Zoological Studies **60**:39 (2021)
doi:10.6620/ZS.2021.60-39

Zoological Studies

Open Access

Larval Morphology of Pit-building Antlions of the Tribe Myrmeleontini (Neuroptera, Myrmeleontidae) from Taiwan

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[†]Deceased, 29 October 2020. This paper is dedicated to the late Professor Chiun-Cheng Ko.

Received 25 December 2020 / Accepted 9 May 2021 / Published 13 July 2021
Communicated by Shen-Horn Yen

The larvae of nine species of the pit-building tribe Myrmeleontini from Taiwan are described, belonging to the genera *Baliga* Navás and *Myrmeleon* Linnaeus. The nine species can be distinguished from each other by the body markings, mandible chaetotaxy and arrangement of the abdominal digging setae. Additionally, this study is also the first to describe the larvae of *M. bimaculatus* Yang and the first to report this species in Taiwan. A key to the larvae of nine examined species from Taiwan is provided.

Key words: Neuroptera, Myrmeleontini, Antlions, Larval morphology, Taiwan.

BACKGROUND

Myrmeleontidae is the largest family within the order Neuroptera, with approximately 2,150 described species (Stange 2004; Machado et al. 2019; Oswald 2020). Certain species of the family exhibit the well-known pit-building behavior as larvae—they construct pitfall traps in loose sand or soil and wait for prey to fall in (Fig. 1) (Stange et al. 2003). The tribe Myrmeleontini is one of the pit-building groups within the family Myrmeleontidae, consisting of approximately 225 species belonging to 10 genera (Machado et al. 2019; Oswald 2020). Among them, the genus *Myrmeleon* Linnaeus is the most specious group, containing approximately 180 species worldwide (Stange et al. 2003; Machado et al. 2019; Oswald 2020). Recent studies on the molecular phylogeny of the family Myrmeleontidae suggested that Myrmeleontini is in need of revision (Michel et al. 2017; Machado et al. 2019).

The larvae of Myrmeleontini are well known at the genus level, with seven out of 10 genera having been reported (*Australeon* Miller and Stange, *Baliga* Navás, *Dictyoleon* Esben-Petersen, *Euroleon* Esben-Petersen, *Myrmeleon*, and *Weeleus* Navás) (New 1982 1983; Matsura 1987; Krivokhatsky 1994 2011; Stange et al. 2003; Miller and Stange 2012; Badano and Pantaleoni 2014). Several previous studies have provided simple descriptions and illustrations of the larvae, but the detailed larval morphology of many species remain unexplored (Matsura 1987; Stange et al. 2003; Badano and Pantaleoni 2014). Lin et al. (2019) recorded 11 species of Myrmeleontini in Taiwan. The larvae of eight Taiwanese species of Myrmeleontini were described by Stange et al. (2003), but the description only focused on the coloring and arrangements of the body markings and lack descriptions of characters such as the mandible chaetotoxy and the arrangements of the digging setae.

In the present study, we described the larvae of nine species of Myrmeleontini collected in Taiwan (both from the main and associated islands), including one species from the genus *Baliga* and eight species from the genus *Myrmeleon*. *Myrmeleon bimaculatus* Yang, originally recorded in southeast China, is recorded in Taiwan for the first time. This study did not include the larvae of *M. bore* (Tjeder), *B. brunneipennis* (Esben-

Citation: Lin YH, Liao JR, Ko CC. 2021. Larval morphology of pit-building antlions of the tribe Myrmeleontini (Neuroptera, Myrmeleontidae) from Taiwan. Zool Stud **60**:39. doi:10.6620/ZS.2021.60-39.

Petersen), or *B. micans* (McLachlan).

MATERIALS AND METHODS

The antlion larvae were collected in the field by searching for pitfall traps (collection site shown in Fig. 2); some individuals were reared to the adult stage in order to obtain adult specimens and to identify them using the key provided by Stange et al. (2003). The larvae were kept in small plastic containers filled with sand at room temperature and 60% humidity. Antlion larvae were mainly fed with larvae of *Tribolium castaneum* (Herbst) and adults of *Drosophila melanogaster* Meigen, some larger individuals were also fed larvae of *Tenebrio molitor* Linnaeus. Specimens were examined and measured with a Leica® EZ4 stereo microscope. Photographs of the larvae were taken with a Canon® EOS 400D or Canon® EOS 850D digital camera equipped with Canon® lens MP-E 65 mm and then stacked using Helicon Soft® software Helicon Focus; the obtained images were processed using the software Adobe Photoshop® CC 2019. Morphological terminology and measurements mainly follow Badano and Pantaleoni (2014), terminology of the chaetotaxy follows Lipovšek Delakorda et al. (2009). Taxonomic treatment followed Stange (2004).

The larva instars were indicated as L1 (1st instar), L2 (2nd instar), L3 (3rd instar). The specimens were preserved in 95% ethanol.

RESULTS

TAXONOMY

Family Myrmeleontidae Latreille, 1802
Subfamily Myrmeleontinae Latreille, 1802

Fig. 1. Habitats of the Myrmeleontini larvae, A, Underneath trunks of giant woods (*M. alticolus*). B, On open sand dunes (*M. persimilis*). C, Underneath rock overhangs (*M. taiwanensis*). D, Underneath artificial buildings (*M. wangi*).

Tribe Myrmeleontini Latreille, 1802

Diagnosis of 3rd instar larva: Head with sessile ocular tubercle. Mandibles provided with 3 pairs of equidistant teeth in which the apical tooth is slightly stronger, external margins of the mandibles provided with a fringe of long setae, at least 1 seta is present after the apical tooth. Labial palpi 3- or 4-articulated, segments 2–4 shorter than the basal width of the mandible. Thorax and abdomen with sessile setiferous processes. Mesothoracic spiracle not raised on tubercle. Abdominal spiracles inconspicuous. Metathoracic leg with a fringe of setae. VIII abdominal sternite with odontoid processes. IX abdominal sternite provided with a pair of sessile rastra each bearing at least 3 digging setae.

Genus *Baliga* Navás, 1912

Baliga asakurae (Okamoto, 1910)

(Figs. 3A, 4A, 5)

Stange et al. (2003) provided simple descriptions of the larvae, and mainly focused on the coloring and body markings. Hayashi et al. (2020) also provided a detailed description of the larvae. The examined larval specimens were identified by using molecular characters.

Description of 3rd instar larva: Size: Average body length 10.38 mm (7.95–11.75); head length 2.39 mm (2.10–2.69), head width 2.00 mm (1.63–2.19), mandible length 2.83 mm (2.28–3.11), ratio head width/length 0.84, ratio mandible length/head length 1.19.

General coloring: Ochre, with dark brown markings, ventral side paler.

Head: Sub-rectangular, longer than wide. Sparsely covered with black setae. Ocular tubercle sessile. Mandibles slender, reddish brown, slightly longer than the head capsule, provided with 3 equidistant teeth with the apical tooth slightly stronger. Interdental mandibular setae: (8–12)(2–3)(1–2)(1). Clypeo-labrum and the base of internal margin of the mandibles with long dolichasters. External margin of the mandible with a fringe of long setae, dorsal side of the mandible covered with short setae, ventral side of the mandible with a covering of short setae on both external and internal to the maxilla, reaching the basal tooth. Labial palpus 4-articulated, with fringe of black setae underneath,

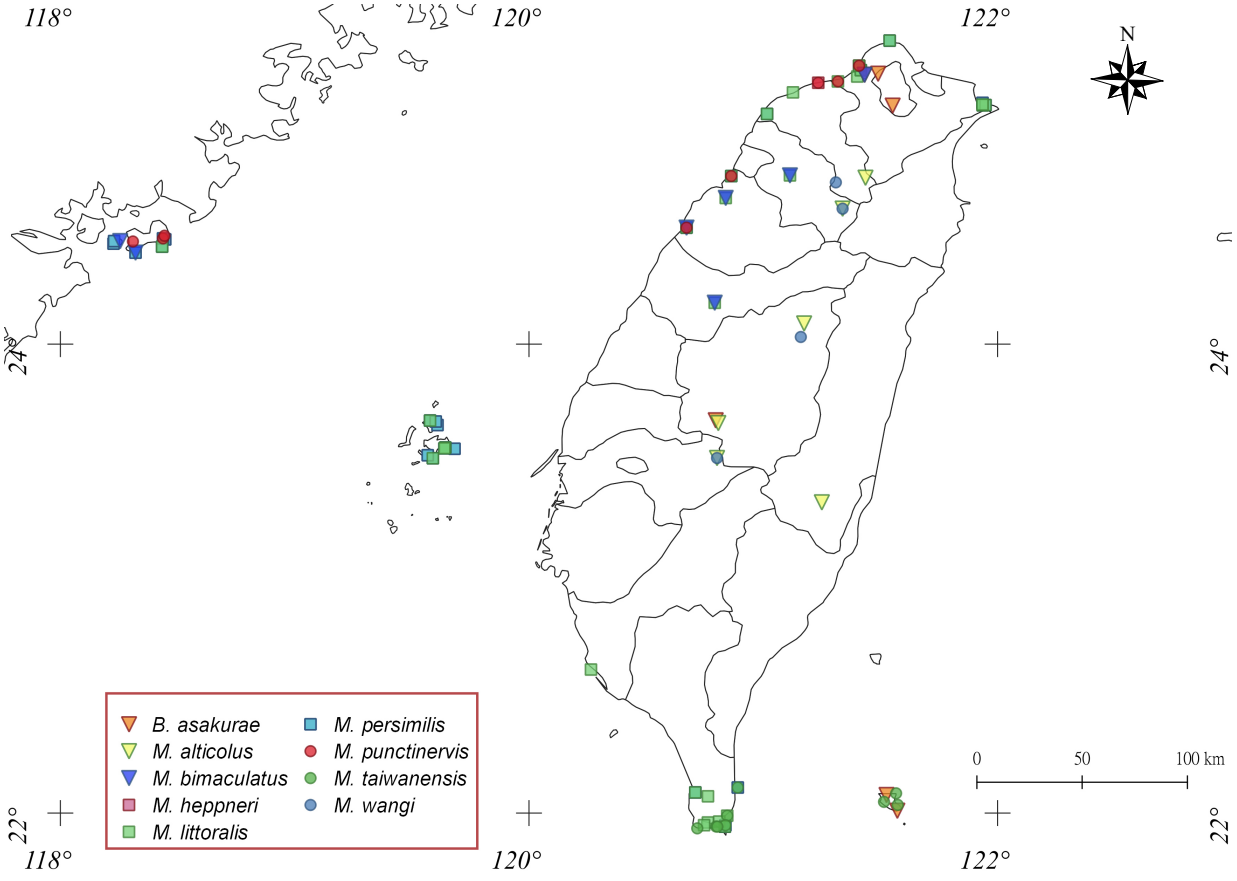

Fig. 2. Collection sites of Myrmeleontini larvae in Taiwan.

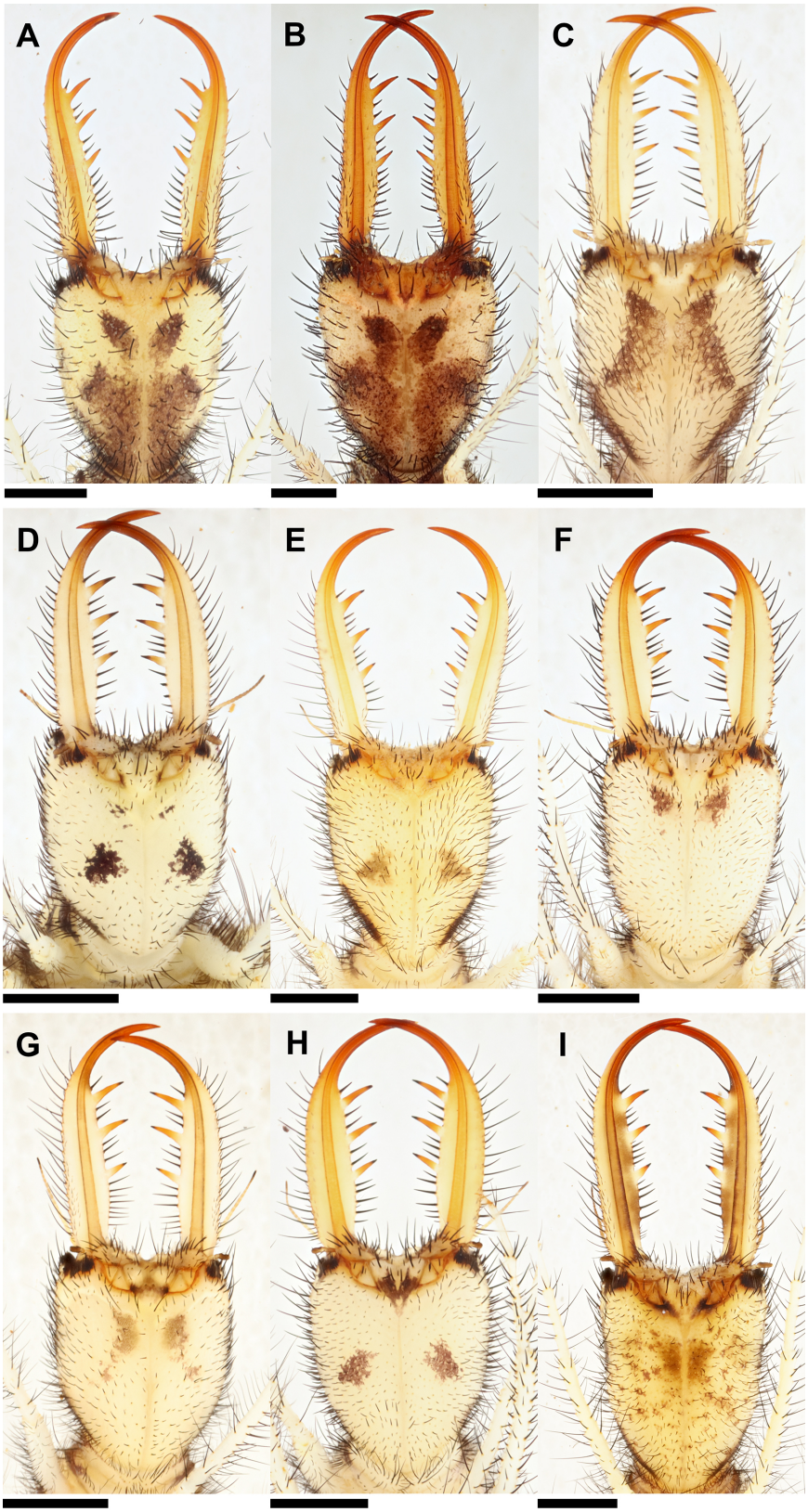

Fig. 3. Head of 3rd instar larvae of Myrmeleontini of Taiwan, ventral view; A, *Baliga asakurae*; B, *Myrmeleon alticolus*; C, *Myrmeleon bimaculatus*; D, *Myrmeleon heppneri*; E, *Myrmeleon littoralis*; F, *Myrmeleon persimilis*; G, *Myrmeleon punctinervis*; H, *Myrmeleon taiwanensis*; I, *Myrmeleon wangi*. Scale bar = 1 mm.

few extending over labial palpus. Dorsal side of the head capsule with a dark medial band on the clypeolabrum, followed by a pair of dark brown spots on the anterior side of head capsule, posterior side with a pair of dark triangular markings and a pair of short brown stripe on the external margin. Lateral side of the head with a faint brown spot near the middle and a dark spot on the posterior side extending toward the dorsal side of the head capsule. Ventral side of the head with an anterior pair of small, dark triangular spots and a pair of outwardly curved dark brown band covering the posterior half reaching markings on the lateral side of the head capsule.

Thorax: Pronotum with two pairs of brown stripes, covered with short setae. Body setae black.

Legs: Pale brown, hind legs with brown spots on the apical end of coxae and femur.

Abdomen: Setae black. VIII abdominal sternite with a pair of black spots, odontoid processes distinct, posterior margin with hair-like setae. IX abdominal sternite elongated, with a pair of outwardly curved pale brown stripes, covered with hair-like setae, digging setae absent, or with few reduced digging setae. Rastra sessile, each bearing 3 peg-like digging setae with the external ones longer, 1 seta on the external side.

Materials examined: Taiwan. Nantou County. Xitou Nature Education Area, Lugu Township / 18. X. 2019 / Y. H. Lin leg., 1 L3; same locality / 19. X. 2019 / Y. H. Lin leg., 1 L3. New Taipei City. Bali District 3rd Cemetery, Bali District / 24. II. 2020 / Y. H. Lin leg., 1 L3. Taipei City. Fujhoushan Park, Da'an District / 17. III. 2020 / Y. H. Lin leg., 4 L3. Guiziken Trail, Beitou District / 29. II. 2020 / Y. H. Lin leg., 9 L3. Taitung County. Hongtou Forest Trail, Lanyu Township / 16. VII. 2020 / Y. H. Lin leg., 4 L3. Iraraley (Langdao) Village, Lanyu Township / 17. VII. 2020 / Y. H. Lin leg., 2 L3.

Bio-ecology: *B. asakurae* is an inland species, found in forest from sea-level to altitude around 1,400 m a.s.l.. The larvae build pitfall in protected environments

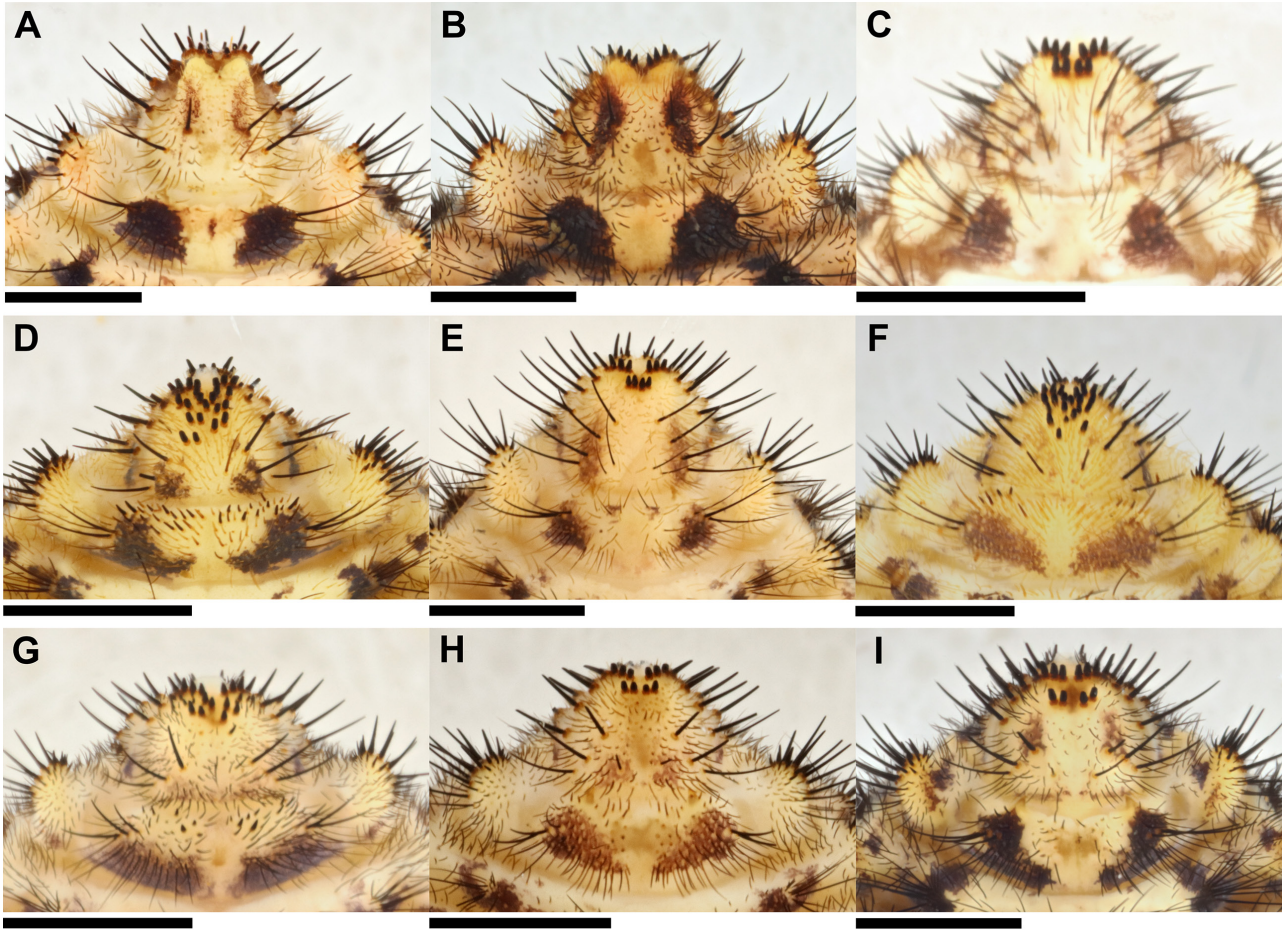

Fig. 4. IX abdominal sternite of 3rd instar larvae of Myrmeleontini of Taiwan, ventral view; A, *Baliga asakurae*; B, *Myrmeleon alticolus*; C, *Myrmeleon bimaculatus*; D, *Myrmeleon heppneri*; E, *Myrmeleon littoralis*; F, *Myrmeleon persimilis*; G, *Myrmeleon punctinervis*; H, *Myrmeleon taiwanensis*; I, *Myrmeleon wangi*. Scale bar = 1 mm.

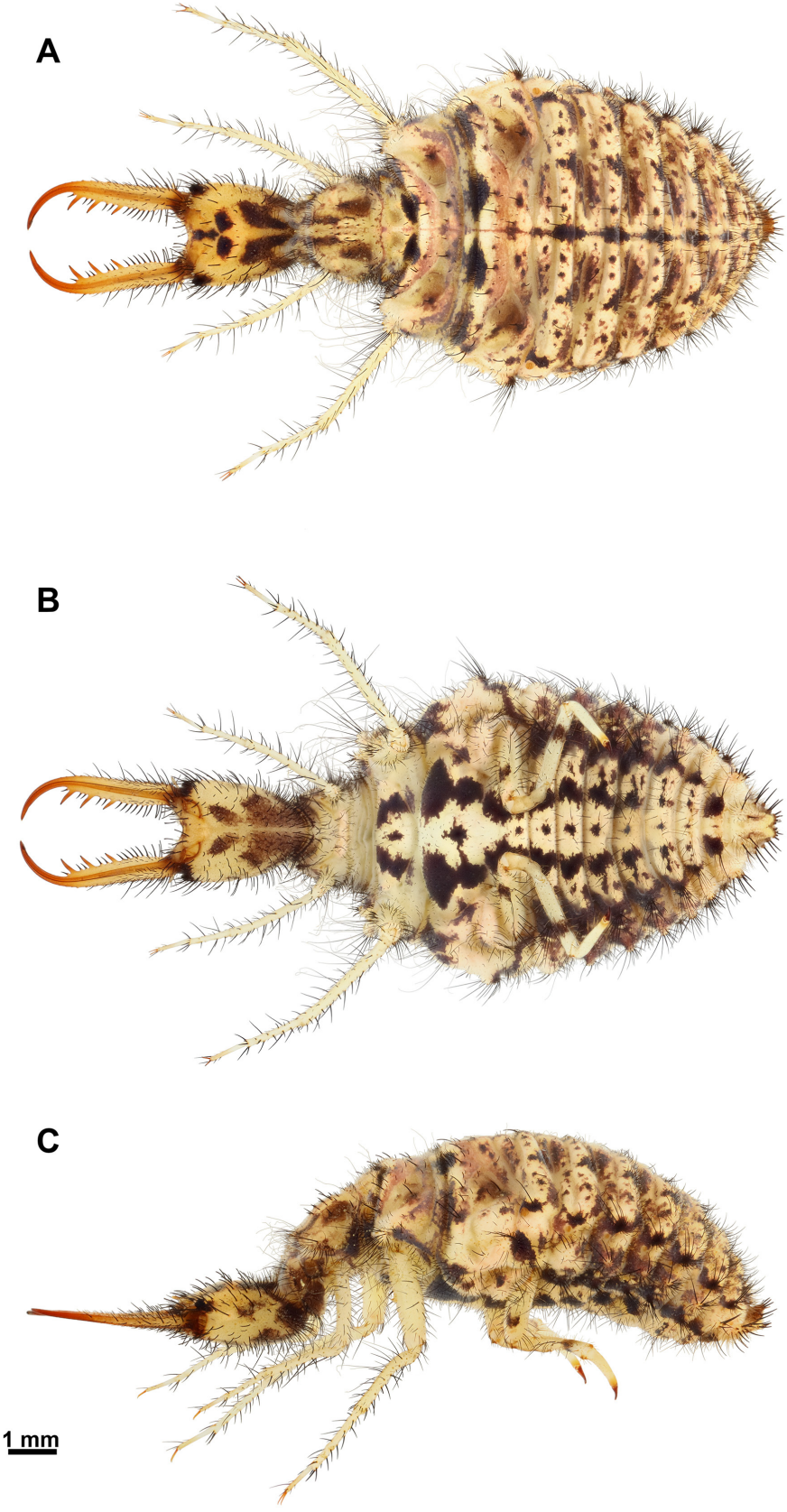

Fig. 5. *Baliga asakurae* (Okamoto, 1910), 3rd instar larva. A, dorsal view; B, ventral view; C, lateral view.

such as under rock overhangs, under artificial buildings, and underneath the root of trees. When disturbed, the larvae will curl up their bodies and stay still, making them similar to the gravels in the surrounding environment. This behavior is also observed in the larvae of *M. alticolus* and *M. bimaculatus*.

Distribution: Endemic to Taiwan, also in the surrounding island—Lanyu.

Remarks: The larvae of this species are similar to those of *M. alticolus*, but differ in the shape of setae on the clypeo-labrum and on the base of the mandibles, because *B. asakurae* has long dolichasters and *M. alticolus* has pointed setae. These species also differ in the number of digging setae on the rastra, because *B. asakurae* has 3 digging setae on each rastrum while *M. alticolus* has 4 digging setae; the two species also inhabits similar environments at different altitudes. This species is also similar to *B. micans* in the overall shape of the head and mandibles and the long dolichasters on the clypeo-labrum (see Matsura 1987: figs. 1, C, F, Hayashi et al. 2020: fig. 7), but the head markings on *B. asakurae* are broader.

The figures stated the larvae of *B. asakurae* in Stange et al. (2003) were incorrect, and appeared to be the larvae of *M. wangi*.

Genus *Myrmeleon* Linnaeus, 1767

Myrmeleon alticolus Miller and Stange, 1999

(Figs. 3B, 4B, 6)

Description of 3rd instar larva: Size: Average body length 9.88 mm (7.34–11.92); head length 2.53 mm (2.24–2.77), head width 2.14 mm (1.95–2.37), mandible length 2.95 mm (2.60–3.18), ratio head width/length 0.85, ratio mandible length/head length 1.17.

General coloring: Ochre, with dark brown markings, ventral side paler.

Head: Sub-rectangular, longer than wide. Sparsely covered with black setae. Ocular tubercle sessile. Mandibles slender, reddish brown, slightly longer than the head capsule, provided with 3 equidistant teeth with the apical tooth slightly stronger. Interdental mandibular setae: (6–10) (2–4) (1–3) (1). Clypeo-labrum with pointed setae. External margin of the mandible with a fringe of long setae, dorsal side of the mandible covered with short setae, ventral side of the mandible with a covering of short setae on both external and internal to the maxilla, reaching the basal tooth. Labial palpus 4-articulated, with fringe of black setae underneath, few extending over labial palpus. Dorsal side of the head capsule with a dark medial band on the clypeo-labrum, followed by a pair of dark brown spots on the anterior side of head capsule, posterior side with a pair of dark, triangular markings, posterior margin with pale markings extending toward the lateral side of the head. Lateral side of the head with a faint brown V-shaped band near the middle, connecting dorsal and ventral head markings, and a dark spot on the posterior side. Ventral side of the head with an anterior pair of pale brown triangular spots and a pair of outwardly curved pale brown band covering the posterior half, extending toward the lateral side of the head.

Thorax: Pronotum with a pair of broad brown stripes, covered with short setae. Body setae black.

Legs: Pale brown, hind legs with brown spots on the apical end of coxae and femur.

Abdomen: Setae black. VIII abdominal sternite with a pair of black spots, odontoid processes distinct, posterior margin with hair-like setae. IX abdominal sternite elongated, with a pair of outwardly curved dark brown stripes, covered with hair-like setae, digging setae absent, or with few reduced digging setae. Rastra sessile, each bearing up to 4 peg-like digging setae with the external ones longer, 1 seta on the external side.

Materials examined: Taiwan. Chiayi County. Alishan, Alishan Township / 21. VIII. 2020 / Y. H. Lin leg., 4 L3. Hsinchu County. Smangus, Jianshi Township / 19. VIII. 2020 / Y. H. Lin leg., 1 L3. Hualien County. Pattonkuan Historic Trail, Zhuoxi Township / 28. I. 2020 / Y. Sun leg., 1 L3. Nantou County. Fenghuang Mountain, Lugu township / 21. XI. 2020 / K. W. Chan leg., 1 L3; same locality / 28. XI. 2020 / Y. H. Lin leg., 2 L3. Highland Experimental Farm N.T.U., Meifeng Farm, Renai Township / 15. V. 2020 / Y. H. Lin leg., 1 L1, 1 L3; same locality / 16. V. 2020 / Y. H. Lin leg., 1 L2; same locality / 17. V. 2020 / Y. H. Lin leg., 2 L3. Taoyuan City. Daguan Mountain, Fuxing District / 10. VII. 2020 / Y. H. Lin leg., 7 L3.

Bio-ecology: This species was found in forests above 1,600 m. a.s.l.. The larvae build pitfall in protected environments such as under rock overhangs, under artificial buildings, underneath the root of trees, or inside hollows of giant trees (Fig. 1A). This species curl up the body when disturbed, like *B. asakurae* and *M. bimaculatus*.

Distribution: Endemic to Taiwan.

Remarks: See remarks for *B. asakurae*. The larvae of *M. alticolus* and *B. asakurae* were observed to be similar in morphology, thus, the placement of *M. alticolus* is to be revised.

Myrmeleon bimaculatus Yang, 1999

(Figs. 3C, 4C, 7, 8)

The larvae of *M. bimaculatus* are described here for the first time, and the species is reported in Taiwan for the first time. An image of the adult is also provided

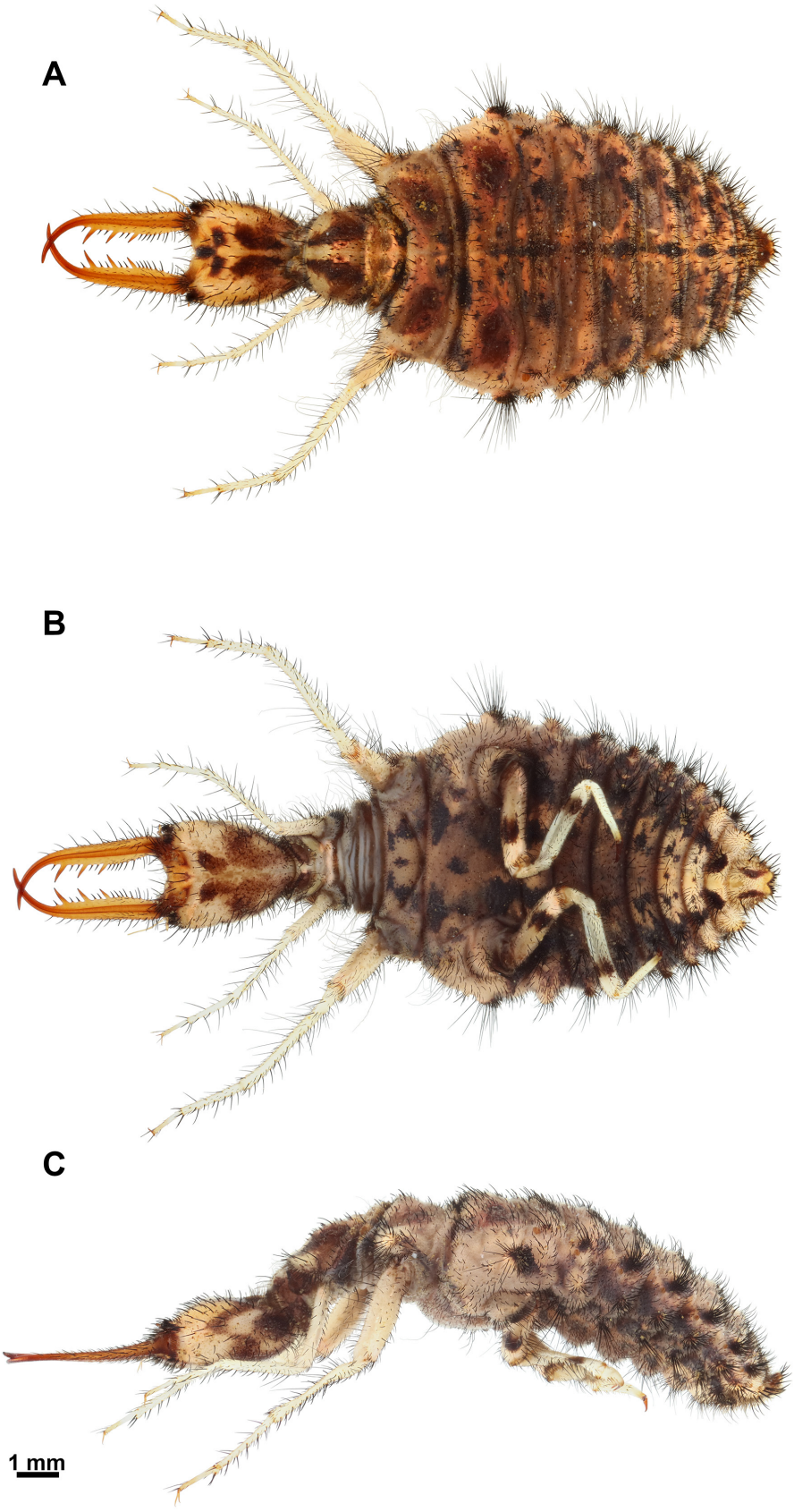

Fig. 6. *Myrmeleon alticolus* Miller and Stange, 1999, 3rd instar larva. A, dorsal view; B, ventral view; C, lateral view.

(Fig. 8).

Description of 3rd instar larva: Size: Average body length 8.06 mm (6.71–9.13); head length 1.78 mm (1.72–1.84), head width 1.49 mm (1.40–1.59), mandible length 1.85 mm (1.73–1.99), ratio head width/length 0.84, ratio mandible length/head length 1.04.

General coloring: Pale ochre, with dark brown body markings.

Head: Sub-rectangular, longer than wide. Covered with short, black setae, ventral side with a setae-less medial line. Ocular tubercle sessile. Mandibles pale brown with apex reddish, slightly longer than the head capsule, provided with 3 equidistant teeth with the apical tooth slightly stronger. Interdental mandibular setae: (5–6)(2–3)(2–3)(1). Clypeo-labrum with pointed setae. External margin of the mandible with a fringe of long setae, dorsal side of the mandible with a sparse covering of short setae, ventral side of the mandible with a few setae at base. Labial palpus 4-articulated, with fringe of black setae underneath, not extending over labial palpus. Dorsal side of the head capsule with a dark brown spot on the clypeo-labrum, a pair of brown stripes on the anterior side, followed by a pair of dark brown spots, a pair of pale brown markings near the middle of the head, and a pair of small black markings on the posterior side. Lateral side of the head with a dark brown spot near the middle and a dark brown spot on the posterior side. Ventral side of the head with a pair of brown outwardly curved markings in the middle, occasionally broken into separated spots.

Thorax: Pronotum with a pair of brown stripes, covered with short setae. Body setae black.

Legs: Pale brown, unspotted.

Abdomen. Setae black, with pale brown setae on the ventral side. VIII abdominal sternite with a pair of dark brown spots, odontoid processes distinct, posterior margin with hair-like setae. IX abdominal sternite with a median row of 4 peg-like digging setae divided into 2 groups. Rastra sessile, each bearing 3 peg-like digging setae similar in size, 1 seta on the external side.

Materials examined: Taiwan. Hsinchu County. Hengshan St. Wood Factory, Hengshan Township / 26. XI. 2019 / J. W. Chuang leg., 1 L3, 2 L3 laboratory reared to adult. Kinmen County. Qilinshan Forest Park, Lieyu Township / 03. IX. 2020 / Y. H. Lin leg., 1 L3, 2 L3 laboratory reared to adult. Zhaishan, Jinchen Township / 03. IX. 2020 / Y. H. Lin leg., 1 L3 laboratory reared to adult. Miaoli County. Shangrila Paradise Amusement Park, Zaoqiao Township / 06. VIII. 2017 / Y. J. Tsao leg., 1 L3 laboratory reared to adult; same locality / 23. IX. 2017 / Y. J. Tsao leg., 2 L3 laboratory reared to adult; same locality / 01. IV. 2018 / Y. J. Tsao leg., 2 L3 laboratory reared to adult; same locality / 05. V. 2018 / Y. J. Tsao leg., 2 L3 laboratory reared to adult; same locality / 07. VII. 2018 / Y. J. Tsao leg., 5 L3 laboratory reared to adult; same locality / 04. VIII. 2018 / Y. J. Tsao leg., 5 L3 laboratory reared to adult; same locality / 01. IX. 2018 / Y. J. Tsao leg., 3 L3 laboratory reared to adult; same locality / 06. X. 2018 / Y. J. Tsao leg., 5 L3 laboratory reared to adult; same locality / 04. XI. 2018 / Y. J. Tsao leg., 1 L3, 10 L3 laboratory reared to adult; same locality / 01. XII. 2018 / Y. J. Tsao and Y. H. Lin leg., 13 L3 laboratory reared to adult; same locality / 12. I. 2019 / Y. J. Tsao leg., 4 L3 laboratory reared to adult; same locality / 17. III. 2019 / Y. H. Lin leg., 1 L3 laboratory reared to adult; same locality / 06. VII. 2019 / Y. J. Tsao leg., 2 L3, 6 L3 laboratory reared to adult. Tongxiao, Tongxiao Township / 21. XII. 2019 / Y. J. Tsao leg., 1 L3 laboratory reared to adult. New Taipei City. Bali District 3rd Cemetery, Bali District / 30. X. 2018 / C. Y. Chiang leg., 4 L3 laboratory reared to adult; same locality / 06. XI. 2018 / C. Y. Chiang leg., 1 L3 laboratory reared to adult; same locality / 29. VIII. 2019 / Y. H. Lin leg., 1 L3, 4 L3 laboratory reared to adult; same locality / 04. IX. 2019 / Y. H. Lin leg., 4 L3 laboratory reared to adult; same locality / 24. II. 2020 / Y. H. Lin leg., 2 L3, 4 L3 laboratory reared to adult. Taichung City. Dakeng Trail No. 4, Beitun District / 24. VI. 2020 / Y. H. Lin leg., 1 L3 laboratory reared to adult.

Bio-ecology: *M. bimaculatus* is an inland species, and it is usually found at low elevations at about 100 m a.s.l.. The larvae build pitfalls in protected areas, such as under rock overhangs or under artificial buildings, and it was even found in a wood factory, where the larvae build pitfalls in sawdust. The behavior of curling up their bodies when disturbed, like *B. asakurae* and *M. alticolus*, was also observed in this species. The larvae may co-habitat with those of *M. littoralis*.

Distribution: Previously recorded in the southeast provinces of China. This is the first record of *M. bimaculatus* in Taiwan, also in the surrounding islands—Kinmen.

Remarks: The larvae of *M. bimaculatus* have their ventral head markings similar to *M. punctinervis*, though broader and longer. The larvae are also distinct from the *Myrmeleon* species of Taiwan in the shorter setae underneath labial palpus and the behavior of curling up when disturbed.

Variations exist on ventral head markings of *M. bimaculatus*, as the stripes may be broken into 2 spots, these variations may cause misidentification with the larvae of *M. punctinervis* or *M. heppneri*.

***Myrmeleon heppneri* Miller and Stange, 1999**

(Figs. 3D, 4D, 9)

Description of 3rd instar larva: Size: Average

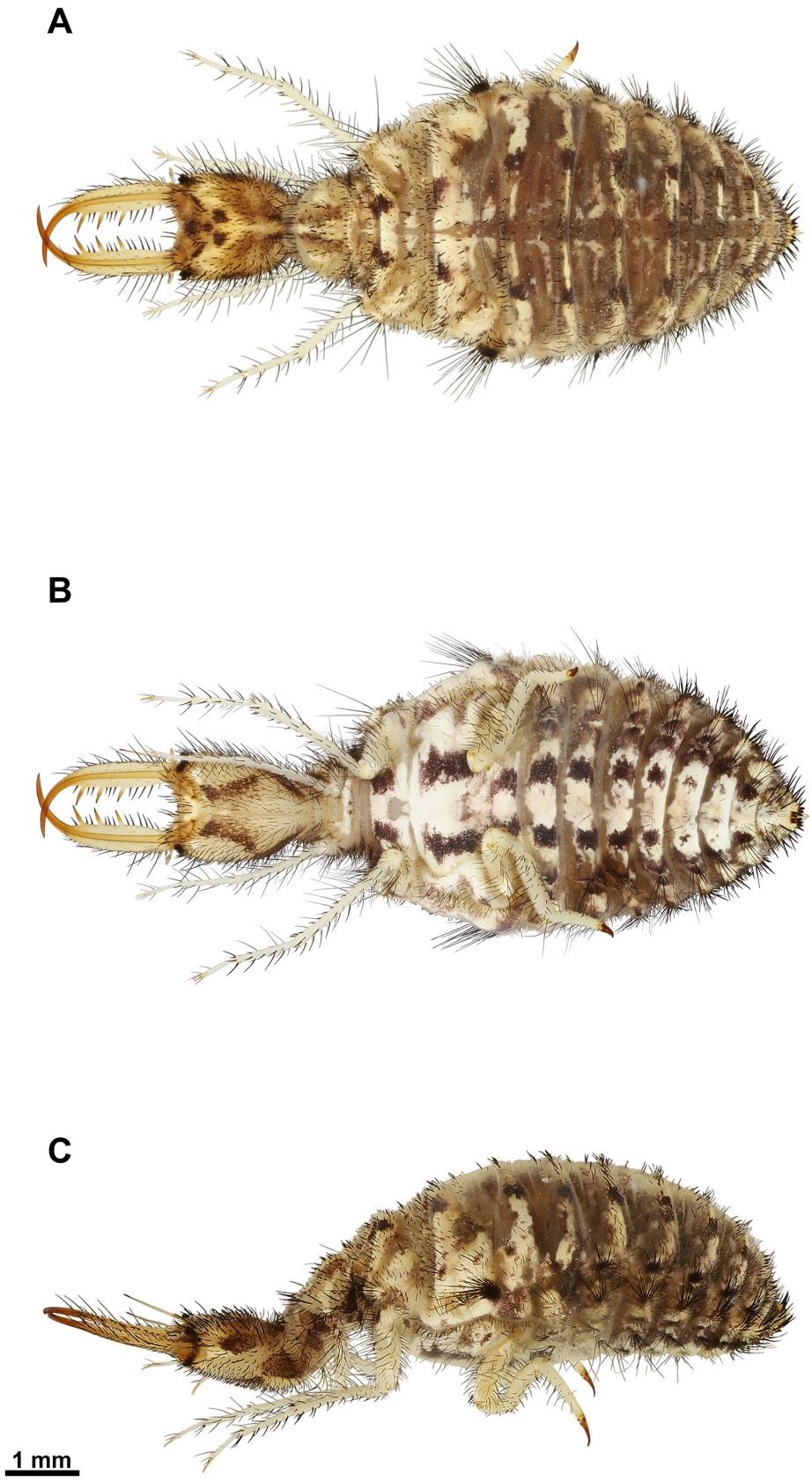

Fig. 7. *Myrmeleon bimaculatus* Yang, 1999, 3rd instar larva. A, dorsal view; B, ventral view; C, lateral view.

body length 6.95 mm (6.17–7.77); head length 1.60 mm (1.42–1.82), head width 1.39 mm (1.29–1.47), mandible length 1.68 mm (1.52–1.80), ratio head width/length 0.87, ratio mandible length/head length 1.05.

General coloring: Pale ochre, slightly yellowish, with dark brown body markings.

Head: Sub-rectangular, longer than wide. Covered with short, black setae; ventral side with a setae-less area in the middle. Ocular tubercle sessile. Mandibles pale brown with apex reddish, as long as the head capsule, provided with 3 equidistant teeth with the apical tooth slightly stronger. Interdental mandibular setae: (4–7)(2–3)(2–3)(1–2). Clypeo-labrum with pointed setae. External margin of the mandible with a fringe of long setae, dorsal side of the mandible with a row of setae along the external margin, ventral side of the mandible without setae. Labial palpus 3-articulated, with fringe of black setae underneath, few extending over labial palpus. Dorsal side of the head capsule with dark markings on clypeo-labrum, a pair of dark spots on the anterior side, followed by a pair of pale brown spots, posterior side with a pair of greyish brown markings, lateral margins with greyish brown stripes. Lateral side of the head with a posterior dark spot. Ventral side of the head pale, with a pair of small dark spots on the anterior side and a pair of larger dark spots on the posterior side, occasionally fusing into a stripe.

Thorax: Pronotum with two pairs of dark brown stripes, covered with short setae. Body setae black.

Legs: Pale brown, unspotted.

Abdomen: Setae black, with pale brown setae on the ventral side. VIII abdominal sternite with a pair of dark brown markings, odontoid processes reduced, posterior margin with black stout setae interspersed with pale brown setae. IX abdominal sternite with a pair of small dark brown spots, irregularly dispersed with at least three rows of digging setae. Rastra sessile, each bearing 4 stout, peg-like digging setae equal in size.

Materials examined: Taiwan. Taoyuan City. Zhuwei Beach, Dayuan District / 27. X. 2019 / Y. H. Lin leg., 9 L3; same locality / 08. XI. 2019 / Y. H. Lin leg., 2 L3, 1 L3 laboratory reared to adult; same locality / 14. VI. 2020 / Y. H. Lin leg., 2 L3, 1 L3 laboratory reared to adult.

Bio-ecology: *M. heppneri* is one of the rarest species of *Myrmeleon* of Taiwan, only recorded from very few beaches. The larvae build pitfall on open sand dunes, usually under vegetation on downwind slopes, with similar habitat preference to *M. persimilis*. In Zhuwei Beach of Taoyuan City, *M. persimilis* are absent while a stable population of *M. heppneri* were found; therefore, interspecific competition among these species requires further exploration.

Distribution: Endemic to Taiwan. Only recorded in Tamsui Beach and Zhuwei Beach in the north-west coast of Taiwan.

Remarks: The larvae of *M. heppneri* resembles *M. persimilis* in the arrangement of digging setae on IX abdominal sternite and in the absence of setae on the ventral side of the mandibles, the two can be distinguished by the markings on head capsule.

Variations exist on ventral head markings of *M. heppneri*, because the anterior and posterior spots might fuse together forming a stripe, or they might be barely visible. These variations may cause misidentification with the larvae of *M. punctinervis* or *M. bimaculatus* if

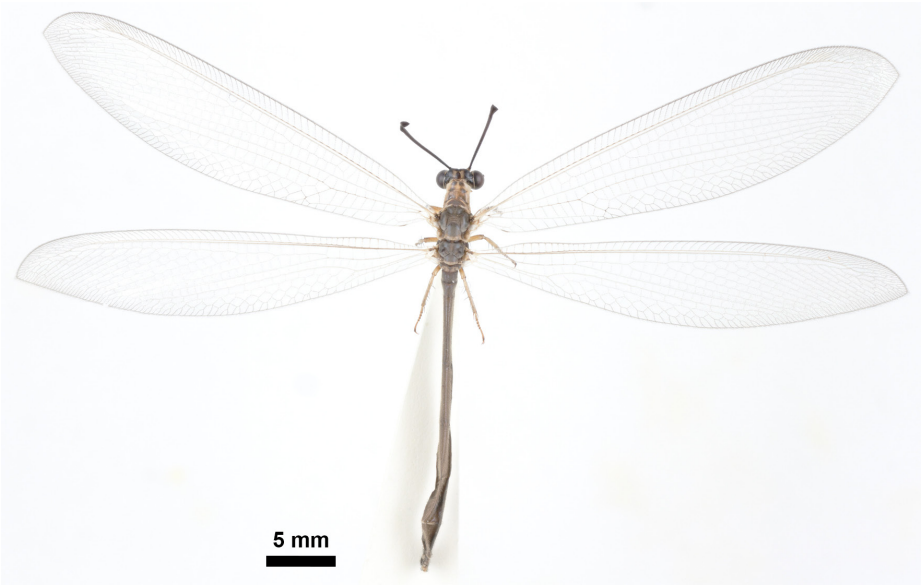

Fig. 8. *Myrmeleon bimaculatus* Yang, 1999, adult, dorsal view.

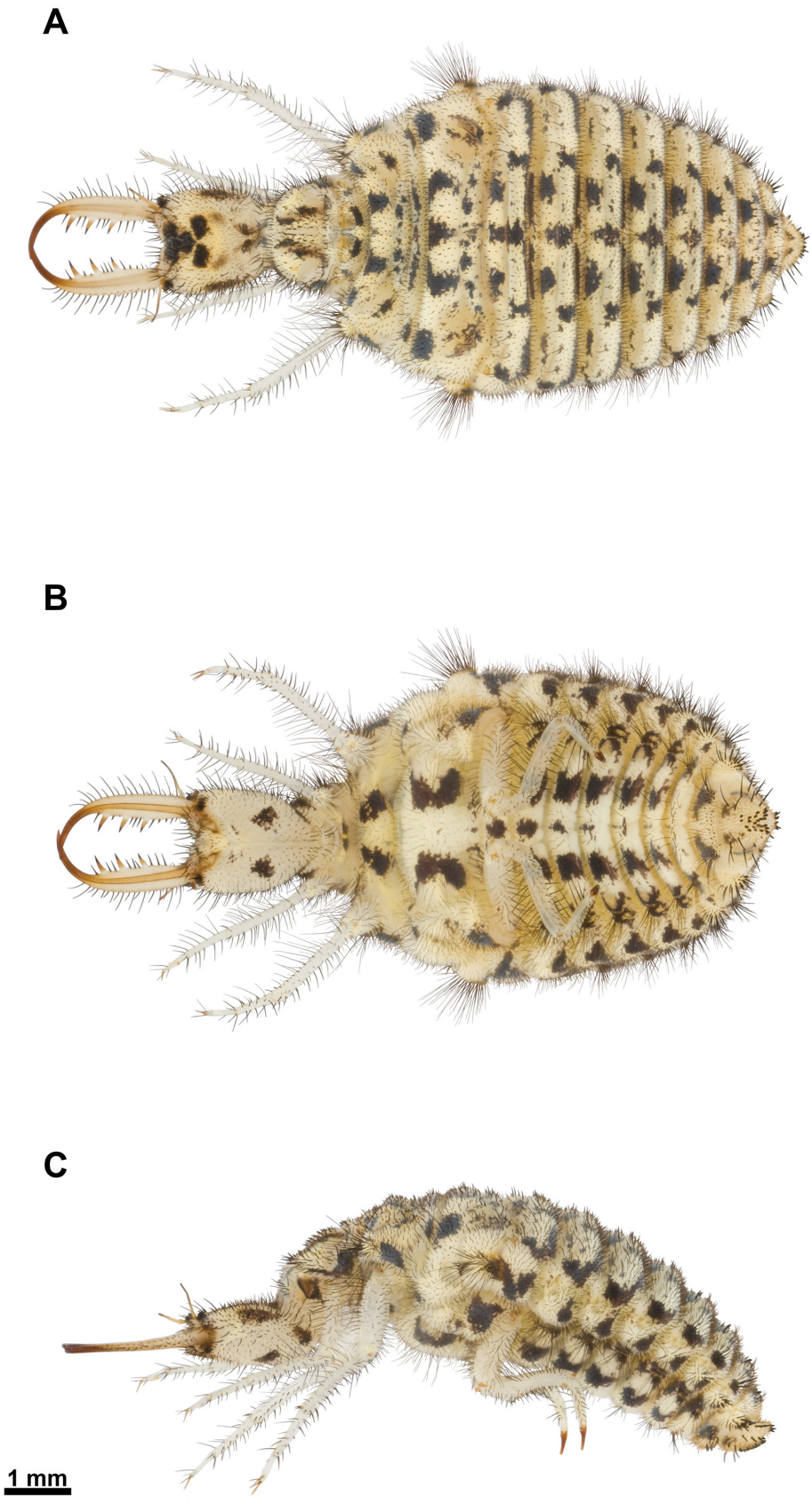

Fig. 9. *Myrmeleon heppneri* Miller and Stange, 1999, 3rd instar larva. A, dorsal view; B, ventral view; C, lateral view.

depending solely on ventral head markings.

Myrmeleon littoralis Miller and Stange, 1999

(Figs. 3E, 4E, 10)

Despite this species is included in the key to antlion larvae of Taiwan by Stange et al. (2003), the larvae of this species is described here for the first time.

Description of 3rd instar larva: Size: Average body length 9.15 mm (7.79–10.93); head length 1.92 mm (1.75–2.22), head width 1.63 mm (1.60–1.71), mandible length 1.95 mm (1.76–2.24), ratio head width/length 0.85, ratio mandible length/head length 1.02.

General coloring: Pale ochre, slightly reddish, with dark brown body markings.

Head: Sub-rectangular, longer than wide. Densely covered with short, black setae. Ocular tubercle sessile. Mandibles pale brown with apex reddish, as long as the head capsule, provided with 3 equidistant teeth with the apical tooth slightly stronger. Interdental mandibular setae: (6–10)(2–4)(2–3)(1). Clypeo-labrum with pointed setae. External margin of the mandible with a fringe of long setae, dorsal side of the mandible with a sparse covering of short setae on the margins, ventral side of the mandible with a sparse covering of setae external to the maxilla, reaching the basal tooth, and few isolated setae disposed internal to the maxilla. Labial palpus 4-articulated, with fringe of black setae underneath, few extending over labial palpus. Dorsal side of the head with a dark spot on clypeo-labrum, a pair of dark spots on the anterior side of head capsule with a small pale brown spot in between, posterior side with V-shaped dark markings. Lateral side of the head with two large dark markings, one close to the dorsal side and the other on the ventral-posterior side, occasionally fused together. Ventral side of the head with a pair of triangular dark brown spots on the posterior side.

Thorax: Pronotum with a pair of pale brown stripes, covered with short setae. Body setae black.

Legs: Pale brown, unspotted.

Abdomen: Setae black, with pale brown setae on the ventral side. VIII abdominal sternite with a pair of dark brown spots, odontoid processes distinct, posterior margin with hair-like setae. IX abdominal sternite with a median row of 4 peg-like digging setae. Rastra sessile, each bearing 3 peg-like digging setae, of which the external one is the longest, 1 seta on the external side.

Materials examined: Taiwan. Hsinchu County. Hengshan St. Wood Factory, Hengshan Township / 26. XI. 2019 / J. W. Chuang leg., 2 L3 laboratory reared to adult. Kaohsiung City. Qijing Beach, Qijing District / 16. XI. 2019 / Y. H. Lin leg., 6 L3 laboratory reared to adult. Kinmen County. Liaoluo Seashore Park, Jinhu Township / 04. IX. 2020 / Y. H. Lin leg., 2 L2, 2 L3. Miaoli County. Qiding Seaside Park, Zhunan Township / 08. XI. 2019 / Y. H. Lin leg., 1 L3 laboratory reared to adult. Shangrila Paradise Amusement Park, Zaoqiao Township / 23. IX. 2017 / Y. J. Tsao leg., 1 L2 laboratory reared to adult; same locality / 12. I. 2018 / Y. J. Tsao leg., 1 L2 laboratory reared to adult, 1 L3 laboratory reared to adult; same locality / 03. III. 2018 / Y. J. Tsao leg., 1 L2 laboratory reared to adult, 1 L3 laboratory reared to adult; same locality / 05. V. 2018 / Y. J. Tsao leg., 1 L3 laboratory reared to adult; same locality / 09. VI. 2018 / Y. J. Tsao leg., 1 L3 laboratory reared to adult; same locality / 07. VII. 2018 / Y. J. Tsao leg., 1 L3 laboratory reared to adult; same locality / 04. VIII. 2018 / Y. J. Tsao leg., 1 L3 laboratory reared to adult; same locality / 01. IX. 2018 / Y. J. Tsao leg., 1 L3 laboratory reared to adult; same locality / 06. X. 2018 / Y. J. Tsao leg., 1 L2 laboratory reared to adult, 1 L3; same locality / 04. XI. 2018 / Y. J. Tsao leg., 2 L2 laboratory reared to adult, 1 L3, 2 L3 laboratory reared to adult; same locality / 01. XII. 2018 / Y. J. Tsao leg., 1 L2, 1 L2 laboratory reared to adult, 1 L3, 7 L3 laboratory reared to adult; same locality / 12. I. 2019 / Y. J. Tsao leg., 1 L3, 3 L3 laboratory reared to adult; same locality / 06. VII. 2019 / Y. J. Tsao leg., 1 L3; same locality / 17. VIII. 2019 / Y. J. Tsao leg., 1 L3 laboratory reared to adult. Tongxiao Beach, Tongxiao Township / 04. V. 2020/ Y. H. Lin leg., 1 L3. New Taipei City. Fulong Seaside Park, Gongliao District / 07. VI. 2019 / Y. H. Lin leg., 1 L3, 2 L3 laboratory reared to adult. Laomei, Shimeng District / 04. VIII. 2019 / Y. H. Lin leg., 4 L3, 2 L3 laboratory reared to adult. Laoqiankeng Road, Bali District / 30. X. 2019 / Y. H. Lin leg., 1 L3, 3 L3 laboratory reared to adult; same locality / 20. IV. 2020 / Y. H. Lin leg., 2 L3. Linkou Canyon, Linkou District / 08. XI. 2019 / Y. H. Lin leg., 1 L3 laboratory reared to adult; same locality / 07. XI. 2020 / Y. H. Lin leg., 4 L3. Longmeng Bridge, Gongliao District / 15. XII. 2019 / Y. H. Lin leg., 2 L3, 1 L3 laboratory reared to adult. Longmeng Camping Ground, Gongliao District / 15. XII. 2019 / Y. H. Lin leg., 2 L3 laboratory reared to adult. Shalun Seaside Resort, Tamsui District / 04. VII. 2018 / Y. H. Lin leg., 1 L3 laboratory reared to adult; same locality / 01. VI. 2019 / Y. J. Tsao leg., 3 L2 laboratory reared to adult, 3 L3 laboratory reared to adult; same locality / 03. IX. 2019 / Y. H. Lin leg., 1 L2, 1 L3, 5 L3 laboratory reared to adult. Wazihwei Beach, Bali District / 11. IX. 2019 / Y. H. Lin leg., 2 L3 laboratory reared to adult. Penghu County. Aimen Beach, Huxi Township / 16. I. 2020 / Y. H. Lin leg., 6 L3, 4 L3 laboratory reared to adult. Houliao Beach, Baisha Township / 13. I. 2020 / Y. H. Lin leg., 2 L3 laboratory reared to adult. Lintou Park, Huxi Township / 13. I. 2020 / Y. H. Lin leg., 2 L3. Shanshui Beach, Magong City / 16. I. 2020 / Y. H. Lin leg., 2 L3 laboratory reared to adult. Pingtung County.

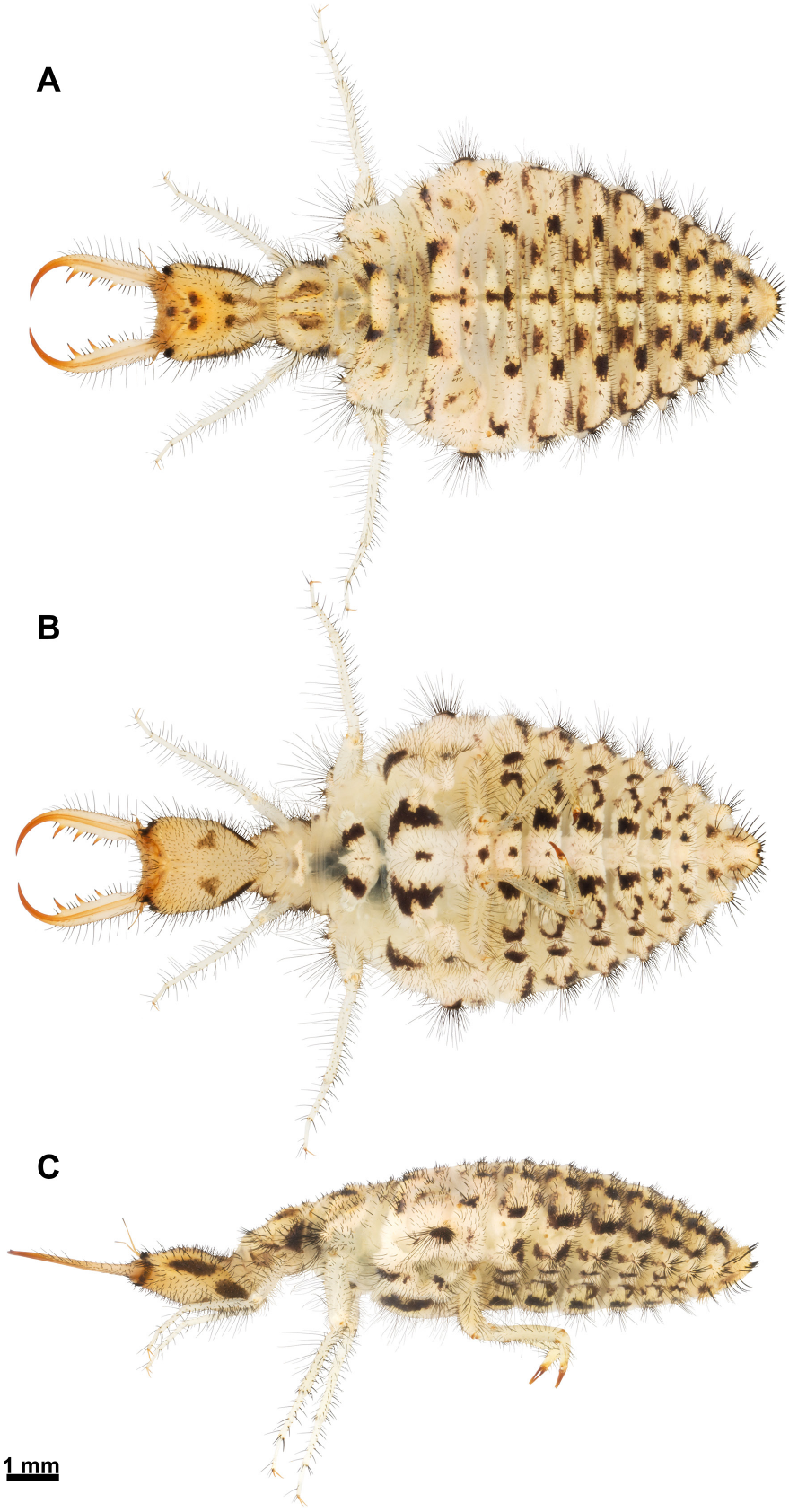

Fig. 10. *Myrmeleon littoralis* Miller and Stange, 1999, 3rd instar larva. A, dorsal view; B, ventral view; C, lateral view.

Gangkou Beach, Manzhou Township / 03. II. 2020 / Y. H. Lin leg., 1 L3. Houbihu Beach, Hengchun Township / 04. II. 2020 / Y. H. Lin leg., 1 L3, 1 L3 laboratory reared to adult. South Bay, Hengchun Township / 03. II. 2020 / Y. H. Lin leg., 1 L3, 1 L3 laboratory reared to adult. Taichung City. Dakeng Trail No. 4, Beitun District / 24. VI. 2020 / Y. H. Lin leg., 2 L3 laboratory reared to adult. Taoyuan City. Caota Sand Dunes, Guanyin District / 08. XI. 2019 / Y. H. Lin leg., 1 L3 laboratory reared to adult. Yongan Seaside Park, Xinwu District / 08. XI. 2019 / Y. H. Lin leg., 1 L3, 3 L3 laboratory reared to adult.

Bio-ecology: *M. littoralis* can be observed from coastal wind-break to low-elevation forests. The larvae build their pits in sheltered conditions, wherever a suitable loose substratum is present, at base of trees, near escarpments, under rock overhangs or under artificial structures such as buildings and bridges, it was even found in a wood factory, where the larvae build pitfalls in sawdust. The larvae of *M. littoralis* may co-habitat with those of *M. bimaculatus*, *M. taiwanensis* and *M. punctinervis*. The larvae of this species are able to move both forward and backward.

Distribution: Endemic to Taiwan. This species is found along the western coast and the inland areas, also in the surrounding islands—Penghu and Kinmen.

Remarks: One of the most common species in Taiwan. The larvae can be identified by the head markings.

***Myrmeleon persimilis* Miller and Stange, 1999**

(Figs. 3F, 4F, 11)

Description of 3rd instar larva: Size: Average body length 7.79 mm (6.51–9.31); head length 1.81 mm (1.63–1.96), head width 1.52 mm (1.42–1.60), mandible length 1.87 mm (1.78–1.97), ratio head width/length 0.84, ratio mandible length/head length 1.03.

General coloring: Pale ochre, with greyish body markings.

Head: Sub-rectangular, longer than wide. Densely covered with short, black setae, ventral side with short, brown setae interspersed. Ocular tubercle sessile. Mandibles thick, pale brown with apex reddish, as long as the head capsule, provided with 3 equidistant teeth with the apical tooth slightly stronger. Interdental mandibular setae: (5–8)(2–5)(2–3)(1–2). Clypeo-labrum with pointed setae. External margin of the mandible with a fringe of long setae, dorsal side of the mandible with a row of short setae along the external margin, ventral side of the mandible without setae. Labial palpus 4-articulated, with fringe of black setae underneath, few extending over labial palpus. Dorsal side of the head capsule with dark markings on the clypeo-labrum, anterior side with a pair dark brown spots followed by a pair of pale brown spots, posterior side with a pair of small dark brown markings, lateral margins with pale brown bands. Lateral side of the head without markings. Ventral side of the head with a pair of anterior brown spots.

Thorax: Pronotum with a pair of pale brown stripes, covered with short setae. Body setae black.

Legs: Pale brown, unspotted.

Abdomen: Setae black, covered with pale brown setae on the ventral side. VIII abdominal sternite with a pair of pale brown markings, odontoid processes reduced, posterior margin with several stout black setae and pale brown (sometimes dark) filiform setae. IX abdominal sternite with irregularly dispersed stout digging setae. Rastra sessile, each bearing 3 stout, peg-like digging setae equal in size, 1 seta on the external side.

Materials examined: Taiwan. Kinmen County. Kinmen County Agriculture Research Institute Recreation Farm, Jinhu Township / 02. IX. 2020 / Y. H. Lin leg., 1 L2. Liaoluo Beach, Jinhu Township / 04. IX. 2020 / Y. H. Lin leg., 3 L3. Qingnian Farm, Jinhu Township / 02. IX. 2020 / Y. H. Lin leg., 1 L3. Shuangkou Beach, Lieyu Township / 03. IX. 2020 / Y. H. Lin leg., 1 L3. Zhaishan, Jinchen Township / 03. IX. 2020 / Y. H. Lin leg., 1 L3. Miaoli County. Qiding Seaside Park, Zhunan Township / 08. XI. 2019 / Y. H. Lin leg., 4 L3. Tongxiao Beach, Tongxiao Township / 04. V. 2020/ Y. H. Lin leg., 10 L3, 2 L3 laboratory reared to adult. New Taipei City. Fulong seaside park, Gongliao District / 07. VI. 2019 / Y. H. Lin leg., 2 L3, 2 L3 laboratory reared to adult. Laomei, Shimeng District / 04. VIII. 2019 / Y. H. Lin leg., 2 L2, 1 L3. Longmeng Camping Ground, Gongliao district / 15. XII. 2019 / Y. H. Lin leg., 3 L3. Longmeng Beach, Gongliao district / 15. XII. 2019 / Y. H. Lin leg., 4 L3. Shalun Seaside Resort, Tamsui District / 30. I. 2019 / K. W. Chan leg., 1 L3 laboratory reared to adult; same locality / 18. V. 2019 / Y. H. Lin leg., 3 L3; same locality / 03. IX. 2019 / Y. H. Lin leg., 5 L3, 1 L3 laboratory reared to adult; same locality / 13. X. 2019 / Y. H. Lin leg., 6 L3. Wazihwei Beach, Bali District / 11. IX. 2019 / Y. H. Lin leg., 1 L3. Penghu County. Aimen Beach, Huxi Township / 16. I. 2020 / Y. H. Lin leg., 3 L3, 1 L3 laboratory reared to adult. Chikan Beach, Baisha Township / 13. I. 2020 / Y. H. Lin leg., 3 L3. Houliao Beach, Baisha Township / 13. I. 2020 / Y. H. Lin leg., 10 L3, 2 L3 laboratory reared to adult. Lintou Park, Huxi Township / 13. I. 2020 / Y. H. Lin leg., 4 L3, 1 L3 laboratory reared to adult. Lizhengjiao Beach, Huxi Township / 16. I. 2020 / Y. H. Lin leg., 4 L3, 2 L3 laboratory reared to adult. Qitou Beach, Baisha Township / 13. I. 2020 / Y. H. Lin leg., 4 L3. Shanshui Beach, Magong City / 16. I. 2020 / Y. H.

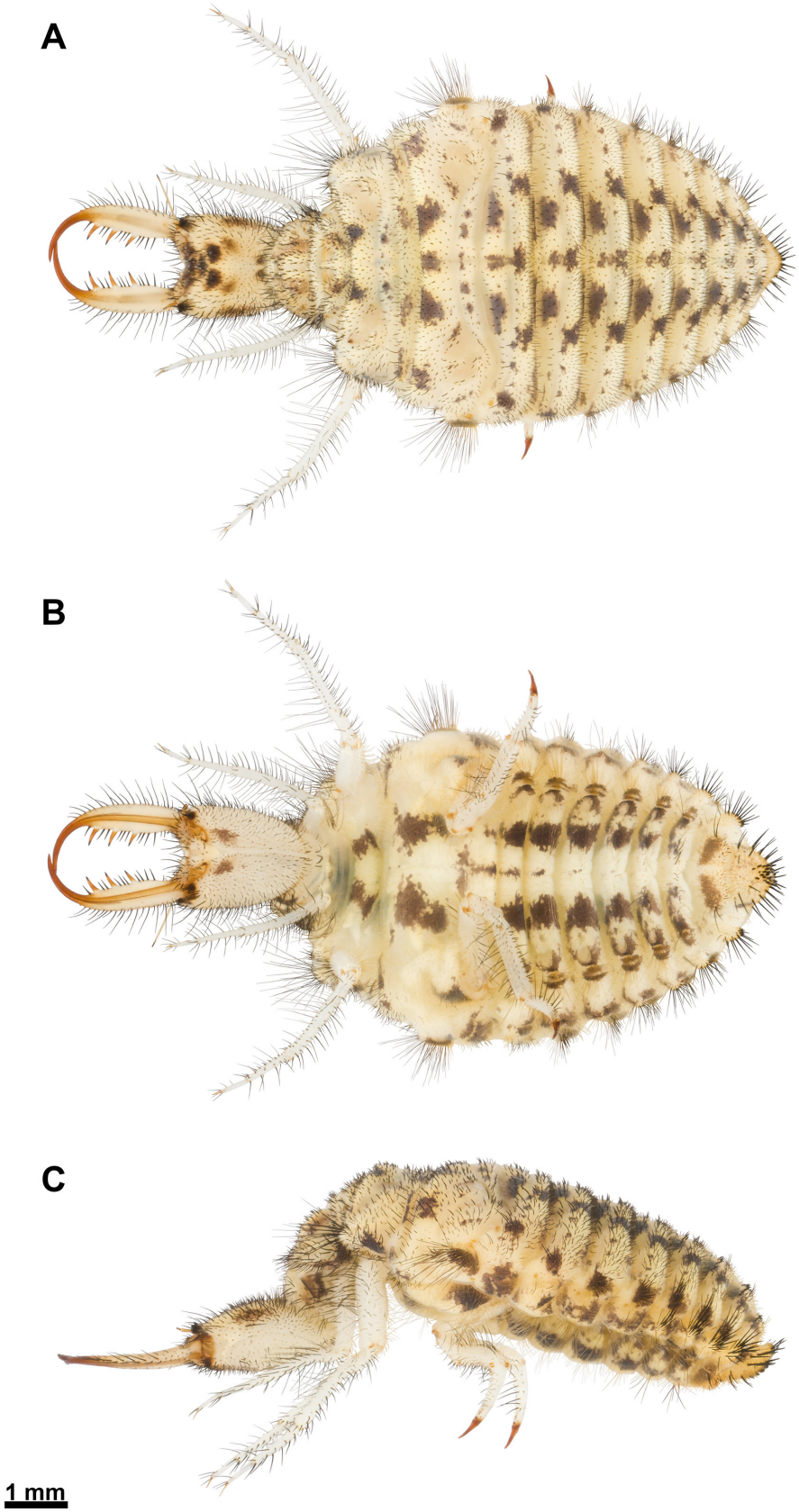

Fig. 11. *Myrmeleon persimilis* Miller and Stange, 1999, 3rd instar larva. A, dorsal view; B, ventral view; C, lateral view.

Lin leg., 5 L3. Shili Beach, Magong City / 13. I. 2020 / Y. H. Lin leg., 5 L3, 1 L3 laboratory reared to adult. Pingtung County. Dawan Beach, Hengchun Township / 03. II. 2020 / Y. H. Lin leg., 1 L3 laboratory reared to adult. Fengchuisha beach, Hengchun Township / 12. II. 2019 / K. W. Chan leg., 1 L3 laboratory reared to adult; same locality / 03. II. 2020 / Y. H. Lin leg., 6 L3. Jiupeng Desert, Manzhou Township / 04. II. 2020 / Y. H. Lin leg., 1 L3 laboratory reared to adult. Taoyuan City. Yongan Seaside Park, Xinwu District / 08. XI. 2019 / Y. H. Lin leg., 2 L3.

Bio-ecology: *M. persimilis* is a common species in Taiwan, and can be collected in most of the sandy beaches around Taiwan, except in the eastern coast. The larvae build pitfall on open sand dunes, especially on downwind slopes (Fig. 1B). The larvae of *M. persimilis* may co-habitat with those of *M. punctinervis*.

The behavior of flexibly switching between building pitfall traps and ambush foraging strategies were observed in the larvae of this species (Tsao and Okuyama 2012).

Distribution: Endemic to Taiwan. *M. persimilis* is found on beaches along the western shore, also in the surrounding islands—Penghu and Kinmen.

Remarks: The larvae of *M. persimilis* resembles *M. heppneri* in the arrangement of digging setae on IX abdominal sternite and the absence of setae on the ventral side of the mandibles, the two can be distinguished by the markings on head capsule.

***Myrmeleon punctinervis* Banks, 1937**

(Figs. 3G, 4G, 12)

Description of 3rd instar larva: Size: Average body length 8.27 mm (6.97–9.65); head length 1.89 mm (1.76–2.02), head width 1.47 mm (1.35–1.54), mandible length 2.04 mm (1.86–2.11), ratio head width/length 0.77, ratio mandible length/head length 1.08.

General coloring: Pale ochre, with greyish body markings.

Head: Sub-rectangular, longer than wide. Covered with short, black setae, ventral side setae sparse. Ocular tubercle sessile. Mandibles pale brown with apex reddish, as long as the head capsule, provided with 3 equidistant teeth with the apical tooth slightly stronger. Interdental mandibular setae: (4–9)(2–3)(2–3)(1). Clypeo-labrum with pointed setae. External margin of the mandible with a fringe of long setae, dorsal side of the mandible with a row of short setae along the external margin, ventral side of the mandible with a sparse covering of setae external to the maxilla, reaching the basal tooth. Labial palpus 4-articulated, with fringe of black setae underneath, few extending over labial palpus. Dorsal side of the head capsule with the clypeo-labrum dark brown, the anterior side with a pair of dark brown spots, followed by a pair of brown triangular markings, reaching the brown markings on the lateral margins. Lateral side of the head with a dark brown spot on the dorsal-posterior side. Ventral side of the head with a pair of brown outwardly curved stripes in the middle.

Thorax: Pronotum with a pair of broad brown stripes, covered with short setae. Body setae black.

Legs: Pale brown, unspotted.

Abdomen: Setae black, covered with pale brown setae on the ventral side. VIII abdominal sternite with a pair of pale brown trapezoid bands, odontoid processes distinct, posterior margin with short, pointed setae. IX abdominal sternite with a median row of 4 pointed digging setae, irregularly interspersed with short digging setae. Rastra sessile, each bearing 4 (occasionally 5) pointed, peg-like digging setae, of which the external one is the longest.

Materials examined: Taiwan. Kinmen County. Kinmen County Forest Affair Place, Jinsha Township / 02. IX. 2020 / Y. H. Lin leg., 1 L2, 2 L3, 1 L3 laboratory reared to adult. Qingnian Farm, Jinhu Township / 02. IX. 2020 / Y. H. Lin leg., 1 L3 laboratory reared to adult. Tongan Wharf, Jincheng Township / 12. VII. 2020 / K. T. Lin leg., 1 L3. Miaoli County. Qiding Beach, Zhunan Township / 08. XI. 2019 / Y. H. Lin leg., 3 L3; same locality / 04. V. 2020 / Y. H. Lin leg., 2 L3, 4 L3 laboratory reared to adult. Tongxiao Beach, Tongxiao Township / 04. V. 2020 / Y. H. Lin leg., 5 L3, 2 L3 laboratory reared to adult. Nantou County. Qiedongkeng, Zhushan Township / 27. XI. 2020 / Y. H. Lin leg., 1 L3. New Taipei City. Linkou Canyon, Linkou District / 08. XI. 2019 / Y. H. Lin leg., 1 L3, 2 L3 laboratory reared to adult. Shalun Seaside Resort, Tamsui District / 30. I. 2019 / K. W. Chan leg., 2 L3 laboratory reared to adult. Taoyuan City. Zhuwei Beach, Dayuan District / 14. VI. 2020 / Y. H. Lin leg., 2 L3, 2 L3 laboratory reared to adult.

Bio-ecology: The larvae of *M. punctinervis* build pitfall in open environments, and they can be collected on sand dunes, near escarpments, beside artificial buildings, and also on river banks. The larvae of *M. punctinervis* may co-habitat with larvae of *M. persimilis* or *M. littoralis*. Capability of moving forward and backward was observed by Stange et al. (2003) and our personal observations.

Distribution: Endemic to Taiwan. This species is found on beaches along the western coast and the surrounding islands—Kinmen, also recorded in inland river banks.

Remarks: The larvae of *M. punctinervis* are similar to those of *M. taiwanensis* in dorsal head markings and pointed IX abdominal sternite digging setae, and

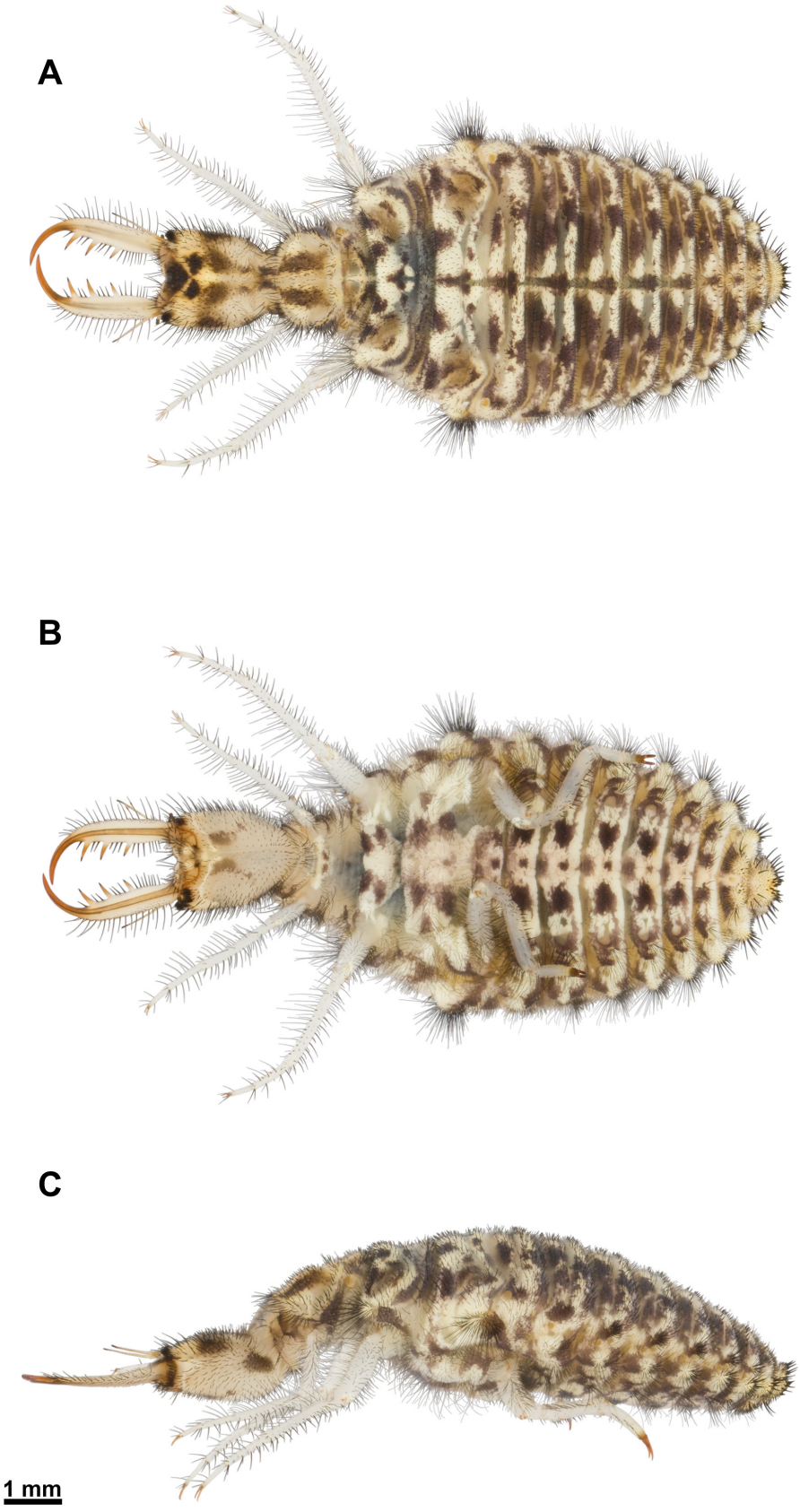

Fig. 12. *Myrmeleon punctinervis* Banks, 1937, 3rd instar larva. A, dorsal view; B, ventral view; C, lateral view.

they are also similar to *M. bimaculatus* in ventral head markings. The ventral head markings may vary in width or shape.

Miller et al. (1999) mentioned that a species complex may exist in this species, and Stange et al. (2003) also pointed out that the larvae of this species show different movement patterns from different localities, in which one can move forward while the other cannot, the species complex and behavior difference requires more specimens for confirmation.

Myrmeleon taiwanensis Miller and Stange, 1999

(Figs. 3H, 4H, 13)

Description of 3rd instar larva: Size: Average body length 7.68 mm (6.35–8.52); head length 1.82 mm (1.69–1.99), head width 1.56 mm (1.48–1.67), mandible length 1.90 mm (1.68–2.10), ratio head width/length 0.85, ratio mandible length/head length 1.04.

General coloring: Pale orche, with brown body markings.

Head: Sub-rectangular, longer than wide. Covered with short, black setae. Ocular tubercle sessile. Mandibles pale brown with apex reddish, as long as the head capsule, provided with 3 equidistant teeth with the apical tooth slightly stronger. Interdental mandibular setae: (4–7)(2–4)(2)(1). Clypeo-labrum with pointed setae. External margin of the mandible with a fringe of long setae, dorsal side of the mandible with a row of short setae along the external margin, ventral side of the mandible without setae. Labial palpus 3-articulated, with fringe of black setae underneath, few extending over labial palpus. Dorsal side of the head capsule with the clypeo-labrum dark brown, the anterior side with a pair of dark brown spots, followed by a pair of brown stripes, touching with brown markings on the lateral margins. Lateral side of the head with a small pale brown spot on the dorsal-posterior side. Ventral side of the head with a dark brown marking on the clypeo-labrum, a pair of brown spots slightly posterior to the middle.

Thorax: Pronotum with a pair of lateral brown stripes, covered with short setae. Body setae black.

Legs: Pale brown, unspotted.

Abdomen: Setae black. VIII abdominal sternite with a pair of pale brown markings, odontoid processes distinct, posterior margin with short filiform setae. IX abdominal sternite with a median row of 4 peg-like digging setae. Rastra sessile, each bearing 3 stout, peg-like digging setae equal in size, 1 seta on the external side.

Materials examined: Taiwan. Pingtung County. Baishawan, Hengchun Township / 04. II. 2020 / Y. H. Lin leg., 4 L3 laboratory reared to adult. Dawan Beach, Hengchun Township / 03. II. 2020 / Y. H. Lin leg., 2 L3 laboratory reared to adult. Fengchuisha Beach, Hengchun Township / 29. IX. 2019 / Y. J. Tsao leg., 3 L3; same locality / 03. II. 2020 / Y. H. Lin leg., 2 L3, 4 L3 laboratory reared to adult. Gangkou beach, Manzhou Township / 03. II. 2020 / Y. H. Lin leg., 3 L3, 3 L3 laboratory reared to adult. Jiupeng Desert, Manzhou Township / 04. II. 2020 / Y. H. Lin leg., 2 L3 laboratory reared to adult. Taitung County. Shuangshiyan, Lanyu Township / 14. VII. 2020 / Y. H. Lin leg., 3 L3. Yeyin Beach, Lanyu Township / 15. VII. 2020 / Y. H. Lin leg., 1 L3, 1 L3 laboratory reared to adult; same locality / 16. VII. 2020 / Y. H. Lin leg., 2 L3 laboratory reared to adult. Yeyou River mouth / 17. VII. 2020 / Y. H. Lin leg., 1 L3, 1 L3 laboratory reared to adult.

Bio-ecology: *M. taiwanensis* is a coastal species. The larvae builds pitfall in protected sites, and they are often found in wind-break forests, and also under rock overhangs of rocky shores (Fig. 1C). The larvae of *M. taiwanensis* may co-habitat with those of *M. littoralis*.

Distribution: *M. taiwanensis* is found by the coast in the southern parts of Taiwan, including the surrounding island - Lanyu. This species is also recorded in Okinawa Island, Iriomote Island, Ishigaki Island and Yonaguni Island of Japan (Sekimoto 2014, Hayashi et al. 2020).

Remarks: The larvae of this species are similar to *M. littoralis* in overall morphology and ventral head markings. The two species can be distinguished by the shape of dorsal head markings, presence of markings on the ventral side of the clypeo-labrum, and the segmentation of the labial palpus (three-segmented in *M. taiwanensis*).

Hayashi et al. (2020) also described the larvae of this species from Japan, stating that there are no clear differences between the Japanese and Taiwanese specimens.

Myrmeleon wangi Miller and Stange, 1999

(Figs. 3I, 4I, 14)

Description of 3rd instar larva: Size: Average body length 9.85 mm (7.72–12.75); head length 2.40 mm (2.11–2.59), head width 1.84 mm (1.65–2.00), mandible length 2.57 mm (2.43–2.88), ratio head width/length 0.77, ratio mandible length/head length 1.07.

General coloring: Pale brown, covered with dark brown body markings, ventrally very pale with dark brown spots.

Head: Sub-rectangular, longer than wide. Densely covered with short, black setae. Ocular tubercle sessile. Mandibles pale brown with apex reddish, dorsal side with brown markings, slightly longer than the head capsule, provided with 3 equidistant teeth with the

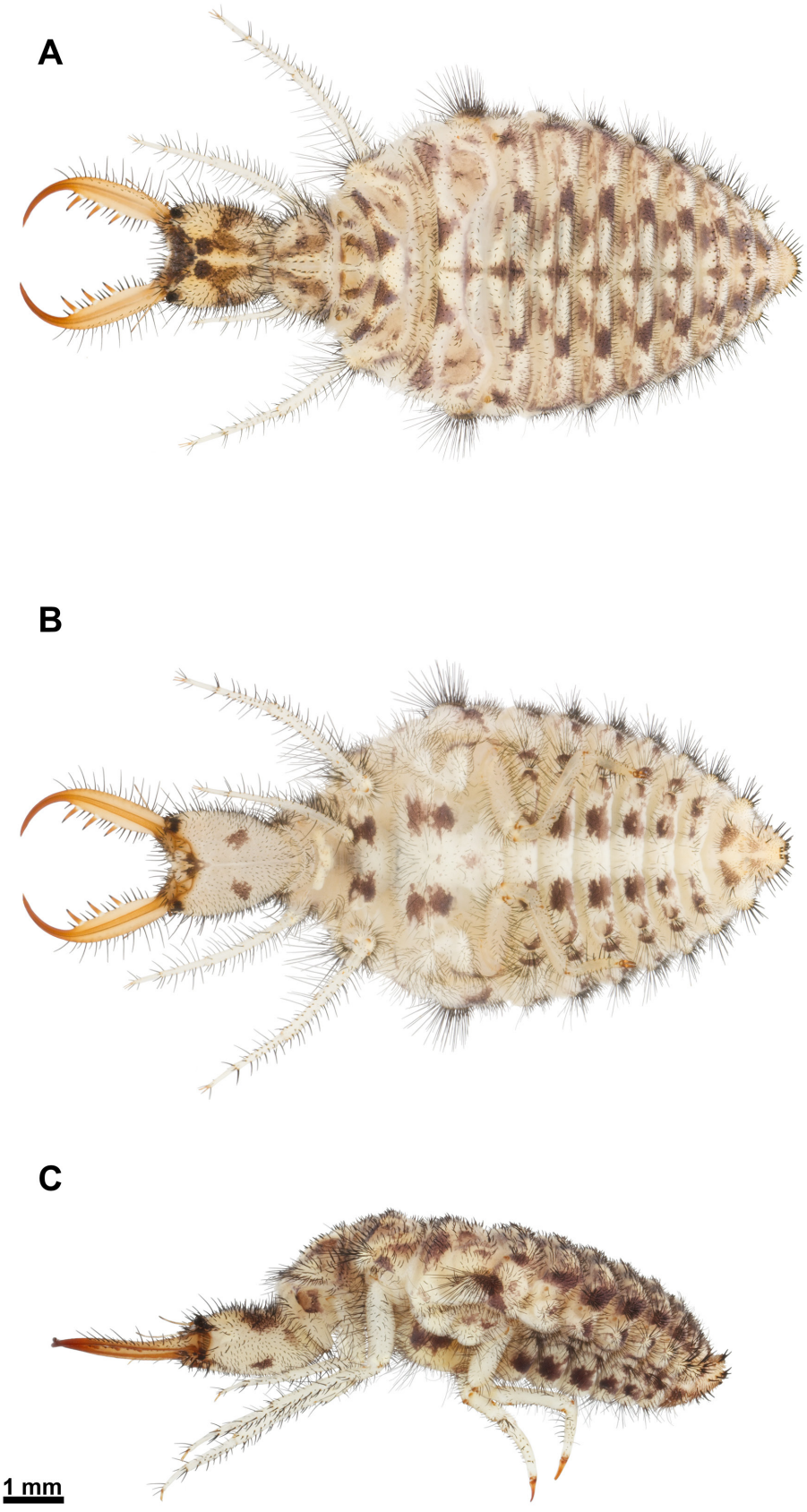

Fig. 13. *Myrmeleon taiwanensis* Miller and Stange, 1999, 3rd instar larva. A, dorsal view; B, ventral view; C, lateral view.

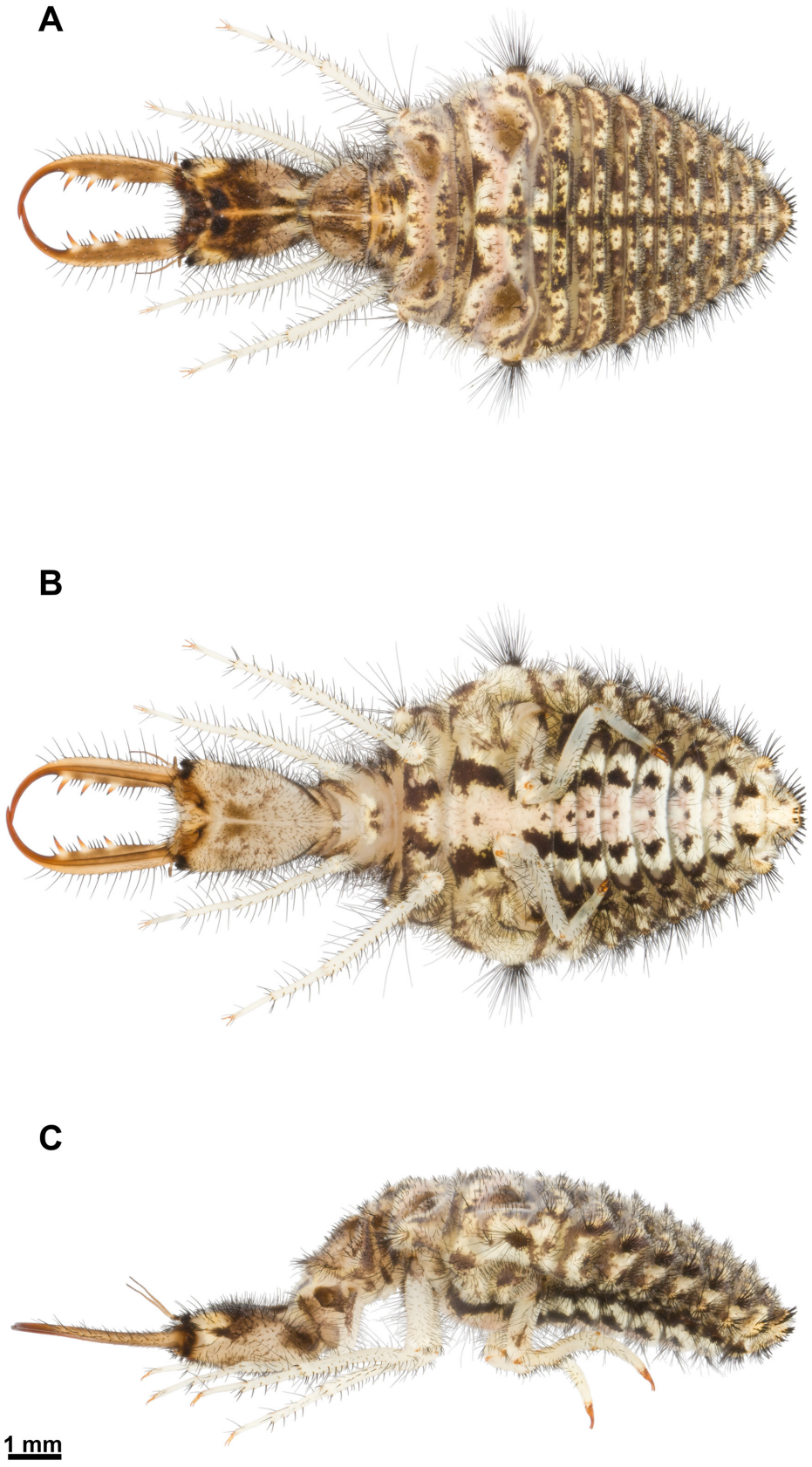

Fig. 14. *Myrmeleon wangi* Miller and Stange, 1999, 3rd instar larva. A, dorsal view; B, ventral view; C, lateral view.

apical tooth slightly stronger. Interdental mandibular setae: (7–11)(3–5)(2–4)(1–2), with setae distinctly shorter at base. Clypeo-labrum with pointed setae. External margin of the mandible with a fringe of long setae, dorsal side of the mandible with a row of short setae on the external margins and a sparse covering of short setae internally, ventral side of the mandible with a sparse covering of setae external to the maxilla, extending over the basal tooth. Labial palpus 4-articulated, with fringe of black setae underneath, none extending over labial palpus. Dorsal side of the head with the clypeo-labrum dark brown, a pair of black spots on the anterior side, followed by a pair of dark brown triangular markings extending to the posterior end, lateral margin with brown stripes extending from beside the medial dark spot and pale brown spots on the posterior side. Lateral side of the head with an anterior dark marking extending from the dorsal side and a large dark brown posterior spot. Ventral side of the head with a pair of pale brown spot in the middle, laterally mottled with small pale brown spots.

Thorax: Pronotum brown, with a pair of lateral brown stripes and a pale median ochre line in between, covered with short setae. Body setae black.

Legs: Pale brown, fore- and mid coxae with a basal brown stripe on the outer surface, hind coxae with an apical brown marking on the outer surface.

Abdomen: Setae black. VIII abdominal sternite with a pair of dark brown spots, odontoid processes distinct, posterior margin with short filiform setae. IX abdominal sternite with a pair of pale brown markings, a median row of 4 peg-like digging setae divided into 2 groups. Rastra sessile, each bearing 3 peg-like digging setae, of which the external one is the longest, 1 seta on the external side.

Materials examined: Taiwan. Chiayi County. Alishan, Alishan Township / 21. VIII. 2020 / Y. H. Lin leg., 1 L3. Hsinchu County. Lidong lodge, Jianshi Township / 19. VIII. 2020 / Y. H. Lin leg., 3 L2. Smangus, Jianshi Township / 19. VIII. 2020 / Y. H. Lin leg., 2 L2, 6 L3, 2 L3 laboratory reared to adult. Nantou County. Highland Experimental Farm N.T.U., Chunyang Farm, Renai Township / 16. V. 2020 / Y. H. Lin leg., 6 L3, 2 L3 laboratory reared to adult.

Bio-ecology: *M. wangi* is a montane species, recorded above 1,000 m. a.s.l.. The larvae of this species build pitfall in protected environment such as underneath rock overhangs or artificial buildings (Fig. 1D).

Distribution: Endemic to Taiwan.

Remarks: This is a large species among the Myrmeleontini of Taiwan. The markings on the legs are similar to the Afrotropical species *Myrmeleon quinquemaculatus* Hagen and the European species *M. formicarius* Linnaeus, *M. gerlindae* Hölzel, and *M. punicanus* Pantaleoni and Badano (Pantaleoni and Badano 2012; Badano and Pantaleoni 2014; Badano 2020).

Key to the larvae of tribe Myrmeleontini from Taiwan

1. IX abdominal sternite elongated, without or with few reduced digging setae; hind femur with a dark brown spot (Figs. 4A–B, 5B, 6B) 2
- IX abdominal sternite with at least 1 row of digging setae; hind femur without markings (Figs. 4C–I, 6B, 9B, 10B, 11B, 12B, 13B, 14B) 3
2 Clypeo-labrum with long dolichasters; rastra with 3 digging setae and 1 long setae (Figs. 3A, 4A) ..... *B. asakurae*
- Clypeo-labrum with pointed setae; rastra with 4 digging setae and 1 long setae (Figs. 3B, 4B) ..... *M. alticolus*
3 VIII abdominal sternite with stout black setae or short brown setae dispersed on the posterior margin (Fig. 4D, 4F, 4G) 4
- VIII abdominal sternite with long hairlike or spiniform setae dispersed on the posterior margin (Fig. 4C, 4E, 4H, 4I) 6
4 Ventral side of the mandibles without setae (Fig. 3D, 3F) 5
- Ventral side of the mandibles with short setae at base on the external margins (Fig. 3G) ..... *M. punctinervis*
5 Ventral side of the head with a pair of black spots on the posterior side and a pair of small black markings on the anterior side (Figs. 3D, 9B) ..... *M. heppneri*
- Ventral side of the head with only a pair of brown spots on the anterior side (Figs. 3F, 11B) ..... *M. persimilis*
6 Coxae with dark brown markings (Fig. 14B–C) ..... *M. wangi*
- Coxae without markings 7
7 Ventral side of the head with a pair of outwardly curved brown band (sometimes broken in the middle); the fringe of setae below labial palpi not reaching labial palpi (Figs. 3C, 7B) ..... *M. bimaculatus*
- Ventral side of the head with a pair of dark brown spots on the posterior side; the fringe of setae below labial palpi with a few setae extending over labial palpi (Figs. 3E, 3H, 10B, 13B) 8
8 Dorsal side of the head with a pair of brown stripes connecting with lateral markings; ventral side of the head with a dark brown marking on the clypeo-labrum; ventral side of the mandibles without setae; labial palpi 3-articulated (Figs. 3H, 13A) .... *M. taiwanensis*
- Dorsal side of the head with a pair of brown stripes not connecting with lateral markings; ventral side of the head without a markings on the clypeo-labrum; ventral side of the mandibles short setae at base; labial palpi 4-articulated (Figs. 3E, 10A) .... *M. littoralis*

DISCUSSION

Larval morphology is crucial to solve the complex systematics of Myrmeleontidae and can be used to define the tribe (Stange and Miller 1990; Stange 1994 2004; Badano and Pantaleoni 2014; Badano et al. 2017). Our result revealed that the two species—*B. asakurae* and *M. alticolus*—are unique among Taiwanese Myrmeleontini larvae due to the rather elongated head and mandibles and the absence of digging setae on the IX abdominal

sternite, these characters are also congruent with the Japanese *Baliga* species—*B. micans*, *B. ryukyuensis* Hayashi & Matsumoto, *B. kimurai* Hayashi & Matsumoto—in Hayashi et al. (2020), separating these species from other described Myrmeleontini larvae. Based on the morphological similarity between the larvae of *B. asakurae*, *M. alticolus* and the Japanese *Baliga* species, it seems likely that *M. alticolus* also belongs to *Baliga*. Both *B. asakurae* and *M. alticolus* inhabit forests at distinctly different altitudes. The larvae of these two species curl up their bodies when disturbed or dug out of their pitfall traps; this behavior is also observed in *M. bimaculatus* and is probably associated with the respective environment: pitfall traps built in gravel or soil substrates larger than sand. However, the larval morphology of most Myrmeleontini species remain largely unknown. Further confirmation of larval morphology and findings on the relationships among genera are needed.

Two coastal and sand dune-dwelling species from Taiwan, *M. persimilis* and *M. heppneri*, share some similar morphological characters, such as irregularly arranged digging setae, stout setae on VIII abdominal sternite, and the absence of setae on the ventral side of the mandibles. These characteristics are similar to those of *M. inconspicuus* Rambur, *M. mariaemathildae* Pantaleoni, Cesaroni & Nicoli Aldini, and *M. almohadarum* Badano, Acevado, Pantaleoni & Monserrat, all of which inhabit coastal sand dunes, as well as other habitats like river banks and dry riverbeds. The three European species are closely related, suggesting that these characters and the preference of open habitats are likely due to affinities. However, more studies are required to confirm the relationship between the European and the Oriental species (Pantaleoni et al. 2010; Badano and Pantaleoni 2014; Badano et al. 2016).

In our study, four species of *Myrmeleon* were found on the Kinmen Islands, a group of islands near the coastline of southeast China. Three species—*M. littoralis*, *M. persimilis*, and *M. punctinervis*—are endemic to Taiwan and have never been recorded in mainland China. Our results suggest that the species composition of Myrmeleontini in southeast China, such as species described in Yang (1999) and Wang et al. (2018), may be similar to that in Taiwan. Further expeditions and specimen collections are required to understand the biodiversity of antlions in East Asia.

CONCLUSIONS

The tribe Myrmeleontini is diverse and has a global distribution, and is characterized by larval behavior of building pitfall traps. However, knowledge of morphology and biology of many species is still insufficient. In the present study, we described the detailed morphologies of the larvae of nine species of Myrmeleontini. The morphologies of the larvae of *B. asakurae* and *M. alticolus* may indicate a unique larval morphology of the genus *Baliga*, and can also serve as a clue for solving the complex phylogeny of the tribe Mymeleontini using larval characters in future studies.

Acknowledgments: We are grateful to Davide Badano (Sapienza University of Rome, Italy) for kindly providing valuable suggestions on the larval morphology. We thank to Yuchen Zheng (China Agricultural University, China) for kindly providing photos of the paratype of *M. bimaculatus*. We thank to Yu-Jen Tsao (MOST and NTU, Taiwan), Kai-Wei Chan (NTU, Taiwan), Chien-Yu Chiang (NTU, Taiwan), Kai-Ti Lin (NTU, Taiwan), Yi Sun (NTU, Taiwan) and Mei-Ling Chan (NMNS, Taiwan) for providing valuable specimens. We thank to Wallace Academic Editing for English editing of the draft. We sincerely thank to Wen-Chi Yeh (TFRI, Taiwan), Yun-Yin Yeh (TFRI, Taiwan) for providing assistance of the photographs, and Jyh-Jong Cherng (Taipei, Taiwan) for providing information of coastal habitats. We sincerely thank Hui-Yun Tseng for providing assistance in our research. The study is supported by grants MOST 108-2621-B-002-005-MY3 from the Ministry of Science and Technology, Taiwan.

Authors' contributions: All authors drafted and revised the manuscript. YHL and JRL conceived the study, YHL carried out the field collection and taxonomic works, CCK was the head of the present research group and provided funding.

Competing interests: The authors declare that they have no conflict of interests.

Availability of data and materials: The specimens were deposited into the collections of National Taiwan University Insect Museum (NTU).

Consent for publication: Not applicable.

Ethics approval consent to participate: Not applicable.

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