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Immature stages of *Calycopis bellera* (Hewitson) and *C. janeirica* (Felder) (Lepidoptera, Lycaenidae, Theclinae, Eumaeini): Taxonomic significance and new evidence for detritivory

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Abstract

Details of egg, larval, and pupal morphology are described and illustrated for *Calycopis bellera* (Hewitson) and *C. janeirica* (Felder), with a special emphasis on larval chaetotaxy. Wild-caught *Calycopis* females laid eggs on dead leaves in the laboratory, and the caterpillars successfully completed development on an artificial agar diet to which no leaves were added. Males and females of the sexually dimorphic *C. bellera* had been previously placed in different genera or different species groups. *Calycopis janeirica* had been chronically misidentified (and misspelled *C. jeneirica*). Males and females of this species appear to be correctly associated for the first time. Whereas *C. bellera* has five larval instars—as reported previously for *C. caulonia*—*C. janeirica* has four. Morphological characters of the immatures of *C. bellera* and *C. janeirica* are summarized in a table and compared with those of other reared *Calycopis* species.

Key words: artificial diet, chaetotaxy, life history, morphology, rearing, systematics

Introduction

Calycopis Scudder is the largest Neotropical genus of eumaeine hairstreaks (Lycaenidae: Theclinae: Eumaeini) with 64 described and ten undescribed species (Robbins 2004b). The species level taxonomy of *Calycopis*, however, is poorly resolved for two reasons. First, it is difficult to associate the sexes in many species because of sexual dimorphism (Robbins 2004a). With both male and female type specimens, species level taxonomy and nomenclature are a problem. Second, intraspecific variation has been poorly assessed (Robbins 2004a), and in at least one case, two recognized morphological species in *Calycopis* were reared from the same mother (Duarte unpubl.).

Although caterpillars of the vast majority of butterflies eat vascular plants (Ehrlich & Raven 1965), larval detritivory was proposed by S. Johnson (1985) for *Calycopis cecrops* (Fabricius) and *C. isobeon* (Butler & H. Druce), two closely related North and Central American species that may be conspecific (Field 1967a; Robbins 1994). Larval detritivory is uncommon in the Macrolepidoptera (Powell *et al.* 1998), but caterpillars of some species eat dead leaves (Hohn & Wagner 2002) while others eat fungi and algae (Rawlins 1984; Wagner *et al.* 2008). Detritivores may obtain most of their nutrition from detritus or from the micro-organisms living on detritus (e.g., Findlay & Tenore 1982; Hohn & Wagner 2002), but it is unknown which is more important in *Calycopis*.

In accord with the proposal of detritivory, females of *C. cecrops* oviposit on dead leaves on the ground (Gifford & Opler 1983), and its caterpillars are found in the leaf litter (W. Steiner pers. comm.). In the laboratory, females of *C. caulonia* (Hewitson), a species closely related to *C. cecrops* and *C. isobeon* (Field

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1967a), oviposit on dead leaves, and its caterpillars were reared using a vitamin enriched agar-based diet without the addition of plant leaves (Duarte *et al.* 2005).

We initiated a project to rear species of *Calycopis* and allied genera and to describe their immature stages (Duarte 1999, 2003; Duarte *et al.* 2005). The short term objectives are to clarify species level taxonomy, especially for sexually dimorphic groups, and to further document evidence for detritivory. The long term objective is to obtain new morphological information on immatures that can be used to infer phylogenetic relationships within *Calycopis* and eventually among the genera of the *Lamprospilus* Section (*sensu* Robbins 2004a, b; Robbins & Duarte 2004).

The primary goal of this paper is to describe and illustrate the immature stages of two sexually dimorphic detritivorous hairstreak butterflies, *Calycopis bellera* (Hewitson) and *Calycopis janeirica* (Felder) (Figs. 1, 2). Using the laboratory methods introduced in Duarte *et al.* (2005) for inducing females to oviposit and for rearing larvae, we detail the egg, larval, and pupal morphology of *C. bellera* and *C. janeirica*, and compare this morphology with that of *C. cecrops*, *C. isobeon*, and *C. caulonia*.

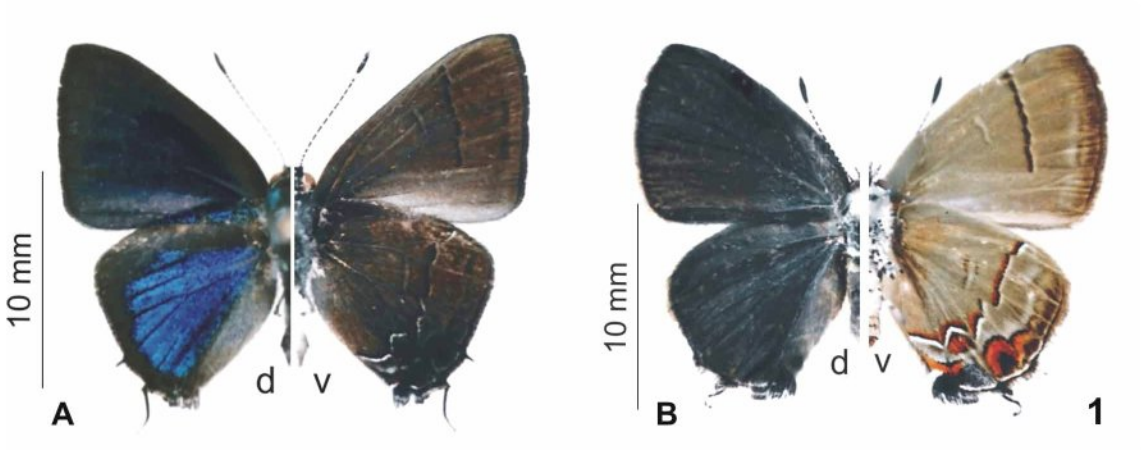


FIGURE 1. *C. bellera*, adult. A. Male. B. Female. Abbreviations: d, dorsal; v, ventral.

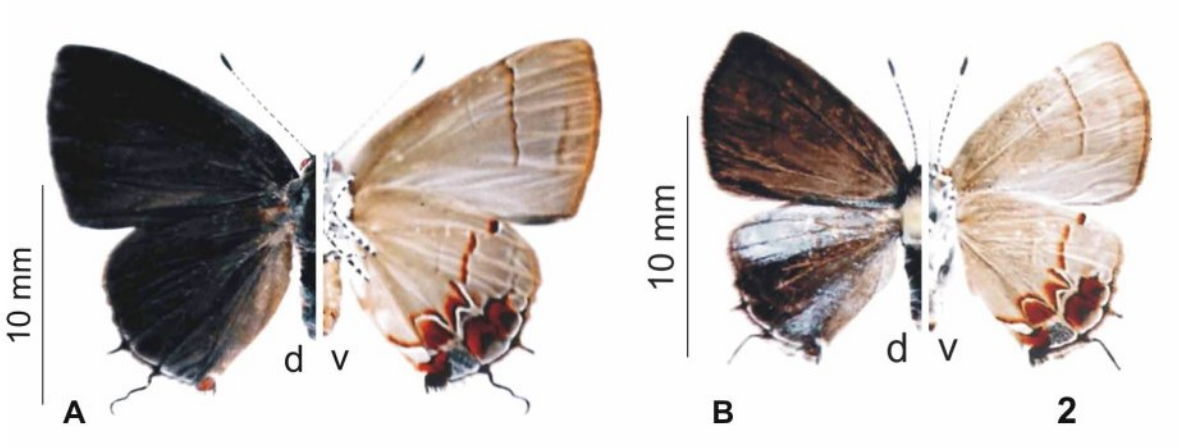


FIGURE 2. *C. janeirica*, adult. A. Male. B. Female. Abbreviations: d, dorsal; v, ventral.

Taxonomic history

Field (1967a) placed *C. bellera* (female type specimen) and *C. devia* (Möschler, 1883, male type specimen) in different species groups. Johnson (1991) put *C. bellera* in *Calycopis* and *C. devia* in *Morphissima* Johnson. Both Field (1967a) and Johnson (1991) treated *C. devia* as a subspecies of *C. xeneta* (Hewitson), but Robbins (2004b) recognized them as separate species because they are sympatric without intergradation in Panama.

Robbins (2004b) also treated *C. bellera* and *C. devia* as synonyms (associated females and males, respectively) based upon the results that are reported in this paper. *Calycopis bellera* occurs from Panama to southern Brazil in lowland forest.

Identification and spelling of the name *Thecla janeirica* Felder (unspecified number of female types) has been problematic since Hewitson (1877) synonymized the name with *Papilio beon* Stoll and misspelled it *T. jeneirica*. Field (1967a) corrected the spelling, but placed it in a species group with *C. caulonia*. This identification was uncertain, however, because he could not locate a type. Johnson (1988, 1991) followed Field's identification, but re-introduced the misspelling *C. jeneirica*. A female syntype of *Thecla janeirica* in Naturhistorisches Museum Wien (Vienna) has a lectotype label written by G. Lamas (unpublished designation). The female syntype belongs to a lineage of South American *Calycopis* species (*C. cissusa* [Hewitson] is perhaps the best known name) that are phylogenetically distinct from those species that Field (1967a) placed in *Calycopis* (Duarte & Robbins unpubl.). The type of *C. janeirica* is from Rio de Janeiro, where one species in this lineage occurs (Duarte & Robbins unpubl.), and it is the oldest name in the lineage. These facts form the basis for the identification in this paper. This species complex occurs primarily in deciduous forest and dry scrub throughout the tropical parts of South America (Duarte & Robbins unpubl.). We do not yet know how many species comprise this complex throughout South America.

Material and methods

Study site. Three females each of *C. bellera* and *C. janeirica* were collected 3–10 February 1999 in an area of Tijuca National Park (Rio de Janeiro State, southeastern Brazil, elevation ca. 50 m) known as Represa dos Ciganos, a western suburb of the city of Rio de Janeiro located at the Serra dos Pretos Forros near Cardoso Fontes Hospital, and Grajaú-Jacarepaguá and Três Rios roads. Based on specimens in the National Museum of Natural History (USNM), Washington, DC, USA, this forest was at one time a high diversity area for butterflies.

Rearing procedure and preservation of immatures. The experimental and analytical protocols detailed in Duarte *et al*. (2005) were followed with the goal of standardizing laboratory rearings of detritivorous species. The same artificial diet on which caterpillars of *C. caulonia* were reared was used with larvae of *C. bellera* and *C. janeirica* (Troetschler *et al*. 1985 modified by Duarte *et al*. 2005). Eggs, larvae and pupae were reared in a greenhouse (Curitiba, state of Paraná, Brazil) from February to April 1999 under natural conditions of temperature and humidity. Preservation of immatures follows Duarte *et al*. (2005).

Statistics. Mean, standard deviation, and number of individuals are represented by the abbreviations X, SD, and N, respectively. Means and standard deviations of development times for each immature stage, larval instar, and egg to adult interval were calculated (Zar 1984).

Setal terminology. Although Balmer & Wright (2008) recently proposed a new terminology for some thoracic setae in Lycaenidae, comparative studies are few, and it may be premature to recognize a new nomenclature for setal homologies. For this reason, we continue to use the setal nomenclature in Hinton (1946) and Stehr (1987).

Microscopy. See Duarte *et al*. (2001, 2005).

Vouchers. Five voucher specimens of each immature stage of each species are deposited in the Coleção de Lepidoptera, Museu de Zoologia, Universidade de São Paulo, Brazil (MZUSP). The mothers and their adult offspring are deposited at MZUSP, with a male and female of each species also deposited at USNM.

Description of the immature stages. The immature stages of *C. bellera* and *C. janeirica* are described separately below and compared with each other. Morphological comparisons with *C. caulonia* refer to the results in Duarte *et al*. (2005) and with *C. isobeon* and *C. cecrops* to those in Rawson & Hessel (1951) and Downey & Allyn (1981, 1984).

Description of the immature stages

Calycopis bellera (Hewitson, 1877) (Figs. 3–38)

Egg (Figs. 3, 4, 19–24). Immediately following oviposition, egg with blue tint, but whitening as embryo develops; exochorion always whitish. Similar to *C. caulonia*, *C. cecrops*, and *C. isobeon*. Differing from *C. caulonia* in having only three or four micropylar openings and no chorionic thickenings or "islands" protruding from floor of rosette cells (Fig. 21). Exochorion sculptured with pentagonal and hexagonal cells outlined by intersected carinate ribs (Fig. 22). Aeropyles opening on top of elongate spinelike protuberances (Figs. 23, 24). First instar may eat the chorion partially or entirely (Fig. 4).

Diameter 0.76–0.86 mm (X = 0.81 mm, SD = 0.03, N = 39); height 0.40–0.50 mm (X = 0.43 mm, SD = 0.03, N = 30). Duration 6–11 days (X = 8.89 days, SD = 1.59, N = 62).

First instar (Figs. 5, 6, 25–29, 31, 32). Superficially similar to other *Calycopis* species previously described. Head sub-quadrangular, hypognathous, uniform pale brown, with or without darker maculae; smooth surface, with prominent hyaline setae (*sensu* Ballmer & Pratt 1988) of different sizes (see details on larval chaetotaxy below). Length of frontoclypeus about five times length of epicranial suture (Fig. 25). Anteclypeus membranous. Labrum and mandibles light brown. Mandibles with cutting edge dark brown, with six teeth; differing from *C. caulonia* by absence of tooth on oral surface (Fig. 29; Duarte *et al.* 2005: 16, fig. 16); two mandibular setae, one nearer condyle about two times length of other (we do not know yet if mandible morphology of detritivores differs significantly from that of regular folivores). Six blackish stemmata on each side of head positioned as follows: stemmata 1–5 in semicircle; stemma 5 nearer base of antenna; stemma 6 horizontally aligned with stemma 2 (Fig. 26). Body onisciform (Figs. 5, 6), translucent yellowish-brown at emergence, translucent yellow after feeding on artificial diet; three vivid red longitudinal stripes from mesothorax to last abdominal segment, infrequently paler on dorsal, supra-, and subspiracular areas; subspiracular stripe on seventh abdominal segment deflecting ventrally to base of proleg of tenth abdominal segment. Integument corrugated, numerous crenulations covering outer surface except ventrally. Segments A3–A6 and A10 characterized by a pair of prolegs with uniordinal crochets in uniserial mesoseries, interrupted near center by conspicuous fleshy pad; two anterior and two posterior crochets on segments A3–A6 (Fig. 31); segment A10 with three crochets, two anterior and one posterior (Fig. 32).

Head capsule width 0.28–0.32 mm (X = 0.31 mm, SD = 0.02, N = 30). Body length 1.9–2.6 mm (X = 2.12 mm, SD = 0.16, N = 30). Duration 4–10 days (X = 6.28 days, SD = 1.47, N = 61).

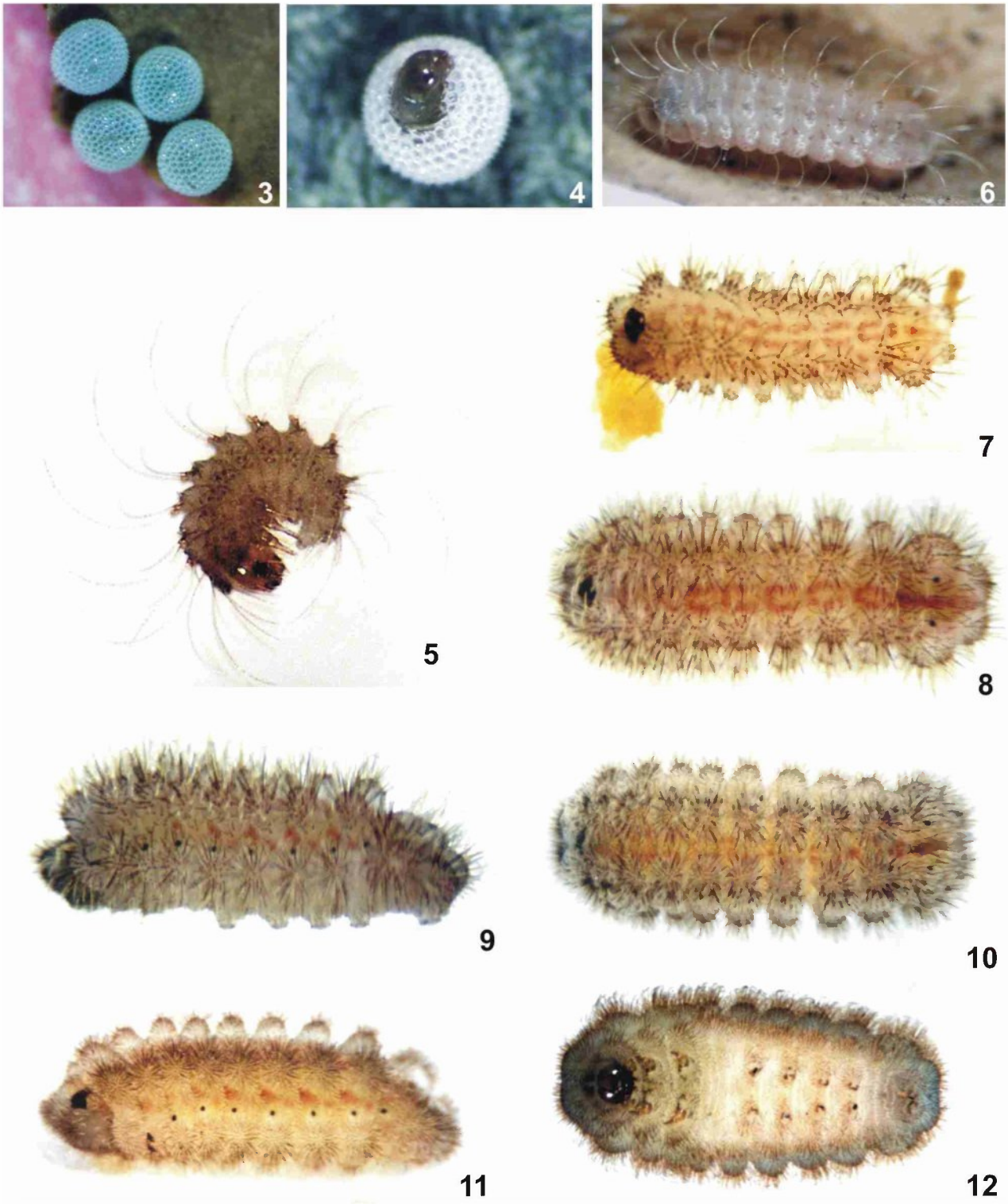
Head chaetotaxy (Figs. 25, 26). Excluding labrum (described separately below), 16 pairs of tactile and microscopic setae and 12 pairs of pores, distributed in groups adfrontal (AF), anterior (A), cephalo-dorsal (CD), clypeal (C), frontal (F), lateral (L), microgenal (MG), posteriodorsal (P), stemmatal (S), and substemmatal (SS). Setae AF2, CD3, F1, F2, L1, and P2 absent in *C. bellera*. Differs from that of *C. caulonia* in the following: A1 about two fifths length of A2; with third anterior seta, A3, the shortest of the group, dorsal of stemma 1; CD group comprising only two setae, CD1 and CD2; S3 posterior and ventral to stemma 6; pore Sa aligned with and ventral of S3; all SS setae equal in size.

Labrum chaetotaxy. Identical to that of *C. caulonia* (see Duarte *et al.* 2005: 12, fig. 29).

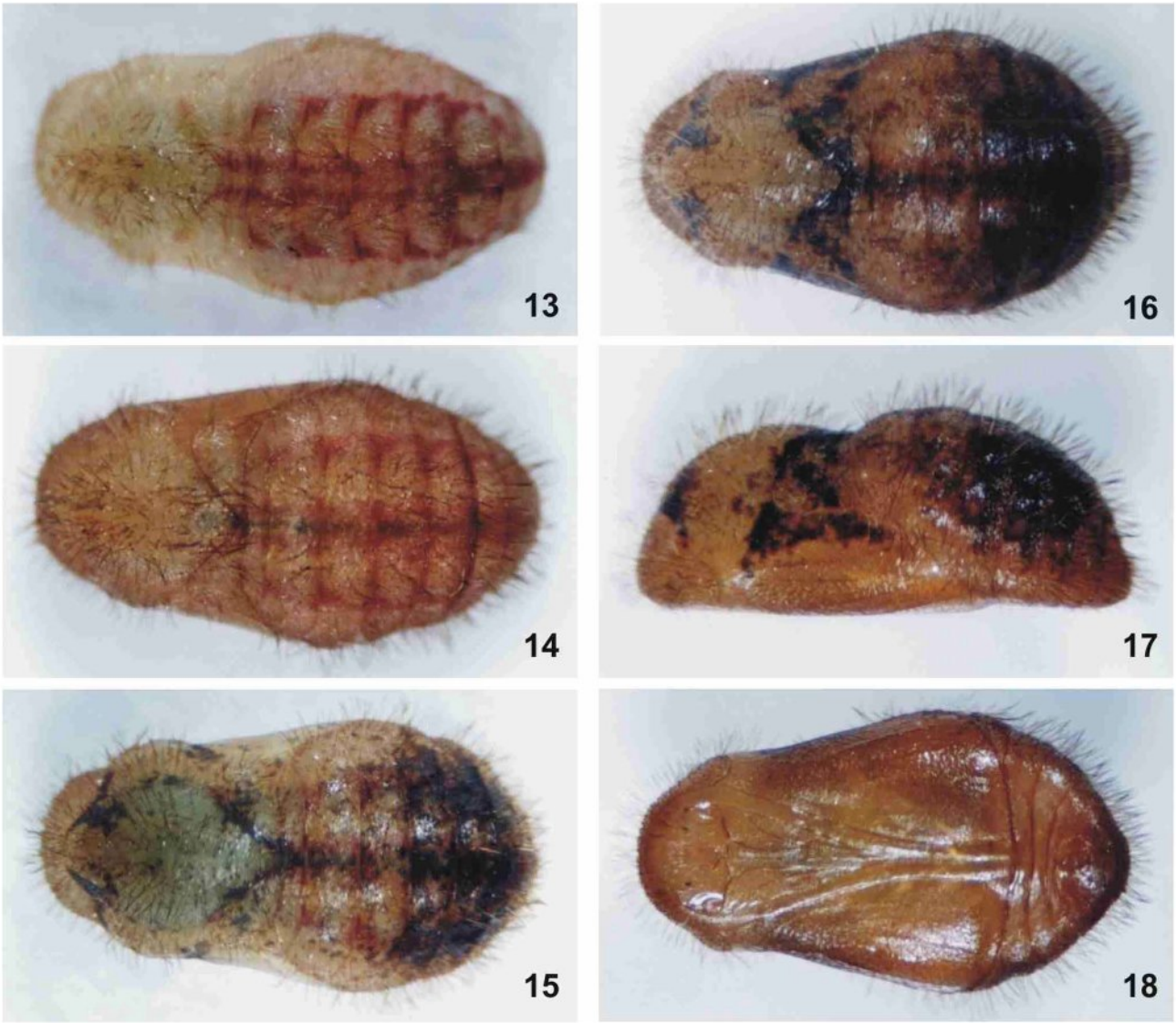
Body chaetotaxy (Fig. 27). With 128 pairs of primary setae and 22 pairs of pore cupola organs (PCOs) in the groups dorsal (D), lateral (L), microscopic dorsal (MD), microscopic subdorsal (MSD), paraproctal (PP), subdorsal (SD), ventral (V), and XD (considered "a special group developed only on the anterior margin of the prothoracic plate" by Hinton (1946: 19), and according to Stehr (1987), it should not be considered an extra seta of dorsal group), distributed as follows:

Prothorax (Fig. 27). Identical to that of *C. caulonia* first instar (see Duarte *et al.* 2005: 13, figs. 30, 32). The term "fringe group" (F1, F2, F3) proposed by Ballmer & Wright (2008) for those setae located anteriorly and laterally to the dorsal shield on T1, which Duarte *et al.* (2005) treated as MSD1(?), MSD2(?) and L1, has not been adopted in the present study because the alternative terminology of Ballmer & Wright (2008) requires further comparative studies to resolve unambiguously problems of setal homology.

Mesothorax (Fig. 27). Differing from *C. caulonia* in having MD1 much shorter, about a tenth length of D1. Duarte *et al.* (2005) referred to the seta anterior and/or dorsal to a subdorsal pore cupola organ (SDL) as MD1. With regard to the mesothorax, this interpretation is identical to that of Ballmer & Wright (2008), but in opposition to these authors, we did not observe extra subprimary dorsal setae associated with D1 and D2 on this or the following segments.



FIGURES 3–12. *C. bellera*, egg and larva. 3. Newly laid eggs, dorsal view. 4. First instar leaving the chorion. 5. Newly hatched larva lateral view. 6. First instar after feeding on artificial diet. 7. Second instar larva, dorsal view. 8. Third instar larva, dorsal view. 9. Fourth instar larva, lateral view. 10. Fifth instar larva, dorsal view. 11. Fifth instar larva, lateral view. 12. Fifth instar larva, preparing to pupate, ventral view.



FIGURES 13–18. *C. bellera*, pupa. 13. Immediately after molting, dorsal view. 14. After two hours, dorsal view. 15. After 24 hours, dorsal view. 16. Darkened individual, dorsal view. 17. Idem, lateral view. 18. Idem, ventral view.

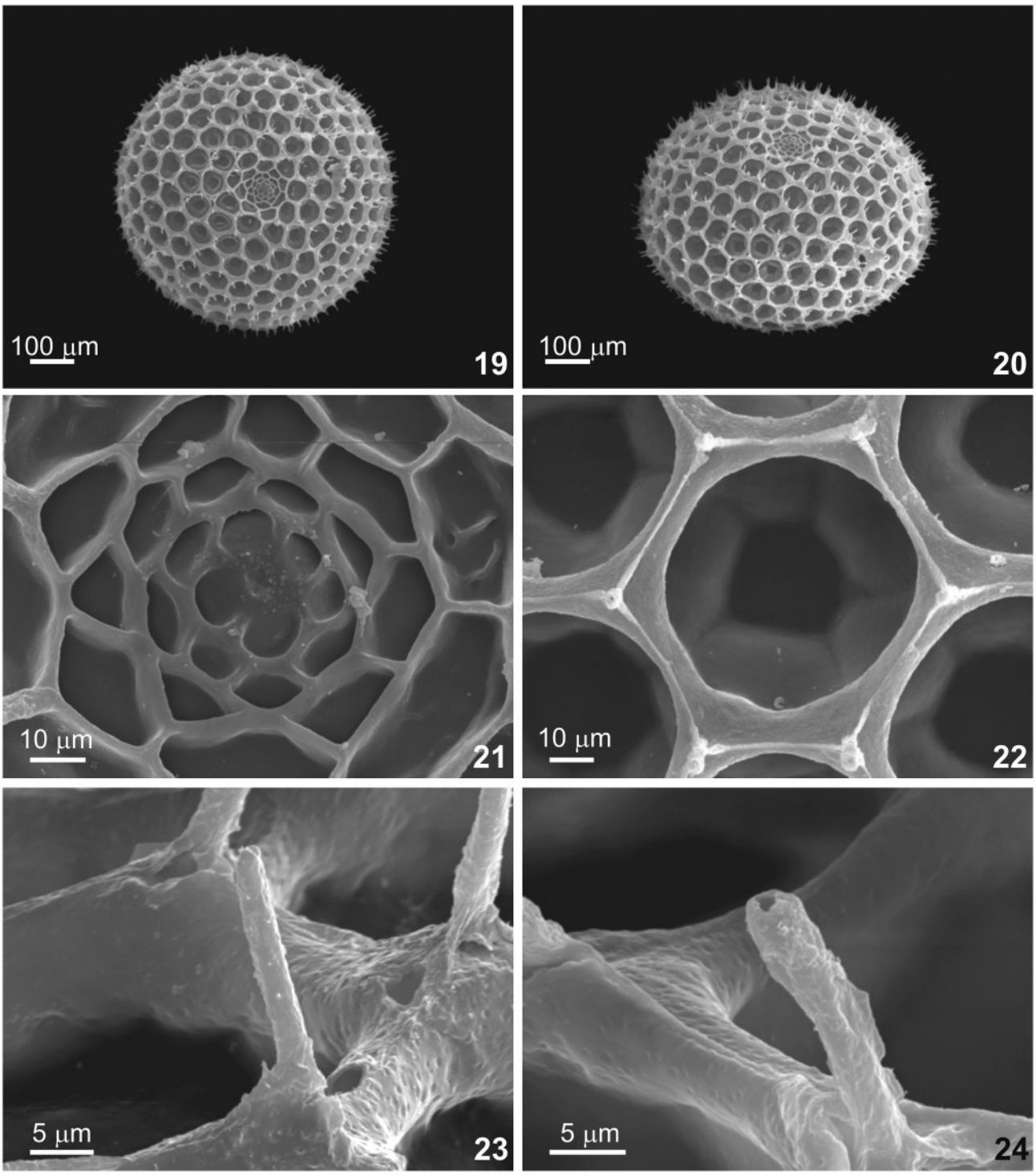
Metathorax (Fig. 27). Identical to that of *C. caulonia* first instar (see Duarte *et al*. 2005: 15, fig. 30), including conspicuous subdorsal pore cupola organ (SDL) almost half the width of metathorax in both species.

Abdominal segment 1 (Fig. 27). Same number of setae as in *C. caulonia* first instar, but with subventral PCOs lacking (SVL of Ballmer & Pratt 1992). We follow Hinton (1946) and use the term SD1 for the tactile seta anterior or antero-dorsal to the spiracle even though in recent works the same seta has been termed MSD1 referring to its ambiguous proprioceptor property (Hassenfuss & Kristensen 2003, Ballmer & Pratt 2008). In both *C. bellera* and *C. janeirica*, SD1 is associated with a subdorsal PCO (SDL).

Abdominal segment 2 (Fig. 27). Identical to that of *C. caulonia* first instar (see Duarte *et al*. 2005: 15, fig. 30).

Abdominal segments 3-6 (Fig. 27). Distinguished from those of *C. caulonia* first instar by absence of V2 (see Duarte *et al*. 2005: 15, fig. 30).

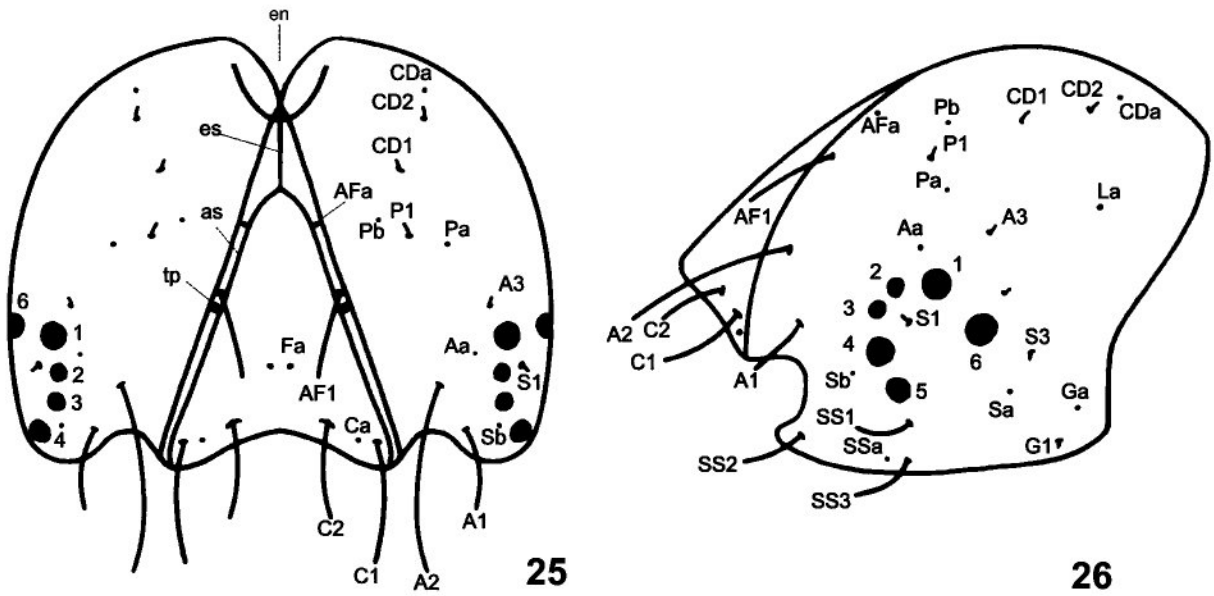
Abdominal segment 7 (Fig. 27). Like *C. cecrops*, *C. isobeon* and *C. caulonia*, with a dorsal PCO (DL of Ballmer & Pratt 1992) joined to chalaza of D1. Differs from *C. caulonia* first instar by presence of a subventral PCO associated with SV1.



FIGURES 19–24. *C. bellera*, scanning electron microscopy of egg. 19. Dorsal view. 20. Dorso-lateral view. 21. Micropylar area (rosette with four cells). 22. Cup-shaped cell of the exochorion. 23. Spine-like protuberance (=tubercle) arising from intersected ribs of the exochorion. 24. Aeropyle on top of tubercle.

Abdominal segment 8 (Fig. 27). Differing from *C. caulonia* in having L3 much shorter, approximately half the length of L2.

Abdominal segments 9+10 (Fig. 27). Setal homologies for A9 and A10 are not yet well resolved and should be considered provisional (see also Ballmer & Wright 2008). Differing from *C. caulonia* by lacking SD2 and a pore cupola organ anteriorly associated with suranal shield, and by presence of V1 on A9. Length and position of setae similar to those of *C. caulonia*.



FIGURES 25–26. *C. bellera*, head chaetotaxy of first instar. 25. Anterior view. 26. Lateral view. Abbreviations (see text for setal nomenclature): as, adfrontal suture; en, epicranial notch; es, epicranial suture; tp, tentorial pit.

Second instar (Figs. 7, 30, 33, 34). Head translucent, turning dark brown after a few minutes; stemmata blackish. Primary setae with same distribution and size patterns of first instar, including those of labrum. Secondary setae present. Mandibles with seven teeth, six visible externally, one located internally (Fig. 30); same number of setae as first instar. Integument yellowish dorso-laterally, whitish ventrally, with two reddish longitudinal stripes extending from mesothorax to last abdominal segment: one stripe located mesodorsally; the other stripe paler and located dorsal to spiracle, consisting of oblique lines converging to base of anal proleg. Integument with brown, spiculate secondary setae, supported by conical chalazas radially distributed in nipplelike dorsal and subspiracular processes (Fig. 7). Dentritic setae (see also Duarte *et al.* 2005: 17, fig. 53) interspersed with spiculate setae on this and later instars. Dendritic setae also present in *C. caulonia* (Hewitson), *C. isobeon* (Butler & Druce), and *C. vitruvia* (Hewitson) (Duarte *et al.*, 2005; Duarte, unpubl.). These species along with *C. bellera* and 15 other *Calycopis* species (*C. cecrops* (Fabricius), *C. bactra* (Hewitson, 1877), *C. lerbela* Field, 1967, *C. nicolayi* Field, 1967, *C. xeneta* (Hewitson, 1877), *C. centoripa* (Hewitson, 1868), *C. thama* (Hewitson, 1877), *C. torqueor* (H. H. Druce, 1907), *C. vibulena* (Hewitson, 1877), *C. origo* (Godman & Salvin, 1887), *C. partunda* (Hewitson, 1877), *C. indigo* (H. H. Druce, 1907), *C. anfracta* (H. H. Druce, 1907), *C. anastasia* Field, 1967, and *C. fractunda* Field, 1967) have been considered to constitute a natural group supported by male genitalic characters (Duarte & Robbins in preparation). Other characteristics identical to *C. caulonia*: prothorax wider and shorter than other thoracic segments; prothoracic shield trapezoidal, longer than wide, rounded anteriorly, number and position of setae and pore cupola organs variable; integument highly sculptured and distinctive, with uniformly-spaced oval depressions over epicuticular surface; pattern of oval depression similar in remaining instars; prolegs with uniordinal crochets in uniserial mesoseries, interrupted near center by a conspicuous fleshy pad (Figs. 33, 34), separating the crochets into anterior and posterior groups.

Head capsule width 0.44–0.48 mm (X = 0.46 mm, SD = 0.02; N = 30). Body length 2.88–4.68 mm (X = 3.72 mm, SD = 0.58, N = 30). Duration 4–7 days (X = 5.15 days, SD = 0.66, N = 60).

Third instar (Figs. 8, 35, 36). Similar to previous instar. Differing superficially in having a greater number of spiculate and dendritic setae covering most of larval body, conferring a darker color pattern to it. Prothoracic shield and prolegs identical to those of *C. caulonia* (Duarte *et al.* 2005: 19, figs. 33, 57).

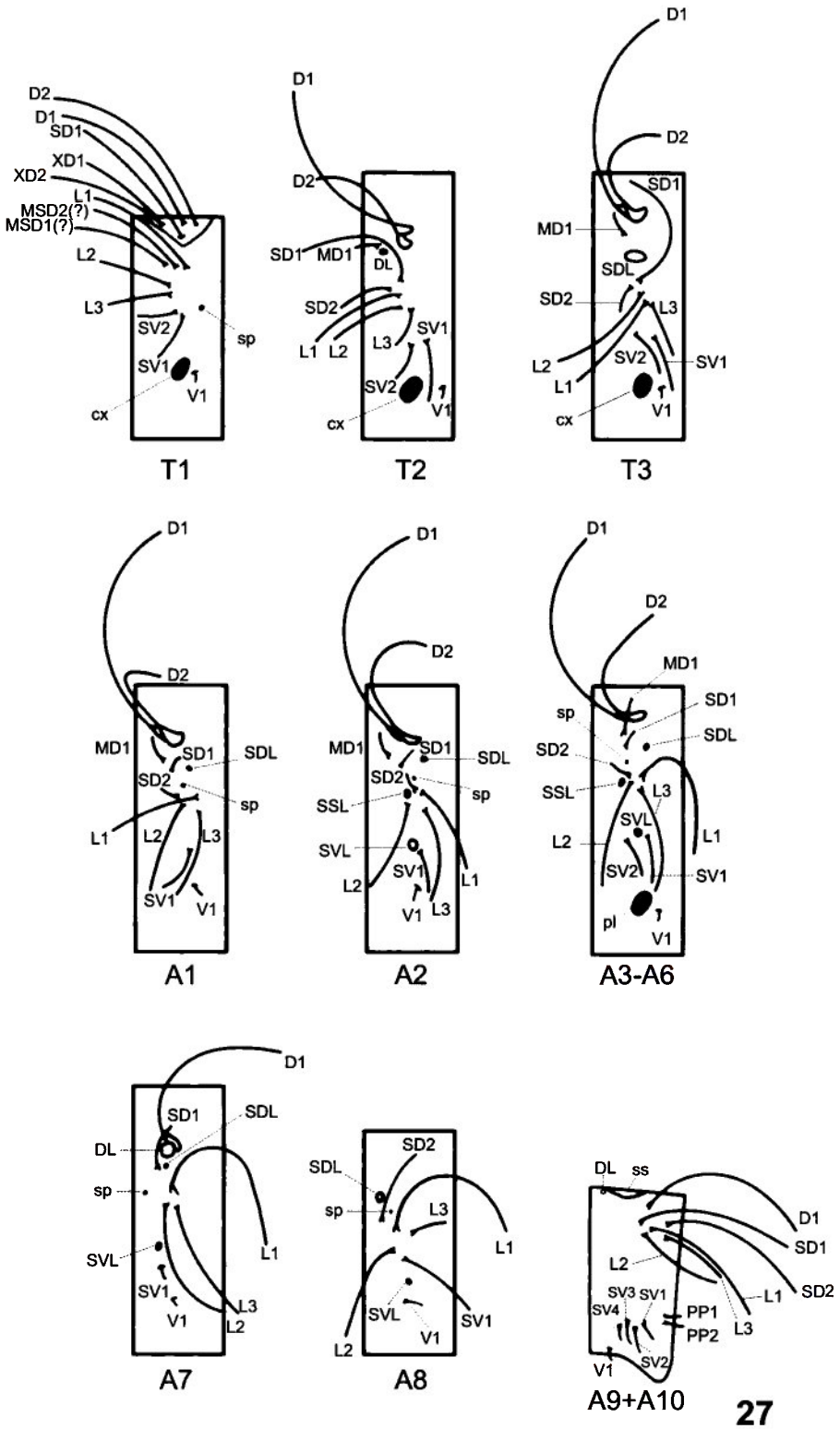


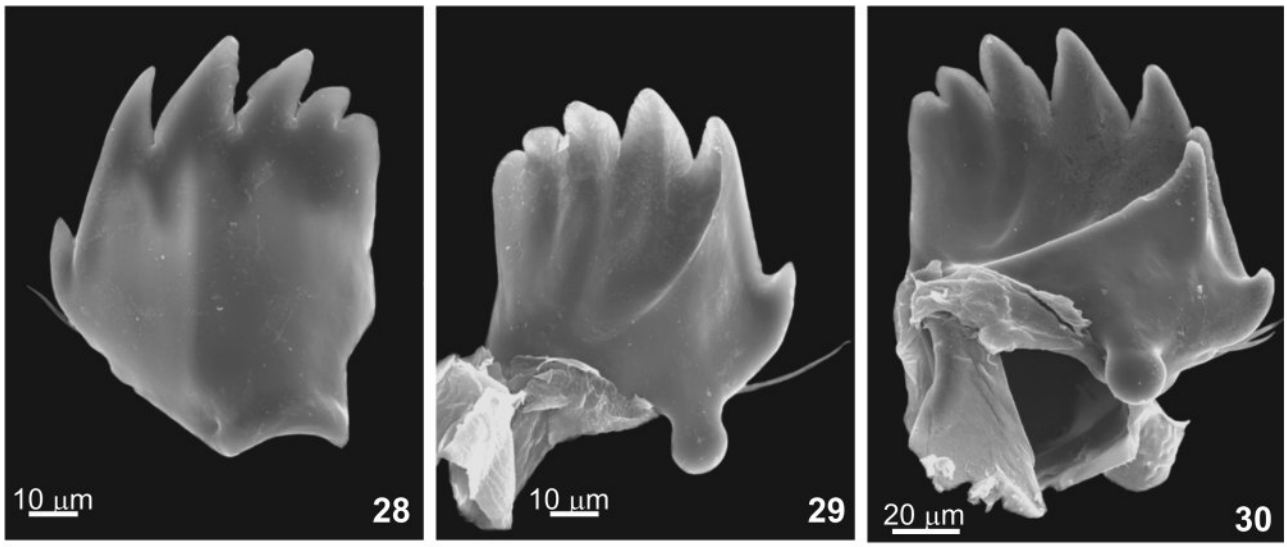
FIGURE 27. *C. bellera*, body chaetotaxy of first instar. Dorso-lateral view. Abbreviations (see text for setal nomenclature): A, abdominal segment; cx, coxa; pl, proleg; sp, spiracle; ss, suranal shield; T, thoracic segment.

Head capsule width 0.52–0.76 mm (X = 0.64 mm, SD = 0.06; N = 30). Maximum body length 9.20 mm (X = 8.64 mm, SD = 0.68, N = 30). Duration 5–9 days (X = 6.43 days, SD = 0.96, N = 60).

Fourth instar (Figs. 9, 37, 38). Similar to third instar, but greater number of spiculate and dendritic setae (Fig. 9). As in *C. caulonia*, mandibles with three setae rather than two. Integument yellowish, but darker than

in previous instar due to abundance of setae covering larval body; longitudinal stripes conspicuous, similarly positioned as second instar larva. Other morphological characteristics not differing from that described for *C. caulonia*.

Head capsule width 0.92–1.12 mm (X = 0.97 mm, SD = 0.06; N = 30). Maximum body length 12.64 mm (X = 11.68 mm, SD = 0.96, N = 10). Duration 4–10 days (X = 6.66 days, SD = 1.48, N = 56).



FIGURES 28–30. *C. bellera*, scanning electron microscopy of larva (left mandible). 28. First instar, external view. 29. Idem, internal view. 30. Second instar, internal view.

Fifth instar (Figs. 10–12). Color pattern and shape of head, labrum, and mandibles similar to previous instar. Greater number of secondary setae, concentrated on antero-medial region of frontoclypeus. Ground color of integument yellowish or greenish (Figs 10–12). Prolegs identical to previous instar, except for number of crochets, but with same distribution and arrangement. Other morphological characteristics as described for *C. caulonia*. Mature larvae of *C. bellera* also lack a dorsal nectar organ. However, as with other non-myrmecophilous lycaenid larvae, they possess PCOs, which are hypothesized to release substances that deter aggression in ants. Larvae of *Calycopis* have not been reported being tended by ants either in the laboratory or in nature, as in some eumaeines (Pierce *et al*. 2002). In addition to PCOs, we also found specialized setae (dendritic setae of Ballmer & Pratt 1988) considered to be important in maintaining communication between larvae and ants (see Fiedler 1991; Pierce *et al*. 2002).

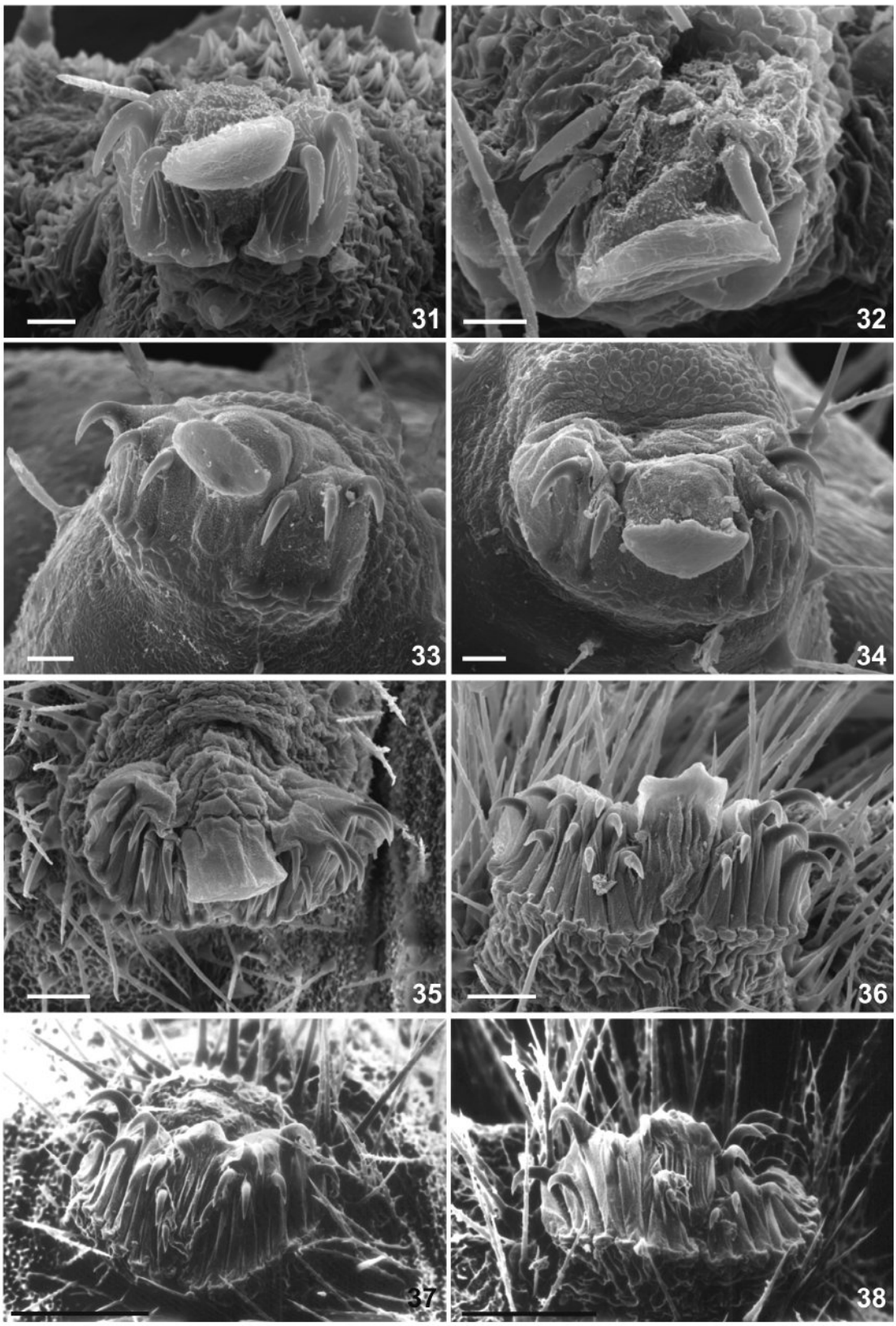
Head capsule width 1.28–1.44 mm (X = 1.38 mm, SD = 0.06; N = 30). Maximum body length 17.60 mm (X = 14.25 mm, SD = 1.98, N = 30). Duration 6–20 days (X = 12.21 days, SD = 2.80, N = 53).

Pupa (Figs. 13–18). Identical to that of *C. caulonia*. Head and thorax initially translucent light green (Fig. 13). Abdomen dorsally with vivid red maculae extending laterally, but not reaching spiracles (Fig. 13). Integument darkening gradually in some individuals (Figs. 14–18). Dark brown maculae scattered on dorsal and lateral body, densely covered with small golden, prominent setae.

Pupal width on metathorax 3.0–4.0 mm (X = 3.2 mm, SD = 0.3, N = 30), on segment A3 4.0–6.0 mm (X = 4.8 mm, SD = 0.4, N = 30). Pupal length 7.9–11.1 mm (X = 9.0 mm, SD = 0.8, N = 30). Duration 11–17 days (X = 12.56 days, SD = 1.16, N = 41).

Larval development on artificial diet. All five larval instars fed on artificial diet, which supported complete development, as in *C. caulonia*. Data on development times from egg to adult are summarized in Table 1. Females of *C. bellera* emerged from pupae as adults earlier on average (X = 55.28 days, SD = 4.21, N = 25) than males (X = 59.13 days, SD = 3.69, N = 16).

Cannibalism. When confined in containers, cannibalism among mature larvae was frequent as it was in *C. caulonia*. Cannibalistic behavior is likely to be widespread in the genus.



FIGURES 31–38. *C. bellera*, scanning electron microscopy of larva (prolegs). 31. First instar, left proleg of third abdominal segment (uniordinal crochets in uniserial mesoseries). 32. Idem, left proleg of last abdominal segment. 33. Second instar, left proleg of third abdominal segment. 34. Idem, left proleg of last abdominal segment. 35. Third instar, left proleg of third abdominal segment. 36. Idem, left proleg of last abdominal segment. 37. Fourth instar, left proleg of third abdominal segment. 38. Idem, left proleg of last abdominal segment.

TABLE 1. Life cycle of *C. bellera* and *C. janeirica* in laboratory (from egg to adult).

Species	Interval	Duration (days) X	SD	Range (days)	N
C. bellera	Egg to adult	56.78	4.40	50–68	41
	Egg to male	59.13	3.69	55–68	16
	Egg to female	55.28	4.21	50–66	25
C. janeirica	Egg to adult	51.48	2.17	47–55	46
	Egg to male	52.39	1.71	49–55	28
	Egg to female	50.06	2.07	47–53	18

Taxonomy. Reared females (Fig. 1b) match the female lectotype of *Thecla bellera* deposited in the Natural History Museum (London), which was designated by Field (1967a). The dorsal surface is brown without shining blue scales, which differentiates this species from related *Calycopis* species. Reared males (Fig. 1a) match the male holotype of *Thecla devia* deposited in Museum für Naturkunde der Humboldt-Universität (Berlin), which has a 1994 red holotype label added by G. Lamas. The ventral hindwing cubital spot is brown/black and the ventral wings lack central dark patches, which differentiates this species from other related *Calycopis* species (Field 1967a). The male associated with the female in Field (1967a) has an orange-red cubital spot on the ventral hindwing and is a different species, but we are uncertain which species it represents.

Calycopis janeirica (Felder, [1863]) (Figs. 39–83)

Egg (Figs. 39, 40, 60–65). With regard to color pattern, shape, and chorionic ornamentation, the egg of *C. janeirica* looks like the eggs of *C. bellera*, *C. caulonia*, *C. cecrops*, and *C. isobeon*. Chorionic "islands" (*sensu* Downey & Allyn 1981) protrude from floor of rosette cells. There are three micropylar openings in *C. janeirica* (Fig. 62), six in *C. caulonia*, and three or four in *C. bellera*.

Diameter 0.72–0.80 mm (X = 0.78 mm, SD = 0.02, N = 35); height 0.40–0.52 mm (X = 0.43 mm, SD = 0.03, N = 35). Duration 6–11 days (X = 9.14 days, SD = 1.01, N = 55).

First instar (Figs. 41–44, 66–71, 75, 76). Morphologically similar to that of *C. bellera* and *C. caulonia*, but distinguished by the presence of whitish maculae at base of dorsal and lateral setae (Fig. 42). Mandibles of first instar of *C. janeirica* resemble those of *C. bellera* with six teeth and no tooth on oral surface (Figs. 69, 70).

Head capsule width 0.24–0.32 mm (X = 0.28 mm, SD = 0.03, N = 35). Body length ranging from 1.20 mm to 3.52 mm (X = 2.33 mm, SD = 0.85, N = 30). Duration 4–8 days (X = 6.05 days, SD = 0.80, N = 55).

Head chaetotaxy (Figs. 66, 67). Same number of primary setae and pores as *C. bellera* and *C. caulonia*, and as in *C. bellera*, setae AF2, CD3, F1, F2, L1, and P2 are absent in *C. janeirica*. A1, A2, AF1, C1, and C2 usually shorter than those of *C. bellera* (Fig. 66), but size of setae vary intra- and interspecifically (Duarte *et al*. 2005).

Labrum chaetotaxy. Identical to that of *C. caulonia* (Duarte *et al*. 2005: 12, fig. 29) and *C. bellera*.

Body chaetotaxy (Fig. 68). Same number of primary setae and pore cupola organs as in *C. bellera* (this paper), distributed as follows:

Prothorax (Fig. 68). Identical to that of *C. bellera* and *C. caulonia* first instar (see Duarte *et al*. 2005: 13, figs. 30, 32).

Mesothorax (Fig. 68). Identical to that of *C. bellera* and differing from *C. caulonia* in having MD1 much shorter, about a tenth length of D1.

Metathorax (Fig. 68). Identical to that of *C. bellera* and *C. caulonia* first instar (see Duarte *et al*. 2005: 12, 15, fig. 30), including a conspicuous subdorsal pore cupola organ (SDL) of almost half the width of metathorax in all species.

Abdominal segment 1 (Fig. 68). As in *C. bellera*, with 10 pairs of setae and one pair of subdorsal PCOs (SDL of Ballmer & Pratt 1992). D2 slightly shorter than D1. Unlike *C. caulonia*, subventral PCOs (SVL of Ballmer & Pratt 1992) are lacking in *C. janeirica* as well as in *C. bellera*.

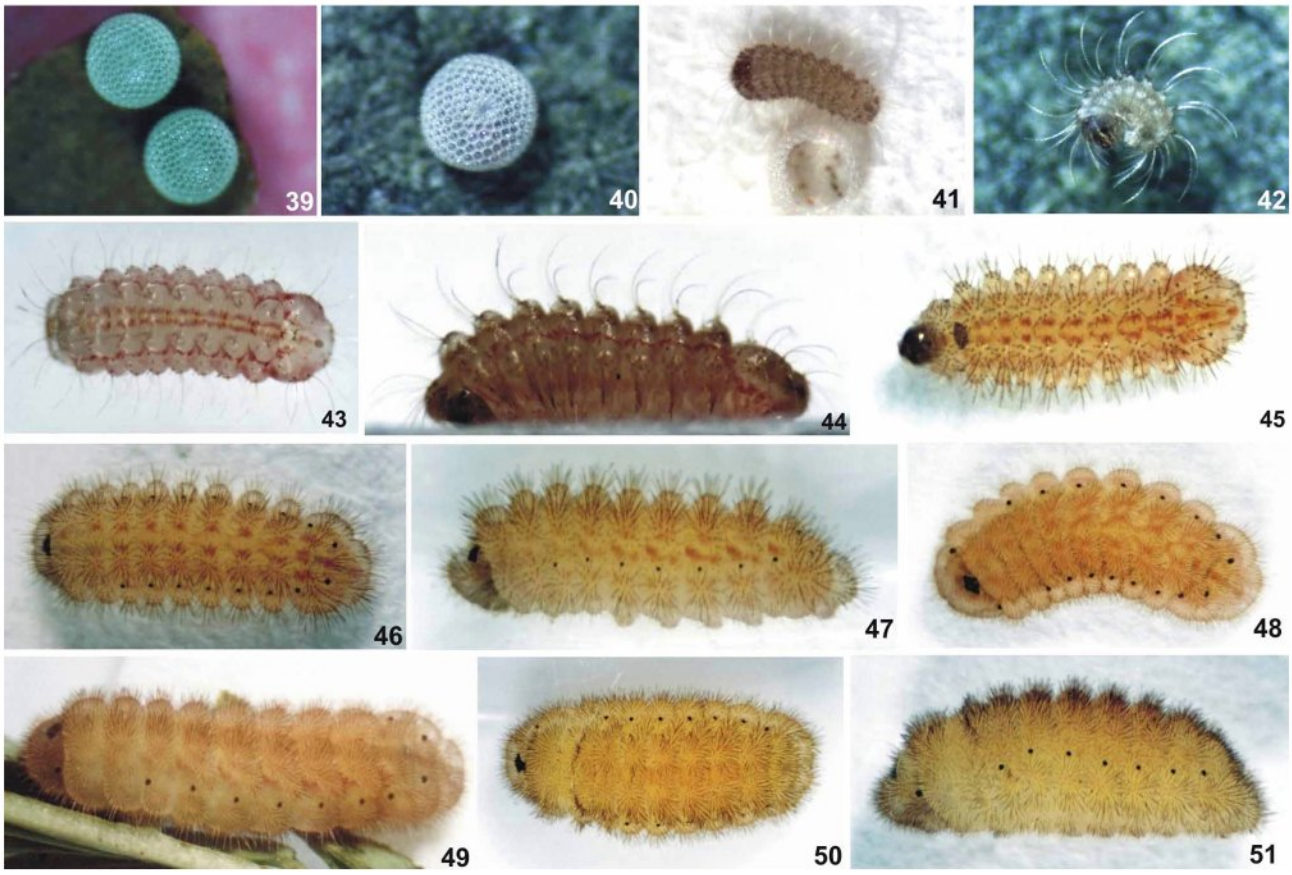
Abdominal segment 2 (Fig. 68). Similar to that of *C. bellera* and *C. caulonia* (Duarte *et al*. 2005: 15, fig. 30). D1 and D2 as in previous abdominal segment.

Abdominal segments 3–6 (Fig. 68). Identical to those of *C. bellera,* but missing a pair of subdorsal PCOs on each segment (SDL of Ballmer & Pratt 1992). Distinguished from those of *C. caulonia* first instar by absence of V2 (Duarte *et al*. 2005: 12, 15, fig. 30).

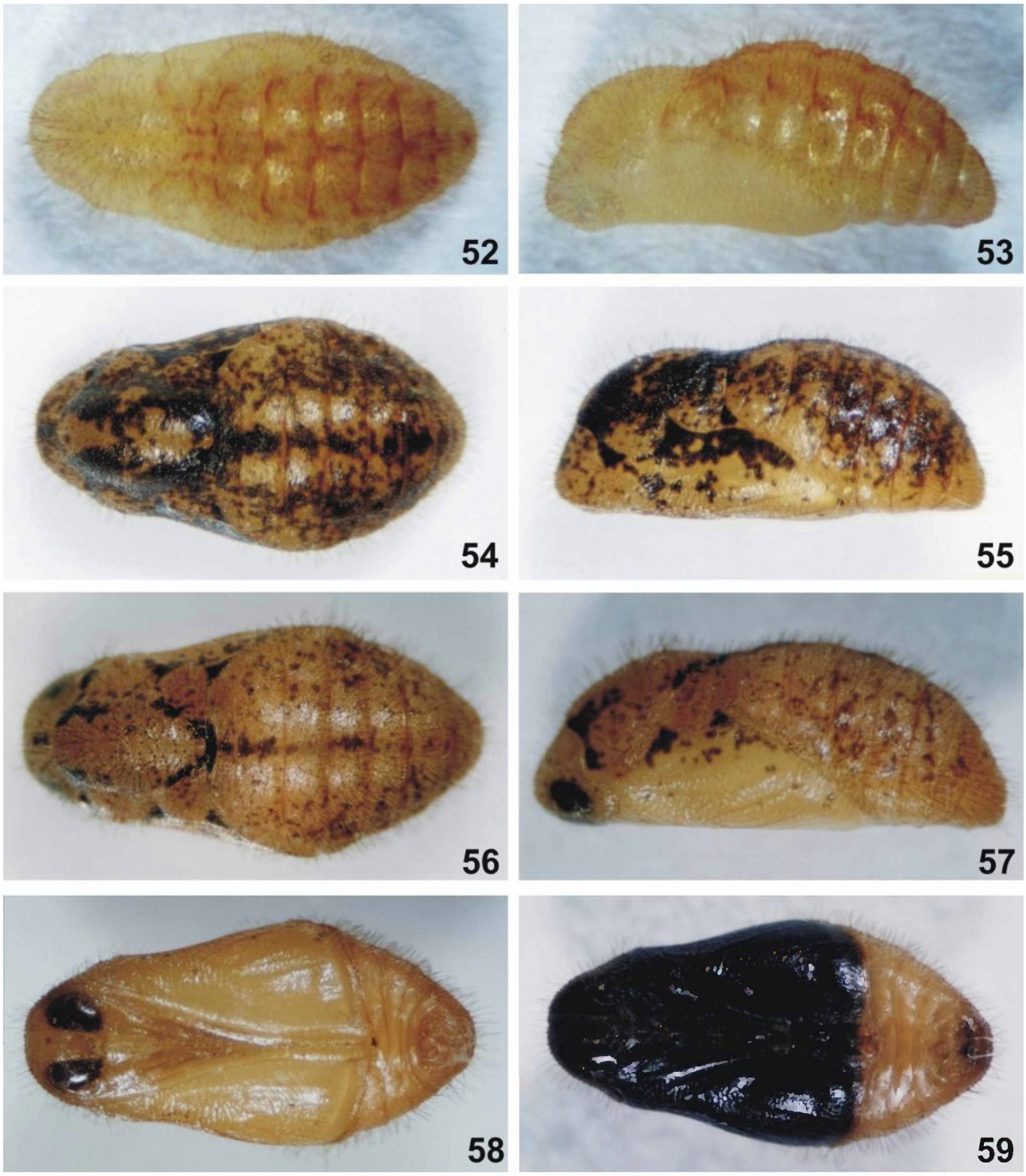
Abdominal segment 7 (Fig. 68). As in *C. bellera*, *C. cecrops*, *C. isobeon* and *C. caulonia*, with a dorsal PCO (DL of Ballmer & Pratt 1992) joined to chalaza of D1. Differs from *C. bellera* by lacking SV1 and subventral PCOs (SVL of Ballmer & Pratt 1992). These PCOs also absent in first instar of *C. caulonia* (Duarte *et al*. 2005: 12, 15, fig. 30).

Abdominal segment 8 (Fig. 68). Differs from *C. bellera* in having L3 almost as long as L2; SV1 much shorter, nearly equal to length of V1 as in *C. caulonia*. Unlike both *C. bellera* and *C. caulonia*, subventral PCOs missing.

Abdominal segments 9+10 (Fig. 68). Differs from *C. bellera* by the presence of SD2 on ninth segment. Differs from first instar of other *Calycopis* with chaetotaxy available by presence of SV1 on A9. Length and position of setae similar to those of *C. caulonia*.



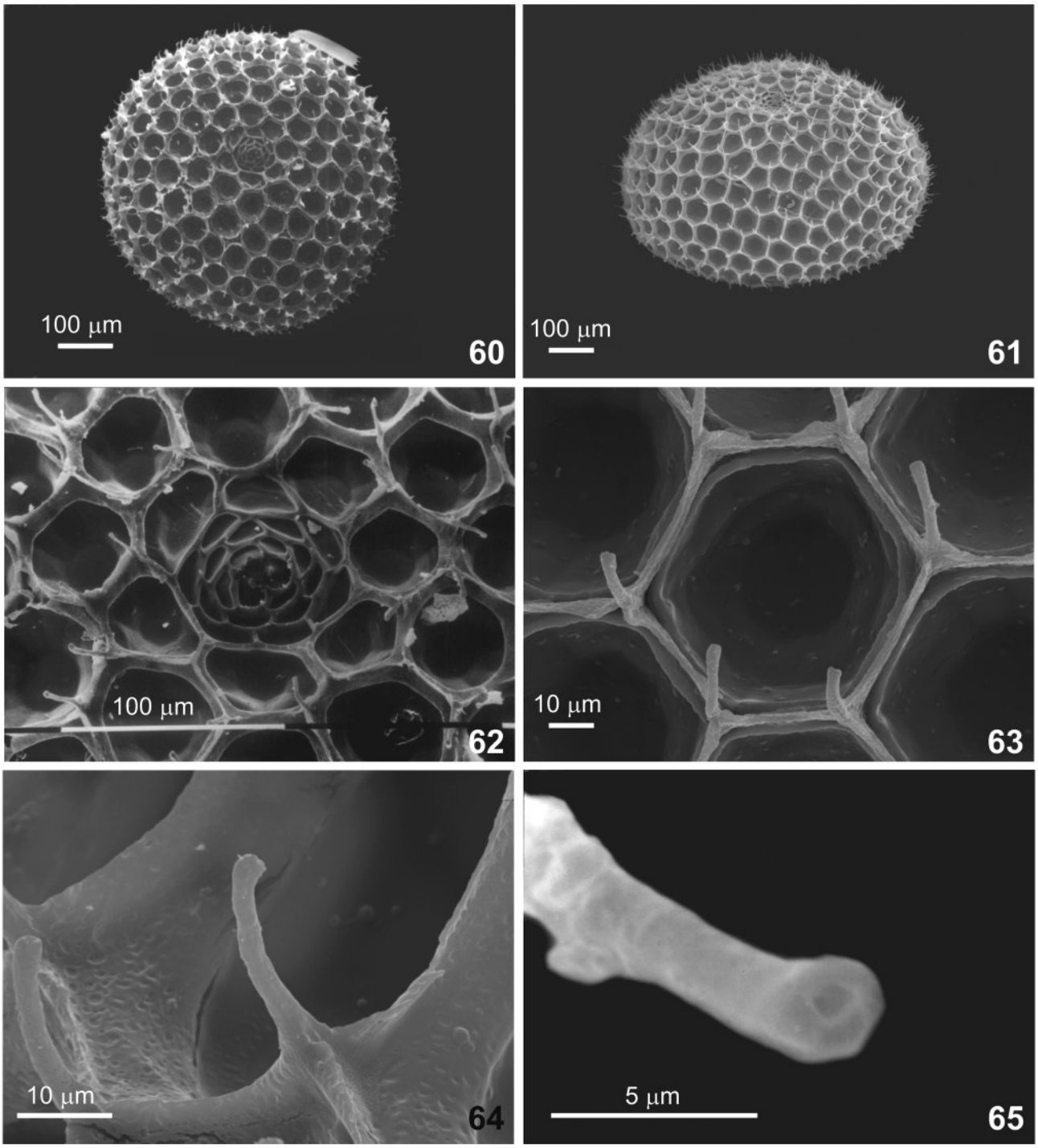
FIGURES 39–51. *C. janeirica*, egg and larva. 39. Newly laid eggs, dorsal view. 40. Mature egg, dorsal view. 41. Newly hatched larva lateral, dorsal view. 42. Idem, lateral view. 43. First instar after feeding on artificial diet, dorsal view. 44. First instar preparing to molting, lateral view. 45. Second instar, dorsal view. 46. Third instar, dorsal view. 47. Idem, lateral view. 48. Fourth instar, dorsal view. 49. Idem, dorso-lateral view. 50. Idem, preparing to pupate, dorso-lateral view. 51. Idem, lateral view.



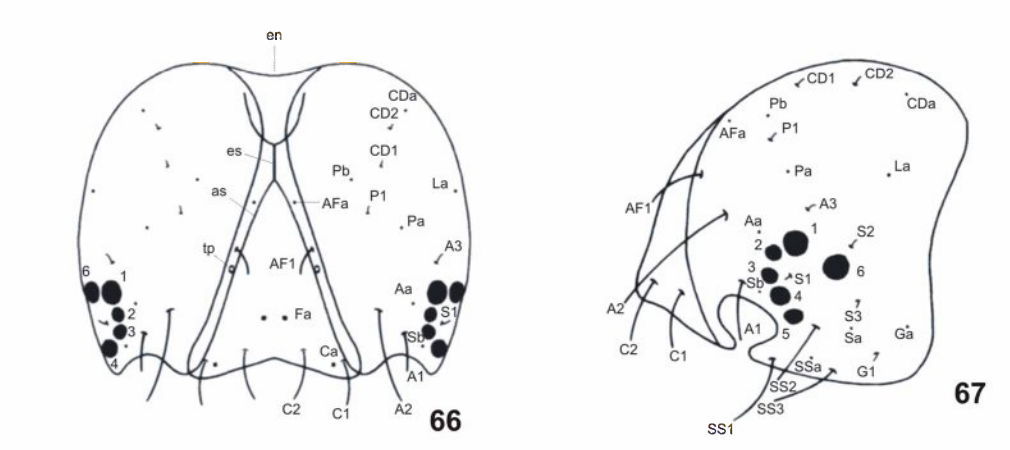
FIGURES 52–59. *C. janeirica*, pupa. 52. After molting, dorsal view. 53. Idem, lateral view. 54. After 24 hours, dorsal view. 55. Idem, lateral view. 56. At middle of pupal stage (specimen with few dark brown maculae), dorsal view. 57. Idem, lateral view. 58. Idem, ventral view (it is already possible to see the imago's eyes). 59. At end of pupal stage (one day after of this picture adult emerged), ventral view.

Second instar (Figs. 45, 72, 77, 78). Cephalic color pattern resembling that of *C. bellera* and *C. caulonia*. Mandibles identical to those of *C. bellera* with six teeth visible externally as well with a toothlike process located ventrally on oral surface (Fig. 72); same number of setae as first instar. Integument coloration identical to *C. bellera*, including the two longitudinal reddish stripes extending dorsally and laterally from mesothorax to last abdominal segment. Unlike *C. bellera* , *C. caulonia*, *C. isobeon*, and *C. vitruvia* (Duarte *et*

al. 2005; Duarte unpubl.), dendritic setae (*sensu* Ballmer & Pratt 1992) missing on this and later instars. Prothoracic shield pentagonal with number and position of setae and pore cupola organs variable. Other characteristics identical to *C. caulonia* and *C. bellera*: prothorax wider and shorter than other thoracic segments; integument highly sculptured and distinctive, with uniformly-spaced oval depressions over epicuticular surface; pattern of oval depression similar in remaining instars; prolegs with uniordinal crochets in uniserial mesoseries, interrupted near center by a conspicuous fleshy pad (Figs. 77, 78), separating the crochets into anterior and posterior groups.



FIGURES 60–65. *C. janeirica*, scanning electron microscopy of egg. 60. Dorsal view. 61. Dorso-lateral view. 62. Micropylar area (rosette with three cells). 63. Cup-shaped cell of the exochorion. 64. Spine-like protuberance (=tubercle) arising from intersected ribs of the exochorion. 65. Aeropyle on top of tubercle.



FIGURES 66–67. *C. janeirica*, head chaetotaxy of first instar. 66. Anterior view. 67. Lateral view. Abbreviations (see text for setal nomenclature): as, adfrontal suture; en, epicranial notch; es, epicranial suture; tp, tentorial pit.

Head capsule width 0.38–0.52 mm (X = 0.46 mm, SD = 0.04; N = 30). Body length 3.68–6.16 mm (X = 4.31 mm, SD = 0.64, N = 30). Duration 3–5 days (X = 3.96 days, SD = 0.61, N = 54).

Third instar (Figs. 46, 47, 79, 80). Similar to previous instar. Differing in having greater number of spiculate setae on thorax and abdomen, prothoracic shield sagittiform, and prolegs with biordinal crochets in uniserial mesoseries (Figs. 79, 80). The typical velvet aspect produced by numerous dendritic setae and found in mature larvae of *C. bellera* and *C. caulonia* is lacking in *C. janeirica*.

Head capsule width 0.62–0.76 mm (X = 0.68 mm, SD = 0.07; N = 30). Body length 7.36–8.16 mm (X = 7.63 mm, SD = 0.24, N = 30). Duration 4–8 days (X = 6.87 days, SD = 1.03, N = 52).

Fourth instar (Figs. 48–51, 73, 74, 81, 82). Similar to previous instar in shape and color of head, but with a greater number of secondary setae concentrated on antero-medial region of frontoclypeus. Mandibles with three setae rather than two (Figs. 73, 74). Integument orange-yellow with numerous golden secondary setae (Figs. 48–51). Prothoracic shield in two symmetrical parts. Prolegs with triordinal crochets in uniserial mesoseries (Figs. 81, 82).

Head capsule width 0.92–1.16 mm (X = 1.02 mm, SD = 0.11; N = 30). Body length 8.96–17.60 mm (X = 13.96 mm, SD = 4.13, N = 30). Duration 9–15 days (X = 12.23 days, SD = 1.511, N = 47).

Pupa (Figs. 52–59, 83). Similar to those of *C. bellera* and *C. caulonia*. Head and thorax initially translucent light yellow (Figs. 52, 53). Abdomen dorsally with intersegmental pale red maculae extending laterally, but not reaching spiracles (Figs. 52, 53). Integument darkening gradually to light brown, with dark brown maculae and small golden prominent setae scattered on dorsal and lateral body (Figs. 54–57). Differing from all other reared *Calycopis* species by the presence of dendritic setae around A6 spiracle (Fig. 83).

Pupal width on metathorax 2.88–4.96 mm (X = 3.86 mm, SD = 0.54, N = 30), on segment A3 3.68–5.76 mm (X = 4.63 mm, SD = 0.57, N = 30). Pupal length 6.72–11.04 mm (X = 9.33 mm, SD = 1.15, N = 30). Duration 9–14 days (X = 13.00 days, SD = 1.07, N = 46).

Development on artificial diet. Caterpillars of *C. janeirica* have four instars rather than five as in *C. bellera* and *C. caulonia*. All larval instars of *C. janeirica* fed on artificial diet, which supported complete development. Data on development times from egg to adult are summarized in Table 1. Females of *C. janeirica* emerged from pupae as adults earlier on average (X = 50.06 days, SD = 2.07, N = 18) than males (X = 52.39 days, SD = 1.71, N = 28), as was the case with *C. caulonia* and *C. bellera*.

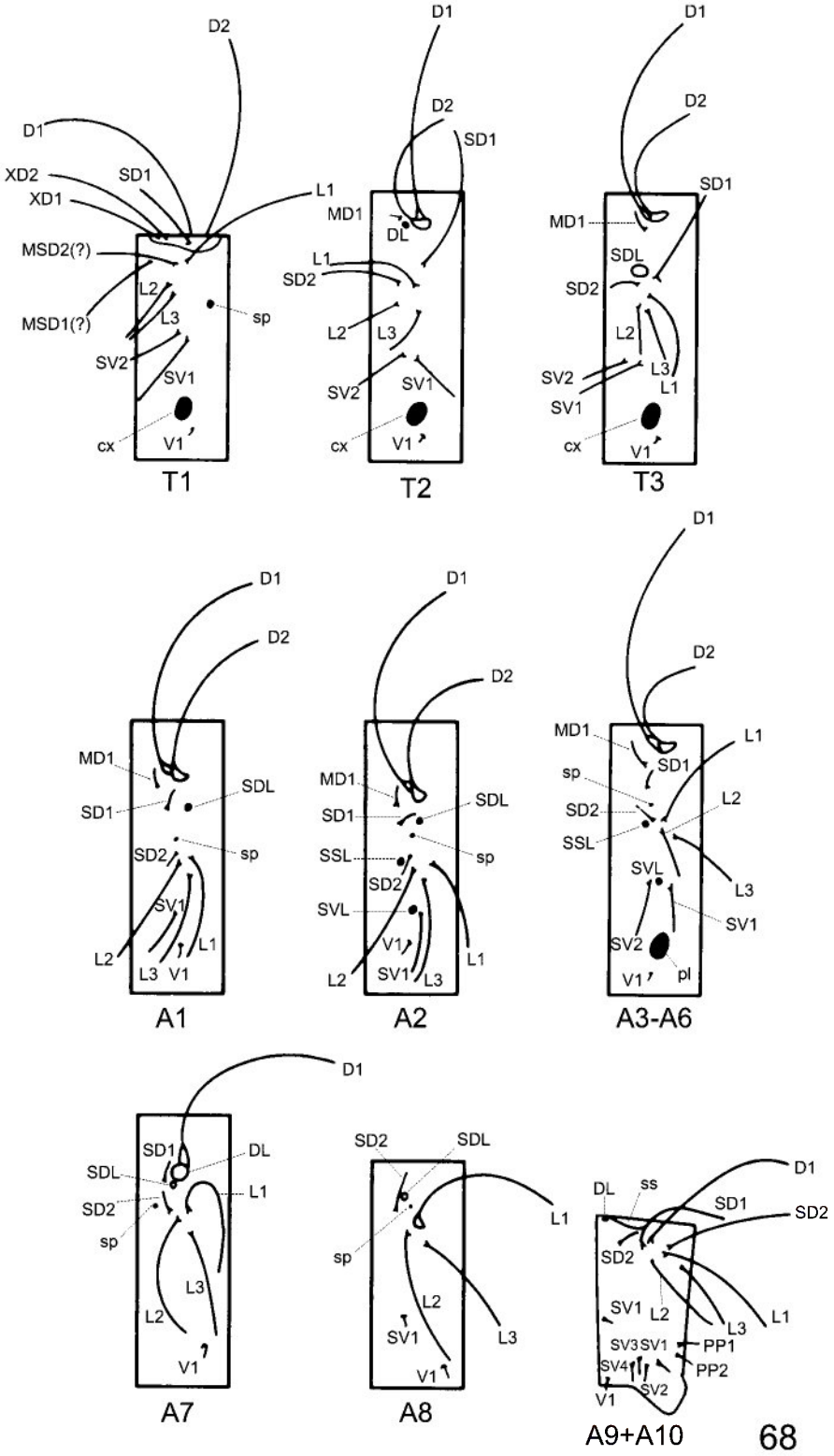
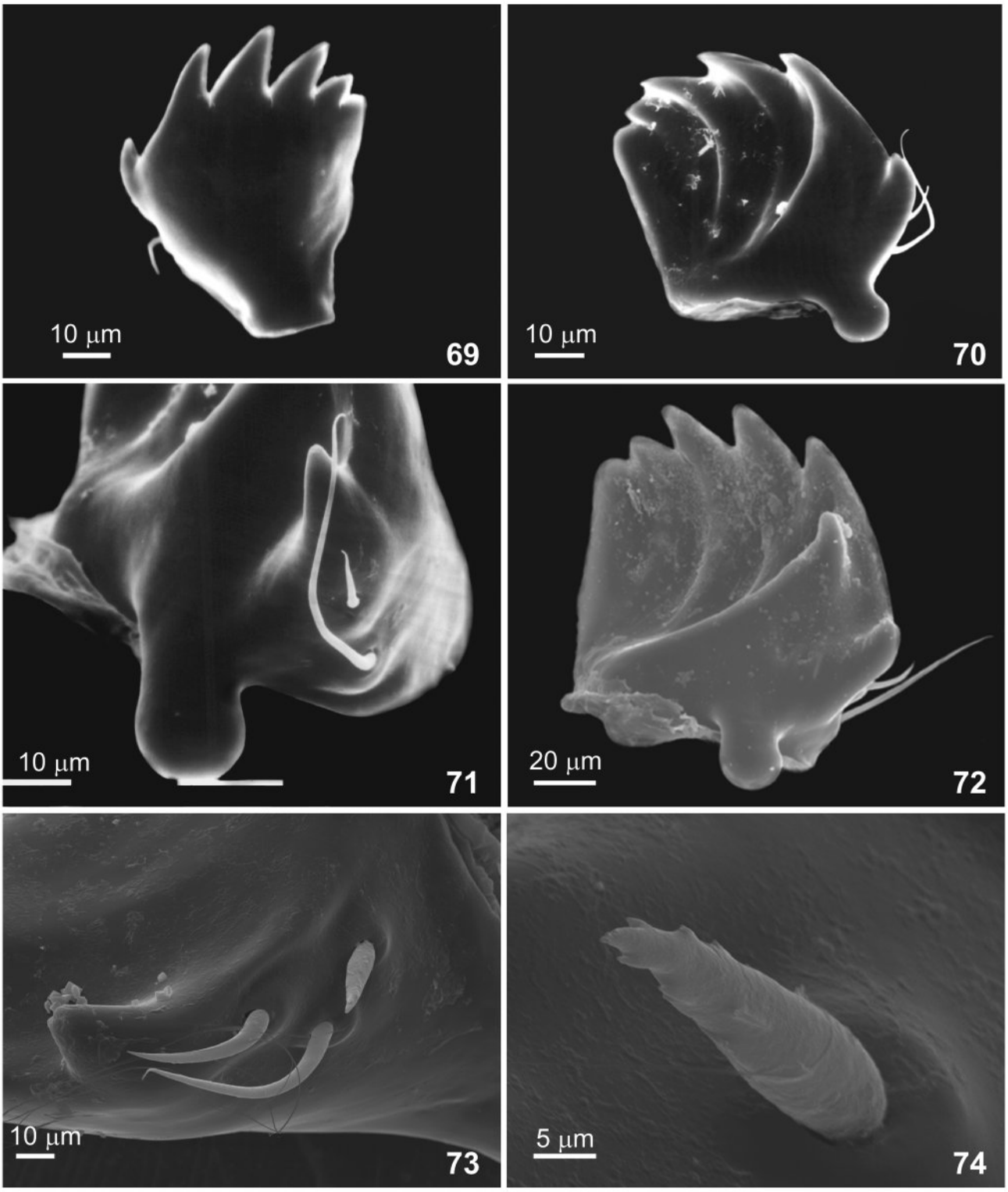


FIGURE 68. *C. janeirica*, body chaetotaxy of first instar. Dorso-lateral view. Abbreviations (see text for setal nomenclature): A, abdominal segment; cx, coxa; pl, proleg; sp, spiracle; ss, suranal shield; T, thoracic segment.

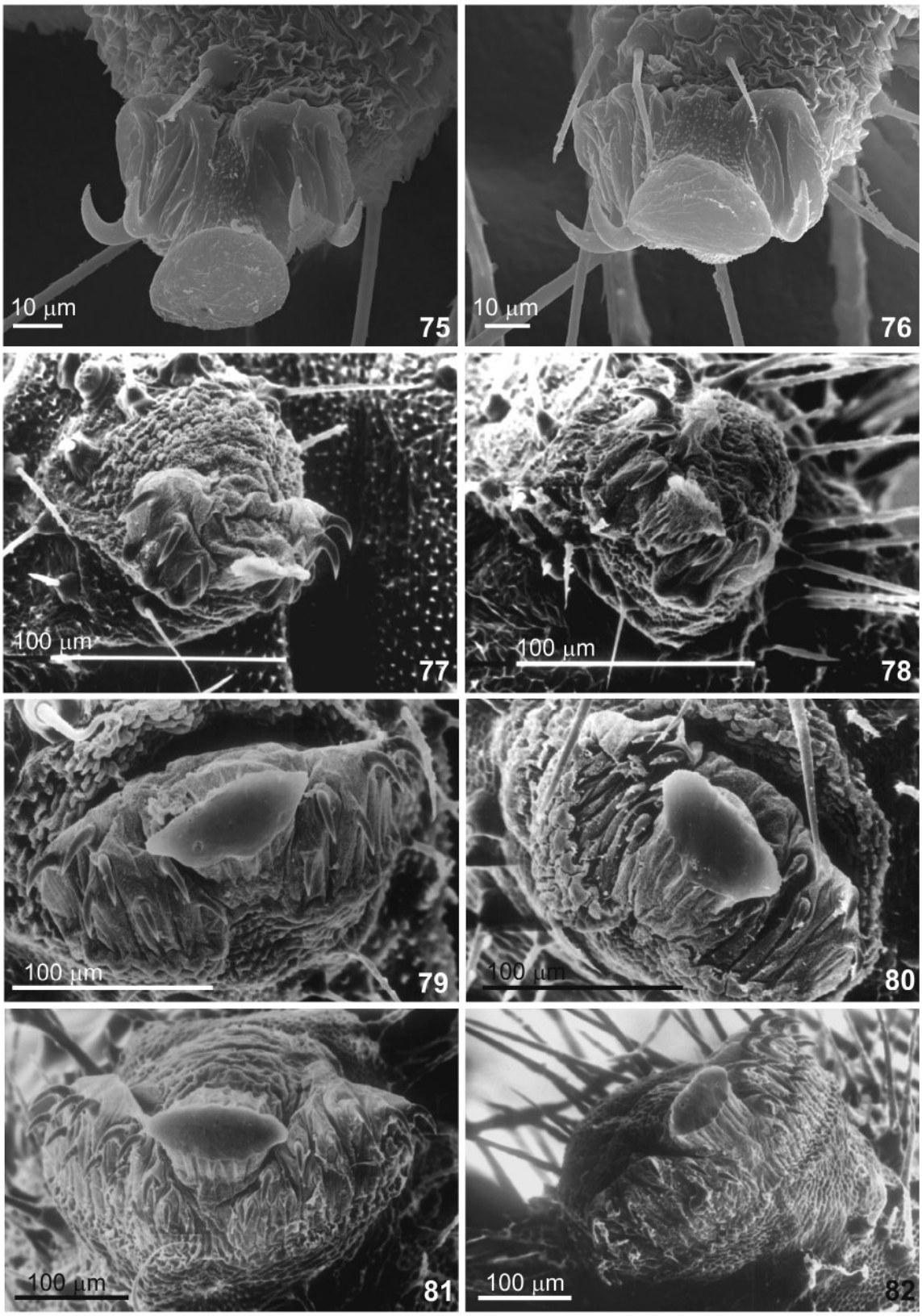
Cannibalism. As with other *Calycopis*, when mature larvae were confined in containers, cannibalism was frequent.

Taxonomy. The previous identification of *C. janeirica* was incorrect (Field 1967a; Johnson 1988, 1991), and the reasons for our identification of this species were outlined above. In southern Brazil, including our

reared adults, the male dorsal hindwing lacks blue and the female dorsal hindwing has blue, but the extent of this coloration in the female is variable. In other parts of South America, the amount of dorsal hindwing blue is variable in both sexes, and the number of species involved is yet to be determined.



FIGURES 69–74. *C. janeirica*, scanning electron microscopy of larva (left mandible). 69. First instar, external view. 70. Idem, internal view. 71. Idem, two mandibular setae, ventral view. 72. Second instar, internal view. 73. Fourth instar, three mandibular setae, ventral view. 74. Detail of the third seta present only on the last larval instar.



FIGURES 75–82. *C. janeirica*, scanning electron microscopy of larva (prolegs). 75. First instar, left proleg of third abdominal segment (uniordinal crochets in uniserial mesoseries). 76. Idem, left proleg of last abdominal segment. 77. Second instar, left proleg of third abdominal segment. 78. Idem, left proleg of last abdominal segment. 79. Third instar, left proleg of third abdominal segment. 80. Idem, left proleg of last abdominal segment. 81. Fourth instar, left proleg of third abdominal segment. 82. Idem, left proleg of last abdominal segment.

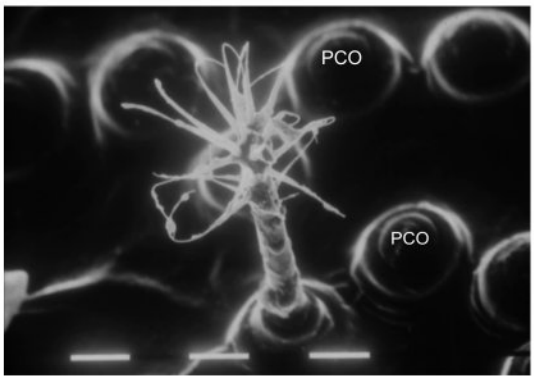


FIGURE 83. *C. janeirica*, scanning electron microscopy of pupa. Typical dendritic seta found around A6 spiracle. Abbreviation: PCO, pore cupola organ.

Discussion

The reared adults from this project improve the association of *Calycopis* males and females. Although *C. bellera* is a common and widespread species, its males and females as determined by our rearings had previously been placed in different species groups (Field 1967a,b) or in different genera (Johnson 1991). The female type of *C. cissusa* from Pará, Brazil has the same wing pattern as the female syntype of *C. janeirica* from Rio de Janeiro, Brazil, but the male of *C. cissusa* in Johnson (1990, 1991) has blue scaling on the dorsal hindwing that is lacking in the males of *C. janeirica* that we reared. We do not yet know if the blue scaling is geographically variable.

The lab results in this paper are consistent with the hypothesis that *Calycopis* are physiologically and behaviorally capable of being detritivores. The six wild-caught *Calycopis* females laid eggs readily on dead leaves in the laboratory. Although many butterflies, including Lycaenidae, can be reared on an artificial diet to which dried, ground leaves of the foodplant are added (Morton 1981; Mark 1993, 1995), caterpillars of *C. bellera* and *C. janeirica* ate and completed development on an agar-based artificial diet without the addition of plant material.

The wealth of morphological detail of the immatures of *C. bellera* and *C. janeirica* is summarized (Table 2) and compared with that of other reared *Calycopis* species. It is premature to hypothesize which of these characters might prove to be phylogenetically informative, but we note three conspicuous characters. First, although number of larval instars is variable within Lycaenidae (e.g., Clark & Dickson 1971; Ballmer & Pratt 1989), there appears to be four larval instars in most Eumaeini (e.g., Robbins & Aiello 1982; Ballmer & Pratt 1988). The primary exceptions are some species of *Callophrys* Westwood (subgenus *Mitoura* Scudder) with six instars (Ballmer & Pratt 1988) and some species of *Calycopis* with five instars (Duarte *et al.* 2005; this paper), which may be a synapomorphy within the genus. Second, the unusual, rather conspicuous pore cupola organs (PCOs) (dorsal lenticle or DL of Ballmer & Pratt 1992; see also Duarte *et al.* 2005: fig. 41) on the larval 7th abdominal segment are known, so far, only from *Calycopis* – these PCOs have also been recorded by Ballmer & Wright (2008) in *Ahmetia achaja* (Lycaenidae, Lycaeninae), but they clearly differ from those of *Calycopis* by their size and location. Third, "short spines and deep fossae" of *Calycopis* eggs was first noted by Downey & Allyn (1984: 18) and occur in all *Calycopis* species we have reared.

TABLE 2. Characters of immature stages of five *Calycopis* species.

	Characters	*C. bellera*[1]	*C. caulonia*[2]	*C. cecrops*[3,4]	*C. isobeon*[3,5]	*C. janeirica*[6]
Egg	Mean diameter (mm)	0.81 ± 0.03	0.56 ± 0.01	0.33	unknown	0.78 ± 0.02
Egg	Mean height (mm)	0.43 ± 0.03	0.31 ± 0.03	unknown	unknown	0.43 ± 0.03
Egg	Micropylar area: number of micropylar openings	3 or 4	6	unknown	unknown	3
Egg	Annulus: cell shape	sub-triangular	sub-triangular	sub-triangular	sub-triangular	sub-triangular
Egg	Annulus: ribs delimiting its cells	large	large	large	large	large
Larva	Number of larval instars	5	5	unknown	unknown	4
1st instar	Mean width of the head capsule (mm)	0.31 ± 0.02	0.19 ± 0.01	unknown	unknown	0.28 ± 0.03
1st instar	Mandibles: number of teeth of the cutting edge (external view)	5	6	unknown	unknown	5
1st instar	Frontoclypeus length	about five times length of epicranial suture	about four times length of epicranial suture	unknown	unknown	about five times length of epicranial suture
1st instar	Thoracic and abdominal chaetotaxy: number of setae	128 pairs	130 pairs	unknown	unknown	128 pairs
1st instar	Thoracic and abdominal chaetotaxy: number of pore cupola organs (PCOs)	22 pairs	29 pairs	unknown	unknown	22 pairs
1st instar	Mesothoracic chaetotaxy: length of seta MD1	about a tenth of D1	about a fifth of D1	unknown	unknown	about a tenth of D1
1st instar	Metathorax: SDL size	larger diameter almost half the width of metathorax	larger diameter almost half the width of metathorax	unknown	unknown	larger diameter almost half the width of metathorax
1st instar	Abdominal segment 1: number of PCOs	one pair (SDL)	two pairs (SDL, SVL)	unknown	unknown	one pair (SDL)
1st instar	Abdominal segment 2: number of PCOs	three pairs (SDL, SSL, SVL)	three pairs (SDL, SSL, SVL)	unknown	unknown	three pairs (SDL, SSL, SVL)
1st instar	Abdominal segments 3-6: number of PCOs	three pairs (SDL, SSL, SVL)	four pairs (SDL, SSL, 2 SVL)	unknown	unknown	three pairs (SDL, SSL, SVL)
1st instar	Abdominal segment 7: number of PCOs	two pairs (DL, SDL)	two pairs (DL and SDL)	DL present	DL present	two pairs (DL, SDL)
2nd instar	Mean width of the head capsule (mm)	0.46 ± 0.02	0.29 ± 0.01	unknown	unknown	0.46 ± 0.04
2nd instar	Dendritic setae	present (from this instar to following instars)	absent	unknown	unknown	absent
3rd instar	Mean width of the head capsule (mm)	0.64 ± 0.06	0.43 ± 0.04	unknown	unknown	0.68 ± 0.07
3rd instar	Dendritic setae	present	present (from this instar to following instars)	unknown	unknown	absent
4th instar	Mean width of the head capsule (mm)	0.97 ± 0.06	0.62 ± 0.03	unknown	unknown	1.02 ± 0.11
5th instar	Mean width of the head capsule (mm)	1.38 ± 0.06	0.75 ± 0.09	unknown	unknown	-
Pupa	Mean length (mm)	9.00 ± 0.80	9.00 ± 0.80	unknown	unknown	9.33 ± 1.15
Pupa	Dendritic setae around A6 spiracle	absent	absent	unknown	unknown	present

Source: (1, 6) this paper; (2) Duarte *et al.* (2005); (3) Rawson & Hessel (1951); (4) Downey & Allyn (1981); (5) D. Harvey (pers. comm.).

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