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Fireflies of Pulau Ubin, Singapore

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Abstract. Surveys from 2012–2016 uncovered at least six morphospecies of fireflies (Coleoptera: Lampyridae) within five genera on Pulau Ubin, Singapore—*Pteroptyx valida*, *Diaphanes* sp., *Colophotia* c.f. *praeusta*, *Curtos* sp. and possibly *Stenocladius* sp. and *Diplocladon* sp. (Coleoptera: Rhagophthalmidae). *Curtos* sp. is possibly a new record for Singapore. The distribution of species was likely closely associated with habitat type. With about 50% of the country's firefly diversity, Pulau Ubin is an important site for the conservation of fireflies in Singapore.

Key Words. fireflies, Lampyridae, Rhagophthalmidae, Pulau Ubin, Singapore

INTRODUCTION

The term 'firefly' refers loosely to insects that exhibit bioluminescence in the dark. True fireflies, however, refer to beetles in the family Lampyridae. *Diplocladon* sp., which belongs to the family Rhagophthalmidae, only exhibits glowing in the larval stage and not the adult stage. A previous survey of fireflies in Singapore (Chan et al., 2012), although focused on Singapore Island, included Pulau Ubin, where only one species (*Pteroptyx valida*) was recorded.

Pulau Ubin is an island situated off the north-eastern corner of Singapore Island (Fig. 1). It is about 1,020 ha in area, stretching about 8 km from east to west, and about 2 km from north to south. Much of the island's original vegetation, 'presumably lowland rain forest and mature mangrove forest' (Turner et al., 1992), had been cleared for settlements, cultivation of rubber, coconut, fruits and other cash crops, prawn farming, and granite mining. In his report of 1825, Resident John Crawfurd mentioned that there were already a few tree loggers living on the island (Turnbull,

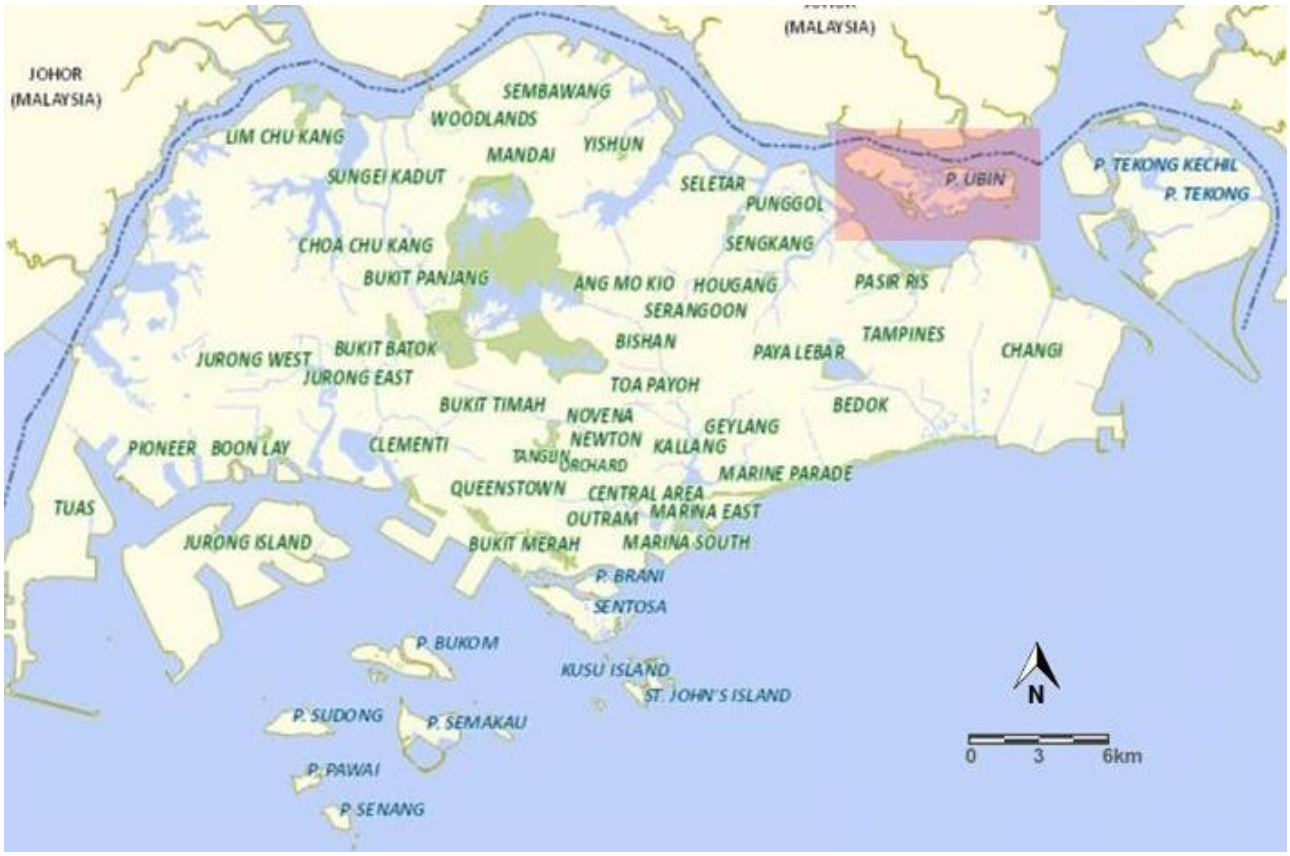

Fig. 1. Location of Pulau Ubin in Singapore.

1989). The human population grew to 2,028 in 1970 (Arumainathan, 1970), but with the eventual phasing out of the main economic activities, namely granite mining and rubber cultivation, most residents on Pulau Ubin resettled to Singapore Island. Further resettlement saw the number of people residing on Pulau Ubin on a daily basis dwindle to 44 in 2017.

The reduction of the local populace and cessation of impactful activities like granite mining, prawn farming and cultivation of plantation crops allowed for the regeneration of natural vegetation and increase in wildlife habitats. Pulau Ubin's native species assemblage in 2017 includes 725 vascular plants, 33 mammals, 231 birds, 43 reptiles, 7 amphibians, 177 butterflies, and 54 dragonflies and damselflies.

The aim of this survey was to better determine the diversity and distribution of fireflies on Pulau Ubin, as part of efforts by the National Parks Board (NParks) to establish and maintain a baseline inventory of the island's biodiversity. The information gathered will enable NParks to formulate management strategies for the long-term conservation of Pulau Ubin's natural heritage.

MATERIAL AND METHODS

A total of 37 night surveys were carried from October 2012 to December 2016. Survey transects were spread throughout the island in different habitats (Figs. 2, 3), and lasted from 1930 hours (after sunset) to 2230 hours. Locations referred to were based on the gazetteer provided by NParks (Fig. 4). Surveys along open paths were conducted in the dark. For surveys in forested areas, surveyors manoeuvred in a leap and bound fashion, moving a distance with the lights and then stopping to looking for fireflies in the dark, before moving on with lights again. Fireflies spotted were collected if they were within reach. After several encounters, it was possible for observers to identify some of the fireflies to genera on the fly (Lloyd, 1969) based on their flashing behaviour. Apart from a representative specimen taken for each species, all other fireflies were returned to their original location of capture after a series of photographs were taken. These specimens will be deposited in the Lee Kong Chian Natural History Museum, National University of Singapore. All specimens were identified to the lowest possible taxonomic level with the help of experts, Lesley A. Ballantyne and Wan F.A. Jusoh.

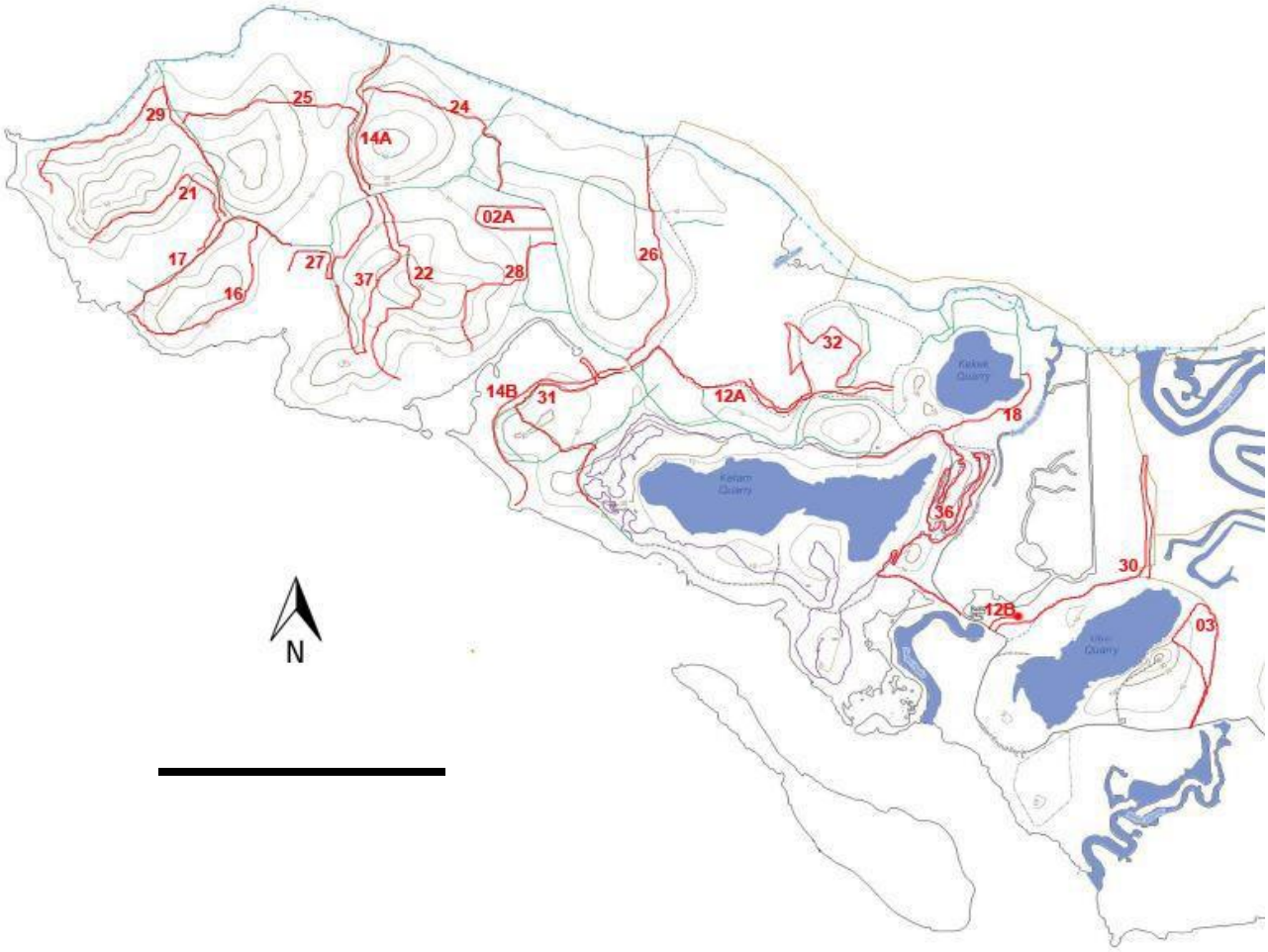

Fig. 2. Transects in the western part of Pulau Ubin. Each number represents a night of survey. Scale bar = 1 km.

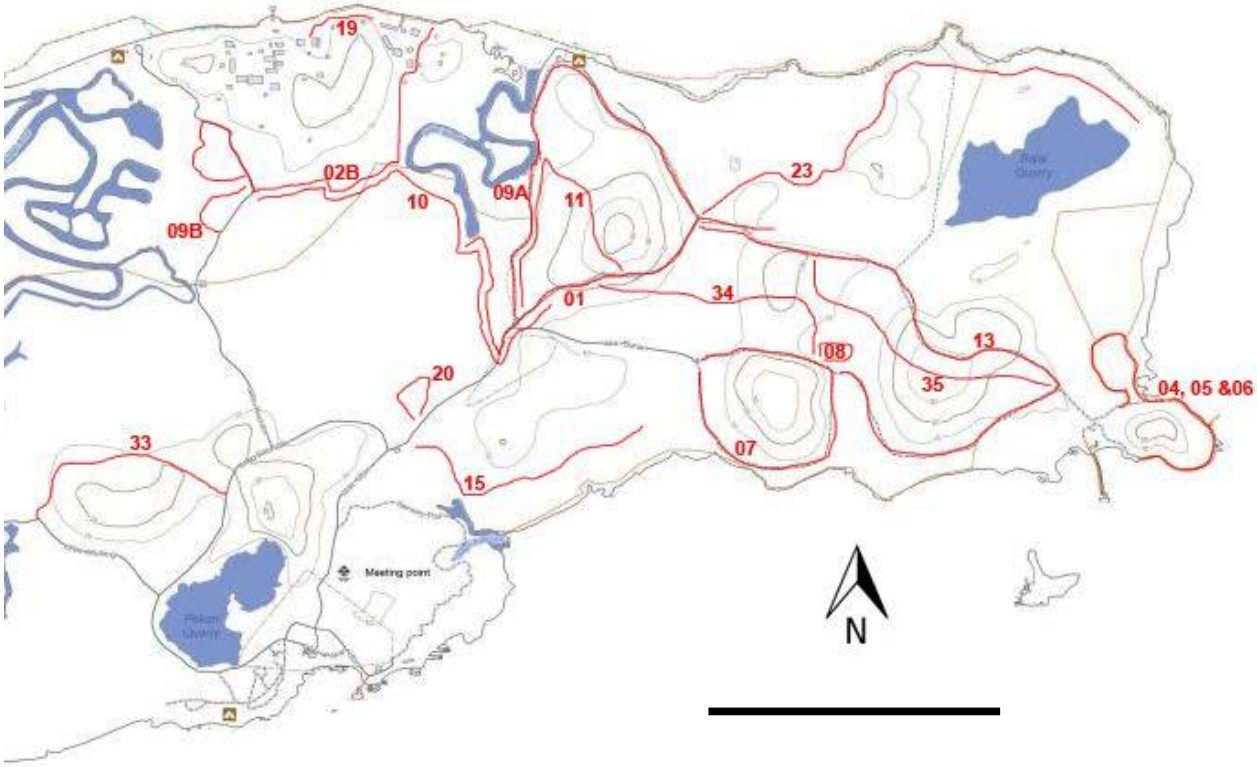

Fig. 3. Transects in the eastern part of Pulau Ubin. Each number represents a night of survey. Scale bar = 1 km.

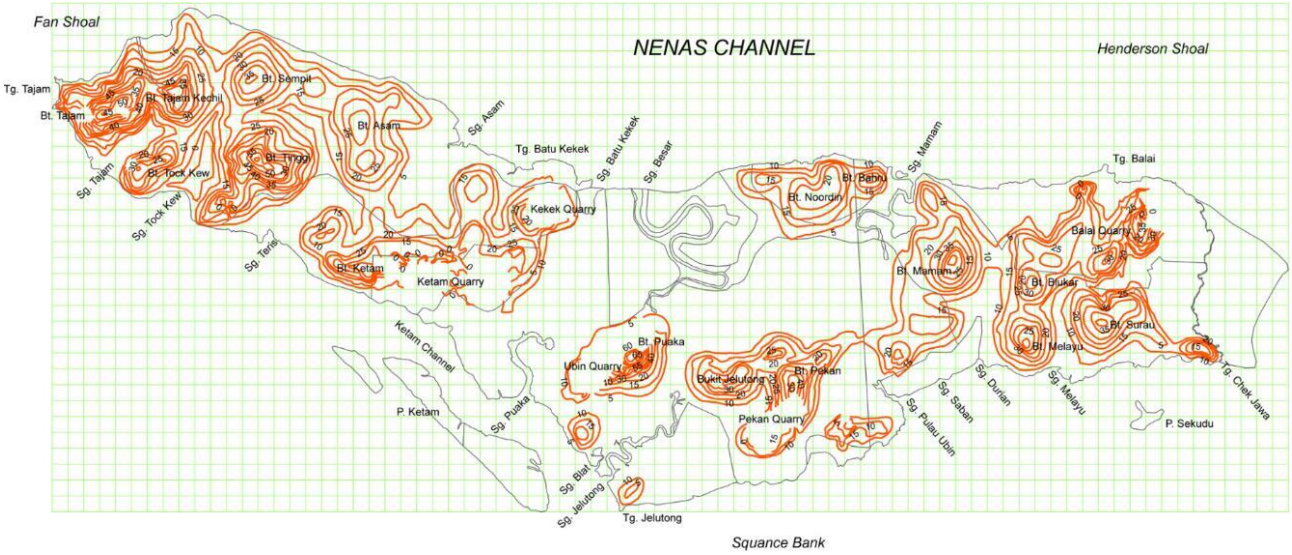

Fig. 4. Ubin gazetteer with names of locations.

OBSERVATIONS AND RESULTS

There were 123 records with adult fireflies and more than 30 records with larvae. At least six morphospecies of fireflies were detected—*Colophotia* cf. *praeusta*, *Curtos* sp., *Diaphanes* sp., *Pteroptyx* cf. *valida*, and larvae from two unidentified species, possibly *Stenocladius* sp. and *Diplocladon* sp. With the exception of *Diplocladon*, which belongs to the family Rhagophthalmidae, all the other taxa belong to the family Lampyridae. The distribution of each encounter and genus during the survey period, can be seen in Figs. 17 and 18.

Colophotia* cf. *praeusta (Fig. 5)

Colophotia sp. (Fig. 5) was found at Tanjong Chek Jawa (Fig. 6) and Kekek Quarry. There were four encounters (3% of total survey records) with adult fireflies, flying from 1–3 m above ground, with a slight orange-yellow flashing

Fig. 5. *Colophotia* sp. (a), Ventral view of female found at Tanjong Chek Jawa on 21 August 2013; (b), dorsal view of same female; (c), ventral view of male found at Kekek Quarry on 30 December 2014; (d) dorsal view of same male. Scale bar = 1 mm.

Fig. 6. Habitat at Tanjong Chek Jawa where *Colophotia* sp. was found.

bioluminescence. A male specimen, 3 m up in a tree at Kekek Quarry, was caught using a telescopic pole and net. Pending confirmation from experts, the species has been identified as *C. praeusta*.

***Curtos* sp.** (Figs. 7, 8)

Found at only one locality, this species was observed at the western forest of Pulau Ubin (Fig. 17) in an ecotone between secondary forest and low-lying scrubland. There were 33 sightings (27% of all survey records) with both males and females emitting a bright green flashing bioluminescence (the last segment of the female does not glow). Specimens were about 4 mm in size. The substrate was moist and abundant with leaf litter.

Fig. 7. *Curtos* sp. (a), Dorsal view of male found on 29 April 2015; (b), ventrolateral view of same male. Scale bar = 1 mm.

Fig. 8. *Curtos* sp. (a), Dorsal view of female found on 29 April 2015; (b), ventral view of same female. Scale bar = 1mm.

***Diaphanes* sp.** (Figs. 9, 10)

There were many encounters of *Diaphanes* sp. in the western part of Pulau Ubin and one locality at Tanjong Chek Jawa. Only males were found flying around at about 1–2 m above ground, with a constant non-flashing bright green bioluminescence. A specimen of what is suspected to be a larviform female was collected at Bukit Tajam Kechil. Adults were observed on 54 occasions (44% of all survey records), usually at the fringe of secondary forest (Fig. 11) with a nearby freshwater source.

Fig. 9. *Diaphanes* sp. (a), Dorsal view of male found along a trail at Tanjong Chek Jawa on 21 August 2013; (b), ventrolateral view of same male; c) wing venation of same male; (d) dorsal view of male found at Bukit Tajam Kechil on 29 December 2015. Scale bar = 1 mm.

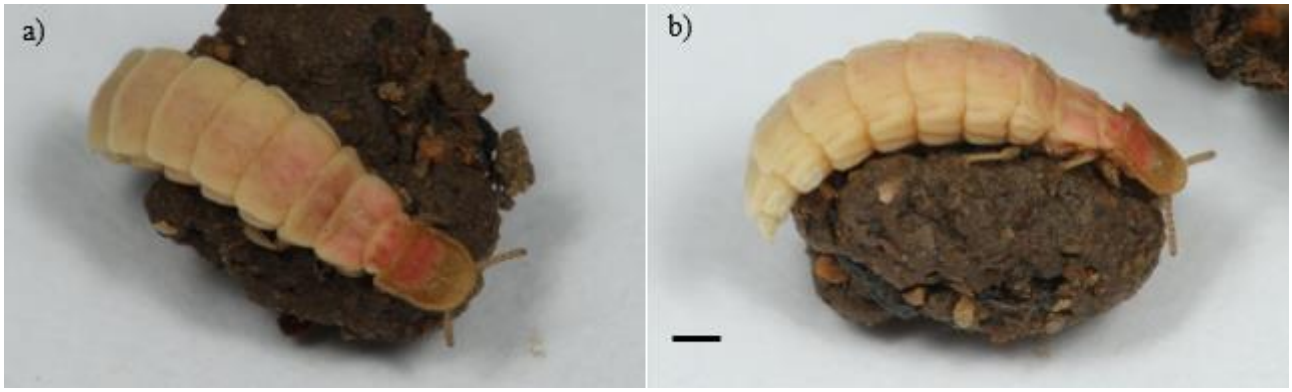

Fig. 10. (a), Dorsal view of possible larviform female found at Bukit Tajam Kechil on 29 December 2015; (b), lateral view of same female. Scale bar = 1 mm.

Pteroptyx* cf. *valida (Figs. 12, 13)

All encounters were in or near mangroves (Fig. 14). This species emits a slight yellowish-green flashing bioluminescence.

Fig 11. Habitat at Tanjong Chek Jawa where *Diaphanes* sp. was found.

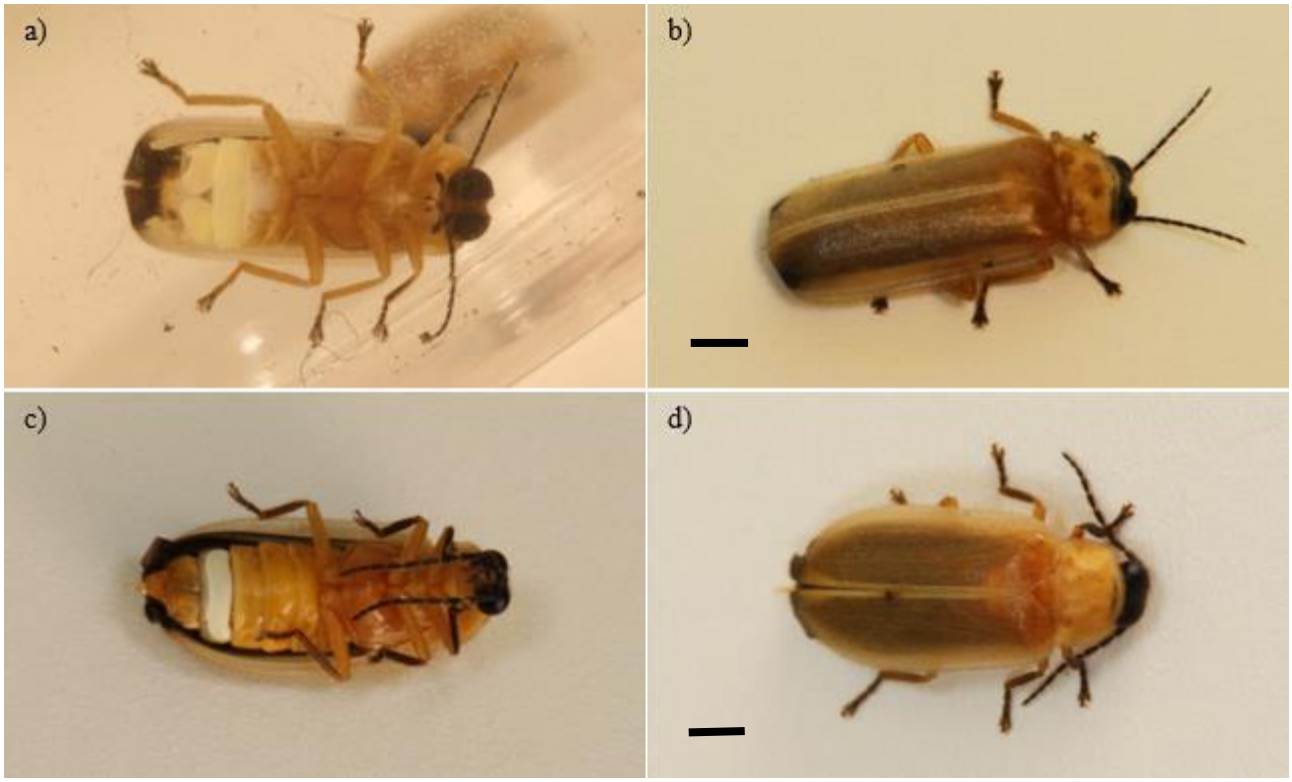

Fig. 12. *Pteroptyx* sp. (a), Ventral view of male found at Puaka East on 18 June 2014; (b), dorsal view of same male; (c), ventral view of female found north-east of Sungei Pulau Ubin on 23 September 2014; d) dorsal view of same female. Scale bar = 1mm.

Adults were observed flying from 1–5 m above ground in between trees, with males usually higher up. Larval forms, sometimes with prey, were found only in mangroves. Based on photographs and past records, the species was tentatively listed as *P. valida*.

Fig. 13. Larva of *Pteroptyx* sp. with prey found at along boardwalk at Tanjong Chek Jawa on 5 July 2013. Scale bar = 1mm.

Fig. 14. Habitat at Tanjong Chek Jawa where *Pteroptyx* sp. was found.

***Diplocladon* sp.?** (Fig. 15)

This species was encountered only once in the survey. A specimen was collected from a fallen tree branch, after rain. It was suspected to be a *Diploclodon* sp. based on the locations of the bioluminescent spots on its body, similar to *Diplocladon* sp. found on the main island of Singapore (Chan et al., 2012). This species belongs to family Rhagophthalmidae and is not a true firefly all of which belong to the family Lampyridae.

Fig. 15. Possible *Diplocladon* sp. (a), Dorsal view of larva found at Bukit Tajam Kechil on 29 December 2015; (b), glow locations on same larva; (c), dorsolateral view of same larva. Scale bar = 1cm.

***Stenocladius* sp.?** (Fig 16)

A single larva was collected from the moist forest floor at a trail leading to Tanjong Chek Jawa. The specimen was about 4 mm in length and had two constant glow lines on each side. It was suspected to be *Stenocladius* sp. based on its glow pattern.

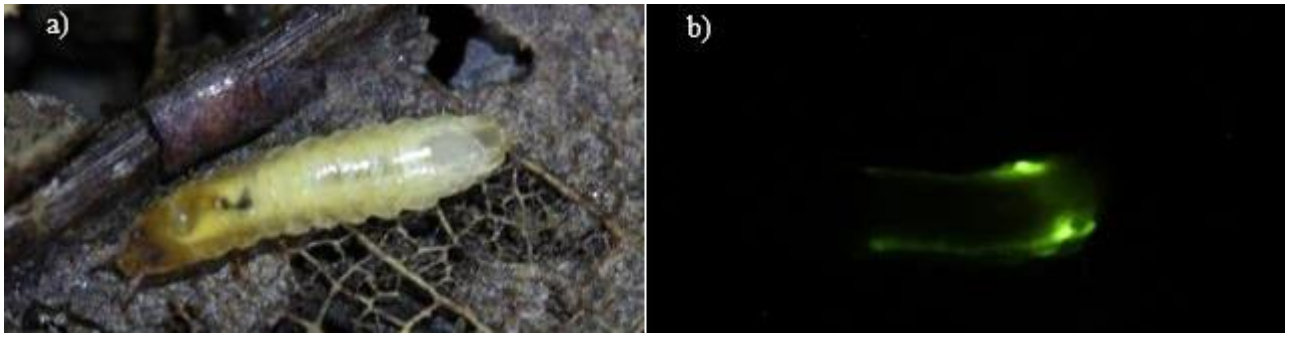

Fig. 16. Possible *Stenocladius* sp. (a), Dorsal view of larva found at Tanjong Chek Jawa on 16 September 2016; (b), glow of same larva. Scale bar = 1mm.

DISCUSSION

Chan et al. (2012) recorded possibly seven genera and 11 species of fireflies in Singapore, and found only *Pteroptyx valida* on Pulau Ubin. The current survey establishes that firefly diversity on Pulau Ubin is much higher, with least five genera and six morphospecies. This is about half of the species diversity known from Singapore, with a possible new record for Singapore, *Curtos* sp., presently known only from Pulau Ubin.

Species distribution (Figs. 17, 18) appeared to be largely associated to habitat type, with *Curtos* sp. found only in secondary forest at a single locality at Bukit Tinggi, and *Diaphanes* sp. occurring in secondary forest in the eastern and western parts of Pulau Ubin. While Chan et al. (2012) found only one specimen (male) in Nee Soon Swamp Forest, *Diaphanes* sp. was abundant and easily found on Pulau Ubin. *Pteroptyx* c.f. *valida* was noted to be associated with mangroves. *Pyrocoelia* sp. was not detected on Pulau Ubin. More research is needed to elucidate the distribution patterns of firefly species on Pulau Ubin, but the degree of habitat disturbance (Luk et al., 2011) and light pollution (Costin & Boulton, 2016) are likely to be key factors.

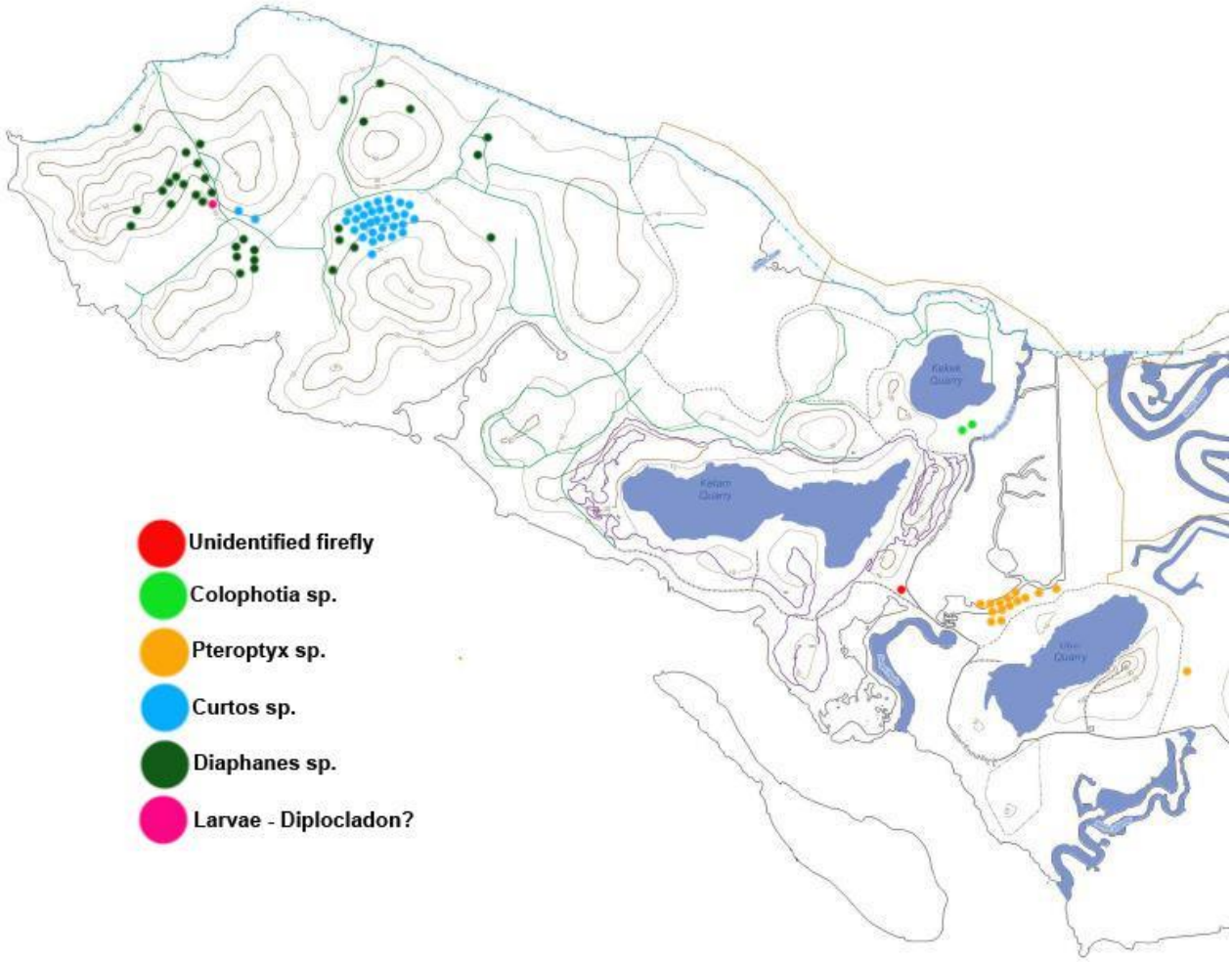

Fig. 17. Records of fireflies in the western part of Pulau Ubin. Each spot signifies a record.

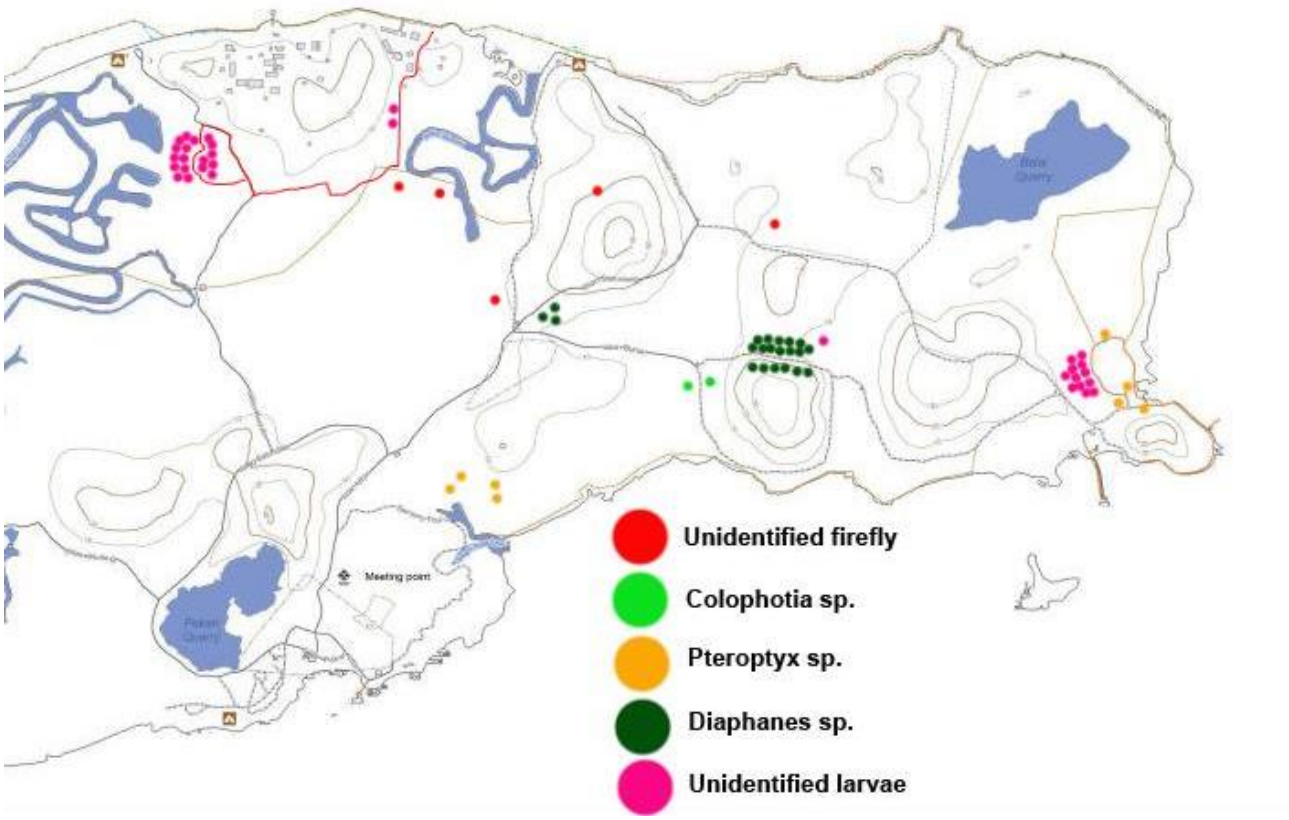

Fig. 18. Records of fireflies in the eastern part of Pulau Ubin. Each spot signifies a record.

An interesting observation was that *Pteroptyx* sp. males were found flying higher than females. It is hypothesised that when females are scarce, the males adopt a higher position to search for the bioluminescent flashes of the females. Lloyd (2000) noted that males often seem to be found flying higher when it was darker during the later hours of the evening and when in forest cover, but qualified that such deductions are hard to quantify in nature due to many variables. More research is needed to confirm the hypothesis.

Chan et al. (2012) reported the success of trials to raise juvenile *Pteroptyx valida ex-situ* on a variety of molluscs prey. The observation of *P.* cf. *valida* larvae with a spider prey, supports the suggestion by Barrows et al. (2008) that *P. valida* predates on a variety of other arthropods as well.

The study and conservation of fireflies in Singapore is hampered by challenges in assessment of local firefly assemblages. This is due to taxonomic complexities of the group, coupled with low number of specimens in collections for comparison. It is hoped that the results, observations and discussions shared here will contribute to improving the situation.

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