THE IMPACT OF LIGHT POLLUTION ON FLASH RATE AND DURATION OF *Pteroptyx bearni* (COLEOPTERA: LAMPYRIDAE)

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2017

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UNIVERSITI MALAYSIA SABAH
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I hereby declare that the material in this thesis is my own except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged.

02 November 2017

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CERTIFICATION

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VIVA DATE	:	**09 AUGUST 2017**

CERTIFIED BY

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"Life is a drama, for life without drama, is not life at all." - Arreis

"The drama of life begins with a wail and ends with a sigh." – Minna Antrim

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ABSTRACT

Fireflies from family Lampyridae (Order: Coleoptera) uses light for mating, as a defence mechanism or to prey others. They emit light via their light organ and only started to flash during the night. However, existence of light pollution may be overwhelming for the communicating firefly and may potentially mute them, making them unable to mate, defend themselves and eat. Hence, light pollution has been rumoured to cause firefly population to dwindle but empirical proof is still lacking especially the direct impact of artificial light to their flash pattern. Therefore this study is trying to investigate the effect of multiple light intensities on the flash rates and flash duration of *Pteroptyx bearni* firefly, as well as to provide a documentation of *Pteroptyx bearni* flashing pattern and to find an alternative and cost-effective ways in monitoring their flashing pattern. Firefly samples were taken from Kawang River, Kinarut by using sweep net. Subjects (N = 76) were brought to the laboratory of Institute for Tropical Biology and Conservation and caged in individual Petri dishes, left in a dark room for one hour then recorded using a camcorder (SONY DCR-SX40) before, during (0.05 lux, n = 19; 0.1 lux, n = 20; 0.3 lux, n = 20; 0.5 lux, n = 17) and after light pollution for five minutes respectively. Flash rates and flash duration were extracted from the video data by converting them into image sequences using FFMPEG and transformed into quantitative value using ImageJ. Friedman test with Wilcoxon signed rank test shows that flash rates is lowest during exposure to 0.1 lux to 0.5 lux of light intensity compared to before and after exposure to light. Flash duration, using similar tests, shows that duration shortens when exposed to 0.1 lux to 0.5 lux of light pollution when compared to before exposure. Generalized Estimating Equation (GEE) test on both rates and duration shows temperature and humidity is affecting their flash rates and duration. *Pteroptyx bearni* flashing pattern is irregular consisting of single and multiple-pulse flash.

ABSTRAK

KESAN PENCEMARAN CAHAYA TERHADAP KADAR DAN TEMPOH KELIPAN Pteroptyx bearni (COLEOPTERA: LAMPYRIDAE)

Kunang-kunang dari family Lampyridae (Order: Coleoptera) menggunakan kelipan untuk mengawan, melindungi diri dan mencari mangsa. Kelipan dihasilkan melalui organ cahaya dan hanya berkelip pada waktu gelap. Cahaya dari luar berpotensi untuk mengganggu aktiviti kelipan mereka. Oleh itu, pencemaran cahaya amat kerap dirujuk sebagai punca populasi kunang-kunang semakin berkurangan tetapi bukti empirik masih belum cukup terutamanya kesan cahaya terhadap corak kelipan mereka. Oleh itu, kajian ini dijalankan untuk menguji kesan cahaya terhadap kadar dan tempoh kelipan kunang-kunang Pteroptyx bearni pada keamatan yang berbeza, menyediakan dokumentasi corak kelipan kunang-kunang Pteroptyx bearni, dan mencari kaedah alternatif dan kos-berkesan untuk memerhati aktiviti kelipan mereka. Sampel kelip-kelip di ambil dari Sungai Kawang, Kinarut dengan menggunakan sweep net. Subjek (N = 76) dibawa ke makmal Institut Biologi Tropika dan Pemuliharaan kemudian dimasukkan ke dalam piring petri berasingan, kemudian diletakkan di dalam bilik gelap selama satu jam dan kemudian dirakam menggunakan kamkorder (SONY DCR-SX40) sebelum, sewaktu (0.05 lux, n = 19; 0.1 lux, n = 20; 0.3 lux, n = 20; 0.5 lux, n = 17) dan selepas didedahkan kepada pencemaran cahaya, masing-masing selama lima minit. Kadar dan tempoh kelipan diambil dari data video dengan cara menukarkan video tersebut kedalam bentuk urutan imej menggunakan FFMPEG kemudian ditukarkan lagi dalam jumlah kuantitatif menggunakan ImageJ. Ujian statistik Friedman dan Wilcoxon Signed Rank menunjukkan kadar kelipan kunang-kunang pada tahap terendah sewaktu didedahkan kepada pencemaran cahaya pada keamatan 0.1 lux hingga 0.5 lux berbanding sebelum dan selepas pendedahan. Manakala tempoh kelipan kunang-kunang semakin pendek apabila didedahkan kepada kecerahan cahaya 0.1 lux hingga 0.5 lux. Ujian statistik GEE menunjukkan wujud kesan suhu dan kelembapan udara terhadap kadar dan tempoh kelipan Pteroptyx bearni. Corak kelipan Pteroptyx bearni adalah tidak tetap dan terdiri daripada kelipan tunggal dan berbilang.

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LIST OF ABBREVIATIONS

.tsv or .TSV	-	Tab-separated value
AD	-	Analog-to-Digital
AMP	-	Adenosine Monophosphate
ATP	-	Adenosine Triphosphate
CO_2	-	Carbon Dioxide
DC	-	Direct Current
f	-	Femur
fpm	-	Flashes per Minute
fps	-	Frame per Second
GEE	-	Generalized Estimating Equation
IPI	-	Interpulse Interval
LBG	-	Lucibufagins
LED	-	Light Emitting Diode
LH_2	-	Luciferin
LO	-	Light Organ
MFC	-	Metafemoral Comb
mg^{2+}	-	Magnesium ion
ms	-	Milliseconds
MT	-	Main Trachea
N	-	Neuron
NA	-	Not Available
ne	-	Neural
NO	-	Nitric Oxide
NOS	-	Nitric Oxide Synthetase
O_2	-	Oxygen
PC	-	Personal Computer
PH	-	Photocyte
PMT	-	Photomultiplier Tube
px	-	Peroxisome
QIC	-	Quasi-likelihood under the independence model criterion

RM	**-**	Ringgit Malaysia
ROI	**-**	Region of Interest
sec	**-**	Seconds
sp.	**-**	Species
t	**-**	Tracheole (or trochanter for insect leg description)
TB	**-**	Tracheal Branch
tc	**-**	Tracheolar cell
TEC	**-**	Tracheal End Cell
TiLIA	**-**	Time-lapse Image Analysis
V7	**-**	Ventrite Number 7

LIST OF SYMBOLS

FR	-	Value of flash rates according to GEE model
FD	-	Value of flash duration according to GEE model