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FIREFLY WEBINAR 2023

Congregation of Fireflies: Monitoring Populations, Landscape Conservation, and Ecotourism

21-22 July 2023

Editors:

A K Chakravarthy

Parvez

IUCN SSC Firefly Specialist Group

Entomological Society of America — Sharing Insect Science Globally

Firefly Asia-Pacific Network

The Naturalist School

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FOREWORD

Fireflies are a charisma of nature that catches the attention of human beings of all ages. With the expansion of agriculture and urbanization, the habitat for biota, particularly fireflies, has shrunk and the use of chemical fertilisers and pesticides has impacted the quality of the remnant habitats. In India, after an era of onslaught on particularly the wild megafauna, a phase of recovery is observed, and presently Indian forests host more than 60% wild populations of Asiatic Elephant, Royal Bengal Tiger, Single-horned Rhinoceros, and are the last abode of Asian Lion on the planet. Having achieved such success and gained a (wildlife) protected status for about 15% of the public forest in the country, attention is now percolating to lower fauna including amphibians and insects.

It is in this context that the Environmental Management and Policy Research Institute (EMPRI) has initiated a project on habitat and abundance survey of fireflies in Karnataka state with development of a breeding protocol for fireflies as a primary objective. This aspiration required an intense survey of literature and networking with people with experience in this regard.

This second in a series of international Firefly webinars on **"congregation of fireflies: monitoring populations, landscape conservation and ecotourism"** is an effort to build partnerships and share knowledge in this field of science. I am extremely pleased that the research team at EMPRI has put the proceedings of webinar together in this publication. This compilation can reach far and wide through EMPRI website, and I am sure it will be made best use of by the students and researchers interested in the subject.

Further, it is a matter of satisfaction that this 2-day webinar held on July 21-22, 2023 has witnessed the participation of a wider academic community from Asia, the Americas, Australia, and IUCN, and has been an opportunity to share piles of experience.

These Proceedings will serve as an excellent reference book for scientists working on fireflies (Lampyridae) around the world. I am sure it will encourage further research and study on fireflies.

I sincerely thank all the authors and participants for their valuable contributions.

Give fireflies a chance! With best wishes.

Jagmohan Sharma IFS PhD
Director General, EMPRI

India Commemorates World Firefly Day – 2023

Proceedings of the International Webinar on Fireflies dated 21 and 22 July 2023, EMPRI, Bangalore, India

(TABLE OF CONTENTS)

DAY – 2

HEAD & RESEARCH SCIENTIST OF FIREFLY PROJECT'S **OPENING COMMENTS AND WELCOMES FOR THE 2ND INTERNATIONAL FIREFLY WEBINAR, ON THE OCCASSION OF WORLD FIREFLY DAY - 2023 AT EMPRI, BANGALORE, INDIA**

I, Dr A K Chakravarthy; Research Scientist, is delighted to welcome you all here today, and my first responsibility is to express my gratitude to those of you who have joined this event off the official hour from all over the world to be here. With regard to the **Congregation of Fireflies: Monitoring Populations, Landscape Conservation, and Ecotourism,** we have more than 450 participants from 45 nations and 24 speakers from 9 nations other than India.

My next duty is to express my gratitude to our Director General of EMPRI for making time in his hectic schedule to join us for the official opening. He will be in touch with you shortly.

We are also pleased to have with us Dr. Lesley Ballantyne, adjunct research fellow from Charles Sturt University, Australia and other officials from the EMPRI, Members of IUCN SSC Firefly Specialist Group, Member of Fireflyers International Network with whom we have a very close relationship, the Invertebrate Conservation Coordinator at the IUCN, Indiana, the members of which provide much of firefly related resource, the Director and Deputy Secretary-General, China Biodiversity Conservation and Green Development Foundation, the UNESCO DESC/ICT4D's Governance and Ethics Working Group and, of course, our Chief expert Dr. Ballantyne who will be guiding us throughout the webinar.

This is the second International Firefly Webinar by EMPRI, that I have hosted as Head and Research Scientist of the Firefly Project. I sincerely hope that this meeting is as successful as the last and that our hospitality meets the same standards.

Last year the theme of the webinar was 'Firefly, Ecology and Environment' which aimed at the young scholars and scientist & expose them to understand the biology and ecology of fireflies and there significance, diversity, bioluminescence and conservation strategies. EMPRI invited following speakers for the webinar. Dr. Lesley Ballantyne, Charles Sturt University, Australia; Dr. Dammika Wijekoon University of Ruhana. Srilanka; Dr. Devanshu Gupta, Zoological Survey of India; Dr. Anurup Gohain Barua, Gauhati University, Assam; Prof. Sara Lewis, Co-chair Firefly Specialist Group, IUCN, USA; and Ms.

Veronica Khoo, Forest Research Institute Malaysia to share their knowledge and research findings on fireflies. Additionally, the suggestion was made at the conclusion of the webinar-2022, which was taken into account and few of them being implemented. If all goes according to plan, this two-day webinar should be incredibly beneficial, gratifying, and pleasant.

Please do not hesitate to contact Mr. Parvez if there is anything we can do to help you or if you require assistance. When it comes to Firefly, we have come a long way since EMPRI's previous webinar. Although we still do not have all the answers, we now understand a lot more about the biology, systematics, diversity, bioluminescence, and conservation management of fireflies.

I request the Director General, the Honourable Dr. Jagmohan Sharma IFS, to open this occasion and make his remarks without further ado.

INAGAURAL ADDRESS FROM THE DIRECETOR GENERAL TO INAUGURATE THE WORLD FIREFLY DAY – 2023

EMPRI initiated a research project in 2022 on fireflies whose populations are steadily declining world over. The project has been initiated with a view to identify and record firefly species in Karnataka and understand their bio-ecology and conserve them. There are about 2400 species described globally. In India, there are about 70 species; we don't know how many more species occur in India. Fireflies are key indicators of the stable functioning of ecosystems. Last year EMPRI conducted an International Webinar on fireflies: Firefly, Ecology and Environment'. This year the theme of the Webinar is 'Congregation of Fireflies; Monitoring, Conservation of Landscape, and Ecotourism' with an aim of protecting large landscapes embracing other biodiversity elements. More than 450 participants from more than 45 countries are participating in this webinar. This webinar is being conducted in association with IUCN and is facilitated by Entomological Society of America (ESA). There are about a dozen experts delivering lectures on a variety of topics like congregation and monitoring of fireflies, bioluminescence signatures, tools and techniques for capturing firefly images, ecotourism, etc. This year there has been a good response from young minds who have shown keen interest to understand fireflies, all of them are going to share their experience in this webinar.

EMPRI reiterates in educating and creating awareness on fireflies via conserving their habitats and it has also established an Asia-Pacific Firefly workers Network **(Firefly Asia-Pacific Network)** so that researchers can share their experience and update knowledge. The team has identified Charmadi Ghats as a potential ecotourism landscape. EMPRI plans to bring out for the first time a checklist of Indian Fireflies and Field Guide to promote fireflies study and conservation. I hope the outreach activities will go a long way in understanding and conserving fireflies in India and beyond. I wish a grand success for this two-day Webinar. "Good Luck"

Abstracts

We will learn from each other

Lesley Ballantyne, Adjunct Professor**,** Charles Sturt University, Australia

(Email: lballantyne@csu.edu.au)

While the firefly fauna of India is far more diverse than that of Australia there are many parallels between the two countries in addressing identification and conservation, especially if any tourism enterprise is developed. The Australian fauna is exclusively Luciolinae while India has at least three subfamilies. Of the 7 or 8 Luciolinae genera found in each area only the genus Pygoluciola appears to be common to both. While firefly taxonomy is well established in Australia it is only beginning again in India. However it appears we can both benefit from determinations using citizen Science. Nidhi Rana and her colleagues have established many sites across the breadth of India where fireflies in ever increasing numbers can be seen, but not yet identified. In Australia we have established a firefly Facebook page and with our own firefly season just starting we hope to have many postings of the different species which can be identified immediately, and which will expand our knowledge of their distribution. The importance of basic taxonomic skills in identifying, describing, and naming the species cannot be overlooked, and an outline was given of ways that Australian taxonomic enterprises can help Indian researchers.

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2. The Wild Life (Protection) Amendment Act, 2022, Firefly and Habitat Protection

T Balachandra, IFS(r), In-Charge, Project Office: Environmental Management and Policy Research Institute, Bangalore, India

(Email: tbalachandra1960@gmail.com)

Mr. Balachantra T, IFS (rtd.) spoke on the Wild Life (Protection) Amendment Act, 2022 (WPA) and its relevance to the protection of firefly & its habitats. In India, the WPA was enacted in 1972, with a purpose to protect wildlife. There are four schedules in the Act under which different degrees of protection is accorded to wildlife depending upon the population status. The speaker enumerated on the endangered insect species in India and highlighted a few endangered species like *Tetramorium mayri, Drupadia scaeva, Epiophlebia laidlawi, Apis karinjodian, and Haematopinus oliveri*).

Despite other insect's protection under laws, fireflies are not yet legally protected. This may be due to Knowledge gaps, less studied, never thought, or unawareness. As fireflies are drastically declining since decades there is a need to protect them by following these steps which may be creating awareness among the people, more studies are required, national and international collaboration is essential to share information for better understanding the insects, networking, assess the species number, and takes steps for legal protection.

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3. Artificial light and living light: A tale of firefly decline

Amrita Pattabiraman, Annamalai University, India

(Email: amirthacdm99@gmail.com)

Fireflies are unique among the myriad of insects because of their ability to produce light, which is one of wonders of nature. There are over 2,200 species of fireflies across globe, some of them produce bioluminescence for various purposes. Certain species use bioluminescence as aposematic display to avoid predation; while many species attract their mate for reproduction. Few species use their light as lures as in the case of predatory Photuris sp. that attracts Photinus sp. male and Arachnocampa luminosa (Skuse) that attracts prey. The aesthetic mass emergence of these fireflies during their breeding season at certain places amazes not only entomologists and wild life enthusiasts but also the common man. The density and diversity of fireflies is dwindling

because of various anthropogenic factors, among which Artificial Light At Night (ALAN) is the most predominant factor. Currently, about one-tenth of world's land surfaces experiences ALAN and the impact of ALAN is steadily expanding. In case of fireflies, ALAN reduces the visibility of brighter bioluminescence to the mate and this impacts the recognizing of the fittest mates. ALAN reduces the ability of glow worms to attract their prey. Masking of firefly light splashes by ALAN leads to prolonged flight and glowing of mates, which ultimately bring about reduction in fecundity. It's our duty to prevent the decline of density and diversity of fireflies because of ALAN. In such a pursuit, creation of awareness among people is the first requisite. Conservation measures such as restricting the light sources to the needy places like roads and foot paths, providing shielding to street lights, avoiding unnecessary lights in garden and forests areas, installation of motion sensitive sensors help in reducing the light pollution and thereby mitigate or minimize the impact of ALAN on fireflies.

4. The Biochemistry of Bioluminescence: A Saga of the 'insect with the lamp' in terms of conservation'

Rajarshi Chattopadhyay, Ramakrishna Mission Vidyamandira, Belur Math, India

(Email: rchattopadhyay031@gmail.com)

Fireflies are a wonderful creation inhabiting this planet. The fact that makes them remarkable is the light producing ability of the adult forms. Luciferase is a general term for enzymes catalyzing visible light emission by living organisms (bioluminescence). In the studies carried out with Photinus pyralis (firefly) luciferase allowed the discovery of the reaction leading to light production. It can be regarded as a two-step process: the first corresponds to the reaction of luciferase's substrate, luciferin (LH_2), with ATP-Mg^{2+} generating inorganic pyrophosphate and an intermediate luciferyl-adenylate (LH_2-AMP); the second is the oxidation and decarboxylation of LH_2-AMP to oxyluciferin, the light emitter, producing CO_2, AMP, and photons of yellow-green light (550– 570 nm). Present literature embarks upon the conservation of the fireflies owing to maintaining the

balance in the environment and ethical issues. However, our study shows one practical application of noble conservation. We here ink down the luciferase system; either in its native form or with engineered proteins, it encloses the analytical assay of molecular biology studies with luc as a reporter gene, including the most recent and increasing field of bioimaging.

5. The Bio-cultural Diversity and the Tandan, Fireflies

Ojit Kumar Singh, Ramjas College, Delhi University, India

(Email: ojitsingh@ramjas.du.ac.in)

Cultural practices and beliefs of many communities are directly influenced by species that surround them and richer the biological diversity the richer will be the culture of the community. Due to it rich biodiversity the culture of the Northeast India including Manipur is rich and diverse. Besides giving livelihood opportunities and services that provide means to achieve wellbeing, the rich diversity of species has been playing a pivotal and an organic role for shaping the cultural ethos of the region. Many emotions and activities of the state are symbolised equally by many species of animals and plants. Insects has been found to be associated in the lives of the people of Manipur and their position in the lives of the people there is unique, notable and attracts serious attention. The position of the fireflies in the wetlands of Manipur has become precarious and fragile. Their populations are drastically reduced and hence demands views and ways to understand the lost. The population of the fireflies is decreasing worldwide, for a variety of reasons. Change in land-use pattern, loss of habitat area and connectivity, extensive use pesticides and weed-killers and light pollutions are the major drivers of the loss of fireflies. The fireflies have been the familiar sights of the wondrous evenings and the early nights. Awareness and change of the attitude will play the important ways to challenge the loss of biodiversity and thereby maintain the richer culture and the practices associated with the different species that surround us. Fireflies are important

tools to assess the biodiversity and their significances both in terms of culture as well as the ecosystem services.

6. Emission spectra from the firefly species *Asymmetricata circumdata*

Amlan Jyoti Borah, Gauhati University, India

(Email: amlanjyoti001@gmail.com)

Firefly is a common organism that attracts biologists, chemists, physicists, and some poets and artists too. The high degree of efficiency of the firefly's light attracts a physicist. Both wavelength and pulse duration at different ambient conditions are being observed for males and females of different species of fireflies. Conclusions are drawn on the light-emitting reaction and configuration of the enzyme luciferase. In those reports, it's been a general trend to mention a single value of the emission peak. But a continuous observation for the last three years on the species *A. circumdata* reveals that the peak wavelength of males fluctuates within the range of 563 to 570 nm. The probable reason may be a slight change in the structure of luciferase within the same species. Therefore, it can be concluded that a single value of peak wavelength may not be used for all the firefly species.

7. Firefly Conservation and the IUCN Red List of Threatened Species

Anna Walker, New Mexico BioPark Society, Mexico

(Email: redlistinverts@bioparksociety.org)

The Red List of Threatened Species is one of several tools compiled and managed by the IUCN to measure the status of biodiversity. With the goal of providing information and analyses on the status, trends, and threats to species, in order to inform and catalyze action for biodiversity conservation, each individual assessment tells us the likelihood of

a species is becoming extinct in the near future. In the context of fireflies, many species around the globe appear to be facing declines, due to threats such as habitat loss, light pollution, and pesticide use. With more than 2,000 species of fireflies, Red List assessments can help determine which species are most threatened with extinction and where threatened species are found, so that we know where to focus conservation actions, and where conservation actions might help multiple species. We can also look at where we know least about our firefly species, so we know where to focus additional research efforts. In summary, Red List assessments are an important tool to inform species conservation.

8. Distribution of Fireflies in western Ghats – Using Maxent model

Sheik Mohammad, Kannur University, India

(Email: rsmshamsudeen@gmail.com)

Lampyrids are one of the charismatic groups of insects and proper studies have never been conducted in Kerala part of western ghats. Present study deal with the distribution data collection and mapping then for future prediction and conservation. Coordinate points was collected from field survey, information from literature and google form data Different points were added and further data was worked out in maxent for predicted analysis. Maxent selects constraints that have maximum entropy (most spread out) for predicting the probability distribution of species, hence it is prone to over fitting, resulting in predicted distribution that are clustered around sampled points. Therefore, a relaxation component called regularization is included in the algorithm. The variable importance in the model was determined by two approaches namely relative contribution of variable to the model and Jack-knife method. The relative contribution values are determined by the increase in gain in the model provided by the variable. Jack-knife approach (leave-one-out) excludes one variable at a time when running the model. In doing so, it provides information on the performance of each variable in the model in terms of how important each variable is at explaining the species distribution and how

much unique information each variable provides (Baldwin, 2009). With the help of developed model, quantitative information on the potential habitats for Hawk Moths was estimated using Q-GIS tools.

9. Beetles in the Himalayas: Taxonomic Diversity, Geographical Distribution and Prospects

Devanshu Gupta, Zoological Survey of India, India

(Email: devanshuguptagb4102@gmail.com)

In terms of the known number of animal species, beetles are the most species-rich group on this planet with over 3,89,487 species classified under 29,500 genera and 176 families in four suborders (Archostemata, Myxophaga, Adephaga and Polyphaga). The beetles are ubiquitous and are found in almost all ecosystems except arctic snow and seawater. With a wide range of anatomical and biological diversity, they represent about a quarter of the world's total animal diversity, and today's era can be described as the age of the beetles. However, the latest documentation and data compilation by Zoological Survey of India (ZSI) on India's known beetle diversity yielded a list of roughly 22,334 known species so far from the country. The number of named beetle species in India could increase as the database of all known species is built by merging all scattered publications about the group into a single online record. Almost half of India's beetle diversity is distributed in the Himalayan region, where 10,533 beetle species from 2,684 genera and 107 families occur, accounting for 47.3% of India's total beetle diversity and almost 2.7% of the world's diversity. Of these, seven families are very diverse: Staphylinidae (21%), Scarabaeidae (10%), Carabidae (9%), Chrysomelidae (9%), Curculionidae (7%), Elateridae (5%) and Tenebrionidae (5%). About half of the species (5,081) are distributed in the central Himalayas, which includes most of the regions of Sikkim, Darjeeling and Kalimpong in the state of West Bengal. The Western Himalayas are similarly rich with 4,075 species, and the Northwest Himalayas have 2,903 species. The eastern Himalayas have been less explored, with only 1,015 species recorded from the highly diverse and less-explored Arunachal Pradesh. Eighty-two species have a wide distribution in the northwest, west, central and eastern Himalayas. In addition to

widespread species, there are also species that have only been reported from a single habitat or location. There are 3,583 such species in the Central Himalayas, 2,241 species in the Western Himalayas, 1,556 species in the Northwest Himalayas and 487 species in the Eastern Himalayas, which have not been recorded in any other Himalayan province. Diversity in the Trans-Himalayan biotic provinces is poorly known, it is highest on the Tibetan Plateau (0.45%), followed by the Ladakh Mountains (0.34%) and Trans-Himalaya-Sikkim (0.21 %). Much of the Trans- Himalayan is cold desert and unfit for life, although beetles from the region have been recorded and further study could potentially lead to a good number of species from the region. Beetles fulfil various ecological roles, e.g. as biocontrol agents, pollinators, decomposers, pests in crops and forest plantations. Therefore, each niche occupied by the beetle communities needs to be explored for habitat analysis and resource management.

Keywords: Biodiversity Hotspots, Checklist, Distribution, Diversity.

10. Food choice and feeding experiment of two firefly species from West Bengal

Dr. Subhamoy Das, Mahishadal Raj College, India

(Email: subhamoydas6@gmail.com)

Habitat destruction, pesticide abuse, loss of wetlands, firefly tourism and urbanization are mentioned by previous author are the major threats of firefly throughout the world and specially West Bengal. But starting from detail ecology to life cycle, microclimate preference to population structure , population interaction to behavioural attributes are really untouched in any species of Indian firefly species . Species-specific information regarding life cycle against various ecological parameters are most important and also ignored. In our present study we worked out the larval food preference of two firefly species viz *Abscondita* sp. and *Sclerotia* sp.

In this present study we compared time selection of feeding behaviour of two species. *Abscondita* prefers early night (7-30 pm to 9-30 pm) whereas *Sclerotia* sp. prefers mid

night (2am to 5 am) and some extend early morning , which is very good example of feeding niche selection of a particular microhabitat. Mode of capturing and handling of prey also differs. Time investment for feeding and speed of feeding also differs. *Sclerotia* sp. invest less time (78 minute +-23) then *Abscondita* (96 minute +-19) . *Sclerotia* sp (4th instar) can consume one Lymnaea luteola (6mm) within 49 minute whereas *Abscondita* sp. can consume slowly (the same in 63 minutes). In present study we use fresh living snail, killed fresh snail, fresh snail flesh without shell, semi-decomposed snail with shell, semi -decomposed snail without shell and fully decomposed snail species with and without shell. Beside we used other food such as earthworm, prawn, fish flesh, chironomid larvae, tadpole, Amphipod and dead centipede. Among various species 9f snail we used Bellamya, Physha acuta, Lymnaea luteola, Endoplanorbis exustus, Segmentina trochoidea, Gyrulas convexiscias and Pila globosa.Rate of feeding and food preferences differs significantly. They never prefer pila and Bellamya as food item in living condition , although dead and decomposed items are not varied significantly. Food choice depends on instar if larva, size of prey, presence or absence 9f other food item, and condition of food (shell less or shelled, decomposed or fresh , dead or alive and also on species of firefly larva). Food choice experiment shows that newly hatched larva prefers decomposed dissolved organic flesh of various Mollusca and invertebrate. But above second instar the larva shifted their food choice from non-living to living Mollusca and other species. Rate of consumption are larval instar specific irrespective to species of firefly. Aquatic larval species of firefly consume relatively less amount than territorial larval species of firefly significantly.

Keywords: food choice, feeding rate, Larval instar, handling time.

11. Impact of temperature on egg hatching of two firefly species from West Bengal

Soma Khatua, Mahishadal Raj College, India

(Email: somakhatua23@gmail.com)

There are many threats of firefly including habitat destruction, pesticide abuse,loss of wetlands, firefly tourism and urbanization are mentioned by previous author in this field. But lack of species-specific information regarding lifecycle against various ecological parameters is most important and also ignored. In our present study we worked out the impact of temperature on hatching success and incubation period of two firefly species viz *Abscondita* sp. and *Sclerotia* sp. In addition to this we also try to solve the problem regarding species specific food choice and larval instar specific food consumption rate. The result shows that the aquatic larval species *Sclerotia* lays egg on aquatic submerged vegetation in bunch of 137 to 346 (345+-65) whereas territorial larval species lays egg on moist soil at Bank of wetlands and the number varied from 78 to 174 (average 96+- 32). The colour, diameter, arrangement, site and substratum of egg laying also varied significantly. Egg hatching percentage of aquatic larval species of *Sclerotia* sp. is 79 % (+-27) having incubation period19 (+-6days). But the egg hatching percentage of territorial larval species of *Abscondita* sp. shows incubation period 39 - 47 days (41+- 7) and percentage of hatching success of egg varied from 23 - to 67 percentage (52+-12). Egg hatching success at different temperatures varied significantly. At 10-, 20-, 30- and 40-degree centigrade temperature the hatching success of aquatic larval species (*Sclerotia* sp.) was 47, 86, 79 and 41 percentage and incubation period were 29, 20, 17 and 13 days respectively in case of aquatic species. The Hatching success at different temperatures varied significantly. At 10-, 20-, 30- and 40-degree centigrade temperature the hatching success of aquatic species was 34, 66, 59 and 31 percentage and incubation period were 59, 41, 37 and 28 days respectively in case of territorial larval species of *Abscondita* sp.

Keywords: Incubation period, Hatching success, Larval instar

12. Light affinities of Fireflies

Amlan Das, Calcutta University, India

(Email: dasamlan@yahoo.co.in)

Dr. Amlan Das delivered a lecture on 'light affinities of fireflies' prior to the experiment the investigation asked questions like; Do fireflies modify their spatial distribution depending on condition of light and food; How fireflies spatially distributed across different elimination zones. Does fireflies light affinities have a gender bias. The investigation designed a box made up of cardboard and offered food and light sources in the box. The following pattern/combination was adopted in the investigation: For both pre-switch and post-switch of light source; with and without the 'food' factor; separate experiments for male and female with sample sizes of N=1, 5, 10, 20 and 40 were performed. In general, The affinity of fireflies at different-light intensity levels varied significantly for both pre switching and post switching of light source, Fireflies significantly (p=0.05) dispersed at two extreme light contrasting ends for all density-levels, while they are more or less evenly distributed within the intermediate lux zones, A significant variation was observed between the male and female distribution in the light and dark zones.

Keywords: light affinities, starvation, firefly, India

13. Role of Ecotourism in Fireflies conservation

Siddhesh Patil, Lala Lajpatrai College of Commerce and Economics, India

(Email: drsiddheshpatil@hotmail.com)

In present era, one of the major industries which are responsible for impacting wildlife is the tourism industry. The adverse impact on wildlife such as fireflies is due to increasing need of greener spaces and the demand towards "true nature experience". Tourism is one of the major causes responsible for the habitat loss & fragmentation which intern responsible for population decline. The other major anthropogenic factors are the artificial night time lights which affects lot of nocturnal creatures including fireflies. As fireflies depend upon bioluminescent courtship signals, the night time light create a major problem in firefly's reproduction process. The excessive use of pesticides creates

major threats to fireflies. Increasing urbanization & excessive growth of industrialization represents a greater hurdle in conservation of firefly species. For conservation of fireflies, steps towards the protection & restoration of firefly habitat is an urgent need. To understand the factors that help to increase firefly's population & conservation of habitat a detail research need to be conducted, which intern help to conserve the species in better way.

Keywords: Fireflies , Tourism, Light pollution , habitat loss, urbanization

14. Study of habitat & behaviour of congregating fireflies

Jithin Jose, Christ College Irinjalakuda, India

(Email: jithinjose2611@gmail.com)

The congregation behaviour of fireflies was studied from 6 different sites of Thrissur district. Study revealed that firefly congregation peaks by 7 pm and starts declining before it reach its lower count by 11 pm. This is because of the increase in the value of abiotic factors such as humidity, wind speed and atmospheric pressure, but decrease in temperature. Two genera of fireflies belonging to the Family Lampyridae were identified from 6 different study sites. *Abscodita*, Ballantyne, Lambkin & Fu, 2013 was the dominant firefly during the entire study followed by *Asymmetricata*, Ballantyne, 2010. More firefly count was observed in Thumburmuzhi and Palappilly and less count observed from Karikulam. Mainly 3 display trees were observed; Havea brasiliensis, Bombax ceiba and Terminalia catappa in six different sites.

Keywords: Congregation, behaviour, Lampyridae, Thrissur, India

Day – 2

15. Accelerating Conservation Action for fireflies at Global scale

Sérgio Henriques, Invertebrate Conservation Coordinator at the IUCN, Indiana.

(Email: shenriques@indyzoo.com)

Dr. Sérgio Henriques, delivered a lecture on Accelerating Conservation Action for fireflies at Global scale. He proudly mentioned that firefly is a **state insect** in Indiana, USA. Ecotourism and education is an essential tool for conserving the fireflies. Currently the population of fireflies is decreasing world over and it may be due to knowledge gaps. There's an urgent need to protect these enigmatic fireflies by conservation cycle. The conservation cycle has three main components viz Assess, Plan and Act, whereas species listing and assessment is require to assess the population trend, planning for such action is required by giving training to the young minds. Action is needed to encourage and support the researchers on fireflies globally. Core Adaptive Management Process includes, assess problem, implement, monitor, evaluate, and adjust are the essential components which need to be followed for research on fireflies.

Keywords: Fireflies, conservation cycle, IUCN, Indiana

16. Firefly Status in India

VP Uniyal, Wildlife Institute of India, India

(Email: uniyalvp@gmail.com)

Dr. VP Uniyal, presented on 'Assessment of fireflies diversity and Anthropogenic Pressures distressing fireflies population in Doon valley, Western Himalaya, India' the twin objectives set for the investigation were to assess the diversity and factors influencing fireflies population in different habitat types in Doon valley, Uttarakhand and

Escalation of fireflies conservational awareness among communities through outreach programs. Forest, aquatic, agriculture and urban habitats were selected and divide into 100X100 m quadrate. Insect net and hand picking were the method to collect the fireflies. Six firefly species under three genera viz *Abscondita, Asymmetricata,* and *Lamrigera* were identified. Habitat loss Climate Change Pathogens Intensive agricultural practices Pesticides Invasive species Loss of plant communities were the threats observed to fireflies in the study area.

Keywords: Distribution, Firefly, Assessment, Threats

17. Overview of Fireflies in Sri Lanka

Dammika Wajikoon, University of Ruhuna, Sri Lanka

(Email: chandanadammika@yahoo.com)

The invited lecture focused on the species and habitat diversity of fireflies in Sri Lanka, as well as the current natural and man-made challenges to them. Conservation recommendations for future protection of fireflies were addressed further. The subfamilies viz luciolinae (11 species), lampyrinae (3 species), ototretinae (2 species) was described from Srilanka. Threats were identified as deforestation, light pollutions, use of pesticide applications. He advanced following recommendations for conservation of fireflies in Srilanka such as protection their natural habitats, reducing artificial developments of natural water canals, minimizing the use of pesticides, avoiding light pollution, restoring their habitats, society awareness.

Keywords: Conservation, recommendations, light pollutions, restoration

18. Light Emissions of Male and Female *Luciola praeusta* Fireflies at Low Temperature

Anurup Gohain Barua, Gauhati University, India

(Email: agohainbarua@yahoo.com)

The light of the firefly has been attracting the attention of both poets and scientists for over a century. In recent times, light emissions from a few Indian species of fireflies at different temperatures have been investigated [1-6]. Changes observed in the steady-state and flash emissions in those investigations indicate interesting aspects of their light-emitting systems in the live condition. In this talk, a presentation will be made on the emission spectra and flashes from both male and female specimens of the species *Luciola praeusta* at temperatures much lower than the ones at which they normally emit. When the temperature is decreased to the region of 11.5–11 °C for males or 16.5–15 °C for females, the wavelength peak demonstrates a shift towards blue and the pulses show abnormal increase in the duration. These changes, which are reversible, indicate a slight change in the structure of the enzyme luciferase catalysing the bioluminescent reaction that produces the light of the firefly. This happening is proposed as the reason for the females generally disappearing a bit earlier than the males at the onset of the winter.

Keywords: Light emission, bioluminescence, *Luciola praeusta*, temperature

19. Knowledge and monitoring of glow-worms and fireflies in Spain

Ramon Guzman, Citizen science web project, www.gusanosdeluz.com

(Email: gusanosdeluz@gmail.com)

Despite their popularity and frequent reference in folklore, glow-worms and fireflies are not well known and rarely are the topic of monitoring and survey studies. Due to the lack of specific studies, there are important gaps of knowledge about these species, even in territories where biodiversity is an important focus of interest.

During the past years, we have been studying the Spanish glow-worms mainly through the records sent to the citizen science web project “¿Has visto una luciérnaga?” (" Have you seen a glow-worm?" www.gusanosdeluz.com), but also through

the observations of online biodiversity webs (iNaturalist, Observation, Biodiversidad Virtual), the study and classification of the National History Museums collections, the specimens collected in field journeys and the analysis and discussion of the previous scientific bibliography.

Besides their relatively scarce number, Spanish Lampyrids species are characterised by a relatively discrete bioluminescence behaviour making they difficult to detect. The usual pattern of bioluminescence is based in a single female whose light starts some minutes from sunset for call the attention of flying males (being representative of this pattern the species *Lampyris noctiluca, Lampyris iberica, Nyctophila recihii, Nyctophila heydeni, Lamprohiza paulinoi* and *Lamprohiza mulsantii*). An exotic species native from South American, *Photinus signaticollis,* has modified this situation, because it shows a male-female light communication pattern and a gregarious bioluminescence behaviour, comparable to a certain extent to the enthralling performances of tropical and subtropical species. *Luciola lusitanica* is other species showing male-female light whose presence is Spain is still under investigation.

Once a first updated review of the species present in Spain has been obtained, there is a need to increase the study of Lampyrids through specific studies based on population monitoring.

Keywords: Spanish glow-worm, monitoring, public awareness

20. Firefly flash behaviour: understanding evolution and conserving diversity

Christopher Cratsley, Fitchburg State University, USA

(Email: ccratsley@fitchburgstate.edu)

Flash signals produced by fireflies (Coleoptera: Lampyridae) represent crucial information for conspecifics, other firefly species, potential predators and as a conservation tool for humans. These signals function in species recognition, mate choice

and competitive interactions within individual firefly species. Furthermore, they can serve as either beacons or aposematic warnings to predators. This complex host of signalling functions helps explain the broad diversity of firefly flash signalling patterns, and has likely played a role in firefly diversification. As humans begin to make greater efforts to conserve fireflies, particularly through community science programs, firefly flash signals can also play a critical role in helping us monitor and ultimately protect firefly populations. The importance of firefly bioluminescence in emerging conservation efforts further reinforces the importance of understanding the diversity and evolution of Lampyrid flash signals.

Keywords: Flash signals, conservation tool, mate choice, predator

21. Fireflies from Mexico: Inclusive taxonomy with local communities

Ishwari G. Gutiérrez Carranza

Colección Nacional de Insectos, Departamento de Zoología, Instituto de Biología, Universidad Nacional Autónoma de México (CNIN-ibUNAM), Circuito Exterior s/n, Ciudad Universitaria, Apartado Postal 70-153, C.P. 04510, Coyoacán, Mexico City, Mexico; *IUCN Species Survival Commission-Firefly Specialist Group*, Gland, Switzerland.
(Email: ishwariggc@gmail.com)

Fireflies' ability to emit light to communicate sexually in the adult stage is a natural phenomenon highly attractive to humans and in recent years, this natural display has positioned entomotourism as a lucrative activity worldwide. Mexico has 285 species, so it ranks second place in the world with the greatest richness of fireflies; until 2021 (and largely thanks to the synchronous flashing species "Photinus palaciosi"), there was a record of 55 sighting sites (although it's estimated that each year the number of such spots increases exponentially) many of which are managed by local communities. However, there's a large disparity between the number of firefly-touristic sighting sites and those who actually know the identity of the present species. Considering that taxonomic knowledge is fundamental for understanding biodiversity and creating conservation plans, since 2021, the project "Inclusive taxonomy with local communities" was created with the aim of providing workshops and training and also grant institutional

accreditations ("certificates") for their fireflies' species identification. So far, support has been provided to seven sighting sites belonging to four Mexican States, where a total of 10 firefly species have been identified, of which: two were new species, three new State records were registered and one new record for our country was documented. Additionally, as a result of the project, one scientific paper has been published to date. Finally, during the 2023 firefly season, another four sighting sites have been visited.

Keywords: Light ability, entomotourism, taxonomy, knowledge

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22. **Firefly Conservation in China**

Ms. Lei Ping,

China Biodiversity Conservation and Green Development Foundation, China

(Email: linda.wong@cbcgdf.org)

The Shenyang-Haikou National Highway Expansion Project, backed by a substantial 15.7 billion investment, began in December 2022 as the inaugural expansion endeavour of the Guangzhou North Second Ring Road. The expansion zone, which includes the Badou Interchange, has significant overlap with the firefly habitat of Tianlu Lake Forest Park. According to our investigation, This habitat is a unique ecological treasure in Guangzhou, boasting ten different firefly species.

To advocate for preserving these habitats, a movement named "Disappearing Fireflies Park" was launched, encouraging people to raise their voices and explore workable solutions. This park serves as a haven for both human residents (Guangzhou citizens) and the diverse wildlife that resides there, including fireflies, spiders, frogs, Cibotium barometz, snakes, and butterflies. The park is especially known for its bright fireflies at night and officially opened on July 14, 2023, at 19:30. Night tours are offered periodically to engage the public in this conservation effort.

Nowadays, an increasing number of individuals are visiting the "Disappearing Fireflies Park" independently to pay homage. Efforts are underway to persuade the government to consider preserving the firefly habitat. While the future of these firefly habitats

remains uncertain, the creation of the "Disappearing Fireflies Park" reflects the determination to try and protect them.

Keywords: China, firefly, monitoring, firefly-park, habitat

23. Monitoring congregating fireflies using a non-destructive method: Digital night photography

Veronica Khoo, Forest Biodiversity Division, Forest Research Institute Malaysia (FRIM), Kepong 52109 Selangor, Malaysia
(Email: veronica@frim.gov.my)

Globally, it is known that the insect population is declining at an alarming rate. Various methods have been used to monitor insect population, for example, trappings and visual surveys of the species intended to monitor. A non-destructive method has been developed to monitor the congregating fireflies found in Selangor River that is located in Selangor, Malaysia. This river is well-known as it is one of the pioneer sites for firefly watching in this country. The local community perceived there is a decline in the firefly population, however, no data was able to support the claims. Through the long-term monitoring conducted on a monthly basis, the index of abundance of the firefly population seemed to show a downward trend, thus, confirming the perception of the locals. The method on carrying out the long-term monitoring using digital photography has been published and is discussed here, with hopes that an adaptation of the method can be used in other congregating firefly habitats.

Keywords: Selangor River, Monitoring, Population, Decline, Malaysia

24. Understanding the impact of artificial lighting at night on the common glow worm

Jeremy Niven, University of Sussex, United Kingdom
(Email: j.e.niven@sussex.ac.uk)

The negative effects of artificial lighting at night (ALAN) on insects are increasingly recognised and have been postulated as one possible cause of declines in insect populations. Insects that rely on bioluminescence to signal to attract males, such as glow-worms and fireflies, are likely to be particularly severely affected by ALAN because it may disrupt reproduction. Here I focus on the impact of ALAN on the common glow-worm (Lampyris noctiluca).

Adult female common glow-worms (*Lampyris noctiluca*) are larviform using a bioluminescent 'glow' to attract volant males (reviewed in Tyler, 2002). Males fly at night searching for, detecting and then homing in on the female glow. It is this reliance on a bioluminescent signal that makes glow-worms potentially so susceptible to ALAN. Recent studies corroborate the harmful effects by showing glow-worms are undergoing range contraction in the UK that may be linked to ALAN (e.g. Gardiner and Didham, 2020, 2021), though the evidence is correlative.

Numerous studies have shown that ALAN can interfere with the ability of males to reach females (e.g. Ineichen and Rüttimann, 2012; Stewart et al., 2020; Kivelä et al., 2023). Typically, these studies involve direct illumination of 'dummy' females (green LED funnel traps) by ALAN. These studies demonstrate that even dim direct ALAN can reduce the numbers of males able to find females.

Here we explore the behavioural effects of ALAN on male glow-worms using a 'dummy' female LED in a Y-maze. Brighter illumination reduces the number of males reaching the LED and also increases the time taken by males to reach it. This is due to males spending more time in the central arm of the Y-maze and with their head retracted beneath their head shield. All these effects reverse rapidly after males are returned to darkness. Thus, ALAN is capable of both preventing males from reaching and increases the time they take to reach female glow-worms.

We also explore the impact of indirect ALAN on glow-worm mating. We constructed a barrier of white LED lights to mimic the effects of street lighting. We show that the presence of a light barrier significantly reduces the number of male glow-worms that reach a patch of dummy females in comparison to a control in which the light barrier

was absent. This shows that an interposed light barrier can interfere with glow-worm mating with broad implications for the potential impacts of ALAN.

These findings coupled with extensive previous work suggest that ALAN impacts upon the mating of adult glow-worm

Keywords: ALAN, Impact, Glow-worm, behaviour

25. Distribution of fireflies in South-West and South-East Asia.

Oliver Keller, Florida Museum, USA

(Email: okeller1977@gmail.com)

Dr. Oliver highlighted the distribution of fireflies in South-West South-East Asia, he stated that there is 12 subfamilies of fireflies in this world. In South West and East-Asia, the fireflies were accounted for 18 countries under 4 subfamilies, 52 genera, and 493 species. From 1750 to 2023 a gradual increase in the number of species documentation has been reported. A maximum number of more than 80 species were described during 1920s. The data on fireflies showed that countries in South East-West Asia exhibit a good % of endemism. This scenario in India is that 86 species of fireflies in 3 subfamilies and 25 genera having 58% of endemism has been so far recorded. He concluded the talk with the following points for way forward on fireflies: Much work remains, South-East Asia on a good trajectory, South-West Asia has great potential, Good taxonomic practices, and Ototretinae needs special attention.

Keywords: Overview, globally, Firefly, Distribution

Recommendations:

A total of 25 talks were delivered by National and International speakers. The topic covered fireflies studies throughout the world in the area of biology, bioluminescence, diversity – distribution, ecotourism, monitoring, legal-protection & conservation, taxonomy, threats and mitigations. Various aspects of firefly congregation's monitoring and conservation of landscape, methodology and techniques for highly emphasizes, and a regional views were also covered. The abstract booklet contains 25 abstracts from national and international experts.

The deliberation was marked by hectic discussion and active participations via questions and answers sessions. Last year also an international webinar on fireflies was conducted by EMPRI on 22 July 2022 with the theme 'Firefly, Ecology and Environment'. The following recommendations were highlighted.

1. There is a need to organize a firefly taxonomic workshop-and-hands-on-training, especially for firefly researchers and scholars from South-West and South-East Asian countries.
2. Endangered species of fireflies, jewel beetles, lyctids, stag and dung beetles that are crucial for ecosystem functioning and whose populations are on the decline across countries should be provided legal protection.
3. A policy for traffic and public light in areas of firefly congregations should be promulgated to mitigate the impact of Artificial Light At Night (ALAN) on firefly congregations and populations.
4. Injudicious use and application of pesticides and other chemicals should be banned/regulated at a certain level as it affects not only fireflies but also other biodiversity elements.
5. Berembeng tree (*Sonneratia caseolaris*), Indian almond (*Terminalia catappa*), Red silk-cotton tree (*Bombex ceiba*), Areca nut (*Areca cathechu*), Rubber (*Hevea braziliensis*), and *Ficus sp.* are the preferred firefly courtship display trees which are being commercially exploited. This practice be banned.
6. Biotic factors that influence fireflies the most are the presence of suitable trees for courtship and food (snails, nectar and sap), vegetation health and the absence

of tree species having insecticide properties (Saponins). Abiotic factors like water level in soil, air temperature and humidity, rainy seasons, altitude, wind direction and speed and air pollution also influence firefly populations and need to be considered by developing conservation plans.

7. Techniques and approaches for studying, monitoring and conserving firefly congregations were highlighted in the webinar and emphasis was laid on their standardization and use. The firefly workers should update their approaches and study plans before initiating studies on fireflies.
8. Dr. Oliver Keller, Florida Museum, USA, is compiling the World Firefly Checklist, and it was urged that workers and researchers should coordinate and help him in updating the checklist.
9. Research on subfamilies such as Ototretinae and lampyrinae needs special attention, especially in South West and South Eastern countries.
10. Firefly workers are actively monitoring and estimating the population at several places in Karnataka and capturing images using software and models to gain insight into firefly emergence and congregation. This should be further encouraged.
11. Awareness about initiatives like *EMPRI – Firefly Asia–Pacific Network, IUCN SSC Firefly Specialist Group, Fireflyers International Network, Firefly Biopark in China, and Mexico* that are actively coordinating for protecting fireflies, creating public awareness and taking conservation issues forward, should be promoted.
12. India holds 51% of firefly endemics out of 86 species listed so far. This emphasizes the need to accord priority to those forest areas in India while developing conservation plans.
13. Dr Oliver Keller pointed out that there is a wide gap from 1850–1980s on firefly research in India. This reveals there is an immediate need for studying fireflies.
14. Island countries like Sri Lanka and Maldives might have held species from the mainland/Deccan plateau of India, which may serve as a gene pool. So, emphasis with regard to the conservation of species and landscapes in India is crucially important.

15. Estuaries, river banks and mangroves need immediate and special attention for firefly conservation globally, as these are very fragile and are being put to commercial use such as beach resorts, ecotourism, sand mining and settlement of fishermen communities. These habitats must receive priority in conservation.
16. The major threats to fireflies include: habitat loss, pesticide use, invasive species, climate change, artificial lights at night, unplanned urbanization, human interference and habitat fragmentations, and water pollution.
17. The following conservation actions are necessary: Fireflies should be declared as a protected species group under the law; Large-scale in-situ and ex-situ conservation should be encouraged; more research and outreach activities should be undertaken to create awareness; and Firefly habitats having tourist potential should be declared - Protected Habitats (Firefly Sanctuary or conservation reserve) in Karnataka.

The webinar concluded on a satisfactory note with thanks to all the supportive organizations - International Union of Conservation of Nature and Natural Resources, Switzerland, Firefly Asia-Pacific Network, India, University of Agriculture Sciences, GKVK, Bangalore, Entomological Society of America, the UAS, and NGO The Naturalist School.

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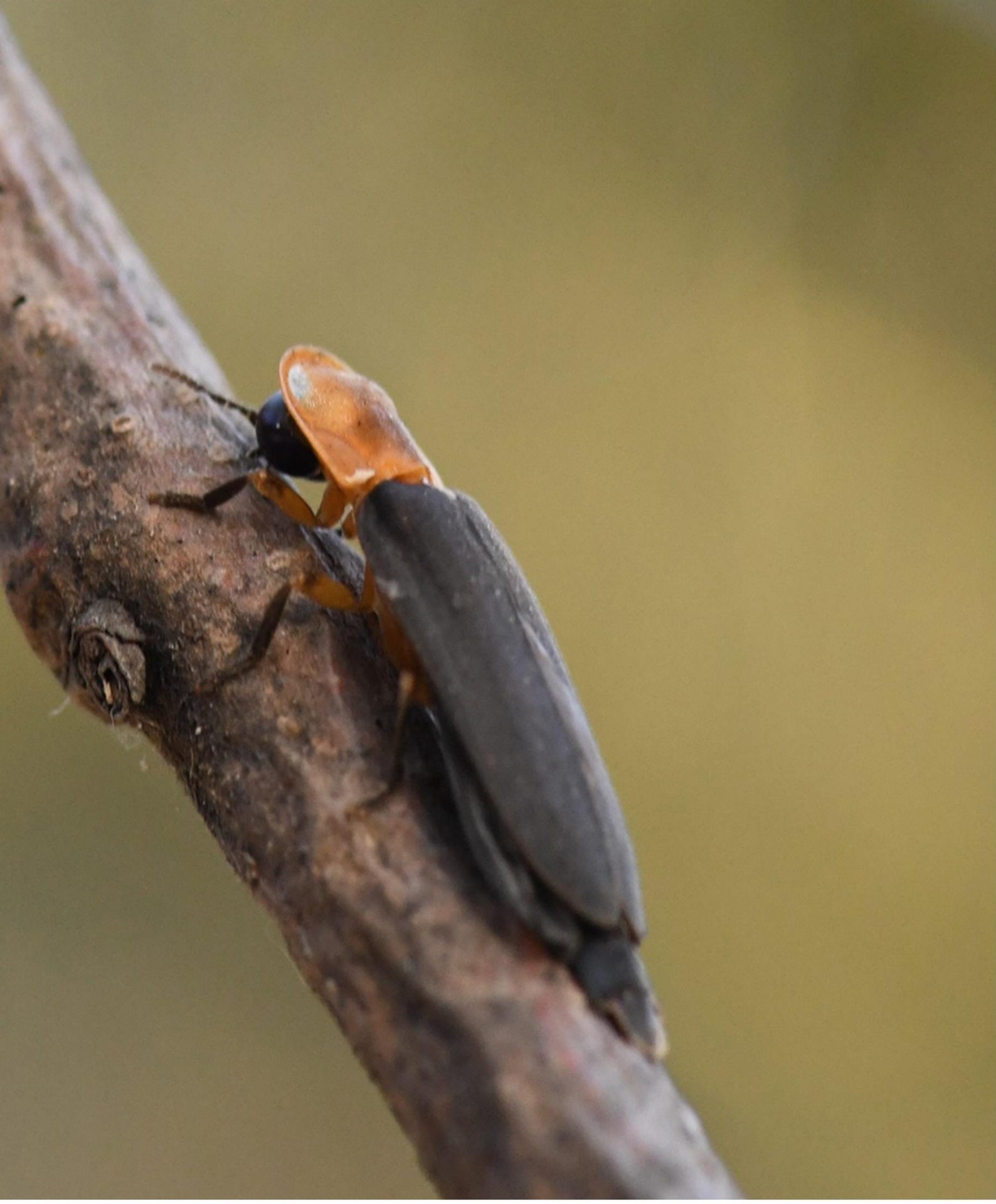

Environmental Management & Policy Research Institute
Department of Forest, Ecology, and Environment,
Government of Karnataka
Hasiru Bhavan, Doresanipalya Forest Campus, Vinayakanagar Circle
J.P Nagar 5th Phase, Bengaluru-560078, Karnataka
https://empri.Karnataka.gov.in