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STUDY OF THE MORPHOLOGY OF *ALTICA FRAGARIAE* (NAKANE) (COLEOPTERA: CHRYSOMELIDAE: ALTICINAE), WITH FIRST DESCRIPTIONS OF THE LARVAE AND PUPAE

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Abstract.—*Altica fragariae* (Nakane) (Coleoptera: Chrysomelidae: Alticinae) is an oligophagous insect whose host plants are Rosaceae. It is distributed in China and Japan. The first descriptions of the larvae and pupae and detailed morphological study of the eggs and adult are presented. Illustrations and descriptions are provided for the morphology of the adult, larva, pupa, and egg. Additionally, the taxonomic history, distribution, and biological notes of the species are reviewed, including associations with host plants and laboratory studies. Comparisons are made with the other species of *Altica* Geoffroy. The main differences between *Altica fragariae* and other species of *Altica* are the morphology of male and female genitalia, punctures of the pronotum in the adult, color, body length, and chaetotaxy of the larvae and pupae. Sensilla of the antennae and the setae of the tarsus of males and females are discussed.

Key Words: *Altica fragariae* (Nakane), morphology, egg, larvae, pupae, adult, biology

Altica fragariae (Nakane) belongs to the genus *Altica* Geoffroy (Coleoptera: Chrysomelidae: Alticinae). The genus *Altica* was established by Geoffroy in 1762, the type species is *Chrysomela oleracea* Linnaeus, 1754, from Sweden. It is a large genus of flea beetles with over 300 known world species (Konstantinov and Vandenberg 1996). Among them, 28 species are distributed in China, and six of them are endemic species. The classification of this genus is not easy because of their similar color and morphology.

There have been several important works on Chinese species of *Altica*, including Ogloblin (1921, 1925), Chen (1936), Ohno (1960), Gressitt and Kimoto (1963), Scherer (1969), Lopatin (1977), Chen and Wang (1981), Wang (1992, 1996), and Gruev and Döberl (1997). There also have been some studies on the morphology of *Altica*, such as Kangas and Rutanen (1993), Konstantinov (1987, 1998, 2002), Konstantinov and Lopatin (1987), Lee and Furth (2000), and LeSage and Denis (1999). *Altica fragariae* was first described by Nakane from Japan in 1955 and was placed in the genus *Haltica*. There are also some studies by Ohno (1960), Kimoto (1966), Wang (1996), Guo et al. (1996), and Wang et al. (2005), but there are no detailed morphological study on this species.

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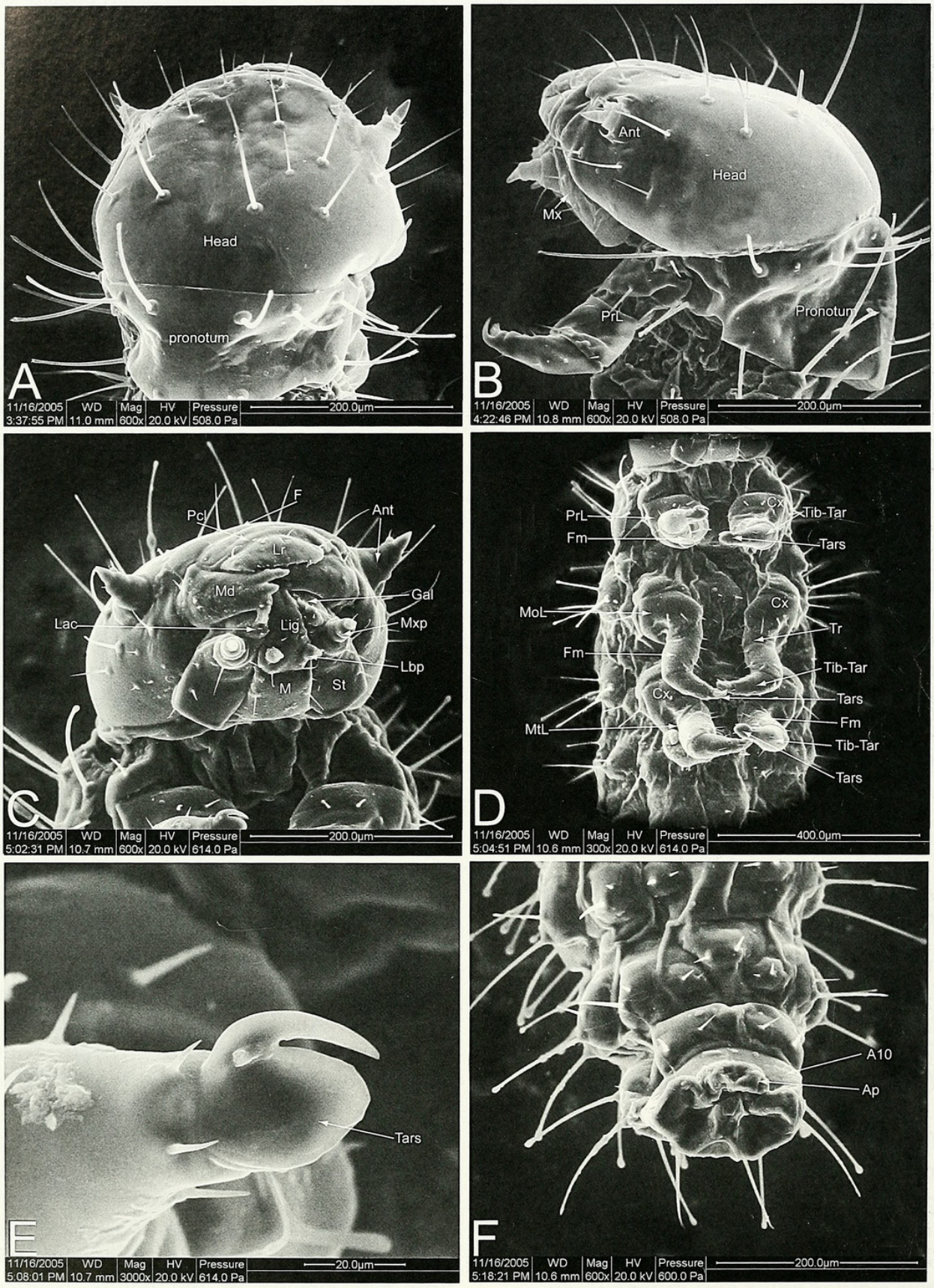


Fig. 1. *Altica fragariae*: first instar larva. A, Drosal view of head. B, Lateral view of head. C, Frontolateral view of head. D, Ventral of thorax. E, Apex of foreleg. F, Ventral view of apical abdomen. Abbreviations: A10: Abdominal segment 10; Ap: Anal plate; Ant: Antennae; Cx: Coxae; F: Frons; Fm: Femur; Gal: Galea; Lac: Lacinia; Lbp: Labium palpi; Lig: Ligula; Lr: Labrum; M: Mentum; Md: Mandible; MoL: Mesoleg; MtL: Metaleg; Mx: Maxillae; Mxp: Maxillary palpi; Pcl: Post clypeus; PrL: Proleg; St: Stipe; Tars: Tarsungulus; Tib-Tar: Tibia-Tarsus.

Concerning the larvae and pupae, very little work have been done. LeSage et al. (2004) gave a thorough introduction to the history of the North America species from Riley (1870) to Lawson (1991). LeSage et al. (2004) also gave a detailed descriptions of larvae, eggs, and pupae of *Altica chalybea* Illiger and *A. woodsi* Isely, and compared the differences between these two species. The only treatment for China is Kimoto and Takizawa (1995) who described the larvae of *Altica birmanensis* Jacoby, *A. caerulescens* (Baly), *A. cyanea* (Weber), *A. cirsicola* Guérin-Méneville, *A. coerulea* (Olivier), *A. japonica* Ohno, and *A. himalayensis* (Chen) from Taiwan.

In this paper, a morphological study of eggs, larvae, pupae, and adults of *Altica fragariae* is presented, including illustrations and descriptions. Distribution and biological notes also are given. Further study of the functional morphology should be done to explain differentiation of the morphology as related to the differentiation of their feeding habits.

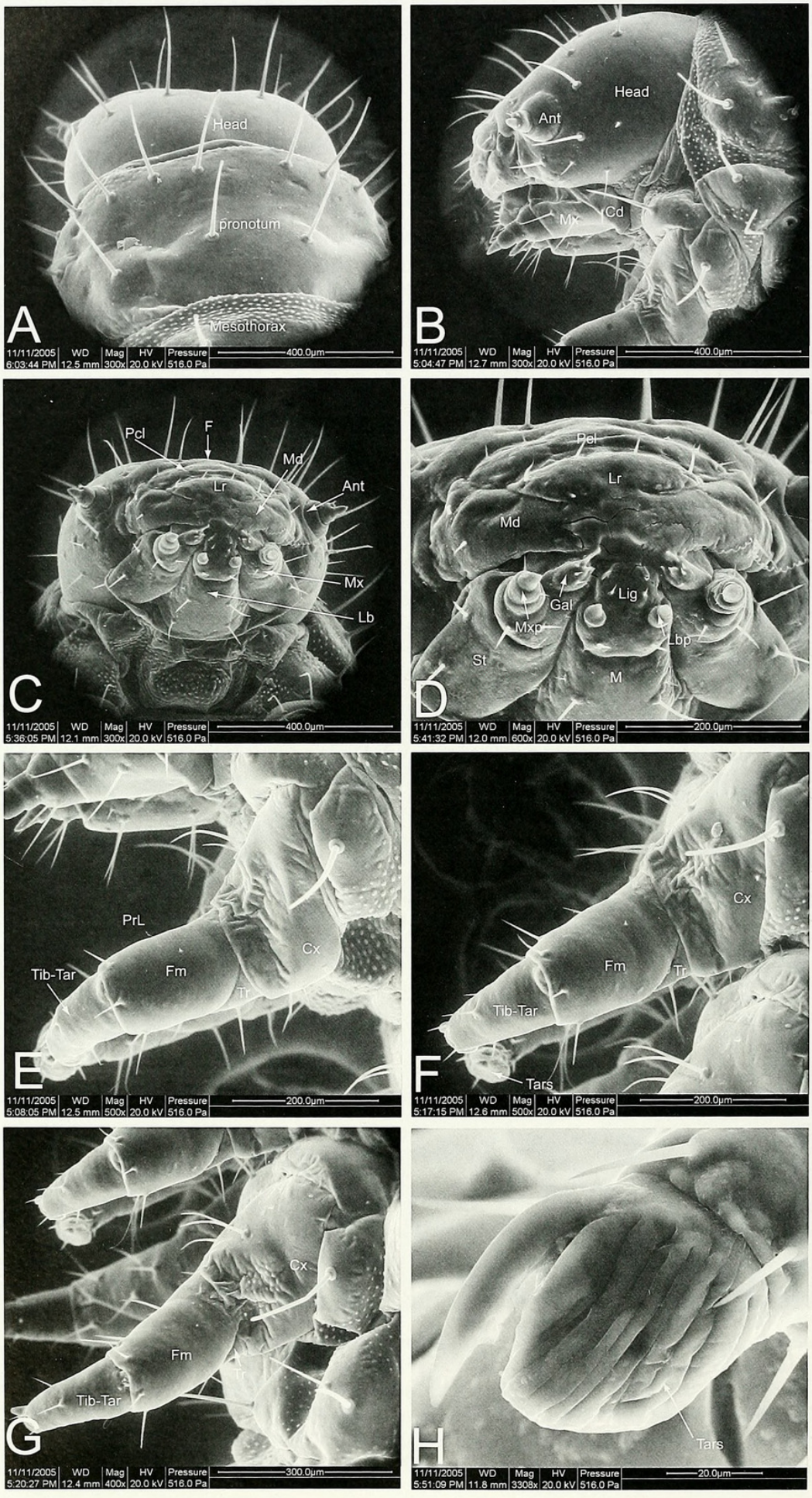
Distribution

Altica is distributed throughout the world. Among them, 28 species occur in China, and six of them are endemic species. *Altica fragariae* is mainly distributed in China, Russia, Korea, and Japan. In China, it is recorded from Jilin, Beijing, Shandong, Jiangsu, Hunan, Hubei, Fujian, and Guizhou. They are always on the forest floor at altitudes less than 800 m.

Biological Notes

Altica fragariae is an oligophageous species of flea beetle. Based on field observations by Wang et al. (2005), *A. fragariae* feeds on *Agrimonia pilosa* Ledeb., *Potentila flagellaris* Willd. ex Schlecht, *Geum aleppicum* Jacq., and *Fragaria ananassa* Duchesne besides its primary host plant, *Duchesnea indica* (Andrews) Focke. All belong to the family Rosaceae. Based on our field observations, *Altica fragariae* is the predominant population among the species of *Altica* in the mountainous region of Beijing. It lives in shady, moist, and concealed conditions of the forest floor. Adults and larvae always live on the underside of the leaves and are difficult to find. Females deposit eggs singly or more usually in clusters on the underside of leaves, usually along the central and tributary veins, and occasionally along leaf edges. Normally, they prefer to oviposit on the more withered and yellow last two leaves at the bottom of the host plants. Females consistently smear each egg with a thin layer of excrement, but its biological significance is not known. Philips (1977a, 1997b) suggested that the smear contains a deterrent to arthropod predators or parasites. The first two instars of the larvae feed on the underside of the leaves, and the veins and upper surface are left intact. The third-instar larvae and adults also feed on the underside of the leaves, making the leaf surface appear as a sieve.

This species usually completes two or three generations per year in Beijing and with an overlap of generations. Overwintering adults emerge in early spring and are first observed on the host plants in mid-March, after which a period of feeding, and mating occurs. Oviposition is in May; after about 7–14 d the first-instar larvae hatch. There are three larval instars each lasting about seven days. Before winter, the overwintering adults burrow about three to five cm below the dead wood and dead leaves for hibernation. We observed a few adults in late October. In addition, the beetle overwinters with noticeable aggregation behavior. We have found a big group of thousands of hibernating individuals gathered in about one square meter of dead leaves in early spring. As a result, feeding damage was often


A
Head
pronotum
Mesothorax
11/11/2005 6:03:44 PM WD 12.5 mm Mag 300x HV 20.0 kV Pressure 516.0 Pa 400.0µm
B
Head
Ant
Mx
Cd
11/11/2005 5:04:47 PM WD 12.7 mm Mag 300x HV 20.0 kV Pressure 516.0 Pa 400.0µm
C
Pcl
F
Md
Lr
Ant
Mx
Lb
11/11/2005 5:36:05 PM WD 12.1 mm Mag 300x HV 20.0 kV Pressure 516.0 Pa 400.0µm
D
Pcl
Lr
Md
Gal
Lig
Mxp
Lbp
St
M
11/11/2005 5:41:32 PM WD 12.0 mm Mag 600x HV 20.0 kV Pressure 516.0 Pa 200.0µm
E
PrL
Cx
Tib-Tar
Fm
Tr
11/11/2005 5:08:05 PM WD 12.5 mm Mag 500x HV 20.0 kV Pressure 516.0 Pa 200.0µm
F
Cx
Fm
Tr
Tib-Tar
Tars
11/11/2005 5:17:15 PM WD 12.6 mm Mag 500x HV 20.0 kV Pressure 516.0 Pa 200.0µm
G
Cx
Fm
Tib-Tar
11/11/2005 5:20:27 PM WD 12.4 mm Mag 400x HV 20.0 kV Pressure 516.0 Pa 300.0µm
H
Tars
11/11/2005 5:51:09 PM WD 11.8 mm Mag 3308x HV 20.0 kV Pressure 516.0 Pa 20.0µm

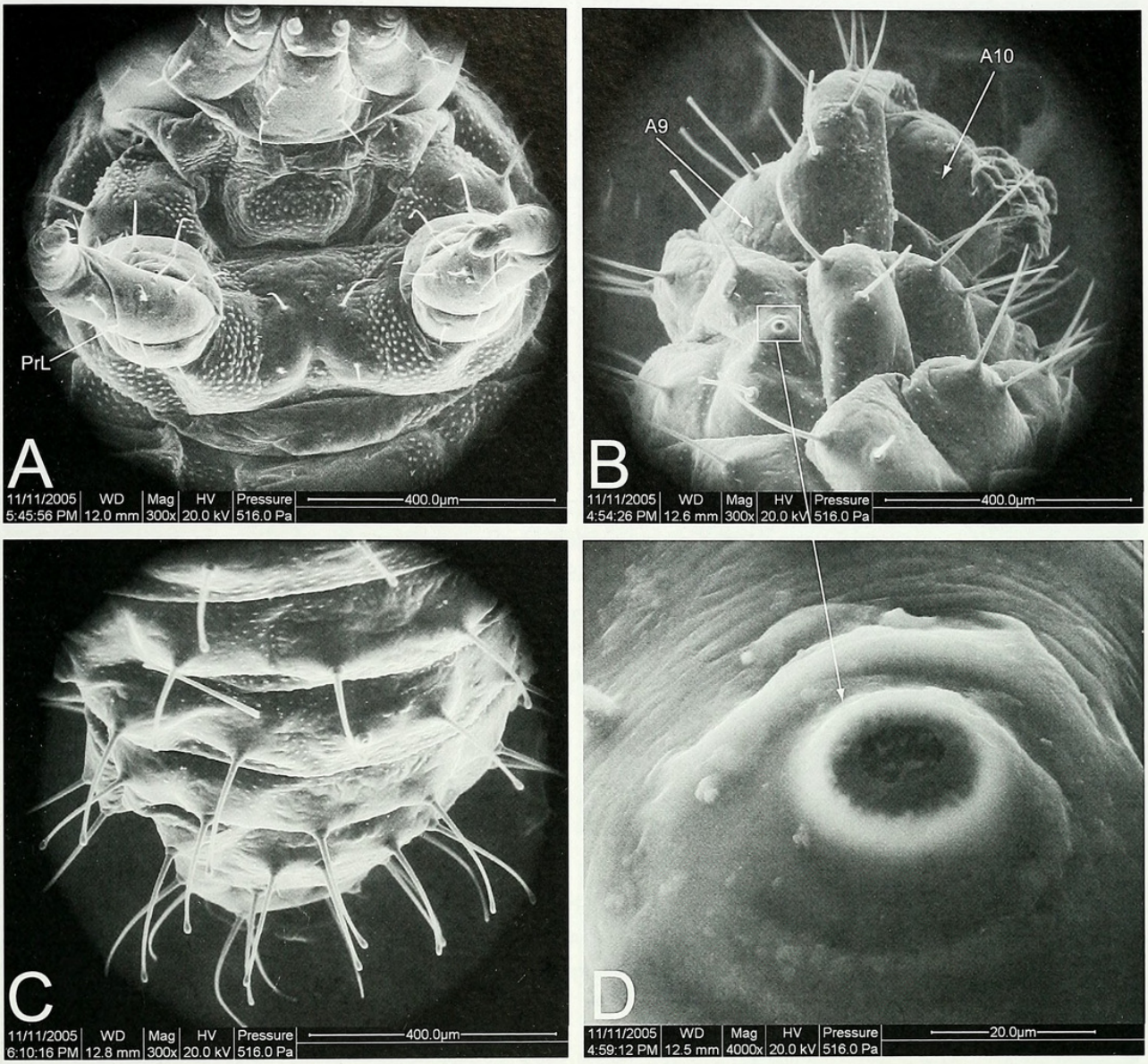


Fig. 3. *Altica fragariae*: mature larva. A, Ventral view of prothorax. B, Lateral view of apical segment of abdomen. C, Dorsal view of apical segments of abdomen. D, Spiracle. Abbreviations: A9: Abdominal segment 9; A10: Abdominal segment 10; PrL: Proleg.

localized by post-hibernating adults in spring.

Material and Methods

All stages of *Altica fragariae* are described. Ten individuals of each stage were observed, each three times.

All specimens were collected in Badaling Forestry Centre (40.3°N, 116.0°E), Beijing, China in June and July, 2005, and were reared in 12 × 11.5 cm glass jars with sand on the bottom and with host plants. Fresh leaves were added every day and wilted leaves removed.

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Fig. 2. *Altica fragariae*: mature larva. A, Dorsal view of head. B, Lateral view of head. C, Frontal view of head. D, Mouthpart. E, Proleg. F, Mesoleg. G, Metaleg. H, Apex of proleg. Abbreviations: A10: Abdominal segment 10; Ap: Anal plate; Ant: Antennae; Cd: Cardo; Cx: Coxae; Fm: Femur; Gal: Galea; Mx: Maxillae; F: Femur; Lac: Lacinia; Lig: Ligula; Lr: Labrum; Md: Medible; MoL: Mesoleg; MtL: Metaleg; Mxp: Maxillary palpi; St: Strip; M: Mentum; Lbp: Libium palpi; Pcl: Post clypeus; PrL: Proleg; Fm: Femur; Tr: Trochanter; Tib-Tar: Tibia-Tarsus; Tars: Tarsungulus.

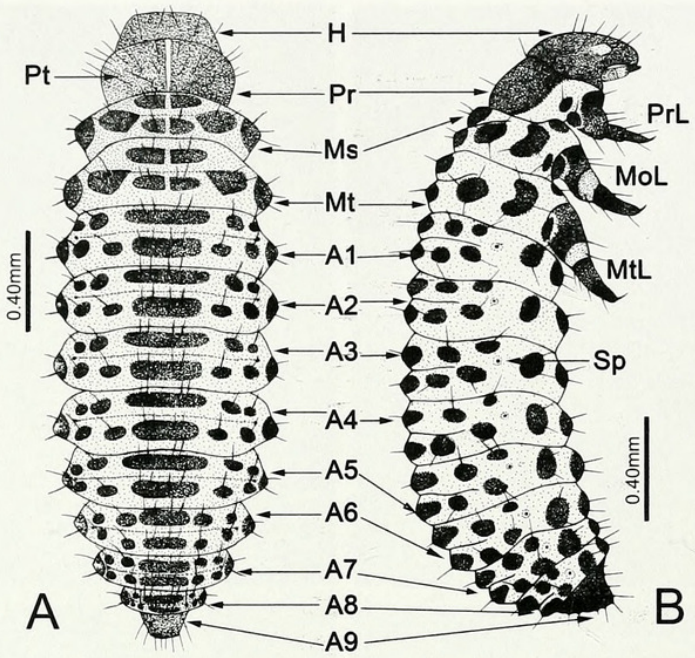

Fig. 4. *Altica fragariae*: mature larva. A, Habitus, dorsal view. B, Habitus, lateral view. Abbreviations: A1, A2, A3, A4, A5, A6, A7, A8, A9: Abdominal segment 1, 2, 3, 4, 5, 6, 7, 8, 9; Ant: Antenna; H: Head; Mol: Mesoleg; Ms: Mesothorax; Mt: Metathorax; MtL: Metaleg; Pr: Pronotum; Pt: Prothorax; PrL: Proleg; Sp: Spiracle.

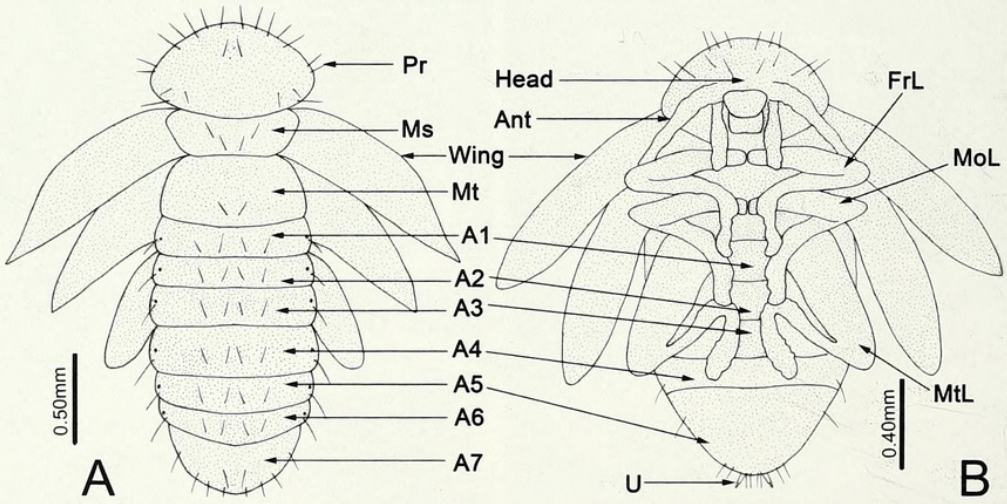

Fig. 5. *Altica fragariae*, Pupa. A, Habitus, dorsal view. B, Habitus, ventral view. Abbreviations: A1, A2, A3, A4, A5, A6, A7: Abdominal segmenets 1, 2, 3, 4, 5, 6, 7; FrL: Foreleg; MoL: Mesoleg; MtL: Metaleg; Ms: Mesothorax; Mt: Metathorax; Pr: Pronotum; U: Urogomphi.

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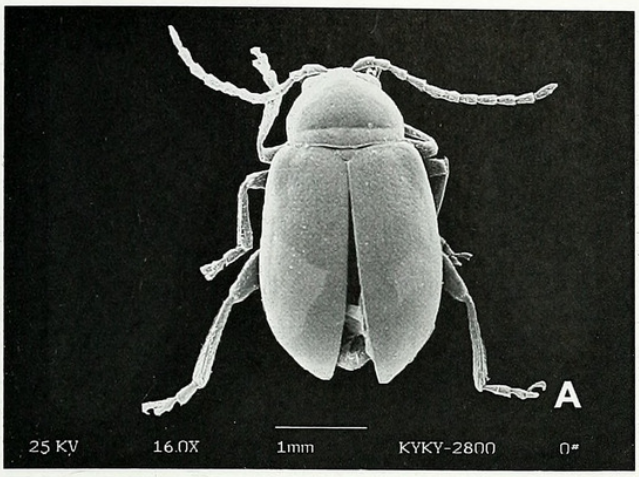
Fig. 6. *Altica fragariae*, adult. A, Habitus, dorsal view. B, Habitus, lateral view. C, Frontal view of head. D, Lateral view of head. E, Eyes. F, Partial view of eyes. G, Pronotum. H, Posterior setigerous pore of pronotum. Abbreivations: An: Antennae; Clp: Clypeus; E: Eye; Fls: Frontolateral sulcus; Ft: Frontal tubercle; Lb: Labium; Lbr: Labrum; Md: Mandible; Mfs: Midfrontal sulcus; Mx: Maxilla; Ors: Orbital sulcus; S: Setae; Scs: Supracallinal sulcus; Sfs: Suprafrontal sulcus; Sos: Supraorbital sulcus; Sp: Setigerous pore.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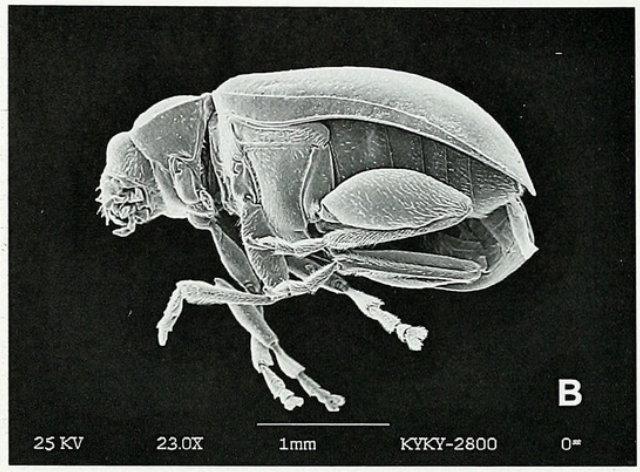
B
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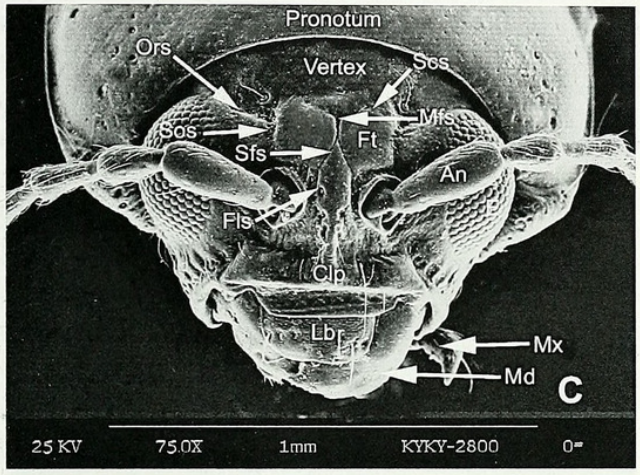
Pronotum
Ors
Vertex
Scs
Mfs
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C
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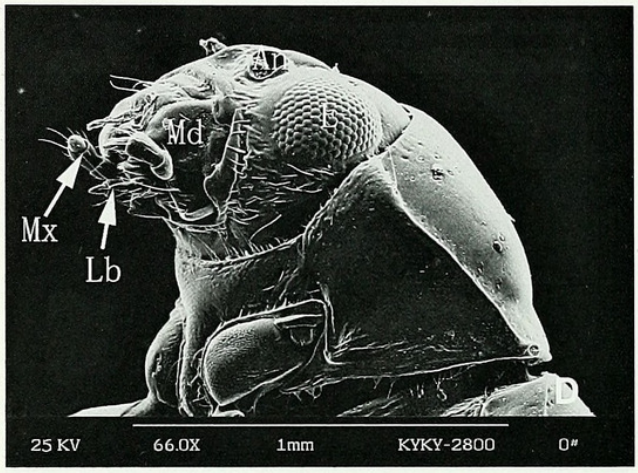
Md
Mx
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D
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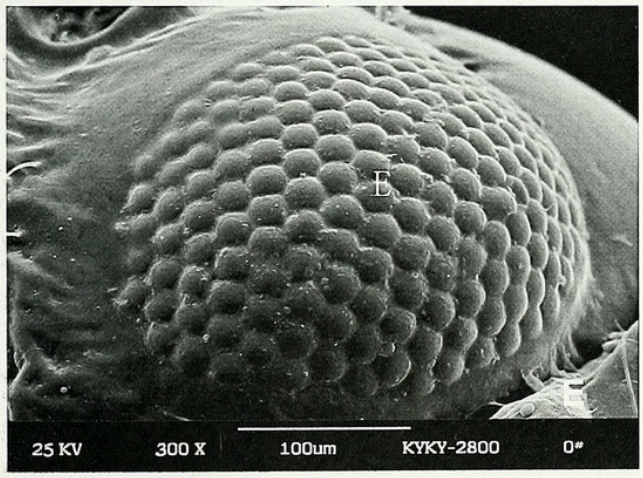
E
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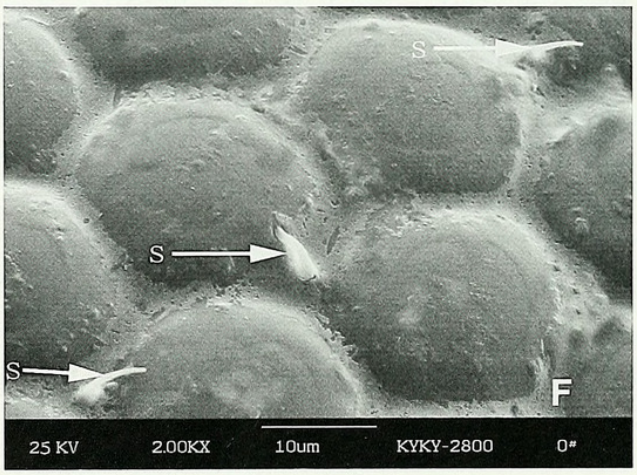
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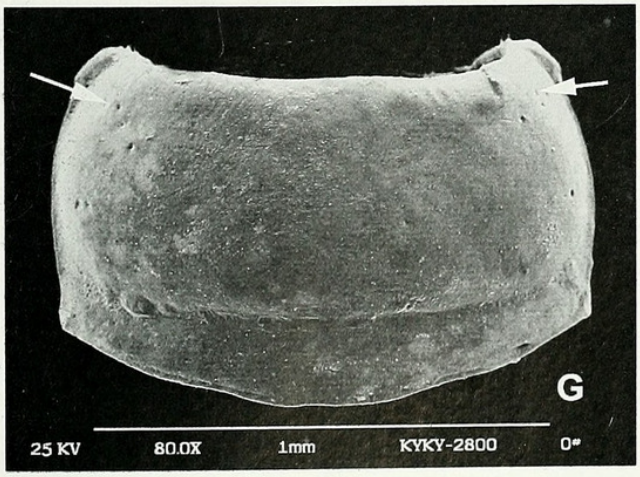
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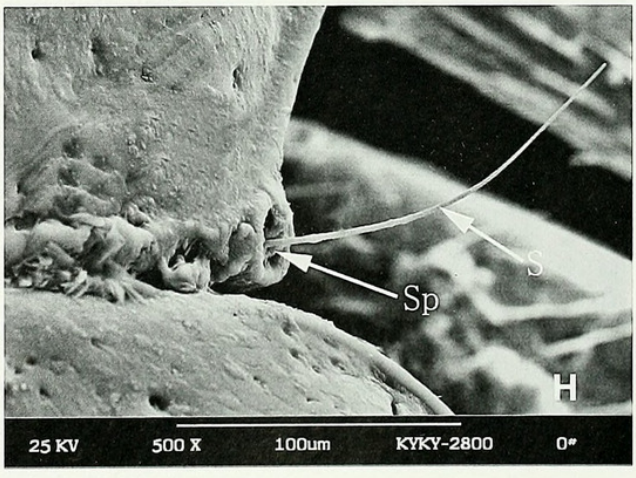
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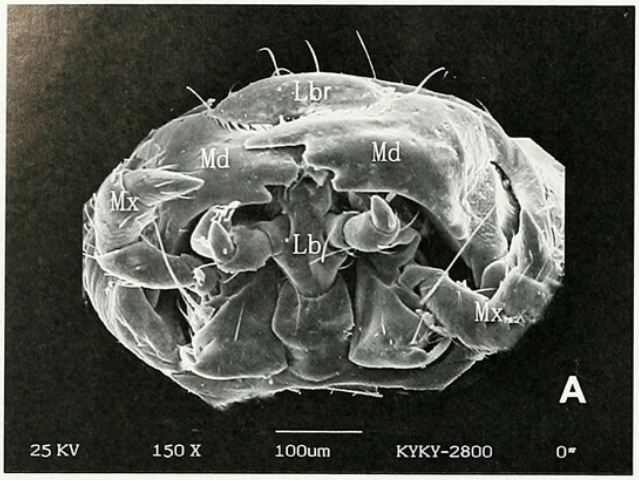
Lbr
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A
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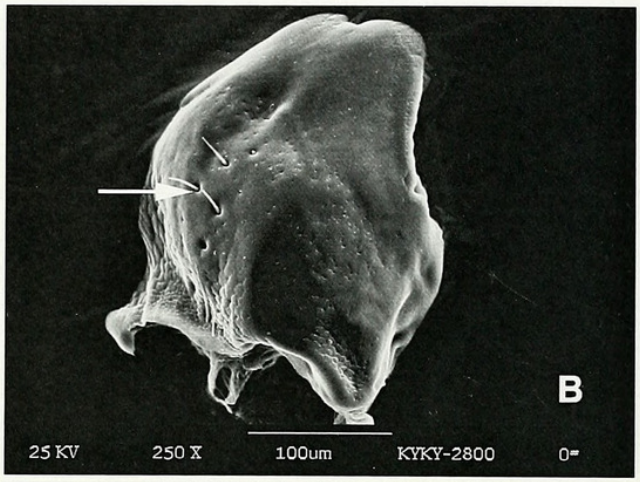
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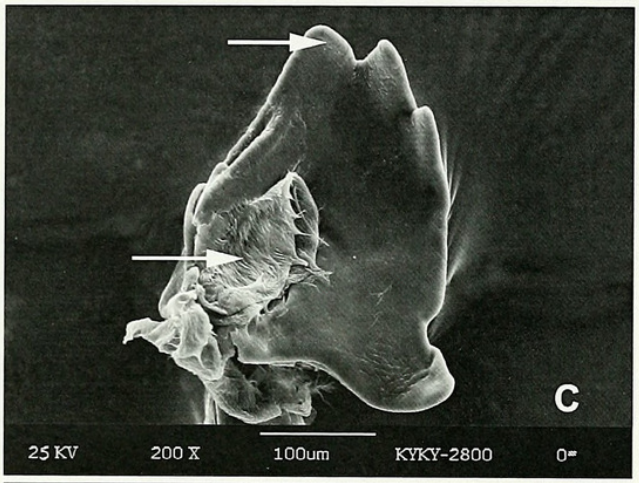
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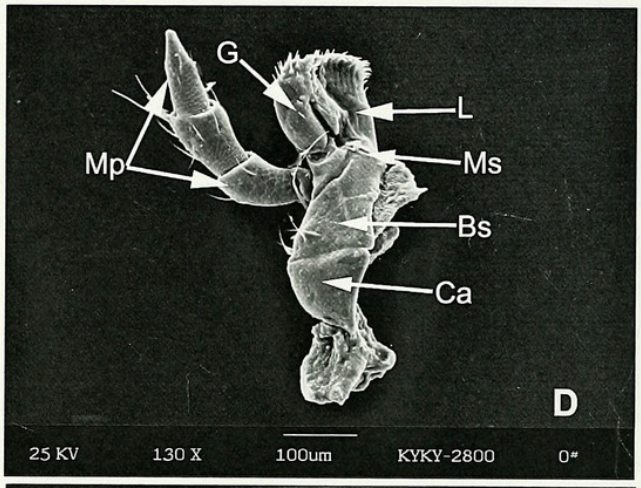
G
L
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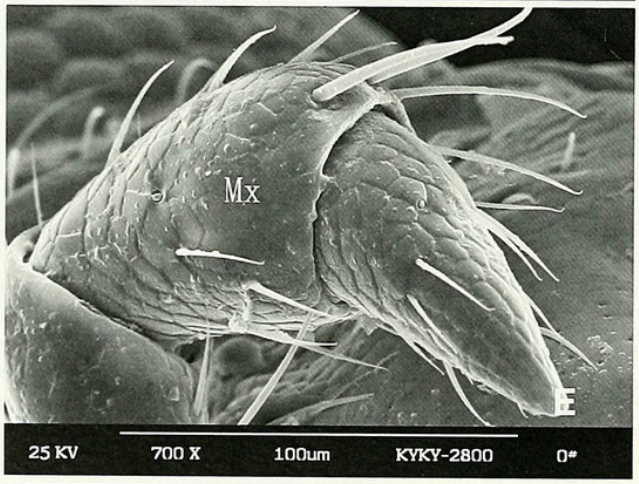
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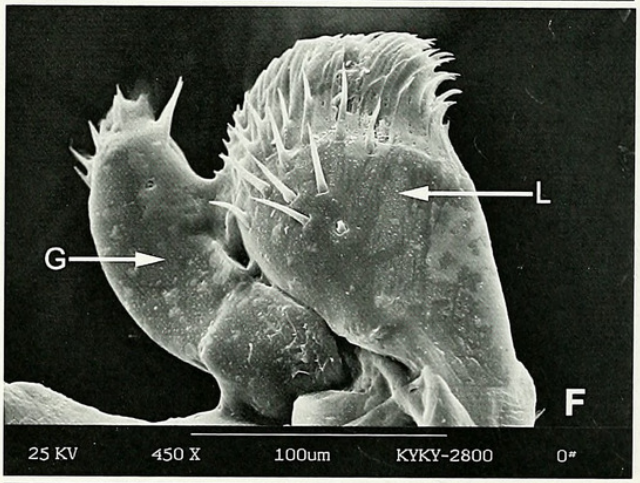
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G
F
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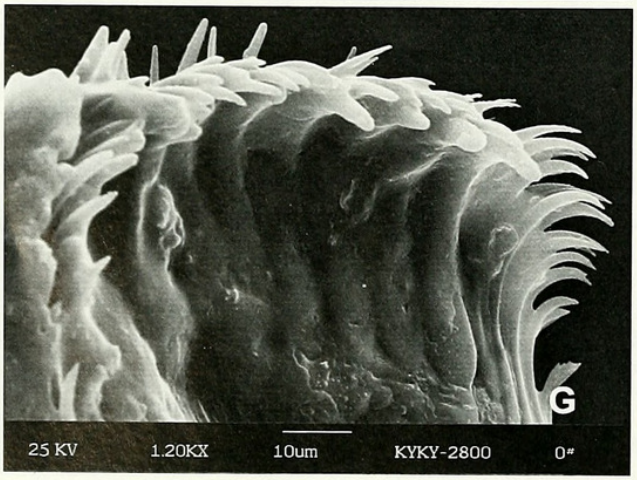
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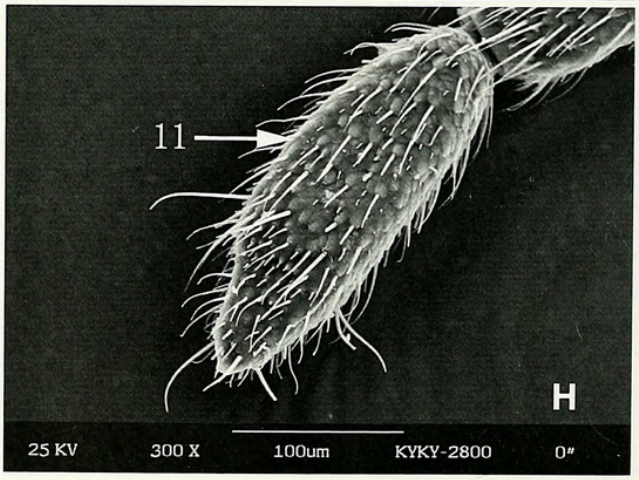
11
H
25 KV 300 X 100um KYKY-2800 0#

Jars were kept closed except when adding leaves and removing dead materials. Rearing was at 25°C, 16: 8 LD, and 80% humidity. Intervals of egg laying and eclosion, different instars, and pupation were recorded.

Adults were dissected and stored in pure alcohol, and some put in a 10% solution of potassium hydroxide for study of the head, mouthparts, and internal skeleton. All materials, including adults and larvae, were put into an ultrasonic cleaner before studying them under the SEM. Adult samples were dehydrated in different percentages of alcohol followed by air drying and gold-sputter coating. Specimens were photographed with a KYKY 2800 SEM. Larvae were transferred directly from pure alcohol onto an SEM-stub and into the microscope with XL20 ESEM-TMP without prior fixation or coating at low vacuum. This technique gave a much better result than the traditional method of fixation and gold-sputter coating. However, because larvae degrade rapidly, they should not be removed from alcohol until immediately before study under the microscope. They can be retrieved and stored again in alcohol after being studied. In order to study the mandibles that are normally covered by the clypeus and labrum, we removed them from the larvae by dissection in alcohol. In the SEM microscope, we photographed the front, lateral, and dorsal views of the larval head, and closeups of the anterior view of the mouthparts and legs. Drawings of the skeleton were made with a camera lucida on a Leica MZ 125. For the female genitalia a Zeiss Axioplan microscope and AnalySIS® software were used. All pictures were evaluated and assembled with Adobe Photoshop® CS 8.0 and Illustrator® CS software.

The terminology follows Suzuki (1988, 1994), Konstantinov and Vandenberg (1996), Cox (1998), and Cox et al. (1999).

The specimens studied are deposited in Institute of Zoology, Chinese Academy of Sciences, Beijing, P. R. China (IZAS).

Description of Eggs, Larvae and Pupae

Egg (Figs. 11G, H).—*Color:* Usually yellowish. *Morphometrics*: Length: 0.48–0.52 mm, width: 0.20–0.23 mm. *Form*: Cylindrical, rounded at both apices (Fig. 11G), widest at middle and narrowing towards base and micropyle region (narrowest below micropyle region), sometimes symmetrical, apex flattened, with a shell and strip of excrement on surface, and with many air holes and some separated irregular polygon loops (Fig. 11H).

Eggs are laid in star-shaped clusters perpendicular to the substrate with end opposite the micropyle affixed to the back of the leaves.

First-instar larva (Fig. 1).—*Shape:* Eruciform. *Color:* Living specimens dark yellowish; alcohol specimens deep dark yellowish. *Morphometrics:* Length: 0.08–0.12 mm.

The morphology of first-instar larva is similar to the mature larva. We do not give a detailed description, but illustrate the morphology to show the basic morphological features.

Mature larva (Figs. 2–4).—*Habitus*: Eruciform (Figs. 4A, B); slightly curved when preserved.

Color: Living specimens bright yellow, sclerites dark. Alcohol specimens dark yellow, with head, pronotum, legs, and

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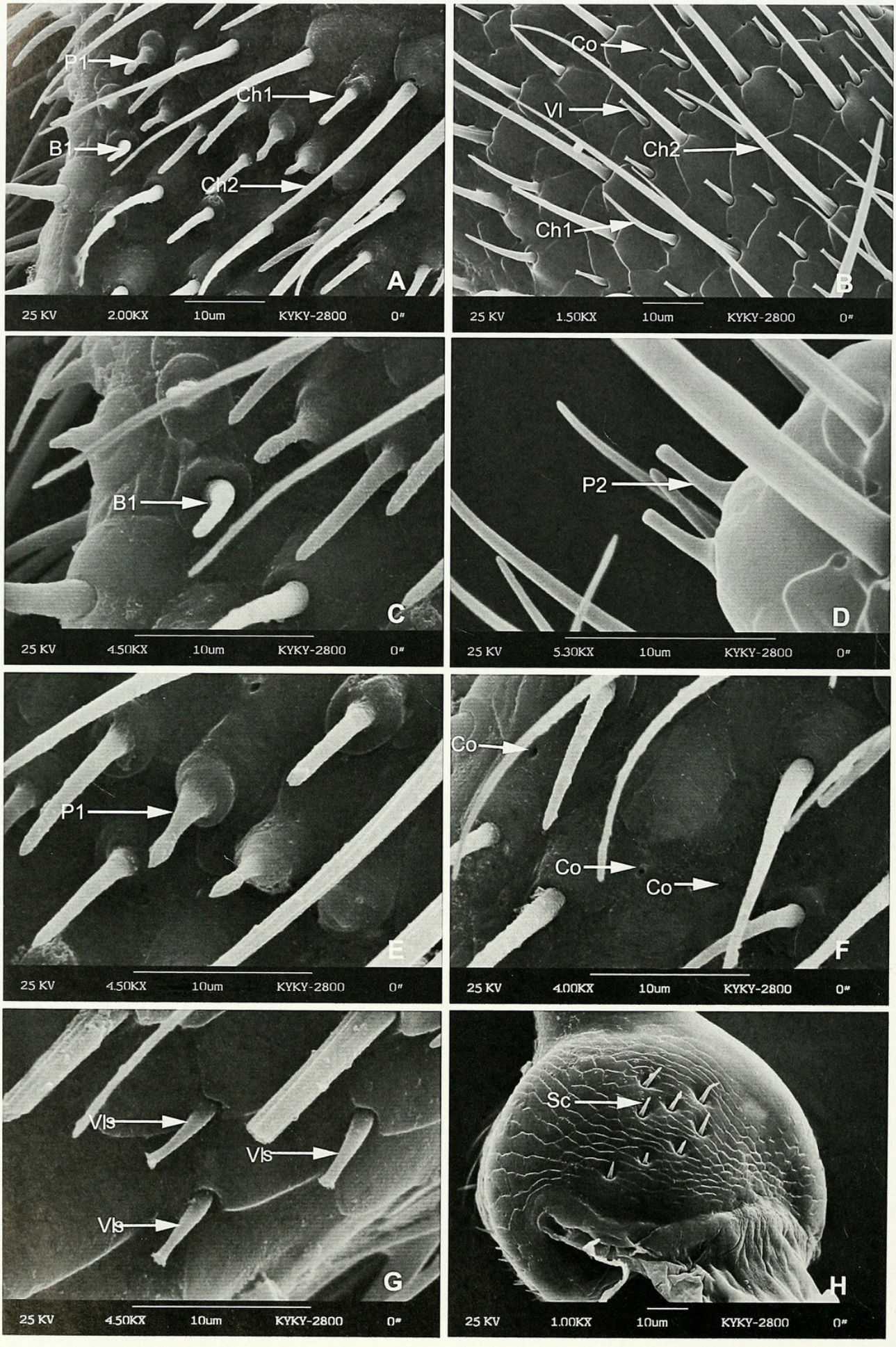
Fig. 7. *Altica fragariae*, adult. A, Ventral view of mandible. B, Dorsal view of maxillae. C, Ventral view of mandible. D, Ventral view of Maxilla. F, Ventral of lacinia and galea. G, Setae of lacinia. H, Apical segment of antennae. Abbreviations: G: Gelea; L: Lacinia; Lb: Labium; Lbr: Labrum; Md: Mandible; Mp: Maxillary palpi; Mx: Maxilla.


P1
Ch1
B1
Ch2
A
25 KV 2.00KX 10um KYKY-2800 0°
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25 KV 1.50KX 10um KYKY-2800 0°
B1
C
25 KV 4.50KX 10um KYKY-2800 0°
P2
D
25 KV 5.30KX 10um KYKY-2800 0°
P1
E
25 KV 4.50KX 10um KYKY-2800 0°
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Co
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Vls
Vls
Vls
G
25 KV 4.50KX 10um KYKY-2800 0°
Sc
H
25 KV 1.00KX 10um KYKY-2800 0°

sclerites dark brown. *Morphometrics:* Length: 3.70–4.05 mm.

Head: Rounded, hypognathous, heavily sclerotized; Y-shaped, bowing outwards towards antennal sockets (Figs. 2A, B). Epicranial stem short; endocarina robust, extending from base of frontal arms to clypeus. Frons bearing 5 pairs of long setae (4 dorsal, 1 ventrolateral) and 1 pair of sensory pores close to frontal suture. Vertex highly convex, each epicranial half bearing 3 long setae (2 dorsal, 1 ventrolateral) and 2 sensory pores along with endocarina. Stemmata absent. Antenna 2-segmented (Fig. 2B); antennal socket pronounced, located at ends of frontal arms; basal segment partially membranous bearing 2 sensory pores (1 ventral, 1 dorsal), membranous area bearing 2 peglike sensilla dorsally; distal segment conical, slightly sclerotized basally. Postclypeus (Figs. 2C, D) transverse, edges rounded laterally, bearing 2 pairs of sensilla and 1 pair of scamiform setae. Labrum (Figs. 2C, D) transverse, sclerotized, lateral edges rounded, with pronounced anterior median invagination; dorsal surface bearing 2 pairs of long setae and 1 pair of sensory pores; anterior margin bearing 2 pairs of stout pedunculate setae laterally and 1 pair of short setae medially. Epipharynx with central apical patch of microtrichia grouped in a short transverse row, 1 sensillum lateral to microtrichia, and 3 patches of campaniform sensilla (each composed of 5 sensilla) in a straight longitudinal line (each composed of 3 sensilla) in a straight longitudinal line. Mandibles (Figs. 2C, D) symmetrical, robust, 5-toothed, dentae 1 and 2 bearing small serrations; external face bearing 2 prominent setae and 1 sensory pore; penicillus formed of a single row of diagonally oriented thickened setae; mola absent. Maxilla (Figs. 2C, D) with cardo transverse, highly sclerotized bearing 2 short seta laterally; stipes elongate with two sclerotized areas, one basal bearing 1 lateral and 1 ventrolateral seta and 1 sensory pore anterior to ventrolateral seta and mesad to lateral seta, other sclerotized area smaller near palp bearing 1 seta verntrally; mala with lightly sclerotized basal area bearing 1 seta ventrally, highly sclerotized apex with 8 setae arranged in a circle around 1 stout pedunculate seta (appearing 2-segmented), dorsally bearing straight longitudinal row of long stout setae; maxillary palp 3-segmented, first segment bearing 2 ventromesal and 1 dorsolateral sensory pore, second segment bearing 1 dorsal and 1 ventrolateral seta and 2 ventral sensory pores, distal segment bearing 1 dorsal seta and 2 sensory pores and 1 seta ventrally. Labium (Figs. 2C, D) with submentum sclerotized, basal portion clearly melanized, bearing ventrally 2 pairs of long median setae and 1 short seta at each ventrolateral corner; mentum lightly sclerotized, bearing 2 well-developed and 1 sensory pore on each side; labial palp 2-segmented, basal segment with 2 ventromedial sensory pores and 2 ventrolateral setae, distal segment with 1 ventrolateral sensory pore, 2 lateral setae (hidden in a groove), and 1 lateral elongate placoid sensillum. Hypopharynx heavily covered with microtrichia; apically bearing 2 campaniform sensilla, 2 short setae, and 1 peglike sensillum, entire array forming a circle on ingestion surface. Gula absent.

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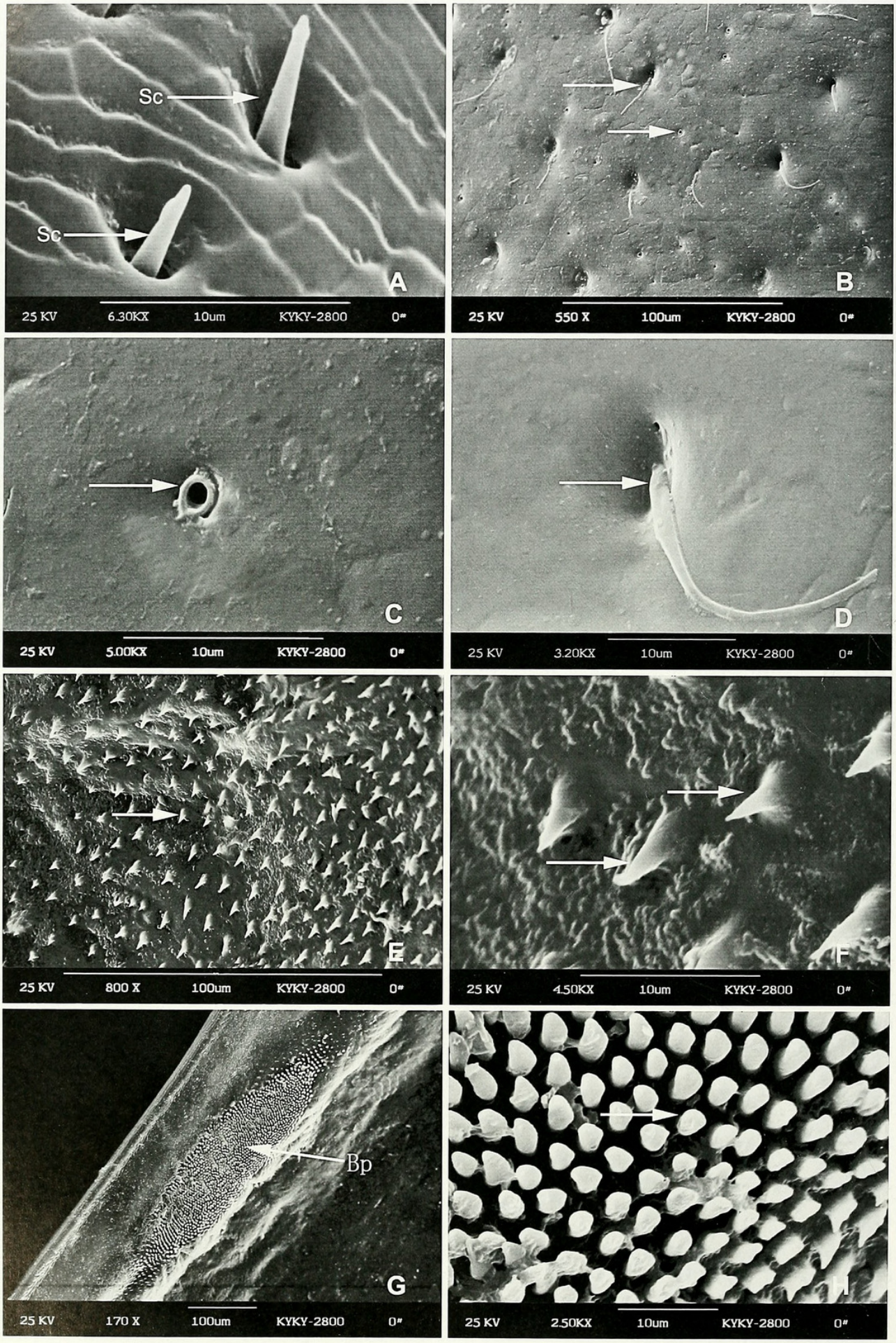
Fig. 8. *Altica fragariae*, adult. A, Antennae sensilla of last segment. B, Antennae sensilla of 10th segment. C, Sensilla basiconica. D, Sensilla petioliform 2. E, Sensilla petioliform 1. F, Sensilla coeloconica. G, Vase-like sensilla. H, Scape. Abbreviations: B1: Basiconica sensilla 1; Ch1: Chaetonica sensilla 1; Ch2: Chaetonica sensilla 2; Co: Sensilla coeloconica; P1: P1-Petioliform sensilla 1; P2: Petioliform sensilla 2; Sc: Scape setae; Vls: vase-like sensilla.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D
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E
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F
25 KV 4.50KX 10um KYKY-2800 0°
Bp
G
25 KV 170 X 100um KYKY-2800 0°
H
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Thorax (Figs. 4A, B): Prothorax narrower than other thoracic segments; pronotum with 2 transverse tubercles, each with 5 setae, and 2 lateral unisetose tubercles; prosternum with 2 pairs of medial setae. Meso- and metathorax (Figs. 4A, B) subequal, wider than prothorax; both nota with 2 anterior and 2 posterior unisetose tubercles arranged in a transverse row, 2 large lateral bisetose tubercles, and 2 large lateral trisetose tubercles. Meso- and metasterna with 1 anterior median bisetose tubercle, 2 posterior bisetose medial tubercles and 2 bisetose tubercles laterally. Mesothoracic spiracle annuliform.

Legs (Figs. 2E–H, 3A): Increasing in size from pro- to metathorax, 5-segmented, all setae on legs filiform; coxae largely trapezoidal bearing 8 setae (5 short, 3 long); trochanters largely membranous distally, with 4 setae (4 long) and 2 sensilla; femur strongly sclerotized dorsally but membranous ventrally, with 6 setae (3 short, 3 long); tibia with 7 setae (5 long, 2 short) and 1 sensory pore; tarsungulus bearing setiform pulvillus with long, setalike, basiconic sensillum at base (Fig. 2H).

Abdomen (Figs. 3B, C, 4A, B): Segments I–VII bearing well-defined sclerites, arranged dorsally into two transverse rows, with similar chaetotaxy (Fig. 4A, B); dorsally 1 anteromedian tubercle with 4 setae, posterior tubercles parallel to anterior one with 4 setae, and 8 long dorsolateral unisetose tubercles; laterally with 2 unisetose tubercles; ventrally with 1 anteromedian bisetose tubercle, 2 posterior bisetose tubercles arranged in a transverse row, and 2 ventrolateral bisetose tubercles. Segment VIII similar to previous abdominal segments, except for fusion of interior and exterior scutoscutellar sclertites into single scutoscutellar sclerite, with 4 (2 pairs) of large capitate scutoscutellar setae. Segment IX dorsally fused together into semicircular pygidium; with 5 pairs of large capitate pygidial setae. Ventral sclerites fused together into narrow tranverse band baring 2 pairs of filiform setae. Segment X not visible in dorsal view, in form of fleshy pygopod with 1 anterior lobe, 1 posterior lobe, and 1 pair of lateral lobes, and a weakly slcerotized narrow transverse sclertite at anterior portion.

Pupa (Fig. 5).—*Morphometrics:* Length: 3.70–3.91 mm. *Color*: Grayish yellow. With dark brown tubercules at base of spiracles.

Head (Figs. 5A, B): Rounded, not visible in dorsal view, bearing 1 pair of long setae on eyes, 1 pair of setae above eyes, and 1 pair subantennal setae, situated on frons near midline. Mouthparts well developed and distinct. Labrum subquadrate, apex emarginated medially. Mandible and maxillary and labial palpi subglobose.

Thorax (Figs. 5A, B): Pronotum trapezoidal, twice as wide as long, bearing 10 pairs of setae: anterior area bearing 5 pairs of setae (2 pairs located close to midline) and 3 pairs of setae anterolaterally, 1 pair centrally on disk, and 5 posterolateral pairs of setae (2 setae at 1/4th of posterior pronotal margin and 3 seta at posterior corner of pronotum).

Abdomen: Abdominal segments I–VI bearing dorsally 2 pairs of long setae evenly spaced across dorsal surface, setae borne on small conical tubercles; segments I–V bearing 1 pair of sclerotized annular spiracles and 1 pair of pleural

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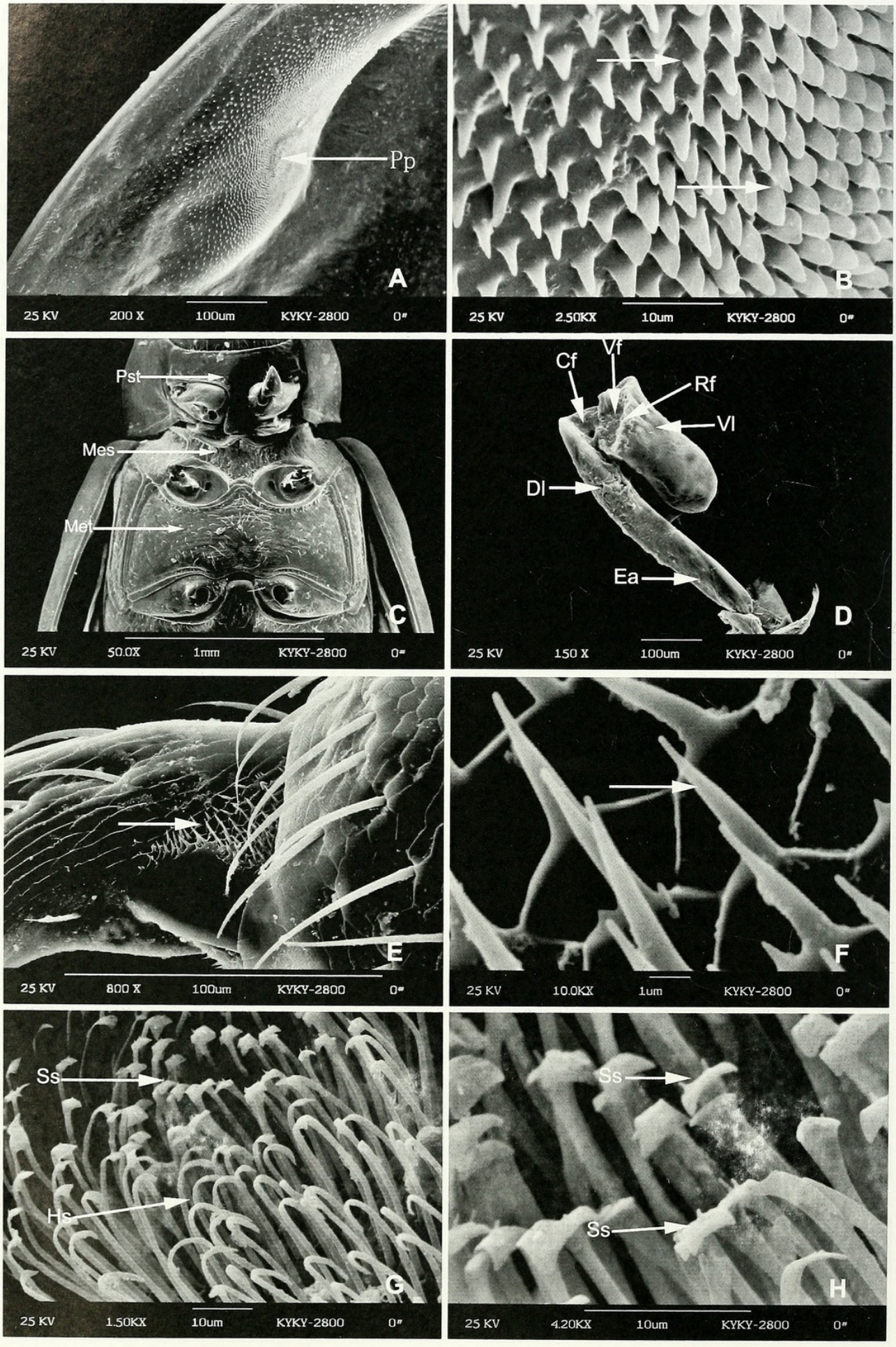
Fig. 9. *Altica fragariae*, adult. A, Scape setae. B, Punctures of elytra. C, Puncture without setae. D, Puncture with setae. E, Ventral surface of elytra. F, Setae of elytra ventral surface. G, Basal patch. H, Setae of basal patch. Abbreviations: Bp: Basal patch; Sc: Scape setae.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F
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G
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Ss
H
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setae, originating from a small tubercle vertroposterior to each spiracle; segment VI bearing dorsally 2 pairs of setae and 1 pair of pleural setae appearing ventral; segment VII semicircular; with 5 pairs of dorsal setae. Segment VIII reduced, bearing 1 pair of sharp black urogomphi. Segments IX and X reduced, hidden under segment VII.

Morphology of Adult

(Figs. 6, 7, 8, 9, 10, 11, 12, 13)

General features.—Dark blue, shiny metallic, convex in lateral view (Figs. 6A, B). Body length: 3.50–4.00 mm; width: 1.80–2.20 mm.

Head.—*External structures* (Figs. 6C–F): Subprognathous, vertex smooth, almost impunctate; each side with a setigerous pore and a moderately long seta near eyes (Fig. 6C). Frontal tubercles more distinct and quadrate, separated by a shallow longitudinal furrow; interantennal space somewhat broad and very convex, with basal part acute, inserted between two tubercles and anterior part narrower, each side with several punctures (Fig. 6C). Orbital sulcus well developed, supracallinal sulcus absent, midfrontal sulcus well developed, antennal calli almost completely separated, supra-antennal sulcus extremely deep, suprafrontal sulcus poorly developed, antennal calli and top of frontal ridge meet, separated by shallow groove, frontolateral sulcus well developed, anterofrontal ridge convex and well separated from clypeus, frontoclypeal suture well developed, clypeus usually with anterior margin straighter, subgenal suture poorly developed, gena with some setigerous pores (Fig. 6C). Compound eyes large, rounded and protruding, with sharp setae between ommatidia (Figs. 6E, F).

Labrum (Figs. 6C, D, 7A, 13A): Trapezoidal, with strongly rounded anterolateral edges. Flat, sclerotized, with 2 posterolateral elongated tormae and numerous marginal setae on anterior, medially sinuate margin, upper surface with 6 symmetrically placed setigerous pores.

Mandibles (Figs. 6D, 7A–C): Highly sclerotized, broadly triangular, with rounded lateral margins and well-developed apex, mostly symmetrical. External side broad at base and narrowing towards apex. Proximal half slightly inclined dorsomedially (Fig. 7B). Ridge on anterolateral dorsal side of mandible slightly bent externally (Fig. 7B). Basal half of dorsal side slightly convex, with 3 distinct denticles on distal part; outer surface very convex with 5 setae and very complicated sculpturing (Fig. 7B), inner surface strongly concave with a membranous prostheca covered by many small setae (Fig. 7C).

Maxilla (Figs. 6D, 7D–G): Consisting of a basal segment (cardo), basistipes, mediastipes, galea, and lacinia. Cardo subtriangular, with several long setae or spines. Basistipes elongate triangular, surface with several short spines. Mediastipes firmly connected with lacinia, surface with several short setae. Mesal edge of lacinia continuous with a semimembranous lamella, densely covered and with hairs anteriorly. Distal margin of lacinia with a row of large, finger-shaped blunt thorns (Fig. 7G). Galea composed of 2 galeomeres. Galeomere I

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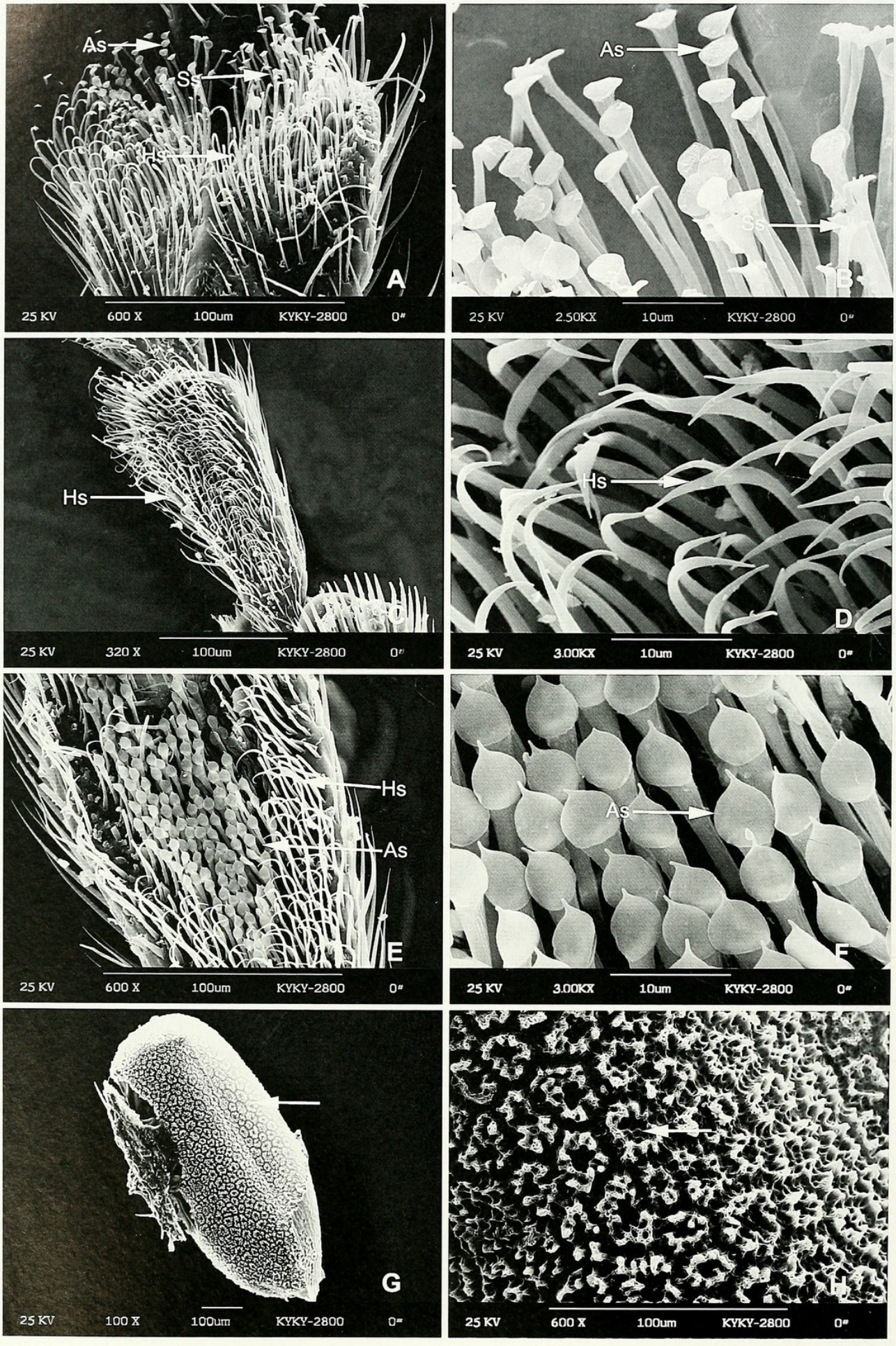
Fig. 10. *Altica fragariae*, adult. A, Posterior patch. B, Setae of posterior patch. C, Ventral surface of thorax. D, Metafemoral spring. E, Setae of basal tibiae. F, Amplificatory setae. G, Female third tarsus. H, Spatulate setae. Abbreviations: Cf: Central furrow; Dl: Dorsal lobe; Ea: Extended arm; Hs: Hooked setae; Mes: Mesosternum; Met: Metasternum; Pp: Posterior patch; Pst: prosternum; Rf: Recurve flange; Ss: Spatulate setae; Vf: Ventral furrow; Vl: Ventral lobe.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subquadrangular in dorsal view. Galeomere II elongate-ovid, distal part covered with rows of short hairs (Figs. 7D, F). Maxillary palp elongate, 4-segmented. Palpomere I very short. Palpomeres II and III distally widening and bent inwards. Ultimate palpomere elongate and spindle-shaped, longer than wide, shorter than palpomere III (Figs. 7D, E).

Labium (Figs. 6D, 13B): Prementum broad, subquadrangular. Hind margin not clearly separated from gular suture. Mentum and hypopharynx forming a morphological and functional unit. Mentum large, heavily sclerotized. Anterior margin with prominent process; surface of mentum uneven, with a regular but sparse vestiture of short hairs. Labial palp 3-segmented, inserted on distal part of palpiger below paired mentum sclerites. Palpomere I long, palpomere II approximately cylindrical, longest, lateral margin with small spine. Palpomere III shorter than II, apex pointed. Internal and external margins with setae.

Antenna (Figs. 7H, 8A–H, 9A): 11-segmented, posteriorly almost reaching middle of elytra, first segment club-shaped, dorsomedial part with several setae, long and almost same length as last segment, second segment shortest, third segment longer than second, fouth segment slightly longer than third, from fourth segment more piligerous, last segment with apex acute (Fig. 7H); proportion of each segment: 1.2: 0.7: 0.9: 1.0: 1.1: 0.9: 0.9: 1.0: 1.0: 0.9: 1.2. Ultrastructure of 2 types of sensilla chaetonica (Figs. 8A, B), 1 type of sensilla basiconica (Figs. 8A, C), 1 type of sensilla coeloconica (Figs. 8B, F), 2 types of sensilla petioliform (Figs. 8A, D, E), and 1 type of vaselike sensilla (Fig. 8G).

Thorax.—*Prothorax* (Figs. 6D, G, H): Length: 1.20–1.40 mm; width: 0.80–1.00 mm; each corner with setigerous pore and anterior seta much longer than posterior one (Fig. 6H). Anterior margin straighter, lateral margin slightly arched, basal margin slightly more arched in middle; anteriorlateral angle acute, incrassate, posteriorlateral angle obtuse; surface almost smooth, with sparse and fine punctures, disc impunctate especially with some strong punctures near anterior angle; with a transverse groove before basal margin, almost straight, each side almost reaching lateral margin. Lateral wall of prothorax exclusively formed by hypomeron. Hypomeron broad and impunctate (Fig. 6D). Pleuron fused with trochantinus; trochantinopleuron not visible externally. Prosternum well developed. Prosternal process triangular, broader and protruding behind between two coxal cavities, slightly constricted between procoxae, apex truncate. Surface without punctures and pubescences. Procoxal cavities open behind (Fig. 6D).

Mesothorax (Fig. 10C): Scutellum subtriangular, smooth and impuntate. Ventral side somewhat broad and concave, including anepisternum and epimeron with pubescence and with some wrinkles.

Elytra (Figs. 6A, B, 9B–H, 10A, B): Length: 2.20–2.40 mm; width: 2.80–3.20 mm; completely concealing abdomen (Fig. 6A). Elytra broader than pronotum at base, with close and confused punctures, more distinct than on

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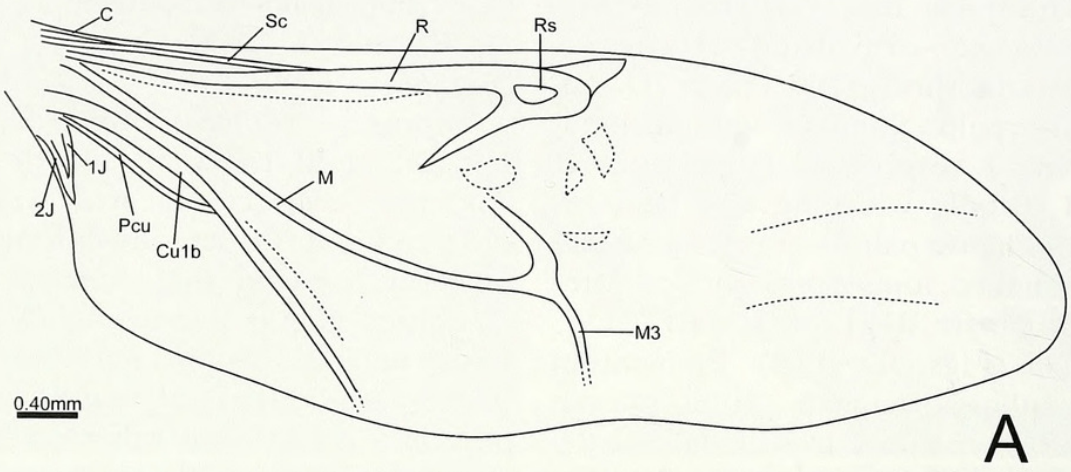
Fig. 11. *Altica fragariae*, adult. A, Male third tarsus. B, Amplificatory of male third tarsus. C, Female first tarsus. D, Hooked setae. E, Male first tarsus. F, Acetabula setae. G, Egg. H, Surface of egg. Abbreviations: As: Acetabula setae; Hs: Hooked setae; Ss: spatulate setae.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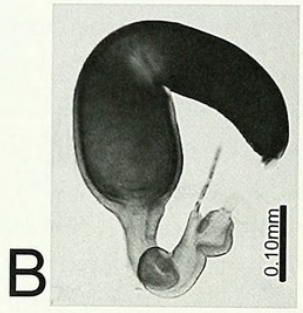
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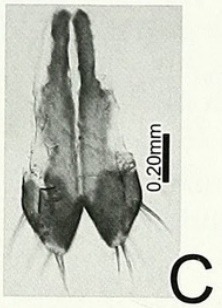
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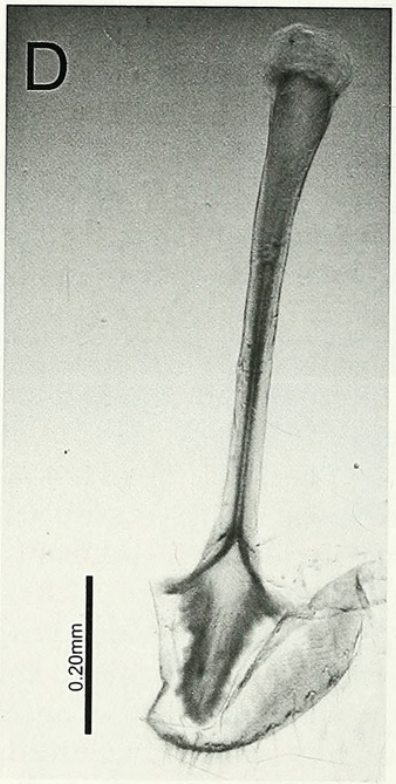
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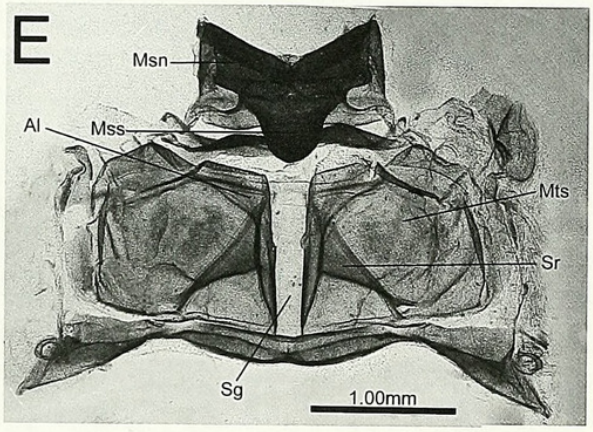
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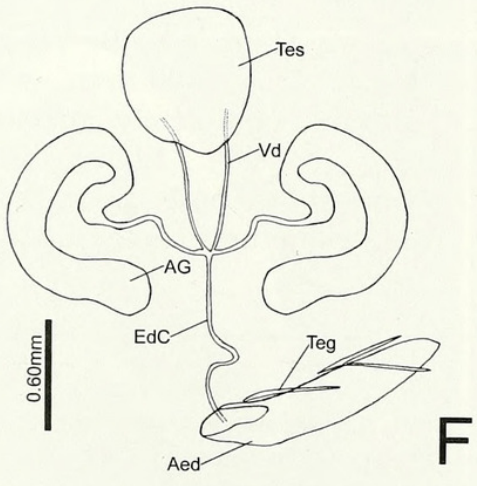
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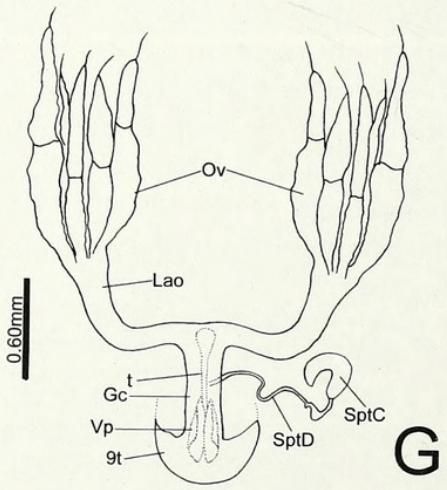
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pronotum, and posterior part with sparser punctures, with some fine punctures between larger ones, also with some slightly shagreened wrinkles between punctures (Figs. 9B–D). Ventral surface composed of microtrichia (Figs. 9E, F). Ventral surface of elytral suture with two patches (basal and posterior) for connection. Basal patch forms metascutal interlocking device, composed of scalelike microtrichia (Figs. 9G, H). Posterior patch composed of stalklike microtrichia (Figs. 10A, B). Epipleura widened anteriorly, without punctures and wrinkles (Fig. 6B).

Metathorax (Figs. 10C, 12E, 13C, D): Ventral side including anepisternum and epimeron with sparse pubescence and wrinkles (Fig. 10C). Metanotum well pigmented and sclerotized, about 2 times as wide as long, slightly arched, except for vertical anterior part. Scutum with distinct anterolateral bulges and ridges (Fig. 10C). Alacristae long and distinct, extending from anterior margin of horizontal part of scutum to hind margin. Scutoscutellar ridge crossing alacristae anteriorly, thus lowered area between alacristae composed of a very large scutellar portion and a very small anterior scutal portion. Scutellar groove narrow (Fig. 12E). Exposed part of anepisternum nearly parallel-sided, rather elongate. Epimeron largely covered by elytra. Metasternum evenly convex, anteromedially projecting between mesocoxae. Transverse suture separating mesosternum from katepisternum. Katepisternum exposed in total length, but narrowed close to median line. Metacoxae separated, slightly narrowed laterally, almost reaching lateral metathoracic margin (Fig. 10C). Metendosternite well developed (Figs. 13C, D), stalk with narrow sulcus arising from base of metasternal processes, without basal extention, arms with small, medially fused triangular extension, apical part with small extension, ventral process narrower and stalk longer than wide.

Hindwing (Fig. 12A): Well developed, venation as typical *Altica* morphology. Vein C short and strong, Sc close to and below C, R very strong forming a small cell Rt apically, M_{1+2} and r-m absent, Cu1a also absent, Cu1b and Pcu coalesce apically. Hind wing venation developed in about 1/2 of wing.

Legs (Figs. 6A, B, 10D–H, 11A–F): Procoxae cone-shaped. Trochanters of moderate size, femora very inflated, tibiae slender, basal part with microtrichia composed of triangular area (Figs. 10E, F). Third segment of tarsi bilobed. Claws appendiculate. Ultrastructure of first and third tarsi different between male and female. Female always with one type of hooklike setae (Figs. 10G, 11A, C, D, E), male always with two types of setae, the former same as female, the latter acetabula-like setae (Figs. 11A, B, E, F). Metafemoral spring with straight dorsal lobe, a rather long extended arm, obtuse, often small, basal angle of ventral lobe, and significant sclerotized recurve flange (Fig. 10D).

Abdomen (Figs. 6B, 12B, C, D, F, G, 13E–G).—Abdominal sternite 5-seg-

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Fig. 12. *Altica fragariae*, adult. A, Hindwing. B, Spermatheca. C, Vaginal palpi. D, Tignum. E, Metanotum, dorsal view. F, Male reproductive system. G, Female reproductive system. Abbraviations: 1J: 1st jugal vein; 2J: 2nd jugal vein; 9t: 9th tergits; Aed: Aedeagus; AG: Accessory gland; Al: Allocrista; C: Costa; Cu1b: Cubital vein 1b; Edc: Ejaculatory; Gc: Genitalia chamber; Lao: Lateral oviduct; M: Medial vein; M_3: Medial vein 3; Msn: Mesonotum; Mss: Mesoscutellum; Mts: Metascutum; Ov: Ovary; Pcu: Precubital vein; R: Radial vein; Rs: Radial sector; Sc: Subcosta; Sg: Scutellar groove; SptC: Spermatheca capsule; SptD: Spermatheca duct; Sr: Scutoscutellar ridge; T: Tignum; Teg: Tegmen; Tes: Testis; Vd: Vas deferens; Vap: Vaginal palpi.

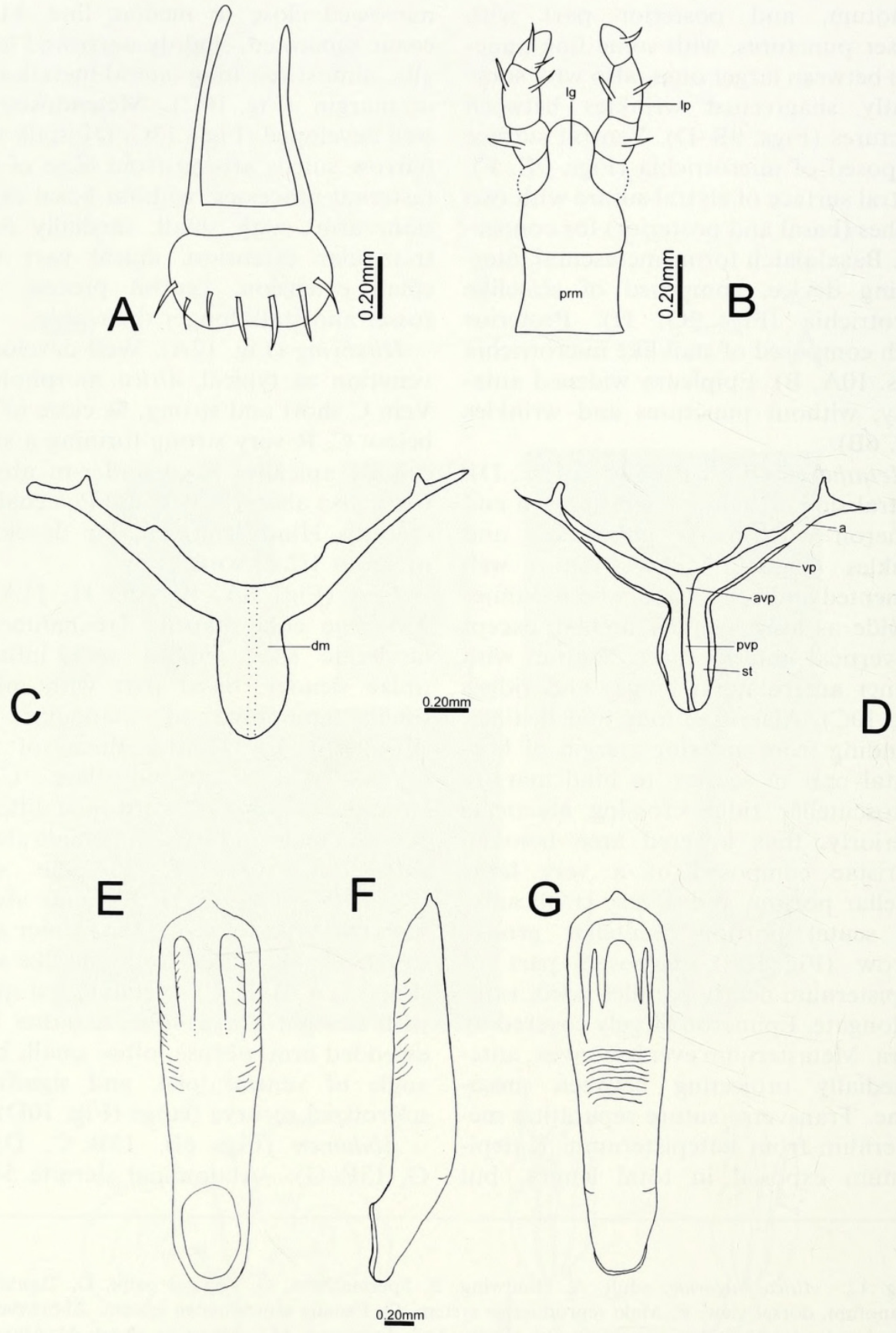

Fig. 13. *Altica fragariae*, adult. A, Labrum. B, Labium. C, Metendosternite, dorsal view. D, Metendosternite, verntral view. E, Aedeagus, ventral view. F, Aedeagus, lateral view. G, Aedeagus, dorsal view. Abbreviations: A: Arm; Avp: Anterior part of ventral process; Dm: Dorsal membrane; Lg: Ligule; Lp: Labial palpi; Prm: Promentum; Pvp: Posterior part of ventral process; St: Stalk; Vep: Ventral projection.

mented, with dense pubescence and shallow punctures. Last sternite of male trilobed, unconspicuous, that of female rounded.

Male reproductive system (Fig. 12F).—Internal reproductive system with spherical testis; a pair of tubular vas deferens, almost uniform in width but somewhat expanded at middle; ejaculatory duct connected with vas deferens at anterior part and opens into internal sac, inner chamber of aedeagus invaginated at apex; accessory glands are secretory organs of mucous substances and connected with anterior end of ejaculatory duct, length and width always varied.

Aedeagus (Figs. 13E–G.): With a very small denticle at apex. In ventral view, convex in middle, each side with a short longitudinal groove near apex, surface of lateral part of groove and lateral side of aedeagus with some transverse wrinkles (Fig. 13E). In lateral view, almost straight and slightly acute at apex, slightly concave about 1/3 length from apex and with some oblique wrinkles (Fig. 13F). In dorsal view, with a narrow longitudinal sclerotized part medially, each side with bifurcate, median part with transverse winkles (Fig. 13G).

Female reproductive system (Fig. 12G).—Consisting of a pair of ovaries, varying in shape; lateral oviduct short and uniform in width; common oviduct extends from opening of lateral oviduct to genital opening; genital chamber connected with common oviduct at anterior part and with spermatheca in lateral part; vaginal palpi and tignum at end of genital chamber.

Spermatheca (Fig. 12B): With receptacle longer than pump, internal side of receptacle convex, external side almost straight, receptacle elongate, longer than wide, maximum width at base, pump moderately narrow, horizontal part curved; vertical part shorter than horizontal part, duct not exceeding middle of receptacle, making a very narrow loop away from receptacle.

Vaginal palpi (Fig. 12C): With middle of membranous part nearly as long as sclerotized part, lateral margin almost parallel to medial, pointed apically, median margin almost straight.

Tignum (Fig. 12D): Nearly straight, slightly broadened at base and acute at apex, well sclerotized.

Discussion

The taxonomy of *Altica* is very difficult because of their similar morphology. Although there are some important works on *Altica fragariae*, most only emphasize taxonomy. In this paper, we describe and treat the morphology in detail. We draw the following conclusions:

Adults.—The main differences between *Altica fragariae* and other species are the morphology of the male and female genitalia, punctures of the pronotum, and color. In the ultrastructure of the antennae, 2 types of sensilla chaetonica, 1 type of sensilla basiconica, 1 type of sensilla coeloconica, 2 types of sensilla petioliform, and 1 type of vaselike sensilla were found. These characters should be closely related to choosing host plants. The ventral setae of the tarsus in the male and female could be related to mating behavior.

Eggs.—LeSage (2004) described the egg shell as a two-level structure in two species of *Altica*. We also observed that the outermost layer is made of more or less well-defined and symmetrical polygons whereas the second level consists of larger polygons and smaller polygons.

Larvae.—Three larval instars are present in *Altica fragariae*, as previously reported (Woods 1917, 1918; Isely 1920; Paterson 1943; Dirks-Edmunds 1965; Barstow and Gittins 1973; LeSage et al. 2004). The morphology of three instars is similar, but they can be distinguished by color and body size. Also the first instar has egg bursts on the meso- and metathorax.

Pupae.—The difference of *Altica* species can be found in the chaetotaxy, body size, and color.

Though the morphology is dealt with in detail in this paper, several aspects should be described in much more detail with function, such as the setae of the antennae and tarsi. Also, internal skeletal structure should be studied.

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