GLOWING BEHAVIOR OF LAMPYRID LARVAE

Larry Buschman
Kansas State University
Naturalists have long asked
- Why do larvae glow
- There is much speculation—usually not based on data

In the 1970’s I did some research on the topic

Retired several years ago
- Checked what had been done 40 yrs on Fireflies

Surprisingly, my old data was still relevant
- No one else has published this kind of data

Recent work by Raphael De Cock—recognized
- My work complements this work
My approach has been:

+ To **describe** larval glowing behavior
  - as naturalists have done for hundreds of years
  - The way we figured out about adult flashing behavior

+ A good understanding of glowing behavior
  - should give us an indication of which ideas on function
  - are worth considering/testing further

+ I have tested several suggestions on function
  - I will devalue several suggestions on functions
  - But, don’t expect strong argument for any one function
OUTLINE OF PRESENTATION

I. Introduction
II. Description of periodic glowing
III. Glowing in defensive situations
IV. Glowing in various other situations
V. Conclusions
I. INTRODUCTION

A. Types of larval glowing
B. Types of larvae studied
C. My Working Hypothesis
I. INTRODUCTION

TYPES OF LARVAL GLOWING

A. Continuous faint glowing: eggs & pupae
   + Will not be discussed further

B. Periodic glowing: (spontaneous glowing)
   + Rhythmic glowing—usually while crawling

C. Response glowing: (defensive glowing)
   + Response to stimulus or threat—inactive larvae

D. Continuous bright glowing: crawling larvae
   + Perhaps intermediate stage

E. Dark larvae: active non-glowing larvae
   + Perhaps intermediate stage
I. Introduction
Larvae Studied

Pyractomena limbacalis

Photinus consimilis complex

Pyractomena lucifera

“Red” Photuris

Non-red Photuris
I. INTRODUCTION

WORKING HYPOTHESIS:

PERIODIC GLOWING

- Rhythmic glowing
- Glows that can be measured
- Active crawling larvae
- Favorable weather:
  + wet rainy conditions

RESPONSE GLOWING

- Non-rhythmic glowing
- Glows that can’t be measured
- Inactive sedentary larvae
- Unfavorable weather:
  + Dry conditions

Best seen in Photuris red larvae
1. The same larvae will glow periodically when it is wet but several days later they will glow responsively when it is dry. There appears to be a physiological change in the larvae that also shows up in the glowing behavior and activity.

2. There appears to be a time of transition (days) where some larvae are glowing periodically and some are glowing responsively.

3. Continuous bright glowing larvae or Active Non-glowing larvae may be larvae in transition between Periodic and Response Glowing.
II. DESCRIPTION PERIODIC GLOWING

A. Timing of glowing events
B. Diurnal occurrence of glowing
C. Glowing during different activities
D. Glowing relative to physiological events
**METHODS**

- **Field Observations**
  - Carefully approach to within 2 to 4 ft without disturbing
  - Using tape recorder—record the on and off for each glow
  - Also record notes on what larva is doing
  - Transcribe the notes

- **Laboratory Observations**
  - Initially, larvae did not seem to glow normally in the lab
  - Found that newly collected larvae would glow “normally”
  - Larvae were set up transparent containers for observation
  - Using tape recorder as in field
A. MEASUREMENT OF GLOWING EVENTS: PY. LUCIFERA

B. Pyractomena lucifera—5th instar

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Seconds
A. Measurement of *Py. Lucifera* glowing events:

### Glow Duration

- **Field-All Larvae**: 43 larvae, 463 glows
- **Field-Small Larvae**: 6 larvae, 97 glows
- **Lab-All Larvae**: 16 larvae, 670 glows
- **Lab-Small Larvae**: 3 larvae, 62 glows

### Glow Interval

- **Field-All Larvae**: 43 larvae, 463 glows
- **Field-Small Larvae**: 6 larvae, 97 glows
- **Lab-All Larvae**: 16 larvae, 670 glows
- **Lab-Small Larvae**: 3 larvae, 62 glows
<table>
<thead>
<tr>
<th>Firefly</th>
<th>Duration sec</th>
<th>SD</th>
<th>Interval sec</th>
<th>SD</th>
<th>% Time glowing</th>
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<tr>
<td>Field</td>
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<td>Large</td>
<td>2.4</td>
<td>1.7</td>
<td>3.6</td>
<td>2.3</td>
<td>40%</td>
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<tr>
<td>Small</td>
<td>1.9</td>
<td>1.1</td>
<td>2.7</td>
<td>1.9</td>
<td>41%</td>
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<tr>
<td>Lab.</td>
<td></td>
<td></td>
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<tr>
<td>Large</td>
<td>1.1</td>
<td>0.9</td>
<td>2.7</td>
<td>1.8</td>
<td>30%</td>
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<tr>
<td>Small</td>
<td>1.5</td>
<td>0.6</td>
<td>2.7</td>
<td>1.6</td>
<td>36%</td>
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</table>
## Summary for Glowing of 5 Different Kinds of Larvae

<table>
<thead>
<tr>
<th>Firefly</th>
<th>Larvae/glows</th>
<th>Duration sec</th>
<th>SD</th>
<th>Interval sec</th>
<th>SD</th>
<th>% Time glowing</th>
</tr>
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<tbody>
<tr>
<td><em>Py. lucifera</em></td>
<td>43/468</td>
<td>2.4</td>
<td>1.7</td>
<td>3.6</td>
<td>2.3</td>
<td>40%</td>
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<tr>
<td><em>Py. limbacalis</em></td>
<td>3/24</td>
<td>4.1</td>
<td>2.2</td>
<td>4.3</td>
<td>2.4</td>
<td>49%</td>
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<tr>
<td><em>Pn. consimilis</em> lab</td>
<td>5/59</td>
<td>6.5</td>
<td>3.1</td>
<td>6.1</td>
<td>3.9</td>
<td>52%</td>
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<tr>
<td><em>Photuris</em> red</td>
<td>9/103</td>
<td>2.8</td>
<td>1.6</td>
<td>4.7</td>
<td>3.0</td>
<td>37%</td>
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<tr>
<td><em>Photuris</em> non-red</td>
<td>20/245</td>
<td>3.7</td>
<td>2.9</td>
<td>4.4</td>
<td>2.6</td>
<td>46%</td>
</tr>
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</table>
DIURNAL OCCURRENCE OF GLOWING

1. I used to look for larvae after adult activity
2. One day I stayed out later than usual
3. Found more glowing than usual
4. So stayed up to record glowing later in the night
5. Counted glows from a walkway over the marsh
DIURNAL OCCURRENCE OF GLOWING

![Graph showing the diurnal occurrence of glowing with data for 30-Mar, 31-Mar, and 4-Apr.](image)

- **Dusk** is indicated on the graph.

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The graph illustrates the number of glowing occurrences over different hours from 6:00 PM, with data points for three different dates: 30-Mar, 31-Mar, and 4-Apr. The x-axis represents hours from 6:00 PM, ranging from 0 to 14, and the y-axis represents the number of glowing occurrences, ranging from 0 to 200.
a. Larvae glow during locomotion

b. Light organ faces forward during locomotion
c. Light illuminates circle forward to the light organ
d. Rear light could protect eyes

Test: Glowing should increase when they come to obstacle
GLOWING DURING DIFFERENT ACTIVITIES

% of Glows
During Different Activities

Grows per 100 sec
During Different Activities

- P. lucifera
  14 larvae, 662 glows
- P. limbicollis
  9 larvae, 86 glows
- Photinus
  5 larvae, 50 glows
- Photuris
  11 larvae, 149 glows

Activities

Crawl  Search  Groom  Still

Percents Of Glows

- P. lucifera
  14 larvae, 103.5 min
- P. limbicollis
  9 larvae, 45.8 min
- Photinus
  5 larvae, 33.8 min
- Photuris
  11 larvae, 52.9 min
Field Observations:

Compare responses-- larvae glowing periodically vrs. larvae glowing responsively

Record responses to escalating threat

Slight disturbance----
Pick up in hand--------
Release-----------------

Record: glow vrs. dark—flee vrs. freeze
III. GLOWING IN DEFENSIVE SITUATIONS

Red *Photuris*

<table>
<thead>
<tr>
<th>Stimulus/reaction</th>
<th>Periodic</th>
<th>Continuous</th>
<th>$X^2$</th>
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<tr>
<td>Disturbed</td>
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<td></td>
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<tr>
<td>glow/dark</td>
<td>9/12</td>
<td>23/7</td>
<td>0.0008</td>
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<tr>
<td>flee/freeze</td>
<td>2/28</td>
<td>5/25</td>
<td>NS</td>
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<tr>
<td>Hand</td>
<td></td>
<td></td>
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<tr>
<td>glow/dark</td>
<td>16/11</td>
<td>16/5</td>
<td>NS</td>
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<tr>
<td>Release</td>
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<tr>
<td>glow/dark</td>
<td>11/16</td>
<td>15/6</td>
<td>NS</td>
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<tr>
<td>flee/freeze</td>
<td>17/10</td>
<td>17/4</td>
<td>NS</td>
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</table>
### III. GLowing IN DEFENSIVE SITUATIONS

**X^2 values**

<table>
<thead>
<tr>
<th>Stimulus/reaction</th>
<th>Py. lucifera</th>
<th>Red Photuris</th>
<th>Non-Red Photuris</th>
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<tr>
<td>Disturbed</td>
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<tr>
<td>glow/dark</td>
<td>NS</td>
<td>0.0008</td>
<td>0.0021</td>
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<tr>
<td>flee/freeze</td>
<td>NS</td>
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<td>NS</td>
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<td>flee/freeze</td>
<td>NS</td>
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<td>NS</td>
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</table>
Does glowing/activity change over time or with physiological changes?

IV. GLOWING OVER TIME

a. Time in captivity

b. Feeding status

c. Pupation
IV. GLOWING OVER TIME

- Methods—laboratory observations
  - Larvae were set up in see-through containers
  - Larvae were field collected
    - One group 11 days in captivity
    - Another group 1 day in captivity
  - Observed them indirectly red light
  - Recorded glowing and crawling activity
    - Scan of all containers (5-10 sec per group of 5 containers)
    - 5 times each 30 min = total 20 observations
Glowing by Py. lucifera Larvae

Collected 27 March

4 Fed Larvae  5 Unfed Larvae

Collected 8 April

5 Fed Larvae  5 Unfed Larvae
Activity by *Py. lucifera* Larvae

Collected 27 March

- 4 Fed Larvae
- 5 Unfed Larvae

Collected 8 April

- 5 Fed Larvae
- 5 Unfed Larvae
### IV GLOWING OVER TIME

<table>
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<tr>
<th>Species/Collection</th>
<th>Glowing</th>
<th>Crawling</th>
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<tr>
<td><strong>Py. lucifera</strong></td>
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<tr>
<td>11 days captive</td>
<td>0.2</td>
<td>2.9</td>
</tr>
<tr>
<td>1 day captive</td>
<td>12.9</td>
<td>7.0</td>
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<tr>
<td><strong>Pn. consimilis</strong></td>
<td></td>
<td></td>
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<tr>
<td>11 days captive</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>1 day captive</td>
<td>3.9</td>
<td>2.7</td>
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<tr>
<td><strong>Pr. Non-red</strong></td>
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<tr>
<td>11 days captive</td>
<td>3.3</td>
<td>0.2</td>
</tr>
<tr>
<td>1 day captive</td>
<td>0.03</td>
<td>5.5</td>
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</table>
Effect of Approaching Pupation on Glowing and Activity

11 Py. lucifera Larvae

1 Photinus larva

-5 -4 -3 -2 -1 PP 1 P

April Date

Glows Activity

Active Observations

April Date

Glows Activity
Effect of Approaching Pupation on Glowing and Activity

3 Photuris Larvae

Active Observations

April Date

Golds

Activity

Py. lucifera
V. GLOWING IN OTHER SITUATIONS

Glowing during predation/feeding

Larvae under water

Glowing during other interactions-competitors
GLOWING DURING PREDATION

- Larvae collected while feeding
  - Some glowing while feeding
  - Usually associated with dragging prey
- Larvae collected at feeding stations
  - Some glowing while larvae approach
  - Little glowing while feeding
- Observations in the laboratory
  - Similar to above
- *Photuris* attacking live caterpillars
  - Some glowing during wrestling

- Glowing seems incidental during predation/feeding
Py. lucifera would crawl under water
- They would glow continuously while under water
- They would glow periodically while dragging up a snail

Both Py. lucifera and Pn. consimilis
- When I was wading in marsh—my steps would pull vegetation into the water
- Larvae on that vegetation would glow continuously
- Pn. consimilis would float, Py. lucifera would not
GLOWING DURING INTERACTIONS WITH OTHER ARTHROPODS

- Other insects at feeding stations
  - Ants (large-small), spiders, daddy longlegs (Harvestman), others

- Watched a *Photuris* larva join a kill site that was covered with ants. They crawled over him but did not attack. **Little glowing.**

- Watched a *Photuris* larva pull a caterpillar away from a daddy longlegs. **Little glowing.**
VI. CONCLUSIONS

1. Periodic glowing associated with favorable wet conditions
2. Response glowing associated with unfavorable dry conditions

3. Periodic glowing associated with locomotion
   1. But locomotion not always associated with periodic glowing

4. Glowing changes with physiological changes.

5. Larvae respond differently to threat depending
   1. Periodic glowing larvae or
   2. Response glowing larvae.

6. Periodic glowing does not seem to be associated with:
   1. Illumination
   2. Predation
   3. Competition