FLASH BEHAVIOR AND ECOLOGY OF THAI LUCIOLA 
FIREFLIES (COLEOPTERA: LAMPyRIDAe)

JAMES E. LLOYD AND STEVEN R. WING  
Department of Entomology and Nematology  
University of Florida  
Gainesville, FL 32611-0143, USA

TAWATCHAI HONGTRAKUL  
Pesticide Research Laboratory  
Department of Agriculture  
Bangkhen, Bangkok 9, Thailand

ABSTRACT

The advertising flashes and general ecology of four species of Luciola fireflies from the Bangkok, tidal region of Thailand are reported, and comparisons made with other species. The general signal systems and aquatic life-histories found fit with what has been reported for other Asian and Australian Luciolinae.

RESUMEN

Se reporta sobre los destellos de anuncio y de la ecología general de cuatro especies de Luciola en la región donde hay cambios de mareas en Bangkok, Tailandia, ye se comparan con otras especies. El sistema general de señales e historias de la vida acuática se ha encontrado que concuerdan bien con lo que se ha reportado de otros Luciolinos de Asia y Australia.

Thailand fireflies are known almost exclusively for the synchronous flashing behavior of a single, "superstar" species, Pteroplatyr malacciae Gorham, which, at least before its
habitat had been extensively altered, occurred in aggregations of thousands on mangroves along estuaries and in inland swamps within the tidal reaches of large rivers. However, Thailand has several other species of Lampyridae, some of which we saw during field work in the vicinity of Bangkok (Lloyd & Wing 1981, Wing et al. 1983, Lloyd et al. 1989). We record here observations made on Luciola (Luciolinae) species from 19 July to 13 August 1980.

Luciola japonica (Thunb.) was the most commonly seen firefly during our study, and was always associated with standing water. It occurred around and over ponds, flooded grasslands and rice paddies, and along roadside ditches and canals. Luminescing adults frequently were seen landing and perching on, and taking off from emergent vegetation in these habitats. The larvae probably are aquatic, an ecology known for several other Asian Luciolinae (e.g., Luciola cruciata Motsch., Yuma 1984). Occasionally larval glows could be seen on and under standing water, and lampyrid larvae were collected there. In captivity, these fed on snails from their habitats, including Helicella crosseana and siamensis; Lymnaea (= Radix) auriculata and rubiginosa; and Filopudina spp. Salinity at one road-side ditch site was 13.2 ppt, showing a tidal influence even two miles inland from a large river and at a point several miles up river from the Gulf (LaMotte reek kit, 0.2-.40 ppt).

Males began flying and flashing 33-37 min after sunset (n = 2 evenings), that is, 1.5-1.7 crep units after sunset (Nielson 1961). The number of active males gradually increased for the next hour or so, was reduced considerably by 3 hours after sunset (ss+3 hrs), and by ss+4, only occasional individuals were seen. Males flew 1-2 meters above the vegetation in their sites, emitting long trains of short, bimodal flashes (Fig. 1). The first peak in each flash was much less intense than the second, and was somewhat variable in form (Fig. 2a-d); the variation seen in recordings is probably partially due to the movement (orientation) of flying males relative to the PM-recorder (photo-multiplier recording methods are described in Lloyd 1973). The duration of 87 recorded flashes of 9 males ranged from 160 to 190 mSec (26.1°C); height ratio (ratio of relative intensity of first peak to that of second peak) ranged 0.09 to .34; and the modulation rate of the two peaks ranged from 12.5 to 17.9 Hertz (Table 1). Note that with respect to these last two parameters, there was less variability than might be concluded by the range extremes. Table 1 gives values for the flashes of five males as examples.

Flash trains were of three forms: (1) bright flashes were emitted at a fast rate (Fig. 1, center of trace; e.g., 2.5 Hertz at 26.1°C); (2) flashes were emitted at half the fast rate; (3) flashes were emitted at the fast rate, but alternate flashes were much reduced in intensity (Fig. 1, beginning and end of trace shown) in a manner reminiscent of that noted in Luciola huonensis Ballantyne in New Guinea (Lloyd 1973). During late even-

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<td>60 00</td>
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<td>50 10</td>
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<td>170 10</td>
<td>60 10</td>
<td>.11 .06</td>
<td>14.9 .9</td>
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<td>14</td>
<td>170 10</td>
<td>60 10</td>
<td>.12 .03</td>
<td>14.9 .7</td>
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Fig. 1-6. Chart traces of firefly flashes. Horizontal axis, time as indicated by timelines; vertical axis, relative intensity. flashes were recorded at 26.1°C. (1-3) L. japonica: (1) Train of male flashes, fast rate, but see text. (2) Sample of variation in bimodal flashes. (3) Flicker of landing male. (4-5) Flashes of L. cingulata: (4) Male flash pattern (advertising flash). (b) Two sections of a sputtery flicker emitted by a male after he received a response to his advertising flash. (6) Simulated flash pattern of male L. nr. carinata. Actually only the second flash was recorded; for illustration, a first flash, based on the profile of the recorded second flash, was sketched in position, with an appropriate adjustment made in the falling (AFC) baseline to connect the two.

ing, the slow rate seemed to be more common than the fast, possibly relating to lower male density, that is, reduced male competition. Table 2 gives values in PM-recordings of the flash periods of six males as examples.
TABLE 2. Flash periods of six males, one at half rate, photomultiplier recorded at 26.1°C. Mean interval and standard deviation in sec; N is number of intervals measured.

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<tr>
<th>Male</th>
<th>Interval</th>
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<tr>
<td>3</td>
<td>.38</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td>.39</td>
<td>30</td>
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<tr>
<td>13</td>
<td>.40</td>
<td>22</td>
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<tr>
<td>14</td>
<td>.39</td>
<td>20</td>
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<tr>
<td>17</td>
<td>.39</td>
<td>17</td>
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<tr>
<td>22A</td>
<td>.78 (half)</td>
<td>4</td>
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Males flying within 10 meters of each other sometimes synchronized their flashes. Their synchrony appeared to be as precise as occurs in Pteroptyx malaccae, rather than imprecise, as seen in certain other fireflies (e.g., in Photinus carolinus Green, in the Appalachian Mountains of eastern North America, Lloyd 1966, unpub. obs. J. Sivinoki, JEL, SRW). Synchrony was noted at both fast and slow rates. Landing males, and males approaching and hovering near attractive sources of light on the substrate, emitted flickers (Fig. 3) or apparent glows (not electronically recorded) that may actually have been subliminally (for human eyes) modulated. Landing and flying females also emitted glows and flickers.

Numerous apparent conspecific specimens in two Thai collections (Acknowledgements) suggest that adults of this species are active throughout the year, and that the species is widely distributed in Thailand.

Luciola cinquata. E. Oliver (tentative identification) was seen flying over flooded grassland and rice paddies. It was never observed before 22+147 min, and was noted as late as 25+22 min. Males flew 3-9 meters above the ground, and emitted one-third sec long, flare-like flashes at 3.5 sec intervals (s = 0.29, range = 2.9-3.9 sec, n = 8, stopwatch; 25.8-27.2°C). Two PM-recordings of advertising flashes reveal a rather sharp ON transient (Fig. 4), which was not suspected from field observations. In the field, the flashes are reminiscent of those of Florida’s Pyrausta montana occidenta (LeConte), a species also found in open, wet grassland (JEL unpub. obs.).

Males could be attracted toward a half-sec flash of a penlight emitted immediately after each of their flashes, from as far away as 45 meters (n = 12 of 12 males). When they had approached to 1-4 meters, they began to emit a short “sputtery” flicker after the penlight flash (Fig. 5). This behavior was previously noted in males of four species of New Guinea Pteroptyx (Lloyd 1973). Males would not approach the flash of the penlight further unless it was left ON (n = 4 of 4 males), suggesting that responding females may glow between their response flashes, or perhaps begin glowing during the final moments of a male’s approach. Males landed within a few inches of the glowing decoy. This experiment was first suggested by the approach of a male to the orange glow of the light-emitting diodes of an electronic stopwatch.

Numerous possibly conspecific specimens in Thai collections were labeled L. chinesis and L. substrata, and suggest that adults of this species are active throughout the year and that the species occurs throughout Thailand.

Luciola nr. carinata: Three males of this species, judging from flash pattern, were seen flying with L. cinquata. They flew slowly 2-6 meters above the ground, and emitted a two-flash pattern at 3 sec intervals. The flashes of a pair were spaced at an estimated 0.6-1.0 sec interval, and appeared to be without sharp intensity transients. However, the single PM-recording shows an asymmetrical, 620 mSec flash whose rise time is only 60 percent as long as its decay (Fig. 6). The recorded male was attracted
briefly toward a short penlight flash that was emitted immediately after the second flash of his pattern.

_Luciola circumdata_ Motsch.: Although collections indicate that this species occurs throughout the year, and throughout Thailand, we saw few (<5). Males emitted single, short flashes in continuous trains, while flying 2-5 meters above the ground. Flash period was estimated to be about 0.7 sec, and flash duration about 200 msec. The general appearance of flashing is similar to that of _Photinus frontalis_ LeConte in eastern North America, and _Luciola salmonina_ limbutipes Pic on Guadalcanal (Lloyd 1973 and unpub.), though the former’s flash is much shorter. These fireflies irregularly interrupt their trains by omitting single or several flashes.

Behavior voucher specimens (Lloyd 1966) are in the JEL collection, and will eventually be deposited in the Florida State Collection of Arthropods.

**DISCUSSION**

Observations on the sexual signals of Asian Luciolinae, in particular those made in Japan over the past decade by Nobuyoshi Ohba (1983 and refs.), along with the excellent and comprehensive taxonomic work on the group by Lesley Ballantyne (1968, 1987 and in prep.), will permit questions to be asked of the flashing data that are of broad ecological and higher systematic significance, to complement our current use of flashes for species-level characterization and taxonomy. Ohba (1983) has made progress along these lines, addressing, for example, signaling systems, seasonal and geographic occurrence, and “reproductive isolation.” Future comparisons and analyses of differences between the signal systems of Asian and New World fireflies, the latter having the high-impact influence of _Photinus_ spp. predation by signal-targeting involving both aerial attack and attractive signal mimicry, and the former often involving considerable mate choice opportunity (Lloyd 1984), should reveal important facts about signal evolution (see Burk 1982).

**ACKNOWLEDGEMENTS**

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**REFERENCES CITED**


LABORATORY STUDIES ON THE IMMATURE STAGES OF ATRICHOPOGON WIRTHI (DIPTERA: CERATOPOGONIDAE)

KAI LOK CHAN
Department of Zoology
National University of Singapore
Kent Ridge, Singapore 0511

JOHN R. LINLEY
Florida Medical Entomology Laboratory
University of Florida
200 9th Street S.E.
Vero Beach, FL 32962

ABSTRACT

In the laboratory, at 24-26°C and 90 + % relative humidity, the immature stages of Atrichopogon wirthi Chan & Linley (Diptera: Ceratopogonidae) were completed in 2-3 weeks. The mean durations (days) of the individual stages were, respectively: egg 3.3, 1st instar 1.7, 2nd instar 2.0, 3rd instar 2.3, 4th instar 4.1, pupa 3.0. The mean overall duration was 16.4 days.

RESUMEN

Se completaron en 2-3 semanas en el laboratorio a 24-26°C y 90 + % humedad relativa, las etapas inmaduras de Atrichopogon wirthi Chan y Linley (Diptera: Ceratopogonidae). El average de la duración (días) de las etapas individuales fueron, respectivamente: huevo 3.3, 1er estadio 1.7, 2nd estadio 2.0, 3er estadio 2.3, 4to estadio 4.1, y pupa 3.0. El average total de la duración fue de 16.4 días.