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ORIGINAL ARTICLE

A spectacular new antlion species of the subfamily Dendroleontinae (Neuroptera: Myrmeleontidae) from Malaysia

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Abstract A new species of the antlion subfamily Dendroleontinae, namely *Layahima weiweii* **sp. nov.**, is described. The new species appears to be closely related to *L. wuzhishana* (Yang, 2002), which is herein re-described in detail. These two closely related species are compared based on morphological and molecular data.

Key words Neuropterida, Myrmeleontiformia, antlion, Oriental Region.

1 Introduction

The antlion genus *Layahima* Navás, 1912 belongs to the tribe Acanthoplectrini of subfamily Dendroleontinae (Machado *et al.*, 2019). The adults of *Layahima* can be characterized by the short legs, the broad and round wings with some vague markings, the wings without Banksian lines and pilula axillaris, the pair plate-form male gonocoxites 9, the arched male gonocoxites 11, the intumescent female terminalia, the short digitiform female gonocoxites 8, and the absence of female anterior gonocoxites 8 (Stange, 2004; Wan *et al.*, 2006).

Layahima is endemic to the Oriental Region and currently includes seven species: *L. contracta* (Walker, 1860) from India, *L. zonata* (Navás, 1919) from Vietnam, and five species from China: *L. chiangi* Banks, 1941, *L. elegans* (Banks, 1937), *L. valida* (Yang, 1997), *L. wuzhishana* (Yang, 2002) and *L. yangi* Wan & Wang, 2006 (Stange, 2004; Wan *et al.*, 2006; Wang *et al.*, 2018; Ábrahám & Giacomino, 2020).

It is worth noting that *L. wuzhishana* is a distinctive species of *Layahima*. The species has a pair of tufts consisted of long black setae on anterolateral mesonotum, the tibia spurs longer than the length of tarsomere 5, and the female gonapophyses 8 sclerotized. These unique characters indicate that the relationship between *L. wuzhishana* and the other *Layahima* species requires further investigation.

In the present paper, we describe a new species: *Layahima weiweii* **sp. nov.**, closely related to *L. wuzhishana*. The finding of this new species could provide further understanding of the interspecific relationships within *Layahima*.

2 Materials and methods

Genitalia were prepared by clearing the apex of the abdomen with 15% KOH in 135℃ for seven minutes. After rinsing the KOH with distilled water, the apex of the abdomen was transferred to glycerin for further examination. Habitus photos were taken by using Nikon® D850 digital camera with AF-S Micro Nikkor 105 mm 1/2.8G ED lens. Head and thorax were photographed by Nikon® D850 digital camera with Laowa® 25mm F/2.8 2.5–5.0X Ultra Macro lens.

The classification system of Myrmeleontidae follows Machado *et al.* (2019). Terminology of wing venation mainly

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follows Breitkreutz *et al.* (2017), while that of wing fields follows Machado & Oswald (2020). Terminology of genitalia mainly follows Aspöck & Aspöck (2008) and Badano *et al.* (2017).

A total of four specimens of three species (*L. valida* (Yang, 1997), *L. weiweii* **sp. nov.** and *L. wuzhishana*) were sampled for the sequencing of partial mitochondrial (mt) genomes (except control region, 14,908 bp). The genomic DNA was extracted from the mesothoracic muscle of adults or larvae by using TIANamp Micro DNA Kit (TIANGEN®, Beijing, China). For sequencing of the mitogenomes, we constructed a 350 bp paired-end sequencing library for each specimen and used Illumina NovaSeq platform to obtain 4 Gb of sequence data. Raw reads were trimmed of adapters using BWA (Burrows-Wheeler Aligner) software (Li & Durbin, 2010). All specimens we sequenced were assembled mapping to the mitogenome as the reference sequence using Geneious Prime 2020 (Kearse *et al.*, 2012), with the parameters set as follows: 95% minimum overlap identity, 4 maximum ambiguity, and a minimum overlap of 25 bp. Each mitochondrial contig was inputted into MITOS web service (Bernt *et al.*, 2013) for initial annotation. The resultant gene boundaries were checked by alignment with homologous genes of the published mitogenomes (GenBank accession number: KY364372).

The mitogenomes herein sequenced are deposited in GenBank, with accession numbers as follows: *Bullanga florida* (Navas, 1913) (voucher number: BFFJ1, GenBank number: MW737610); *Distoleon nigricans* (Okamoto, 1910) (voucher number: DHAH1, GenBank number: MW737614); *Layahima valida* (Yang, 1997) (voucher number: LVGX1 and LVGZ1, GenBank number: MW853769 and MW863311); *L. weiweii* **sp. nov.** (voucher number: LWBO, GenBank number: MW853768); *L. wuzhishana* (Yang, 2002) (voucher number: LWHN1 and LWVC, GenBank number: MW853766 and MW853767) (Table 1). Phylogenies were inferred using Bayesian inference (BI) and Maximum-likelihood (ML) methods. The BI analysis was conducted using MrBayes 3.2.6 (Ronquist *et al.*, 2012) via the CIPRES web portal (http://www.phylo.org). The BI analysis in MrBayes contained four simultaneous Markov chain Monte Carlo (MCMC) runs of 10 million generations, and tree samples were output every 1000 generations with a burn-in of 25%. The ML analysis was performed in IQ-Tree web server (http://iqtree.cibiv.univie.ac.at/) with 1000 bootstrap. Trees were visualized and edited with FigTree v1.4.4 (Rambaut, 2019). Genetic distances of the COI fragments were calculated using MEGA 6.0 (Tamura *et al.*, 2013) with the Kimura 2 Parameter (K2P) model (Kimura, 1980).

All specimens herein examined are deposited in the Entomological Museum, China Agricultural University (CAU), Beijing, China.

Table 1. Collection information of sequenced antlion species in present study.

Name	Locality	Date	Collector	GenBank number
Distoleon nigricans	China: Anhui, Lu'an, Jinzhai County, Mazongling tree farm (650 m)	22.VIII.2018	Yuchen Zheng	MW737614
Bullanga florida	Fujian, Quanzhou, Dehua County, Shuikou Town, Mt. Shiniushan, Shuntian Load	18.IV.2020	Yuchen Zheng	MW737610
Layahima valida	China: Guangxi, Nanning, Wuming District, Mt. Damingshan, Neichao (200 m)	18–21.V.2020	Yan Lai	MW853769
Layahima valida	China: Guizhou, Qiannan, Libo County, Maolan National Reserve, Banzhai Village	25.V.2010	Yan Li & Dan Zhou	MW863311
L. weiweii **sp. nov.**	Malaysia: Sabah, Mt. Trusmadi, Borneo Jungle Girl Camp (1200 m)	27.IV.2016	Hu Li	MW853768
L. wuzhishana	China: Hainan, Ledong, Jianfengling, Mingfenggu (950 m)	24–27.V.2020	Chao Wu	MW853766
L. wuzhishana	Vietnam: Cao Bang, Hoa An District, Deo Gao Lae (330 m)	22.V.2012	Xingyue Liu	MW853767

3 Taxonomy

Myrmeleontidae
Dendroleontinae
Acanthoplectrini

Layahima Navás, 1912

Layahima Navás, 1912: 36; Banks, 1941: 3; Stange, 1976: 309; Stange, 2004: 92; Wan *et al.*, 2006: 35; Wang *et al.*, 2018: 61; Ábrahám & Giacomino, 2020: 38. Type species: *Layahima nebulosa* Navás, 1912, by original designation.

Noues Navás, 1919: 13; Stange, 1976: 309 (as synonym). Type species: *Noues zonatus* Navás, 1919, by original designation.
Asialeon Yang, 1997: 614; Stange, 2004: 76; Wan *et al*., 2006: 35 (as synonym). Type species: *Asialeon validus* Yang, 1997, by original designation.

Diagnosis. Frons wider than compound eye; vertex raised. Pronotum as long as wide. Legs short; tibial spurs slightly curved, shorter than tarsomere 5. Wings distally rounded. Forewing mediocubital area with some indistinct brown markings; RP origin basal to MP fork. Banksian lines absent. Male pilula axillaris absent. Male gonocoxites 9 present as a pair of broad plates, with apex strongly sclerotized and scaly; gonocoxites 11 widely arched. Female anterior gonocoxites 8 absent; posterior gonocoxites 8 thumb-shaped, depressed laterally; gonapophyses 8 absent; digging setae on gonocoxites 9 blunt.

Distribution. China, India, Malaysia, Vietnam.

The *Layahima wuzhishana* group

Included species. *Layahima weiweii* **sp. nov.**, *Layahima wuzhishana* (Yang, 2002).

Diagnosis. Width of frons equal to diameter of compound eye. Pronotum as long as wide; mesonotum covered with an anterolateral pair of tufts of long black setae; mesonotum medially immaculate. Tibial spurs barely curved, longer than tarsomere 5 length. Forewing subcostal area with a series of discontinuous dark brown markings and dots; mediocubital area with some indistinct brown markings; rhegma present as two indistinct brown markings; base of cubital area with a brown spot. Hindwing generally transparent. Banksian lines absent. Male pilula axillaris absent. Male gonocoxites 9 present as a pair of elongate plates posteriorly, apex strongly sclerotized and scaly; sagittal gonocoxites 11 narrow, median part prominent. Female anterior gonocoxites 8 absent; posterior gonocoxites 8 thumb-shaped, depressed laterally; gonapophyses 8 sclerotized; digging setae on gonocoxites 9 blunt.

Distribution. China, Malaysia, Vietnam.

Remarks. This species-group is here proposed by some unique characters in *Layahima*, *i.e.*, width of frons equal to diameter of compound eye, the mesonotum with an anterolateral pair of tufts consisted of long black setae, tibial spurs longer than the length of tarsomere 5 and barely curved, and the sclerotized female gonapophyses 8. In the other species of *Layahima*, the frons is wider than the diameter of compound eye; the mesonotal tufts of long setae are absent; the tibial spurs are shorter than the length of tarsomere 5 and curved; and the female gonapophyses 8 are not sclerotized.

***Layahima weiweii* sp. nov.** (Figs 1, 2A, 3A–B, 4A, C, E, G, I, K)

Diagnosis. Body largely yellow. Antennae nearly four times as long as pronotum; vertex with a black transverse band anteriorly, and with a pair of dark brown spots and indistinct transverse dark brown lines medially; frons with a nearly rhombic black marking. Pronotum with some indistinct brown markings; anterolateral mesonotum with a pair of tufts consisted of long black setae, and with a pair of long triangular dark brown stripes laterally. Tibial spurs long, barely curved. Abdominal terga 3–8 yellow alternating with dark brown. Male sternum 9 pentagonal; median part of gonocoxites 11 prominent in ventral view, protruding backward in lateral view.

Description. Size. Head width 2.47–2.64 mm, forewing length 22.20–23.86 mm, hind wing length 22.12–23.93 mm.

Head. Vertex raised, covered with some short setae, a black transverse band present anteriorly, a pair of dark brown spots and indistinct transverse dark brown lines present medially, and a pair of dark brown markings present posterolaterally (Fig. 3A). Antennae nearly four times as long as pronotum; scape and pedicel generally yellow, covered with some short setae; flagellomeres generally yellow, each segment with a circular brown marking. Frons with a nearly rhombic black marking (Fig. 3B). Clypeus yellow with a few setae. Labrum brown. Maxillary palpus generally pale yellow, but brown distally. Labial palpus pale brown, apical segment fusiform, with a brown marking. Mandibles yellowish brown with distal half dark brown.

Thorax (Fig. 3A). Yellow, with dark markings. Pronotum longer than wide, covered with some long black setae; three indistinct brown markings present anteriorly, a pair of longitudinal black stripes present laterally, and an indistinct brown marking present medially. Mesonotum covered with a pair of tufts consisted of long black setae anterolaterally; anterior part generally dark brown, laterally with a pair of long triangular dark brown stripes and a pair of small spots; mesoscutellum with a pair of black marking posteriorly. Metanotum generally dark brown. Pleurae with three black stripes.

Legs. Short, pale yellow, with dark markings. All femora covered with many short black setae; all tibiae covered with some long black setae; tibial spurs brown, elongate and barely curved; tarsomeres 1–4 generally brown; tarsomeres 5 brown, with distal half dark brown, and with a few short tapered setae ventrally. Foreleg: Coxa brown, with a dark brown spot; femur generally yellow, dark brown dorsally; tibia generally pale yellow, an irregular brown marking present basally, distal

part dark brown; tibial spurs reaching base of tarsomere 5. Midleg: Coxa with basal half black and distal half yellow; femur generally yellow, dark brown distally; tibia generally pale yellow, with some brown dots, basal 1/3 with a dark brown spot, distal part dark brown; tibial spurs reaching base of tarsomere 5. Hind leg: Coxa with basal half black and distal half yellow; femur generally yellow, dark brown distally; tibia generally pale yellow, basal 1/3 with a dark brown spot, distal part dark brown; tibial spurs reaching tip of tarsomere 4; tarsomere 1 longer than that of fore- and midleg.

Wings (Fig. 2A). Long, distally rounded. Banksian lines absent. Male pilula axillaris absent. Pterostigma pale. Forewing slightly longer than hindwing. Veins dark brown alternating with pale stripes. Forewing subcostal area with a series of discontinuous dark brown markings and dots; mediocubital area with some indistinct brown marking; rhegma present as two indistinct brown markings; base of cubital area with a brown spot; crossvein on posterior costal space mostly branched; RP origin with CuA fork alignment; presectoral area with five crossveins; RP with eight branches. Hindwing generally transparent; subcostal area with some brown dots; presectoral area with one crossvein; RP origin basal to MP fork.

Abdomen. Tergum 1 generally pale yellow, dark brown basally; tergum 2 generally dark brown; Yellow alternating with dark brown on terga 3–8. Male genitalia: Tergum 8 subrectanglar in lateral view. Sternum 9 covered with some long setae, pentagonal (Fig. 4A). Gonocoxites 9 medially curved internally; posterior part present as a pair of elongate plates, apex strongly sclerotized and scaly (Fig. 4E). Gonocoxites 11 arrow-shaped, median part prominent in ventral view; protruding backward in lateral view (Fig. 4E, G). Gonapophyses 11 weakly developed. Ectoproct covered with long setae (Fig. 4C). Female genitalia unknown.

Type material. Holotype. ♂, Malaysia: Sabah, Mt. Trusmadi, Borneo Jungle Girl Camp (1200 m), 30 April 2018, Zhuo Chen leg. (CAU). Paratypes. 1♂, same locality as holotype, 27 September 2015, Chao Wu leg. (CAU); 1♂, same locality as holotype, 1–7 May 2017, Chao Wu leg. (CAU); 3♂, same locality as holotype, 27 April 2016, Hu Li leg. (CAU); 2♂, same locality as holotype, 29 April 2016, Xiumei Lu leg. (CAU); 1♂, same locality as holotype, 5 May 2019, Guanyuan Cao leg. (CAU).

Distribution. Malaysia (Sabah).

Etymology. The new species is dedicated to the entomologist, science writer and amber collector Weiwei Zhang (Chongqing), who kindly helped us to obtain these important specimens.

Remarks. This species is very similar to *L. wuzhishana*, but can be distinguished from the latter by its yellow body, the vertex with a pair of dark brown spots and indistinct transverse dark brown lines, the pronotum with indistinct brown markings anteriorly and medially, the mesonotum with a pair of long triangular dark brown stripes laterally, the median part of male gonocoxites 11 narrower in ventral view, and the anterior gonocoxites 11 protruding backward in lateral view. *L. wuzhishana* can be distinguished from *L. weiweii* **sp. nov.** by the following characters: the body pale yellow, the vertex with a pair of large dark brown markings medially and then extending to lateral part, the pronotum with a pair of curved dark brown stripes medially, the mesonotum with a pair of long trapezoid dark brown stripes laterally, the abdominal terga 3–8 each with an arrow-shaped pale yellowish marking, the median part of male gonocoxites 11 prominent and wide in ventral

Figure 1. *Layahima weiweii* **sp. nov.**, male holotype, habitus. Scale bar = 10.0 mm.

view, and the anterior gonocoxites 11 not protruding in lateral view.

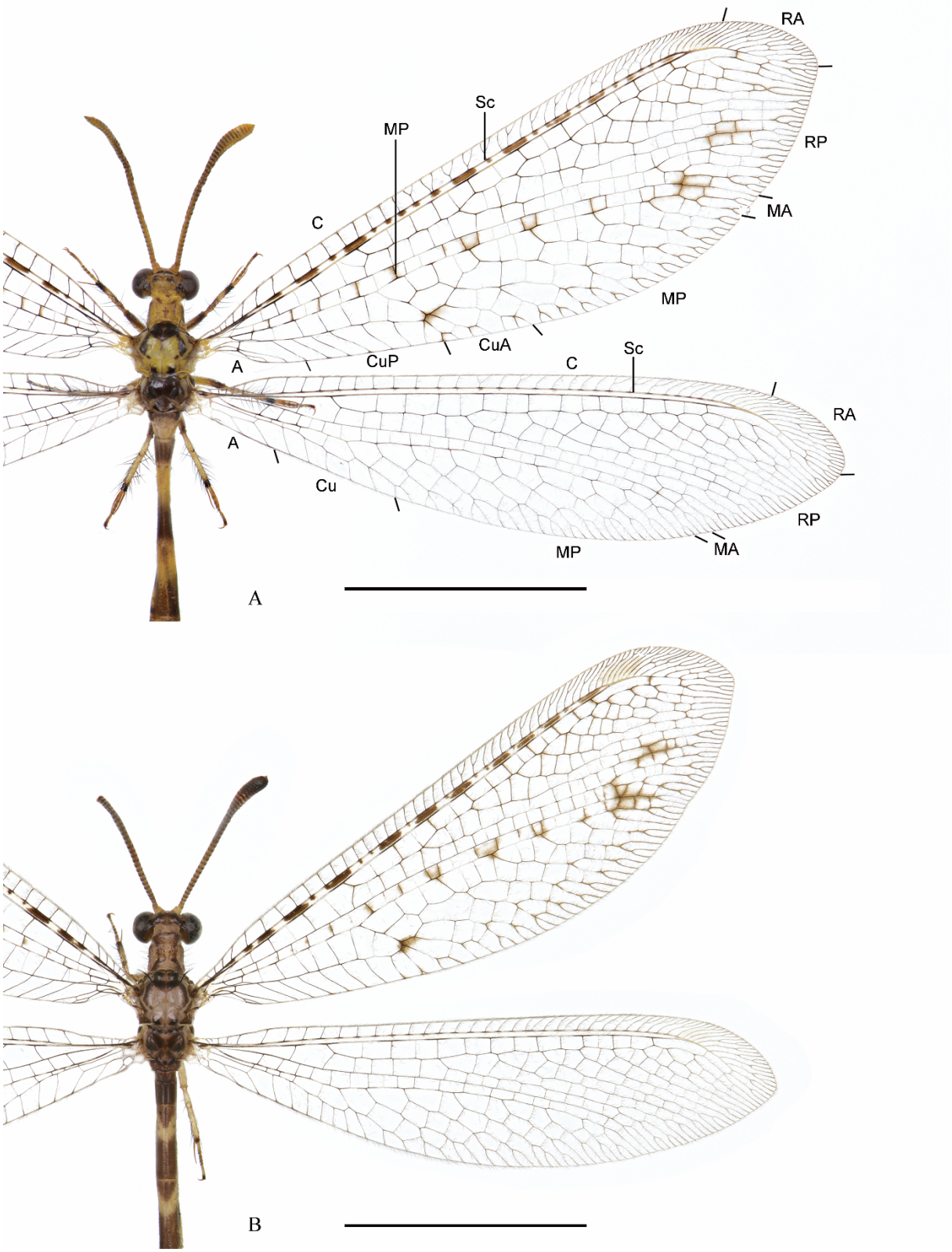

Figure 2. The *Layahima wuzhishana* species group, wings. A. *L. weiweii* **sp. nov.**, male holotype. B. *L. wuzhishana* (Yang, 2002), male. Abbreviations: C—costa; Sc—subcosta; RA—radius anterior; RP—radius posterior; MA—media anterior; MP—media posterior; CuA—cubitus anterior; CuP—cubitus posterior; A—anal veins. Scale bars = 10.0 mm.

***Layahima wuzhishana* (Yang, 2002)** (Figs 2B, 3C–D, 4B, D, F, H, J, L, 5A–C)

Dendroleon wuzhishanus Yang, *In* Yang & Wang, 2002: 297. Type locality: China, Hainan, Mt. Wuzhishan.

Layahima wuzhishanus: Wang *et al.*, 2018: 65.

Diagnosis. Body overall pale yellow. Antennae nearly four times as long as pronotum; vertex with a black transverse band anteriorly, a pair of large dark brown markings present medially and extending to lateral part, a pair of dark brown spots present medially; frons with a nearly pentagonal dark brown marking. Pronotum with a pair of curved dark brown stripes and some dark brown dots medially; mesonotum with a pair of tufts consisted of long black setae, and with a pair of long trapezoid dark brown stripes laterally. Tibial spurs long, barely curved. Abdominal terga 3–8 each with an arrow-shaped pale yellowish marking. Male sternum 9 pentagonal, basally narrow; median part of gonocoxites 11 prominent and wide in ventral view. Female anterior gonocoxites 8 absent; gonapophyses 8 sclerotized; digging setae on gonocoxites 9 blunt.

Redescription. Size. Head width 2.54–2.75 mm, forewing length 23.69–28.23 mm, hind wing length 20.36–26.42 mm.

Head. Vertex raised, covered with some short setae, a black transverse band present anteriorly, a transverse dark brown lines present medially, a pair of large dark brown markings present medially and extending to lateral part, and a pair of dark brown spots present posteromedially (Fig. 3C). Antennae nearly four times as long as pronotum; scape and pedicel generally pale yellow, covered with some short setae; non-intumescent part of flagellum generally pale yellow, each segment with a brown marking; intumescent part of flagellum generally black dorsally and pink ventrally. Frons with a nearly pentagonal dark brown marking (Fig. 3D). Clypeus pale yellow with a few setae. Labrum pale brown. Maxillary palpus generally pale yellow. Labial palpus pale brown, apical segment fusiform, with a brown marking. Mandibles pale yellowish brown with distal half dark brown.

Thorax (Fig. 3C). Pale yellow, with dark markings. Pronotum longer than wide, covered with some long black setae; a pair of curved dark brown stripes and some dark brown dots present medially, and a pair of longitudinal black stripe present laterally. Mesonotum covered with a pair of tufts consisted of long black setae anterolaterally; anterior part generally dark brown, laterally with a pair of long trapezoid dark brown stripes; mesoscutellum with a pair of black markings posteriorly. Metanotum generally dark brown. Pleurae with three black stripes.

Legs. Short, pale yellow, with dark markings. All femora covered with many short black setae; all tibiae covered with

Figure 3. The *Layahima wuzhishana* species group. A. *L. weiweii* **sp. nov.**, male holotype, head and thorax, dorsal view. B. *L. weiweii* **sp. nov.**, male holotype, frons. C. *L. wuzhishana* (Yang, 2002), male, head and thorax, dorsal view. D. *L. wuzhishana*, male, frons. Red arrow indicates the tuft of long black setae on mesonotum. Scale bars = 1.0 mm.

some long black setae; tibial spurs brown, elongate and barely curved; tarsomeres 1–4 generally brown; tarsomere 5 brown with distal half dark brown, and with a few short tapered setae ventrally. Foreleg: Coxa pale yellow, with a brown marking; femur generally pale yellow, dark brown dorsally; tibia generally pale yellow, an irregular brown marking present basally, distal part dark brown; tibial spurs reaching base of tarsomere 5. Midleg: Coxa generally pale yellow, brown basally; femur generally pale yellow, pale brown distally; tibia generally pale yellow, with some brown dots, distal part dark brown; tibial spurs reaching base of tarsomere 5. Hind leg: Coxa generally pale yellow, brown basally; femur generally yellow, pale brown distally; tibia generally pale yellow, basal 1/3 with a short transverse dark brown line, distal part dark brown; tibial spurs reaching tip of tarsomere 4; tarsomere 1 longer than that of fore- and midleg.

Wings (Fig. 2B). Long, distally rounded. Banksian lines absent. Male pilula axillaris absent. Pterostigma pale. Forewing slightly longer than hindwing. Veins dark brown alternating with pale. Forewing subcostal area with a series of discontinuous dark brown markings and dots; mediocubital area with some indistinct brown markings; rhegma present as two indistinct brown markings; base of cubital area with a brown spot; crossvein on posterior costal space mostly branched; RP origin align with CuA fork; presectoral area with four to five crossveins; RP with eight to nine branches. Hindwing generally transparent; subcostal area with a few indistinct brownish dots; presectoral area with one crossvein; RP origin basal to MP fork.

Abdomen. Terga 1–2 generally dark brown; terga 3–8 each with an arrow-shaped pale yellowish marking. Male genitalia: Tergum 8 subrectanglar in lateral view. Sternum 9 covered with some long setae, pentagonal, basally narrow (Fig. 4B). Gonocoxites 9 medially curved internally; posterior part present as a pair of elongate plates, apex strongly sclerotized and scaly (Fig. 4F). Gonocoxites 11 arrow-shaped, median part prominent and wide in ventral view (Fig. 4F). Gonapophyses 11 weakly developed. Ectoproct covered with some long setae, rounded in lateral view (Fig. 4D). Female genitalia: Sternum 7 covered with many long setae. Pregenital plate sclerotized and rounded, external part with a tiny triangular prominent (Fig. 5B). Anterior gonocoxites 8 absent; posterior gonocoxites 8 covered with many soft setae, thumb-shaped, depressed laterally (Fig. 5B–C). Gonapophyses 8 sclerotized, anterior part wider than posterior part (Fig. 5B). Gonocoxites 9 oval, covered with

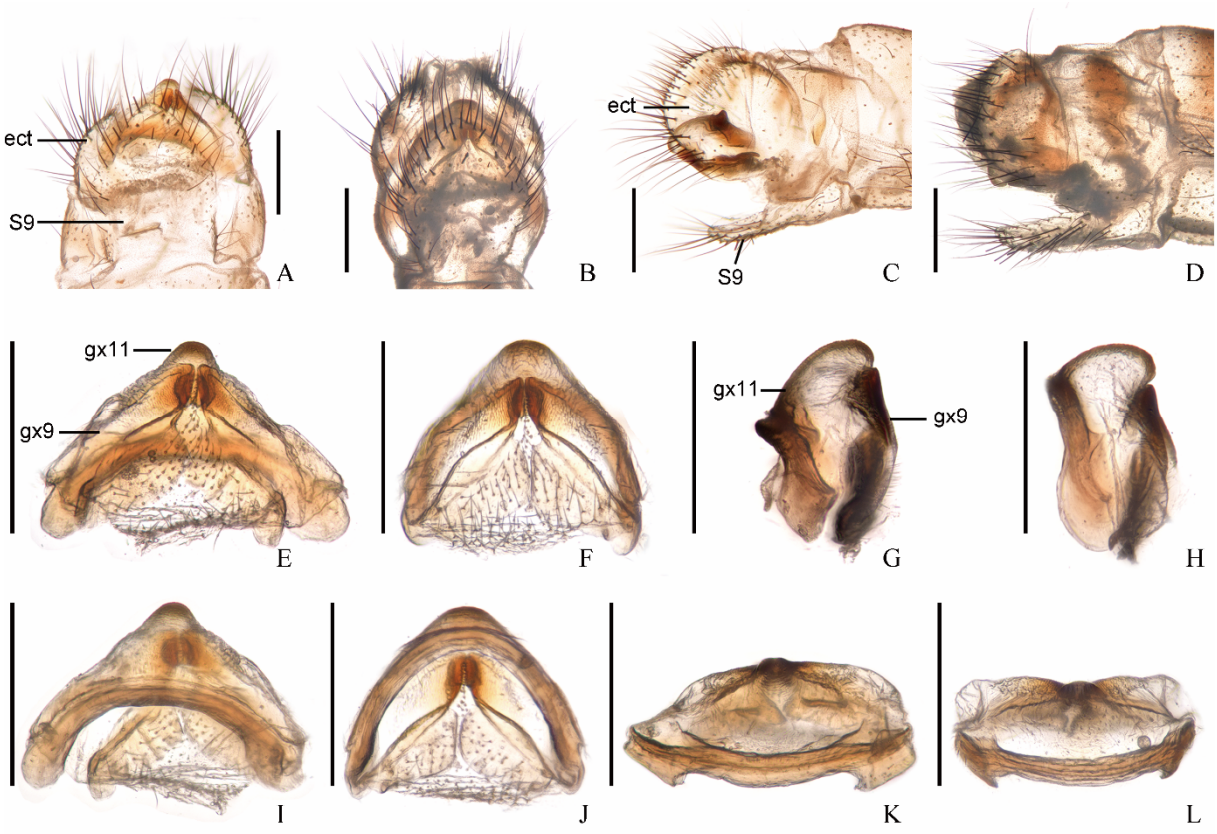

Figure 4. The *Layahima wuzhishana* species group, male terminalia and genitalia. A, C, E, G, I, K. *L. weiweii* **sp. nov.** B, D, F, H, J, L. *L. wuzhishana* (Yang, 2002). A–B. Terminalia, ventral view. C–D. Terminalia, lateral view. E–F. Genitalia, ventral view. G–H. Genitalia, lateral view. I–J. Dorsal view. K–L. Genitalia, caudal view. Abbreviations: ect—ectoproct; gx—gonocoxites; gp—gonapophyses; S9—sternum 9. Scale bars = 1.0 mm.

many blunt digging setae (Fig. 5B). Ectoproct covered with some long setae (Fig. 5C).

Material examined. Holotype. ♀, China: Hainan, Mt. Wuzhishan, Wuzhishan International Resort (800 m), 1 June 1997, Chikun Yang & Jiafang Cheng leg. (CAU). Additional material. 1♂, China: Hainan, Ledong County, Jianfengling, Mingfenggu (950 m), 24–27 May 2020, Chao Wu leg. (CAU); 1♂, China: Yunnan, Hekou County, Nanxi Town (132 m), 21 May 2009, Hu Li leg. (CAU); 1♂, Vietnam: Cao Bang, Hoa An District, Deo Gao Lae (330 m), 22 May 2012, Xingyue Liu leg. (CAU).

Distribution. China (Hainan, Yunnan); Vietnam (Cao Bang).

Remarks. It is worth noting that the female gonapophyses 8 of *L. wuzhishana* are sclerotized. However, in other members of *Layahima* with female records, the female gonapophyses 8 are absent. This unique female genital character of *L. wuzhishana* indicates that the interspecific phylogeny of *Layahima* requires further study. Unfortunately, the female of *L. weiweii* **sp. nov.** is unknown.

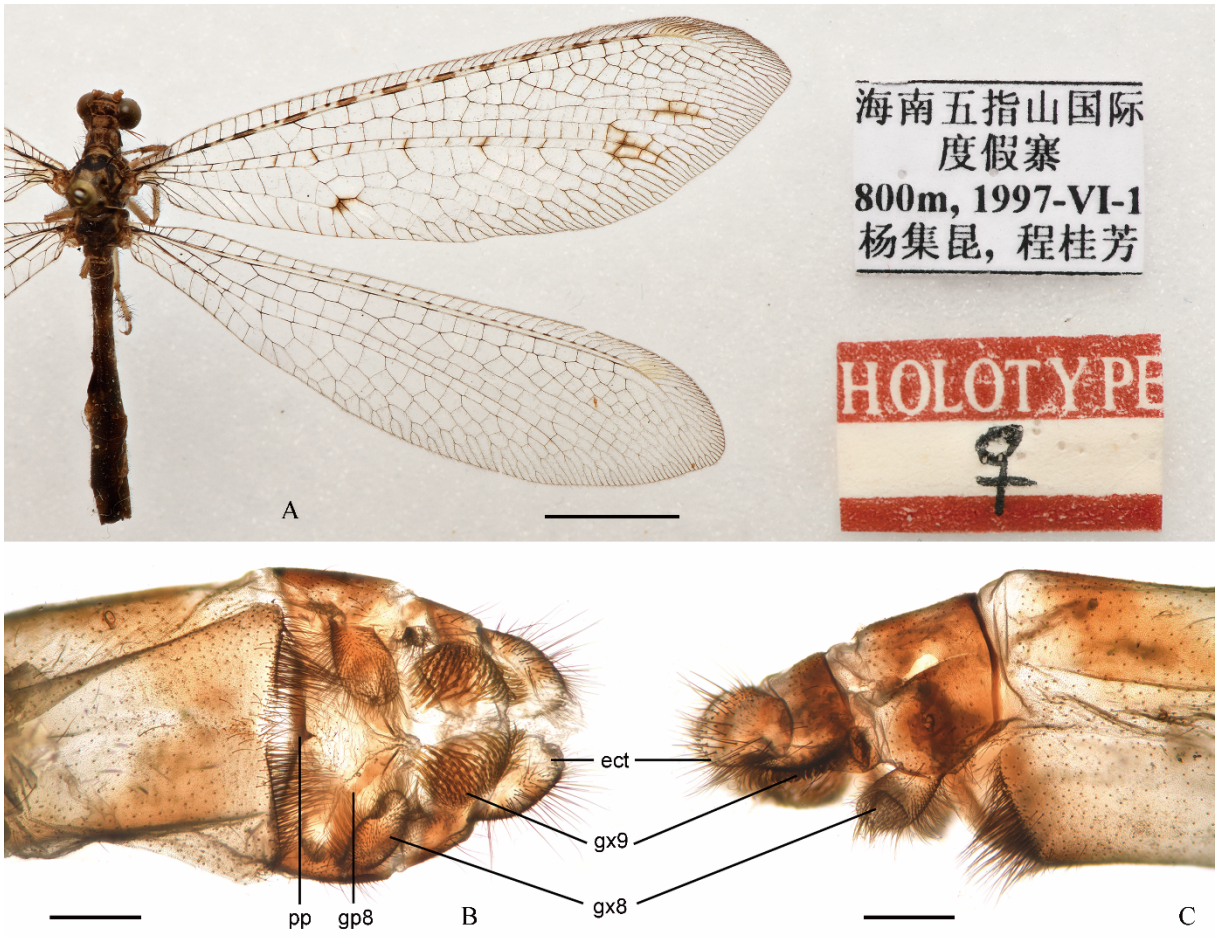

Figure 5. *Layahima wuzhishana* (Yang, 2002), female holotype. A. Habitus, type label and collecting label. B. Female holotype, genitalia, ventral view. C. Female holotype, genitalia, ventral view. Abbreviations: ect—ectoproct; gx—gonocoxites; gp—gonapophyses; pp—pregenital plate; S—sternum. Scale bars: A = 5.0 mm; B–C = 1.0 mm.

4 Molecular identification

The COI interspecific genetic divergence among the five species of Myrmeleontidae ranged from 0.119–0.209 (Table 2). The genetic divergence between *L. weiweii* **sp. nov.** and *L. wuzhishana* ranged from 0.119–0.121, while the intraspecific genetic divergence within *L. wuzhishana* was 0.011 and the intraspecific genetic divergence within *L. valida* was 0.002. The genetic divergence between *L. weiweii* **sp. nov.** and *L. valida* ranged from 0.180–0.182. The genetic divergence between *L. wuzhishana* and *L. valida* ranged from 0.159–0.165. The topologies of the BI and ML trees are identical and received high

nodal supports (Fig. 6).

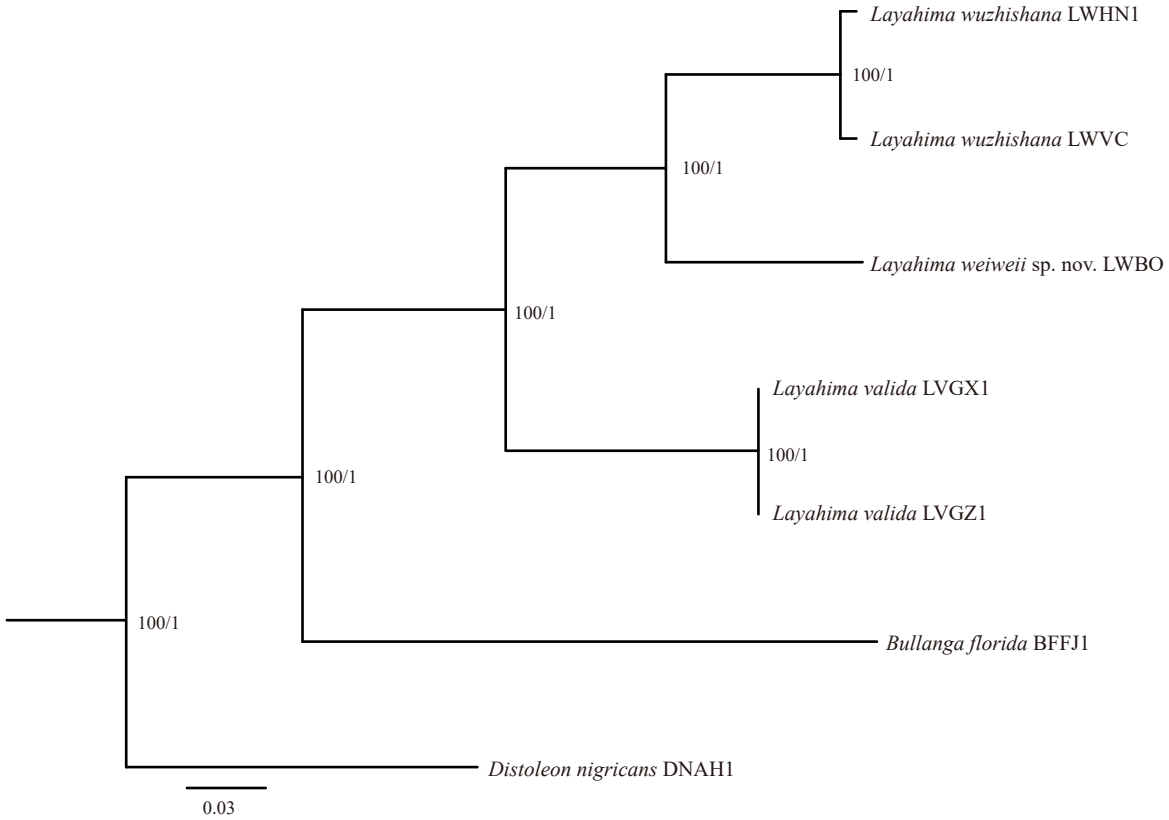

Figure 6. Phylogenetic relationships among selected species of Myrmeleontidae based on mitochondrial genomic data. Tree topologies are identical among the Maximum likelihood and Bayesian inference. Nodal supports include the posterior probabilities of Bayesian inference/bootstrap values of Maximum likelihood analysis.

Table 2. Genetic divergence among seven antlion species based on COI sequence data.

	Distoleon nigricans MW737614	*Bullanga florida* MW737610	*Layahima valida* MW853769	*Layahima valida* MW863311	*L. weiweii* MW853768	*L. wuzhishana* MW853766
Distoleon nigricans MW737614						
Bullanga florida MW737610	0.179					
Layahima valida MW853769	0.200	0.207				
Layahima valida MW863311	0.199	0.206	0.002			
L. weiweii **sp. nov.** MW853768	0.199	0.209	0.182	0.180		
L. wuzhishana MW853766	0.177	0.189	0.162	0.159	0.121	
L. wuzhishana MW853767	0.180	0.190	0.165	0.162	0.119	0.011

5 Discussion

Machado *et al.* (2019) established a new classification of Myrmeleontidae, in which Dendroleontini under the

traditional classification of Stange (2004) was raised to be a subfamily, *i.e.*, Dendroleontinae. Actually, the same subfamilial status of Dendroleontinae have been adopted in Banks (1911), Stange (1961), Hölzel (1974), Krivokhatsky (2011), *etc*. This subfamily is now divided into two tribes, *i.e.*, Acanthoplectrini and Dendroleontini. *Layahima* is the only representative genus of Acanthoplectrini from the Oriental Region, and it is the sister group of the remaining members of this tribe (all endemic to the Australian Region). Machado *et al.* (2019) also speculated that Acanthoplectrini might have originated from Asia and subsequently dispersed to Australia.

Layahima was previously recorded from southern China and Indochina Peninsula, but not known in the Malay Archipelago until the present report. Concerning distribution, the discovery of *L. weiweii* **sp. nov.** from Borneo represents the hitherto southernmost record of *Layahima*. Borneo is located near the west of the Wallace's line. By far, no species of *Layahima* has been found from any island east to the Wallace's line. It is interesting and important to investigate whether there is any species of *Layahima* or close relative of this genus from these islands, because it may verify the hypothesis of the Asian origin of Acanthoplectrini proposed by Machado *et al.* (2019), or alternatively recover the Oceanian origin of this tribe. The exploration of the species diversity of *Layahima* in the Oriental Region is also helpful for understanding of the biogeography of Acanthoplectrini.

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