2014 International Firefly Symposium

Program & Abstracts Book

August 11-15, 2014 | Gainesville, Florida, USA
Hilton University of Florida Conference Center

www.conference.ifas.ufl.edu/firefly

UF | UNIVERSITY of FLORIDA
College of Agricultural and Life Sciences
Department of Entomology and Nematology

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August 11, 2014

Dear Friends and Colleagues,

Welcome to Gainesville, Florida, and the 2014 International Firefly Symposium, an exciting opportunity to network with each other, to share valuable information about fireflies, and to experience a salt marsh firefly display! I hope you find the 2014 meeting to be both fun and informative.

I am delighted to report that representatives from 12 countries are attending this year's conference! This clearly demonstrates the high level of interaction and collaboration across international boundaries in our field. While this number is impressive, I look forward to the year in which the meeting attracts double the number of countries in attendance.

This year's program covers many different topics related to fireflies. Presentations over taxonomy, phylogeny, genetics, behavior, conservation, ecology, diversity, ecotourism, education and art are being given. In addition, the field trip to Cedar Key provides everyone with a chance to see a unique firefly habitat, the Florida salt marsh. I encourage you if possible to take some additional time while here to explore Florida's natural beauty.

It's often difficult to carve time out of a busy schedule to attend a weeklong conference; I certainly appreciate your attendance and participation this year. A debt of gratitude goes out to our moderators and sponsors, without whom this symposium would not have been possible. I also owe special thanks to Jasmine Garcia and the staff of the UF/IFAS Office of Conferences and Institutes for all the hard work they've done to ensure that the 2014 International Firefly Symposium operates smoothly.

Thanks for coming, and enjoy the conference!

Sincerely,

Marc A. Branham
Host, 2014 International Firefly Symposium
Associate Professor
University of Florida

The Foundation for The Gator Nation

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A Brief History of the International Firefly Symposium

By Raphaël De Cock and Marc Branham

The philosophy behind organizing the first Firefly Meeting was to bring together people from around the world with an interest in fireflies (and other bioluminescent beetles) at a venue open to not only scientists, but educators, naturalists and artists. Artistic activities involving fireflies represent an essential link in promoting these insects and their conservation to a wider audience, especially those works combining art, science and education. By providing a venue for an international meeting, the organizers hoped to foster collaborative partnerships between those interested in many different aspects of fireflies.

The series of meetings that has become the International Firefly Symposium arose from a meeting hosted in 2007 by the Parque Biológico de Gaia, a center for environmental education and a nature reserve in Vilanova de Gaia, Portugal. The **2007 meeting**, officially called the International Firefly Meeting, later renamed the **Firefly Network Meeting**, was hosted and organized by Mr. Nuno Gomes Oliveira and Dr. Raphaël De Cock. The Parque Biológico de Gaia was a natural choice for the first meeting as the park director, Mr. Oliveira, is dedicated to the study and conservation of fireflies. Fireflies are found in the reserve and nightly firefly excursions remain a popular activity for more than 10,000 visitors yearly.

In 2008, the Queen Sirikit's Botanic Garden Organization and the Committee for the *Fireflies in Thailand Project* organized the **1st International Firefly Symposium** in Chiang Mai, Thailand. Mr. Bampot Napompeth served as the keynote speaker. The **Firefly Network Meeting** was held in conjunction with the symposium, and the meeting committee formally decided that it would be beneficial to hold a symposium every two years.

In 2010, the Forest Research Institute Malaysia (FRIM) and the Malaysian Nature Society organized the **2nd International Firefly Symposium** in Subang, Selangor, Malaysia. Drs. Nobuyoshi Ohba and Lesley Ballantyne served as keynote speakers. An additional activity associated with but held prior to this meeting was a training course on the Identification and Taxonomy of South East Asian Fireflies, taught by Drs. Lesley Ballantyne and Ming-Luen Jeng (July 27-31, 2010). The **Network Meeting** was held on the last day of the symposium. At the 2010 symposium, it was formally decided that in order to provide more time for planning future symposia as well as for conducting firefly projects between meetings, symposia would be held every three years. At the 2010 meeting, the University of Florida was elected as the venue for the International Firefly Symposium in 2013.

Due to several unforeseen scheduling issues, the meeting originally scheduled for 2013 was moved to 2014. In August of 2014, the University of Florida will be hosting the **2014 International Firefly Symposium** in Gainesville, Florida. In the interest of simplicity, the numbering system for the symposium was dropped from the title and replaced with the year the meeting will be held. The University of Florida has been a center for firefly research for over 45 years, due to the influential career of Dr. James E. Lloyd, professor emeritus. Dr. Lloyd has agreed to serve as the keynote speaker at the 2014 meeting.

2014 Symposium Organizers

***Marc Branham**, Symposium Host*
University of Florida / IFAS
Department of Entomology and Nematology

***Jasmine Garcia**, Symposium Coordinator*
University of Florida / IFAS
Office of Conferences and Institutes

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Agenda-at-a-Glance

Monday, August 11, 2014	
4:00pm–8:00pm	Registration Open // Poster Presenters and Sponsors Set-up Displays
6:00pm–7:00pm	Welcome Networking Social
Tuesday, August 12, 2014	
8:00am–9:00am	Morning Refreshments / Poster Viewing
9:00am–10:30am	Welcome and Keynote Address
10:30am–10:50am	Refreshment Break / Poster Viewing
10:50am–12:30pm	General Session
12:30pm–1:30pm	Group Lunch *(provided)*
1:30pm–2:20pm	General Session
2:20pm–2:40pm	Refreshment Break / Poster Viewing
3:00pm–3:30pm	Bus Loading
4:45pm–9:15pm	Dinner and Tour of Firefly Habitat in Cedar Key, Florida
10:30pm	Group Returns to Hotel
Wednesday, August 13, 2014	
8:00am–9:00am	Morning Refreshments / Poster Viewing
9:00am–10:40am	General Session
10:40am–11:00am	Refreshment Break / Poster Viewing
11:00am–12:15pm	General Session
12:15pm–1:30pm	Group Lunch *(provided)*
1:30pm–3:10pm	General Session
3:10pm–3:30pm	Refreshment Break / Poster Viewing
3:30pm–4:45pm	General Session
6:00pm	Informal Dinner at Department of Entomology and Nematology followed by an Evening on Own to Explore Gainesville
Thursday, August 14, 2014	
8:00am–9:00am	Morning Refreshments / Poster Viewing
9:00am–10:40am	General Session
10:40am–11:00am	Refreshment Break / Poster Viewing
11:00am–12:15pm	General Session
12:15pm–1:30pm	Group Lunch *(provided)*
1:30pm–3:15pm	General Session
3:15pm–3:35pm	Refreshment Break / Poster Viewing
4:45pm	Walk to Florida Museum of Natural History
5:00pm–5:30pm	Guided tour of the Butterfly Rainforest – A Natural Exhibit
5:30pm–7:30pm	Networking Reception and Dinner at Museum
7:30pm–9:00pm	Attendees on Own to Visit Museum Exhibits and Return to Hotel
Friday, August 15, 2014	
8:00am–9:00am	Morning Refreshments / Poster Viewing
9:00am–11:00am	Closing General Session
11:00am	Symposium Concludes // Poster and Sponsor Display Removal

Detailed Program Agenda

For full author recognition, see the Symposium Abstracts beginning on page 15.

Monday, August 11, 2014	
4:00pm – 8:00pm	Registration Office Open *[Century Ballroom Prefunction Area]*
4:00pm – 8:00pm	Poster Presenters and Sponsors Set-up Displays *[Century Ballroom A]*
6:00pm – 7:00pm	**Welcome Networking Social** *[Century Ballroom A]*
Tuesday, August 12, 2014	
8:00am – 9:00am	**Morning Refreshments / Poster Viewing** *[Century Ballroom A]*
9:00am – 9:15am	Welcome and Official Opening *[Century Ballroom A]*
9:15am – 10:30am	**Keynote Address** *[Century Ballroom A]*
Moderator	***Marc Branham***
9:15am – 10:15am	**James E. Lloyd** – Fireflies Come of Age
10:15am – 10:30am	Question and Answer Session
10:30am – 10:50am	**Refreshment Break / Poster Viewing** *[Century Ballroom A]*
10:50am – 12:30pm	**Session 1: Taxonomy, Phylogeny and Genetics** *[Century Ballroom A]*
Moderator	***Lesley Ballantyne***
10:50am – 11:15am	**Paul Marek** – The evolution of bioluminescence in the Sierra luminous millipedes
11:15am – 11:40am	**Gavin J. Martin** – A molecular phylogeny of Lampyridae and its implications to the evolution of firefly signaling systems
11:40am – 12:05pm	**Abner B. Lall** – Colors of the night: Do fireflies detect the color of their bioluminescence?
12:05pm – 12:30pm	**Yelena M. Pacheco** – A phylogenetic comparison of populations of *Pyractomena* in the western United States
12:30pm – 1:30pm	**Group Lunch** *[Albert's Restaurant at Hilton University of Florida]*
1:30pm – 2:20pm	**Session 2: Taxonomy, Phylogeny and Genetics (continued)** *[Century Ballroom A]*
Moderator	***Ming-Luen Jeng***
1:30pm – 1:55pm	**Kathrin F. Stanger-Hall** – A phylogeny of North American *Photinus* fireflies: Implications for taxonomy and signal evolution
1:55pm – 2:20pm	**Marc A. Branham** – A long term off-site collection enhancement loan of Lampyridae from the US National Collection to the University of Florida: A history and plan for the future
2:20pm – 2:40pm	**Refreshment Break / Poster Viewing** *[Century Ballroom A]*
3:00pm – 3:30pm	**Bus Loading** *[Conference Center Driveway]*
4:45pm – 9:15pm	**Dinner and Tour of Firefly Habitat in Cedar Key, Florida**
10:30pm	Group Returns to Hotel

Detailed Program Agenda (continued)

Wednesday, August 13, 2014	
8:00am – 9:00am	**Morning Refreshments / Poster Viewing** *[Century Ballroom A]*
9:00am – 10:40am	**Session 3: Biology and Behavior** *[Century Ballroom A]*
Moderator	***Veronica Khoo***
9:00am – 9:25am	**Lawrent "Larry" L. Buschman** – The bioluminescent behavior of some North American lampyrid larvae
9:25am – 9:50am	**Andrew Moiseff** – Female *Photinus carolinus* lateralize their response flashes
9:50am – 10:15am	**Raphael De Cock** – The enigmatic Blue Ghost Firefly *Phausis reticulata* (Coleoptera: Lampyridae): Observations on its courtship, mating and oviposition behaviors
10:15am – 10:40am	**Lawrent "Larry" L. Buschman** – Courtship flash communication in two *Photuris* fireflies
10:40am – 11:00am	**Refreshment Break / Poster Viewing** *[Century Ballroom A]*
11:00am – 12:15pm	**Session 4: Biology and Behavior (continued)** *[Century Ballroom A]*
Moderator	***Anchana Thancharoen***
11:00am – 11:25am	**Sara M. Lewis** – Comparative study of nuptial gifts in some North American and Asian fireflies
11:25am – 11:50am	**Xinhua Fu** – Sexual dimorphism, mating systems, and nuptial gifts in several genera of Asian fireflies (Coleoptera: Lampyridae)
11:50am – 12:15pm	**Somyot Silalom** – The life history of the common Giant Terrestrial Firefly, *Lamprigera tenebrosus* (Coleoptera: Lampyridae) in Thailand
12:15pm – 1:30pm	**Group Lunch** *[Albert's Restaurant at Hilton University of Florida]*
1:30pm – 3:10pm	**Session 5: Biology and Behavior (continued)** *[Century Ballroom A]*
Moderator	***Christopher Cratsley***
1:30pm – 1:55pm	**Jen-Zon Ho** – Ants as a diet for the life cycle of the Torrential Firefly *Luciola cereta* (Coleoptera: Lampyridae)
1:55pm – 2:20pm	**John W. Wenzel** – A new firefly larva from Dominican amber and phylogenetic hypothesis of larval feeding behavior across Lampyridae (Coleoptera: Lampyridae)
2:20pm – 2:45pm	**Yuichi Oba** – Evolution of firefly luciferase and biosynthetic origin of firefly Luciferin
2:45pm – 3:10pm	**Vor Yiu** – Towards an easy and cheap method to record and analyse firefly flash patterns
3:10pm – 3:30pm	**Refreshment Break / Poster Viewing** *[Century Ballroom A]*
3:30pm – 4:45pm	**Session 6: Conservation, Ecotourism and Education** *[Century Ballroom A]*
Moderator	***Xinhua Fu***
3:30pm – 3:55pm	**Veronica Khoo, *on behalf of Nada Badruddin*** – Fireflies in the grounds of the Forest Research Institute Malaysia (FRIM): Studies on their diversity and seasonality
3:55pm – 4:20pm	**Veronica Khoo** – Conservation of the Selangor River population of *Pteroptyx tener* in Malaysia: Results of seven years of monitoring
4:20pm – 4:45pm	**Mahadimenakbar M. Dawood** – Studies on congregating fireflies (Coleoptera; Lampyridae; *Pteroptyx* sp.) in Sabah, Malaysia
6:00pm	**Informal Dinner at University of Florida Department of Entomology and Nematology followed by Evening on Own to Explore Gainesville**

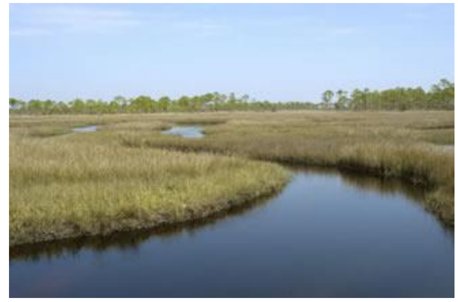
Detailed Program Agenda (continued)

Thursday, August 14, 2014	
8:00am – 9:00am	**Morning Refreshments / Poster Viewing** *[Century Ballroom A]*
9:00am – 10:40am	**Session 7: Conservation, Ecotourism and Education (continued)** *[Century Ballroom A]*
Moderator	***Sara Lewis***
9:00am – 9:25am	**Chiahsiung Wu** – Habitat restoration of the Aquatic firefly, *Aquatica ficta* (Olivier, 1909) restoration in Taipei city, Taiwan
9:25am – 9:50am	**Anchana Thancharoen** – Toxicity and behavioral responses of the freshwater firefly larvae, *Luciola aquatilis*, to glyphosate herbicide
9:50am – 10:15am	**Stefan Ineichen** – Light into darkness. The significance of glowworms and fireflies in European culture
10:15am – 10:40am	**Christopher Cratsley** – Approaches to incorporating fireflies in STEM education
10:40am – 11:00am	**Refreshment Break / Poster Viewing** *[Century Ballroom A]*
11:00am – 12:15pm	**Session 8: Conservation, Ecotourism and Education (continued)** *[Century Ballroom A]*
Moderator	***Somyot Silalom***
11:00am – 11:25am	**Choong Hay Wong** – Piloting and using Citizen Science to monitor the fireflies in Kuala Selangor Nature Park, Selangor State, Malaysia
11:25am – 11:50am	**Don Salvatore** – Firefly Watch: A Citizen Science project to monitor firefly numbers
11:50am – 12:15pm	**Lynn Faust** – Milkweed Fireflies: The occurrence and behaviors of 5 adult North American fireflies, *Photinus pyralis*, *Photinus cooki*, *Pyropyga minuta* and *Photuris* sp. on milkweed *Asclepias syriaca*
12:15pm – 1:30pm	**Group Lunch** *[Albert's Restaurant at Hilton University of Florida]*
1:30pm – 3:15pm	**Session 9: Ecology and Diveristy; Art** *[Century Ballroom A]*
Moderator	***Vor Yiu***
1:30pm – 1:55pm	**Zachary H. Marion** – Extending the concept of diversity partitioning to characterize phenotypic complexity
1:55pm – 2:20pm	**Radim Schreiber** – Photographing the glow of fireflies up-close (Art Presentation)
2:20pm – 2:45pm	**James K. Fischer** – Fireflies and the photic field
2:45pm – 3:15pm	Open Question and Answer Session / Poster Visitation
3:15pm – 3:35pm	**Refreshment Break / Poster Viewing** *[Century Ballroom A]*
4:45pm	Walk to Florida Museum of Natural History
5:00pm – 5:30pm	Guided tour of the Butterfly Rainforest - A Natural Exhibit
5:30pm – 6:15pm	**Networking Reception** *[Museum's Thompson Gallery]*
6:15pm – 7:30pm	**Dinner and Special Presentation** *[Museum's Central Gallery]*
7:30pm – 9:00pm	Attendees on Own to Visit Museum Exhibits and Return to Hotel
Friday, August 15, 2014	
8:00am – 9:00am	**Morning Refreshments / Poster Viewing** *[Century Ballroom A]*
9:00am – 11:00am	**Session 10: Selangor Declaration Discussion and Firefly Research Network** *[Century Ballroom A]*
Moderators	***Choong Hay Wong and Raphael De Cock***
9:00am – 9:50am	Selangor Declaration for the Conservation of Fireflies / Updates and Discussion
9:50am – 10:40am	Firefly Research Network Meeting
10:40am – 11:00am	Closing Remarks
11:00am	Symposium Concludes Poster and Sponsor Display Removal

Tour of Cedar Key and Firefly Habitat

Tuesday, August 12, 2014

Itinerary:



3:00-3:30pm	Load bus
3:30pm	Depart Hilton UF Conference Center
3:30-4:45pm	Travel to Cedar Key
4:45-6:00pm	Shopping and sightseeing
6:00-8:00pm	Dinner and presentation at The Island Room restaurant
8:00-8:15pm	Travel to salt marsh
8:15-9:15pm	View habitat and behavior of the Florida Intertidal firefly Micronaspis floridana
9:15-10:30pm	Travel to Hilton UF Conference Center
10:30pm	Bus returns to hotel

Description:

In addition to educational opportunities, the symposium will provide camaraderie and a great chance to explore the natural beauty of northern Florida.

On Tuesday evening, participants will have the opportunity to visit the coastal town of Cedar Key – a quiet island community nestled among many tiny keys on the Gulf Coast of Florida. Long admired for its natural beauty and abundant supply of seafood, it is a tranquil village, rich with the almost forgotten history of old Florida. Upon arrival, attendees will have some time to explore the many shops and sights of the Key, including antique shops, art galleries, and food stores. The business district is centered around Dock Street and Second Street, but there are plenty of shops along State Route 24 and on the side streets of Cedar Key. After sightseeing, attendees will head to The Island Room restaurant for a delicious dinner featuring traditional Florida cuisine, as well as a short presentation on the Florida clamming industry. Finally, this evening tour will take participants to the Cedar Key salt marsh, where they can observe the habitat and behavior of the Florida Intertidal Firefly Micronaspis floridana, a monotypic species found only in association with salt marsh habitats.

What to Wear & Bring:

Casual field attire such as lightweight long sleeves and long pants and closed shoes, bug repellent, and binoculars. There is a wooden boardwalk over the salt marsh that will be accessed for firefly viewing. Keep in mind that the weather will be humid, and comfortable clothes suitable for warm weather are suggested.

Food Provided:

Dinner at The Island Room restaurant. Menu to feature traditional Florida cuisine including Cedar Key clam chowder, a seafood boil, and baked fresh fish.

Driving Distance:

Cedar Key is located approximately 60 miles southwest of Gainesville on the Gulf Coast of Florida.

Cost of Tour:

Included with completed and paid symposium registration. Guests may attend the evening tour in Cedar Key for an additional $60.00 fee per guest.

Poster Directory

For full author recognition, see the Symposium Abstracts beginning on page 15.

Poster
Number

1 **The Shadow Ghosts, *Phausis inaccensa*: Photographic Notes on Habitat, Seasonality, Mating and Egg Guarding Behaviors and Early Instar Larvae -- *Lynn Faust*,** *Emory River Land Company*

2 **A Bahamas Population of the Threatened Florida Intertidal Firefly *Micronapsis floridana* -- *Lynn Faust***, *Emory River Land Company*

3 **Structure and Function of the Larval Visual System in the Firefly (*Photuris*) -- *Fred Murphy***, *University of Connecticut*

4 **Life Cycle and Photic Behavior of Winter Fireflies in the Alishan Area of Southwestern Taiwan -- *Hua-Te Fang***, *Endemic Species Research Institute*

5 **Creatures of Light: Nature's Bioluminescence – A Traveling Museum Exhibition -- *Marc Branham***, *University of Florida*

6 **Description of Life Cycle and Preimaginal Stages of *Alecton discoidalis* Laporte, 1833 under Laboratory Conditions -- *Marc Branham***, *University of Florida*

7 **Actualization of the Presence and Distribution of Spanish Fireflies Based on a Five Year Survey (2009-2013) by Means of a Photo-Biodiversity Database -- *Raphael De Cock***, *University of Antwerp*

8 **Biodiversity Surveys of Firefly Species: Practical Examples of Small Scale Studies from Southern Spain (2012) and Southeast France (2013) -- *Raphael De Cock***, *University of Antwerp*

9 **Call for a Discussion about the Set-Up of a more Standardized Protocol to Adequately Describe the Bioluminescent Behaviors of Fireflies Observed in the Field -- *Raphael De Cock***, *University of Antwerp*

10 ***Photuris* Fireflies Threatened with Sea Level Rise in the Delaware and Chesapeake Estuaries -- *Christopher Heckscher***, *Delaware State University*

11 **Hope for Barber's Fireflies: Photuris in the Washington, DC, Area and in Rehoboth Beach, Delaware -- *Heloise Morgan***

12 **Genome Size Evolution in North American Fireflies -- *Sarah Sander***, *University of Georgia*

13 **Diversity of Aquatic Fireflies in the Philippines -- *Ming-Luen Jeng***, *National Museum of Natural Science*

14 ***Pyropyga* Sp.: First Invasive Alien Firefly in Japan -- *Yuichi Oba***, *Nagoya University*

Symposium Abstracts

Listed alphabetically by presenting author last name.
Presenting author names appear in **bold**

CREATURES OF LIGHT: NATURE'S BIOLUMINESCENCE – A TRAVELING MUSEUM EXHIBITION

Marc A. Branham[1] *and John Sparks*[2]
[1]Dept. of Entomology and Nematology, University of Florida, Gainesville, FL, USA
[2]Dept. of Ichthyology, American Museum of Natural History, New York, NY, USA

The Creatures of Light traveling exhibition brings the world of bioluminescence to the public in an exciting experience that includes larger-than-life models of organisms, digital interactive displays, a scale model of a deep-sea submersible and even live flashlight fish. Visitors move through a series of immersive environments complete with soundscapes to experience where bioluminescent organisms occur and how they use bioluminescence to survive. Starting in a forest of glowing mushrooms and millipedes, visitors continue through a firefly-filled meadow, across a bay of luminous dinoflagellates, along a glowing coral reef, and, finally, into the deep sea. The exhibition was organized by the American Museum of Natural History, New York, in collaboration with The Canadian Museum of Nature, Ottawa, Canada, and The Field Museum, Chicago. Nearly one million visitors have seen the exhibition since its opening in spring 2012. Attendance has continued to exceed expectations. Details of the exhibitions content, press releases, and current tour schedule will be presented.

Contact Information: Marc A. Branham, P.O. Box 110620, Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611 USA, Email: marcbran@ufl.edu

DESCRIPTION OF LIFE CYCLE AND PREIMAGINAL STAGES OF *ALECTON DISCOIDALIS* LAPORTE, 1833 UNDER LABORATORY CONDITIONS

Ormaily Madruga[1] *and* ***Marc A. Branham***[2]
[1]Museo Nacional de Historia Natural de Cuba, La Habana, Cuba
[2]Department of Entomology and Nematology, University of Florida, Gainesville, FL, USA

Alecton discoidalis Laporte, 1833 is the most widespread species of the only firefly genus endemic to Cuba. It is commonly found in limestone landscapes across the western half of the country. Larvae of *A. discoidalis* were collected at Pan de Matanzas and reared through the adult stage under laboratory conditions. They were fed mainly terrestrial snails from the families Potamiidae and Helicinidae. These molluscs are frequently found in their habitat, but larvae also fed on other snails such as the introduced *Praticolella griseola*. The temperature of the rearing environment ranged between 18 and 30 ^{o}C and relative humidity varied between 33 and 90 %. Adults can copulate immediately after emergence. Five after mating, approximately 70 eggs were laid per female. Egg incubation lasted 25 or 30 days, when 62 eggs were hatched. The imaginal period had a median duration of 172.5 days, from September to June. *Alecton discoidalis* had between four and seven larval instars. Females had more larval instars than males due to the need to the need to gain more body mass. Larval mortality was very high; most likely the result of low humidity and prey availability. Prepupa showed a median duration of 4 days while the pupal stage was 7 days. Eggs, larvae and pupa were described and illustrated, with emphasis on the general body shape, as well as the larval morphology of the head, antennae and mouthparts. In contrast with the original description, the female of *A. discoidalis* is brachypterous.

Contact Information: Marc A. Branham, P.O. Box 110620, Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611 USA, Email: marcbran@ufl.edu

A LONG TERM OFF-SITE COLLECTION ENHANCEMENT LOAN OF LAMPYRIDAE FROM THE US NATIONAL COLLECTION TO THE UNIVERSITY OF FLORIDA: A HISTORY AND PLAN FOR THE FUTURE

Marc A. Branham
Department of Entomology and Nematology, University of Florida, Gainesville, FL, USA

In 2012, the University of Florida received an off-site collection enhancement loan of the lampyrid specimen holdings of the National Museum of Natural History, Smithsonian Institution, Washington, D.C. Due to budget cuts and staff reductions, several parts of the US National collection were deactivated, whereby limiting expansion, accessibility and some curatorial activities. The lampyridae were part of the collection that was deactivated. In order to ameliorate this situation, eighty-four drawers of pinned specimens and six jars of alcohol specimens were transported from Washington to the University of Florida were the collection is housed in association with the Branham Laboratory, Department of Entomology and Nematology. The Lampyridae included in these holdings total nearly 28,000 specimens (including both identified and undetermined specimens) and 78 holotype specimens. Marc Branham is responsible for overseeing the curation, maintenance, and enhancement of the collection for the duration of the off-site loan. A brief history of this collection, its taxonomic and zoogeographical strengths will be presented as well as plans for its ongoing curation and expansion.

Contact Information: Marc A. Branham, P.O. Box 110620, Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611 USA, Email: marcbran@ufl.edu

THE BIOLUMINESCENT BEHAVIOR OF SOME NORTH AMERICAN LAMPYRID LARVAE

Lawrent "Larry" L. Buschman
Kansas State University, Manhattan, Kansas, USA

This analysis of the bioluminescent behavior of Lampyrid larvae is intended to give a better understanding of the ecological context of this behavior. Most of the field work was done in Gainesville, Florida, while others were made in East Tennessee or in the laboratory. It is important to understand that there are at least four distinct bioluminescent behaviors that need to be considered. Continuous faint glowing is a generalized body glow that is not focused in the light organs such as the glowing of eggs and pupae. This glowing is so faint that it can be missed unless one allows the eyes to become dark adapted for some fifteen to twenty minutes. This glowing is probably important in some physiological function, such as immunology or detoxification. Response glowing (also called defensive glowing) is bright glowing from the light organs that lasts up to several seconds, usually in response to some kind of disturbance. This type of glowing appears to function in defense because it occurs in situations where the larvae can be understood to be in danger. Periodic glowing (also called spontaneous glowing) is a rhythmic spontaneous glowing lasting several seconds and produced by the larval light organs. Periodic glowing is usually observed when the larvae are active and undisturbed. The function of periodic glowing is the subject of speculation, but is usually thought to be associated with aposematic defense. Continuous bright glowing is a spontaneous and more or less continuous glowing produced by the light organs and occurs when larvae are active. It appears to be a transitional stage between periodic glowing and response glowing. These different bioluminescent behaviors are associated with different ecological and physiological conditions. Response and periodi**c** glowing appear to represent two ends of the "motivational continuum" for larvae in response to environmental conditions. During wet favorable conditions larvae are active in the habitat and glow periodically. These larvae go dark in response to disturbance. When the habitat dries out these larvae become inactive and dark (stop periodical glowing). These inactive larvae glow responsively when disturbed. *Pyractomena* larvae gradually stop glowing as they approach pupation. Fed larvae are more active glowing than starved larvae. These behaviors will be described in more detail for larvae from 3 different North American Lampyrid genera.

<u>Contact Information</u>: L.L. Buschman, 963 Burland Dr., Bailey, Colorado, 80421, Email: lbuschma@ksu.edu

COURTSHIP FLASH COMMUNICATION IN TWO *PHOTURIS* FIREFLIES

Lawrent "Larry" L. Buschman
Kansas State University, Manhattan, Kansas, USA

Field observations were made on *Photuris versicolor quadrifulgens* Barber and several other fireflies in East Tennessee in 2012. Females collected during the field observations were allowed to lay eggs in soil and the larvae were reared in the laboratory. Larvae from two species matured in spring of 2013 and were available for behavioral observations. These laboratory-reared male and female fireflies were known to be the same species because they were brothers and sisters (which is not known for field collected males and females). In addition, the mating status of the laboratory-reared fireflies was known (which not possible with field collected fireflies). In the laboratory, the flash communication between male and female happened so fast that it could not be described with confidence, so video equipment was used to record the flash exchanges. Analysis of the flash exchange in *Photuris quadrifulgens* revealed that the male advertising flash pattern was 2 to 5 pulses emitted at 0.7 sec intervals. The female response flash was 2 to 7 pulses emitted at 0.18 sec intervals. The female flash train often started during the third male flash, but sometimes it started as early as the first male flash or as late as after the male flash train was over. Males also seemed to synchronize flashes with each other when one was in dialogue with a female. In a second species, *Photuris tremulans* Barber (tentative ID), the male advertising flash pattern was a single pulse emitted at 2.7 sec intervals. The female response flash was 1 to 20 pulses emitted at 1.0 sec intervals. The female flash train started 0.8 sec after a male flash and her third flash sometimes synchronized with the next male flash. The flash exchange become continuous with the male flashing ca. 3 sec and the female flashing three times in ca. 3 sec. Males did not seem to synchronize with each other when one was in dialogue with a female. The flash communication of these two *Photuris* fireflies is different from the flash answer flash communication typically seen in *Photinus* fireflies. The flash communication of these two *Photuris* fireflies also differed from each other so it seemed they might belong to different groups within the genus. We need to know more about the communication of other species in the genus *Photuris*. This is one of the first "complete" descriptions of the courtship communication for fireflies in the genus *Photuris,* but there are many questions that remain to be addressed.

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APPROACHES TO INCORPORATING FIREFLIES IN STEM EDUCATION

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Fireflies capture the imagination of adults and children alike through their bioluminescent displays. The appeal of Lampyrids provides an opportunity to engage the public with concepts in science, technology, engineering and mathematics (STEM). However, the challenge for many scientists is to appropriately differentiate their research findings for different audiences. Primary school, college and mass media each offer unique avenues for educating about firefly biology. This study examines educational outreach in k-12 science events, college classrooms, and television programming with the goal of distinguishing key learning outcomes and potential pitfalls in each setting. The U.S. Common Core Standards and Next Generation Science Standards are used to provide a framework for identifying appropriate foci for educational efforts across a diverse set of learning environments and learner characteristics.

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ACTUALIZATION OF THE PRESENCE AND DISTRIBUTION OF SPANISH FIREFLIES BASED ON A FIVE YEAR SURVEY (2009-2013) BY MEANS OF A PHOTO-BIODIVERSITY DATABASE

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In 2010, we presented a poster at the International Firefly Symposium at Selangor, Malaysia, with preliminary results of a web-survey on the distribution of lampyrid species in Spain based on data of one year (2009-2010) coming from the web-survey "Have you seen a glow-worm?" (http://gusanosdeluz.es) and a photo-biodiversity database called "Biodiversidad Virtual" (http:// biodiversidadvirtual.org). After five years of continued surveying and evaluating of uploaded photos, we present here an actualized status of the presence and distribution of glow-worm firefly species in Spain. Based on a literature study, at least 11 species of Lampyridae are expected in the Iberian peninsula: *Lampyris noctiluca, L. iberica, L. raymondi, Nyctophila heydeni* (only on Balearic islands), *N. raymondi, Lamprohiza paulinoi, L. mulsanti, Phosphaenus hemipterus, Phosphaenopterus metzneri, Pelania mauretanica, Luciola lusitanica*. From May 2009 till December 2013, in total 169 online forms were received and 629 photos from the web photo data base Biodiversidad Virtual (www.biodiversidadvirtual.org) were examined. Some extra insights came from recent discoveries of new lampyrid species for Spain in the Tajo International Park (Extremadura, Spain): *Lamprohiza paulinoi* and *Phosphaenopterus metzneri* (de la Rosa et al. 2011). Numbers per species: *Lamprohiza* sp. 22, *Lamprohiza mulsanti* 6, *Lamprohiza paulinoi* 17, *Lampyris sp* 152, *L .iberica* 22, *L. noctiluca* 18, *Nyctohphila reichii* 488, *Nyctophila heydeni* 22, *Phosphaenus hemipterus* 1, *Phosphaenoperus metzneri* 1

In this poster we will present photos and distribution maps (per province of Spain) for each species or species group and a discussion

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BIODIVERSITY SURVEYS OF FIREFLY SPECIES: PRACTICAL EXAMPLES OF SMALL SCALE STUDIES FROM SOUTHERN SPAIN (2012) AND SOUTHEAST FRANCE (2013)

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This study presents data about recent small scale survey excursions in search of firefly species in Southern Spain performed as a volunteer for the Spanish lampyrid project "¿Has visto una luciérnaga?" (Have you seen a glow-worm? http://gusanosdeluz.es) end of May 2012, and a short four day excursion trip to the region of Provence-Alpes-Côte d'Azur in France, at the beginning of June 2013. The main aim in Spain was to find and study populations of recently discovered new species in the Tajo International Park (Extremadura, West Spain). Secondary aims were to survey lampyrids in this and other regions in South Spain (National Park of Grazalema) and in East Spain (Bugarra - Community of Valencia and Alcalá del Júcar Castilla La Mancha). These data also served in another poster at this symposium: *Actualization of the Presence and Distribution of Spanish Fireflies Based on a Five Year Survey by Means of a Photo-Biodiversity Database* (Guzmán Álvarez, J.R. and De Cock, R.). In France, my goal was to retrieve and study the species historically mentioned by Édouard Bugnion (1929; ***Le ver-luisant provençal et la luciole niçoise*****.** Association des naturalistes de Nice et des Alpes-Maritimes, Nice); *Luciola lusitanica* and the endemic *Lamprohiza delarouzei.* The overall aim of this poster is to demonstrate how small scale firefly surveys can add important new insights in the distribution, behavior and ecology of species.

At all sites lampyrid populations were encountered by using a combination of surveying techniques mentioned in De Cock & Guzmán (2013; Lampyrid Journal). Especially the use of glow lures (LED and Betalights) and the incorporation of these in funnel bottle traps in order to attract and survey difficult to observe non-luminescent glow-worm firefly males has been successfully tested during these field trips. The presence of an isolated population of *Lampyris iberica* is now officially confirmed by the finding of larvae in the extreme South of Spain, and the species was also very abundant in the surveyed location in West Spain. *Phosphaenopterus metzneri* larvae and pupae were found in West Spain, but also in Portagem (Parque Natural da Serra de São Mamede, Portugal). *Lamprohiza paulinoi* adults were spotted in West and East Spain. In France, populations of *Lamprohiza delarouzei* were found in Beaureceuil and Le Pont de Bayeux (Aix-en-Provence) and in the Parc Naturel Départemental du Rives du Loup (La Colle-sur-Loup, Nice). Since the males don't glow, only the female spectrum of bioluminescence is presented here. I also found males and larvae of the flashing species, *Luciola lusitanica*, in the Parc Naturel Départemental du Rives du Loup*.* I collected video-data of the male flash behavior and I also got measurements of the male spectrum of bioluminescence. The flash characteristics (mean flash duration and interflash pauses) of the males are presented. These expeditions also yielded samples for further taxonomic, morphological and genetic research.

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CALL FOR A DISCUSSION ABOUT THE SET-UP OF A MORE STANDARDIZED PROTOCOL TO ADEQUATELY DESCRIBE THE BIOLUMINESCENT BEHAVIORS OF FIREFLIES OBSERVED IN THE FIELD

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I would like to set-up a discussion meeting, preferably during this Firefly Symposium, in order to exchange ideas and eventually to compile a document in group with guidelines how to describe the several bioluminescent behaviors that luminescent creatures, and fireflies in particular, may display in the field. The idea is to come to the compilation of a clear standardized protocol and classification key to describe these bioluminescent behaviors.

Why? First of all, since many firefly species are characterized and even identifiable by their bioluminescent displays, especially the flashing species, it is important that we describe effectively and concisely what we observe in the field in order that observations done during field trips, expeditions or firefly surveys become maximally useful. The need of an adequate classification of bioluminescent behaviors becomes even more important for the description of newly discovered species, especially if measuring equipment like spectrophotometers and video cameras are not at hand. Secondly, such an exercise may be important especially to the non-English speakers like myself, for appropriate descriptions in papers and reports. Indeed, examples in the literature are manifold, where “flash” is used instead of the meant “glow”, or where a species is being described as “glowing” whereas graphs or photos clearly depict a flashing species. On the other hand, different authors often use different terminologies for the same flash types. Many ideas may come from the literature on marine bioluminescence, but these may not always apply well to fireflies. Next, there are questions like how to adequately describe the color of bioluminescence in the field; often the color of glows and flashes is observed from too far away while the human eye does not discriminate well color at such low light intensities, whereby descriptions become untrustworthy, not to mention age effects in observers. Clear and more standardized classifications for the description of colors and intensities observed - for example in the form of charts with comparisons to generally recognizable intensity classes and color types with ranges of wavelengths per color class -, may become useful tools. Another point is about timing characteristics: when do we speak of a continuous glow, modulated glow, intermittent glow, glow pulse, or a flash? How to classify different flash types (single, double, triple, flickering and modulated types, etc.). Also, timing characteristics (flash lengths, interflash pauses) or types of luminescent behaviors may depend on environmental factors such as temperature, humidity, ambient light, time, (micro)habitat, locality, or even circumstances (courtship, oviposition, larval glow types, spontaneous versus disturbance induced luminescent behaviors); so these should also be carefully registered when describing the bioluminescent behavior of a specimen in the field. We should also address to all possible types of synchronous flash behaviors.

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THE ENIGMATIC BLUE GHOST FIREFLY *PHAUSIS RETICULATA* (COLEOPTERA: LAMPYRIDAE): OBSERVATIONS ON ITS COURTSHIP, MATING AND OVIPOSITION BEHAVIORS

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In contrast to most other North American fireflies that use precisely-timed flash dialogs for courtship, males of *Phausis reticulata* Say (Fender 1966) glow as they fly slowly over the forest floor searching for females, that emit long-lasting courtship glows. At peak mating season in forested regions of the southern Appalachian Mountains, large numbers of these low-flying males create a remarkable and eerie display. This Blue Ghost firefly display has become increasingly popular, and annual tours held at DuPont State Forest in North Carolina and nearby sites now constitute an ecotourist attraction. Surprisingly little work has been done on *P. reticulata* courtship and mating behavior, and nothing is known of female oviposition patterns. Several authors have suggested that pheromones might play a role in courtship but no particular experimental studies have been conducted till now.

The goal of this study was to provide additional insight into the reproductive ecology of this enigmatic and rather atypical firefly species. Working with field populations in Knoxville area and the Great Smoky Mountains NP (Tennessee, USA), we observed *P. reticulata* courtship and copulation behaviors. We also performed controlled field experiments to investigate courtship signals used by *P. reticulata* females, including the relative importance of pheromones and bioluminescent glows. Additionally, we report here for the first time spectral measurements of *P. reticulata* bioluminescent signals used during courtship, the variation in male flight behaviors, intraspecific variation in female light organ patterns, and detailed descriptions of copulation and female oviposition behavior, including female egg guarding.

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LIFE CYCLE AND PHOTIC BEHAVIOR OF WINTER FIREFLIES IN THE ALISHAN AREA OF SOUTHWESTERN TAIWAN

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Winter fireflies are distributed primarily in mountains at medium to high elevations. They are still active at 10°C. Their biological characteristics are unique but seldom investigated. This study examined the winter fireflies found in Taiwan's Alishan area at various altitudes (1,000-1,700 m), including their life cycle and photic behavior. Four species of winter fireflies that belong to the same genus were identified in the investigation, including *Diaphanes niveus*, *D*. *cheni*, *D*. *lampyridies*, and *D*. *nubilus*. The field occurrence of the fireflies begins in November and ends in the following March. The occurrence time becomes earlier with the increase in elevation. Field surveys of earthworms which the larvae of these fireflies feed on were conducted in the surrounding area and we found 16 species belonging to 3 families and 3 genera. These earthworm species are possible food sources. Among the four species of winter fireflies mentioned above, we made a more detailed study on *D*. *lampyridies.* Larvae of *D. lampyridies* that emit light can be found in the field in October and can successfully become adult fireflies by feeding them with earthworms such as *Perionyx excavatus* and *Eisenia fetida*. Beginning in December, female *D*. *lampyridies* can be found in the fields. After adults of *D*. *lampyridies* were collected, reared, and paired, one female can lay up to 151 eggs. The eggs survived through winter and hatched by next April. Adult fireflies typically fly around Chinese fir and bamboo forests and are most active during the hours after dark. They glow continuously with a wavelength ranging from 542 to 549 nm. Although the abundances of winter fireflies are not as high as spring fireflies, their flash pattern, compared with spring fireflies that mostly emit flashes of light, is spectacular and can be used to promote firefly watching eco-tourism.

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A BAHAMAS POPULATION OF THE THREATENED FLORIDA INTERTIDAL FIREFLY *MICRONAPSIS FLORIDANA*

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Since 2003, field observations and captive studies have documented the presence, seasonality, habitat, flash and mating behaviors, oviposition and life stages of *Micronaspis floridana* Green 1954 on low, narrow, scrub covered, semi-tropical 3.4km long Deep Water Cay off the southeast coast of Grand Bahama Island in the Bahamas. Adults (8-12mm) and larvae were found year around in the narrow strip where backwater mangroves meet land. Highest numbers were found March-May. Males flew in the open < 2m over the waters and black and red mangroves of the low to high marsh to 3+m around taller bordering mangroves. Temperatures <20°C, wind over force 2 or bright moonlight discouraged display. Maximum display occurred from 45-90 minutes after sunset. Males flashed a single or bimodal flash (1st part brightest) every 1-2 seconds depending on temperature. To my eyes, flashing of both sexes appeared yellow but at close range was green. Females, slightly larger, often gathered in loose groups, perched up to 1m on coral rubble or vegetation emitted a unique roiling flash-glow that can last > 1 minute continuously. The female aimed by curling her tail under and laterally exposing circular areas on each end of her lantern that continuously glowed while the central lantern constantly modulated in intensity. Female glow-flash response appeared contagious, causing other females to display. Males and females mate multiple times and copulation lasts from 1 to 8+ hours. A captive female lived 24 days, laid 15 orange round eggs (0.5mm) in two clusters just prior to death. Eleven larvae, found in the high marsh, initially ranging from 4-11mm, were easier to keep than most species. Though omnivorous eaters, they preferred snails. When placed in water, larvae floated like canoes with head and tail upturned. One larva pupated at 12mm after 14 weeks and eclosed as a male12 days later and lived 10 days. Local fisherman reported seeing these “lamplighters” on other nearby cays. This poster is the first photo documentation of a Bahamas sub-population of *Micronaspis floridana* with details of life habits.

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MILKWEED FIREFLIES: THE OCCURRENCE AND BEHAVIORS OF 4 ADULT NORTH AMERICAN FIREFLIES, *PHOTINUS PYRALIS*, *PHOTINUS COOKI, PYROPYGA MINUTA* AND *PHOTURIS* SP. ON MILKWEED *ASCLEPIAS SYRIACA*

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One hundred and fifty nine fireflies, male and female, from 5 species and 4 genera actively associated with common milkweed *Aesclepias syriaca* were documented over a one year period from July 2013 to July 2014. Five sites in 5 counties in East Tennessee were surveyed, spanning a general triangle with 50-100 km legs. *Lucidota atra*, *Photinus pyralis, P. cooki, Pyropyga minuta* (and possibly *P. decipiens)* and *Photuris sp*.(versicolor complex, probably several species) repeatedly exhibited 7 common behaviors of nectaring from individual blooms and stigmatic slits and actively mouthing floral stems, recurved sepals and uppermost leaves, feeding from 9 - 175+ minutes. Milkweed pollinia were attached to the legs of 3 of the 5 species. Maximum firefly presence was clustered at modified corn growing degree day (mGDD) range of 1900-1950 mGDD and observed on survey days, July 7 and 8, 2013 and June 27-29, 2014, falling to low but persistent numbers before and after. These firefly behaviors were observed primarily in the 4 hours before sunset and after sunrise. Twelve *Photuris* larvae were observed feeding on milkweed rhizomes in captivity. Reports of milkweed-firefly associations documenting four of the above species and at least 3 additional firefly species and one additional genera, *Photinus indictus*, *Pyropyga decipiens* and *Pyractomena* sp., spanning 90 years across the eastern US are provided along with recent photo/video documentation of similar behaviors witnessed from Texas to Canada. This is the first report describing milkweed-firefly relationships.

Keywords: pollinia, defensive chemicals, lightning bug, firefly, cardenolide, lucibufagin

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THE SHADOW GHOSTS, *PHAUSIS INACCENSA*: PHOTOGRAPHIC NOTES ON HABITAT, SEASONALITY, MATING AND EGG GUARDING BEHAVIORS AND EARLY INSTAR LARVAE

Lynn Faust

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From April 28 to June 25, 2013, adult populations of *Phausis inaccensa* Leconte 1878 were investigated in East Tennessee in the forests of the Cumberland Mountains, Cumberland Plateau and Great Tennessee Valley and later followed in captivity until the final resulting larvae died. Three sites were from 49 to 78 kilometers apart. Elevation ranged from 274m to 493m. Found on dry sandy forested ridges and moist green woodland hollows, *P. inaccensa* had broad habitat presence. The mating season was specific with all adult behavior occurring from late April to late May at this latitude and elevation, *modified corn growing degree day* range 429-757F, 240-425C. Lanternless males were never seen to glow during courtship searching, though one male glowed from a pale abdominal patch when caught in a glue trap and afterwards during copulation. Pale larviform females, glowing green from two terminal tail spots, began their display an hour after sunset nightly, from a low perch or leaf litter near their daytime shelter. Females arched in display with tail held higher than head. Dark males quickly landed near (average 60mm), but not on the females and scrambled the rest of the way. Males and females (4.7-7mm) mated briefly <10 minutes and multiple times. Two females, at least 2 weeks old, each laid a clutch of 20-30 eggs two to 4 days after their final mating. Females then refused male advances and guarded their egg clutch until their death 3 and 11 days later. When threatened (12 times), both females abandoned their clutch, yet quickly returned when conditions were safe. Spherical pale yellow eggs, 0.5mm, kept in native soil at local photoperiod, humidity and temperature, hatched over a 2 day period beginning days 34-35. Pale gray, bristled 1.5mm larvae, lived <11 days. Though initially active and offered a variety of foods, the larvae never ate and died during their 1st or just after their 2nd instar. This poster is the first photographic documentation of female egg guarding, oviposition, female and larval appearance.

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FIREFLIES AND THE PHOTIC FIELD

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Quoted in the film Brilliant Darkness: Hotaru in the Night; Dr. James Lloyd equates the potential disappearance of fireflies to a 'canary in a coal-mine', highlighting the environmental dangers posed by current practices in artificial night lighting. This paper outlines potential impacts of artificial night lighting upon wildlife, and the importance of wildlife sensitivity in architectural and other lighting design for environmental sustainability. Finally, it invokes concepts of the 'photic field' to advance photo-biology and photo-ecology beyond inquiries related solely to abstract and ill-suited ecological assessment criteria limited to mere luminous intensity.

We argue, along with others, that artificial night lighting obtains at least three scopes of impact for all animals: physiology, sensory ecology and activity partitioning in time and space. After reviewing the supporting literature for such arguments, we then discuss the role of biodiversity loss prevention in architecture. Architecture, as a discipline and profession, has for the most part ignored wildlife conservation efforts in general, let alone strategies designed to conserve firefly species. We argue that as dominant forms of sustainable architecture, which seek to reduce green house gas emissions and therefore global warming and ocean acidification, actually have wildlife conservation as their unstated purpose, hope exists that change is coming. For architectural sustainability efforts to be justified, the direct impacts of architecture on biodiversity must be addressed. And to take this one step further, for wildlife and biodiversity conservation efforts to be successful, more attention must be paid to habitat degradation challenges due to artificial night lighting. Finally, if habitat degradation challenges are to be fully understood by photo-biologists and photo-ecologists, more rigorous assessment criteria must be established beyond those that rely merely upon so-called luminous intensity.

We highlight one potential path towards more rigorous assessment criteria. After revisiting and rethinking the 'Photic Field' concept, developed by Parry Moon and Domina Spencer, this paper crafts a three-fold system of photo-ecological interpretation. Such an alignment incorporates consideration of the dynamic 'form' of light to complement readings of relational intensities and qualities. By incorporating the 'form' of light within assessments, the paper likewise attempts to address psycho-social problems closely related to the challenges of nocturnal habitat conservation: eg. human visual perception and anxiety. It taps into existing conversations on 'light' from art criticism and psychoanalysis, developing these along articulated readings of light from the natural sciences.

As flies the firefly, so goes the night. In linking disparate disciplines in this way, new paths are opened for nocturnal habitat conservation.

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SEXUAL DIMORPHISM, MATING SYSTEMS, AND NUPTIAL GIFTS IN SEVERAL GENERA OF ASIAN FIREFLIES (COLEOPTERA: LAMPYRIDAE)

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Many insect taxa show conspicuous sexual dimorphism in which females lack functional wings and are therefore incapable of flight. Previous studies in fireflies indicated this loss of female flight is correlated with males which do not produce spermatophores (nuptial gifts). Here we examine the relationship between sexual dimorphism and nuptial gifts in 24 Asian fireflies in 13 genera, and describe the reproductive anatomy of males and females. Our results showing production of spermatophores in species with flightless females contradict patterns described from other firefly species with flightless females and provide insight into the role of male-derived substances in mating systems.

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PHOTURIS FIREFLIES THREATENED WITH SEA LEVEL RISE IN THE DELAWARE AND CHESAPEAKE ESTUARIES

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In the Delaware and Chesapeake estuaries, three firefly species in the genus *Photuris* are immediately threatened by sea level rise. *Photuris bethaniensis* and *P. mysticalampas* are currently only known from a handful of coastal lowland freshwater wetlands in a single county in Delaware, representing their entire known global range. Most known colonies of both occur on protected public land. However, under current sea-level rise models, passive protective measures will not prevent their eventual global extirpation. *Photuris salina* may be more widespread globally, but its rarity and association with salt and brackish coastal marshes will make it highly vulnerable to seal level rise range-wide including the Delaware and Chesapeake estuaries. The loss of these species would represent 16% of the known species in the genus. Efforts should be made to locate additional populations of all three species to gauge a better understanding of the current threat of global extinction from climate change.

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ANTS AS A DIET FOR THE LIFE CYCLE OF THE TORRENTIAL FIREFLY *LUCIOLA CERETA* (COLEOPTERA: LAMPYRIDAE)

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Black-winged firefly *Luciola cerata* Olivier was determined under room temperature 18-30 ℃, RH = 80 ±5 % and L: D =10: 14 for its life cycle and is considered to be univoltine. The larval stage was the longest (21-23 weeks approximately) with larvae active across March – December in Taiwan. Males have a slightly shorter larval duration and longer pupal duration than the females. Males can have only four larval instars while females have five. In the laboratory larvae were fed a mixture of eggs, larvae, pupae and adults of ants, *Crematogaster* spp. Larvae are carnivorous and in the field are non specific in their prey. Mature larvae would accept different prey (e.g. prepared meat of snails, slugs, some insects, and chopped beef, pork and pig liver) and built a mud cocoon to pupate, which of external shape and lip are distinctive. Various mites parasitise both larvae and pupae and affect their movement and activities. A parasitic fungus, *Metarhizium anisopliae* identified from larvae and pupae in the field and laboratory can kill both larvae and pupae. Habitat management for conservation of the black-winged firefly in Taiwan is proposed.

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LIGHT INTO DARKNESS. THE SIGNIFICANCE OF GLOWWORMS AND FIREFLIES IN EUROPEAN CULTURE

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The lampyrids belong to the few insects that have been named and observed accurately since thousands of years. The most common names in European languages are formed as diminutives of light and related terms or they are composed of a term like light, fire and glow in combination with bug, fly or worm. There is a huge variety of idiomatic names – in Italian dialects e. g. are reported about 500 different expressions denominating species like *Lampyris noctiluca* or *Luciola italica*. Beyond that lampyrids are interpreted as signs or used as metaphors in a wide range of semantic fields and lead to a vast network of chains of associations including so distinct and even contradictory significances as childhood, crop, doom, elves, fear, habitat change, idyll, love, luck, mortality, prostitute, solstice, stars and fleetingness of words and cognition. All these connotations are evoked by six features of the observed lampyrids: light in the darkness, season of appearance, mating, direction of flying in case of species like *Lamprohiza splendidula* and *Luciola sp*., flashing (of *Luciola*-fireflies) and finally disappearance of lampyrids in landscape and perception. The examples of the presence of lampyrids in literature, visual arts, music and evidence in traditional popular culture collected during the last years show that the accent of the connotations is shifted by the change of cultural context: in early times the seasonal indication was relevant for the agricultural calendar, the romantic connotations had their golden age during Belle Époque while in recent decades the associations circle around the disappearance of glowworms and fireflies. Although the observer is normally not aware of the full richness of significances the extraordinary complexity of connotations is an important factor for the fascination produced by lightning bugs during summer nights.

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DIVERSITY OF AQUATIC FIREFLIES IN THE PHILIPPINES

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Aquatic fireflies are considerably rare in Lampyridae. Around 20 out of 2000 documented species are known to have aquatic immatures. They belong to Luciolinae exclusively, and have a geographic distribution mostly in East and Southeast Asia. No aquatic firefly has yet been documented in the Philippine archipelago. We explored several islands in East Visayas and Luzon during 2012-2013 and discovered three forms of aquatic firefly larvae. All of them were benthic dwellers in small forest streams and live sympatrically with each other in some habitats. Two of them have tracheal gills whereas the third one is metapneustic. Molecular phylogeny based on partial sequences of COI and EF1 alpha genes revealed independent origins of these aquatic forms. Their phylogenetic relationship with the other known aquatic fireflies in the Asian continent was discussed.

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CONSERVATION OF THE SELANGOR RIVER POPULATION OF *PTEROPTYX TENER* IN MALAYSIA: RESULTS OF SEVEN YEARS OF MONITORING

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Firefly ecotourism in the coastal town of Kuala Selangor plays a significant role in generating income for the tourism sector in Malaysia. The synchronizing fireflies, *Pteroptyx tener* congregate on *Sonneratia caseolaris,* which can be found lining the riverbanks of the Selangor River. As part of efforts to conserve the firefly population, a monitoring program using digital night photography was initiated in 2006. Currently in its seventh year, the monitoring program has shown that there has been a drop in the firefly population and changes in seasonal peak abundances. The primary reason for the drop in the population could be the loss of breeding habitat. From the years 2006–2008, peak adult firefly abundance occurred between June and August, with a secondary but less distinct peak occurring between December and February. From the years 2009–2013, the population trend reversed, with the primary peak occurring from December to February, and the secondary peak from May to July for the years 2009–2010, and towards the end of the year for 2011–2013. The primary peak was sharp and distinct in the first two years, but lower and more spread out in the remaining years. Possible causes for these changes are discussed including loss of breeding habitat as well as rainfall patterns. The monitoring program also led to detection of land clearing by private land owners for agricultural purposes. Efforts were then made by the state government to acquire sections of the Selangor River in the District of Pasangan and to gazette land up to 50 m from the river as a Protection Zone under the Selangor Waters Management Authority Enactment 1999. However, the firefly population continues to face threats, and much effort is still needed to ensure their conservation.

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FIREFLIES IN THE GROUNDS OF THE FOREST RESEARCH INSTITUTE MALAYSIA (FRIM): STUDIES ON THEIR DIVERSITY AND SEASONALITY

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The Forest Research Institute Malaysia (FRIM) is not only an established tropical forest research centre; its campus is a lush forested area where visitors and tourist come to appreciate and experience its natural environment. Activities such as jogging, biking, and trekking along various nature trails are common in FRIM. There is also a campsite where night walk activities are conducted for the campers. On such night walks, visitors can see flashes made by the flying fireflies in the forested areas. Realising the potential of the presence of fireflies in FRIM as another attraction to visitors and nature lovers, a preliminary study of the diversity of fireflies in FRIM was initiated in 2011. The study went further to determine any seasonality effect on firefly distribution and abundance. Understanding how weather influences firefly behavior is important before any plans are made to promote them to the public. The first part of the study focuses on identifying firefly diversity along eight nature trails and five areas between April and August 2011. The seasonality study was conducted in 2013. Sampling of fireflies was conducted in four time periods representing high rainfall (in April and November) and low rainfall seasons (in February and June). The adult fireflies found during the study could be grouped into 7 possible species from 6 genera, while the larvae were grouped into 10 possible species from 7 genera. The abundance of fireflies in FRIM was found to be influenced by seasons, with different firefly species observed to be more common during certain months. FRIM's forested area has a diverse group of fireflies, and they have the potential to be another of FRIM's attractions, indirectly promoting the importance of conserving nature.

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COLORS OF THE NIGHT: DO FIREFLIES DETECT THE COLOR OF THEIR BIOLUMINESCENCE?

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Scotopic color vision in dim starlight has been well documented in the nocturnal hawkmoth *Deilphila elpenor* which possesses three receptors: near-uv, blue and green. Do nocturnal and vespertine fireflies possess color vision? Electroretinographic (ERG) determination of spectral sensitivity [S(λ)] of the dark- and chromatic-adapted compound eyes of nocturnal *Photuris lucicrescens* revealed the presence of three spectral mechanisms in the green (λ_{max}= 550 nm), blue (λ_{max}= 435 nm), and near-uv (λ_{max}= 380 nm). Spectral tuning exists between ERG S(λ) and species bioluminescence (BL) emission. The action spectrum of the *Photinus pyralis* female's behavioral response to simulated male yellow flash matched the ERG S(λ) as well the species BL emission. However when blue light was added to the yellow flash simulating the male BL, there was a marked inhibition of flashing response in the female. Similar inhibition of flashing in the female was observed when the yellow simulated flash was superimposed on a blue adaptation light. In a phototactic experiment with males of the nocturnal glow-worm *Lampyris noctiluca,* inhibition was observed in the males when blue (λ_{max}= 485 nm) light was added to the simulated green (λ_{max}= 555 nm) BL of the female. Among invertebrates generally, the blue (-) and the green (+) receptor systems are antagonistic to one another to facilitate color vision. Hence we propose that fireflies have capability for detecting colors at night.

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COMPARATIVE STUDY OF NUPTIAL GIFTS IN SOME NORTH AMERICAN AND ASIAN FIREFLIES

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Nuptial gifts are materials that are transferred from one sex to the other during courtship and mating. These gifts are foundational components of fitness, influencing mating systems, reproductive behaviors and linking male and female energy budgets. In recent years, fireflies have become a model system for understanding the interaction between nuptial gifts and other life history characteristics. In North American *Photinus* fireflies, spermatophore nuptial gifts increase female fecundity and lifespan while also influencing male patterns of sperm precedence. Despite fitness benefits, worldwide extant firefly species vary in nuptial gift production, with a lack of male gift production linked to an increase in female size and loss of flight. To further evaluate connections between nuptial gifts and life history parameters, we adopt a comparative approach utilizing de novo descriptions and comparisons of the structure, production and distribution of nuptial gifts across several major firefly genera from North America and parts of Asia. Nuptial gifts, male accessory glands and female reproductive tracts from several North American species including representatives of *Photuris*, *Pyractomena* and *Photinus* and species of the Asian genera *Luciola*, *Aquatica* and *Pyrocoelia* are viewed from a comparative perspective. By comparing reproductive ecology across firefly species, we hope to shed light on the relationship between nuptial gifts, mating systems, and life history features.

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FIREFLIES COME OF AGE

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Much has changed in the study of fireflies over the past 100 years: in field study, horse-drawn carriages, delivery trucks, trolleys, Model-Ts, and electric "torches" are out; F-100 pickups, Land Cruisers, Land Rovers, department vans, and headlamps with variable intensity and focus are in. Taxonomic and other studies, and philosophical or theoretical considerations of fireflies which were at that time done almost entirely at the bench, remote, far way in a museum—except for a few neglected though revolutionary and beckoning studies by McDermott, Barber, and Mast, and a few silly contributions to the journal *Science*—are now augmented, amended, or initiated through field study and the biochemistry lab. One hundred years ago firefly species, in spite of Darwin' brilliance, were still viewed as fixed and unchanging, but since then they have become recognized as a taxonomic embarrassment, seemingly a phenomenon of considerable mystery, and recognized as works in progress, in life, in the museum, and in the lab. Today we know many critical details of firefly natural history, and are aware that by paying attention to signaling behavior in the field we can not only get broader taxonomic representation for work at the bench, but get important clues for understanding operational species as well as their evolutionary relationships. And today, after the revolutionary breakthroughs in population genetics of the mid-twentieth century, our focus has been changed, so that as we chase swarms of synchronous flashing fireflies along East Asian rivers, estuaries, and canals, we are aware of the need for zooming in on what our brilliant selfish individuals are doing rather than being mesmerized by the spectacle, the epiphenomenon. Finally we know, have learned, how fragile our fireflies are, and now, as it seems they are slipping away, we are not letting them go quietly, but making certain that others know what we all are losing.

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THE EVOLUTION OF BIOLUMINESCENCE IN THE SIERRA LUMINOUS MILLIPEDES

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Endemic to the Sierra Nevada Mountains of California, millipedes of the genus *Motyxia* are bioluminescent and produce a continuous bluish-green light with a peak wavelength of 495 nm. There are eight described species with varying intensities of emitted light, and aggregations of the brightest species, *Motyxia sequoiae*, can reach up to 200 individuals beneath a single large oak tree in the Sierra Nevada foothills. Light from the millipede is emitted in the cuticle from pipe-like organs of unknown identity, and is considered to be generated via a photoprotein. Luminescence intensifies when the millipede is handled, and was recently shown to serve as an aposematic signal to deter nocturnal mammalian predators. Based on recent fieldwork in California, I discovered a ninth species of bioluminescent millipede with the faintest light emission of any known species. Here I show, based on molecular phylogenetics that this species is the evolutionary sister group to *Motyxia* and likely represents an early-diverging lineage of the genus that retains a number of primitive features (*e.g.*, faint light emission, diminutive size, and cryptic coloration). Ancestral character state reconstruction and a test of a directional model of continuous trait evolution, indicates that light evolved gradually through time. Discovery of this unique species affords a closer glimpse of the early evolutionary circumstances and setting in which this unique and complex innovation evolved.

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EXTENDING THE CONCEPT OF DIVERSITY PARTITIONING TO CHARACTERIZE PHENOTYPIC COMPLEXITY

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Many, if not most phenotypes can be considered complex traits, consisting of multiple, subsidiary parts that function and evolve as integrated units. These trait complexes vary qualitatively in their individual components (e.g., chemical compounds, cell types, genes expressed) and quantitatively in the counts, concentrations, or amounts of those components. As trait complexity increases, so does the challenge of measuring and analyzing that complexity in intuitive yet biologically meaningful ways that capture both qualitative and quantitative aspects of the variation.

Ecologists have long formalized community complexity in terms of well-known diversity indices. We extend that conceptual framework to describe phenotypic complexity as the diversity—or effective number—of distinct subsidiary traits making up an individual's phenotype. Then, using a hierarchical framework, we illustrate how the total phenotypic diversity within a particular level (e.g., individual, species, life- history strategy) can be partitioned into within-group (i.e., α diversity, average effective number of subsidiary traits in a replicate) and between-group components (β diversity, effective number of completely dissimilar trait combinations).

We then demonstrate the utility of our method with examples from our own research on multivariate chemical defenses from multiple populations of several species of North American fireflies (Coleoptera: Lampyridae), exposing biologically significant differences in complexity and diversity that standard analyses would not reveal. Our unified, hierarchical view of complexity and diversity suggests the use of analytical methods developed in population genetics and community ecology to characterize complex phenotypes, and helps place questions about the ecology and evolution of complexity in a population/community context.

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A MOLECULAR PHYLOGENY OF LAMPYRIDAE AND ITS IMPLICATIONS TO THE EVOLUTION OF FIREFLY SIGNALING SYSTEMS

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Fireflies are one of the most captivating groups of organisms due to their bioluminescence. However, this behavior although well studied behaviorally, is not well understood from an evolutionary perspective (e.g., How many origins does bioluminescence have?). A total evidence phylogenetic study (morphology and molecules combined) of the family is lacking. Such a phylogeny has the potential to resolve competing theories of the monophyly of subfamilies and the position of several taxa that may or not be members of Lampyridae (Pterotinae and Ototretinae). Further, an accurate phylogenetic reconstruction is crucial to understanding the interactions of adult sexual signaling systems at both the morphological and the molecular level. Of interest in this study is the hypothesized ancestral sexual signal system modality (pheromone or bioluminescence) and the association between antennal type and bioluminescence.

We recovered all subfamilies except Lampyrinae as monophyletic (Photurinae sitting within the Lampyrinae). There is still not resolution between the position of Pterotinae and Ototretinae. We provide further evidence, as have others, that the ancestral sexual communication system is pheromone only. Simple (filiform to serrate) antennae are strongly associated with use of bioluminescence and branching (bipectinate) antennae are associated with its absence.

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STUDIES ON CONGREGATING FIREFLIES (COLEOPTERA; LAMPYRIDAE; *PTEROPTYX* SP.) IN SABAH, MALAYSIA

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Five species of congregating firefly (Lampyridae; *Pteroptyx* sp.) in mangrove forests of Sabah Malaysia had been recorded. The recorded species are *P. tener*, *P. bearni* (formerly known as *P. similis* in Sabah), *P. gelasina*, *P. valida*, and *P. malaccae*. In certain places of Sabah, these congregating fireflies are used for firefly-watching activity. The activity has no any negative impact on the mangrove ecosystem, and apart from this, it helps generate a profitable income for local tourism operators. In light of these, congregating fireflies could be designated as an umbrella species for the conservation of the mangrove ecosystem. Nevertheless, in spite of the number of studies on congregating firefly in Sabah, only a few scientific findings had been reported and published in local journal, bulletin, monograph or proceeding. No scientific findings were published in international journals. In this paper, the authors searched and compiled Sabah's congregating firefly studies. The compilation suggests that firefly studies were concentrated at the Klias peninsula, and were mainly focused on species diversity, population density, description of their habitats and display trees; while bionomics and life-cycle of these congregating fireflies are scantly known. Besides Klias peninsula, the other areas studied and its findings published include the Kinabatangan floodplain, Paitan, Tuaran, Sepilok, and Pulau Sakar off the coast of Lahad Datu, while another two unpublished studies were of the Kota Kinabalu city. More scientific studies are needed since the only habitat for congregating fireflies, the mangrove area, is fast depleting due to infrastructural development and mangrove deforestation pressures.

Keywords: *Pteroptyx*, firefly, mangrove, Sabah, Malaysia

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FEMALE *PHOTINUS CAROLINUS* LATERALIZE THEIR RESPONSE FLASHES

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Fireflies use an interactive flash code in their courtship behavior. Flashes are produced by a specialized organ, the lantern, which is located on their ventral abdominal surface. To communicate effectively, the light produced by one firefly must be visible to another firefly (or fireflies). We studied postural changes associated with flashing that could function to increase the visibility of flashes.

P. carolinus females were captured in Great Smoky Mountains National Park (Elkmont, TN 35.6535° N, 83.58° W) and maintained singly in 9 cm diameter clear Petri dishes. Conspecific male-like flash patterns were synthesized and presented through individual LEDs positioned 90° to the left or right a female's midline (30 cm away and at a height of 1 – 5 cm). Female responses to these *counterfeit signals* were videographed under infrared illumination. The video was analyzed frame-by-frame to reconstruct the female flash behavior.

Several movements of the abdomen were associated with the females' responses (i.e., courtship flashing) including a sequential combination of pitch, roll, and yaw of the abdomen that reoriented lantern immediately prior to flashing. Females responded significantly more often with lateralized flashes directed to the same side as the stimulating LED (72% ± 21) compared to responses to the non-LED side (16% ± 14) or downward (13% ± 17) ($p < 0.01$, ANOVA with Fisher's pairwise comparisons, N=14).

The flash gesture adds a new perspective to the complexity of the behaviors associated with flash communication in fireflies. Lateralization of the flash gesture reveals that the female's visual system processes information about the location of male's flashes as well as their temporal pattern. It may also be a tangible indicator of *female choice* and could play a role in sexual selection.

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HOPE FOR BARBER'S FIREFLIES: PHOTURIS IN THE WASHINGTON, DC, AREA AND IN REHOBOTH BEACH, DELAWARE

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Recent anecdotal observations have raised concerns about the loss of lampyrid populations in the U.S. Herbert Spencer Barber studied *Photuris* fireflies in the Washington D.C. area over 50 years ago providing a baseline to which to compare current populations. A combination of light pollution and safe access to the original observation sites has made exact reproduction of the original study impossible. Samples of fireflies were collected, and identified nonetheless. Two *Photinus* species (*scintillans* and *pyralis)* were also identified.

Fireflies were collected from three locations in lower Montgomery County, Md, and three locations in Sussex County, De. Data collected included date, time, GPS location, temperature, height above sea level, environment, and flash patterns. Fireflies were pinned, and identified using foregoing data and by inspection using a magnifying microscope. *Photuris versicolor, frontalis, hebes, cinctipennis, lucicrescens,* and *salina* were found.

Observations in four other locations in Montgomery County revealed, via flash pattern, the presence of at least three of these species. In several environments with tall trees *Photuris* was identified as well. Of note, in areas or streets with significant artificial lighting, *Photuris* were absent.

Although their habitat has been decreased, at least some of these firefly species continue to exist. Most are seen in forested, undeveloped areas (Rock Creek Park, Chesapeake and Ohio Parks), but even in residential neighborhoods with tall trees, they may be observed.

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STRUCTURE AND FUNCTION OF THE LARVAL VISUAL SYSTEM IN THE FIREFLY (*PHOTURIS*)

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The firefly, a nocturnal holometabolous beetle, spends most of its life in larval form. The larval form of metamorphic insects bear little resemblance to the adult animal. We have been studying the differences between larval and adult visual systems. The highly developed visual system of the adult supports the reception and processing of temporally patterned conspecific flashes. Beginning with the prominent compound eyes, visual information is processed in well-defined anatomical areas: the lamina, medulla and lobula. In contrast, larvae possess two small, single lens eyes known as stemmata. The detailed anatomy of firefly stemmata and the projections of the larval visual periphery to the CNS have not been well defined. Here we investigated the structure and function of stemmata in the larval *Photuris* firefly.

The stemmata were positioned laterally, ~500 um apart, on each side of the larva's 'head-like' structure. A nerve bundle ~20 um in diameter projected from the base of the stemmata and extended ~1500 um to the protocerebrum. As the stemmatal nerve approached the protocerebrum additional nerves from surrounding tissues became incorporated, creating a single nerve bundle that projected to the central ganglia. Cobalt backfills revealed that the axons from the stemmatal nerve were arranged laterally within this bundle. We investigated the gross anatomy of the larval brain by examining 10 um sections of the brain stained with H&E and Cresyl Violet, with an emphasis on the target of the stemmatal nerves. Horizontal serial sections revealed the anterolateral position of this nerve bundle as it entered the anterior surface of the brain. The projections of the stemmatal axons are the focus of our continuing histological studies.

To investigate the possible functions of the larval visual system we performed phototactic behavioral assays to test the hypothesis that the visual system might mediate a phototactic response to light at intensities that mimic daytime luminescence. A light source was positioned ~1m above the exposed half of a 22x33 cm chamber while the other half was covered to prevent illumination. Multiple trials were conducted placing 10 or 20 larvae in a central position within the exposed half of the chamber under light intensities ranging from 20-110 lux. Upon exposure to light, larvae migrated approximately 15cm to the dark half of the chamber. At bright intensities (> 100 lux) 76% of larvae, on average over four trials, moved from the light to the dark side within 2 minutes. In comparison, at low intensities (< 25 lux) on average 50% of the larvae remained on the illuminated side in trials with a minimum duration of 10 minutes. This trend suggested that larvae exhibit a more rapid and robust negative phototactic response to high light intensities. These behavioral experiments are being extended to test the sensitivity of this behavior at lower levels of illumination and in response to specific wavelengths.

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EVOLUTION OF FIREFLY LUCIFERASE AND BIOSYNTHETIC ORIGIN OF FIREFLY LUCIFERIN

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Firefly bioluminescence is an oxidation reaction of firefly luciferin catalyzed by firefly luciferase. To understand the evolution of this luciferin-luciferase system, we have studied the molecular evolution of the firefly luciferase gene and the biosynthesis of firefly luciferin.

We reconstructed a molecular phylogenetic tree of Lampyridae using 18S ribosomal RNA genes. The result showed that the enigmatic genera *Stenocladius* and *Drilaster* form a subclade in Lampyridae lineage, while *Rhagophthalmu*s and *Phengodes* form a clade separate from the lampyrid clade. These results agree with the traditional classifications: Ototretinae in the Lampyridae, and Rhagophthalminae in the Phengodidae.

Firefly luciferase genes have been isolated from the adult or larva of over 30 lampyrid species. Recently, we isolated paralogous genes of firefly luciferase from *Luciola cruciata* and *Aquatica lateralis*. These paralogs were placed at the most basal position of the molecular phylogenetic tree of firefly luciferases. These findings suggest that fireflies possess dual luciferase genes that originated by a gene duplication event that occurred before the Lampyridae diverged. One paralog is expressed and used in the luminescence of larval and adult lanterns, while another is used in glowing eggs and pupae. We also isolated homologous genes of firefly luciferase from nonluminous beetles. The gene product possessed the catalytic function of fatty acyl-CoA synthesis, suggesting that beetle luciferase arose from a fatty acyl-CoA synthetase.

Biosynthesis of firefly luciferin is not clearly understood. Very recently, we revealed that firefly luciferin is biosynthesized from one molecule of hydroquinone and two molecules of cysteine by stable isotope incorporation studies using living adult *A. lateralis* (Oba et al., 2013, PLoS ONE). We also found that toxic hydroquinone is stored in firefly as a glycosylated, and thus less toxic form, arbutin. Arbutin was also detected in some nonluminous insects and plants.

Taken together, our findings demonstrate that the luciferin-luciferase system of fireflies evolved from the genes and compounds of existing metabolic pathways. We found that firefly luciferase evolved from a basic enzyme for fatty acid metabolism, fatty acyl-CoA synthetase, by gene duplication and subsequent mutations. Furthermore, we found firefly luciferin, a special substrate for luminescent beetles, is biosynthesized from common metabolites, arbutin and cysteine.

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PYROPYGA SP.: FIRST INVASIVE ALIEN FIREFLY IN JAPAN

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In Japan, four subfamilies, nine genera, and 50 species of Lampyridae have been reported. Of these, one *Pyropyga* species was collected in 1986 by the author (TF) from a wharf of Tokyo and is still only observed in the Tokyo area. The adult form of this species is 4.5-6.0 mm in body length, and inhabits dry riverbed meadows. The adults emerge from June to October. The author (YO) observed one larva on the ground of dry riverbed at the end of April.

By our laboratory rearing experiments, we found that (1) the larvae feed on earthworms and snails, (2) the larval period is about one month, (3) the larvae are luminous, possessing a pair of photophores on the 8th abdominal segment, (4) the pupal period is about 5 days, (5) the prothorax of the pupae emit a weak glow continuously, and occasionally emit light from the larval photophores, (6) the ultraweak luminescence of the adult was detected by CCD camera, (7) the adults mate and spawn several eggs, and the eggs hatch within two weeks, (8) the larvae hatched in autumn overwinter as larval stages, and pupate during the next spring, and (8) virgin females do not spawn eggs. Finally, (9) the DNA barcode sequence from the mitochondrial *COI* region of this species was deposited on GenBank (AB608774).

The genus *Pyropyga* was previously only recorded in North, Central, and South America. We expect the *Pyropyga* observed around Tokyo is an alien species from North America. Because it is morphologically similar to *P. minuta* distributing in United States and Mexico, including genetalia. However, the details of its taxonomy and origin are still unknown. While many invasive alien insect species have been introduced into Japan, this *Pyropyga* sp. is first belonging in the Lampyridae . We need further morphological and genetic comparison studies between this Japanese *Pyropyga* sp. and American *Pyropyga* to finalize its classification. We would appreciate if other researchers could provide American *Pyropyga* specimens, preferably in ethanol for DNA analysis purposes, to assist us in completing this study.

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A PHYLOGENETIC COMPARISON OF POPULATIONS OF *PYRACTOMENA* IN THE WESTERN UNITED STATES

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While fireflies are well known for their bioluminescence there appear to be places where few if any species bioluminesce as adults. One such place is the eastern United States where little is known about the few species that are reported to bioluminesce. *Pyractomena dispersa* Green is a species of lampyrid found mainly in eastern areas of the United States but also has isolated populations in Utah, Idaho, Nevada and Western Canada. This project is aimed to compare several western populations of *P. dispersa* from Idaho and Utah to those in the east using molecular genetic tools. The goal of this project is to determine the relationship between and among populations of *P. dispersa* from the West principally but also with the more commonly known species from the East.

Collected specimens will be analyzed based on phylogenetic reconstructions of molecular data, primarily COI sequences, in order to determine relatedness between populations. Looking at the genetic diversity found within the DNA provides the needed information to compare across populations of *P. dispersa*. In addition to simply determining the relationship between western populations, the molecular data should be able to provide insight about the evolutionary patterns between western and eastern populations.

P. dispersa is a species with a large and disjunct distribution. Targeted research on the group is lacking. It is our goal to find out more about the species and provide the necessary taxonomic resources supported by molecular data but using traditional morphological characters to further our understanding of the species for both evolutionary and conservation based studies.

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FIREFLY WATCH: A CITIZEN SCIENCE PROJECT TO MONITOR FIREFLY NUMBERS

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Spotting fireflies is a special part of warm summer nights in North America, but lately they seem to be disappearing from our landscape. There is much anecdotal evidence from adults who remember summer evenings full of fireflies but haven't seen them in years. Firefly watch was designed with three goals in mind: to determine if fireflies are in fact declining, to make people consider if the choices they make are affecting firefly numbers and to educate people about the natural history of fireflies.

Firefly Watch enlists the help of ordinary citizens across North America to monitor firefly populations in their back yard throughout the summer. Using an online portal, volunteers describe the habitat they are monitoring, including how often their habitat is mowed, distance from light and water, use of pesticides, week killers and fertilizers. Then, on a weekly basis, they count the number of fireflies seen in a ten second period. Weather data is also recorded.

By asking questions about the use of night lights, fertilizers, weed killers and pesticides, volunteers come to understand that actions they take regarding the environment may have an effect on firefly populations in particular and wildlife in general.

Although fireflies are a favorite insect, most people know little to nothing of their natural history. Through the information contained on the Firefly Watch web site, people gain an appreciation for the complex lives of fireflies as well as an appreciation for natural history in general.

Firefly Watch was started in 2008. To date, over 5,000 volunteers from 40 US states and 6 Canadian provinces have participated in the project.

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GENOME SIZE EVOLUTION IN NORTH AMERICAN FIREFLIES

Sarah Sander
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Genome size varies dramatically across the tree of life. Certain taxonomic groups have received more attention than others. Here we document variation in genome size across 22 species of firefly (Coleoptera: Lampyridae). We find considerable differences in genome size within a genus and up to 5-fold across genera. Further, we investigate genetic and physiological correlates with genome size expansion/contraction.

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PHOTOGRAPHING THE GLOW OF FIREFLIES UP-CLOSE (ART PRESENTATION)

Radim Schreiber
www.FireflyExperience.org, Fairfield, Iowa, USA

Firefly Experience is an independent art project created by award winning photographer Radim Schreiber. Since 2009 Radim has been photographing and video recording fireflies in the Midwest, particularly in Iowa, using the latest technology for low light photography. Radim's photographs portray fireflies, mostly up-close, in their own natural environment, lit only with their natural glow. Radim is hoping that his photographs and footage will inspire people to appreciate fireflies and care more for the natural environment.

Radim's firefly photos have received numerous awards and have been shown on local television. Here are the most significant awards:

2012 - Editor's favorite submissions to the photo contest. National Geographic Photo Contest
2011 - 1st place, 41st annual National Wildlife Photo Contest
2011 - 1st place, Smithsonian Magazine 8th Annual Photo Contest
2011 - 2nd place, International Garden Photographer of the Year Photography Contest

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THE LIFE HISTORY OF COMMON GIANT TERRESTRIAL FIREFLY, *LAMPRIGERA TENEBROSUS* (COLEOPTERA: LAMPYRIDAE) IN THAILAND

Somyot Silalom
Queen Sirikit Botanic Garden, Mae Ram, Mae Rim, Chiang Mai, Thailand

The life cycle of Lamprigera tenebrosus was studied under laboratory modification in Queen Sirikit Botanic Garden, Chiang Mai, Thailand, based on three hundred ninety nine larvae. Each larva was separately reared in a transparent box containing a soil mixture. Cryptozona siamensis, a common Siamese terrestrial snail, was fed each larva. Last female instar larva was fed by giant African terrestrial snails, Achatina fulica. Females underwent five instars, while males underwent only three. The complete life cycle was one year. Average pronotal widths of the male from the first to third instars were 5.92, 8.34, and 10.54 mm, respectively while the female from first to fifth instars were 5.99, 8.46, 11.55, 14.96, and 17.33 mm, respectively. The first instar larvae hatch from November to December. Other instars occurred within one to three months of the occurrence of first instar larvae. Pupation occurred in July. Female adults lived two months and had a life span two times longer than the males, which lived approximately a month.

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A PHYLOGENY OF NORTH AMERICAN *PHOTINUS* FIREFLIES: IMPLICATIONS FOR TAXONOMY AND SIGNAL EVOLUTION

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We constructed a molecular phylogeny of 34 *Photinus* species (52 taxa), 7 *Ellychnia* species and 3 outgroup taxa. The appropriate model of evolution for the phylogenetic analysis was determined through jModelTest 2.1 (Darriba et al. 2012). To evaluate the support for the inferred phylogenetic relationships among *Photinus* fireflies, we report the Bayesian posterior probabilities and two fast approximate likelihood-based measures of branch support: the approximate likelihood ratio test (aLRT), and aBayes, a Bayesian-like transformation of aLRT, (Anisimova et al. 2010). We used Mesquite v. 2.75 (Madison and Madison 2005) to reconstruct ancestral character states. To test for phylogenetically corrected relationships between traits (Garland et al. 1992) we used independent contrast analysis (PDAP-PDTREE v. 1.15, Midford et al. 2008, Garland et al. 1999, Garland and Ives 2000; see protocol in South et al. 2001).

The species in the genus *Ellychnia* formed a monophyletic group within the genus *Photinus*. Specifically, *Ellychnia* placed as the sistergroup of the *P. pyralis* group. The traditional separation of *Photinus* fireflies into Division I and Division II species (based on morphological traits of male genitalia: Green 1956) was confirmed by molecular evidence. However, within Division II, molecular data favor splitting the *punctulatus* group (Green 1956) into two separate groups. In addition, two species changed their taxonomic group affiliations. Population samples of *P. pyralis* and of *P. scintillans* each formed a monophyletic clade, but a monophyletic grouping of *P. consimilis* was not supported. Cryptic species may be present in several *Photinus* taxa.

To fully understand the role of selection in the evolution of animal communication systems, studies of natural and sexual selection need to be integrated (Boughman 2002). Based on our molecular phylogeny we investigated the effects of both sexual and natural selection on flash signal evolution in *Photinus* fireflies. With 35 described species, simple ON-OFF visual signals, variation in light signal traits, along with field data on habitat types, sympatric congeners and predators, the North American firefly genus *Photinus* offers an ideal study system to test hypotheses on the evolution of male and female visual signal traits. Our analysis of 20 *Photinus* species with information on both male and female signal traits, suggests at least two pattern generators for signal production in fireflies. We identified reproductive character displacement (reducing mating mistakes) as a main factor for signal divergence among sympatric *Photinus* taxa. In addition, male flash pattern intervals and female response delays were positively correlated with the number of sympatric taxa of predatory *Photuris* fireflies. In the flash communication system of *Photinus,* sexual signals are a compromise between optimizing mating success (sexual selection) and minimizing predation risk (natural selection). No significant effect on signal traits due to habitat type was apparent.

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TOXICITY AND BEHAVIORAL RESPONSES OF THE FRESHWATER FIREFLY LARVAE, *LUCIOLA AQUATILIS,* TO GLYPHOSATE HERBICIDE

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In Thailand, glyphosate are used widely for weed control with increasing of usage tends every year. Contamination of the pesticide in soil or water can affect ecological niches of many living things, including fireflies that inhabit in agricultural ditches, ponds and freshwater areas. Without any studies have confirmed the effects of chemical pollution in water, this study was to examine the acute and chronic toxicity of 2 formulations of glyphosates, Glyphosate 48% and Roundup®, on larval stages of *Luciola aquatilis* firefly. For acute toxicity study, six different concentrations, 0, 1,000, 2,000, 4,000, 6,000 and 8,000 ppm of glyphosate herbicides were exposed to 6 larval stages and revealed that LC_{50} in 96 hours of Glyphosate 48% ranged from 4,165–6,827 ppm and of Roundup® ranged from 4,289–21,169 ppm. Those showed both formulations of glyphosate are low toxic for firefly larvae. However, the treated larvae showed abnormal behaviors such as climbing out of the contaminated solution, raising the posterior abdominal spiracles above the water surface, stop feeding and showing incomplete molting. Histological study of glyphosate exposued larvae showed that Glyphosate 48% induced formation of abnormal cells in digestive system and in excretory system. The cells in swollen or burst and dramatically decrease of fat body was observed. Probably, those will lead to abnormal growth and death of firefly larvae. For the chronic toxicity test, control and 2 ppm of Glyphosate 48% (calculation concentration in agricultural ditches) were used to culture the firefly larvae in whole life cycle to observe mortality rate and developmental time. The mortality rate of L1 to pupae under glyphosate contaminated water was not significantly different from control but showed shorter developmental time significantly. However, the chemical compounds did not only lead to an acute death in firefly, on the other hand it can create long term-effect on larval growth, and consequently larva could not develop into adults. Uses of chemical substances in agricultural fields therefore need to be more cautious and should always follow the instruction in order to minimize environmental harm.

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A NEW FIREFLY LARVA FROM DOMINICAN AMBER AND PHYLOGENETIC HYPOTHESIS OF LARVAL FEEDING BEHAVIOR ACROSS LAMPYRIDAE (COLEOPTERA: LAMPYRIDAE).

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In relation to some orders of insects, beetle larvae (order Coleoptera) are generally poorly known and are difficult to identify. Firefly larvae of the family Lampyridae are no exception. They can be difficult to locate in the field and correctly associated with adults for accurate identification. Further, as the larvae of this family are predators, they are difficult to rear from eggs. We recently had the opportunity to study a well-preserved firefly larva from Dominican amber (18-20 MYA), that represents the first fossilized larva for the family Lampyridae. A phylogenetic analysis of morphological characters was used to compare this fossil to extant larvae and to study larval character evolution.

Based on its morphology, we hypothesize that this fossil larva was arboreal in habit and fed on arboreal snails. When known larval feeding behavior across Lampyridae is plotted onto our phylogeny, a trend from terrestrial, to terrestrial + arboreal, to strictly arboreal habit is recovered. In addition, arboreal habit also seems to have been lost in one region of the tree. Most fireflies and their close relatives are specialists on snails, and snail feeding appears to be retained throughout the group. The relationship of this fossil to extant genera currently found in Hispaniola is discussed and a formal morphological description is in progress.

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PILOTING AND USING CITIZEN SCIENCE TO MONITOR THE FIREFLIES IN KUALA SELANGOR NATURE PARK, SELANGOR STATE, MALAYSIA

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Kuala Selangor Nature Park (KSNP) is located at the estuarine of Selangor River where the famous firefly watching site for the congregating synchronous fireflies, *Pteroptyx tener,* are found further upstream. Three species of fireflies are found in KSNP. Two of them are congregating species *Colophotia praeusta* and *Pteroptyx valida* and a roving firefly *Pyrocoelia* spp. The congregating firefly monitoring study was done over a year to provide the baseline data for any changes to the firefly and determine monitoring methods for the public. The study includes basic observation on the behavior and habitat requirement done twice monthly. During these periods, we had university's students from various disciplines having their annual co-curriculum programme in KSNP tested out the monitoring methods and compared for any changes in the fireflies over one year period. The comparison was made between February 2013 and February 2012 survey by The National University of Malaysia (UKM) showed the main congregating firefly habitat range and the changes in range and density.

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HABITAT RESTORATION OF THE AQUATIC FIREFLY, *AQUATICA FICTA* (OLIVIER, 1909) RESTORATION IN TAIPEI CITY, TAIWAN

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The yellow-rimmed firefly, *Aquatica ficta* (Olivier, 1909) was one of the three aquatic fireflies in Taiwan and the population numbers were declined due to the habitat loss or habitat quality deterioration. In order to saving an original population in private land, Yongjian ecopark that belonged to a construction company, Yuanlih group. An ecological ditch and two ecological ponds were constructed after a series of 1-year scientific surveys, including climate, geological, hydrological, botany, zoological and entomology census from June 2012 to December 2013. The results indicated that the Yongjian ecopark was all a wetland based on geology, hydrology studies, and the fauna studying results showed that there were at least 6 species of fireflies, including 5 terrestrial species and *A. ficta*. Beside fireflies, there were over 300 animals lived around or along the ecological ditch and ponds. The key factor of this restoration case was the attitude of the construction company's managers; they made this project as "ecological development" case rather than "engineering development". This case showed that the fireflies' habitat restoration could be practice by private commercial company beside conservation NGO and relative government department. The design detail of ecological ditch and ponds would be presented in oral talk.

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TOWARDS AN EASY AND CHEAP METHOD TO RECORD AND ANALYSE FIREFLY FLASH PATTERNS

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Emission of species-typical flash patterns by some fireflies had been noticed and reported more than 100 years ago. Analysis of flash patterns has been used in taxonomical, physiological, biological and ecological studies of fireflies for decades. Current methods of recording and analysing firefly flash patterns involve complicated and expensive equipment, making the work unpopular. Nevertheless, flash patterns of some firefly species emitting very high frequency flash pulses are not precisely measured and reported. Different consumer grade digital cameras and different camera settings are used to take videos and long exposure photos of flashes of various Hong Kong Luciolinae species. Videos are analysed by using the computer software Time Lapse Images Analyser and graphs of flash patterns exported. Procedure of using the software is described. Long exposure photograph is shown to be an effective way to display variation of flash pattern amongst mass flying individuals of the same species as well as a useful mean to supplement flash pattern information for species emitting high frequency flash pulses. Influences of different equipment settings are described and optimal equipment settings are proposed. Limitations of current equipment are discussed. Terminology of describing firefly flash patterns is also reviewed and discussed.

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