Behavioral and Morphological Observations

of *Ignelater luminosus in Dominica*

Nadia Reyes and Vanessa Lee

Texas A&M University

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Dr. Lacher

Dr. Heyman

Abstract:

Ignelater luminosus is one of the few species of insects that exhibit bioluminescence on the island of Dominica. Several methods were used to attract the male *I. luminosus* including the use of faux females and real females. Observations were conducted at the Archbold Tropical Research and Education Center, Springfield Dominica in the proximity of Bee House and the surrounding foliage and the Check Hall River. Visual observations were conducted each evening for approximately one hour after sunset from 25 May – 8 June 2010 for a total 15.5 hours over the course of 11 nights. In addition, behaviors were filmed using videography to document behaviors. We present the results of our observations including the numbers of *I. luminosus* observed each night.

Introduction:

Understanding bioluminescent insects is essential not only scientific research, but also for biotechnological and environmental purposes. For example, due to their sensitivity, fireflies act as environmental indicators for excessive artificial light. Their light can also aid in the recovery of degraded water ways by detecting microbiological pollution in water bodies and industrial products. Vadim Viviani, a post graduate professor at the Sao Paulo State University, and his group of researchers are studying luciferase, which is the enzyme responsible for the emission of light in bioluminescent insects. They plan to develop biotechnological, biomedical, and environmental products to combat disease, including drugs-synthesizing processes and pathogens detection that cause illnesses (Viviani, 2006).

The species *Ignelater luminosus* is a bioluminescent beetle in the family Elateridae found in Dominica. The most distinctive characteristic of this unique beetle is that both the male and

female have two light producing organs that are situated on each side of the pronotum. *I. luminosus* use its bioluminescence during flight and also when the insect is disturbed at rest (Stiling, 1986). A few studies, including the studies done by Edith Kretch (2000) and Michael Kerekgyarto (2002) from Texas A&M University, indicate that this light is also used in courtship.

Edith Kretch describes how the *I. luminosus* exhibits sexual dimorphism in antennal length, size of dorsal light spots, overall size. Male antennae are elongate and surpass the hind angles of the pronotum. The females tend to be larger in size with larger and more convex pronotal lights. The most prominent difference between males and females, however, is that males have a ventral light located on the base of the first abdominal sternite and faces the posterior face of the metasternum under the hind coxae. She also mentions that the ventral light is used to search for the female and can only be seen when the abdomen is lifted in a certain way.

The previous studies conducted focused on only the courtship behavior on *I. luminosus.* Kretch (2000) found that the males keep their pronotal lights turned on until a female is found. Once they find a female, the males turn on their ventral light and fly in circles around the female. Kerekgyarto (2002) found that light intensity did not play a significant role in male preference for a mating partner. In this study, not only courtship behavior will be evaluated, but also if weather, humidity, and lunar phase affect the *I. luminosus* density. The objectives of this study are to 1) observe any possible flight pattern in the male in the presence of a faux female or real female, 2) film these behaviors using light gathering video, 3) observe density changes that may be related to the weather or lunar phases, 4) and conduct morphological observations in the lab to evaluate the morphology of the male ventral light. Our hypotheses are that males have a specific flight pattern when approaching females and cool weather and moonlight will decrease density.

Materials and Methods:

Field Methods and Collection

We typically conducted our observations from 1900 to 2000. Our first night of observations was on the 26 of May at Check Hall River where we had negligible observations and on the 27 of May at Bee House in which we observed several *I. luminosus* in order to gain a perspective of their uninfluenced behavior. We also made some observations with weather and lunar influences. We captured females to use as bait using simple hand capture and also collected several males using nets and faux females in order to compare morphology and study their anatomy closer.

On May 29, 2010 we went up to a more secluded, vegetated area west of Bee House to observe how the males approached the faux female. The faux female was generated using a Light Emitting Diode created by an electrician at Mid-State Electronics in Bryan, Texas (Figure 1). On May 30, 2010 we went up to the same area to acquire some female *I. luminosus* and successfully caught 2 males with the use of an aerial insect net. On June 3, 2010 we took a Canon XL 5.5-88mm IS F 1.6-2.6 video camera to film the courtship behavior of the male on either a real female or faux female. From June 4, 2010 through June 8, 2010, we used a Sony TRV 900 3-CCD video camera mounted on a Slik Insta-Lok 500G-FL tripod to attempt to film the courtship behavior of the male. Along with the courtship behavior observations, we recorded the number of *I. luminosus* that appeared each night. The Sony camera is rated as 0 lux, for its ability to capture images in very low light.

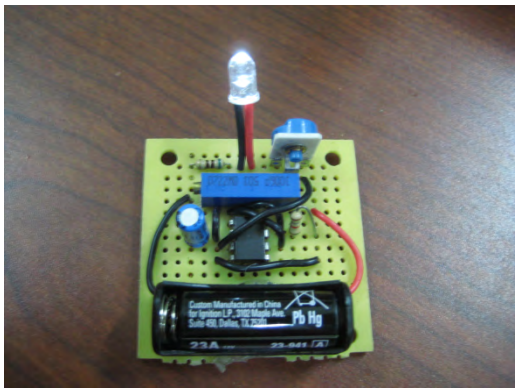

Figure 1: This LED was used as the faux female. It has the ability to alter frequency of blinking and light intensity.

Laboratory Methods

We fumigated one male *I. luminosus* in a kill jar using ethyl acetate in order to dissect and better examine the morphology of their ventral light system. To do so, we used a Leica EZ 4 Dissecting Microscope and Bioquip soft-tip forceps. We used a Cannon Power Shot SD750 to take photographs for clarification.

Results:

Field Observations

We observed *I. luminosus* on 11 nights for a total of 15.5 hours from 1900 to 2000 (Table 1). We observed three types of male flight patterns and three typical height approaches in response to females (Diagram2 and 3). Flight patter 1 was typically observed during the first pass and was usually 5 feet or higher off the ground. Flight pattern 2 was seen during either the first or second pass and was at approximately 3 to 4 feet from the ground. Pattern 3 was observed during final approaches and was closest to the ground and female, usually at about 1 to 2 feet from the ground.

Date/Time	Location	Moon Phase	Weather	# of *I. luminosus* observed
May 26, 2010 10:00pm-10:30pm	Check Hall River	FM-1	83°F; 77% humidity/mostly cloudy	0
May 27, 2010 7:00pm-8:30pm	Bee House	Full Moon	82.4°F; 79% humidity/mostly cloudy	8
May 29, 2010 7:00pm-8:30pm	Area west of Bee House	FM+2	82.4°F; 79% humidity/ mostly cloudy	4-5
May 30, 2010 6:45pm-8:30pm	Area west of Bee House	FM + 3	77°F; 84% humidity/ partly cloudy	13-17
June 1, 2010 7:00pm-8:30pm	Area west of Bee House	FM +5	79°F; 79% humidity/ scattered clouds	7-10
June 2, 2010 7:30pm-8:15:pm	Area west of Bee House	FM + 6	83°F; 86% humidity/overcast (Showers occurred about an hour earlier)	3-4
June 3, 2010 7:00pm-8:30pm	Area west of Bee House	FM + 7	81.6°F; 80% humidity/mostly cloudy	8
June 4, 2010 6:45pm-8:30pm	Area west of Bee House	FM + 8	83°F;79% humidity/mostly cloudy	5
June 6, 2010 7:00pm-8:30pm	Area west of Bee House	FM + 10	85°F;80% humidity/mostly cloudy	3
June 7, 2010 7:00pm-8:30pm	Check Hall River	FM +11	83°F; 80% humidity/mostly cloudy	2-4
June 8, 2010 7:00pm-7:45pm	Check Hall River	FM +12	76°F Showers occurred around 7:30pm	3-4

Table 1: The location, moon phase, and weather were recorded to observe how they affect the number of *I. luminosus*.

We noted that while males will approach singularly, they will also approach and investigate in groups. When the males approached in groups, they tended to remain a fair distance apart and distribute themselves in the proximity of the female (Diagram 1). The males would approach the female using flight patterns 2 or 3 either singularly or in groups of two.

Laboratory Observations

Male and female *I. luminosus* were closely examined in order to observe their morphologies (Figure 2, 3 and Diagram 1).

Figure 2: Male *I. luminosus*

Figure 3: Female *I. luminosus*

We found many consistencies with Edith Kretch's observations of *I. luminosus* morphologies. In addition to her description we observed that males tended to be lighter in color and are more pubescent. The hairy texture, when rubbed off from handling, could be removed to reveal the same coloration as the female. We also discovered that there is a significantly larger gap between the thorax and the abdomen when compared to the females. We believe this larger gap allows the male to better bend its abdomen backwards and expose his ventral light.

When examining the male *I. luminosus,* we found that the ventral light was surprisingly small considering how bright it is when turned on and compared to the larger dorsal lights (Figure 4 and Diagram 5).

Figure 4: A pinned male *I. luminosus* with the ventral light exposed in the gap between the thorax and abdomen

Discussion:

Field Observations

We observed *I. luminosus* using its ventral light to locate and view potential female mates and to seemingly navigate in dense foliage. We have observed it being used to investigate objects from distances of approximately 8 to 13 inches. While we observed our females for extended periods of time we did not observe any fading of their dorsal lights. Their lights remained on the entire time and at no point did they turn them off. This may be because they were not seeking mates or because they were stressed due to their confinement in 15 ml and 25 ml glass vials.

We confirmed Kretch's observation that males tend to travel in small groups of 3 to 5 individuals. We would go with extended periods of time with no activity and then 3 to 5 would suddenly arrive within a minute of each other. They would be in the surrounding foliage and would approach in one and two at a time to investigate the female and faux female.

We found that males would approach both the faux female, which was blinking at about a 1.5 sec interval, and the real captive females, which did not blink. We believe that pattern 1 is used as an investigative pass and patterns 2 and 3 are used to further investigate and 3 is especially used in preparation for the male to use its ventral light and/or land (Diagram 2).

Based on our observations and counts of males, as a function of lunar phase and rainfall (Table 1), we believe that *I. luminosus* populations and behavior are affected by rainfall and possibly by lunar phases. We hypothesize that the lack of heavy rainfall has reduced the number of *I. luminosus* that are looking for mates. Low amounts of rainfall could have affected our results in that seasonal change could be essential to mating behavior and lifecycle. For instance, females may not be willing to mate due to the dry, cooler climate not being suitable for potential offspring or that they have yet to reach sexual maturity due to season. Lunar phases appeared to affect the overall numbers we observed in that our numbers were steadily reducing the more the moon waxed. However, the length of this study is not sufficient to draw substantiated conclusions.

The use of videography was attempted for 5 nights from June 3-8. We had limited success using the equipment either a Canon XL 5.5-88mm IS F 1.6-2.6 video camera and a Sony TRD 900 3-CCD video camera mounted on a tripod. Both cameras were unable to film *I. luminosus* behavior due to the short distance they had to be to the female in order to film. These

cameras were limited to approximately 1.5 to 2.0 feet from the female because of lighting issues. This close proximity did not allow for wide shots of the surrounding aerial environment and therefore missed their behaviors. We were unable to add artificial light as it would interfere with our results. We also noted that the lights emitted from the cameras themselves may have deterred the males from approaching as there were 3 lights, the camera's red recording light, the light from the camera's eye piece, and the female all in close proximity. All data collected using our equipment and set up were unproductive.

Potential sources of error include human error in counting numbers of *I. luminosus*. This is because *I. luminosus* are hard to distinguish in the dark based on the fact that the species *Aspidosoma ignitum* (a firefly from the family Lampyridae) is also found in high numbers in the same locations during the same time. They are often confused in the dark because of their similar bioluminescent color and flight patterns. We found the only way to differentiate between them for sure was to get close enough to see the *I. luminosus'* two dorsal lights as the Lampyridae only has one low abdominal light. Another source of error could be from double counting individual *I. luminosus*. June 6 and 7 we observed two locations at once that were in close proximity. However, we were careful to communicate to each other whether individual males were headed in either of our directions and were to not count those individuals twice. Due to *I. luminosus* behavior of traveling in groups and intertwining flight patterns we might have been a bit high in some of our counts.

An explanation for lower numbers could be that the *I. luminosus* move higher or lower in altitude in accordance with season, weather, or pressure. This hypothesis will require further testing to evaluate. Further projects seeking to document their behaviors should look into

alternatives for filming and lighting. The exploration of infrared lights and thermal imaging camera gear could hold more promise than using conventional video cameras.

Laboratory Observations

We discovered through the dissection of our male that the ventral light is located in the grove between the thorax and the abdomen (Diagram 5). It is only visible when the beetle bends its abdomen backwards towards the head. We believe this behavior is only possible during flight because its abdomen movement in the upward direction is limited by its tough forewings. The ventral light is larger than the two smaller dorsal lights located on either side of the thorax and is roughly diamond shaped. We hypothesize that when the male is luminescing it can and most likely always luminesces all three lights at once but the ventral is only visible when the male lifts and separates its abdomen from its thorax. The ventral light being protected with the abdomen could explain the bright, yet small ventral light as compared to the two dorsal lights with comparable light emitting capability. We believe that the ventral light does not need a thick covering to protect it where the dorsal lights are exposed and require a thicker layer for protection.

Overall, we 1) did observe specific flight patterns in the male a female, 2) we were unsuccessful in filming these behaviors with our recording equipment, 3) recorded density changes that seem to correlate, however inconclusively, with weather or lunar phases, 4) and observations in the lab has allowed us to update the morphology and function of the male ventral light.

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