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Larval morphology and life history of *Ascalaphus dicax* Walker, 1853 (Neuroptera: Myrmeleontidae, Ascalaphinae)

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Abstract
The larvae of *Ascalaphus dicax* are redescribed based on specimens reared under laboratory conditions. The third instar larva of this species resembles in overall morphology the congener *A. festivus*, though differing in body pattern and arrangement of thoracic and abdominal setiferous processes.

Key words: Myrmeleontiformia, owlfly, larva, Oriental region, India.

Introduction

Ascalaphids, or owlflies, are a widespread group of Neuroptera including 596 species (Machado et al. 2019) and are among the most familiar representatives of the order, due to their large size, striking appearance, and dragonfly-like hunting behaviour (Tjeder 1992). Ascalaphids are traditionally treated as a family-rank group - i.e., Ascalaphidae - and as the sister-group to Myrmeleontidae, as also supported by morphology based cladistic analyses (Stange 1994; Aspöck et al. 2001; Badano et al. 2017; Badano et al. 2018). However, phylogenomic analyses with an exhaustive taxon sampling recover ascalaphids as nested within Myrmeleontidae, effectively demoting them to a subfamily-rank clade of the latter, as Ascalaphinae (Winterton et al. 2018; Machado et al. 2019) (for an alternative classification, see Jones 2019). Ascalaphid larvae are largely sedentary predators remaining motionless for long periods, keeping their jaws spread open and relying on camouflage to ambush prey. Despite their conspicuous habits as adults, their larvae are poorly known and remain scarcely investigated, except for some European (Hagen 1873; Navás 1915; Rousset 1973; Pieper & Willmann 1980; Badano & Pantaleoni 2014) and North American (Henry 1976, 1977, 1978a, 1978b; Gepp 2019) species. The preimaginal stages of ascalaphids from the tropics - where most of their diversity is located - remain largely undescribed or, at best, not assigned to a species (e.g., Tjeder 1992; Michel 2001). However, some early studies on the life-history of ascalaphids dealt with Indian species: Gravely & Maulik (1911) described two larval morphotypes (one of which assigned to "*Pseudoptynx*"), while Ghosh (1913) described the larva of *Ascalaphus dicax* Walker, 1853. The aim of the present study is to redescribe the larval morphology of the latter species, highlighting characters missing in the previous description, comparing it with congeners and reporting new data on the development of this species under laboratory conditions.

Materials and methods

Rearing

The eggs were collected on the twig of *Caesalpinia pulcherrima* on 2nd May 2018 in urban Bengaluru, Southern India. The egg mass contained more than 50 eggs. Thirteen eggs (out of the 53 eggs collected) were reared to adulthood to study their life cycle. The eggs were kept in a glass vial until hatching. All hatched larvae were separated and kept individually in glass test tubes with a small piece of tissue paper as substratum and maintained at 25 ±2°C and 50 ± 10% relative humidity at the National Insect Museum (NIM), ICAR−NBAIR, Bengaluru. First instar larvae were occasionally fed with blaberid nymphs (Blattodea: Blaberidae gen. sp.), larvae of *Plutella xylostella* (L.) (Lepidoptera: Plutellidae), *Tribolium* sp. (Coleoptera:

Tenebrionidae) and lepismatids (Zygentoma: Lepismatidae gen. sp.) to test their preferences. Blaberids appeared to be the optimal food source (see also Badano & Pantaleoni 2014). First and second instar larvae were fed once a week, with first or second/third instar blaberid nymphs, respectively. Third instar larvae were fed twice a week with larger blaberids. Mature larvae, which were about to pupate, were separately transferred to dedicated containers with a layer of sand, plant debris, and twigs to facilitate cocoon formation. The specimens were identified at species level based on the emerged adults and deposited at NIM, ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, India.

Imaging

Photos were taken with a Leica© M205A stereo microscope provided with a Leica© DC420 inbuilt camera, using auto montage software (version 3.8).

Terminology

Morphological terminology mainly follows Badano & Pantaleoni (2014). Classification follows Machado et al. (2019).

Results

Life history

Egg. Oval, whitish, without stalk, neatly laid in series on plant stem (Fig. 1). The eggs hatched five days after collection (Fig. 2).

Larva. The larvae are ambush hunters that covers themselves with debris (Figs 5, 6). The larval stages are overall similar in morphology, though differing in size (Figs 3–13). The first instar is generally darker and differs from later instars in head capsule proportions and body chaetotaxy (Figs 3–6). The second and third instars mainly differ in size (Figs 7, 8). The first instar lasted 46.33 ± 3.94 days, the second and the third instars 108.58 ± 8.74 days and 56.75 ± 7.46 days, respectively (Tables 1, 2).

Cocoon. The mature larvae spun a spherical cocoon into the soil (Fig. 14–16). The pupal period lasted for 25.42 ±1.35 days. The average life span from the first instar larva to adult was 237.08 ±7.92 days (Table 1).

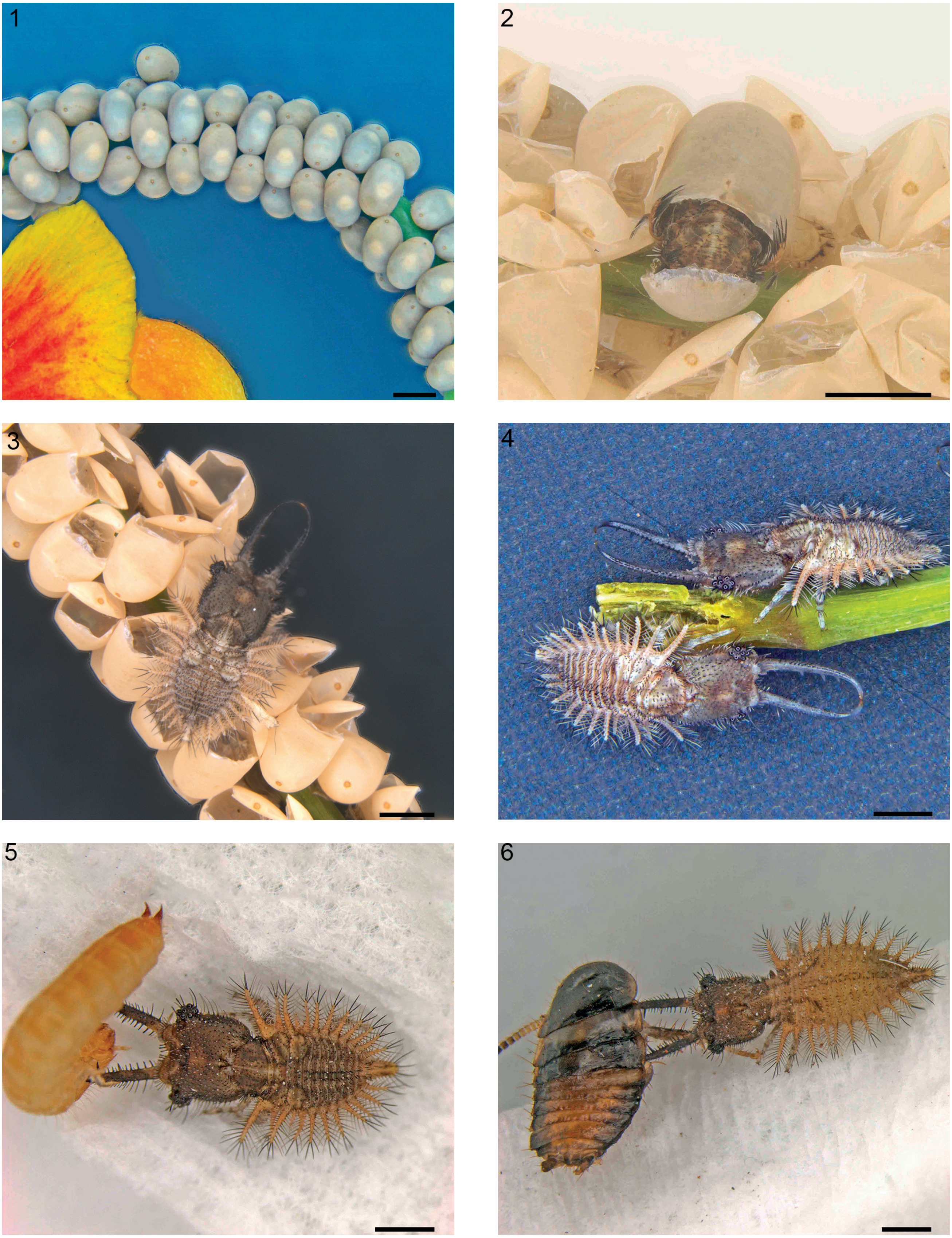
Morphology

Myrmeleontidae Latreille, 1802
Ascalaphinae Lefèbvre, 1842
Ascalaphini Lefèbvre 1842
***Ascalaphus* Fabricius, 1775**

Larval diagnosis (based on *A. festivus* and *A. dicax*). Head capsule cordate, with dorsal depression; antenna thin, longer than ocular tubercle; ocular tubercle large, wider than long; mandible with pseudo-teeth and three teeth, of which the median largest; labial palp three-articulated (excluding premental element); mesothorax with scolus-like processes, metathorax with anterior process tubercle-like and posterior process scolus-like; spiracle of abdominal segment 1 dorsal; abdominal segments 1-8 with dorsal scolus-like processes and ventral processes reduced (except on segments 1 and 2) or entirely absent; sternite 8 with short odontoid processes bearing dolichasters; sternite 9 with short rastra bearing 3-4 digging setae; body dolichasters mostly bristle-like.

Specimen ID	Larva 1	Larva 2	Larva 3	Larva Total	Cocoon	Preimaginal development
1	29	142	35	206	29	235
2	29	96	76	201	29	230
5	36	94	55	185	27	212
6	37	90	55	182	17	199
7	40	76	123	239	29	268
9	41	161	47	249	28	277
11	49	138	42	229	26	255
12	49	138	69	256	28	284
13	49	121	26	196	30	226
16	63	65	71	199	21	220
17	63	95	41	199	24	223
20	71	87	41	199	17	216
Mean (± SE)	**46.33±3.94**	**108.58±8.74**	**56.75±7.46**	**211.67±7.22**	**25.42±1.35**	**237.08±7.92**

Table 1 – Developmental times (days) of *Ascalaphus dicax* larvae under laboratory conditions.



Figs 1-6 – *Ascalaphus dicax* Walker, 1853. 1, egg mass; 2, hatching first instar larva; 3, first instar larva on hatched eggs; 4, first instar larvae; 5, first instar larva preying on *Tribolium* larva; 6, first instar larva feeding on blaberid nymph. Scale bar: 1 mm.

Specimen ID	Date 1st moult	Date 2nd moult	Date of cocoon formation	Date adult emergence	Diet
1	7.06.18	28.11.18	02.01.19	31.01.19	Blaberids
2	7.06.18	12.09.18	28.11.18	27.12.18	Blaberids
5	14.06.18	17.09.18	12.11.18	10.12.18	Blaberids
6	15.06.18	14.09.18	9.11.18	26.11.18	Blaberids
7	18.06.18	3.09.18	05.01.19	04.02.19	*Tribolium* for one day after hatching; later blaberid
9	19.06.18	28.11.18	14.01.19	12.02.19	*Plutella* for 4 days after hatching; later
11	27.06.18	12.11.18	25.12.18	21.01.19	Blaberids
12	27.06.18	12.11.18	21.01.2019	19.02.19	*Plutella* for three days after hatching; later blaberid
13	27.06.18	27.10.18	27.11.18	24.12.18	Blaberids
16	11.07.18	15.09.18	26.11.18	18.12.18	Blaberids
17	11.07.18	15.10.18	26.11.18	20.12.18	*Tribolium* for 2 days; later blaberids
20	19.07.18	15.10.18	26.11.18	14.12.18	Blaberids

Table 2 – Rearing and development of *Ascalaphus dicax* larvae under laboratory conditions.

***Ascalaphus dicax* Walker, 1853**

Material examined. **INDIA**: Bengaluru: ICAR-NBAIR Yelahanka campus; 2.v.2018 (date of egg collection); coll. Ashwath. 14 larvae preserved in alcohol, 10 adults (1♂, 9♀) pinned and 3 (1♂, 2♀) in alcohol.

Description of third instar larva

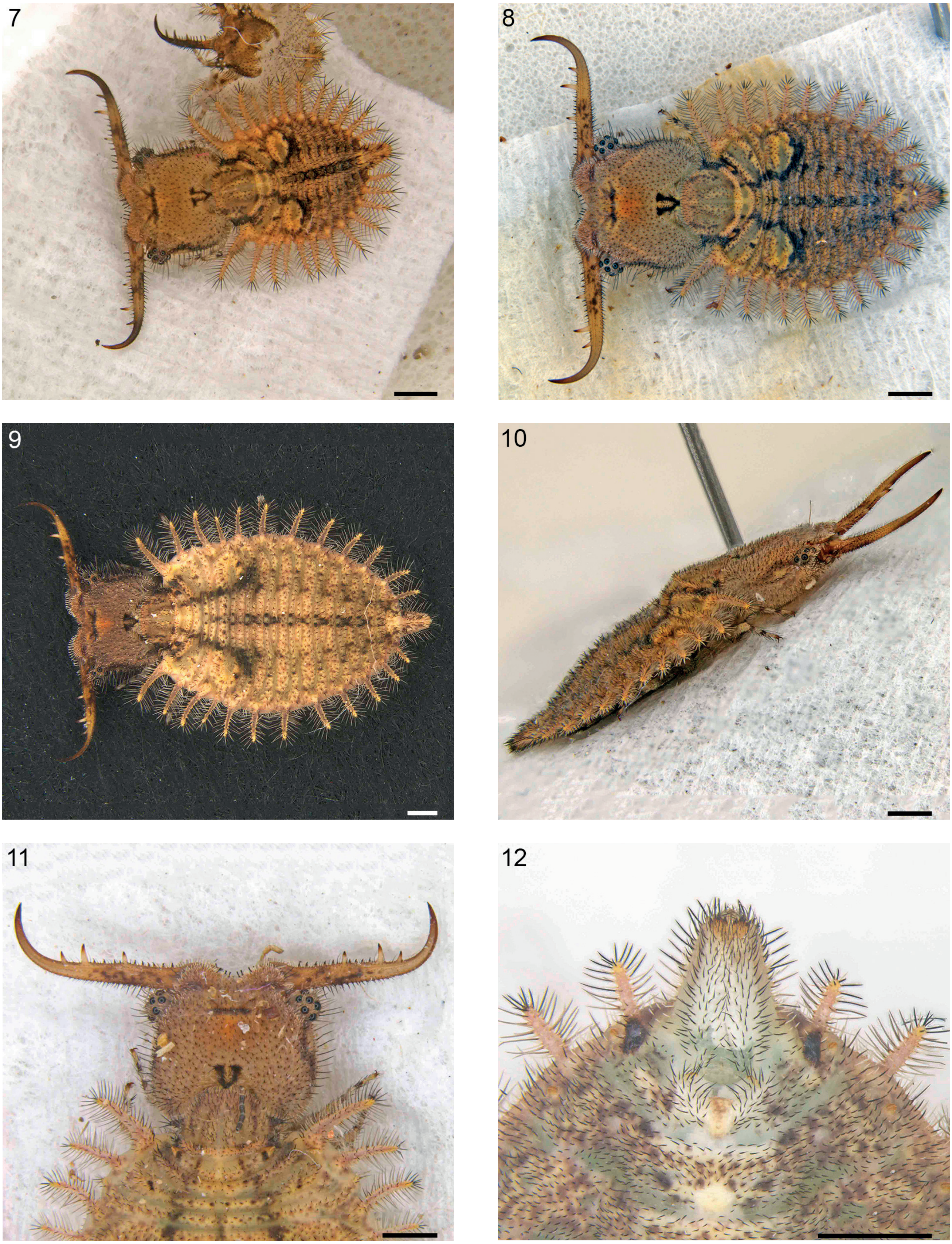
Size. Based on 1 specimen. Head to tip of abdomen: 13.71 mm; head capsule length: 3.39 mm; head capsule width: 3.21 mm; mandible length: 4. 35 mm.

Colouration. Head capsule brown, slightly darker than the rest of body; fronto-clypeal suture with a faint dark marking; lateral margin with a dark stripe. Ventral side of head capsule brown mottled dark brown at setae insertion. Mandible light brown, basal half mottled dark brown. Thorax light brown, with dorso-lateral paler areas bordered by darker markings. Abdomen light brown, darker than thorax, with a median series of dark brown markings and paired lateral faint stripes. Scolus-like processes slightly paler than the rest of abdomen. Ventral side of abdomen pale. Setae covering the body mostly dark with whitish setae interspersed among them. Setae on mouthparts mostly whitish.

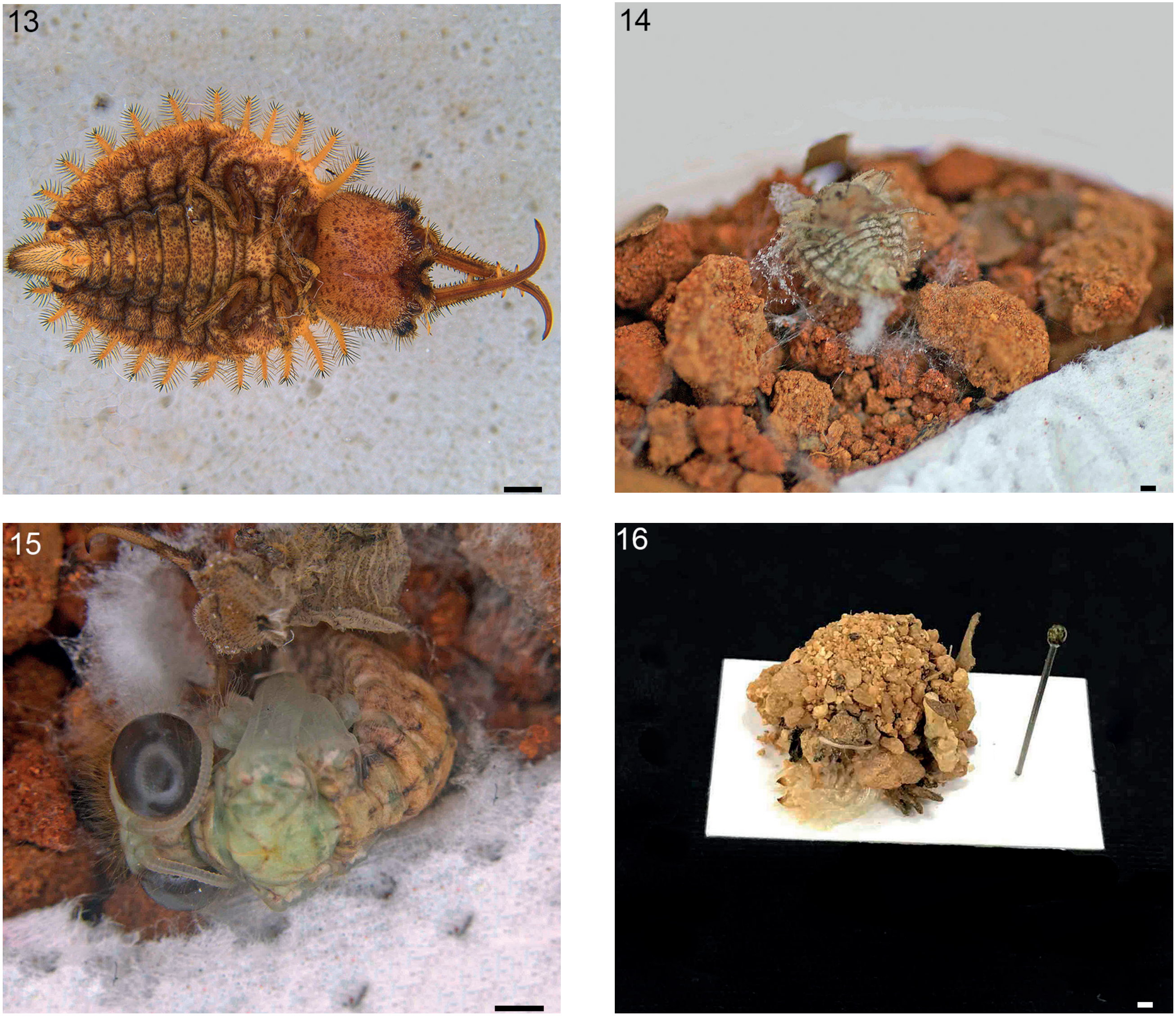
Head. Head capsule wider than long, cordate; lateral margins straight, slightly dilated posteriorly (Fig. 11). Dorsal side of head capsule covered with short robust setae. Margin of labrum with median incision, bordered by white setae. Ocular tubercle comparatively large, elliptical in cross-section, with well-developed stemmata, bordered by long dolichasters. Mandible longer than head capsule, straight and curved at apex, 3-toothed; interdental pseudo-teeth (5–4) (5–4) (0); external margin of mandible with long, thin setae (Fig. 11).

Thorax. Prothorax with lateral process, pronotum covered with sparse short setae (Figs 8, 9). Mesothoracic spiracle prominent, cone shaped. Mesothorax with anterior and posterior setiferous processes scolus-like, long and slightly flattened; the anterior process is longer than the remainder of body protuberances. Metathorax with anterior process reduced, tubercle-like and posterior process scolus-like. Thoracic processes with long, robust setae on margins and shorter robust dorsal setae.

Abdomen. Abdomen wide, slightly flattened. Lateral margin with a dorsal series of setiferous processes similar in shape and size to those on thorax (Fig. 9). Ventral series of processes absent (Fig. 13). Abdominal spiracles ventral, ex-



Figs 7-12 – *Ascalaphus dicax* Walker, 1853. 7, second instar larva after first moult; 8, young third instar larva; 9, mature third instar larva; 10, young third instar larva, in lateral view; 11, third instar larva, detail of the head, dorsal view; 12, third instar larva, last sternites, ventral view. Scale bar: 1 mm.



Figs 13-16 – *Ascalaphus dicax* Walker, 1853. 13, third instar larva, ventral view; 14, larva spinning cocoon; 15, pupa; 16, cocoon. Scale bar: 1 mm.

cept on segment 1 where the spiracle is dorsal. Abdominal segment 9 longer than wide, with rastra provided with 4 short triangular digging setae (Fig. 12).

Discussion

The genus *Ascalaphus* comprises over 20 species distributed in the Afrotropical, Palaearctic, and Oriental regions (Prost 2013; Machado et al. 2019). However, several *Ascalaphus* species are poorly known and preimaginal stages were described only for the widespread Afrotropical and Western Palaearctic *A. festivus* (Rambur, 1842) and the Indian *A. dicax* (Ghosh 1913; Badano & Pantaleoni 2014). The larvae of *A. dicax* and *A. festivus* are similar in overall morphology, also sharing similar body proportions. *Ascalaphus dicax* notably differs from *A. festivus* in colouration, lacking the conspicuous light and dark bicolour pattern characteristic of the latter, though both species share the mottled ventral side of the head capsule. *A. dicax* is also characterized by longer thoracic and abdominal setiferous processes than *A. festivus*, being at least 5 times longer than wide (ca. 3 times longer than wide in *A. festivus*). Moreover, *A. dicax* bears a pair of processes on the lateral margin of the pronotum, which are absent in *A. festivus*. *A. dicax* also differs from *A. festivus* lacking the ventral series of abdominal setiferous processes (present but mostly vestigial in *A. festivus*). Our observations are largely concordant with the previous study by Ghosh (1913), but we also noticed some differences. Notably, Ghosh (1913) reported that the processes of the third instar larvae were shorter than in younger larvae. However, the specimens examined in the present study had long processes in all instars, suggesting that Ghosh's observations might involve another species, also considering that his study predated the revision of Oriental *Ascalaphus* species by Kimmins (1949).

Larvae of *A. dicax* confirm that ascalaphid larvae embody a wealth of information of systematic and taxonomic relevance, but the scarce knowledge of their preimaginal stages still impairs thorough comparisons among taxa.

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