

Hymenopteran parasitoids of the ant-eating spider *Zodarion styliferum* (Simon) (Araneae, Zodariidae)

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Academic editor: Gavin Broad | Received 15 August 2012 | Accepted 27 December 2012 | Published 1 February 2013

Citation: Korenko S, Schmidt S, Schwarz M, Gibson GAP, Pekár S (2013) Hymenopteran parasitoids of the ant-eating spider *Zodarion styliferum* (Simon) (Araneae, Zodariidae). ZooKeys 262: 1–15. doi: 10.3897/zookeys.262.3857

Abstract

Calymmochilus dispar Bouček & Andriescu (Hymenoptera, Eupelmidae) and *Gelis apterus* (Pontoppidan) (Hymenoptera, Ichneumonidae) are newly recorded as parasitoids of the ant-eating spider *Zodarion styliferum* (Simon) (Araneae, Zodariidae). The larvae of both parasitoid species fed on juvenile spiders. The final instar larva and pupa of *C. dispar* and the male of *G. apterus* are described for the first time. Both species represent new distribution records for Portugal. The biology and host associations of the parasitoids are discussed.

Keywords

Ectoparasitoid, host, *Calymmochilus*, *Gelis*, larva, pupa, male description

Introduction

Several groups of Hymenoptera develop on spider hosts, their larvae either feeding on the spider or on its eggs (Fitton et al. 1987). Species known to use spiders as hosts include those of Ichneumonidae (Ichneumonoidea), Eulophidae, Eupelmidae, Eurytomidae and Pteromalidae (Chalcidoidea), Diapriidae (Diaprioidea), Scelioninae (Platygastridae, Platygastridae), Pompilidae (Vespoidea), and Sphecidae (Sphecoidea) (Aubert 1969; Fitton et al. 1987; Noyes 2012). The parasitoids attack a number of spiders ranging from ground dwelling and fast moving hunters like wolf spiders of the family Lycosidae (Kessler and Fokkinga 1973) to web spiders such as orb-web weavers of the family Araneidae (Gonzaga and Sobczak 2011) that stay on webs during most of their life. Some parasitoids parasitize a wide range of spider species whereas others are narrow specialists of a single species (Fitton et al. 1987). The parasitoids and predators include solitary species or those that develop in small broods feeding in cocooned spider egg masses to endoparasitoids that develop individually within eggs, and from external koinobiont parasitoids of mobile spiders to idiobionts that paralyse one (Pompilidae) or more (Sphecidae) spiders as prey (Austin 1985; Eberhard 1970; Gauld and Dubois 2006).

Zodarion Walckenaer is the most species-rich genus of ant-eating spiders in the family Zodariidae Pickard-Cambridge (Araneae) (Platnick 2012). They are restricted almost exclusively to the Palearctic region with at least 35 species reported for the Iberian Peninsula (Platnick 2012). Available data on their biology show that all species are compulsory ant eaters (Wiehle 1928; Cushing and Santangelo 2002; Pekár 2004; Pekár et al. 2005a,b, 2011). Some *Zodarion* spiders (Fig. 1A) are Batesian mimics with various colour patterns and morphological resemblance to ants. They are crepuscular and often nocturnal wanderers. During the day they remain hidden in igloo-shaped retreats (Fig. 1B) that are attached to the underside of rocks or dead wood. The igloos provide protection against unfavourable environmental conditions and enemies such as ants.

The only previous record of a predator or a parasitoid of a *Zodarion* spider is that of a larva tentatively identified as a parasitoid feeding on *Z. cyrenaicum* Denis, 1935 in Israel (Pekár et al. 2005a). Here we newly present information about two parasitoids associated with *Z. styliferum* (Simon, 1870) in Portugal, *Calymmochilus dispar* Bouček & Andriescu (Chalcidoidea, Eupelmidae) and *Gelis apterus* (Pontoppidan) (Ichneumonoidea, Ichneumonidae). Notes on their biology are provided and the final instar larva and pupa of *C. dispar* and the male of *G. apterus* are described for the first time.

Methods

During 2008–2011 we conducted 31 field excursions in 18 localities in Central and Southern Portugal, in early spring between the last week of March and the first week of April in 2008–2010, and in late spring in the last week of May in 2011. Different habi-

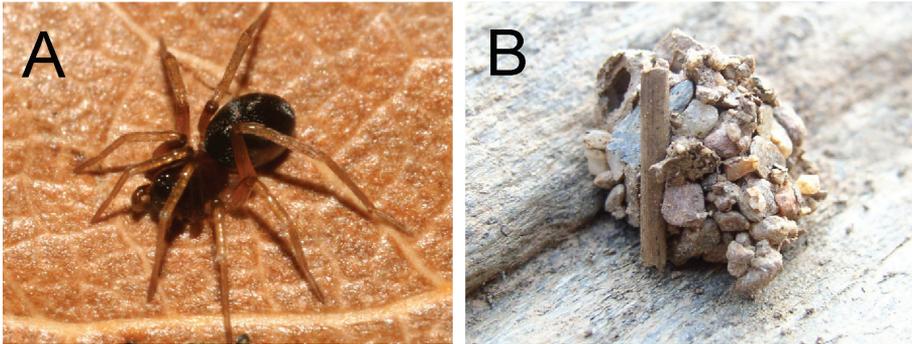


Figure 1. Spider host, juvenile *Zodarion styliferum* (A), igloo-shaped retreat (B).

tats were investigated, including arid meadows with sparse vegetation, meadows surrounding a castle, sand beaches with sparse vegetation, slopes of river banks, olive groves, and wooded habitats. Larvae and pupae of hymenopteran parasitoids were collected from the igloos of *Z. styliferum* in seven localities (Fig. 2). Entomological pincers were used to open the spider igloos and parasitized spiders were transferred to plastic containers using an aspirator. The whole igloo was collected if there was a pupa inside an igloo.

The diversity of *Zodarion* spiders, their abundance, and the rate of the parasitism was recorded for each of the localities where *G. apterus* and *C. dispar* parasitized spiders. The rate of parasitism per excursion was calculated as the number of parasitized spiders compared to all observed spiders during the excursion. Parasitoid larvae and pupae were reared until emergence of the adult wasps (1 of the 11 specimens was lost). Duration of the pupal stage, size of the pupa, and sex of the adult wasp were recorded. Emerged wasps were preserved in pure ethanol and identified using Bouček and Andriescu (1967), Gibson (1995), and Schwarz (1995, 1998 and 2002). Spiders were identified using Pekár and Cardoso (2005). The juvenile *Zodarion* hosts were identified to species-level based on knowledge of the species diversity in the investigated localities and using distinct differences in body proportions and coloration among occurring species. Wasp specimens are deposited in the private collection of M. Schwarz, Eben, Austria, the Canadian National Collection of Insects (CNCI), Ottawa, Canada, and the collection of Zoologische Staatssammlung, Münchhausenstr (ZSM), Munich, Germany. Morphological terms largely follow Gibson (1997) for Chalcidoidea and Schwarz (1998, 2002) for Ichneumonidae. The mature female and male larva and pupa of *C. dispar* were described based on photographs taken once they were detached from the spider at two day intervals and reared to adults.

Microphotographs of adult wasps (Figs 3, 5) were obtained using a Nikon D300s DSLR camera with a Leitz Photar 1:2/25 mm lens connected via a Novoflex Universal Bellows (total views) and a ProgRes SpeedXT core 5 (Jenoptik AG) camera attached to Leitz M205 stereo microscope (images of heads). Images were captured in raw format, developed using Adobe Lightroom 3, and extended depth-of-field images obtained using Zerene Stacker 1.04 (Zerene Systems LLC). Stacked images were enhanced using

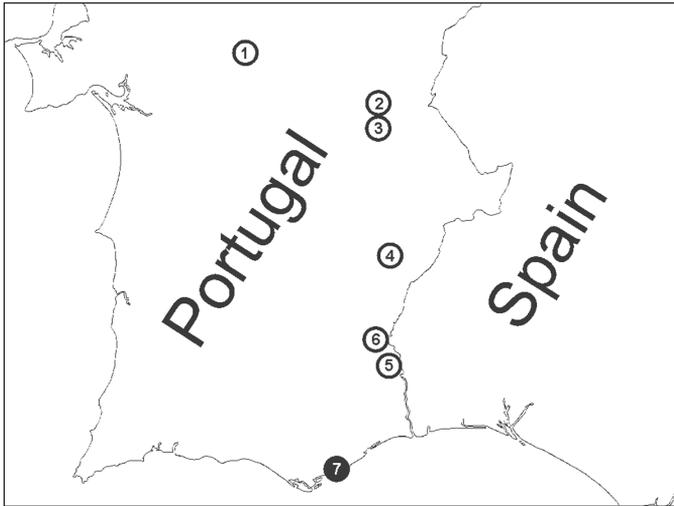


Figure 2. Localities where parasitoids were recovered from *Z. styliferum*. White circle = spiders parasitized by *Gelis apterus*, black circle = spiders parasitized by *Calymnochilus dispar*. Localities, in order from north to south: **1** Montemor o Novo – surrounding of castle ruins **2** Monsaraz – old olive grove **3** Alqueva – bank of water reservoir close to Moura **4** Ribeira de Limas – arid habitat with sparse vegetation **5** Alcoutim – arid habitat with sparse vegetation **6** Mesquita - arid habitat with sparse vegetation **7** Moncarapacho – arid slope in road surrounding.

Adobe Photoshop CS5 (Adobe Systems Inc.). The microphotographs of the cocoons, larvae and pupae (Figs 4, 6) were obtained using an Olympus U-TV 0.5 XC-3 camera with ColorView Soft Imaging System III-U software attached to an Olympus SZX-ILLK200 microscope.

Results

Host and parasitism rate

Three species of *Zodarion* were recorded from seven localities where parasitoids were found (Fig. 2). *Zodarion styliferum* (Simon, 1870) was dominant in all localities, whereas *Z. alacre* (Simon, 1870) and *Z. atlanticum* Pekár & Cardoso, 2005 were collected rarely. Parasitoids were found only in the igloos of *Z. styliferum*, which were parasitized, by the larvae of one species of Eupelmidae, *C. dispar*, and one species of Ichneumonidae, *G. apterus*. This represents the first host records for these two species and new distribution records for Portugal. *Calymnochilus dispar* was recovered from only 1 of the 18 surveyed localities (Fig. 2, locality 7) where 2 of 10 examined igloos of *Z. styliferum* were parasitized. *Gelis apterus* was recovered from 6 of the 18 localities surveyed (Fig. 2, locality 1 – 6), with an average parasitism rate of 7% (min – max = 3% – 13%, SD = 0.03).

Species survey

Hymenoptera: Eupelmidae (Eupelminae)

Calymmochilus dispar Bouček & Andriescu, 1967

http://species-id.net/wiki/Calymmochilus_dispar

Figures 3A–D, 4A–J

Calymmochilus dispar Bouček & Andriescu (1967): 233–238. Holotype female, Romania, Agiea, 28.vii.1964, A. Andriescu (not examined).

Recognition. *Calymmochilus dispar* is the only one of four European species of *Calymmochilus* (Noyes 2012) with brachypterous females. Bouček and Andriescu (1967) provided a detailed description of both sexes of *C. dispar* in German, which are summarized below. The descriptions of the larval and pupal stages are new.

Description. Female (Fig. 3A, C). Length 3.0–4.6 mm. Body mostly brown to black, but partly with greenish or bluish metallic lustre, particularly frontovertex; antenna brown, clava yellowish-brown; legs brown with apices of tibiae and tarsi except for apices yellowish-brown. Head (Fig. 3C) slightly broader than mesosoma. Supraclypeal area (Fig. 3C: Sa) with about five transverse carinae and glabrous interspaces, strongly inclined from clypeus, hence clypeus below face level. Clypeus (Fig. 3C: Cl) protruding over the mandibles, with a strongly elevated carina and a serrate margin. Lower face with a blunt crest extending from clypeus almost to ventral margin of eye (Fig. 3C: Cr). Mandible (Fig. 3C: Md) very slender, sickle-shaped. Antenna long and slender, all funicular segments longer than broad, anellus about 1.3× as long as broad, clava as long as 3.5 apical funicular segments. Mesonotum dorsoventrally compressed, with alutaceous surface sculpture. Mesoscutum flat, on same level as scutellar-axillar complex. Axillae distinguished from scutellum by only slightly finer surface sculpture. Propodeum transverse, anteriorly with a distinct transverse carina connecting propodeal spiracles, with indistinct plicae and median carina; callar region strongly declining posteriorly. Prepectus slightly larger than tegula. Wings reduced, infuscate fore wing barely extending to base of metasoma (Fig. 3A). Metasoma evenly tapered posteriorly, syntergum tapered with rounded apex, laterally curved over to conceal very slightly exerted ovipositor sheaths.

Male (Fig. 3B, D). Length 1.4–2.3 mm. Head and body very dark brown to black with blue metallic lustre, metasoma brown (Fig. 3B). Antenna brown. Legs brown with knees and tarsi except for apices yellowish-brown. Head (Fig. 3D) slightly broader than thorax, nearly triangular in frontal view. Structure of lower face, clypeus (Fig. 3: Cl), and mandibles (Fig. 3: Md) similar to female except crest extending from clypeus to compound eye indicated only by slight elevation. Antenna (Fig. 3B) long, each funicular segment at least twice as long as broad, anellus indistinct and hardly discernible, claval segments fused. Mesoscutum convex with distinct notauli. Wings fully developed. Scutellum strongly convex, almost parallel-sided, with strongly inclined

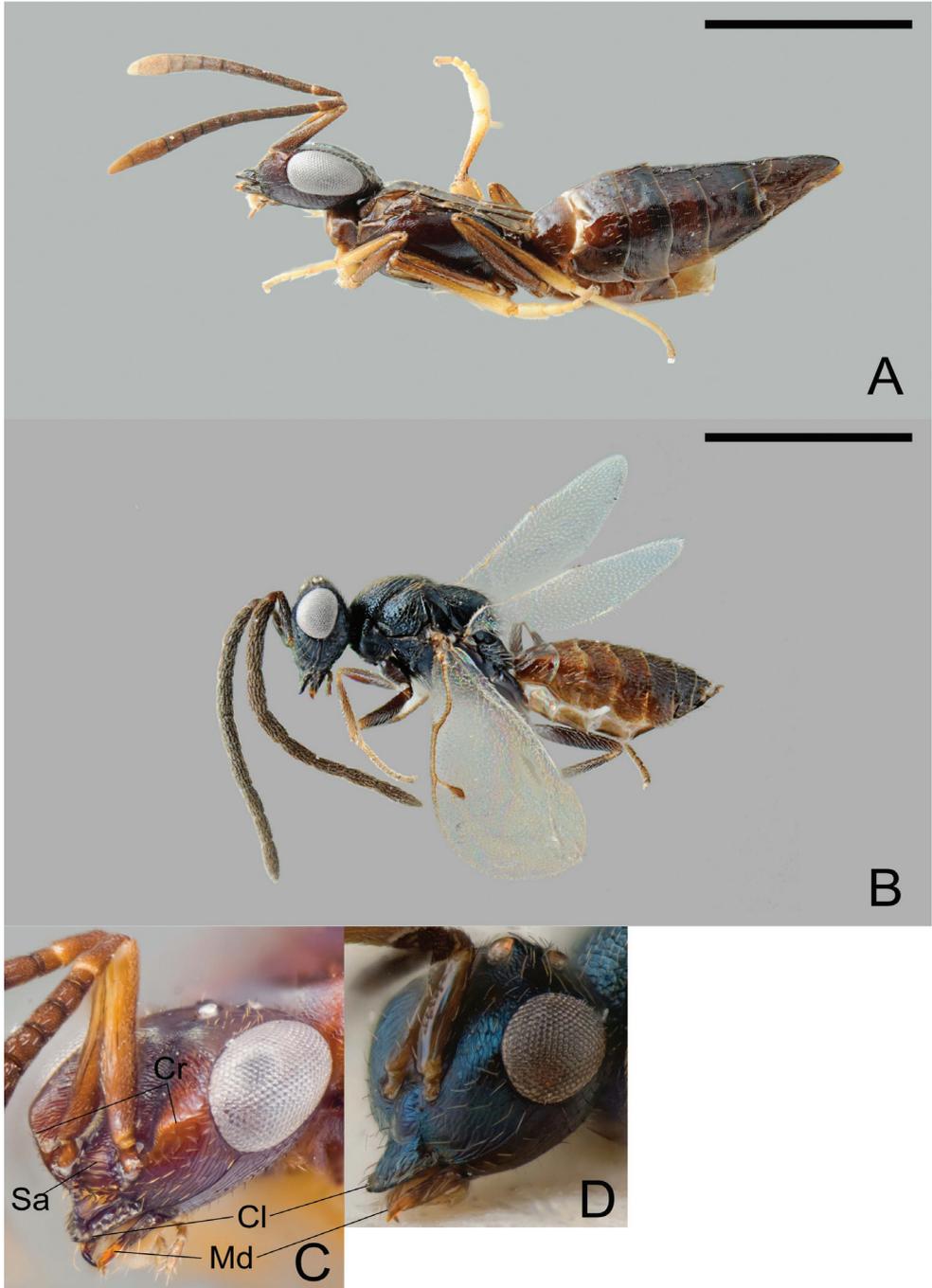


Figure 3. *Calymmochilus dispar*, female in lateral view (A), head (C); male in lateral view (B), head (D). Abbreviations: Cl: clypeus; Cr: crest; Sa: supraclypeal area; Md: mandible. Scale = 1 mm.

sides. Metanotum almost vertical, dorsellum almost triangular with surrounding furrow, dorsally with sharp carina. Propodeum with distinct median carina.

Larva (Fig. 4A, B, F). Brownish-yellow, female length about 2.5 mm (N = 1) and male length = 1.6 mm (N = 1). Mature larva with one pair of long, strong, dorsal setae (0.25–0.3× maximal diameter of larva) on each body segment plus two pairs of smaller dorsal setae (0.8× length of longer setae), one pair between long dorsal setae of first and second segment and second pair between those of second and third segment; laterally with one pair of smaller lateral setae (0.5–0.6× length of dorsal setae) on each body segment and irregularly placed short setae. Larval head very weakly sclerotized (not easily discernible in photographs).

Pupa (Fig. 4C–E, G–J). Pupa brown, about 3 mm length for female (Fig. 4C) and 2.2 mm for male (Fig. 4G). Eyes and mandibles becoming dark brown (Fig. 4C, H) as part of sclerotization process after 3 days. Eyes and mandibles dark brownish-black and first dark spots appearing inside pupa (Fig. 4D, I) seven days after pupation; pupa completely dark brown (Fig. 4E, J) after nine days.

Material. PORTUGAL, Faro district: 1 ♂ and 1 ♀ Moncarapacho; rocky slope near road, in spider igloos under rocks (37°05'N, 7°47'W, Fig. 2, locality 7), penultimate larvae attached to spider abdomen, 31.iii.2009, S. Korenko leg., larvae pupated 7.iv.2009 (male) and 8.iv.2009 (female), adults emerged 22.iv.2009, (1 ♂, CNCI; 1 ♀, ZSM).

Distribution. Armenia, Bulgaria, Croatia, France, Germany, Italy, Serbia, Spain, Yugoslavia (Noyes 2012) and Portugal (new record).

Host. Juvenile *Z. styliferum* with prosoma length of 0.4–0.5 mm (N = 2) (new host record).

Biology. The two *Z. styliferum* igloos from which *C. dispar* were reared were collected in an open, rocky habitat with sparse vegetation. When collected, a larva was attached to the abdomen of an immobilised juvenile inside the igloo. Exuviae of the previous moults were attached to the apex of the abdomen of the last instar. The larvae did not build any cocoon inside the igloo, being protected only by their long setae. The final instar and prepupal stage combined lasted 7 days for the male and 8 days for the female, after which the larvae pupated. The female emerged 15 days and the male 16 days after pupation at 23°C (±1.5°C).

Remarks. Little is known about the biology and host associations of *Calymmochilus* wasps. Previously, *C. russoi* Gibson, 1995 was reared from olive branches infested with *Phloeotribus scarabaeoides* (Bernard, 1788) (Coleoptera, Scolytidae) (Russo 1938) and *C. longbottomi* Gibson, 1998 was reared from *Synsphyronus lathrius* Harvey, 1987 (Pseudoscorpionidae, Garypidae) (Austin et al. 1998). The *Z. styliferum* host was of a similar body size and created structurally similar igloos as the pseudoscorpion documented by Austin et al. (1998). Larvae of *C. dispar* do not create a cocoon for pupation; rather they use the already built spider igloo to help protect the bare larvae, which is isolated from the inner surface of the igloo by their long dorsal setae. The larvae we reared from the two *Z. styliferum* igloos were on the underside of a rock approximately

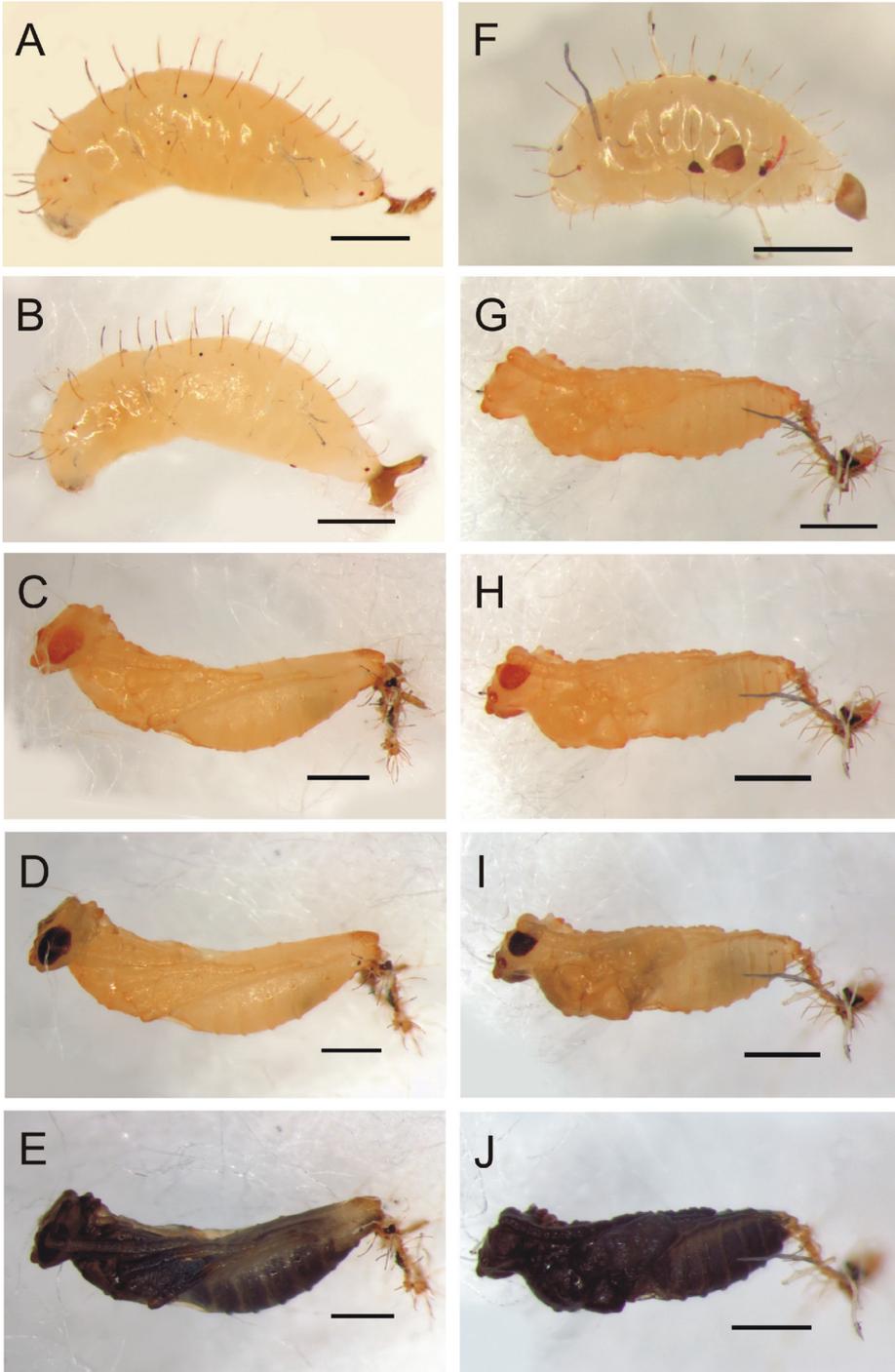


Figure 4. *Calymmochilus dispar*, mature larva (A, B, F) and pupa (C–E, G–J). Female final instar larva (A, B); female pupa after two days (C), six days (D), nine days (E). Male final instar larva (F). Male pupa after one day (G), four days (H), six days (I), nine days (J). Scale = 1 mm.

5 cm apart from each other. The parasitized pseudoscorpions reared by Austin et al. (1998) were also located under rocks, whereas the beetle larvae associated with *C. russoi* were under tree bark (Russo 1938). These concealed habitats presumably provide additional shelter for the *Calymmochilus* larvae and support Bouček (1988), who suggested that *Calymmochilus* species are primarily associated with hosts in sheltered places, e.g. under bark or rocks. The unusual, protuberant clypeus that characterizes adults may be a structural adaptation to help the adults emerge and the female to access restricted spaces to parasitize new hosts. However, it remains to be shown whether *C. dispar* is narrowly associated with *Zodarion* species or parasitizes taxonomically more diverse hosts in similar niches.

Hymenoptera: Ichneumonidae (Cryptinae)

Gelis apterus (Pontoppidan, 1763)

http://species-id.net/wiki/Gelis_apterus

Figures 5A–C, 6A–B

Ichneumon apterus Pontoppidan (1763): 692–693. Holotype female, missing. Comments about description in Schwarz (1995).

Recognition. Schwarz (2002) gave a key to the western Palearctic species of *Gelis* with apterous females, and Schwarz (1995, 1998) provided a diagnosis and description of the female of *G. apterus*. The main diagnostic features of the female are summarised below; the descriptions of the male and pupa are new.

Description. Female (Fig. 5A). Length 3.2–5.5 mm. Apterous. Body mostly black but base of antenna orange and thorax, propodeum and first segment of gaster varying from entirely black to nearly entirely orange; legs mainly blackish or dark brown with yellowish brown parts; tibiae white basally. Antenna with 21–25 segments; third segment (without anellus) 3.7–4.4× as long as wide. Malar space 1.2–1.3× as long as wide. Mesoscutum in lateral view not or only weakly sloping anteriorly, with a strong or weak median longitudinal furrow. Mesopleuron with fine striation anteriorly or more rarely almost entirely striate. Metapleuron entirely granulate or more rarely partly smooth and lustrous. Hind femur 4.0–4.9× as long as wide. Ovipositor sheath 1.9–2.5× as long as hind tibia. Ovipositor curved upwards, its tip with only very weak teeth ventrally.

Male (Fig. 5B, C). Length 3.0–4.1 mm. Macropterous. Body mostly black but mandible with teeth reddish, palpi brown, and tegula yellowish brown or brown. Legs with coxae, trochanters, trochantelli and femora except for following black or blackish brown; fore and mid femora yellowish-brown apically; tibiae basally whitish (most distinct on hind tibia), fore tibia except basally, and mid tibia except basally and apically yellowish-brown, hind tibia except basally blackish brown; tarsi brown or blackish brown. Fore wing with pterostigma brown except white basally. Body mostly distinctly granulate and matt, without distinct punctures. Antenna with 21–23 segments; third

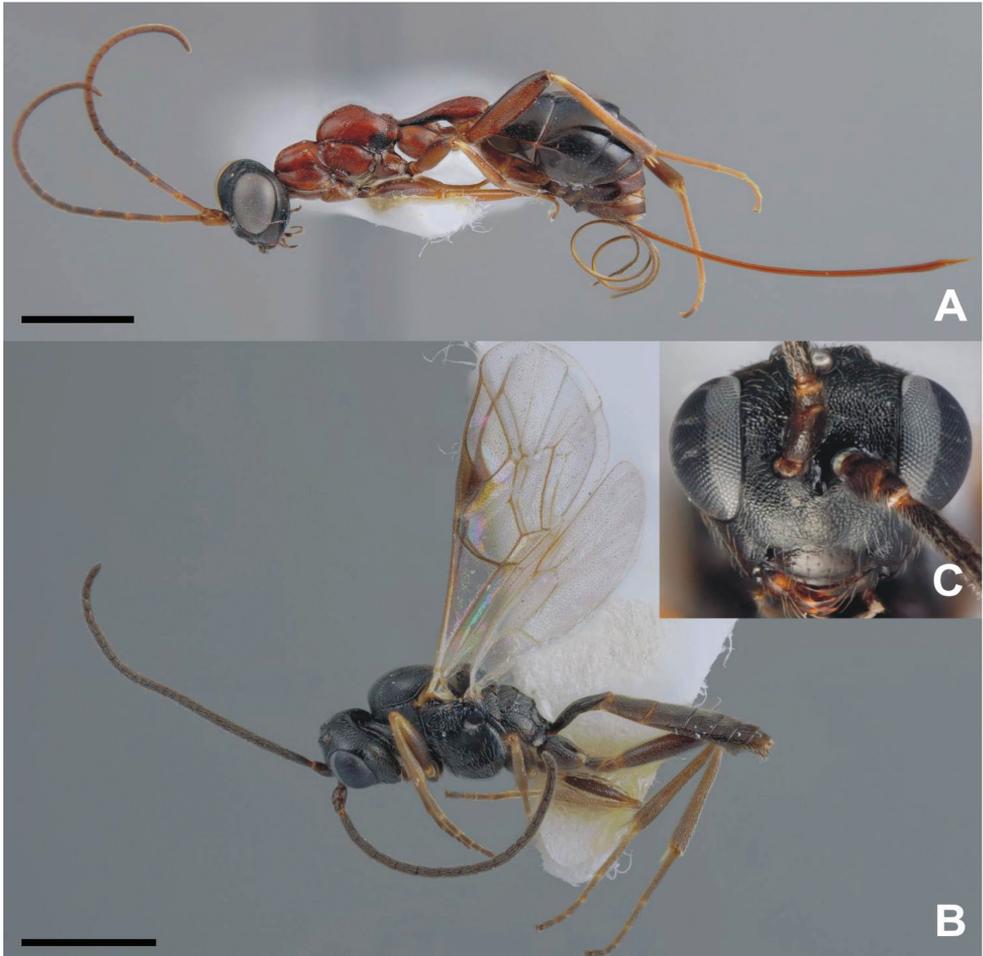


Figure 5. Adult of *Gelis apterus*, female in lateral view (A), male in lateral view (B), and male head in front view (C). Scale = 1 mm.

segment (without anellus) 2.9–3.3× as long as wide; segments 11–13 with linear tyloids. Clypeus in profile evenly and rather weakly convex, smooth or weakly granulate dorsally in addition to some scattered punctures; lower margin convex and region just above lower margin depressed. Mandible rather long, its teeth of equal length, outer surface with a distinct swelling subbasally. Malar space 1.2× as long as basal width of mandible, and without a furrow. Genal carina joining oral carina behind base of mandible. Ocelli small. Head behind eyes in dorsal view moderately narrowed and distinctly convex. Pronotum without dorsomedian longitudinal ridge. Mesopleuron with fine granulation and weak rugosity, speculum and hind margin below speculum smooth. Prepectal carina present but rather weak. Propodeum of moderate length and with both transverse carinae complete and distinct; longitudinal carinae anterior to posterior transverse carina rather weak and absent basally except for lateral longitudinal

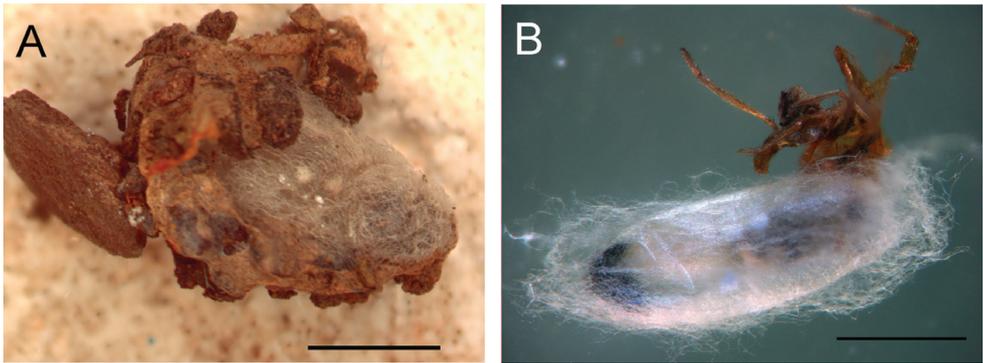


Figure 6. Pupa of *Gelis apterus*, inside the spider igloo (A) during pupation when parasitized spider was removed from igloo (B). Scale = 2 mm.

carina; propodeum lustrous between transverse carinae and with longitudinal striation about as distinct as longitudinal carinae; lustrous anterior to posterior transverse carina, nearly smooth and with distinctly separated area petiolaris. Legs slender with hind femur 5.0–5.1× as long as wide. Fore wing with areolet rather small. Gaster with first segment slender, without median dorsal carinae, and with dorsolateral and ventrolateral carinae rather weak.

Pupa (Fig. 6A, B). Pupa brownish (becoming dark brown as part of sclerotization process), about 5.5–7 mm.

Material. PORTUGAL, Beja district: 2 ♀ Ribeira de Limas, direction to Guadiana River, slope close to unpaved road (37°51'N, 7°31'W, Fig. 2, locality 4), 24.v.2011, S. Korenko leg. (1 pupa and 1 larva), larva on *Z. styliferum*, pupated 25.v.2011, adults emerged 5.vi.2011 and 7.iv.2011. Specimens deposited in collection of M. Schwarz.

Évora district: 1 ♂ Montemor o Novo, surrounding of castle ruins (38°38' N, 8°13'W, Fig. 2, locality 1), 10.iv.2010 (pupal stage), S. Korenko leg., adult emerged 12.iv.2010. 1 ♀ Monsaraz, olive grove (38°26' N, 7°32' W, Fig. 2, locality 2), 11.iv.2010, E. Líznarová and S. Korenko leg., larva on *Z. styliferum*, pupated 21.iv.2010, adult emerged 4.v.2010 (one empty cocoon and one larva that died in the laboratory were also collected from same locality). 1 ♀ and 1 ♂ Alqueva close to Moura, bank of water reservoir (38°12'N, 7°32'W, Fig. 2, locality 3), 11.iv.2010, S. Korenko leg., larvae on *Z. styliferum*, pupated 14.iv.2010, adults emerged 27.iv.2010 (female) and 28.iv.2010 (male), female escaped.

Faro district: 1 ♀ Casa do Canavial close to Mesquita in Guadiana Valley Natural Park (37°32'N, 7°31'W, Fig. 2, locality 6), 4.iv.2008, S. Korenko leg., larva on *Z. styliferum*, pupated 21.iv. 2008, emergence date not recorded. 1 ♀ and 1 ♂ Alcoutim, view terrace close to town (37°27'N, 7°28'W, Fig. 2, locality 5), 29.iii.2009, S. Korenko and S. Pekár leg., larvae on *Z. styliferum*, pupated 2.iv.2009 (female) and 1.iv.2009 (male), adults emerged 9.iv.2009.

Distribution. South and Central Europe (Schwarz 1998) including Portugal (new record), Azerbaijan, Tajikistan (Schwarz 1998).

Hosts. Juvenile spiders of *Z. styliferum* with prosoma length averaging 2.47 mm (N = 9, min/max = 1.6/3.2 mm) (new host record).

Biology *Gelis apterus* and its spider hosts appear to be associated with open arid habitats with sparse vegetation. Females attack the host spiders in the igloo, penetrating the igloo wall with their long ovipositors (laboratory observation). Unfortunately nothing more is known about oviposition behaviour. The larva makes a cocoon inside the spider igloo before pupation (Figs. 6). Details about the sclerotization process of the pupa were not recorded because of its location in the cocoon. The cocoon consists of white to brownish weaved threads which fill space inside the spider igloo. Adults emerged 9–14 days after pupation.

Remarks. Females of *G. apterus* reared from *Z. styliferum* in Portugal differ from those collected in other parts of Europe by somewhat longer ovipositor sheaths and the thorax laterally having smooth patches. In these two features they resemble the closely related species *G. atratus* (de Stefani, 1884), but females of *G. apterus* reared from *Z. styliferum* do not have the mesoscutum sloping downwards caudally.

The previously unknown macropterous males of *G. apterus* are very distinct from their apterous females. Males of *Gelis* are often unknown or unassociated with females because of the difference in aptery and because they are more difficult to distinguish in many species. The two sexes of *G. apterus* possess very few similar features that indicate they are conspecific and we consider the males we reared as *G. apterus* primarily because they were reared with females of *G. apterus*, and because only females of *G. apterus* were reared from *Z. styliferum*.

Diagnostic features of *G. apterus* males include an evenly and weakly convex, smooth or mainly smooth clypeus, long mandible and malar space, moderately narrowed and distinctly convex head, and the pattern of sculpture and carinae of the propodeum. These features enable separation of males from those of most other *Gelis* species. However, it is expected that the unknown males of *G. atratus* will be very similar to *G. apterus* and the two may not be easily distinguishable.

We found *G. apterus* associated with *Z. styliferum* in several parts of Central and South Portugal, and it seems to be widespread but in low abundance throughout the Iberian Peninsula based on the observation of three empty pupae inside *Zodarion* igloos in the Spanish provinces of Málaga and Granada (Korenko unpub.). *Gelis* is a large genus of parasitoid wasps that are worldwide in distribution but with most species in the Holarctic region. Some species are fully-winged but many are ant-like micropterous or wingless. Hosts of different species of *Gelis* include eggs or larvae or cocoons or cocoon-like structures of a wide range of holometabolous insects as well as egg sacs of spiders. Fitton et al. (1987) listed ten *Gelis* species reared from spider egg sacs of both wandering and web-building spiders. The larvae of *Gelis* species known to attack spiders have been regarded as exclusively feeding on spider eggs (Fitton et al. 1987). We did not observe this for *G. apterus*, which fed on juvenile spiders. Diurnally active female *G. apterus* presumably attack nocturnal *Zodarion* that are resting in their igloos during the day.

Zodarion styliferum is common in Portugal and has two overlapping generations (Pekár unpub.). Juvenile spider hosts are therefore available to *G. apterus* during the whole year and likely provide a highly available resource. *Gelis apterus* is documented from South – Central Europe to 70° eastern longitude. Several *Zodarion* species have overlapping distributions within this area. Their life history, behaviour, body size and igloo architecture are similar to *Z. styliferum* and could be potential hosts for *G. apterus*. Although we did not rear *G. apterus* from either *Z. alacre* or *Z. atlanticum*, this may simply reflect their relative rarity and low parasitism rates. Whether *G. apterus* is also associated with *Zodarion* species outside of the Iberian Peninsula is not known. Knowledge of the host range of *G. apterus* in other parts of its range is essential to confirm whether *Zodarion* spiders are their only hosts and, if not, understand how an association with spider hosts evolved.

Acknowledgements

We would like to thank Rudolf Macek for permitting us to use his photography in figure 1A. SK was supported by the project of European Science Foundation and Ministry for Education and Youth of the Czech Republic CZ.1.07/2.3.00/30.0040.

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On newly and recently recorded species of the genus *Lema* Fabricius (Coleoptera, Chrysomelidae, Criocerinae) from Taiwan

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Academic editor: A. Konstantinov | Received 22 October 2012 | Accepted 11 January 2013 | Published 1 February 2013

Citation: Lee C-F, Matsumura Y (2013) On newly and recently recorded species of the genus *Lema* Fabricius (Coleoptera, Chrysomelidae, Criocerinae) from Taiwan. ZooKeys 262: 17–38. doi: 10.3897/zookeys.262.4152

Abstract

New records of four species (*Lema lacertosa* Lacordaire, 1845, *L. diversipes* Pic, 1921, *L. cyanella* (Linnaeus, 1758), *L. trivittata trivittata* Say, 1824 and additional information on one recently recorded species (*L. solani* Fabricius, 1798) are reported for Taiwan. *Lema diversipes* Pic, 1921 is removed from synonymy with *L. lacertosa* Lacordaire, 1845; both species are redescribed. A lectotype is designated for *L. phungi* Pic, 1924. The synonymies of *L. phungi* Pic, 1924 and *L. jeanvoinei* Pic, 1932 with *L. lacertosa* Lacordaire, 1845 are supported. A revised key to the known species in Taiwan is provided.

Keywords

Lema diversipes, *Lema lacertosa*, flagellum, genitalia, Insecta, Taiwan

Introduction

Lema Fabricius is the largest genus of the subfamily Criocerinae and is distributed worldwide (Monrós 1959, Schmitt 1988). Most members are relatively small in size and good flyers, so it is usually not easy to collect multiple individuals of the same species simultaneously (Vencl et al. 2004). A lot of species were described in the early era of chrysomelid taxonomy, and the descriptions were very brief and mainly based

on color patterns (Warchałowski 2011). These factors cause difficulties in the identification of *Lema* specimens to species, which is an encumbrance to phylogenetic and evolutionary work on the group in spite of their interesting morphology (stridulatory organ: Schmitt and Traue 1990, reproductive systems: Matsumura and Suzuki 2008) and ecology (plant-insects interactions: Schmitt 1988, Morton and Vencl 1998, Vencl and Morton 1999a, b, Vencl et al. 2004). Recently, to resolve this situation, the introductory but comprehensive taxonomic works which include Asian or Palearctic *Lema* species were published (Schmitt 2010, Warchałowski 2010, 2011). Accumulation of faunal information based on reliable identification is desired to establish a robust hypothesis of an evolutionary scenario for *Lema* as the next step.

The Taiwanese islands, the focus of this study, are located in eastern-south Asia and are a subtropical to tropical region. Although taxonomic and/or faunal studies of Taiwan were done by Chùjō (1951), Kimoto and Chu (1996), Kimoto and Takizawa (1997), and Lee and Cheng (2007, 2010), some species were newly found through the effort of the Taiwan Chrysomelid Research Team since 2007. In addition, taxonomic confusion occurs with *Lema lacertosa* Lacordaire, 1845. To resolve it, we studied all available type specimens of the synonyms of *L. lacertosa*.

Materials and methods

Most of Taiwanese populations were collected by the Taiwan Chrysomelid Research Team. These specimens are kept in Matsumura's private collection (Jena, Germany) temporarily, and these will be deposited in the laboratory of Systematic Entomology of Hokkaido University (Japan) at a future date. In addition to these specimens, we used specimens which were borrowed from Muséum National d'Histoire Naturelle (MNHN, Paris, France), the laboratory of Systematic Entomology of Hokkaido University (SEHU, Sapporo, Japan), and the Taiwan Agricultural Research Institute (TARI, Taichung, Taiwan). In the results section, the following symbols are used to describe information on data labels exactly: a slash (/) indicates that words were written on one line of a data label, and double slashes (//) indicates that they were written on another label.

Scanning electronic microscopy (LSM-6510, JEOL) images were captured to observe fine structures in detail. To observe male and female genitalia, firstly we softened dried specimens by warming them in distilled water over night (50–60°C). Then, the abdomen was removed from the body, and softened in KOH solution (ca. 5–10%) for two days. Then we observed the genitalia under the microscope (Olympus SZX12) and drew them.

Terminology. The terminology for the exoskeleton is based mainly on Chùjō (1951), the male genitalia on Sharp and Muir (1912), and the female reproductive organs on Suzuki (1988). For descriptions of internal-sac sclerites we followed the terminology established by Tishechkin et al. (2011). Because Tishechkin et al. (2011) named sclerites based on the position during copulation (internal sac inverted), their “dorsal” and “ventral” sclerites correspond to “ventral” and “dorsal” sclerites of Matsumura and Yoshizawa (2012) who named each sclerites based on the position in repose.

Results

Lema (Lema) diversipes Pic, 1921 stat. res.

http://species-id.net/wiki/Lema_diversipes

Lema diversipes Pic, 1921: 3 [Yunnan] (Paris); Monrós 1959: 185; treated in Gressitt and Kimoto 1961: 69 (synonym of *L. lacertosa*).

Type series. Holotype ♀: “Pe Yen Tsing/ Yunnan// Lema // voir Mouhoti Baly // diversipes/ n sp// type // MUSEUM PARIS / 1958/ coll. M. Pic // HOLOTYPE (red label) // MNHN/ EC2232”.

Material examined. Taiwan: 22 exs.: Taipei: Shihting, 11.VIII.2007, leg. M.-H. Tsao (6 exs. in SEHU; 16 exs. in TARI).

Diagnosis. *Lema diversipes* can be separated from *L. lacertosa* by the following combination of characters: body is distinctly larger and relatively stout in shape; anterior margin of the clypeus is waved and protruded slightly; posterior lines of the vertex groove slightly curved; almost all of the ventral surface is black; sternites covered by pubescence, except the posterior margins of the sterna 1-4 glabrous.

Redescription. Body coloration (Figs 1–2). Dorsum (holotype): Head reddish-brown except for black apex of mandible, antenna yellowish-brown; pronotum and elytra reddish-brown, scutellum brown; prolegs orange except for coxae which are brownish-orange, mesolegs blackish-brown, metalegs black. Dorsum (Taiwanese individuals): Antennomeres 1–4 orange, 5–11 blackish-brown; profemur and tibia orange, procoxae, trochanter, tarsi and claws blackish-brown. Venter: prosternum orange; meso- and metasterna black; abdomen blackish-brown. Pubescence white.

Head (Figs 5–7). Slightly longer than wide; vertex not so raised, coarsely covered with relatively long setae, its surface smooth, with shallow fovea on top, in some cases, fovea longitudinally elongate; area between X-shaped vertex groove and compound eye bearing relatively long setae; orbital area triangular, very densely covered with pubescence; frontal tubercle glabrous; frontoclypeus triangular, bearing relatively long setae, central region glabrous; labrum with ca. Eight relatively long setae, anterior margin corrugated, medial part anteriorly projected; antenna filiform, ca. 0.6 times as long as body length, antennomeres 1 and 2 subglobular and almost glabrous with a few setae, antennomeres 3–11 bearing velutinous setae, antennomeres 5–11 each ringed along apex by a few long setae, antennomere 3 slightly shorter than 4, antennomere 5 slightly longer than 6, antennomeres 6-10 subequal in length, antennomeres 3–10 elongate but slightly thickening apically, apex of antennomere 11 conically prominent.

Pronotum (Figs 9 and 12). Subequal in width and length, laterally constricted in middle; surface sparsely, coarsely punctate also micropunctate between larger punctures; transverse groove present near base with fovea medially; anterior and basal margins narrowly margined, basal margin densely pubescent; a long seta present in anterior and posterior angles.

Scutellum (Fig. 9). Trapezoidal and relatively longitudinally elongated, posterior angles round, in some specimens posterior margin completely rounded; sparsely pubescent.

Elytra (Figs 1–2). 1.7 times longer than wide; very slightly depressed on anterior region in Taiwanese individuals but not depressed in the holotype. Lateral margin parallel; punctures slightly weakening posteriorly, interspaces smooth and slightly raised on apical $\frac{1}{3}$.

Pygidium. Anterior $\frac{1}{3}$ densely covered with short hair-like projections except for stridulatory organ in anterior middle; posterior $\frac{2}{3}$ with dense, stout setae.

Palpi of mouth parts (Fig. 8). Apical palpomere of maxillary palpi relatively slender, conico-cylindrical; other palpomeres elongate, tapering basally. Labial palpi with four palpomeres, apical three palpomeres relatively stout, apical palpomere conico-cylindrical.

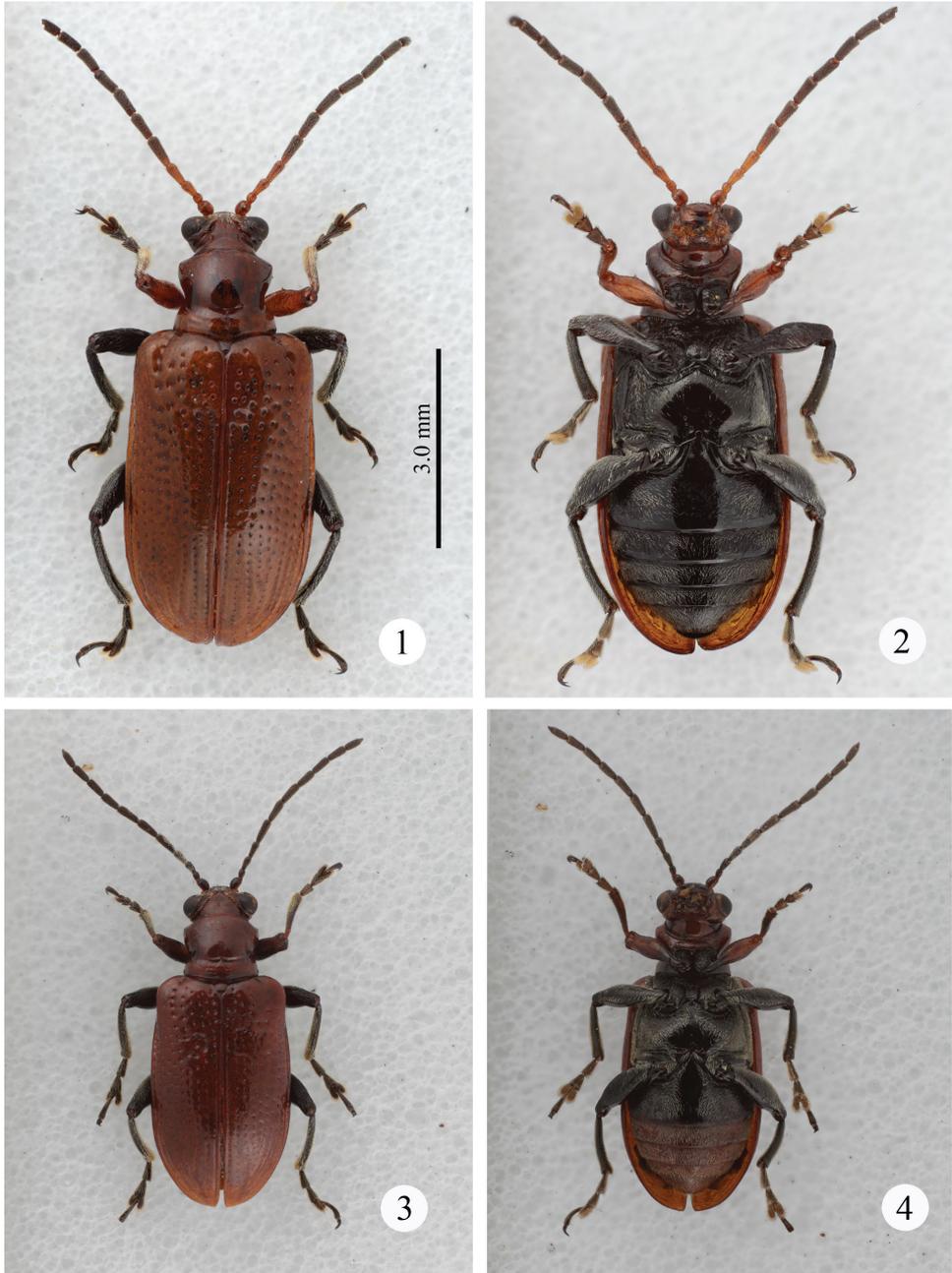
Prothorax (lateral and ventral, Figs 10, 11, and 13). Anterior part of prosternum transversely oblong, posterior margin covered with pubescence, anterior region glabrous with very fine lotus-pod like structures, some specimens with transverse wrinkles. Prosternal process very narrow and higher than anterior part, with pubescence on ridgeline, widened posteriorly. Surface of pronotal hypomeron smooth. Posterior arms of pronotal hypomeron not closed and forming arms, but prosternal process bridges them. Anterior and posterior margins of prothorax with pubescent fringe; anterior margin fringed with two rows of setae; anterior margin with curved and straight setae and posterior margin with one straight seta.

Mesothorax (Fig. 13). Surface of mesosternum with deep transverse wrinkles, posterior $\frac{1}{2}$ with pubescence; posterior process with small ridge along posterior margin, its surface covered with relatively long setae. Mesepisternum and mesepimeron entirely covered with dense pubescence.

Metathorax (Fig. 13). Metasternum oblong; almost all margins with ridge; surface of median $\frac{1}{2}$ glabrous except margin sparsely covered with relatively long setae; lateral $\frac{1}{2}$ densely pubescent; ridgeline of posterior ridge with dense pubescence. Metepisternum with dense pubescence, lateral $\frac{1}{3}$ with glabrous area.

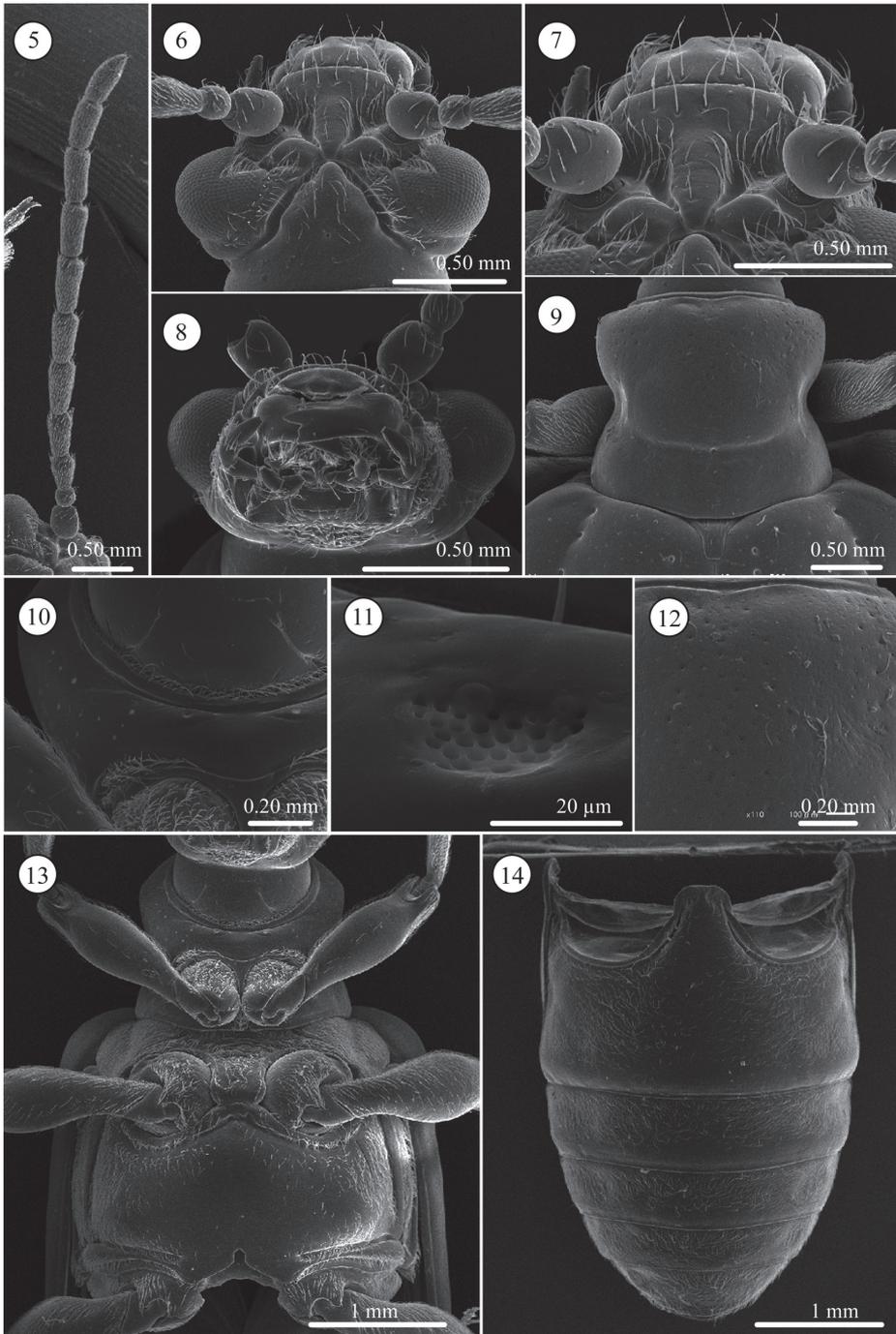
Legs (Fig. 13). Procoxae conico-cylindrical, with dense and relatively long pubescence, procoxae glabrous except with relatively long setae on anterior ridgeline; profemora almost glabrous except lateral apex with dense pubescence ventrally, in dorsal view with relatively dense pubescence except for basal $\frac{1}{2}$ of inner margin glabrous. Mesocoxae spherical, with dense, relatively long pubescence on lower anterior $\frac{1}{2}$; mesotrochanters glabrous except with a few long setae on posterior ridgeline; meso- and metafemora with dense pubescence in ventral view, glabrous except for lateral $\frac{1}{5}$ with dense pubescence in dorsal view; metatrochanters glabrous except with a few short setae on posterior ridgeline; meso- and metatibiae slender and uniform in shape, covered with dense pubescence, basal $\frac{1}{2}$ with slightly curved pubescence, apical $\frac{1}{2}$ with transparent straight, stiff pubescence, lateral margin of its apex bordered with translucent brown spines, and armed with two subequal black-brown very short spines on ventral margin.

Abdominal sterna (Fig. 14). Surface almost entirely densely covered by short pubescence except posterior margin of sterna 1–4 glabrous; lateral area near base of sternite one with more or less glabrous patch, middle of lateral region more or less depressed.

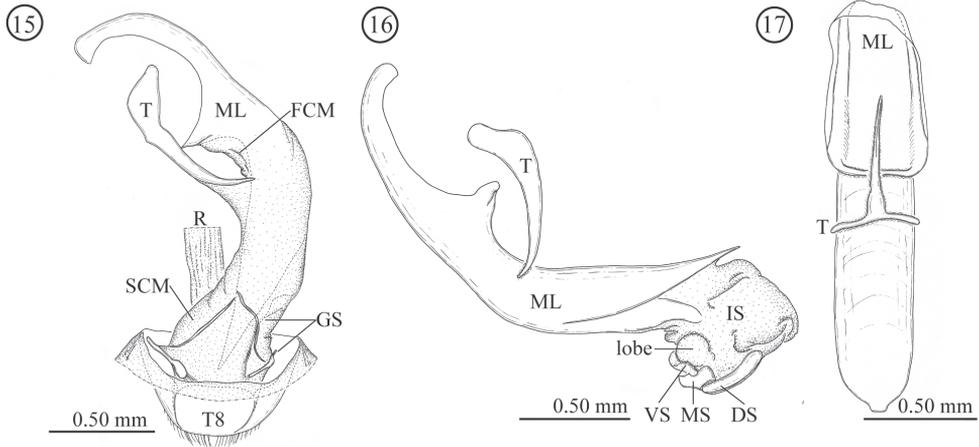


Figures 1–4. Habitus. **1–2** *Lema diversipes* **1** dorsal view **2** ventral view **3–4** *Lema lacertosa* **3** dorsal view **4** ventral view. (all at the same scale)

Male genitalia (Figs 15–17). Consisting of five parts: tergite 8, gastral spiculum, tegmen, median lobe and internal sac. Tergite 8 similar to that of the female as described below. Gastral spiculum consisting of two pairs of twig-like sclerites, one pair



Figures 5–14. *Lema diversipes*. **5** left antenna **6** head, dorsal view **7** frontoclypeus, dorsal view **8** mouth parts **9** prothorax, dorsal view **10** frontal area of prothorax with lotus-seeds-like structure, ventral view **11** lotus-pod like structure, enlarged **12** prothorax with fine punctures, dorsal view **13** thorax, ventral view **14** abdomen, ventral view.



Figures 15–17. Male genitalia of *Lema diversipes*. **15** entire genitalia in ventral view **16** aedeagus in lateral view, right side corresponds to posterior end **17** median lobe and tegmen in ventral view; DS: dorsal sclerite; FCM: first connecting membrane; GS: gastral spiculum; IS: internal sac; ML: medial lobe; MS: median sclerite; R: rectum; SCM: second connecting membrane; T: tegmen; T8: tergite 8; VS: ventral sclerite.

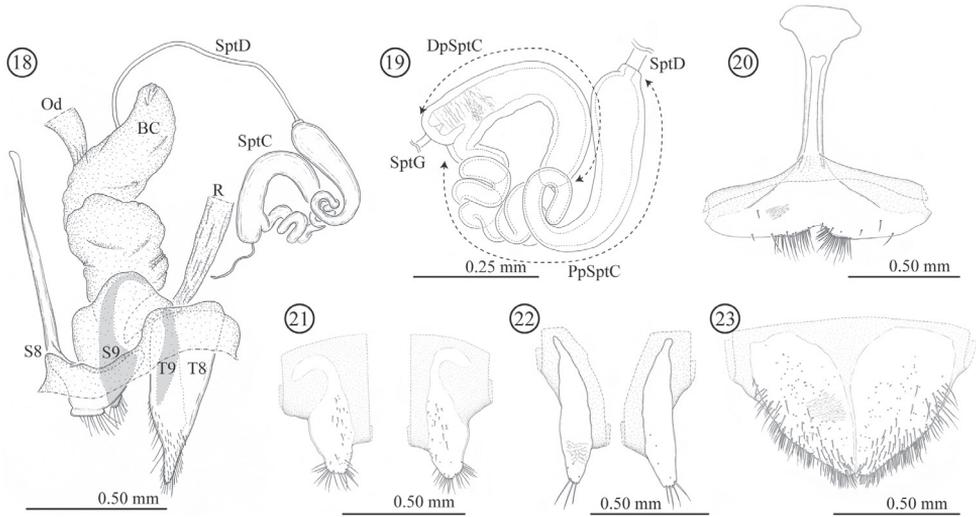
longer than the other, shorter pair asymmetrical and spoon-like in ventral view. Basal piece of tegmen triangular with rounded corner in lateral view, tapering toward base. Median lobe relatively slender, median foramen expanding and occupying $\frac{1}{3}$ of ventral surface in lateral view, ventral end of median orifice with rectangular protrusion which has rounded corner. Internal sac without flagellum and pocket as observed in *L. laceratosa*; having dorsal-, median-, and ventral sclerites; dorsal, median and ventral sclerites block-like; ventral sclerite covered with a pair of rounded lobes formed by a membrane.

Female genitalia and a part of reproductive systems (Figs 18–23). Bursa copulatrix balloon-like with its wall thickened but soft. Spermatheca with relatively long duct (0.79 mm, N = 1), opening to ventral side of bursa copulatrix. Wall of spermathecal capsule well sclerotized and thick; distal part of spermathecal capsule hook-shaped, proximal part strongly coiled; inner surface completely covered by very fine winkle-like sculpture. Genitalia consisting of four parts: tergites 8 and 9, and sternites 8 and 9; sclerotization of tergite 8 gradually weakened toward midline; sternite 8 with stick-like apodeme; tergite and sternite 9 consisting of a pair of sclerites; tergites 8 and 9 largely covered by scale- to winkle-like sculpture, marginal region of tergite 8 covered by relatively stout setae; both sides of the sternite 8 covered by scale-like sculpture; posterior area of sternite 9 weakly wrinkled.

Measurements. Elytral length: male: 4.53 ± 0.22 mm (mean \pm SD, N = 5), female: 5.14 ± 0.03 mm (N = 2). Elytral width: male: 2.68 ± 0.06 mm, female: 2.92 ± 0.06 mm. Pronotum length: male: 1.44 ± 0.04 mm, female: 1.46 ± 0.07 mm. Pronotum width: male: 1.43 ± 0.05 mm, female: 1.58 ± 0.08 mm.

Host plant. (Figs 43–44) Fabaceae: *Pueraria lobata* (Willd.) subsp. *thomsonii* (Benth.) Ohashi .

Distribution. China, Taiwan (**new record**).



Figures 18–23. Female genitalia of *Lema diversipes*. **18** entire female genitalia and a part of reproductive system in lateral view **19** spermathecal capsule **20** sternite 8 **21** sternite 9 **22** tergite 9 **23** tergite 8; BC: bursa copulatrix; Od: oviduct; R: rectum; SptD: spermathecal duct; SptG: spermathecal gland; SptC: spermathecal capsule; PpSptC: proximal part of spermathecal capsule; DpSptC: distal part of spermathecal capsule; S8: sternite 8; S9: sternite 9; T8: tergite 8; T9: tergite 9.

Remarks. Condition of holotype. Right side of the head and abdomen in dorsal view with wormholes. Almost all pubescence of the body surface is lost. However punctures remain, which enable us to know setal arrangement. Comparing the arrangement of the punctures and setae in newly collected Taiwanese specimens, we identified the specimens collected in Taiwan as *Lema diversipes* and described the characteristic of setae based on the Taiwanese specimens.

Justification of resurrection of *Lema diversipes* and removing it from synonymy of from *Lema lacertosa*. *Lema diversipes* was synonymized under *Lema lacertosa* by Gressitt and Kimoto (1961) without explanation, and researchers have followed this treatment (Kimoto and Gressitt 1979, Schmitt 2010, Warchałowski 2011). The two species which we identified as *Lema lacertosa* and *Lema diversipes* in this study clearly differ in their external appearance, the genital structure, and their host plants. Feeding on Fabaceae plants for *L. diversipes* is very rare in members of the genus *Lema* (Schmitt 1988).

The original descriptions (Lacordaire 1845, Pic 1921) and redescriptions (Baly 1865) of the species are not detailed enough to distinguish them, but the measurements in the original- or re-descriptions differs greatly between them (*L. lacertosa*: 2 2/3 lin. = 5.64 mm described by Baly 1865, *L. diversipes*: 8 mill = 8 mm described by Pic 1921). Although we asked curators in the Natural History Museum (London), the Muséum National d'Histoire Naturelle (Paris), the Brussels Museum, the Bishop Museum (Hawaii) and the Museum of Comparative Zoology (Cambridge), we could not find the type specimen of *Lema lacertosa*. However, reading taxonomic papers, we judge that chrysomelid taxonomists have a consensus of the characters dis-

tinguishing *Lema lacertosa* (e.g. Gressitt and Kimoto 1961, Kimoto and Gressitt 1979, Warchałowski 2011). In fact, we found Indian *Lema* specimens which were identified as *L. lacertosa* was quite similar to the smaller Taiwanese *Lema* specimens. We compared generally accepted species as *L. lacertosa* and the holotype of *L. diversipes*. The holotype of *L. diversipes* is clearly distinguished from *L. lacertosa*, and we judged *L. diversipes* should be treated as a separate species.

***Lema (Lema) lacertosa* Lacordaire, 1845**

http://species-id.net/wiki/Lema_lacertosa

Lema lacertosa Lacordaire, 1845: 339 [Bengal] [type depository unknown]; Baly 1865: 11; Jacoby 1908: 35; Monrós 1959: 186; Gressitt and Kimoto 1961: 69; Kimoto and Gressitt 1979: 249; Schmitt 2010: 362; Warchałowski 2011: 69.

Lema phungi Pic, 1924: 13 [Tonkin, Vietnam] (MNHN); Monrós 1959: 188; Warchałowski 2011: 69 (as probable synonym of *L. lacertosa*). **synonymy confirmed**

Lema jeanvoinei Pic, 1932: 11 [Hanoi, Vietnam] (MNHN); Monrós 1959: 186; Warchałowski 2011: 69 (as probable synonym of *L. lacertosa*). **synonymy confirmed**

Type series. *Lema phungi*: lectotype 1 ♀, here designated, labeled: Hoa Binh/ Tonkin// Phungi/ Pic// Muséum Paris/ 1958/ Coll. Pic// SYNTYPE// MNHN/ EC3057//; paralectotype: 1 ♀// Hoa Binh/ / Tonkin// Phungi/ Pic// Museum Paris/ 1958/ Coll. Pic// SYNTYPE// MNHN/ EC3058//.

Lema jeanvoinei. 1 ♀// Tonkin/ Hanoi/ 7. IV. 1918/ JEANVOINE// Dessous/ et/ membres/ largement/ noirs// jeanvoinei/ n sp// Museum Paris/ 1958/ Coll. Pic// HOLOTYPE// MNHN/ EC3059//.

Material examined. Taiwan: 4 exs.: Chiayi, Minhsiung, 29.IV.2010, leg. W.-T. Liu (TARI); 2 exs.: Chiayi, Niutoulun, 30.III.2010, leg. W.-T. Liu (TARI); 2 exs.: Kaoshiung, Niaosung, 2.VI.2008, leg. C.-H. Liu (TARI); 1 ex.: Kaoshiung, Taiao, 8.IX.2008, leg. W.-T. Liu (TARI); 1 ex.: Nantou, Chichi, 19.VIII.2010, leg. W.-T. Liu (TARI); 5 exs.: Pingtung: Chaochou, 5.XI.2009, leg. J.-C. Chen (TARI); 3 exs., same locality, 16.III.2010, leg. M.-H. Tsou (TARI); 11 exs., same locality, 2.VI.2010, leg. M.-H. Tsou (2 exs. in SEHU; 9 exs. in TARI); 3 exs.: Pingtung, Hengchun, 9.VII.2011, leg. J.-C. Chen (TARI); 1 ex.: Pingtung, Kaoshih, 8.V.2012, leg. J.-C. Chen (TARI); 1 ex.: Pingtung, Nanjen Lake, 3.I.2011, leg. J.-C. Chen (TARI); 1 ex., same locality, 29.IV.2011, leg. J.-C. Chen (TARI); 5 exs.: Pingtung, Wukoushui, 21.VIII.2010, leg. J.-C. Chen (TARI); 1 ex.: Taipei, Kuantu, 15.IX.2010, leg. S.-F. Yu (SEHU); 2 exs., same locality, 8.VI.2011, leg. S.-F. Yu (TARI); 1 ex.: Taitung, Anshuo, 7.XI.2011, leg. J.-C. Chen (TARI); 3 exs.: Taoyuan, Meihuali, 14.VII.2010, leg. H. Lee (SEHU); 5 exs.: Taoyuan, Chungli, 19.X.2010, leg. H. Lee (TARI); 4 exs.: Taoyuan, Kuanyin, 16.VI.2010, leg. M.-H. Tsou (TARI). **Malaysia:** 3 exs.:

Negeri Selangor, Ulu Gombak, (Univ. Malaysia Field Studies centre. 220 m alt.), 10.III.2009, leg. Y. Matsumura (SEHU); 1ex.: Negeri Selangor, Ulu Gombak (Univ. Malaysia Field Studies/ centre. 220 m alt.) 8.XI.2009, leg. Y. Matsumura (SEHU); 1ex: Jalan Pahang Perk, Batu 19 (570m alt.), 8.XI.2009, leg. Y. Matsumura et al. (SEHU). **India:** 2 exs.: Calcutta, 14-19.X.1978, leg. JAP-IND CO TR (SEHU).

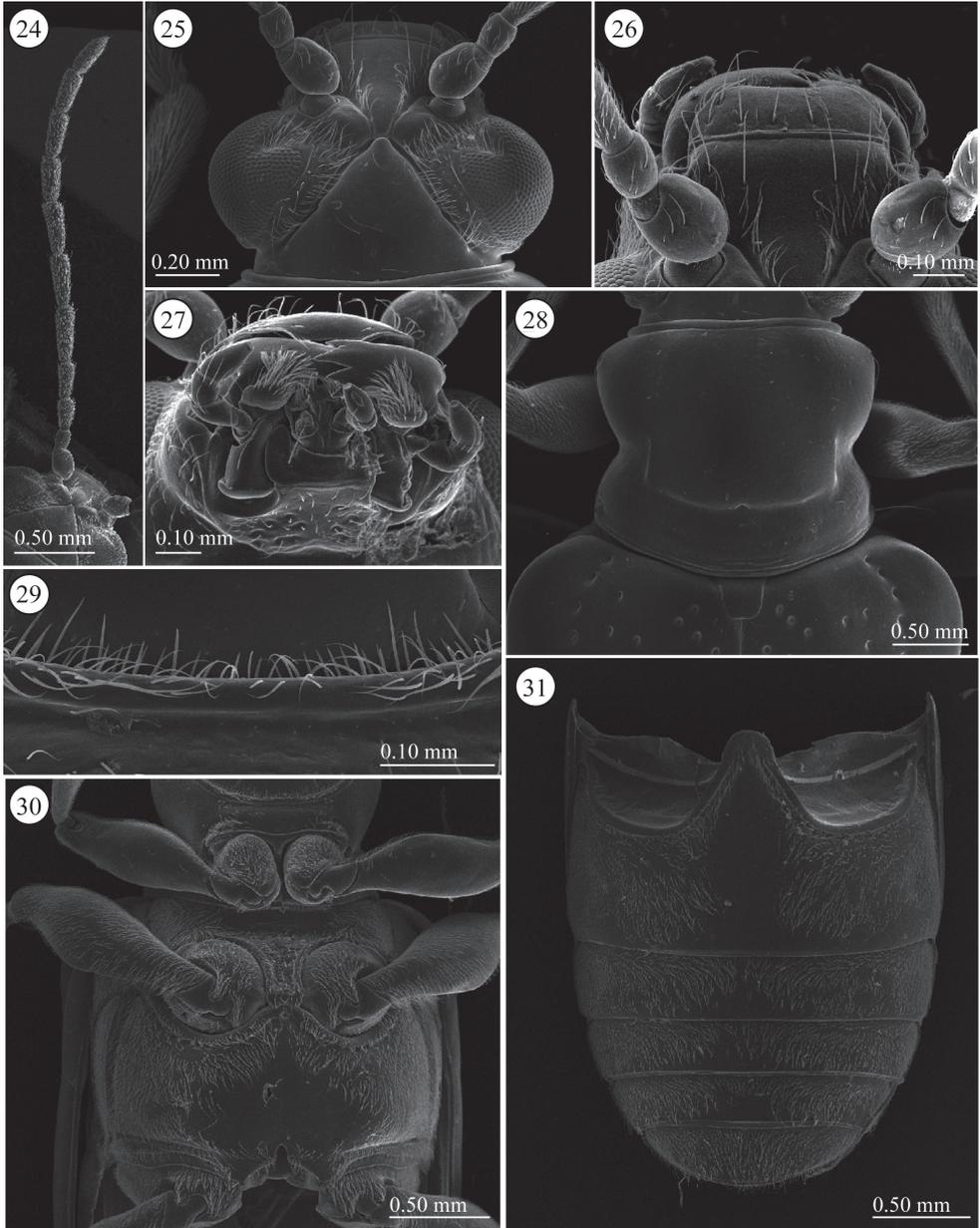
Diagnosis. *Lema lacertosa* can be separated from *L. diversipes* by the following combination of characters: body is distinctly smaller; anterior margin of the clypeus is curved inward and slightly concave; posterior lines of the vertex groove nearly straight; anterior region of the ventral surface is nearly black and posterior $\frac{1}{3}$ (sterna 2-5) orange to brown; sterna almost entirely covered by pubescence, except around midline of the sternum 1 glabrous.

Redescription. Body coloration (Figs 3–4). Dorsum: Labrum and anterior $\frac{1}{2}$ of frontoclypeus black, antenna brownish-black except antennomeres 1 and 2 which are orange to brown; remaining part of head, pronotum, scutellum and elytra brownish to reddish-orange. Procoxae black, protrochanters brown, profemora, protibiae, and protarsi orange with diffuse brown to blackish line; meso- and metatrochanters brown, femora, tibiae, and tarsi of meso- and metalegs black. Venter: anterior $\frac{1}{3}$ - $\frac{1}{2}$ of prothorax orange, remaining area black to brownish-black; meso- and metathorax black; first abdominal sternite black to blackish-brown, other sterna orange to brown. Pubescence white. Antenna lighter colored than other parts, protrochanter and apical section of procoxae orange; proleg black basally. Basal $\frac{1}{2}$ of first abdominal sternite black; especially in Malaysian populations with brighter orange color.

Head (Figs 24–26). Width and length almost equal; vertex not raised, glabrous, surface smooth; area between X-shaped vertex groove and compound eye with relatively long setae, covered with fine sculpture; orbital area triangular, densely covered with pubescence; frontal tubercle indistinct, glabrous; frontoclypeus triangular, covered with setae, setae relatively dense on posterior $\frac{1}{2}$, medial line region glabrous; labrum with ca. Seven relatively long setae, anterior margin curved inward and slightly concave; antenna filiform, ca. 0.7 times as long as body length, antennomeres 1–2 subglobular and almost glabrous with a few setae, antennomeres 3–11 bearing velutinous pubescence, apex of antennomeres 5–11 ringed with a few long setae, antennomere 3 subequal in length to 4, antennomeres 3+4 slightly longer than 5, antennomere 4 or 5 longest depending on individuals, antennomeres 6–10 subequal in length, antennomeres 3–10 cylindrical slightly thickening apically, apex of antennomere 11 conically prominent.

Pronotum (Fig. 28). Slightly wider than long to almost equal, laterally constricted at middle; surface with a few small punctures around midline and anterior angles, rest with very fine punctures, transverse groove present near base with fovea in middle, anterior and posterior margins narrowly margined, posterior ridge internally with dense short setae. A long seta present in each anterior and posterior angle.

Scutellum (Fig. 28). Trapezoidal and relatively wide, posterior margin concave, indistinct in some specimens. Surface glabrous, but in three of five Taiwanese specimens covered with a few setae.



Figures 24–31. *Lema lacertosa*. **24** left antenna **25** head, dorsal view **26** frontoclypeus, dorsal view **27** mouth parts **28** prothorax, dorsal view **29** frontal fringe of prothorax, ventral view **30** thorax, ventral view **31** abdomen, ventral view.

Elytra (Figs 3–4). 1.7 times longer than wide; one of six Taiwanese specimens very slightly depressed anteriorly but not depressed or indistinctly impressed in the other specimens. Lateral margins parallel; punctures slightly weakening posteriorly.

Pygidium. Anterior $\frac{1}{3}$ densely covered with short hair-like projections except for stridulatory organ in anterior middle, size of stridulatory organ relatively small; posterior $\frac{2}{3}$ with dense, stout setae.

Palpi of mouth parts (Fig. 27). Apical maxillary palpomere relatively stout and conico-cylindrical but not enlarged; other palpomeres cylindrical, narrowing basally; one of two Indian specimens examined with relatively slender apical palpomere. Labial palpi with four palpomeres, apical three palpomeres relatively stout but not enlarged, apical palpomere conico-cylindrical.

Prothorax (lateral and ventral, Figs 29–30). Anterior area of prosternum transversely oblong anteriorly, with pubescent patch posteriorly, glabrous anteriorly, some specimens with very weak transverse wrinkles. Prosternal process very narrow and not raised, widened posteriorly. Surface of pronotal hypomeron smooth. Posterior arms of pronotal hypomeron normally not closed in most specimens, but closed in one Malaysian specimen and fused in one Indian specimen; prosternal process with bridge arms, bridge relatively short and not completely covering arms. With pubescent fringe anteriorly and posteriorly; anterior margin fringed with two rows of setae.

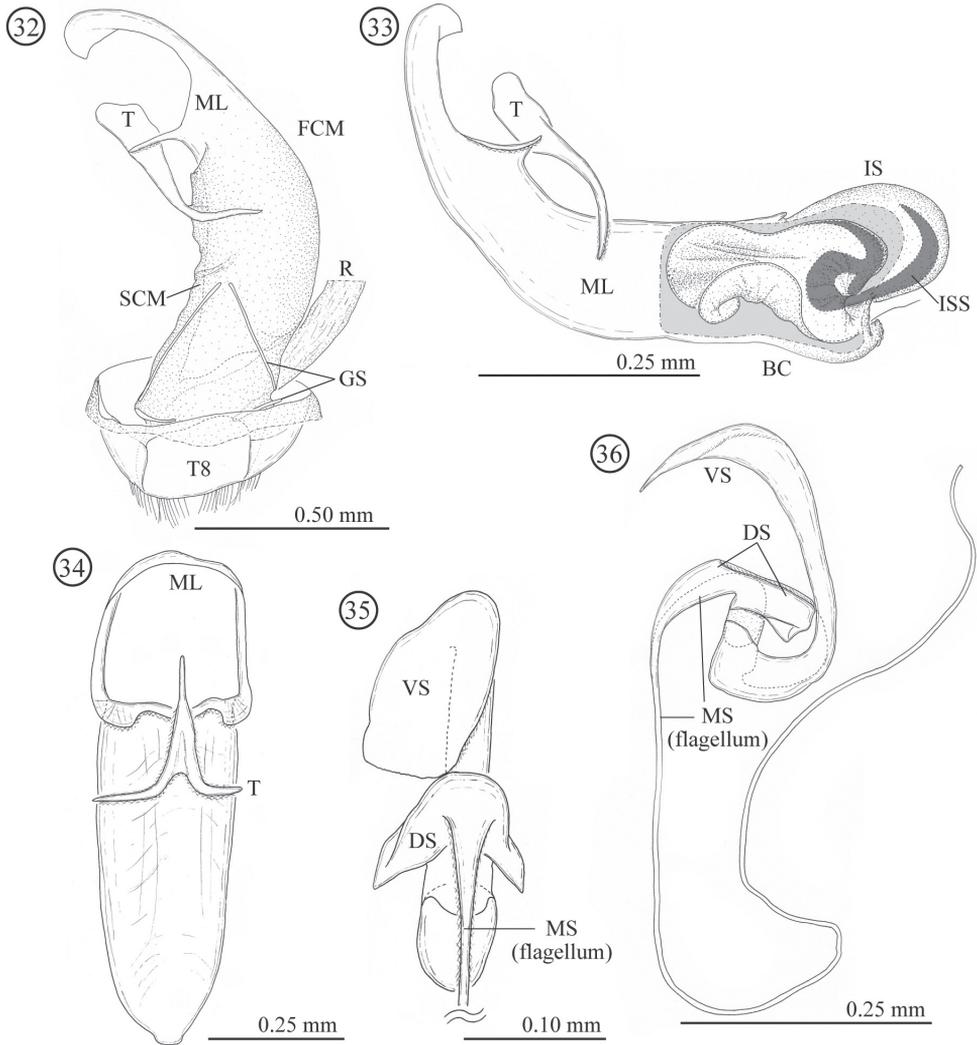
Mesothorax (Fig. 30). Surface of mesosternum with fine sculpture and pubescence; posterior process with ridge along margin, pubescence on posterior ridge relatively long. Mesepisternum and mesepimeron with dense pubescence.

Metathorax (Fig. 30). Metasternum oblong; almost entire margin with ridge; surface of medial area glabrous and other areas covered with pubescence; medial part of anterior ridge with relatively long pubescence; posterior margin between metacoxae with curved pubescence. Metepisternum with dense pubescence, lateral $\frac{1}{3}$ with glabrous area overlapping elytra.

Legs. Procoxae conico-cylindrical, densely covered with pubescence, procoxae glabrous, with relatively long setae on anterior ridgeline; profemora nearly glabrous except apex laterally with pubescence ventrally, dorsum with relatively dense pubescence except for glabrous base. Mesocoxae spherical, densely pubescent on lower anterior $\frac{1}{2}$; mesotrochanters glabrous with very long pubescence on posterior ridgeline; meso- and metafemora with dense pubescence ventrally, glabrous dorsally except for dense pubescence apically. Metacoxae pubescent; metatrochanters glabrous except with long pubescence on posterior ridgeline; tibiae slender and only slightly tapering apically, covered with dense pubescence, basally $\frac{1}{3}$ to $\frac{1}{2}$ with slightly curved pubescence, apically with straight, transparent setae, almost glabrous dorsally; tibiae with lateral margin bordered with translucent brown spines apically, and armed with pair of very short, subequal, black-brown spines ventrally.

Abdominal sterna (Fig. 31). Surface almost entirely densely covered by short pubescence; only around midline of sternite one glabrous, some specimens more or less depressed laterally.

Male genitalia (Figs 32–36). Consisting of five parts: tergite 8, gastral spiculum, tegmen, median lobe and internal sac. Tergite 8 similar to that of female as described below. Gastral spiculum consisting of two pairs of twig-like sclerites, one pair longer than the other. Basal piece of tegmen rectangular in lateral view, tapering toward base.



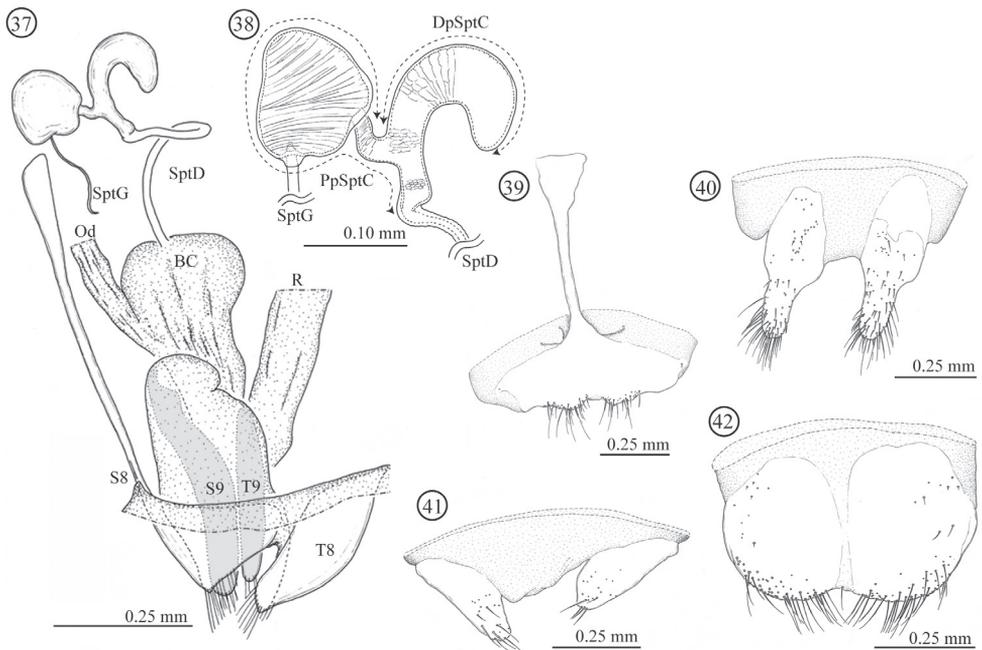
Figures 32–36. Male genitalia of *Lema lacertosa*. **32** entire genitalia in ventral view **33** aedeagus in lateral view; outer membrane of internal sac was partly removed. Right side corresponds to posterior end **34** median lobe and tegmen in ventral view **35** internal-sac sclerites in dorsal view, basal part is enlarged **36** internal-sac sclerites in lateral view; Bc: body cavity; DS: dorsal sclerite; FCM: first connecting membrane; GS: gastral spiculum; IS: internal sac; ISS: internal-sac sclerites; ML: median lobe; MS: median sclerite; R: rectum; SCM: second connecting membrane; T: tegmen; T8: tergite 8; VS: ventral sclerite.

Median lobe stout, median foramen expanding and occupying $\frac{1}{3}$ of ventral surface in lateral view, ventral end of median orifice round with rectangular and rounded protrusion. Internal sac with specialized state as in many members of the subgenus *Lema*, i.e. having pocket for storing elongated flagellum; median and ventral sclerites forming flagellum (1.58 mm, N=1); dorsal sclerite not separated.

Female genitalia and a part of reproductive systems (Figs 37–42). Spermathecal duct relatively long (0.36–0.49mm, N = 2) with no specialized structure in opening to bursa copulatrix. Spermathecal capsule well sclerotized, its wall relatively thick; distal part hook-shaped, inner surface covered by winkle-like sculpture, junction area to spermathecal duct covered by scale-like sculpture; proximal part with a large potato-like structure, inner surface covered by transverse winkles. Spermathecal gland opening on a light-bulb like structure. Genitalia of four parts: tergites 8 and 9, and sternites 8 and 9; tergites 9 and sternite 9 consisting of a pair of sclerites; sclerotization of tergite 8 gradually weakened toward midline; sternite 8 with stick-like apodeme; posterior area of sternite 8 covered by scale-like sculpture; upper area of tergite 8 weakly covered by scale-like sculpture and lower area with fine pointed projections.

Measurements. Specimens collected from India. Elytral length: male: 3.04 mm (N=1), female: 3.38 mm (N=1). Elytral width: male: 1.77 mm, female: 2.00 mm. Pronotum length: male: 1.00 mm, female: 1.15 mm. Pronotum width: male: 1.04 mm, female: 1.27 mm.

Specimens collected from Taiwan. Elytral length: male: 3.36 ± 0.21 mm (mean \pm SD, N=2), female: 3.56 ± 0.15 mm (N=4). Elytral width: male: 1.96 ± 0.11 mm, female: 2.05 ± 0.13 mm. Pronotum length: male: 1.08 ± 0.05 mm, female: 1.09 ± 0.05 mm. Pronotum width: male: 1.15 ± 0.02 mm, female: 1.20 ± 0.07 mm.



Figures 37–42. Female genitalia of *Lema lacertosa*. **37** entire female genitalia and a part of reproductive system in lateral view **38** spermathecal capsule **39** sternite 8 **40** sternite 9 **41** tergite 9 **42** tergite 8; BC: bursa copulatrix; Od: oviduct; R: rectum; SptD: spermathecal duct SptG: spermathecal gland; SptC: spermathecal capsule; PpSptC: proximal part of spermathecal capsule; DpSptC: distal part of spermathecal capsule; S8: sternite 8; S9: sternite 9; T8: tergite 8; T9: tergite 9.

Specimens collected from Malaysia. Elytral length: male: 3.15 mm (N=1), female: 3.57 ± 0.21 mm (N=4). Elytral width: male: 1.81 mm, female: 2.13 ± 0.14 mm. Pronotum length: male: 0.96 mm, female: 1.10 ± 0.03 mm. Pronotum width: male: 1.13 mm, female: 1.21 ± 0.05 mm.

Host plant. (Figs 45–46) Commelinaceae: *Commelina communis* L., 1753.

Distribution. India, Malaysia, and Taiwan (**new record**). This species is also recorded from Laos, Vietnam, S. China, and Singapore (Kimoto and Gressitt 1979), and Nepal (Schmitt 2010). These identifications require confirmation.

Remarks. Justification of identification of *Lema lacertosa*. Although Kimoto and Gressitt (1979) stated the type depository, they did not observe types and the type could not be located (see also remarks under *L. diversipes*). However from investigation of the literature we judged that there is a consensus for the identity of *L. lacertosa* among chrysomelid taxonomists. Features of the commonly accepted species have no contradiction with the original description and the specimens which we examined and identified as *L. lacertosa*.

Although we could not locate the holotype of *Lema lacertosa*, we have no evidence regarding the disappearance of the holotype. In addition, the identity of this species is relatively stable, so we do not designate a neotype for this species.

Lema (Lema) cyanella (Linnaeus, 1758)

http://species-id.net/wiki/Lema_cyanella

Material examined. Taiwan: 4 exs.: Taipei, Juifang, 10.II.2010, leg. H. Lee (TARI); 1 ex., same locality, 21.II.2010, leg. M.-H. Tsou (TARI); 2 exs., same locality, 6.III.2010, leg. M.-H. Tsou (TARI); 11 exs., same locality (= Nanya trail), 15.III.2010, leg. H. Lee (TARI); 2 exs., same locality, 19.III.2010, leg. H. Lee (TARI); 5 exs., same locality, 20.III.2010, leg. H. Lee (TARI); 8 exs., same locality, 1.IV.2010, leg. M.-H. Tsou (TARI); 1 ex., same locality, 18.IV.2010, leg. M.-H. Tsou (TARI); 1 ex., same locality, 25.IV.2010, leg. M.-H. Tsou (TARI); 2 exs.: Taipei, Pinglin, 1.VII.2008, leg. H. Lee (TARI).

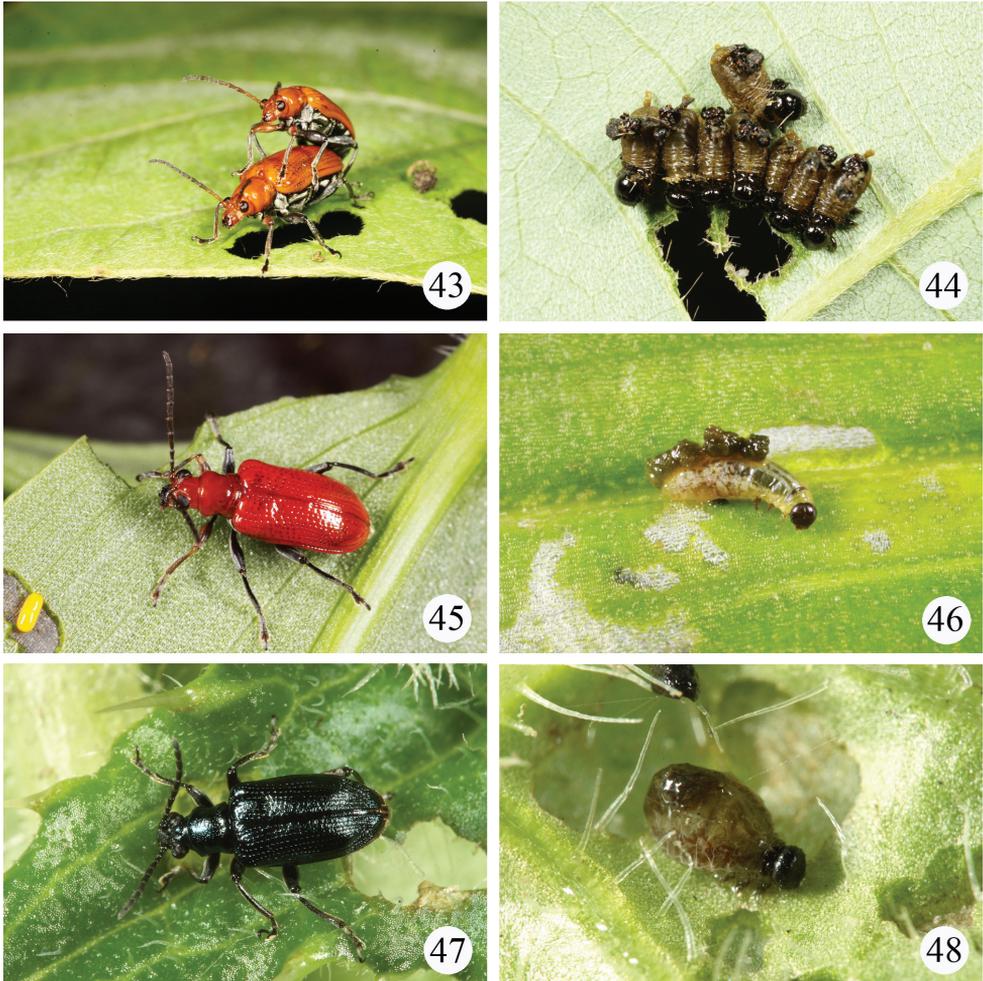
Remarks. This species was redescribed by Matsumura et al. (2011) who presumed *Cirsium japonicum* DC and *C. suffultum* Matsum. (Asteraceae) to be its host plants. Here *C. japonicum* (Figs 47–48) is confirmed as a host plant by field observations and laboratory rearing.

Distribution. Europe, China, Mongolia, Korea, Taiwan (**new record**), Japan.

Lema (Petauristes) solani Fabricius, 1798

http://species-id.net/wiki/Lema_solani

Material examined. Taiwan: 19 exs.: Chiayi, Chungpu, VIII.2007, leg. H.-T. Shih (TARI); 1 ex.: Hsinchu, Mamei, 4.V.2008, leg. S.-F. Yu (TARI); 1 ex.: Nantou, Wanfengtsun, 21.IV.2007, leg. W.-T. Liu (TARI); 1 ex.: Taichung, Pahsienshan,

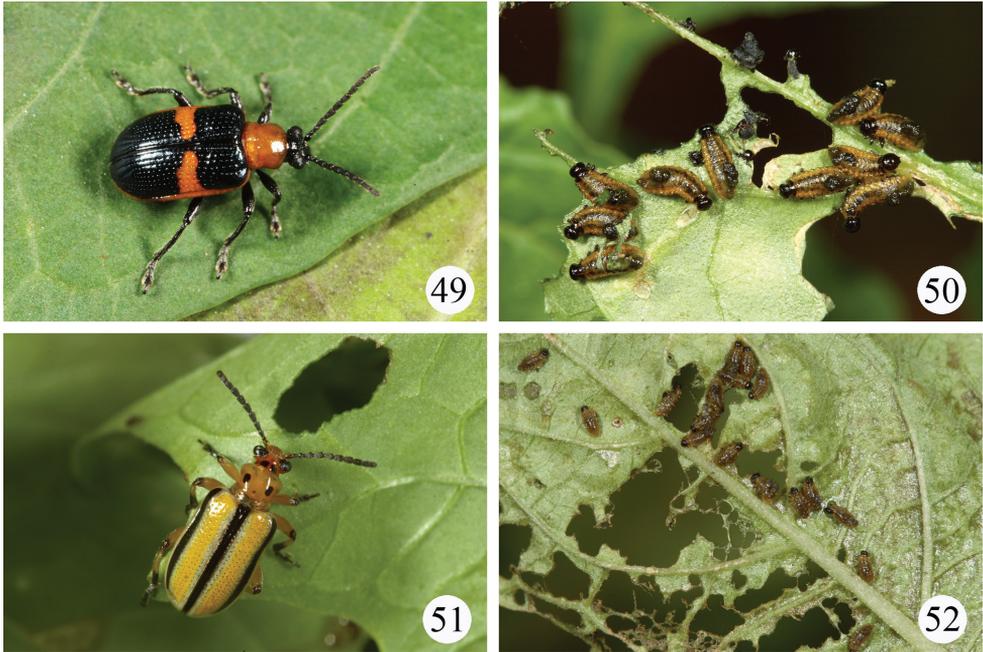


Figures 43–48. Live adults or larvae in the field. **43–44** *Lema diversipes* on *Pueraria lobata* (Willd.) subsp. *thomsonii* (Benth.) Ohashi **43** a pair of adults **44** a cluster of larvae **45–46** *Lema lacertosa* on *Comelina communis* L. **45** adult **46** larva **47–48** *Lema cyanella* on *Cirsium japonicum* **47** adult **48** larva.

5.VIII.2007, leg. W.-T. Liu (TARI); 4 exs.: Taichung, Tahsuehshan, 1.V.2012, leg. W.-T. Liu (TARI); 3 exs.: Tainan, Danei, 9.VII.2007, leg. W.-T. Liu (TARI); 1 ex.: Tainan, Meiling, 12.III.2011, leg. M.-L. Jeng (TARI); 2 exs.: Taipei, Sanchih, 7.VIII.2011, leg. C.-C. Cheng (TARI); 5 exs., same locality, 13.VIII.2011, leg. H. Lee (TARI); 2 exs.: Taoyuan, Luchu, 16.VI.2009, leg. W.-T. Liu (TARI).

Remarks. Lee and Cheng (2007) were the first to record this species from Taiwan although it is an introduced species originally distributed from the Eastern United States to Texas (White 1993). Species of the genus *Solanum* (Solanaceae) were reported as its host plants in the US. Adults and larvae were found feed on leaves of *Solanum americanum* Miller (Figs 49–50) in Taiwan. *Solanum americanum* is also an introduced species for Taiwan.

Distribution. Eastern United States to Texas, Taiwan.



Figures 49–52. Live adults and larvae in the field. **49–50** *Lema solani* on *Solanum americanum* **49** adult **50** larvae **51–52** *Lema trivittata trivittata* on *Physalis angulata* **51** adult **52** larvae.

Lema (Petauristes) trivittata trivittata Say, 1824

http://species-id.net/wiki/Lema_trivittata_trivittata

Material examined. Taiwan: 2 exs.: Taitung, Lanyu island, 5.V.2012, leg. S.-F. Yu (TARI); 16 exs.: Yunlin, Pichiao, 16.VI.2010, leg. H. Lee (TARI); 2 exs., same locality (= Tuku), 30.VI.2010, leg. H. Lee (TARI); 2 exs., same locality, 9.VII.2010, leg. H. Lee (TARI).

Remarks. This species is also an introduced one for Taiwan because its original distribution is limited to the United States and Canada (White 1993). Recently Aoyagi (2012) and Kawaji (2012) reported occurrence of *Lema trivittata* from Miyako and Iriomote islands of Japan. Although they did not mention the subspecies name, from the pictures in the papers we considered that they are same subspecies. Considering the geographic placement of the two islands and Taiwan, the origin of invasion could be once and rapidly spread.

Beetles were found to feed on leaves of *Physalis angulata* L. (Figs 51–52) and *P. peruviana* L. in Taiwan. Both plants are introduced species for Taiwan originally from the United States. Aoyagi (2012) also mentioned that the probable host plant is *Physalis angulata* L. in Miyako island of Japan and warned that it is a potential pest for cultivation of a leaf tobacco which is one of popular cultivation in the island.

Distribution. United States and southern Canada, Taiwan (**new record**), and Japan (Ryukyu: Miyako and Iriomote islands).

Key to species of the genus *Lema* from Taiwan (modified after Kimoto and Takizawa 1997)

A key to 11 known species of *Lema* from Taiwan was presented by Kimoto and Takizawa (1997). Of these species, *L. postrema* Bates, 1866 is a junior synonym of *L. fortunei* Baly, 1859 (Schmitt 2010); *L. coromandeliana* (Fabricius, 1798) is a junior synonym of *L. praeusta* (Fabricius, 1792) (Warchałowski 2011).

- | | | |
|----|--|----------------------------------|
| 1 | Elytron without scutellar row of punctures | (subgenus <i>Petauristes</i>) 2 |
| – | Elytron with a short scutellar row of punctures | (subgenus <i>Lema</i>) 7 |
| 2 | Elytron blackish-blue | 3 |
| – | Elytron yellowish-brown | 5 |
| 3 | Entire elytron blackish-blue | 4 |
| – | Lateral margin of elytra yellow, with transverse yellow band at middle | <i>L. solani</i> Fabricius |
| 4 | Generally reddish-brown except antenna black | <i>L. fortunei</i> Bates |
| – | Generally black except head and prothorax reddish-brown ... | <i>L. honorata</i> Baly |
| 5 | Entire elytra yellowish..... | <i>L. pectoralis</i> Baly |
| – | Elytra with black spots or stripes..... | 6 |
| 6 | Elytra with three black, longitudinal stripes | <i>L. t. trivittata</i> Say |
| – | Elytra with large, black spots at base and subapex; in some specimens entire elytra black except apex..... | <i>L. koshunensis</i> Chûjô |
| 7 | Mesotibia with a distinct denticulation in middle | <i>L. coronata</i> Baly |
| – | Mesotibia without distinct denticulation | 8 |
| 8 | Pronotum with two transverse furrows at basal ½ | <i>L. praeusta</i> (Fabricius) |
| – | Pronotum with one transverse furrow at basal ½ | 9 |
| 9 | Generally blackish-blue..... | 10 |
| – | Generally yellowish-brown | 12 |
| 10 | Pronotum without punctures..... | <i>L. cyanea</i> Fabricius |
| – | Pronotum with punctures | 11 |
| 11 | Abdominal ventrites III-V yellowish-brown, vertex relatively flat..... | <i>L. concinnipennis</i> Baly |
| – | Abdominal ventrites blackish-blue, vertex swollen | <i>L. cyanella</i> (Linnaeus) |
| 12 | Middle and hind legs black except front femur reddish-brown | 13 |
| – | All legs yellowish-brown | 14 |
| 13 | Body longer (7.5–8.2 mm), abdominal ventrites I-V black (Fig. 2)..... | <i>L. diversipes</i> Pic |
| – | Body shorter (4.5–5.5mm), abdominal ventrites II-V reddish-brown (Fig. 4) | <i>L. lacertosa</i> Lacordaire |
| 14 | Elytron with basal and postmedian black spots | <i>L. esakii</i> Chûjô |
| – | Entire elytron yellowish-brown..... | 15 |

- 15 Elytron with transverse furrow behind humerus; vertex without pubescence.
 *L. rufotestacea* Clark
 – Elytron without transverse furrow; vertex with dense pubescence
 *L. coomani* Pic

Acknowledgments

We greatly thank P. Jolivet, M. Schmitt, M. Minami for giving us information on a repository of Lacordaire's collection and M. Mantilleri, M. Ôhara, R. G. Beutel for type loans. P. Limbourg, P. Philip, N. E. Pierce kindly coped with our asking for the type repository. YM also thanks to H. Takizawa for valuable discussions on the taxonomic treatments and K. Yoshizawa, H. Yoshitomi, H. Suenaga, M. Maruyama, I. Yao, T. Kanbe, T. Shimosawa, and M. Shimomura for their cooperation. We thank the Taiwan Chrysomelid Research Team for assistance in collecting specimens, including J.-C. Chen, H. Lee, W.-T. Liu, M.-H. Tsou, and S.-F. Yu, and M.-H. Tsou and T.-H. Lee for taking photos of dead or live specimens. This study was supported by JSPS Research Fellowships for Young Scientists and for Research Abroad. We thank C. L. Staines for reviewing the draft.

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Larvae of five horticulturally important species of *Chrysopodes* (Neuroptera, Chrysopidae): shared generic features, descriptions and keys

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Academic editor: A. Contreras-Ramos | Received 14 October 2012 | Accepted 27 December 2012 | Published 1 February 2013

Citation: Silva PS, Tauber CA, Albuquerque GS, Tauber MJ (2013) Larvae of five horticulturally important species of *Chrysopodes* (Neuroptera, Chrysopidae): shared generic features, descriptions and keys. ZooKeys 262: 39–92. doi: 10.3897/zookeys.262.4119

Abstract

An expanded list of generic level larval characteristics is presented for *Chrysopodes*; it includes a reinterpretation of the mesothoracic and metathoracic structure and setation. Keys, descriptions and images of Semaphoront A (first instar) and Semaphoront B (second and third instars) are offered for identifying five species of *Chrysopodes* (*Chrysopodes*) that are commonly reported from horticultural habitats in the Neotropical region.

Resumo

Uma lista expandida das características larvais em nível de gênero é apresentada para *Chrysopodes*, incluindo a reinterpretação da estrutura e das cerdas do mesotórax e metatórax. Chaves, descrições e imagens do semaforonte A (primeiro instar) e semaforonte B (segundo e terceiro instares) são fornecidas para a identificação de cinco espécies de *Chrysopodes* (*Chrysopodes*) comumente encontradas em habitats hortícolas na região Neotropical.

Keywords

Systematics, immature stages, Neotropical lacewings, comparative morphology

Introduction

Chrysopodes is one of the main groups of predaceous insects that have value in the biological control of arthropod pests in Neotropical agriculture (Albuquerque et al. 2001, Freitas and Penny 2001, Silva et al. 2007, Gonzalez Olazo and Heredia 2010). The genus is widespread and relatively large; it occurs throughout all of tropical and subtropical America and presently it consists of 47 species (Tauber et al. 2012). Many species in the genus are commonly found in disturbed habitats, most often in orchards and plantations. One species is reported from the United States (see Tauber 2003, Tauber and Flint 2010), substantially more from Mexico and Central America, and many more from South America.

Navás (1913) described *Chrysopodes* on the basis of the external adult features of a single species. Subsequent researchers included ~30 additional species in the genus, recognized generically distinctive genitalic characteristics, and divided the group into two subgenera: *Chrysopodes* with sickle-shaped mandibles and *Neosuarius* with broadly-tipped mandibles (Adams and Penny 1985, Brooks and Barnard 1990; also see Banks 1945). Thereafter, other species of *Chrysopodes* (*Chrysopodes*) were described (Penny 1998, 2001, 2002, Freitas and Penny 2001, Tauber et al. 2012), and the subgenus *Chrysopodes* (*Neosuarius*) was revised (Tauber 2010). The subgenus *Chrysopodes* (*Chrysopodes*) is currently under revision (Tauber, C. A. in preparation).

Although most of the taxonomic work on the genus *Chrysopodes* has focused on the adult stage, an extensive suite of morphological traits was shown to distinguish *Chrysopodes* larvae from those in other genera of Chrysopini (Tauber 2003). To date, species-specific larval characteristics have been described for two *Chrysopodes* (*Neosuarius*) species: *Chrysopodes* (*Neosuarius*) *collaris* (Schneider) and *Chrysopodes* (*Neosuarius*) *porterinus* (Navás) (Tauber 2003, Monserrat and Freitas 2005). It is reasonable to expect that further comparative study of the larvae will provide important information for the systematics of *Chrysopodes* and increase the value of this group of natural enemies for ecological investigations and agricultural use.

With the above in mind, we describe and provide images of the larvae of five additional species of *Chrysopodes*. All five species are in the subgenus *Chrysopodes* (*Chrysopodes*): *C. (C.) divisus* (Walker), *C. (C.) fumosus* Tauber & Albuquerque, *C. (C.) geayi* (Navás), *C. (C.) lineafrons* Adams & Penny, and *C. (C.) spinellus* Adams & Penny. Also, we present keys for identifying the larvae (all instars) of the five species. Prior to doing so, we make some minor corrections and important additions to an earlier list (Tauber 2003) of larval features that distinguish *Chrysopodes*. The genus-level features (i.e., those that are shared by larvae of all *Chrysopodes* species studied to date) are listed on the Appendix.

Methods

The specimens used in our study were reared from field-collected females. The rearing, preservation, descriptive procedures, and terminology are identical to those pub-

lished previously (Tauber 2003, <http://esa.publisher.ingentaconnect.com/content/esa/aesa/2003/00000096/00000004/art00008>). We suggest that readers refer to the illustrations and explanatory material in that paper when using the keys, descriptions and images here. Voucher specimens (adult females with their laboratory-reared offspring, and the larval specimens used in the study) are deposited in the Essig Museum, University of California, Berkeley, the insect collection at the Universidade Estadual do Norte Fluminense, Campos dos Goytacazes, and the research collections of the authors.

The earlier study of *Chrysopodes* larval traits (Tauber 2003) was based on laboratory-reared specimens from eight species. Subsequently, two of these “species” were found to be the same; this species is included here [*C. (C.) spinellus*: Tauber Lots 2001:007, 2002:026]. In addition, three other species from the earlier study are included here [*C. (C.) divisus*: Tauber Lots 96:017, 96:018, 96:019, 99:020, 99:043, *C. (C.) geayi*: Tauber Lot 2001:003, previously referred to as “*pulchella*”, and *C. (C.) fumosus*: Tauber Lot 2002:021]. Two of the remaining lots from the earlier study will be described elsewhere [Tauber Lots 96:006, 99:037], and one [*C. (N.) collaris*] was described earlier (Tauber 2003).

In our previous work, we have used two terms “submedian setae” (e.g., Mantoaneli et al. 2011) and “submesal setae” (e.g., Tauber et al. 2011) to refer to the dorsal abdominal setae that Tsukaguchi (1995) termed “submedian setae”. Here, to be consistent with Tsukaguchi, we use one term, “submedian setae”.

It is noteworthy that bilateral asymmetry in setal numbers is common, and that specimens occasionally exhibit variation in the numbers and sizes of setae (especially in the dorsal thoracic setae and the submedian abdominal setae) of all instars. The numbers presented here reflect this asymmetry. Also, in our descriptions, unless stated otherwise, all setae, other than the submedian setae, are smooth and pointed (not thorny, hooked or blunt).

Shared Generic Characteristics

The chrysopid life cycle includes a larval stage with three instars. The first instar differs markedly in structure, setation and often coloration from the other two instars, which differ from each other only in minor ways, largely related to size. Thus, for taxonomic purposes, the first instar constitutes Semaphoront A, whereas Semaphoront B includes both the second and third instars and Semaphoront C encompasses all instars (= the larva) (See Wheeler 1990). We use the term “semaphoront” in our descriptions because of its systematic and phylogenetic value. Specifically: (i) the term highlights the relative degree of morphological change that occurs with each instar during metamorphosis, (ii) it reflects accurately the relative value of the three chrysopid instars to phylogenetic analysis, and (iii) the commonality of the pattern of variation among semaphoronts across chrysopid taxa, and indeed taxa in other insect orders (see Wheeler 1990), itself is of considerable biological interest.

Chrysopid genera fall into two general categories: those with “naked” larvae and those with “trash-carrying” larvae. *Chrysopodes* larvae are typical examples of the lat-

ter – that is, they have compact, globose bodies, hooked abdominal setae, and well developed thoracic and abdominal tubercles that bear elongate setae adapted for carrying small pieces of plant or animal debris. Furthermore, *Chrysopodes* larvae express a unique set of morphological and setal characters that distinguishes them from the larvae of other trash-carrying genera (Tauber 2003; for additional comparisons, see Díaz-Aranda and Monserrat 1995, Tsukaguchi 1995, Monserrat and Díaz-Aranda 2012).

In general, the species studied here exhibit all of the larval characteristics proposed earlier to typify *Chrysopodes* (Tauber 2003); moreover, several additional characteristic features were discovered during the current study. Thus, we provide an up-dated list of shared *Chrysopodes* generic-level characteristics (Appendix); those that are new as a result of the current study are marked with an asterisk. Among the most distinctive features that were previously unreported are the uniquely shaped submedian setae (SMS) on the anterior abdominal segments of all instars (Fig. 1C). These long, smooth, hooked setae are slender and bent throughout the midregion, but their hooked tips are robust, rigid and laterally compressed. We have not seen this type of seta on larvae of other neotropical Chrysopini.

Keys to larvae of five *Chrysopodes* (*Chrysopodes*) spp. commonly found in Brazilian fruit orchards

Note: To identify cephalic setae, see Fig. 5 on page 477 of Tauber (2003). For body setae, see Fig. 10 on page 482 (Semaphoront A) and Figs 6 and 8 on pages 478 and 480 (Semaphoront B) of the same article – <http://esa.publisher.ingentaconnect.com/content/esa/aesa/2003/00000096/00000004/art00008>

First instar (Semaphoront A)

- 1 Head predominantly brown; epicranial marking entire (with mesal and lateral arms wholly or partly confluent) and fused mesally (Figs 2A, 2D); abdominal segments A1-A5 each with total of more than 14 long, hooked, dorsal setae (spiracular and submedian setae)..... **2**
- Head predominantly white to cream-colored; epicranial marking consisting of two longitudinally elongate brown stripes, with mesal and lateral arms completely separate (Figs 2B-C, 2E); abdominal segments A1-A5 each with total of 14 long, hooked, dorsal setae (spiracular and submedian setae)..... **3**
- 2 Cranium with two dorsal setae (S1 and S11) thorny (Fig. 5A in Tauber 2003); dorsum of abdominal segments A1-A5 each with total of more than 30 elongate, smooth, hooked setae (submedian and spiracular setae) (Fig. 5C)..... ***C. (C.) divisus***
- Cranium with four dorsal setae (S1, S4, S6 and S11) thorny; dorsum of abdominal segments A1-A5 each with total of 16–20 elongate, smooth, hooked setae (submedian and spiracular setae) (Fig. 19C) ***C. (C.) lineafrons***

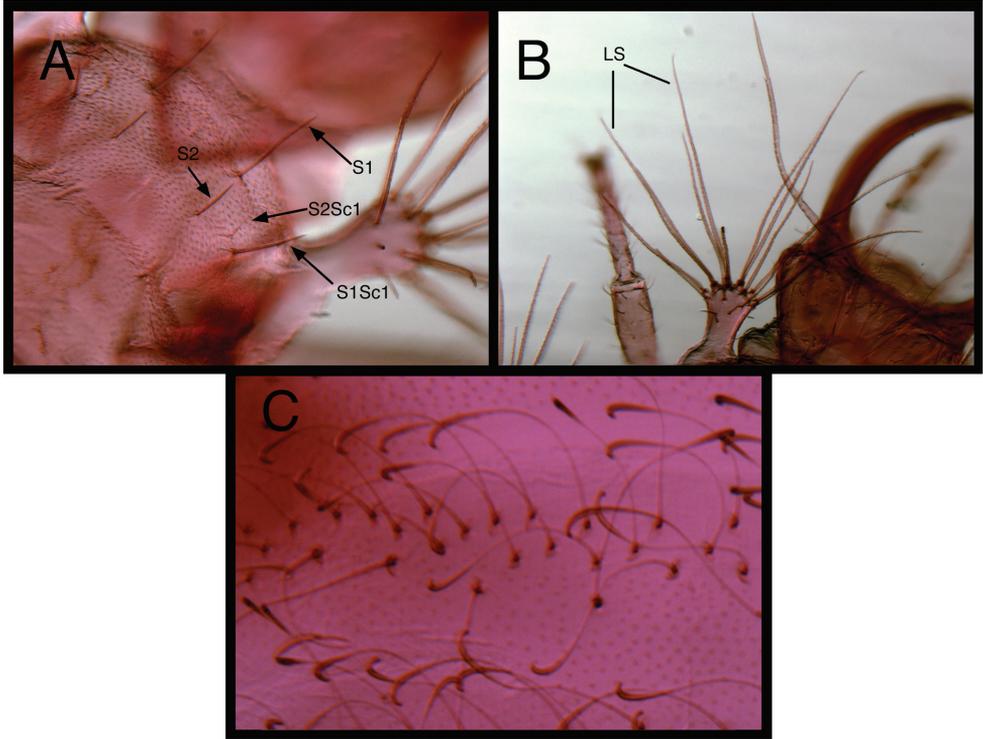


Figure 1. Examples of dorsal setae that typify *Chrysopodes* larvae (laboratory-reared third instar *Chrysopodes divisus*) **A** Two types of dorsal prothoracic setae: (1) thorny, pointed or blunt (**S1**, **S1Sc1**) and smooth, pointed (**S2**, **S2Sc1**) [Note the position of the setae relative to the dark sclerite.] **B** Elongate, robust, thorny, blunt or spatulate setae on lateral tubercle (**LS**) **C** Elongate, smooth, hooked submedian setae of anterior abdominal segments [Note the narrowed and bent middle section and the enlarged, laterally flattened, hooked terminus.].

- 3 Paired frontal marking with posterior ends straight, not meeting mesally (Fig. 2B) **C. (C.) fumosus**
- Paired frontal marking with posterior ends curved inward, meeting mesally (Fig. 2C, 2E)..... **4**
- 4 More than three (usually six) cranial setae (S1, S3, S4, S5, S6, S11) thorny (Fig. 5A in Tauber 2003); large lateral tubercles on thorax and abdomen with setae (LS) light amber to light brown (Fig. 23C)..... **C. (C.) spinellus**
- Only two or three cranial setae (S1, S11, sometimes S4) thorny; large lateral tubercles on thorax and abdomen with setae (LS) dark brown (Fig. 14C) **C. (C.) geayi**

Second and third instars (Semaphoront B)

- 1 Epicranial mark broad, with two arms wholly or partly confluent; paired frontal markings broadly fused mesally (Figs 3A, 3D, 4A, 4D) **2**

- Epicranial mark consisting of two paired longitudinal stripes (= mesal and lateral arms); paired frontal markings close to each other, but separate, except sometimes posterior tips curve and meet mesally (Figs 3B–C, 3E, 4B–C, 4E) **3**
- 2 Mesal and lateral arms of epicranial marking fully confluent throughout (Figs 3A, 4A); cranial seta S1 smooth; pronotum with sparse covering of largely transparent spinules; metathorax with posterior fold bearing transverse row of 14–15 long, thorny setae arising from robust, brown chalazae and one pair of smooth, lateral setae arising from smaller chalazae (Figs 6C, 7A, 8A) ***C. (C.) divisus***
- Mesal and lateral arms of epicranial marking confluent basally, separate distally (Figs 3D, 4D); cranial seta S1 thorny; pronotum with dense covering of dark brown spinules; metathorax with posterior fold bearing transverse row of 12 to 13 long, thorny setae arising from robust, brown chalazae (Figs 20C, 21A, 22A) ***C. (C.) lineafrons***
- 3 Paired frontal marking with posterior ends straight, not meeting mesally (Figs 3B, 4B); all cranial setae smooth ***C. (C.) fumosus***
- Paired frontal marking with posterior ends curving and meeting mesally (Figs 3C, 3E, 4C, 4E); cranial seta S1 thorny **4**
- 4 Cranium with three to four pairs of small secondary setae between S1 and S4 (Fig. 5B in Tauber 2003); pronotum with paired sclerite (Sc1) light brown to transparent, forked basally with mesal arm very faint, lateral arm light brown to transparent; midline of pronotum with only one sclerite (Sc2), no secondary sclerites (Figs 3E, 4E) ***C. (C.) spinellus***
- Cranium without secondary setae (Fig. 5A in Tauber 2003); pronotum with paired sclerite (Sc1) dark brown, forked basally into distinct mesal and lateral arms that extend around base of lateral tubercles; midline of pronotum with several secondary sclerites in addition to Sc2 (L2: one to two; L3: five to seven) (Figs 3C, 4C) ***C. (C.) geayi***

Larval descriptions

Because the Appendix lists the generic-level characteristics that are shared by all *Chrysopodes* larvae studied to date, the individual descriptions presented here are restricted to those larval characteristics that distinguish the species.

***Chrysopodes (Chrysopodes) divisus* (Walker, 1853)**

http://species-id.net/wiki/Chrysopodes_divisus

Figs 2–9

Discussion. *Chrysopodes divisus* is probably one of the most common and widespread of the *Chrysopodes* species. It has a large number of synonyms (see Adams and Penny

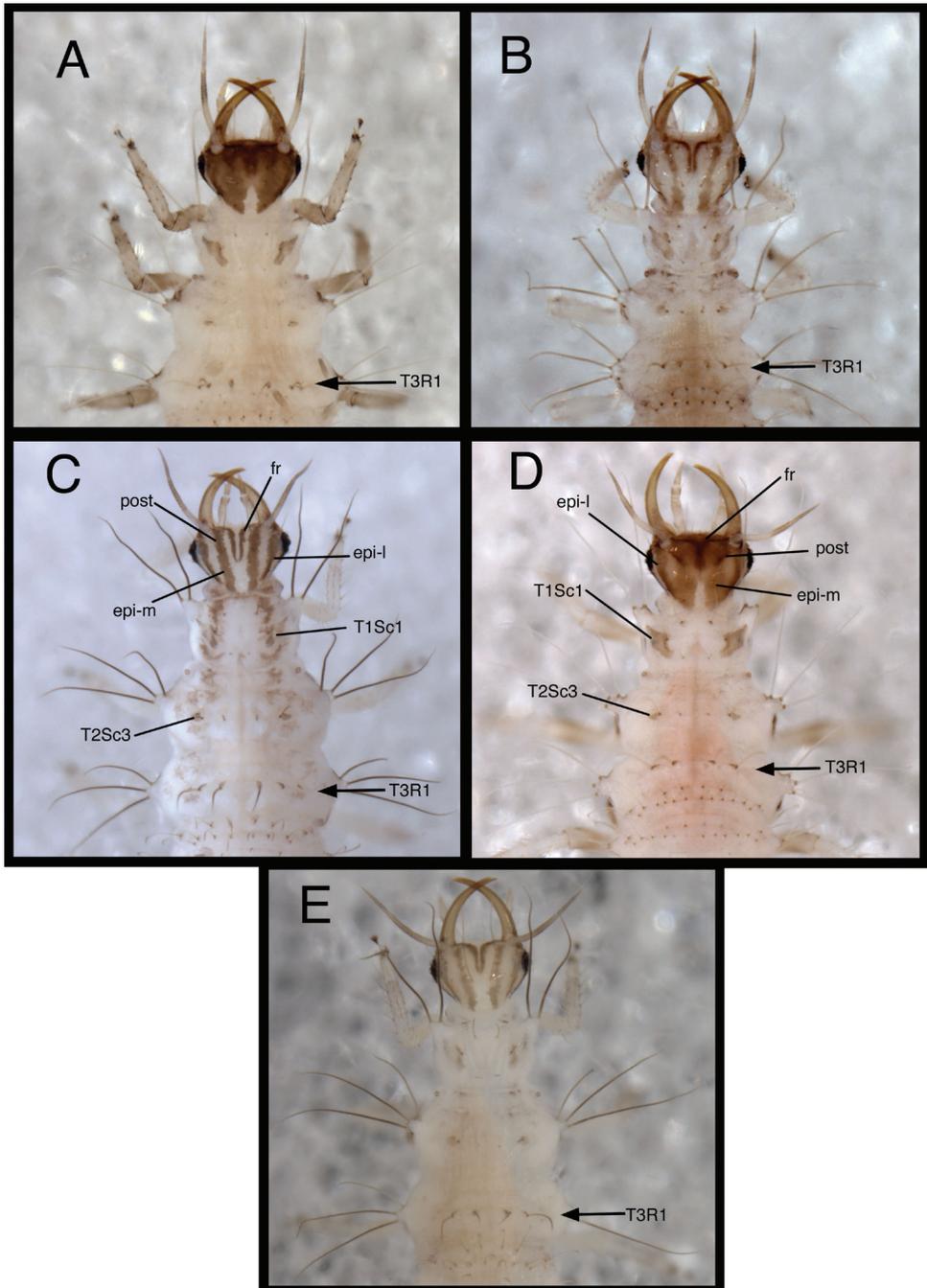


Figure 2. Head and thorax, dorsal, first instar **A** *Chrysopodes (C.) divinus* **B** *Chrysopodes (C.) fumosus* **C** *Chrysopodes (C.) geayi* **D** *Chrysopodes (C.) lineafrons* **E** *Chrysopodes (C.) spinellus*. Abbreviations: **epi-l** epicranial marking, lateral arm **epi-m** epicranial marking, mesal arm **fr** frontal marking **post** postfrontal marking **T1Sc1** first primary prothoracic sclerite **T2Sc3** third primary mesothoracic sclerite **T3R1** meta-thoracic row of robust, thorny setae.

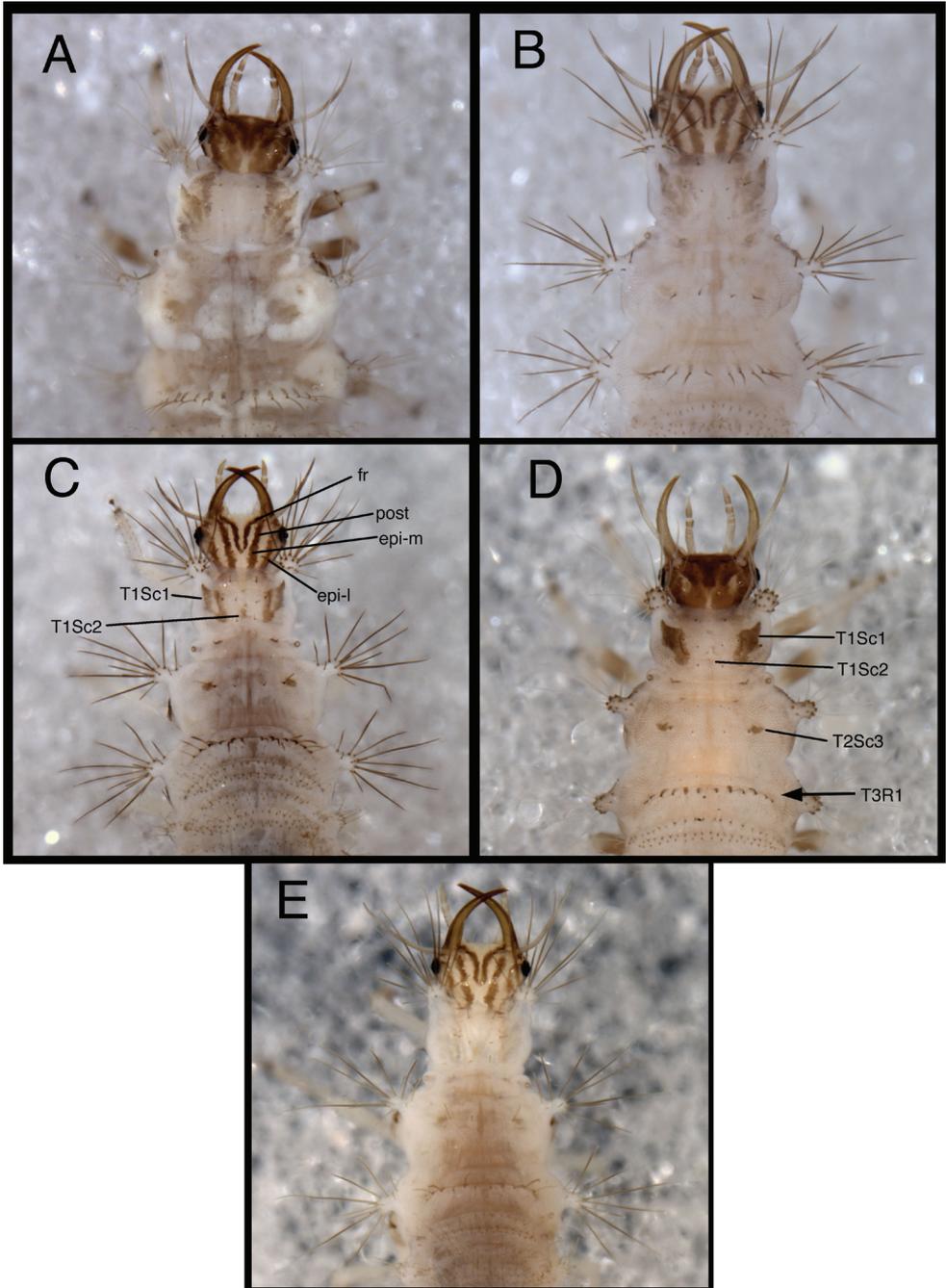


Figure 3. Head and thorax, dorsal, second instar **A** *Chrysopodes* (*C.*) *divisus* **B** *Chrysopodes* (*C.*) *fumosus* **C** *Chrysopodes* (*C.*) *gayi* **D** *Chrysopodes* (*C.*) *lineafrons* **E** *Chrysopodes* (*C.*) *spinellus*. Abbreviations: **e****pi**-**l** epicranial marking, lateral arm **e****pi**-**m** epicranial marking, mesal arm **f****r** frontal marking **p****ost** postfrontal marking **T1Sc1**, **T1Sc2** first and second primary prothoracic sclerites **T2Sc3** third primary mesothoracic sclerite **T3R1** metathoracic row of robust, thorny setae.

1985), and originally it was placed in the subgenus *C. (Neosuarius)*. Recently it was moved to *C. (Chrysopodes)* on the basis of adult characteristics (Tauber 2010).

Adults of *C. (C.) divisus* are recognized by their relatively narrow costal cells, dark gradate veins, facial markings and very distinctive male and female genitalia. They can be identified using current keys and redescriptions (Adams and Penny 1985, Freitas and Penny 2001).

Known geographic distribution. Argentina, Brazil, British Guiana, Colombia, Cuba, Jamaica, Paraguay, Peru, Uruguay, and Venezuela (Adams and Penny 1985, Freitas and Penny 2001).

Larval diagnosis. *Chrysopodes (C.) divisus* larvae (all instars) are relatively short, compact, and rotund. Their bodies are white to light cream-colored, with brown to light brown prothoracic sclerites; most of the long setae are cream-colored to light brown. The extensive brown head markings of *C. (C.) divisus* (all instars) are similar to those of *C. (C.) lineafrons* in that: (i) The confluent frontal markings, together with the dark brown intermandibular region, form an extensive dark brown, triangular to T-shaped mark on the anterior region of the head. (ii) The mesal and lateral arms of the epicranial markings are completely or partially confluent; together with the dark brown postfrontal markings, they cover most of the posterior and mesolateral regions of the head.

The first instar of *C. (C.) divisus* is distinguished from *C. (C.) lineafrons* by the lack of thorns on all cranial setae other than S1 and S11, metathorax with a large number of setae ($n = 6-7$) in row (R1) on posterior fold, and a large number of abdominal SMS on segments A1 to A5 ($n > 30$). Second and third instars (Semaphoront B) are characterized by cranial setae that are all without thorns, prothorax that is white to cream-colored and without a conspicuous covering of brown spinules, and metathorax that has a large number of setae ($n = 14-15$) in row (R1), which, in the L3, is flanked laterally by a pair of long, smooth setae.

First instar. (Semaphoront A). *Body* (Fig. 5A) short, globose, compact in shape, 2.5–2.9 mm long. *Head* (Figs 2A, 5B) 0.38–0.39 mm wide; mandibles 0.35–0.39 mm long (ratio, mandible length : head width = 0.95–1.02 : 1). Dorsum of cranium predominantly brown, with wedge-shaped, white area posteromesally. Epicranial marking entire, light brown mesally, darker brown laterally. Postfrontal marking darker brown than most of epicranial marking, contiguous basally with distal margin of epicranial marking, extending to anterior base of antenna. Frontal marking paired, but fused mesally, dark brown anteriorly, narrow, extending anteriorly from midregion of cranium, bending toward inner basal margin of mandible. Intermandibular, clypeal area brown. Cranial setae light amber; S1, S11 long, thorny, others smooth, shorter.

Gena, ventral margin of cranium brown; genal marking with small white spot behind eye. Labial palpus tinged with light brown, slightly darker distally. Mandibles amber, with brown basolateral spot. Antenna with scape brownish, pedicel white basally, brown distally, flagellum light brown.

Thorax (Figs 2A, 5A) mostly cream to white, with sclerotized structures light to very light brown; episternum light brown. Legs white, with base of coxa light brown, femur

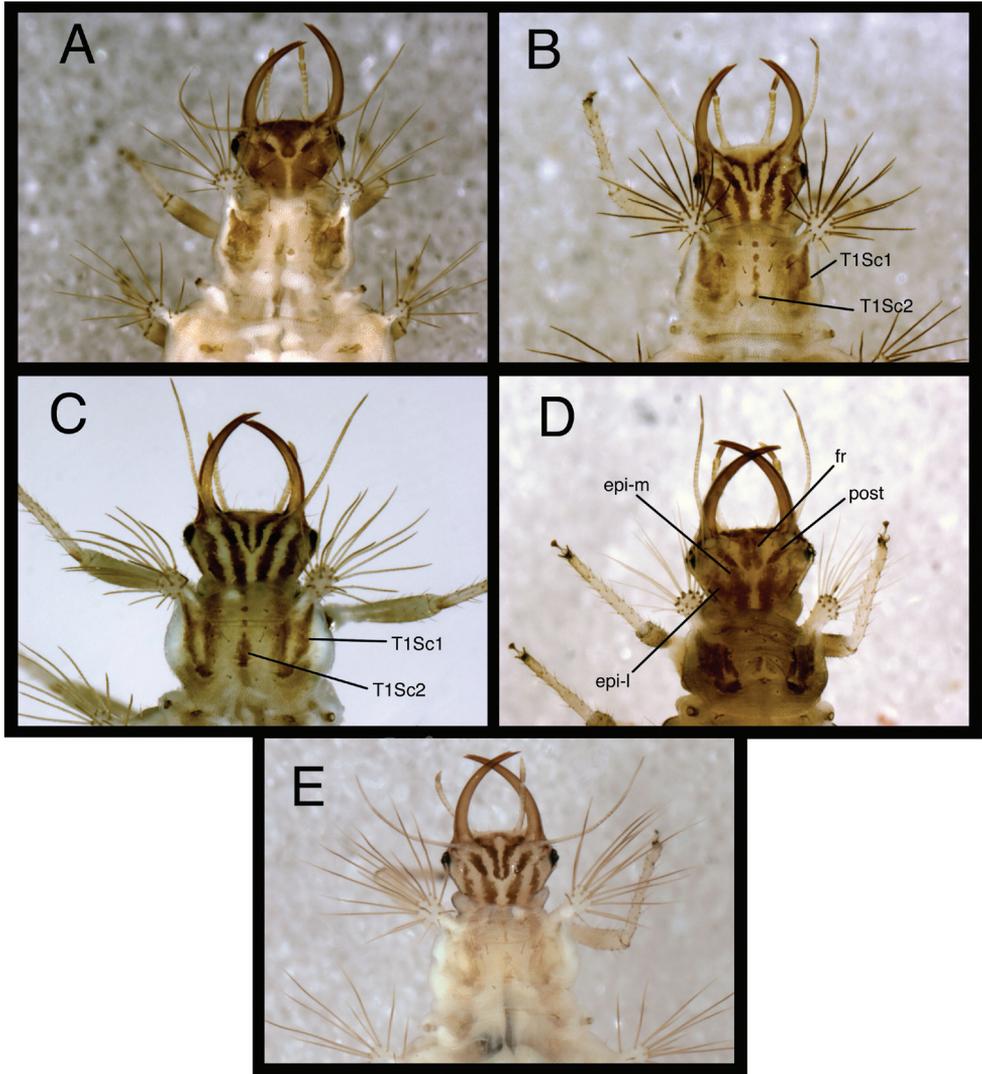


Figure 4. Head and thorax, dorsal, third instar **A** *Chrysopodes (C.) divisus* **B** *Chrysopodes (C.) fumosus* **C** *Chrysopodes (C.) geayi* **D** *Chrysopodes (C.) lineafrons* **E** *Chrysopodes (C.) spinellus*. Abbreviations: **epi-l** epicranial marking, lateral arm **epi-m** epicranial marking, mesal arm **fr** frontal marking **post** postfrontal marking **T1Sc1**, **T1Sc2** first and second primary prothoracic sclerites.

(especially distal half) tinged with brown, dorsum of tibia, tarsus tinged with light brown; tarsal claws, empodia brown. LS cream to white; other setae white to cream.

T1: Row of three very small setae (R1) at anteromesal base of LTs. Sc1 brown mesally, basolaterally, with cream colored interior; S2Sc1 small, immediately above S1Sc1. S1 long, S3 intermediate-length. T2: Spiracle with lips of atrium protruding above integumental surface. Sc1, Sc2, transparent; Sc3 marked with light brown;

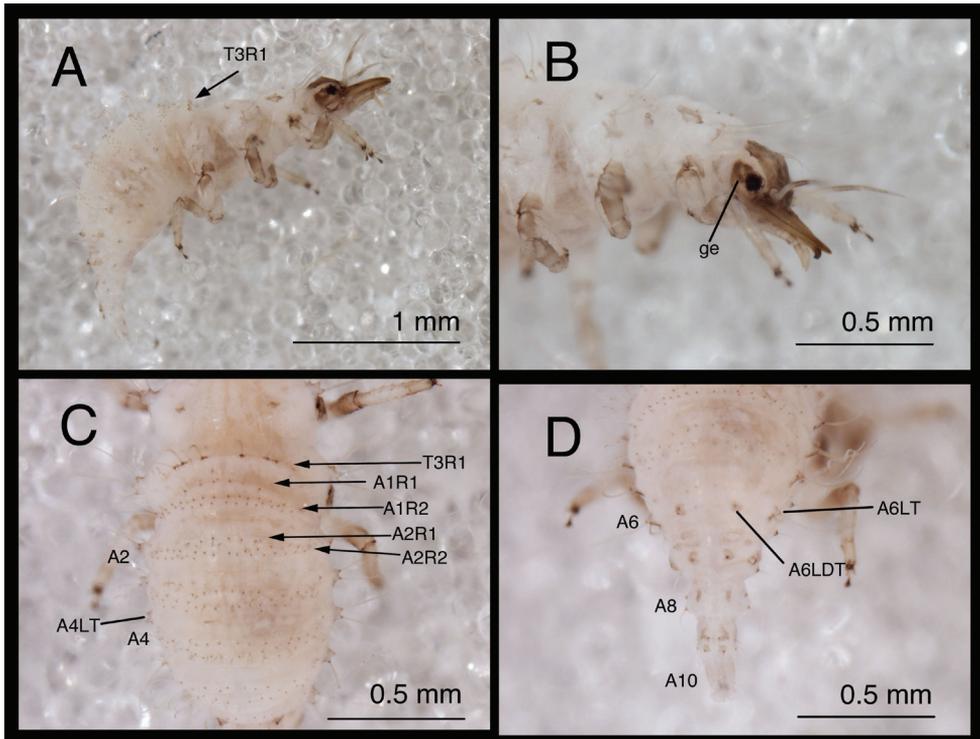


Figure 5. *Chrysopodes (C.) divisus*, first instar **A** Habitus, lateral **B** Head, lateral **C** Abdominal segments A1 to A5, dorsal **D** Abdominal segments A6 to A10, dorsal. *Abbreviations:* **A2, A4, A6, A8, A10** abdominal segments **A1R1, A1R2** anterior and posterior rows of submedian setae (SMS) on first abdominal segment **A2R1, A2R2** anterior and posterior rows of SMS on second abdominal segment **A4LT** lateral tubercle on fourth abdominal segment **A6LDT, A6LT** laterodorsal tubercle, lateral tubercle on sixth abdominal segment **ge** genal marking **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

S2Sc3 variable, medium-length to long; S2 smaller. T3: S1Sc1, S2Sc1 present, S1Sc2 very small, sometimes absent, S2Sc2 usually present. Posterior fold with row (R1) of six (sometimes seven) long, thorny, pointed setae on chalazae with ovate, light brown marks anteriorly; lateral two chalazae on each side juxtaposed.

Abdomen (Figs 5C-D) white to cream-colored, with LTs, LDTs tinged with light brown.

A1: Dorsum with ten to twelve SMS in single anterior row, with 34–42 SMS in double to triple row posteriorly; spiracles at end of posterior row, without distinguishable SSp. A2: Dorsum with ~10 SMS in single anterior row, with ~44 SMS in double to triple posterior row; anterior row bending posteriorly at each end, coalescing with setae in posterior row; spiracle at end of posterior row, with SSp near anterodistal margin. A3-A5: Dorsum with ~8 (A3, A4) or 6–7 (A5) SMS in single anterior row, with ~36 (A3), ~32 (A4), ~26 (A5) SMS in double to triple posterior row; anterior row bending posteriorly at each end, coalescing with posterior row;

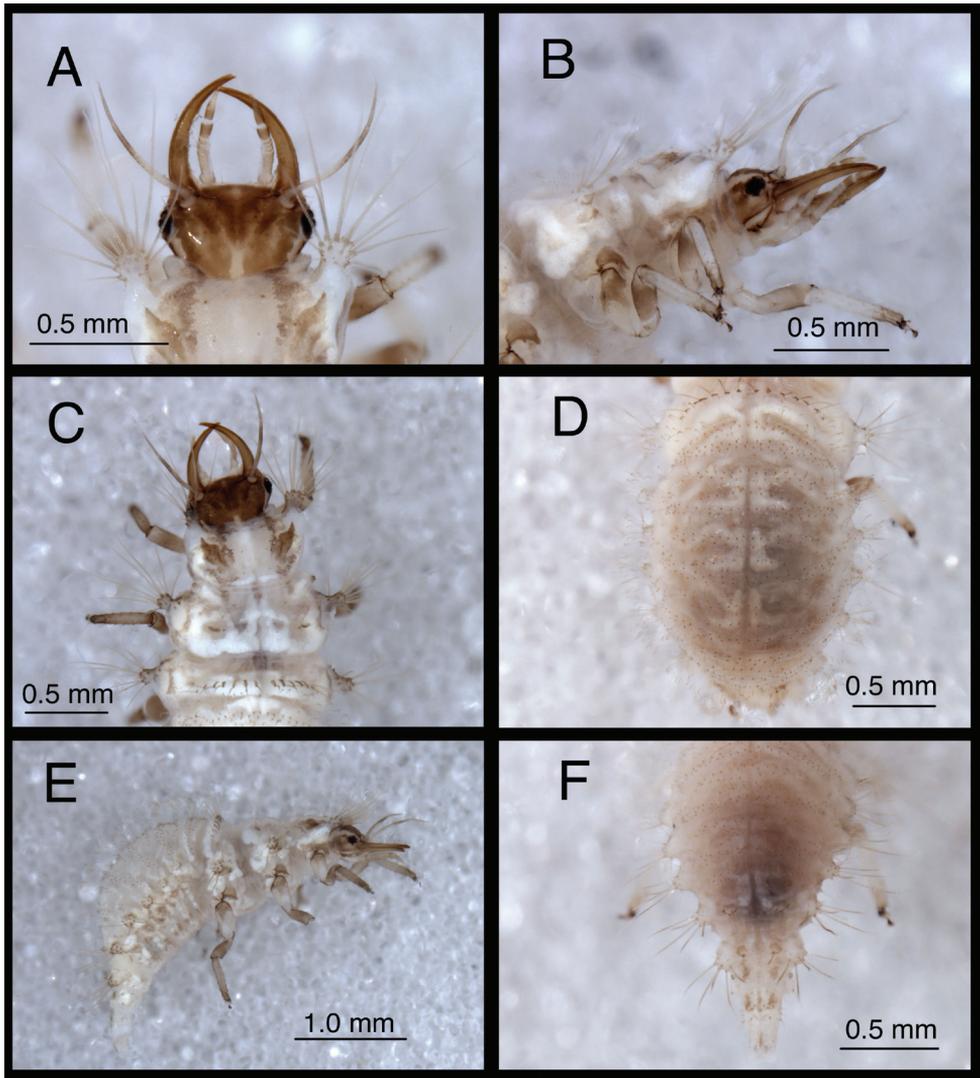


Figure 6. *Chrysopodes (C.) divisus*, second instar **A** Head, dorsal **B** Head, lateral **C** Head and thorax, dorsal **D** Abdominal segments A1 to A5, dorsal **E** Habitus, lateral **F** Abdominal segments A6 to A10, dorsal.

spiracle with SSp anteroventrally. A6: Anterior region with four SMS; spiracle with SSp mesally. A7: Anterior region with pair of microsetae; spiracle with SSp mesally. A8: Venter with two pairs of medium-length setae posteriorly, one pair of short setae slightly anteriorly.

Second and third instars. (Semaphoront B). *Body* (Figs 6E, 7A–B) length 3.3–3.4 mm (L2), 5.7–6.3 mm (L3); surface white to cream-colored, with light to dark brown integumental spinules somewhat dense, dark on pronotum; primary pronotal, mesonotal sclerites brown to dark brown, other dorsal marks small, brown; sclerites around coxae dark brown, abdomen with light to very light brown stripe laterally.

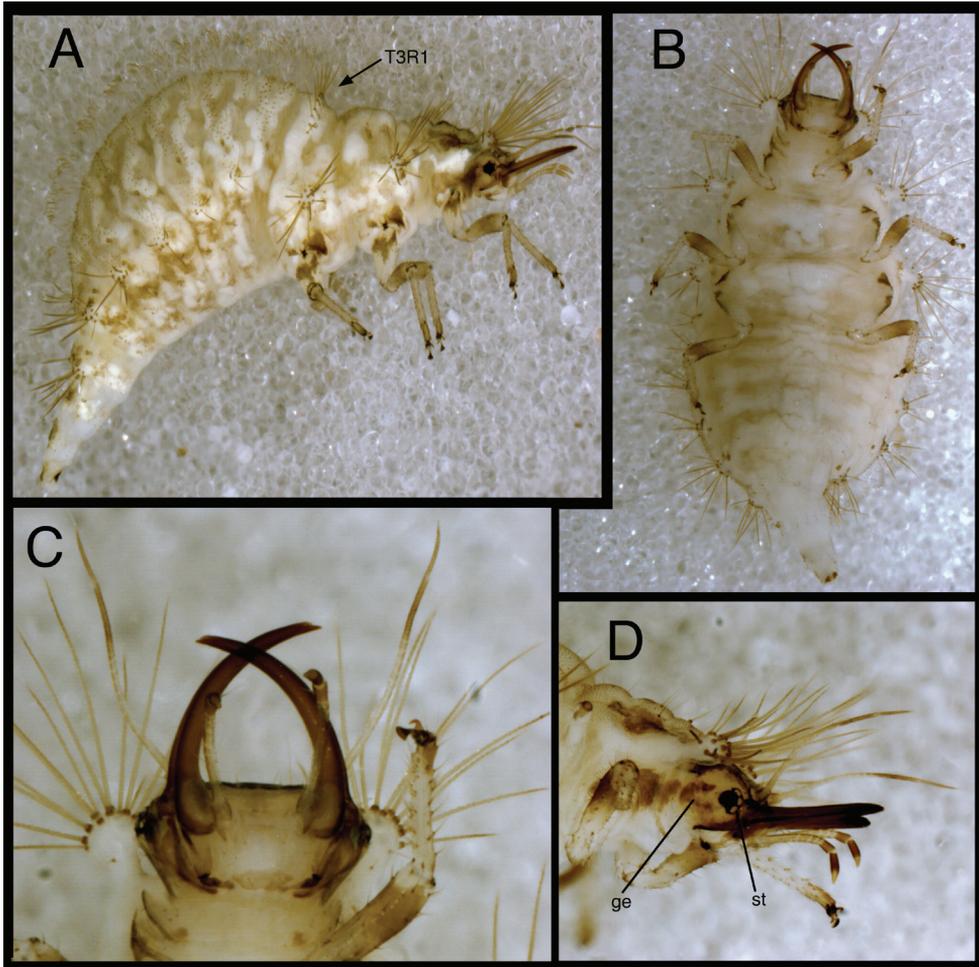


Figure 7. *Chrysopodes (C.) divisus*, third instar **A** Habitus, lateral **B** Habitus, ventral **C** Head, ventral **D** Head, lateral. Abbreviations: **ge** genal marking **st** stemmata **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

Head (Figs 3A, 4A, 6A–B, 7C–D) cream-colored, with extensive brown and dark brown markings. Epicranial marking undivided, with mesal and lateral arms distinguishable, but broadly connected throughout, both arms in contact with posterior margin of head; lateral arm dark brown basally, lighter distally, extending from distal one-fourth of posterior cranial suture to lateral base of mandible; mesal arm light brown, extending from base of head, becoming confluent with postfrontal marking. Postfrontal marking very dark brown, narrow throughout, extending to inner base of scape. Frontal marking dark brown, with left, right arms contiguous with each other and with intermandibular marking, forming broad, triangular, dark brown anterior marking. Clypeolabral region distal to anterior marking cream-colored. Gena cream-colored, with brown marking basally, becoming lighter brown, forking near midregion,

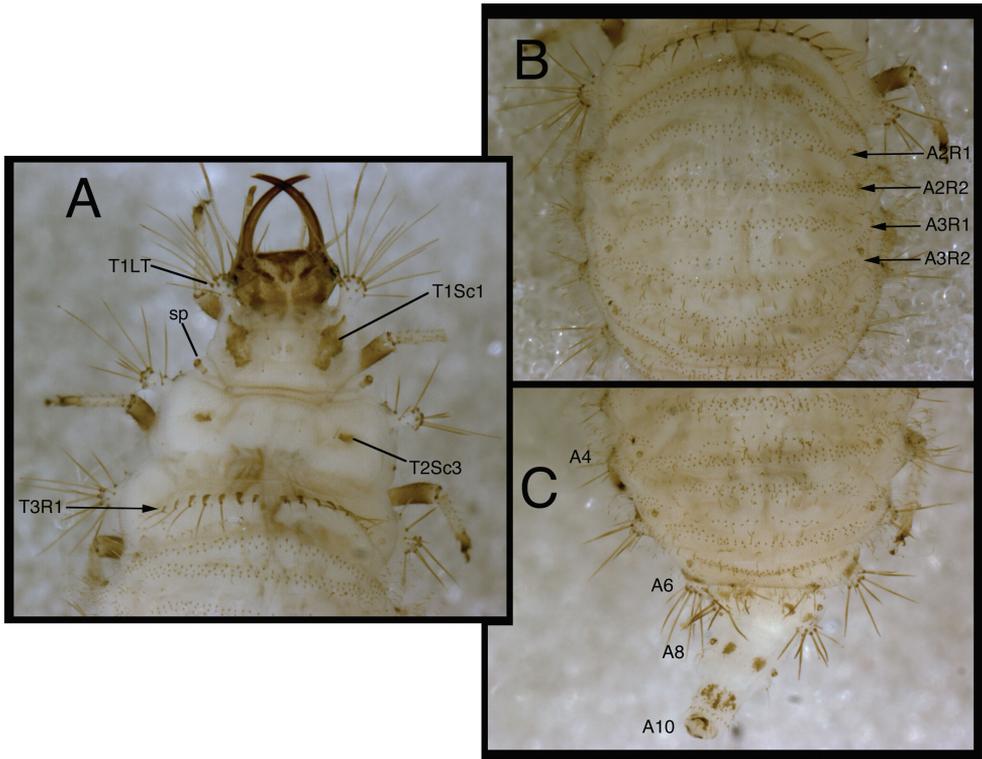


Figure 8. *Chrysopodes (C.) divisus*, third instar **A** Thorax, dorsal **B** Abdominal segments A1 to A5, dorsal **C** Abdominal segments A6 to A10, dorsal. **Abbreviations:** **A4, A6, A8, A10** abdominal segments **A2R1** double row of submedian setae (SMS) on anterior fold of second abdominal segment **A2R2** double/triple row of SMS on posterior fold of second abdominal segment **A3R1** double row of SMS on anterior fold of third abdominal segment **A3R2** double/triple row of SMS on posterior fold of third abdominal segment **sp** spiracle (on anterior subsegment of mesothorax) **T1LT** prothoracic lateral tubercle **T1Sc1** first primary prothoracic sclerite **T2Sc3** third primary mesothoracic sclerite **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

extending to base of eye. Mandible, maxilla dark brown laterally and distally, amber mesally, base with dark brown mesal mark. Labial palpus: basal segment cream-colored with light brown mesally; mesal segment ringed with light brown laterally, cream-colored mesally, with terminal subsegment brown; terminal segment dark brown basally, light brown distally. Antenna: scape, basal, mesal sections of pedicel cream-colored to amber, distal section of pedicel very light brown, flagellum light brown. Venter cream-colored to white; margin of cranium brown to dark brown; cardo, stipes brown; base of mentum with light brown patch.

All cephalic setae smooth, pointed; S1 slightly robust, medium length, S11 long, S2–10, S12 short to medium length; Vx setae fairly long, robust; with one to two pairs of secondary setae. Anterior margin of head protruding, straight with angled lateral margins; mesal pair of anterior setae much longer than two lateral pairs.



Figure 9. *Chrysopodes (C.) divisus*, egg (-5 days old).

Head width across eyes, 0.53–0.59 mm (L2), 0.78–0.83 mm (L3); mandible length, 0.52–0.56 mm (L2), 0.81–0.90 mm (L3); ratio mandible length to head width = 0.92–1.0 : 1 (L2), 1.0–1.1 : 1 (L3). Tip of mandible with six teeth mesally.

Cervix brownish dorsally, slightly darker laterally; venter cream-colored mesally, light brown laterally; white ventrally.

Thorax (Figs 3A, 4A, 6B–C, 6E, 7A–B, 8A) white to cream-colored; dorsum, especially pronotum tinged with brown, the darkness of which depends on density, color of integumental spinules; with sclerites, markings brown; LTs white to cream-colored, with LS amber. Venter white to cream-colored, unmarked. Legs: coxa white, with brown on basodorsal surface; trochanter cream-colored to white, base of femur cream-colored, becoming brownish mesally, cream-colored at tip; tibia white with brown setae; tarsus tinged with light brown; empodium brown; claws amber.

T1: LT with 14–17 (L2), 17–19 (L3) LS. Sc1 large, rhomboid, extending around posterior base of LT, darker brown laterally than mesally. Sc2 triangular, appearing as paired brown marks, with two small, irregularly shaped sclerites (brown) above; sometimes small brown spots anteriorly. S2, S3 smooth. T2: Anterior sclerite (Sc1) light brown to brown; spiracles on prominent protuberances. Posterior subsegment with Sc2 light brown; Sc3 pronounced, brown. LT with 12–13 (L2), 16–19 (L3) LS. T3: Sc1 transparent. LT with 11–13 (L2), 13–18 (L3) LS. Posterior fold with 14 to 15 robust, thorny setae; L3 sometimes with additional pair of long, smooth, pointed setae laterally, arising from smaller chalazae.

Abdomen (Figs 6D–F, 7A–B, 8B–C) white to cream-colored, tinged with light brown, with small light brown to brown spots anterior to bases of LTs; spots more diffuse on A5–A8; white fat-body visible beneath integument; setae mostly light brown to amber-colored. A6, A7 each with pair of large, dark brown marks surrounding LDTs. A8 with pair of dark brown marks mesal to spiracles; A9 with pair of large, dark brown marks anterolaterally, dark brown mark mesally; A10 with inverted U-shaped, dark brown mark. Venter white to cream-colored, unmarked, except with some light brown pigmentation ventrolaterally on S5–S9 (some specimens); tip of A10 with pair of small, abutting, triangular dark brown marks.

A1: Dorsum with ~78–88 (L2), 142–172 (L3) SMS in two double-triple transverse bands between spiracles. A2-A5: Dorsum with 64–112 (L2), 120–196 (L3) SMS in two broad transverse bands. LTs each with 11–21 (L2), 29–40 (L3) LS: one to five robust, thorny, blunt to spatulate LS on distal surface; remaining LS long, smooth, hooked, in large patch on dorsal surface. A6: Dorsum with transverse band of 20–30 (L2), 56–66 (L3) SMS across anterior of segment; midsection with one to two pairs of smooth setae, mesal pair hooked (similar to SMS), lateral pair short, pointed. LT with nine to eleven (L2), ten to eleven (L3) LS of various sizes. A7: Dorsum with one to two pairs of very small setae (S1, S2) anteriorly, between spiracles; LDTs each with one medium-length, robust, thorny, blunt to spatulate LDS, one to two smaller, smooth, pointed LDS; pair of very small setae between LDTs. LT with ten to 13 (L2), ten to 14 (L3) LS of various sizes. A8: Anterior region with one to two pairs of very small setae (S1, S2). Venter with pair of medium-length setae between LTs, two to three smaller setae slightly anteroventral to LTs. A9: Dorsum with one pair of very small setae anteriorly. Middle and posterior regions with two transverse rings of setae extending around segment; each ring with ~14–16 short to medium-length setae, several in each ring robust. A10: Dorsum with several pairs of small setae on V-shaped anterior sclerites, one slightly anterior to terminus. Two pairs of robust lateral setae. Venter with ~five pairs of small setae in V-shaped pattern, posterior row of microsetae anterior to terminus.

Egg. At oviposition, light yellowish green to green, with white micropyle; ovoid, 0.82 to 1.06 mm long, 0.36 to 0.43 mm wide. Stalk smooth, hyaline, 2.89 to 6.80 mm long.

Larval specimens examined. Numerous lots, each originating from a single gravid female collected in **Brazil, Bahia:** Cruz das Almas, VI-19–96 (Tauber Lots 96:017C, 96:018B, 96:019B, 96:019D); Camacan, Reserva Serra Bonita, 800 m., X-3 to 7–2005 (Tauber Lot 2005:032). **Distrito Federal,** Brasília, X-22 and 23–2003 (Tauber Lots 2003:035, 2003:036, 2003:038). **Minas Gerais,** Lavras, UFLA Campus, coffee orchard, X-12–2005 (Tauber Lot 2005:020); Lavras, Parque Ecológico Cachoeiras do Rio Bonito, X-14-2005 (Tauber Lot 2005:028). **Rio de Janeiro:** Conceição de Macabu, Santo Agostinho, V-21-2002 (Tauber Lot 2002:020); Conceição de Macabu, Fazenda Carrapeta, II-28-2002, IV-29 to V-6-2003 (Albuquerque Lot 2002:05, Tauber Lot 2003:007); Santa Maria Madalena, Terras Frias, III-30-1999 (Tauber Lot 99:043). **Rio Grande do Sul:** Cachoeira do Sul, São Nicolau, I-16-2007 (Tauber Lots 2007:023A, 2007:023B). Two field-collected L3 from RJ, Conceição de Macabu, Santo Agostinho, V-2-2003.

Biology. Adults and larvae of this species were collected on shrubs in disturbed, dry forest habitats. Adults are agile; they exhibit fast, evasive flight, usually inward toward the interior of the bush or tree.

Based on the following observations, we think that *C. (C.) divisus* adults may enter a diapause-mediated dormancy. Adults collected during the spring in Minas Gerais (Parque Ecológico Cachoeiras do Rio Bonito) were yellow to yellowish brown, and they had a greasy appearance. In addition, their prothoracic stripes were pronounced, broad and relatively dark reddish brown. In the lab, reproduction by these adults did not oc-

cur until after they had been held under warm, long-day conditions with ample food and water for over a week. Moreover, reproduction was correlated with the assumption of bright green coloration, the loss of some of the reddish brown coloration on the thorax, and a narrowing of the prothoracic stripes. In other Chrysopini adults, e.g., species of *Chrysoperla*, changing behavioral and color patterns like those described for *C. (C.) divisus* have been shown to be part of the diapause syndrome (Tauber et al. 1986).

In the lab, eggs from all the lots listed above were deposited separately (with isolated stalks), in small groups with no particular pattern; the stalks were sticky, but without droplets. During the first 24 hours after oviposition, the eggs were bright yellowish green to green, without spots. On the second day, they began to develop a bluish brown color, with grey or brownish mottling which became more pronounced as hatching approached (Fig. 9). At $24 \pm 1^\circ\text{C}$, hatching occurred within six to eight days (lots from three females collected in Cruz das Almas, $n = 17 - 48$ eggs/female).

In one case, a small proportion ($n = 2$ of 28) of the eggs laid by a female from Minas Gerais had a prolonged incubation period (approximately one week to ten days longer than the usual six- to eight-day incubation period). They were a dark bluish brown color during the period of delay. The cause of the prolongation is unknown; however, the resulting larvae developed normally and appeared healthy.

Larvae of *C. (C.) divisus* carry pieces of woody plant material and other dry debris on their backs. In the rearings ($24 \pm 1^\circ\text{C}$) from three females collected at Cruz das Almas, development of the various stages required: L1, 5–8 days; L2, 5–7 days; L3, 5–9 days; cocoon, 16–20 days; complete development from oviposition to adult emergence, 40–48 days. Among the offspring of each of the three females, the sex ratio was approximately 1 : 1 ($n = 19-33$ individuals / female). The developmental and reproductive responses of *C. (C.) divisus* to a broad range of temperatures are reported elsewhere (Silva et al. in prep.).

***Chrysopodes (Chrysopodes) fumosus* Tauber & Albuquerque, 2012**

http://species-id.net/wiki/Chrysopodes_fumosus

Figs 2–4, 10–13

Discussion. Adults of this recently described species are readily distinguished from other *Chrysopodes* species. Specifically, the *C. (C.) fumosus* forewings have venation that is extensively crassate and uniquely patterned; the membrane surrounding many of the crossveins is heavily fumose – thus, the species name. Both the male and female genitalia are distinctive and should be examined for accurate identification of the species (see description and figures in Tauber et al. 2012).

Known geographic distribution. Brazil, Venezuela (Tauber et al. 2012).

Larval diagnosis. Like the larvae of *C. (C.) geayi* and *C. (C.) spinellus*, *C. (C.) fumosus* larvae have largely white to cream-colored heads with brown, longitudinally elongate and divided epicranial markings; the intermandibular and clypeal regions are unmarked. Their frontal markings are distinguished from those of the other two spe-

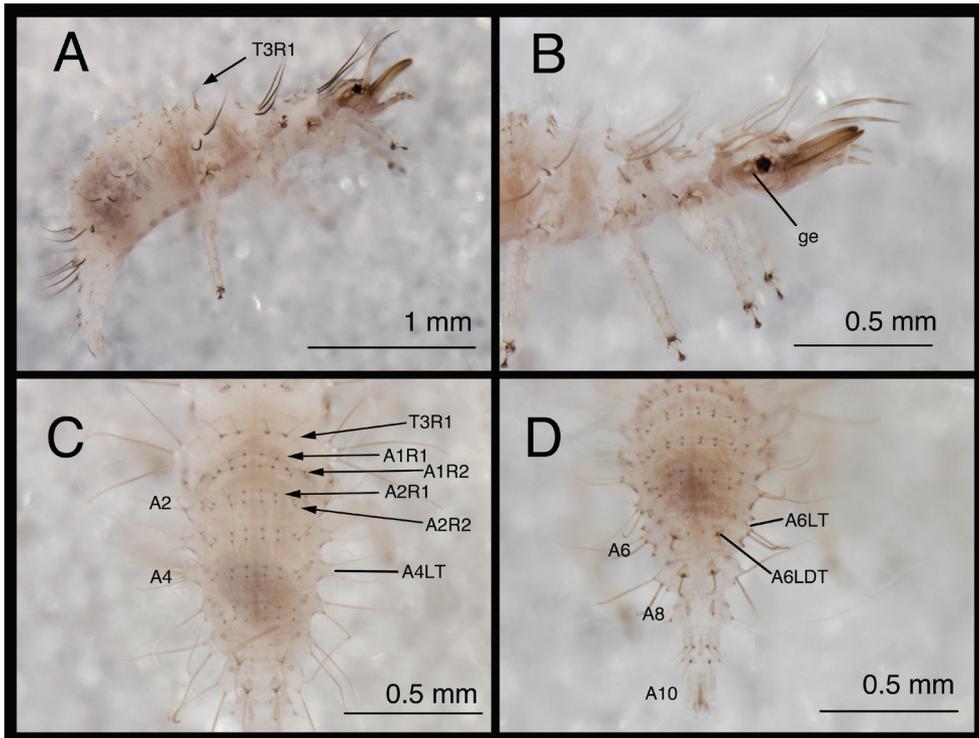


Figure 10. *Chrysopodes (C.) fumosus*, first instar **A** Habitus, lateral **B** Head, lateral **C** Abdominal segments A1 to A5, dorsal **D** Abdominal segments A6 to A10, dorsal. *Abbreviations:* **A2, A4, A6, A8, A10** abdominal segments **A1R1, A1R2** anterior and posterior rows of submedian setae (SMS) on first abdominal segment **A2R1, A2R2** anterior and posterior rows of SMS on second abdominal segment **A4LT** lateral tubercle on fourth abdominal segment **A6LDT, A6LT** laterodorsal tubercle, lateral tubercle on sixth abdominal segment **ge** genital marking **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

cies in that their posterior ends are straight and do not curve or connect mesally. *C. (C.) fumosus* Semaphoront A also differs from those of the other two species in that it has only two thorny cranial setae (S1, S11). And, *C. (C.) fumosus* Semaphoront B is distinguished from *C. (C.) geayi* and *C. (C.) spinellus* in that all of its cranial setae (including S1) are without thorns.

First instar. (Semaphoront A). *Body* (Fig. 10A) 2.3–2.8 mm long. Surface predominantly white to cream-colored, with some, small, light brown marks, light dusting of brown, especially on sides and venter.

Head (Figs 2B, 10B) 0.39–0.41 mm wide; mandibles 0.36–0.38 mm long (ratio, mandible length : head width = 0.86–0.96 : 1). Cranium mostly white to cream colored, with elongate, narrow, light brown markings. Epicranial marking consisting of two, unconnected, narrow, longitudinally elongated stripes (arms); mesal arm contiguous with postfrontal marking, extending from base of cranium to anteromesal margin of

antennal socket; lateral arm lighter brown, more diffuse than mesal arm, extending from posterolateral margin of cranial suture approximately to distal base of mandible. Postfrontal marking indistinguishable, fused with mesal arm of epicranial marking. Frontal marking narrow, extending from midregion of cranium anteriorly to level of antennal socket, then curving laterally toward lighter brown mark at mesal margin of mandibular base; posteromesal ends of marking curving inward, fusing narrowly at tip. Intermandibular, clypeal areas white. Cranial setae amber to light brown; S1, S11 long, thorny, robust; others shorter, smooth; Vx setae small.

Gena, ventral region of head capsule brown, with white spot in anterior region of genal mark. Labial palpus white, marked with light brown on basal segment, distal two annuli of middle segment, base of terminal segment. Mandibles amber to light brown. Antenna with light brown scape, pedicel white basally, light brown distally; flagellum light brown.

Thorax (Figs 2B, 10B) mostly white, with sclerotized structures light brown to brown, small patches of light brown; episternum light brown. Legs white; base of coxa brown; tibia, tarsus tinged with very light brown; tarsal claws, empodia, brown. LS light brown to brown; other setae amber to light brown.

T1: Row of three very small setae (R1) at anteromesal base of LTs not observed. Sc1 with edges brown, center white; S2Sc1 very small, immediately above S1Sc1. S1, S3 intermediate-length, robust. T2: Spiracle with lip of atrium protruding above integumental surface. Sc1, Sc2, Sc3 light brown; S2Sc3, S2 long, robust, thorny, of approximately equal size. T3: S1Sc1, S2Sc1, S1Sc2 very small; S2Sc2 absent. Raised posterior fold with row (R1) of four very long, robust, thorny setae on chalazae with ovate, light brown marks anteriorly.

Abdomen (Figs 10C–D) white to cream-colored, with light dusting of brown, especially on A4–A6; sides and venter of these segments also with diffuse brown tinge. LTs, LDTs white with brown chalazae; chalazae of most dorsal setae brown.

A1–A5: Dorsum with 12 SMS in two rows, with four mesal pairs equally spaced, two lateral-most pairs juxtaposed; spiracle with SSp elongate, robust, mesal to spiracle; chalazae of all SMS and SSp large, robust. A6: Anterior region with two SMS. Spiracle with very small SSp mesally. A7: Anterior region without setae or microsetae. Spiracle without apparent SSp. A8: Venter with one pair of medium-length setae posteriorly.

Second and third instars. (Semaphoront B). *Body* (Figs 11E, 12A) length 3.1–3.4 mm (L2), 6.7–7.2 mm (L3); surface cream-colored, with light to dark brown integumental spinules, brown to dark brown dorsal, lateral markings on thorax and abdomen.

Head (Figs 3B, 4B, 11A–B, 12C–D) cream-colored, with dark brown markings. Epicranial marking dark brown, consisting of two narrow, elongate arms, separate from each other, both in contact with posterior margin of head; lateral arm extending from distal ~one-fifth of posterior cranial suture to upper level of eye, not touching eye, becoming broader distally; mesal arm extending from base of head, becoming confluent with postfrontal marking, which extends to inner base of scape. Postfrontal marking very dark brown, narrow throughout. Frontal marking dark brown, with each

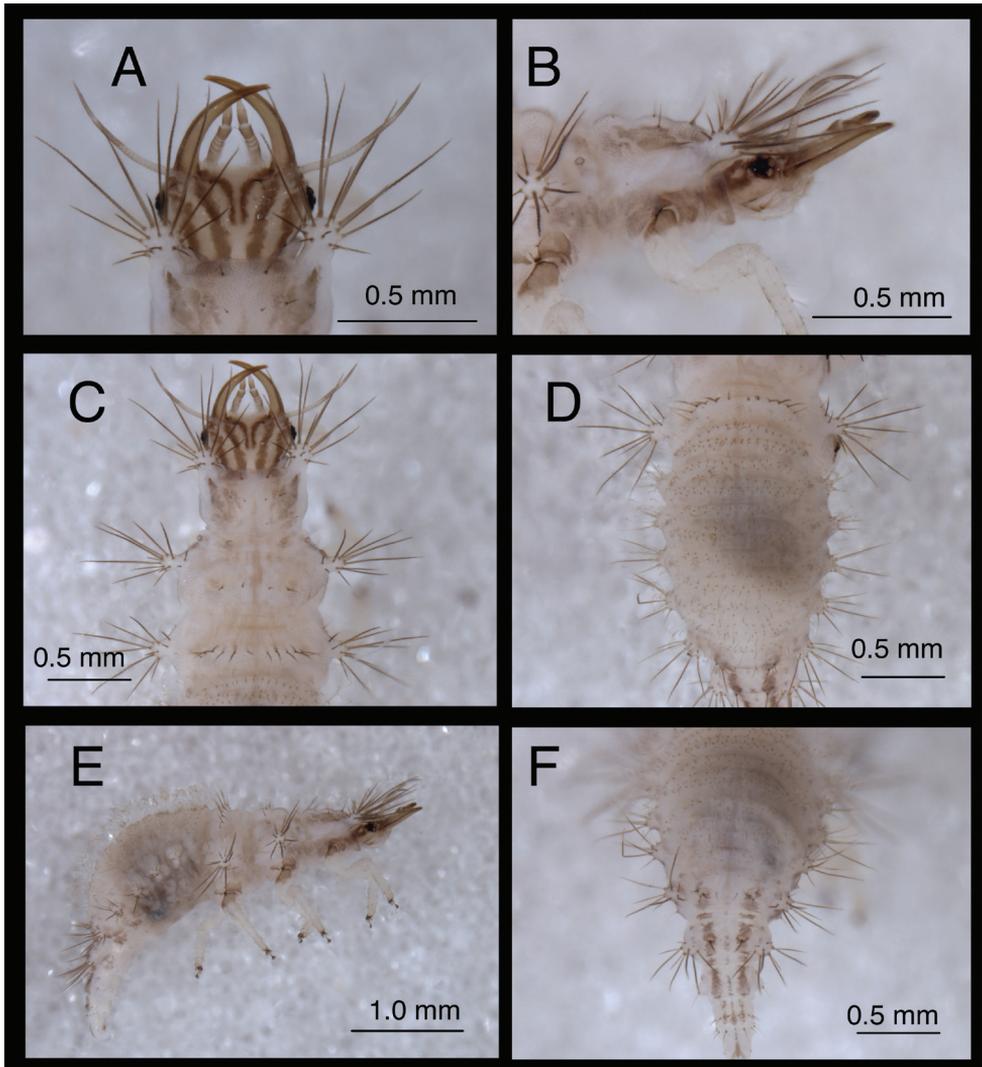


Figure 11. *Chrysopodes (C.) fumosus*, second instar **A** Head, dorsal **B** Head, lateral **C** Head and thorax, dorsal **D** Abdominal segments A1 to A5, dorsal **E** Habitus, lateral **F** Abdominal segments A6 to A10, dorsal.

arm narrow, separate, extending from midsection of head, beyond tentorial pits to inner base of mandibles; darkness extending onto mandibles. Intermandibular marking absent. Clypeolabral region cream-colored tinged with light brown. Gena cream-colored, with large, brown marking from base of eye almost to posterior margin of cranium, with cream-colored mesal spot. Mandible, maxilla amber basally, mesally, becoming dark brown distally. Labial palpus: basal segment cream-colored with very slight tinge of brown; mesal segment ringed with light brown laterally, cream-colored mesally, with terminal subsegment brown; terminal segment dark brown basally, light

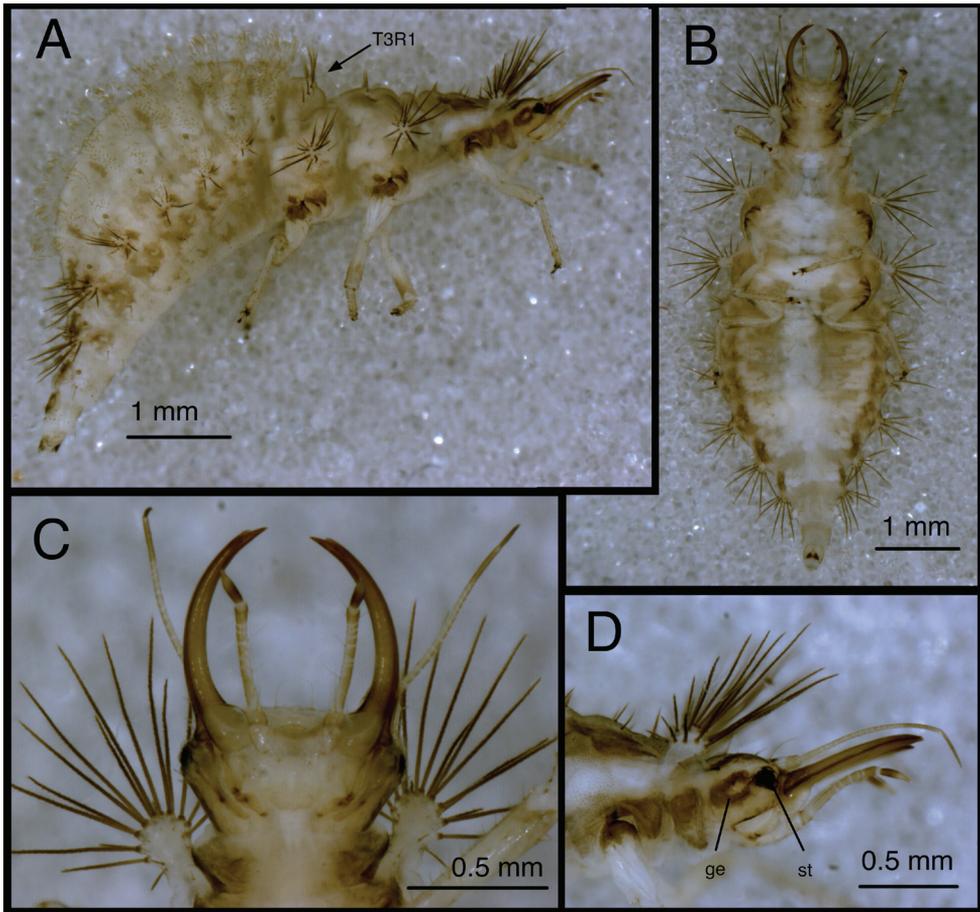


Figure 12. *Chrysopodes (C.) fumosus*, third instar **A** Habitus, lateral **B** Habitus, ventral **C** Head, ventral **D** Head, lateral. Abbreviations: **ge** genal marking **st** stemmata **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

brown distally. Antenna: scape and pedicel (basal, mesal sections) cream-colored, distal section of pedicel light brown, flagellum brown. Venter cream-colored, except margin of cranium, cardo with longitudinal brown marks; mentum unmarked.

All cephalic setae smooth, pointed; S1-10, S12 of medium length, S11 long; Vx setae fairly long, robust.

Head width across eyes, 0.57–0.58 mm (L2), 0.77–0.85 mm (L3); mandible length 0.51–0.57 mm (L2), 0.82–0.85 mm (L3); ratio mandible length to head width = 1.0–1.1 : 1 (L2), 0.97–1.1 : 1 (L3). Tip of mandible with four teeth mesally.

Cervix cream-colored, tinged with light brown dorsally; sides with pair of broad brown patches; venter cream-colored mesally, light brown laterally.

Thorax (Figs 3B, 4B, 11C, 12A-B, 13A) cream-colored, tinged with light brown, with sclerites, markings brown; LTs white to cream-colored, with LS brown to dark

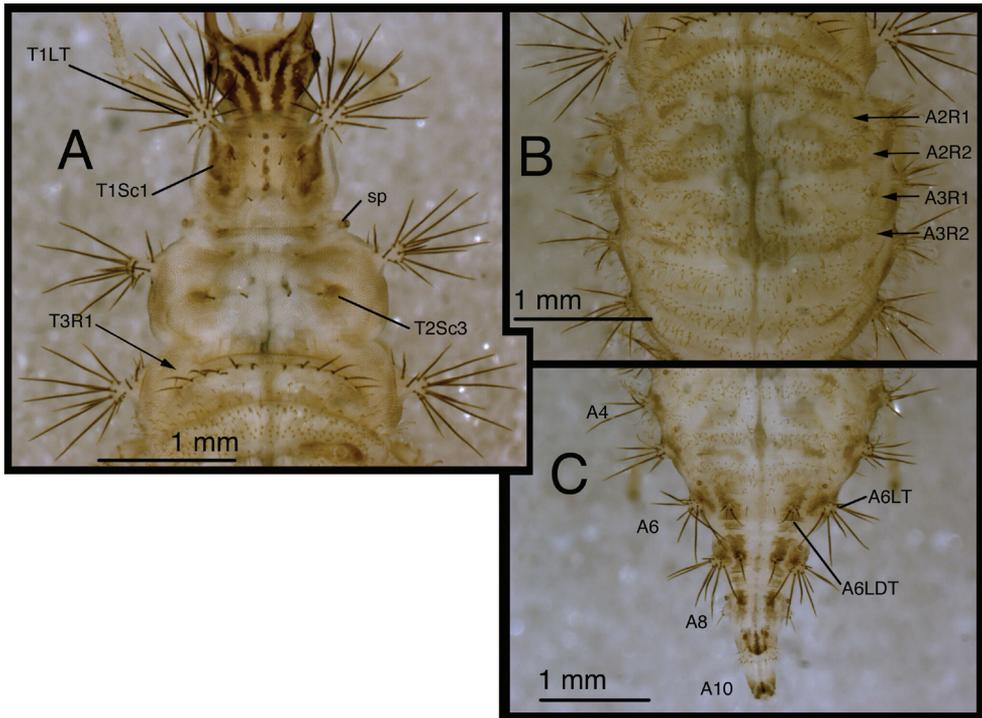


Figure 13. *Chrysopodes (C.) fumosus*, third instar **A** Thorax, dorsal **B** Abdominal segments A1 to A5, dorsal **C** Abdominal segments A4 to A10, dorsal. *Abbreviations:* **A4, A6, A8, A10** abdominal segments **A2R1** double row of submedian setae (SMS) on anterior fold of second abdominal segment **A2R2** double/triple row of SMS on posterior fold of second abdominal segment **A3R1** double row of SMS on anterior fold of third abdominal segment **A3R2** double/triple row of SMS on posterior fold of third abdominal segment **A6LDT, A6LT** laterodorsal tubercle, lateral tubercle on sixth abdominal segment **sp** spiracle (on anterior subsegment of mesothorax) **T1LT** prothoracic lateral tubercle **T1Sc1** first primary prothoracic sclerite **T2Sc3** third primary mesothoracic sclerite **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

brown. Venter white to cream-colored, unmarked. Legs: coxa white, with dark brown marking on basodorsal surface; trochanter, base of femur cream-colored; tip of femur with light brown band; tibia, tarsus, tinged with light brown; empodium, claws, base of claws dark brown.

T1: LT with 14–18 (L2), 16–20 (L3) LS. Sc1 large, rhomboid, extending around posterior base of LT, darker brown laterally than mesally. Sc2 triangular, mostly brown, with small secondary sclerite above. Notum with four brown spots in longitudinal row along midline. S2, S3 thorny. T2: Anterior sclerite (Sc1) light brown; spiracles on small protuberances. Posterior subsegment with Sc2 light brown; Sc3 pronounced, brown. LT with 13–17 (L2), 16–20 (L3) LS. T3: LT with 11–15 (L2), 14–18 (L3) LS. Posterior fold with row (R1) of twelve robust, thorny setae.

Abdomen (Figs 11D–F, 12A–B, 13B–C) largely cream-colored, tinged with light brown, with light brown to brown markings surrounding bases of LTs; markings becoming darker posteriorly; white fat-body visible beneath midline section (especially posteriorly); robust, thorny setae dark brown; other setae light brown to amber-colored. A5 with pair of light brown spots mesal to LTs. A6, A7 each with pair of large, diffuse, dark brown marks surrounding LDTs. A8 with pair of dark brown marks mesal to spiracles. A9 with U-shaped dorsal mark containing darker longitudinal mark along midline, with pair of lighter brown marks extending onto top of LTs. A10 dark brown distally. Venter white along midsection, cream-colored to light brown laterally; areas mesal to LTs with extensive, diffuse brown marks. Midsection of A10 with pair of small, abutting, triangular dark brown marks.

A1: Dorsum with ~54–59 (L2), ~90–94 (L3) SMS in two double-triple transverse bands between spiracles. A2–A5: Dorsum with 42–86 (L2), 100–166 (L3) SMS in two broad transverse bands. LTs each with 9–13 (L2), 13–20 (L3) LS; apical four to eight LS long, robust, thorny, pointed to blunt; remaining LS less robust, smooth, hooked, in patch on dorsal surface. A6: Dorsum with transverse band of ~26 (L2), ~45 (L3) SMS across anterior of segment; midsection with two pairs of smooth setae, mesal pair hooked, lateral pair pointed. LTs with ~9 (L2), ~15 (L3) LS of various sizes. A7: Dorsum with two pairs of very short setae (S1, S2) anteriorly, between spiracles. LDTs each with one medium-length, robust, thorny, blunt to spatulate LDS, one to two shorter, thorny, robust LDS, one to three small, smooth, pointed LDS. LTs with ~8 (L2), ~11 (L3) LS of various sizes. A8: Dorsum with two to three pairs of very small setae anteriorly; two to three pairs of small setae posteromesal to spiracles; four pairs of small, posterior setae in transverse row mesal to LTs. Venter with three transverse rows of setae, each with three to four smooth, pointed setae of increasing size posteriorly. A9: Dorsum with one pair of very small setae anteriorly. Middle and posterior regions with two transverse rings of setae extending around segment; each ring with ~16–18 short to medium-length setae, several in each ring robust. A10: Dorsum with two pairs of small setae: one posterior to V-shaped anterior sclerites, one slightly anterior to terminus. Two pairs of lateral setae, robust. Venter with ~five pairs of small setae, posterior row of microsetae anterior to terminus.

Egg. At oviposition, light green, with white micropyle; ovoid, 0.99 to 1.08 mm long, 0.40 to 0.41 mm wide. Stalk smooth, hyaline, 4.39 to 5.42 mm long.

Larval specimens examined. Several lots, each originating from a single gravid female collected in **Brazil, Rio de Janeiro:** Conceição de Macabu, Santo Agostinho, V-21-2002, V-2-2003 (Albuquerque Lot 2002:012, Tauber Lots 2002:021, 2003:016); two field-collected L3, Conceição de Macabu, Santo Agostinho, V-2-2003.

Biology. Adults and larvae of *C. (C.) fumosus* were collected on citrus and other fruit trees in mixed agricultural situations. The adults are very agile; they make short, fast, evasive flights, usually downward and toward the interior of the tree. In the lab, eggs were deposited separately (with isolated stalks), in small groups with no particular pattern; the stalks were sticky, but without droplets. The larvae carry pieces of woody plant material and other debris; they are agile, but not particularly fast moving.

***Chrysopodes (Chrysopodes) geayi* (Navás, 1910)**

http://species-id.net/wiki/Chrysopodes_geayi

Figs 2–4, 14–18

Discussion. Among *Chrysopodes (Chrysopodes)* species, *C. (C.) geayi* [= *C. (C.) pulchellus* (Banks); see Legrand et al. 2008] are relatively large bodied. Adults have distinctive forewings: tall costal cells (especially basally); quadrate intramedian cell; sinuate subcostal, radial and radial sector veins; irregular gradate veins. Both the female and male genitalia are distinctive. Adults of this species can be identified using the key and information in Adams and Penny [1985: 423, as *C. (C.) pulchella*].

Known geographic distribution. Brazil (Banks 1910: 152, as *Allochrysa pulchella*), French Guiana (Navás 1910), Suriname (Banks 1944, not confirmed). See Adams and Penny (1985), Adams (1985), Legrand et al. (2008).

Larval diagnosis. *Chrysopodes (C.) geayi* larvae are recognized by their relatively large size, dense setation, and unique pronotal Sc1 sclerites (having dark brown lateral and mesal bands and an unmarked, cream-colored central band). The *C. (C.) geayi* dorsal head markings resemble those of *C. (C.) fumosus* and *C. (C.) spinellus* (longitudinally elongate and divided, brown epicranial markings; unmarked intermandibular and clypeal regions). However, unlike as in *C. (C.) fumosus* [but not *C. (C.) spinellus*], the posterior ends of the frontal markings curve and connect with each other mesally. Semaphoront A of *C. (C.) geayi* is distinguished from that of *C. (C.) spinellus* by the presence of thorns on only two or three cranial setae (S1, S11, sometimes S4) and its dark brown thoracic and abdominal LS. The *C. (C.) geayi* Semaphoront B differs from *C. (C.) spinellus* [but not *C. (C.) fumosus*] by the presence of several secondary sclerites on the pronotal midline.

First instar. (Semaphoront A). *Body* (Fig. 14A) 2.7–3.1 mm long. Surface predominantly white to cream-colored, with some small, light brown marks, light dusting of brown, especially on sides and venter.

Head (Figs 2C, 14B) 0.42–0.45 mm wide; mandibles 0.37–0.39 mm long (ratio, mandible length : head width = 0.84–0.92 : 1). Cranium mostly white, with elongate, brown to dark brown markings. Epicranial marking consisting of two, unconnected, elongate, brown stripes; mesal arm contiguous with postfrontal marking, extending from base of cranium to anteromesal margin of antennal socket; lateral arm brown, especially dark basally, extending from posterolateral margin of cranial suture approximately to distal base of mandible. Postfrontal marking indistinguishable, fused with epicranial marking. Frontal marking narrow, paired, extending from midregion of cranium anteriorly to level of antennal socket, then bending laterally toward mesal margin of mandibular base; mesal ends of marking curving inward, fusing narrowly at tip. Intermandibular, clypeal area white. Cranial setae amber to brown; S1, S11 long, thorny; S4 intermediate-length, smooth or thorny; others short, smooth.

Gena brown with small central white spot, ventral region of head capsule white to cream-colored, with ventral margin of head capsule brown. Labial palpus white, with

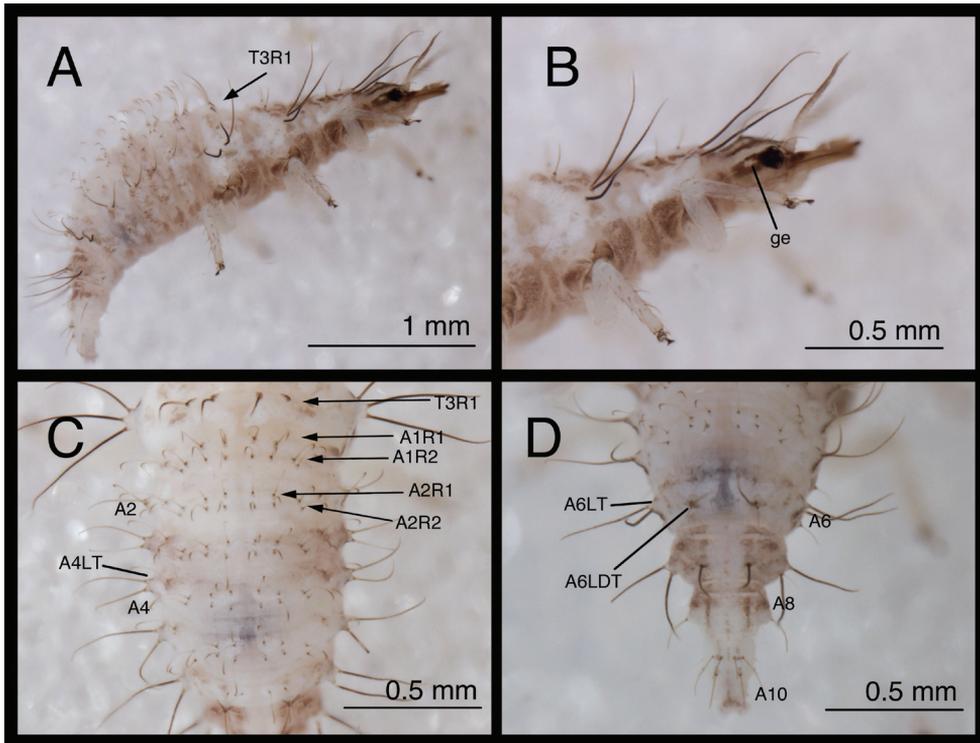


Figure 14. *Chrysopodes (C.) geayi*, first instar **A** Habitus, lateral **B** Head, lateral **C** Abdominal segments A1 to A5, dorsal **D** Abdominal segments A6 to A10, dorsal. *Abbreviations:* **A2, A4, A6, A8, A10** abdominal segments **A1R1, A1R2** anterior and posterior rows of submedian setae (SMS) on first abdominal segment **A2R1, A2R2** anterior and posterior rows of SMS on second abdominal segment **A4LT** lateral tubercle on fourth abdominal segment **A6LDT, A6LT** laterodorsal tubercle, lateral tubercle on sixth abdominal segment **ge** genal marking **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

tinge of light brown on basal segment, lateral side of middle segment, darker brown on distal annulation, terminal segment. Mandibles amber to light brown, with dark brown basally. Antenna with light brown scape, pedicel light brown basally, brown distally; flagellum brown. Cervix with pair of light brown sublateral spots.

Thorax (Figs 2C, 14B) mostly white, with small to large patches of brown forming pair of submedian longitudinal, brown bands; sclerotized structures mostly light brown; pleural region with distinct brown band running through episterna, epimera, membranes between; episternum, epimeron dark brown. Legs white; base of coxa dark brown, tibia, tarsus tinged with very light brown; tarsal claws, empodia, brown. LS dark brown; other setae amber to dark brown.

T1: Row of three very small setae (R1) at anteromesal base of LTs present. Sc1 with distal section light brown, center white; S2Sc1 very small, immediately above S1Sc1. S1 intermediate-length; S3 intermediate-length to short, thorny. T2: Spiracle with lip of atrium protruding slightly beyond level of integumental protuberance. Sc1, Sc2,

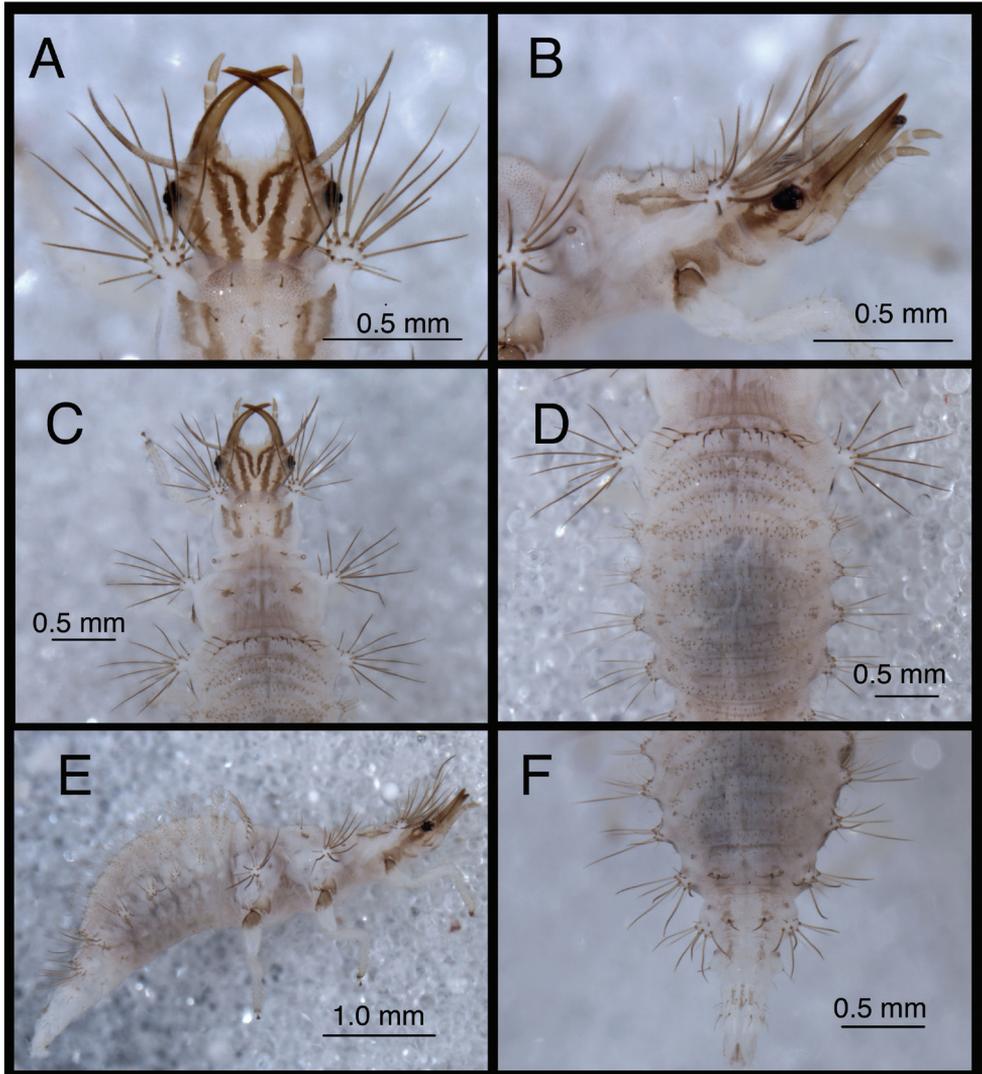


Figure 15. *Chrysopodes (C.) geayi*, second instar **A** Head, dorsal **B** Head, lateral **C** Head and thorax, dorsal **D** Abdominal segments A1 to A5, dorsal **E** Habitus, lateral **F** Abdominal segments A6 to A10, dorsal.

Sc3 light brown; S2Sc3, S2 small to intermediate length, thorny, of approximately equal size. T3: S1Sc1, S2Sc1, S1Sc2 very small; S2Sc2 absent. S1, S2 absent. Raised posterior fold with row (R1) of four very long, robust, thorny, pointed setae on chala-zae with ovate, light brown marks anteriorly.

Abdomen (Figs 14A, 14C–D) white, with light dusting of brown, especially on sides and venter of A2–A6, dorsum of A7, A8. LTs, LDTs marked with brown; most dorsal chala-zae brown to dark brown.

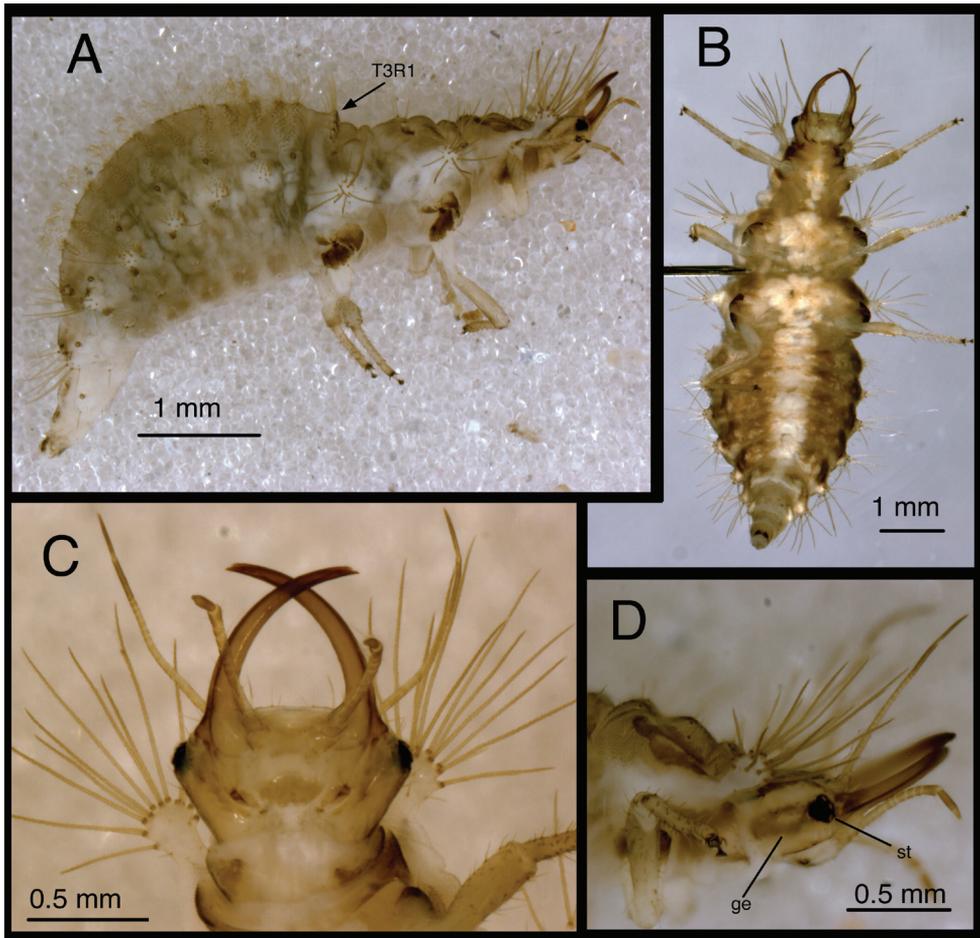


Figure 16. *Chrysopodes (C.) geayi*, third instar **A** Habitus, lateral **B** Habitus, ventral **C** Head, ventral **D** Head, lateral. Abbreviations: **ge** genal marking **st** stemmata **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

A1-A5: Dorsum with 12 SMS in two rows, with lateral-most two pairs juxtaposed. Spiracle with SSp elongate, robust, mesal to spiracle. A6: Anterior region with two SMS. Spiracle with SSp mesally. A7: Anterior region without setae or microsetae. Spiracle anterior to LT, without apparent SSp. A8: Venter with two pairs of medium-length setae posteriorly.

Second and third instars. (Semaphoront B). *Body* (Figs 15E, 16A–B) length 4.6–5.1 mm (L2), 7.5–7.9 mm (L3); surface white to cream-colored, with light to dark brown integumental spinules especially dense, dark on pronotum; primary pronotal, mesonotal sclerites brown to dark brown, other dorsal marks brown; sclerites around coxae, base of coxae dark brown, abdomen (lateral) with brownish hue interrupted by white lateral stripe through abdominal lateral tubercles.

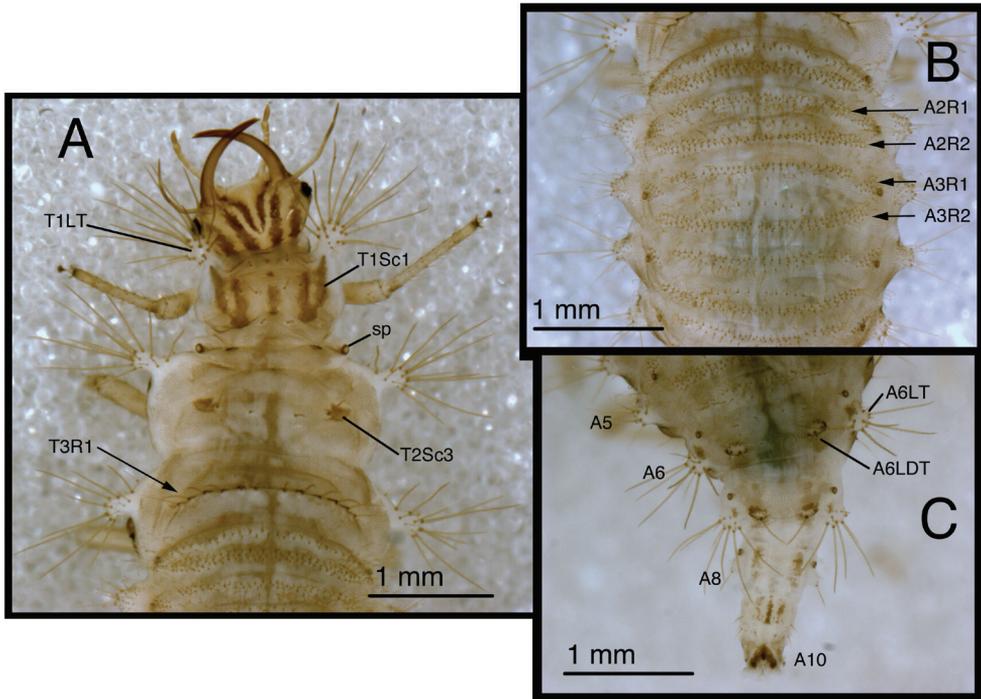


Figure 17. *Chrysopodes (C.) geayi*, third instar **A** Thorax, dorsal **B** Abdominal segments A1 to A4, dorsal **C** Abdominal segments A5 to A10, dorsal. **Abbreviations:** **A5, A6, A8, A10** abdominal segments **A2R1** double row of submedian setae (SMS) on anterior fold of second abdominal segment **A2R2** double/triple row of SMS on posterior fold of second abdominal segment **A3R1** double row of SMS on anterior fold of third abdominal segment **A3R2** double/triple row of SMS on posterior fold of third abdominal segment **A6LDT, A6LT** laterodorsal tubercle, lateral tubercle on sixth abdominal segment **sp** spiracle (on anterior subsegment of mesothorax) **T1LT** prothoracic lateral tubercle **T1Sc1** first primary prothoracic sclerite **T2Sc3** third primary mesothoracic sclerite **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

Head (Figs 3C, 4C, 15A–B, 16C–D) cream-colored, with brown to dark brown markings. Epicranial marking brown, with two elongate arms, separate from each other, both in contact with posterior margin of head; lateral arm extending from distolateral margin of cranium to upper level of eye, touching eye, tapering distally; mesal arm extending from base of head, becoming confluent with postfrontal marking, which extends to inner margin of scape. Postfrontal marking dark brown, narrow throughout. Frontal marking dark brown, with each arm narrow, separate (except at basal tip), extending from midsection of head, beyond tentorial pit to inner base of mandible; base of each arm tapering, turning mesally, contacting tip of other arm. Intermandibular marking absent. Clypeolabral region cream-colored, tinged with light brown. Gena cream-colored, with large, brown marking from base of eye to posterior margin of cranium, with small, cream-colored mesal spot. Mandible, maxilla amber basally, mesally, dark brown laterally, distally. Labial palpus: basal segment cream-colored with very

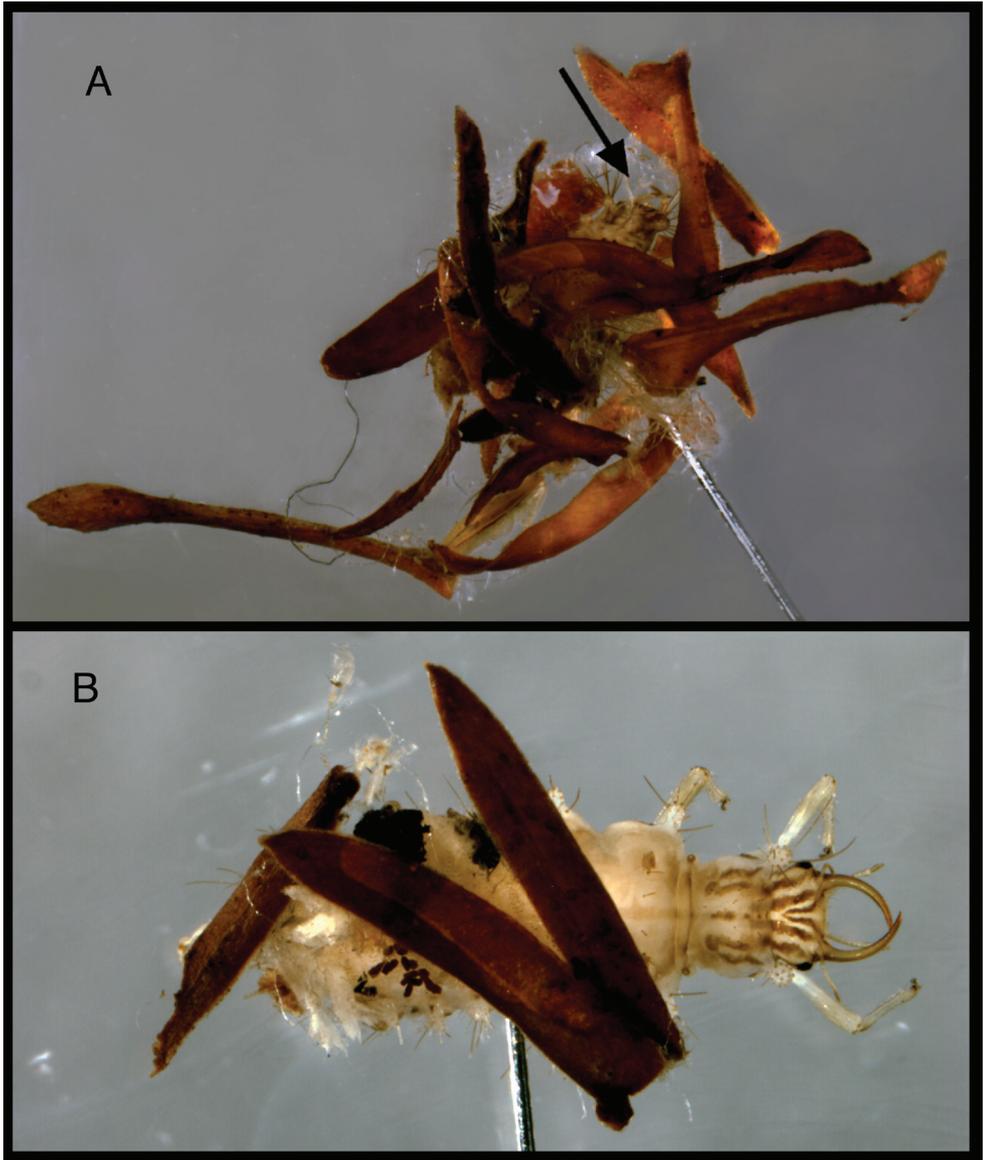


Figure 18. *Chrysopodes (C.) geayi*, field-collected L3 with dorsal trash packet **A** Campos dos Goytacazes, Parque Estadual do Desengano, Babilônia, V-4-2003, Albuquerque, Tauber and Tauber (TRC) [Arrow indicates dorsum of head] **B** Santo Antônio do Imbé, Parque Estadual do Desengano, III-31-1999, Albuquerque, Tauber and Tauber (TRC).

slight tinge of brown; mesal segment ringed with brown laterally, cream-colored mesally, with terminal subsegment brown; terminal segment brown. Antenna: scape and pedicel (basal, mesal sections) light brown, distal one-fifth of pedicel, entire flagellum, darker brown. Venter cream-colored, with large, white central area; margin of cranium, cardo with dark brown longitudinal marks; mentum with large, brown spot basally.

Cephalic seta S1 moderately long, thorny, S2–S12 smooth, S11 long; Vx setae relatively long.

Head width across eyes, 0.64–0.66 mm (L2), 0.98–1.05 mm (L3); mandible length, 0.51–0.58 mm (L2), 0.91–0.98 mm (L3); ratio mandible length to head width = 0.82–0.87 : 1 (L2), 0.93–0.99 : 1 (L3). Tip of mandible with four teeth mesally.

Cervix: dorsum cream-colored, tinged with light brown; sides with pair of broad brown patches; venter brown laterally, becoming cream-colored mesally.

Thorax (Figs 3C, 4C, 15C, 15E, 16A–B, 17A) white to cream-colored; dorsum lightly tinged with brown, the darkness of which depends on density, color of integumental spinules; with sclerites, markings brown; LTs white, with LS amber to light brown. Venter white to cream-colored, with light brown tinge laterally where spinules extend toward ventral surface, without other marks. Legs: coxa white, with dark brown on dorsal surface; trochanter cream-colored to white, base of femur cream-colored, becoming brownish distally; tibia white to tinged with very light brown, with light brown setae; tarsus very light brown with dark tip; empodium brown; claws amber.

T1: LT with 15–19 (L2), 18–22 (L3) LS. Sc1 with elongate brown marks laterally, mesally, cream-colored streak centrally; two heavily sclerotized rods extending from base of sclerite, mesal one stretching along mesal margin of Sc1 to mesal base of LT, lateral one forked distally, with mesal fork extending onto posterolateral margin of LT, lateral fork extending laterally below posterior base of LT. Sc2 triangular, included in elongate mesal brown mark, with two small, brown, secondary sclerites anteriorly. S2, S3 thorny. T2: Anterior sclerite (Sc1) brown; spiracles on small protuberances. Posterior subsegment with Sc2 light brown; Sc3 pronounced, brown. LT with 15–19 (L2, L3) LS. T3: LT with 14–18 (L2, L3) LS. Posterior fold with row (R1) of twelve robust, thorny setae.

Abdomen (Figs 15D–F, 16A–B, 17B–C) white to cream-colored, with light brown chalazae and setae; white fat-body visible beneath integument; setae mostly amber-colored. A6, A7 each with pair of large, dark brown marks dorsal to LTs; LDTs white with dark brown chalazae, brown marks anterior and posterior to LDTs. A8 with pair of dark brown marks mesal to spiracles. A9 with three elongate brown marks dorsally. A10 with inverted V-shaped, dark brown dorsal mark; light brown laterally. Venter white to cream-colored, without marks, except with some light brown pigmentation ventrolaterally; tip of A10 with pair of small, triangular dark brown marks.

A1: Dorsum with 62–76 (L2), ~ 156–188 (L3) SMS in two double-triple transverse bands between spiracles. A2–A5: Dorsum with 62–114 (L2), 176–268 (L3) SMS in two broad transverse bands. LTs each with 9–14 (L2), 12–34 (L3) LS: four to eight long, robust, thorny, pointed to spatulate LS on distal surface; remaining LS less robust, smooth, hooked, in patch on dorsal surface. A6: Dorsum with transverse band of 22–32 (L2), 42–56 (L3) SMS across anterior of segment; midsection with two pairs of smooth setae, mesal pair hooked, lateral pair pointed. LT with 8–10 (L2), ~ 11–14 (L3) LS of various sizes. A7: Dorsum with three pairs of very short setae anteriorly, between spiracles. LT with ~ 8–10 (L2), 11–14 (L3) LS of various sizes. A8: Dorsum with two

pairs of very small setae between spiracles; four pairs of small setae in transverse row between LTs. Venter with two transverse rows of setae, each with three to four smooth, small, pointed setae. A9: Dorsum with one pair of very small setae anteriorly. Middle and posterior regions with two transverse rings of setae extending around segment; each ring with ~14–16 short to medium-length setae, several in each ring robust. A10: Dorsum with two pairs of small setae: one posterior to V-shaped anterior sclerites, one slightly anterior to terminus. Two pairs of lateral setae, robust. Venter with ~five pairs of small setae, posterior row of microsetae anterior to terminus.

Egg. Green, ovoid, 0.95–1.00 mm long; 0.43–0.45 mm wide; stalk hyaline, 10.7–12.6 mm long.

Larval specimens examined. Several lots, each originating from a single gravid female collected in **Brazil, Rio de Janeiro:** Campos dos Goytacazes, Parque Estadual do Desengano, Babilônia III-27-2001, X-26-2003 (Tauber Lot 2001:003, Albuquerque Lot 2003:018); Campos dos Goytacazes, near Parque Estadual do Desengano, Fazenda Boa Vista, V-16-2002 (Tauber Lot 2002:016); Campos dos Goytacazes, Distrito de Morangaba, Fazenda São Julião, X-18-2005 (Tauber Lot 2005:034). Two field-collected specimens from RJ, all collected by Albuquerque, Tauber and Tauber: an L3 collected from Santo Antônio do Imbé, Parque Estadual do Desengano on III-31-1999, and an L3 from the Babilônia site, collected on V-4-2003.

Biology. Eggs of *C. (C.) geayi* are deposited separately, with isolated stalks, in no particular pattern. Adults were collected in disturbed, forested areas of coastal Brazil. Occasionally, we encountered fairly substantial numbers in moist habitats near streams. The two larvae (L2, L3) from small trees in the field at Babilônia and Santo Antônio do Imbé (see data above) were both carrying relatively sparse coverings of plant material (brownish leaflets or bracts) and fibers loosely attached to the dorsal setae. On the two specimens from different localities, the leaflets or bracts appeared to be from the same or similar type of plant (Fig. 18).

Chrysopodes (Chrysopodes) lineafrons Adams & Penny, 1987

http://species-id.net/wiki/Chrysopodes_lineafrons

Figs 2–4, 19–22

Discussion. *Chrysopodes (C.) lineafrons* occurs widely throughout South America where it frequently has been reported from cropping systems, especially tropical fruit orchards (Adams and Penny 1985, González Olazo et al. 1999, Freitas and Penny 2001, Silva et al. 2007). It is a relatively small-bodied species that can be recognized by its facial markings, parallel and dark gradate veins, and distinctive genitalia (male and female). Adults can be identified using the keys in Adams and Penny (1985) and Freitas and Penny (2001).

Known geographic distribution. Argentina (Gonzalez Olazo et al. 1999); Brazil (Adams and Penny 1985, Freitas and Penny 2001, Silva et al. 2007).

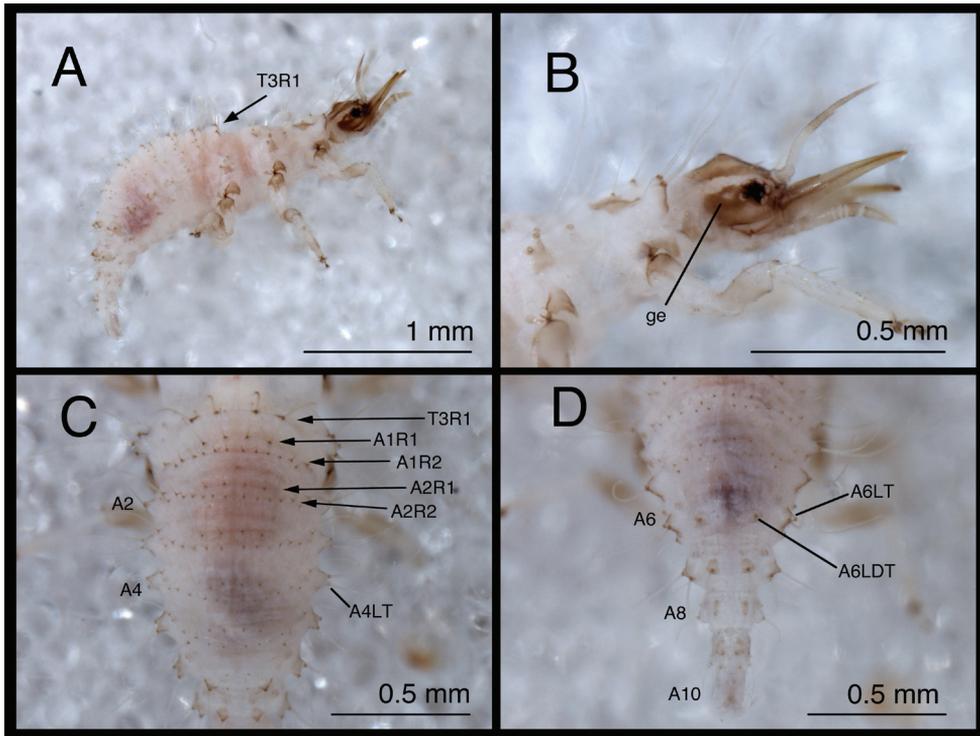


Figure 19. *Chrysopodes (C.) lineafrons*, first instar **A** Habitus, lateral **B** Head, lateral **C** Abdominal segments A1 to A5, dorsal **D** Abdominal segments A6 to A10, dorsal. *Abbreviations:* **A2**, **A4**, **A6**, **A8**, **A10** abdominal segments **A1R1**, **A1R2** anterior and posterior rows of submedian setae (SMS) on first abdominal segment **A2R1**, **A2R2** anterior and posterior rows of SMS on second abdominal segment **A4LT** lateral tubercle on fourth abdominal segment **A6LDT**, **A6LT** laterodorsal tubercle, lateral tubercle on sixth abdominal segment **ge** genal marking **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

Larval diagnosis. The dorsal head markings of *Chrysopodes (C.) lineafrons* larvae are similar to those of *C. (C.) divisus* (Figs 2–4). However, *C. (C.) lineafrons* (Semaphoront A) can be differentiated from *C. (C.) divisus* by the smaller number of robust, thorny setae on the posterior fold (R1) of the metathorax ($n = 4$) and the smaller number of smooth, hooked SMS on abdominal segments A1–A5 ($n = 16$). A dense coating of spinules on the dorsal integument gives the *C. (C.) lineafrons* larval body (Semaphoront B) a distinctive dark brown hue (most notable on the thorax and abdominal segments A1–A6, including the pleural and ventral regions). Other distinguishing characteristics of *C. (C.) lineafrons* Semaphoront B are the thorny cranial setae S1, S4, S6, S11, the large, dark brown pronotal plates (Sc1), and the presence of secondary sclerites on the pronotal midline.

First instar. (Semaphoront A). *Body* (Fig. 19A) 2.5–2.6 mm long; surface predominantly white to cream-colored, with some, small, light brown to brown markings.

Head (Figs 2D, 19B) 0.40–0.41 mm wide; mandibles 0.35–0.37 mm long (ratio, mandible length : head width = 0.85–0.90 : 1). Cranium mostly brown, with elongate, white to cream-colored area posteromesally extending from margin of cranium anteriorly to base of frontal markings, pair of white to cream-colored areas between lateral arm of epicranial marking and postfrontal marking. Epicranial marking light brown mesally, darker brown laterally, with mesal and lateral arms fused posteriorly; lateral arm extending around antennal sockets, above eyes; mesal arm fused with postfrontal marking. Postfrontal marking diffuse, darker brown than most of epicranial marking, contiguous basally with distal margin of epicranial marking (mesal arm), extending anteriorly almost to mesal margin of antennal base. Frontal markings thin, dark brown, paired but fused mesally, extending laterally across anterior of head to middle of mandibular base, merged with brown intermandibular coloration. Cranial setae light amber; S1, S4, S6, S11 thorny; S1, S11 long, others shorter; Vx setae very small.

Gena, ventral margin of head capsule brown, with small clear patch within genal mark. Labial palpus tinged with light brown, slightly darker distally. Mandibles light brown. Antenna with light brown scape, pedicel white basally, brown distally; flagellum brown.

Thorax (Figs 2D, 19A) mostly cream to white, with sclerotized structures light brown to brown; episternum brown. Legs white, with base of coxa brown, femur (especially distal half) tinged with brown, dorsum of tibia tinged with light brown; tarsal claws, empodia, brown. LS light amber; other setae cream to light amber.

T1: Row of three small setae (R1) near base of LT not observed. Sc1 brown throughout, but slightly lighter mesally; S2Sc1 small, immediately above S1Sc1. S1 long; S3 intermediate-length, slightly thorny. T2: Spiracle with lip of atrium raised above integumental surface. Sc1, Sc2 transparent: Sc3 marked with light brown; S2Sc3 variable, from medium-length to long, S2 smaller than S2Sc3. T3: S1Sc1 present, S2Sc1 (sometimes absent), S1Sc2 very small. S2Sc2 absent. Raised posterior fold with row (R1) of four long, thorny, pointed setae on chalazae with ovate, light brown marks anteriorly.

Abdomen (Figs 19C–D) white to cream-colored, with LTs, LDTs tinged with light brown, chalazae of most dorsal setae brown.

A1–A2: Dorsum with four to six SMS in anterior row, with 12 to 16 SMS in posterior row. Spiracles far lateral to anterior row, with SSp mesally. A3–A5: Anterior and posterior rows of SMS largely coalesced, with four to six SMS in anterior row, ten to 14 SMS in curved, posterior row. Spiracle with SSp near anteromesal margin. A6: Anterior region with row of two to six SMS, pair of small, straight setae lateral to SMS. Spiracle with pair of small SSp mesally. A7: Anterior region without setae or microsetae. Spiracle with SSp mesally. A8: Venter with two pairs of medium-length setae posteriorly, one pair of short setae anteriorly.

Second and third instars. (Semaphoront B). *Body* (Figs 20E, 21A–B) length 3.3–3.9 mm (L2), 5.8–6.8 mm (L3); surface white to cream-colored, with dense brown integumental spinules throughout, especially dense, dark on pronotum, mesonotum; primary pronotal, mesonotal sclerites brown to dark brown; dark brown marks ante-

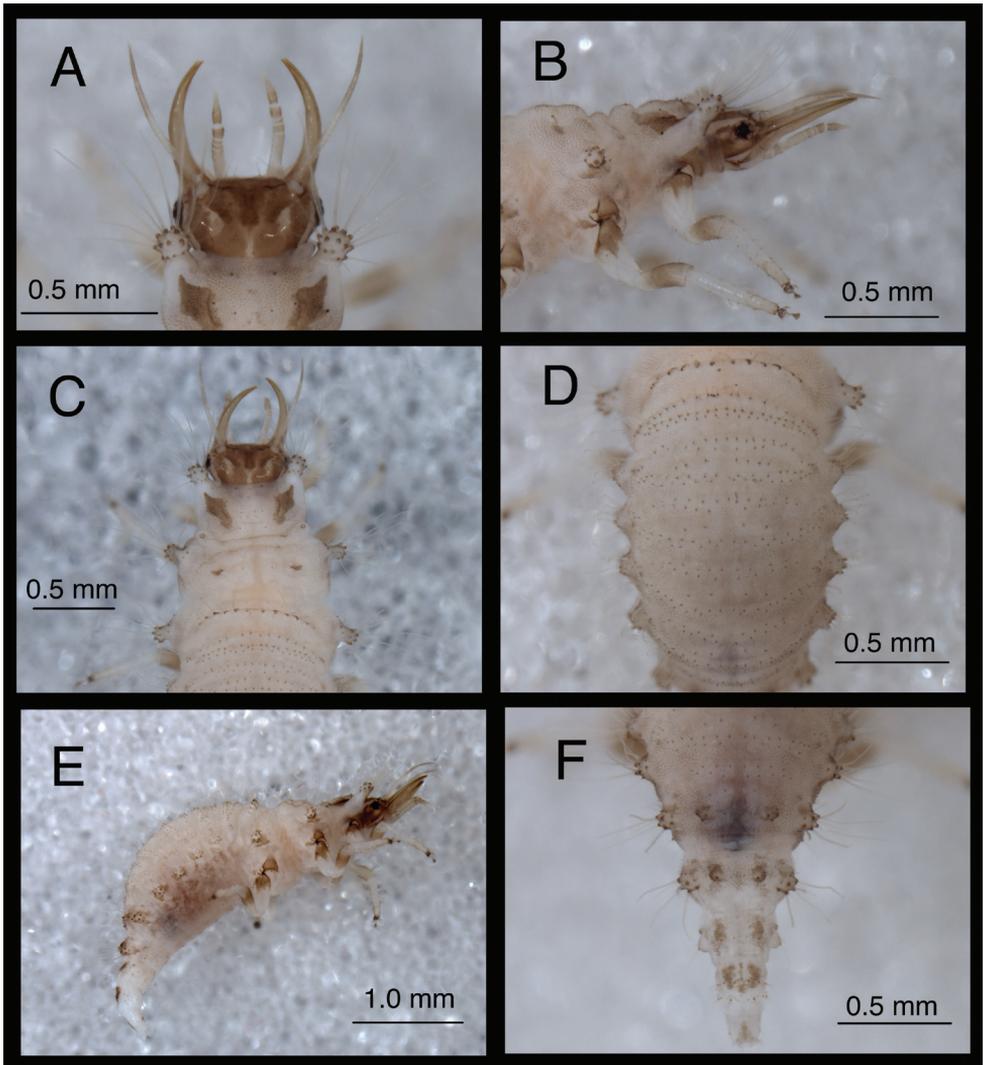


Figure 20. *Chrysopodes (C.) lineafrons*, second instar **A** Head, dorsal **B** Head, lateral **C** Head and thorax, dorsal **D** Abdominal segments A1 to A5, dorsal **E** Habitus, lateral **F** Abdominal segments A6 to A10, dorsal.

rior and posterior to lateral tubercles; sclerites anterior to coxae dark brown, lateral section of abdomen mostly light brown to brown.

Head (Figs 3D, 4D, 20A–B, 21C–D) dorsum cream-colored, with brown to dark brown markings. Epicranial marking brown, with mesal and lateral arms in broad contact mesally; both arms in contact with posterior margin of head; lateral arm extending from distolateral margin of cranium to upper level of eye, distal part tapering, broken, almost surrounding dorsal margin of eye; mesal arm extending from base of head, almost confluent with postfrontal marking. Postfrontal marking dark brown, narrow

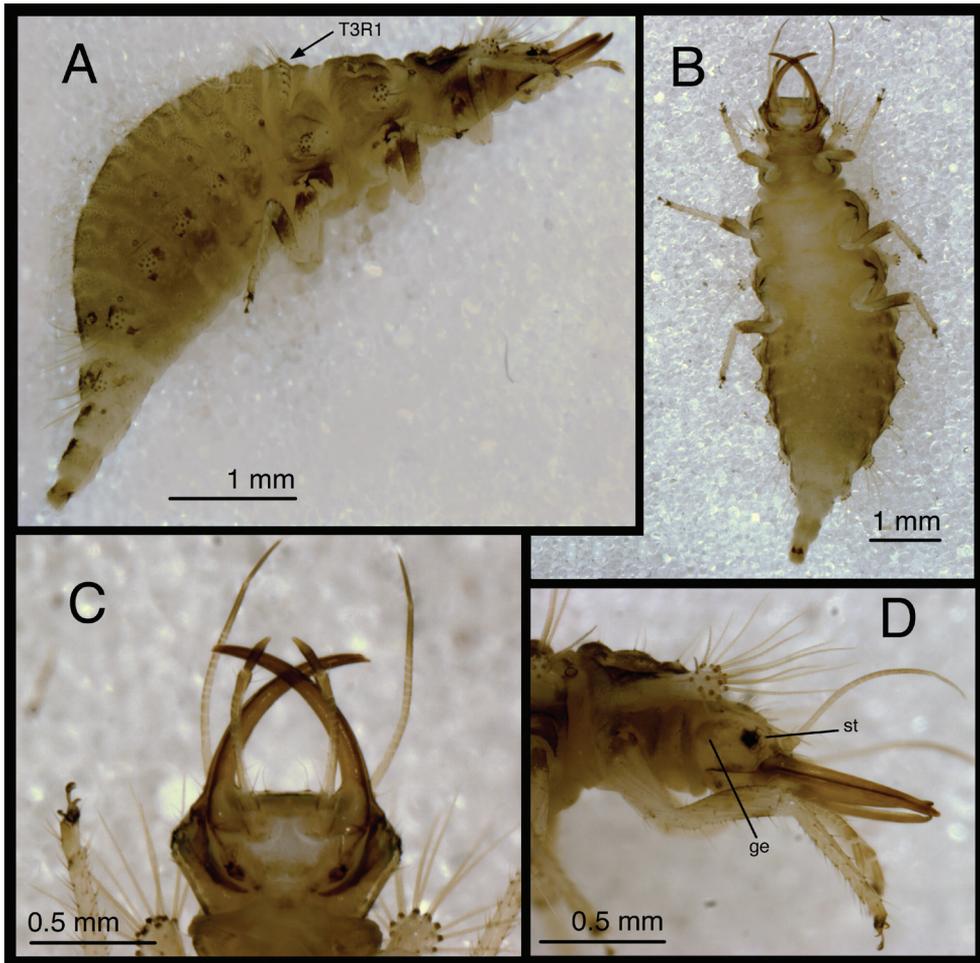


Figure 21. *Chrysopodes (C.) lineafrons*, third instar **A** Habitus, lateral **B** Habitus, ventral **C** Head, ventral **D** Head, lateral. Abbreviations: **ge** genal marking **st** stemmata **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

throughout, extending toward inner margin of scape. Frontal marking dark brown, basal arms confluent with each other, forming broad central mark, extending from midsection of head, beyond tentorial pits to intermandibular marking; base of each arm rounded. Intermandibular marking dark brown, broad mesally, tapering laterally, at base of mandibles. Clypeolabral region cream to white. Gena cream-colored, with large, brown, forked marking near base of cranium, with tips of fork reaching approximately 3/4th distance to eye. Mandible, maxilla amber basally, mesally, dark brown laterally, distally. Labial palpus: basal section cream-colored with very slight tinge of brown laterally; mesal segment tinged with brown laterally, cream-colored mesally, with terminal subsegment brown; terminal segment brown. Antenna: scape amber; basal section of flagellum cream-colored with slight tinge of brown; distal 1/4th of

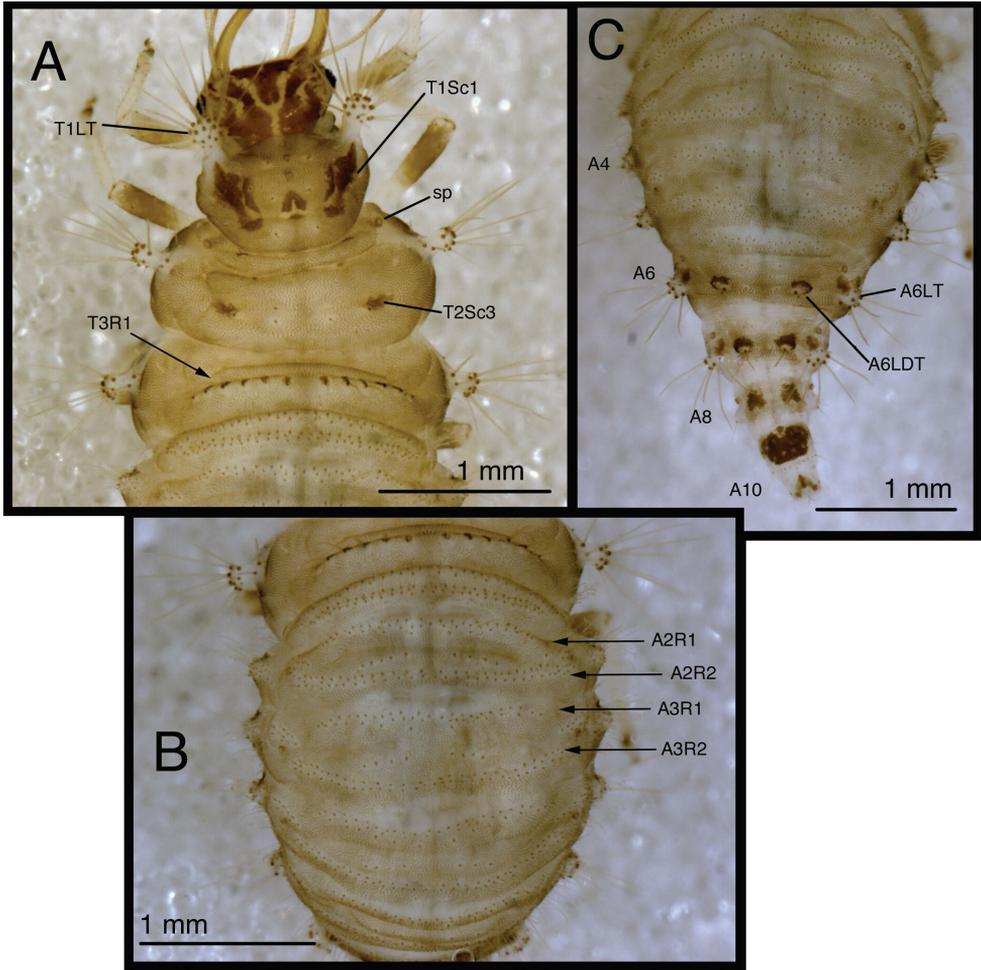


Figure 22. *Chrysopodes (C.) lineafrons*, third instar **A** Thorax, dorsal **B** Abdominal segments A1 to A5, dorsal **C** Abdominal segments A4 to A10, dorsal. *Abbreviations:* **A4**, **A6**, **A8**, **A10** abdominal segments **A2R1** double row of submedian setae (SMS) on anterior fold of second abdominal segment **A2R2** double/triple row of SMS on posterior fold of second abdominal segment **A3R1** double row of SMS on anterior fold of third abdominal segment **A3R2** double/triple row of SMS on posterior fold of third abdominal segment **A6LDT**, **A6LT** laterodorsal tubercle, lateral tubercle on sixth abdominal segment **sp** spiracle (on anterior subsegment of mesothorax) **T1LT** prothoracic lateral tubercle **T1Sc1** first primary prothoracic sclerite **T2Sc3** third primary mesothoracic sclerite **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

pedicel, flagellum, darker brown. Venter amber, with large, white central area; margin of cranium, cardo dark brown; mentum with rectangular, brown spot basally.

All cephalic setae present; S1, S11 long; S2–S10, S12 medium length to short; S1 thorny; S4, S6, S11 lightly thorny (thorniness difficult to see except under high magnification, especially on L2); other setae smooth. Vx setae relatively short. Ante-

rior margin of head straight, with angled lateral margins; mesal pair of anterior setae medium-length, lateral two pairs short or very short.

Head width across eyes, 0.55–0.61 mm (L2), 0.91–0.96 mm (L3); mandible length, 0.49–0.55 mm (L2), 0.96–1.00 mm (L3); ratio mandible length to head width = 0.87–0.93 (L2), 1.02–1.07 (L3). Tip of mandible with six teeth mesally.

Cervix brownish, with dense covering of spinules; sides with pair of broad brown patches; venter brown throughout, darker laterally.

Thorax (Figs 3D, 4D, 20C, 20E, 21A–B, 22A) brown dorsally, laterally, ventrolaterally, tinged by dense covering of brown spinules; sclerites, chalazae dark brown; LTs white, with LS white to light brown; chalazae cream-colored. Venter white to cream-colored mesally, with tinge of brown anteriorly, laterally, where spinules extend to ventral surface, without marks. Pleural region with small brown marks near the base of LTs. Legs: coxa white, with dark brown on dorsal surface; trochanter cream-colored to white, femur brown basally, dark brown distally; tibia white to tinged with very light brown, with light brown setae; tarsus tinged with very light brown; empodium, base brown; claws amber. Episternum with large brown mark; epimeron with small brown mark(s).

T1: LT with 15–19 (L2), 18–24 (L3) LS. Sc1 extending around posterior base of LT, dark brown laterally, mesally, with cream-colored to light brown, elongate streak with broad base. Three sclerites on midline: Sc2 triangular, cream-colored, with two brown spots anteriorly, mesal brown spot posteriorly, two smaller, light brown sclerites anterior to Sc2 [not all apparent on L2]. S2, S3 thorny. T2: Anterior sclerite (Sc1) brown; spiracle on small protuberance. Posterior subsegment with Sc2 transparent; Sc3 pronounced, dark brown. LT with 12–16 (L2), 14–18 (L3) thorny, robust LS, most long, several basal ones shorter. T3: LT with 12–16 LS (L2, L3). Posterior fold with 12–13 robust, thorny setae.

Abdomen (Figs 20D–F, 21A–B, 22B–C) dorsum light brown to brown throughout, LTs of A2–A5 with dark brown anterior spots, sometimes posterior spots; LS white to amber, with dark brown chalazae; chalazae of dorsal setae dark brown. A6, A7 each with pair of large, dark brown marks dorsal to LTs, pair ventral to LTs; dark brown marks surrounding anterior lateral margins of LDTs; LDTs white with dark brown chalazae; SMS amber-colored. A8 with pair of dark brown marks mesal to spiracles. A9 with dorsum almost entirely dark brown. A10 with dark brown, inverted V-shaped mark; light brown laterally. Sides of A2–A6 with large, diffuse, brown patch below each LT; venter lightly tinged with brown, light brown mesally, darker brown laterally; A7–A8 mostly white ventrally; A9 light brown ventrally; venter of A10 with pair of small, contiguous, triangular dark brown marks.

A1: Dorsum with 40–76 (L2), ~128–150 (L3) SMS in two double-triple transverse bands between spiracles; bands not extending laterally beyond spiracles. A2–A5: Dorsum with 41–102 (L2), 119–173 (L3) SMS in two broad transverse bands. LT with 10–15 (L2), 18–30 (L3) LS: five to seven robust, thorny, blunt LS of various lengths, on distal surface; remaining LS less robust, smooth, hooked in patch on dorsal surface. A6: Dorsum with transverse band of 16–28 (L2), 28–38 (L3) SMS across anterior of segment; midsection with two pairs of smooth setae, mesal pair hooked, long,

lateral pair pointed, shorter. LT with 9–11 (L2), 11–17 (L3) robust, thorny, blunt LS of various sizes. A7: Dorsum with two pairs of short setae between spiracles. LT with 8–10 (L2), 10–13 (L3) LS of various sizes. Venter with setal number and size variable, usually with two pairs of setae anteriorly (both small, smooth), three pairs of sublateral setae posteriorly (two lateral-most pairs robust, thorny, mesal pair small, smooth). A8: Dorsum with two pairs of small setae between spiracles; four pairs of small setae in transverse row between LTs. Venter with scattered, small setae anteriorly, two robust, thorny setae on small chazae between LTs. A9: Dorsum with one pair of very small setae anteriorly. Middle and posterior regions with two transverse rings of setae extending around segment; each ring with ~14–16 setae of various sizes, several in each ring robust. A10: Dorsum with one pair of setae anteriorly, two pairs mesally, patch of several setae distally; one pair of small setae posterior to V-shaped anterior sclerites. Lateral region with two pairs of robust setae, two to three pairs of smaller setae. Venter with ~two pairs of robust setae, five pairs of small setae.

Egg. At oviposition, green, with white micropyle; ovoid, 0.92 to 0.99 mm long, 0.40 to 0.44 mm wide. Stalk smooth, hyaline, 3.1 to 6.2 mm long.

Larval specimens examined. Several lots, each originating from a single gravid female collected in **Brazil, Bahia:** Cruz das Almas, VI-19-96 (Tauber Lot 96:020B). **Rio de Janeiro:** Campos dos Goytacazes, Estação Experimental Pesagro, VI-20-2006 (Albuquerque Lot 2006:08).

Biology. Adults of *C. (C.) lineafrons* are commonly found in citrus and other orchards (see summary in Silva et al. 2007).

In the lab, eggs were deposited separately (with isolated stalks), in small groups with no particular pattern. During the first 24 hours of oviposition, the eggs were bright green, with dark green blotches. On the second day, they began to develop a bluish brown tone, with brownish mottling; by the third day the eggs were greyish blue to pinkish, with brown mottling. At $24 \pm 1^\circ\text{C}$, hatching occurred within six days ($n = 12$).

Larvae of *C. (C.) lineafrons* carry dense packets of woody plant material and other dry debris; they exhibit a side-to-side rocking motion. Development of the various stages (population from the state of Bahia: Cruz das Almas, $24 \pm 1^\circ\text{C}$, $n = 14$) required: L1, 4–5 days; L2, 3 days; L3, 3–4 days; cocoon, 15 days; complete development from oviposition to adult emergence, 32 days. These data coincide well with the results from extensive rearings of *C. (C.) lineafrons* from the state of Rio de Janeiro (Campos dos Goytacazes) (see Silva et al. 2007).

Experimental life history studies of *C. (C.) lineafrons* in the laboratory and the field (southeastern Brazil) indicate: that the species can undergo development and reproduction all-year-round without interruption or dormancy; that during this time up to eight generations can be produced; and that temperature conditions play an important role in determining the rates of reproduction and development both in the lab and in the field (Silva et al. 2007). The species is considered to have excellent potential for mass rearing and for use in the biological control of pests in fruit orchards (Silva et al. 2007).

***Chrysopodes (Chrysopodes) spinellus* Adams & Penny, 1987**

http://species-id.net/wiki/Chrysopodes_spinellus

Figs 2–4, 23–26

Discussion. *Chrysopodes (C.) spinellus* was described from the Amazon region (Adams and Penny 1985); since then, it has not received particular attention. However, we, and others (e.g., Freitas and Penny 2001) have collected it in Brazilian agricultural habitats. We suspect that it is one of the more widespread and common species of *Chrysopodes (Chrysopodes)* in Brazilian agricultural settings.

Although the female and male genitalia of *C. (C.) spinellus* are distinctive, both sexes show considerable variation, and the species is not easily distinguished from other *Chrysopodes (Chrysopodes)* species. The species will be dealt with in an up-coming revision of the subgenus *Chrysopodes* (C. A. Tauber, in preparation). Meanwhile, the keys and information in Adams and Penny (1985) and Freitas and Penny (2001) are helpful for identification.

Known geographic distribution. Brazil (Adams and Penny 1985, Freitas and Penny 2001).

Chrysopodes (C.) spinellus was reported from Argentina (with larval description) (Gonzalez Olazo and Heredia 2010); however, the species identification in that report appears to be in error. The larva (L3) that was illustrated had a darkened head like both *C. (C.) divisus* and *C. (C.) lineafrons*, and it lacked the longitudinally elongate, separate mesal and lateral epicranial markings of *C. (C.) spinellus*. The illustrations more closely resemble *C. (C.) divisus* than *C. (C.) lineafrons*.

Larval diagnosis. Like the larvae of *C. (C.) geayi* and *C. (C.) fumosus*, *C. (C.) spinellus* larvae have largely white to cream-colored heads with longitudinally elongate and divided, brown epicranial markings; the intermandibular and clypeal regions are unmarked. And, as in *C. (C.) geayi*, but not *C. (C.) fumosus*, the posterior ends of the frontal markings curve and connect with each other mesally. The first instar of *C. (C.) spinellus* differs from those of *C. (C.) geayi* and *C. (C.) fumosus* in that it usually has six thorny cranial setae (S1, S3, S4, S5, S6, S11), and the LS are amber to light brown (not dark brown or black). The *C. (C.) spinellus* Semaphoront B differs from both *C. (C.) geayi* and *C. (C.) fumosus* in having a thorny cranial seta S1, secondary cranial setae between S1 and S4, but no secondary sclerites on the pronotal midline.

First instar. (Semaphoront A). *Body* (Fig. 23A) 2.7–2.8 mm long; surface predominantly white to cream-colored, with some, small, light brown marks.

Head (Figs 2E, 23B) 0.39–0.41 mm wide; mandibles 0.36–0.37 mm long (ratio, mandible length : head width = 0.90–1.01 : 1). Cranium white, with elongate, narrow, light brown markings. Epicranial marking with lateral and mesal arms unconnected, narrow, longitudinally elongate, light brown; mesal arm contiguous with postfrontal marking, extending from base of cranium to anteromesal margin of antennal socket; lateral arm lighter brown, more diffuse than mesal arm, extending from posterolateral

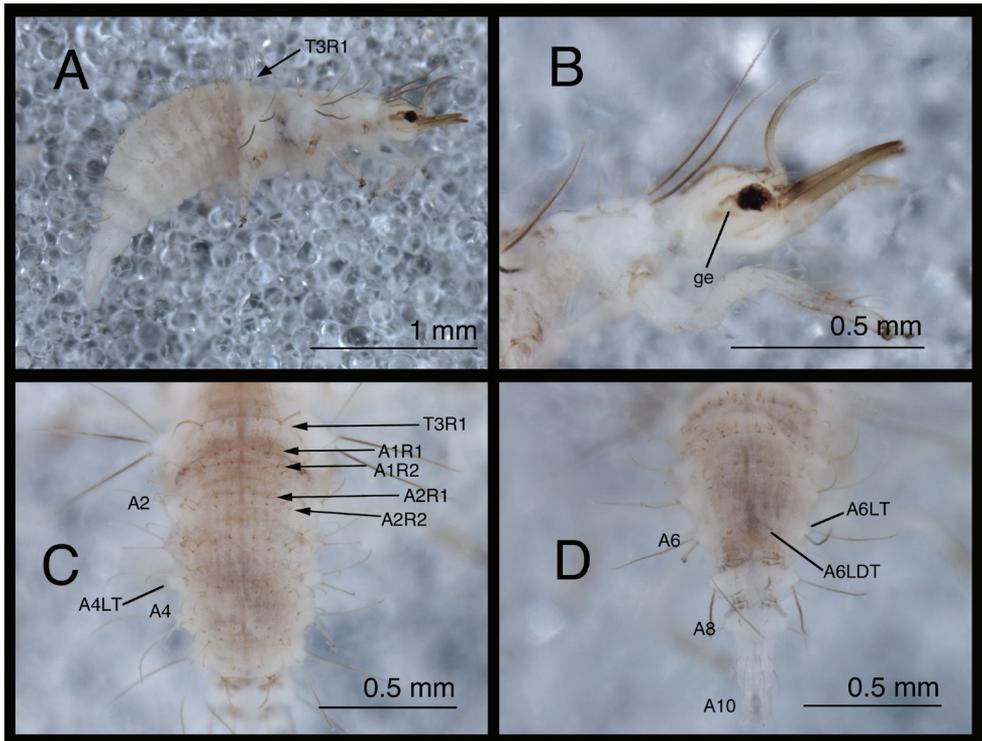


Figure 23. *Chrysopodes (C.) spinellus*, first instar **A** Habitus, lateral **B** Head, lateral **C** Abdominal segments A1 to A5, dorsal **D** Abdominal segments A6 to A10, dorsal. *Abbreviations:* **A2, A4, A6, A8, A10** abdominal segments **A1R1, A1R2** anterior and posterior rows of submedian setae (SMS) on first abdominal segment **A2R1, A2R2** anterior and posterior rows of SMS on second abdominal segment **A4LT** lateral tubercle on fourth abdominal segment **A6LDT, A6LT** laterodorsal tubercle, lateral tubercle on sixth abdominal segment **ge** genal marking **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

margin of cranial suture approximately to base of eye. Postfrontal marking indistinguishable, fused with epicranial marking (mesal arm). Frontal marking narrow, extending from midregion of cranium anteriorly to level of antennal socket, then curving laterally toward lighter brown mark at mesal margin of mandibular base; mesal ends of paired frontal marking bending mesally at tips. Intermandibular, clypeal area white. Cranial setae amber to light brown; S1, S3, S4, S5, S6, S11 thorny, robust; S1, S4, S11 long, others shorter; S2, S5 closely spaced; Vx setae small.

Gena, ventral margin of head capsule mostly white, with light brown genal mark posterior to eye, with clear spot near anterior margin. Labial palpus mostly white, middle segment tinged with light brown laterally, distal segment mostly tinged with brown. Mandibles amber to light brown, with dark brown basolateral spot. Antenna with scape light brown, pedicel white basally, brown distally; flagellum light brown.

Thorax (Figs 2E, 23A) mostly white, with sclerotized structures light brown to brown; episternum brown. Legs white, with base of coxa brown, distal one-fourth of

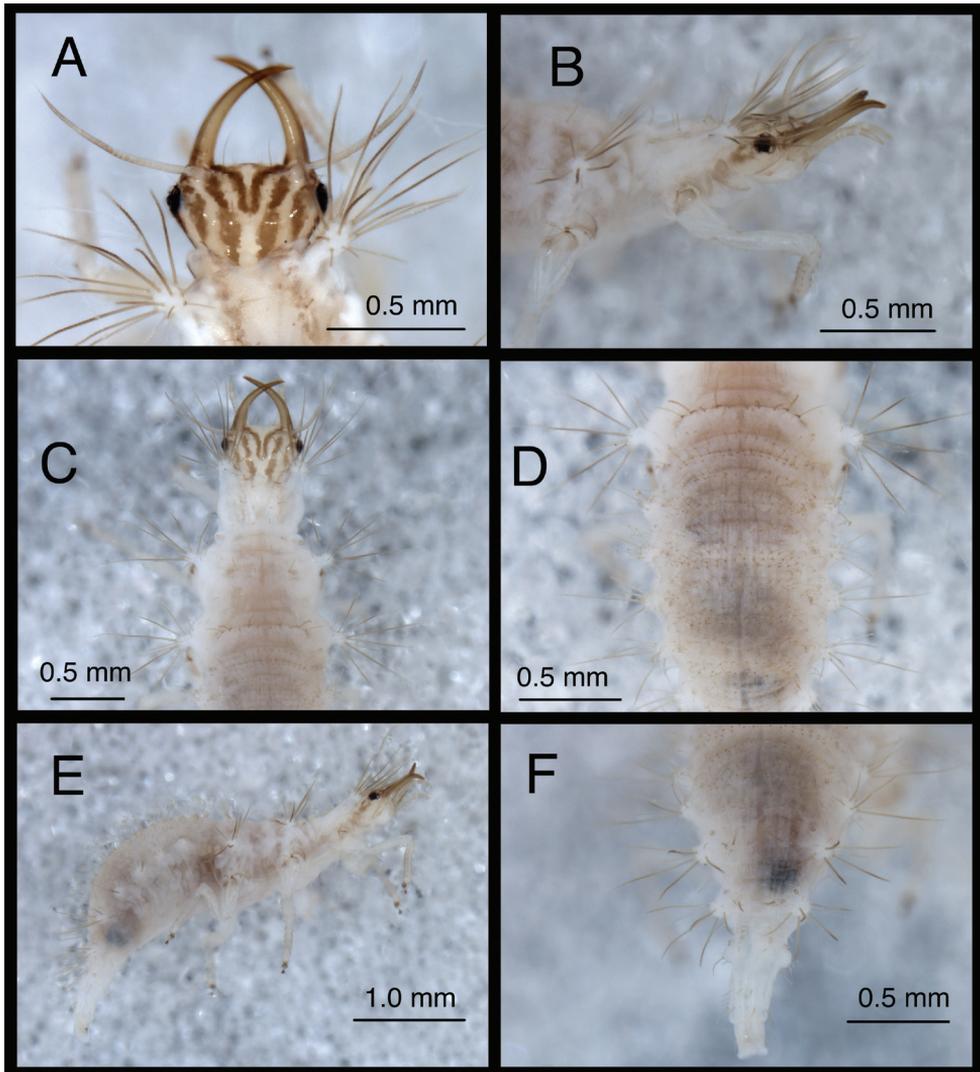


Figure 24. *Chrysopodes (C.) spinellus*, second instar **A** Head, dorsal **B** Head, lateral **C** Head and thorax, dorsal **D** Abdominal segments A1 to A5, dorsal **E** Habitus, lateral **F** Abdominal segments A6 to A10, dorsal.

tibia, basal one-half of tarsus tinged with brown; tarsal claws, empodia, brown. LS brown; other setae amber to brown.

T1: Row of three very small setae (R1) at anteromesal base of LTs. Sc1 with scattered brown areas, especially laterally; S2Sc1 small, immediately above S1Sc1. S1, S3 intermediate-length. S2, S3 thorny. T2: Spiracle with lip of atrium flush with level of integumental surface. Sc1, Sc2 transparent; Sc3 light brown; S2Sc3 medium-length to long, slender, S2 shorter. T3: S1Sc1, S2Sc1 usually present, S1Sc2 very small; S2Sc2 absent. Raised posterior fold with row of four robust, thorny, pointed setae on chalazae with ovate, light brown marks anteriorly.

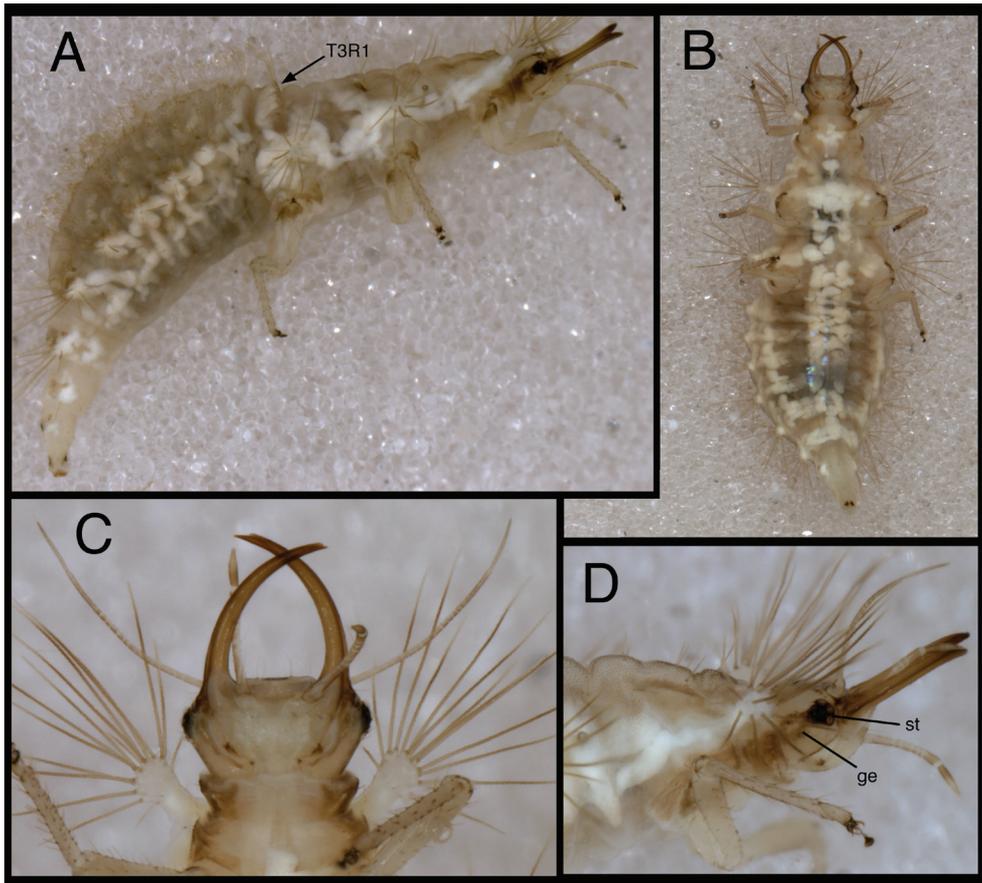


Figure 25. *Chrysopodes (C.) spinellus*, third instar **A** Habitus, lateral **B** Habitus, ventral **C** Head, ventral **D** Head, lateral. Abbreviations: **ge** genal marking **st** stemmata **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

Abdomen (Figs 23C–D) white to cream-colored, with patch of brown on dorso-lateral margin of A1; anterior regions of A7, A8 marked with diffuse, scattered brown patches. LTs, LDTs white; chalazae of most dorsal setae brown.

A1–A5: Dorsum with 12 SMS in two rows, with four mesal pairs equally spaced, two lateral-most pairs juxtaposed; spiracle with SSp elongate, robust, mesal to spiracle; chalazae of all SMS and SSp not large. A6: Anterior row with two SMS, pair of small, straight setae lateral to SMS; spiracle at anterior base of LT, without apparent SSp. A7: Anterior region without setae or microsetae. Spiracle without apparent SSp. A8: Venter with two pairs of medium-length setae posteriorly.

Second and third instars. (Semaphoront B). *Body* (Figs 24E, 25A–B) 4.1–4.2 mm (L2), 5.8–7.0 mm (L3); surface white to tan, with light brown integumental spinules throughout; primary pronotal, mesonotal sclerites light brown; base of lateral

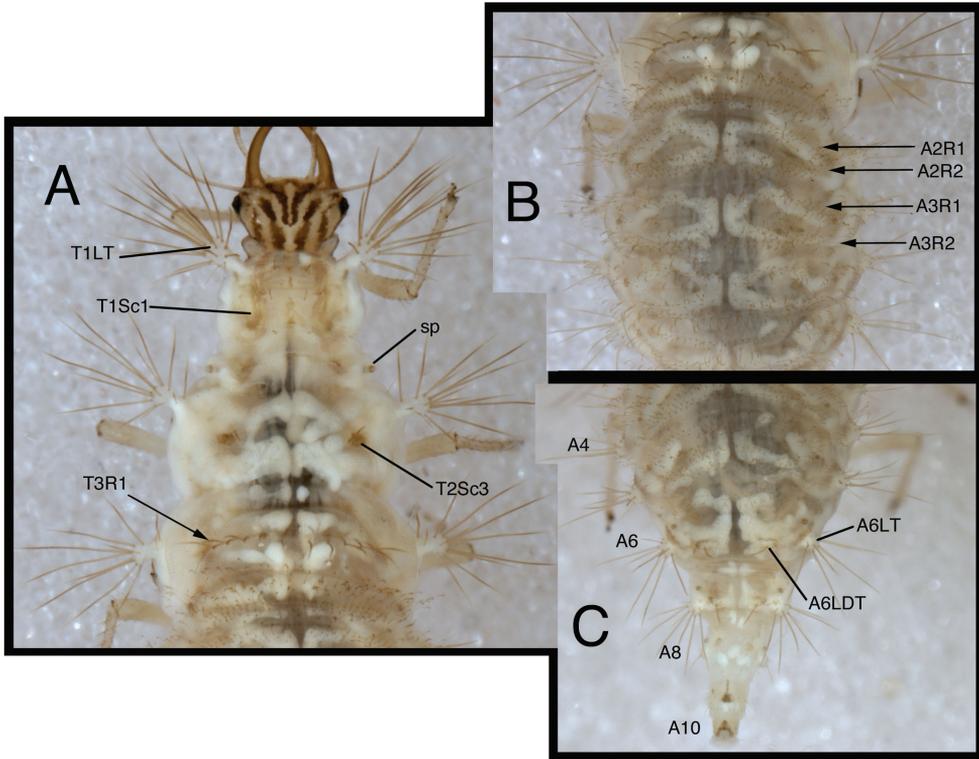


Figure 26. *Chrysopodes (C.) spinellus*, third instar **A** Thorax, dorsal **B** Abdominal segments A1 to A5, dorsal **C** Abdominal segments A6 to A10, dorsal. *Abbreviations:* **A4, A6, A8, A10** abdominal segments **A2R1** double row of submedian setae (SMS) on anterior fold of second abdominal segment **A2R2** double/triple row of SMS on posterior fold of second abdominal segment **A3R1** double row of SMS on anterior fold of third abdominal segment **A3R2** double/triple row of SMS on posterior fold of third abdominal segment **A6LDT, A6LT** laterodorsal tubercle, lateral tubercle on sixth abdominal segment **sp** spiracle (on anterior subsegment of mesothorax) **T1LT** prothoracic lateral tubercle **T1Sc1** first primary prothoracic sclerite **T2Sc3** third primary mesothoracic sclerite **T3R1** row of long, sturdy, thorny setae on raised posterior fold of metathorax.

tubercles without marks; lateral section of thorax, abdomen light brown to brown, with lateral tubercles and area below white; sclerites anterior to coxae brown.

Head (Figs 3E, 4E, 24A–B, 25C–D) cream-colored, with brown to dark brown markings. Epicranial marking brown, consisting of two elongate arms, separate from each other, both in contact with posterior margin of head; lateral arm extending from distolateral margin of cranium to lower level of eye, becoming narrow distally, extending to upper level of eye; mesal arm extending from base of head, contacting postfrontal marking near base of frontal marking. Postfrontal marking dark brown, robust throughout, extending to inner margin of antennal base. Frontal marking dark brown, with each arm narrow, separate (except at basal tip), extending from midsection of head,

beyond tentorial pits to inner base of mandibles; base of each arm tapering, turning mesally, contacting tip of other arm. Intermandibular marking present as light brown connection between distal ends of frontal marking. Clypeolabral region beyond intermandibular marking cream-colored. Gena cream-colored, with large, brown marking from base of eye to posterior margin of cranium, with small, closed, cream-colored mesal spot distally. Mandible, maxilla amber basally, mesally, brown laterally, distally. Labial palpus: basal segment cream-colored with very slight tinge of brown; mesal segment ringed with brown laterally, cream-colored mesally, with terminal subsegment brown; terminal segment brown basally, cream-colored distally. Antenna: scape light brown, basal one third of pedicel cream colored, distal two-thirds of pedicel darker brown, flagellum cream-colored with slight tinge of brown. Venter cream-colored, with large, white central area; margin of cranium with light brown longitudinal marks; cardo marked with dark brown; mentum with very light brown spot basally.

Cephalic seta S1 moderately long, thorny, S2–S12 smooth, only S11 long; Vx setae moderately long; three to four pairs of small secondary setae between S1 and S4.

Head width across eyes, 0.5–0.6 mm (L2), 0.84–0.86 mm (L3); mandible length, 0.54–0.57 mm (L2), 0.86–0.90 mm (L3); ratio mandible length to head width = 0.91–0.99 : 1 (L2), 1.00–1.05 : 1 (L3). Tip of mandible with six teeth mesally.

Cervix cream-colored, tinged with light brown; sides with pair of broad brown patches; venter brown laterally, becoming cream-colored mesally; with three pairs of small setae ventrally.

Thorax (Figs 3E, 4E, 24B–C, 24E, 25A–B, 26A) light brownish dorsally, tinged by covering of light brown spinules; sclerites, chalazae light brown; LTs white, with LS white to light amber; small tubercles beneath primary setae cream-colored to white. Venter cream-colored, with white mesal stripe, largely without marks. Legs: coxa white, with dark brown on dorsal surface; trochanter white to cream-colored, femur white, with slight tinge of brown distally; tibia white to tinged with very light brown, with light brown setae; tarsus white, tinged with very light brown; empodium, base brown; claws amber.

T1: LT with 16–17 (L2), 17–19 (L3) LS; five to six short, smooth setae anterobasally. Sc1 large, extending up mesal base of LT, light brown mesally, transparent laterally. Sc2 triangular, light brown; without secondary sclerites. S2, S3 thorny. T2: Sc1 light brown; spiracle on small protuberance. Posterior subsegment with Sc2 transparent to very light brown; Sc3 pronounced, brown. LT with 12–13 (L2), 17–19 (L3) LS. T3: LT with 11–13 (L2), 16–18 (L3) LS. Posterior fold with ten to twelve robust, thorny setae.

Abdomen (Figs 24D–F, 25A–B, 26B–C) dorsum cream-colored to tan, with patches of white fat body visible beneath integument throughout; chalazae of dorsal setae amber to light brown; LTs white, LS cream-colored to amber. A6 with pair of brown marks anterodorsal to LTs; A6, A7 with brown marks anterior to LDTs. A8 with pair of small, light brown marks mesal to spiracles; A9 with dark brown mark mesal to spiracles. A10 with dark brown, inverted U-shaped mark distally; light brownish laterally. Sides of A2–A5 with large, diffuse, very light brown patch below each LT; venter mostly light brown laterally, white mesally; A6–A10 mostly white ventrally; venter of A10 with pair of small, dark brown marks.

A1: Dorsum with 40–56 (L2), ~116–124 (L3) SMS in two double-triple transverse bands between spiracles. A2-A5: Dorsum with 66–84 (L2), 134–174 (L3) SMS in two broad transverse bands. LTs each with 8–11 (L2), 11–21 (L3) LS: four to nine long, robust, thorny, usually pointed LS on distal surface; remaining LS less robust, smooth, hooked in patch on dorsal surface. A6: Dorsum with transverse band of 16–18 (L2), 44–58 (L3) SMS across anterior of segment; midsection with two pairs of smooth setae, mesal pair long, hooked, lateral pair short, pointed. LT with 7–8 (L2), ~14 (L3) LS of various sizes. A7: Dorsum with three pairs of very short setae anteriorly, between spiracles. LT with 6–7 (L2), 9–12 (L3) LS of various sizes. A8: Dorsum with three pairs of very small setae between spiracles; three pairs of small setae in transverse row between LTs. Venter with four transverse rows of setae, each with three to four smooth, small to medium-length, pointed setae. A9: Dorsum with one pair of very small setae anteriorly. Middle and posterior regions with two transverse rings of setae extending around segment; each ring with ~14–16 short to medium-length setae, several in each ring robust. A10: Dorsum with one pair of small setae posterior to V-shaped anterior sclerites. Several pairs of lateral setae. Venter with ~five pairs of small setae, posterior row of microsetae anterior to terminus.

Egg. At oviposition, green, with white micropyle; ovoid, 0.92 to 0.97 mm long, 0.42 to 0.44 mm wide. Stalk smooth, hyaline, 8.8 to 10.1 mm long.

Larval specimens examined. Several lots, each originating from a single gravid female collected in **Brazil, Rio de Janeiro:** Campos dos Goytacazes, Parque Estadual do Desengano, Babilônia, III-27-2001, XI-22-2003 (Tauber Lot 2001:007, Albuquerque Lot 2003:023); Campos dos Goytacazes, near Parque Estadual do Desengano, Fazenda Boa Vista, V-16-2002 (Tauber Lots 2002:026, 2002:029); Campos dos Goytacazes, Distrito de Morangaba, Fazenda São Julião, X-18-2005 (Tauber Lot 2005:035).

Biology. The thermal influence on rates of development and reproduction in *C. (C.) spinellus* will be reported elsewhere (Silva et al., in preparation).

Acknowledgements

We thank the following who assisted with obtaining specimens: V. Becker, E. M. G. Fontes, F. Franca, S. L. Lapointe, J. S. Multani, A. Nascimento, C. S. S. Pires, E. A. Silva, B. Souza, E. R. Sujii, A. J. Tauber, and P. J. Tauber. CAT and MJT acknowledge L. E. Ehler and M. Parella for their cooperation in a variety of ways.

Our project is long-standing; it is a pleasure to acknowledge the support from the following agencies and institutions: the USDA/NRI (Competitive Grant 9802447, MJT, CAT), the National Geographic Society (MJT, CAT, GSA), the National Science Foundation (Grants INT-9817231, DEB-0542373, MJT, CAT), the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq, Brazil – Grants 300504/96-9, 466439/00-8, 475848/04-7, 484497/07-3, GSA), Regional Project W-1385, Cornell University, and the Universidade Estadual do Norte Fluminense.

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Appendix

Characteristics of *Chrysopodes* larvae. See the figures cited here and also Figures 5–10 in Tauber (2003). Asterisks indicate new characters or significant changes from the features listed previously (Tauber 2003).

All Instars (Semaphoront C)

General

Setation & spiracles

- (1) setae of four types
 - (a) smooth, pointed, short to long [most cephalic setae, some setae on abdominal segments A6-A10, some ventral setae, all small setae] (Fig. 1)
 - (b) thorny, pointed to blunt or slightly spatulate, medium length to long [some cephalic setae, most setae on thoracic lateral tubercles (LS), some primary thoracic setae, some LS on A2-A6, some setae on latero-dorsal tubercles of A6, A7 (LDS), some ventral setae] (Fig. 1)
 - (c) smooth, hooked, long (some LS on A2, A3 of L1, some LDS on A6, A7 of L3)
 - (d) smooth, arising from brown chalazae, with elongate, narrow stem, laterally flattened terminal hook [abdominal submedian setae (SMS) on A1-A5, anterior region of A6] (Fig. 1)
- (2) setal bases usually brown
- (3) spiracles simple (with cylindrical sides, atrium not enlarged), with brownish margins

Head

General

- (4) mandible with four to six small terminal “teeth” (serrations)
- (5) mandibular base with one seta and dorsal row of four placoid organs (Rousset 1966)
- (6) stipes elongate, narrow, folded inward on longitudinal axis
- (7) stemmata black

Cranial markings

- (8) epicranial (mesal and lateral), postfrontal, frontal markings present
- (9) genal marking present, forked anteriorly or, more usually, with clear spot near anterior margin

Cephalic setae

- (10) labrum with three pairs of setae (mesal pair long, lateral pairs shorter)
- (11) all primary setae, including S12 present, S1, S11 long
- (12) short, stout seta laterally on tip of pedicel
- (13) long terminal seta on tip of flagellum

Thorax**General**

- (14) lateral tubercles (LTs) about two times longer than broad
- (15) primary setae straight, with pointed tips
- (16) secondary setae absent

Prothorax

- (17) paired lateral sclerites (Sc1) large, rhomboid, marked with brown, with associated seta S1Sc1 relatively long, thorny, stemming from brown chalaza
- (18) primary seta S1 thorny, stemming from brown chalaza, S5 absent
- (19) venter with one pair of very small setae mesal to coxae (minute on L1)

Mesothorax

- (20) *segment divided into two distinct subsegments: anterior subsegment with single fold (= "lobe" of Snodgrass 1935), posterior subsegment consisting of two transverse folds, separated by subtle transverse groove (folds on posterior subsegment difficult to discern on L1)
- (21) anterior subsegment bearing pair of small sclerites (Sc1) anteriorly, pair of spiracles (Sp) laterally
- (22) *posterior subsegment: anterior fold bearing large tubercles (LTs) laterally, pair of small sclerites (Sc2) anteriorly; posterior fold bearing large, usually brown sclerite (Sc3) on anterolateral margin (posteromesal to LTs); Sc3 with one small seta (S1Sc3) and one longer, thorny seta (S2Sc3)¹
- (23) spiracles located on rounded, lateral protuberances, without associated setae (SSp)
- (24) venter with one pair of very small setae on anteromesal margin

Metathorax

- (25) *segment with three transverse folds; anterior two folds separated by subtle, transverse groove; dorsal surface of both folds level with mesothorax; dorsum of posterior fold prominently raised above anterior two folds, separated from anterior folds by subtle groove
- (26) S1, S2² absent
- (27) posterior fold with transverse row (R1) of long, robust, thorny setae arising from large chalazae, each with brown, teardrop-shaped mark on anterior surface
- (28) *each transverse fold with pair of small, transparent sclerites (Sc1, Sc2, Sc3); Sc1, Sc2 (when visible) located on anterior margin of fold; Sc3 (when visible) nestled in anterolateral corner of groove above R1; Sc2, Sc3 sometimes difficult to discern (L1, L2)
- (29) venter with pair of very small setae on anteromesal margin

¹ S2Sc3 on Semaphoront B was identified as S5 by Tauber (2003).

² These two setae were incorrectly illustrated and described as present on Semaphoront B by Tauber (2003).

Abdomen**General**

- (30) overall shape gibbous
- (31) depth of A2-A5 greater than depth of thorax, width not greater than thorax
- (32) A6-10 becoming narrow and tubular distally; segments not withdrawn
- (33) *terminus with pair of eversible, membranous pouches (small on L1)

Folding and submedian setae (SMS)

- (34) *A1-A5 each with two, ill-defined, transverse folds separated by small grooves; each fold bearing transverse row of SMS
- (35) *A6-A10 without folding; A6 with row of SMS anteriorly, without SMS posteriorly; A7-A10 without SMS

Tubercles and associated setae

- (36) A1 without pleural or ventral region; without lateral tubercles (LTs) or laterodorsal tubercles (LDTs)
- (37) A2-A7 with LTs robust
- (38) A8 with LTs round, fleshy
- (39) A2-A5, A8-A10 without LDTs
- (40) A6, A7 each with pair of LDTs

Spiracles

- (41) A1-A8: spiracles (Sp) sessile
- (42) A1, A6, A7: Spiracular setae (SSp) small, smooth, pointed (when present); *A2-A5 with SSp indistinguishable from SMS; A8 without SSp

Primary setae

- (43) dorsal setae S1, S2 absent from all segments
- (44) *venter with following setae: A2-A7 each with pair of sublateral setae and pair of submedian setae. Sublateral setae short, smooth, extending from small chalazae on segments A2, A3, becoming larger, smooth or thorny, stemming from larger chalazae or small tubercles on segments A4, A5, stemming from small tubercles with at least one other small seta on segments A6, A7. Submedian setae long, smooth, slender on A2, A3, short on A4-A7. Note: Occasionally, one or more of the above setae may be absent, or additional ones may be present.

First instar (Semaphoront A)**Head****Eyes**

- (1) *stemmata black, with integument between all stemmata brown to black
- (2) *exterior margin of stemmata with thin, brown border

Appendages

- (3) antenna: scape without setae

- (4) mandible with four terminal “teeth” (serrations), without basal setae
- (5) labial palpus: distal margin of basal segment with two setae: one lateral, one mesoventral; middle segment with two distal setae; distal segment without setae

Venter

- (6) palpiger with two pairs of distal setae
- (7) mentum with two pairs of anterior setae, one pair of posterior setae

Thorax

Prothorax

- (8) lateral tubercle (LT) with two LS; one microseta between LS
- (9) paired lateral sclerites (Sc1) extending anteriorly to base of LT
- (10) posteromesal sclerite (Sc2) not discernible
- (11) primary setae S1, S3 intermediate-length to long, thorny; S2 short, adjacent to S1Sc1, S4 absent

Mesothorax

- (12) LT with three LS; no microseta
- (13) *Sc1 with two small associated setae (S1Sc1, S2Sc1), one on each side; S3Sc1 absent. Sc2 with two small associated setae (S1Sc2, S2Sc2) laterally; S3Sc2 absent
- (14) primary setae: S1 short to minute or absent, S2³ intermediate-length to long, thorny

Metathorax

- (15) *posterior fold with four to seven (perhaps eight) R1 setae
- (16) *Sc1 with one to two small associated setae (S1Sc1, S2Sc1) (sometimes absent)
- (17) Sc2 difficult to discern, sometimes with small associated seta (S1Sc2)
- (18) Sc3 with one small associated seta (S1Sc3), sometimes absent
- (19) primary setae S1, S2 not discernible

Abdomen

Folding and setae

- (20) *A1-A5 each with two primary rows of SMS, sometimes lateral two SMS juxtaposed
- (21) A6 with anterior area bearing single transverse row of SMS; posterior area without SMS

Tubercles and associated setae

- (22) A2-A7: LT robust basally, tapering, sclerotized distally, bearing two long, robust setae (LS)
- (23) *A2-A3: LT with one thorny, pointed LS, one smooth, hooked LS
- (24) A4-A7: LT with two thorny, pointed to blunt LS
- (25) A8: LT with one medium-length, thorny, pointed LS, one short, smooth LS

³ Identified as S1 by Tauber (2003).

(26) A6, A7: LDT bearing one long, robust, thorny LDS, one short, thorny LDS (A6) or two small LDS (A7)

(27) *A6, A7: with pair of small setae between LDTs

Spiracular setae

(28) *A1: spiracle with or without SSp

(29) *S2-A5 with single pair of smooth, hooked SSp

(30) *A6, A7 with small, smooth, pointed SSp present or absent

(31) A8 without SSp

Setation of terminal segments

(32) *A9: anterior section with two pairs of robust, thorny, pointed to blunt setae dorsally, one pair laterally

(33) A9: posterior section with one pair of robust, thorny setae dorsally, one pair laterally, three pairs ventrally

(34) *A10: with scattered small setae, microsetae

Second and third instars (Semaphoront B)

General

Integument

(1) dorsal and ventral surface with rounded, brownish spinules

(2) spinules generally pointed, without microsetae

Head

Eyes

(3) *integument surrounding three anterior and central stemmata brown

(4) *integument around outer margin of posterior two stemmata unmarked

Appendages (antenna & labial palpus)

(5) scape with robust seta on distolateral margin

(6) tip of pedicel with relatively long, stout lateral seta

(7) terminal flagellar seta long

(8) basal segment of labial palpus with one small, dorsal seta, one medium-length, lateral seta, one long, ventral seta

(9) middle segment of labial palpus (L3) with ~five annulations, eight setae (three near apex of segment)

(10) middle segment of labial palpus (L2) with ~four annulations, six setae (three near apex of segment)

(11) distal segment of labial palpus without setae, with small rings throughout; ventral surface with two small, longitudinal sensory organs

Venter

(12) palpiger with two intermediate-length setae

(13) mentum (L3) with two pairs of long setae anteriorly below palpiger, one pair of long setae laterally above stipes, one pair of medium-length setae posteriorly

(14) mentum (L2) with two pairs of anterior setae, one pair of posterior setae

Thorax

General

(15) LTs well sclerotized, papiliform, with globose terminus

Prothorax

(16) paired lateral sclerites (Sc1) extending well onto the base of LT

(17) posteromesal sclerite (Sc2) present, marked with brown, triangular, smaller than Sc1

(18) *secondary sclerites present or absent

(19) S2Sc1 present, short

(20) primary setae S1 thorny, S2, S3 smooth or thorny, S4 short, smooth

(21) row of three small setae (R1) usually on anterolateral margin of notum (sometimes obscured beneath cervical fold)

Mesothorax

(22) Sc1 with two (L2) to three (L3) small associated setae – one mesal (S1Sc1), two lateral (S2Sc1, S3Sc1-L3 only)

(23) Sc2 with two very small associated setae, both lateral (S1Sc2, S2Sc2)

(24) *Sc3 with two associated setae – S1Sc3 short, smooth, S2Sc3 intermediate-length to long, thorny

(25) *primary setae S1, S2 smooth, short to medium-length, anterior to Sc3; S3 robust, thorny, intermediate length to long, usually located in transverse row with S2Sc3; S4 small when present, often absent

Metathorax

(26) *Sc1, Sc2, Sc3 each with pair of sclerites bearing one to two small, associated setae (S1Sc1, S2Sc1, S1Sc2, S2Sc2, S1Sc3 sometimes absent)

(27) posterior fold with ten to 16 robust, thorny R1 setae

Abdomen

(28) *A1-A5: dorsum with transverse folds spinule-covered, separated by shallow groove without spinules

(29) each fold bearing double or triple transverse band of submedian setae (SMS)

(30) A2-A7: LTs hemispherical to slightly flattened apically, with brown marks anteriorly and posteriorly (sometimes light, sometimes absent from L2)

(31) *A2-A5: LTs each with one to eight long, thorny, robust, blunt to spatulate LS apically (size, thorniness, robustness of these LS increasing posteriorly), with subapical dorsal setae long, smooth, hooked, similar to SMS

(32) A6, A7: all LS long, thorny, robust, blunt to spatulate, restricted to apical region of LT

(33) A8: LT bearing one medium-length, thorny, pointed seta (LS), one or more short, smooth LS

(34) A6, A7 with LDTs, each bearing one to two long, robust, pointed or blunt (not hooked), thorny setae (LDS) stemming from large, brown chazae, sometimes a long, smooth, hooked LDS, and three to four smaller, smooth or thorny LDS

- (35) A6, A7 with pair of short, pointed setae between LDTs
- (36) A1-A5 with patches of setae near or around each spiracle [These setae are indistinguishable in size and shape from SMS, and the patches often merge with the anterior rows of SMS. Thus, here, they are included with the SMS.]
- (37) A6, A7, A8 with single pair of small, pointed SSp