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A terminology for the taxonomy of Weevil larvae (Coleoptera : Curculionoidea) *1

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I. Introduction

In comparison with many other families of beetles, the Weevil larvae have only received of minor interest by entomologists. Main reason for this has probably been the difficulty for separating the larvae into species owing to their uniformity.

It is the purpose of this paper to demonstrate this terminology in a description and to explain, by means of figures and discussion, the meanings of the terms employed. In future papers, then, it will be possible to avoid continued repetition of explanations of terms the precise meaning of which, in connection with Weevil larvae, may not be found in standard glossaries.

The descriptions of Weevil larvae in the older literature are mostly very schematic and quite useless for identification. Eichelbaum(1903) and Hopriins(1905) are probably the first of those who studied the larval characters of Weevils in detail. Emden (1938-1952) evaluated the taxonomic characters and published excellent papers on the larvae with two tergal folds and on the Curculionidae Adelognatha and Alophinae.

The terminology for the systematics of the Weevil larvae was reviewed by Anderson (1947) to make a standard for the description.

II. Materials and Methods

The gross morphological features of entire larvae were examined on alcohol-preserved material. Then, they were macerated in 10% KOH for several minutes and dissected under a stereoscopic microscope.

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The head capsule with attached mouthparts was first removed from the body by a cut made with a fine forceps around the edges of the occipital foramen. The maxillae and labium as a unit were removed from the head capsule and the mandibles were dilated. The head was sketched by this condition from dorsal and ventral sides. Then the mandibles with attached tendons were removed from the head capsule. Mouth parts and skins were mounted on microscopic slides for detailed examinations.

For the examination of the muscles, living larvae were killed by injecting the fixative (equivalent mixture of 95% alcohol and 30% folmarin) from the lateroposterior part of the body so as to stretch the plicae and muscles, and preserved in alcohol. The larvae were cut just into halves in the middle by a razor blade, and then the internal organs and fat-bodies were removed by a fine forceps under stereoscopic microscope. The halves were stained with acetic fuchsin and the fat-bodies between muscles were carefully removed. The halves were then put in water in a small dish and observed under the stereoscopic microscope up to X80 magnification.

III. MORPHOLOGY AND TERMINOLOGY

1. Head. (Fig. 1:D.E)

The head is described "free" when all or nearly all the head capsule is visible in well-preserved larvae, and "retracted" when the posterior part of the head capsule is embedded in the prothorax and cannot be observed in properly preserved larvae without dissection. In the former condition, the head capsule is pigmented posteriorly and the posterior margin is often broadly rounded or transverse in dorsal view, and often the posterior epicranial setae are located behind the middle. In the retracted head, it is more prognathous and the posterior part is usually not pigmented, the principal setae are located before the anterior edge of the pronotum in dorsal view, and the posterior margin of the head is often oval to broadly oval or broadly emarginate.

The length of the head is measured from the posterior edge of the cranium to the anterior margin of the epistoma, and the width of the head is measured at the widest place.

The colour of the head capsule is brownish to yellowish brown and generally darker than body. Its anterior edge, the epistoma, is well sclerotized and darker. In certain genera, the head capsule has a pair of pale stripes on each side of the epicranial suture, and in some cases it is variegated with brownish spots, or with mesh-like fine structures.

The epicranium is defined as the head capsule exclusive of frons, and divided medianly into two halves by the epicranial suture. The setae on the epicranium are abundant and evenly scattered in the Anthribidae, and regularly arranged in the other families. The epicranial setae in the families Attelabidae, Brentidae, Apionidae, Curculionidae, and Rhynchophoridae are defined into four groups for the taxonomic purpose as follows:

(1) Dorsal epicranial setae. There are typically five paris of dorsal setae on the epicranium, and termed the dorsal epicranial seta 1 to 5. The seta 1 is located close to the junction of the frontal and epicranial sutures, and the seta 5 is close to the antenna. The seta 4 is absent in some genera.

(2) Lateral epicranial setae. There are usually with two setae on each side before the middle, which are termed lateral epicranial seta 1 and 2.

(3) Ventral epicranial setae. There are generally two pairs of setae on the ventral surface of the cranium, and with one or two pairs of additional setae in some genera.

(4) Posterior epicranial setae. There are four minute setae arranged in a longitudinal line behind the dorsal epicranial seta 2 as a rule. The epicranium bears several sensilla, one between the dorsal epicranial setae 1 and 2, one before the dorsal epicranial seta 4, one between the lateral epicranial setae 1 and 2, one to three on the ventral side near the inner margin, and one on each side of the row of the posterior epicranial setae.

The frons (Fig. 1:D) is a subtriangular area on the anterior dorsal surface of head limited posteriorly and laterally by the frontal sutures and anteriorly by the frontoclypeal suture. Anterior margin is thickened and strengthened transversely to form the epistoma, which is branched posteriorly as a short internal ridge between the antenna and catapophysis on each side. This part has a short incision on the inside from the anterior margin and is inserted in the anterior tentorial arm. The forns bears many setae in the Anthribidae, or five frontal setae termed 1 to 5 from the basal to anterolateral setae and two sensilla in the other families in general. The relative position of the frontal setae is constant and some setae are often absent leaving the basal sockets. Therefore, the setae or their basal sockets are easily referred to their number according to their relative positions.

The catapophysis (Fig. 1:D) is referred to the dorsal articulatory process of mandible from the anterior margin of the frons exterior to the base of the clypeus. It is usually not convex but on the same surface with frons, and strongly sclerotized.

The epicranial suture (Fig. 1:D) is always present and more or less inflected internally. This inflection is continued anteriorly and form a dark-coloured median line on the frons termed the endocarina. The epicranial suture and the endocarina are a median cleavage line of the head when moulting.

The frontal sutures (Fig. 1:H) are indistinct or absent in the Attelabidae and some Anthribidae, or distinct throughout and reaching the basal articulating membranes in the Apionidae and Brentidae, or terminating anteriorly at the base of the antennae and not reaching the anterior margin of the epicranium in the other families.

The antennae (Fig. 1:D) are located in the frontal area and distant from the frontal sutures in the primitive families, while in the higher families the frontal sutures terminate at the antennae. They are two-segmented in the Attelabidae, and one-segmented in the other families. According to Anderson (1947b), the antennae in the Curculionidae consist of a membranous, skin-like "basal article", which always supports a number of setae or processes, and an "accessory sensory appendage", which has not any setae or processes.

In this paper, the membranous "basal article" is named the "base of antenna", and the "accessory sensory appendage" as simply "segment" for convenience.

The ocellus (Fig. 1:D) is composed of several black spots and without a convex lens in may larvae of the Anthribidae and Attelabidae. It is two-paired with a convex lens each in some larvae, or the posterior ocellus is absent in many larvae, or the ocellus is completely absent in the Scolytidae and some Curculionidae.

The clypeus (Fig. 1:D) is more or less sclerotized transversely along the epistoma, but not so in the Anthribidae. It bears two setae and one sensillum on each side near basal margin. In the Anthribidae, they are located very close to the basal margin of clypeus or almost on the anteriorly declined edge of the epistoma, and often invisible dorsally in the ordinary slides. The clypeus is transversely trapezoid with straight or weakly curved side margins in most cases, but is rarely angulate before the basal angles in some Hylobiinae.

The labrum (Fig. 2:A) has a pir of processes produced from the basal corners into the clypeal zone in the Anthribidae. This processes are termed the tormae by Anderson (1947a), while by some other authors the tormae are referred to the labral rods of Anderson (1947b). In the other families, the basal margin of the labrum is truncate or broadly produced into the clypeal zone in the middle. It bears usually three pairs of labral setae, but some have four pairs of setae in the primitive families. They are referred to by number in description from the interior to exterior setae. There are also a pair of basal sensilla in the primitive families, or one median sensillum in the advanced families, and a pair of lateral sensilla in general. The lateral sensilla are located between the labral setae 1 and 3 on each side in general, but in the Rhynchophoridae they are close to anterior margin between labral setae 2.

The mandibles (Fig. 1:J) are short, stout, heavily sclerotized, and slightly convex dorsally or externally as opposed to the concave ventral or inner face. They are usually bidentate at apex, and with one to three additional teeth on the cutting edge. The teeth are sharper soon after moulting and more or less worn out in the course of grazing. There are two setae on the outer surface of the mandible in general. These are referred to as the mandibular seta 1 for the more posterior or dorsal seta, and the mandibular seta 2 for the rest.

The epipharynx bears (Fig. 2:B) a pair of dark-coloured, rod-like structures, the labral rods. They are the epipharyngeal rods or the tormae of some authors, but they are basically a part of the labrum according to Anderson (1947b) and thus he named them as the labral rods. There are three well-defined groups of setae on the epipharynx. These are: (1) Anterolateral setae along the anterior margin lateral to the base of each labral rod. In descriptions only the number on one side is given. (2) Anteromedian setae near the anterior margin between the bases of labral rods. In descriptions total number is given. The shapes of setae are more or less different among each pair, and the dorsal

pair has often been mistaken as labral seta by some authors. (3) Median spines between the labral rods, posterior to the anteromedian setae. In descriptions total number is given.

The epipharynx bears several sensory pores, which are small and very often clustered in two between the anterior and median pairs of the median spines. The numbers and the relative positions of these setae and sensilla are nearly always contant for a given species or group of species.

The maxillae (Fig. 2:C) are situated alongside the labium, and composed of cardo, main body (stipes + palpifer + lacinia + galea) and maxillary palpus. The maxillary mala is provided with setae along its inner margin. In the ordinary slide, the bases of these setae visible in a ventral view are arbitrarily called the ventral setae of mala, and those which apparently arise from the dorsal surface are referred to as the dorsal setae of mala. The ventral setae are arranged irregularly and variable in size. The dorsal setae are usually arranged more regularly in a row. The latter are usually separated into two groups by their shapes and positions. In most Anthribidae and Attelabidae, the mala has a thorn-like tooth in the middle in dorsal or ventral aspects. This is apparently an anteriorly protruding part of the lacinia and limited anteriorly by an indefinite concave line from the galea and the arrangement and shape of the setae are different between these two areas. There is usually a small seta anterior to the base of this tooth in the Rhynchitinae. The maxillary palpus consists of two segments. The basal segment has two sensilla on the ventral surface and one seta on the ventral inner surface. In some larvae, a free process arises from the dorsolateral surface of apex of the basal segment, which is called the accessory process of maxillary palpus, and finger-shaped or obtuse setaceous according to the species groups. This process is fused with the apical segment to form a slit-like structure in some larvae, or this is completely absent in many species.

The labium (Fig. 2:C) consists of the prementum, mentum and submentum in the Anthribidae, and the posterior two parts are fused to form the postmentum in the remaining families. In the latter case, they are often called the mentum or prelabium and submentum or postlabium, respectively, by some authors. Their boundary is completely obliterated in the Attelabinae. The prementum (Fig. 2:C) bares a pair of labial palpi, which are often one- or two-segmented. The prementum has a pair of setae in general. The setae are bounded posteriorly by the premental sclerite in many larvae, which is pigmented and prolonged anteriorly on each side to the dorsal base of the labial palpus and often produced anteriorly and posteriorly in the middle. The premental sclerite (Fig. 2:C) bears a pair of sensilla in general.

The postmentum (Fig. 2:C) is broadly membranous on the posterior part of the labium and has three pairs of setae in many larvae, while in the Anthribiae the larvae have more than three pairs of setae and some have four pairs of setae in the Attelabidae.

The ligula (Fig. 2:C) is a median membranous lobe between the labial palpi, and

bears four short setae and a pair of sensilla in many species.

2. Thorax (Fig. 3.4)

The tergum with its areas is separated in all segments including the abdomen from the combined pleural and sternal regions by the dorsopleural sulcus throughout the entire length of body. This sulcus is easily determined by the attachments of the lateral muscles and oblique pleural muscle. The tergal areas of the prothorax are fused together to a great extent and cannot be clearly homologized with the areas of the pterothorax. The mesothorax and metathorax are similar to each other in structure. The tergum of the pterothorax is subdivided into the dorsum, alar area, spiracular area and epipleurum.

The dorsum of the mesothorax and metathorax (Figs. 3.4) is divided into the prodorsum and postdorsum (Figs. 3.4) by a distinct sulcus.

The alar area (Figs. 3.4) on each side of the mesothorax and meta- thorax is both delimited dorsally and ventrally by diagonal grooves. These grooves are often indistinct, but clearly defined by the insertions of the tergopleural interior and exterior muscles.

The spiracular area (Figs. 3.4) of the mesothorax is well defined by the spiracular muscle and usually lies above the epipleural sulcus. It is poorly limited dorsally by a diagonal groove, into which a tergopleural exterior muscle attaches. The spiracular area of the metathorax is easily defined by its position as a similar subtriangular area to that of the mesothorax, but the spiracular muscle is absent.

The epipleurum (Figs. 3.4) is usually smaller than that of the abdomen and the dorsal border to the spiracular area is often indistinct.

The pleurum (Figs. 3.4) of the thorax is much smaller than that of the abdomen. The tergopleural sulcus is more or less sinuate and its rear part is weak in some larvae.

The sternal (Figs. 3.4) region is divided into three areas, the pedal area, sternum and sternellum.

The pedal area (Figs. 3.4) of the thorax is homologous to that of the abdomen judging from the similarity of their musculatures. The legs are present in Ithycerus, either present or absent in the Anthribidae and Brentidae, and usually absent in the other families. They are small and sclerotized in some brentids and Ithycerus, but usually not sclerotized in the others. In the Curculionidae, fleshy and two-segmented legs are present in Gymnetron, and their traces are observable in each pedal area as a weak oval swelling in many other genera.

The first thoracic spiracles has its place in the fore-front of the mesothorax in the Anthribidae and Attelabinae, in the intersegmental sulcus in Cylas and Nanophyes, and in the rear of the prothorax in the others. The second thoracic spiracle is absent.

The setae of thorax are plenty and irregularly arranged in the primitive families, but their arrangements in the higher families are typically as follows: The prodorsum of the mesothorax and metathorax bears one seta. The postdorsum bears four setae. The alar

area usually has one seta. The spiracular area has one to three setae. The epipleurum bears one or two setae, which is long on the mesothorax and metathorax, but short or often absent on the prothorax. The pleurum of the prothorax bears two setae, and of the mesothorax and metathorax bears one seta. The pedal area has seven setae, of which four are located on the oval swelling. The sternum has one seta on each side.

3. Abdomen (Figs. 3.4)

The abdomen consists of ten segments. The second to sixth segments of the abdomen are usually identical so far as areas and arrangements of setae are concerned and are referred to as the typical abdominal segment. The first and seventh segments may or may not be identical with those of the typical segment in their areas and arrangements of the setae.

The tergum is well defined ventrally as in the thorax by the dosopleural sulcus. In the abdominal segments, two tergopleural interior muscles originate from the fragmata at the anterior part of the dorsopleural sulcus, and inserted into the upper junction and the other obliquely to the postdosal sulcus. The spiracular muscle and the tergopleural exterior muscle originate also from the same fragmata and the former is inserted into the base of the spiracle and the latter is to the epipleural sulcus.

The tergum is subdivided into the dorsum, epipleurum and spiracular area according to Anderson (1947b), and the dorsum is subdivided into two to three or four folds by transverse sulci.

The dorsum is separated into the prodorsum and postdorsum by the prodorsal sulcus and the tergopleural interior muscle is inserted dorsally to a small hollow in the postdorsum in Araecerus, (Fig. 5:A) Phialodes (Fig. 5:C) and Apoderus (Fig. 5:D). This hollow develops into a distinct paradorsal sulcus and divids the postdorsum into median and lateral areas in Exechesops (Fig. 5:B) and Apion (Fig. 5:G). The prodorsal external muscle is one and the postdorsal external muscle are three in number in these genera.

In the Rhynchitinae, the dorsal area is subdivided into three folds by two sulci. The prodorsal external muscle and the postdorsal external muscle 1 attach the posterior sulcus, and the postdorsal external muscle 2 attaches the anterior sulcus. These facts suggest the possibility that the posterior part of the prodorsum and the lateral area of the postdorsum between two sulci as seen in some anthribids make up the median fold.

The median fold is wider and intervenes between the anterior and posterior folds in the Curculionidae, Scolytidae and Rhynchophoridae examined. In Rhynchaenus (Fig. 5:H) and Cionus (Fig. 5:I), the prodorsal external muscle is one and the postdorsal external muscles are three in number, and the transverse sulci are delicate. The other genera of the Curculionidae have well-marked three tergal folds and two prodorsal external muscles. The postdorsal external muscles are three to five in number.

In Lixus, the dorsum is subdivided into four folds. The dorsal longitudinal exterior

muscle originates from the anterior intersegmental sulcus and inserted in the third sulcus on the postdorsum.

In the Rhynchophoridae, the dorsal muscles are highly devel- oped and both the prodorsal and postdorsal external muscles are greatly increaed in number.

The lateral part of the posterior fold is separable into the paradorsal tergal area in some larvae by the insertions of the tergopleural muscles. But, its dorsal and lateral boundaries are usually indefinite and the mode of the insertions of the tergopleural muscles are variable among the genera examined.

The spiracular area in the abdomen is poorly defined dorsally and well defined laterally by the epipleural sulcus. There are usually one or two oblique sulci from the upper junction to the posterior part of the epipleural sulcus. In Phialodes, one sulcus runs above the spiracle, while in Araecerus, Apion, Tomicus(Fig. 6:E), etc. it runs below the spiracles. Two sulci are present in Curculio (Fig. 6:D) including the spiracle between them. The muscles are not inserted into these sulci.

The epipleurum is a lateral area of the tergum and limited ventrally by the dorsopleural sulcus and dorsally by the epipleural sulcus. The latter sulcus is defined by the insertions of the tergosternal muscles except for Cionus, in which the latter muscles are absent.

The pleurum is a distinct area below the tergopleural sulcus throughout the body. This area is defined by the presence of a few pleural setae externally, and by the insertion of a diagonal muscle from the anterior part of the tergopleural sulcus to the posterior part of the pleurosternal sulcus. In Myocalandra (Fig. 6:C) and some other genera of the Rhynchophoridae, the pleurum is subdivided into two or more lobes dorsoventrally. This is probably due to the great increase of the ventral muscles, and not due to the arrangement of the lateral muscles. Their lateral muscles are not different from those of the other groups.

The sternum is subdivided into two areas by a sulcus and the sternellum is not developed in the larvae of the Anthribidae, Attelabidae and Apionidae. The sternum is subdivided into three areas and the sternellum is present in the Curculionidae, Scolytidae and Rhynchophoridae.

The setae are abundant and irregularly arranged on the thorax in the primitive families, but are regular in the advance families as follows: The prodorsum bears one seta. The postdorsum bears five setae in a row. The spiracular area has two setae. The epipleurum and pleurum bears two setae, respectively. The pedal area bears one seta. The eusternum bears two setae on each side. The setae are fewer on the eighth and ninth segments.

The anus is surrounded by the lobes of anus, which are the remnants of the tenth segment of the abdomen. When the anus is located approximately in the center of the posterior end of body it is referred to as terminal.

The abdominal spiracles are present on the first to eighth segments in general. The eight spiracle is absent in Apion. The abdominal spiracle is functional only on the eighth segment in the first inster larvae of some Rhynchophoridae, and the first and/or seventh and eighth spiracles are functional in the mature larvae of the Dryophthorinae and Stromboscerinae (Gardner, 1938). Each spiracle consists of a basal collar-like peritreme with or without finger-shaped, annulated or non-annulated air tubes. A spiracle with a single air tube is described as unicameral, and one with two air tubes as bicameral. In some larvae, the spiracle is surrounded completely or partly by weakly sclerotized ring.

要　約

바구미 上科 甲蟲은 世界的으로 6萬種의 記錄이 있는 動物界 最大의 分類群으로서 특히 바구미科, 소나무좀科는 林木의 穿孔性 害蟲으로서 重要時되고 있다.

이들 幼蟲의 硏究는 系統分類學上 重要할 뿐만 아니라 害蟲을 幼蟲으로서 同定한다는 應用面으로도 林業的인 次元에서 대단히 必要함에 本 論文에서는 바구미上科 幼蟲의 形態를 詳細히 관찰 比較硏究에 Key가 되는 形質에 관하여 調査하였다.

1. 頭部 : 單眼, 觸角, 上唇, 下唇, 頭楯, 大腮小腮鬚, 刺毛, 感覺孔, 前頭縫合線上咽頭, 上咽頭帶
2. 胸部·腹部 : 前背板, 後背板, 氣門, 上側板側板, 肢部, 胸部와 第1腹節의 皺와 筋肉의 關係, 刺毛

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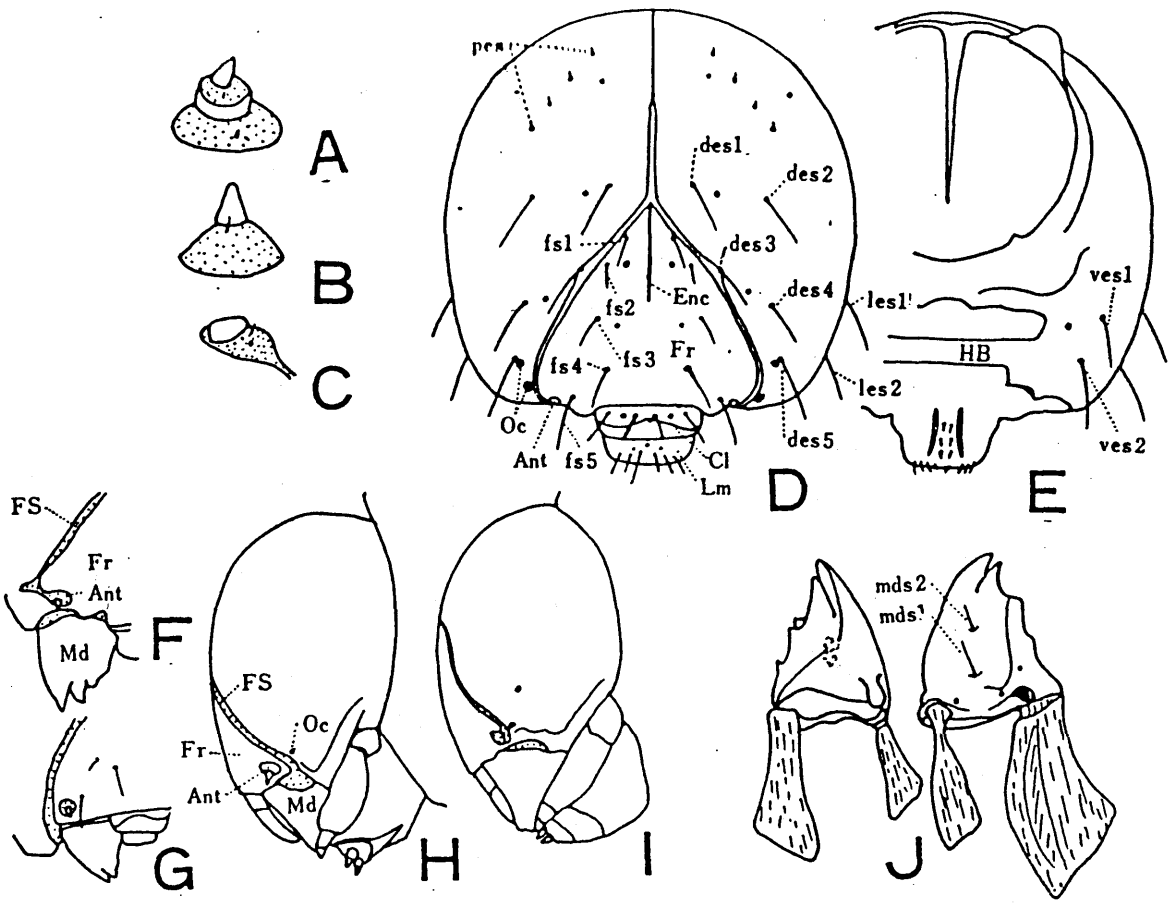

Fig. 1 Head

A. Antennae with two segments. B. Antennae with one segment. C. Antennae broader than long. D. Head, dorsal. E. Head, ventral. F.I. Frontal sutures not reaching the articulating membrane but ending at the base of antennae. G.H. Frontal sutures reaching the articulating membrane of mandibles. J. Mandible.

Ant: antenna. Cl: clypeus. desl to des5: dorsal epicranial setae. Enc: endocarina. Fs: frontal suture. Fr: frons. fsl to fs5: frontal setae. HB: hypopharyngeal bracon. Lm: labrum. les1 to les2: lateral epicranial setae. Md: Mandible. mds1 to mds2: mandibular setae. Oc: ocellus. pes: posterior epicranial setae. ves1 to ves2: ventral epicranial setae.

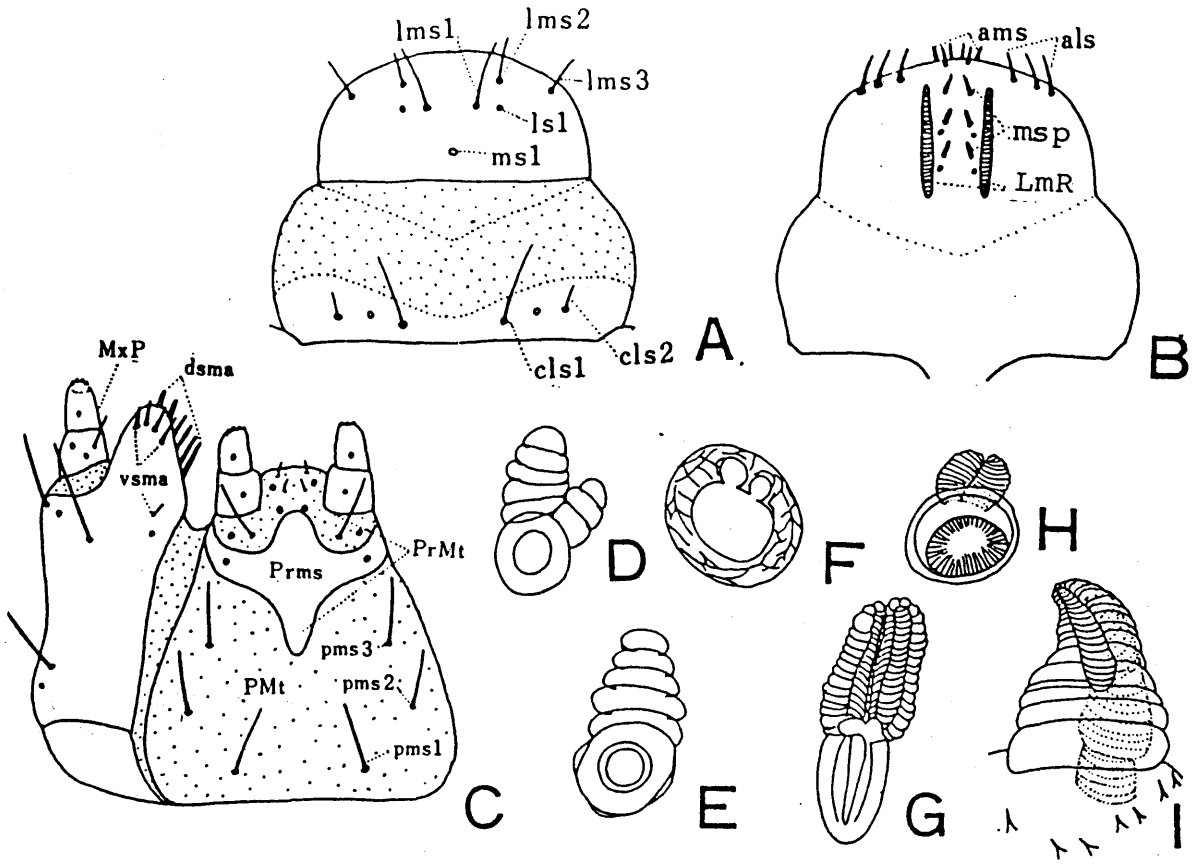

Fig.2. Mouth Parts and Spiracles

A. Labrum, dorsal. B. Epipharynx. C. Labium. D. Spiracle of Ceuthorhynchidius albosuturalis (Roelofs). E. Spiracle of Apion collare Schilsky. F. Larinus latissimus Roelofs. G. Dyscerus perforatus (Roelofs). H. Phialodes rufipennis roelofs. I. Deporaus unicolor Roelofs.

als: anterolateral setae of epipharynx. ams: anteromedian setae of epipharynx. cls1 to cls2: clypeal setae. dsma: dorsal setae of mala. LmR: labral rod. lms1 to lms3: labral setae. lsl: lateral sensillum of labrum. msl: median sensillum of labrum. msP: median spines of epipharynx. MxP: maxillary palpus. Prms: premental sclerite. PrMt: prementum. PMt: postmentum. pms1 to pms3: postmentum setae.

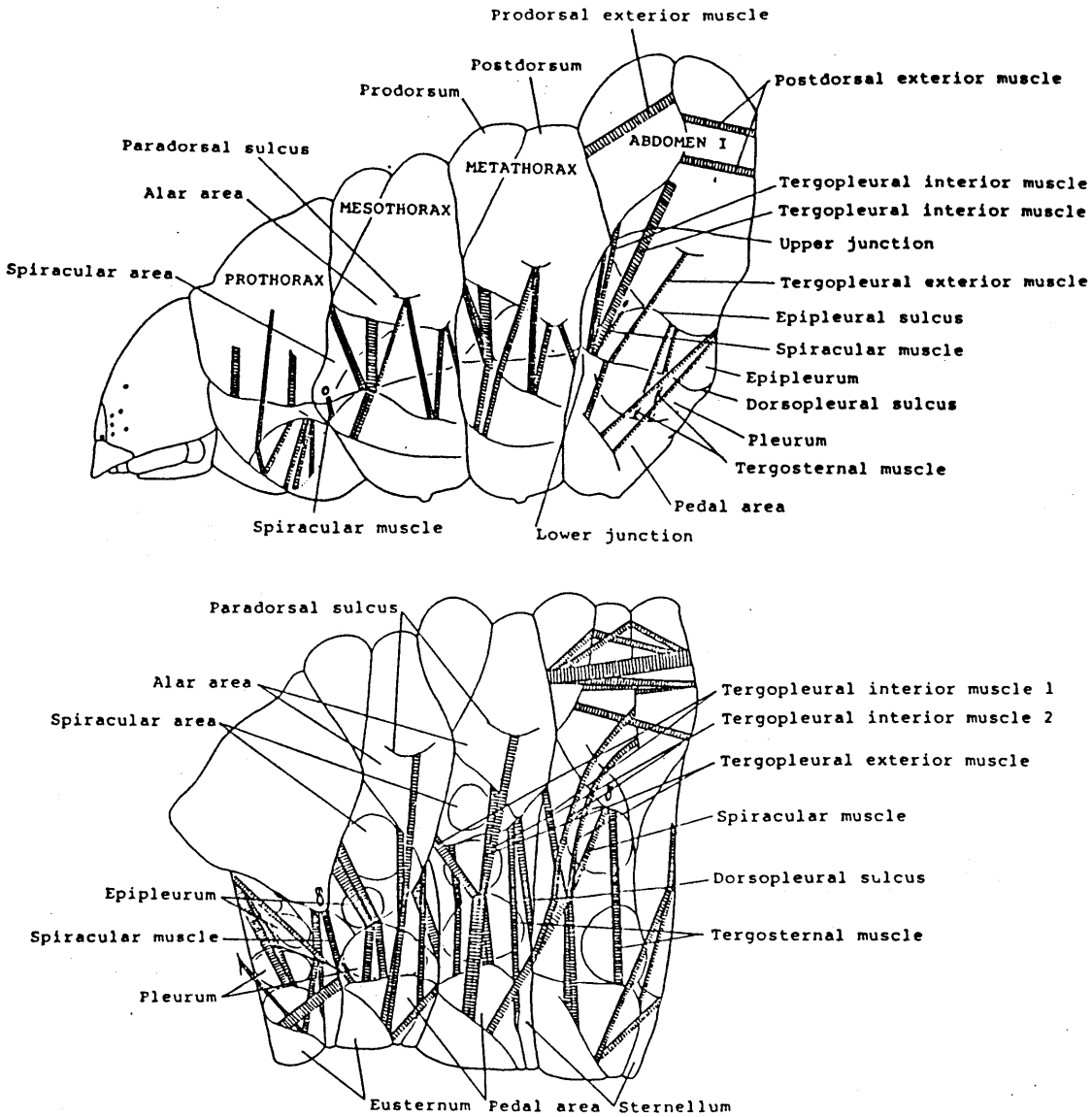

Fig. 3. The thoracic and abdominal areas and the lateral muscles.
Above: Phialodes rufipennis (Attelabini)
Below: Curculio dentipes (Curculionini)

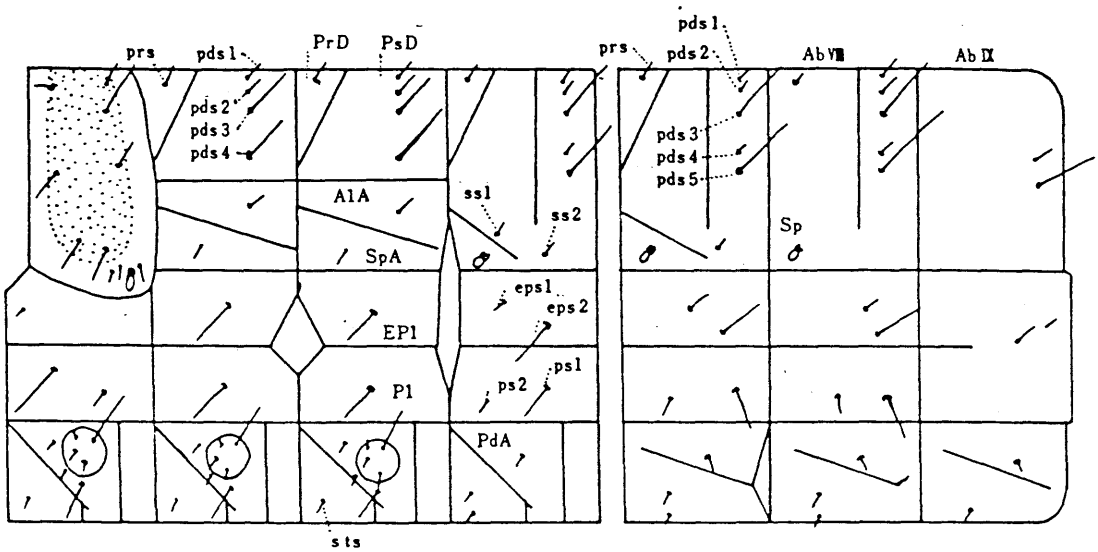

Fig. 4. Setal map of body.

AbI to AbX: abdominal segments. AIA: alar area. EPI: epipleurum. eps1 to eps2: epipleurum setae. sts: sternal seta. prs: prodorsal setae. pds1 to pds4: postdorsal setae. PrD: prodorsum. PsD: postdorsum. Pl: pleurum. ps1 to ps2: pleurum setae. PdA: pedal area. prs: prodorsal setae. pds1 to pds5: postdorsal setae. SpA: spiracular area. Sp: spiracle. ss1 to ss2: setae of spiracular area.

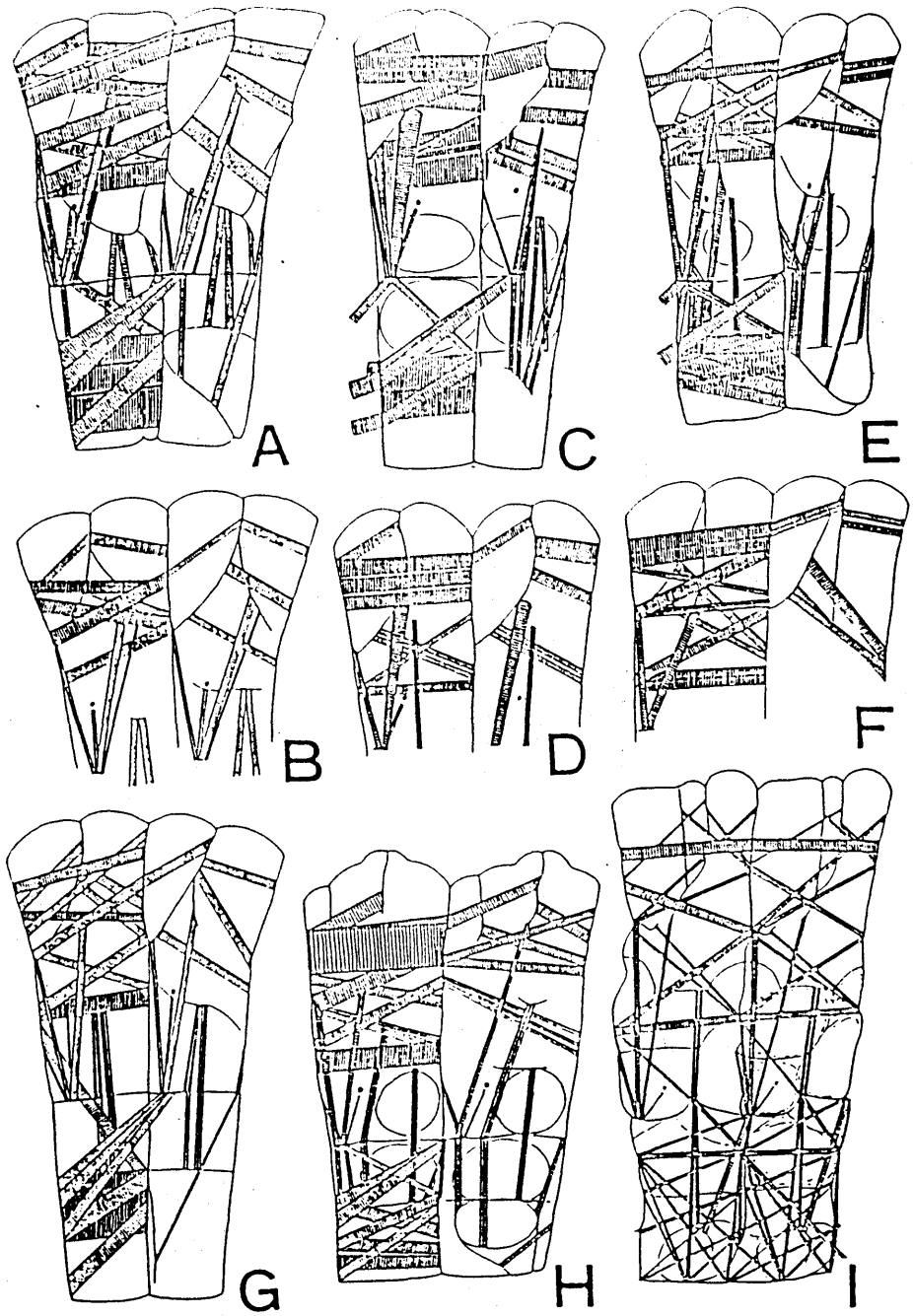

Fig. 5. The muscles of the typical abdominal segments.
A. Araecerus fasciculatus. B. Exechesops leucopis. C. Phialodes rufipennis.
D. Apoderus nitens. E. Mechoris ursulus. F. Byciscus venustus. G. Apion japonicus.
H. Rhynchaenus horii. I. Cionus hilleri.

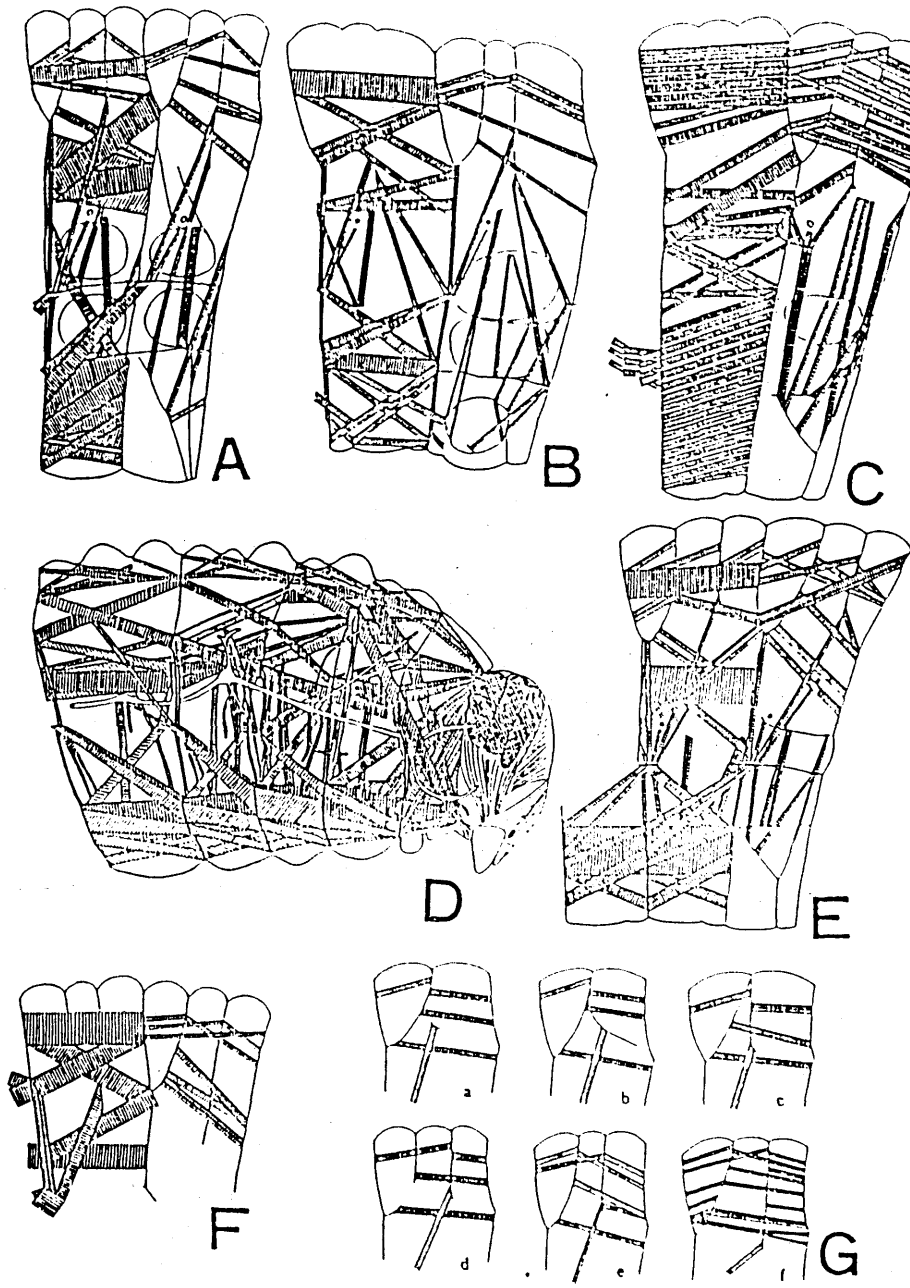

Fig. 6. A,B,C,D,F: The muscles of the typical abdominal segments.
A. Curculio dentipes. B. Hypera basalis. C. Myocalandra exarata. D. Curculio dentipes, medial view of the left half. E. Tomicus piniperda. F. Episomus mundus. G. Schema of the tergal folds (a. Araecerus. b. Apion. c. Byctiscus. d. Rhynchaenus. e. Curculio. f. Myocalandra).