



## Description of *Luciola aquatilis* sp. nov., a new aquatic firefly (Coleoptera: Lampyridae: Luciolinae) from Thailand

ANCHANA THANCHAROEN<sup>1</sup>, LESLEY A. BALLANTYNE<sup>2</sup>, MARC A. BRANHAM<sup>3</sup> &  
MING-LUEN JENG<sup>4</sup>

<sup>1</sup>Department of Biology, Faculty of Science, Mahidol University, 10400, Thailand. E-mail: koybio@yahoo.com

<sup>2</sup>School of Agricultural and Veterinary Sciences, Charles Sturt University, PO Box 588, Wagga Wagga, NSW 2678, Australia

<sup>3</sup>Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611–0620, USA

<sup>4</sup>Division of Entomology, Natural History Museum and Biodiversity Research Center, University of Kansas, 1501 Crestline Drive, Suite 140., Lawrence, KS 66049–2811, USA

### Abstract

A new species of aquatic firefly belonging to *Luciola* Laporte is described and illustrated based on external morphology of both males and females, and the genitalia of males. *Luciola aquatilis* sp. nov., a common firefly in Thailand was formerly commonly misidentified as *Luciola brahmia* Bourgeois. Other *Luciola* species that resemble *L. aquatilis* are discussed, as well as past confusion concerning their taxonomic affinities.

**Key words:** Coleoptera, Lampyridae, *Luciola aquatilis*, firefly, new species, Thailand

### Introduction

Thailand is recognized as a biodiversity hotspot (Brooks et al. 2002). Only 14 described firefly species representing six genera (*Diaphanes* (1 sp.), *Lamprigera* (1 sp.; *Lamprophorus* is a junior synonym), *Luciola* (4 spp.), *Pteroptyx* (2 spp.), *Pyrocoelia* (5 spp.) and *Pyrophanes* (1 sp.)) are recorded from Thailand (Hutacharn et al. 2007). Estimates of actual species numbers (Dr. Angoon Lewvanich, Firefly Project under HM Queen Sirikit's Initiative, Botanical Garden Organization, Ministry of Natural Resource and Environment, Thailand, personal communication) are thought to be more than twice this figure. Difficulties in accessing type specimens as well as the large diversity of some genera and the taxonomic uncertainty of many species have made identification to the species level quite difficult.

The new species described in this work is familiar to researchers in Thailand, though for many years it was incorrectly identified as *Luciola brahmia* Bourgeois. Not only was this species not described, but it is morphologically very similar to several other described *Luciola* species, hence the confusion. There is a possibility that this undescribed species was recorded by Olivier (1885) from Java as *Luciola japonica* Thunberg which has “grayish brown elytra with dark vague basal marking and black apical marking on elytra” (Kawashima et al. 2003). This similarity to other described *Luciola* species complicated efforts to diagnose the true status of this species. The situation was resolved by a group effort made by the authors of this manuscript.

While working on a larval description co-authors Branham and Thancharoen contacted Ballantyne for comment. Ballantyne and Fu (working with Ballantyne at the time) concluded that larval specimens that they

were describing as *Luciola substriata* Gorham were almost identical to those Branham and Thancharoen were describing as *L. brahmina*. Ballantyne suggested the possibility that their distinctively colored species was misidentified. She confirmed this after examining adults compared with the type of *L. brahmina* from MHN Paris. This was also confirmed by A. Lewvanich, who examined photos of the type of *L. brahmina*. Jeng noted that adults of the Thai species Branham and Thancharoen were studying resembled *L. japonica*, but was most likely new. Therefore there is a consensus that these specimens represent an undescribed species in the genus *Luciola* that bears considerable similarity to *L. brahmina*, *L. japonica* and *L. substriata*, and that this new species is described here.

## Materials and methods

Specimens used in this description originated from ditches in an agricultural area of Samut Prakarn Province, Thailand. Males were observed in flight over fresh water while females were found perching on nearby trees and on floating aquatic plants. Specimens were collected and reared for several generations in the insectary at the Department of Biology, Faculty of Science, Mahidol University under a 13L:11D cycle and at 24–29°C. Ten specimens, subsequently designated as holotype and paratypes, were randomly selected from the mass rearing in the laboratory and preserved in 70% ethyl alcohol.

The habitus photograph of the holotype male was taken using a Microptics® Digital Imaging System (Nikon D1X) before being hydrated in warm water for subsequent dissection. Male genitalia were extracted following the technique described in McDermott and Buck (1959) and examined under a Leica MZ16 stereomicroscope after being placed on a concave slide in 85% lactic acid. Drawings were made using a compound microscope (NIKON Eclipse E600) fitted with a camera lucida.

Terms and description of adult morphological characters follows Ballantyne (1968), Ballantyne and Lambkin (2000, 2001, 2006), Ballantyne and McLean (1970) and Fu and Ballantyne (2006).

Abbreviations of taxonomic characters and their measurements used in this paper are as follows: ASD = distance between antennal sockets, ASW = antennal socket width, GHW = greatest head width (horizontally measured across eyes), LL = lateral lobe aedeagus, LO = light organ, ML = median lobe aedeagus, MN = mesonotal plate, MPP = median posterior projection of ventrite 7, MS = mesoscutellum, PLP = posterolateral projections of ventrite 7, SIW = smallest interocular width (distance between eye edges above antennal socket), legs or parts are numbered (1 = pro-, 2 = meso- and 3 = metathoracic), T = abdominal tergite (follow by number), V = abdominal ventrite (follow by number).

It is important to understand terminology associated with firefly abdominal segments as these can vary between authors. In *Luciola*, males have seven visible abdominal segments while females have eight. The first abdominal segment in both sexes, as in many lampyrid genera, is represented solely by the abdominal tergite, seen only on the dorsal abdominal surface. Therefore, the first visible abdominal segment on the ventral surface represents abdominal segment two. We use “V” (= ventrite) to represent the actual abdominal segment. Therefore, V7 refers to the sixth visible, ventral abdominal segment, which is the true seventh abdominal segment (Ballantyne and McLean 1970).

## *Luciola aquatilis* Thancharoen, sp. nov.

(Figs. 1–4)

**Specimens examined. Holotype:** Male, from laboratory culture. The original individuals were collected from Samut Prakarn Province, Thailand, 13° 40'20.01" N, 100°33' 13.50" E, Bangyor district, Phrapradaeng, 4.88 m, xi.2003. collected by A. Thancharoen. **Paratypes:** 9 males, 10 females, same data as holotype. Additional

material examined: LAOS: 6 males and 2 females, Vanvieng, Vanvieng Resort, alt. 233 m, 18°54'43.5"N, 102°26'36.5"E, 27–28.V.2004, M.L. Jeng.

**Diagnosis.** The dominant characteristics of *L. aquatilis* males that distinguish it from other aquatic *Luciola* are its brownish dorsal coloration with dark regions present at base and apex of elytra, elytral punctuation in lines, sclerites associated with aedeagal sheath, and shape of aedeagal sheath.

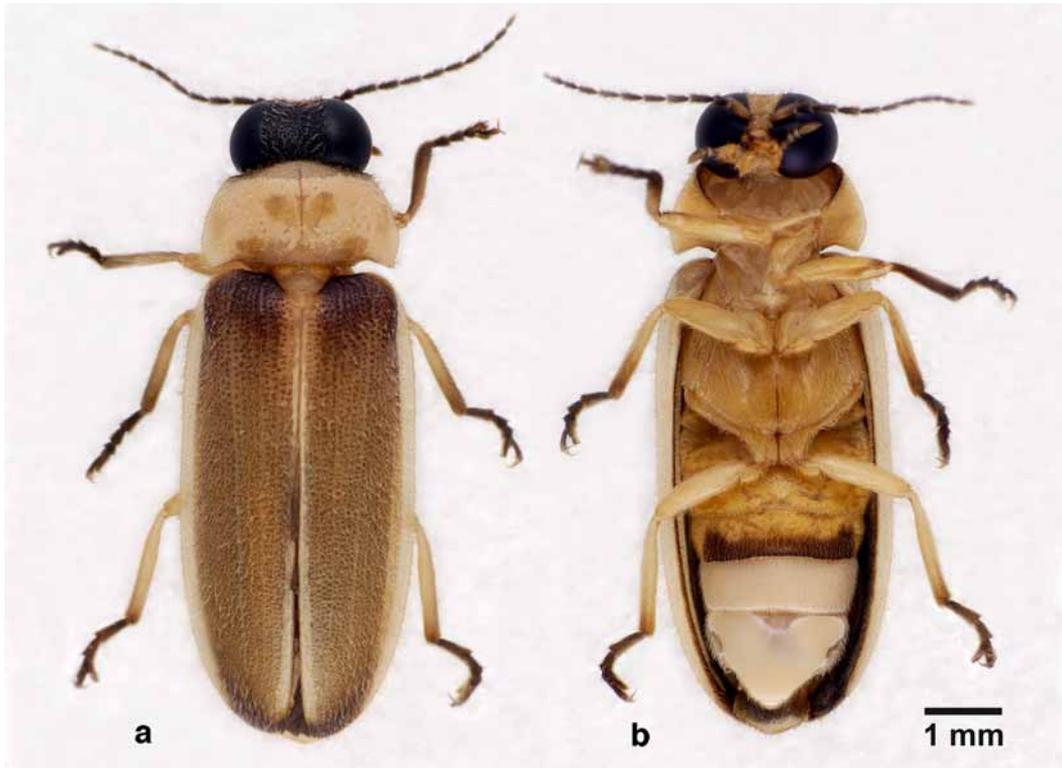


FIGURE 1. Habitus of *L. aquatilis* male. (a) dorsal, (b) ventral.

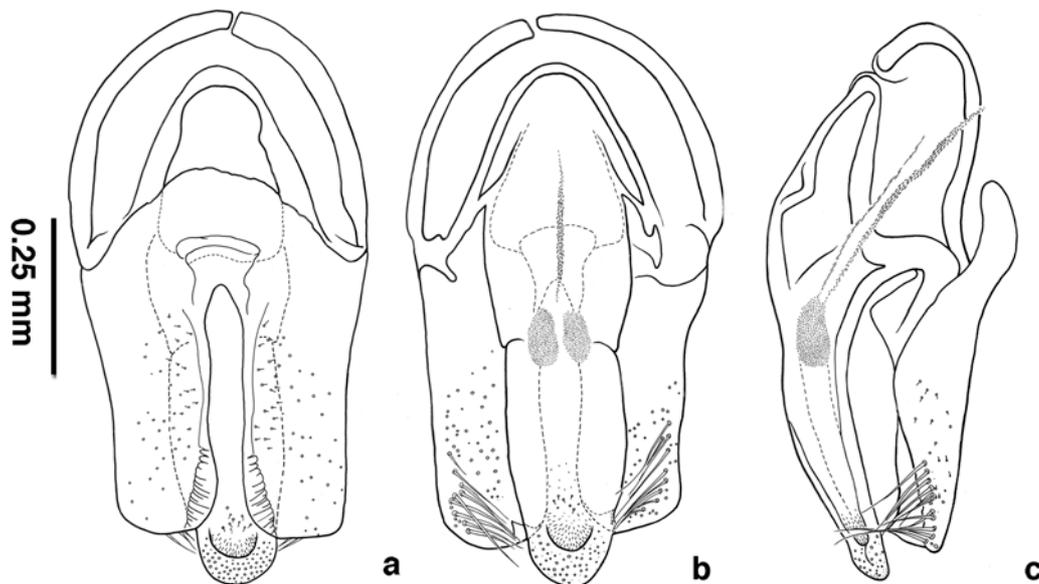


FIGURE 2. Aedeagus of *L. aquatilis*, distal tip oriented down, (a) dorsal, (b) ventral, (c) lateral.

**Description of male.** Body elongate, slender, three times as long as wide (Fig. 1); 7.5–9.0 mm long; 3.0–3.5 mm wide; width/length 0.35–0.45 mm (n=10). Pronotum pale creamy yellow, no apparent darker marking on dorsal surface; pubescence pale; fat body dense under cuticle except along anterior and posterior margin

and obliquely oval areas either side of mid line, which may appear as slightly darker areas on dorsal surface; MS and MN pale brown; elytra brown, darker than pronotum, with basal 1/6 and apical tip both black, semi-transparent along outer margins with a white lateral band extending along lateral margins from humerus to near apex but not around apex, sutural margin of elytra also bearing a narrower white band which expands in posterior half, nearly reaching apex; elytral punctures dark brown and slightly paler towards apex; vertex of head black between eyes, frons and below pale brown; antennae and maxillary palpi dark brown, labial palpi pale brown; ventral surface of pro-, meso- and metathorax light brown; anterior legs with pale creamy yellow coxae, trochanters and femora, and dark brown tibiae and tarsi; middle and posterior legs with pale creamy yellow coxae, trochanters, femora and tibiae except for brown apical 1/3 of mesotibiae and apical 1/4 of metatibiae; abdominal ventrites light brown except V4 with dark brown marking across posterior 1/3, with underlying fat body, V5 wholly occupied by light organ, V6 almost completely occupied by light organ, which is medially emarginated across its anterior margin, this area being pale brown; MPP pale brown, semitransparent.

**Head.** Head moderately exposed in front of pronotum; vertex minimally depressed; GHW 1.9–2.1 mm; ASW 0.13–0.17 mm; SIW 0.30–0.33 mm; posterolateral eye excavation absent; ASD = 1/2 ASW; frons-vertex junction not obviously defined; functional mouthparts with large hairy lobes of maxillae and labium; apical segment of maxillary palpus ovoid, longer than wide; apical segment of labial palpus laterally flattened, elongate and dentate along its inner margin; antennal length 1.5 × GHW, 11 segmented, scape longer than pedicel, all segments slender and elongate, flagellar segments 5–9 a little shorter than the rest, apex or tip of flagellar segment 9 rounded.

**Pronotum.** 1.4–1.5 mm long, 2.5–2.8 mm wide, width/length ratio = 1.67–2.0; 1/5 as long as whole body; median anterior margin broadly rounded; not projecting beyond anterolateral corners, which are broadly rounded; lateral margins diverging along their length without sinuosity; posterolateral corners broadly pointed, acute (80–90°), projecting beyond posterior medial margin; lateral margin near posterolateral corners not indented; dorsal surface mainly smooth and flat except for a depressed medial line intersecting a depressed posterior margin; hypomera thickened.

**Elytron.** Length 6.0–7.5 mm; lateral margins subparallel along anterior 2/3 and converging in apical 1/3; punctuation larger and more spare than on pronotum, punctures appear as darkened pits aligned in rows along elytral length; 2 wider and apunctate non-elevated interstitial lines delimited by punctures, all interstitial lines more or less equal in color; apex not deflexed.

**Legs.** All femora and tibia simple and straight, not swollen or curved; basitarsi 1 not excavated on their inner edges; basitarsus 3 not swollen; lacking metafemoral comb.

**Abdomen.** Six visible ventrites (actual segments 2–7); LO occupies V6 completely and all of V7 except for a small anteromedian area which appears triangular; LO reaches to sides and posterior margin of V7; lateral margins of V7 converge posteriorly to rounded entire MPP; posterolateral corners round, not produced; posterior margin of V7 without hairy lobes or pointed projections; ventral surface of V7 lacking median longitudinal groove, carina, or dimple; T8 lightly sclerotized, posterior visible section wider than long, wider across the middle and slightly converging to apex, with median posterior margin shallowly emarginated, slightly longer than V7 and inclined ventrally where it may partially engulf the MPP and part of the posterior margin of V7. T8 has elongate slender arms that stretch well under T7.

**Aedeagus.** Length/width 0.71–0.77 (Fig. 2); LL and ML nearly asymmetrical; LL a little shorter than ML; maximum width across LL/maximum width of ML 1.0; ML elongate and slender, slightly curving ventrally, preapical ventral area produced and round; LL flat and as wide as ML, separated in apical 2/3 of their length, inner apices turned inward and hook-like; LL with several long setae along external margin.

**Aedeagal Sheath.** Length 2.0 mm × 0.6 mm wide (Fig. 3). Syntergite (T9+10) at its broadest width about the same as V9. V9 strongly asymmetric, as in *L. substriata*, with apex bifurcate and elevated.

**Description of female.** Body 7.3–8.4 mm long; 3.2–4.5 mm wide; width/length 0.43–0.55 (Fig. 4). Forewings and hind wings fully developed; coloration and shape similar to male, but light organ restricted to

V6, V2–V5 light brown except 2/3 of V5 black at posterior end, V7–V8 pale and semitransparent, V7 appears white due to underlying fat body. Head: GHW 1.6–1.9 mm; SIW 0.9–1.12 mm; small eyes when compare with male; can be retracted completely into pronotal cavity. Pronotum: 1.5–2.0 mm long; 2.5–3.4 mm wide; 1/5 as long as body; width/length 1.5–2.1. Light organ: occupying all of V6; shallowly emarginated at 1/6 from lateral margins of posterior margin; V7 not heavily sclerotized, lateral margins converge posteriorly, broadly concave along posterior margin.

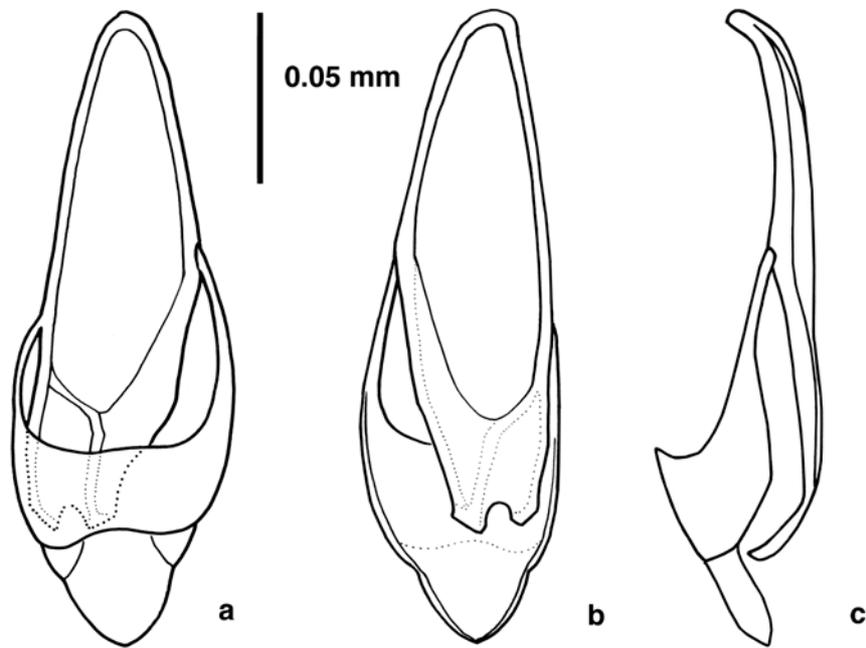


FIGURE 3. Aedeagal sheath of *L. aquatilis*, distal tip oriented down, (a) dorsal, (b) ventral, (c) lateral.

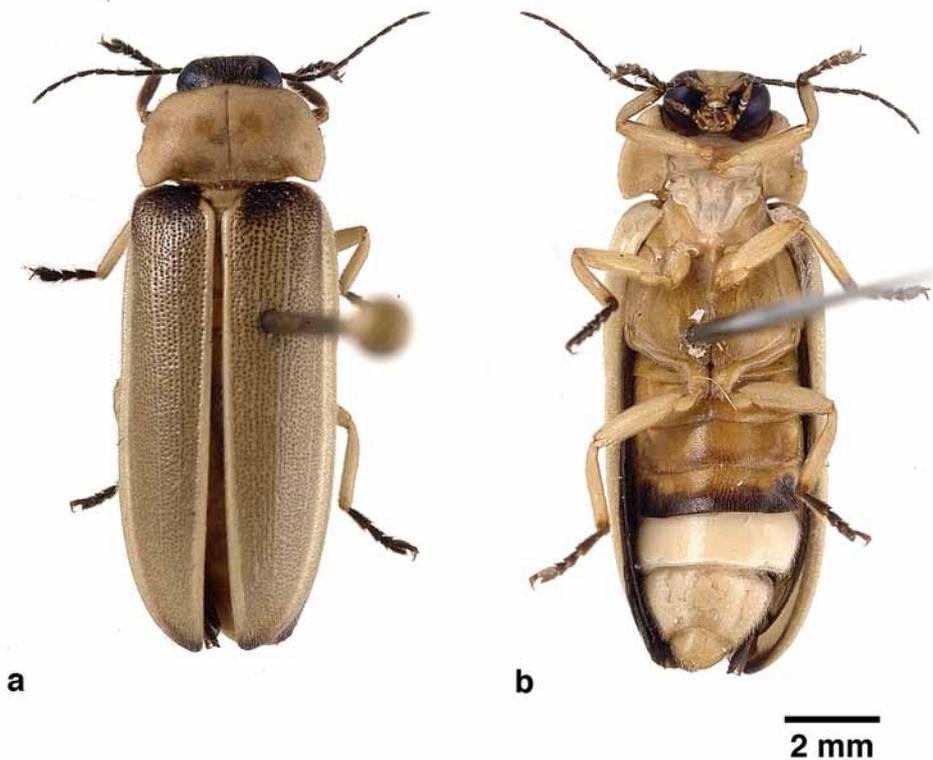


FIGURE 4. Habitus of *L. aquatilis* female. (a) dorsal, (b) ventral.

**Geographical Distribution.** Distributed across the following provinces of Thailand: Samut Prakan, Nakhon Pathom, Phra Nakhon Si Ayutthaya, Chanthaburi, Nakhon Ratchasima, in areas possessing standing sources of freshwater such as ditches, ponds, swamps and rice fields. It is also known from Laos: Vientiane Province, Vangvieng.

**Etymology.** The species epithet is formed from the Latin root “aqua” for water; *aquatilis*, meaning to live in or near water.

**Specimen Deposition.** The holotype is deposited in the collection of the American Museum of Natural History (AMNH). Two paratypes have been deposited in each of the following five museum collections: Museum National d’Histoire Naturelle, Paris, France (MNHN), Museum of Natural History of Thailand, Pathum Thani, Thailand (THMNH), Entomological Museum of the Department of Agriculture, Bangkok, Thailand (DOA), Chulalongkorn University Natural History Collection (CUMZ), and The Natural History Museum, London, England (BMNH).

## Discussion

*Luciola* is a large genus of 268 species restricted to the Old World (Ballantyne 1992; Fu & Ballantyne 2006; McDermott 1966), and appears to possess an enormous amount of morphological variation. Unlike most immature lampyrids, the larvae of several *Luciola* species are fully aquatic and are limited to the Asian region (Jeng et al. 2003a, some uncertain cases were reported from Africa). These larvae are known to live entirely underwater, most possess tracheal gills and all appear to feed on aquatic snails. Last instar larvae exit the water and pupate in earthen cells not far from the waters edge. The larvae of *L. aquatilis* are fully aquatic yet are morphologically distinct from the other known fully aquatic *Luciola* larvae (Thancharoen and Branham, in prep.) Phylogenetic analyses and taxonomic keys for adults have been produced for several regional faunas but none exist for the genus as a whole (Ballantyne 1968; Ballantyne & Lambkin 2000, 2001, 2006; Ballantyne & McLean 1970; Jeng et al. 2003 a, b; Suzuki 2001; Suzuki et al. 2002). As with many groups of beetles, some incorrectly identified specimens are more readily available than type specimens, further complicating efforts to assess the correct identity of a species. Therefore, determining species affinities can be difficult. In this section we provide evidence that confirms our decision that *L. aquatilis* is a new species.

In our efforts to determine whether this species was already described, we observed that adult *L. aquatilis* bear rows of serial punctures along the elytra. In the most recent world-wide catalog of Lampyridae, McDermott (1966) listed 11 species of *Luciola* which were described with elytral punctures in lines. However, none of these species matches the dorsal color pattern observed on *L. aquatilis*.

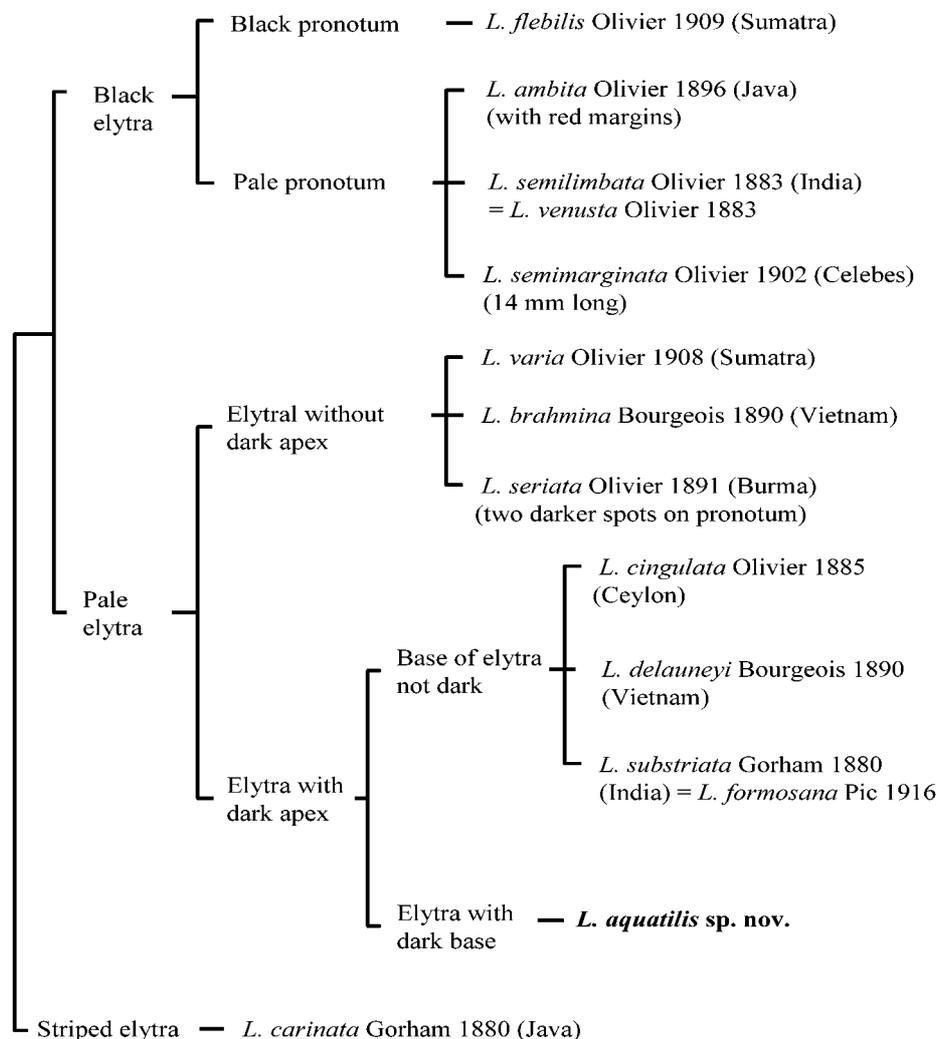
The presence of serial punctures was not mentioned in the original description of *L. japonica*. However, Kawashima et al.’s (2003) photo of the holotype in dorsal view shows a color pattern and elytral punctation that are similar to those of *L. substriata*. Kawashima et al. (2003) considered the species was not from Japan despite its original designation. Since it is likely that this type is a female, this species should probably be regarded as *Species Incertae*. Olivier (1885) identified *L. japonica* from Java and it is this misidentification that probably led to the current problems, since his specimens appear to be very similar, if not identical to those described here as new, and their color pattern is unlike that of the *L. japonica* holotype designated by Thunberg. Both Jeng and Ballantyne examined Olivier’s collection in MNHN in Paris and arrived at this conclusion independently.

Of the species originally described as having linear elytral punctation (Fig. 5), four have black elytra. *Luciola flebilis* Olivier (from Sumatra), is entirely black dorsally, while the remaining three species: *L. ambita* Olivier (from Java), *L. semilimbata* Olivier (from India), and *L. semimarginata* Olivier (from Sulawesi) all have dark elytra. The latter two species may have been based on females, and *L. semimarginata* is at least 14.0 mm long. Furthermore, Olivier (1902) synonymised *L. venusta* Olivier (from India) with *L. semilimbata*.

*Luciola carinata* Gorham (from Java) has a distinctive dorsal color pattern with elytral interstitial lines well developed and paler than most of the elytra, which may carry fine paler lines between these interstitial lines. In addition, the holotype's aedeagus is similar to that of *L. substriata* (Ballantyne, unpublished).

*Luciola varia* Olivier (Sumatra) is pale dorsally with no dark marks at elytral apex and may well be similar to *L. brahmina*, while *L. seriata* Olivier (Burma) has pale elytra but 2 darker spots on the pronotum. Three species are pale dorsally with a dark elytral apex. *Luciola cingulata* Olivier (Ceylon) was synonymized with *L. substriata* (Gorham 1895), but this synonymy was omitted from McDermott (1966), most probably in error. *Luciola delauneyi* Bourgeois, from Vietnam, was described as similar to *L. chinensis* (Linnaeus) from China.

*Luciola substriata*, represented by both the Taiwanese (Jeng et al. 2003) and mainland Chinese, Hubei Province, populations (Fu et al. 2005), has larvae in which the behavior and morphology (of both larva and adult) is similar to that of this new species, while differing markedly in adult color patterns. Jeng et al. (2003) examined Gorham's collection (in MNHN) but did not locate a specimen labeled as the type. Based on their examination of other specimens in this collection identified as *L. substriata*, they synonymised *Luciola formosana* Pic (Taiwan) with *L. substriata*, which they partially redescribed and discussed, based on their Taiwanese specimens.



**FIGURE 5.** A bifurcating schematic separating species that show a resemblance to *L. aquatilis* based on the related 11 species that possess linear elytral punctuation.

## Acknowledgements

We thank Dr. Paul Johnson and two anonymous reviewers for helpful comments on this manuscript. The first author is grateful to Drs. L.A. Ballantyne and X.H. Fu for alerting her to the possibility that the species she was studying may be misidentified; and to Dr. Angoon Lewvanich who studied this species in Thailand and provided many useful suggestions. Financial support for this project was from the Thailand Research Fund through the Royal Golden Jubilee Ph.D. Program (Grant No. PHD/0231/2543).

## References

- Ballantyne, L.A. (1968) Revisional studies of Australia and Indomalayan Luciolini (Coleoptera: Lampyridae: Luciolinae). *University of Queensland Papers*, Department of Entomology, University of Queensland Press II, no. 6, 103–139.
- Ballantyne, L.A. (1992) Revisional studies on flashing fireflies (Coleoptera: Lampyridae). Doctoral Dissertation. University of Queensland, St. Lucia, Brisbane, Australia. 420 pp. [unpublished]
- Ballantyne, L.A. & Lambkin, C. (2000) Lampyridae of Australia (Coleoptera: Lampyridae: Luciolini). *Memoirs of Queensland Museum*, 46(1), 15–93.
- Ballantyne, L.A. & Lambkin, C. (2001) A new firefly, *Luciola* (*Pygoluciola*) *kinabalua*, new species (Coleoptera: Lampyridae), from Malaysia, with observations on a possible copulation clamp. *Raffles Bulletin of Zoology*, 49(2), 363–377.
- Ballantyne, L.A. & Lambkin, C. (2006) A phylogenetic reassessment of the rare SE Asian firefly genus *Pygoluciola* Wittmer (Coleoptera: Lampyridae: Luciolinae). *Raffles Bulletin of Zoology*, 54(1), 21–48.
- Ballantyne, L.A. & McLean, M.R. (1970) Revisional studies on the firefly genus *Pteroptyx* Olivier (Coleoptera: Lampyridae: Luciolinae: Luciolini). *Transactions of the American Entomological Society*, 96, 223–305.
- Brooks, T.M., Mittermeier, R.A., Mittermeier, C.G., Gustavo A. B. da Fonseca, Rylands, A.B., Konstant, W.R., Flick, P., Pilgrim, J., Oldfield, S., Magin, G. & Craig Hilton-Taylor (2002) Habitat Loss and Extinction in the Hotspots of Biodiversity. *Conservation Biology*, 16(4), 909–923.
- Fu, X.H. & Ballantyne, L.A. (2006) *Luciola leii* sp nov., a new species of aquatic firefly (Coleoptera: Lampyridae: Luciolinae) from mainland China. *The Canadian Entomologist*, 138, 339–347.
- Fu, X.H., Ohba, N., Vencl, F.V. & Lei, C.L. (2005) Structure, behavior and the life cycle of an aquatic firefly, *Luciola substriata* (Coleoptera: Lampyridae), in China. *The Canadian Entomologist*, 137, 83–90.
- Gorham, H. S. (1895) List of the Coleoptera in the collection of H. E. Andrewes Esq. from India and Burma, with descriptions of new species and notes. *Annales de la Societe Entomologique de Belgique* XXXIX, 293–307.
- Hutacharern, C., N. Tubtim & Dokmai, C. (2007) Checklists of Insects and Mites in Thailand. Department of National Parks, Wildlife and Plant Conservation, Bangkok, Thailand, 319 pp.
- Jeng, M.-L., Lai, J. & Yang, P.-S. (2003a) Lampyridae: a synopsis of aquatic fireflies with description of a new species (Coleoptera). In: Jäch, M.A. & Ji. L. (Eds.), *Water Beetles of China. Vol.III*. Zoologisch Botanische Gesellschaft in Österreich and wiener Coleopterologenverein, Vienna, Austria, pp. 539–562.
- Jeng, M.-L., Yang, P.-S. & Lai, J. (2003b) Notes on the Genus *Luciola* (Coleoptera, Lampyridae, Luciolinae) of Taiwan. *Special Bulletin of the Japanese Society of Coleopterology Tokyo*, (6), 247–262.
- Kawashima, I., Suzuki, H. & Satô, M. (2003) A check-list of Japanese fireflies (Coleoptera, Lampyridae and Rhagophthalmidae). *Japanese Journal of Systematic Entomology*, 9(2), 241–261.
- McDermott, F.A. (1966) Lampyridae. In: W.O. Steel (Ed.), *Coleopterorum Catalogus Supplementa, pars 9 (editio secunda)* S-Gravenhage: W. Junk. pp. 1–149.
- McDermott, F.A. & Buck, J.B. (1959) The lampyrid fireflies of Jamaica. *Transactions of the American Entomological Society*, LXXXV, 1–112.
- Olivier, E. (1885) Catalogue des Lampyrides faisant partie des collections du Musée Civique de Gênes. *Annali del Museo Civico di Storia Naturale di Genova* (2a), 2, 333–374.
- Olivier, E. (1902) Catalogue des espèces de 'Luciola' et genres voisins décrits jusqu'à ce jour. *Revue Scientifique du Bourbonnais et du centre de la France* 15, 69–88.
- Suzuki, H. (2001) Studies on biological diversity of firefly in Japan. *International Journal of Industrial Entomology*, 2(2): 91–105.
- Suzuki, H., Satô, Y. & Ohba, N. (2002) Gene diversity and geographic differentiation in mitochondrial DNA of the Genji Firefly, *Luciola cruciata* (Coleoptera: Lampyridae). *Molecular Phylogenetics and Evolution*, 22(2), 193–205.