Systematic revision of the repository collection of Canthoroidea in the Department of National Museums, Colombo, Sri Lanka (Coleoptera: Cantharidae, Lampyridae, Lycidae, Rhagophthalmidae)

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Abstract: The collection of Sri Lankan Cantharoidea in the National Museums Colombo was initiated and identified by European and British collectors in the early 1800s. Their collection has been reserved as “Sri Lankan firefly collection” in the National Museums, Colombo. Subsequently no systematic studies have been undertaken in an attempt to confirm the identifications and update the classification of these specimens using recent taxonomic information. During January to June in 2010, we examined 1,214 dry mounted specimens using a stereo microscope to determine external morphology in an attempt to reclassify specimens using up to date taxonomy. The collection originally was arranged into 4 families classified under 27 genera and 63 species. In our opinion, there are 4 families, containing 29 genera and 61 species including 27 Lampyridae species. The collection is clearly marked with labeled specimens indicating any authority for the suggested changes.

Keywords: Cantharoidea, Museum collection, Reclassification, Sri Lanka.

INTRODUCTION

The collection of specimens of Sri Lankan Cantharoidea was carried out by European and British naturalists in the 18th century. They built up the museum collection through expedition and contributed to our present knowledge of the Sri Lankan fireflies. Documentation of the Sri Lankan Cantharoidea was initiated with the establishment of the British rule. Findings of these surveys and studies were recorded in the “Fauna of British India” Series (Arrow, 1910; 1917; 1931).

Tennent (1861) recorded 2,007 insect species in 9 orders in Sri Lanka. A list of Sri Lankan beetles in the collection of the Colombo Museum in 1890 recorded 1,510 insect species (Haly, 1890). Tennent (1849) included 28 species of fireflies belonging to five genera from Sri Lanka (Appendix 1). Twenty nine species of Cantharoidea were recorded by Green (1912). Thirty species of Cantharoidea have been recorded as a dominant group of nocturnal insects in terrestrial and aquatic environments in Sri Lanka by Baker (1937) and Bertrand (1973). McDermott (1966) listed 31 species of Lampyrids from Sri Lanka (Appendix 2).

Among the originally recorded 24 Lampyrid species from Sri Lanka, Luciola melaspis and L. cingulata have been recorded from Southern Province (McDermott 1964, 1966), while the endemic species, Harmatalius ototreinae has been recorded from Central Province of Sri Lanka. Olivier (1885) reported Luciola chinesis, L. cingulata and L. doriae from Galle in Southern Province in Sri Lanka. The occurrence of aquatic Lampyrid larvae in Sri Lanka has been reported by Bertrand (1973).

In 2010, Ballantyne prepared the “Geographical list of Luciolinae fireflies in South-east Asia”, including 258 species using the information of McDermott (1966) list. Out of that, type specimens of 16 species of Lampyrids recorded from Sri Lanka were located in the Natural History Museums in London and Paris. A study was carried out in 2009 on Lampyrid distribution and species composition in agro ecosystems and other natural habitats in Southern Province of Sri Lanka (Wegiriya et al., 2009; Bogahawatte et al., 2009). They identified and
classified the collected Lampyrids to a certain extent (7 species) and their studies highlighted the importance and need for a taxonomic revision of Sri Lankan Lampyrids.

Studying the systematics of Cantharoidea in Sri Lanka is an important aspect of biodiversity and conservation of the country. Further, it will be helpful to discard the outdated taxonomy and incorrect identifications and to introduce correct identifications to the list of Sri Lankan insects.

The objective of the present study was to investigate the previous taxonomic information of Cantharoidea specimens deposited at the Department of National Museums, Colombo, Sri Lanka and to revise their systematics using currently valid taxonomic information.

MATERIALS AND METHODS

The collection of Cantharoidea specimens in the ‘Sri Lankan firefly collection’ at the Department of National Museums, Colombo were used for the study.

Specimen selection and data collection

Dry mounted adult firefly specimens of 1,214 categorized as ‘Sri Lankan fireflies’ were examined using a compound light microscope (maximum magnification 40×) from January to June in 2010. Each specimen was photographed using a Dino-Lite digital microscope (Dino Capture- version 2.5). List of the Cantharoidea species and information labels including collector’s name, location, date, and their taxonomy available at the Department of National Museums, Colombo were recorded. Practical and handling limitations of reference specimens were also recorded.

Identification of species

The genus/species level of repository specimens was confirmed using external morphological characters such as colour pattern of dorsal and ventral side of the body, light organ shape, number of light segments and type of antenna. Information available in taxonomic keys, photographs of type specimens deposited in London and Paris museums were used to confirm the identifications (Ballantyne and Lambkin, 2009; Jeng, 2008). The modern identification techniques such as genitalia dissection was not applied due to practical limitations and regulations of the museums. Hence, taxonomic identification of many of the Luciolinae was difficult.

Systematic revision and classification

Identified specimens and their external morphological characters were compared with the updated taxonomic information up to 2013 in South-east Asia (Ballantyne and Lambkin, 2009; Ballantyne et al., 2013; Jeng, 2000, 2001, 2003b, 2008 and 2010; Branham, 2001). The list of recorded Cantharoidea from the museum was updated including their revised classification (Table 1).

RESULTS

Observed species of Cantharoidea deposited at the Department of National Museums, Colombo

Specimens at the Department of National Museums, Colombo have been categorized into 63 species of 27 genera in 4 families (Table 1). However, all these specimens have been allocated as ‘Sri Lankan firefly collection’ in the National Museums, Colombo.

All specimens have been collected before early 18th century, e.g., Lyropaeus fallex (in 1419), Hatiogewani dishaota (in 1411), Lycostomus similis (in 1450). Hence, some of these specimens are already destroyed, lost or damaged due to handling and fungal attacks. Some specimens are not returned by researchers while others have been sent abroad for further identification. Specimens of the following species which have been recorded from Sri Lanka in publications were not found in this collection at present: Lycostomus spraeustus, Taphes brevicollis, Xylobanus costifer, Xylobanus humerifer, Plateros testaceus, Plateros exsertus, Plateros limbaticollis, Luciola candezei, Luciola promelaena, Luciola antennalis, Luciola horni, Luciola nicolieri, Luciola perplexa, Luciola ochracea, Diaphanes bugnioni, Harmatelia discalis, Ditoneces scabripennis, Lucernut slateralis, Lucernuta oblonga, Micronychus terminates, Lamprophorus lutosipennis, Dilophotes bugnioni, Ectodaphus languidus, Lamprophorus slutescens.
The list of Cantharoidea deposited at the Department of National Museums, Colombo is updated in the present study and their classification is revised according to the updated taxonomy in South-east Asia.

**DISCUSSION**

This study focused on the revision of the Cantharoidea deposited in the ‘firefly collection’ at the Department of National Museums, Colombo using the updated systematics of south-east Asian region. The repository collection of the Cantharoidea at the Department of National Museums, Colombo, could be categorized into nocturnal and diurnal firefly species based on external morphology of specimens such as the type of the antenna and presence of light organs in abdominal ventrites (diurnally active species have well-branched, unispectinate, antenna and no light organs). As such, repository specimens of Family Lampyridae consisted mainly of nocturnal species and diurnal species that belonged to genus *Harmatelia*. Repository specimens of Family Cantheridae, Lycidae and Rhagophthalmidae consisted of species identified as diurnal fireflies (Jeng, 2010).

According to the old taxonomic information the original repository collection at the Department of National Museums, Colombo represented 63 species belonging to 27 genera in 4 families. Present systematic revision reveals that the number of species of the repository specimens is reduced to 61 and the number of genera is increased to 29 in 4 families. The present systematic revision of these recorded species was conducted based on newly introduced two new genera of Luciolinae namely genus *Abscondita* and *Asymmetricata* and the amendment of four species of the genus *Luciola* to two species of genus *Abscondita*. As such, species namely *Luciola melaspis* and *L. promelaena* are revised to *Abscondita promelaena*, while *Luciola chinensis* and *L. vespertinae* are revised to *Abscondita chinensis*.

Among the specimens, 19 species belonged to the Subfamily Luciolinae which has its highest diversity in South-east Asia (Ballantyne et al., 2005). In 2013, Ballantyne et al. described a new genus *Abscondita* based on the shapes of male light organs and features of the genitalia. Consequently, specimens labeled as *Luciola melaspis* and *Luciola promelaena* were placed under *Abscondita promelaena* (Walker). Specimens standing originally under *Luciola chinensis* and *Luciola vespertina* were placed under *Abscondita chinensis*, and those standing under *Luciola perplexa* were placed under *Abscondita perplexa*.

In 2009, Ballantyne et al. suggested that the new genus *Asymmetricata* based on the asymmetric nature of the 8th abdominal tergite. Specimens identified in the collection as *Luciola humeralis* and *Luciola impressa* were moved under the genus *Asymmetricata*. This does not constitute any formal realignment of these species at this stage, but we recognized that males of both these species possessed a asymmetrical abdominal tergite 8 characteristic of the genus *Asymmetricata*.

Ballantyne et al., (2009) proposed another subdivision, *Luciola substriata* complex based on the similarity of the shape of male’s light organ in 7th abdominal ventrite and the presence of sclerites surrounding the aedeagal sheath. Species including *L. substriata*, *L. aquatilis*, *L. cingulata*, *L. seriata* and *L. brahmina* were assigned to that complex. According to this taxonomic revision, *L. cingulata* should be grouped under the subdivision of *L. substriata* complex.

Available literature records in south-east Asia were not sufficient to revise the systematics of other Luciolinae species at the Department of National Museums, Colombo. Hence, their systematics were not revised. In addition systematics of *Luciola candezei*, *L. antennalis*, *L. horni*, *L. nicollieri*, and *L. ochracea* were not done due to unavailability of specimens at the Department of National Museums, Colombo.

Out of the Luciolinae in the south-east Asia, *Luciola antennalis*, *L. horni*, *L. cingulata*, *L. doriae*, *L. humeralis* and *L. auritula* were originally recorded from Sri Lanka (McDermott, 1966). However, the species of *L. auritula* has not been included in the list of fireflies at the Department of National Museums, Colombo.
Table 1: Annotated list of Canthoroidea deposited at the Department of National Museums, Colombo and their revised classification according to the updated systematics in South-east Asia

| Species                  | assigned group/complex |
|--------------------------|------------------------|
| **Lycidae**              |                        |
| *Atelius expansicornis*   | Diurnal                |
| *Calochromus m. similans*| Diurnal                |
| *Cantharis dimidiata*     | Nocturnal              |
| *Cautires dignus*         | Nocturnal              |
| *Diaphanes lutescens*     | Nocturnal              |
| *Diaphanes olivieri*      | Nocturnal              |
| *Diaphanes taptopbanus*   | Nocturnal              |
| *Diaphanes vitrifera*     | Nocturnal              |
| *Diapoma greeni*          | Nocturnal              |
| *Diapoma adamsi*          | Nocturnal              |
| *Dictoneces aculeatus*    | Diurnal                |
| *Dictoneces pubicornis*   | Diurnal                |
| *Dictoneces pubipennis*   | Diurnal                |
| *Dilaphotes bugioni*      | Diurnal                |
| *Ditonesce soabripennis*  | Nocturnal              |
| *Ditonesce terminalis*    | Diurnal                |
| *Ectodaphus languardius*  | Diurnal                |
| *Harmatelia bilinia*      | Pan-ototretines (Diurnal) |
| *Harmatelia discalis*     | Pan-ototretines (Diurnal) |
| *Ichthyurus bicaudata*    | Diurnal                |
| *Lamprophorus diffinis*   | Nocturnal              |
| *Lamprophorus lutescens*  | Nocturnal              |
| *Lamprophorus latosipennis* | Nocturnal              |
| *Lamprophorus tenebrosus* | Nocturnal              |
| *Lucernata ablonga*       | Nocturnal              |
| *Lucernata lateralis*     | Nocturnal              |
| *Luciola antennalis*      | Nocturnal              |
| *Luciola candzei*         | Nocturnal              |
| *Luciola chinensis*       | Nocturnal              |
| *Luciola cingulata*       | Nocturnal              |
| *Luciola doria*           | Nocturnal              |
| *Luciola extricans*       | Nocturnal              |
| *Luciola horni*           | Nocturnal              |
| *Luciola humeralis*       | Nocturnal              |
| *Luciola impressa*        | Nocturnal              |
| *Luciola intricata*       | Nocturnal              |
| *Luciola melaspis*        | Nocturnal              |
| *Luciola ncollieri*       | Nocturnal              |
| *Luciola nigripes*        | Nocturnal              |
| *Luciola ochracea*        | Nocturnal              |
| *Luciola perplexa*        | Nocturnal              |
| *Luciola promelaena*      | Nocturnal              |
| *Luciola vespertina*      | Nocturnal              |
| *Lycostomus analis*       | Diurnal                |
| *Lycostomus internexus*   | Diurnal                |
| *Lycostomus praeustus*    | Diurnal                |
| *Lycostomus similis*      | Diurnal                |
| *Lyropaeus fallax*        | Diurnal                |
| *Metriorrhynchus astuts*  | Diurnal                |
Repository specimens of eight firefly species at the Department of National Museums, Colombo have been classified under two genera namely Lamprophorus and Diaphanes belonged to Subfamily Lampyrinae. In 2000, Jeng et al. redescribed the genus Lamprophorus as Lamprigera. According to that, the recorded repository specimens of Lamprophorus diffinis, L. lutescens, L. lutosipennis and L. tenebrosus should be revised as Lamprigera diffinis, L. lutescens, L. lutosipennis and L. tenebrosus.

In 2001, Jenget al. described the systematics of genus Diaphanes in detail. The repository specimens of Diaphanes lutescens, D. olivieri, D. taprobanus and D. vitriferawere identified using Jeng’s paper. Among them, two species namely D. lutescens and D. olivieri were originally recorded from Sri Lanka (McDermott, 1966). Firefly species of genus Harmatelidia are presently considered as one of the diurnal firefly groups (Jeng, 2008). According to the old systematics, Harmatelidia bilinia and H. discarlis have been classified into Subfamily Pterotinae and Family Prilidae.

In 2008, Jeng suggested the new paraphyletic group, Ototretadrilinae-Ototretinae complex to Family Lampyridae and it contained diurnally active firefly species which were earlier belonged to Family Drilidae and Prilidae. According to that, the systematics of genus Harmatelidia should be revised to Group Pan otoetretines, Subfamily Ototretadrilinae-Ototretinae complex and Family Lampyridae. The confirmation of the taxon and the revision of systematics of species such as Diaptoetoma greeni and D. adamsi, and Rhagophthalimus species (R. confuses) are complicated due to lack of literature records and valid systematic information.

Repository species belonged to Family Cantharidae (Cantharis dimidiata) and Family Lycidae (Genera Lycostomus, Tapes, Metriorrhynchus, Cautires, Xylobanus, Ateilus, Plateros, Dictoneces, Ectodaphus, Micronychus, Calochromus, Dilophotes, Lyropaeus) are presently considered as diurnally active species (Jeng, 2008). Further classification and identification of these species cannot be completed due to lack of valid taxonomic information of these families.

Systematics of Cantharoidea specimens deposited in the ‘firefly collection’ at the Department of National Museums, Colombo has not been updated since their original work began in early eighteenth century by Europeans. In this study, some of the repository firefly specimens were revised using currently valid taxonomic information of south-east Asia and it will be useful for future researchers, taxonomists and scientist for their studies on Sri Lankan insect fauna.

**CONCLUSION**

Of the 63 species in four genera listed in table 1, due to lack of updated taxonomic information and access to specimens, we were unable to further address thirty Lycidae, one Cantharidae, two of uncertain position (Lucernuta), and eight species of Luciola. Of the Luciola many were not present in this collection although having been recorded from Sri Lanka. We have been able to confirm identity of four species of Diaphanes, and moved four species of Lamprophorus to Lamprigera while not confirming their identity.
Similarly, two species of Rhagophthalmus and two of Harmatelia were reclassified to different subfamilies. We have had most success with certain Luciolinae where there is an updated recent taxonomy, and here we were able to transfer five Luciola species to Abscondita, two to Asymmetricata, and another to a new genus which is in review.

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Appendix 1: The list of Canthoroidea recorded from Sri Lanka (extracted from “The list of Animals in Ceylon” by Sr. J.E. Tenant, 1849).

| Genus       | Species                  |
|-------------|--------------------------|
| 1           | Colophotia humeralis (Walker) |
| 2           | Colophotia vespertina (Walker) |
| 3           | Colophotia perplexa (Walker) |
| 4           | Colophotia intricata (Walker) |
| 5           | Colophotia extricans (Walker) |
| 6           | Colophotia promelas (Walker) |
| 7           | Dictyopterus internexus (Walker) |
| 8           | Harmatelia discalis (Walker) |
| 9           | Harmatelia bilinear (Walker) |
| 10          | Lampyris tenebrosa (Walker) |
| 11          | Lampyris diffinis (Walker) |
| 12          | Lampyris lutescens (Walker) |
| 13          | Lampyris vitrifer (Walker) |
| 14          | Lycus triangularis (Hope) |
| 15          | Lycus geminus (Walker) |
| 16          | Lycus australis (Walker) |
| 17          | Lycus fallax (Walker) |
| 18          | Lycus planicornis (Walker) |
| 19          | Lycus melanopterus (Walker) |
| 20          | Lycus pubicornis (Walker) |
| 21          | Lycus duplex (Walker) |
| 22          | Lycus costifer (Walker) |
| 23          | Lycus revocans (Walker) |
| 24          | Lycus dispellens (Walker) |
| 25          | Lycus pubipennis (Walker) |
| 26          | Lycus humerifer (Walker) |
| 27          | Lycus expansicornis (Walker) |
| 28          | Lycus divisus (Walker) |

Appendix 2: List of Canthoroidea originally recorded from Sri Lanka based on McDermott, 1966

Firefly species

| Firefly species                                      | Genus     | Species                  |
|------------------------------------------------------|-----------|--------------------------|
| 1 Diaphanes brunioni (Bourg, 1909)                    |          | Luciola humeralis (Walker, 1858) |
| 2 Diaphanes lutescens (Walker, 1858)                  |          | Luciola impressa (Walker, 1858) |
| 3 Diaphanes olivieri (Gorham, 1895)                   |          | Luciola intricata (Walker, 1858) |
| 4 Harmatelia bilinea (Walker, 1858)                   |          | Luciola melaspis (Walker, 1858) |
| 5 Harmatelia discalis (Walker, 1858)                  |          | Luciola nicolieri (Walker, 1858) |
| 6 Harmatelia distinetia (Bourg, 1909)                 |          | Luciola ochracea (Walker, 1858) |
| 7 Lamprophorus lutosipennis (Walker, 1974)            |          | Luciola promelaena (Walker, 1858) |
| 8 Lamprophorus tenebrosus (Motsch, 1861)              |          | Luciola perplexa (Walker, 1858) |
| 9 Lampyris vitrifer (Walker, 1858)                    |          | Lychnaris lateralis (Gorham, 1880) |
| 10 Luciola antennalis (Bourg, 1905)                    |          | Lychnaris oblonga (Motsch, 1861) |
| 11 Luciola auritula (E. Olivier, 1910)                |          | Ochotyra obscura (P. Melong, 1921) |
| 12 Luciola candezella (E. Olivier, 1885)              |          | Ochotyra semistuta (Pascoe, J, 1862) |
| 13 Luciola chinensis (Linnaeus, 1767)                 |          | Rhagophthalmus confusing (E. Olivier, 1911) |
| 14 Luciola cingulata (E. Olivier, 1885)               |          | Rhagophthalmus filiformis (E. Olivier, 1911) |
| 15 Luciola doriae (E. Olivier, 1885)                  |          | Rhagophthalmus notaticolis (P. Melong, 1916) |
| 16 Luciola horni (Bourg, 1905)                        |          |                           |