BIOLOGY OF THE FALSE WIREWORM ELEODES SUTURALIS¹ SAY²

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INTRODUCTION

The false wireworm *Eleodes suturalis* Say is now a serious menace to the production of wheat and other small grains in both irrigated and nonirrigated districts in some of the more recently settled, semiarid regions of the Middle West. It is an impressive illustration of a truth repeatedly emphasized by the late Prof. F. M. Webster (33, p. 72)⁴, namely, that insects formerly supposed to be of little or no economic importance have frequently—

come suddenly into prominence and become immensely destructive to crops.

Its principal damage is caused in the fall by the larvae feeding upon the recently sown wheat grain and its sprouts, thus retarding or preventing the formation and growth of the young plant. It also injures or destroys growing wheat in the spring.

The comparatively recent development of *Eleodes suturalis* as a pest is due largely to artificial change in its environment and food plants. Large areas formerly devoted to grazing have been brought under cultivation, and this has diminished or almost eliminated a number of the native food plants and has caused the insect to attack some of the crops now grown in their place. This change of food plants and possibly better facilities for hibernation in the cultivated fields have resulted in a steady increase in abundance of the pest.

Although, owing to the partial control effected by meteorological conditions and parasites in each infested locality, the more destructive outbreaks of this false wireworm have occurred only at irregular intervals, yet the activities of the pest have been reported with increasing frequency each year since 1910 in widely separated districts within its range, indicating that the species is likely to become increasingly injurious in future years.

The territory under discussion comprises more especially the semiarid sections of western Texas, New Mexico, Colorado, Oklahoma, Kansas, Nebraska, and the Dakotas, west of the ninety-seventh meridian, and the life-history notes are based upon studies made in the years from 1914 to 1917, inclusive, in the latitude of southern Kansas, the deductions therefrom being based upon behavior of the specimens under observation.

HISTORY

This insect belongs to the extensive coleopterous family Tenebrionidae, and to a group popularly known by the expressive term of "stink-

¹ Order Coleoptera, family Tenebrionidae.
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⁴ Reference is made by number (italic) to "Literature cited," p. 565-566.
bugs." It was first authentically described under the name of *Blaps suturalis* by Thos. Say (23, p. 257) in 1824. This description was republished (24, p. 30, pl. 16, fig. 2) in the same year and subsequently appeared under the same name in Say's Collected Works (25, p. 30, pl. 16, fig. 2) in 1859. The insect was removed from the genus Blaps in 1829 and placed in the genus Eleodes by Eschscholtz (7, p. 10), who indicated the generic structural characters of the insect upon which the change was based. Le Conte (16, p. 182-183) in 1858, following his description of *Eleodes suturalis* var. texana, emphasized that the species discussed is—

**Allied to *Eleodes suturalis*, but much larger and narrower, with the sides of the thorax and elytra still more strongly margined.**

It is interesting to note that the genus Eleodes by that time embraced a large number of species of very varied form, and those described by Le Conte served yet further to illustrate the protean character of the genus. Le Conte (17, p. 121-122, pl. 12, fig. 5) in 1859, in further discussion of *Eleodes suturalis* var. texana, reviewed the description already published and directed attention to the exceedingly great variations of the species within the genus. Lacordaire (15, p. 148-149, pi. 51, fig. 3) in 1859 merely directed attention to the more commonly known distinguishing characters between this and related species. Horn (11, p. 306) in 1870, in his monographic revision of the Tenebrionidae, separated *Eleodes suturalis* from *E. obscura* and *E. acuta* by the flat or concave thorax, and further separated *E. suturalis* and *E. texana* according to rounded sides of the elytra in the former and the parallel sides of the elytra in the latter. He added further concerning *E. suturalis* that—

The general form of this species agrees with the two already mentioned [*Eleodes obscura* and *E. acuta*], differing, however, in having both the thorax and elytra with a very acute margin, generally slightly reflexed in the latter, always so in the former, so that the dorsum appears either flattened or concave in accordance with the degree to which they are upturned. The sides of the elytra are rounded, never parallel, the dorsum is always flat. The anterior femora are not very acutely toothed, frequently merely sinuate . . . Many specimens have a broad red band along the suture of the elytra.

Concerning *Eleodes texana* Lec., Horn directed attention to the fact that it, too, was acutely margined. In comparing it with *E. suturalis* he noted that the thoracic margin is much wider and more reflexed, the thorax broader, the sides more strongly rounded, the apex deeply emarginate with acute angles, and the base trisinuate and with acute angles. The elytra are more acutely margined than in *E. suturalis*, the dorsum slightly concave, longer and more parallel and in the males slightly produced, their surface also feebly sulcate with striae of coarse, closely placed punctures. The anterior femora of the male are armed with a rather short acute tooth. Horn (12, p. 34) in 1874, after making further study of the various species from more widely separated localities in Texas, became—

convinced that this species [*E. texana*] is merely a large variety of *E. suturalis* Say.

Casey (4, p. 394) in 1890, in discussion of generic differences between Blaps and Eleodes, made comparison of the form of the mentum between *Blaps mortisaga* and *Eleodes suturalis*, but indicated that the facts relative thereto were of doubtful taxonomic importance. Blaisdell (3, p. 199-205, pl. 1, fig. 14, 19, 23) in 1909, in his very full discussion of the characters of the typical form of *E. suturalis* and of the variety *E. texana*, left little to be desired. He reviewed the salient type characters of *E.*
suturalis as given by Say. These are as follows: Reddish brown along suture. Thorax with edge deeply concave in front, lateral margin dilated and reflected; anterior angles with a small escurred point. Elytra scabrous, grooved, lateral edge reflected, slightly elevated and acute. He also reviewed the salient type characters as given by Le Conte of *E. suturalis* var. texana. These are as follows: Thorax with the disk slightly convex, sides broadly depressed and slightly reflexed, sides greatly rounded, subsinuate behind; anterior angles acutely acuminate; basal angles rectangular. Elytra with dorsum plane, sides parallel and margined. He also placed emphasis on the more conspicuous diagnostic characters—the more or less reflexed elytral margins, with the pronotal margins acute and reflexed, and the concave disk. The variety texana differs in its elongate and parallel form, the typical species being less elongate and with the elytral margins distinctly arcuate. Gebien (9, p. 251) in 1910 enumerated references to taxonomic literature on both the typical form and the variety texana.

A brief but able review of the economic importance of the genus Eleodes was given by McColloch (18) in 1918, in which he cited the existing principal records of injury and directed attention to the fact that very little has been recorded concerning this genus from an economic standpoint, because—

It is only within recent years that the false wireworms have been recognized as pests of growing crops.

Swenk (27, p. 336) in 1909, in discussing injury to growing crops in southwestern Nebraska by *Eleodes opaca* Say, directed attention to the presence of *Eleodes suturalis* in suspicious numbers with that species. Hyslop (14, p. 74) in 1912 recorded the rearing of an adult of this species by Mr. Theo. Pergande from a larva injuring wheat in Saline County, Kans. This scarcity of information and lack of recognition as an economic pest is probably due to a number of causes. The larva bears considerable superficial resemblance to that of a true wireworm, of the family Elateridae, and it is likely that much damage to growing crops really caused by false wireworms has been reported as caused by the true wireworms. Then, too, the subterranean habit and obscure work of the larva of this false wireworm render its presence unnoticed without close search. Also, the adult is seldom observed, for it does not often appear from beneath cover in open spots except late in the evening or early in the morning, as the light and heat of the day drive it to shelter.

### DISTRIBUTION

**Colorado:** Canyons near Boulder, H. F. Wickham (3, p. 203); Denver, altitude 5,183 feet, October, H. Soltau (3, p. 203); Gillette, altitude 9,933 feet, H. F. Wickham (37, p. 294); Golden, altitude 5,693 feet, May, H. G. Dyar and A. N. Caudell (3, p. 203), September, H. F. Wickham; La Junta, altitude 4,052 feet, H. F. Wickham (37, p. 294); Berkeley, H. F. Wickham (37, p. 294); Orchard, altitude 4,403 feet, H. F. Wickham (37, p. 294); Limon, altitude 3,360 feet, September, H. F. Wickham; Sterling, altitude 3,932 feet, August, H. F. Wickham.

**Iowa:** Lyon County, June, B. Shimek (38, p. 33, 4); Sioux City, altitude 1,104 feet, August, H. F. Wickham; “Western Iowa,” T. H. Macbride (36, p. 60).

**Kansas:** Argonia, altitude 1,242 feet, March to November, J. S. Wade; Augusta, altitude 1,214 feet, August, E. G. Kelly; Belleville, altitude 1,514 feet, July, W. E. Pennington; Colby, altitude 1,318 feet, August, J. S. Wade; Dodge City, altitude 2,480 feet, June, V. King, August, J. S. Wade; Ellis, altitude 2,119 feet, August, J. S. Wade; Ellsworth, altitude 1,534 feet, April to October, E. G. Kelly; Garden City, altitude 2,829 feet, August, J. S. Wade; Harper, altitude 1,417 feet, June, J. S. Wade; Hays, altitude 1,999 feet, April, E. G. Kelly, July, H. E. Smith; Kingman, altitude
It is exceedingly probable that this insect has a wider distribution than the existing records indicate, and it is quite possible that it may occur over the greater part of the arid and semiarid regions of the Middle Western States. Wickham (55, p. 86) in 1890 says:

E. suturalis I never took west of Albuquerque, where it is rather rare.

In a discussion by the senior writer (30, p. 2-3) in 1921 of the ecological factors governing the distribution of this and related species, it was pointed out that its distribution is closely related to the marked variations of altitude from approximately sea level to over 6,000 feet and to the occurrence of soils of light, sandy type, as it is known that the larval stages thrive best in such soil. The adults, however, have been collected in small numbers several miles from such sandy locations.

**FOOD PLANTS**

Normally this insect fed upon the seed, root systems, and other portions of native grasses and other plants, upon dead vegetable matter in the soil, and occasionally upon living and dead animal tissue. As the prairies rapidly became settled farther and farther westward, however, these food plants were more and more replaced by cultivated crops, especially by winter wheat and other cereals, the grain of which when available...
has become in large part their food. Of these introduced plants, the insect in the larval or adult stage, or in both stages, is known to feed more or less upon the following: Wheat (*Triticum vulgaré* Vill.), oats (*Avena sativa* L.), corn (*Zea mays* L.), rye (*Secale cereale* L.), millet (*Setaria itálica* Beauv.), alfalfa (*Medicago sativa* L.), kafir (*Holcus sorghum* L.), fleshy roots of sugar beets (*Beta vulgaris* L.), and several garden crops, notably the bean (*Phaseolus vulgaris* L.), and tubers of the potato (*Solanum tuberosum* L.). So far as known, wheat appears to be its favorite food, and this crop seems to suffer most from the depredations of the insect. Curiously enough, the injury to wheat is so great, and that occurring in the other crops enumerated is so slight by comparison, that a rotation introducing some of these crops, as will be shown later, has proved to be an efficient control measure. Although the beetle is known to feed to a greater or less degree upon practically all of the food plants enumerated, the greatest injury is wrought by the larva.

**CHARACTER OF INJURY**

The principal infestation of wheat occurs in the fall soon after sowing. As soon as the grains commence to soften in the process of germination, they are attacked by the larva. At times two or more larvae may attack a single grain, and eat out its entire contents, leaving only the empty husk, but more often only one larva was found feeding upon a grain. The characteristic nibbling of the ends and gnawing out of the germ of the grain by the larva when once seen may afterwards be easily recognized. The young sprouts are also occasionally injured, though even when not attacked they wilt and die as soon as nourishment is no longer obtainable from the infested grain. When the plant is not attacked until well sprouted, the results are quite similar. Even the most vigorous plants seldom if ever put forth new roots.

In the fall the infestation is often confined to the more impoverished areas in a field, but in spring the larvae may be present in numbers among the roots of tall and apparently healthy plants in the more productive areas. Where the surface is of a rolling character, infested fields soon present, in the fall, a parched or spotted appearance, the knolls standing out at first distinct and bare, although before harvest they become overgrown by grass and weeds. After the wheat has grown up somewhat around these devastated spots, the bare areas often become filled with dried thistles, blown there by the wind.

In addition to the injury caused by the larva, wheat in the shock or stack is damaged noticeably by the adult, which nibbles the ends of the grains.

The maximum injury to fall-sown grain occurs almost invariably during years when normal moisture is lacking. Frequently in the sandy, arid districts there are no rains during early fall, and the seed wheat lies in the ground for weeks after seeding. It is during these protracted dry seasons, while the grain is unable to sprout, that the larva is most injurious. During seasons when sufficient moisture is present at seeding time to cause the plants to sprout at once, less damage is done.

In only one year thus far, namely, that of 1910, has the pest invaded in destructive numbers the eastern portion of the area indicated. In the early summer of that year large numbers of adults were found in that area in the vicinity of straw stacks and beneath old weedy wheat bundles which had been discarded from the previous harvest. These waste
bundles were rather well distributed over the various fields, which thus become generally infested. The fall of that year, being a very dry one over the entire area of distribution, was favorable for this pest; since the wheat was seeded early and did not sprout until quite late, much of it was destroyed by the insect. Comparison of infested with noninfested fields showed that the former were trashy while the latter invariably were clean.

The insect has been known almost completely to destroy early sown seed wheat in early fall before sprouting has occurred, and growing wheat the following spring. More often, however, in dry autumns it attacks and destroys seed wheat in little spots or small areas all over a field, especially in the vicinity of straw stacks or piles of rubbish and weeds. Where the destruction is not complete, the injury is indicated here and there by the dwarfed or stunted plants. The larva is ravenous and very active, and sometimes as many as from four to six are present about a single wheat grain and its sprouts. Several full-grown larvae have been found in a linear foot of a single drill row feeding upon the seed. Owing to their obscure, underground work a farmer frequently reseeds more than once in a single season without comprehending the true cause of his losses.

The percentage of yield lost through depredations of this pest cannot always be determined. Frequently the extent of damage is not appraised by the grower, especially during dry autumns, until late in the season when rendered apparent by the large, bare spots over the fields or the stunted, depleted condition of the growing crop. In extreme cases entire fields of wheat have been destroyed completely so that the crop was not worth harvesting.

DESCRIPTION

EGG (FIG. 1)

The egg is elliptic-cylindrical, bluntly oval in longitudinal section and circular in cross section. It is opaque ivory white, and the surface appears smooth both under low and high power of the microscope. It reflects light slightly from the lighted side. The shell is sufficiently tough not to become seriously distorted when the egg is rolled around in the soil. Average length 1.5 to 2 millimeters; width 1 millimeter.

MATURE LARVA

Length 28 millimeters; color testaceous, with head and anterior portion of legs somewhat dark colored; prosternum, prehypopleuron, and posterior margins of prothorax, and posterior margins of the following segments castaneous-testaceous; anterior and posterior margins of prothorax and posterior margins of the following segments longitudinally finely striated. Surface corneous. Form elongately cylindrical, about nine times as long as wide (Pl. 1, C); dorsally convex, ventrally slightly flattened; pygidium movable in the directions up and down, conical, mucronate. Head, ventral sides of the thoracic segments, anterior portion of the sternum of first and posterior margin of eight abdominal segments, ninth sternum, legs, and pygidium clothed with rigid or soft setae; rest of body glabrous with few, thin hairs.

Craniun rounded (Pl. 1, B), nutant, exserted, three-fifths as long as wide (from epistomal margin (epi) to occipital foramen), broadest medianly, dorsally somewhat convex. Anterior frontal angle (fa) rounded. Frons (f) three-fourths length of

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\[\text{Description and Plates 1 and 2, by R. A. St. George.}\]
cranium, a little wider than long with extreme width anteriorly; side margin convex. Epicranial halves (epc) meeting dorsally; epicranial suture one-fourth length of cranium; ventrally the halves are separated by the gula (Pl. r, I, gu); dorsally with a few, laterally and ventrally with numerous thin setae. Gula distinct, coriaceous, subquadrate, with tentorial pits (tp) just below middle of side margins. Clypeus (Pl. I, B, e) trapezoidal, widest posteriorly, length to extreme width as 1 to 4, medially with slight transverse ridge, each side with two well-developed setæ near lateral margin; side margins of anterior half testaceous, rest membranous; posterior half with side margins testaceous, rest castaneous-testaceous. Labrum (lab) well developed, movable, transversely rectangular, almost three times as wide as long, anterior half membranous, posterior half castaneous-testaceous; anterior margin broadly emarginate, anterior corners strongly rounded; medianly also along lateral and frontals margins with slight deepening; disk on each half usually with a median transverse series of three or four setæ; along the side and frontal margins are about eight much longer and thinner setæ, with a few smaller ones between them; behind those along the anterior corner, but on the ventral side of labrum, may be two to three parallel series of shorter, stronger, somewhat curved setæ (Pl. r, A). Ophthalamic spots absent. Antenna closely behind the mandible, attached to distinctly colored rim below dorsal mandibular fossa; basal antennal membrane well developed, posterior part somewhat corneous; three articles; basal article subcylindrical, about as long as labrum, second article as long as basal, more clavate; apical article very small, cylindrical, bearing a few tactile hairs at apex; no supplementary appendix beside the apical article. Mandibles of right and left side differing in shape; both apically bifid (Pl. r, E, G, a, a), each with one tooth (t) between apex and molar part (m); tooth of right mandible, however, prominent and placed near apex, that of left less developed and placed close to molar part; molar part of right mandible with bituberculate crown, that of left mandible with hollow crown, laterally with cutting part deeply excavated, several soft setæ placed closely together near base, halfway between condyle and molar part; exterior surface ("back of the mandible") distally with a slightly carinate margin (c), proximally with a soft skinned, whitish swelling (s) mostly on dorsal surface; three strong setæ from anterior portion of swelling and three or four from posterior; portion opposite molar part and below whitish swelling excavated (e), with several small, soft setæ near ventral mandibular condyle; dorsal surface of mandible somewhat flattened. Maxilla dorsally completely covered by mandible, coriaceous (Pl. r, I); palpus surrounding mala (ma) with one-fourth of its own length; maxillary palpiger (pag) small, ring-shaped; three articles; basal article somewhat clavate, slightly shorter than that of labial palpus; second article a little longer than basal, subcylindrical, bearing a thin setæ near apex on outer side; apical article half as long and thick as second, conical, apically covered with tactile hairs; mala on ventral (exterior) surface apically bearing one or two fine hairs (Pl. r, I, ma); stipes (sti) fused with mala; base of stipes (bs) near articulation of carido, short, bearing a few thin setæ; proximal half of inner margin (is) of stipes connected with maxillary articulating area (ar), distal half (is), right behind mala, free, bearing a few short, weak setæ; just below palpiger and along exterior margin many long, thin setæ; carido (ca) about as long as maxillary palpus, entire, adjacent to curved hypostomal thickening (hyp) which lies between fossa for ventral mandibular condyle (fm) and fossa for tip of carido (fc); inner margin of carido near center with an indication of fusion with maxillary articulating area, posterior margin bearing a few short hairs. Maxillary articulating area (ar) protuberant, divided into halves; exterior half connected with maxilla, subdivided into an upper and lower portion, an oval elevation arising from upper portion, lower portion again divided in two and coriaceous, its exterior part connected with carido, without setæ; interior half connected with submentum, entire, without setæ. Submentum (rm) coriaceous, trapezoidal, broadest posteriorly; side margins slightly concave and adjacent to maxillary articulating area; surface bearing numerous long, thin setæ medianly. Mentum (me) coriaceous, subquadrate, slightly wider anteriorly, side margins free; surface bearing a few long, thin setæ. The two stipes labii (stia) fused into a slightly chitinized unit carrying on each side a few short hairs; labial palpus about as long as stipes labii; two articles; basal article cylindric; apical article conical, shorter than basal article, apically covered with tactile hairs; ligula (Pl. r, D, ii) small, narrow, conical, with a terminal pair of setæ; on buccal surface a parallel longitudinal series of thin setæ. Hypopharyngeal sclerite (Pl. r, F, H, hsc)
supported above hypopharyngeal bronch (hbr) by a chitinous plate from which it extends; elongate, subrectangular, somewhat rounded at base, projecting, strong, heavily chitinized; anteriorly tricuspidate; disk excavate with a slight swelling posteriorly. The hypopharyngeal bronch is a well-developed rod in the buccal membrane between the ventral mandibular articulations and the hypopharyngeal region; in the latter region the rod is heavily chitinized, near the former region slightly membranous. Epipharynx (Pl. 1, A, eph) forming the buccal surface of labrum, soft-skinned, with posterior, transverse, broad, sinuous, chitinous band that carries one pair of stublike, sharp teeth; on soft-skinned part anteriorly to these teeth a pair of tiny hooks; near anterior margin and below transverse chitinous band many scattered ring-shaped punctures.

Legs well developed, surrounded at base by a large articulating area (Pl. 2, E, ar). Prothoracic legs considerably stronger than those of mesothorax and metathorax. Articulating area laterally with a few (three or four) short hairs. Coxa (Pl. 2, D, F, cox) of first pair attached so closely together that they are nearly contiguous at base, nearly as long as wide, coriaceous; many fine scattered hairs on exterior and interior surfaces; trochanter (tr) about as long as coxa, anterior face (Pl. 2, D) slightly coriaceous, posterior face (Pl. 2, F) membranous, on inner side distally with two spinelike setae arising from a plate-like callous wart, also a few thin hairs; femur (fe) as long and about as wide as coxa, anterior face coriaceous, usually armed with six or seven large spinelike setae and two to three thinner setae, also with many scattered hairs; tibia (ti) nearly as long as femur and about half as thick, with anterior face coriaceous, distally usually armed with five or six spinelike setae and two to three more slender setae, also many scattered hairs; tarsus (ta) about as long as coxa, tibia, falcate, strong but rather slender, surface facing backwards, excavate, basal portion enlarged, gradually narrowing to apex; on posterior tarsal side with round, rather soft-skinned region which bears distally, at base of excavation on either side, a strong chitinous seta. Second (Pl. 2, D, F) and third pairs of legs inserted farther apart, much more slender and anterior faces less coriaceous than the first pair; the arrangement of setae and proportion of the articles vary somewhat from those of the first pair, but the two pairs are themselves alike. Coxa (cox) about twice as long as wide, with many scattered hairs except on exterior surface; trochanter (tr) about half as long and half as wide as coxa, distally with two spinelike setae, also with a few other thin hairs; femur (fe) as wide as, but not quite twice as long as trochanter, armed, usually, with five chitinous spines, posterior face apically with two spinelike setae, exterior surface with many fine scattered hairs; tibia (ti) about as long as but somewhat narrower than trochanter, usually armed with four chitinous setae, posterior face with two spinelike setae, exterior surface with very few scattered hairs; tarsus (ta) a little shorter than tibia, slender, surface facing backwards excavate, basal portion similar to tarsus of prothoracic leg.

Ventral intersegmental region between head and prothorax joined by slightly chitinous presternal area (Pl. 2, E, y) with two minute setae each side and a slightly chitinized subconical area (pou) with two minute setae which partly separate the pre-sternal area and form the preeuusternal subdivision of the eusternum; this joint region much wider than gula. Ventral intersegmental region between prothorax and meso- thorax, and between mesothorax and metathorax, distinct, membranous, composed of poststernellar, preepipleural, and presternal areas.

Prothoracic eusternum (Pl. 2, E, eu) large, trapezoideal; the prehypopleural chitinizations (h1 and h2), and especially the prehypopleural chitinization h1, large and strong, internally adjacent to ventral intersegmental region; sternellar region (stl) behind front legs, almost fused with eusternum, forming together a clepsydra-shaped region; poststernellum (z) transverse, somewhat spindle-shaped; prothoracic tergal shield (te) transverse, subquadrate, with anterior and posterior margins as mentioned above; right back of anterior margin as also near posterior margin a transverse series of setae, usually composed of three setae anteriorly and four posteriorly on each side; lateral margin with a few thin setae, grouped mostly anteriorly and posteriorly.

Mesothorax and metathorax with large eusternal region; no separation of a pre-eusternal subdivision indicated, as in other forms such as Merinus laevis Oliv.7 Pre-sternal areas (Pl. 2, E, y) distinct, subtriangular, anteriorly slightly chitinized, bearing two setae adjacent to poststernellum (z) of the preceding segment which has a few short hairs; prehypopleural chitinization (h1) well developed, bearing many small setae; posthypopleural chitinization (h2) very small, not to be confused with adjacent oval chitinizations in articulating skin of leg; coxae rather distant; poststernellum of metathorax not present; preepipleurum of mesothorax and metathorax (e1) subtriangu-

7 Although no separation of a pre-eusternal region is indicated, the areas correspond to those in Merinus laevis in which such a division is indicated. In this connection it may be pointed out that no well developed preesternum is present in Merinus laevis as is in this form.
lar, the former carrying first thoracic spiracle, the latter the rudimentary second thoracic spiracle; epipleuron (e) of both segments well developed, lobe somewhat prominent and bearing a few setae, more or less fused with the corresponding preepipleura; postepipleuron, (e₁) triangular; mesothoracic and metathoracic tergal shields (te₁) transverse, subrectangular, about three times as wide as long, right behind anterior margin with a dark transverse line; posterior margin darker than rest of segment, longitudinally finely striated, setae arranged as on protergum. The typical abdominal segments with fused sternal areas (ster) covered by a single transversely rectangular shield, posteriorly darker, with band longitudinally striated; setae on first seven terga with two transverse series, the anterior of these usually having four setae on each side and posteriorly two; on eighth tergum the setae arranged similarly anteriorly, posteriorly with three on each side; sternum of first abdominal segment anteriorly densely set with setae; a few extending along lateral margin, similar arrangement lacking on other abdominal segments; posteriorly with two short setae on each side; hypopleural region (hy) indistinct, epipleural region (ep) narrow, adjacent to tergal shield, anteriorly, on first abdominal segment, with from one to four small setae, on rest of segments a single seta only; tergal shield (ter) laterally carrying spiracle, above which is a dark line; second and third sterna usually with three or four short setae grouped together, near which is a long, thin seta anteriorly on each side and posteriorly with two long, thin setae on each side. Sternum of third to eighth segments usually with two setae anteriorly and two posteriorly near lateral margins; sternum of eighth segment with setae arranged anteriorly as on third to eighth, posteriorly with several setae arranged in a transverse series among margin, first six abdominal segments transverse, seventh and eighth subquadrate.

Ninth abdominal segment smaller than preceding segment, coriaceous, with dorsal part or pygidium conically produced (Pl. 1, C; Pl. 2, A, G, H), above somewhat concave, below broadly convex, with apex pointing upward, mucronate; apex slightly chitinized, on each side with a short spinelike seta; lateral margin set with a series of strong, short, spinelike setae, below which are many soft hairs; near anterior margin a transverse series of short hairs, back of which is a transverse series of longer, thin hairs, and posteriorly a few setae; convex surface with scattered fine setae; ventral part of ninth segment small, transverse, soft, with many short setae. Tenth segment separated from ninth above and below by articulating membrane. Tenth abdominal (anal) segment (Pl. 2, A, H) small, with upper and lower transverse anal lips, the lower lip on each side with conical and, except at tip, setose ambulatory papilla. Spiracles (Pl. 2, B) annular, broadly oval, transversely placed; opening linear, unprovided by hairs, at bottom of cup-shaped peritreme.

The foregoing description conforms with Dr. A. G. Böving's (30, p. 326-329, pl. 31, 32) description of the larva of Embaphion muricatum, with which it is closely related. The following characters of the larva of Embaphion, however, will separate the two species.

Pygidium pointing upward, subconically produced, above somewhat flattened, apex obtuse, lateral margin with a series of strong, short setae; whole surface with fine scattered setae; whitish swelling on back of mandible, opposite the molar part, with three to four strong setae from the anterior portion, two from the posterior; ventral intersegmental region between head and prothorax about the width of gula, with two minute soft setae on each side of the slightly chitininous preterminal area; two transverse ophthalmic spots present just behind antenna; ligula on buccal surface not setose; disk on each half of labrum with median transverse series of five large setae and an anterior series of three long, thin, and straight setae; right behind these but on ventral side of labrum another series of four shorter, stronger, and curved setae; femur and tibia of prothoracic leg each usually armed with fine spinelike setae.

8 Because the tergum is so convex the proportions in the figure do not quite agree with the text.
9 This line is not as well developed on the metathorax and may even be lacking.
10 There are usually from 9 to 11 setae on each margin. Because they differ somewhat in number in various specimens, and sometimes on opposite sides of the same specimen, they do not offer very reliable characters.
11 This character will separate Embaphion from all Eleodes larvae as represented in the United States National Museum Collection, which consists of the following material given to the Museum by the senior author: Eleodes acutipennis Lec.; E. carbonaria (Say), E. estricina (Say), E. fusciformis Lec., E. hispilabris (Say), E. longicollis Lec., E. opaca (Say), E. obscura (Say), E. obtusa (Say), E. sponza Lec., and E. tricosta (Say).
When first formed the pupa is opaque white, but after a short time the eyes become visible and the thoracic segments become more distinct and take on a pale cream color. No other notable change takes place until the time for emergence. Just prior to emergence the elytra and thorax become yellowish brown. Pupa dorsally acute, ventrally somewhat flattened. Head pressed to prothorax. Pronotum rather broad and protruding above the head so as to make the head nearly invisible from above. Caudal segment bearing a pair of thick fleshy spikelike lobes directed posteriorly. Between dorsal and pleural abdominal plates an irregular deep depression forming a distinct submarginal groove. Pleural margin of abdominal segments bearing irregular semicrescentic plates each having tuberculous bristles in fanlike arrangement. Head, antennae, and legs free. Body smooth. There is considerable variation in size. Approximate average length 23 millimeters, width 8.5 millimeters.

ADULT (FIG. 3)

The following description is taken from Blaisdell (3, p. 199–202, pl. 1, fig. 19):

Oblong, more or less strongly elongate, dorsum flattened and slightly concave, black, frequently with a broad reddish band along the elytral suture, epipleurae often tinged with the same color.

Head a little less than twice as wide as long, and scarcely one-half as wide as the pronotum; surface plane to slightly convex, frequently more or less impressed along the frontal suture, sometimes transversely so between the eyes, and laterally within the moderately prominent sides of the frons, opaque, moderately, coarsely, irregularly, and densely punctate, usually with small impunctate areas.

Antennæ rather stout, scarcely reaching the prothoracic base; outer four joints slightly compressed and just perceptibly dilated; third joint about equal to the next two combined; fourth, distinctly longer than the fifth; the latter to the seventh, inclusive, subequal and slightly longer than wide; eighth, triangular and about as long as wide; ninth and tenth, suborbicular; eleventh, short ovate.

Pronotum widest at the middle and about one-half wider than long; disc opaque, smooth, slightly convex, finely and sparsely punctate, with small impunctate areas about the center, frequently with irregular impressions; laterally longitudinally impressed from within the apical angles to a very short distance in advance of the basal angles, terminating in feeble basal impressions, the depressions are generally transversely rugulose; apex deeply emarginate and more or less obsolete margin; sides broadly and more or less strongly reflexed, evenly arcuate or sometimes very feebly and broadly angulate at middle, slightly sinuate in front of the basal angles, marginal bead moderately coarse; base truncate and feebly trisinuate, distinctly margined, two-fifths to one-half wider than the apex; apical angles acute, subacute, prominent and more or less everted; basal angles rectangular.

Propleurae opaque and smooth, very finely and sparsely to obsolete, muricate punctate, more or less rugulose at times, and defined from the reflexed pronotal margin by a longitudinal concavity.

Elytra oblong, one-third to twice as long as wide and more or less opaque; base feebly emarginate, and about equal to the contiguous prothoracic base; humeri obtuse and not prominent, rounded beneath the basal angles of the pronotum; sides evenly arcuate to subparallel, apex scarcely to feebly produced; disc plane to slightly convex, very suddenly deflexed laterally, angle of deflexion forming an acute and moderately reflexed margin, which becomes obsolete a short distance before the apex, more or less suddenly obliquely declivous posteriorly; surface sulcate, intervals feebly convex, each with a single series of rather distantly placed punctures, the four inner sulci with but a single series of closely placed submuricate punctures, remaining sulci
with numerous closely and irregularly placed punctures, which become denser and rather more strongly muricate towards margin; apical declivity somewhat more strongly sulcate and scabrous; inflexed sides not convex, obsoletely sulcate, irregularly and muricately punctured.

_Épitêtre_ moderately narrow, uncinately dilated beneath the humeri, and gradually narrowing to apex; surface usually more or less obsoletely punctate.

_Sterna_ and _parapleurœ_ more or less obsoletely or strongly punctate and rugulose.

_Abdomen_ finely and more or less sparsely, obsoletely punctate and rugulose.

_Legs_ moderate. Anterior femora armed in the sexes; protibial spurs and protarsi nearly alike in the sexes, the spurs are quite strongly divergent. The first joint of the protarsi is more or less thickened and slightly produced at apex beneath, bearing a tuft of yellowish pubescence.

_Male._—About twice as long as wide. _Antenae_ scarcely reaching to the basal margin of the prothorax. _Elytra_ moderately, suddenly, and obliquely declivous posteriorly; apex slightly acuminate. Abdomen slightly oblique, moderately convex, broadly impressed on the first two segments. Anterior femora with an acute tooth about one-fourth distance from the apex; posterior spur of the protibiae apparently a little longer and slightly stouter than the anterior, frequently they appear to be quite equal in length, both are rather stout and acute; first joint of the protarsi with the produced tip beneath rather thick and bearing a small obtuse tuft of modified spinules, groove not evident.

_Female._—Less than twice as long as wide. _Antenae_ reaching to about the posterior fifth of the prothorax. _Elytra_ quite suddenly obliquely or vertically declivous posteriorly. _Abdomen_ oblique, evenly and strongly convex. Anterior femora with a small obtuse tooth, sometimes scarcely more than sinuate in outer fourth; posterior spur of the protibiae a little longer and stouter than the anterior, both are acute, moderately thick, and gradually narrowed from the base; first joint of the protarsi slightly and transversely produced at tip beneath, bearing a transverse tuft of spinules, which is more or less acute, groove more or less obsolete.

The male genital characters do not apparently show any racial differentiation.

_Male._—Edeagophore of the usual oblong-ovate form.

_Basale_ oblong, scarcely arched, and may be sparsely punctate laterally at apex.

_Apicale_ rather broadly triangular, moderately depressed, surface more strongly convex apically, with a median membranous groove in apical half; sides rather straight to slightly arcuate; apex scarcely produced and more or less deflexed, _subacute_; base broadly lobed at middle, and sinuate laterally.

_Sternite_ transverse. Each lobe with the external border more or less evenly arcuate, and the internal short and straight to feebly arcuate, with apex rounded; surface densely punctate and setose in apical two-thirds, setae quite long and not extending upon the membrane across the sinus; the latter nearly closed by the same. The lobes internally at base and cephalad to the sinus are rendered semicircularly sinuate by an interlobar transversely oval membranous area, the membrane of which is frequently transversely rugose.
LIFE HISTORY AND DEVELOPMENT

The insect hibernates in the adult stage beneath piles of rubbish, grass, weeds, and refuse, or buried in soft sandy soil, and in the burrows of small mammals; it also hibernates in the larval stage, buried deeply in the soil. In the latitude of southern Kansas the adult is abroad in the fields depositing eggs in early spring, and is present in the fields until late November. Some of the adults have been known to live two or three years. The egg is deposited in soft loose soil at a depth of about three-fourths of an inch to 1 inch. Frequently from 10 to 60 eggs are found in a single nest. The egg hatches in from 8 to 10 days, depending on the moisture and temperature, and the young larva a short time thereafter begins to feed very actively upon vegetable tissue and roots in the soil. Where development occurs under favorable weather conditions and with adequate food supply, the larva grows rapidly, reaches maturity, and enters the pupal stage in about 110 to 130 days, though this period may be accelerated or prolonged by abnormal conditions. The pupal stage continues for a period varying from 10 to 22 days, during which time the insect is comparatively motionless in an earthen cell at a depth of about 3 inches in the soil and takes no food, and at the end of this period transformation to the adult stage occurs. This adult in turn often produces another generation of larvae in late summer. Such larvae when about half grown (and at a depth of about 2 to 5 inches in the soil at wheat-seeding time) reach their period of greatest destructiveness about the time the newly sown fall wheat is coming through the ground. Numbers of the larvae of this generation usually overwinter as larvae at considerable depths beneath the ground or in loose soil beneath refuse. Some of these larvae have been found in November at a depth of 7 inches and in December at a depth of 14 inches in the soil. It should be noted that there is considerable overlapping of generations, hence larvae of widely varying size often coexist in the same field.

The newly hatched larva does not immediately become active but remains for a little while in the soil, at the place where the egg was hatched and in the cavity formerly occupied by it. The toughness of the eggshell is indicated by the fact that the empty shell retains its shape for some time after the larva has emerged therefrom. The integument of the newly hatched larva is rather tender but nevertheless enables it to survive rather rough handling. When newly hatched the larva averages 2.5 millimeters in length and about 0.3 millimeter in width, and is semiopaque white. The general proportions of the newly hatched larva do not vary to any noticeable degree from those of the older larva, but there is an occasional slight variation in size. The larva begins to feed lightly not long after hatching, and appears to grow with greatest rapidity during the first three or four weeks, as it more than doubles in size during this period. Following the second molt the rate of growth becomes less marked. Larvae invariably are present in infested fields in greatest numbers in the vicinity of straw stacks, or in the absence of these, in the neighborhood of or beneath scattered bundles of grain which contain such a large percentage of weeds that they have been discarded and left behind by the harvesters. It has been repeatedly noticed that the infestation in many fields invariably appears to originate and spread from such straw stacks and is always more severe in their vicinity. In fields not sown to wheat the larvae are not found scattered generally over the field but are usually grouped in numbers in the soil.
around straw or grain stacks or other shelters, and have been found in
the moist soil far under such straw stacks beneath a layer of straw
5 feet in depth. In fields recently sown to wheat they are usually
disseminated irregularly over the field, but are in greatest numbers near
the shelters, and are sometimes in such abundance that as many as
265 larvæ of this and related species have been found in three adjacent
drill rows within 3 linear feet.

Cannibalism is rather common, both under artificial rearing and under
normal field conditions, and where the larvæ are abundant in a field it is
not uncommon to find numbers of partly devoured larvæ here and there
at the spots of their greatest activity. This is most noticeable, however,
under field conditions during the early period soon after germination of
the grain, when the larvæ are most busily feeding and where conditions
may be such as to produce crowding. Under average field conditions
sufficient numbers of larvæ are not destroyed in this way, however, to
render cannibalism a factor of value from an economic standpoint, as this
larva is normally phytophagous. The larva appears sensitive to dis-
turbance of any kind. If touched it will often feign death and remain
motionless for a time before attempting to escape. If taken between
the fingers, the pressure sufficient to hold it causes it to make the most
frantic efforts to escape, and it twists and wriggles its body with greatest
activity into almost every possible position, ejecting quantities of a
colorless fluid apparently from between its dorsal segments. Presumably
this fluid is defensive or repulsive and is one of its means of protection
from birds and other enemies of similar feeding habits.

The larva, being very quick and active, can move easily over smooth
surfaces and bury itself in the loose soil with greatest ease. It is able
also to penetrate compact soil with little apparent difficulty, since it has
been found working in ground of considerable hardness at a depth of
2 inches, but if the soil be fairly loose, its friableness and dryness appear
to facilitate larval movements. When very young it is unable to survive
long in perfectly dry earth, but as it becomes larger it does not appear
to be greatly affected by this condition, although it prefers slightly moist
soil. The larva is keenly susceptible to an overabundance of moisture
and often comes to the surface of the ground and remains there for several
hours following hard, dashing rains. It is negatively phototrophic and
when exposed to light hides with the utmost rapidity under any shelter
it can find. When artificially confined in a Petri dish, it soon crawled
beneath the layers of filter paper or blotting paper at the bottom of the
vessel.

When ready to molt the larva remains comparatively motionless for
some time before the skin splits and it is able to free itself therefrom.
Molting occurs in its channels, and wriggling from its exuvia, the larva
remains comparatively inactive for a short time until the new skin
has hardened somewhat. Considerable difficulty was experienced in
obtaining the length of instars, as it was necessary to do this under
laboratory conditions, and a number of types of cages were tried and
discarded before one suitable for the purpose could be evolved. The
irregularity in time of molting, the proper regulation of food and mois-
ture, and the difficulty of finding the exuvæ in the cage also added to
the complexity of the problem, and many hundreds of larvæ died in
various forms of cages and through a variety of causes before the desired
information could be obtained. The type of cage from use of which
satisfactory data at last were secured consisted of a 2-ounce, seamless,
tin salve box, in which was placed a one-fourth inch layer of plaster of Paris, covered by a thick coating of India ink, and a small disk of dark-colored blotting paper slightly smaller than the diameter of the box. The newly hatched larva when isolated in such a cage, having the plaster of Paris slightly moistened, and with split wheat grains for food, appeared to thrive normally to pupation at an even temperature of about 60° F. as long as the moisture therein could be kept properly regulated. Curiously enough, soil in the cage was not an absolute essential. It was found that normally there are six instars. The length of these instars, according to records made daily from observations upon the survivors of 50 isolated specimens, averaged as follows: From hatching to first molt, about 6 days; from first to second molt, about 10 days; from second to third molt, about 21 days; from third to fourth molt, about 26 days; from fourth to fifth molt, about 14 days; from fifth to sixth molt, about 27 days; from sixth molt to pupation, about 18 days. It was found, however, that the length of the period between instars was often prolonged because of temperature, hibernation, moisture, quantity of food, and other like factors.

Many of the larvae in the field reach the fourth or fifth instar during late fall and overwinter in that condition. During this period they penetrate to considerable depths in the soil, feed but little, and are comparatively inactive. Commencing early in March, if the spring is a normal one, they feed until ready to pupate. Just before pupation the larva prepares its earthen cell and enters upon a semiquiescent stage which continues from 4 to 10 days.

The period of pupation lasts for approximately 17 days, after which the adult emerges. It is comparatively inactive for a short time after this until its chitin has turned from pale brown to black and has become harder. The recently emerged adult is always brighter and has a deeper gloss than an older one. Mating most frequently takes place about 6 or 7 days after issuance from pupation, and egg laying begins about 20 to 22 days thereafter. There is seldom much variation in the method of oviposition; the female burrows into the soil to a depth of approximately three-fourths to 1 inch, loosens up a tiny area of soil, and at intervals deposits there the eggs in bunches consisting of two or three to several dozen, within an area having a diameter of not more than 2 inches. The average number deposited by a series of 100 females, from which count was kept, was 108 eggs, while the maximum number deposited by a single female within this series was 335 eggs. When disturbed, the adult has a curious habit, common to other species of this group, of standing still, placing its head to the ground, and tilting upward the posterior portion of its body until it appears fairly to stand upon its head, and it remains motionless in that position for several minutes. By and by, if not further disturbed, it resumes its normal position and continues its activities. If sufficiently annoyed, it ejects in a lateral direction from anal glands a strong astringent fluid having a highly offensive odor and evidently protective in function. Gissler (10) in 1879, in discussion of another species of Eleodes of similar habits, first described this secretion and the glands from which it is ejected.

The adult, being crepuscular, reaches its period of greatest activity during the cooler portion of the day, in early morning, in late evening, or during twilight hours, and like other nocturnal insects is not noticeable in fields during the brighter, warmer hours of the day except when deliberate search is made for it. It may then be found under grain
bundles, shocks, and edges of stacks, in burrows of small mammals, beneath piles of manure and dried Russian thistles, along fence rows, or beneath other convenient shade or cover. The adult does not crawl up into such bundles or shocks to any noticeable degree, but remains on the ground beneath them, and appears to prefer shocks or bundles which have settled rather closely to the ground instead of those resting lightly upon the stubble. It also selects for shelter the old dried piles of weeds and trash rather than fresh, green, newly cut piles of such débris. The amount of excrement present with the adult when found indicates that it often remains for a considerable period in the same spot. It also has been noted that an adult is occasionally present at night beneath street lights in towns within the infested areas, but it is not attracted to lights in large numbers. Webster (32, p. 32) in 1912 stated that an adult of *Eleodes suturalis* was observed devouring chinch bugs (*Blissus leucopterus* Say) at Wellington, Kans. D. J. Caffrey in 1915, while conducting a series of observations relating to insects predacious upon the New Mexico range caterpillar (*Hemileuca oliviae* Ckll.) noted that adults of *Eleodes suturalis* would not feed upon dead *Hemileuca* larvae.

At the approach of cold weather in late fall the adult seeks a hibernating place, usually beneath the rubbish previously used as shade and cover, and there it often penetrates to a considerable depth in the soil. It is probable that little or no food is taken during hibernation, and at such times, when an adult has been dug out or uncovered, it seems to be in a semidormant condition, and even after being taken into a warm room does not resume its normal activity for some hours. If kept out of hibernation and subjected to winter weather it speedily perishes.

**NATURAL ENEMIES**

Swenk (27, p. 335-336) in 1909 and McColloch (19, p. 191) in 1919 recorded that they experienced more or less difficulty in conducting successful rearings of false wireworms because of the presence of what was presumably a bacterial disease of the larvæ. A disease similar to that discussed by them also was encountered by the writer in rearing work with *Eleodes suturalis*. The presence of this upon a larva would first be noticed in the form of one or more small, irregular, reddish-brown spots on the thoracic and abdominal segments, and these spots usually would become larger in area until the death of the larva. In a number of instances it appeared to cause the death of the larva without having increased appreciably in size; at other times it would become larger until it encircled the body, and the larva notwithstanding would remain alive and reach the adult stage apparently without serious inconvenience; normally, however, the spot increased steadily in diameter and in doing so sooner or later caused the death of the larva. Presumably the disease was capable of spreading to other larvæ, for healthy larvæ, when placed with sick ones, frequently contracted the disease, though the customary isolation of the larvæ in individual cages probably was responsible for preventing its general spread.

The larva, while under laboratory conditions, occasionally was attacked by fungi, notably *Sporotrichum globuliferum* Spec. and *Metarrhizium anisopliae* Metschn. McColloch (19, p. 191) also noted the presence of fungi, presumably of these species, in his rearing work.
If the cage containing the larva was not sterilized regularly and carefully various species of tiny soil mites (Acariña) occasionally would be present in scattering numbers.

A number of insects may be associated under normal field conditions with the larval and adult stages of this species and thus far a few of these, notably the larvae of a species of Calosoma, of Harpalus caliginosus Fab., and of an undetermined species of robber-fly of the genus Erax, are known to attack Eleodes suturalis larvae. Various species of field mice, snakes, frogs, spiders, and centipedes also frequently are associated with the insect in varying numbers, but their presence usually does not appear seriously to disturb its activities. The pupa of E. suturalis sometimes has been attacked and killed by the ant Tetramorium caespitum L., and the adult occasionally has been attacked by the ant Pogonomyrmex occidentalis Cress. The adult is freely eaten by chickens.

Barrows and Schwarz (1, p. 64) in 1895, in discussing food habits of the common crow, stated that the finding of some specimens of the genus Eleodes in a few stomachs of crows from Kansas and Nebraska leads them to the supposition that if a larger number of stomachs from that region could be examined, specimens of this and allied genera would be found well represented, and they add:

These beetles, so characteristic of the fauna of the arid region of the West, fulfill most of the requirements of insect food preferred by the Crows; they are terrestrial, large, hard, and possess a strong, offensive odor.

The records of the Bureau of Biological Survey of the United States Department of Agriculture show that birds of the following species have fed on beetles of the genus Eleodes, the fragments of which could not be specifically identified though it is probable that some of them have been E. suturalis Say: Crow, Corvus brachyrhynchos Brehm; hairy woodpecker, Dryobates villosus L. (2, p. 15); sparrow hawk, Falco sparverius L.; road-runner, Geococcyx californianus Lesson; red-headed woodpecker, Melanerpes erythrocephalus L.; mocking bird, Mimus polyglottos L.; sage thrasher, Oreoscoptes montanus Townsend; magpie, Pica pica hudsonia Sabine; robin, Planesticus migratorius L.; purple grackle, Quiscalus quiscula hudsonia; Sabine, meadow lark, Sturnella magna L.; Arkansas kingbird, Tyrannus verticalis Say; yellow-headed blackbird, Xanthocephalus xanthocephalus Bonaparte.

The Bureau of Biological Survey has records of a number of other species of Eleodes which are preyed upon by birds.

Riley (21, p. 432; 22) records rearing a parasite from an adult of Eleodes suturalis collected by C. E. Ward, Belvidere, Nebr., on April 27, which later was identified as Perilitus sp. The edges and corners of a cigar box in which the host beetle had been kept overnight were lined with the elliptical whitish cocoons of the parasite. Nearly three weeks elapsed between the time the larvae left the host and the emergence of the parasites. A dissection of the beetle showed that most of the contents of its abdomen had been absorbed. Viereck (29, p. 561), in 1913, published a description of this species, naming it Perilitus eleodis (fig. 4), the type being reared from an adult of Eleodes suturalis collected at Argonia, Kans. The specimens formerly received from Belvidere, Nebr., are indicated as mostly stramineous. It was found that the species was closely related to Perilitus gastrophysae Ashmead—of which it may prove to be only a variety. . . .
McColloch (18, p. 220) in 1918 reared a number of adults of *Perilitus eleodis* from *Eleodes tricostata* and fortunately secured considerable noteworthy information of value on the life history of the parasite. He also (19, p. 190) reared the same parasite from *E. opaca* Say.

Several hundred specimens of *Perilitus eleodis* were reared at intervals from July 18 to October 22 from adults of *Eleodes suturalis*. They issued as larvae from the anal opening of the adult hosts and pupated as tiny silken cocoons occurring in clusters here and there over the bottom of the cages. These cocoons were sometimes attached to a portion of the cage walls and sometimes were matted together in the soil which had been placed in the cages to facilitate egg laying. The adult parasites soon after emergence became active and moved about restlessly over the cages, and when present in cages containing host beetles would crawl about over them and attempt to oviposit promiscuously at any of the body sutures, usually on the ventral side. The beetle appeared to be in extreme fear of these parasites and would scramble around in greatest excitement as soon as one of them drew near. It would also make frantic efforts to push off the parasites when attacked by them. Upon finding a soft spot in which to place the egg, the rather long and upcurved ovipositor of the adult parasite was thrust through a suture of the body wall of the beetle. Each beetle thus attacked was isolated for further parasites, but unfortunately in no instance were additional ones obtained. The beetles sometimes lived for several hours after the parasites issued. The maximum number of parasites secured from a single host individual was 121. *Perilitus eleodis* also was reared by the senior writer from adults of *Eleodes hispilabris* Say, *E. obsoleta* Say, *E. tricostata* Say, and *E. extricata* Say.

**CONTROL MEASURES**

Extensive experiments conducted some years ago by Curtis (6, p. 170-178), Treat (28, p. 82), Ormerod (20, p. 111-118), Weed (34, p. 213), Comstock and Slingerland (5, p. 199-250), and Forbes (8, p. 48-51) in attempting to find a remedy for true wireworms, afford clues in the search for control measures for this pest, for although these entomologists failed to find remedies which were in every way satisfactory, their work was of great value in pointing out the uselessness of several suggested schemes for avoiding crop injury by subterranean pests. Bearing in mind the suggestions embodied in the published records of their work,
the senior writer’s experiments for destruction of *Eleodes suturalis*

were carried on along somewhat similar lines, though in a supplementary

way without duplication of experimental work and with special reference
to the habits of the species under consideration. Emphasis was placed on
experiments for the protection of the planted seed, the destruction of the
larva, and the destruction of the pupa and beetle.

As the protection of the seed was deemed more especially desirable,
much attention was given to this phase of inquiry. Wheat seed was
treated with a great variety of preparations and then subjected to attack
by the larva in the hope of finding some effective repellant or poison,
but in every case these proved ineffective, for they not only failed to kill
the larva, but, what was worse, they often retarded or entirely prevented
the germination of the seed. Coating the seed or soaking it in solutions
or preparations of tar, shellac, copperas, strychnine, cyanid of potassium,
turpentine, kerosene, and similar substances all proved ineffective and
of no practical value since either the cost was prohibitive or the larvæ
devoured quantities of treated kernels and apparently experienced no ill
effects therefrom. It is believed that in these experiments the imprac-
ticability of all methods of this general character in attempting to protect
the seed was fully demonstrated.

In experiments relative to the destruction of the pupa and beetle it
was found that all the various insecticides applied to the soil in hope of
killing the insect infesting it proved ineffective if used in reasonable
amounts. While it is true that some of these substances, such as crude
petroleum or turpentine, will destroy the insect when used in large
quantities, the amount and strength necessary to accomplish this result
often was so great as to destroy all the vegetation in the infested areas,
and, further, to render the cost of application over large areas prohibitive.
It was also demonstrated that certain fertilizers may have a slight value
as insecticides, though their principal merit appears to be in the stimulation
of the growth of the plant and in soil drainage. Salt, lime, crude potash,
cyanide of potassium, and other substances likewise have been found im-
practical since they either do not affect the larvæ at all, or to do so must
be used in quantities so enormous that they either prove destructive to all
vegetation or are too expensive. It was found that trapping the larva and
the adult with baits of poisoned vegetables may have a possible value in
intensive farming on small acreages, but it is impracticable with extensive
acreages of winter wheat and with farming methods as practiced in the
infested areas. At the period of their greatest abundance in summer,
repeated experiments were performed in attempts to kill the adults with
poisoned bran mash, using the standard formulas for grasshopper control,
but the mortality caused by use of these baits was exceedingly small and
would not warrant expectation of obtaining practical control by such
means. Late fall or spring plowing would be very effective in turning
up and destroying the pupa, but as the crop on the ground usually is
winter wheat, the nature and condition of the host plant at that par-
ticular time does not of course render such treatment at all practicable.

The easiest and most effective control measure thus far indicated is
the judicious rotation of wheat with other crops for two or more seasons,
especially with corn or some other crop which may be regularly and
frequently cultivated. Infestations are always much heavier where
rotation has not been practiced. It is also highly desirable that all
accumulations of rubbish, dead grass, matted weeds, old straw stacks,
old discarded bundles of mixed weeds and grass, and other shelter and hibernating quarters be burned or entirely removed. Especial emphasis should be placed on the burning of piles of dead Russian thistles, which at present are so common in fields and along the roadsides of farms in the central and western portion of the infested region. Although the scope of this paper does not permit detailed discussion of control measures for more than one species within this family, it is probable that effective control measures will be found not to differ greatly for most of the other related species of economic importance.

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Eleodes suturalis

A.—Epipharynx (eph) and anterior margin of labrum of larva.

B.—Head of larva from above: lab, labrum; cl, clypeus; fa, anterior angle of front; epi, epistoma; f, frons; epc, epicranium.

C.—Lateral view of larva.

D.—Maxillae and ligula of larva seen from buccal cavity: ma, mala; li, buccal surface of ligula.

E, G.—Dorsal side of left mandible of larva and ventral side of right, respectively: a₁ and a₂ bicuspidate apex; t, tooth of cutting edge; m, molar part; c, carinate edge on exterior side of cutting part of mandible; s, soft-skinned, seta-bearing elevation below carinate edge; e, excavation below soft-skinned elevation.

F.—Hypopharyngeal region, oesophagus, and hypopharyngeal bracon of larva, corresponding to piece removed from D: hsc, hypopharyngeal sclerite; hbr, hypopharyngeal bracon; fm, mandibular ventral fossa; oes, oesophagus.

H.—Hypopharyngeal region of larva; same as F but reversed: hsc, base from which hypopharyngeal sclerite originates; hbr, hypopharyngeal bracon; fm, mandibular ventral fossa; oes, oesophagus.

I.—Second and third mouth parts of larva from ventral side: gu, gula; tp, tentorial pit; sm, submentum; me, mentum; stla, stipes labii; li, ligula; hyp, hypostoma; fm, fossa for mandible; hbr, hypopharyngeal bracon; fc, fossa for caro; ar, maxillary articulating area; ca, caro; stti, stipes maxillaris; bs, base of stipes; is, and is₂, inner margin of stipes; ma, mala maxillaris (probably lacinia); pap, basal membrane of maxillary palpus; epc, epicranium.
Eleodes suturalis

A.—Pygidium of larva, side view: IX, IX, ninth abdominal ("pygidal") segment, dorsal and ventral parts; X, tenth abdominal ("anal") segment, showing upper and lower lips.

B.—First thoracic spiracle of larva.

C.—Left mesothoracic leg of larva showing posterior face: cox, coxa; tr, trochanter; fe, femur; ti, tibia; ta, tarsus, claw-shaped.

D.—Left prothoracic leg of larva, showing anterior face: cox, coxa; tr, trochanter; fe, femur; ti, tibia; ta, tarsus.

E.—Ventral view of part of head, of thoracic segments, and of anterior portion of first abdominal segment of larva: epc, epicranium; gu, gula; y, presternum; peu, preeusternal subdivision of eusternum; eu, eusternum; stl, sternellum; z, poststernellum; ar, articulating membrane of leg; h1, prehypopleurum; h2, posthypopleurum; e1, preepipleurum; e2, postepipleurum; te, thoracic tergite; ster, sternal shield of abdominal segments; hp, abdominal hypopleurum; ep, abdominal epipleurum; ter, abdominal tergite.

F.—Left prothoracic leg of larva showing posterior face: cox, coxa; tr, trochanter; fe, femur; ti, tibia; ta, tarsus.

G.—Pygidium of larva, dorsal view.

H.—Pygidium of larva, ventral view: IX, ninth abdominal ("pygidal") segment, ventral part; X, tenth abdominal ("anal") segment, showing upper and lower lips; anus, anus.