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Larval and pupal morphology of three species of the genus *Psammoecus* Latreille (Coleoptera: Silvanidae: Brontinae) in Japan with reference to the number of larval instars

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Abstract

The last instar larva and the pupa of *Psammoecus scitus* Yoshida & Hirowatari, all instar larvae of *P. simoni* Grouvelle, and the last instar larva of *P. hiranoi* Yoshida & Hirowatari are described, and their morphologies are compared among species and instars. Larval association for *P. simoni* was confirmed by DNA barcoding. Apart from a brief description of the pupa of *Cryptamorpha brevicornis* (White) illustrated by Hudson (1924), the pupal morphology of Brontinae is described in detail for the first time. Potentially informative characters for phylogeny of larval and pupal morphology of Silvanidae are discussed.

Key words: Cucujoidea, Telephanini, immature stages, mouth parts

Introduction

The silvanid genus *Psammoecus* Latreille (Brontinae, Telephanini) includes about 80 described species which are almost global in distribution (Thomas & Leschen 2010; Thomas & Yamamoto 2007). Ten species of *Psammoecus* are distributed in Japan (Hirano 2009, 2010, Yoshida & Hirowatari 2013, 2014). This genus may include important pests and invasive species. *Psammoecus triguttatus* Reitter was recorded being transferred with products (Lu & Han 2006 and Yoshida & Hirowatari 2014) like other silvanid taxa (Halstead 1986). However, little ecological information exists regarding this genus. Except for descriptions of larvae of *P. trimaculatus* Motschulsky (Pal 1985) from India and *P. triguttatus* Reitter (Hayashi 1992) from Japan, there is very little morphological and ecological information of their immature stages (for a summary, see Klausnitzer 2001).

Pupal morphology of Silvanidae has been reported only for four species. In addition, there have been no studies comparing larval morphology among species and instars in the family and no report of the number of instars in Brontinae except for the assumption of *Dendrophagus crenatus* (Paykull) having five larval instars (Crowson & Ellis 1969). Thus, accumulation of morphological differences among larval instars and ecological information such as the number of larval instars in the Silvanidae are required.

The families of Cucujoidea, especially primitive groups including the Silvanidae, are phylogenetically problematic taxa (Leschen *et al*. 2005). In the family Silvanidae, there has been only one preliminary phylogenetic analysis (Thomas & Nearns 2008). It selected no more than three larval characters which character state for about half the number of species was unknown. Therefore, accumulation of descriptions of cucujoid immature stages contributes to more accurate inference of their phylogenetic relationships because larval morphology provides useful information for phylogenetic studies (e.g. Lawrence *et al*. 2011; Leschen *et al*. 2005; Thomas & Nearns 2008). Pupal morphology also provides useful information for phylogenetic analyses (e.g. Penz 1999; Reinert *et al*. 2004), and descriptions of pupal morphology of problematic taxa should be performed where feasible.

In this paper, we describe the last instar larva and the pupa of *P. scitus* Yoshida & Hirowatari, all instar larvae of *P. simoni* Grouvelle, and the last instar larva of *P. hiranoi* Yoshida & Hirowatari, with comparison of larval

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a brief description of the pupa of *Cryptamorpha brevicornis* (White) illustrated by Hudson (1924). There is little knowledge of pupal morphology in Silvanidae (*Cathartus quadricollis* (Guérin-Méneville), Allotey & Morris 1993; *Eunausibius wheeleri* Schwarz & Barber and *Coccidotrophus socialis* Schwarz & Barber, Böving 1921; *C. brevicornis*, Hudson 1924). However, their pupal morphologies, such as teeth on lateral margins of prothorax and protuberances on lateral portions of 2nd to 7th abdominal segments, were considered to be informative characters. We confirmed that pupae of other *Psammoecus* species (possibly *P. hiranoi*) bear similar teeth and protuberances on each corresponding portion. The pupa of *C. brevicornis* illustrated by Hudson (1924) did not seem to present such peculiar teeth and protuberances on lateral margins of prothorax and abdominal segments. Thus, these characters are considered to be possible synapomorphies for *Psammoecus*.

Larval instars. In the present study, it is inferred that *P. simoni* has five larval instars based on head capsule width measurements. The published number of larval instars of the Brontinae was based on the assumption that *D. crenatus* has five larval instars (Crowson & Ellis 1969). In the Silvaninae, *Cathartus quadricollis* was reported to have five larval instars (Allotey & Morris 1993) and *Ahasverus advena* (Waltl) was reported to have four or five instars, which depend on fungus species given as diet (David *et al*. 1974). Based on these observations, five larval instars seems to be common in the family Silvanidae. However, most cucujoid families are known to have three or four larval instars (e.g. four larval instars: Cerylonidae [see Halstead 1968]; Endomychidae [see Leschen & Carlton 1993]; and three larval instars: Helotidae [see Lee *et al*. 2007]; Phalacridae [see Steiner & Singh 1987]; Cryptophagidae [see Hinton & Stephens 1941]; Erotylidae [see Skelley *et al*. 1991]) except for the Sphindidae (see Burakowski & Ślipiński 1987) having five larval instars and the Cucujidae (see Bonacci *et al*. 2012) having seven larval instars maximum. In addition, Leschen & Carlton (1993) suggested that four larval instars may be a synapomorphy for the cerylonid series (they listed Coccinellidae, Cerylonidae and Endomychidae as the cerylonid series), based upon the occurrence of three larval instars within the more primitive Cucujoidea (they listed Phalacridae, Cryptophagidae, Erotylidae, Corylophidae, Latridiidae and Nitidulidae as the primitive Cucujoidea). However, the Corylophidae and the Latridiidae are included in the cerylonid series (Leschen *et al*. 2005), and, as stated above, a part of the primitive cucujoid families were found to have more than three larval instars (Sphindidae and Silvanidae, five larval instars; Cucujidae, seven larval instars maximum). In addition, the number of larval instars may be variable among individuals of the same species due to various factors (Allotey & Morris 1993; David *et al*. 1974). Thus, determination of the number of larval instars as evolutionarily informative for clusters of families within Cucujoidea seems to be difficult and will require more data.

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