

## Larval Morphology and Biology of *Halticorcus kasuga* (NAKANE) (Coleoptera, Chrysomelidae)

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**Abstract** Larval morphology of the flea beetle, *Halticorcus kasuga* (NAKANE, 1963), is described with mining habit and life history for the first time. The larva is characterized by the following features: body flattened dorso-ventrally; thorax tuberculate, each venter with one sclerotized tubercle (ES-SS) and two pairs of setae, meso- and metathoraces each with DLe, and mesothorax and abdominal segment 1–8 each with triangular lateral projection. Larva of *H. kasuga* is very similar to *H. sauteri* (CHEN, 1934), but the number of mandibular teeth is different. In mining habit, larvae can change their mining leaves, of which the frequency depends on the leaf-size. This species is concluded to be univoltine. Adults are appeared in the early April, abundant in the middle of September, and overwinter from the end of October.

### Introduction

*Halticorcus* LEA, 1917 is a small genus of the subfamily Alticinae and contained about 35 species from the Oriental and Australian Regions and also in Japan and Korea of the Palearctic Region (HEIKERTINGER & CSIKI, 1940; SAMUELSON, 1969; KIMOTO & CHU, 1996; KONSTANTINOV & PRATHAPAN, 2008).

*Halticorcus* has peculiar habit that the larvae are leaf-miners of ferns. Six families of ferns are known as their hosts: Adiantaceae, Gleicheniaceae, Oleandraceae, Polypodiaceae, Pteridaceae and Thelypteridaceae (SUZUKI & MINAMI, 2008). Their mining habits were reported on four species: *H. hiranoi* (TAKIZAWA, 1982) and *H. sauteri* (CHEN, 1934) (KATO, 1991), *H. platycerii* LEA, 1917 (HAWKESWOOD, 2003), and *H. bhaumiki* (BASU et SENGUPTA, 1976) (PATRA & BERA, 2007). Morphologically, FROGGATT (1917) illustrated the larva of this genus on *H. platycerii* for the first time from Australia. KATO (1991) described the larva of *H. sauteri* from Japan with biological information.

In Japan, four species are known to occur from the Honshu to the Ryukyus, and all of them are associated with Polypodiaceae (SUZUKI *et al.*, 2008). Among them, *H. kasuga* (NAKANE, 1963) is the northernmost species of this genus and occurs from Honshu to Kyushu. SUZUKI *et al.* (2008) recorded the following epiphytic ferns as the hosts: *Lepisorus thunbergianus* (KAULF.) CHING, *L. onoei* (FR. et SAV.) CHING, *Lemmaphyllum microphyllum* C. PRESL. and *Pyrrosia linearifolia* (HOOK) CHING. ISOWA (2010) reported feeding habits and host preference of the adult.

In this paper, the larva of *H. kasuga* is described for the first time with biological information such as the mining habit and life history.

### Materials and methods

Larvae of *Halticorcus kasuga* were collected by the first author at the Hakone Town,

Kanagawa Prefecture from June 2008 through August 2009. They were fixed in 70% alcohol. The larvae were proved to this species in confirmation of the emergence by rearing. In total, 182 specimens were measured the head width and body length and 22 ones were observed in detail by dissection. Observation was made under stereoscopic and compound microscopes. The head and legs were detached and immersed with the remaining body in 10% KOH solution for 24 hours at room temperature. Additionally, four larval specimens of *Halticorcus* sp. were also examined, the specimens collected by Dr. Haruo TAKIZAWA at Pulau Gaya, Kota Kinabalu, Borneo (Sabah) from March 21th, 2008. The terminology was followed after BÖVING & CRAIGHEAD (1931) except that of tubercle followed KIMOTO & TAKIZAWA (1994). All the specimens used will be deposited in the collection of the Laboratory of Entomology, Tokyo University of Agriculture, Atsugi.

Biological observation was conducted on the above mentioned locality from March to October 2009 and was done in the laboratory. Seasonal fluctuation of *H. kasuga* population was observed at five stations in the Hakone Town. These stations were selected from the area, where host plants and flea beetles were abundant. Number of adults was counted about 15 minutes in each station. Numbers of eggs and larvae were counted about 15 minutes at one station by the following manner. Mining larvae were counted transparently. Number of eggs was counted by the new oviposition sites since eggs were covered with adult secretion.

#### Description of the Larva of *Halticorcus kasuga* (NAKANE)

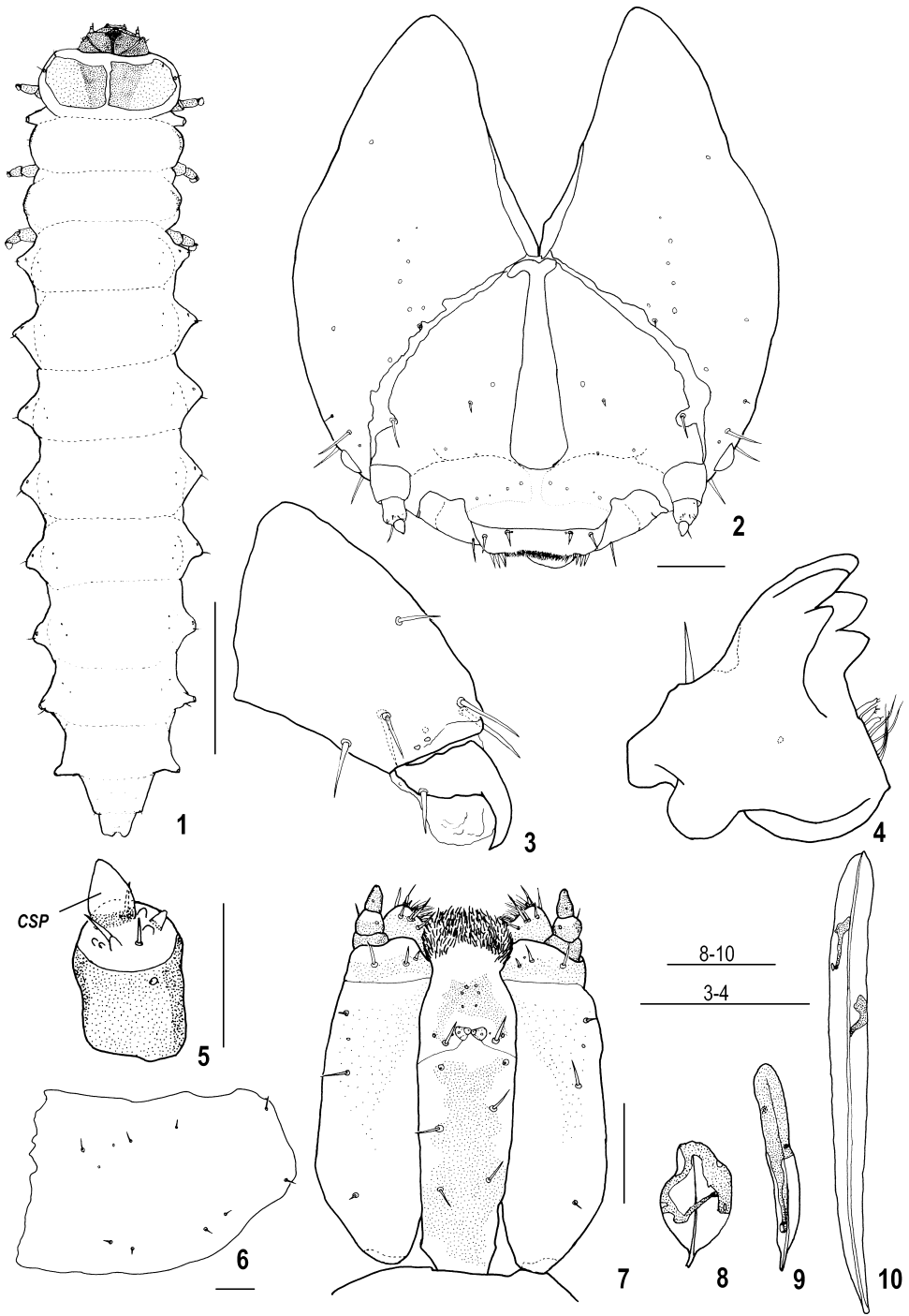
##### *Last instar larva* (Fig. 1)

Body yellow, flattened dorso-ventrally and subparallel-sided, with small number of minute setae; head, mandibles, median part of prothoracic dorsal tubercle and pro- to metathoracic ventral ones brown; other tubercles, spiracles and legs pale brown.

Head (Fig. 2) prognathous, flattened and well sclerotized; frontal suture widely divergent and curved; epicranium largely produced posteriorly on hind corner, moderately retractile into prothorax, with one longer pair and two shorter pairs of dorsal setae, three pairs of lateral setae and ten pairs of dorsal sensilla; frons with one longer pair and one shorter pair of setae and three pairs of sensilla; one pair of stemmata each situated behind antenna. Antenna (Fig. 5) 1-segmented, with three setae, one large conical sensory papilla (CSP), six sensorium and one sensillum. Clypeus with four pairs of sensilla; labrum weakly emarginated anteriorly, with two pairs of setae and one pair of sensilla; epipharynx with five, rarely four pairs of setae and numerous short setae. Mandible (Fig. 4) well sclerotized, palmate, with five distal teeth, one seta, one sensillum and seven to ten penicilli. Maxillary palp (Fig. 7) 3-segmented, 1st without seta nor sensillum, 2nd with one seta and one sensillum, 3rd with one sensillum; palpifer with three setae and one sensillum; stipes with three setae and one sensillum; galea fused with lacinia, with six setae, one joint-like appendix and numerous fine setae. Labial palp 1-segmented; prementum and postmentum separated barely by suture; prementum with one pair of setae and five pairs of sensilla; postmentum with two pairs of setae and pair of sensilla; ligula with numerous setae.

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Figs. 1–10. Larva of *Halticorcus kasuga* (1–7) and mines on the host plants (8–10). — 1, Last instar larva, dorsal view (Scale = 1.0 mm); 2, head, dorsal view; 3, left hind leg, lateral view; 4, mandible, ventral view (0.1 mm); 5, antenna, dorso-lateral view (0.05 mm); 6, prothoracic dorsal tubercle; 7, lower mouth parts, ventral view (0.1 mm); 8, mines on leaf of *Lemmaphyllum microphyllum*; 9, ditto, *Lepisorus onoei*; 10, ditto, *L. thunbergianus* (20 mm).



Prothorax (Figs. 6, 11) with large tubercle (D-DL) on tergum; D-DL with nine pairs of short setae and two pairs of sensilla; venter with one sclerotized tubercle (ES-SS) on median line; ES-SS with two pairs of short setae. Mesothorax with triangular lateral projection; mesothoracic spiracles annuliform, situated on tip of epipleuron, with peritreme sclerotized; meso- and metathoraces each with pair of weakly sclerotized tubercles (DLe) on tergum; DLe with three setae; venter with one sclerotized tubercle (ES-SS) on median line; ES-SS with two pairs of setae, smaller than prothoracic ES-SS. Leg (Fig. 3) unciform; tibia with six, rarely seven setae and three sensilla; tarsungulus falciform, curved at distal portion, enlarged base with one seta; pulvillus bladder-like.

Abdominal segment 1–8 each with triangular lateral projection; 9th segment and pygopod each with six pairs and one pair of minute setae on tergum, respectively; abdominal spiracles on first eight segments similar to mesothoracic spiracles, but smaller.

Body length:  $5.60 \pm 0.85$  mm (n=78).

Head width:  $0.68 \pm 0.10$  mm (n=78).

#### *Second and first instar larvae*

Similar to the last instar except for head width and body length.

Body length: 2nd instar larva,  $3.89 \pm 0.61$  mm (n=63); 1st instar larva,  $2.38 \pm 0.45$  mm (n=41).

Head width: 2nd instar larva,  $0.49 \pm 0.09$  mm (n=63); 1st instar larva,  $0.36 \pm 0.04$  mm (n=41).

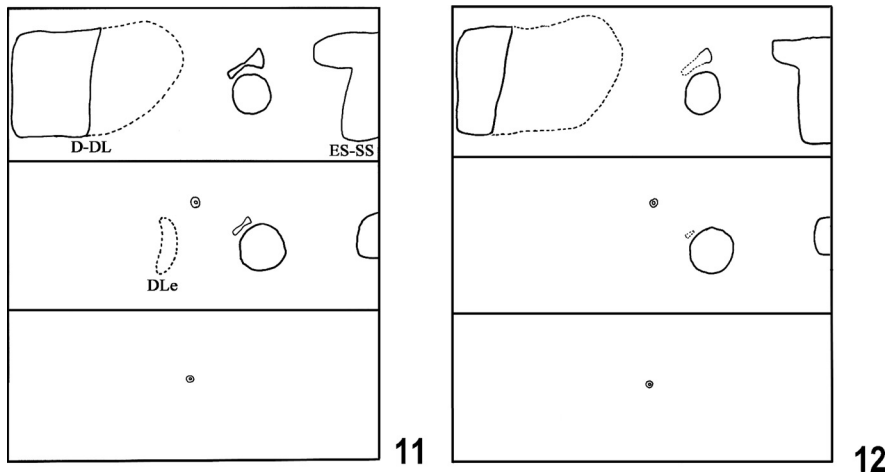
### Comparison

KATO (1991) described the second instar larva of *H. sauteri*. It is very similar to that of *H. kasuga*. Both species seem to share the following common characters: body flattened and subparallel-sided; prothoracic dorsal tubercle largely sclerotized, and mesothorax and abdomen projecting laterally. However, there are some differences in the head width and mouth parts, especially in the number of mandibular teeth (Table 1).

Additionally, larvae of undetermined *Halticorcus* sp. collected from Borneo (Sabah) were also examined for comparison with *H. kasuga*. The Bornean species possesses the well-developed mesothoracic and abdominal lateral projections. And, they also share the similar tubercle pattern though DLe is absent in the Bornean species (Figs. 11, 12).

Table 1. Difference between the second instar larvae of *Halticorcus kasuga* and *H. sauteri*.

| Character                     | <i>H. kasuga</i>           | <i>H. sauteri</i> (after KATO, 1991) |
|-------------------------------|----------------------------|--------------------------------------|
| Head width (mm)               | $0.49 \pm 0.09$            | 0.42                                 |
| Mandible (distal teeth)       | 5                          | 4                                    |
| Stipes                        | 3 setae and 1 sensillum    | 3 setae and 2 sensilla               |
| Palpifer                      | 3 setae and 1 sensillum    | 2 setae and 1 sensillum              |
| Labial palps                  | 1 segment                  | 2 segments                           |
| Maxillary palps (1st segment) | without seta and sensillum | 1 sensillum                          |
| Maxillary palps (2nd segment) | 1 seta and 1 sensillum     | 1 seta                               |
| Maxillary palps (3rd segment) | 1 sensillum                | not stated                           |



Figs. 11–12. Tubercle patterns of *Halticorcus* species (upper, prothorax; middle, mesothorax; lower, 2nd abdominal segment). — 11, *H. kasuga*; 12, Bornean *Halticorcus* sp.

### Biological notes

#### *Mining habit*

The hatched larvae usually mined mature leaves, and sometimes young ones. They directly mined from oviposition site of *Lepisorus thunbergianus*, *L. onoei* and *Lemmaphyllum microphyllum* (Figs. 8–10). Larvae mined facing the ventral side of body to the upper surface of leaf in position. Larvae usually mined towards the tip of leaf in initial stage, and across the midrib. Eventually, mining area spread to most part of leaf in some cases. Sometimes mines of two or more larvae coalesced into one and were shared in common. Larvae disposed their frass inside the mine cavity. The frass was disposed linearly on *L. thunbergianus* and *L. onoei*, and muddily on *L. microphyllum*.

Larvae changed their mining leaves in the following manner. Larvae left the mined leaf from the under surface or leaf margin, moved to another leaf and mined into it from the under surface (Fig. 13). Numbers of mined leaves by each larva which became fully matured were counted in the laboratory. A single larva mined 1.8 leaves of *L. thunbergianus* ( $n=8$ ), 3.0 of *L. onoei* ( $n=10$ ) and 6.9 of *L. microphyllum* ( $n=10$ ) in average, respectively. Some larvae stayed in mine of *L. thunbergianus* if the leaves were large enough in size and fully matured in the single leaf. On the contrary, if the leaf was small in size, the number of mined leaves was increased. Leaf-size of each *Lepisorus* species is larger than that of *Lemmaphyllum microphyllum* (Iwatsuki, 1992). Also adult host preference was significantly lower in *Lemmaphyllum microphyllum* than two other *Lepisorus* species (ISOWA, 2010).

Larvae molted twice inside the mine. Matured larvae left the leaves, moved to the base of the host and pupate in the soil or mosses near the bases of epiphytic ferns.

Mining habits are mostly concordant with other congeners: full depth mines (HERING, 1951), larvae mine matured leaves and usually changed from one mined leaf to another.

#### *Life-history* (Fig. 15)

Duration of each stage at room temperature is as follows: incubation period of egg was about



Figs. 13–14. Larva and oviposition site of *Halticorcus kasuga*. — 13, Larva enters another leaf from under surface; 14, oviposition site next to feeding scar.

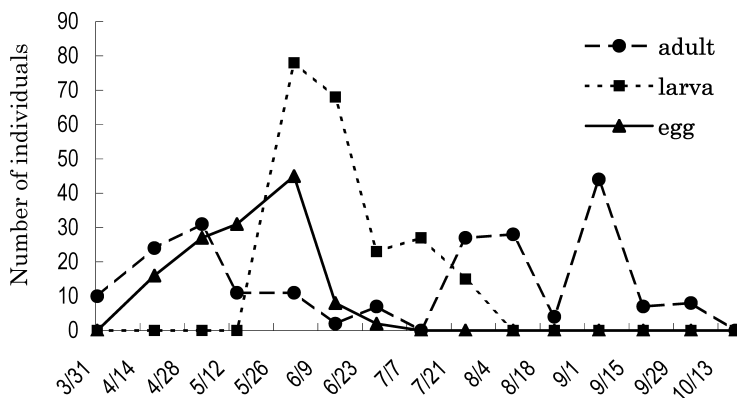


Fig. 15. Seasonal fluctuation of *Halticorcus kasuga* population in 2009.

12 days; larval duration was about 40 days including prepupal duration, which was about 14 days, and pupal duration was about 14 days.

In the field, overwintered adults were appeared in the early April and oviposit in the middle of April. Adults usually laid eggs singly on a leaf and covered eggs with secretion. They lay eggs next to (or near) feeding scar in most cases (Fig. 14). Several eggs are often laid in a single leaf as is known in other two Japanese species: *H. sauteri* and *H. hiranoi* (KATO, 1991). Eggs (new oviposition sites) were found by the end of June. HAWKESWOOD (2003) reported similar ovipositing manner in *H. platycerii*.

Larvae were found from June to early August, and most abundant during the rainy season from June to July. However, it is estimated that the larvae will begin to appear earlier than June judging from the fact that adults started oviposition in the middle of April.

New adults were appeared in the late July. They decreased once at the end of August to early September probably due to the aestivation, and became abundant in the middle of September. They decreased again from the late September. Adults overwinter under the bark or base of host from the end of October.

This species is concluded to be univoltine.

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### 要 約

磯輪亮太・小島弘昭：トホシニセマルトビハムシ *Halticorcus kasuga* (NAKANE) (コウチュウ目ハムシ科) の幼虫形態と生態。——トホシニセマルトビハムシ *Halticorcus kasuga* の幼虫を記載し、幼虫の潜葉習性及び本種の生活史について報告した。幼虫は扁平な体で、中胸及び腹部側縁が突出する。また、胸部に硬皮板を有し、腹面の硬皮板上には2対の感覚毛を有する。本種は KATO (1991) が記載したムツボシニセマルトビハムシ *H. sauteri* の2齡幼虫に酷似するが、大腮歯数などで区別できる。また、ボルネオからえられた本属の1種は DLe を欠くという点を除いてほぼ同様の硬皮板配列を示す。本種の幼虫は潜葉した葉から出て、他の葉に潜り直すことが可能で、その頻度は葉の大きさの影響を受ける。野外では年1化性で、越冬していた成虫は4月から活動を始め、9月中旬に最も多くの個体が出現し、10月末から越冬する。

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