

# Comparative Morphology of the Mouthparts of the Curculionoidea (Coleoptera), their Feeding Mechanism and Relationship to Classification. Part I. Family Brentidae

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**Abstract** - The Brentidae is characterized by the reduced labial palpi, which is located in cavities on the apicoental margin of the prementum. The postcoila of two subfamilies of this family is deep and bowl-like on ental surface of the hypostomal arms. The mouthparts treated in here comprise the labrum, clypeus, mandibles, maxillae, labium, hypostoma and the septum of the preoral cavity. The terms are followed principally after Ting and Morimoto. The detail terminology for the mandibles are newly given. [Insecta, Coleoptera, Comparative morphology, Mouthparts, Brentidae].

## INTRODUCTION

The Curculionoidea is the superfamily with the largest number of species in the animal kingdom, estimated 60,000 described species or about 5 percent of the total animal species (Morimoto 1981). But recent exploration data from the tropical rain forests is estimated as the numbers of the actual living insects on the earth far more than 30 to 50 million species (Erwin 1982) or between 10 to 80 million species (Stork 1988), and especially the Curculionoidea comprised more than 13% of the total species of insects (Erwin 1982). Consequently, the estimated weevil species may have came up to several millions on the earth, and their systematics must play an important role not only in understanding biodiversity but to establish a general reference framework for various fields of entomology.

The most obvious character of the Curculionoidea is the prolongation of the head into rostrum, of which the functional significance may fundamentally be the adaptation for drilling the oviposition hole as already discussed (Morimoto 1962a, 1981; Thompson 1992). Ting (1936) and Morimoto (1962a) clarified the fundamental structures of the mouth organs, but they discussed with one

by one for each part by dissection and not on the compound structures *in situ*. Present study is intended to observe the complicated mouthparts in their original positions mostly by SEM and partly the binocular microscope, and to infer their feeding mechanisms and relationship to classification.

## MATERIALS AND METHODS

The materials observed in this work are mostly inhabitants in Japan including 5 species in 2 subfamilies as in the following list (Table 1). Their mouth parts were observed mostly by the scanning electron microscope, JSM-T200, and

**Table 1.** Examined species of the Family Brentidae

Subfamily	Tribe	Species
Cyladinae		<i>Cylas formicarius</i> (Fabricius, 1798)
		<i>Cerobates</i> ( <i>Cerobates</i> ) <i>formosanus</i> Schoenfeldt, 1911
Brentinae	Stereodermini	<i>Trachelizus japonicus</i> Morimoto, 1976 (male, female)
	Trachelizini	<i>Baryrhynchus poweri</i> Roelofs, 1879 (male, female)
	Arrhenodini	<i>Pseudorychodes insignis</i> (Lewis, 1884) (male, female)

partly by the ordinary methods under the compound ( $\times 60-600$ ) and stereo-scope microscopes ( $\times 5-320$ ). Additional data were obtained by direct observation of many Asian species through the stereoscopic microscope as usual. A list of species examined by SEM arranged in Morimoto's system (1962b, 1981).

## RESULTS

Results obtained are summarized as follows.

### *Cylas formicarius* (Fabricius, 1978)

(Figs. 1A, 2A; Pl. 1)

Clypeal margin weakly produced and evenly concave in the middle, with two paraclypeal setae.

Mandibles move obliquely, meet anteroposteriorly when they are retracted. Ventral articulation well developed, ball-like postartis received tightly by postcoila, which is deeply concave from inner edge a little behind apex of hypostomal arm. Exterior surface with a distinct flexion between dorsal and ventral condyles and the surface basal to the flexion forms a smooth and evenly curved articular surface. Apical tooth large and sharp. Dorsal cutting edge rather sharp, with obtuse dorsal tooth. Ventral cutting edge obtuse, with ventral tooth sharp, but a little smaller than apical tooth. Inner concavity shallow, oblique, and consequently three teeth arranged almost straight. Exterior surface with two long setae in front of basal flexion.

Maxillae move nearly vertically, maxillary palpi three-segmented, apical palpomere with several nipple-like papillae at its apex and with several longitudinal sensory pores on the exterior surface, first and second palpomeres each with a seta, each segment with a sensory pore. Galea fused with lacinia and forming mala, which is about twice as long as wide, with dense setae.

Prementum ovate, slightly asymmetrical, with two pairs of long setae on ventral surface. Labial palpi small, two-segmented, inserted in sockets on ental surface at sides behind apex. Postmentum short, with well developed receptacle of cardo on each side. Hypostomal arms produced apically to the level of labial palpi, postcoila deeply concave from apicointerior margin a little behind apex.

### *Cerobates (Cerobates) formosanus*

Schoenfeldt, 1911

(Figs. 1B, 2C; Pl. 1)

Clypeal margin weakly produced apically on each side of the middle, without paraclypeal seta and cleft.

Mandibles move obliquely, meet anteroposteriorly when retracted. Ventral articulation well developed, ball-like postartis received tightly by postcoila, which is deep round concavity behind apex of hypostomal protrusion and narrowly distant from its margin. Exterior surface with a distinct flexion between the dorsal and ventral condyles and surface basal to the flexion forms a smooth and evenly curved articular surface. The outer surface of the mandibles have widely distributed several short setae. Teeth of mandibles as in the preceding, two-notched and three teeth arranged almost straight. Exterior surface with scattered small punctures, each with a minute seta.

Maxillae as in the preceding, but maxillary clefts wider and lateral (ventral) margins of cardo and stipes more exposed.

Prementum and postmentum as in the preceding, but the ventral surface smooth, with a pair of long setae.

### *Trachelizus japonicus* Morimoto, 1976

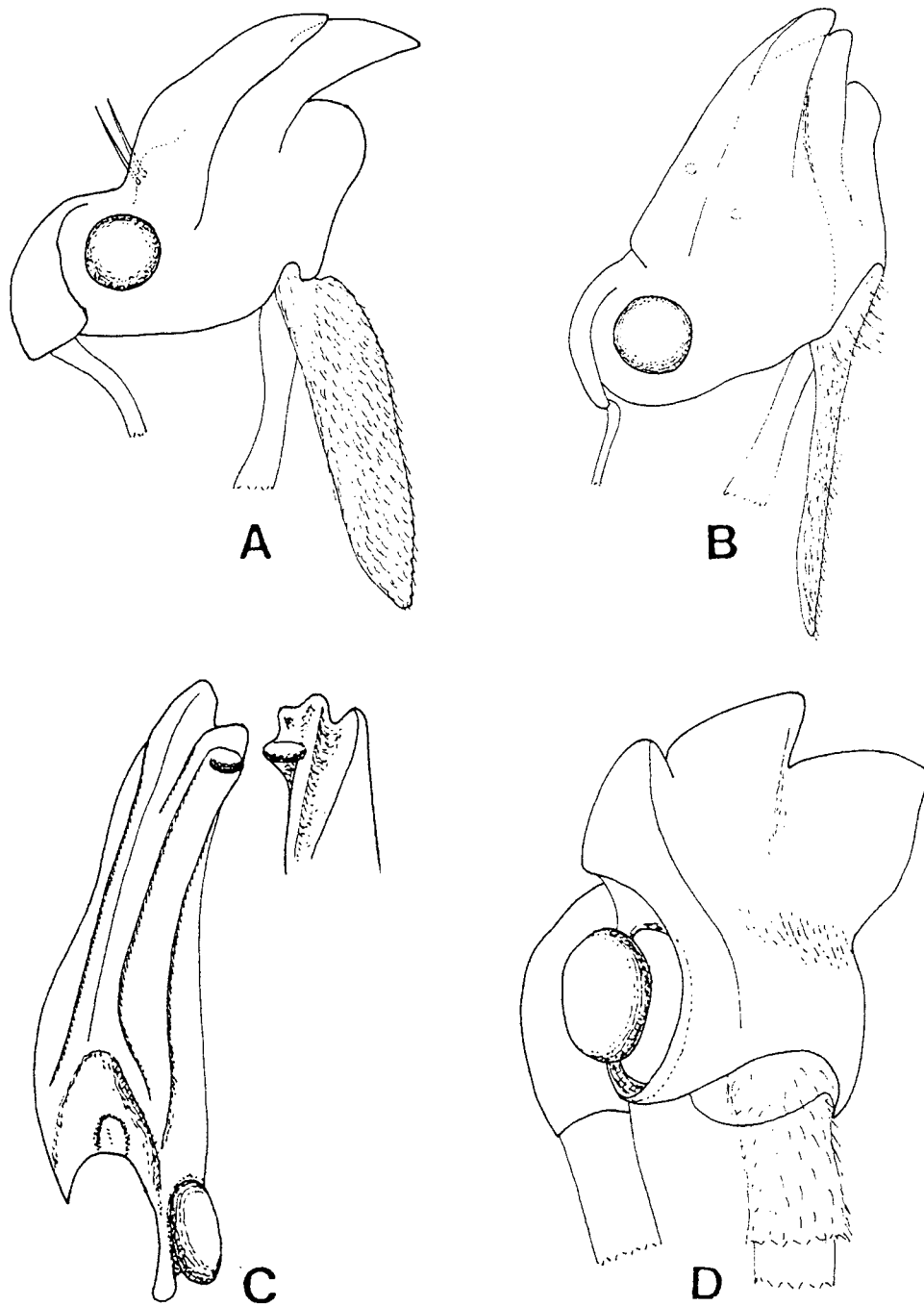
(Pl. 2)

Clypeal margin sexually dimorphic, deeply concave in mesal part in male, or slightly concave or almost straight in the middle in female.

Mandibles move obliquely, meet at the median line when retracted. Exterior surface more flat and less curved than the preceding, flexion between condyles weak. Teeth sharp and the tip pointed, nearly of the same size, and arranged in a straight line. Ventral cutting edge close to exterior margin, obtuse. Inner concavity obsolete. Exterior surface with scattered small punctures, each with a minute seta. Maxillae move almost vertically, almost concealed except for palpi owing to narrow maxillary clefts.

Maxillary palpi three-segmented, apical palpomere longer than wide, with papillae and longitudinal sensory pores, first and second palpomeres each with a seta.

Prementum narrow, about twice as long as wide, smooth, with a pair of setae behind the middle. Postmentum short, as long as wide. Maxillary clefts deep, weakly diverging apically. Hypo-



**Fig. 1.** Mandibles. A: *Cylas formicarius*. B: *Cerobates (cerobates) fromosanus*. C: *Baryrhynchus poweri* Roelofs (male). D: *Baryrhynchus poweri* Roelofs (female).

stomal arms extending apically to the level of apex of prementum.

***Baryrhynchus poweri* Roelofs, 1879**

(Figs. 1C, D, 2B, D; Pl. 3, 4)

Sexually dimorphic species.

**Male:** Clypeal margin weakly bisinuate with

faint paraclypeal clefts.

Mandibles long, slender, pincers-like, leaving big space between clypeus and mandibles when retracted. Dorsal tooth apical, large, sharply pointed. Apical tooth small, bluntly pointed. Ventral tooth hook-like on left mandible, hook-like tooth and subsidiary one on right mandible. Dor-

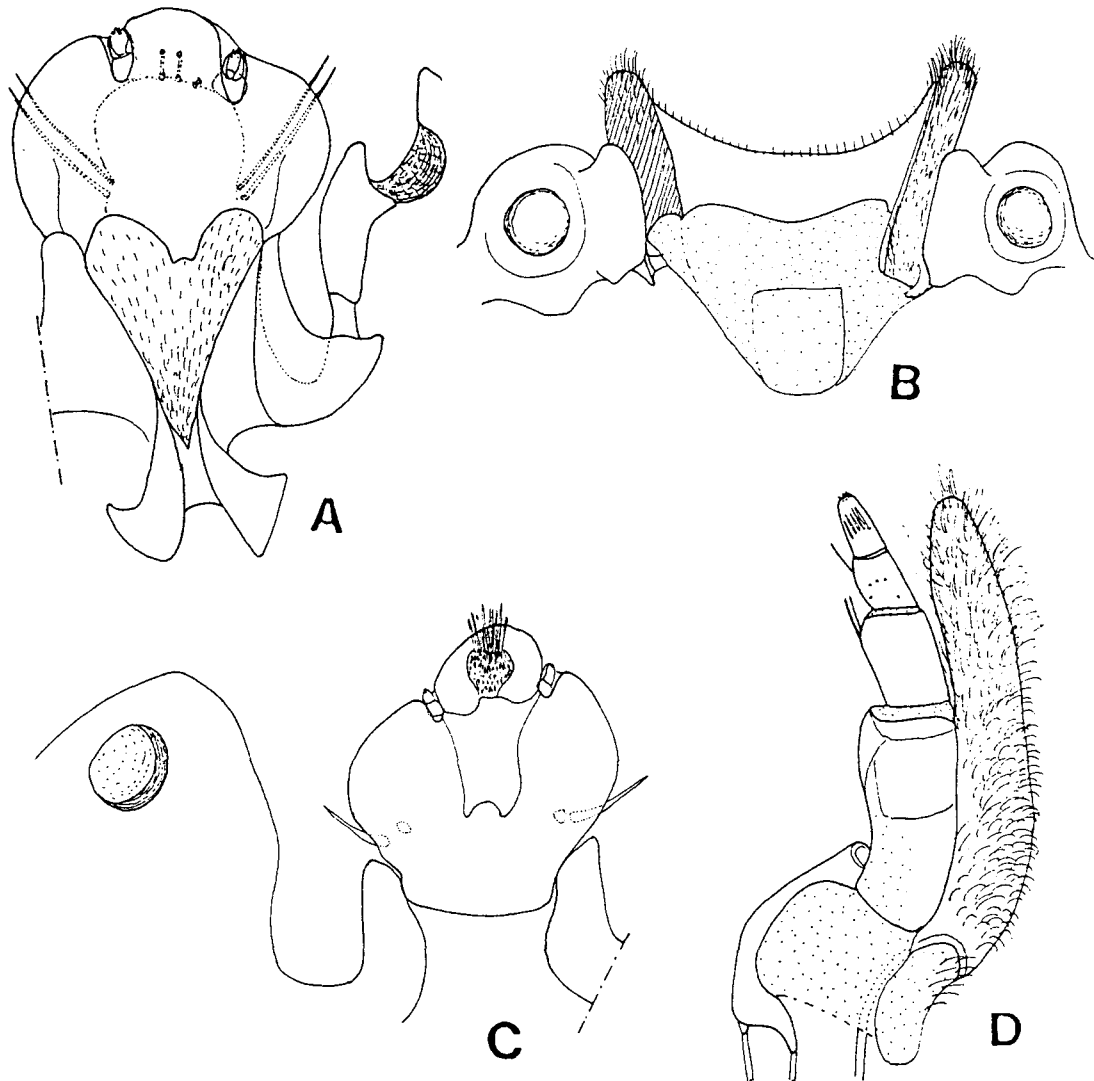


Fig. 2. A-C: Labium, ventral. D: Maxilla, ventral.

A: *Cylas formicarius*. B: *Baryrhynchus poweri* (male). C: *Cerobates (Cerobates) formosanus*. D: *Baryrhynchus poweri* (female)

sal and ventral cutting edges low, but keeled, with an additional keel between them from ventral tooth, interspace between dorsal and additional keels concave on distal half, that between additional and ventral keels flat.

Maxillae concealed by prementum except for palpi, flat, almost vertical, mala slender, about 7 times as long as wide, lying along lateral surface of prementum, with dense setae on both sides, cardo short, curved. Maxillary palpi slender, each palpomere a little longer than wide, apical palpomere with papillae at apex and elongate sensory pores at side.

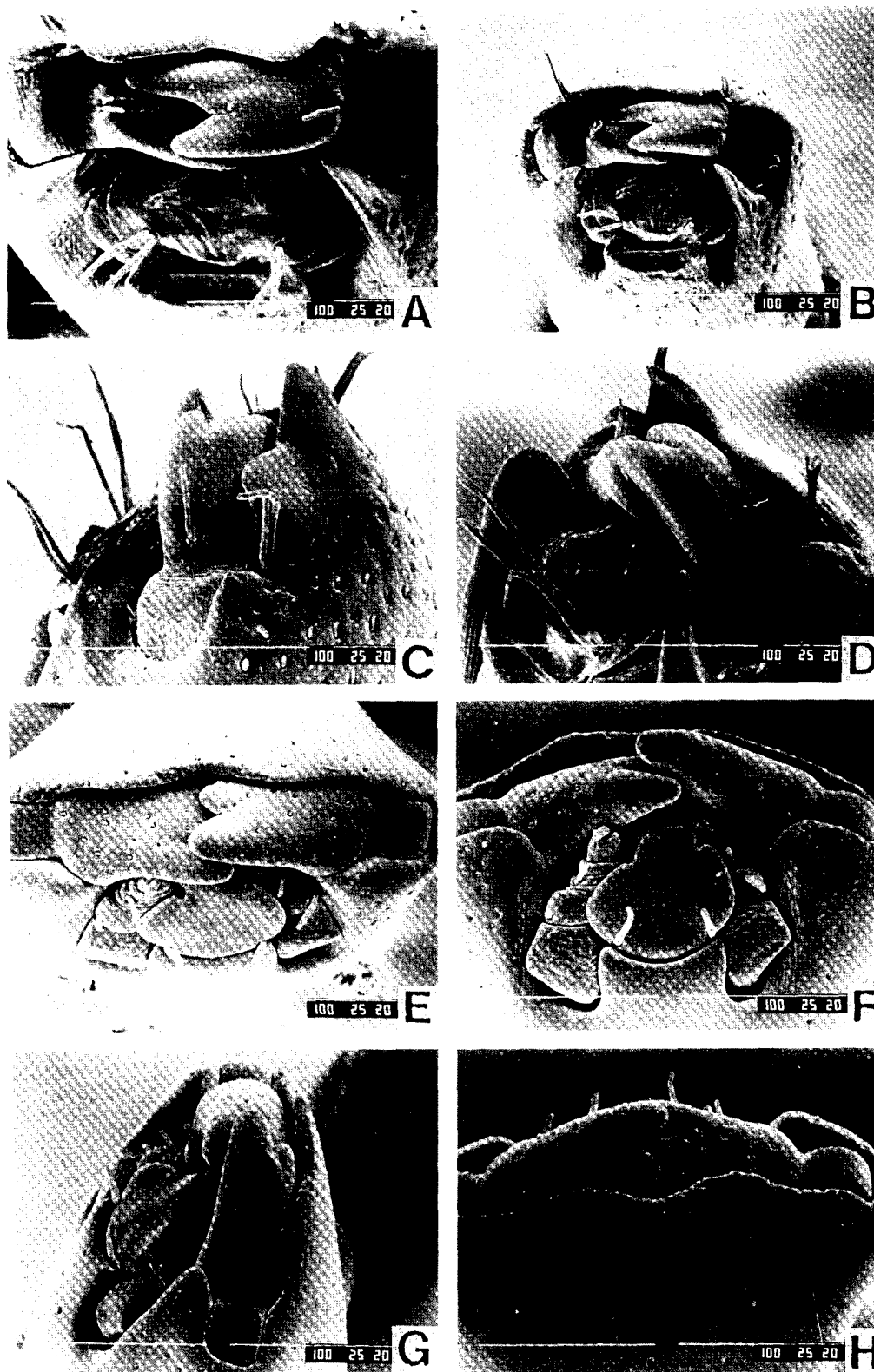
Prementum wider than long, evenly concave at apex, with fine setae along apical margin, which

are denser at apicolateral corners, lateral surface almost vertically truncate, ventral surface with two pairs of long setae. Postmentum very short. Hypostomal arms robust, rounded at apex, with postcoila as in the preceding.

**Female:** Clypeal margin straight, with oblique paraclypeal clefts.

Mandibles meet mesially. Teeth arranged in a straight line, dorsal tooth the largest, apical tooth median and ventral tooth smallest in size, inner surface not concave, dorsal and ventral cutting edges obtuse, postartis ball-like, with concave surrounding.

Maxillae flat, stipes and male fused, mala about 4 times as long as wide.



**Plate 1.** A-D: *Cylas formicarius* (Fabricius).

A: apical view. B: ventral view. C, D: lateral view. C, D: left mandible.

E-H: *Cerobates (Cerobates) formosanus* Schoenfeldt.

E: apical view. F: ventral view. G: lateral view. H: dorsal view. G: left mandible.



Plate 2. *Trachelizus japonicus* Morimoto. (male, female).

A, B: apical view. C, D: ventral view. E: dorsal view. F: ventrolateral view.

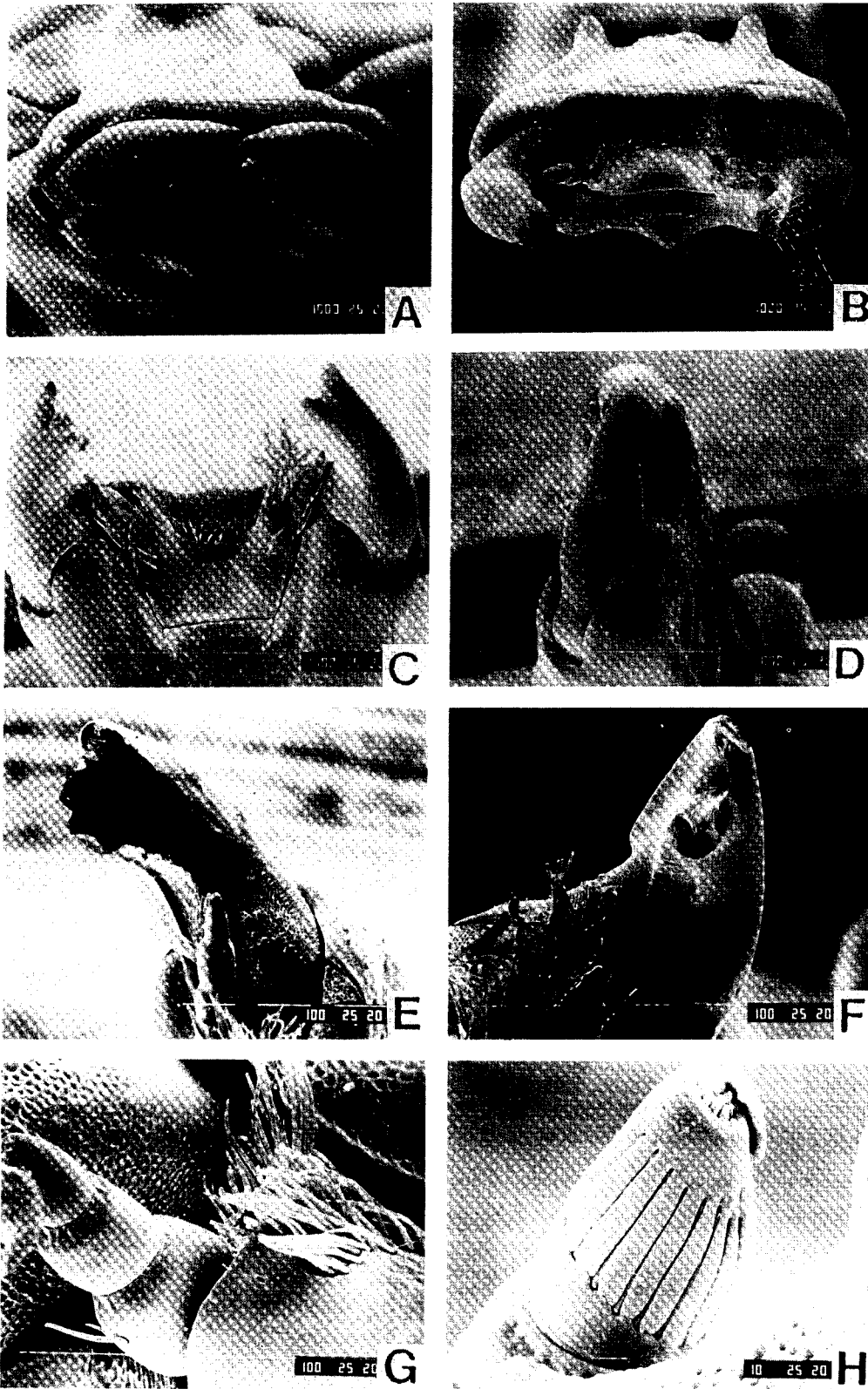
Prementum oblong, about twice as long as wide, with several long setae in mesal line, with dense setae at apex of ental surface. Postmentum very short. Hypostomal arms robust, rounded at apex, reaching apically to the level of apex of prementum.

***Pseudorychodes insignis* (Lewis, 1884)**  
(Pl. 5)

Sexually dimorphic species in less extent.

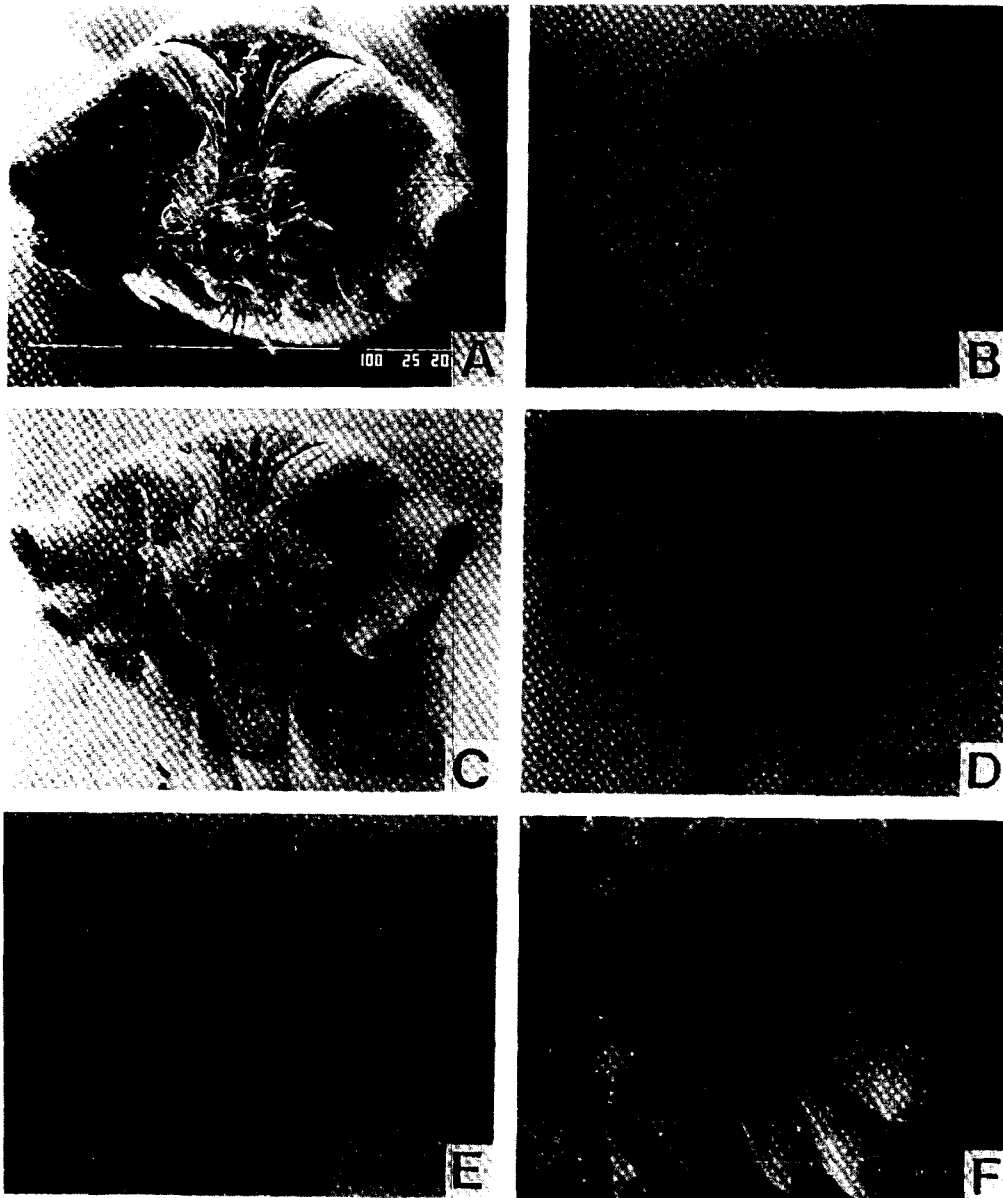
**Male:** Clypeal margin broadly concave in the middle, paraclypeal sulci faint.

Mandibles meet medianly when retracted, leaving a small space between clypeus and mandibles. Apical and dorsal teeth nearly of the same size, ventral tooth smaller, three teeth arranged in a straight line on right mandible, with two teeth, ventral tooth small and much interior to apical tooth on left mandible. Dorsal and ventral cutting edges blunt, without any additional keel



**Plate 3.** *Baryrhynchus poweri* Roelofs, male.

A, B: apical view. C: ventral view. D, E: lateral view. F, G, H: ventrolateral view. E: right mandible. F: left mandible. G: maxillary palp. H: terminal segment of maxillary palp.



**Plate 4.** *Baryrhynchus poweri* Roelofs, female.

A: apical view. B, F: apicoventral view. C, D: ventral view. D: ventrolateral view. F: left mandible.

on inner surface. Exterior surface with scattered small punctures, each with a small scale.

Maxillae vertical, stipes narrowly visible between prementum and hypostomal arm, maxillary palpi exposed, robust, three-segmented, apical palpomere with papillae at apex and elongate sensory pores at sides, first and second palpomeres each with a seta.

Prementum hexagonal, widest at the middle, almost parallel-sided to the base, with a long setae behind the middle near side margin and a minute setae behind apicolateral corner on each

side. Postmentum very short. Hypostomal arms robust, reaching apically to the level of apex of prementum.

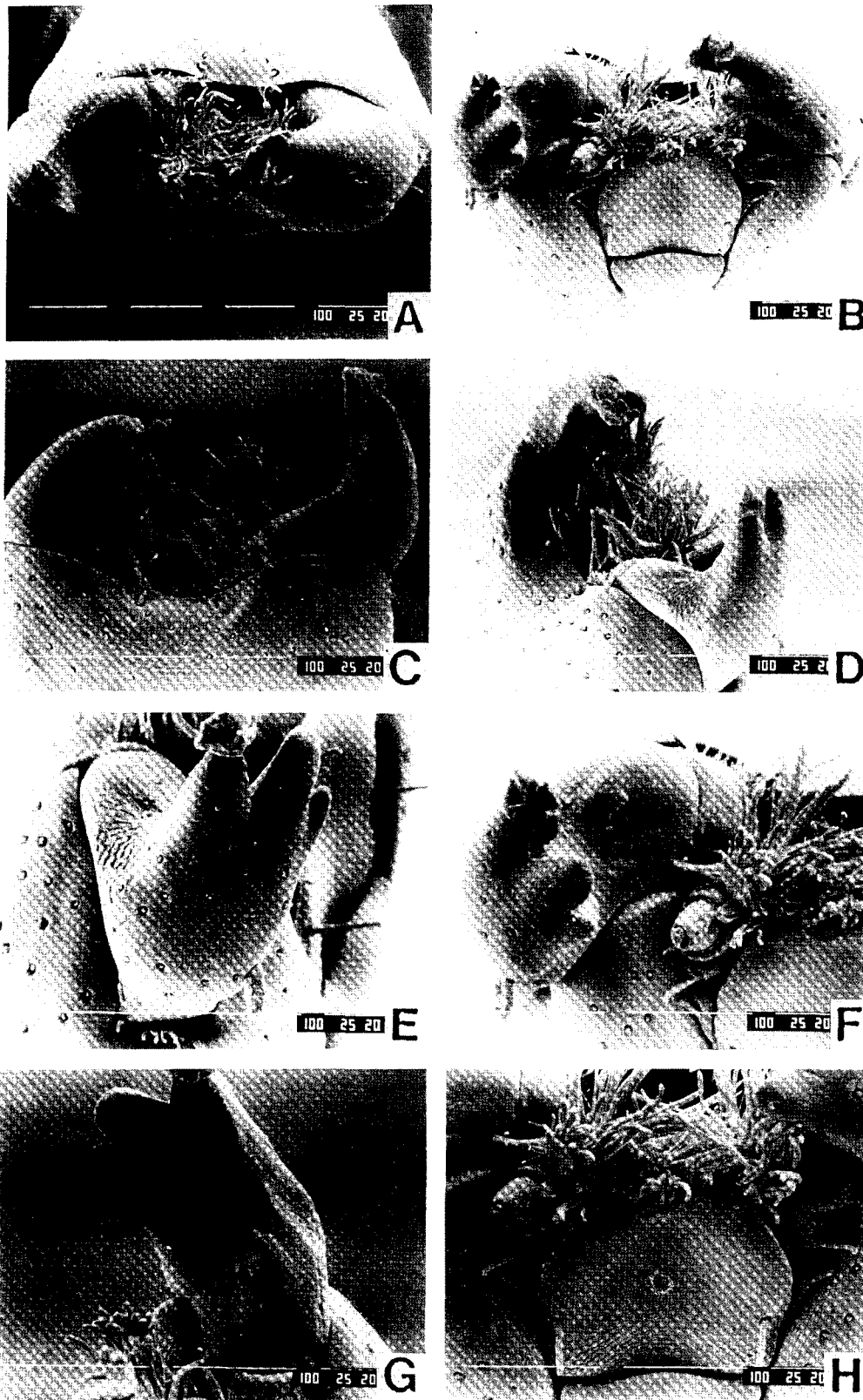
**Female:** Clypeal margin broadly concave in the middle, paraclypeal sulci faint.

Mandibles flat, directing apically in parallel to each other in most specimens. Dorsal tooth largest, apical tooth median, and ventral tooth smallest in size.

Maxillary clefts weakly diverging apically to each other.

Prementum narrower, 4 times as long as wide,





**Plate 5.** *Pseudorychodes insignis* (Lewis).

A: apical view. B, F, H: ventral view. C: dorsal view. D: dorsolateral view. E, G: lateral view. E-G: right mandible. F: maxillary palp and prementum.

with a few setae on the ventral surface. Postmentum shorter and narrower than prementum, parallel-sided, about 3 times as long as wide.

### General morphology of the family Brentidae

**The septum of the preoral cavity.** The septum is absent.

**The labrum.** The labrum is completely absent.

**The clypeus.** The clypeal margin produced apically, and shallowly and evenly concave in the middle, or shallowly bisinuate in the male with widely distant mandibles.

**The mandibles.** The mandibles move obliquely upwards. They meet at the median line or lie upon the other anteroposteriorly when they are retracted. The preartis is nearly the same structure, and the postartis is well developed. The precoila is crescent-shaped and protruding, the postcoila is well developed, deeply concave from the margin in *Cylas*, or concave as a round deep pit behind apex of the hypostomal protrusion. The outer surface has a distinct flexion between the dorsal and ventral condyles and the exterior surface basal to the flexion forms a smooth and evenly curved articular surface and produced as a lobe of lamella. The mandibles are typically two-notched and three-toothed on the mesal margin in both sexes. The dorsal and ventral cutting edges are obtuse, the latter edge lies close to or on the exterior margin, and the inner concavity becomes a flat, convex or slightly concave oblique surface embracing maxillae between them when mandibles are retracted. Then, the teeth are arranged in a straight line by the enlargement of interoventral surface between dorsal and ventral cutting edges. Those are comparable to the apical, dorsal and ventral teeth of the primitive weevils. The outer longitudinal groove and long setae are absent except for *Cylas*, which has a long and a few minute setae in front of the flexion. The postcoila is deep and located on the hypostomal arm a little behind the apex, into which the postartis of mandible fits tightly.

**The Maxillae.** The maxillae move nearly vertically and the maxillary palpi are three-segmented. The apical segment of the maxillary palpus bears several nipple-like papillae at its apex and several longitudinal sensory pores on dorsal or lateral wall. The galea has become fused with the lacinia, and the lacinia bears setae on its mesal margin. The stipes, except for its

mesal margin where it is fused with the lacinia, is defined.

**The labium.** The prementum is more or less wider than postmentum, with one to three pairs of setae. The labial palpi are small, one- or two-segmented, and inserted in sockets on ental surface of prementum. The ligula is not visible from ventral side. The postmentum is extremely short.

### Feeding mechanisms

The mandibles of the Brentidae examined can be classified into three groups by their features. The first group comprises *Cylas* and *Cerobates*. Their mouth parts are not sexually dimorphic, and the mandibles meet anteroposteriorly more or less curved internally when retracted. This type may be efficient for chewing. The second type is seen in *Trachelizus*, and females of *Baryrhynchus* and *Pseudo-rychodes*. Their rostrum is cylindrical, and their mandibles are apically stretched, flat and more straight, and apically directing. These rostrum and mandibles can be regarded as an adaptation for drilling. Third type is observed in the males of sexually dimorphic genera, *Baryrhynchus* and *Pseudorychodes*. Their rostrum is much robust and transverse than in female by the great expansion of the median area of the clypeus and labium. Their mandibles are by no means suitable for chewing nor drilling (Ting 1933; Butt 1951; Evans 1963). The maxillae are widely distant and only movable along lateral vertical surface of prementum for a short distance. The male weevils of this type can suck liquid at most through slit-like narrow preoral cavity between the clypeus and prementum.

### Considerations on the classification of the Brentidae

The labial palpi are two-segmented and inserted in sockets on the ental surface of prementum a little behind apical margin (Crowson 1955), and by this character the genus *Cylas* was transferred to this family from the Apionidae (Morimoto 1976). But *Cylas* is distinct from the other brentids by the ventral articulation of mandibles, of which the postcoila is deeply concave from the inner edge a little behind the apex of the hypostomal protrusion, whereas in the other brentids the postcoila is a round deep excavation a little inside from the inner edge behind the apex of

**Table 2.** Mouthparts of the Family Brentidae

	clypeus	mandibles	maxillae	labium	
				prementum	labial palpi
<i>Cylas formicarius</i>	weakly produced, with two setae	move obliquely, meet antero-posteriorly	move vertically, palpi three-segmented	ovate	small, two-segmented, inserted in sockets
<i>Cerobates (Cerobates) formosanus</i>	weakly produced apically, without seta	move obliquely, meet antero-posteriorly	move vertically, palpi three-segmented	ovate, with a pair of long setae	small, two-segmented, inserted in sockets
<i>Trachelizus japonicus (male)</i>	deeply concave in mesal part	move obliquely, meet median line	move vertically, palpi three-segmented	narrow, with a pair of long setae	two-segmented
<i>Trachelizus japonicus (female)</i>	slightly concave or almost straight	move obliquely, meet median line	move vertically, palpi three-segmented	narrow, with a pair of long setae	two-segmented
<i>Baryrhynchus poweri (male)</i>	weakly bisinuate	long, slender, pincers-like, leaving space when retracted	concealed by prementum, palpi slender	wider than long, with fine setae	two-segmented
<i>Baryrhynchus poweri (female)</i>	straight	meet mesially	concealed by prementum, flat	oblong, with several long setae	two-segmented
<i>Pseudorychodes insignis (male)</i>	broadly concave	meet medianly, leaving a small space when retracted	move vertically, palpi exposed, robust, three-segmented	hexagonal, with a long setae	two-segmented
<i>Pseudorychodes insignis (female)</i>	broadly concave	flat, move parallel	move vertically, palpi exposed, robust, three-segmented	narrow, with a few setae	two-segmented

hypostomal protrusion. The maxillae are generally flat, with many setae on mala, but some of the setae along inner margin are very robust and large in *Cylas* and *Cerobates*. Obtained data of the family Brentidae are summarized as Table 2.

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## 바구미상과(딱정벌레목) 갑충 구기의 비교형태와 그 섭식기작과 분류와의 관계에 대한 연구. Part I. Family Brentidae

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**적 요** - 바구미류의 섭식행동과 산란공을 파는 운동과 구기의 복합적인 구조를 알기 위해서는 원래의 위치에서의 복잡한 구기구조의 관찰이 행하여져야만 한다. 이러한 목적을 위하여 Brentidae의 바구미류에 대하여 주사전자현미경을 사용하여 구기를 본래의 위치에서 관찰하고, 여기에 해부에 의한 연구도 병행하여 얻은 구기구조에 대한 연구의 결과는 다음과 같다. 이 과에 속하는 바구미는 아랫입술 수염이 퇴화되어 하순전기절의 꼭대기의 구멍에 위치하고 있다. 대악후관절구는 깊이파인 사발과 같은 구조로서 하순완의 안쪽 표면에 위치하고 있다.