

Larval morphology of some Anisopliini grain beetles with a key to their larvae (Coleoptera: Scarabaeoidea: Rutelidae: Anomalinae)

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Abstract. The third instar larvae of three *Anisoplia* species, *Anisoplia baetica* Erichson, 1847, *Anisoplia depressa* Erichson, 1847 and *Anisoplia remota* Reitter, 1889 are described and illustrated to show the diagnostic characters of the species. The third instar larva of the monospecific genus *Anthoplia*, represented by *Anthoplia floricola* (F., 1787) is also described and illustrated. These four species are included in a revised key to the larvae of Anisopliini, which now includes four genera, and ten species. The taxonomic status of *Anthoplia* based on the larval morphology, is discussed.

INTRODUCTION

The tribe Anisopliini includes a total of five genera in the Palearctic Region (Baraud, 1986): *Chaetopteropia* Medvedev, 1949, *Hemichaetoplia* Baraud, 1986, *Brancoptia* Baraud, 1986, *Anthoplia* Medvedev, 1949, and *Anisoplia* Schönherr, 1817. The first three genera comprise a total of 20 species showing a circummediterranean distribution except for the Iberian peninsula. The monospecific genus *Anthoplia* is known from North Africa (Morocco, Algeria, Tunisia and Libya) and from almost all of the Iberian Peninsula except the Northwest (Baraud, 1992). The genus *Anisoplia* is the most abundant and the most widely spread genus of Anisopliini; with over 50 species, this Eurasian genus does not extend further north than the line joining Paris-Berlin-Moscow (Machatschke, 1961).

Adults of Anisopliini feed exclusively on grass pollen, whereas the larvae are polyphagous and feed on the roots of many plants. Although the larvae of many Anisopliini species have been considered as pests of several crops (Bogachev, 1946), little is known about the larval morphology, or adult and larval biology of the tribe. Medvedev (1949) illustrated dorsal and ventral views of the last abdominal segment of *Chaetopteropia segetum* (Herbst, 1783), *Anisoplia (Autanisoplia) austriaca* (Herbst, 1783), and *Anisoplia (Anisoplia) deserticola* Fischer, 1824. Few years later, Medvedev (1952) improved on the descriptions of these species and described the larvae of *Brancoptia leucaspis* (Castelnau, 1840), *Anisoplia (Anisoplia) alazanica* Zaitzev, 1918 and *Anisoplia (Anisoplia) farraria* Erichson, 1847, and provided a key to the species of *Anisoplia*. However, he could not separate *A. alazanica* from *A. farraria*. In the short description he gave of *A. farraria* he emphasized the similarity between *A. farraria* and *A. alazanica*, and did not illustrate the first species. Zacharieva-Stoilova (1962) contributed to the knowledge of Anisopliini larvae by describing and illustrating the last abdominal segment (ventral and dorsal view) and the head of *Anisoplia (Anisoplia) lata* Erichson, 1847 and *Anisoplia (Anisoplia)*

agricola (Poda, 1761). However, none of these contributions constituted a detailed description and no more new descriptions have been published.

Studies of larvae suggested that larval morphology could be very useful in the systematic analysis of the Scarabaeoidea (Ritcher, 1966; Edmonds & Halfpeter, 1978; Verdú et al., 1998)

In this study, we describe the third larval instar of *Anisoplia (Anisoplia) baetica* Erichson, 1847, *Anisoplia (Anisoplia) depressa* Erichson, 1847, *Anisoplia (Anisoplia) remota* Reitter, 1889 and *Anthoplia floricola* (F., 1787). These species are included in a revised key to the larvae of Anisopliini.

MATERIAL AND METHODS

A total of 10 to 20 adult specimens of each species were kept in plastic breeding cages (20 cm high, 15 cm wide) with soil and grass. The lid was an opening (6 cm in diameter) covered with a gauze screen. These breeding cages were maintained in an environmental chamber at 25°C : 20°C (L : D), 80 ± 5% RH, and a photoperiod of 15L : 9D. The breeding cages were examined weekly and the results recorded.

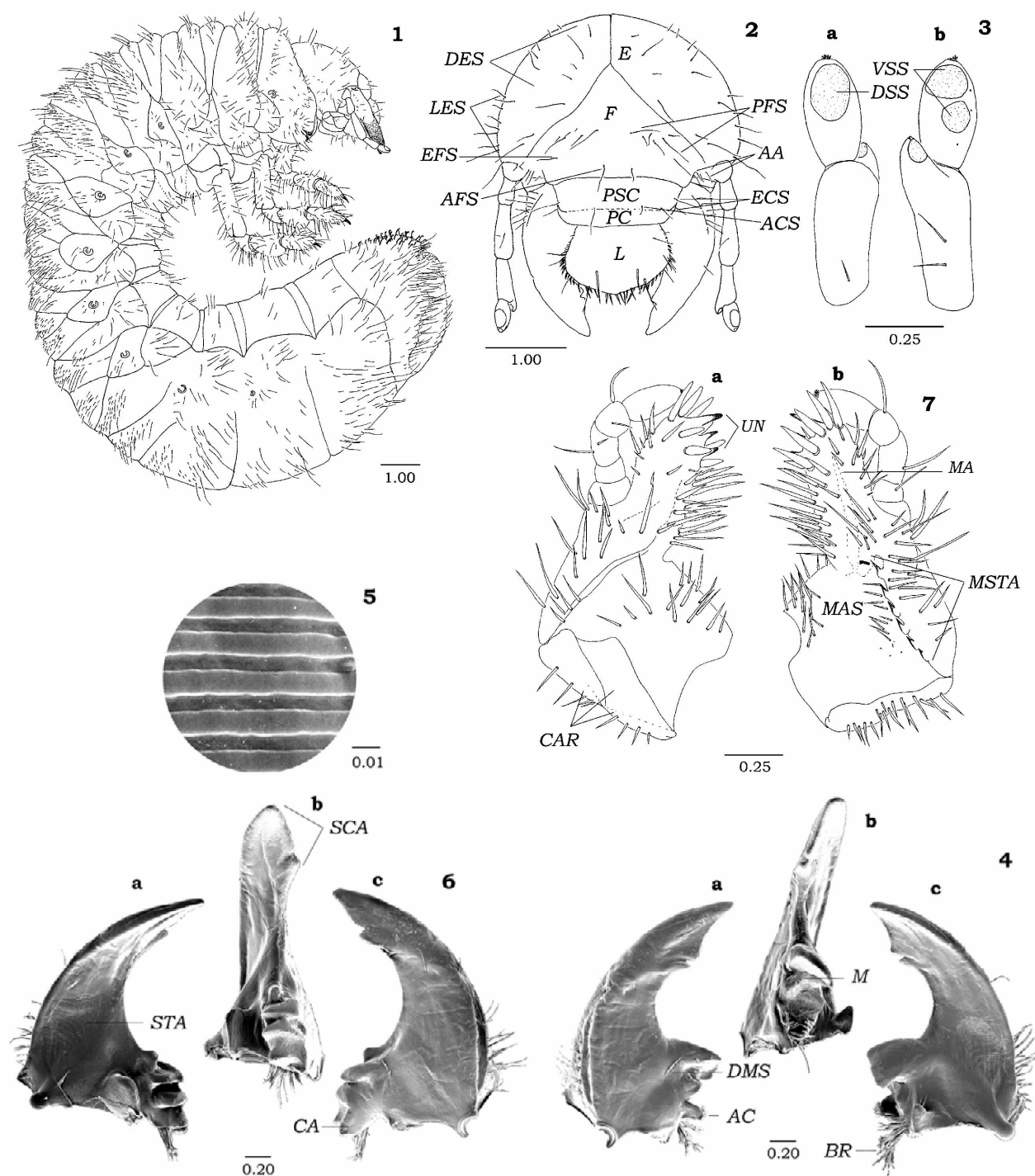
The different larval instars of each species were fixed in KAAD solution (Came, 1951) for 24 h and preserved in 70% ethanol. Specimens are deposited in the Collection of Entomology of the University of Alicante, Spain (CEUA). In the description of larvae the anatomical designations of Ritcher (1966) were used. The median of some characters is presented in brackets.

RESULTS

Common morphological characteristics of the third instar larvae of Anisopliini.

Body. Total length 25–28 mm. Body C-shaped, arched at the level of 4th abdominal segment (Figs 1, 14).

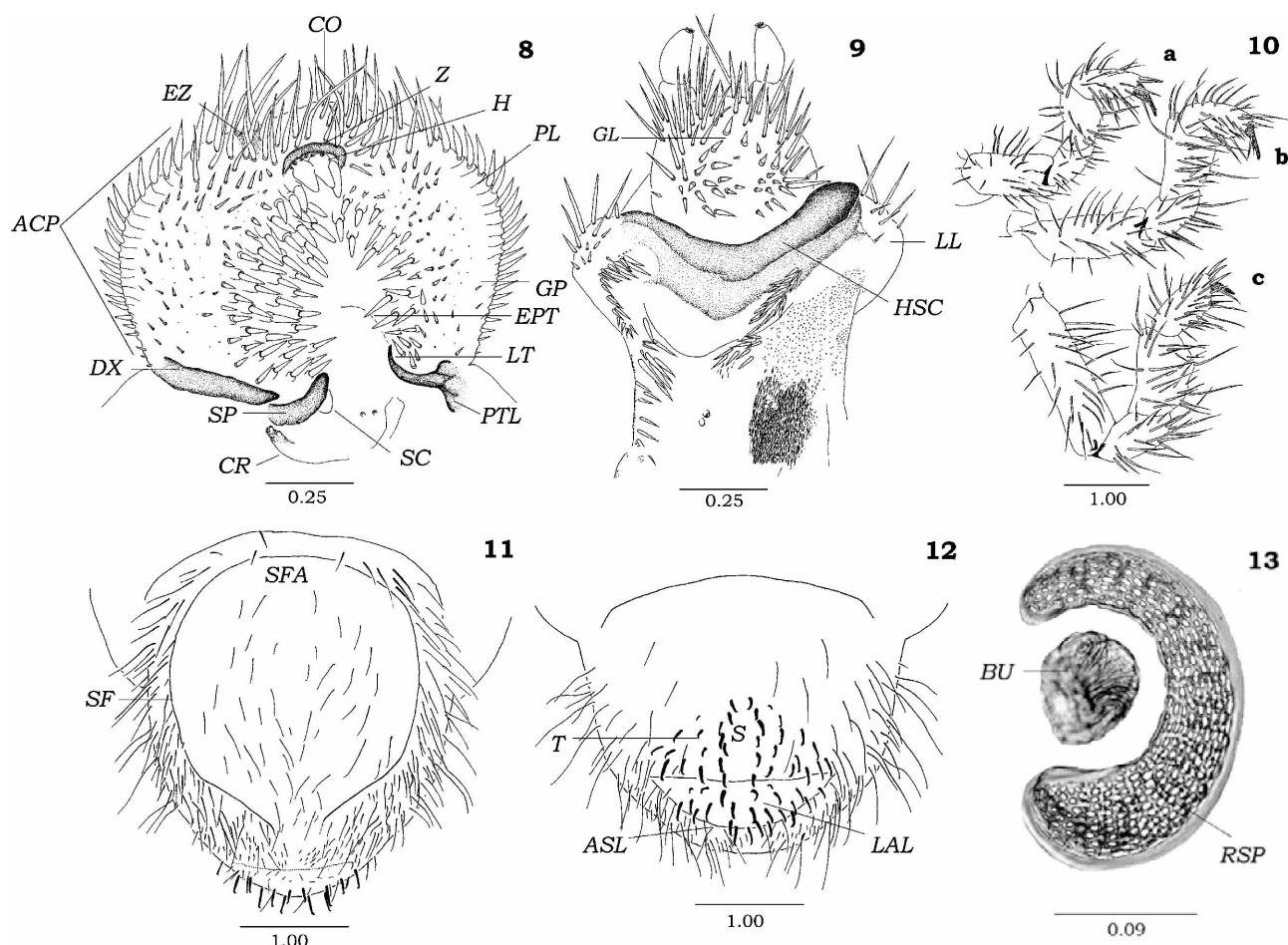
Head. Maximum width of head capsule 2.8 mm (Figs 2, 15, 27, 38). **Cranium.** Colour light yellowish. Frons (*F*) sparsely punctate, with 4–8 posterior frontal seta (*PFS*), 1 anterior angle seta (*AA*) and 1 exterior frontal seta (*EFS*) on each side. Dorsoepicranium with 4–8 small to medium setae (*DES*) in a line diverging from center–base of head;



Figs 1–7: *Anthoplia floricola* third-instar larva. 1 – habitus; 2 – frontal view of head (*E* – epicranium, *DES* – dorsoepicraneal setae, *LES* – lateral external setae, *F* – frons, *PFS* – posterior frontal setae, *EFS* – exterior frontal setae, *AFS* – anterior frontal setae, *ECS* – exterior clypeal setae, *ACS* – anterior clypeal setae, *PC* – preclypeus, *PCS* – postclypeus, *L* – labrum); 3 – dorsal (a) and ventral (b) view of apical antennal segment showing sensory spots (*DSS* – dorsal sensory spots, *VSS* – ventral sensory spots); 4 – dorsal view (a), lateral view (b) and ventral view (c) of left mandible (*DMS* – dorso molar setae, *M* – molar area, *AC* – acia, *BR* – brustia); 5 – stridulatory area of mandible; 6 – dorsal view (a), lateral view (b) and ventral view (c) of right mandible (*STA* – stridulatory area, *SCA* – scissorial area, *CA* – calx); 7 – ventral (a) and dorsal (b) view of maxilla (*MA* – mala, *UN* – unci, *MSTA* – maxillary stridulatory area, *MAS* – maxillary articulating area, *CAR* – cardo).

11–16 medium to long lateral setae (*LES*). *Clypeus*. Shape trapezoidal, with 2 anterior clypeal setae and 2 external clypeal setae on each lateral edge of postclypeus (*PSC*); preclypeus (*PC*) weakly sclerotized. *Labrum* (*L*)

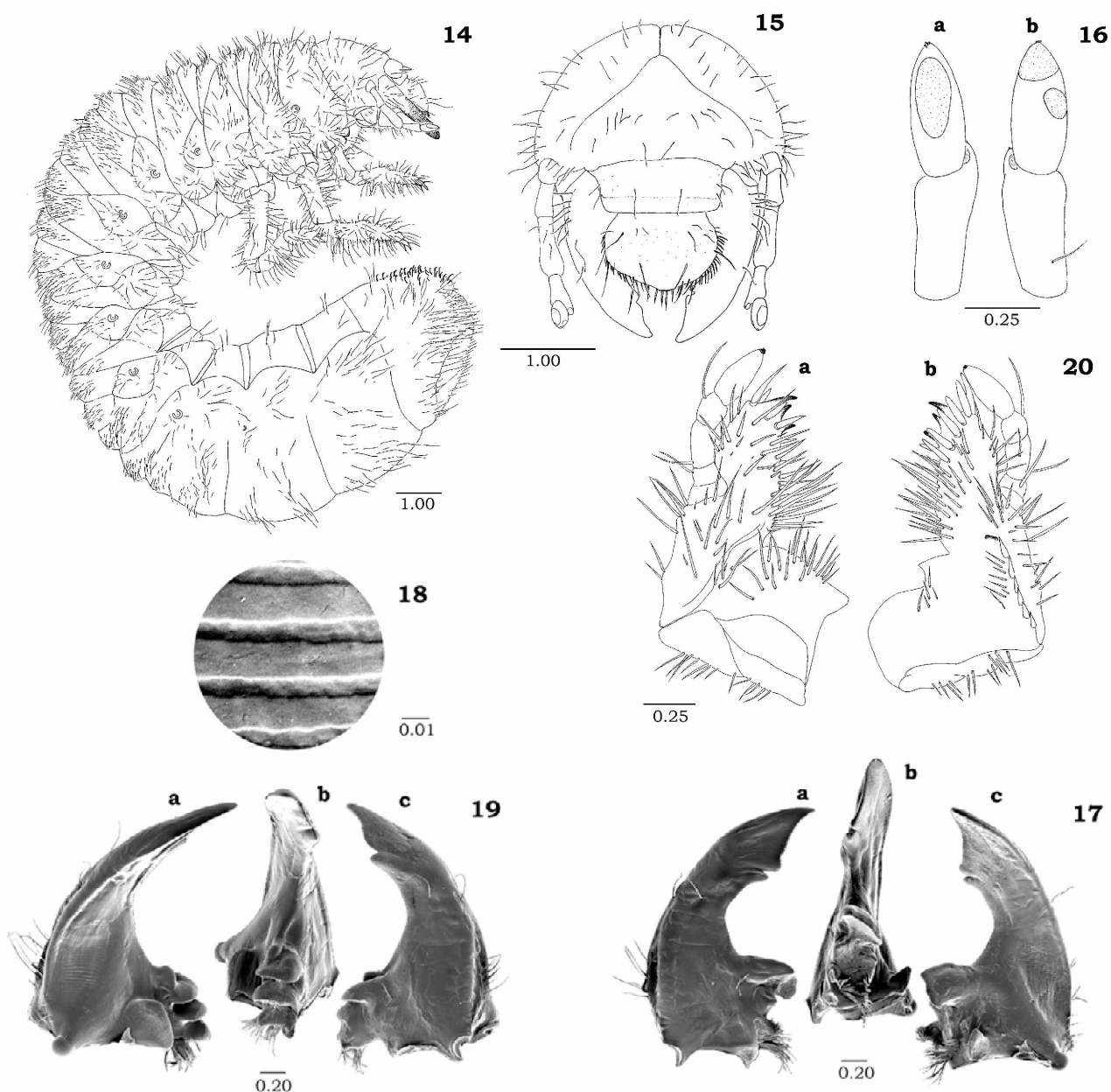
asymmetrical; longer and narrower than clypeus, sparsely punctate and with 2–3 posterior setae near the base, 2 anterior setae near the apex and 4 stout setae at apex flanked by a prominent, pointed seta. *Epipharynx*. Pleg-



Figs 8–13: *Anthoplia floricola* third-instar larva. 8 – epipharynx (*H* – haptomerum, *Z* – zygom, *EZ* – epizygom, *CO* – corypha, *ACP* – acanthoparia, *PL* – plegmatium, *GP* – gymnoparia, *DX* – dexiotorma, *LT* – laetorma, *PTL* – pternotorma, *EPT* – epitorma, *SP* – sclerotized plate, *SC* – sensorial cone, *CR* – crepis); 9 – hypopharynx (*GL* – glossa, *LL* – lateral lobes, *HSC* – hypopharyngeal sclerome); 10 – legs – prothoracic (a), mesothoracic (b), metathoracic (c); 11 – dorsum of last abdominal segment (*SF* – subcircular furrow, *SFA* – subcircular furrow area); 12 – venter of last abdominal segment (*T* – tegilla, *S* – septula, *ASL* – anal slit, *LAL* – lower anal lobe); 13 – prothoracic spiracle (*RSP* – respiratory plate, *BU* – bulla).

matium (*PL*) composed of 10–19 plegmata. Corypha (*CO*) with 2 stout setae flanked by a sensillum on each side. Epizygom (*EZ*) present. Haptomerum (*HM*) consisting of a curved, sclerotized zygom (*Z*) with about 10 sensilla, and 3 prominent, backward projecting heli (*H*). Acanthoparia (*ACP*) with about 20 flattened setae, sickle-shaped and decreasing in size posteriorly. Chaetoparia (*CHP*) well-developed, covered with longitudinal rows (4 on the right and 2–3 on the left) of long, stout setae and many smaller and finer setae near the gymnoparia (*GP*). Epitorma (*EPT*) slightly apparent, dividing pedium. Laetorma (*LT*) with pternotorma (*PTL*) present. Dexiotorma (*DX*) slightly sinuated, broadest at base; pternotorma absent. Haptolachus (*HL*) complete: crepis (*CR*) lightly sclerotized in the form of a transverse bar expanded laterally with 2 sensilla on the right. Both nesia (sclerotized plate (*SP*) and sensorial cone (*SC*)) present. Center of haptolachus with 2 sensilla. Mandibles (Figs 4, 6, 17, 19, 30, 32, 41, 43). Asymmetrical, with 2 scissorial teeth anterior to scissorial notch and 1 tooth posterior to notch. Ventral surface bearing a large, ovate stridulatory

area (*STA*). Dorsal surface with 1 seta near the proximal end of the scissorial area and 1–2 dorsomolar setae. Left mandible with molar area (*M*) bilobed. Basomedian angle with brustia (*BR*) of setae. Acia (*AC*) present. Molar area of right mandible consisting of 4 lobes. Calx (*CA*) bearing a brustia of long setae. Maxilla (Figs 7, 20, 29, 40). Galea and lacinia fused, forming mala (*MA*). Mala with large uncus at apex and 2 subterminal unci (*UN*) fused at base and equal in size; surface with 3–4 indistinct rows of setae. Unci of mala surrounded by a circle of 8 stout setae. Cardo with 12–16 setae. Stridulatory area (*MSTA*) with a row of apically pointing stridulatory teeth and a distal, blunt tubercle. Labium. Glossa (*GL*) covered posteriorly with about 40 stout setae and distally with many, slender setae. Hypopharyngeal sclerome (*HSC*) asymmetrical; produced on right side into a strong, truncate process. Both lateral lobes (*LL*) with 8–18 setae arranged in 2–3 rows. Antenna. 4-segmented. First segment about half as long as second segment. Apical segment fusiform, bearing 1 dorsal (*DSS*) and 2 ventral sensory spots (*VSS*).



Figs 14–20: *Anisoplia baetica* third-instar larva. 14 – habitus; 15 – frontal view of head; 16 – dorsal (a) and ventral (b) view of apical antennal segment showing sensory spots; 17 – dorsal view (a), lateral view (b) and ventral view (c) of left mandible; 18 – stridulatory area of mandible; 19 – dorsal view (a), lateral view (b) and ventral view (c) of right mandible; 20 – ventral (a) and dorsal (b) view of maxilla.

Thorax. Thoracic spiracles with C-shaped respiratory plate (Figs 13, 26, 35, 46). *Legs* (Figs 10, 23). Prothoracic legs (a) shorter than the mesothoracic (b) and metathoracic (c) pair. Claws slightly curved, bearing 2 setae at base. Claws of prothoracic and mesothoracic legs equal in length, those of metathorax half as long.

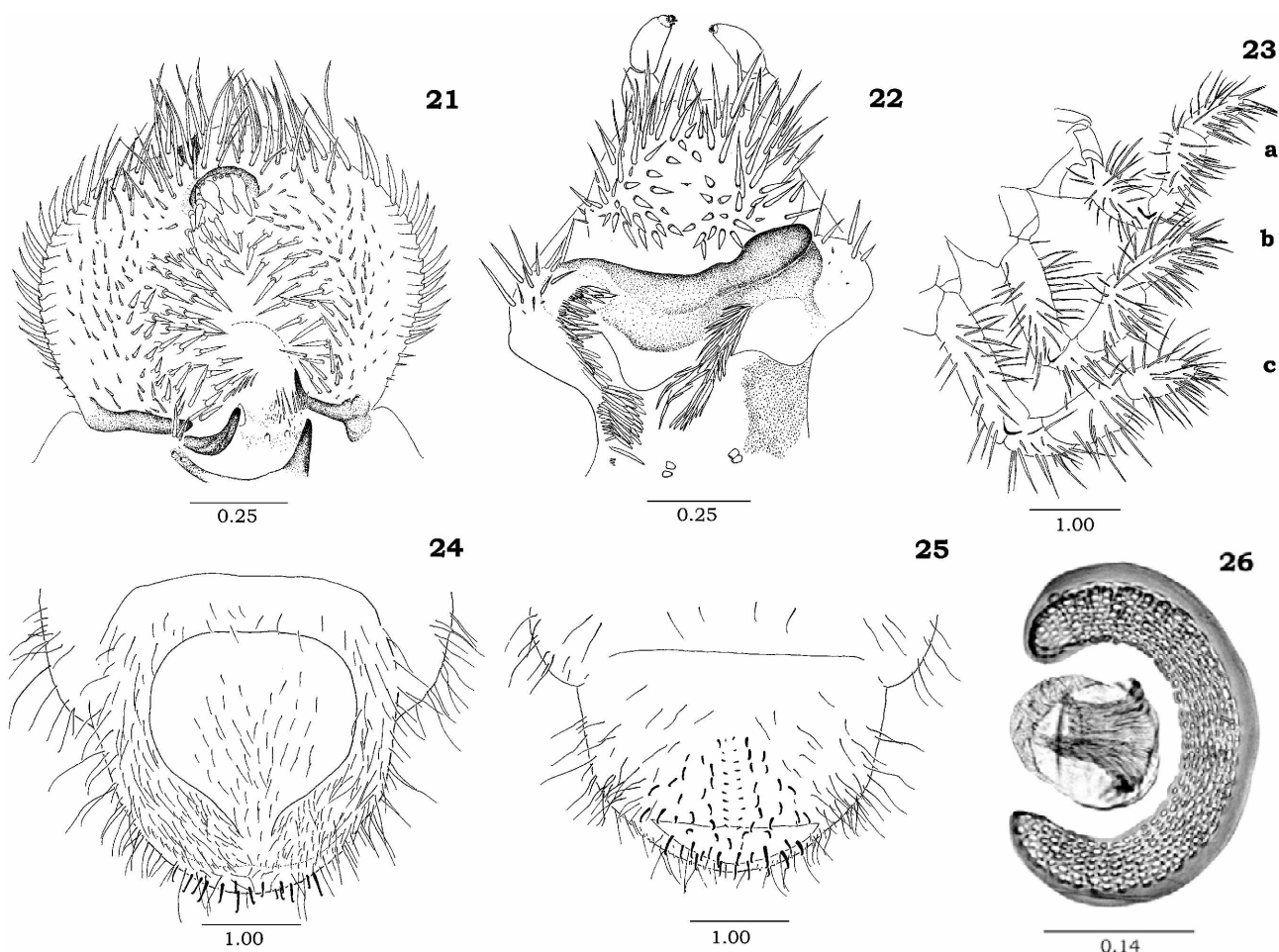
Abdomen. Dorsa of abdominal segments I–VII with 3–5 rows of short setae, each posterior row bearing long setae. Abdominal segments VIII–IX with sparse, medium to long setae. Spiracular area of abdominal segments with 16–23 short to medium setae. The spiracles of the abdominal segments II–VII similar in size, those of I and VIII conspicuously smaller (Figs 1, 14). Pleural lobes of abdominal segments with 10–22 long setae. Dorsum of

the last abdominal segment (Figs 11, 24, 36, 47) with subcircular furrow (*SF*) present. Tegilla (*T*) composed of 11–21 hamate setae. Anal slit (*AS*) transverse, arcuate. Lower anal lip (*LAL*) possessing 21–28 hamate setae.

***Anthoplia floricola* (F., 1787) third instar larva.**

Head. Mandibles. Stridulatory area consisting of many transverse ridges (Fig. 5); inter-ridge area 1.6 times the ridge width at centre. *Maxilla* (Fig. 7b). Stridulatory area with row of 5–7 (5) acute teeth and distal truncate process. Maxillary articulating area (*MAS*) with a row of 7–13 (8) setae just parallel to stridulatory teeth.

Thorax. Size of prothoracic spiracles 0.21 mm high and 0.15 mm wide (Fig. 13); respiratory plate with infe-



Figs 21–26: *Anisoplia baetica* third-instar larva. 21 – epipharynx; 22 – hypopharynx; 23 – legs – prothoracic (a), mesothoracic (b), metathoracic (c); 24 – dorsum of last abdominal segment; 25 – venter of last abdominal segment; 26 – prothoracic spiracle.

rior lobe conspicuously larger than superior lobe and with 8 holes across diameter at middle; holes suboval.

Abdomen. Raster without palidium (Fig. 12); Septula defined and elongated. Area defined by the subcircular furrow of dorsum of tenth abdominal segment being about 56% of the dorsal surface of the segment. Vestiture of the *SFA* with isolated short and long setae, usually absent from lateral margins (Fig. 11).

Material studied. Description based on 20 third instar larvae reared from eggs laid by adults collected at Arenales del Sol, Alicante (Spain), V-1997, Micó & Verdú leg.; La Mata, Torrevieja, Alicante (Spain), V-1996, Micó & Verdú leg.; Villena, Alicante, V-1996, Micó leg.

Anisoplia baetica Erichson, 1847 third instar larva.

Head. Mandibles. Stridulatory area consisting of many transverse ridges (Fig. 18); inter-ridge area 2.1 times the ridge width at centre. *Maxilla* (Fig. 20b). Stridulatory area with row of 5–7 (6) acute teeth and distal truncate process. Maxillary articulating area with a row of 8–13 (9) setae just parallel to stridulatory teeth.

Thorax. Size of prothoracic spiracles 0.28 mm high and 0.21 mm wide (Fig. 26); Lobes of respiratory plate equal; distance between both lobes as wide as diameter of

spiracle or slightly narrower; respiratory plate with 8 holes across diameter at middle; holes suboval.

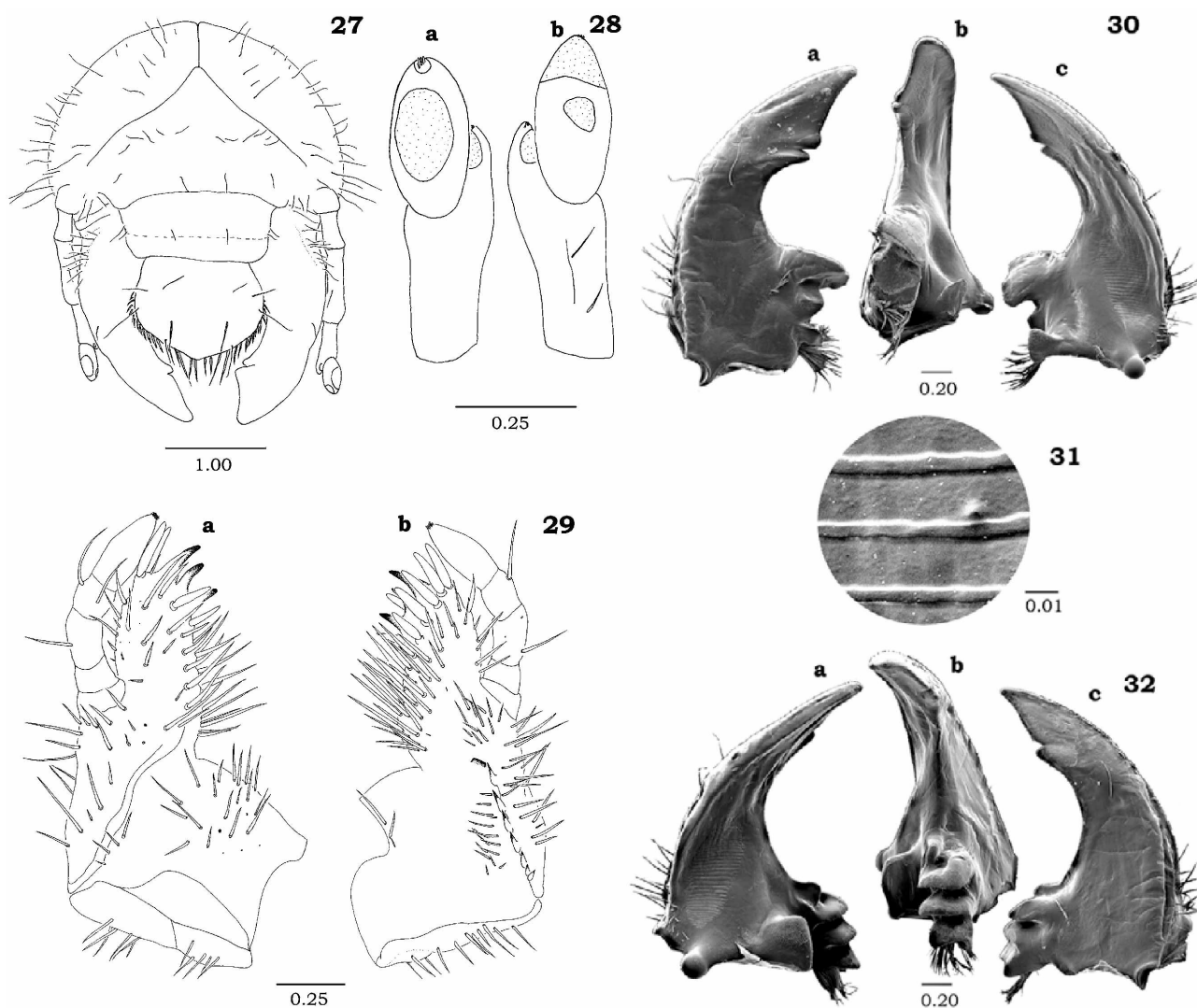
Abdomen. Raster with palidium possessing two parallel rows of 6–10 (8) pali (Fig. 25). Area defined by the subcircular furrow of the dorsum of tenth abdominal segment about 43% of the dorsal surface of the segment. Vestiture of the *SFA* with setae equal in length on centre and apex, absent from lateral and basal margins (Fig. 24).

Material studied. Description based on 12 third instar larvae reared from eggs laid by adults collected at Huélagos, Teruel (Spain), VII-1997, Micó & Galante leg.; Embalse de Celemin, Cadiz (Spain), V-1997, Micó & Verdú leg.

Anisoplia remota Reitter, 1889 third instar larva.

Head. Mandibles. Stridulatory area consisting of many transverse ridges (Fig. 31); inter-ridge area 4 times the ridge width at centre. *Maxilla* (Fig. 29b). Stridulatory area with row of 5–7 (6) acute teeth and distal truncate process. Maxillary articulating area with a row of 11–23 (16) setae just parallel to stridulatory teeth.

Thorax. Size of prothoracic spiracles 0.24 mm high and 0.18 mm wide (Fig. 35); Lobes of respiratory plate equal; distance between both lobes less than diameter of



Figs 27–32: *Anisoplia remota* third-instar larva. 27 – frontal view of head; 28 – dorsal (a) and ventral (b) view of apical antennal segment showing sensory spots; 29 – ventral (a) and dorsal (b) view of maxilla; 30 – dorsal view (a), lateral view (b) and ventral view (c) of left mandible; 31 – stridulatory area of mandible; 32 – dorsal view (a), lateral view (b) and ventral view (c) of right mandible.

the spiracle at the middle; respiratory plate with 8 holes across diameter at middle; holes suboval.

Abdomen. Raster possessing two parallel rows of 6–8 (7) pali (Fig. 37). Area defined by the subcircular furrow of the dorsum of tenth abdominal segment 45% of the dorsal surface of the segment. Vestiture of the *SFA* with setae equal in length on centre and apex, absent from lateral and basal margins (Fig. 36).

Material studied. Description based on 30 third instar larvae reared from eggs laid by adults collected at Arenales del Sol, Alicante (Spain), V-1997, Micó & Verdú leg.; Embalse de Ull-decona, Castellón (Spain), VI-1997, Micó & Verdú leg.; Villar de Olalla, Cuenca (Spain), VII-1997, Micó & Galante leg.

***Anisoplia depressa* Erichson, 1847 third instar larva.**

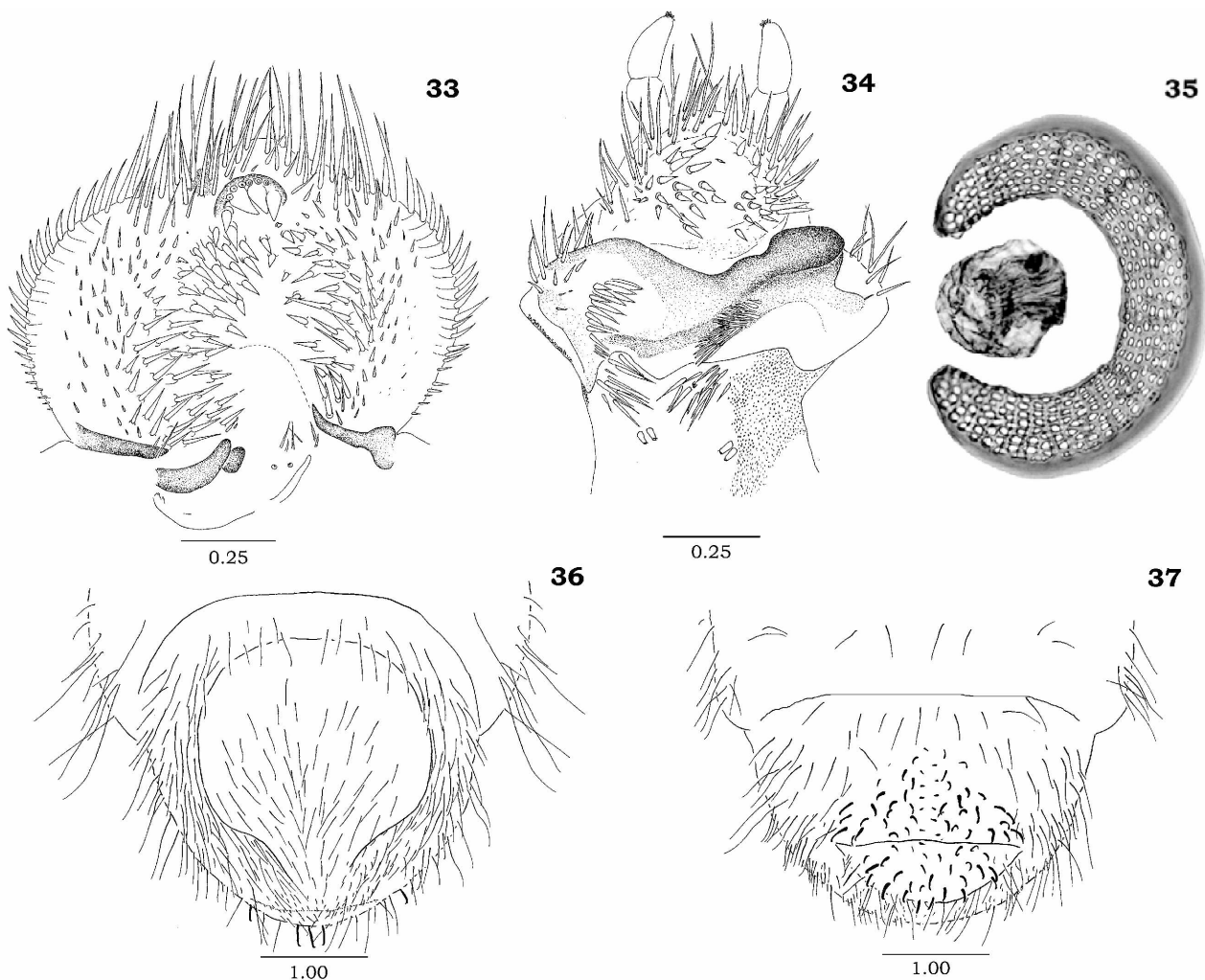
Head. Mandibles. Stridulatory area consisting of many transverse ridges (Fig. 42); inter-ridge area 2.5 times the ridge width at centre. *Maxilla* (Fig. 40b). Stridulatory area

with row of 5–7 (6) acute teeth and distal truncate process. Maxillary articulating area with a row of 8–14 (12) setae just parallel to stridulatory teeth.

Thorax. Size of prothoracic spiracles 0.25 mm high and 0.17 mm wide (Fig. 46); Lobes of respiratory plate equal; distance between both lobes wider than the diameter of spiracle at middle; respiratory plate with 6 holes across diameter at middle; holes suboval.

Abdomen. Raster without palidium (Fig. 48); Septula defined and elongated. Area defined by the subcircular furrow of the dorsum of tenth abdominal segment 56% of the dorsal surface of the segment. Vestiture of the *SFA* with short and long setae on centre and apex, absent from lateral and basal margins (Fig. 47).

Material studied Description based on 12 third instar larvae reared from eggs laid by adults collected at Prioro, León (Spain), VII-1999, Micó & Verdú leg.; Rivera de la Granja, Salamanca (Spain), VII-1998, Micó & Galante leg.



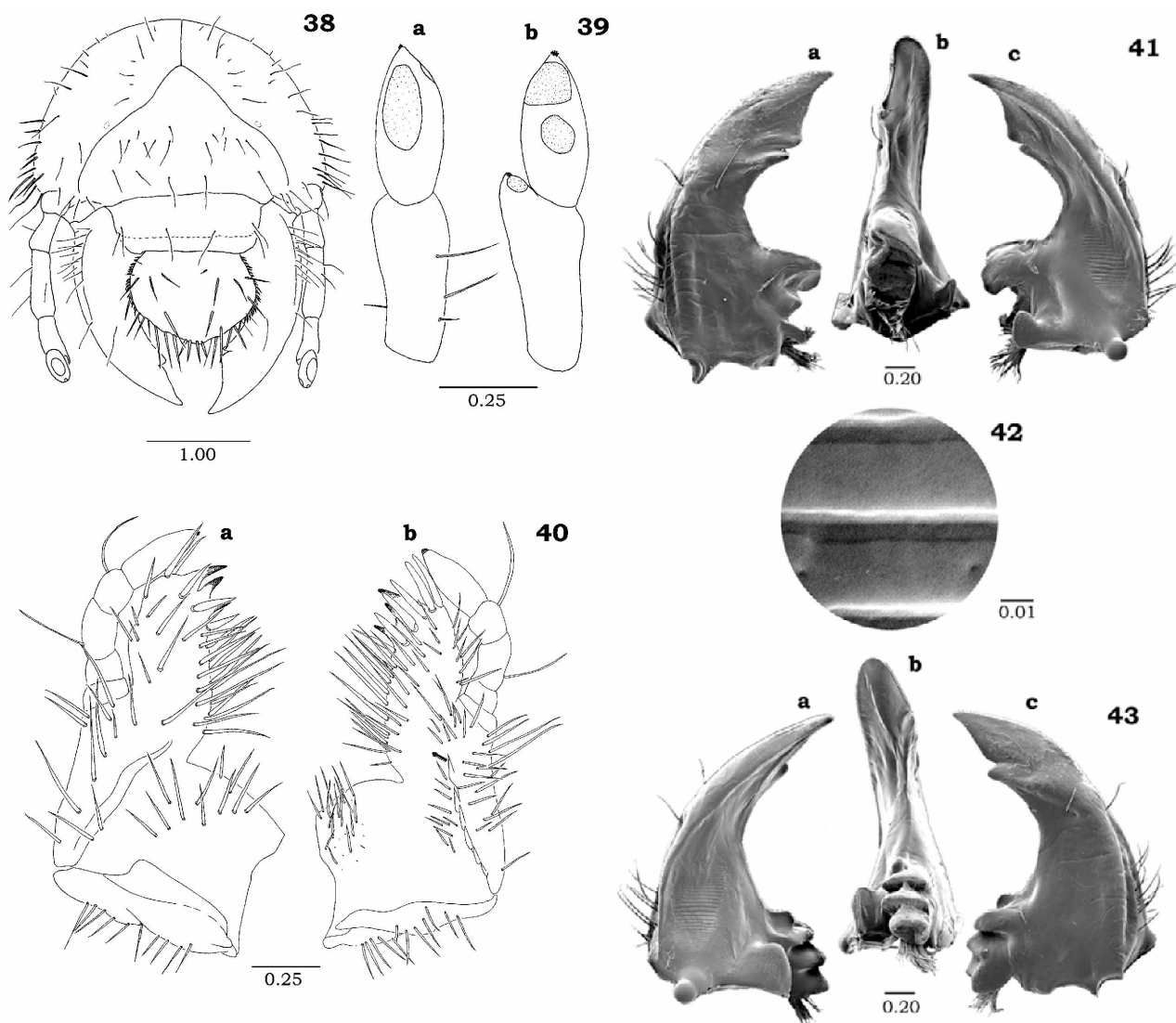
Figs 33–37: *Anisoplia remota* third-instar larva. 33 – epipharynx; 34 – hypopharynx; 35 – prothoracic spiracle; 36 – dorsum of last abdominal segment; 37 – venter of last abdominal segment.

Key to the known larvae of Anisopliini

Diagnostic characters of *Chaetopteropia segetum*, *Anisoplia austriaca*, and *Anisoplia deserticola* are those of Medvedev (1949, 1952). Diagnostic characters of *Brancoplia leucaspis* and *Anisoplia farraria* are those of Medvedev (1952). Diagnostic characters of *Anisoplia lata* and *Anisoplia agricola* are those of Zacharieva-Stoilova (1962), Giljarov (1964), Paşol (1967), and Klausnitzer & Krell (1997). The description of *Anisoplia farraria* (Medvedev, 1952) was too incomplete for including this species in the revised key.

1. Palidium present. 2
- 1'. Palidium absent. 9
2. Subcircular furrow on the dorsum of last abdominal segment square. *Chaetopteropia segetum* (Herbst).
- 2'. Subcircular furrow on the dorsum of last abdominal segment round. 3
3. Third antennal segment as long as the second segment.
- *Anisoplia lata* Erichson
- 3'. Third antennal segment shorter than the second segment. . . 4
4. Area defined by the subcircular furrow on dorsum of last abdominal segment (*SFA*) large (more than 70% of dorsum of last abdominal segment). Palidium with 6 pali per row. . .
- *Brancoplia leucaspis* (Castelnau).

- 4'. *SFA* small (between 40– 50% of dorsum of last abdominal segment). Palidium with more than 7 pali per row, rarely 6. 5
5. *SFA* uniformly setose. *Anisoplia austriaca* (Herbst).
- 5' *SFA* bare of setae at least on basal margin (Figs 24, 36) . . . 6
6. *SFA* with the central longitudinal area hairless. 7
- 6'. *SFA* central area setose (cf. *Anisoplia agricola* Poda)* . . . 8
7. *SFA* almost spherical. Distance between the base of the segment and the geometric center of the *SFA* equal to the distance between this point and the base of the segment.
- *Anisoplia alazanica* Zaitzev.
- 7'. *SFA* more flattened. Distance between the apex of the segment and the geometric center of the *SFA* 1.5 times the distance between this point and the base of the segment.
- *Anisoplia deserticola* Fischer.
8. Stridulatory area of mandible with an inter-ridge area 2.1 times the ridge width (Fig. 18). Maxillary articulating area with a row of 8–13 (9) setae just parallel to stridulatory teeth (Fig. 20b). *Anisoplia baetica* Erichson.
- 8'. Stridulatory area of mandible with an inter-ridge area 4 times the ridge width (Fig. 31). Maxillary articulating area with a row of 11–23 (16) setae just parallel to stridulatory teeth (Fig. 29b). *Anisoplia remota* Reitter.



Figs 38–43: *Anisoplia depressa* third-instar larva. 38 – frontal view of head; 39 – dorsal (a) and ventral (b) view of apical antennal segment showing sensory spots; 40 – ventral (a) and dorsal (b) view of maxilla; 41 – dorsal view (a), lateral view (b), and ventral view (c) of left mandible; 42 – stridulatory area of mandible; 43 – dorsal view (a), lateral view (b) and ventral view (c) of right mandible.

9. Lobes of the prothoracic spiracle equal in size (Fig. 46). Stridulatory area of mandible with an inter-ridge area 2.5 times the ridge width (Fig. 42). *Anisoplia depressa* Erichson.

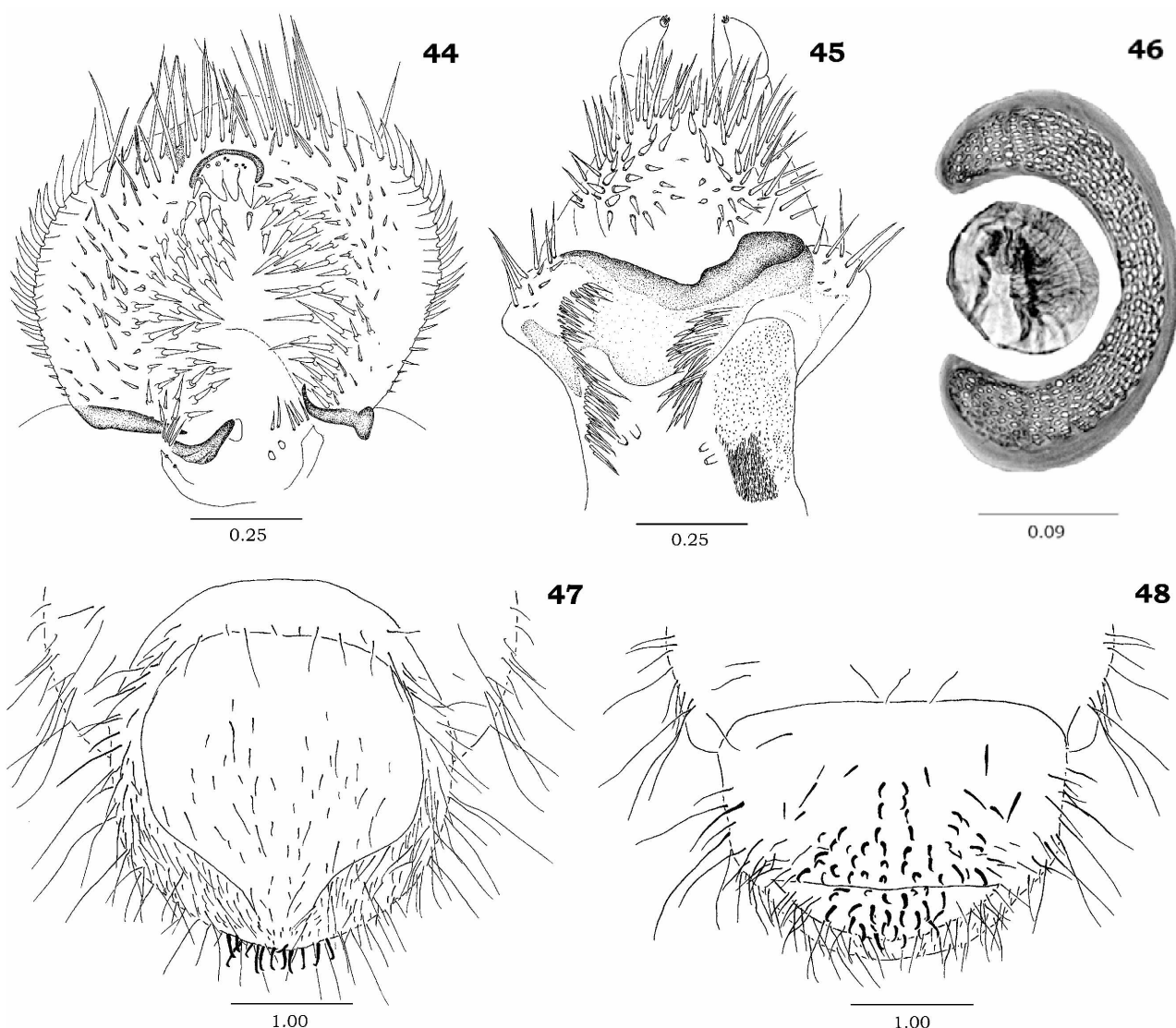
9'. Inferior lobe of the prothoracic spiracle conspicuously larger than superior lobe (Fig. 13). Stridulatory area of mandible with an inter-ridge area 1.6 times the ridge width (Fig. 5). *Anthoplia floricola* (Fabricius).

(*)With the characters of *Anisoplia agricola* in the literature, further differentiation is impossible.

DISCUSSION

Until now, the larval characteristic defining Anomalinae was the possession of a raster consisting of 2 monostichous palidia (Ritcher, 1966). However, the absence of a palidium in *A. depressa* and *Anthoplia*, refutes this assertion. Larvae of Anisopliini can be distinguished from other Anomalinae by the abdominal spiracles: those on I

and VIII are conspicuously smaller in Anisopliini larvae. In contrast, in other Anomalinae the spiracles on abdominal segments VII–VIII are similar in size and conspicuously larger than the spiracles on I–VI (Ritcher, 1966). Of the characters used in the diagnosis of species of Anisopliini, we favour those found on the last abdominal segment and the stridulatory area of mandibles. The shape of the stridulatory area on the mandibles and the number of ridges are normally cited in descriptions of larvae (Vanin & Costa, 1980; Jameson et al., 1994), however, the width of the ridges and the width of the inter-ridge area are not normally described. In the Anisopliini larvae studied, this is a species specific diagnostic character, which may be related to intraspecific communication between larvae. In other Anomalinae, the other mouthparts, such as epipharynx and hypopharynx, are morphologically uniform, probably because of their similar feeding habits. The shape and vestiture of the *SFA*



Figs 44–48: *Anisoplia depressa* third-instar larva. 44 – epipharynx; 45 – hypopharynx. 46 – prothoracic spiracle; 47 – dorsum of last abdominal segment; 48 – venter of last abdominal segment.

are very useful species specific characters and the size and shape of the *SFA* allows the separation of *Chaetopteroptia* and *Brancoplia* from other genera. In contrast, it is difficult to separate the genus *Anthoplia* from *Anisoplia* morphologically. In fact, only a few specific characters distinguish *Anthoplia* from *Anisoplia depressa*. Our results indicate it is not possible to separate *Anthoplia* from *Anisoplia* on the basis of larval morphology. However, more *Anisopliini* larval descriptions are needed before the phylogenetical trends in the group and the systematic position of the monospecific genus *Anthoplia* can be determined.

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