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The Larvae of European Ascalaphidae (Neuroptera)

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Abstract

The larvae of all the European genera of Ascalaphidae are compared for the first time, highlighting the differential characters for identification purposes. The larva of the genus *Ascalaphus* is described for the first time while those of *Puer, Bubopsis* and *Deleproctophylla* are deeply revised. Actually, the larvae of *Ascalaphus festivus* (Rambur), *Puer maculatus* (Olivier), *Bubopsis agrionoides* (Rambur), *Deleproctophylla australis* (Rambur), *Libelloides latinus* (Lefebvre), *Libelloides corsicus* (Rambur) and *Libelloides siculus* (Angelini) are described or accurately depicted for the first time. The known larvae of the genus *Libelloides* are reviewed.

Key words: Myrmeleontiformia, larval morphology, identification, Mediterranean, Western Palaearctic

Introduction

The family Ascalaphidae comprises the most visually remarkable members of the order Neuroptera due to large dimensions, aerial predatory behaviour and dragonfly-like (or even butterfly-like) habits, allowing an immediate recognition also for occasional observers. Otherwise they are one of the more poorly known families of the order in respect to biology, ecology and especially larval morphology. This discrepancy appears particularly noteworthy considering that it is a fairly large family (ca. 430 species) widely distributed in tropical and temperate areas of the world (U. Aspöck & H. Aspöck 2007). The most comprehensive modern accounts on ascalaphid larvae are a series of works by Henry (1976, 1977, 1978a, 1978b), mostly dealing with the American fauna and Tjeder (1992), who described a considerable number of African larvae but he was unfortunately unable to associate them with the respective species. The state of knowledge of the larvae of European species is surprisingly poor and inadequate, as only two recent studies exist: Rousset (1973), comparing three *Libelloides* species, and Pieper & Willmann (1980), on the larvae of some Balkan taxa. Older accounts on the larvae, such as Hagen (1873), van der Weele (1909) and Navás (1915), despite offering interesting insights, are often inaccurate and the identifications are not rarely doubtful or wrong. The insufficient knowledge of the larvae is also a serious obstacle to understand the reciprocal relationship within Ascalaphidae and related families, as larval morphology has a fundamental role in the phylogeny and classification of Neuroptera (U. Aspöck 1992; U. Aspöck *et al.* 2001; Beutel *et al.* 2010; Winterton *et al.* 2010).

The aim of this research, the result of three years of field samplings, is providing for the first time comparative descriptions and an identification key to all the European genera of Ascalaphidae, including some poorly known and rare species.

Material and methods

Ascalaphid larvae are notably difficult to find in the field due to their camouflaging behaviour and low population densities, therefore most species were obtained from eggs laid in captivity by field-collected adult females.

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Nevertheless accurate field research was conducted, permitting to find some of the most interesting species. The larvae were reared in laboratory in order to obtain the 3rd instar, the best stage for morphological comparisons. The specimens were kept in a dedicated room with a mean temperature of 25°C and 60% humidity, while during winter they were moved into an unconditioned room to simulate natural conditions. The larvae were reared in small cylindrical containers of plastic with rough paper as substratum. The nourishment was composed by cockroaches (Blattodea: Blaberidae gen. sp.) of adequate size; occasionally yellow mealworm larvae, *Tenebrio molitor* Linnaeus (Coleoptera: Tenebrionidae) and bean aphids, *Aphis fabae* Scopoli (Hemiptera: Aphididae) were offered instead.

Morphological comparisons were mainly conducted using a Leica® MZ9.5 stereomicroscope while a Leica® MZ16 stereomicroscope coupled with a Leica® DFC320 digital camera was used for photographs and measurements. The obtained photographs were elaborated using LAS (Leica® Application Suite) applied software Version 2.5.0 R1 and later processed using the software Adobe Photoshop® CS5 Extended Version 12.0.

The specimens were measured according to the protocol applied by Cesaroni *et al.* (2010) on antlion larvae: the body length of larvae (BL) was measured from the head (excluding mandibles) to the tip of abdomen; the length of the head capsule (HL) was measured ventrally from the clypeo-labrum to the head insertion with the thorax, the head width (HW) was taken just below the eye tubercles, at the point of maximum width; the length of the mandibles (ML) was measured from the apex to the base. In order to underline the respective proportions of the head and mouthparts, the ratio head capsule width/head capsule length (HW/HL) and mandible length/head capsule length (ML/HL) were calculated. The number of interdental pseudo-teeth (spiniform setae) is reported for each species as a formula: (a)(b)(c), where a = number of pseudo-teeth in the gap between mandible base and basal tooth; b = number of pseudo-teeth in the gap between basal and median teeth; c = number of pseudo-teeth in the gap between median and apical teeth. The number of setae between the apical tooth and the apex of mandible has been omitted as they are always absent in the examined species.

The larval instars are sometimes indicated as L1 (1st instar); L2 (2nd instar); L3 (3rd instar).

The larvae were preserved in 95° ethanol and deposited in the collections of the authors.

Larval morphology

(Fig. 1)

Chaetotaxy. The larvae of Ascalaphidae are mostly covered by dolichasters, a modified type of seta characteristic of larval Myrmeleontiformia. In this family, dolichasters are the main type of macrotrichia, covering the whole body, including mouthparts. The typical dolichaster is a robust, hollow seta set on an enlarged base, with a star-shaped distal end and normally with a geometrical cross section. As dolichasters often have a diagnostic value, Henry (1976) distinguished various types of this setae according to their shape: “goblet-shaped”, “clavate”, “scale-like”, “stellate-tipped” and “plumose”. A further type of dolichasters, present in some taxa, is represented by extremely elongated, thin, “hair-like”, hollow setae. Dolichasters firmly retain soil particles and debris, therefore playing an important role in the camouflaging behaviour characteristic of the larvae of many species.

Body protuberances. One of the more striking characters of ascalaphid larvae is represented by the conspicuous protuberances disposed on the lateral sides of the body. These structures are everted cuticular processes of the thorax and abdomen, bearing dolichasters on the sides and the apex; thus they are termed here pedunculated setiferous processes. Their prominence, shape, setae-thickness and disposition have a considerable diagnostic value. Many recent authors (MacLeod 1970; Henry 1976, 1978a, 1978b; Tjeder 1992) named these structures scoli, singular scolus. Nevertheless the use of this name appears inappropriate for ascalaphid larvae, as the term was originally coined on lepidopterous larvae (Fracker 1915) and extended to the larvae of Coccinellidae (Gage 1920), to define a ramified projection at least 5 times as high as wide with a single seta disposed at the apex of each branch. However, in larvae of Ascalaphidae they are often shorter (often not over 3 times as high as wide) and unbranched; not rarely these processes are flattened with the setae disposed on the external margin. With the aim to solve this incongruence but at the same time respecting the present nomenclature, this type of pedunculated setiferous process is termed here scolus-like process. In many genera, the reduction of some processes is evident (normally, but not always, the ventral abdominal series; see later), in these cases the short remaining protuberances are named tubercle-like processes after their shape.

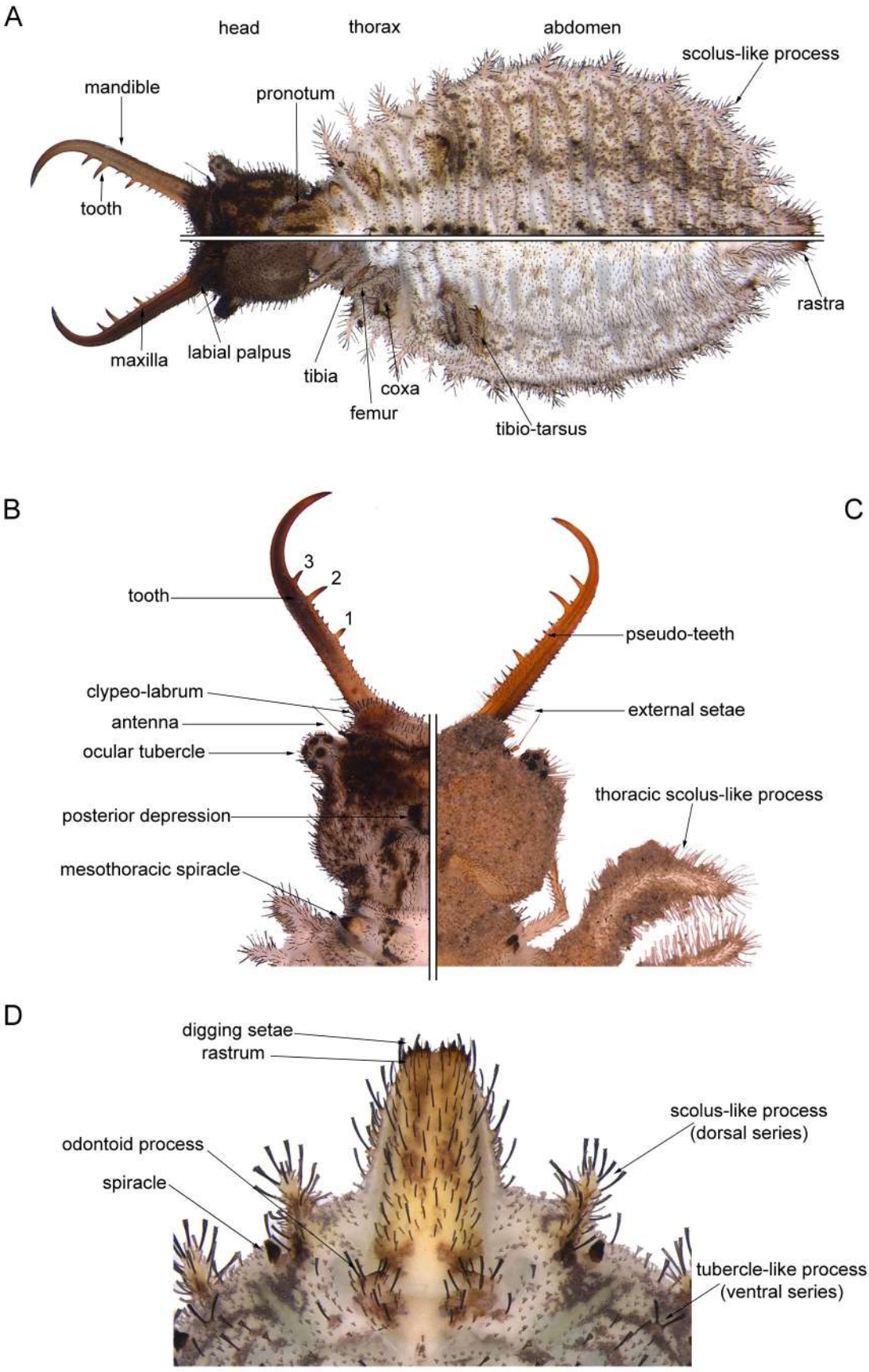

FIGURE 1. Taxonomic characters of Ascalaphidae larvae. A, *Deleproctophylla australis* dorsal and ventral view; B, head of *Ascalaphus festivus*; C, head of *Puer maculatus*; D, VIII and IX sternites of *Libelloides siculus.*

Head. The head is comparatively large and heavily sclerotized, often noticeable dilated posteriorly. The anterior margin of the clypeo-labrum is concave, with a median incision more or less pronounced according to the genus. On the dorsal side, the tentorial pits are well recognizable as oblique incisions running from the base of the antennae to the middle. A pair of oblique frontal sutures distinguishes the anterior portion of the head from the epicranial area, converging with a median straight epicranial suture dorsally running from the middle toward the posterior part of the head. The occipital foramen is disposed on the dorsal side and the surrounding area is depressed, allowing to partly withdraw the head under the pronotum. In some taxa, the dorsal depression is very deep, reaching the middle, otherwise it is limited to the posterior portion of the head. The small and filiform antennae are raised on a short protuberance, dorso-laterally disposed between the mandibles and the ocular tubercles; they are composed by a short scapus, a comparatively long pedicel and a slender flagellum. The ocular tubercles, whose shape and size are of diagnostic value, are equipped with 7 stemmata (6 dorsal and 1 ventral). The sclerotized labium is disposed in the ventroanterior portion of the head, encased by the lateral sclerites of the head capsule. The basal portion of the palpi, at the insertion on the mentum, is noticeably large and swollen. In other works on the larvae of Ascalaphidae, it has been considered a prelabial lobe (MacLeod 1964; Rousset 1973; Henry 1976; Tjeder, 1992); nevertheless this structure would be more properly a basal labial palpomere as noted on Myrmeleontidae larvae (Friheden 1973; Principi 1943, 1947; Nicoli Aldini 2007). The labial palpus is 4-segmented, the elongated distal palpomere bears a sensorial pit. The gula is well recognizable posteriorly to the labium, prosecuting as a straight line on the ventral side of the head. The ventral tentorial pits are relatively inconspicuous, partly hidden by the labium. The jaws are very large, composed by conspicuous, dorsally placed, mandibles and narrow, ventrally-placed, maxillae; both elements are elongated and curved apically, forming sucking tubes with the median furrow. The mandibles are armed with teeth and a diversified array of setae along the internal margin. Jaws play an important role in taxa identification, bearing important diagnostic characters such as: relative dimensions, shape and thickness, disposition and dimension of mandibular teeth. Ascalaphid larvae are provided with 3 pairs of teeth, of which the median pair is larger than the others. On the internal margin of the mandible, among teeth, stout setae raised on a mandibular protuberance are present. These structures are termed "pseudo-teeth" or "spiniform-setae", representing the intermediate stage between the true teeth and the setiferous tubercles from which they originate.

Thorax. The prothorax is the smallest thoracic segment and it is composed by an inconspicuous anterior subsegment and a larger posterior one, bearing the first pair of legs and dorsally covered by a large tergite, the pronotum. Meso- and metathorax are overall similar and noticeably broader than the prothorax. The mesothorax bears the only pair of thoracic spiracles. The most remarkable feature of their tergites, meso- and metanotum, is represented by the pedunculated scolus-like setiferous processes disposed on the sides. Most larvae are equipped with two pairs of processes for each segment, thought they are secondarily reduced or lost in some genera. The anterior pair of mesothoracic setiferous processes is often the most prominent. The metathorax appears very short from a dorsal view because it is partly covered by the first abdominal tergite.

Legs. The leg pairs are similar, but differing in some details. They are composed by a large and robust coxa, trochanter, femur, tibia and a tarsus composed of one segment and a reduced, claws- bearing pretarsus. The metathoracic pair of legs notably differs from the previous pairs due to the fusion of the tibia and tarsus. The prothoracic legs are characterized by small but noteworthy modifications allowing to grasp or hold small soil particles used to cover the body. This kind of camouflaging behaviour has been observed in *Libelloides* and *Ululodes* Smith, 1900 (Withycombe 1925; Henry 1976, 1977; Pantaleoni 1991).

Abdomen. The abdomen is composed by 10 segments, nevertheless the X segment is normally not visible being telescopic and retracted inside the IX and VIII ones; it specializes in spinning the cocoon with silk secreted by the Malpighian tubules. The tergites are not normally discernible as they merge with the soft and elastic pleural area, while the sternites are usually well recognizable. A pair of lateral spiracles is present on the first eight segments. In Ascalaphinae, a tendency to locate the first pair on the dorsal side is evident in some genera. In the subfamily Haplogleniinae, the first and second pairs of abdominal spiracles are distinctly disposed on the dorsal side (Hagen 1873; Henry 1978a, 1978b; Badano pers. obs.). The lateral sides of the body are characterized by the presence of setiferous processes, disposed dorsally and ventrally to the abdominal spiracles, permitting to distinguish a dorsal and a ventral series. Originally both series of setiferous processes were prominent and scolus-like (Henry 1978a), however in most genera the ventral series is secondarily reduced to small, tubercle-like setiferous processes. In some groups the first pairs of dorsal setiferous processes migrate on the dorsal side,

following the spiracles. The last sternites bear modified macrochaetae which allow to the larva to anchor itself to the substratum. In most genera, the posterior margin of the VIII sternite is characterized by the presence a pair of small tooth-like structures, termed odontoid processes, partly covered by dolichasters. The IX segment is cone-shaped and longer than wide; its posterior margin is provided with a pair of sclerotized protuberances each bearing 3 or 4 short and robust setae; these structures are termed here rastra, singular rastrum (from the Latin rastrum, rastri, rake), a term recently coined to define the clearly homologous structures present in Myrmeleontidae larvae (Badano & Pantaleoni 2014).

Larval development and life cycle

The life cycle of most species of Ascalaphidae remains poorly known. In the species whose oviposition have been observed (including *Ascalaphus*, *Bubopsis*, *Deleproctophylla* and *Libelloides*), the adult female lays the eggs on a stem, neatly disposing them in series. Egg hatching occurs after about 30 days, obviously influenced by temperature. Ascalaphidae have three larval stages whose duration is influenced by the photoperiod and secondarily by food availability and temperature. The larvae are strictly ambush hunter predators, catching the prey ending up in proximity of the jaws. The overwintering stage is always represented by the larva, whose development varies according to the individual. In the European species, the mature larvae spin a sub-spherical cocoon for pupation in spring or early summer and this stage lasts at least 30 days according to the temperature. In laboratory-conditions most species are able to reach the third instar in one year. Field samplings clearly indicate that most species are univoltine or semivoltine. In some cases, such as *Bubopsis*, the whole life cycle lasts more than two years in the field.

Larval stages recognition

The larval stages of the same species are noticeably similar in overall morphology, mainly differing in dimensions. The 1st instar larva is distinguished by different relative proportions of head and jaws and the sparser setation covering the body. The whole pattern is generally darker. The main difference between 2nd and 3rd instar larvae is represented by dimensions.

Genus-level characters are normally recognizable in all larval stages, despite species recognition in early stages can be extremely difficult.

Key to the genera of larvae of European Ascalaphidae

1 Head one and a half times wider than long; ocular tubercles flattened; scolus-like processes very large and flattened: 3 main pairs of thoracic scolus-like processes and 8 pairs of dorsal abdominal scolus-like processes; ventral series of abdominal processes absent (Fig. 5). . . . . *Puer*

\- Head as wide as long; ocular tubercles cylindrical; 4 pairs of thoracic scolus-like processes and 8 pairs of dorsal abdominal scolus-like processes; ventral series of abdominal processes present but mostly tubercle-like (Figs. 4, 6–16) 2

2 Base of the mandible covered with white dolichasters; mandibular teeth relatively small, distance between the base of the mandible and the basal tooth noticeably longer than that between the basal and apical teeth; ocular tubercles with a distinct apical bump; ventral series of abdominal processes composed by scoli-like processes on the four anterior segments and tubercle-like ones on the following segments (Figs. 6–7) . . . . . *Bubopsis*

\- Base of the mandible not covered with white dolichasters; teeth relatively large; distance between the base of the mandible and the basal tooth similar to that between the basal and the apical teeth; ocular tubercles without a distinct apical bump; ventral series of abdominal processes composed by scoli-like processes on the first two anterior segments and tubercle-like ones on the following segments (Figs. 4, 8–16) 3

3 Dorsal posterior depression of the head capsule very deep, reaching the middle of the head; ocular tubercles large, wider than long; first pair of abdominal scoli-like processes of the dorsal series and first pair of abdominal spiracles disposed on the dorsal side (Fig. 4) . . . . . *Ascalaphus*

\- Dorsal posterior depression of the head capsule shallow, not reaching half of the head length; ocular tubercles longer than wide or as long as wide; first pair of abdominal scoli-like processes of the dorsal series and first pair of abdominal spiracles disposed on the lateral sides (Figs. 8–16) 4

4 Head dilated posteriorly, body covered by short goblet- and stick-shaped dolichasters (Figs. 3E, 10–16) . . . . . *Libelloides*

\- Head not dilated posteriorly; body exclusively covered by stick-shaped dolichasters (Figs. 3D, 8–9) . . . . . *Deleproctophylla*

Ascalaphus **Fabricius, 1775**

Diagnosis. Dorsal side of the head capsule with a deep posterior incision, reaching the middle of the head; antennae thin, longer than the ocular tubercles; ocular tubercles large, wider than long; mandibles equipped with three teeth, the median tooth is the largest and closer to the apical tooth than to the basal tooth; mandibles with interdental pseudo-teeth; labial palpi four-articulated, segments 2–4 thin, slightly longer than the basal width of the mandible, last segment swollen; thoracic scolus-like processes cylindrical; mesothorax with two sub-equal pairs of processes; metathorax with a small anterior pair of scolus-like processes followed by a larger posterior pair; first pair of abdominal spiracles placed dorsally; abdomen with eight pairs of dorsal scolus-like processes, ventral series composed by two pairs of scolus-like processes on the first two anterior segments and six pairs of short tubercle-like processes on the following segments; VIII sternite with short odontoid processes bearing dolichasters; IX sternite with two short rastra each bearing three digging setae (Fig. 2A); body covered by black, bristle-like dolichasters (Fig. 3A).

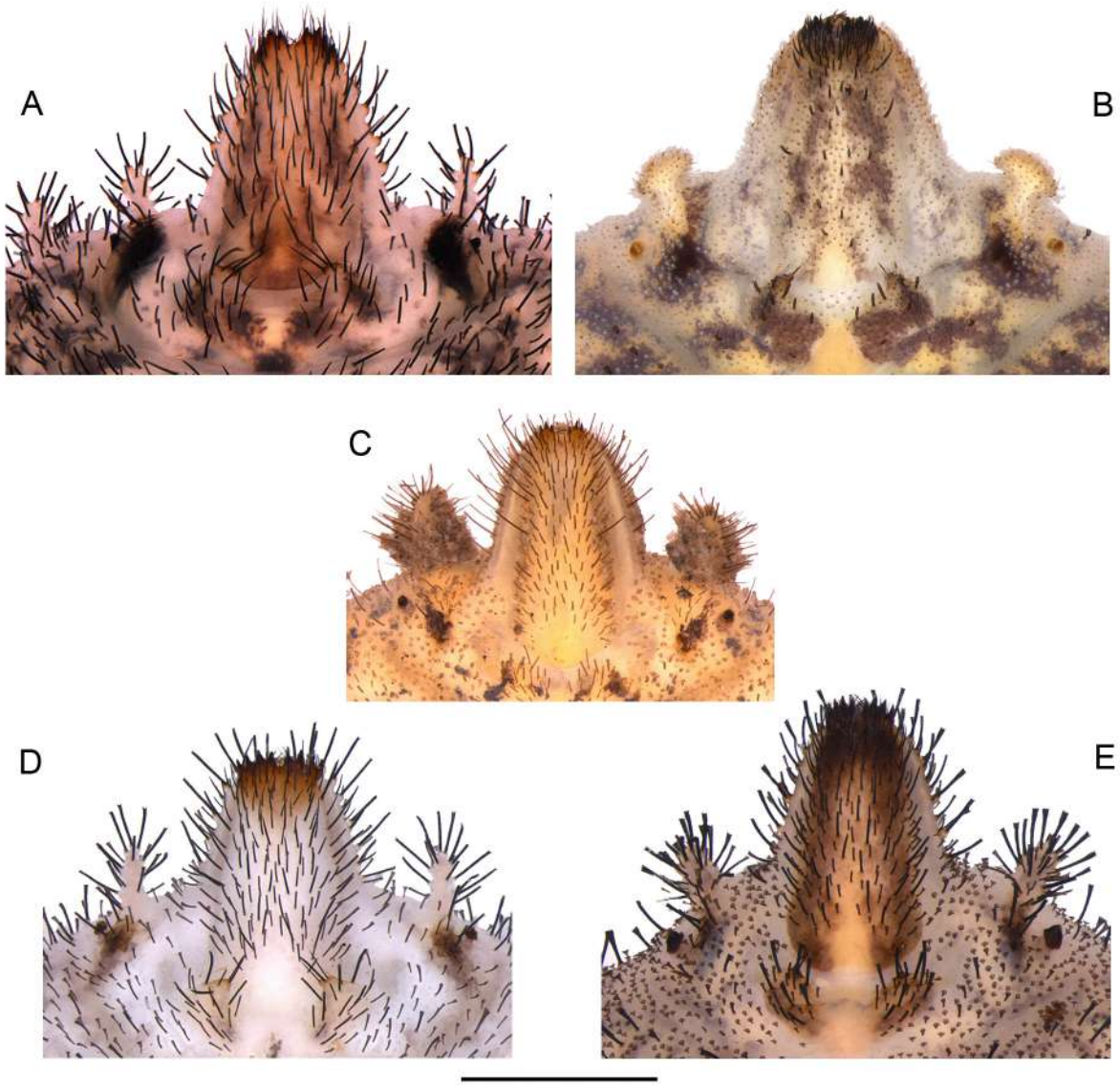

FIGURE 2. VIII and IX abdominal sternites of 3rd instar larva of Ascalaphidae. A, *Ascalaphus festivus*; B, *Bubopsis agrionoides*; C, *Puer maculatus*; D, *Deleproctophylla australis*; E, *Libelloides macaronius*. Scale bar: 1 mm.

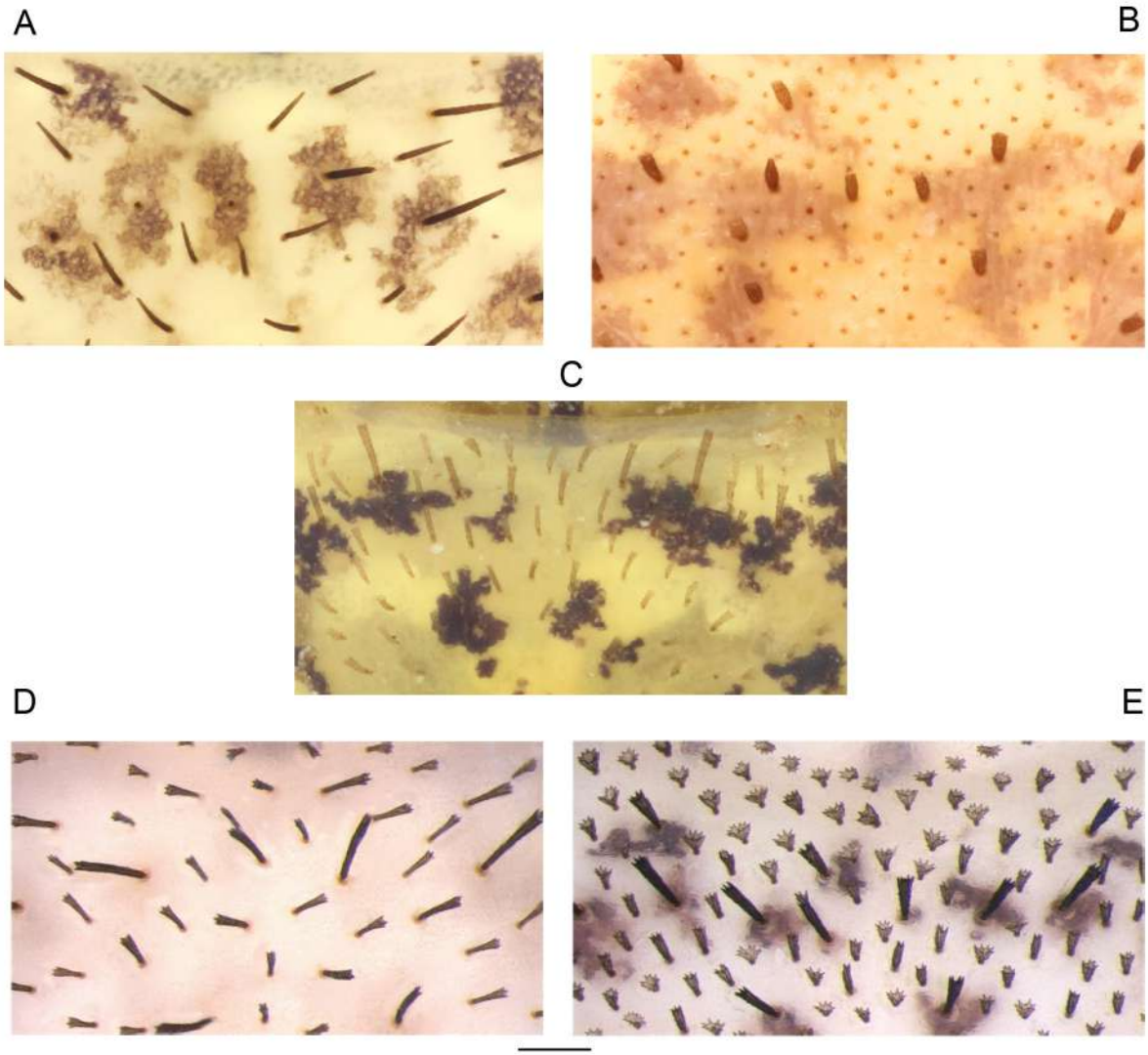

FIGURE 3. Chaetotaxy of the VIII abdominal sternite of 3rd instar larva of Ascalaphidae. A, *Ascalaphus festivus*; B, *Bubopsis agrionoides*; C, *Puer maculatus*; D, *Deleproctophylla australis*; E, *Libelloides longicornis*. Scale bar: 100 μm.

Examined species. *A. festivus* Rambur, 1842.

Comments. The complex taxonomy of the genus *Ascalaphus* is unsolved and the correct placement of the Oriental species remains uncertain. In the present sense *Ascalaphus* comprises over twenty species distributed in the Afrotropical, Western Palaearctic and Oriental regions. *A. festivus* has been recently reported for the European fauna (Pantaleoni *et al.* 2013). The larvae of this genus are described here for the first time because the only existing account refers to an Indian species (Ghosh 1913) which probably does not belong to this taxon (New 2003). Michel (2001) described the eggs of an African species.

Ascalaphus festivus Rambur, 1842

(Figs. 1B, 2A, 3A, 4)

The larvae of this species are described here for the first time. A photo of newly hatched 1st instar larvae appears in U. Aspöck & H. Aspöck (1999).

Examined specimens. Italy. Sardinia, 2 L3 laboratory-reared from a female collected at Sant'Anna Arresi, Porto Pino, coastal marshes, VII.2005; 2 L3 and 1 L3 laboratory-reared to adult, laboratory-reared from a female collected in the same locality, IX.2008 (R. A. Pantaleoni, D. Badano & A. Letardi).

FIGURE 4. *Ascalaphus festivus* Rambur, 1842, 3rd instar larva (Italy: Sardinia, Sant'Anna Arresi, Porto Pino). Dorsal (above), ventral (middle) and lateral (below) view; a–e: diagnostic characters, see species description.

Description of 3rd instar larva. Size (based on 4 specimens): BL 14.98 mm; HL 3.07 mm (2.88–3.18), HW 3.69 mm (3.51–3.79), ML 3.73 mm (3.47–3.97), HW/HL 1.20, ML/HL 1.21. Body bicoloured: anterior part of the body whitish with dark markings, posterior half of the abdomen dark brown with white markings, ventral side of the body whitish and mottled with brown; scolus-like processes mostly whitish; dorsal side of the head capsule mainly dark brown with paler areas on the clypeo-labrum and on the posterior half, ventral side brown, mandibles brown, darker apically; legs pale; setae of the body black. Head wider than long, slightly dilated posteriorly and with a deep dorsal posterior depression (Fig. 4c); ocular tubercles large, wider than long (Fig. 4b); mandibles straight, longer than the head capsule (Fig. 4a); interdental pseudo-teeth: (4–2)(4–2)(0); external margin of the mandible equipped with short setae. Pronotum covered by sparse short setae; mesothoracic spiracles ochre with a darker apex. Abdominal spiracles dark, the first pair positioned on the dorsal side (Fig. 4d); first pair of abdominal scolus-like processes positioned dorsally, black in colour (Fig. 4e), contrasting with the white following pairs.

Bio-ecology. In Sardinia *A. festivus* has been exclusively found in coastal salt marshes on back-dunes, living among rushes growing on a humid sandy substratum. In Africa this species is mainly reported from grasslands and similar biotopes. The larval habitat remains to be determined however the larvae probably live among the impenetrable tufts of rushes.

Distribution. This species has been reported from almost the whole African continent and Middle East, nevertheless it has been often confused with congeners thus a careful revision of the existing records appears necessary to establish its actual distribution.

Remarks. *A. festivus* is the only member of the genus whose larva is adequately described. The larva is easily recognizable due to the peculiar bicolour pattern of the body.

Puer Lefèbvre, 1842

Diagnosis. Head capsule one and a half times wider than long; antennae thin, longer than the ocular tubercles; ocular tubercles small, flattened, wider than long and forward directed; opening gap of the jaws larger than 180°; mandibles closely approximated at the insertion; mandibles narrow, armed with three pairs of teeth and with numerous pseudo-teeth; median tooth larger than the other teeth and closer to the apical tooth; base of the mandible covered with hair-like dolichasters; labial palpi four-articulated, segments 2–4 as long as the basal width of the mandible, last segment swollen; thorax provided with elongated and flattened scolus-like processes; mesothorax bearing two pairs of scolus-like processes of which the anterior ones are bent at 90°; metathorax with an anterior pair of large scolus-like processes and a posterior pair of very short tubercle-like processes; first pair of abdominal spiracles placed on the dorsal side, the following seven pairs on ventral side; abdomen with eight pairs of dorsal scolus-like setiferous processes, ventral series absent except a pair of tubercle-like setiferous processes on the first abdominal segment; VIII sternite without odontoid processes; IX sternite with two short rastra each bearing three digging setae (Fig. 2C); body thickly covered with short, pale dolichasters (Fig. 3C); long and thin dolichasters are present on the setiferous processes.

Examined species. *P. maculatus* (Olivier, 1789)

Comments. The genus *Puer* is exclusive of the Western Palaearctic Region, comprising two species: *P. maculatus* and *P. algericus* van der Weele, 1909 reported for South-Western Europe, North Africa and Middle East (U. Aspöck & H. Aspöck 1987; H. Aspöck *et al.* 2001; Badano & Pantaleoni 2012). The larva of this genus was exclusively treated by Hagen (1873) thought the validity of his account was questioned (H. Aspöck *et al.* 1980).

Puer maculatus (Olivier, 1789)

(Figs. 1C, 2C, 3C, 5)

Description of Hagen (1873) effectively refers to this peculiar and rare species, despite his identification was mainly based on geographical assumptions thus it was considered doubtful by later authors (H. Aspöck *et al.* 1980).

Examined specimens. France. Hérault, Argelliers, Les Hauts de Boscorre, holm oak wood on calcareous rocks, VI.2011 (B. Michel & D. Badano), 2 L3.

FIGURE 5. *Puer maculatus* (Olivier, 1789), 3rd instar larva (France: Hérault, Argelliers). Dorsal (above), ventral (middle) and lateral (below) view; a–f: diagnostic characters, see species description.

Description of 3rd instar larva. Size (based on 2 specimens): BL 10.43 mm; HL 2.21 mm (2.12–2.30), HW 3.24 mm (3.23–3.25), ML 2.60 mm (2.59–2.62), HW/HL 1.47, ML/HL 1.17. General colouring ochre with grey markings and spots, ventral side noticeably paler, mottled with grey; dorsal side of the head capsule light brown, ventral side of the head light brown with a dark area on the mouthparts, mandibles brown; legs ochre; setae black, most dolichasters grey. Head rectangular, dorsal side with a narrow posterior depression; long setae are present at the base of the forward-placed ocular tubercles (Fig. 5b); mandibles narrow, close at the base (Fig. 5c), longer than the head capsule (Fig. 5a); basal tooth equidistant between the base of the mandible and median tooth; interdental pseudo-teeth (4–3)(4–3)(0); thin and hair-like dolichasters are present at the base of the mandible; external margin of mandible equipped with short setae, longer toward the base. Pronotum covered with short dolichasters; mesothoracic spiracles black; anterior pair of mesothoracic scoli-like processes very large, bent at 90° (Fig. 5d). First pair of abdominal spiracles dorsally disposed, black in colour (Fig. 5e); the following seven pairs disposed ventrally; dorsal series of abdominal scolus-like processes positioned on the lower sides of the body, in contact with the substrate (Fig. 5f).

Bio-ecology. *P. maculatus* is associated with open Mediterranean biotopes with isolated trees or scrubs on extensive barren rocky areas. The investigated site is characterized by thick hedges of holm oaks interspersed with wide surfaces of cracked limestone. The larvae live adhering to the inferior surface of flat stones, normally disposed under larger rocks. The cocoon is spun and fixed in the same condition. The larva is extremely motionless and it is camouflaged by the fine rock dust retained by the dolichasters. The larval and pupal stages were both collected during the first decade of June, just before the known flight period in the area (Michel & Kral 2008).

Distribution. *P. maculatus* has been reported for southern France, Iberian Peninsula and Israel.

Remarks. The larva of *P. maculatus*, the only member of the genus whose larva is known, is remarkable due to the flattened habitus and peculiar morphology, noticeably differing from the other European Ascalaphidae.

Bubopsis McLachlan, 1898

Diagnosis. Head capsule rectangular with a shallow posterior depression; antennae thin, as long as the ocular tubercles; ocular tubercles prominent with a distinct apical protuberance; mandibles long and thin with the apical half bent outward, equipped with three relatively small teeth, distance between the base of the mandible and the basal tooth larger than that between the basal and apical teeth; the median tooth is the largest and closer to the apical tooth than to the basal tooth; interdental pseudo-teeth very small; mandible base covered with white dolichasters; labial palpi four-articulated, with segments 2-4 as long as the width of the mandible; mesothorax with two pairs of scolus-like processes bent at 90°; metathorax with a large anterior pair of bent scolus-like processes and a posterior pair of small cylindrical scolus-like processes; first pair of abdominal spiracles placed on the lateral sides; dorsal series of abdominal scolus-like processes prominent, one pair for each segment; ventral series composed by four pair of short scolus-like processes on the anterior four segments and by tubercle-like processes on the following segments, 8th segment without recognizable processes; VIII sternite with short odontoid processes bearing dolichasters; IX sternite with short rastra each bearing three digging setae (Fig. 2B); body extensively covered by whitish scale-like dolichasters (Fig. 3B).

Examined species. *B. agrionoides* (Rambur, 1838), *Bubopsis* sp. (Libya).

Comments. The genus *Bubopsis* comprises at least 8 species distributed in the Mediterranean Basin, Middle East and India. Hagen (1873) described for the first time a larva of this genus as "*Theleproctophylla barbara*" as he identified the specimen only on a geographic basis, ignoring the presence of the genus *Bubopsis* in Anatolia. His description is accurate enough to assign it to this genus for certain, as also suggested by Escribano (1921). Over a century later, the larva of *B. andromache* U. Aspöck, H. Aspöck & Hölzel, 1979 was finally described and illustrated by Pieper & Willmann (1980).

Bubopsis agrionoides (Rambur, 1838)

(Figs. 2B, 3B, 6)

Larva of this species is described here for the first time.

FIGURE 6. *Bubopsis agrionoides* (Rambur, 1838), 3rd instar larva (France: Hérault, Argelliers). Dorsal (above), ventral (middle) and lateral (below) view; a–e: diagnostic characters, see species description.

Examined specimens. France. Hérault, Argelliers, Les Hauts de Boscorre, holm oak wood on limestones; VI.2011, (D. Badano & B. Michel) 3 L3 and 2 L2 laboratory-reared to L3; same locality VII.2011, (D. Badano), 1 L3 and 1 L2 laboratory-reared to L3.

Description of 3rd instar larva. Size (based on 7 specimens): BL 13.86 mm; HL 3.09 mm (2.90–3.34), HW 3.59 mm (3.32–3.82), ML 4.07 mm (3.89–4.25), HW/HL 1.32, ML/HL 1.16. General colouring ochre with extensive grey markings and spots, dorsal side of the head capsule grey with ochre markings, ventral side of the head grey, mandibles black; legs dark grey; body extensively covered by white dolichasters. Head wider than long, slightly dilated posteriorly with a deep dorsal posterior depression; ocular tubercles with an apical bulge (Fig. 6b); clypeo-labrum thickly covered by white dolichasters (Fig. 6c); mandibles noticeably longer than the head capsule, distal portion bent outward (Fig. 6a); teeth small, distance between the base of the mandible and the basal tooth larger than that between the teeth; interdental pseudo-teeth: (4–2)(5–2)(0); base of the mandible covered by white dolichasters; external margin of the mandible covered by short setae. Pronotum thickly covered by white dolichasters; mesothoracic spiracles yellowish; mesothoracic scolus-like processes bent backward; first pair of metathoracic scolus-like processes conspicuous, each process characterized by one anterior and one posterior protrusion (Fig. 6d); second pair very short, unnoticeable, cylindrical in shape (Fig. 6e). Abdominal spiracles disposed on the lateral sides, the pair on the 1st abdominal segment situated slightly above the others; dorsal series of abdominal scolus-like processes conspicuous, each process with one anterior and one posterior protrusions; IX sternite with short rastra, surrounded by black robust setae (Fig. 2B).

Bio-ecology. *B. agrionoides* is associated with open, rocky Mediterranean biotopes, such as: scrublands, open woods and grasslands with isolated trees. The studied larvae were collected on the soil under large stones in barren calcareous areas surrounded by holm-oak hedges. The larvae are exclusively ambush predators and they camouflages themselves using the rock dust retained by the dolichasters. The development period of this species probably lasts two years, as suggested by the contemporary presence of L2, L3 and adults in the same period of the year.

Distribution. Western Mediterranean faunal element reported from southern France, Iberian Peninsula, Morocco and Lampedusa Island (Italy).

Remarks. Larvae of the genus *Bubopsis* are poorly known. Besides *B. agrionoides*, only the larvae of *B. andromache* have been identified, although the existing description (Pieper & Willmann 1980) is not adequate to differentiate the two species.

***Bubopsis* sp.**
(Fig. 7)

One larva belonging to an undetermined North African species of *Bubopsis*, undoubtedly differing from both *B. agrionoides* and *B. andromache*, is here briefly described in order to provide a comparison with congeners. The specimen was collected in a Libyan locality in close proximity with the Egyptian border. At the present state of knowledge, only *B. hamatus* (Klug, 1834) is reported from the area (H. Aspöck *et al.* 2001).

Examined specimens. Libya. Cyrenaica, Porto Bardia; III.1927 (Confalonieri) (Museo civico di Storia naturale "G. Doria", Genova), 1 L3.

Description of 3rd instar larva. Size: BL 10.50 mm, HL 2.70 mm, HW 2.90 mm, ML 4.09 mm. General colouring grey with a median white stripe, dorsal side of the head capsule grey, ventral side of the head dark grey, mandibles black; legs dark grey; body, including mandibles, extensively covered by white dolichasters. Head wider than long, not dilated posteriorly, with a deep dorsal posterior depression; ocular tubercles with an apical bulge; clypeo-labrum thickly covered by white dolichasters; mandibles noticeably longer than the head capsule, distal portion bent outward; teeth small, distance between the base of the mandible and the basal tooth larger than that between the teeth; interdental pseudo-teeth: (4)(2)(0); mandibles extensively covered by white scale-like setae reaching the median tooth (Fig. 7a). Pronotum thickly covered by white dolichasters shaping a median white stripe (Fig. 7b); mesothoracic scolus-like processes bent backward. Abdominal spiracles disposed on the lateral sides; dorsal series of abdominal scolus-like processes conspicuous.

Remarks. This interesting larva notably differs from *B. agrionoides* and *B. andromache* for the thick covering of scale-like white setae on the dorsal side of the mandible, reaching the median tooth and for the dorsal median white stripe composed by dolichasters.

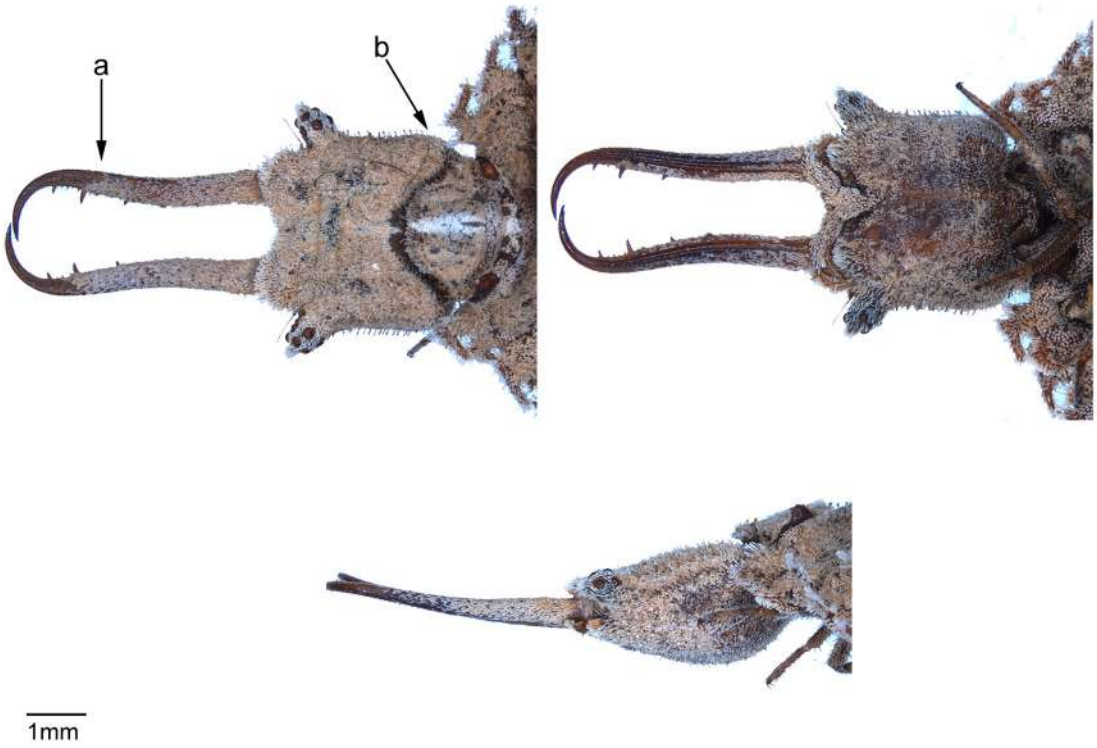

FIGURE 7. *Bubopsis* sp., 3rd instar larva (Libya: Cyrenaica). Dorsal (above), ventral (middle) and lateral (below) view of the head; a–b: diagnostic characters, see species description.

Deleproctophylla Lefèbvre, 1842

Diagnosis. Head capsule not dilated posteriorly, dorsal side with a posterior depression; antennae thin, longer than the ocular tubercles; ocular tubercles cylindrical with a small apical protuberance; mandibles armed with three teeth, the median tooth is the largest and closer to the apical tooth than to basal tooth; mandibles equipped with interdental pseudo-teeth; labial palpi four-articulated, segments 2-4 thin, slightly longer than the basal width of the mandible; meso- and metathorax each bearing two sub-equal pairs of cylindrical scolus-like processes; first pair of abdominal spiracles placed on the lateral sides; abdomen with eight pairs of dorsal cylindrical scolus-like processes, ventral series formed by two pairs of scolus-like processes on the first two anterior segments and six pairs of very short tubercle-like processes on the following segments; VIII sternite with short odontoid processes bearing dolichasters; IX sternite with short rastra each bearing four digging setae (Fig. 2D); body covered with elongated, stick-shaped, dolichasters (Fig. 3D).

Examined species. *D. australis* (Fabricius, 1787); *D. dusmeti* Navás, 1914.

Comments. *Deleproctophylla* is a western Palaearctic genus including 5 species distributed in the Mediterranean basin and Central Asia (H. Aspöck *et al.* 2001). The only reliable report on the larva of this genus regards *D. dusmeti* (Escribano 1921), while description of the larva of "*Theleproctophylla barbara*" from Anatolia by Hagen (1873) actually refers to the genus *Bubopsis*.

Remarks. Species delimitation and recognition in the genus *Deleproctophylla* are extremely complex, especially between the European *D. australis* and *D. dusmeti*, showing a considerable overlapping in characters normally considered useful for identification purposes. Similarly the larvae of *D. australis* and *D. dusmeti* do not display any valuable diagnostic features and the identification appears exclusively possible by means of their vicariant distribution and bio-molecular analysis (unpublished data).

***Deleproctophylla australis* (Fabricius, 1787)**
(Figs. 1A, 2D, 3D, 8)

Larva of this species is described here for the first time.

Examined specimens. Italy. Sardinia, 6 L3, laboratory-reared from a female collected at Monti (SS), VII.2010 (D. Badano).

Description of 3rd instar larva. Size (based on 6 specimens): BL 10.66 mm; HL 2.50 mm (2.24–2.72), HW 2.69 mm (2.42–2.92), ML 2.98 mm (2.77–3.22), HW/HL 1.07, ML/HL 1.19. General colouring pale brown, almost whitish, with brown markings and shades, ventral side of the body whitish with brown markings; dorsal side of the head capsule dark brown with paler markings, ventral side dark brown with paler posterior stripes, mandibles brown; legs brown; setae of the body black. Head quadrate, as wide as long, without a pronounced posterior dilatation (Fig. 8b), dorso-posterior emargination of the head capsule relatively deep; mandibles longer than the head capsule (Fig. 8a); interdental pseudo-teeth: (5–6)(2–3)(1–0); external margin of the mandible covered with short setae. Pronotum with a distinct median pale stripe bordered by dark brown areas; mesothoracic spiracles pale brown; anterior pair of mesothoracic scolus-like processes with a ventral dark brown spot at the base (Fig. 8c). Abdominal spiracles brown, disposed on the lateral sides; dorsal series of scolus-like processes white; VIII sternite with two distinct brown spots on the sides (Fig. 8d).

Bio-ecology. *D. australis* is strictly associated with arid Mediterranean environments such as grasslands, low scrublands and glades. The habits of the larvae are still poorly known however they clearly live on the soil surface among stones and tufts of plants.

Distribution. This species is present in the Apennine Peninsula, Tyrrhenian islands (Corsica, Sardinia and Sicily) and Balkan Peninsula.

Remarks. The larva of *D. australis* is not recognizable from *D. dusmeti*, sharing the same morphological features, proportions and even the slightest details such as the markings at the base of the first pair of mesothoracic setiferous processes and on the VIII sternite. Larval stages of the other members of the genus are currently unknown.

***Deleproctophylla dusmeti* Navás, 1914**
(Fig. 9)

Navás (1915) attributed a freshly hatched larva, a not diagnostic instar, to this species. Few years later, Escribano (1921) described and illustrated the larva and life-history of this ascalaphid.

Examined specimens. France. Hérault, 1 L3 laboratory-reared from a female collected at Saint Paul et Valmalle, VII.2011 (D. Badano). Alpes Maritimes, 3 L3 laboratory-reared from a female collected at Villeneuve Loubet, VII.2011 (D. Badano).

Description of 3rd instar larva. Size (based on 4 specimens): BL 10.42 mm; HL 2.52 mm (2.44–2.68), HW 2.83 mm (2.44–2.94), ML 3.16 mm (2.96–3.34), HW/HL 1.12, ML/HL 1.25. General colouring pale brown with darker shades, ventral side whitish with dark brown markings; head capsule dark brown, dorsal side of the head with paler markings, ventral side dark brown with paler posterior stripes, mandibles brown; legs brown; setae of the body black. Head slightly longer than wide (Fig. 9b); mandibles longer than the head capsule (Fig. 9a); interdental spiniform setae: (~5)(2–3)(1–0); external margin of the mandible covered by short setae. Pronotum brown with a pale median stripe; first pair of mesothoracic scolus-like processes with a dark spot at the base (Fig. 9c). Abdominal spiracles brown; VIII sternite with a pair of lateral brown spots (Fig. 9d).

Bio-ecology. Ecology of this species is similar to the congener *D. australis*, living in open arid Mediterranean environments with herbaceous vegetation.

Distribution. *D. dusmeti* is reported from the Iberian Peninsula and southern France.

Remarks. See *D. australis.*

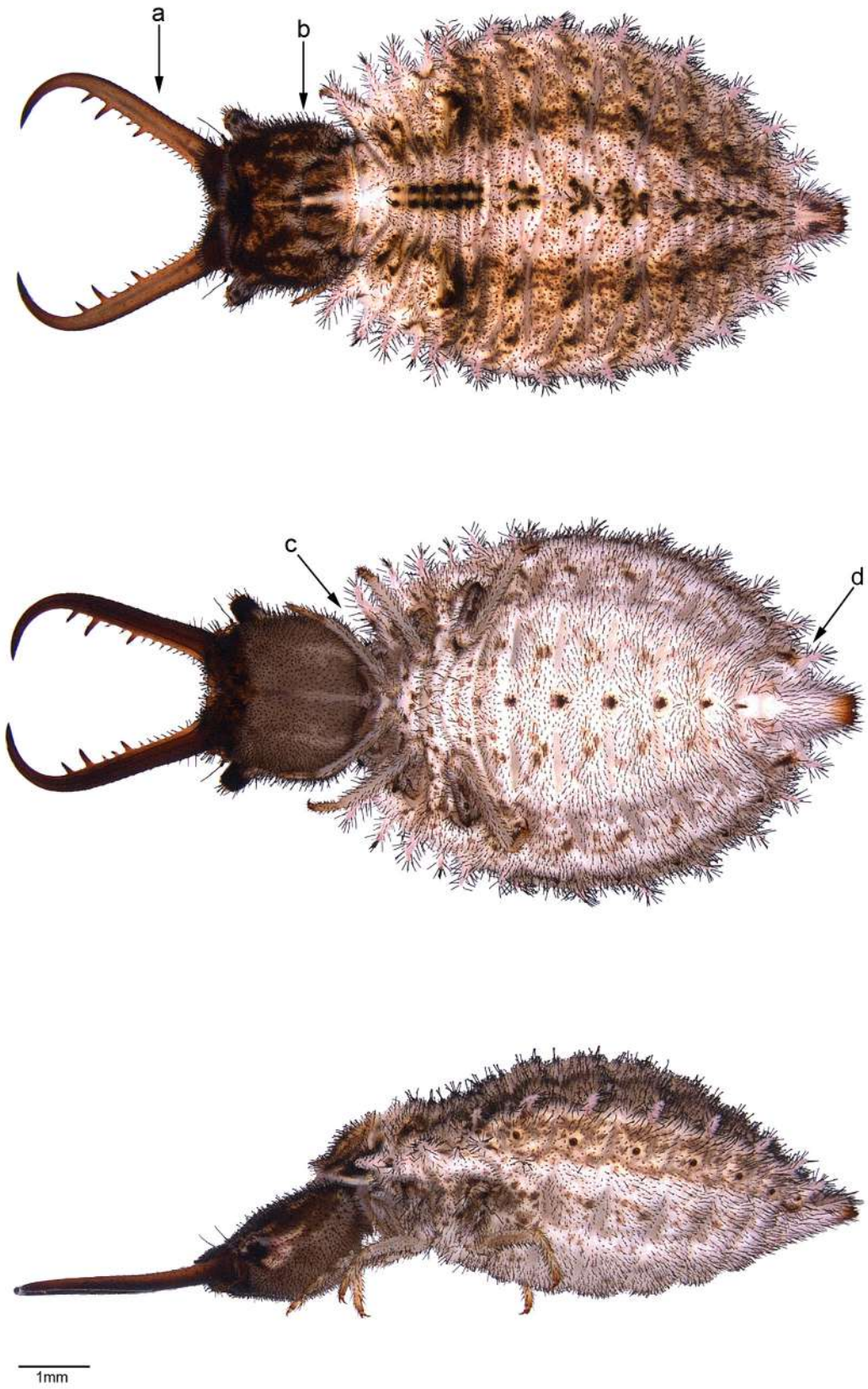

FIGURE 8. *Deleproctophylla australis* (Fabricius, 1787), 3rd instar larva (Italy: Sardinia, Monti). Dorsal (above), ventral (middle) and lateral (below) view; a–d: diagnostic characters, see species description.

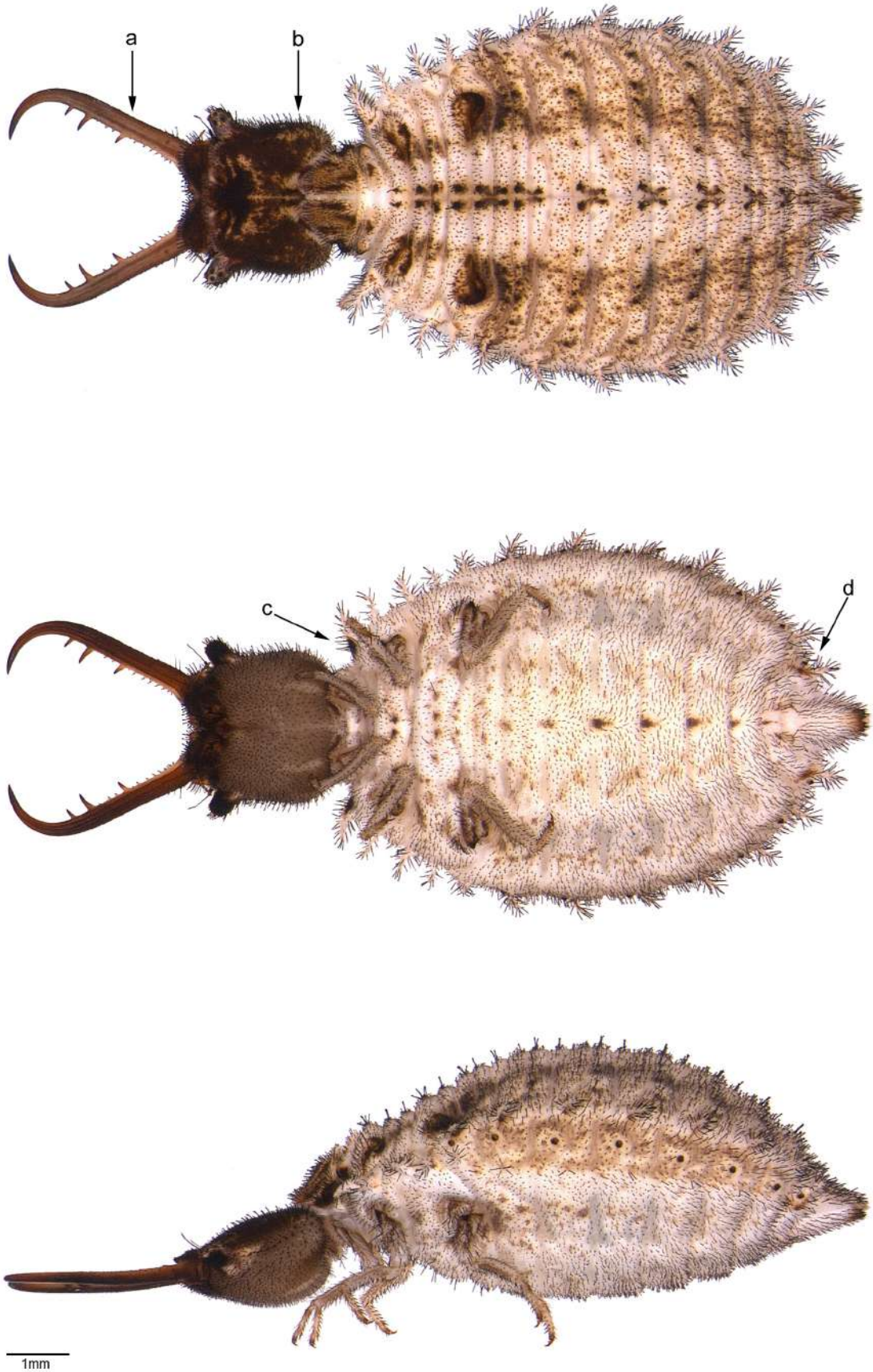

FIGURE 9. *Deleproctophylla dusmeti* Navás, 1914, 3rd instar larva (France: Alpes Maritimes, Villeneuve Loubet). Dorsal (above), ventral (middle) and lateral (below) view; a–d: diagnostic characters, see species description.

Libelloides Schäffer, 1763

Diagnosis. Head capsule dilated posteriorly, dorsal side with a pronounced posterior depression; antennae thin, longer than the ocular tubercles; ocular tubercles cylindrical; mandibles armed with three teeth, the median tooth is the largest and closer to the apical tooth than to basal tooth; mandibles equipped with interdental pseudo-teeth; labial palpi four-articulated, segments 2-4 thin, longer than the basal width of the mandible; mesothorax bearing two sub-equal pairs of cylindrical scolus-like processes; metathorax provided with a large anterior pair of scolus-like processes followed by a posterior pair half the size of the previous ones; first pair of abdominal spiracles placed on the lateral sides; abdomen with eight pairs of dorsal cylindrical scolus-like processes, ventral series formed by two pairs of scolus-like processes on the first two anterior segments and very short tubercle-like processes on the following six segments; VIII sternite with short odontoid processes bearing dolichasters; IX sternite with two short rastra each bearing four digging setae (Figs. 1D, 2E); body covered with short goblet-shaped dolichasters and stick-shaped ones (Fig. 3E).

Examined species. *L. coccajus* (Denis et Schiffermüller, 1775), *L. latinus* (Lefèbvre, 1842), *L. longicornis* (Linnaeus, 1764), *L. macaronius* (Scopoli, 1763), *L. ictericus* (Charpentier, 1825), *L. siculus* (Angelini, 1827), *L. corsicus* (Rambur, 1842).

Comments. The genus *Libelloides* is a characteristic faunal element of the Palaearctic region. Despite the status of some taxa needs to be evaluated, *Libelloides* includes at least 19 species of which about 12 are present in Europe, mainly in the western Mediterranean area (H. Aspöck *et al.* 2001). The larval morphology and ecology of this genus are poorly known: the first accurate study on this subject was realized by Brauer (1854) while the genus characters of the larvae were defined by Hagen (1873). Notably only two recent comparative works on this subject exist (Rousset 1973; Pieper & Willmann 1980). The larvae of *L. cunii* (Selys-Longchamps, 1840), *L. lacteus* (Brullé, 1832) and *L. rhomboideus* (Schneider, 1845) are actually known (van der Weele 1909; Navás 1915; Pieper & Willmann 1980) but their descriptions are excessively concise or referring to not diagnostic instars, for this reason adequate comparisons are not normally possible with the exception of *L. lacteus*, tentatively inserted in the key. Furthermore, Navás (1915) described a larva as *L. hispanicus* (Rambur, 1842), but this identification appears questionable.

Remarks. The larvae of the different species of *Libelloides* show a noticeable overlapping in the macroscopic characters normally used for identification purposes, such as: chaetotaxy, morphometry and the general pigmentation pattern. The relative difficulty to find the larvae in the field and their camouflaging behaviour make these light differences even more unsuitable. In particular, their camouflage is so effective that the different species are not recognizable if not artificially cleaned making visible the pigmentation pattern.

Key to the known larvae of *Libelloides*

1	Abdominal scolus-like processes rounded, unbranched	*L. lacteus* (from Pieper & Willmann 1980)
-	Abdominal scolus-like processes elongated, branched	2
2	Ventral side of the head capsule with longitudinal pale stripes (Figs. 12,16)	3
-	Ventral side of the head capsule without pale stripes (Figs. 10,11,13–15)	4
3	Dorsal side of the head with yellow markings; thorax and its scolus-like processes yellowish; legs with yellowish femora and tibiae; IX abdominal sternite yellowish (Fig. 16)	*L. siculus*
-	Dorsal side of the head brown; thorax and its scolus-like processes grey; legs with brown femora and tibiae; IX abdominal sternite with contrasting dark markings (Fig. 12)	*L. longicornis*
4	IX abdominal sternite with contrasting dark markings (Figs. 10–13)	5
-	IX abdominal sternite monochrome, without contrasting dark markings (Figs. 14, 15)	7
5	Dorsal side of the head capsule pale brown with a median trapezoidal dark marking; IX abdominal sternite with two anterior dark spots; ventral side of abdominal scolus-like processes dark (Fig. 11)	*L. latinus*
-	Dorsal side of the head capsule dark brown without a median marking; IX abdominal sternite without dark spots; ventral side of abdominal scolus-like processes pale (Figs. 10, 13)	6
6	Odontoid processes of VIII abdominal sternite dark brown; no more than 3 (normally 1-2) pseudo-teeth between the basal and median teeth (Fig. 10)	*L. coccajus*
-	Odontoid processes of VIII abdominal sternite pale; at least 4 pseudo-teeth between the basal and median teeth (Fig. 13)	*L. macaronius*
7	General colouring of the body, including the ventral side, dark brown; dorsal side of the head capsule with distinct dark spots at the base of the larger dolichasters (Fig. 15)	*L. corsicus*
-	General colouring of the body pale; dorsal side of the head capsule without distinct dark spots at the base of dolichasters (Fig. 14)	*L. ictericus*

***Libelloides coccajus* (Denis et Schiffermüller, 1775)**
(Fig. 10)

The first accounts about the larva of this species are not informative (Hagen 1873) or unreliable (Xambeu 1903; Lacroix 1923), while Eglin (1940) discussed the hatching behaviour of the first instar larvae. Surprisingly the first exhaustive description of the larva of this species, one of the more common and widespread European ascalaphids, was relatively recently realized by Rousset (1973). Finally, a photo of a larva appears in U. Aspöck & H. Aspöck (1999).

Examined specimens. France. Alpes Maritimes, 15 L3 laboratory-reared from a female collected at Venanson, VI.2011 (D. Badano). **Italy.** Liguria, 4 L3 laboratory-reared from a female collected at Mt. Toraggio (IM), VII.2010 (D. Badano).

Description of 3rd instar larva. Size (based on 19 specimens): BL 10.53 mm; HL 2.66 mm (2.51–2.91), HW 3.10 mm (2.89–3.30), ML 3.09 mm (2.87–3.29), HW/HL 1.16, ML/HL 1.16. General colouring brown with dark markings and areas, dorsal side with a median paler stripe, ventral side of the body pale, mottled with grey; dorsal side of the head capsule brown with a darker anterior area, ventral side of the head completely brown, mandibles brown; legs with dark brown coxae and pale brown femora, tibiae and tarsi; setae of the body black. Head wider than long, noticeably dilated posteriorly (Fig. 10b); mandibles longer than the head capsule (Fig. 10a); interdental pseudo-teeth: (3–4)(1–3)(0–1); external margin of the mandible with short setae reaching the apical tooth, base of the mandible covered by long setae; dorsal and ventral sides of the mandible covered by short and sparsely disposed setae. Pronotum covered by short setae, brown in colour with a pair of darker stripes; mesothoracic spiracles ochre with a dark apex. Abdominal spiracles dark brown; VIII sternite equipped with a pair of brown spots in correspondence of the odontoid processes (Fig. 10c); IX sternite pale with a dark posterior margin.

Bio-ecology. *L. coccajus* is a common, euryoecious species associated with an ample array of open biotopes from the lowlands to mountains such as: grasslands, glades, low scrublands and sparse woods, being exclusively absent from sites with excessive grazing. The larvae are ambush hunters living on the soil surface, camouflaged among the rocks and the tufts of herbaceous plants. Generally *L. coccajus* has the earliest flight period, as the first adults emerge in early April.

Distribution. Widely distributed in western and central Europe (Spain, France, Italy, Switzerland, Germany, Czech Republic).

Remarks. The larva of *L. coccajus* lacks noteworthy diagnostic characters, being mostly recognizable due to the dark brown hue of the body and the dilated posterior margins of the head capsule.

***Libelloides latinus* (Lefèbvre, 1842)**
(Fig. 11)

Larva of this species is described here for the first time, as the only existing account is a note by Pantaleoni (1991) on the camouflaging behaviour.

Examined specimens. Italy. Liguria, 22 L3 laboratory-reared from a female collected at Pompeiana (IM), VII.2010 (D. Badano).

Description of 3rd instar larva. Size (based on 22 specimens): BL 12.08 mm; HL 2.58 mm (2.37–2.73), HW 2.95 mm (2.77–3.11), ML 2.77 mm (2.55–3.03), HW/HL 1.14, ML/HL 1.07. General colouring grey mottled dark grey, dorsal side of the body with a median paler stripe, ventral side of the body pale with grey spots; dorsal side of the head capsule pale brown with a dark marking on the clypeo-labrum and a median trapezoidal dark marking with a yellowish border disposed at the level of the eye tubercle (Fig. 11b), dark spots are present at the insertion of the larger dolichasters on the head surface, ventral side of head brown with a darker marking on the mouthparts, mandibles brown; legs with dark brown coxae and pale femora, tibiae and tarsi with a median darker area; setae of the body black. Head wider than long, slightly dilated posteriorly; mandibles slightly longer than the head capsule (Fig. 11a); interdental pseudo-teeth: (3–4)(1–3)(0–1); external margin of the mandible covered by short setae. Pronotum pale brown with dark brown stripes; mesothoracic spiracles ochre with a dark apex. Abdominal spiracles dark brown; dorsal series of abdominal scolus-like processes with a dark marking at the base of each process (Fig. 11c); IX sternite pale with dark markings at both the anterior and posterior extremities (Fig. 11d).

FIGURE 10. *Libelloides coccajus* (Denis et Schiffermüller, 1775), 3rd instar larva (Italy: Liguria, Mt. Toraggio). Dorsal (above), ventral (middle) and lateral (below) view; a–c: diagnostic characters, see species description.

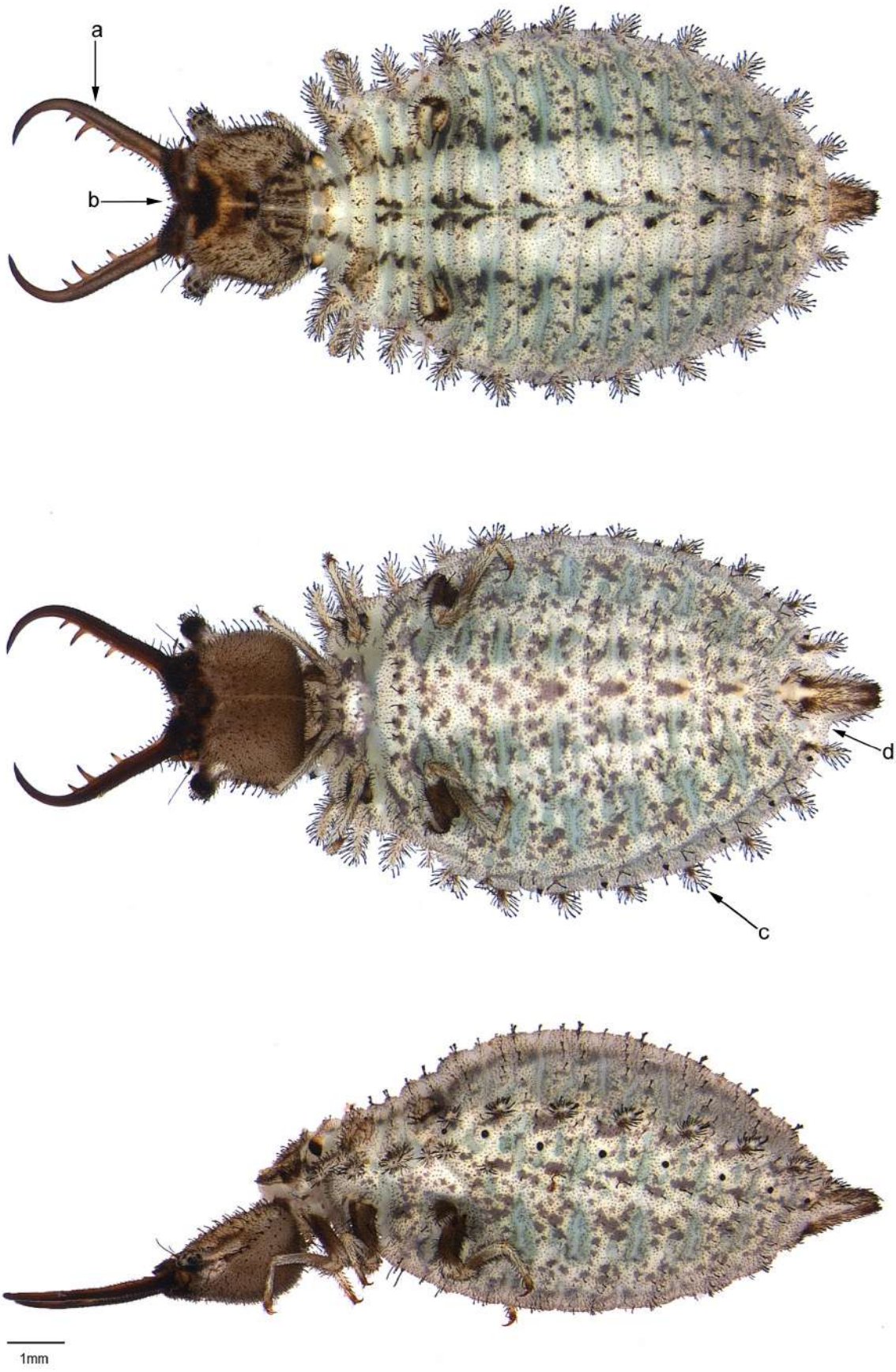

FIGURE 11. *Libelloides latinus* (Lefèbvre, 1842), 3rd instar larva (Italy: Liguria, Pompeiana). Dorsal (above), ventral (middle) and lateral (below) view; a–d: diagnostic characters, see species description.

Bio-ecology. *L. latinus* is a lowland and hillside species of open environments, rarely found over 700 m of altitude (Pantaleoni 1990a, 1990b). This ascalaphid is typical of open Mediterranean biotopes such as grasslands and scrublands. The larvae are ambush predators living on the soil surface, camouflaging themselves with detritus.

Distribution. This species is an endemism of the Apennine Peninsula, not crossing the Po river and absent from most of northern Italy; there are some reports from neighbouring areas of southern France. The absence of *L. latinus* in Sicily is particularly noteworthy as this ascalaphid is well known for Aspromonte, the southernmost part of the peninsula.

Remarks. The larva of *L. latinus* is mainly recognizable thanks to the pigmentation pattern of the head and the characteristic dark spots on the inferior side of the dorsal series of abdominal scolus-like processes.

Libelloides longicornis (Linnaeus, 1764)

(Figs. 3E,12)

The first description of the larva of this species was realized by Navás (1915) as the previous accounts were simply brief reports about the discovery of the eggs and 1st instar larvae (Ragonot 1878; McLachlan 1878) while other old descriptions were inconclusive (Lacroix 1923; Rabaud 1927). Rousset (1973) redescribed the larvae, comparing them with congeners.

Examined specimens. **France.** Var, 17 L3 laboratory-reared from a female collected at Mt. Aurelien, VI.2011 (D. Badano).

Description of 3rd instar larva. Size (based on 17 specimens): BL 11.18 mm; HL 2.63 mm (2.49–2.77), HW 3.17 mm (2.91–3.42), ML 3.06 mm (2.77–3.34), HW/HL 1.20, ML/HL 1.16. General colouring grey with a darker grey pattern, dorsal side with a median paler area, ventral side pale mottled with dark grey; head capsule brown with a darker anterior portion, ventral side of the head brown with a darker area on the mouthparts and with a pair of distinctive longitudinal pale stripes (Fig. 12c), mandibles dark brown; legs with dark brown coxae and paler femora, tibiae and tarsi; setae of the body black. Head wider than long, noticeably dilated posteriorly (Fig. 12b); mandibles longer than the head capsule (Fig. 12a); interdental pseudo-teeth: (3–4)(1–3)(0–1); external margin of the mandible with short setae. Pronotum pale brown with indistinct brown stripes; mesothoracic spiracles ochre with a black apex. Abdominal spiracles dark brown; VIII abdominal sternite pale with the exception of the odontoid processes; IX sternite pale with a dark apex.

Bio-ecology. *L. longicornis* is a common and euryoecious species occurring in open environments such as: grasslands, pastures, glades and scrublands. In Italy this ascalaphid is mainly associated with mountainous biotopes and reports from lowlands are mainly attributable to stranded individuals (Pantaleoni 1990a, 1990b), while in southern France this species shows a remarkably wider altitudinal range and it is common in Mediterranean environments (Puisségur 1967; Badano pers. obs.). The larvae are ambush predators living on the soil surface.

Distribution. Reported from Portugal, Spain, France, Switzerland, Italy and Germany.

Remarks. The larvae of *L. longicornis* are easily recognizable, with the exception of the Sicilian endemic *L. siculus,* thanks to the presence of longitudinal pale stripes running on the ventral side of the head. However *L. longicornis* and *L. siculus* are easily set apart for the different body colouring, besides the presence of *L. longicornis* in Sicily is unproven and unlikely ([Bernardi] Iori *et al.* 1995).

Libelloides macaronius (Scopoli, 1763)

(Figs. 2E, 13)

Brauer (1854, 1855) deeply treated the larval morphology and life history of this species, representing the first accurate account regarding an ascalaphid larva. Later descriptions of the larva were realized by Hagen (1873) and Pieper and Willmann (1980). A photo of a larva is shown in U. Aspöck & H. Aspöck (1999).

Examined specimens. Italy. Friuli Venezia Giulia, 3 L3 laboratory-reared from a female collected at Trieste (TS), VI.2010 (L. Morin).

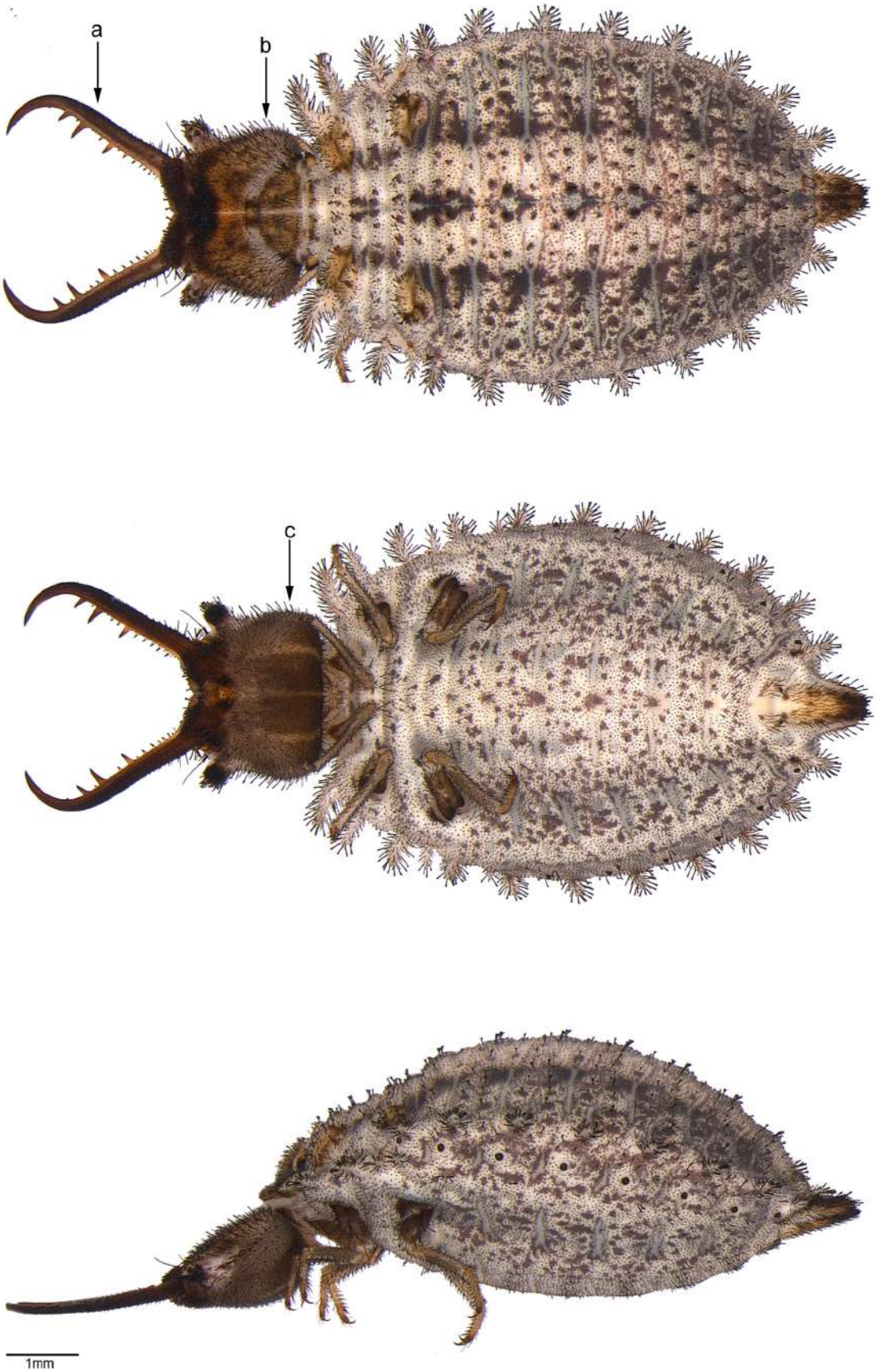

FIGURE 12. *Libelloides longicornis* (Linnaeus, 1764), 3rd instar larva (France: Var, Mt. Aurelien). Dorsal (above), ventral (middle) and lateral (below) view; a–c: diagnostic characters, see species description.

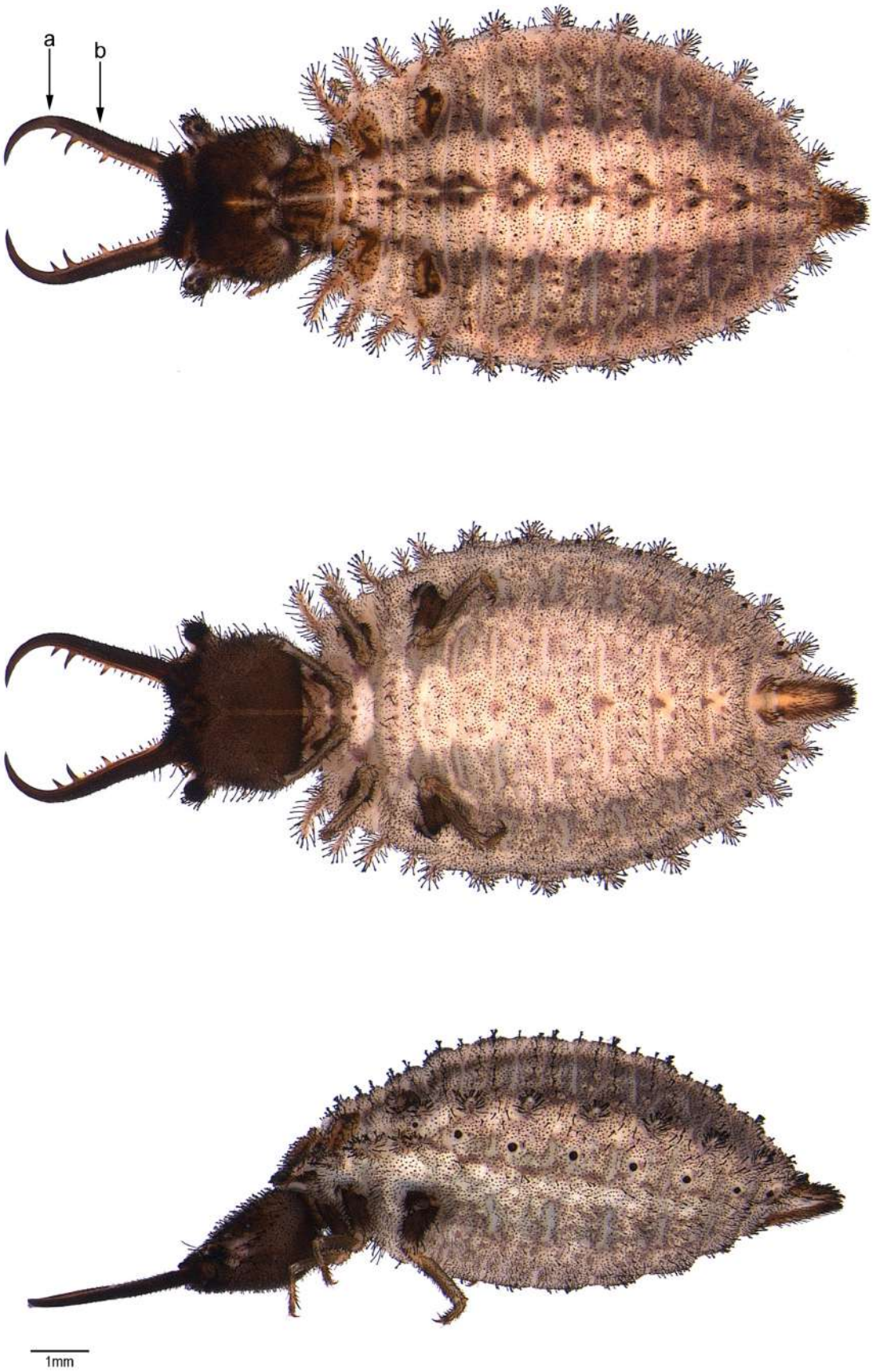

FIGURE 13. *Libelloides macaronius* (Scopoli, 1763), 3rd instar larva (Italy: Friuli-Venezia Giulia, Trieste). Dorsal (above), ventral (middle) and lateral (below) view; a–b: diagnostic characters, see species description.

Description of 3rd instar larva. Size (based on 3 specimens): BL 11.81 mm; HL 2.43 mm (2.38–2.49), HW 2.81 mm (2.77–2.86), ML 2.77 mm (2.63–2.90), HW/HL 1.15, ML/HL 1.14. General colouring pale brown with dark areas and markings, dorsal side with a median paler stripe, ventral side pale mottled with dark grey; head capsule dark brown, anterior portion darker, ventral side of the head dark brown, mandibles dark brown; legs with dark brown coxae and lighter femora, tibiae and tarsi. Head wider than long, slightly dilated posteriorly; mandible longer than the head capsule (Fig. 13a) interdental mandibular pseudo-teeth (4–5)(3–4)(0–1) (Fig. 13b); external margin of the mandible covered by short setae. Pronotum brown with darker stripes and covered with short setae; mesothoracic spiracles brownish with black apex. Abdominal spiracles dark brown; VIII sternite with brown spots on the odontoid processes; IX sternite with longitudinal brown markings and a dark apex (Fig 2E).

Bio-ecology. *L. macaronius* is a widespread, euryoecious species occurring in open habitats with herbaceous vegetation from the sea level to the mountains. This ascalaphid is a typical species of steppes and similar biotopes, explaining its wide distribution in Central Asia. The larvae live on the soil in the same environments inhabited by the adults.

Distribution. Widely distributed in central and eastern Europe and Asia, from easternmost part of northern Italy (surroundings of Trieste) eastward to western China.

Remarks. The larva of *L. macaronius* disposes on average of a greater number of pseudo-teeth (3–4) between the basal and median mandibular teeth than congeners.

Libelloides ictericus (Charpentier, 1825)

(Fig. 14)

As for other congeners, the first exhaustive description of the larvae of this species was realized by Rousset (1973) while older accounts are doubtful (Xambeu 1903; Lacroix 1923).

Examined specimens. France. Hérault, 28 L3 laboratory-reared from a female collected at Saint Paul et Valmalle, VI.2011 (D. Badano).

Description of 3rd instar larva. Size (based on 28 specimens): BL 10.60 mm; HL 2.36 mm (2.15–2.56), HW 2.67 mm (2.38–2.95), ML 2.61 mm (2.42–2.94), HW/HL 1.13, ML/HL 1.10. General colouring greyish ochre mottled with brown, dorsal side with a median paler stripe, ventral side of the body pale mottled with grey; dorsal side of the head capsule dark brown, darker anteriorly and with paler areas on the sides, ventral side of the head brown with a darker anterior area on the mouthparts and with a pale marking on the labium, mandibles brown with paler teeth; legs with dark brown coxae and paler femora, tibiae and tarsi; setae of the body black. Head wider than long, dilated posteriorly; mandibles longer than the head capsule (Fig. 14a); interdental pseudo-teeth: (4–5)(2–3)(1) (Fig. 14b); external margin of the mandible with short setae. Pronotum brown with darker stripes; mesothoracic spiracles ochre with a dark apex. Abdominal spiracles dark brown; IX sternite completely pale without markings (Fig. 14c).

Bio-ecology. *L. ictericus* occurs in open arid environments with herbaceous vegetation. In southern France this ascalaphid is a typical lowland species, while in North Africa it can attain mountainous altitudes (H. Aspöck *et al.* 1980). The larvae live on the soil surface, hiding among herbs and rocks.

Distribution. Western Mediterranean faunal element known for North Africa, Iberian Peninsula and southern France.

Remarks. The larvae of *L. ictericus* differ from the other *Libelloides* species for the completely pale IX abdominal sternite. Moreover, most of the specimens of *L. ictericus* have 1 pseudo-tooth between the median and apical teeth in both mandibles while the frequency of this bristle in the other *Libelloides* species is significantly lower in both mandibles.

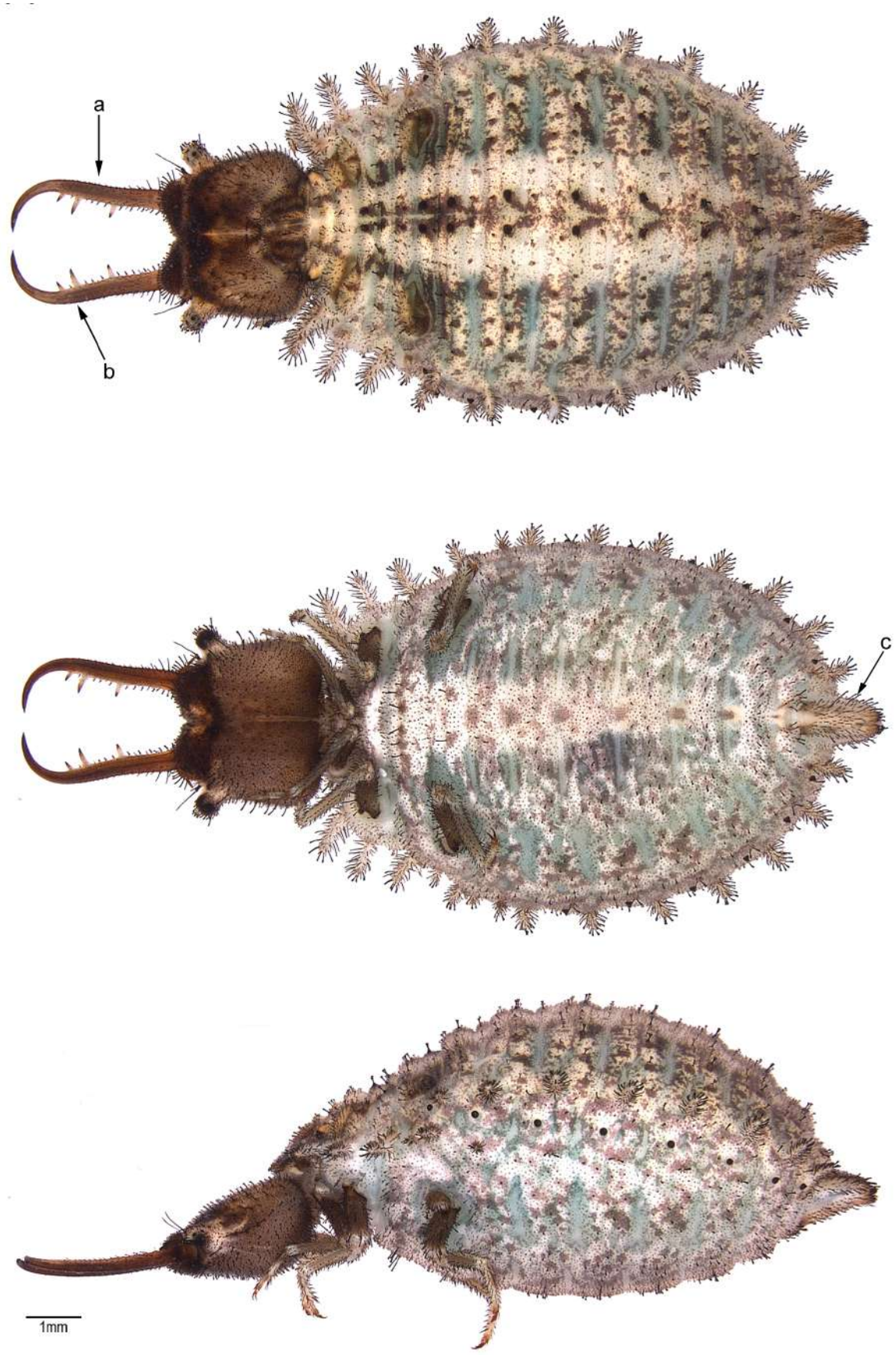

FIGURE 14. *Libelloides ictericus* (Charpentier, 1825), 3rd instar larva (France: Hérault, St. Paul et Valmalle). Dorsal (above), ventral (middle) and lateral (below) view; a–c: diagnostic characters, see species description.

***Libelloides corsicus* (Rambur, 1842)**
(Fig. 15)

The larvae of this Tyrrhenian endemic species are described here for the first time.

Examined specimens. Italy. Sardinia, 6 L3 laboratory-reared from a female collected at Mt. Doglia, Alghero (SS), VI.2010 (D. Badano); 2 L3 laboratory-reared from a female collected at Berchidda (SS), VI.2010 (D. Badano); Berchidda (SS), open cork oak wood, pitfall trap, VI.2010 (M. Verdinelli & S. Cossu), 2 L1.

Description of 3rd instar larva. Size (based on 8 specimens): BL 8.86 mm; HL 1.92 mm (1.81–2.06), HW 2.30 mm (2.13–2.41), ML 2.10 mm (2.00–2.28), HW/HL 1.20, ML/HL 1.09. General colouring dark brown with darker areas and markings, dorsal side with a median paler stripe, ventral side of the body brown with darker areas (Fig. 15c); dorsal side of the head capsule brown with dark markings on the clypeo-labrum extending on the sides and with dark spots at the base of larger dolichasters (Fig. 15b), ventral side completely brown, mandibles dark brown with paler teeth; legs with brown coxae and paler femora, tibiae and tarsi; setae of the body black. Head wider than long, slightly dilated posteriorly; mandibles slightly longer than the head capsule (Fig. 15a); interdental mandibular pseudo-teeth: (~5)(2–3)(0–1); external margin of the mandible covered by short setae. Pronotum brown with dark brown stripes; mesothoracic spiracles ochre with a dark apex. Abdominal spiracles dark brown; IX sternite dark brown.

Bio-ecology. *L. corsicus* is a relatively euryoecious species that is associated with open habitats such as grasslands, meadows, scrublands, glades and open woods from the sea level to the mountains. The larvae live on the soil, camouflaged between stones and tufts of herbs.

Distribution. Tyrrhenian endemism reported from Corse, Capraia, Sardinia and nearby islets.

Remarks. *L. corsicus* is the only species of the genus *Libelloides* in its Tyrrhenian range, making its identification unequivocal. The pigmentation pattern of the larvae clearly differentiates it from the closely related but allopatric *L. ictericus* and *L. siculus*. Finally, the larvae of this species are on average smaller than congeners.

***Libelloides siculus* (Angelini, 1827)**
(Figs. 1D, 16)

The larvae of this Sicilian endemic species are described here for the first time.

Examined specimens. Italy. Sicily, 19 L3 laboratory-reared from a female collected in Madonie (PA), VI.2010 (M. Romano).

Description of 3rd instar larva. Size (based on 19 specimens): BL 9.72 mm; HL 2.06 mm (1.87–2.22), HW 2.50 mm (2.25–2.70), ML 2.37 mm (2.19–2.58), HW/HL 1.21, ML/HL 1.15. General colouring greyish ochre thickly mottled with grey, dorsal side with a median paler stripe, ventral side paler, mottled with grey; dorsal side of the head capsule dark brown with conspicuous yellow markings (Fig. 16b), ventral side dark brown with two pale longitudinal markings (Fig. 16d), mandibles dark brown; legs with dark brown coxae and yellowish femora, tibiae and tarsi (Fig. 16e); setae of the body black. Head wider than long, slightly dilated posteriorly; mandibles slightly longer than the head capsule (Fig. 16a); interdental pseudo-teeth: (~4)(~2)(0–1); external margin of the mandible with short setae. Thorax and its scolus-like processes yellowish, visually distinct from the greyish abdomen (Fig. 16c); pronotum dark brown with yellow stripes and covered with short setae; mesothoracic spiracles yellow with black apex. Abdominal spiracles dark brown; VIII sternite with brown spots covering the short odontoid processes; IX sternite yellowish (Fig. 1D).

Bio-ecology. This species inhabits open, grassy habitats from the sea-level to the mountains (Madonie, Peloritani, Etna). The larvae are soil dwelling ambush hunters, as the other members of the genus.

Distribution. *L. siculus* is an endemism of Sicily and nearby islands.

Remarks. The larva of *L. siculus* is recognizable for the pale longitudinal markings on the ventral side of the head and the yellowish colour of the head markings, thorax and legs. The above mentioned characters also clearly differentiate *L. siculus* from the closely related but allopatric *L. ictericus* and *L. corsicus*. Notably, this species shares its range with only one congener, *L. coccajus*.

FIGURE 15. *Libelloides corsicus* (Rambur, 1842), 3rd instar larva (Italy: Sardinia, Alghero, Mt. Doglia). Dorsal (above), ventral (middle) and lateral (below) view; a–c: diagnostic characters, see species description.

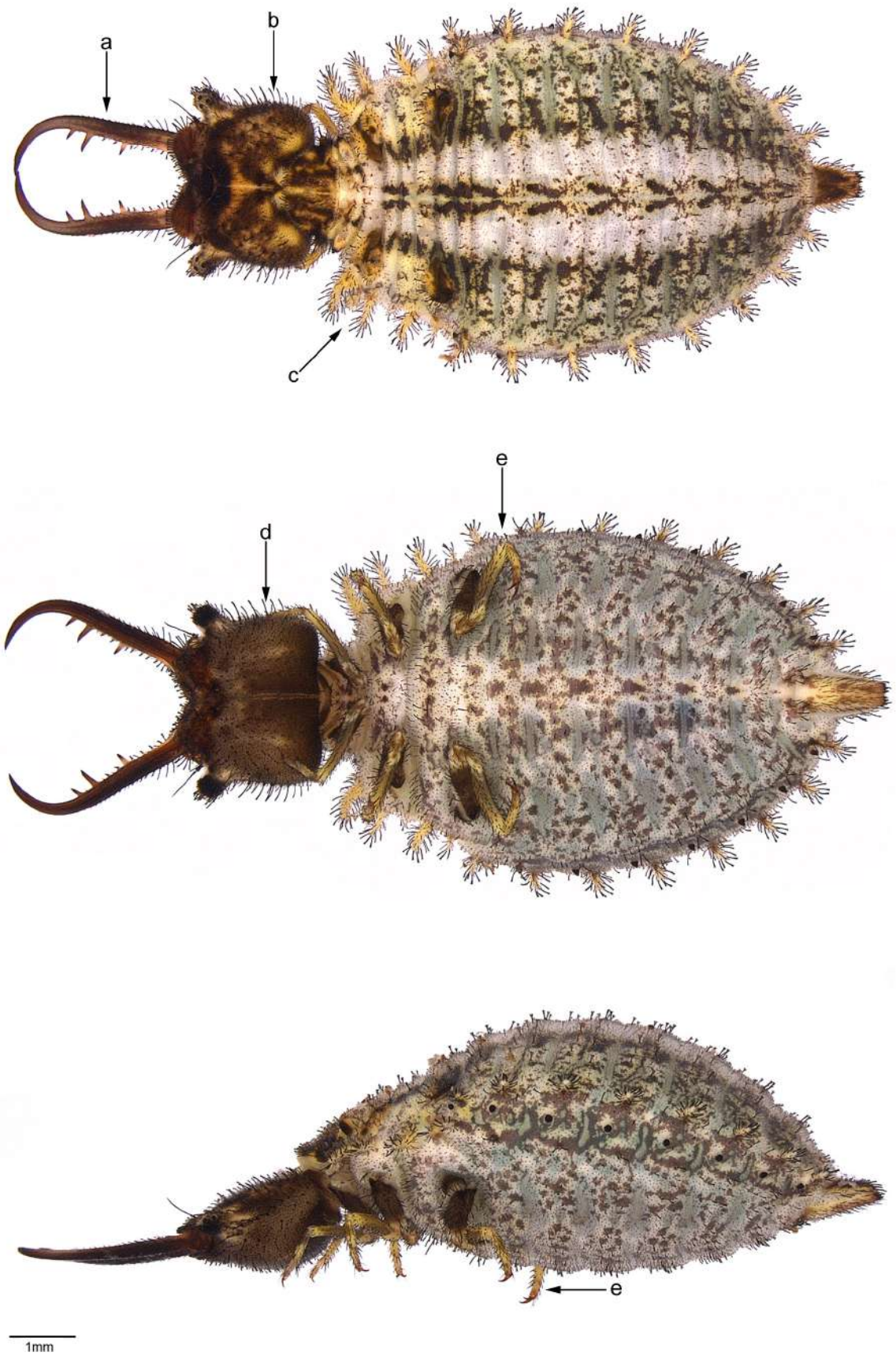

FIGURE 16. *Libelloides siculus* (Angelini, 1827), 3rd instar larva (Italy: Sicily, Madonie). Dorsal (above), ventral (middle) and lateral (below) view; a–e: diagnostic characters, see species description.

Discussion

According to the classic taxonomic arrangement of van der Weele (1909), the European genera of Ascalaphidae as currently defined would belong to three different tribes: Encyoposini van der Weele 1909 (*Bubopsis*), Ascalaphini (*Ascalaphus* now *Libelloides*, *Deleproctophylla* and *Puer*) and Suhpalacsini van der Weele 1909 (*Helicomitus* now *Ascalaphus*), for the complex taxonomic history of the latter two groups, see Tjeder (1972) and Tjeder & Hansson (1992). A comparative study of the morphology of the different genera casts doubts on the value of these tribes, underlines the necessity of a deepened revision of the whole family. The larvae of the examined genera, except the highly peculiar *Puer*, show an overall similar morphology mainly differing in genus-level characters, such as: relative proportions of body parts, chaetotaxy of the body and mandibles and shape of setiferous processes. Henry (1978a) underlined some trends in Ascalaphinae, regarding the migration of the first pair of abdominal spiracles and of the first pair of setiferous processes toward the dorsal side and the progressive atrophy of the ventral series of processes. The condition of the first pair of abdominal spiracles on the dorsum, thus visible from above, is attained in *Ascalaphus* and *Puer*; in *Ascalaphus* also the first pair of abdominal scolus-like setiferous process of the dorsal series is definitively placed on the back, following the first pair of spiracles. On the contrary, in *Bubopsis*, *Deleproctophylla* and *Libelloides* the first abdominal pair of spiracles is disposed on the lateral sides, not visible from above, although in *Bubopsis* it is slightly oriented toward the dorsum. In these genera the first pair of dorsal abdominal scolus-like processes is disposed on the sides. The genera *Ascalaphus*, *Bubopsis*, *Deleproctophylla* and *Libelloides* are provided with a ventral series of abdominal setiferous processes, although most of them are small and tubercle-like. *Bubopsis* differs from the other genera because the pairs of setiferous processes of the ventral series on the four anterior segments are well developed and scolus-like. In the other taxa only the pairs on the first two abdominal segments retain the typical elongated shape of scoli while the others are tubercle-shaped. *Deleproctophylla* and *Libelloides* larvae are noticeably similar and they are mainly set apart by chaetotaxy, confirming a close relationship between them. On the contrary, *Puer* remains an enigmatic genus, whose affinities remain obscure. Van der Weele (1909) suggested a relationship with the other European genera with spotted wings but this placement was dismissed by careful studies of adult characters (U. Aspöck & H. Aspöck 1987; Badano & Pantaleoni 2012). At the same time the larva of this genus shows an entire combination of characters which clearly separate it from all the other European genera. Only the position of the first pair of abdominal spiracles links this species with *Ascalaphus*, as supported by adult genitalia (U. Aspöck & H. Aspöck 1987; Badano & Pantaleoni 2012). It is extremely noteworthy the high number of characters shared by the larvae of *Puer* and the American genus *Ululodes* Smith (Henry 1976). Both genera are characterized by adaptations of the mouthparts to open the mandibles more than 180°, very long dolichasters on the lateral sides of the head, angular shape of the first pair of thoracic scolus-like processes, secondary atrophy of some pairs of thoracic setiferous processes, abdominal spiracles ventrally located and absence of ventral series of abdominal setiferous processes. Nevertheless, these remarkable affinities are surely due to convergence and not to a true relationship, as suggested by notable differences such as: the position of the first pair of abdominal spiracles (ventral in *Ululodes*), the presence of only one developed pair of mesothoracic setiferous processes for each segment in *Ululodes* (the second pairs are vestigial) and the extreme opening gap of the mandibles of the latter, besides undeniable adult characters. Henry (1978a) proposed that these characters were exclusive of the American lineage of Ascalaphinae but the morphology of the larva of *Puer* is instead indicative that these features are actually adaptations to adhere to the substrate independently acquired by non-related genera.

Conclusion

Europe harbors about 20 species of Ascalaphidae. The larvae of 15 species are surely known after this study, which deals with 12 species from Europe and an additional one from North Africa, of which 7 are exhaustively described here for the first time including *Ascalaphus festivus* (Rambur), *Puer maculatus* (Olivier), *Bubopsis agrionoides* (Rambur), *Deleproctophylla australis* (Rambur), *Libelloides latinus* (Lefebvre), *L. corsicus* (Rambur) and *L. siculus* (Angelini), therefore representing all the European genera. The still inadequately known larvae mostly belong to the Iberian and Balkan endemic species of *Libelloides*; in some cases older descriptions of these species actually exist (van der Weele 1909; Navás 1915; Pieper & Willmann 1980) but they are doubtful or excessively concise. Despite the genus *Libelloides* is reasonably well known, the specific status of some taxa has been often

questioned and an accurate study of larval characters is potentially an important clue to solve these problems. A clear example is represented by the *Libelloides ictericus*-group: most authors considered *L. corsicus* and *L. siculus* as subspecies of *L. ictericus* exclusively on the similar pattern of the wings (McLachlan 1876; van der Weele 1909; H. Aspöck *et al.* 1976; H. Aspöck *et al.* 1980; H. Aspöck *et al.* 2001). The noticeable differences between the larvae of these three species, comparable to those observed in other congeners, undoubtedly warrant them a specific status as also confirmed by biogeography. Finally, larval biology and ecology still remain poorly known topics in great need of accurate investigations in the field.

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