly emerged adults commence to appear. They are quite soft on first emerging and take two or three days to become thoroughly hardened. These adults feed during the remainder of the summer, congregating in large numbers under the grain sacks, shocks, and any convenient shelter. They eat a small amount of grain and other vegetable matter and go into hibernation without mating. In the spring they resume activity and mate, thus completing the life cycle. They hibernate under boards, in squirrel holes, and in the ground. Prof. W. T. Shaw, of the Washington State College, in digging out burrows of a ground squirrel (*Citellus columbianus*), found specimens at a depth of 6 feet below the surface in the burrows. I have dug out the hibernating beetles at a depth of about 6 inches in the soil in wheat fields and also in barrel root-cages.

Larvæ of *Eleodes suturalis* were received by Mr. Theo. Pergande¹ on October 26, 1898, from McPherson, Kans. These pupated before May 19 and adults emerged May 30. From this note it would seem that *Eleodes suturalis* varies from *Eleodes letcheri vandykei* in its life

¹ Bureau of Entomology Notes, No. 8186.

history, hibernating as mature larvæ or pupæ and transforming to adults much earlier in the season than the latter.

The adults of the species herein treated seem normally to live but one season, but Dr. F. E. Blaisdell records keeping adults of *Eleodes dentipes* in confinement for over four years.

NATURAL ENEMIES AND PARASITES.

The hard chitinous integument, together with the offensive secretions, of these beetles render them almost immune to attack by birds. Several western vesper sparrows (*Poæcetes gramineus confinis*), two horned larks (*Otocoris alpestris* var.), a killdeer plover (*Oryechus vociferus*), a "billy" owl (*Speotyto cunicularia hypogæa*), and a Brewer's blackbird (*Euphagus cyanocephalus*) were shot while feeding in the grain fields and the stomach contents examined; these failed to show any evidence that the birds had fed on adult *Eleodes*.

Of the domesticated birds, chickens and ducks eat adult *Eleodes* in large numbers. Twenty-five beetles were fed to one hen and were eaten very greedily. Young turkeys would not eat these insects. They would seize the beetle and immediately drop it and shake the head violently as though they disliked the taste, and after two or three similar experiences would learn to recognize these insects and would not touch them.

A large number of these beetles were fed to confined pheasants, and though the conditions were very abnormal, the results may be suggestive. Reeves pheasant (*Phasianus reevesi*) and the silver pheasant (*Gennæus nychthemerus*) ate the beetles freely, while the golden pheasant (*Chrysolophus pictus*) and the Lady Amherst pheasant (*Chrysolophus amherstæ*) refused even to notice the beetles. However, these birds seemed quite annoyed by our presence, and might have eaten the beetles had they not been frightened. No Chinese pheasants (*Phasianus torquatus*) were available, so we can not say whether or not these birds would be of any value as enemies of *Eleodes*.

From several sources we were informed that the sage hen (*Centrocercus urophasianus*) feeds largely on these beetles, the crop at times being gorged with the black chitinous fragments. In the records of the Bureau of Biological Survey of this department the following birds are listed as feeding more or less extensively on adult *Eleodes*:

California shrike (*Lanius ludovicianus gambeli*), road-runner (*Geococcyx californianus*), Lewis's woodpecker (*Asyndesmus lewisi*), western crow (*Corvus brachyrhynchos hesperis*), bronzed grackle (*Quiscalus quiscula æneus*), red-headed woodpecker (*Melanerpes erythrocephalus*), curve-billed thrasher (*Toxostoma curvirostre*), hairy woodpecker (*Dryobates villosus* var.), western mocking bird (*Mimus polyglottos leucopaterus*), western robin (*Planesticus migratorius propinquus*), the field plover (*Bartramia longicauda*), the mallard (*Anas platyrhynchos*), and the baldpate (*Mareca americana*).

Dr. Blaisdell¹ refers to the ground owl (*Speotyto cunicularia hypogæa*) as one of their enemies, and further states that the butcher bird impales them on thorns.

It is very generally known among the farmers of the wheat regions of the Pacific Northwest that the Brewer's blackbirds (*Euphagus cyanocephalus*) follow the plow and eat the "white worms" (*Eleodes* pupæ) when the summer-fallow is being worked. The birds are to be seen walking in the furrows and flying away with their beaks filled with the soft white pupæ.

The western bluebirds (*Sialia mexicana occidentalis*) were seen at Govan, Wash., in large flocks feeding on the larvæ which had been driven to the surface by an unusually heavy rain.

The stomachs of several horned toads (*Phrynosoma douglasii douglasii*) were examined and found to contain fragments of *Eleodes* larvæ, but several of these toads kept in captivity refused to eat the adult beetles, though they would feed voraciously on other beetles. These little horned toads, or, as they are locally known, sand toads, are without doubt one of the most valuable animals in the western dry-farming regions. In the Southwest a larger species (*Phrynosoma cornutum*), with long stout spines on the head, supplants the former species. These toads move very rapidly and eat enormous numbers of insects. The garden toad (*Bufo* sp.) is recorded in the files of the Bureau of Biological Survey as feeding on *Eleodes*. Dr. Blaisdell² gives the skunk as a natural enemy of these beetles.

In the files of the Bureau of Entomology there is a note (No. 8186) by Mr. Theo. Pergande, wherein he records having received two larvæ from McPherson, Kans. These pupated, and later one of these pupæ was killed by an ant (*Tetramorium cæspitum*).

Another of Mr. Pergande's notes³ records receiving an adult of *Eleodes suturalis* from Mr. C. E. Ward, of Belvidere, Nebr. This beetle was placed in a cigar box, and on examining the box on the following morning a large number of larvæ were noticed crawling about. These larvæ later spun cocoons around the edge of the box and were believed to be microgasterid parasites that had issued from the beetle. The adult parasites were later determined as *Perilitus* n. sp., and these are preserved in the National Museum collections.

The author found an adult beetle with the abdomen nearly filled by a nematode worm, but lost the specimen, making further determination impossible. Mr. Myron Swenk⁴ records a disease, probably caused by bacteria or a fungus, that attacks the larvæ. The

¹ Bul. 63, U. S. Nat. Mus., p. 29, 1909.

² Loc. cit., p. 29.

³ Proc. Ent. Soc. Wash., vol. 2, pp. 211, 219, 1892.

⁴ Jour. Econ. Ent., vol. 2, p. 335, 1909.

first symptom of this disease is a small red spot on one of the body segments, usually on the first thoracic or the terminal abdominal segment. This spot enlarges, finally encircling the body, and within a very short time the insect succumbs. This disease was so prevalent as to interfere with much of Mr. Swenk's experimental work.

REMEDIAL AND PREVENTIVE MEASURES.

If a field is well stocked with false wireworms at the time wheat is sown, remedial measures are of little avail, as was demonstrated by our experiments carried out in the Big Bend country of Washington. The insects are well adapted to the present agricultural practices of the spring-wheat growers in the Pacific Northwest. Here the plowing of summer-fallow land is commenced as early as possible in the spring, which in the average season is in April. Those who can spare teams and men often commence while the seeding of the crop in other fields is in progress. The most progressive farmers then disk their fallow land in June so that this will be well finished when haying commences.

By slightly modifying this procedure an enormous number of these beetles would be destroyed. Instead of plowing early in the spring and disking in summer, reverse the process. Disk as early as the land can be worked and the apparatus is available, which will usually be in April. This will conserve the moisture fully as well as plowing. Then plow as late as possible; if the land has been well disked and the men and horses can be spared, it is well to defer this plowing to late July and early August. At this time the beetles are in the pupal, or, as they are commonly called, "white-worm," stage. They can not move through the ground as can the active larvæ, but can merely squirm when irritated. The plowing, which should be deep to be effective, turns out great numbers of these pupæ, and they are either eaten by birds or killed by the burning sun. Many more are destroyed by being crushed or suffocated in the broken pupal cells. Aside from killing many *Eleodes* pupæ, this practice of late plowing the summer-fallow would greatly aid in weed eradication. The early disking would not bury the weed seed to retard germination; all the seed would develop; then the late plowing would destroy the entire crop of weeds. If the weeds start very early, a second disking may be necessary, as weeds very rapidly deprive the soil of its moisture.

Concerted effort and very thorough work are absolutely essential to render this treatment appreciably effectual. The cooperation of all the farmers over a considerable area is advised, as the adult beetles walk rapidly and will readily reinfest a well-treated ranch, coming in from an adjoining, poorly worked field or pasture.

This treatment is by no means advocated for those farmers who find it impossible to disk their summer-fallow, as leaving the land untouched until July would cause all the accumulated winter's moisture to evaporate, and the plowing would simply be stirring the dust and be of no value whatever.

In the spring of 1910 a series of experiments was carried out at Wilbur, Wash., to determine the value of certain substances alleged to be useful as poisons or repellents against elaterid larvæ. *Eleodes* larvæ were also quite numerous in the fields where these experiments were carried out; hence mention of the results, though relating principally to another insect, may not be out of place here.

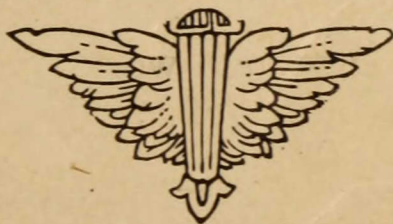
Seed in bulk was treated with the following substances: Lead arsenate, at the rate of two-thirds of a pound per bushel of seed, dissolved in water; strychnine sulphate, at the rate of two-thirds of an ounce per bushel of seed, dissolved in water; coal tar applied until seed was all coated, then sanded until dry. The substances were stirred into the grain thoroughly with a wooden paddle and then allowed to dry several days.

The experiments were sown in strips with a wheat seeder 11 feet wide and one-half of a mile long. Untreated check strips were planted between each treated plat.

Just after sprouting the percentage of damage done by insects was estimated by counting the damaged and undamaged seed in several areas of 1 square yard each in each plat. The results were entirely negative as all the plats, including the checks, were about equally attacked.

These treatments, even had they been found efficient, would have been impracticable from an economic standpoint. The poisons were too expensive and the application too expensive and laborious, and, in addition, the coal-tar treatment, even after drying several days, so clogged the seed cups on the seeder as to cause very uneven distribution of seed.

ADDITIONAL COPIES of this publication
may be procured from the SUPERINTEND-
ENT OF DOCUMENTS, Government Printing
Office, Washington, D. C., at 5 cents per copy



UNIVERSITY OF FLORIDA



3 1262 09216 6510