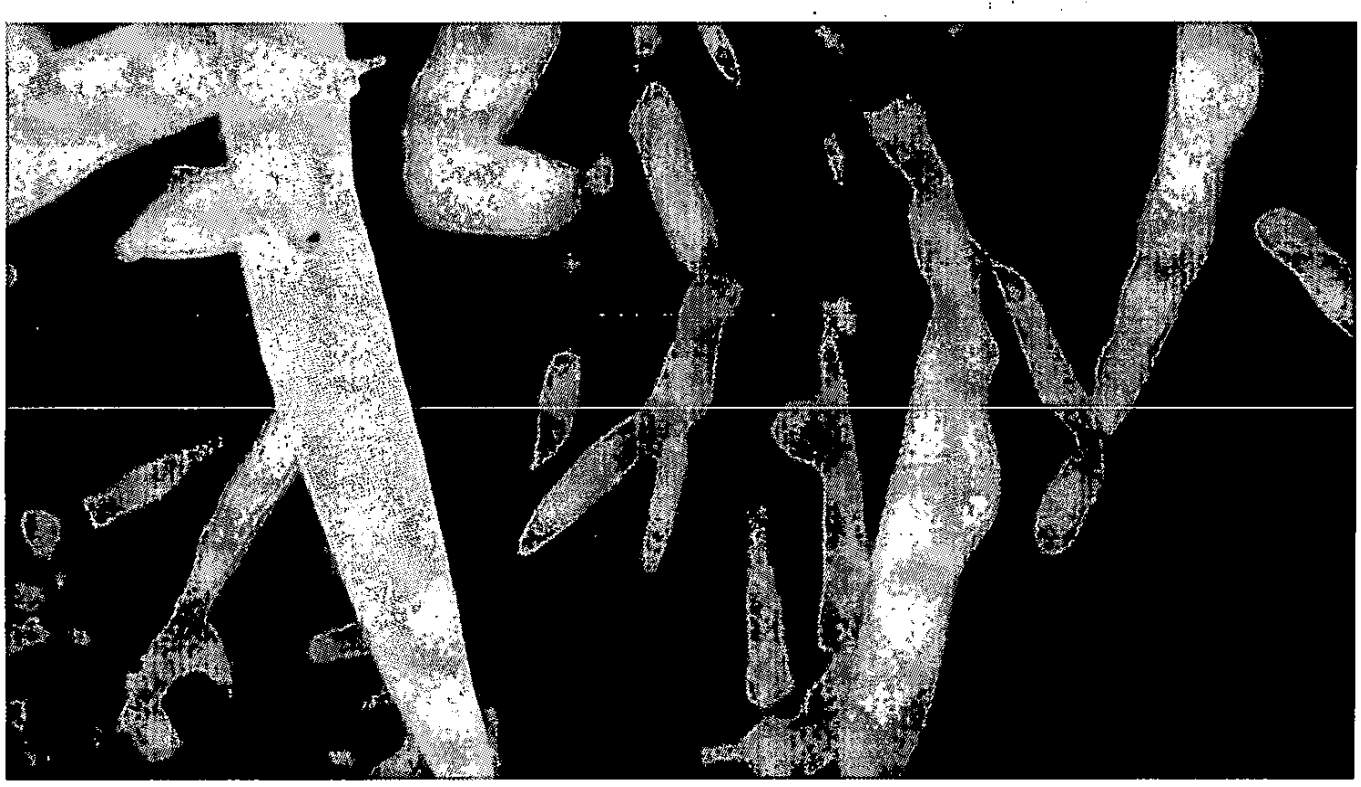
FINAL REPORT

Diversity and abundance of Lampyrids in Natural habitats and Agro Ecosystems in the southern province of Sri Lanka

RG/2005/EB/03



FINAL REPORT

1.0 Information regarding Project/Project Personnel:

1.1 Grant number: RG/2005/EB/03

1.2 Title of the project:

Diversity and abundance of Lampyrids in Natural habitats and Agro Ecosystems in the Southern province of Sri Lanka

1.3 Principal Investigators:

Dr. H.C.E.Wegiriya (31.10.2008 – 30.10.2009 Sabbatical leave)

Dr. C.N.L.Bogahawatta

1.4 Co-Investigators: **none**

1.5 Institute where research is being carried out:

Department of Zoology, University of Ruhuna, Matara

1.6 Date of award: 29. 08. 2005

Date project was initiated (if different from above) 23. 02. 2006

1.7 Date of completion of the project: 30.10.2010

1.8 **Total allocation of funds (Rs)** 991, 903.00

672, 246.00 - received

1.9 Total spent 472 267.00

1.10 Number of research students employed:

One Research Assistant, Total 19 months of service

~~Mr. D.P.M.N.C.Waidyarathna - from 10.03.2006 to 20.03.2006~~

Mr. R.S.P.K.M. Rajapaksha - From 01. 10.2006 - 31.05.2008

1.11 Post graduate degree completed with date: none

1.12 Number of Technical Assistants and or labourers employed and period of service:

One Technical Assistant, Total 12 months of service

Mr. Gihan Anurudda - from 01.07.2008 to 30.06.2009

Service of one Temporary field Assistant was taken only during the sampling

1.13 Publications/ Communications arising from the project during the reporting period:

Full papers – refereed journals

1. Bogahawatta, C.N.L., Wegiriya H.C.E. and Rajapaksha (2009)Species diversity of Fireflies (Coleoptera : Lampyridae) in selected natural and agricultural habitats in Southern Sri Lanka. Rohana: Research journal of the University of Ruhuna , 7, 1-11pp

Refereed full papers – Oral presentations in proceedings

2. Wegiriya, H.C.E., Bogahawatta, C.N.L. and Rajapaksha, R.S.P.K.M. (**2007**), Species composition of Fireflies in selected natural habitats and agroecosystems in the Hambantota district. Proceedings of 5th Academic sessions, University of Ruhuna, Matara, Sri Lanka, 5 pp 55 -59.

Refereed full papers – Oral presentations in International conferences

3. Bogahawatta, C.N.L., Wegiriya, H.C.E. and Rajapaksha, R.S.P.K.M. (**2008**), Species diversity of fireflies in selected natural habitats and agroecosystems in Matara district of southern province Sri Lanka, Proceedings of International symposium on "Diversity and conservation of fireflies" Queen Sirikit Botanic Garden, Chiang Mai, Thailand 11-17pp

4. Wegiriya, H.C.E., Bogahawatta, C.N.L. and Rajapaksha, R.S.P.K.M. **(2008)**, Impact of rainfall on the abundance of lampyrids in selected habitats in southern Sri Lanka, Proceedings of the International symposium on "Diversity and conservation of fireflies" Queen Sirikit Botanic Garden, Chiang Mai, Thailand, 18-25pp

Refereed abstracts – Oral presentations in International conferences

5. Wegiriya, H.C.E., Bogahawatta, C.N.L. and Wijekoon W.M.C.D. **(2010)**, Regional diversity of fireflies of the subfamily Luciolinae (Coleoptera: Lampyridae) in Sri Lanka. The second International firefly symposium 2010, Subang, Selangor, Malaysia, 29-30pp

Refereed abstracts – Poster presentations in International conferences

6. Wegiriya, H.C.E., Bogahawatta, C.N.L. and Rajapaksha, R.S.P.K.M. **(2008)**, Fireflies and Ecotourism: A study on fireflies in selected natural forests in southern Sri Lanka, Proceedings of International symposium on "Diversity and conservation of fireflies" Queen Sirikit Botanic Garden, Chiang Mai, Thailand, 176pp

2.0 Executive summary of the project

Sampling of fireflies in five selected habitats in Hambantota, Matara and Galle Districts of Southern Province was conducted during October 2006 to December 2009. Samplings were carried out in two natural habitats; a mangrove forest and a natural forest and three agricultural habitats *i.e.* vegetable/ paddy cultivation, coconut and tea plantations in each district. Transect sampling was done using sweep nets. Collections of fireflies were carried out from 6.30 p.m. to 9.30 p.m. within the study period.

From the collected adult fireflies eight firefly species namely, *Luciola chinensis, L. melaspis, L. humeralis, L.cingulata, Dioptoma greeni, D. ademsi, Diopenus latesence Lampigera tenebrosa* and *Honasca necrobiodes* were identified using the available taxonomic information and reference collections at National Museum Colombo and HORDI Gannoruwa. However other fireflies were identified only up to the genus level due to the unavailability of specimens in the reference collection. All of these unidentified species were belong to the genus *Luciola.* Firefly larvae other than mature *Lampigera* sp and *Stenocladius* sp were not classified.

However, leading firefly taxonomists in the South East Asia and Australia indicated that it is necessary to revise the taxonomy of Sri Lankan fireflies in par with the recent taxonomic revisions of fireflies in the world. According to the recent reviews, L. *chinensis* is categorized under *L.praeusta* complex together with four other Sri Lankan luciolones namely, *L. vespertine, L.intricata, L.perplexa* and *L.promelaena.*

Present study also revealed that *L. chinensis (L.praeusta)* was the dominant lampyrid species in all habitats of three districts in Southern Province. The abundance of *L. chinensis* was well marked in all three agro ecosystems *i.e.* Matara (65%), Galle (58%) and Hambantota (53%). However in natural ecosystems in all the three districts their percentage abundance was less than 40%. Among other firefly species *L. melaspis* was highly abundant in tea plantations of three districts. Four species, *L. cingulata, D. ademsi* and *D. latesence* were the least abundant.

Studies on factors which favour the abundance of fireflies indicated that rainfall shows positive impact on the abundance of fireflies. Important predators of fireflies are

spiders and they were entangled in spider webs. Gastropod mollusks namely slugs and snails are the most important prey of firefly larvae and larviform females.

Studies on active time indicate that fireflies are active mostly from 7.00 pm to 9 30 pm though they could be seen throughout the night. They start initially at ground vegetation level and tend to fly higher. However, congregate synchronous flashing behaviors which are very common in *Pteroptyx* fireflies in South-east Asian countries were not observed in fireflies in the Southern region.

Mean values of Shannon's Diversity index showed that the highest species diversity in natural habitats of Galle District. Results also indicated that natural habitats had higher species diversity than the agro ecosystems in all three districts. Unidentified Luciolinae species indicated that the possibility of new species or colour morphs of fireflies in Sri Lankan firefly fauna.

Present study gives valuble information on fireflies in Sri Lanka. It is essential to carryout island wide sampling to study the firefly fauna in Sri Lanka. Larviforms and larvae of fireflies play a significant role as predators of snails and slugs, hence important as natural enemies of agriculturally important molluscan pests.

The high abundance of fireflies in our natural environments could be incorporate into future ecotourism activities as different firefly species have different light emitting patterns. Continuation of these studies very important for Biodiversity studies of Sri Lanka as it is known to have unique firefly species such as endemic fireflies, diurnal fireflies well as very active predators of harmful invertebrates.

Keywords: *Fireflies, Diversity, Natural habitats, Agro-ecosystems, Sri Lanka*

3.0 Report in detail

3.1 Introduction / Background

"Firefly" or "lightening bug" is the common name for the nocturnal luminous insects belonging to the beetle family Lampyridae. There are over 2000 species of fireflies inhabiting the tropical, temperate regions and throughout the world (Booth *et al* 1993, Rooney & Lewis 2000). These known 2000 species of Lampyrids belong to 100 genera and seven subfamilies. The subfamily Luciolinae is restricted to the warmer parts of the Old World, while Lampyrinae occur throughout the New World and in Eurasia and Africa (Lawrence, 1995). Two hundred and eighty species of fireflies have been recorded from Asia and thirty species have been recorded from Sri Lanka (Wijesekera and Wijesinghe, 2003).

Taxonomic studies on Sri Lankan firefly fauna conducted by European and North American scientists dates back to the eighteenth century. Documentation of the Sri Lankan firefly fauna began during the British rule. Early work on the fireflies of Sri Lanka is contained in the 'Fauna of British India' series (Arrow, 1910 - 49). Thirty species of fireflies have been recorded by Green (1912), Baker (1937) and Bertrand (1973). Of them, sixteen species have been recorded from Central and North East Provinces of Sri Lanka belonging to subfamily Luciolinae. From Southern Province, three species belonging to subfamily Luciolinae, namely *Luciola chinensis*, *L. melaspis* and *L. cingulata* have been recorded (Mc Dermott, 1966). The endemic species, *Harmataliua ototretinae* is restricted to the Central Province of Sri Lanka.

Biology of fireflies

Most known firefly species are bioluminescent as adults and they have special light organs on the underside of the abdomen (McDermott 1964, Wigglesworth 1972).

Wingless adult females of certain Lampyridae and glowing larvae are commonly known as "glowworms"

Fireflies use these Greenish/yellow glows as a form of communication. They communicate with their lit tails which is an important part of their courtship and mating. Both male and female are luminous. The rhythmic flashes produced vary by sex and species. It is believed that the flashes are part of a signal system for attracting mates.

After mating female fireflies/larviform females (glow worms) lay eggs in among vegetation and are usually hidden in crevices in the moist soil. Usually larvae hatches from the eggs after 15 to 20 days. The larvae are carnivorous, feeding on other insects, snails, and slugs. Despite their diminutive size, the larvae are the fierce predators. They roam leaf litter in search of tiny snails and slugs, which they bite and inject with a neurotoxin that both immobilizes and liquefies its meal. They then suck their prey empty. Length of the larval period may wary and could be from several weeks to months. After 4-6 instar stages larvae moult into inactive pupal stage. Pupal duration is generally less than two weeks. Emerging adults lives for only four to five weeks and complete life cycle takes about six to seven months.

The significance of bioluminescence in fireflies

The main attraction of fireflies is the flashes of lights they produce. The organ which produce the light is known as photic organ or light organ and located in the last one or two segments of ventral side of the abdomen. The light of a firefly is actually cold light, producing very little wasted heat. Unlike an ordinary incandescent light bulb, for instance, which transforms only about 3 percent of electrical energy into light, firefly light is 90 to 98 percent efficient. Their light is produced through a chemical reaction that involves three compounds: a small organic molecule called luciferin adenosine triphosphate (ATP), a molecule that drives the synthesis of protein; and the catalyst luciferase. When luciferase is added to luciferin and ATP in the presence of oxygen, the energy of ATP causes the luciferin to glow.

Fireflies mainly use these flashes to communicate during the reproduction . The bioluminescent advertisement seems counterproductive, destined to draw predators such as frogs and birds. New research, however, shows that most fireflies in every life stage contain potent steroids. These poisons cause vomiting reactions to the predators which feed upon them *i.e* when thrushes are fed insects painted with an inconspicuous firefly extract, they promptly vomit up their meals. The glow is indeed an warning signal for their predators.(Tweit 1999)

Due to the aesthetic value conferred by their light flashing behaviour, lampyrids are increasingly studied for their use in night Zoos. In Southeast Asian countries such as Malaysia and Thailand fireflies are very important tourist attraction. In mangrove ecosystems *Pteroptyx* sp fireflies congregate in certain mangrove trees especially *Sonneratia caseolaris* and display synchronize flashing patterns and tourists from all over the world are visiting these places to observe them.

Present status of fireflies in the world

Generally fireflies are more abundant in tropical countries than the temperate countries. They are associated with diverse habitats including grasslands forests like terrestrial habitats to aquatic habitats including intertidal mangroves to various water bodies. In mangrove ecosystems of Southeast Asian countries such as Malaysia and Thailand *Pteroptyx* sp fireflies are very important tourist attraction. However most of these fireflies face serious threats such as habitat degradation, urbanization and light pollution. Therefore these countries play special attention to protect their firefly populations (Wong, 2008, Ineichen, 2008 and Nada *et al.* 2008).

In farming communities of Sri Lanka, there is a general belief that fireflies are minor pests, which feed on the leaves of common crops. However, the role of fireflies as pest of agricultural importance is not investigated yet.

On the other hand firefly larvae are recorded as general predators of invertebrates. As most of the important pests of crops are active during the night investigation of the role

of fireflies as natural enemies will be very useful information for Integrated Pest Management (IPM) programmes. During 1954 and 1955 several hundred larvae of Indian firefly *Lamprophorus* (=*Lampigera*) *tenebrosus* (Walker) were collected from Sri Lanka and shipped to Hawaii, Indonesia, Guam and Philippines to control the giant African snail *Achatina fulica* Bowdich (Bess 1956).

Taxonomic revision of fireflies

Linnaeus, 1758 described the first firefly species, *Lampyris noctiluca* (in Cantharis at that time) in the 10th edition of his "Systema Naturae". The first attempt at a classification of the fireflies was initiated by Laporte, 1833. Oliver (1907) provided keys to the subfamilies and genera of the world and McDermott (1964, 1966) reviewed the taxonomy of the family and produced a supplement to the Coleopteran catalogue. There are nearly 2,000 species and more than 90 genera of Family Lampyridae known from the world (McDermott, 1964). Though fireflies are common and attractive, the taxonomy of higher taxa in Lampyridae is not clear. The delimitation of the family and its subfamilies varies among different taxonomists (Olivier, 1907, 1910; Wittmer, 1944; Green, 1948, 1959; McDermott, 1964, 1966; Nakane, 1968, 1991; Crowson, 1972; Lawrance and Newton, 1995); many genera are of uncertain identity, systematic arrangement and have confusing nomenclatural histories.

The Lampyrides was further subdivided into Lampyrides *vrais* and Luciolides. Olivier, 1907 published numerous species lists and revisions between 1883 and 1907 which culminated in another classification (Olivier, 1907) which recognized nine subfamilies. Green, 1948 published another outline for a classification of the subfamily Lampyrinae based upon the Nearctic fauna. McDermott, 1966 presented a higher classification of the world fauna which recognized seven subfamilies, and included the *Luciolinae* with three tribes, *Luciolini*, *Curtosini* and *Ototretini*. He had (1964) treated the *Luciolinae* as composed of the first two mentioned tribes, with the *Ototretini* separate subfamily. McDermott, 1964, 66 also treated the genus *Curtos* as a separate tribe, starting (1964)

"*Curtos* differs from the rest of the *Luciolinae* to such an extent that it seems advisable to make it a separate tribe".

Studies on Fireflies in Sri Lanka

Early records on firefly fauna in Sri Lanka were done by colonial scientists during the 18th century. Tennent, 1849 published a book "The list of Animals in Ceylon", which has included 28 species of fireflies belonging to five genera. Documentation of the Sri Lankan firefly fauna has been initiated with the establishment of the British rule, when. Results of these surveys and studies were contained in the "Fauna of British India" Series (Arrow, 1910, 1917, 1931). Different taxonomists have been involved to predicate the number of species of firefly in Sri Lanka in various time periods.Firefly species collected from Sri Lanka are kept in leading natural history museums of the world. (Green, 1912, Bertrand, 1973). Since then no work has been carried out on this family of beetles.

The present study on diversity of fireflies in southern province hence will be very important for cataloguing the biodiversity of Sri Lanka in par with modern taxonomic revisions.

3.2 Scientific scope of the project

Overall aim

The main aim of this project was to collect and identify lampyrids found in forests, mangrove forests and near human habitations in agro ecosystems of wet and dry zones of Southern Province, Sri Lanka and determines their diversity, distribution and abundance.

Specific objectives

i. Collection of lampyrids from different study sites in agro-ecosystems and natural ecosystems

ii. Identification of collected lampyrids. Construction of simple taxonomic keys for the identification of the species in field

iii. Determination of diversity, distribution and abundance of lampyrids in the given study areas

iv. Study the impact of environmental factors and biological factors such as fauna and flora which may affect the distribution and abundance of lampyrids.

v. Preparation of a checklist of Lampyrids in Sri Lanka

3.3 Materials and methods including statistical analysis

3.3.1. Study sites

The five sub sampling sites were selected from the macro sites to cover as much as diverse habitats. The two sub sampling sites, forest associated with water bodies, mangrove forest from natural eco system and three sub sampling sites, paddy /vegetable cultivation, coconut and tea plantation were used to collect fireflies.

Table 1: Vegetation type in selected habitats and study locations in Matara, Galle and Hambantota Districts

Sampling locations	Nature of vegetation	Habitat type
(A). Matara District		
Nawimana	Mangroves	Natural
Kekanadura	Forest	Natural
Kamburugamuwa	Coconut	Agricultural
Denipitiya	Vegetable/ Paddy	Agricultural
Kamburupitiya	Tea	Agricultural
(B). Galle District		
Unawatuna	Mangrove	Natural
Hiyare	Forest	Natural
Habaraduwa	Coconut	Agricultural
Imaduwa	Vegetable/Paddy	Agricultural
Wawulagala	Tea	Agricultural
(C). Hambantota District		
Rekawa	Mangrove	Natural
Ambalantota	Forest	Natural
Tangalle	Coconut	Agricultural
Angunakolapelessa	Vegetable/Paddy	Agricultural
Kekiriobada	Tea	Agricultural

Sampling sites

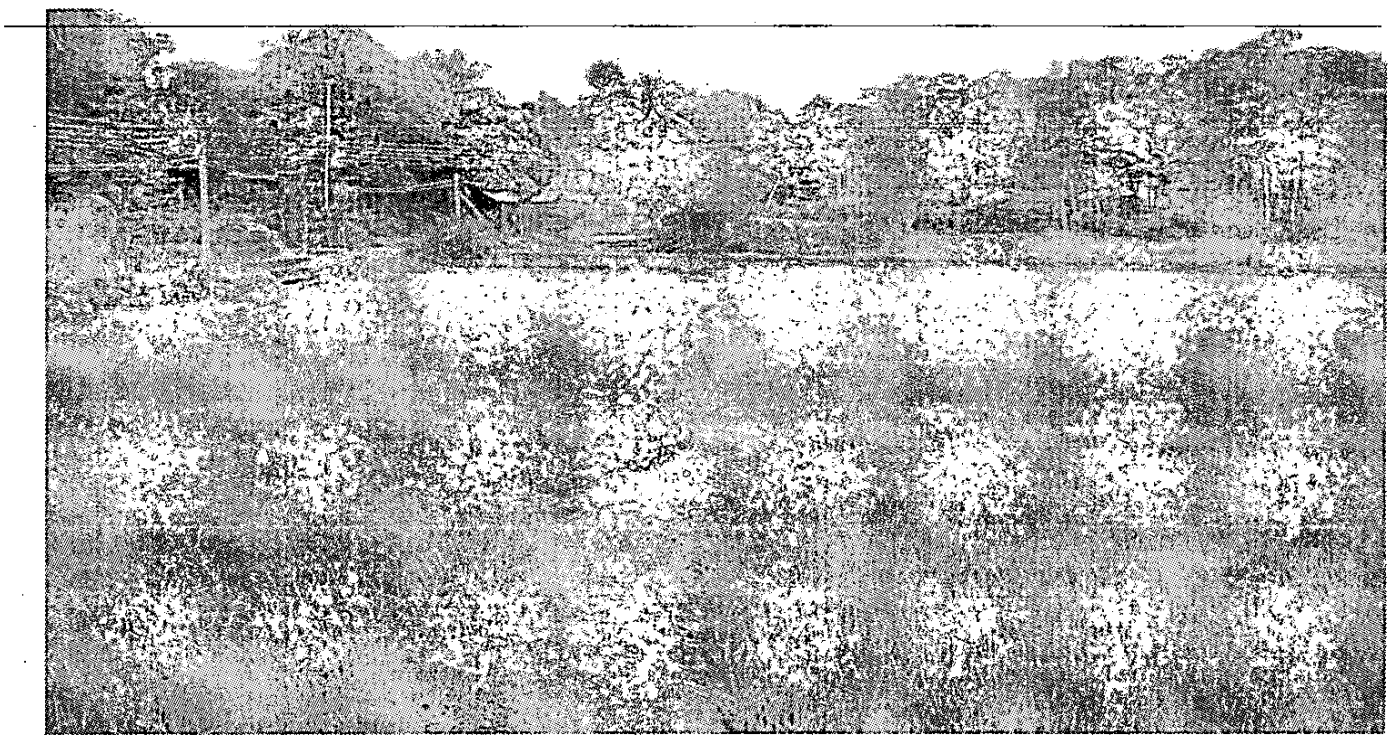


Plate 1: Agro ecosystem - paddy field

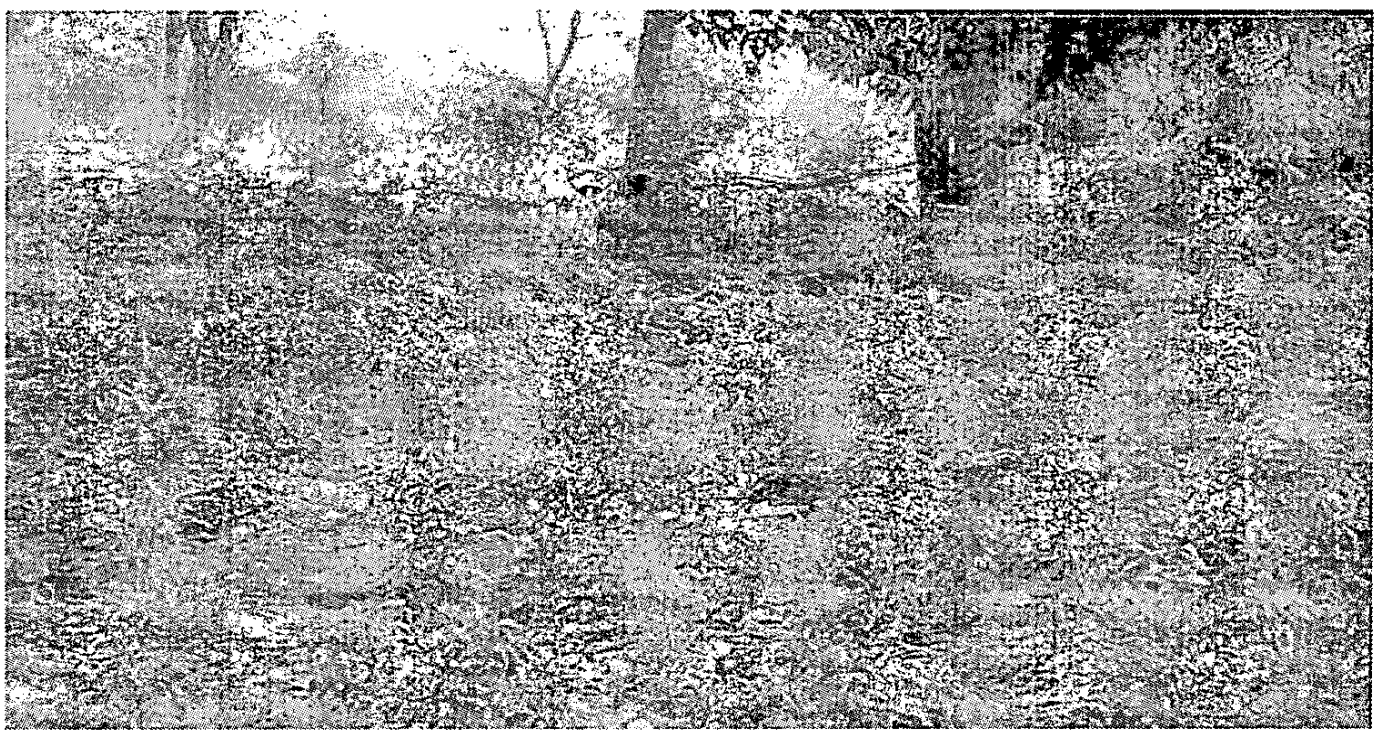


Plate 2: Agro ecosystem - vegetable cultivation

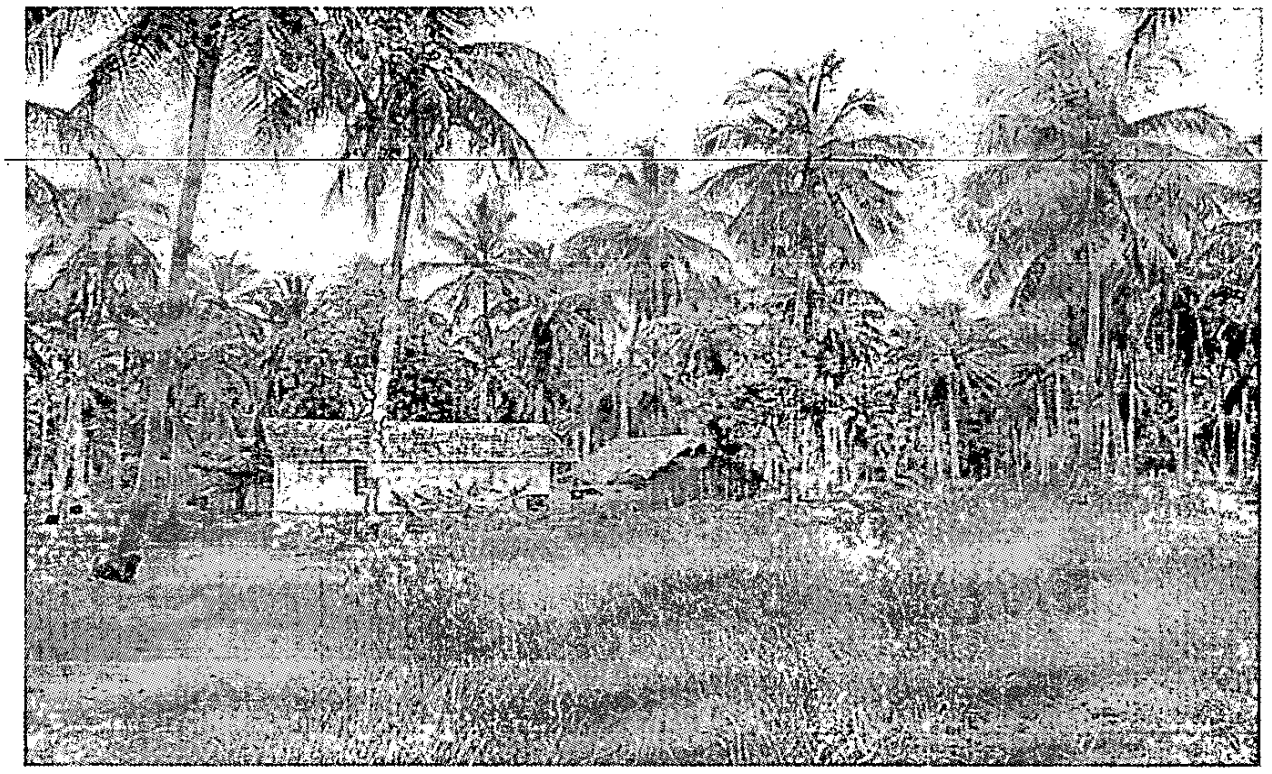


Plate 3 : Agroecosystem - Coconut Plantation

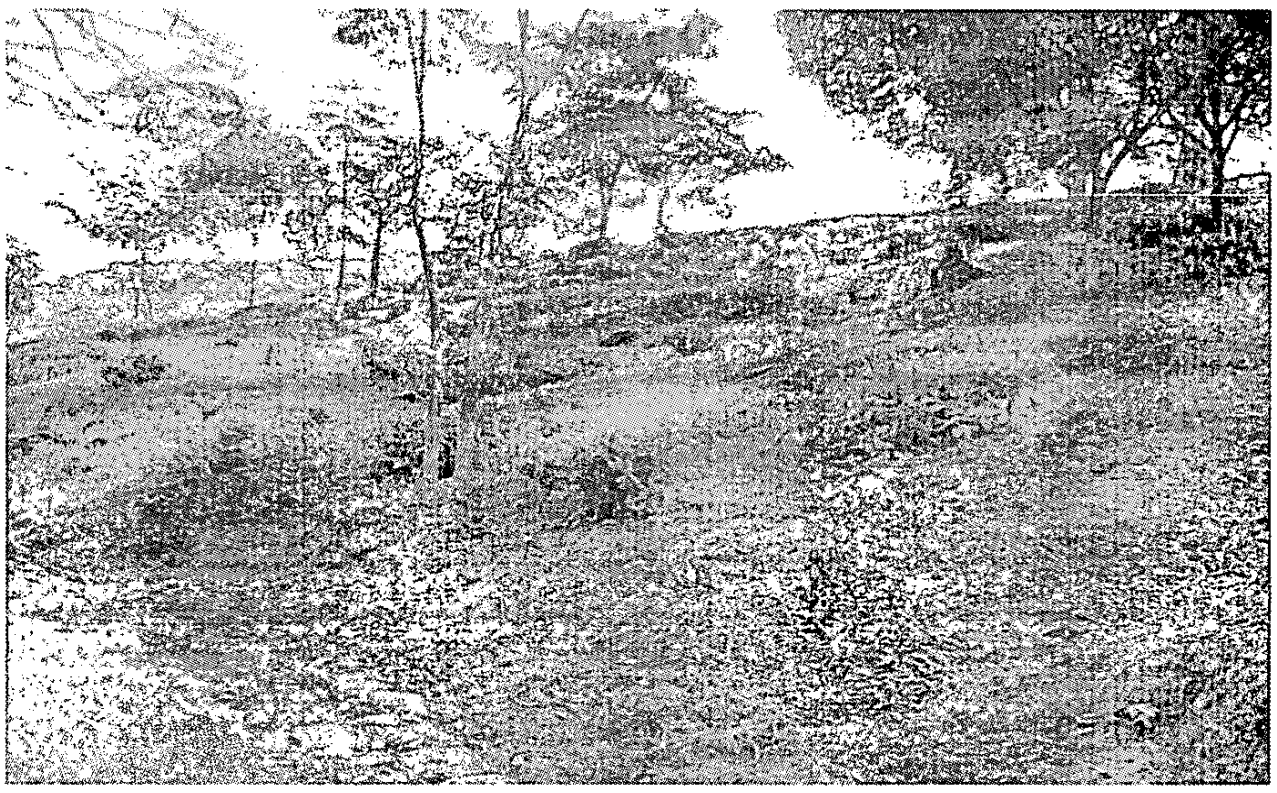


Plate 4 : Agro ecosystem - Tea Plantation

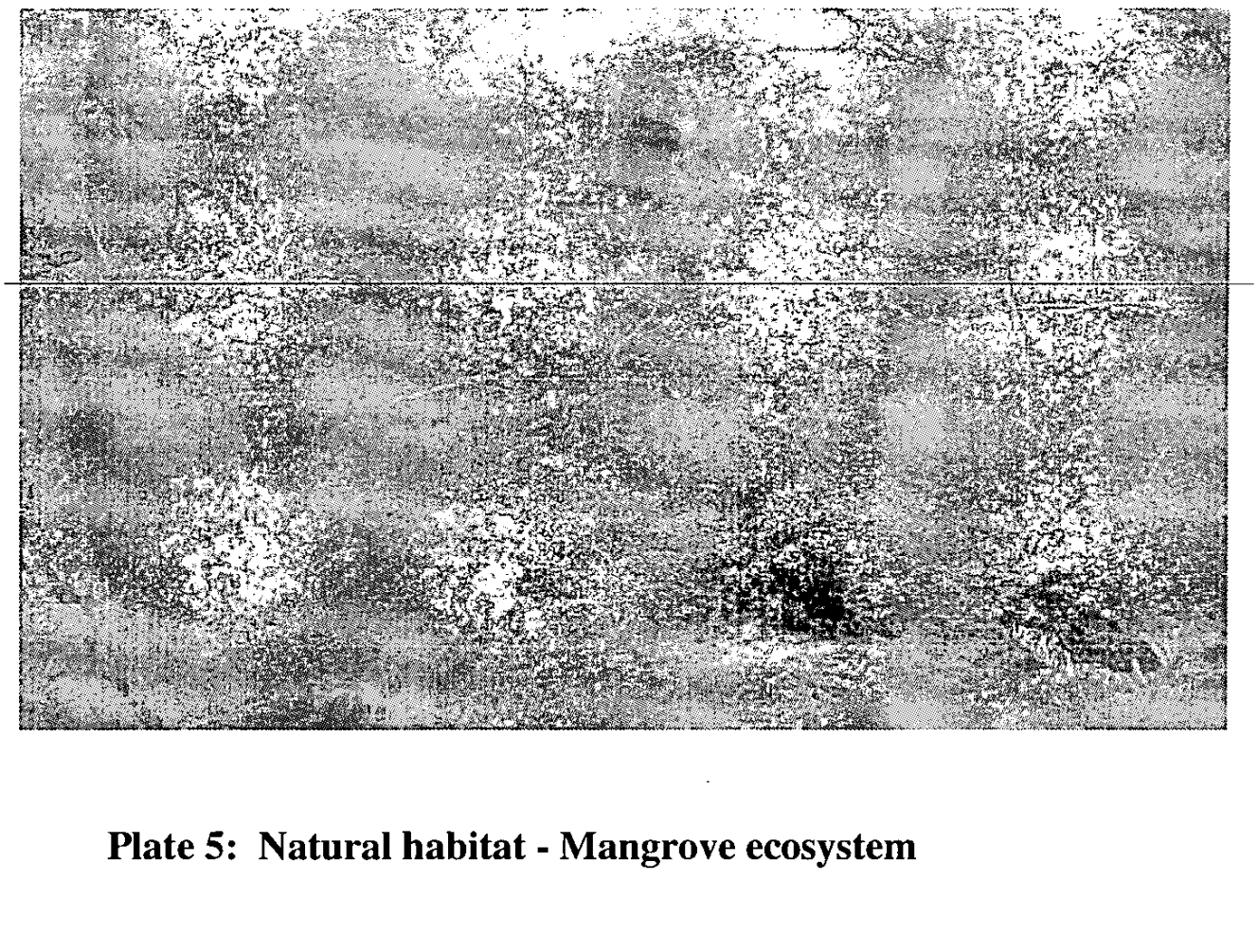


Plate 5: Natural habitat - Mangrove ecosystem

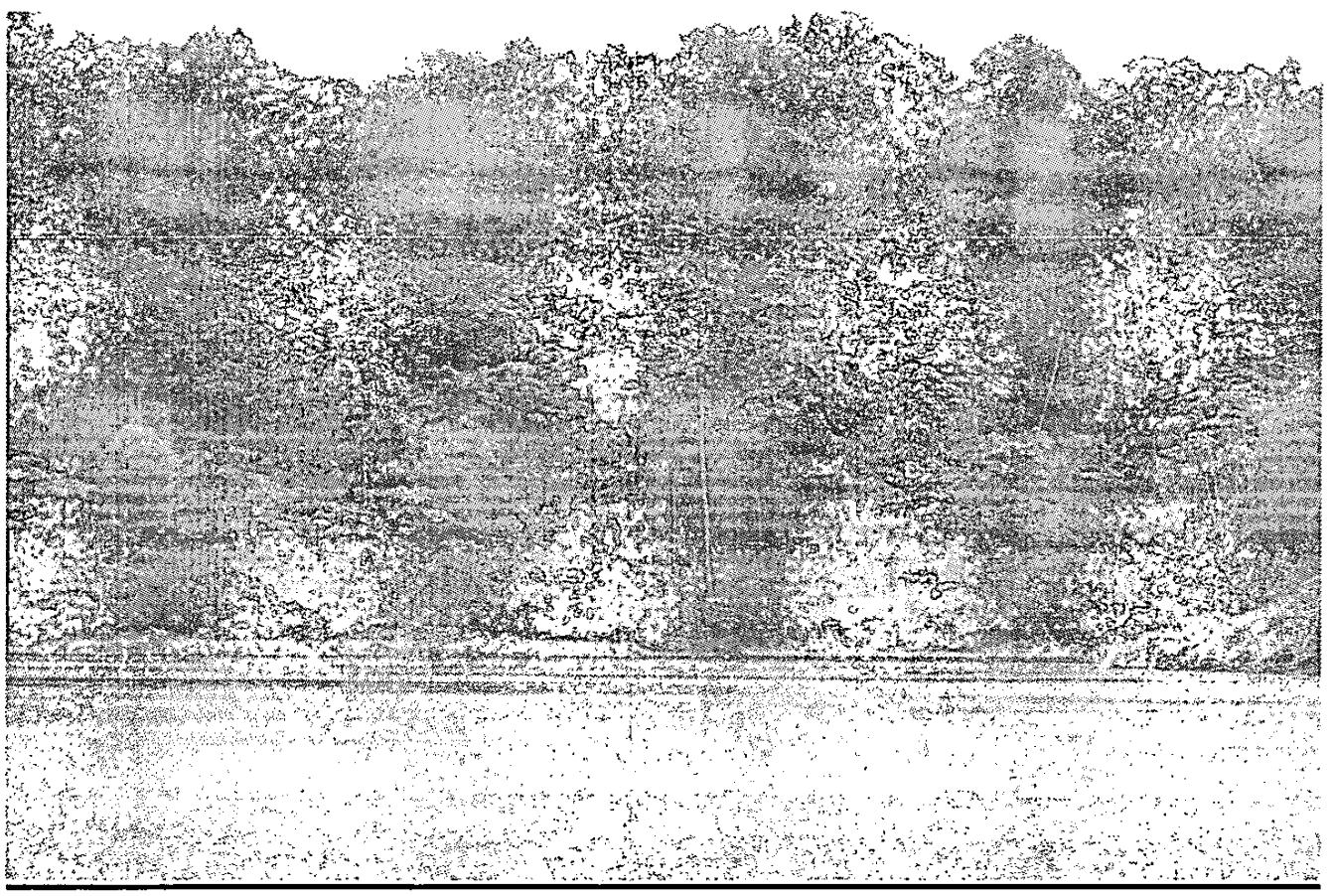


Plate 6: Natural habitat - Forest ecosystem

3.3.2. Collection of study insects

In each habitat about 100 m^2 open areas were selected for the collection of fireflies. Insect nets and hand nets were used for collecting fireflies on flight. Appropriate sampling time for collection of Lampyrids was the time between 18.30 hrs to 21.30 hrs as most of the fireflies were active during this period.

Collected fireflies were kept in polythene bags and brought into the laboratory or study place for counting and identification. Live individuals released back to their original habitats after the investigation.

Sampling in natural ecosystems, agro ecosystems in dry zone and wet zone of three Districts of Southern Province were continued during the period from March 2006 to December 2009 with a great difficulty due to the prevailed security conditions in the country. Weather parameters were obtained from the Meteorology department.

3.3.3. Taxonomy and diversity of lampyrids

Identification of lampyrids

Collected lampyrid adults were identified using the available taxonomic keys of Lampyrids. General identification was carried out at the Department of Zoology, University of Ruhuna, Matara. Reference collections of Lampyrids in the HORDI Department of Agriculture, Gannoruwa and the National Museum, Colombo were used for the identification when necessary. In addition one of the eminent taxonomists, Dr. L.Ballantyne, Honorary Research Fellow of Charles Strut University of Australia helped in identification by providing information through e mails.

In 2008, both investigators had opportunity to participate the International symposium on "Diversity and conservation of fireflies" Queen Sirikit Botanic Garden, Chiang Mai, Thailand. As many taxonomic revisions were done on fireflies and nomenclature of several species was revised we had to revise our identification process in accordance with modern taxonomy. As such there were some changes in subfamily, genus and species level in some species.

Diversity of Lampyrids

Following estimations were done

(a) Frequency of occurrence

$\square_x = B/A$

B = Total number of lands that lampyrid species X were recorded

A = Total number of lands in which lampyrid species X were surveyed

$\square_x$ = Frequency of occurrence of lampyrid species x

(b) Proportional abundance

$Pi = X/Y$

X = Number of individuals recorded from species X

Y = Total number of fireflies were collected

(c) Percentage proportional abundance of lampyrid species and morphospecies

For firefly species X

$= Pi \times 100$

(d) Shannon Wiener diversity index (H*l*)

$H^l = pi \ln pi$

3.4 Results

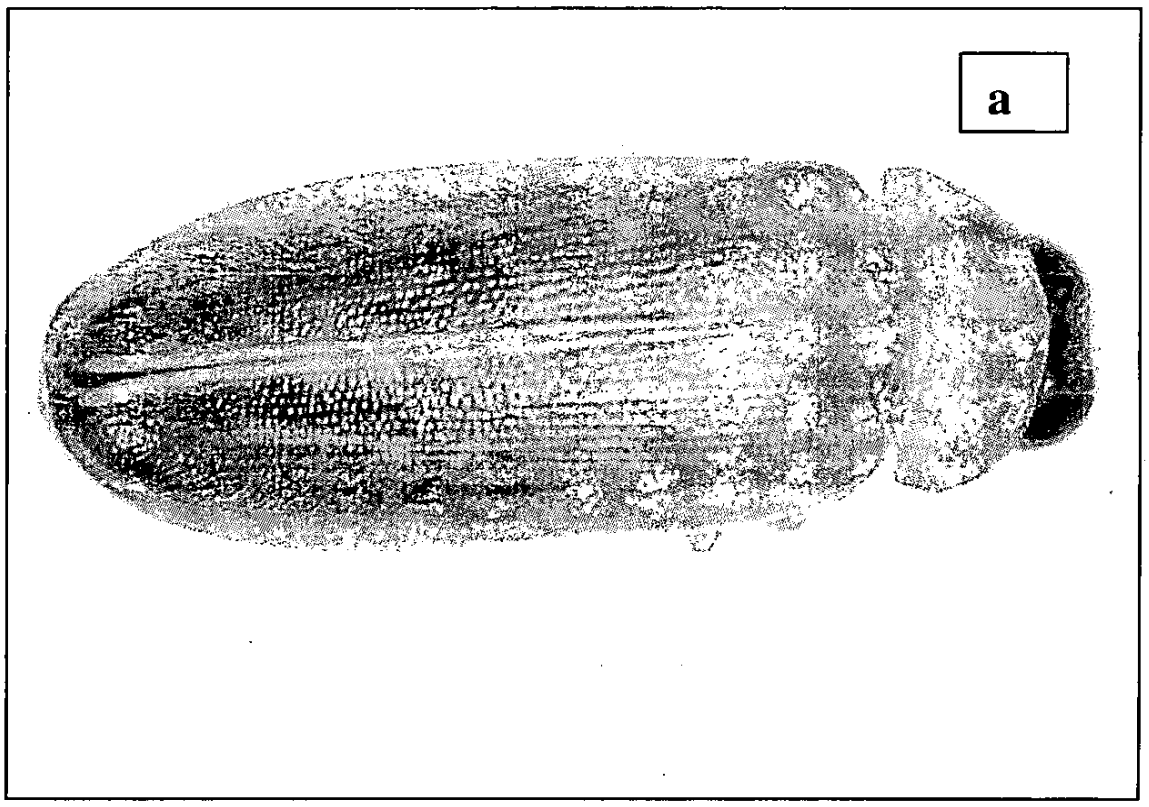
Table 2: Recorded species of fireflies and the present status of their taxonomic revision (2011)

Subfamily	Recorded species	Present taxonomic status
Luciolinae	*Luciola melaspis*	*Not changed*
	Luciola humeralis	*L. humeralis / Asymmetricata humeralis*
	Luciola cingulata	*Not changed*
	Luciola chinensis	*Luciola terminalis*
	Luciola sp. 1	
	Luciola sp.2	
Lampyrinae	*Diaphenes lutesence*	
	Lampigera tenebrosa	
Ototretadrilinae-Ototretinae complex Previous name Matheteinae	*Stenocladius sp 1*	

Recorded species of fireflies

Subfamily Luciolinae

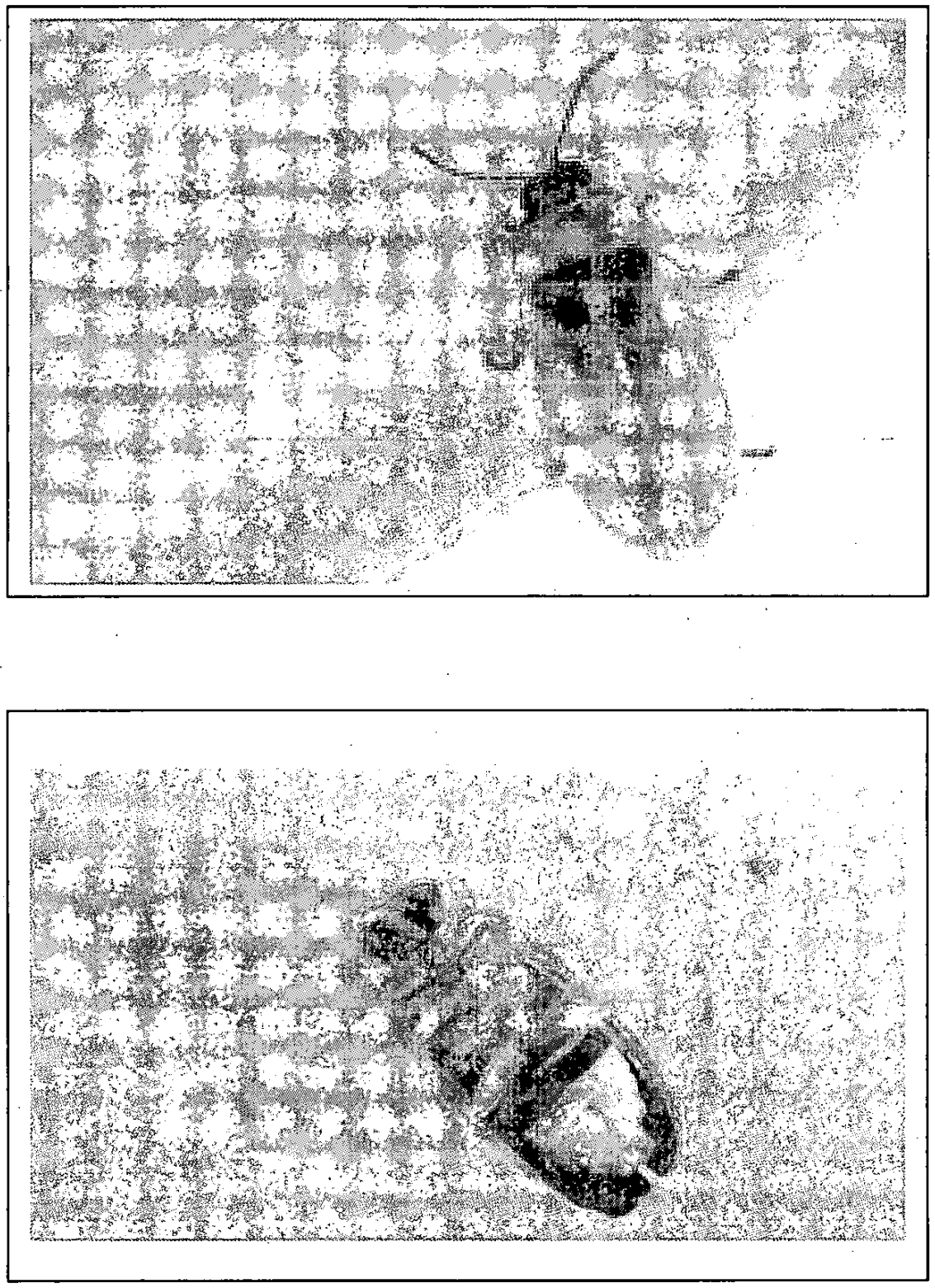
~~***Luciola cingulata***(Olivier, 1885)~~



L. cingulata (Male); (a) dorsal morphology, (b) ventral morphology

Subfamily Luciolinae

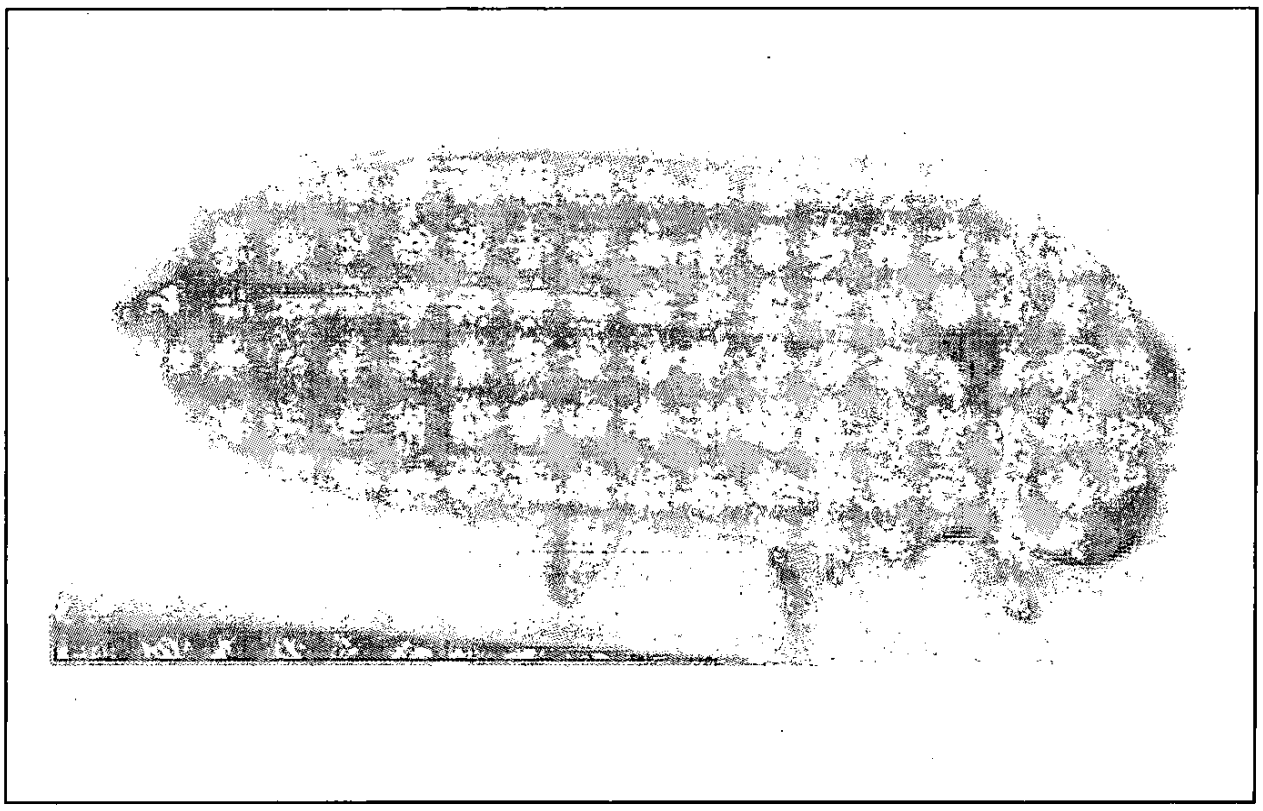
Luciola humeralis / Asymmetricata humeralis (Walker, 1858)

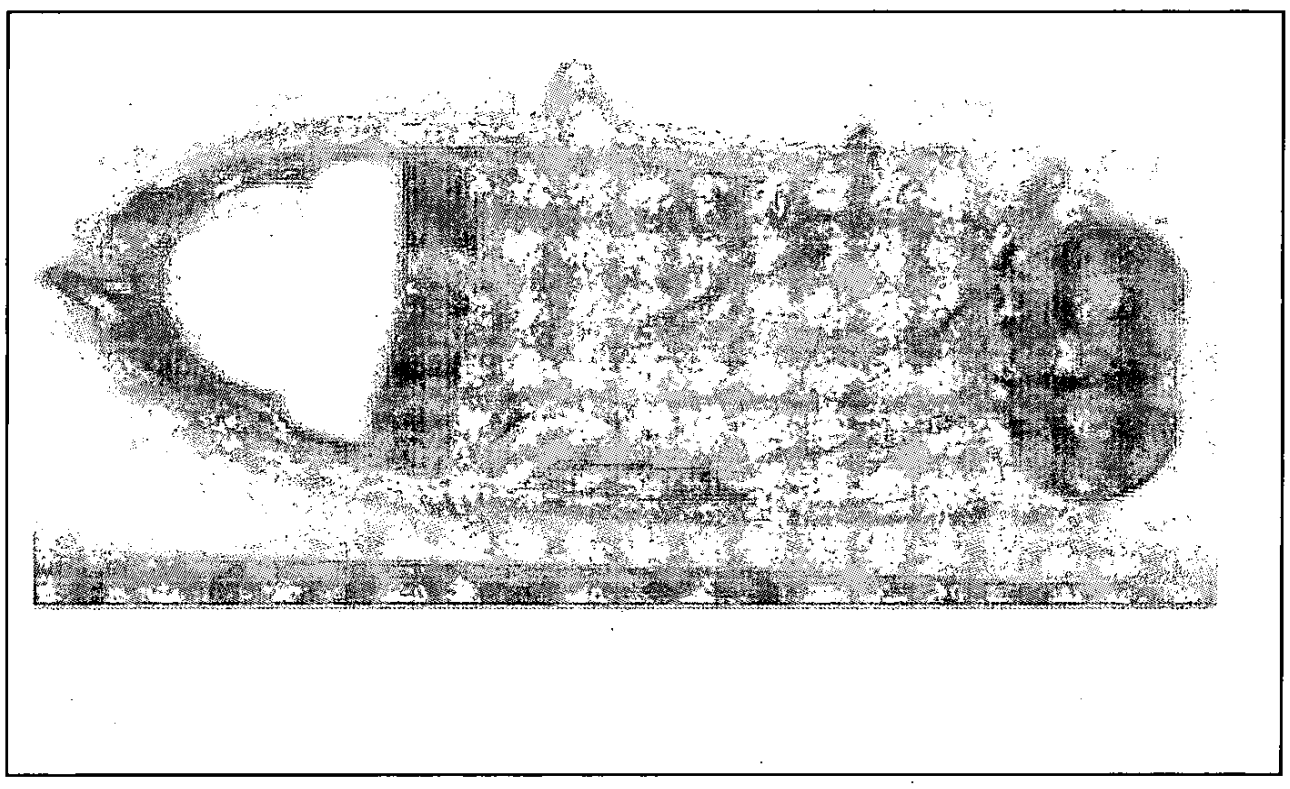


L. humeralis/ A. humeralis (Male); (a) dorsal morphology, (b) ventral morphology.

Subfamily Luciolinae

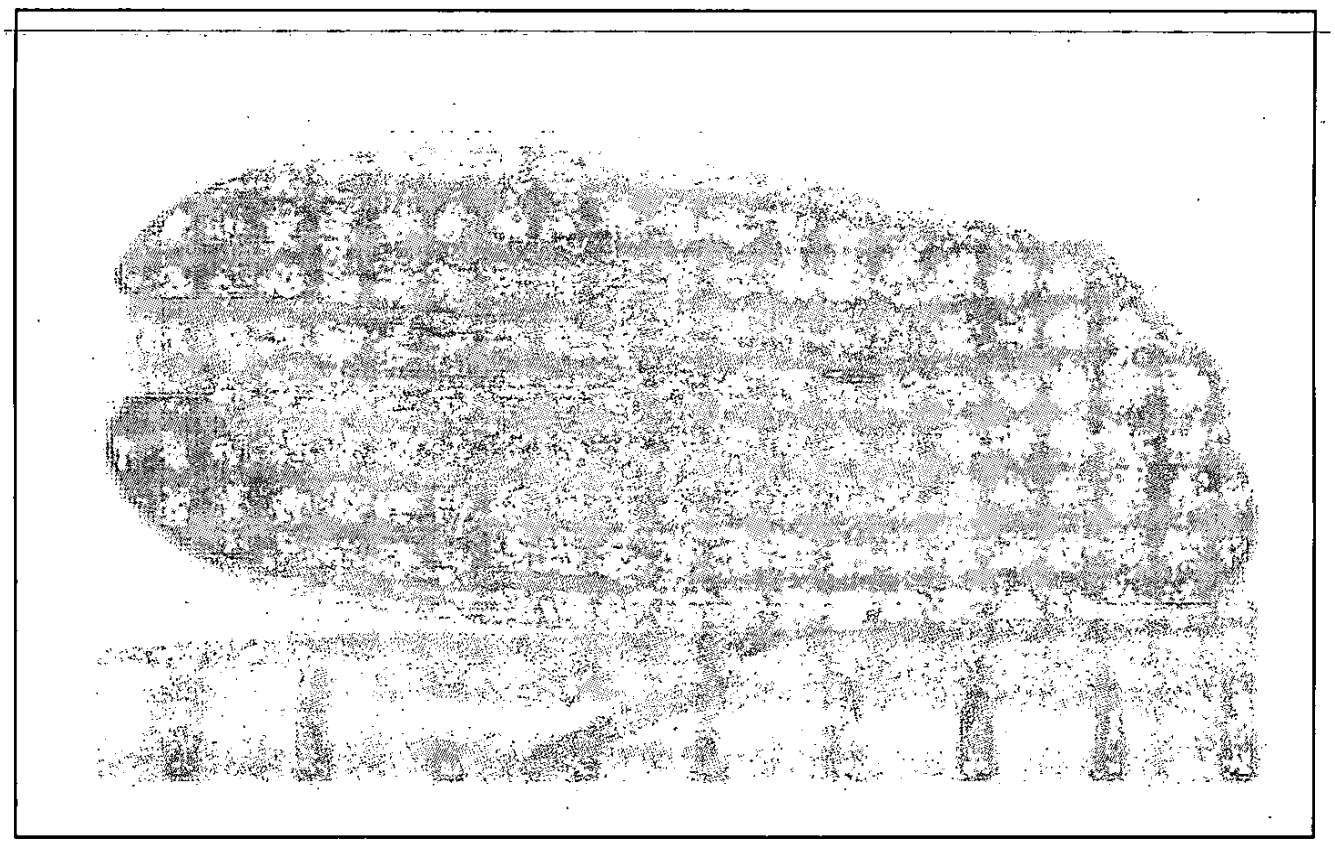
Luciola melaspis (Bourgeois, 1909)

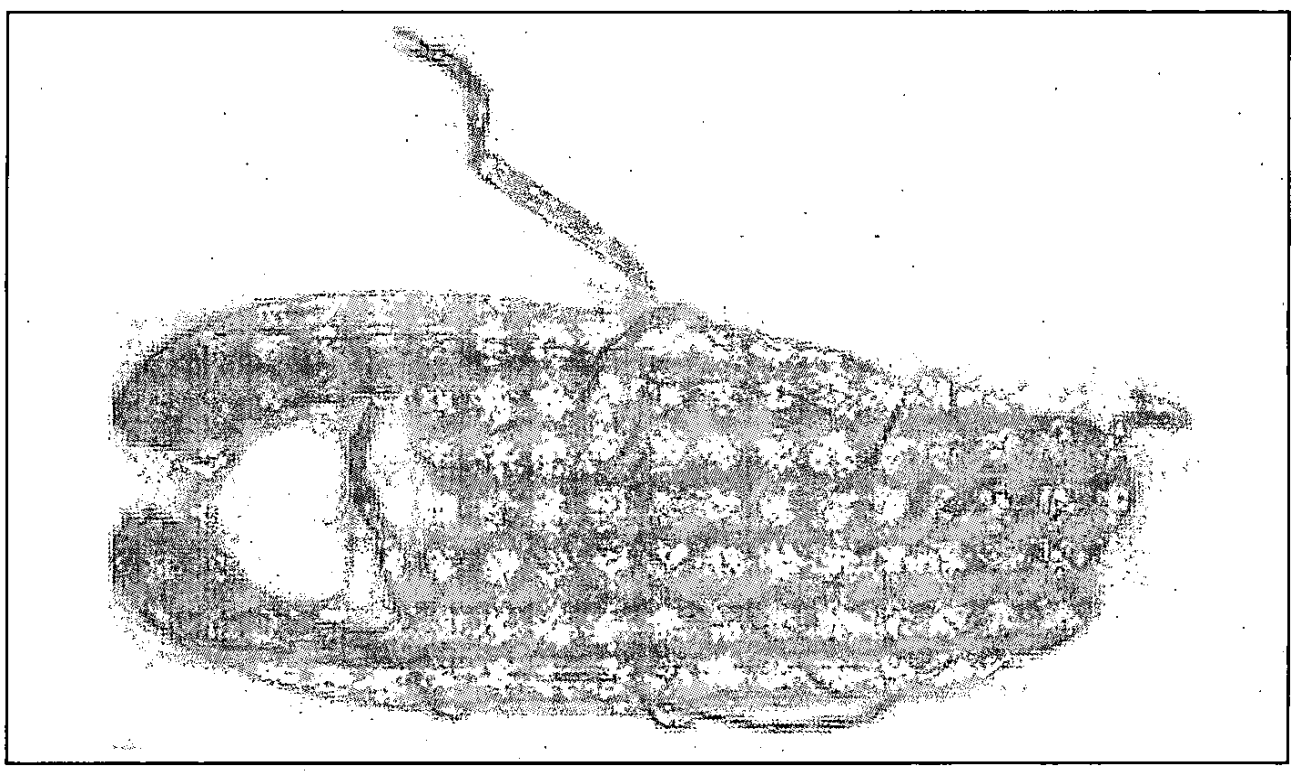




L. melaspis (Male); (a) dorsal morphology, (b) ventral morphology.

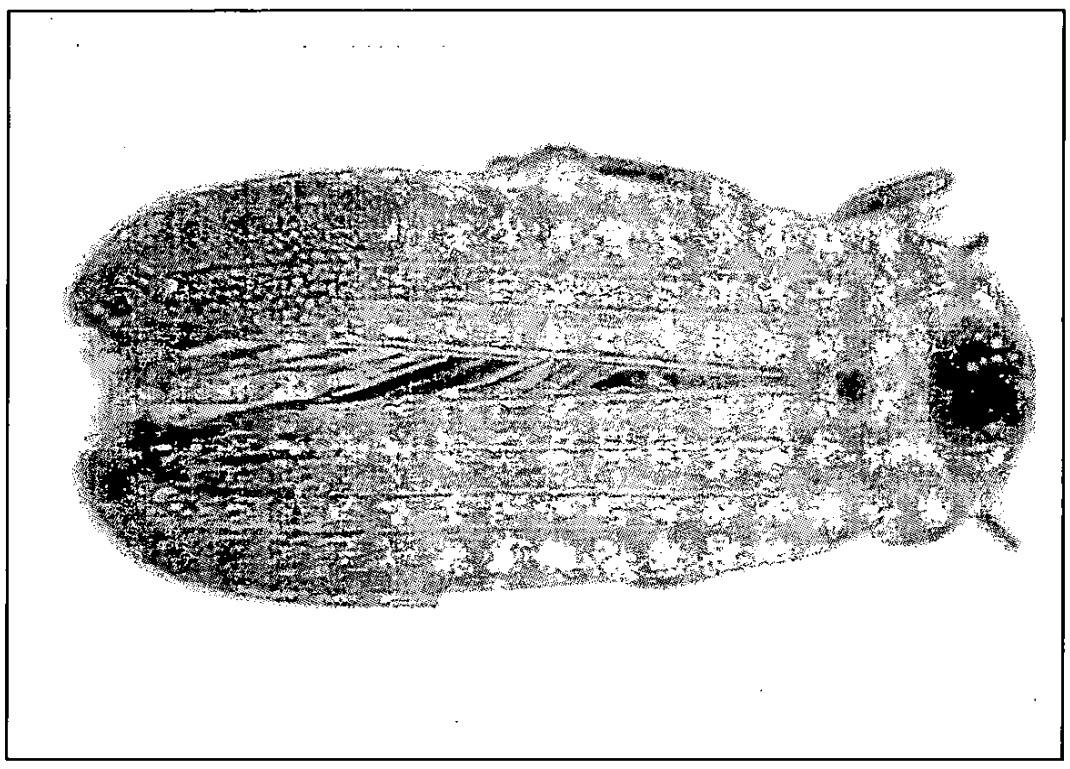
Near (*Luciola terminalis*) (Olivier, 1883)

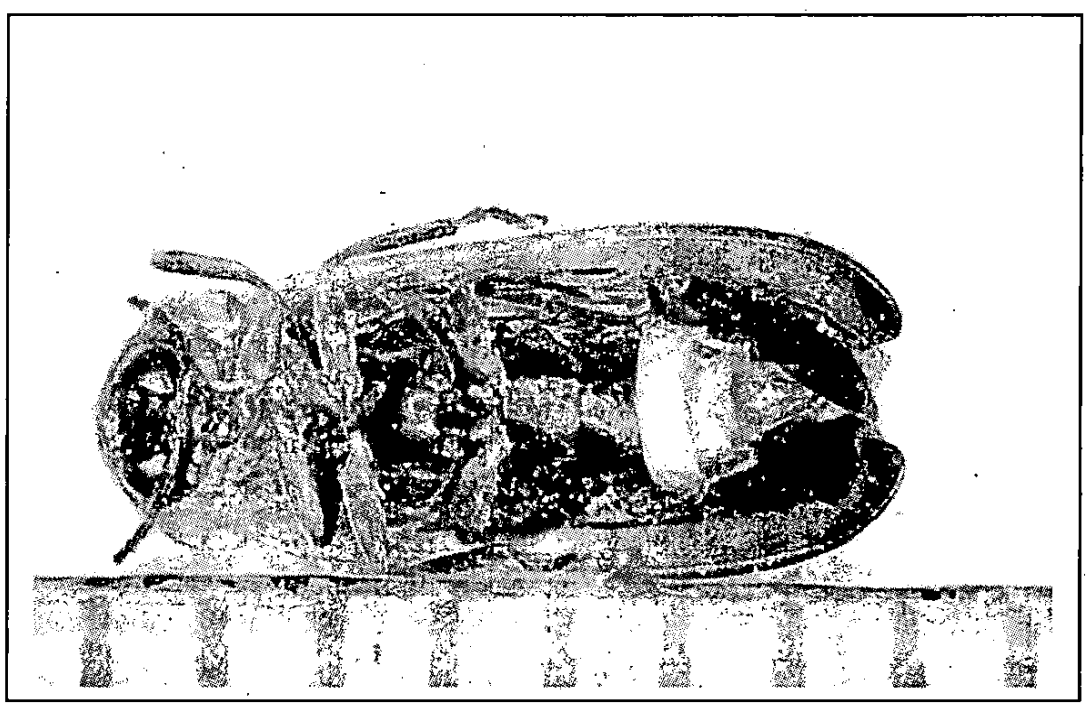




Near *L. terminalis* (Male); (a) dorsal morphology, (b) ventral morphology.

Luciola extricans (Walker, 1858)

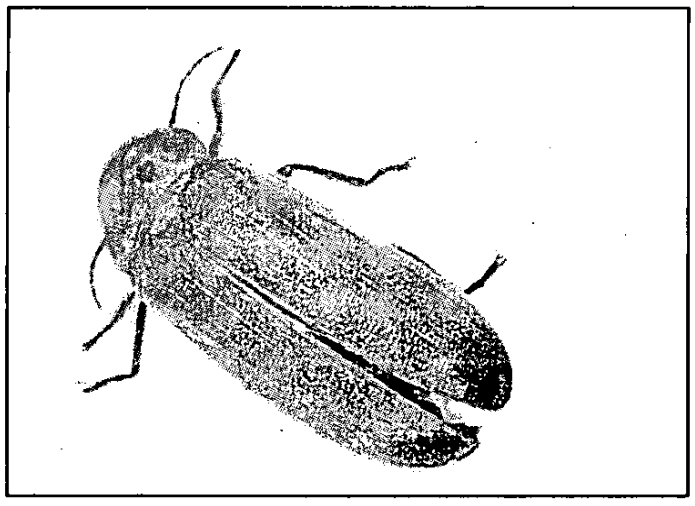


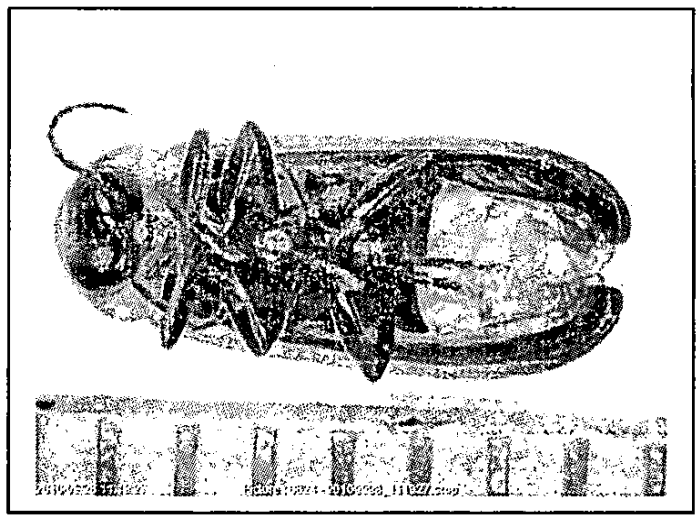


L. extricans (Female); (a) dorsal morphology, (b) ventral morphology.

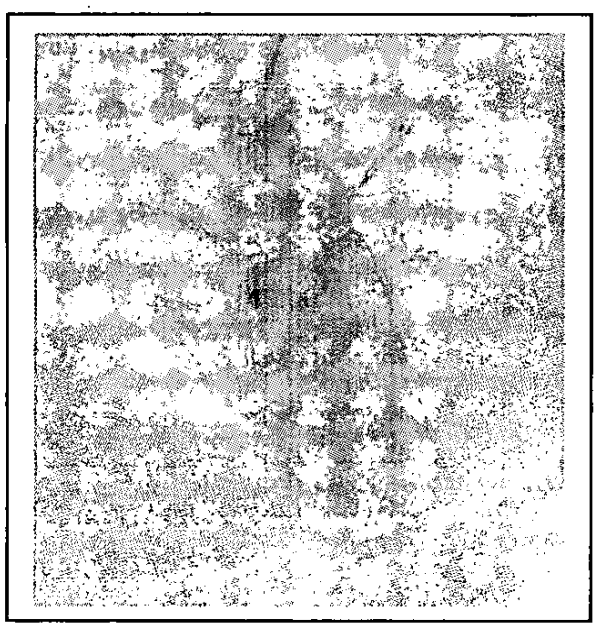
Luciola morphospecies

Morphospecies 1



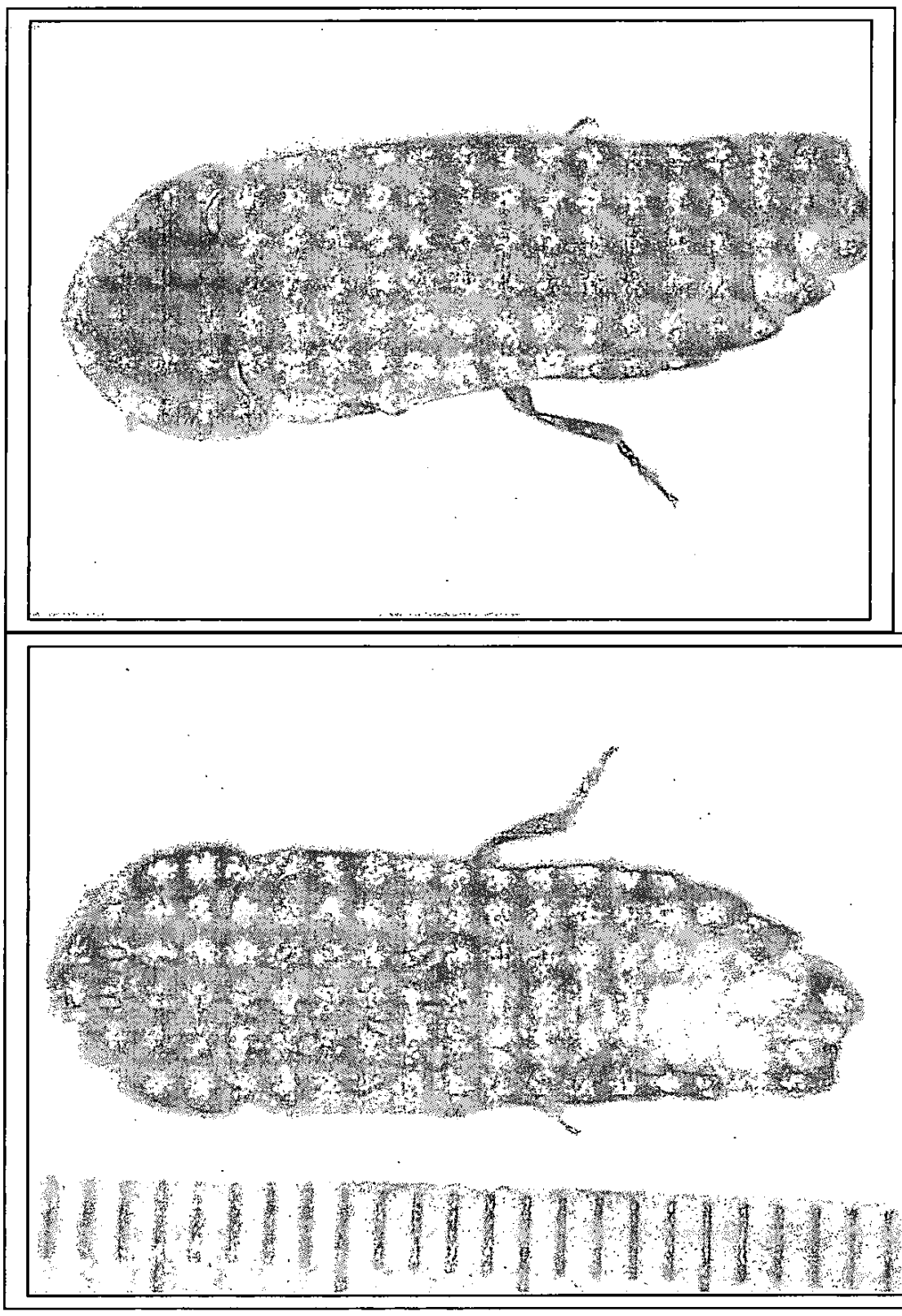


Morphospecies 2



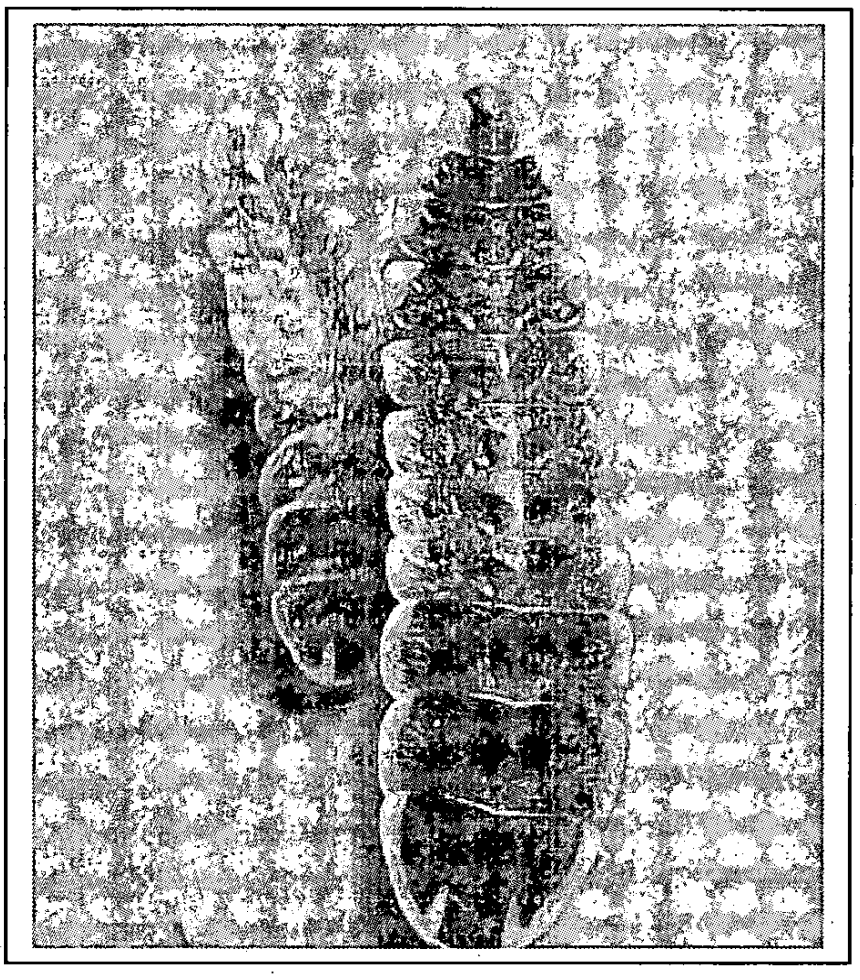
Subfamily – Lampyrinae

Lamprigera tenebrosa (WALKER, 1858)

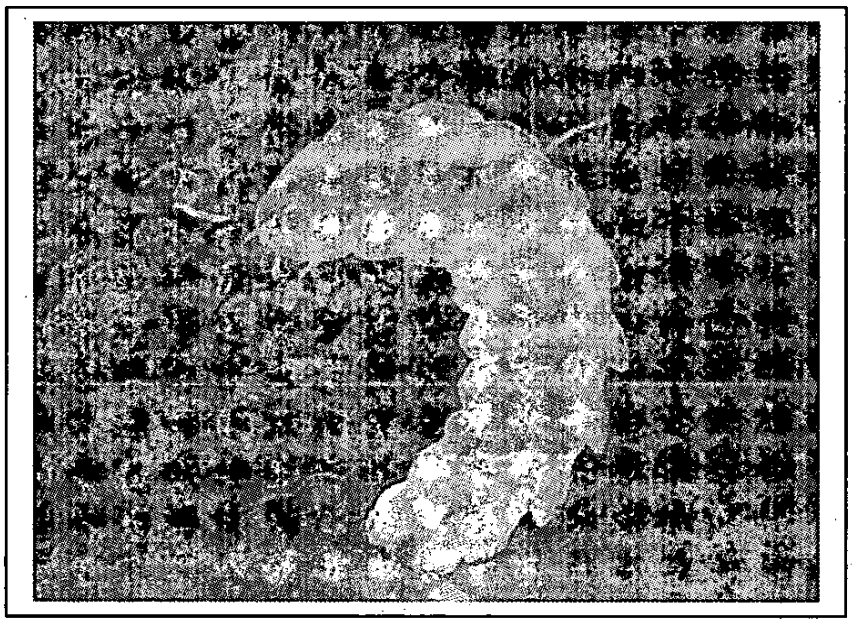


L. tenebrosa (Male); (a) dorsal morphology, (b) ventral morphology.

Larvae and Larviform females of *L. tenebrosa*



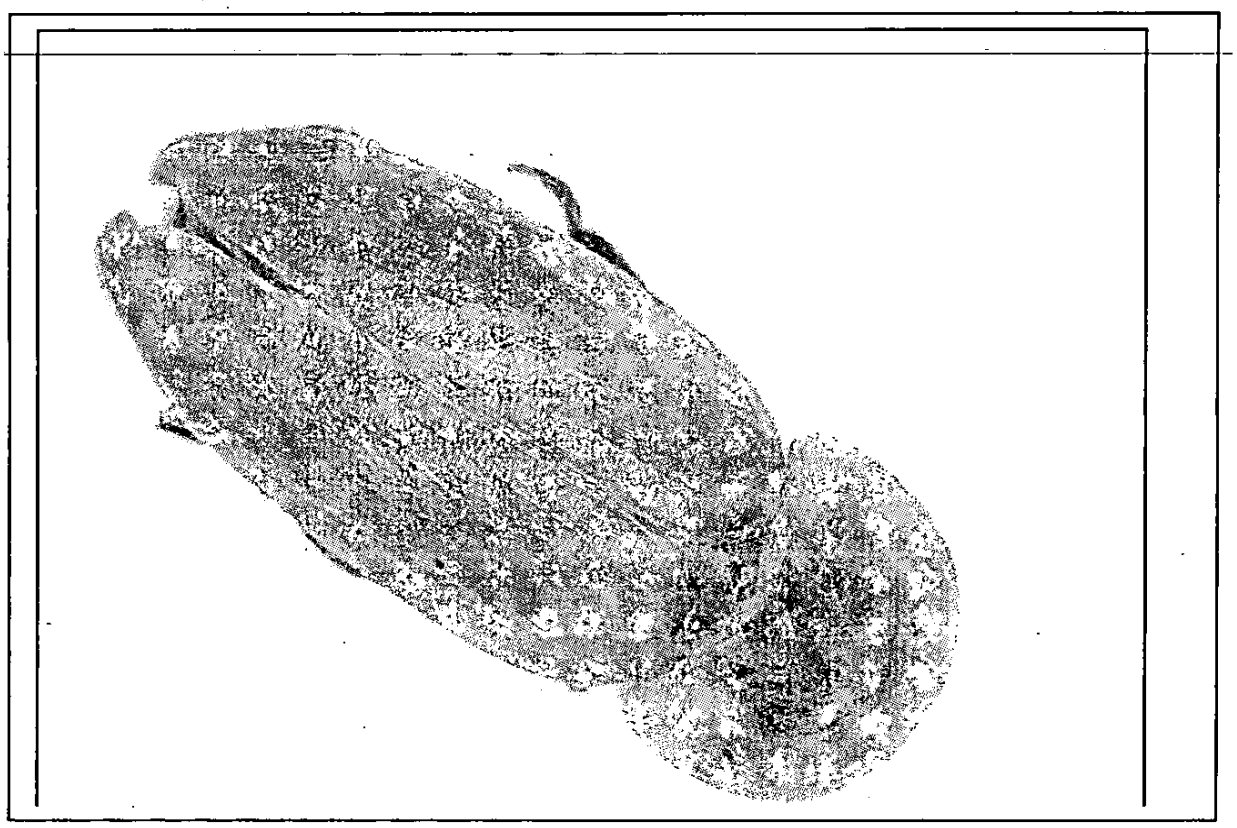
L. tenebrosa larvae

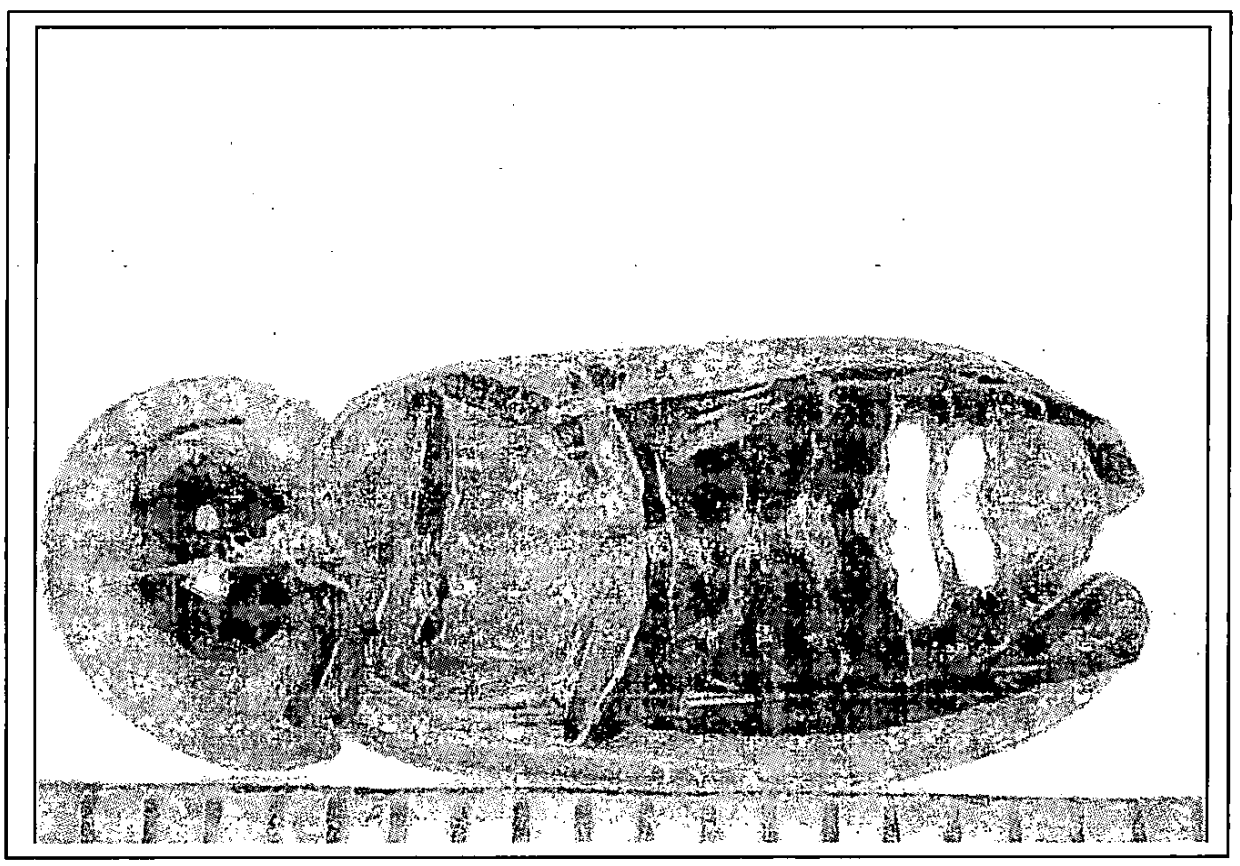


Female *L. tenebrosa*

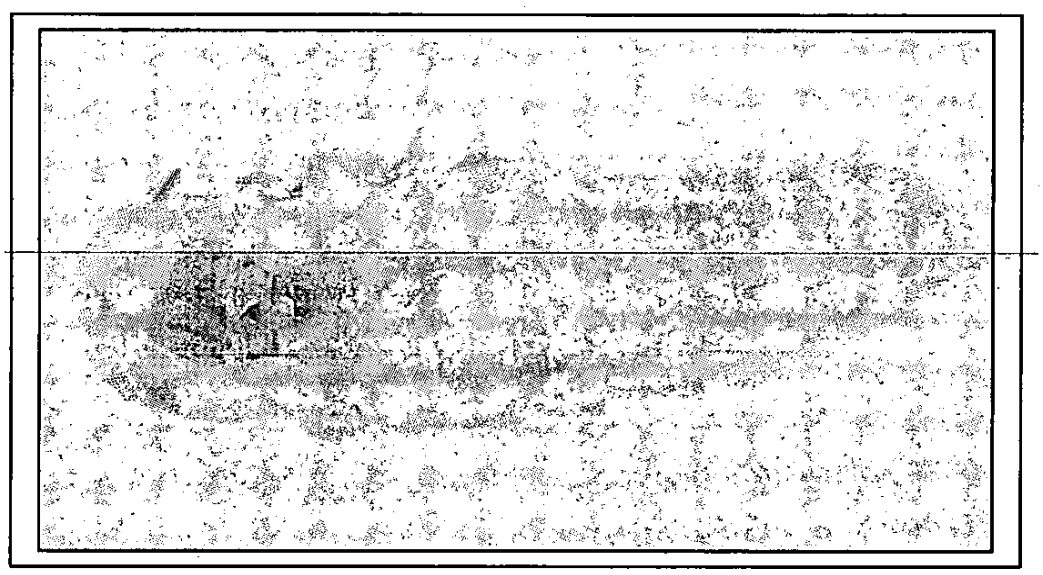
Subfamily – Lampyrinae

Diaphenes lutescens (Walker, 1858)



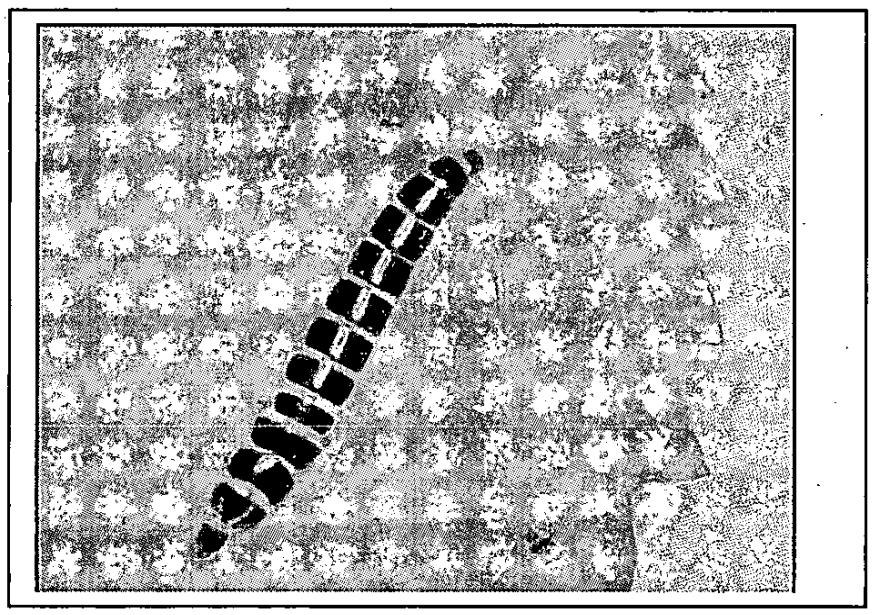


D. lutescens (Male); (a) dorsal morphology, (b) ventral morphology.



Female *D. lutescens*

Sub family- Ototretadrilinae- Ototretinae complex



Larvae of *Stenocladius sp*

Check list of fireflies in Sri Lanka
(all the recorded species including museum collections)

Family Lampyridae – subfamily Luciolinae

Luciola candezei
~~*Luciola antennalis*~~
Luciola chinensis - Recorded during the present survey
Luciola cingulata Recorded during the present survey
Luciola extricans Wlk Recorded during the present survey

Luciola. horni
Luciola humeralis Wlk Recorded during the present survey
Luciola impressa
Luciola intricata Wlk
Luciola melaspis Recorded during the present survey
L. nicollieri
Luciola perplexa Wlk
Luciola chinensis Recorded during the present survey
Luciola vespertina Fabr Recorded during the present survey

Family Lampyridae: subfamily Lampyrinae

Lamprigera tenebrosa Recorded during the present survey
Diaphanes sp Recorded during the present survey

Family Lampyridae: Ototretinae-Ototretadrilinae complex : Matheteinae

Stenocladius sp Recorded during the present survey
Harmatelia bilinear

Family Lampyridae: Rhagophthalminae - According to the new taxonomic revision luminescent members of this group categorized under subfamily Lampyrinae

Rhagophthalmus
Lamprophorus (*Lamprigera*) *tenebrosus*
Diaptoma ademsi
Diaptoma greeni
Diaptoma latesence
Honasca necrodiodes

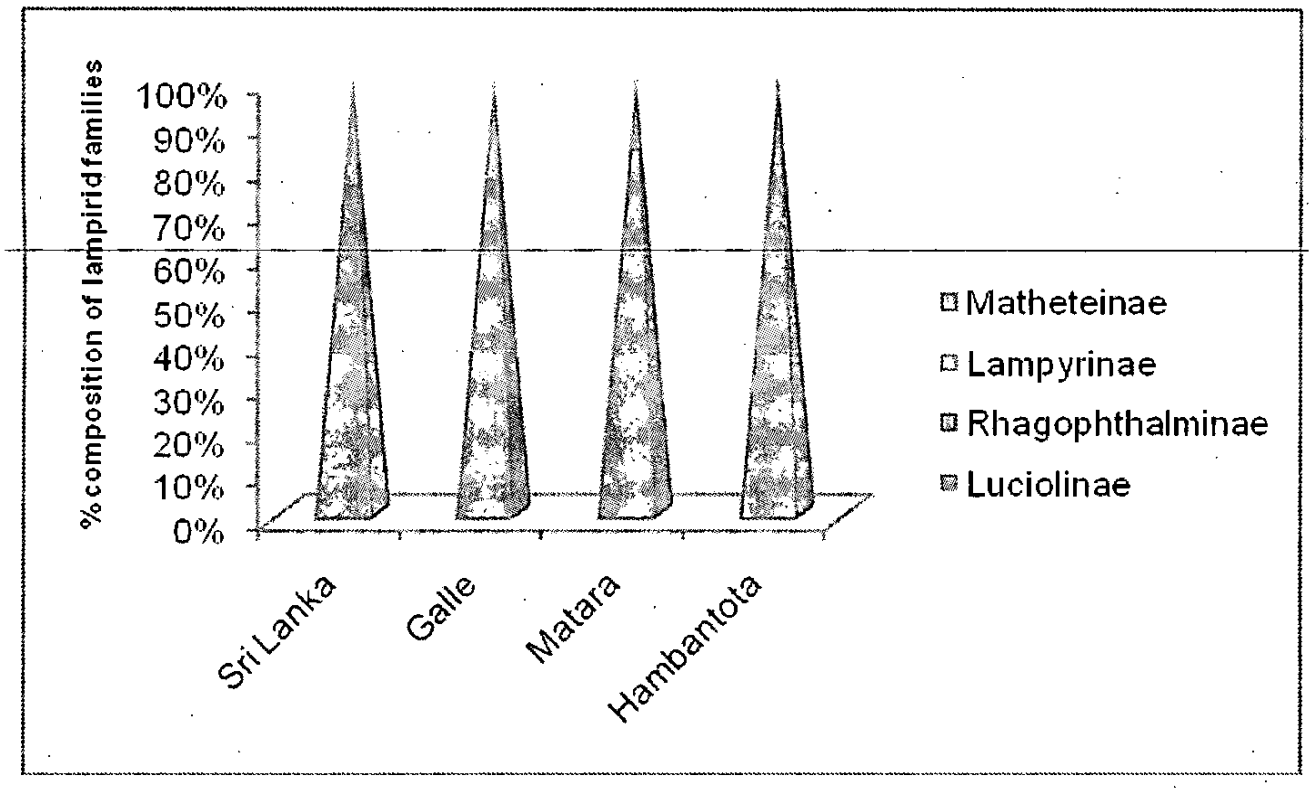


Figure 1: Percentage fireflies belonging to four different sub families recorded during sampling period in Southern Province with reference to recorded species from Sri Lanka

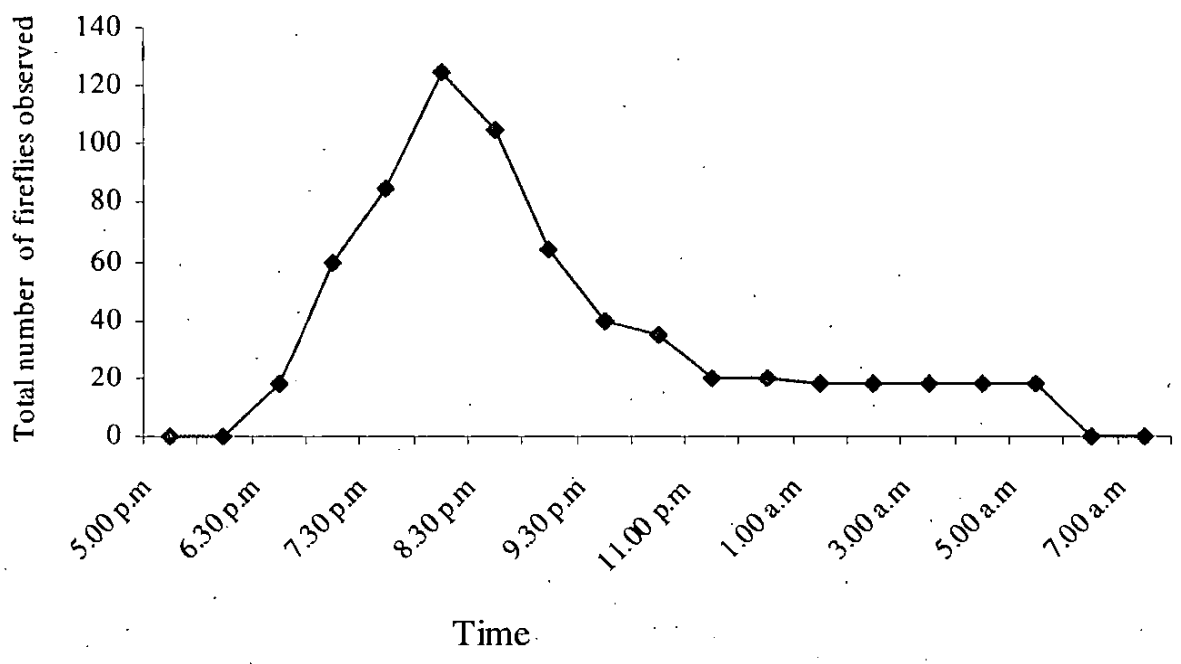


Figure 2: Active time period of fireflies during the sampling period

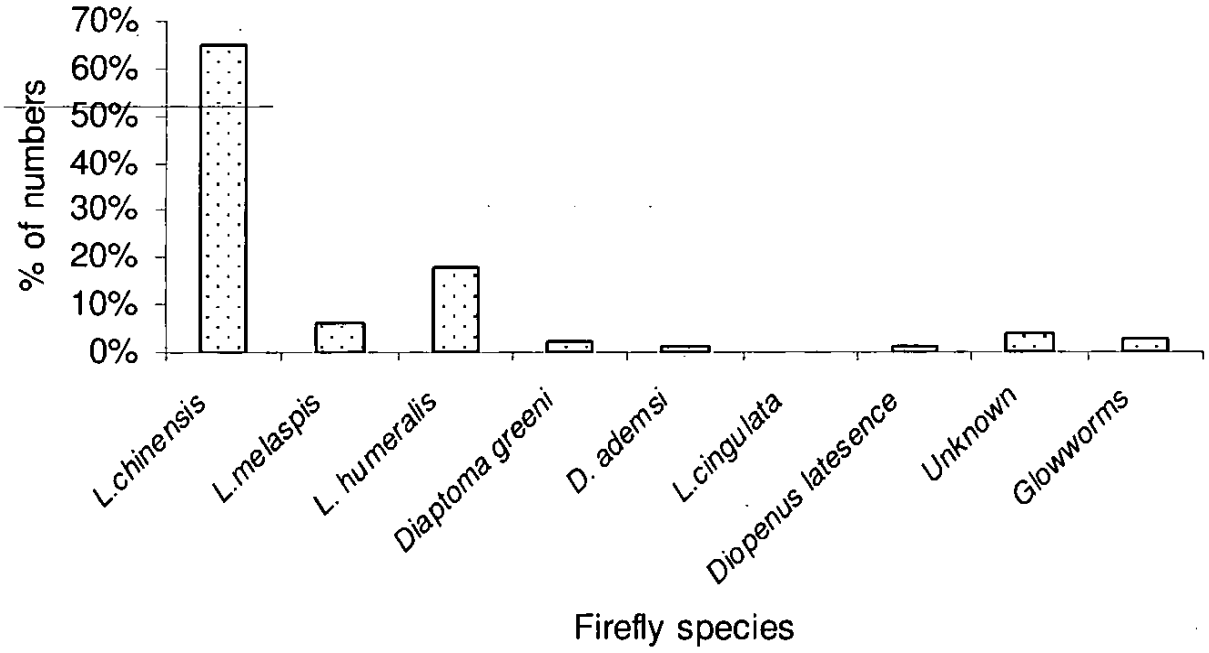


Figure 3a: Percentage of firefly species collected from Matara District

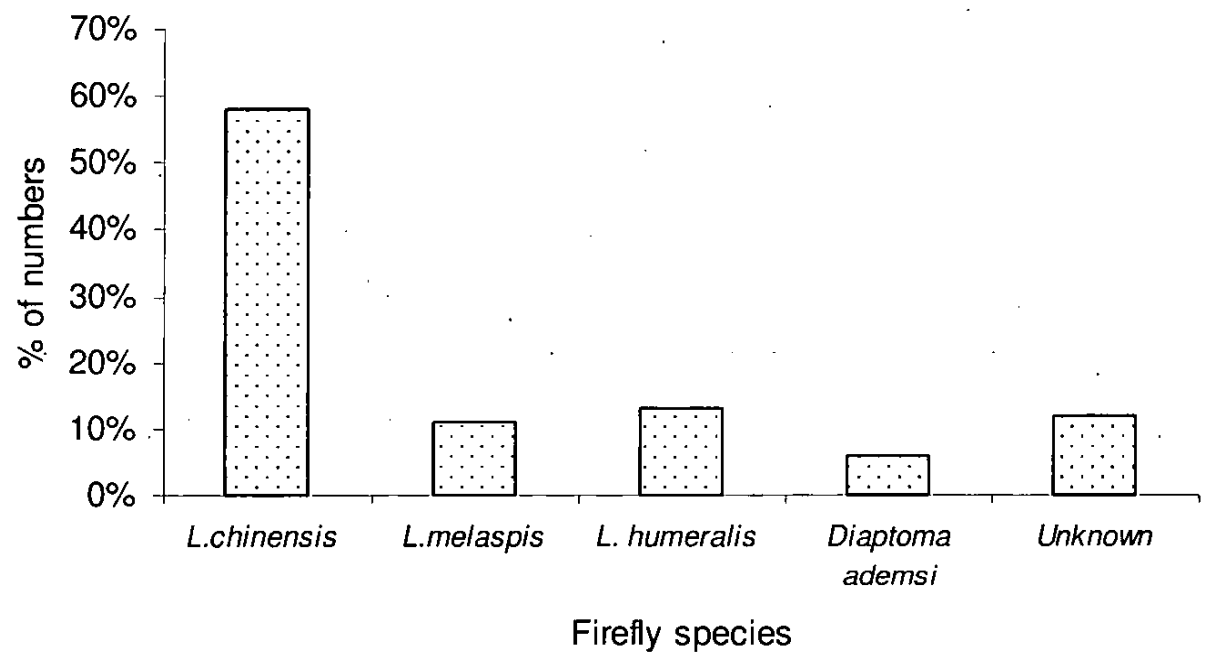


Figure 3b: Percentage of firefly species collected from Galle District

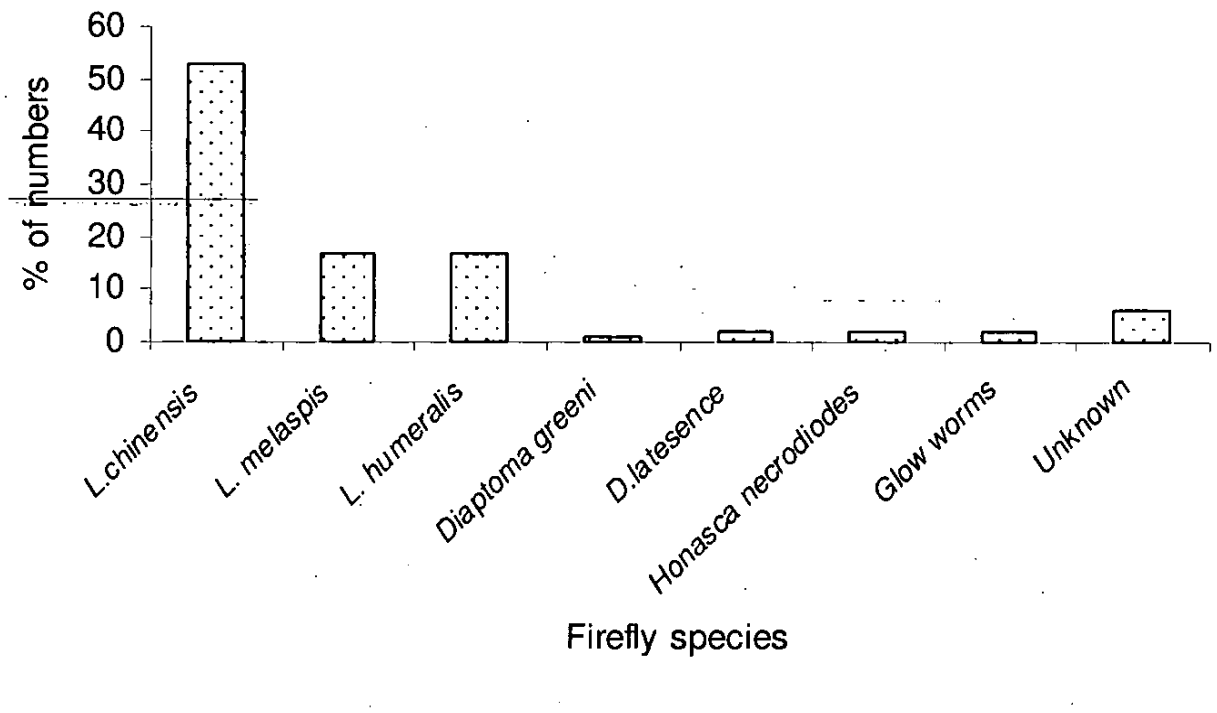


Figure 3c: Percentage of firefly species collected from Hambantota District

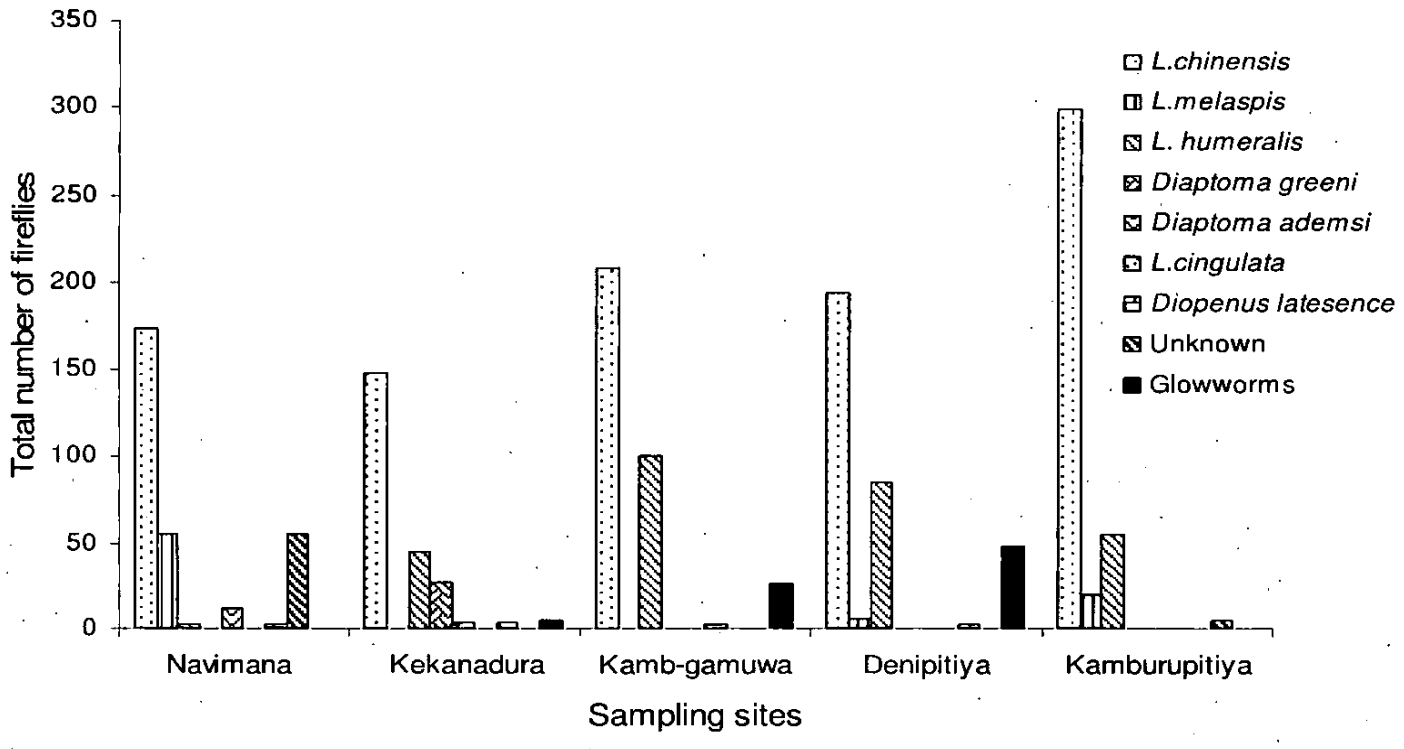


Figure 4a: Number of firefly species collected from five sampling habitats in Matara District

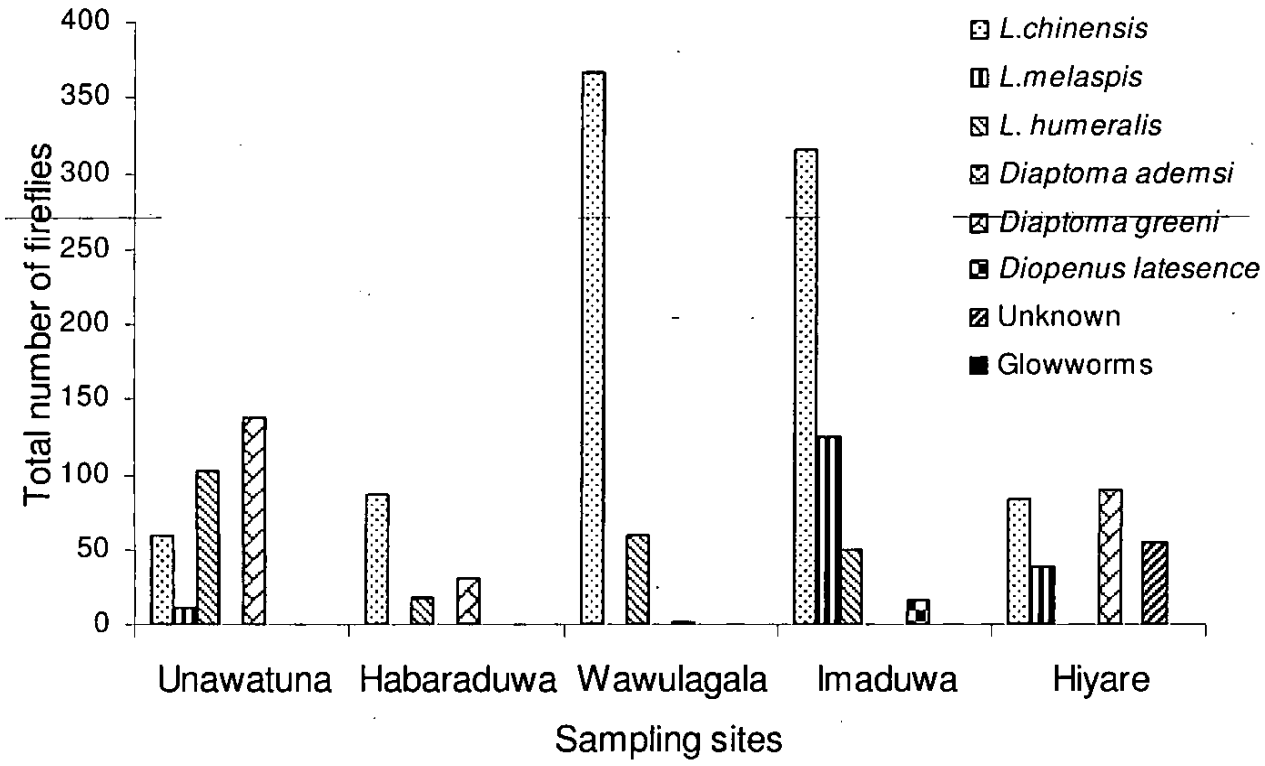


Figure 4b: Number of firefly species collected from five sampling habitats in Galle District

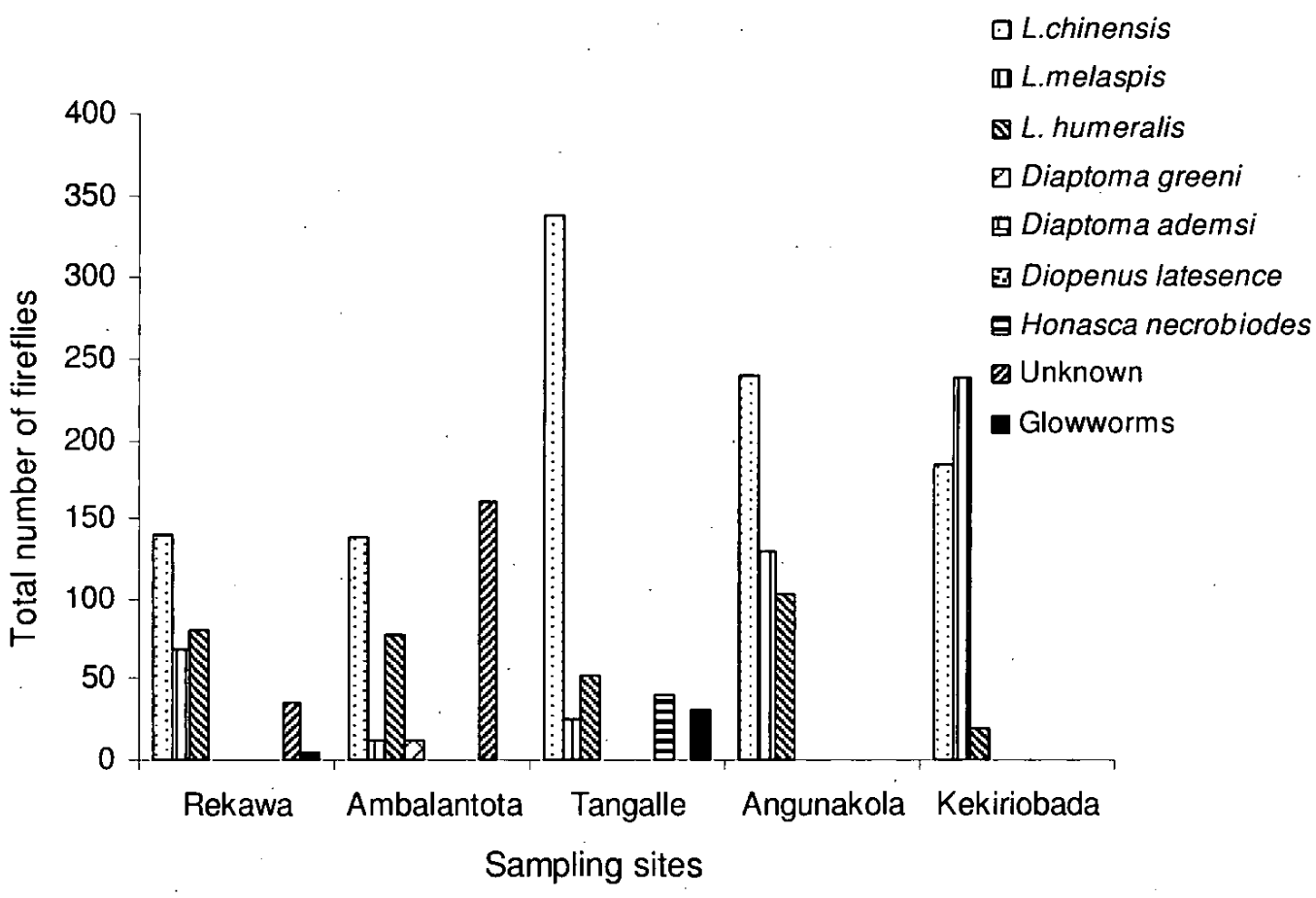


Figure 4c: Number of fireflies in each species collected from five sampling sites in Hambantota District

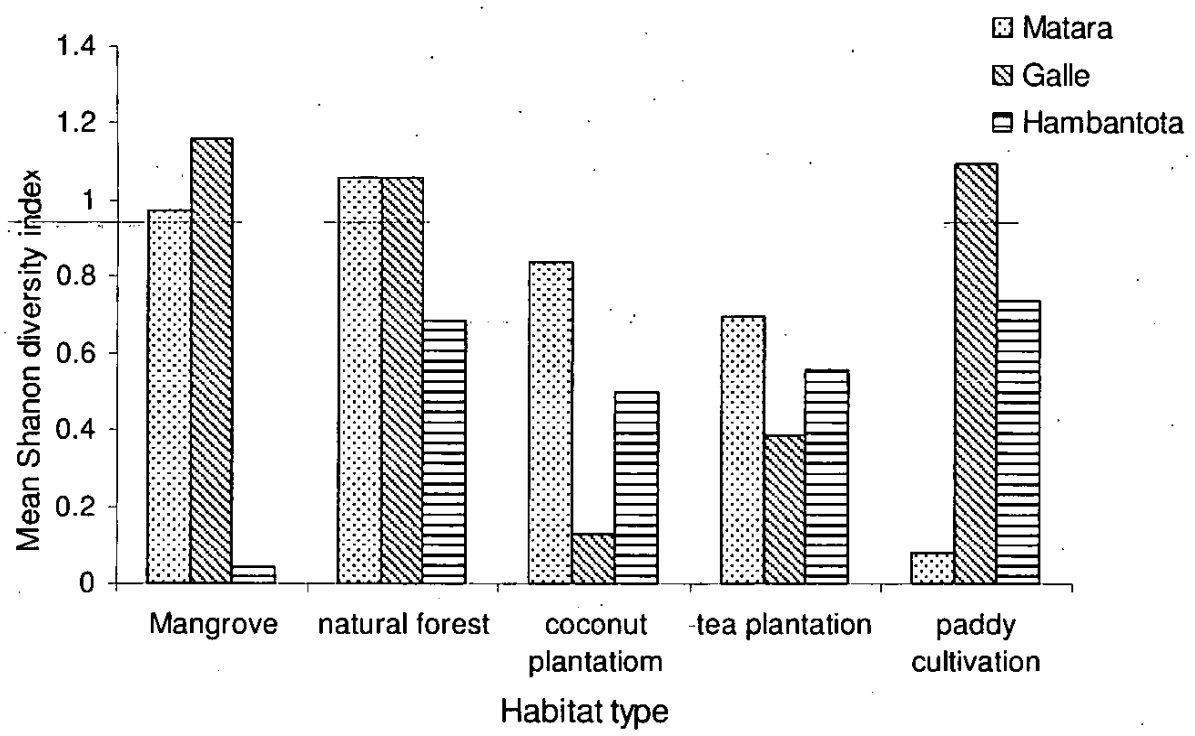


Figure 5: Mean Shannon's diversity index of species of fireflies in five selected habitats in Matara, Galle and Hambantota Districts during the study period

Factors which affect on the abundance of fireflies

Present study indicates that there is a very clear relationship between the rainfall and the abundance of fireflies (Figure 5). Rainy seasons favor the good population increase in fireflies and this is well marked in Matara and Galle districts. In Hambantota district this relationship is not very prominent.

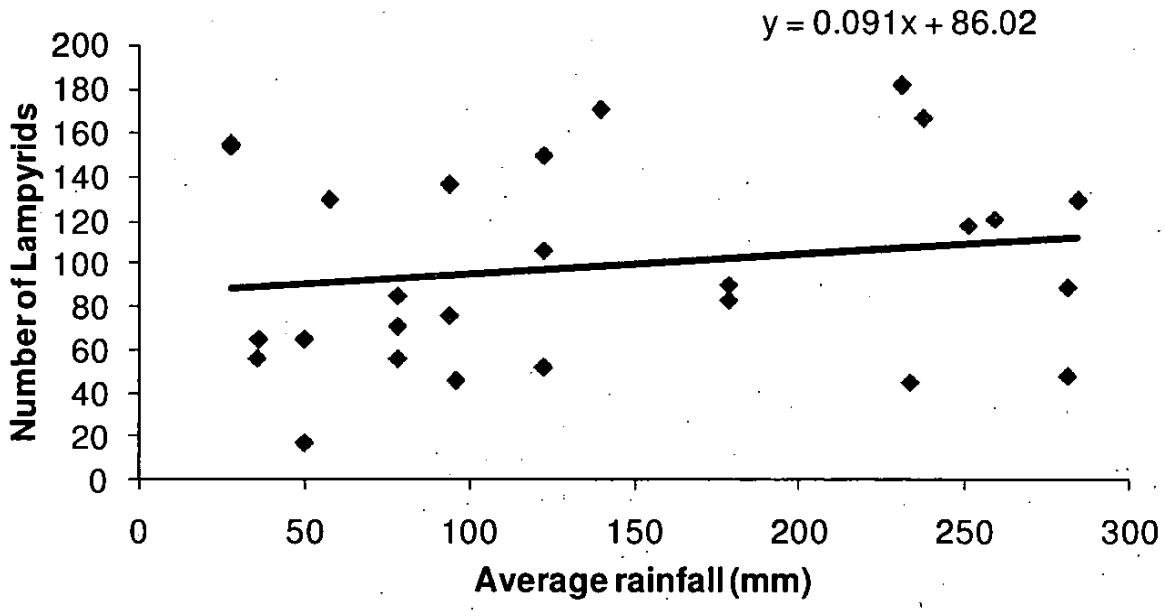


Figure 6. Relationship between total number of lampyrids and rainfall (mm) in selected sampling sites in Southern province

Moon Light and artificial lights

Firefly abundance is reduce in the well lit areas on full moon days. They are mostly confined to the darker shades during these days. Similarly flashing fireflies are always away from the artificial lights such as street lamps.Other than these two physical factors there is no impact of other physical factors on the abundance of fireflies

Predators

Web building spiders seems to be the main predators of fireflies. Fireflies entangled in spider webs are killed by the spiders. Even after the death the light organ of fireflies able to illuminate in the dark and that attrack more fireflies to the sprider webs.

Prey

Many invertebrates are known as preys of fireflies. However, during this investigation, only slugs and snails were observed as the common prey of Lampyrid larvae and larviform females.

Discussion

Present study focused on the abundance and population fluctuations of lampyrids which are active from 6.30 p.m to 9.30 p.m. in selected habitats in Southern province of Sri Lanka. Our study indicates that all the selected ecosystems contained several hundreds of fireflies, the three dominant species were, *L.chinensis, L.humeralis* and *L. melaspis* with two other *Luciola* species which require further taxonomic clarification.

Selection of sampling sites for the present study was based on the vegetation type common to three districts. Vegetations which are specific to each district for example scrub jungles in Hambantota district or wet evergreen forests in Galle district were not selected for this study. Mangoove forests which are common along the coastal side of all three districts were selected as natural vegetation. Tea Plantations which are found in the

higher elevations of the three districts were selected as a relatively stable agroecosystem to compare the firefly abundance. The third sampling site was lowland paddy fields, an agro ecosystem with very high human intervention and very drastic vegetational change within a year.

As a whole all our study suggested that lampyrid population fluctuated with the seasonal changes; these fluctuations could be annual or short cycled (more than one generation per year) or gradual or less than one generation per year. The abundance of these fireflies varies with their natural habitats. There could be many explanations for these observations and further long term studies are required for further clarification.

Also present study discuss only about the fireflies which are active during 6.30 pm to 9.30 pm. This may not give the complete picture of fireflies in the area. However this study provides vital information regarding the firefly abundance of particular ecosystems.

In mangrove ecosystem firefly population decreased gradually during the dry periods and then increase with the rainy period, as such single cycle occurs within the year. Since no external or human influence affects these population fluctuations this would be the normal pattern which could be common under natural conditions.

In tea plantations population variations were not very rapid, it gradually decreased with the year. Tea plantations are very specific ecosytems which require unique conditions and relatively stable with some human interventions. But it has created different ecological conditions for different species of lamyrids than the other two ecosystems. It was dominated by *L.melaspis* in 1st sampling occasion in Hambantota district. However *L.melaspis* populations tend to decreased gradually in second and third samplings. Further studies will be required to analyse the population variations.

Paddy cultivation is a very rapidly changing ecosystem with very high human intervention (Weerarathna and Fernando, 1985). In Wet zone sampling sites fireflies associated with this ecosystem fluctuated in similar manner compared to the other two

ecosystems. In dry zone site (Hambantota district) firefly population was very high during the second sampling. In Hambantota district people cultivate paddy during the dry period using the water in reservoirs. This could be one possible reason for the abundance of fireflies in this particular ecosystem.

Present study provides information on firefly abundance in different habitats I Southern Sri Lanka during the year 2007. This study will be a baseline for a future research in distributions and abundance of fireflies throughout Sri Lanka.

3.6 Conclusions

Sri Lankan firefly fauna is dominated by the fireflies belongs to genus *Luciola.* Within this group *L.chinensis (L. Prausta)* seems to be the most dominant firefly species in most of the ecosystem studied. Natural ecosystems favour the wide diversity of fireflies and rain is most favourable climatic condition for the fireflies.

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3. Problems if any, encountered during the implementation of the project

There were several problems encountered during the project.

1. Finding suitable RA to conduct the research. As this research had conduct during the night we had a great problem in finding suitable person. As we have to appoint a male RA so far we appointed only two RAs and one worked less than a month. Most of the work carried out by the Mr. R.S.P.K.M.Rajapakse the second RA of the project. After that we were unable to find another RA and with the approval of NSF we appointed a TA for the project. Although he worked for a year we were unable to conduct the field sampling regularly due to the security problems in the country.
2. Due to the above mentioned problems the duration of field samplings was extended for nearly four years.
3. Principal investigator of the project Dr. H.C.E.Wegiriya was on sabbatical leave from 30.10.2008 to 30.10.2009. Analysis of results and final report writing was started soon after the completion of field works. But due to the heavy Academic work load and other extracurricular activities on the principal investigator delayed the completion of final report for considerably long period.

Major findings and follow up activities.

Firefly diversity was not well studied in Sri Lanka. Their abundance varies through out the year especially according to the rainfall pattern of the country. Although some of the fireflies were considered as foliage pests by farmers, we did not find any evidence to

prove that. However firefly larvae could consider as a beneficial insects as they heavily prey on snails and slugs which often consider as a serious pests of vegetables. Taxonomy of Sri Lankan fireflies has to revise according to the recent taxonomic revisions of the world.

Several unidentified fireflies were encountered during this study. Their identification and taxonomic revision of fireflies in Sri Lanka is still in the process.

Follow up activities

- Study on firefly fauna of the country - We have started to work on fireflies in Uva and Sabaragamuwa provinces under a small grant from Faculty of Science.
- Design of suitable awareness programmes to promote fireflies as natural enemies of the molluscan pests.
- Molecular taxonomic studies to differentiate species – already started
- Publishing a book on "Fireflies of Sri Lanka" - already started

Section 4

Impact of Research results:

i) Relevance of results achieved to scientific advancement

There is a dearth of information on taxonomy, diversity and ecology of fireflies in Sri Lanka. Many of the taxonomic names given should have to revise according to the recent taxonomic revisions. Our studies will continue up to that level with the collected information from this project and it may take several years to complete. Also because of this work we were able to participate two international conferences on fireflies held in 2008 (Chiang Mai, Thailand) and 2010 (Selangor, Malaysia). In future we may be able to host one of the events in this series.

ii) Relevance of results achieved to national/socio-economic development

Though it was not known to the Sri Lankan community, firefly larvae could be used as predators to control slugs and snail pests of vegetables. Early literature shows that during 1954 and 1955 several hundred larvae of Lampigera tenebrosus were shipped to Hawaii, Indonesia and Guam to control the giant African snail Achatina fulica. Similarly we could aware the farmers to use these active predators to manage these voracious molluscan pests. This will help to reduce the use of pesticides.

iii) Dissemination/application of research output

It is expected to disseminate the knowledge on use of fireflies in pest management to farmers through series of farmer awareness programmes. Also we expect to publish a booklet on fireflies and this will help to educate the naturalists and amateurs to observe flashing fireflies in the field. This could be a key night time activity in Ecotourism programmes.

Section 5

Miscellaneous

i) List of major equipment acquired during the project period and their functionality

Digital camera Sony DSC S40 – functioning

ii) List of publications/communications arising from the project and/or presentations made at seminars, workshops etc. (Please attach copies)

Publications

Full papers – refereed journals

1 Bogahawatta, C.N.L. , **Wegiriya H.C.E.** and Rajapaksha (2009)Species diversity of Fireflies (Coleoptera : Lampyridae) in selected natural and agricultural habitats in Southern Sri Lanka. Rohana: Research journal of the University of Ruhuna , 7, 1-11pp

Refereed full papers – Oral presentations in proceedings

2 **Wegiriya, H.C.E**., Bogahawatta, C.N.L. and Rajapaksha, R.S.P.K.M. **(2007)**, Species composition of Fireflies in selected natural habitats and agroecosystems in the Hambantota district. Proceedings of 5th Academic sessions, University of Ruhuna, Matara, Sri Lanka, 5 pp 55 -59.

Refereed full papers – Oral presentations in International conferences

3 Bogahawatta, C.N.L., **Wegiriya, H.C.E**. and Rajapaksha, R.S.P.K.M. **(2008)**, Species diversity of fireflies in selected natural habitats and agroecosystems in Matara district of southern province Sri Lanka, Proceedings of International symposium on "Diversity and conservation of fireflies" Queen Sirikit Botanic Garden, Chiang Mai, Thailand 11-17pp

4 **Wegiriya, H.C.E**., Bogahawatta, C.N.L. and Rajapaksha, R.S.P.K.M. **(2008)**, Impact of rainfall on the abundance of lampyrids in selected habitats in southern Sri Lanka, Proceedings of the International symposium on "Diversity and conservation of fireflies" Queen Sirikit Botanic Garden, Chiang Mai, Thailand, 18-25pp

Refereed abstracts – Poster presentations in International conferences

5 **Wegiriya, H.C.E**., Bogahawatta, C.N.L. and Rajapaksha, R.S.P.K.M. **(2008)**, Fireflies and Ecotourism: A study on fireflies in selected natural forests in southern Sri Lanka, Proceedings of International symposium on "Diversity and conservation of fireflies" Queen Sirikit Botanic Garden, Chiang Mai, Thailand, 176pp

6. **Wegiriya, H.C.E.**, Bogahawatta, C.N.L. and Wijekoon, W.M.C.D.. **(2010)**, Regional diversity of fireflies of the subfamily Luciolinae (Coleoptera: Lampyridae) in Sri Lanka, at 2nd international firefly symposium held at Selangor, Malaysia.

Section 6

Summary Statement of Expenditure (indicate under Personnel, Equipment, Consumables, Travel and Subsistence and Miscellaneous)

Personnel	RA	= Rs. 212 000.00
	TA	= Rs 96 000.00
	Other	= Rs 9140.00
Equipment		= Rs 53 400.00
Consumables (Local)		= Rs 16 394.00
Travel and Subsistence		= Rs 64 926.00
Miscellaneous		= Rs 23000.00
Total spent		**= Rs 472 267.00**

Section 7

i) Grantees' signatures

ii) Comments of the Head of the Department/signature

iii) Head of the Institution's signature

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