



## The description of the tiger beetle larvae of *Cosmodela aurulenta* (Fabricius, 1801)(Coleoptera, Cicindelidae)

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### Abstract

All larval instars of the tiger beetle species *Cosmodela aurulenta aurulenta* (Fabricius, 1801) which is the type species of the genus *Cosmodela* Rivalier, 1961 are described and illustrated here for the first time, based on material from Bali Island (Indonesia). A brief review of habitat preferences and ecology for adults and larvae of *Cosmodela aurulenta* are provided. Differences between *C. aurulenta* and *C. batesi* (Fleutiaux, 1893) and allied Palaearctic genera of the subtribe Cicindelina are discussed. The preliminary key of known larvae of relevant genera and subgenera of the Oriental Region is given.

**Key words:** Cicindelidae, *Cosmodela aurulenta*, larval instars, description, ecology, key

### Introduction

*Cosmodela* Rivalier, 1961 was established as a separate genus from of the polytypic genus *Cicindela* Linnaeus, 1758 *sensu lato* based on structures of the aedeagus, shape of appendages of head, coloration of elytra and data of geographic distribution (Rivalier 1961).

The tiger beetles of the genus *Cosmodela* are represented by 11 species that occur mostly in the Oriental Region, but also in the southeast Palaearctic region (Wiesner 1992; Putschkov & Matalin 2017). The larvae of this genus are known only for *Cosmodela batesi* (Fleutiaux, 1893) endemic to Taiwan (Putschkov *et al.* 2008). *Cosmodela aurulenta* has a wide geographical distribution and is represented by two subspecies. The nominative subspecies occurs in Malacca (Malaysia, south of Thailand and Burma), Brunei, (Borneo) and Indonesia (Sumatra, Java, Sulawesi) but records for Bali island are new. In contrast, *C. aurulenta juxtata* (Acciavatti & Pearson, 1989) occurs only in Hindustan, Indo-China and China.

### Material and methods

Larvae and adults of *Cosmodela a. aurulenta* were collected from Bali Island on the shore of small streams (S. Indonesia, Bali, Ubud town, 20.10. 2019, legs. A. Putschkov & T. Markina).

The descriptions are based on the following larval material: one larva each of first and second instars and 4 larvae of the third instar.

The nomenclature follows Rivalier (1961, 1970) and Wiesner (1992). Morphological terminology and larval chaetotaxy follow Knisley & Pearson (1984), Putschkov & Cassola (1994) and Putschkov (2013).

The morphological terms are abbreviated as follows: HL—head length (from nasale apex to end of fronto-clypeal-labral area); HW—head width measured at its broadest part, usually at level of stemmata I-II; PNL—pronotum length measured along midline; PNW—pronotum width measured at its broadest part, usually at level of cephalolateral angles or slightly below; A1 and A2—first and second antennal segments; LPI—first labial palpus;

LP2—second labial palpus; PN—pronotum; PN1—half of pronotum with number of discal setae (but without marginal setae); PNa—cephalolateral (anterior) angles of pronotum; PNm—median line of pronotum; T3—third abdominal tergite; AT5—apical tergite; CT5—caudal tergite; LCT5—lateral tergite of 5th abdominal segment (hump); MH—medial hooks; IH—inner hooks on 5th abdominal segment; EU9—posterior part of 9th abdominal sternite; TE9—posterior part of 9th abdominal tergite; PY—pygopod.

## Results

### *Cosmodela aurulenta aurulenta* (Fabricius, 1801)

**Description of third instar larva.** Measurements: HL = 2.10–2.25 (2.14) mm; HW = 3.62–3.84 (3.68) mm; PNL = 2.20–2.35 (2.32) mm; PNW = 3.75–3.94 (3.82) mm.

Head above almost black with faint lustre (sometimes greenish-blue). Most part of head below light brown, but almost black on anterior margin. Maxillae light brown (labium and antennae darkened) but apical region of mandibles and antennae almost black. Maximum width of head on level of stemma I. Nasale transverse, wider base of mandible and slightly rounded at apex, with longitudinal grooves at base. Lateral lobes small, lateral plates below lateral lobes widened, almost rectangular. Disk of clypeus almost smooth. Setae thin, long and acute on apexes (but some of them near stemmata I and II slightly obtuse). All setae reddish-transparent. A1 with 5–6, A2 with 8–10 long setae. Length ratio of antennae (starting with the first) = 1.5:1.8: 1.2:1.0. Galea distinctly longer than maxillary palpus (Fig 4). Maxillae slender, stipes with 1 bristle on internal margin base and almost equal in length to galea. LP1 with three shortened spine-like projections and three long lateral setae. LP2 with one seta near middle. Epicranial suture distinct, longer than diameter of fourth antennomere.

Pronotum almost black. Setae thin, reddish-transparent. Marginal setae acute on apexes, setae on disk of PN slightly obtuse). PNa wide and with slightly rounded apices; swellings of PNa and callous elevations of PN distinct (Fig. 1). PN1 with 8–10 setae, PNm with 4–5 setae, ridge of PNa with 2 setae. Legs light brown, partly darkened above and habitually similar to those of other *Cicindelina* larvae.

Sclerotized areas of abdomen distinct. T3 almost rectangular (angles rounded) and with 10–14 reddish-transparent setae. Hypopleuron consisting of one large sclerites and 3–4 small ones (type I). CT5 and AT5 almost semicircular and not jointed on inner margin (Fig. 2); apex of MH almost reached middle of AT5; LCT5 with 6–7 long setae; CT5 with 20–25 stout setae (similar to those of inner hook) and some thin small setae on posterior margin (Fig. 2); MH with three long setae but upper seta (near middle of MH) slightly displaced and directed nearly upward (Fig. 2), 4.0 times longer than wide on base; IH directed up, its central spine in 3 times shorter lateral setae; IH 0.4 times as long as MH, 2.2–2.4 times longer than wide. TE9 with 6–7 setae (four from them on middle shorter) (Fig. 4). EU9 with two groups of four setae each (Fig. 3). PY with 26–28 setae dorsally and 10–12 thin setae ventrally; apex of PY with 18–20 stout and long setae (Fig. 3).

**Description of second instar larva.** Measurements: HL = 1.25 mm; HW = 2.20 mm; PNL = 1.25 mm; PNW = 2.40 mm.

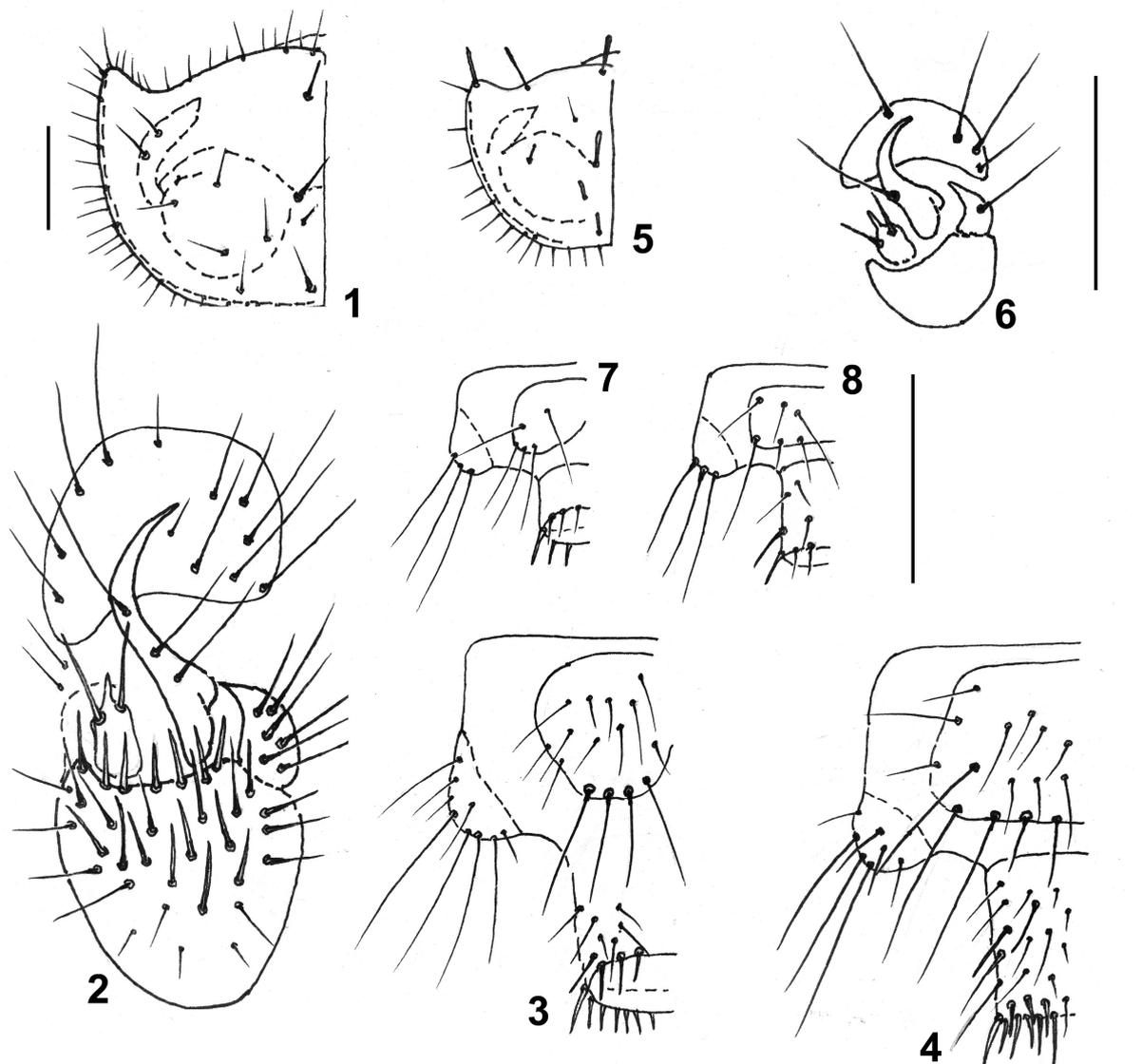
Head above almost black with faint greenish lustre. Antennae and apical parts of mandibles brown, other appendages light brown. Setae thin, acute (only some setae near stemmata I and II obtuse). Most setae reddish transparent, but those on appendages brown. Nasale transverse, apex slightly rounded. A1 with five long setae and A2 with six long setae. Galea slightly longer maxillary palpus. Apex of LP1 with two long lateral setae and three spine-like projections; LP2 with one seta slightly below middle. Epicranial suture distinct.

PN almost black with faint greenish-bronzed lustre. PNa dark brown, slightly rounded and directed forward; setae of PN disk light brown, thin, some of them obtuse, others acute; marginal setae reddish-transparent. Swellings of PNa and callous elevations of PN distinct. PN1 with 8–10 setae, swellings of PNa with 2 setae. Legs brown above, but light brown below.

Sclerotized areas of abdomen distinct, light brown. Third abdominal tergite with 7–8 setae. Sclerites of hump divided, not jointed on inner margin; apex of MH extends beyond middle of AT5; MH 3.3 times longer than wide, with two long setae but upper seta slightly displaced and directed up; IH 0.4 times as long as MH; central spine of IH 0.7 times as long as lateral setae; CT5 with 18–20 stout setae and 6–7 small setae on posterior margin; LCT5 with four long setae. TE9 with seven setae (four of them on middle shorter and 0.3 times as long as lateral setae). EU9

with two groups of four setae. PY with 20 setae dorsally (those near 10 are stout) and seven smaller setae ventrally; apex of PY with 17 setae.

**Description of first instar larva.** Measurements: HL = 0.85 mm; HW = 0.75 mm; PNL = 0.87 mm; PNW = 1.42 mm.



**FIGURES 1–8.** Features of third and first instar larvae of *Cosmodela aurulenta*: 1. Pronotum, III instar (left half); 2. Hump, III instar (right part, dorsal view); 3. Ninth abdominal segment and pygopod, III instar (ventral view); 4. Ninth abdominal segment and pygopod, III instar (dorsal view); 5. Pronotum, I instar (left half); 6. Hump, I instar (left part, dorsal view); 7. Ninth abdominal segment and pygopod, I instar (dorsal view); 8. Ninth abdominal segment and pygopod, I instar (ventral view); (scale bar = 1.0 mm).

Head dark brown. Antennae and apical part of mandibles brown. Other appendages light brown. Setae reddish-transparent, long and obtuse. A1 bare, second and third with two setae apically. Galea slightly longer than maxillary palpus. LP1 with three spine-like projections, LP2 with one seta distinctly below middle.

PN brown with anterolateral angles light brown; anterior margin of PN almost straight (Fig. 5); swellings of PNa and callous elevations of PN distinct; setae on anterior margin and inside PN obtuse; other marginal setae acute. PN1 with five setae, excluding marginal setae (Fig. 5). Legs light brown above.

Sclerotized areas of abdomen slightly chitinized and pale brown. T3 with three setae. MH distinctly curved after middle (Fig. 6), with one seta on middle; IH 0.6 times as long as MH; central spine of IH large; CT5 bare; LCT5 with one long seta; AT5 with four setae (Fig. 6). TE9 with 6 setae. EU9 with two groups of three setae on posterior margin (Fig. 8). PY with eight setae dorsally and bare ventrally; apex of PY with 12 setae (Fig. 7).

**Distribution and ecological peculiarities.** *Cosmodela a. aurulenta* is a common species in Bali Island. Adults and larvae were collected along the shores of small rivers and streams (usually in deep clefts), commonly on clay-sand or sand soils without or with very sparse vegetation (but near forests) (Fig. 9). Larvae usually aggregated at moist sand loose soil. The depth of larval burrows vary from 8–10 cm (first and second instar larvae) to 15–18 cm (third instar larvae). Interesting hidden larval burrow plugs and their function were observed by Lin & Okuyama (2013) in the similar species *Cosmodela batesi*, whose larval III instar differences are compared in Table 1 here.

The habitat of *Cosmodela aurulenta* in other regions has not been recorded, but presumably adults occur near forest streams like some related species (for example, *Cosmodela virgula* Fleutiaux, 1893) (Acciavatti & Pearson 1989).



**FIGURE 9.** The habitats of adults and larvae of *Cosmodela aurulenta* (red arrows indicate locations of larvae burrows).

### Differential diagnosis

The larvae of *C. aurulenta aurulenta* are very similar morphologically to those of *C. batesi*. Some small differences between these species exist in dimensions and coloration of head, PN, AT5, CT5, length of IH and chaetotaxy of some structures (Table 1). The II instar larvae of these species are less distinguishable and the I instar larvae are indistinguishable.

All instar larvae of *Cosmodela* are comparatively more similar to known members of the Palearctic genus *Calomera* Motschulsky, 1862 and then to those of *Cicindela* with similar chaetotaxy of appendages of head (antennal segments, labium, maxillae) and pronotum, form of medial hook, number of setae on tergites of fifth abdominal segment and pygopod. This may confirm the allocation of *Cosmodela* in the large separate group of genera “*Cicindela*” as proposed by Rivalier (1971). Relations derived from morphological and molecular analyses of *Cosmodela* with other genera, particularly *Sophiodela* Nakane, 1955 were recently discussed by Tsuji *et al.* (2016) and Fukuda *et al.* (2019). The authors suggested that *Sophiodela* forms an independent lineage within the genera of Cicindelidae, that it may be a sister group of the genus *Cosmodela*.

**TABLE 1.** Some differences between *Cosmodela aurulenta* and *C. batesi* larvae (III instars)

Features	<i>C. aurulenta</i>	<i>C. batesi</i>
CT5 and AT5	not jointed on inner margin	jointed on inner margin
IH	2.2–2.4 times longer than wide	2.0–2.2 times longer than wide.
PY	with 10–12 thin setae ventrally	with 12–14 thin setae ventrally;
setae on LP2	below the middle	on the middle
Head and PN	almost black	dark brown
HL =	2.10–2.25 (2.14) mm	2.12–2.45 mm
HW =	3.62–3.84 (3.68) mm	3.80–4.20 mm
PNL =	2.20–2.35 (2.32) mm	2.30–2.60 mm
PNW =	3.75–3.94 (3.82) mm.	3.95–4.45 mm

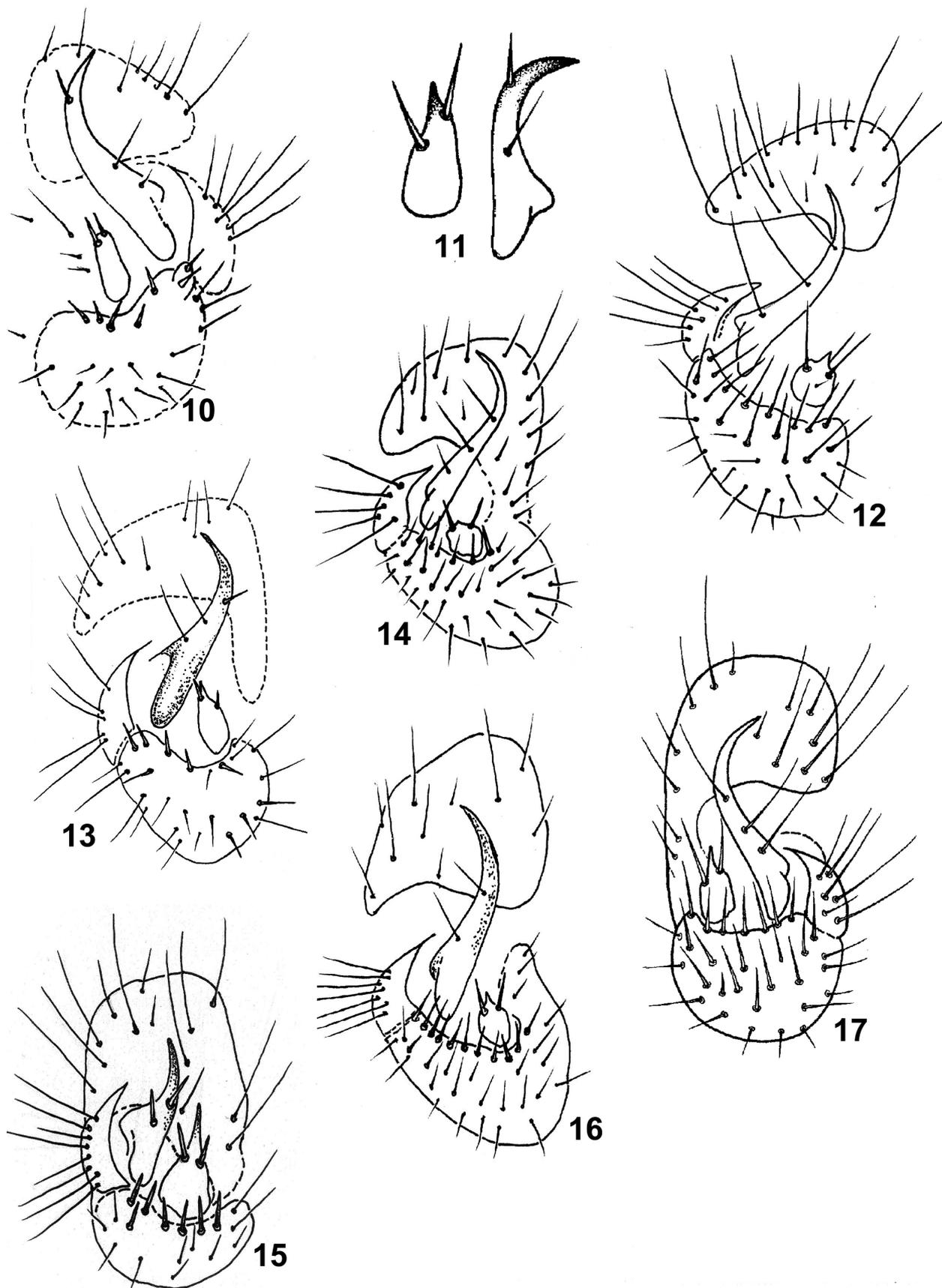
Some differences between larvae of *Cosmodela* and other related Cicindelina species exist in length of IH (especially central spine), sizes of fifth abdominal tergites and darkened coloration of head and PN.

Thus, it is possible to reliably distinguish *Cosmodela* from other genera of the subtribe Cicindelina based on larval features given in the key below. This key is preliminary, since the larval material from the Oriental Region is not numerous (both at the generic and species levels) and is much inferior to that of the Palearctic and Nearctic regions (Leffler 1979; Knisley & Pearson 1984; Putschkov & Cassola 1994; Putschkov 1997, 2013). In this key, we used both larval material collected by ourselves as well as descriptions of larvae described by other authors (Hamilton 1925; Hürka 1970; Lin 2012, 2014). Unfortunately, some of the morphological structures presented in these works are described insufficiently and their features are overlapping. Thus, in the key not only were larvae of Indo-Malayan species used, but other species too, registered in the Oriental Region but more typical for other neighbouring zoogeographic realms. Larvae of the following species were examined: *Calomera littoralis conjunctaepustulata* (Dokhtoureff, 1887), *C. fischeri elongatosignata* (Horn, 1922), *Cicindela* (*s. str.*) *gemmata* Faldermann, 1835, *C. (s. str.) granulata* Gebler, 1842, *Cylindera* (*s. str.*) *obliquefasciata* (Adams, 1817), *C. (Eugrapha) sublacerata* (Solsky, 1874).

### Key to the known larva of genera and subgenera in the subtribe Cicindelina of the Oriental Region (the known larvae of species from Oriental Region are given in brackets)

- 1 (4). Anterior margin of PN more concaved, much longer tips of PNa. IH with 8–10 setae. MH 5 times more IH. Width PN less 2.9 mm.
- 2 (3). PN brown with bright copper-blue (sometimes greenish) luster. PN1 with no more 25 setae. Central spine IH very small. .... Genus *Hypaetha* LeConte, 1857.  
..... [*H. biramosa* (Fabricius, 1781)].
- 3 (2). PN light-brown with light greenish luster, but PNa, lateral and posterior margins yellowish. PN1 with 40 or more setae. Central spine IH short but distinct. MH long and thin slightly curved in upper third. .... Genus *Abroscelis* Hope, 1838.  
..... [*A. anchoralis* (Chevrolat, 1848)].
- 4 (1). Anterior margin of PN less concaved, more or slightly longer tips of PNa. IH with 2–6 setae. MH less 5 times longer IH.
- 5 (8). MH with shortened spine-like setae displaced asymmetrically (Fig. 10, 11, 15). IH 1.5–3.0 times less MH. (Fig. 10, 15).
- 6 (7). Only upper seta of MH spine-like and directed upwards (Fig. 10, 11). IH with 2 stout setae apically (Fig. 10) or located asymmetrically (Fig. 11). Central spine of IH absent or well distinct. Tergites of hump separated or in contact outside margin. .... Genus *Myriochila* Motschulsky, 1862.  
..... [*M. melancholica* Fabricius, 1798, *M. speculifera* Chevrolat 1845].

- 7 (6). MH with 2 spine-like shortened setae located asymmetrically one to other (Fig. 15). Central spine of IH large, much longer lateral setae (Fig. 15). Tergites of hump almost fused. .... Genus *Thopeutica* Schaum, 1861. .... [*T. clara* (Schaum, 1860)].
- 8 (5). MH with 2–4 long and thin setae directed outwards. MH more 4 times longer IH. IH with 2–6 long thin setae (Fig. 12, 14).
- 9 (10). IH with 3–6 thin and long setae (Fig. 12). Anterior margin of PN concaved, distinctly longer tips of PNa. MH more 3–4 times longer IH. Central spine of IH small but distinct (Fig. 12). CT5 with 14–16 spine-like setae (Fig. 12). PN1 with 10–22 setae (some of them often slightly bifurcated). .... Genus *Lophyra* Motschulsky, 1861. .... [*L. cancellata* (Dejean, 1825), *L. striolata* (Illiger, 1800)].
- 10 (9). IH with 2 long lateral setae (Fig. 14). PN1 with 8–20 setae. Anterior margin of PN less concaved, slightly longer tips of PNa. All setae of PN acute.
- 11 (16). Width of head and PN less 2.4 mm (III instar) or 1.6 (II instar).
- 12 (13). Central spine of IH long. AT5 and CT5 fused or almost in contact on inner margin (2.0–2.5 times shorter lateral setae). MH with 3 setae: upper seta shortened and directed upward. CT5 with 23–30 (spine-like) stout setae. .... Genus *Cylindera* Westwood, 1831. .... [*Cylindera* (s. str.) *sauteri* (Horn, 1912)].
- 13 (12). Central spine of IH small (4–5 times shorter lateral setae) or absent. MH with 2–4 long and thin setae directed outwards. CT5 with 11–22 stout (spine-like) setae.
- 14 (15). Central spine of IH well developed. Slice-like setae around lateral margins and posterior margin dense. MH widened basally, 2.5–3.0 times longer MH. .... *Cylindera* (*Ifasina*) Jeannel, 1946. .... [*C. (Ifasina) kaleea* (Bates 1866), *C. (Ifasina) psylica* (Bates, 1866)].
- 15 (14). Central spine of IH absent or marked as a point (Fig. 14). PN without slice-like setae. MH slender slightly widened basally, 4.5–5.0 times more IH. .... subgenus *Eugrapha* Rivalier, 1950. .... [*Cylindera* (*Eugrapha*) *elisae* (Motschulsky, 1859)].
- 16 (11). Width of head and PN more 3.0 (III instar) or 2.0 mm (II instar). MH with 2–4 long setae always directed outward. Central spine of IH well developed (Fig. 17) or small (Fig. 16) and with two long symmetrical lateral setae
- 17 (22). Width of head and PN more 3.6 (III instar) or 2.8 mm (II instar). Central spine of IH long, 2.0–2.5 times shorter lateral setae (Fig. 17). Head and PN dark-brown or almost black, without metallic luster.
- 18 (19). CT5 and AT5 at least in contact or fused at inner margin (Fig. 2, 17). MH slender, 4.0–4.5 times more width basally. Upper seta of MH slightly directed upward, other setae directed outside (Fig. 2, 17). IH no more 2.5 times less MH. Central spine of IH long. .... Genus *Cosmodela* Rivalier, 1961. .... [*C. batesi* (Fleutiaux, 1893), *C. aurulenta* (Fabricius, 1801)].
- 19 (18). CT5 and AT5 always widely separated. MH massive, 3–4 times more width basally. Setae of MH directed outside. PN1 with 15–20 stout setae. IH 3–4 times less MH.
- 20 (21). PN indistinctly copper red with a light bluish tint. PN of 2.0–2.2 linear width/length ratio. Central spine of IH 2 times less lateral setae. IH 3 times less MH. CT5 with 12–15 stout setae. .... Genus *Calochroa* Hope, 1838. .... [*C. octogramma* (Chaudoir, 1852)].
- 21 (20). PN dark-brown or almost black with slight metallic luster. PN of 1.7–1.9 linear width/length ratio. Central spine of IH 3 times less lateral setae and widened basally. IH 3.3–4.0 times less MH. CT5 with 16–20 stout setae. .... Genus *Sophiodela* Nakane, 1955. .... [*Sophiodela chinensis* (De Geer, 1774)].
- 22 (17). Width of head and PN less 3.6 (III instar) or 2.7 mm (II instar). Central spine of IH 3–4 times shorter lateral setae. PN brown, with light cooper-violet metallic luster. PNa yellowish-brown. MH with 2–4 long, thin setae. AT5 and CT5 widely separated on inner margin (Fig. 16). .... enus *Calomera* Jeannel, 1946. .... [*C. angulata* (Fabricius, 1798)].



FIGURES 10–17. Tergites of 5<sup>th</sup> segment of abdomen with appendages, III instar (dorsal view): 10. *Myriochile melancholica*; 11. *M. speculifera* (IH and MH); 12. *Lophyra flexuosa*; 13. *Cylindera* (s.str.) *obliquefasciata*; 14. *Cylindera* (*Eugrapha*) *litterifera*; 15. *Thopetica clara*; 16. *Calomera littoralis*; 17. *Cosmodela batesi*; 10, 11, 17—right half; 12–16—left half.

## Conclusion

The larvae of *Cosmodela aurulenta* are very similar those *C. batesi* and share all characters established for the genus and some related species of the Cicindelina subtribe. The following morphological features are relatively specific for *C. aurulenta* larvae: coloration and sizes of head and PN; sizes of tergites of hump; length of appendages of fifth abdominal segment and chaetotaxy of PY.

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