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PYGOLUCIOLA SATOI, A NEW SPECIES OF THE RARE SOUTHEAST ASIAN FIREFLY GENUS *PYGOLUCIOLA* WITTMER (COLEOPTERA: LAMPYRIDAE: LUCIOLINAE) FROM THE PHILIPPINES

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ABSTRACT. **–** A Philippine record of this rare genus is the first outside the Malaysian states of Sarawak and Sabah. *Pygoluciola satoi* new species, is described from males and females, including features of the female abdomen and bursa hooks. All species of this genus are keyed from males, and four species from females. A lectotype male of *Pygoluciola hamulata* (Olivier) is designated and described. Discussion addresses advisability of dissecting type material, reliability of identifications performed when comparisons are made with external type morphology only, interpretation of head coverage in the Luciolinae, definition of the hypomeron, certain artefacts of drying, the orientation of the aedeagus and inclination during intromission.

KEY WORDS. **–** *Pygoluciola satoi,* new species.

INTRODUCTION

The rare southeast Asian firefly genus *Pygoluciola* Wittmer was until now only known from the Malaysian states of Sabah and Sarawak, in published reports of 11 males (in five species) and 10 females (in three species). Now the genus is recorded for the first time outside Malaysia, from the Philippine island of Mindanao and the specimen number increases to 16 males (in six species) and 12 females (in four species). Four of the six species, including this new species, are represented by both males and described females (Ballantyne & Lambkin, 2006).

Pygoluciola was described by Wittmer (1939) for one species *Pygoluciola stylifer*. It was listed as a subgenus of *Luciola* by McDermott (1966) and treated as such by Ballantyne (1968) (who described two new species), Ballantyne & McLean (1970), and Ballantyne & Lambkin (2000, 2001), who (2001) described a new species. Ballantyne & Lambkin's (2006) phylogenetic analysis of the Luciolinae supported the return of *Pygoluciola* to generic status. They gave a full generic redescription and described or redescribed three species including the type, *P. stylifer,* using an expanded format of characters that included internal female morphology. The only species not yet to have been redescribed, *Pygoluciola hamulata* (Olivier), is addressed here. Ballantyne & Lambkin (in prep.) support the assignment of this new species to *Pygoluciola.*

Taxonomy of the Luciolinae has been largely male based and female identification has been until recently, difficult, and based primarily on taking a mating pair or on similarity of label data. Ballantyne & Lambkin (2001, 2006) overviewed the difficulties, and indicated the usefulness of internal structures (such as plates in the bursa) and external structures (such as modifications on the abdominal ventrites) for female identification, the latter especially in the genus *Pygoluciola.* This aspect is further investigated here.

Ming-Luen Jeng recognised that this genus in the collection of the late Dr. Masataka Satô and kindly made the material available for my research.

Pygoluciola satoi, new species, from the Philippines is described from males and females; female morphology includes external features of the female abdomen and bursa structure. Dr. Roberto Poggi (Director, and Curator of Entomology at Museo Civico di Storia naturale 'Giacomo Doria', Genoa, Italy) indicated that while Olivier's (1885) description of *Luciola hamulata* listed two males, only one is present in their collection and should be regarded as a syntype, and suggested I designate this specimen as a lectotype, and it is described. The genus is keyed from six male and four female species.

MATERIALS AND METHODS

Taxonomic characters are based on Ballantyne & Lambkin (2006), and although no phylogenetic analysis is performed

Table 1. Character states for *P. satoi* scored using Ballantyne & Lambkin's (2006) characters.

1,1; 2,3; 3,3; 4,2; 5,1; 6,2; 7,0; 8,0; 9,1; 10 – 18, 0; 19,1; 20,1; 21,0; 22,1; 23,1; 24-26,0; 27,1; 28-29,0; 30,1; 31 – 39, 0; 40-41,1; 42-49, 0; 50, 1; 51-52, 0; 53,2; 54,0; 55,2; 56, 3; 57, 0; 58-59,2; 60,1; 61-62, 0; 63, 1; 64-74, 0; 75, 3; 76, 1; 77 – 79, 0; 80, 1; 81, 1; 82-84, 0; 85, 1; 86-89, 0; 90, 1; 91 – 97, 0; 98, 1; 99, 2; 100, 1; 101, 0; 102, 2.

here, Table 1 gives a scoring for this species based on characters and states described in Ballantyne & Lambkin (2006) and similarities and differences are discussed. Interpretations in the discussion are based on a fourth phylogenetic analysis of the Luciolinae (Ballantyne & Lambkin in prep.).

Explanations in the descriptions accommodate most situations where some of these characters may be elaborated. The basal origin of the epipleuron is determined from above with the specimen horizontal, as the point at which the edge of the epipleuron can first be seen relative to the elytral humerus and the posterior margin of the mesoscutellum, and from below, with the specimen horizontal, whether the base of the epipleuron covers the humerus or the humerus is visible from beneath. Ballantyne & Lambkin's (2006) character 26 is expanded – with the labrum horizontal whether the clypeolabral suture is in line with or in front of the front margin of the eyes, can be determined. The width across the posterior margin of the pronotum is compared to the width across the outer edges of the elytral humeri (elytra closed).

The female from Mount Apo is associated by overall similarity to the male and label data; the other female was then associated by its distinctive morphological similarity to this Mount Apo female.

Figures 1 and 2 were taken with an Altra 20 camera mounted upon an Olympus® SZX12 stereo microscope. Figures 3 and 4 were re-assembled from multiple shots of the same structure (at different depths) using the same camera, with Helicon Focus 4.03. Drawings were done using a drawing tube mounted on an Olympus® microscope.

Abbreviations for taxonomic characters are: ASW, antennal socket width; FS, antennal flagellar segments, referred to by number e.g. FS 3, 4; GHW, greatest head width; ML, median lobe aedeagus; MN, mesonotal plates; MPP, median posterior projection of V7; MS, mesoscutellum; LL, lateral lobe aedeagus; PLP, posterolateral projections of V7; SIW, smallest interocular width; T7, T8, abdominal tergite seven, eight; Vfollowed by a number, abdominal ventrite/s. Numbering of abdominal ventrites follows Ballantyne & Lambkin (2000, 2001, 2006).

Abbreviations for repositories of specimens are:

ANIC – Australian National Insect Collection CSIRO Canberra, Australia
MSNG – Museo Civico di Storia Naturale 'Giacomo Doria', Genoa, Italy
ZRC – Raffles Museum of Biodiversity Research, Zoological reference collection, National University of Singapore, Republic of Singapore

TAXONOMY

List of species of *Pygoluciola* Wittmer

Pygoluciola guigliae (Ballantyne, 1968)
Pygoluciola hamulata (Olivier, 1885)
Pygoluciola kinabalua (Ballantyne & Lambkin, 2001)
Pygoluciola satoi, new species
Pygoluciola stylifer Wittmer, 1939
Pygoluciola wittmeri (Ballantyne, 1968)

Key to species of *Pygoluciola* using males

[Modified and expanded from
Ballantyne & Lambkin (2006)]

1. All tibiae curved; lateral margins of elytra tapering posteriorly (Ballantyne & Lambkin, 2006: Fig. 6) 2
– No tibiae curved; lateral margins of elytra usually sub-parallel-sided 3
2. Apex of median posterior projection of tergite 8 no wider than rest and rounded, not emarginate; lateral margins of pronotum slightly sinuate (Ballantyne & Lambkin, 2006: Figs. 1, 19, 21) .... *P. guigliae* Ballantyne
– Apex of median posterior projection of tergite 8 wider than rest and medianly emarginate; lateral margins of pronotum not slightly sinuate (Ballantyne & Lambkin, 2006: Figs. 4, 25) .. .. *P. stylifer* Wittmer
3. Median posterior projection of abdominal V7 bifurcate at apex (Ballantyne & Lambkin, 2006: Figs. 18, 26) 4
– Median posterior projection of abdominal V7 not bifurcate at apex 5
4. Apex of median posterior projection of abdominal V7 deeply emarginate, laterally ensheathing the downturned apex of tergite 8 and projecting laterally beside it (Ballantyne & Lambkin, 2006: Figs. 18, 26) .... *P. wittmeri* (Ballantyne)
– Apex of median posterior projection of abdominal V7 shallowly emarginate, not laterally ensheathing the downturned apex of tergite 8 and not projecting beside it (Ballantyne & Lambkin, 2001: Figs. 5, 10) ...... *P. kinabalua* (Ballantyne & Lambkin)
5. MPP of V7 elongate slender, ventral surface shallowly depressed along its length, and bearing on its median dorsal surface two slender teeth; posterior apex of MPP not differentiated; lateral margins of tergite 8 downturned (Figs. 5, 6) .... *P. satoi*, new species
– MPP of V7 shorter, about as wide as long, ventral surface not shallowly depressed along its length, and not bearing dorsal teeth; posterior apex (face) of MPP differentiated and shallowly depressed; lateral margins of tergite 8 not downturned .... *P. hamulata* (Olivier)

Key to species of *Pygoluciola* using females

[Extended from Ballantyne & Lambkin (2006)]

1. All tibiae curved .... *P. guigliae* (Ballantyne)
– No tibiae curved 2

2\. Posterior margin of V7 deeply emarginate; bearing a small ridge anterior to median area of deepest emargination; V8 with anteromedian prolongation not any more sclerotised than remainder of V8; tergite 7 with anteromedian area rounded and elevated, lateral areas not flattened .... *P. kinabalua* (Ballantyne & Lambkin)

– Posterior margin of V7 lacking an anteromedian ridge; V8 with anteromedian prolongation well sclerotised and visibly separated from remainder of V7; tergite 7 lacking a rounded and elevated anteromedian area, with lateral areas flattened 3

3 Posterolateral areas of V7 irregularly expanded (Fig. 7) .... *P. satoi* new species

– Posterolateral areas of V7 not expanded .... *P. wittmeri* (Ballantyne)

Pygoluciola hamulata **(Olivier)**

(Figs. 1, 2)

Luciola hamulata Olivier, 1885: 367; 1902: 80; 1907: 52; 1913: 59.
Luciola (*Luciola*) *hamulata* Olivier. McDermott, 1966: 105.
Luciola (*Pygoluciola*) *hamulata* Olivier. Ballantyne, 1968: 121.
Pygoluciola hamulata (Olivier). Ballantyne & Lambkin, 2006: 29.

Lectotype**. –** Male, Borneo, Sarawak, 1865–1866, coll. G. Doria (MSNG). This is the only remaining specimen of the original two in MSNG on which Olivier based his original description. Labels: 1. black ink on card – "Borneo Sarawak 1865–66 coll. G Doria"; 2. red printed label on red margined card 'Typus; 3. black ink male symbol; 4. handwritten in black ink "*hamulata* E. Oliv." Male specimen is hereby designated as the lectotype of *Luciola hamulata* Olivier, 1885.

Distinctive features**. –** Superficially most similar to *P. stylifer*, distinguished by the non curved tibiae of all legs, the entire apex of abdominal tergite 8 (that of *stylifer* is emarginate); distinguished from *P. satoi* by features listed under that species.

Redescription of lectotype male**. –** Glue runs along the dorsal surface between abdomen and elytra and the abdomen is not attached to the thorax but to the elytra; the abdomen was not removed and certain features thus not ascertained on this specimen.

Elongate, moderately slender, 2.5 times as long as wide; 9.1 mm long.

Dorsal surface pale yellowish brown; pronotum semitransparent where fat body is retracted, with pale brown markings near posterior margin to either side of the median line; elytral punctures dark at their bases, more noticeably so in an area that extends posteriorly from elytral base to the mid point of the suture and laterally as far as interstitial line 2; head, antennae, palpi reddish brown, apical segment of maxillary palpi pale yellow on inner surface; apical segment of labial palpi pale light brown; venter of thorax dingy yellow except for red-brown metasternum; legs yellowish except for reddish brown apices of femora 1, and all of tibiae and tarsi of legs 1, 2, and brown tarsi only of legs 3; V2 pale brown, V3, 4 light red brown, semitransparent, V5 dark reddish brown; light organ in V6, 7 deep yellow (post mortem), remainder light brown; visible posterior portion of tergite 8 pale yellowish, rest of tergites not examined.

Pronotum: (Fig. 1); 3.0 mm wide, 1.5 mm long; width/length = 2; 1/6 as long as whole body length; wider across posterior margin than elsewhere; width across posterior margin subequal to width across elytral humeri (elytra closed); median anterior margin rounded, not emarginate, scarcely projecting beyond anterolateral corners, which are narrowly rounded and slightly obtuse, and do not project strongly anteriorly; lateral margins smoothly divergent along their length; posterolateral corners angulate acute, projecting slightly beyond posterior margin, and separated from the slightly emarginated mid posterior margin by shallow emarginations which do not follow the anterior margin of the elytral humerus; dorsal surface mainly smooth, median sulcus not depressed, lateral margins flat and median area largely flat and slightly raised above lateral margins, with irregular small, low, smooth shiny elevations in posteromedian areas; punctures small shallow, some contiguous, some separated by up to their width.

Elytra*:* (Fig. 2); 7.6 mm long; elytral lateral margins divergent in anterior 1/4, subparallel in next 1/4, and gently convergent in posterior 1/2; sutural margins divergent slightly in apical

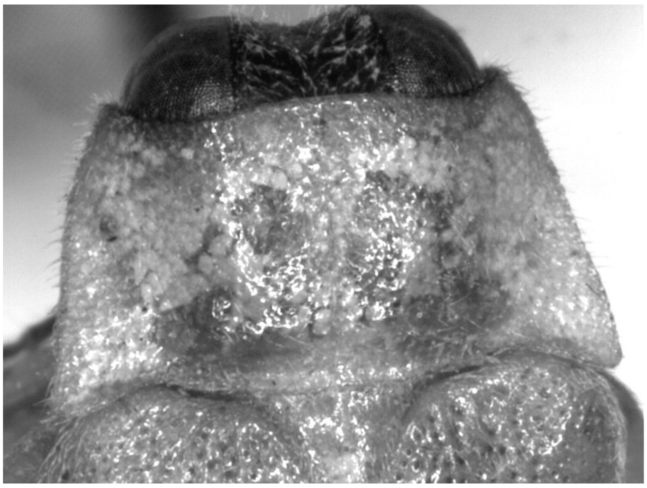

Fig. 1. *Pygoluciola hamulata* (Olivier) Lectotype male dorsal, head and pronotum.

Fig. 2. *Pygoluciola hamulata* (Olivier) Lectotype male dorsal whole body.

1/4; when viewed from below with specimen horizontal, the elytral epipleuron at base covers the elytral humerus (which is thus not visible from beneath); when viewed from above (specimen horizontal) the most anterior portion of the epipleuron becomes visible at the humeral corner and in front of the posterior margin of the MS.

Head: gently depressed between eyes; retracted into the prothoracic cavity but 1/3 of head visible in front of the pronotum; GHW 1.9mm; SIW 0.4 mm; GHW/SIW 5; ASD subequal to ASW; labrum transverse, lateral margins overlie the inner edges of the (closed) mandibles; frons-vertex junction not defined, this area smoothly rounded. Mouthparts well developed; apical segment of labial palpi laterally flattened and bearing on their inner, longest edge, 5–6 projections on both (basal projection 3× as broad as next; 3rd projection from this end is very narrow and short, with longer wider projections to each side; apical projection is narrowly bifurcate). Antennae longer than 2× GHW but < 3× GHW.

Legs: femora and tibiae straight, not swollen or curved.

Abdomen: MPP of V7 appearing short and broad from beneath, curving strongly dorsally with its posterior curved area (which is not visible from below) about as long as the anterior area (which is visible from beneath); posterior face of MPP with narrow sharp edged margins and median area shallowly depressed, and engulfed at its tip by the strongly downturned, slender, and apically rounded apex of tergite 8. No dissections were made of this fragile specimen.

Female and larva not associated.

Pygoluciola satoi, new species
(Figs. 3–9)

Material examined. – **Holotype.** Male, the Philippines. Mindanao: Agko, Mount Apo, 1,000 m, 4 Oct.1978, coll. Shinji Naga (ZRC). **Paratypes**. 2 males, 1 female, same data as holotype. The Philippines, Mindanao: 1 female Baracatan, 1,500 m, 27–29 Jun.1979, coll. M. Satô; 1 male, Gasy, 700 m, South Cotabato Pv., 13 Aug.1985, coll. M. Satô; 1 male, Tudaya-Mainit Hot Springs, 27 Jul.1970, coll. M. Satô (ZRC).

Fig. 3. *Pygoluciola satoi*, new species: dorsal head and pronotum.

Distinguishing features. – Distinguished from *P. guigliae* and *P. stylifer*, both of which have curved tibiae on all legs, by the straight tibiae; from *P. wittmeri* and *P. kinabalua*, both of which have a pronounced emargination at the tip of the MPP, by the lack of such an emargination; from *P. hamulata* by the very slender MPP which is not expanded at its apex (that of *hamulata* is expanded and the posterior face is shallowly depressed),and from all other species by the elevations along the mid dorsal surface of the MPP.

Male. – 8.8–10.2 mm long. Dorsal surface of pronotum yellowish, semitransparent, with median paired brown markings (dark brown in two males, pale brown in two), which widen posteriorly and have straight lateral margins (Fig. 3); fat body retracted from anterior margin of pronotum and this area may appear slightly paler because of the semitransparent cuticle; MS whitish yellow (considerable fat body underlies the cuticle), MN very light brown; elytra medium brown, semitransparent, suture narrowly yellow almost to apex and punctures very dark brown (Fig. 4); head, antennae and palpi quite dark brown except for reddish brown frons and labrum, and paler red brown FS 7–9; ventral surface of pro and mesothorax yellow – orange and semitransparent; metasternum dark brown (semitransparent; underlying muscle may enhance this colour), metepipleural plates yellow; legs with coxae, trochanters and femora yellow (legs 1 have brown area on anterior face of femora), tibiae and tarsi dark brown; basal ventrites semitransparent; V2 yellow; V3 mid brown; V4 brown, V5 darker brown than V4; light organ in V6 yellow with posterior margin very narrowly paler; yellow light organ restricted to anterior (wider) half of V7 and retracted from the lateral margins which are a pale brown; light organ in V6 with narrowly posterior margin; light organ in V7 with fine pale margin, yellow portion in posterior median area is slightly emarginated; paler posterior (narrower) half of V7 light yellowish brown; tergites yellow semitransparent, terminal 2 shinier than preceding.

Pronotum: (Fig. 3) 2.5–2.8 mm wide; 1.3–1.5 mm long; width/length = 2.0; 1/7 as long as whole body length; width across posterior margin slightly less than width across outer margins of elytral humeri (elytra closed); median anterior margin rounded, barely projecting beyond anterolateral corners; anterolateral corners angulate, acutely rounded, and

Fig. 4. *Pygoluciola satoi*, new species: dorsal whole body.

not projecting anteriorly beyond the median anterior margin; lateral pronotal margins diverge along their length, more strongly so in anterior 1/3, with no sinuousity at mid point; posterolateral corners angulate acute, angle is subtended obliquely to the median line of the pronotum, corners barely projecting beyond the median posterior margin, and delimited from the rest of the medianly shallowly emarginate posterior margin by shallow emarginations; dorsal surface of pronotum mainly fairly smooth and flat, irregular small low tubercles in posterolateral areas; very flat in anteromedian area (which lacks a median sulcus) this area followed by a small shallow depression; areas beneath dark markings are slightly convex.

Elytra: (Fig. 4) 7.0–8.7 mm long; two inner (closer to suture) interstitial lines apunctate, paler than rest and laterally defined by punctures but not as well elevated as the suture, remaining two lines faintly defined; margins sub-parallel-sided in anterior 2/3, tapering slightly in posterior 1/3; when elytra closed sutural margins are separate slightly in apical 1/3; with specimen horizontal and viewed from above the most anterior visible portion of the lateral epipleuron is visible just behind the anterolateral humeral corner and in front of the posterior margin of the MS; when viewed from beneath (specimen horizontal), the epipleuron at base covers the elytral humerus which is thus not visible from beneath.

Head: 2/3 of head is retracted into the prothoracic cavity but still visible from above in repose (Fig. 3); vertex moderately depressed; GHW 1.5–1.8 mm; SIW 0.4mm; SIW/GHW 0.22–0.27; antennal sockets separated by more than ASW but not twice ASW; when head is held so labrum is horizontal the clypeolabral suture is well in front of the anterior eye margins; labrum transverse, lateral margins reaching inner edges of mandibles. Mouthparts well developed and assumed functional. Antennae 11 segmented ; about twice as long as GHW.

Legs: no segments swollen or curved.

Abdomen (Figs 5, 6): with a faint short median carina on V2 between bases of coxae 3. Light organs: entire and occupying all of V6; entire in V7, restricted to the anterior wider portion, where it reaches the anterior margin but not the sides, posterior margin of light organ appears to have a short medial emargination, which occurs only in the central yellowed portion. Posterolateral corners of V7 obliterated and lateral margins converge posteriorly; MPP elongate and slender, longitudinally shallowly excavated on its ventral surface, apically entire and bearing two median dorsal projections which are visible from the side; tergites 7 and 8 retain their shape and are smooth, shiny, and still elevated in pinned specimens (due to heavier sclerotisation), while the remaining more anterior tergites are shrivelled and flat; tergite 8 with posterolateral corners of anterior (wider) half curving ventrally; apex of tergite 8 entire and rounded.

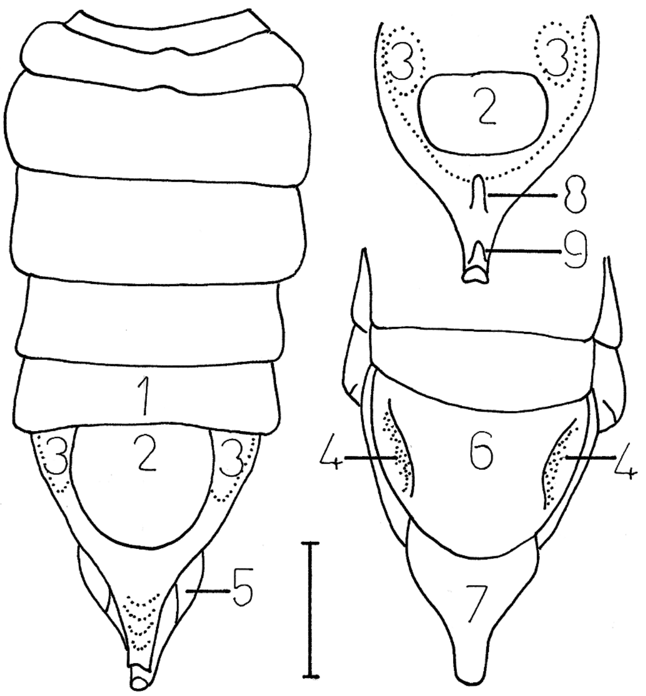

Fig. 5. *Pygoluciola satoi* new species. Features of males: left, male abdomen, ventral; top right ventrite 7 dorsal face; bottom right dorsal tergites 5–8; 1, light organ ventrite 6; 2, light organ ventrite 7; 3, area of attachment of dorso-ventral muscles from ventrite 7 to tergite 7; 4, attachment area on tergite 7 of 3; 5, downturned lateral areas of tergite 8; 6, tergite 7; 7, tergite 8; 8, 9 posterior (9) and anterior (8) median projections on dorsal surface of MPP. Scale bar = 1 mm.

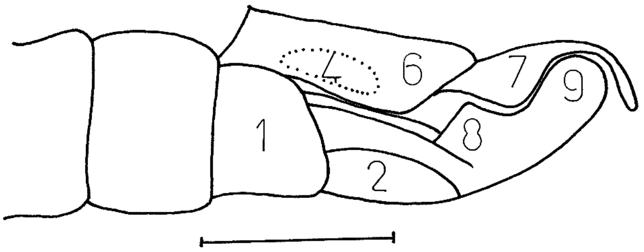

Fig. 6. *Pygoluciola satoi*, new species, male abdomen, lateral (dorsal surface to top of page and abdominal apex to right): 1, light organ ventrite 6; 2, light organ ventrite 7; 4, attachment area on tergite 7 of 3; 6, tergite 7; 7, tergite 8; 8, 9 posterior (9) and anterior (8) median projections on dorsal surface of MPP. Scale bar = 1 mm.

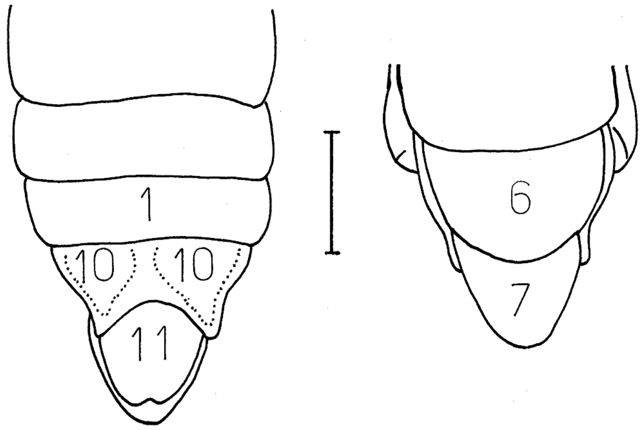

Fig. 7. *Pygoluciola satoi*, new species, female abdomen: left ventrites 4–8; right tergites 6–8; 1, light organ ventrite 6; 6, tergite 7; 7, tergite 8; 10, elevated areas on ventrite 7; 11, ventrite 8. Scale bar = 1 mm.

Aedeagal sheath: (Fig. 9; 2/4 males dissected); sternite 9 with anterior 2/3 elongate slender, and slightly expanded and rounded at its tip, posterior 1/3 much broader, about as wide as long with posterior margin medially emarginated (rounded areas along posterior margin curve slightly upwards); anterior margin of sheath tergite medially emarginate; a narrow well sclerotised transverse plate appears loosely attached at its sides to the lateral margins of the sheath; its precise origin is not known but it may be an anterior portion of the sheath tergite that has separated slightly (this was obvious in the two dissected males).

Aedeagus: (Fig. 8); ML about half as long as LL and apex narrowed, rounded; LL separated for almost all of their length dorsally; LL pale, basal 1/3 well sclerotised, and anterior dorsal margin produced asymmetrically, apical 2/3 pale, fleshy and not sclerotised, bearing hairs along most of their lateral margins, more densely so in basal 1/3.

Female. **–** 9.5 mm long; body 3.4 mm wide across widest point of closed elytra. Only differences to the male are noted.

Macropterous and assumed capable of flight; dorsal colouration as for male; ventral colouration as for male except for light organ material confined to V6, pale anterolateral elevated areas on V7 have fat body material beneath, and V5 dark brown with anterolateral corners a little pale.

Pronotum: 1.4 mm long, 2.6 mm wide; pronotum 1/6 – 1/7 as long as whole body; median anterior margin rounded, not projecting either beyond or behind the angulate obtuse anterolateral corners, and separated from them by rounded shallow emarginations; lateral margins divergent posteriorly; posterolateral corners angulate acute (angle is slightly larger that that of the male), projecting posteriorly as far as the medianly emarginated posterior margin and separated from it by shallow emarginations.

Elytra: 7.4–8.1 mm long; elytral margins subparallel sided in anterior 2/3, converging gently in posterior 1/3; maximum width across elytra 3.4 mm.

Head: is visible narrowly in front of the anterior pronotal margin in both females; GHW 1.5 mm; SIW 0.4 mm; ASD slightly > ASW; head barely depressed between eyes.

Legs: tibiae straight; no femora swollen or curved.

Abdomen: (Fig. 7; one female dissected) with posterior margin of V7 evenly and moderately deeply emarginated; posterolateral corners acute and narrow, projecting posteriorly beyond the median posterior margin of V7 by their width; ventral surface of V7 lacking any median ridges or troughs (surface here smooth); most of lateral areas and posterolateral corners occupied by paired irregular elevations (fat body is clustered beneath and these areas appear paler); anterior half of V8 narrowed and prolonged anteriorly beneath V7, prolonged portion darker, not much shorter than posterior expanded portion; V8 with a very narrow and shallow median posterior emargination; all of tergite 7 and 8 well sclerotised, dark, shiny and maintain a convex outline (convexity not limited to any section) while the remainder of the tergites are flat and shrivelled; posterior margin of tergite 7 evenly rounded; anterior margin of tergite 7 is elevated above the more anterior, dried and flattened tergites.

Female genitalia: Conform to those described in Ballantyne & Lambkin (2006).

Bursa structure: The only structures seen in a softened and partially cleared preparation of the genitalia, and what remained of the reproductive system, are a pair of anteriorly directed hooks lying between the anterior portion of the valvifers and assumed to be bursa hooks.

Etymology. **–** The species is named for its collector the late Dr Masataka Satô, in appreciation of a life dedicated to pursuit of knowledge in entomology and fireflies in particular.

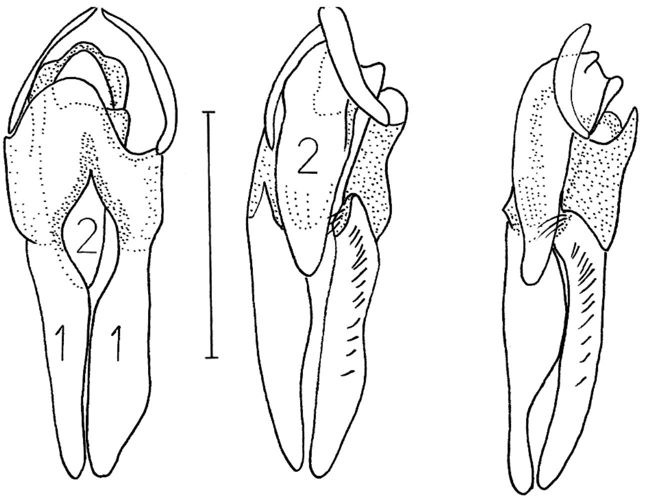

Fig. 8. *Pygoluciola satoi*, new species, aedeagus: 1, lateral lobe; 2, median lobe. Scale bar = 1 mm.

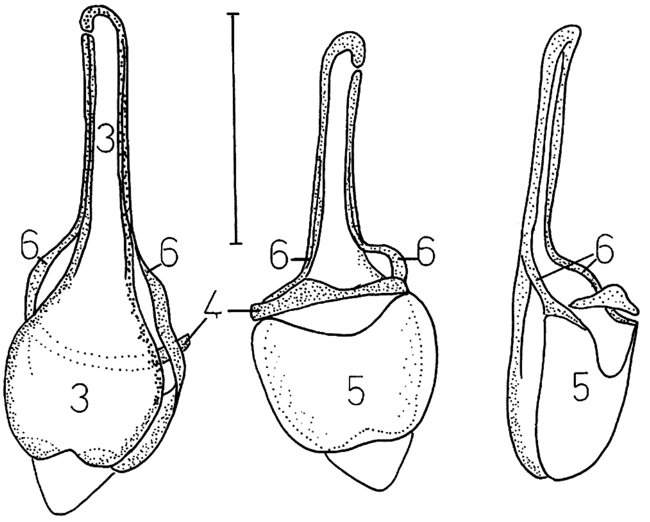

Fig. 9. *Pygoluciola satoi*, new species, aedeagal sheath: 3, sternite; 4, plate associated with sheath tergite; 5, tergite; 6, lateral arms of tergite. Scale bar = 1 mm.

DISCUSSION

This rare genus has not been recorded outside of the island of Borneo (Malaysia) until now. The inclusion of these specimens in *Pygoluciola* is supported by phylogenetic analysis (Ballantyne & Lambkin in prep), and certain differences in aedeagal sheath and abdominal structure are considered specific differences only. Similarity of aedeagal and sheath structure to an Australian species is suggested and should be explored. Ballantyne & Lambkin (2006) considered that drying of pinned specimens could affect structure and thus conjecture about function of various body parts, and this is expanded. Male head coverage by the pronotum in the Luciolinae is discussed, and contrasted with the situation in the Lampyrinae. A series of characters that can be used to characterise and emphasise this difference are listed. The orientation of the aedeagus relative to how it should be labelled in taxonomic descriptions, and its functions within the female body in delivering a spermatophore is explored. Accuracy of identifications not based on comparison with the type, or incomplete type examination (i.e. type not dissected) is questioned, as is identification when types cannot be located or accessed, and solutions are suggested.

Morphology and function – abdominal and aedeagal modifications

Phylogenetic analysis supports the inclusion of this species in *Pygoluciola* (Ballantyne & Lambkin, in prep.) Specimens conform to other described *Pygoluciola* in most aspects especially the narrowed and downturned apex of tergite 8. Hooks are present in the female bursa and possible functions of these hooks were explored (Ballantyne & Lambkin, 2006 where Fig. 37, page 27 has labelling transposed and 'S' represents the gland at the anterior end of the bursa and 'P' the much smaller spermatheca). Female *P. satoi* new species, have elevations on V7 in approximately the same area as those described on *P. guigliae* (Ballantyne & Lambkin, 2006), although they are irregular in outline and their function is unknown.

Males differ from other species in the tapering lateral margins of V7 (rather than being broadly rounded), projections on the dorsal face of the MPP, the longitudinal shallow depression on the ventral face of the MPP, the emarginated apex of the aedeagal sheath sternite and the lateral lobes of the aedeagus, which are a little longer than those of other species. The partially separate narrow plate on the dorsal surface of the aedeagal sheath was not seen in other *Pygoluciola*. It may be an anterior more heavily sclerotised margin of the sheath tergite that is partially detached. The lateral arms of the aedeagal sheath tergite, which in other *Pygoluciola* are more elongate and widely visible at the sides of the sheath ventrite, are shorter, and slightly irregular in outline in this species.

An Australian connection?

The aedeagal pattern of short median lobe, strongly sclerotised basal portion of the lateral lobes, which are only partially separate at their asymmetrical base, and elongate, rather fleshy apical portions is suggestive of the pattern seen in *Luciola cowleyi* Blackburn from the northern coastline of Australia (Ballantyne 1968: Figs. 170–172; Ballantyne & Lambkin, 2000: Fig. 21k). Ballantyne & Lambkin's 2000, 2001, and 2006 phylogenetic analyses did not place *L. cowleyi* with any degree of confidence. Their most recent analysis (Ballantyne & Lambkin in prep) includes *L. cowleyi* within *Pygoluciola*.

Methods of preservation affect taxonomic characters – probable artefacts of drying

Problems with methods of preservation and their impact on interpretation of various characters were discussed (Ballantyne & Lambkin, 2006) and the semitransparency of the cuticle and the consequent problems with interpretation of colour especially of the dorsal surface is overcome by detailing the extent of fat body retraction, and the transparent cuticle, in areas like the pronotum where it causes most problems. Although not always possible, examining both pinned and ethanol preserved specimens may help interpretation.

The apparent 'hook' described by Ballantyne (1968) on the aedeagus is further confirmed here as an area of heavier sclerotisation extending from the heavily sclerotised area at the base of the lateral lobes and running onto the ventral surface. Ballantyne & Lambkin (2006) indicated the problems with interpretation of this area and its function.

The opening at the base of female V7 (Ballantyne & Lambkin, 2001, 2006) is an artefact and another manifestation of the effect of drying – this ventrite has an elongate slender median anterior prolongation onto which attach, at least in part, muscles from the valvifers of the female genitalia. The 'opening' is seen in females from genera other than *Pygoluciola* (Ballantyne work in progress). The juxtaposition of this apparent hole and certain other modifications (transverse ridge, elevated portions in V7), together with the shape of the male terminal segments led Ballantyne & Lambkin (2001) to suggest the presence of a copulation clamp in *Pygoluciola*. While external structures appear in the abdomen of *P. satoi* females, there are no internal structures visible (apart from the bursa hooks) to suggest any function for the elevated portions of V7. No further evidence here supports the possibility of a copulation clamp operating in this genus.

Apart from this apparent hole, the other external female abdominal modifications are not considered to be simply a consequence of drying the specimens.

However while this is the only genus known thus far where there are distinctive external structures on the female abdomen, it is also fair to note that apart from work in progress to use bursa plates as an identification aid (Ballantyne) there has been little attention paid to female morphology in the Luciolinae, which has historically been male based (Ballantyne & Lambkin, 2006).

Ballantyne (1987) suggested that many apparent external male abdominal modifications were a reflection of muscle attachment, contractions of which in dried specimens could distort the cuticle. Some are more obvious consequences like the muscles attaching from the anterolateral portions of V7 to the lateral areas of tergite 7 in *Pygoluciola* males accounting for the depressed areas there (Fig. 5, labels '3, 4'). Muscle attachment and its consequences could at least partially explain the structures seen on female V7 and the tergite 7 and 8.

Head covered or uncovered and how to tell?

Olivier (1907) used the character of head covered to refer to those fireflies with hypomera of the pronotum open in front and head thus concealed beneath the explanate anterior pronotal margin. The Luciolinae did not fall into this category. Olliff (1889) distinguished a new Luciolinae genus *Atyphella* with head completely hidden beneath the pronotum, (where in reality it is retracted within the prothoracic cavity), and his confusion was indicated as he placed *Atyphella* in the Lampyrinae. In *Photuris trivittata* (Lloyd & Ballantyne, 2003) the hypomeron is open and the head concealed under the broadly explanate anterior margin of the pronotum but the head cannot be retracted into a prothoracic cavity which barely exists in this species. In *Atyphella*, certain species, including the type *lychnus* Olliff, have the head concealed both beneath the pronotum and within the prothoracic cavity, but this is as much a reflection here of the head size (that of *lychnus* is quite small) as it is of the shape of the pronotum (Ballantyne & Lambkin, 2000). Many Luciolinae, especially Australian species, have the head at least partially concealed in this manner, and the degree of head concealment may be difficult to quantify. Ballantyne & Lambkin (2000, 2001, 2006) used characters of hypomeron open or closed, and how far the head may be retracted into the prothoracic cavity (and thus often, but not always, covered by the pronotum from above). Head concealment in the Luciolinae, where the hypomeron is closed, can be explored in several ways though none is as clear cut as for those fireflies which have the hypomeron open. The width of the head relative to the width of the prothoracic cavity indicates that the head might fit into this cavity, and whether the head can be retracted into this cavity and if so, how far, can be considered. This is sometimes quite difficult when the head is protruded and not in its resting condition. In most *Pygoluciola* spp. while the head is retracted into the prothoracic cavity the anterior pronotal margin does not protrude in front of the anterolateral corners and the head may thus be visible from above in both males and also females. The hyopomeron is defined here as the 'deflexed portion of the notum (of the prothorax) which is attached directly to the sternum and separated from it by a *notosternal suture'* (Lawrence & Britton, 1991). Jeng (pers. comm.) considers the hypomeron defined in this manner is not always easy to determine and suggests that in such cases determination of whether the hypomeron is closed anteriorly will be difficult.

The aedeagus – which way is up?

Observations of retracted aedeagi in the aedeagal sheath before dissection show them inclined in any manner of ways, some even obliquely. Ballantyne (references herein) has consistently labelled aedeagi with the median lobe (that face with the ejaculatory orifice visible) as the ventral face. Jeng follows the same orientation for aedeagi as I do (Jeng et al. 2003; and Jeng pers. comm.). The functional side of the median lobe, through which ejaculation takes place, is that bearing the ejaculatory orifice, and labelled here as ventral. It may be that continuing to label the aedeagus in this way is a matter of convenience now for comparison with other work, but it may not reflect its morphological or functional orientation, if there actually is one.

Male fireflies produce a spermatophore (Ballantyne, pers.obs.), and this should be introduced directly into the female bursa, which opens from the anterior end of the vagina (Ballantyne & Lambkin, 2006). Wing et al. (1983 Fig. 3) appears to indicate that the aedeagus is orientated such that the ejaculatory orifice is uppermost. However the aedeagus could probably be orientated in any direction since the spermatophore, once discharged, will surely be introduced directly into the bursa. There may be the remote possibility that it could be introduced into the common oviduct instead. Fu & Ballantyne (2006) thought a strong plate at the base of the oviduct in its posterior wall may be to prevent this. However its position on the posterior wall of the oviduct may negate that hypothesis. Wing et al. (1983 Fig. 3) shows the ventral portion of the copulatory clamp, the MPP of ventrite 7, effectively sealing the rest of the female abdomen, (and possibly also the oviduct?) from the bursa.

Luciolinae males usually mount the female from above for intromission but later may assume a tail to tail position. Many other lampyrids remain in the male above, female below, position (Jeng pers comm.). The aedeagus is either orientated differently in these two groups (unlikely), undergoes some torsion in the tail to tail position, or its final position after intromission could be in any orientation and still be effective.

The problem with type specimens

To state the seemingly obvious, identification is a key issue for taxonomists, usually achieved by comparison with type specimens, particularly essential in the Lampyridae where old descriptions are usually inadequate, and specimens soft bodied and given to distortion and colour change when dried. But how reliable is a comparison with type material based just on colour and external morphology? How much weight can we place on identifications performed without comparison to the type, or where there are features of the type that have not been determined? What should we do when we cannot reliably identify a species or confirm that our specimens are new by comparison with types?

A holotype, if there is one, is unique in its taxonomic status. It may also be physically unique as the only known representative of that particular species e.g. *Luciola* (*Photuroluciola*) *deplanata* (Pic), *Atyphella ignota* Olivier (both types in MNHN; Ballantyne observations based on work in progress). Taxonomists have their own opinions whether unique types should be dissected, and a reluctance to dissect type material is understandable, particularly if, as was the case here, the specimen is fragile and representative of a poorly known group. A partial solution is outlined below.

Why redescribe?

Behavioural work should be able to proceed unhindered, but the behaviourists as well as the taxonomists need to know just what they are working on, or that at some stage in the future their material will be reliably identified, and not be hindered by an inadequate taxonomic structure. Firefly taxonomists, few as we are, face added complications – poor original descriptions, and difficulty in obtaining or even locating types. Apart from their age and fragility they are usually in European museums, an extra problem for the cash strapped antipodean taxonomist.

Elucidation of the nature of, and relationships between the many similarly coloured species within the Luciolinae and the genus *Luciola* especially, will only result from study of full morphological descriptions which are based on a set of repeatable and verifiable character sets and states. If the species is a tentative identification as many must be at this stage, the specimens that make up the material should all be treated in the same manner and lodged as taxonomic 'vouchers' (i.e. effectively as 'types') so that at some stage in the future it may be possible for more accurate confirmation of their identity. This can only happen when the specimens can be accurately relocated.

There are already methods that have allowed behavioural work to proceed when a taxonomic framework does not exist. Ballantyne's tentative identifications of New Guinean fireflies in Lloyd (1973) pioneered (as a result of discussions with Lloyd) a way of coping with behavioural data for which there was no suitable taxonomic framework. Species were either identified, or if thought to be new were given code names e.g. *Luciola* species 1; such species groups were represented by behaviour vouchered specimens and the actual taxonomic descriptions/redescriptions followed e.g. Ballantyne (1987) on the genus *Pteroptyx.*

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