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THE BIOLOGY OF MAINE SPECIES OF ALTICA

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* Absent on leave during period of war.

† In collaboration with U. S. Department of Agriculture.

BULLETIN 273

THE BIOLOGY OF MAINE SPECIES OF ALTICA.*

WILLIAM COLCORD WOODS.†

SUMMARY

The flea-beetles commonly classed as *Altica ignita* Ill. form a composite group of closely related species. Three species of the group are named and described in this bulletin: *A. corni*, a black species occurring on dogwood, *A. rosae*, a cupreous species occurring on the wild rose, and *A. ulmi*, a greenish or bluish form found on the elm. The life histories of all three are very similar. They hibernate as adults which, coming out from their winter quarters in late spring, pair and deposit eggs on the leaves of their respective host plants in June and July. The larvae which hatch from these eggs feed on the leaves, skeletonizing them. In all cases there are 3 larval instars averaging about 4 days each. When full grown, the larvae enter the ground where they transform, spending about 5 days as prepupae and 9 days more as pupae before emerging as adults. There is but one generation each year.

The blueberry flea-beetle, *A. torquata* LeC., belongs to the *carinata* group. At least in this species the winter is passed in the egg stage. The larvae hatch in late May, and feed on the opening buds of the blueberry and later on the flowers and foliage. They do great damage when they are abundant. As in the *ignita* group, there are 3 larval instars, and the larval life lasts about 12 days. The larvae when full fed enter the soil to pupate, spending about 6 days as prepupae, and 10 or 11 days as pupae, before the adult beetles emerge. The adults feed freely all summer on the leaves of the blueberry, but do not survive the winter. In July they deposit their eggs, probably

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on the ground at the base of the bushes, and these eggs pass the winter, hatching the following spring. There is only one generation each year.

All of these flea-beetles can be controlled by spraying with arsenate of lead. Parasitic flies were bred from the adults of 2 species and a predaceous bug was found attacking the larva of one species. All are susceptible to fungous and bacterial diseases which doubtless play a large role in holding them in check.

SPECIES DISCUSSED.

So far as the records of this Experiment Station show, 6 species of *Altica,* the typical genus of jumping chrysomelids or flea-beetles, occur in the State of Maine. Since all of them feed on plants of greater or less economic importance, and as these very prolific beetles under favorable conditions may appear quite suddenly in enormous numbers, an acquaintance with their various life histories is important, so that we may know at what period remedial measures may be most effectively applied. Moreover in entomological literature there is great confusion regarding the structural and biological limits of the different species of *Altica,* and in many cases the host plant records are hopelessly mixed up. It is hoped that some light may be thrown upon the specific limits and the biological habits of the insects described in this bulletin.

Four of the 6 recorded species are discussed in this bulletin. These are the dogwood flea-beetle *A. corni* sp. n., the rose flea-beetle, *A. rosae* sp. n., the elm flea-beetle, *A. ulmi* sp. n., and the blueberry flea-beetle, *A. torquata* LeC. A fifth, the alder flea-beetle, *A. bimarginata* Say, has already been treated in bulletin 265 of this Experiment Station, in which is also given a statement of the facts which make it seem proper to drop the "H" and revert to Geoffroy's original spelling of the generic name. The sixth is listed provisionally as identical with what Lugger

(1899 5th Minn. Rept., p. 159) called the lesser grape vine flea-beetle, although it certainly is not *A. ignita* Ill. as he stated.*

Three beetles described in this bulletin as new, *A. corni, A. rosae* and *A. ulmi,* are all forms that in Horn's monograph (1889. A synopsis of the Halticini of Boreal America. Tran. Am. Ent. Soc. v. 16:163-320, pl. 5-6) would fall under the single species *ignita* Ill. It has been stated almost universally that *ignita* Ill. is a very variable species but *ignita* Ill., as it has been commonly interpreted by the best authorities is undoubtedly a composite species which when it has been carefully studied throughout the country will be found to consist of a greater or less number of closely related but distinct species where the characters remain constant and the range of variation is slight. Such indeed is the opinion of Fall (1910. Trans. Am. Ent. Soc. v. 36:153) who states: "In the case of *ignita* this variation is assumed to be very great, but I think it probable that this complex will ultimately be broken up. The opening wedge is here inserted by giving names to three forms.....which by the latest paper on the genus would pass as *ignita.*" Certainly the 3 species of the *ignita* group discussed in this present paper are distinct both structually and biologically, and such characters as color, size, and proportionate length of antennae are constant, as well as the food-habits and immature characteristics which are definite and various.

The writer has grave doubts whether it be permissible to call any of our known American flea-beetles *ignita* Ill., at least until Illiger's type specimen—if it be in existence—has been carefully compared with his description, and the latter proven incorrect. It would not appear scientifically sound to set aside a portion of an author's description arbitrarily merely because

*This is a small green species which the writer has taken only twice in the State, August 1917 and June 1918, both times on woodbine at Orono. Unfortunately the writer has not been able to study this species except very superficially since at present he is in the military service of the United States. This species evidently comes in the *ignita* group, and can be distinguished from the others by its color, size (about 3.5 mm) and the fact that segment 3 of the antenna is equal in length to segment 4. The eggs are yellow, deposited by 1's or 2's on the under surface of the leaves. The ground color of the larva is dull yellow and the pupa is yellow; so far as the writer knows, they do not present any specific characters to differentiate them from other members of this genus.

it does not fit the material in question, and Illiger's original description of *ignita* concludes "plica submarginali," a character that no known species of our fauna, save *bimarginata* Say, possesses. The writer does not think it allowable to determine any species which lacks a submarginal fold as *ignita* Ill. until it has been definitely established that Illiger's original description is incorrect and that the type of *ignita* Ill. lacks submarginal plicae.

If we are to retain an American *ignita* Ill., it seems best, as Fall suggested, to consider the brilliant, coppery-golden form of the middle Atlantic states, the typical *ignita*. This is without doubt the species which Chittenden treated as the strawberry flea-beetle (U. S. Bur. Ent. Bul. 23 n. s., p. 70-79, figs. 17-18), although his description of the coloration of the adult is confusing, and leads one to suspect that more than one species may have been at work on the strawberries.

All 3 species of the *ignita* group from Maine *(corni, rosae, and ulmi)* are quite distinct from this typical *"ignita"* of Chittenden, although all the members of this group are closely related, and the adults can only be separated, aside from color and size which are constant at least in the 3 Maine species, by comparatively minute characters. All the constituents of the group have the ante-basal impression of the thorax deep and entire, and in all the structure of the last ventral segment of the male is the same, at least in so far as the writer has been able to determine. The biological habits (especially the choice of food-plants and the manner of egg deposition) and the color of the fat-body are definite and characteristic for each species. The larvae of all are very much alike; the ground color and the color of the anal proleg vary with the color of the fat-body. In the larva of *"ignita"* of Chittenden tubercle iii (see fig. 10) is present and setiferous on both the mesothorax and the metathorax (Chittenden, l. c., fig. 17); in *corni* and *ulmi* it is present on both, but non-setiferous; and in *rosae*, though present it is non-setiferous on the metathorax, and is usually entirely wanting on the mesothorax. The pupae of all are identical save in size and color.

The references to *ignita* Ill. and *carinata* Germ. are much confused in entomological literature. *Ignita* of Lugger (l. c.) is most certainly distinct from the 3 species of the *ignita* group

discussed above, and is probably a new species, although it appears to belong to this same group. Most of the references in economic literature to *carinata* Germ. should be to *ignita* Ill., and indeed the references to these two species are for the most part so vague that it is impossible to determine to what species they do refer. In the comparatively few instances in which the writer has felt sure that reference was made to one of the 3 species he has described as new, he has included these articles under the bibliography of that species.

Specimens of *corni* and *ulmi* submitted to Mr. C. W. Leng of New York City were reported as unquestionably *ignita* Ill. according to Horn's monograph.

The remaining species treated in this bulletin is the blueberry flea-beetle, *A. torquata* Le C., a member of the *carinata* group. It differs but slightly from the typical *carinata* Germ. as described by Horn, and is possibly identical with it. However since the life history of *torquata* differs from that of a typical *Altica* in that it hibernates as an egg and not as an adult, and since neither the life history of *carinata* nor its range of food plants is known, it seems better to the writer to run the risk of unwarrantably restoring a synonym than possibly to confuse this species with *carinata* Germ. if the 2 be distinct. This beetle, which is very injurious on the blueberry barrens in years when it is abundant, was determined for the writer by Mr. C. W. Leng of New York City.

DEFINITION OF THE TERMS USED IN THE DESCRIPTIONS.

Alutaceous: covered with minute cracks, like the human skin.

Ante-basal groove or impression: an impressed transverse line which may be either deep or shallow, extending entirely or partially across the prothorax slightly cephalad of its base.

Apex of elytron: the distal portion.

Apex of prothorax: the cephalic margin.

Base of elytron: the proximal portion.

Base of prothorax: the caudal margin.

Carina, frontal: an elevated median ridge or keel on the front of the head.

Humeral angle: the outer proximal angle of the elytron.

Metathoracic thickenings: a pair of chitinous bars, running cephalocaudad on the metathorax, one at the base of each wing. (They are inconspicuous in young pupae but become dark brown and prominent in older pupae.)

Plica: a fold; a *submarginal plica* is a lateral fold in the elytron extending caudad from the umbo.

Post-humeral depression: a depression behind the umbo which may or may not be present.

Tubercle, frontal: a chitinous plate immediately caudad of (i. e., superior to) the antenna.

Umbo (plural *umbones)*: an elevation or swelling in the humeral angle of the elytron.

KEYS TO THE MAINE SPECIES OF ALTICA.

Key to the Adults.

(Including *ignita* Ill. and *"ignita"* of Chittenden.)

1. Elytra longitudinally plicate at the sides.....2.
1. Elytra not longitudinally plicate at the sides.....3.
2. Large blue species; 5-6 mm. long.....*bimarginata.*
2. Smaller species; 3-4 mm. long.....*ignita* Illiger.
3. Thorax with a deep ante-basal groove which extends completely across the thorax.....4.
3. Thorax with a moderate ante-basal groove which does not extend completely across the thorax.....8.
4. Thorax distinctly wider at the base than at the apex.....*chalybea.*
4. Thorax scarcely wider at base than at the apex.....5.
5. Brilliant cupreous or golden cupreous.....6.
5. Not so colored.....7.
6. Segment 3 of the antennae longer than segment 4; length 4 mm. .....*"ignita"* of Chittenden.
6. Segment 3 of antennae equal in length to segment 4; length 3 mm. ..... *rosae.*
7. Black; antennae three-fifth the length of the body.....*corni.*
7. Green, blue, or violet; antennae one-half the length of body....*ulmi.*
8. Prothorax less than one-half wider than long.....*carinata.*
8. Prothorax more than one-half wider than long.....*torquata.*

KEY TO THE EGGS.

1 .Eggs deposited in 1's or 2's.....2.
1. Eggs deposited in clusters of 3 or more.....3.
2. Eggs deposited on leaves (usually elm).....*ulmi.*
2. Eggs deposited on stems or ground at base.....*torquata.*
3. Eggs orange, deposited in the tubes of leaf-rooling Lepidoptera ..... *bimarginata.*
3. Eggs pale yellow, deposited on the under surfaces of leaves.....4.
4. On *Cornus* (dogwood).....*corni.*
4. On *Rosa* (rose).....*rosae.*

KEY TO THE LARVAE.

(Including *"ignita"* of Chittenden.)

1. Lateral setae (on tubercle vii-viii) 3 in number.....*bimarginata.*
1. Lateral setae 2 in number.....2.
2. Tubercle iii setiferous on both mesothorax and metathorax .....*"ignita"* of Chittenden.
2. Tubercle iii non-setiferous or absent on mesothorax and metathorax ..... 3.
3. Tubercle iii present on mesothorax.....4.
3. Tubercle iii wanting on mesothorax.....*rosae.*
4. Ground color of larva dirty white.....*corni.*
4. Ground color of larva darker.....*chalybea, torquata, ulmi.*
   (No characters are known to the writer by which these can be separated in alcholic material.)

KEY TO LIVING PUPAE.

1. 3 setae on apex of each femur.....2.
1. 2 setae on apex of each femur.....3.
2. Length 5 mm.; yellow-orange.....*bimarginata.*
2. Length less than 5 mm.; orange.....*torquata.*
3. Color white.....*corni.*
3. Color yellow .....4.
4. Length 4.5 mm. or more.....*chalybea, ulmi.*
4. Length less than 4.5 mm.....*rosae.*

KEY TO ALCOHOLIC PUPAE.

1. 3 setae on apex of each femur.....2.
1. 2 setae on apex of each femur.....3.
2. Length 5 mm. or more.....*bimarginata.*
2. Length less than 5 mm.....*torquata.*
3. Length 4.5 mm. or more.....*chalybea, ulmi.*
3. Length less than 4.5 mm.....4
4. Length 4 mm.....*corni.*
4. Length less than 4 mm.....*rosae.*

ALTICA CORNI, SP. N., THE DOGWOOD FLEA-BEETLE.

TECHNICAL DESCRIPTION OF THE STAGES.

DESCRIPTION OF THE ADULT.

Very elongate oval, somewhat convex; *body above* shining black with strong greenish or purplish metallic reflections; *antennae* black with purplish or greenish reflections, especially the proximal segment: nearly if not quite three-fifths the length of the body, and more than twice the width of the prothorax at its base: segments 2, 3, and 4 gradually increasing in length: segment 4 two and one-half times as long as wide; segment 10 not more than twice as long as wide, usually less; *eyes* black, not prominent, their width as seen from the front less than one-half the interocular distance; *frontal carina* moderately prominent, acute; *frontal tubercles* moderately large, flat, almost contiguous; *vertex* not punctuate; *width of head* across eyes more than two-thirds but less than four-fifths that of the prothorax at its widest point.

Prothorax one-half wider than long; margin well defined; base scarcely wider than the apex, regularly arcuate; sides nearly parallel at the base, convergent at the apex; basal angles prominent, slightly dentiform; apical angles obliquely truncate; surface comparatively finely punctate, but quite densely punctate; *antebasal* groove well defined and entire.

Elytra (across umbones) about one-third wider than the base of the prothorax; each elytron from two and one-half to three times as long as wide, and from two to two and one-half times as long as the width of the base of the prothorax; *surface* alutaceous, comparatively coarsely but densely punctate; *humeral angles* obtuse, more or less rounded; *umbo* slightly prominent; *post-humeral impression* faint.

Scutellum metallic black, like the elytra, sparsely punctate.

Body beneath shining metallic black; abdomen quite densely beset with fine white setae; legs black; the claws red brown, the setae and pulvilli white.

Length 3.5 mm.-4 mm.

Last ventral segment of male sinuate each side; lateral lobes comparatively large; median lobe short, semicircular, flat, the extreme edge sometimes reflexed.

Type locality, Orono, Maine; *male designated as type* deposited in the collection of the Maine Agricultural Experiment Station, Orono, Maine. *Paratypes* (which are also topotypes) deposited in the collection of the Maine Agricultural Experiment Station, Orono, Maine; of Cornell University, Ithaca, New York; and of the United States National Museum, Washington, D. C.

Figures. The last ventral segment of the male is shown in figure 11E.

DESCRIPTION OF THE EGG.

Subcylindrical, irregularly elliptical; surface minutely punctate and finely sculptured, entirely divided into polygonal areas, though the sculpturing is frequently obscure; color varying from yellow to dull orange; length about 1 mm. The eggs are shown in figure 12A.

DESCRIPTION OF THE LARVA.

The numbering of the tubercles. The only important paper with which the writer is familiar that deals with the numbering of the tubercles in chrysomelid larvae is that of Sanderson (1903. Notes upon the structure and classification of chrysomelid larvae. Proc. Ent. Soc. Wash. v. 5:21-30). While the writer is unable to accept all of the conclusions reached in this paper, especially in the homologizing of the thoracic tubercles (because Sanderson's paper takes no account of the individual setae), he hesitates to propose a new system which he recognizes as merely a tentative one. But since in each case he has made two drawings, one showing the actual setal arrangement in the larvae and the accompanying one the numbering of the tubercles used in this bulletin, but little confusion should result, especially as immediately below is appended a cross-reference table showing the corresponding tubercles when numbered according to Sanderson's scheme, and according to the writer's. No one recognizes more plainly than the writer the unsatisfactory points of both schemes, and that both must be displaced when the group as a whole has been carefully studied.

Sanderson.	Woods.
Prothorax.	
i-vi	i-viii
vii-viii	x
ix	xi
x	xii
xiii-xiv	xiii-xiv
Mesothorax and Metathorax.	
i, ii, iii	i, ii, iii
iv	iv-vi
v-vi	v-vii-viii
vii	ix

viii x
ix xi
x xii
xiii, xiv ..... xiii, xiv

Abdomen.

i, ii, iii, iv, v, vi, vii, viii ..... i, ii, iii, iv, v, vi, vii, viii
ix-x ..... ix-x
xiii xiii
xiv ..... xii-xiv

Description of full grown larva. Head, thorax, and abdomen distinct; abdomen composed of 10 segments; pronotum and dorsum of 9th abdominal segment strongly chitinized to form the prothoracic and anal shields respectively; one pair of jointed legs borne by each of the thoracic segments; a single median anal proleg borne by the 10th abdominal segment. Length 5-5.5 mm.

Head directed obliquely downward and forward, strongly chitinized, shining black; the *epicranial suture*, at first extending cephalad along the mesal line, soon splits, passing back of the antenna to the base of the mandible on each side: it divides the head into three large segments, the median dorsal one the *postclypeus*, and the other two forming the *epicranium*; the *clypeus* is very narrow; the *labrum* is moderately large, rounded in front, shining black; *mandibles* dark brown, moderate in size, with notched teeth at the apex; *trochantin* present at its base, non-chitinized; *maxilla* with the cardo completely, the stripes incompletely, chitinized, bearing anteriorly a palpifer with a three-segmented conical palpus, and a very small nodule which probably represents the lacinia; *labium* with a large, slightly chitinized basal piece, the fused submentum and mentum, bearing a ligula, unchitinized except at its base, from which arises a pair of small two-segmented palpi; *antennae* inserted on the side of the head near the base of the mandibles, three jointed, white, the basal segment much larger than the middle segment, and the distal segment very small; *ocelli* wanting; a *membrane* connects the head and prosternum which are not separated by a suture; a small chitinized sclerite in this membrane is probably the *gula*.

Body-wall of thoracic and abdominal segments dirty white, densely beset with dull black cuticular nodules; tubercles i-viii prominent, dull black; tubercles ix-xiv, dull brown.

Abdominal segments 1 to 8 bear setiferous tubercles, segments 1 through 7 being identical; *on the first seven* the arrangement is as follows: tubercles i and ii of each side are confluent forming a mid-dorsal row of two tubercles on each segment (the anterior the larger) bearing two setae each; tubercles iii, iv, v and vi are distinct, bearing one seta each, and the spiracle is borne on a tubercle which lacks setae between

tubercles v and vi, and vii and viii; vii and viii are fused into a single tubercle, the large lateral tubercle, bearing two setae; tubercles ix and x are fused into a single tubercle, bearing two setae; tubercle xi is wanting; tubercle xiii in each case is fused with its fellow of the opposite side forming a row of mid-ventral tubercles, bearing two setae each; tubercles xii and xiv are fused into a single small tubercle, which bears two setae.

Abdominal segment 8: the arrangement of the tubercles is the same except that the fused tubercles i are smaller, and that the ii's and iv's of both sides are fused into a single large tubercle bearing four setae, so that the relative size of the two mid-dorsal tubercles is just opposite that of the other abdominal segments.

Abdominal segment 9 is modified dorsally into a strongly chitinized anal shield, which doubtless represents a fusion of tubercles i-viii, with probably the setae of tubercles ii, iv, v, vi and viii persisting; ventrally it bears a large median tubercle, bearing four setae, which probably represents tubercles xiii and xiv of each side all fused together.

Abdominal segment 10 is very small; it has no setae nor tubercles, but bears ventrally the creamy white anal proleg (which doubtless represents a pair of prolegs fused together); the anal opening, shaped like an inverted Y, lies in the middle of the proleg.

Metathorax: tubercles i and ii are not fused across the middle line, leaving a thin place where the cuticula can yield to the strain and split at the time of molting; tubercle iii is present but non-setiferous; tubercles iv and vi are fused together into a single tubercle bearing two setae; tubercles v, vii, and viii are fused into a single large tubercle, bearing three setae; tubercles ix and x are separate, bearing one seta each; tubercles xi and xii are associated with the base of the coxa, the former strongly chitinized and non-setiferous, the latter bearing one seta; tubercle xiii on each side is fused with its fellow forming a mid-ventral tubercle, bearing two setae; tubercle xiv bears one seta.

Mesothorax: exactly similar to the metathorax except that a spiracle is present above the seta on tubercle ix.

Prothorax: dorsally modified into a strongly chitinized cephalic shield, formed by the fusion of tubercles i-viii; tubercle ix wanting; tubercle x bearing a single seta; tubercles xi and xii lie at the base of the coxa, both bearing a single seta; tubercles xiii and xiv on both sides have fused together, forming a large bell-shaped non-setiferous mid-ventral tubercle.

Spiracles. There are nine pairs of spiracles, eight abdominal and one thoracic; the abdominal spiracles are borne on un-numbered non-setiferous tubercles just above the lateral tubercles (fused vii and viii) of the first eight abdominal segments; the thoracic spiracle is borne on tubercle ix of the mesothorax; an homologous tubercle present on the metathorax shows no trace of a spiracular opening.

Legs. The legs are composed of five segments; the proximal segment is incompletely chitinized ectad and not at all entad; it fits closely into a socket formed by the infolded body wall, with which it is con-

tinuous, and articulates slightly with tubercle xi, which is chitinized and non-setiferous except on the prothorax; tubercle xii is contiguous to this segment caudad; the second segment which is chitinized proximally is barely visible ectad, but is much larger entad; the third segment, strongly chitinized ectad, is about equal in size to the second; the strongly chitinized fourth segment is the longest of the leg segments; the short, strongly chitinized distal segment bears a single pulvillus, and a single inward-curved claw. The setae are the same on all of the legs, except that the proximal segment of the prothoracic leg lacks the anterior seta borne on the ectal surface of the other legs. There is no homology between the segments of the larval legs and those of the adults, as has already been explained in the case of the alder flea-beetle. (Woods 1917. Me. Agr. Exp. Sta. Bul. 265, p. 265.)

Figures. The arrangement of the setae and tubercles of the full grown larva is shown in the following figures; dorsal aspect, figure 10A (prothorax, mesothorax, metathorax, abdominal segments 1, 8 and 9); ventral aspect, figure 11A (prothorax, mesothorax, metathorax, abdominal segments 1, 8, 9 and 10); lateral aspect, figure 10C (prothorax, mesothorax, metathorax, abdominal segments 1, 8, 9 and 10); the numbering of the tubercles according to the writer's scheme in corresponding diagrams, figures 10B, 10D, and 11B respectively; third instar larva, lateral aspect, figure 12E. The structure of the legs, head and mouth parts is exactly the same as in *A. bimarginata,* and has already been figured for that species (Woods. 1917. Me. Agr. Exp. Sta. Bul. 265, figs. 19-20).

Description of the newly hatched larva. The arrangement of setae and tubercles on a just hatched larva is the same as that described for the full grown larva. The tubercles are proportionately larger and crowded more closely together, and the head is proportionately larger. The setae are all clearly capitate. Length, 1 mm.

Head measurements of larvae.

1st instar. Minimum, .29 mm.; maximum, .36 mm.; average, .31 mm. (Estimated from 35 specimens.)

2nd instar. Minimum, .43 mm.; maximum, .52 mm.; average, .45 mm. (Estimated from 17 specimens.)

3rd instar. Minimum, .62 mm.; maximum, .71 mm.; average, .67 mm. (Estimated from 31 specimens.)

Ratio of measurements: 1.45; theoretical measurements: .31; .45; .65; actual average measurements: .31; .45; .67.

DESCRIPTION OF THE PUPA.

Description of just formed pupa. Pure creamy white, caudal spines black, spiracles and setae dark brown. Length 3-3.5 mm.; width 1.5 mm.

The general appearance is that characteristic of chrysomelid pupae: wings and elytra pushed ventrad; the legs sharply bent at the femoro-tibial joint, the femora extending away from the meson, the tibiae toward it, and the tarsi caudad along the middle line of the body; the metathoracic legs passing under the wings, the antennae extending caudad and bent under the mesothoracic legs.

There are nine abdominal segments (unless the anal plate may be reckoned as a vestigial tenth), the last bearing a pair of strong black caudal spines. The arrangement of the setae is that characteristic of the whole genus and does not present any specific character, except that it belongs to the group having two setae on each femur instead of three.

Seven pairs of spiracles are present. The first pair is located on the mesothorax, ventrad of the base of each elytron. The other six pairs are located on the first six abdominal segments. The last pair is smaller than the rest.

There is a considerable range of variation in the pupal setae. The typical arrangement is shown in figures 11C (dorsal aspect), and 11D, (dorsal aspect of tip of abdomen). The pupa of the elm flea-beetle which is almost identical is shown in figures 12F and 12G.

Homologies of pupal and larval setae. There are constantly three setae on each side of the head throughout the Alticini, which the writer has not yet succeeded in homologizing with the larval setae. There are eight setae on the prothorax, which are homologous with those on the cephalic shield of the larva. There are two setae on each side of the mesothorax and the metathorax, homologous with the setae of tubercles ii and iv of the larva. There are four setae on each side of the first 8 abdominal segments; these are homologous with the larval setae of tubercles ii, iv, vi, and viii respectively, and the spiracle occurs between setae vi and viii as in the larva; the spiracle is not developed on segments 7 and 8 of the pupa. On segment 9, there are four setae and a caudal spine on each side, these five probably homologous with the five larval setae.

Any one of these setae may be lacking in any given pupa, and very rarely the caudal spines themselves may be lacking. An extra seta corresponding to the seta of tubercle vi in the larva is sometimes present on the mesothorax or metathorax.

The setae of the pupae are formed by the same trichogen cells which formed the larval setae. They are not hollow sense hairs like the larval setae, but are solid and pointed. They are developed only on the dorsal side, or the anterior and posterior ends of the body, so that their function would appear to be to hold the pupa away from contact with the sides of the pupal cell, since the insect lies with the ventral aspect uppermost.

The accessory trichogen cells (those which will not be utilized in forming the pupal setae) are phagocytized during the prepupal period, after the larva has entered the ground and constructed its cell, so that sense hairs are of no further use to it; and the trichogens which form the pupal setae are themselves phagocytized within 24 hours after pupation. The trichogen cells of the adult hypodermis are entirely unrelated to those of the pupal or larval hypodermis, so far as the writer has been able to ascertain.

Description of the pupa ready to transform. Dorsum of prothorax gray; metathoracic thickenings brown; eyes and antennae jet black; mandibles dark red brown, black tipped; wings, tibiae, tarsi, and caudal portions of femora piceous; elytra colorless (though they appear gray as the wings show through them); otherwise like the newly formed pupa.

BIOLOGICAL HISTORY.

SUMMARY OF REARINGS.

Length of the egg stage. A record which was kept of 215 eggs deposited between June 16 and July 14, inclusive, may be tabulated as follows:

5 hatched in 7 days, 81 in 8 days, 63 in 9 days, 38 in 10 days, 9 in 11 days, and 19 in 12 days; average 9 days.

Length of the first larval instar. A record which was kept of 220 larvae which hatched between June 16 and July 14 inclusive, may be tabulated as follows:

63 molted to the second instar in 4 days after hatching from the egg, 45 in 5 days, 53 in 6 days, 21 in 7 days, 17 in 8 days, 10 in 9 days, and 11 in 10 days; average 6 days.

Length of the second larval instar. A record which was kept of 233 larvae which molted to the second instar between June 22 and July 30 inclusive, may be tabulated as follows:

14 molted to the third instar in 3 days after the first molt, 53 in 4 days, 99 in 5 days, 22 in 6 days, 35 in 7 days, 1 in 8 days, 5 in 9 days, and 4 in 11 days; average 5 days.

Length of the third larval instar. A record which was kept of 173 larvae which molted to the third instar between July 1 and August 7 inclusive, may be tabulated as follows:

13 entered the soil in 2 days after the second molt, 59 in 3 days, 45 in 4 days, 31 in 5 days, 15 in 6 days, 3 in 7 days, 2 in 9 days, and 5 in 13 days; average 4 days.

Length of the prepupal period. A record which was kept of 141 prepupae which entered the soil between July 8 and August 7 inclusive, may be tabulated as follows:

41 transformed to pupae in 5 days after entering soil; 41 in 6 days, 41 in 7 days, 17 in 8 days, and 1 in 9 days; average 6 days.

Length of the pupal period. A record which was kept of 148 pupae which transformed between July 13 and August 13 inclusive, may be tabulated as follows:

6 emerged as adults in 5 days after the pupal molt, 21 in 6 days, 51 in 7 days, 57 in 8 days, 11 in 9 days, and 2 in 10 days; average 7 days.

Causes of variation. The extremes of variation are due very largely to weather conditions. Hot dry weather favors rapid development, and cool damp weather retards it. The season of the year has no apparent bearing on the rapidity of development. There is often great variation in the time required for reaching maturity from individuals all of which hatched from the same egg cluster and lived under identical conditions.

Typical life history. The following is cited as a typical life history: 62 eggs deposited June 25 (1915) hatched July 3; all molted to the second instar on July 7; 16 molted to the third instar on July 11, 37 on July 12, and 9 died in the molt; 29 entered the soil as prepupae on July 14, 8 on July 15, 9 on July 16, 6 on July 19, and 1 died; 12 transformed to pupae on July 19, 2 adults emerging July 26, 7 on July 27 and 3 on July 28; 15 transformed to pupae on July 21, 4 emerging as adults on July 27, 7 on July 28, 2 on July 29, and 2 on July 30; 15 transformed to pupae on July 23, 5 emerging as adults on July 29, 5 on July 30, and 5 on July 31; 3 transformed to pupae on July 26, emerging as adults on August 3; 1 transformed to a pupa on July 27, emerging as an adult on August 4; 6 died before transforming.

SEASONAL HISTORY IN MAINE.

The dogwood flea-beetle passes the winter as an adult hidden away in the debris at the base of the dogwood bushes. They come out from their winter quarters in the spring when the

Cornus leaves are just separating from the blossom buds and are about half an inch long. In 1917 this was on June 2, and this is the earliest date on which the writer has taken a specimen; however in a normal year they probably appear about two weeks earlier. Only one beetle was taken at this time, and there was but slight indication of the work. On June 7 (1917) the leaves were quite well expanded and separated from the blossom buds, the beetles were abundant. In 1917 the dogwood did not blossom until June 18, which is at least 10 days later than is usual in Orono.

The first eggs in 1917 were deposited on June 5, but in 1918 larvae about 3 days old were collected in Orono, so eggs must have been laid at least as early as May 22. Eggs are not ordinarily found until the middle of June, but may be found from then on until the middle of July. In the laboratory, the last eggs were deposited on July 24, (1917). The majority of the eggs are deposited in early July.

The first larva to hatch in the laboratory appeared on June 14 (1917), but larvae were found in the field on June 12 (1917) and on June 3 (1918). Larvae may be found in the field from early June through mid-July, and scatteringly a few even in early August.

The adults are very scarce in the field by the 12th of July, and practically all of the hibernating adults are dead by the 20th. In the laboratory all have died on or before August 1, except for one female which lived until October 2. The writer doubts if they ever live as long as that under natural conditions. The first adult of the new generation was bred on July 15 (1917). The adults of the new generation do not feed at all, but enter into hibernation as soon as they have emerged.

There is only one generation each year, and no indication of a second under any conditions.

DISTRIBUTION.

During the past spring (1918) the writer has had a limited oportunity to observe something of the seasonal history of this species in Connecticut. They were found locally common on the dogwood in Middletown and later in Norfolk. They had already begun to pair on May 17 when they were first observed

and had deposited a few eggs. Eggs were to be found commonly a few days later. The first larvae were found on May 21, which must have come from eggs deposited at least as early as May 13. The Connecticut material exactly corresponds with the Maine material in every way.

THE EGG.

Coloration. When deposited the eggs are orange, but by 24 hours they have become the pale buff characteristic of the species. They do not turn gray before hatching. Each egg is streaked with excrement which lies on it like a black bar. The lateral tubercles of the mesothorax and metathorax show through the egg shell as 4 black spots about 24 hours before the larvae are ready to emerge.

Where deposited. The eggs are always deposited in clusters on the underside of the leaf of the food plant, on any part of the surface, but always so that the cluster lies against a vein. If there is more than one row of eggs, the eggs in the outer rows successively overlap those in the row next inner.

How many deposited. The eggs are deposited in clusters of from 2 to 41, though there are rarely more than 20 in a cluster. A count of 321 egg clusters may be summarized as follows:

Seven clusters were composed of 2 eggs each, 14 of 3, 19 of 4, 18 of 5, 23 of 6, 26 of 7, 25 of 8, 23 of 9, 30 of 10, 22 of 11, 31 of 12, 17 of 13, 20 of 14, 13 of 15, 9 of 16, 4 of 17, 8 of 18, 7 of 19, 1 of 20, 1 of 23, 1 of 29, 1 of 30, 1 of 41; mean of species 12; true average 9.9.

THE LARVA.

Color changes of the larva during growth. The body wall of the larva is covered with minute cuticular nodules, which, together with the tubercles, are the pigmented portions of the body. Just after hatching or immediately after a molt, the integument is translucent, and the larva appears entirely white, as no pigment has yet been formed, and the white fat-body shows through. In a few hours, pigment is formed in the tubercles and in the nodules. As the body wall is not stretched, the tuber-

cles and nodules lie very close together, and give the larva a dark aspect; late in the instar, the general color of the larva is much lighter, since the integument is stretched, the nodules farther apart, and the tubercles smaller in proportion to the body surface.

Such a series of color changes is very characteristic of all of the species treated in this bulletin, and indeed of all flea-beetles which the writer has studied. They are either white or yellow after a molt (according to the color of the fat-body), as there is no pigment in the cuticula; they rapidly become darker, and the darkness is at a maximum a few hours after the molt; then they gradually become lighter throughout the instar, and the coloration of the early and late part of the same instar is frequently quite different.

Hatching. When the larva is ready to emerge from the egg, the shell splits near, but not quite at, the anterior end, a very tiny slit first appearing. Soon a second slit appears parallel to the first. From one or the other of the openings thus formed is pushed out the mesothorax. Gradually the whole thorax is arched out of this opening, first the mesothorax and later the prothorax and metathorax. In about 10 minutes from the time the crack first appears, the fused tubercles v-vii-viii of the two posterior thoracic segments are exposed, and the larva has a decidedly hunch-backed appearance. After a hard struggle of about 10 minutes longer, the head also is withdrawn through this opening, and the legs almost immediately after. The legs are but little used for they are still soft and weak. Nearly all of the hatching process is accomplished simply by alternately contracting and relaxing the body muscles. In about 30 minutes the larva is two-thirds out of the shell, but it is usually another half hour before it finally crawls out completely.

Coloration after hatching. When the larva emerges from the egg shell, it is entirely grayish white, including head, legs, and shields, except for the 4 black spots on the thorax. These spots are formed by the fused tubercle v-vii-viii on each side of the mesothorax and metathorax, which are the only pigmented portions of the cuticula at the time of hatching. The larva becomes fully colored in about 2 hours.

Color description of a first instar larva, early.

Head, legs, prothoracic and anal shields shining black; body dark brown, almost black, lighter ventrally; dorsal and lateral tubercles dull black; ventral tubercles brown.

Color description of a first instar larva, late.

Head, legs, prothoracic and anal shields shining black; general aspect of body yellowish white; tubercles dull olive gray; lateral tubercles of meso- and meta-thorax darker and prominent.

The molt to the second instar (first molt). The process of molting is the same in all of the flea-beetles studied, and is described in detail under the second molt of the elm flea-beetle (page 188).

Coloration after the first molt. 6 min., absolutely pale translucent creamy white, the mandibles brown, setal punctures black; head, legs and prothorax white; 10 min., head, legs, and prothorax slightly darkish; 20 min., the same parts slightly darker, and the tubercles beginning to show dark; 30 min., the same parts somewhat darker; 45 min., head and prothorax quite blackish: tubercles decidedly dark: legs darker than the tubercles, but not as dark as the head; 60 min., head and prothoracic shield black: the body has a dark aspect; 75 min., head and prothoracic shining black, the legs black, the tubercles normally colored; 105 min., fully colored.

Color description of a second instar larva, early. Head, legs, prothoracic and anal shields shining black; general aspect of body almost black (integument yellowish white with the dark brown cuticular nodules very close together); tubercles dull black.

Color description of a second instar larva, late. Head, legs, prothoracic and anal shields shining black; general aspect of body yellowish white, not much lighter ventrally (cuticular nodules lighter brown and farther apart); dorsal and lateral tubercles dark gray brown; ventral tubercles brown; anal proleg white.

The molt to the third instar (second molt). The process of molting is the same in all of the flea-beetles studied, and is described in detail under the second molt of the elm flea-beetle (page 188).

Color description of a third instar larva, early. Head, legs, prothoraic and anal shields shining black; general aspect of body almost black above, lighter ventrally; dorsal and lateral tubercles dull black; ventral tubercles gray; anal proleg white.

Color description of a third instar larva, late. Head, legs, prothoracic and anal shields shining black; general aspect of the body light yellowish gray; dorsal and lateral tubercles deep gray brown; ventral tubercles gray; anal proleg white.

Feeding habits. The larvae skeletonize the leaves, leaving only a network of the veins. They feed mostly on the underside of the leaves,

and are to a slight extent gregarious. They are very sluggish, and their comparatively soft bodies are covered with their powdery excreta. The work of the larvae is illustrated in figure 13B.

THE PREPUPA.

Formation of the pupa cell. In all insects which undergo a complete metamorphosis, the wings are developed internally in the larva as hypodermal invaginations. Soon a part of this invagination evaginates to form the wing-bud proper, and just before the formation of the pupal cuticula, this wing-bud pushes out so as to lie on the outside of the hypodermis. The internal wing-bud of the larva is therefore external in the pupa, because it lay outside the hypodermis when the pupa cuticula was secreted. The period from the outpushing of the wing-bud in the larva until the molt to the pupa, is spoken of as the prepupal period.

In flea-beetles generally, the prepupal period is passed in the earth. As soon as the larva is fully fed, it enters the ground to complete its transformations. Sections of specimens of several different species fixed at this time show clearly that the entrance into the soil closely corresponds with the outpushing of the wing-buds.

The larvae enter any fairly loose soil, pupating about an inch below the surface. Here they construct a rude cell by contortions of the body, and the earth lining it is cemented together by a mucous secretion, probably poured out by the maxillary glands. (Labial glands, the ordinary salivary glands of insects are wanting in the flea-beetles, as in Coleoptera generally.) The earlier prepupa is straight, and can walk, but by the third day, the body is strongly arcuate, and the insect is unable to move its legs, due to the degeneration of the larval muscles.

Color changes of the prepupa. For about two days after entering the soil, the prepupae become darker in color, but then they become lighter, and by the fourth day are almost white.

THE PUPA.

The molt from the prepupa to the pupa. This molt is accomplished in the same way in all of the flea-beetles studied, and is described in detail under the elm flea-beetle (page 190).

Color cycle. When the pupa is first formed, it is a pure creamy white, save for the caudal spines which are black, and the setae and spiracles which are brown. As the pupa grows older, however, certain color changes appear, which are correlated with the progress of the internal metamorphosis, and furnish a reliable indication as to the age of any given pupa.

The first change to be noted is in the eyes, which become a light brown on the third day of pupal life, dark brown on the fourth, and black on the fifth. The wings become light gray usually on the fifth day, although sometimes it is as as late as the seventh day before this change appears, and a dark gray about 24 hours later. The elytra remain colorless, although as they lie over the wings, they appear to be colored. The mandibles become red brown on the fifth day.

The Adult.

Emergence. When the adult is ready to emerge, the elytra are pushed more or less dorsad, and the appendages are more or less straightened out before the skin cracks. The pupal cuticula cracks open along the dorsal line of the mesothorax; this is done by the scutellum, which is raised and lowered. At this same time the wings and elytra begin to increase in size, and about five minutes after the first slit appears, these appendages are about three-fourths as long as the body; meanwhile the metathorax has split way down the mid-dorsal line, and the mesothorax way up. In 8 minutes, the prothorax is free, and the head is exposed as far as the labrum. In 10 minutes the elytra and wings are as long as the body, the mouth parts are all free from the pupal cuticula, and the elytra about one-quarter exposed. All through this process, the insect continually contracts and expands the abdomen.

In 5 minutes more, the elytra are about half free, as well as 6 joints of the antennae, and one-third of the prothoracic femora. The antennae are freed by jerking the head backward as far as possible and then suddenly releasing it. In 24 minutes after the first split the right prothoracic leg was freed, and two-thirds of the elytra exposed. In 27 minutes, the left prothoracic leg was also freed, and a minute later the mesothoracic and metathoracic legs were drawn out almost simultaneously. In 33 minutes, the

beetle had succeeded in kicking the old skin off the end of the abdomen, and was entirely free from the pupal cuticula.

Coloration of adult. As the beetle emerges, the eyes, antennae, mouth parts, and legs (except the proximal two-thirds of all of the femora) are black; the tip of the pygidium is shining violet black, as are also parts of the pronotum and the scutellum. The first change is to be noted in the legs, which become fully colored in about 2 hours. The metathoracic legs are always the first to become pigmented. In about 5 hours, the head is black, except for the occiput, and also the whole of the pronotum. The elytra now begin to be gray and shiny, and are dark gray by 6 hours after emergence. In 7 hours the head is entirely black above. The normal coloration is reached in about 19 hours. The elytra never begin to turn gray until the legs are fully colored, and the beetle is all gray dorsally before it begins to darken up at all ventrally. The beetle is very soft as it emerges, and it remains in the pupal cell for about 20 hours before trying to break out or until it is fully colored and hardened.

Feeding habits. The adults feed freely on the leaves, biting holes through them. The work is characteristic, and is very different from the type of work done by the larvae. The nature of the work is shown in figure 13A. The beetles feed only in the spring. In the summer they enter into a hibernation as soon as they emerge, and feed only to a very limited extent, if at all.

Copulation. The beetles remain paired for several hours when they mate. One female pairs several times during the egg-laying season.

Number of eggs deposited by one female. Each female ordinarily lays about 400 eggs. The greatest number of eggs that was laid by any one female was 698 between June 8 and July 20 (1917). The greatest number laid by one beetle in 24 hours was 41, all in a single cluster, and the next greatest 34, in one cluster of 16 and another of 18.

FOOD PLANTS.

Natural food plants. The only plants on which the writer has ever taken beetles of this species in the field all belong to the genus *Cornus*. In Maine, the writer has found them mostly on the red osier dogwood, *C. stolonifera* Michx, and less frequently

on the panicled dogwood, *C. paniculata* L'Her. In Connecticut he has found them more frequently on the latter species.

Food plant tests. A large number of tests was carried out to determine the possible range of food plants. In these and all other food tests recorded in this paper, the experiments were made as follows: 6 larvae or adults were kept in a clean shell vial without food for 24 hours; then an uninjured leaf of the plant to be tested was introduced, and the insects were left undisturbed for a second 24 hours; at the end of that time the leaves were examined, and a record made as to whether they had been considerably eaten, slightly eaten, or left untouched.

The complete list of food plants used in these experiments is given below. The sequence of plant families and the form of the scientific name follows the use of the latest edition of Gray's Manual.

Family Gramineae, grass family: corn, *Zea mays* L.

Family Salicaceae, willow family: cultivated willow, *Salix* near *nigra* Marsh; heart-leaved willow, *Salix cordata* Muhl.; petiolate willow, *Salix petiolaris* Sm.; beaked willow, *Salix rostrata* Richards; aspen poplar, *Populus tremuloides* L.; balsam poplar, *Populus balsamifera* L.; cottonwood, *Populus deltoides* Marsh.

Family Myriaceae, gale family: sweet fern, *Myrica asplenifolia* L.

Famiy Betulaceae, birch family: hazel, *Corylus rostrata* Ait.; gray birch, *Betula populifolia* Marsh; alder, *Alnus incana* (L.) Moench.

Family Fagaceae, oak family: red oak, *Quercus rubra* L.

Family Urticaceae, nettle family: red elm, *Ulmus fulva* Michx.; white elm, *Ulmus americana* L.

Family Saxifragaceae, saxifrage family: syringa, *Philadelphus coronarius* L.; smooth gooseberry, *Ribes oxycanthoides* L.; European gooseberry, *Ribes Grossularia* L.; red currant, *Ribes vulgare* L.

Family Rosaceae, rose family: cultivated spiraea, *Spiraea* sp.; apple, *Pyrus Malus* L.; mountain ash, *Pyrus americana* (Marsh) DC.; shad bush, *Amelanchier oblongifolia* (T & G) Roem.; hawthorn, *Crataegus* sp.; wild strawberry, *Fragaria virginiana* Duchesne.; cultivated strawberry, *Fragaria* sp.; wild rose, *Rosa virginiana* L.: cultivated rose, *Rosa* sp.; Japanese rose, *Rosa Yvara;* choke cherry, *Prunus virginiana* L.; wild red cherry, *Prunus pennsylvanica,* L. f.; wild plum, *Prunus nigra* Ait.; cultivated plum, *Prunus domestica* L.

Family Leguminosae, pea family: cultivated bean, *Phascolus* sp.

Family Aceridae, maple family: sugar maple, *Acer saccharum* Marsh.

Family Vitaceae, grape family: grape, *Vitis* sp.; wood-bine, *Psedera quinquefolia* (L.) Greene.

Family Tiliaceae, basswood family: basswood, *Tilia americana* L.

Family Onagraceae, evening primrose family: fireweed, *Epilobium angustifolium* L.; Marsh fireweed, *Epilobium palustre* L.; evening primrose, *Oenothera biennis* L.

Family Cornaceae, dogwood family: red osier dogwood, *Cornus stolonifera* Michx.; panicled dogwood, *Cornus paniculata* L'Her.; bunchberry, *Cornus canadensis* L.

Family Ericaceae, heath family: sheep laurel, *Kalmia angustifolia* L.; low blueberry, *Vaccinium pennsylvanicum* Lam.; velvet-leaf blueberry, *Vaccinium canadense* Kalm.

Family Oleaceae, olive family: lilac, *Syringa vulgaris* L.

Family Solanaceae, nightshade family: tomato, *Lycopersicon esculentum* L.

Family Compositae, composite family: Joe Pye weed, *Eupatorium purpureum* L.; goldenrod, *Solidago canadensis* L.

Food plants of the adult dogwood flea-beetle.

(i) Eaten readily.

Alder, red osier dogwood, panicled dogwood, bunchberry.

(ii) Refused.

Corn, cultivated willow, heart-leaved willow, petiolate willow, beaked willow, aspen poplar, balsam poplar, cottonwood, sweet fern, hazel, gray birch, red oak, red elm, white elm, syringa, smooth gooseberry, European gooseberry, red currant, cultivated spiraea, apple mountain ash, shad bush, wild strawberry, cultivated strawberry, wild rose, cultivated rose, Japanese rose, choke cherry, red cherry, wild plum, cultivated plum, bean, sugar maple, woodbine, basswood, fireweed, marsh fireweed, evening primrose, sheep laurel, low blueberry, velvet-leaf blueberry, lilac, tomato, Joe Pye weed.

Food plants of the larva of the dogwood flea-beetle.

(i) Eaten readily.

Red osier dogwood, panicled dogwood, bunchberry.

(ii) Eaten indifferently.

Alder, Japanese rose, (but not the other roses!), evening primrose, fireweed, marsh fireweed, bean.

(iii) Refused.

Corn, cultivated willow, heart-leaved willow, petiolate willow, beaked willow, aspen poplar, balsam poplar, cottonwood, hazel, birch, red oak, red elm, white elm, syringa, European gooseberry, red currant, cultivated spiraea, apple, mountain ash, shad bush, wild strawberry, cultivated strawberry, wild rose, cultivated rose, choke cherry, red cherry, wild plum, cultivated plum, sugar maple, woodbine, basswood, sheep laurel, low blueberry, velvet-leaf blueberry, lilac, tomato, Joe Pye weed.

Natural Enemies.

Fungous diseases. Both in the laboratory and in the field, larvae, pupae, and adults are all very susceptible to the attacks of the parasitic fungus, *Sporotrichum globuliferum* Speng. This widely distributed fungus destroys many of these insects whenever conditions are favorable for its growth, and is without doubt an important agent in holding this species in check.

The prepupae and pupae are quite subject to a wilt disease, which is probably bacterial in its nature, although the writer has not made any attempt to isolate the causative organism.

Insect parasites. The writer has bred only a single parasite from the dogwood flea-beetle, a tachinid fly which works in the adult beetles. This fly which is not very common in Maine was determined for the writer as *Celatoria spinosa* Coquillet by Mr. C. W. Johnson of the Boston Museum of Natural History. The writer has also bred this fly from the beetles of *Altica ulmi* (see page 193), and it has been recorded by Coquillet as bred from the adults of *Diabrotica soror* LeC (Coquillet 1890, Insect Life, v.2:235).

The larvae are internal parasites of the adult beetles. The writer has but little data on the life history, but it seems probable that the flies deposit eggs on the over-wintering beetles in the spring or summer after they have come out from hibernation. The whitish larvae emerge from the beetles when they are full grown, killing their host. In a few hours they shrink up into brown puparia, and the adult flies emerge a week or ten days later.

Control.

Like most flea-beetles, these insects can be controlled by arsenical sprays. A thorough spraying with arsenate of lead at the ordinary strength (3 pounds of the paste or 1 ½ pounds of the powder to 50 gallons of water) as soon as the beetles appear in the spring, and repeated in late June and mid-July for the larvae, is necessary, will hold this species in check whenever it is practicable or desirable to try to keep down their numbers.

ALTICA ROSAE, SP. N., THE ROSE FLEA-BEETLE.

TECHNICAL DESCRIPTIONS OF THE STAGES.

DESCRIPTION OF THE ADULT.

Elongate oval, distinctly convex; *body above,* brilliant cupreous, with metallic reflections; *antennae* piceous, the proximal segment cupreous and quite smooth, the rest pubescent with white setae; slightly more than one-half the length of the body, but less than twice the width of the prothorax at its base; segment 3 longer than segment 2 and very nearly, if not quite as long, as segment 4; segment 4 about two and a half times as long as wide; segment 10 not more than twice as long as wide, usually less; *eyes* black, not prominent, their width as seen from the front less than one-half the interocular distance; *frontal carina* moderate, acute; *frontal tubercles* moderately large, flat, almost continguous; *vertex* not punctate; *width of head* across the eyes about two-thirds that of the prothorax at its widest point.

Prothorax one-half wider than long; margin well defined; base scarcely wider than the apex, regularly arcuate; sides nearly parallel at the base, convergent at the apex; basal angles slightly dentiform, prominent; apical angles obliquely truncate; surface comparatively finely but quite densely punctate; *ante-basal groove* well defined and entire, though sometimes apparently evanescent at the extremities.

Elytra across umbones one-third wider than the base of the prothorax; each elytron slightly more than three times as long as wide, and slightly more than two times as wide as the base of the prothorax, *surface* minutely alutaceous, comparatively coarsely but densely punctate; *humeral angles* obtuse, decidedly rounded; *umbo* not prominent; *post-humeral* depression not strong.

Scutellum colored like the elytra, sparcely punctate.

Body beneath colored like the elytra; abdomen quite densely beset with fine white setae; *legs* colored like the body, except the under surfaces of the tarsal segments which are brown; the claws are red brown; the setae and pulvilli are white.

Last ventral segment of male sinuate each side; lateral lobes comparatively large; medium lobe short, semicircular, flat, the extreme edge sometimes reflexed. The last ventral segment of the male is exactly similar to that of *A. corni,* as shown in figure 11E.

Length 3 mm.

Type locality, Orono, Maine. Male designated as type deposited in the collection of the Maine Agricultural Experiment Station, Orono, Maine. *Paratypes* (which are also topotypes) deposited in the collection of the Maine Agricultural Experiment Station, Orono, Maine; of the Boston Society of Natural History, Boston, Mass.; of Wesleyan University, Middletown, Conn.; of Cornell University, Ithaca, N. Y.; and of the United States National Museum, Washington, D. C.

DESCRIPTION OF THE EGG.

Subcylindrical, irregularly elliptical, surface minutely punctate and finely sculptured, entirely divided into polygonal areas, although the sculpturing is frequently obscured; color varying from yellow to dull orange; length about 1 mm. The eggs are shown in figure 12B.

DESCRIPTION OF THE LARVA.

Description of the full grown larva. Head and legs shining black; prothoracic and anal shields more or less brown; general body color greenish yellow above and below; tubercles brown; general aspect almost black early in the instar, and light yellowish late in the instar; anal proleg light lemon yellow. Length 5-5.5 mm.

All of the other characters, such as the general structure of the body and the arrangement of setae and tubercles, are exactly the same as is described under the larva of the dogwood flea-beetle (page 157), except that tubercle iii is very rarely present on the mesothorax and if present is merely vestigial, and that tubercle iii is frequently absent on the metathorax as well, and if present is usually more or less vestigial. Both are non-setiferous in any case. There is frequently present an extra non-setiferous mid-ventral chitinization on the anterior edge of the thoracic segments.

Description of the newly hatched larva. The arrangement of setae and tubercles is exactly the same as in the full grown larva. The tubercles are proportionately larger, and crowded more closely together, and the head is proportionately larger. Length 1 mm.

Head measurements of larvae.

1st instar. Minimum, .27 mm.; maximum, .31 mm.; average, .30 mm. (Estimated from 11 specimens.)

2nd instar. Minimum, .46 mm.; maximum, .50 mm.; average, .47 mm. (Estimated from 11 specimens.)

3rd instar. Minimum, .62 mm.; maximum, .66 mm.; average, .64 mm. (Estimated from 17 specimens.)

Ratio of measurements: 1.56. Theoretical measurements: .30, .47, .73; actual average measurements: .30, .47, .64.

DESCRIPTION OF THE PUPA.

Description of the just formed pupa. Yellow; setae and spiracles brown; caudal spines black; otherwise exactly like *A. corni* (see page 160). Length 3-3 5 mm.; width 1.5 mm.

Description of pupa ready to transform. Dorsum of prothorax with irregular blackish splotches; metathoracic thickenings brown; eyes, interocular region and mouth parts black; wings dark gray or black; coxae, trochanters, and femora brown, the rest of the leg piceous, except the tarsi and the femoro-tibial joints which are black; otherwise like the newly formed pupa. (The elytra are colorless although they appear gray as the wings lie underneath them and show through.)

BIOLOGICAL HISTORY.

SUMMARY OF REARINGS.

Length of egg stage. A record which was kept of 59 eggs deposited between July 22 and July 31 inclusive, may be tabulated as follows:

18 hatched in 6 days, 37 in 7 days, and 4 in 8 days; average 7 days.

Length of the first larval instar. A record which was kept of 104 larvae which hatched between July 16 and July 30 inclusive, may be tabulated as follows:

18 molted to the second instar in 3 days after hatching, 76 in 4 days, 5 in 5 days, and 5 in 6 days; average 4 days.

Length of the second larval instar. A record which was kept of 96 larvae which molted to the second instar between July 18 and August 3 inclusive, may be tabulated as follows:

7 molted to the third instar in 2 days after the first molt, 32 in 3 days, 40 in 4 days, 16 in 5 days and 1 in 6 days; average 4 days.

Length of third larval instar. A record which was kept of 97 larvae which molted to the third instar between July 17 and August 12 inclusive, may be tabulated as follows:

2 entered soil in 2 days after the second molt, 43 in 3 days, 19 in 4 days, 19 in 5 days, 10 in 6 days, 3 in 7 days, and 1 in 8 days; average 4 days.

Length of the prepupal period. A record which was kept of 111 prepupae which entered the soil between July 20 and August 12 inclusive, may be tabulated as follows:

4 transformed to pupae in 3 days after entering soil, 18 in 4 days, 39 in 5 days, 29 in 6 days, 14 in 7 days, 4 in 8 days, 2 in 9 days, and 1 in 11 days; average 5 days.

Length of the pupal period. A record which was kept of 75 pupae which transformed between July 24 and August 14 inclusive, may be tabulated as follows:

5 emerged as adults in 6 days after the pupal molt, 24 in 7 days, 30 in 8 days, 13 in 9 days, and 3 in 10 days; average 8 days.

Typical life history. The following is cited as a typical life history: 9 eggs deposited July 9 (1917) hatched on July 16; all molted to the second instar on July 20; 3 molted to the third instar on July 24, 5 on July 25, and 1 on July 26; 3 entered the soil as prepupae on July 27, and 6 on July 28; 3 transformed to pupae on July 30, 2 adults emerging on August 7, and one of the pupae dying; 2 transformed to pupae on August 1, emerging as adults on August 8; 4 transformed to pupae on August 2, 2 emerging as adults on August 10 and 2 on August 11.

SEASONAL HISTORY IN MAINE.

Like the other members of the *ignita* group, the rose flea-beetle passes the winter as an adult, hidden away in the debris at the base of the rose-bushes. The writer has not had this species under observation in Maine in the spring, but, judging from Connecticut material, the beetles emerge from their winter quarters and begin ovipositing at approximately the same time as the dogwood flea-beetle. The oviposition period is exceptionally long even for a flea-beetle, and eggs were deposited in the laboratory as late as July 31 (1917). Eggs were found commonly in Maine on July 20 (1918) and the first larvae on July 25 (1918).

Many of the hibernating adults survive until late July, but the latest date to which one lived in the laboratory was August 8 (1917). The first beetle of the new generation to emerge in the laboratory transformed on July 31 (1917).

There is only one generation each year, at least in Maine.

DISTRIBUTION.

The writer has taken this species in Middletown, Conn., and has seen specimens collected in Massachusetts and New York.

In Maine the writer has taken this species in Orono and Ellsworth, and Doctor Patch has collected specimens in Portland, so it is probably generally distributed throughout the State.

THE EGG.

Coloration. The eggs do not as a rule show any change in color before hatching, except that the 4 black thoracic spots show through the shell about 24 hours previous to the emergence of the larva.

Where deposited. The eggs are deposited on the lower surface of the leaves of the food plant. They are always streaked with excrement.

How many deposited. As is customary among chrysomelids, the eggs are deposited in clusters. Usually there are about 7 deposited in each cluster, and the largest number that the writer has found in any one group is 12.

THE LARVA.

Hatching. The process of hatching is exactly the same as that already described for *A. corni* on page 166.

Coloration after hatching. When the larva hatches from the egg it is entirely honey yellow, except for the 4 black thoracic spots characteristic of the just hatched flea-beetles, as the dorsal portion of the lateral tubercles (fused v, vii, and viii) of the mesothorax and the metathorax is the only pigmented portion of the cuticula when the larva ruptures the egg shell. The larva colors up gradually, requiring about 2 hours to reach the normal coloration.

Color description of a first instar larva, early. Head and legs shining black, prothoracic and anal shields brown; body dark olive yellow, tubercles dark black brown, general aspect almost black; anal proleg honey yellow.

Color description of a first instar larva, late. Head, prothoracic shield and legs shining black, anal shield brown; body honey yellow, slightly greenish, both above and below; tubercles dull brown; anal proleg honey yellow.

The molt to the second instar (first molt). The process of molting is the same in all of the flea-beetles studied, and is described in detail under the second molt of the elm flea-beetle (page 188).

Coloration after the first molt. The coloration after the first molt is exactly the same as that described below under the heading "coloration after the second molt."

Color description of the second instar larva, early. Head, legs, prothoracic shield and tubercles shining black; anal shield incompletely

black; body very dark olive brown above, lighter below; general aspect almost black; anal proleg honey yellow.

Color description of the second instar larva, late. Head and legs shining black, prothoracic and anal shields brown; body light greenish yellow above and below, tubercles brown; anal proleg honey yellow.

The molt to the third instar (second molt). The process of molting is the same in all of the flea-beetles studied, and is described in detail under the second molt of the elm flea-beetle (page 188).

Coloration after the second molt. After each molt the larva is entirely pale honey yellow, including the head, legs, shields, and tubercles, except that the spiracles are black, the setal punctures brown, and the mandibles reddish brown. It requires about 2 hours after the legs have been withdrawn from the old cuticula to reach the normal coloration. The process is typically approximately as outlined below:

30 min.: dorsal tubercles slightly dull; 45 min.: head, legs, shields, and tubercles blackish; 60 min.: head brown, shields, tubercles, and legs gray brown, body dull yellow brown; the apodemes of the head show black, and the antennae are fully colored; 75 min.: shields, tubercles, and legs, as well as head, brown; 90 min.: head, shields, legs, and tubercles, dark brown, body dark; 105 min.: head and legs brownish black; 120 min.: head and legs black; 135 min.: normal coloration.

Color description of the third instar larva, early. Head and legs shining black; prothoracic and anal shields incompletely black; tubercles dark brown, body dark olive yellow, whole aspect almost black; anal proleg honey yellow.

Color description of the third instar larva, late. Head and legs shining black, prothoracic and anal shields incompletely brown; body light greenish yellow above and below, tubercles brown; anal proleg honey yellow.

Variation. There is very great variation in the color of the prothoracic and anal shields in all of the instars, especially the last. They may be either black or brown, and completely or incompletely colored. They are more frequently brown than black, especially in the older larvae, and more frequently splotched than uniformly colored.

Feeding habits. The larvae feed exclusively on the underside of the leaves, which they skeletonize in a very characteristic fashion, leaving only a network of the veins and the upper epidermis.

THE PREPUPA.

Formation of the prepupal cell. As soon as it enters the soil the prepupa constructs a rude cell not far below the surface of the ground. The formation of the cell is discussed in more detail under the dogwood flea-beetle (page 168).

Coloration. The color fades out during prepupal life, and in the late prepupa, the legs and head are brown, the tubercles dull brown, and the general aspect of the body is dull yellowish.

THE PUPA.

The molt from the prepupa to the pupa. This molt is accomplished in the same way in all of the flea-beetles studied, and is described in detail under the elm flea-beetle on page 190.

Color cycle. The pupae of the rose flea-beetle pass through a series of color changes correlated with the progress of internal metamorphosis, as do the other chrysomelids which the writer has studied.

On the third day, the eyes become light brown, dark brown on the fourth, and black on the fifth. The mandibles turn reddish brown also, usually on the fifth day. The wings appear very light gray 48 hours before the adult is ready to emerge (usually on the sixth day), and dark gray 24 hours before emergence.

There is, of course, some variation as to the time in which these characters appear, but the appearance and sequence of these pigmentations is perfectly constant.

THE ADULT.

Emergence. The process of emergence is the same in all of the flea-beetles studied, and is described in detail under the dogwood flea-beetle on page 169.

Coloration. When the beetle first emerges, it is soft-bodied, and prevailingly yellow in color. It requires about 24 hours before it is fully hardened and colored, and the beetle remains up to this time in the pupal cell.

Feeding habits. The adults feed freely both in the fall and in the spring on the leaves of their food plants. They eat

little holes through the leaf, so that their work is as characteristic as, and very different from, that of the larvae.

Mating. As is usual among chrysomelids, the beetles remain in copulation several hours, and each female pairs several times in the course of the season.

Number of eggs deposited by one female. The writer has no data as to the number of eggs which one female is capable of depositing, but it is probably at least as high as that of the dogwood flea-beetle (see page 170), as a single female captured on July 22 deposited 51 eggs before the end of the month.

FOOD PLANTS.

Natural Food Plants. The only plants on which the writer has ever found this species in the field, either in Maine or Connecticut, belong to the genus *Rosa*. They seem to prefer the wild roses, but the writer has seen them several times on cultivated roses. The Massachusetts and New York specimens in the Boston Museum of Natural History are also labelled "wild rose". A number of laboratory tests to determine the possible range of food plants is recorded below.

FOOD PLANTS OF THE ADULT ROSE FLEA-BEETLE.*

(i) Eaten readily.
Wild rose, cultivated rose, Japanese rose, wild strawberry, cultivated strawberry.

(ii) Eaten indifferently.
Fireweed, marsh fireweed.

(iii) Refused.
Hazel, gray birch, alder, white elm, smooth gooseberry, cultivated spiraea, meadow sweet, apple, mountain ash, shad bush, choke cherry, red cherry, wild plum, grape, raspberry, evening primrose, red osier dogwood, basswood, low blueberry, hawthorn, golden-rod.

FOOD PLANTS OF THE LARVA OF THE ROSE FLEA-BEETLE.

(i) Eaten readily.
Wild strawberry, cultivated strawberry, wild rose, Japanese rose, cultivated rose.

(ii) Eaten indifferently.
Marsh fireweed.

(iii) Refused.

Corn, cultivated willow, heart-leaved willow, gray birch, alder, red oak, white elm, smooth gooseberry, European gooseberry, red currant, cultivated spiraea, apple, mountain ash, shad bush, choke cherry, red cherry, wild plum, bean, maple, wood-bine, basswood, evening primrose, red osier dogwood, low blueberry, tomato.

NATURAL ENEMIES.

Fungous diseases. This species is susceptible to the same fungous diseases as the dogwood flea-beetle (see page 173).

Insect enemies. The writer has not yet found any parasitic or predaceous insects preying upon this species.

CONTROL.

Same as for the dogwood flea-beetle (see page 173).

ALTICA ULMI, SP. N., THE ELM FLEA-BEETLE.

TECHNICAL DESCRIPTION OF THE STAGES.

DESCRIPTION OF THE ADULT.

Elongate oval, distinctly convex; *body above* shining green, blue, violet, or red violet with greenish or purplish reflections; *antennae* black with purplish or greenish reflections, especially the proximal segment: proximal segment quite smooth, the others more or less pubescent with fine white setae: about one-half the length of the body and somewhat less than twice the width of the prothorax at its base: segments 2-3-4 successively longer: segment 4 nearly if not quite three times as long as wide: segment 10 not more than twice as long as wide, frequently less; *eyes* black, not prominent, their width as seen from the front less than one-half the interocular distance; *frontal carina* moderate, obtuse; *frontal tubercles* moderately large, flat, almost contiguous; *vertex* not punctate; *width of head* across the eyes about two-thirds that of the prothorax at its widest point.

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*For the scientific names of the plants used in these tests, see page 171.

Prothorax one-half wider than long; margin comparatively wide; base scarcely wider than apex, regularly arcuate caudad; sides nearly parallel at the base, convergent at the apex; basal angles minutely dentiform, prominent; apical angles obliquely truncate; surface comparatively finely but quite densely punctate; *ante-basal* groove well defined and entire.

Elytra across umbones one-third wider than the base of the prothorax; each elytron from two and one-half to three times as long as wide, and slightly more than two times as long as the width of the base of the prothorax; surface alutaceous, comparatively coarsely but densely punctate; humeral angles obtuse, more or less rounded; umbo only moderately prominent; post-humeral depression not strong.

Scutellum colored like the elytra, sparsely punctate.

Body beneath colored like the body above; *abdomen* quite densely beset with fine white setae.

Legs colored like the body above, except the under surfaces of the two proximal segments of the tarsi and both surfaces of the three distal segments, which are brown, and the claws, which are red brown; the setae of the legs are white.

Last ventral segment of male sinuate on each side; lateral lobes comparatively large; median lobe short, semicircular, flat, the extreme edge sometimes slightly reflexed. The last ventral segment of the male is exactly similar to that of *A. corni,* as shown in figure 11E.

Length 4.5 mm.-5 mm.

Type locality, Orono, Maine; male designated as type deposited in the collection of the Maine Agricultural Experiment Station, Orono, Maine. *Paratypes* (which are also topotypes) deposited in the collections of the Maine Agricultural Experiment Station, Orono, Maine; of Wesleyan University, Middletown, Connecticut; of Cornell University, Ithaca, New York; and of the United States National Museum, Washington, D. C.

DESCRIPTION OF THE EGG.

Subcylindrical, irregularly elliptical; surface minutely punctate and finely sculptured, entirely divided into polygonal areas, although the sculpturing is frequently obscure; color yellow; length about 1 mm. The eggs are shown in figure 12C.

DESCRIPTION OF THE LARVA.

Description of the full grown larva. Head, legs, prothoracic, and anal shields shining black; general body color almost black, a little lighter ventrally; dorsal and lateral tubercles dull black, ventral tubercles brown; anal proleg yellow. Length 5.5 mm.

All of the other characters, such as the general structure of the body and the arrangement of setae and tubercles, are exactly the same as is described under the larva of *A. corni* (page 157).

Description of the newly hatched larva. The arrangement of the setae and tubercles is exactly the same as in the full grown larva. The tubercles are proportionately larger, and crowded more closely together, and the head is proportionately larger. Length, 1 mm.

Head measurements of larvae.

1st instar. Minimum, .29 mm.; maximum, .33 mm.; average, .31 mm. (Estimated from 30 specimens).

2nd instar. Minimum, .43 mm.; maximum, .55 mm.; average, .48 mm. (Estimated from 33 specimens).

3rd instar. Minimum, .62 mm.; maximum, .74 mm.; average, .68 mm. (Estimated from 65 specimens).

Ratio of measurements: 1.5; theoretical measurements: .31, .48 .72; actual average measurements: .31, .48, .68.

THE PUPA.

Description of just formed pupa. Bright orange yellow (not as orange as *A. bimarginata* Say); setae and spiracles dark brown, caudal spines black, appendages translucent; otherwise exactly like *A. corni* (see page 169). Length 3.5-4 mm; width 2 mm.

Description of pupa ready to transform. Dorsum of prothorax shining gray brown; metathoracic thickenings brown; eyes and antennae black; mandibles dark brown; wings and the greater part of each femur and tibia, piceous; tarsi black; coxae brown; head, between the eyes, dark brown; otherwise like the newly formed pupa. (The elytra are colorless although they appear gray as the wings lie underneath them and show through).

BIOLOGICAL HISTORY.

SUMMARY OF REARINGS.

Length of egg stage. A record which was kept of 46 eggs deposited between June 14 and July 21 inclusive, may be tabulated as follows:

5 hatched in 8 days, 5 in 9 days, 5 in 10 days, 8 in 11 days, 7 in 12 days, 6 in 13 days, 9 in 15 days, and 1 in 19 days; average 12 days.

Length of the first larval instar. A record which was kept of 71 larvae which hatched between June 22 and July 31 inclusive, may be tabulated as follows:

8 molted to the second instar in 5 days after hatching from the egg, 16 in 6 days, 20 in 7 days, 13 in 8 days, 11 in 9 days, 1 in 10 days, 1 in 11 days, and 1 in 12 days; average 7 days.

Length of the second larval instar. A record which was kept of 80 larvae which molted to the second instar between June 28 and August 8 inclusive, may be tabulated as follows:

2 molted to the third instar in 3 days after the first molt, 11 in 4 days, 32 in 5 days, 25 in 6 days, 6 in 7 days, and 4 in 8 days; average 5 days.

Length of the third larval instar. A record which was kept of 68 larvae which molted to the third instar between July 4 and August 8 inclusive, may be tabulated as follows:

5 entered soil in 4 days after the second molt, 17 in 5 days, 23 in 6 days, 12 in 7 days, 3 in 8 days, 1 in 9 days, 5 in 10 days, 1 in 11 days, and 1 in 12 days; average 6 days.

Length of the prepupal period. A record which was kept of 60 prepupae which entered the soil between July 14 and August 15 inclusive, may be tabulated as follows:

1 transformed to the pupal stage in 3 days after entering soil, 9 in 4 days, 23 in 5 days, 19 in 6 days, 4 in 7 days, 1 in 8 days, and 3 in 10 days; average 5 days.

Length of the pupal period. A record which was kept of 44 pupae which transformed between July 22 and August 22 inclusive, may be tabulated as follows:

2 emerged as adults in 6 days after the pupal molt, 10 in 7 days, 18 in 8 days, 10 in 9 days, and 4 in 10 days; average 8 days.

Typical life history. The following is cited as a typical life history: 6 eggs deposited June 20 (1917) hatched July 2; 1 molted to the second instar on July 8, 5 on July 9; 5 molted to the third instar on July 13, 1 on July 14; 3 entered soil as prepupae on July 17, 2 on July 18, and 1 on July 19; 3 transformed to pupae on July 22, emerging as adults on July 30: 3 transformed to pupae on July 23, 1 emerging as an adult on July 30, and 2 on July 31.

SEASONAL HISTORY IN MAINE.

Like the preceding species, the elm flea-beetles hibernate as adults. They pass the winter hidden away under fences or debris at the base of the elm trees, or under the loose bark on

the trunks. They come out from their winter quarters in early June, just as the elm buds are opening. The adults are not very active early in the season, and usually crawl back under the bark for protection during the night. In 1917, the writer found a few pairs on June 2, and by June 5, they were pairing commonly.

The earliest date on which the writer has found eggs in Maine is June 7 (1917) and eggs were not common until late in the month. Many beetles may be found pairing in late June and early July, but the latest date on which eggs have been deposited in the laboratory is July 15 (1917).

The earliest date on which the writer has found larvae is June 25 (1918), but a very few perhaps hatch slightly earlier. Most of the larvae are in the first instar in early July, with a few in the second instar; in mid-July, the great bulk are in the second instar, and a few in the early third; while later in the month, the great majority are in the third instar; although first instar larvae may still be found occasionally even as late as early August.

Most of the overwintering adults are dead by mid-July and the latest date to which one lived in the laboratory is August 10 (1916). The adults of the new generation begin to appear in late July (the earliest date on which one emerged in the laboratory was July 30, (1916), and are common by the tenth of August. They feed freely on the leaves during the rest of the summer and early fall, entering into hibernation at the approach of cold weather.

There is only one generation each year in Maine, although egg laying covers a very long period of time.

DISTRIBUTION.

The elm flea-beetle is common in Connecticut. The writer has also seen specimens collected in Pennsylvania by Professor Robert Matheson of Cornell University.

In Maine, the writer has noticed this species only in several localities and doubtless it is widely distributed through the state.

The Egg.

Coloration. The eggs do not as a rule show any change in color before hatching, except that the 4 black thoracic spots show through the shell about 24 hours previous to the emergence of the larva.

Where deposited. The eggs are deposited on the lower surface of the leaves of the food plant, and at least on the elm, always in the angle formed by the union of one of the secondary veins with the mid-rib. The eggs may or may not be streaked with excrement.

How many deposited. The eggs are never deposited in clusters as in the case with most flea-beetles, but only one or two are laid in any given place. This is in marked contrast to the habits of related species.

The Larva.

Hatching. The process of hatching is exactly the same as that already described for *A. corni* on page 166.

Coloration after hatching. When the larva hatches from the egg, it is bright yellow (less orange than *bimarginata)*; the legs are translucent, the setal punctures brown, and the fused tubercles v-vii-viii of the mesothorax and the metathorax are very dark brown so that the larva appears yellow with four black spots. The coloration of the newly hatched larva, which gradually becomes darker is typically that outlined below:

10 min.: head slightly blackish, tips of the tarsi black, thoracic spots black; 20 min.: abdomen somewhat darkish, tubercles brown, head decidedly blackish, tarsi blackish and the rest of the legs dark; 30 min.: prothorax blackish, as dark as the abdomen, head dark gray; 40 min. legs all gray, tubercles and prothorax gray, head almost black; 50 min.: darker, but no change in the relative coloration; 60 min.: tubercles legs and prothorax dark gray, body gray with only a faint suggestion of yellow, head shining black; 70 min.: no change; 90 min.: head, prothorax, and last joint of legs shining black; 120 min.: normal coloration.

Color description of a first instar larva, early. Head, prothoracic and anal shields, and legs shining black; general body color dull yellow; dorsal and lateral tubercles dull black brown; lateral tubercles (v-vii-viii) of mesothorax and metathorax shining black and very prominent; ventral tubercles brown; anal proleg yellow.

Color description of a second instar larva, late. Head, prothoracic and anal shields, and legs, shining black; general body color bright golden yellow, a little lighter ventrally than dorsally; dorsal and lateral tubercles black, ventral tubercles brown; anal proleg yellow.

The molt to the second instar (first molt). The molt to the second instar is exactly like that to the third instar, and is described below under that heading.

Coloration after the first molt. The coloration after the first molt is exactly the same process as that described below under the heading "coloration after the second molt."

Color description of the second instar larva, early. Head, prothoracic and anal shields, shining black; general body color very dark golden black, somewhat lighter ventrally; dorsal and lateral tubercles black, ventral tubercles brown; anal proleg yellow.

Color description of the second instar larva, late. Head, prothoracic and anal shields, and legs, shining black; general body color dark golden yellow (duller than in the late first instar), a little lighter ventrally; dorsal and lateral tubercles dull black, ventral tubercles brown, anal proleg yellow.

The molt to the third instar (second molt). A number of larvae was carefully watched while they accomplished the second molt. The first step in the process is the rupturing of the old cuticula, which splits along the mid-dorsal line of the metathorax, this crack extending forward on the mid-dorsal line of the mesothorax, the prothorax, and the Y-shaped head suture. Through the opening thus formed, the thoracic segments are arched out, the mesothorax being the first to bulge out. Within 5 minutes after the appearance of the split, the thoracic segments are well out, and in 10 or 15 minutes the head as well is free. All this is accomplished by the alternate contraction and relaxation of the body muscles. The legs are freed immediately after the head. To draw them out from the old cuticula, the body is hunched together, and then the head is thrown back suddenly as far as is possible, which results in extricating them one pair at a time, although these movements take place so rapidly that the legs seem to be withdrawn almost simultaneously. The legs are held appressed for several minutes as they are very soft when they are first drawn out, and the larva clings to the leaf only by the anal proleg. In about 5 minutes the legs are used a little to help push down the old cuticula from the abdomen, and in approximately 15 minutes after they have been withdrawn, the larva

releases the anal proleg, walks out of the old skin, and the molt is complete. This process takes about half an hour. The larva begins to feed immediately.

One can see very plainly that the invaginated portions of the ectoderm molt their chitinized linings, as well as the exposed parts. Under a binocular the molting of the intima of the fore and hind intestines and of the tracheae shows up very clearly. As is supposed to be the case with insects generally, the new setae are not formed inside of the old ones (although they are developed from the same trichogen cells) but lie flat on the body wall, between the new and old cuticulae. They spring up to the normal position as soon as they are free from the molted skin.

Coloration after the second molt. As the larva starts to walk, the body is entirely bright shining orange yellow, except for the brown setal punctures, the reddish brown mandibles, and the translucent legs. The coloration proceeds typically about as follows:

10 min.: no change; 20 min.: body slightly duller, but head, legs and prothorax unchanged; 30 min.: all three thoracic segments and the abdomen dull, head somewhat duller, legs paler; 40 min.: legs pale gray, head still yellow, thorax and abdomen blackish; 50 min.: head and prothorax duller and darker than the rest of the body, tubercles brown; 60 min.: no change; 70 min.: legs black, tubercles dark brown; 85 min.: larva darker, but no relative change; 100 min.: head and legs deep shining black; prothoracic shield dark shining brown; body dark; 115 min.: no change; 130 min.: prothoracic shield shining black; tubercles very dark brown; 150 min.: normal coloration.

Color description of the third instar larva, early. Head, prothoracic and anal shields, and legs shining black; general body color almost black (darker and duller than in early second instar), a little lighter below; dorsal and lateral tubercles dull black, ventral tubercles brown; anal proleg yellow.

Color description of the third instar larva, late. Head, prothoracic and anal shields, and legs, shining black; body dark golden yellow (darker than in late second instar), a little lighter below; dorsal and lateral tubercles dull black, ventral tubercles brown; anal proleg yellow.

Feeding habits. The larvae feed exclusively on the underside of the leaves, which they skeletonize in a very characteristic fashion. Their work is illustrated in figure 95 of bulletin 195 of this Station.

THE PREPUPA.

Formation of the prepupal cell. As is described more in detail under *A. corni* on page 168, the prepupa constructs a rude cell not far below the surface of the ground, as soon as it enters the soil.

Coloration. When the larva first enters soil as a prepupa, the head, shields, and legs are shining black, the body dark golden yellow, and the tubercles very dark brown. During prepupal life the body becomes somewhat duller at first, and the tubercles much lighter. In the late prepupa, the mesothorax and the metathorax are golden yellow above, and the general aspect of the body is golden brown above and golden yellow ventrally. All of the tubercles are light brown.

THE PUPA.

The molt to the pupa. The prepupal skin splits exactly as in the case of a larval molt, beginning at the base of the middorsal line of the metathorax. The pupa wriggles out through the opening thus formed, simply by the alternate contraction and relaxation of the somatic muscles, the head and thorax coming out first and later the abdomen. This molt requires about 50 minutes. The pupa is always formed with the ventral aspect uppermost, and it remains in this position throughout the period.

As was pointed out in the case of the alder flea-beetle (Bulletin 265, page 265), there is no homology between the larval legs and the imaginal legs. At the beginning of the molt, each leg, though fully formed, is curled up into a little pad at the base of the larval leg, but as soon as they are free from the old cuticula, they are straightened out so as lie in the position normal to the pupa. The wings and elytra lie pushed ventrad in the prepupa beneath the larval cuticula, in much the same relationship that they have in the pupa.

As is to be expected, the pupal setae lie flat on the body wall between the larval and pupal cuticulae, and do not extend up into the larval hairs. As soon as they are free from the larval cuticula they spring up into the normal position.

Color cycle. When the pupa is first formed, it is bright yellow, except for the black caudal spines, and the brown setae and spiracles. But as the pupa grows older, certain color changes appear very constantly and furnish a reliable key to the age of the pupa.

On the second day after the pupal molt, the eyes become light brown; they are a medium brown by the third day, and black by the fourth. By the fifth day, the mandibles are reddish brown, and at the same time, the wings become light gray. They become dark gray about 24 hours later.

THE ADULT.

Emergence. The emergence of the adult is exactly like the process already described for *A. corni* on page 169.

Coloration. When the beetle first emerges from the pupal cuticula, the prevailing body color is orange yellow. The eyes are black, as are also the antennae, and the parts of the legs; between the eyes the head is gray, but elsewhere it is yellowish; the labrum is yellow, the mandibles reddish brown, and the maxillae and labium black. All of the coxae are black, save the prothoracic, which are yellowish, as are all of the femora, except distally where they are piceous; the tibiae are black proximally, and the tarsi are black dorsally. There are 2 round gray spots on the pronotum. The elytra are yellow.

In about an hour the tibiae become entirely black, and the procoxae, piceous. The pronotum is gray except around the edges. The wings stretch out their full length behind, fully formed, and not wrinkled. After another hour, the scutellum is brown, and by four hours the elytra while still soft begin to have a greenish iridescence. In 5 hours, the pronotum is entirely dark, with greenish reflections. In 6 hours, the beetle is almost normally colored dorsally, and the ventral surface begins to show signs of coloration. The beetle is very soft when it is first formed, and it remains in the pupal cell for about 24 hours, or until it is fully colored and hardened.

Feeding habits. The adults feed very freely both in the spring and fall on the leaves of their food plants. They eat holes through the leaf, so that their work is as characteristic as, and very different from, that of the larvae. Their work on elm

leaves is shown in figure 94 of Bulletin 195 of this Experiment Station.

Mating. As is usual with chrysomelid beetles, each female pairs several times during the season, before she has finished depositing all of her eggs.

Number of eggs deposited by one female. These beetles do not thrive in confinement as well as most flea-beetles do, and the number of eggs deposited under laboratory conditions is probably somewhat smaller than the number normally deposited under natural conditions. The greatest number of eggs that was deposited by any one female was 181 between June 11 and July 15 (1917). The greatest number laid by one beetle in 24 hours was 17.

FOOD PLANTS.

Natural food plants. The only plant on which the writer has ever found this species in the field is the white elm, *Ulmus americana L.* But in the laboratory, the larvae, especially, ate with more or less readiness a surprisingly large number of other plants.

FOOD-PLANTS OF THE ADULT ELM FLEA-BEETLE.*

(i) Eaten readily.
White elm, red elm, basswood.

(ii) Eaten indifferently.
Cultivated willow, heart-leaved willow, petiolate willow, beaked willow, wild strawberry, cultivated strawberry, wild rose, cultivated rose, Japanese rose, fireweed, low blueberry.

(iii) Refused.
Aspen poplar, balsam poplar, sweet fern, hazel, gray birch, alder, red oak, syringa, smooth gooseberry, European gooseberry, cultivated spiraea, apple, mountain ash, choke cherry, red cherry, wild plum, cultivated plum, sugar maple, woodbine, marsh fireweed, evening primrose, red osier dogwood, bunchberry, sheep laurel, lilac, Joe Pye weed, grape (1).

*For the scientific names of the plants used in these tests, see page 171.

FOOD PLANTS OF THE LARVA OF THE ELM FLEA-BEETLE.

(i) Eaten readily.
White elm, red elm, basswood.

(ii) Eaten indifferently.
Corn, hazel, red oak, European gooseberry, mountain ash, shad bush, wild strawberry, cultivated strawberry, wild rose, cultivated rose, Japanese rose, choke cherry, red cherry, wild plum, cultivated plum, bean, fireweed, marsh fireweed, evening primrose, panicled dogwood, bunchberry, low blueberry, tomato.

(iii) Refused.
Cultivated willow (!), heart-leaved willow, aspen poplar, balsam poplar, sweet fern, gray birch (!), alder (!), syringa, cultivated spiraea, apple, red currant (!), woodbine, red osier dogwood (!), sheep laurel, lilac, Joe Pye weed.

NATURAL ENEMIES.

Fungous diseases. This species is susceptible to the same fungous diseases as *A. corni* (see page 173).

Insect enemies. But two species of insects have been found preying upon the elm flea-beetle, one a parasitic and the other a predaceous form.

The writer has bred a single specimen of *Celatoria spinosa* Coquillet from an adult elm flea-beetle. This is the same species which he has bred in considerably larger numbers from *A. corni* (see page 173).

The nymphs of one of the large soldier bugs *(Podisus modestus)* were found feeding on the larvae of this flea-beetle in Orono during the summer of 1917. Neither of these insect enemies was found in sufficient abundance so that they would appear to be of much effect in controlling the species.

CONTROL.

Same as for *A. corni* (see page 173).

BIBLIOGRAPHY.

Johannsen, Oskar Augustus, and Patch, Edith M. 1911. Maine Agricultural Experiment Station. Bulletin 195, p. 233-234. Figs. 94-95. (*Haltica carinata* as an elm leaf pest).

ALTICA TORQUATA LE CONTE, THE BLUEBERRY FLEA-BEETLE.

TECHNICAL DESCRIPTION OF THE STAGES.

DESCRIPTION OF THE ADULT.

Elongate oval, convex; *body above* brilliant cupreous with metallic reflections; *antennae* cupreous, becoming more or less piceous distally; segments 1-3 nearly smooth, the others (especially the distal ones) quite densely pubescent with fine whitish setae: slightly less than one-half the length of the body, and considerably less than twice the width of the prothorax at its base; segments 2-3-4 successively longer: segment 4 about two and one-half times as wide as long: segment 10 not more than twice as long as wide, frequently less; *eyes* black, their width as seen from the front less than one-half the interocular distance; *frontal carina* moderately prominent, acute; *frontal tubercles* moderately large, almost contiguous; *vertex* not punctate; *width of head* across eyes a little more than two-thirds that of the prothorax at its widest point.

Prothorax about two-thirds wider than long; margin narrow, thickened at the basal and apical angles; base but little wider than the apex, regularly arcuate caudad; sides nearly parallel at the base, convergent at the apex; basal angles subacute, prominent; apical angles rounded; surface alutaceous, comparatively finely and closely punctate; *ante-basal groove* shallow and incomplete.

Elytra (across umbones) one-fourth wider than the base of the prothorax; each elytron three times as long as wide, and slightly more than twice as long as the width of the base of the prothorax; surface minutely alutaceous, comparatively coarsely but densely punctate; humeral angles rounded; umbo scarcely prominent; post-humeral depression slight.

Scutellum colored like the elytra, sparsely punctate.

Body beneath colored like the body above, with strong greenish reflections; abdomen quite densely beset with fine white setae.

Legs colored like the body; claws red brown, pulvilli light brown; setae white; the femora of the hind legs are especially large, even for an *Altica*.

Last ventral segment of male sinuate each side; lateral lobes small, median lobe short, semicircular, flat, with a sharply defined impressed median line running about half the length of the segment.

Length, 5 mm.

Figure 12H is reproduced from the photograph of a beetle of this species. The last ventral segment of the male is shown in figure 11F.

DESCRIPTION OF THE EGG.

Subcylindrical, irregularly elliptical; surface minutely punctate and finely sculptured, entirely divided into polygonal areas, though the sculpturing is frequently obscure; color orange, length about 1 mm. The eggs are shown in figure 12D.

DESCRIPTION OF THE LARVA.

Description of the full grown larva. Head, legs, prothoracic and anal shields shining black; genral aspect dark brown or almost black; tubercles dull black; anal proleg orange. Length 6 mm.

All of the other characters, such as the general structure of the body and the arrangement of the setae and tubercles, are exactly the same as is described under the larva of the dogwood flea-beetle, page .

Description of the newly hatched larva. The arrangement of the setae and tubercles is exactly the same as in the full grown larva. The tubercles are proportionately larger and crowded more closely together, and the head is proportionately larger. The setae are all clearly capitate. Length 1.5 mm.

Head measurements of the larvae.

1st instar. Minimum, .31 mm.; maximum, .35 mm.; average, .33 mm. (Estimated from 9 specimens.)

2nd instar. Minimum, .46 mm.; maximum, .54 mm.; average, .50 mm. (Estimated from 16 specimens.)

3rd instar. Minimum, .69 mm.; maximum, .75 mm.; average, .72 mm. (Estimated from 23 specimens.)

Ratio of measurements: 1.5; theoretical measurements: .33, .50, .75; actual average measurements: .33, .50, .72.

THE PUPA.

Description of just formed pupa. Bright orange (more orange than that of the alder flea-beetle); setae and spiracles dark brown, caudal spines black, appendages translucent; otherwise exactly like that of the dogwood flea-beetle (see page 160). Length 4.5 mm.

Description of the pupa ready to transform. Dorsum of prothorax grayish brown; metathoracic thickenings brown; eyes and antennae black; mandibles dark brown; wings dark gray; legs more or less piceous; otherwise like the newly formed pupa. (The elytra are colorless, although they appear gray as the wings lie underneath them and show through.)

BIOLOGICAL HISTORY.

SUMMARY OF REARINGS.

Length of the egg stage. The eggs are deposited in the summer, but do not hatch until the following spring.

Length of the first larval instar. A record which was kept of 9 larvae which hatched between June 1 and June 4 inclusive, may be tabulated as follows:

6 molted to the second instar in 4 days after hatching from the egg, 2 in 5 days, and 1 in 6 days; average 4.5 days.

Length of the second larval instar. A record which was kept of 31 larvae which molted to the second instar between June 1 and June 5 inclusive, may be tabulated as follows:

1 molted to the third instar in 2 days after the first molt, 15 in 3 days, 14 in 4 days, and 1 in 5 days; average 4 days.

Length of the third larval instar. A record which was kept of 36 larvae which molted to the third instar between June 4 and June 11 inclusive, may be tabulated as follows:

13 entered soil in 3 days after the second molt, 5 in 4 days, 9 in 5 days, 8 in 7 days, and 1 in 8 days; average 5 days.

Length of the prepupal period. A record which was kept of 79 prepupae which entered the soil between June 9 and June 28 inclusive, may be tabulated as follows:

10 transformed to pupae in 5 days after entering soil, 8 in 6 days, 35 in 7 days, 10 in 8 days, 15 in 9 days and 1 in 12 days; average 7 days.

Length of the pupal period. A record which was kept of 61 pupae which transformed between June 15 and July 2 inclusive, may be tabulated as follows:

30 emerged as adults in 10 days after the pupal molt, 20 in 11 days, 6 in 12 days, 3 in 13 days, 1 in 14 days and 1 in 16 days; average 11 days.

Typical life history. The following is cited as a typical life history: 4 eggs deposited in July (1916) hatched June 1 (1917); 1 molted to the second instar on June 5, 2 on June 6, and 1 on June 7; 1 molted to the third instar on June 8, 1 on June 9 and 2 on June 10; 1 died during third instar, 1 entered the soil as a prepupa on June 12, and 2 on June 15; 1 transformed to a pupa on June 18, emerging as an adult on June 29; 1 transformed on June 21, emerging on July 2, and 1 transformed on June 21, emerging on July 3.

SEASONAL HISTORY IN MAINE.

Unlike the other flea-beetles of our fauna, which hibernate as adults, the blueberry flea-beetle passes the winter in the egg

stage, and the writer has no data which would indicate that the beetles ever live over the winter.

The larvae hatch in the spring before the buds are fully expanded, and feed on the opening buds, so that they do great damage if abundant. The writer has taken a few larvae well along in the second instar even as early as June 1, so it is evident that some of the eggs hatch as early as May 24. The majority of larvae hatch in early June, and by the twentieth most of them are in the last instar; very few larvae can be found after the first of July.

The pupal period is passed in the soil and is somewhat longer than that of related species. The first adult beetle bred in the laboratory emerged June 25, and the writer has taken none as early in the field, so this must represent about the earliest date on which they appear. It is 10 days or 2 weeks after emergence before they begin to pair, and several days later before eggs are deposited. The first eggs were deposited in the laboratory on July 12 (1917), and the last on August 16, (1917). The great bulk of eggs is deposited in late July or very early August.

Adults may be taken quite commonly until well into September, but the writer has seen no indication that the beetles ever survive the winter. There is only one generation each season.

Distribution.

The blueberry flea-beetle is widely distributed in Maine, and the writer has taken specimens in Orono, Ellsworth, Cherryfield, and York County. Ordinarily this species is uncommon or rare in the state, but periodically it occurs in great abundance, especially on the blueberry barrens of Washington County, and when it is present in any considerable numbers, is capable of great damage, since it feeds on the opening blossoms, and consequently the attacked bushes bear no fruit. This beetle was increasingly common in 1914 and 1915, and was locally very abundant in 1916; the larvae were common in 1917, but there were very few beetles later in the summer, and no specimens were taken in Orono in 1918, nor were any complaints received of the work elsewhere in the state up to the time this bulletin went to press.

The writer has seen no specimens of this beetle in collections which he was sure were this species outside of the Maine material. But as Le Conte's description was based upon Kansas material, it is probably quite widely distributed through the United States.

THE EGG.

Where deposited. The writer has never succeeded in finding the eggs of this species in the field; but they are probably deposited on the ground at the base of the plants. In the laboratory, the beetles have almost invariably laid their eggs in the cheese cloth on the bottom of the rearing cages, and after careful searches in the field, no eggs were found on the twigs.

The habits of the larvae would tend to confirm this view, for the newly hatched grubs are very uneasy, and wander around several hours before they settle down to feeding.

How many deposited. The eggs are never deposited in clusters (so far as laboratory observations indicate), but are laid either singly or in little groups of 2 or 3.

THE LARVA.

Hatching. The process of hatching was not observed in this species.

Coloration after hatching. The larvae are entirely yellow orange when they hatch from the egg, with the same four black spots on the thorax (dorsal portion of fused tubercles v-vii-viii of the mesothorax and the metathorax) characteristic of the flea-beetles. The larva becomes fully colored in about 2 hours.

Color description of the first instar larva, early. Head, prothoracic and anal shields, and legs shining black; dorsal tubercles dull black, ventral tubercles brown; general aspect dark brown, or almost black above, and dark golden brown ventrally; anal proleg yellow.

Color description of the first instar larva, late. Head, prothoracic and anal shields, and legs, shining black; all tubercles brown; body above dark golden brown, lighter ventrally; anal proleg yellow.

The molt to the second instar (first molt.) The process of molting is the same in all of the flea-beetles studied, and is described in detail under the second molt of the elm flea-beetles (page 188).

Coloration after the first molt. The coloration after the first molt is exactly the same as that described below under the heading "coloration after the second molt."

Color description of the second instar larva. The second instar larva, both early and late, is colored exactly like the third instar larva.

The molt to the third instar (second molt). The process of molting is the same in all of the flea-beetles studied and is described in detail under the second molt of the elm flea-beetle (see page 188).

Coloration after the second molt. When the larva molts from the second instar to the third, it is entirely bright orange yellow at the time of the molt, including head, legs, and shields. The cuticula gradually becomes pigmented, and the normal coloration is attained about 2 hours after the larva has shed its skin.

Color description of the third instar larva, early. Head, legs, prothoracic and anal shields shining black; all of the tubercles dull black; general aspect dark brown or almost black above, scarcely lighter ventrally; anal proleg yellow.

Color description of the third instar larva, late. Head, legs, prothoracic and anal shields shining black; all of the tubercles brown; general aspect dark golden brown above, lighter ventrally; anal proleg yellow.

Feeding habits. The larvae feed voraciously on the opening buds and flowers of the blueberry, and later on the leaves. When they are abundant they can cause severe losses, as they destroy the blossoms and hence preclude the possibility of the plant setting fruit. Even when they do not sterilize the blossoms, they so injure the vitality of the plants that such berries as are produced are small and sour. Unlike the larvae of most flea-beetles, they do not skeletonize the leaves, but eat holes through them or eat out irregular notches in the sides.

THE PREPUPA.

Formation of the prepupal cell. As soon as the prepupa enters the soil, it constructs a rude cell not far below the surface of the ground. The formation of the cell is discussed in more detail under the dogwood flea-beetle (page 168).

Coloration. The color fades out during the prepupal, and in the late prepupa, the tubercles are dull brown, and the general aspect of the body is golden brown dorsally, and golden ventrally.

THE PUPA.

The molt from the prepupa to the pupa. This molt is accomplished in the same way in all flea-beetles, and is described in detail under the elm flea-beetle on page 190.

Color cycle. The pupae of the blueberry flea-beetle pass through a series of color changes correlated with the progress of internal metamorphosis, as do the other chrysomelids which the writer has studied.

On the fifth day of pupal life, the eyes become light brown, dark brown on the sixth, and black on the seventh. The mandibles also turn reddish brown, usually on the sixth day. Forty-eight hours before emergence the wings appear very light gray, and dark gray about 24 hours previous.

There is of course some variation as to the time in which these characters appear, but the appearance and sequence of these pigmentations is perfectly constant.

THE ADULT.

Emergence. The process of emergence is the same in all of the flea-beetles studied, and is described in detail under the dogwood flea-beetle on page .

Coloration. The adult when just emerging from the pupa is entirely yellow, except that there are grayish spots on the pronotum, the antennae are piceous, and the legs are black at the femero-tibial joints. The body is very soft. In 6 hours the legs, head, elytra and pronotum are light gray and the antennae black. In 9 hours the beetle is almost normally colored above, but the ventral side has not yet become pigmented to any considerable extent. The normal coloration and hardness are not attained for about 24 hours after emergence and the beetle does not leave the pupal cell until that time.

Feeding habits. The adult beetles feed very voraciously on the leaves of the blueberry as soon as they have emerged, and continue feeding all summer. The character of their work is shown in figure 13C. They soon strip the bushes of their leaves and may do considerable damage.

Mating. As is usual among chrysomelids, the beetles remain in copulation several hours, and each female pairs several times before she finishes oviposition.

Number of eggs deposited by one female. The writer has no very trustworthy data as to the number of eggs which one female is able to deposit, for the beetles do not thrive in the laboratory. No individual which he has isolated has deposited more than 25 eggs, but this is doubtless far below the normal capacity. The writer would guess that the normal would approximate that of the elm flea-beetle (about 200), rather than that of the more prolific dogwood flea-beetle (about 600).

FOOD PLANTS.

Natural food plants. The only plant on which the writer has ever taken this species in the field is the low blueberry, *Vaccinium pennsylvanicum* Lam. Neither the adults nor larvae will eat the closely related velvet-leaf blueberry, *V. canadense* Kalm. A number of laboratory tests to determine the possible range of food plants is recorded below.

FOOD PLANTS OF THE ADULT BLUEBERRY FLEA-BEETLE.*

(i) Eaten readily.
Low blueberry.

(ii) Eaten indifferently.
Red oak.

(iii) Refused.
Corn, cultivated willow, heart-leaved willow, aspen, balsam poplar, cotton-wood, sweet fern, hazel, gray birch, alder, red elm, white elm, syringa, smooth gooseberry, European gooseberry, red currant, cultivated spiraea, apple, mountain ash, shad bush, wild strawberry, cultivated strawberry, wild rose, cultivated rose, Japanese rose, choke cherry, wild red cherry, wild plum (!), cultivated plum, bean, sugar maple, woodbine, basswood, fireweed, marsh fireweed, evening primrose, red osier dogwood, panicled dogwood, bunchberry, sheep laurel, velvet-leaf blueberry (!), lilac, tomato, Joe Pye weed.

FOOD PLANTS OF THE LARVA OF THE BLUEBERRY FLEA-BEETLE.

(i) Eaten readily.
Low blueberry.

(ii) Eaten indifferently.
Red oak, wild plum.

(iii) Refused.

*For the scientific names of the plants used in these tests see page 171.

Shad bush, wild rose, cultivated rose, red currant, velvet-leaf blueberry (!).

NATURAL ENEMIES.

Fungous diseases. This species is susceptible to the same fungous diseases as the dogwood flea-beetle (see page 173).

Insect enemies. The writer has not yet taken any predaceous insects preying upon this species, nor bred any parasites from any of the stages.

CONTROL.

The writer has not had occasion to make any experiments in the control of this species, but there seems no reason to doubt that it can be controlled by spraying with arsenate of lead at the ordinary strength (6 pounds, paste form, to 100 gallons of water) wherever it is practicable to apply this remedy. The first application should be made in early June for the larvae, and if necessary, a second between the 10th and 15th of July for the adults.

It is only on the extensive blueberry barrens of the state that this species appears in sufficient numbers to cause appreciable damage, and here the very nature of the land and its remoteness from the towns, makes spraying and similar methods of control practically out of the question.

Without doubt the practice of burning the barrens periodically keeps this as well as other insects (notably the blueberry maggot) in check, as it seems perfectly certain that the eggs, whether deposited on the ground as the writer suggested or on the bushes, would be killed by the fire. If it were noted some summer that the beetles were especially abundant on any given area of the barrens, it would probably be well to burn over that area the following spring for the sake of destroying the eggs, even if that particular section would not normally be burned over in the regular rotation.

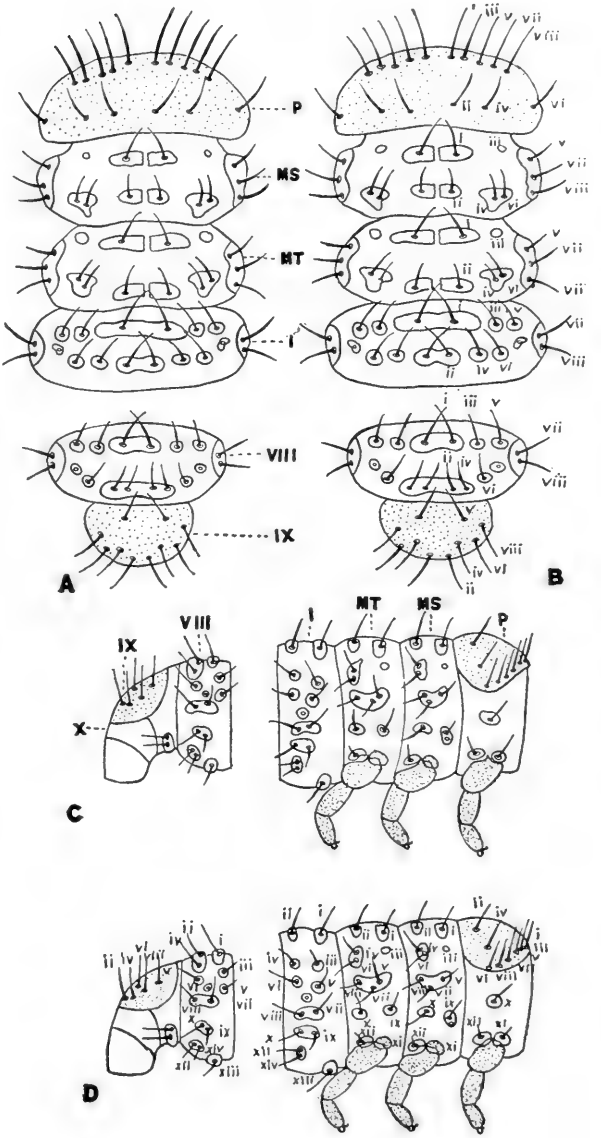

Figure 10. *Altica corni.* A, dorsal aspect of larva, showing setae and tubercles; B, same with setae numbered; C, lateral aspect of larva; D, same with setae numbered. For explanation see pages 157-158.

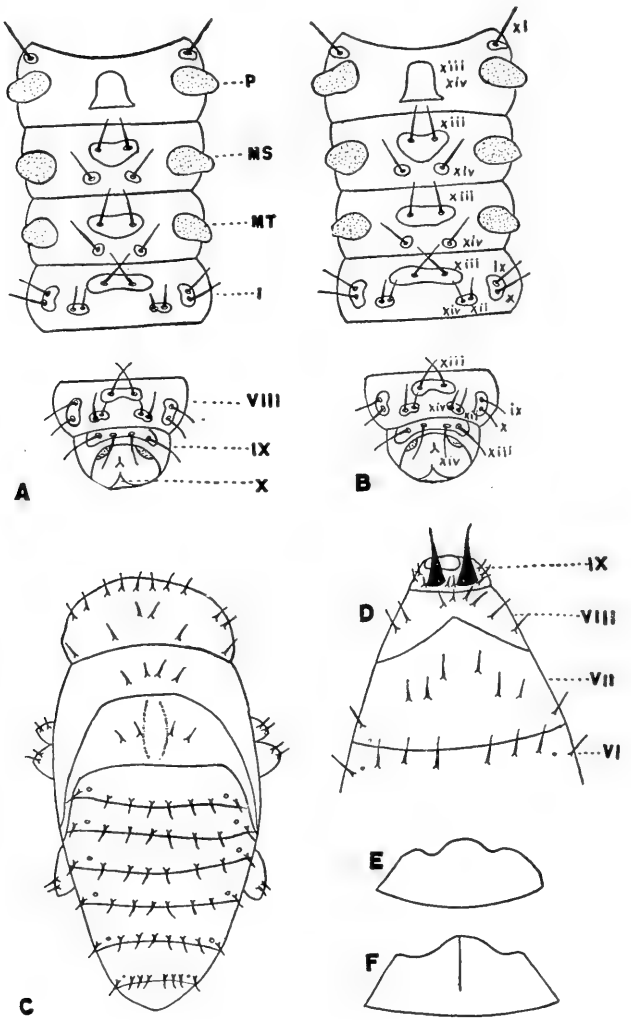

Figure 11. A-E, *Altica corni;* F, *Altica torquata* Lec. A, ventral aspect of larva; B, same with setae numbered; C, dorsal aspect of pupa; D, dorsal aspect of tip of abdomen of pupa; E, last ventral segment of male; F, last ventral segment of male.

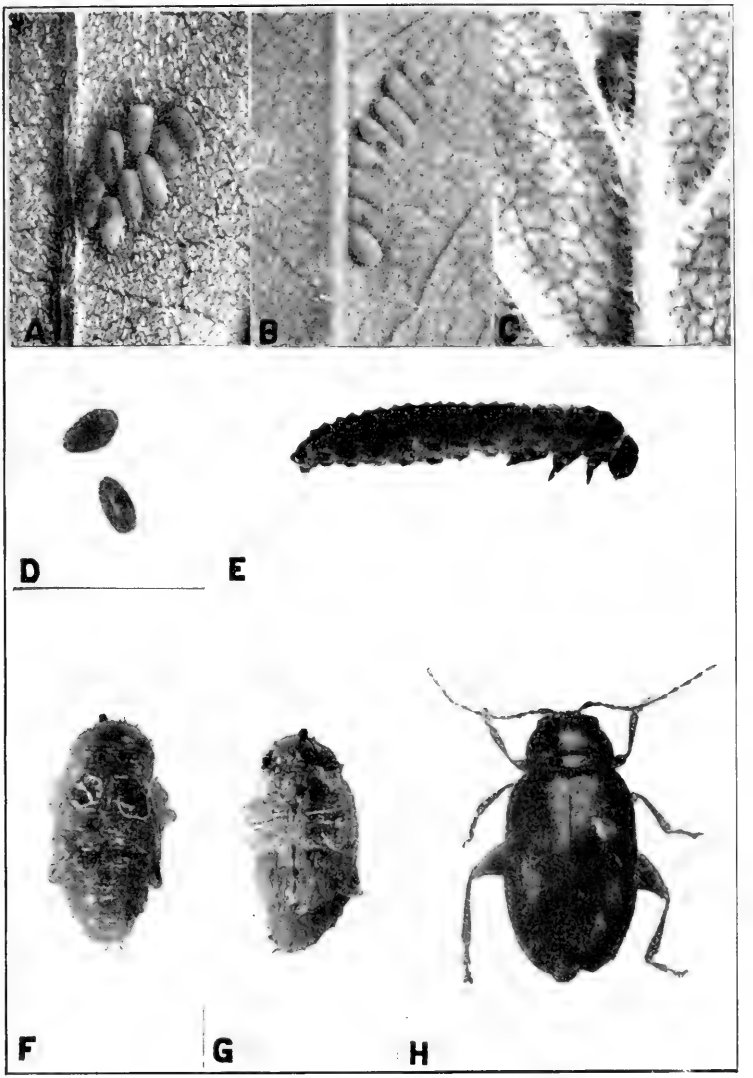

Figure 12. a, eggs of *A. corni;* b, eggs of *A. rosae;* c, eggs of *A. ulmi;* d, eggs of *A. torquata;* e, larva of *A. corni;* f, pupa of *A. ulmi,* dorsal aspect; g, pupa of *A. ulmi,* ventral aspect; h, adult of *A. torquata.*

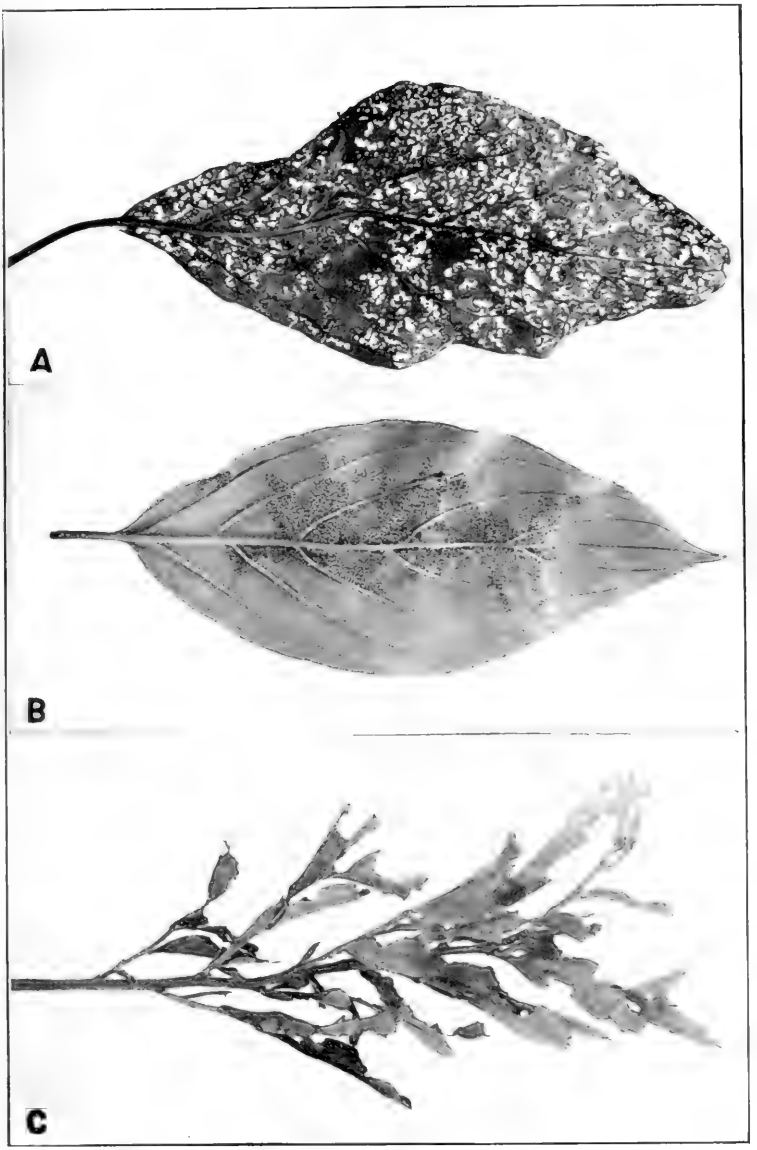

Figure 13. a, work of adult *A. corni;* b, work of larvae of *A. corni;* c, work of adult *A. torquata.*