



**Black Soldier Fly Larvae**  
**Composting at WMU**  
*Phase 2: Breeding*

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## **ABSTRACT**

Black Soldier Fly Larvae (BSFL) demonstrated in phase I experiments their capacity to reduce solid waste at 20:1 ratios; displaying strong potential for large-scale solid waste reduction at commercial entities and businesses. To have an efficient system, with continual cycles of waste reduction year-round, the larvae must be self-renewing. This encompasses creating and maintaining environmental conditions in which adult black soldier flies can breed and oviposit. That said, adult fly conditions are primarily ambient, whereas the conditions for optimal larvae waste consumption relied on internal compost conditions. Phase II comprises of monitoring ambient and internal temperature, relative humidity (RH), and light to determine optimal conditions for breeding, oviposition, and egg eclosion.

## METHODOLOGY

All research took place in a 12' X 24' south-facing controlled climate research room at Western Michigan University's (WMU) Finch Greenhouse (FGH) inside a screened breeding structure. Within the breeding structure stood a Protapod<sup>TM</sup>, a house-made DIY Bin, two leachate collection buckets, two pupae collection buckets, two house plants and seven burlap sacks. Food for the BSFL was sourced through WMU's Bistro3 Cafeteria. HOBO<sup>®</sup> Data Loggers were used to collect temperature, relative humidity and light measurements.

### Breeding Structure

Setup began by designing and constructing a 16'X 6'X 7' screened structure to isolate the flies. Please reference Appendix III, Section 1 for a detailed materials list created to build the structure. The structure stood in a controlled climate room at WMU's FGH. The room heated at 80°F and vented at 84°F. The humidity maintained by soaking seven burlap sacks three times per week. Four burlap sacks covered the floor and three hung from the top of the screened structure.

### BSFL Feedstock

Post-consumer food waste was sourced through WMU's Bistro3 Cafeteria as a feedstock for the BSFL. This cafeteria was chosen because it is currently the only cafeteria on main campus that has a food pulper. A food waste pulper increases efficiency of food waste collection, decreases contaminants and creates a consistent texture that is easily processed by the BSFL<sup>1</sup>.

### Food Waste Pick-up

When a student in Bistro3 cafeteria returns a plate, the dishwasher scrapes the organic waste into a running water stream. The water stream pushes the organic material into a food waste pulper, which spits pulped organic waste into a 10-gal collection bucket<sup>2</sup>.

Two full 10-gal buckets were collected three times a week to feed the larvae. This amount of waste was much larger than the actual amount needed to feed the larvae. However, since this was the first time collecting food waste from Bistro3 cafeteria, we created a safety food stock for the BSFL to avoid any interruption in the feeding cycle. All excess food waste was dumped at the Gibbs House Permaculture Research and Demonstration Site's static compost pile.

### BSF Lifecycle

To begin the BSF lifecycle, 80,000 larvae were ordered from Symton Black Soldier Fly Solutions. The order was split in half between each compost bin: ~40,000 larvae to the Protapod<sup>TM</sup> and ~40,000 to the DIY bin. Please reference Phase I: *Black Soldier Fly Larvae Composting at Bell's*

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<sup>1</sup> Please reference Appendix III, Section 2 for a visual representation of the pulper.

<sup>2</sup> Please reference Appendix III, Section 3 for a visual representation of the collection buckets.

*Brewery* for a full description of the BSF lifecycle and compost bins. Please reference Appendix III, Section 4 for a visual representation of the adult breeding cycle.

#### Data Collection

Onset HOBO® Data Loggers were the primary source of data collection. Each logger recorded data every five minutes. Device readouts were conducted every two weeks starting February 29, 2016 and ending May 13, 2016.

##### *HOBO® U12 Temperature/ Relative Humidity/Light/ External Data Logger (U12-012)*

The external logger collected maximum, minimum, and average data on temperature, relative humidity, and light intensity in the breeding structure every five minutes.

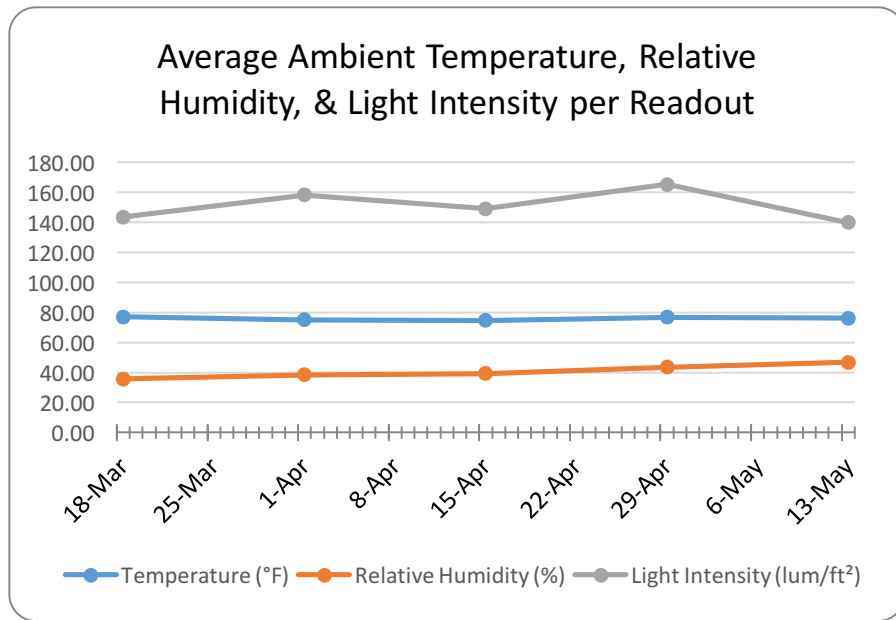
##### *HOBO® Pendant Temperature/ Light Data Logger (UA-002-64)*

The internal logger collected maximum, minimum, and average data on temperature and light intensity within the DIY compost pile every five minutes. Water-proof housing allowed for placement inside compost pile, however did not allow for data collection on relative humidity.

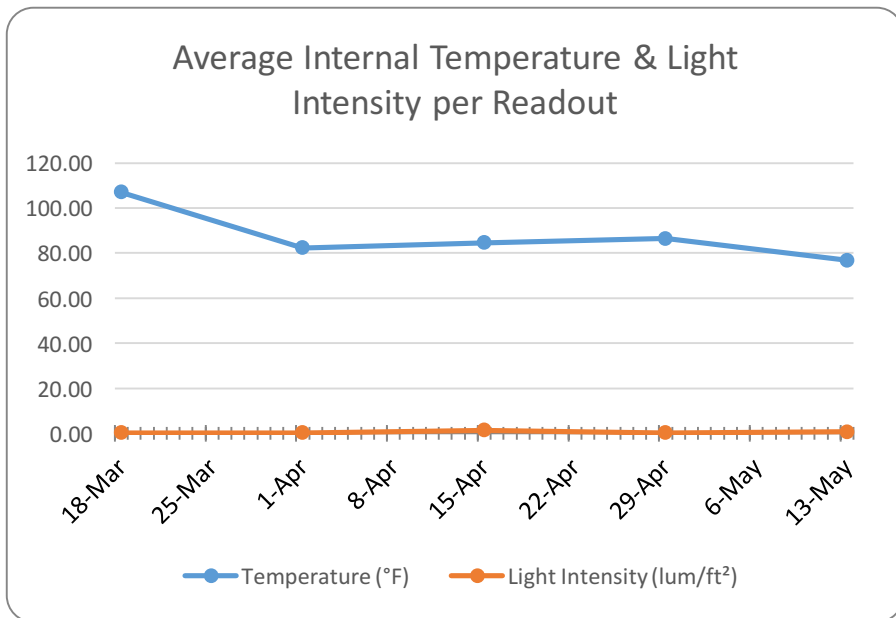
Human observation and notes were used as a secondary source of data. This was to gain more perspective on physical behaviors the data loggers could not record. Three times per week (Monday, Wednesday, and Friday) - when the team was feeding and watering - individual(s) would sit inside the screened structure for approximately 10-30 minutes at a time and take notes on adult fly and larval behaviors.

## **RESULTS & DISCUSSION**

BSF mating and oviposition (laying of eggs) were observed within a small range of conditions that were likely influenced by both temperature, relative humidity, and ambient light intensity.



**Figure 1:** Mean ambient temperature, relative humidity, and light intensity in screened breeding structure per two-week readout.



**Figure 2:** Mean internal compost temperature and light intensity per two-week readout.

Through February 29, 2016 and May 13, 2016 the average ambient temperature inside the breeding structure was 75.94 ° F; ambient relative humidity: 40.46%; and an ambient light intensity: 150.72 lum/ft<sup>2</sup>. The average internal temperature inside the DIY compost bin was 88.55 ° F; average internal light intensity was 0.52 lum/ft<sup>2</sup>. Mating and oviposition was observed during the peak of the day (10:00-14:00) at ambient temperature ranges between 87.1° F and 70.63° F and at an ambient relative humidity between 60.4% and 33.2%. Egg eclosion, or the emergence of an adult insect from its pupal casing, was not physically observed; however, was likely successful at all temperatures due to the increased adult population inside the screened structure.

<b>Readout date</b>	<b>Avg. Ambient Temperature (° F)</b>	<b>Avg. Ambient Relative Humidity (%)</b>	<b>Avg. Ambient Light Intensity (lum/ft<sup>2</sup>)</b>
160318	79.13	41.77	24.00
160401	72.33	39.50	29.50
160415	76.84	34.79	315.00
160429	79.18	29.98	364.50
160513	75.12	48.86	83.40
	<b>76.52</b>	<b>38.98</b>	<b>163.28</b>

Based on the above results, a temperature range between 87.1° F and 70.63° F with a relative humidity range between 60.4% and 33.2% and direct sunlight is recommended for a BSF breeding structure.

## **LIMITATIONS OF ANALYSIS AND PROPOSED FUTURE WORK**

Though the controlled climate in FGH was a benefit, it also had its drawbacks. Each time air vents opened to maintain room temperature, the relative humidity would drop 15%. In addition, the ambient temperatures required to breed adult BSFs negatively impacted the internal compost pile temperature.

Moving forward, we recommend utilizing fog nozzles to maintain relative humidity rather than regularly soaking burlap sacks. We also recommend utilizing a camera, or some type of device to monitor and observe fly behavior. We do not recommend using pulped food waste due to its thick consistency. In the beginning pulped waste seemingly aided in the processing by BSFL. We now believe that the thick consistency of the organic waste contributed to anaerobic conditions and house fly populations. This is because of the increased moisture levels per volume of food waste.

The system will move back to the Gibbs House Permaculture Research and Demonstration Site in May 2016 for continued breeding and observations to refine existing practices and understanding of variables influencing the BSF life cycle and composting effectiveness. In addition, the project will continue to test theories to confirm whether existing practices and recommendations are valid.

In view of the future, we would like to integrate the BSFL Composting system with other projects at WMU's Office for Sustainability, such as Aquaponics.



## REFERENCES

- 1     Leist, A. (2015) Black Soldier Fly Larvae Composting at Bell's Brewery.
- 2     Lord, W. D., Goff, M. L., and Adkins, T.R., "The Black Soldier Fly *Hermetia Illucens* (Diptera: Stratiomyidae) As a Potential Measure of Human Post-mortem Interval: Observations and Case Histories," *Journal of Forensic Sciences*, JFSCA, Vol. 39, No. 1, January 1994, pp. 215-222.
- 3     Tomberlin, J. K., & Sheppard, D. C., "Factors Influencing Mating and Oviposition of Black Soldier Flies (Diptera: Stratiomyidae) in a Colony," *Journal of Entomological Science*, Vol. 37, No. 4, October 2002, pp. 345-352

## APPENDICES

### APPENDIX I:

#### Contact List of Group Participants

Contact	Email	Phone
Dusenbury, Kate	kate.e.dusenbury@wmich.edu	(248) 943-4427
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### APPENDIX II:

#### External Contact List

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## **APPENDIX III:**

### **Image Archives**

#### **1) Breeding Structure**

##### **a. Materials list for screened structure**

Quantity	Item Description
(25)	8' 2x4 untreated lumber
(3)	12' 2X4 untreated lumber
(25)	8' furring strips
(~175)	2" screws
(~172)	3" screws
(1)	94' X 4' standard window screen

##### **b. View inside breeding structure**



## **2) Food waste pulper at WMU's Bistro3 Cafeteria**



## **3) Food waste collection bucket**

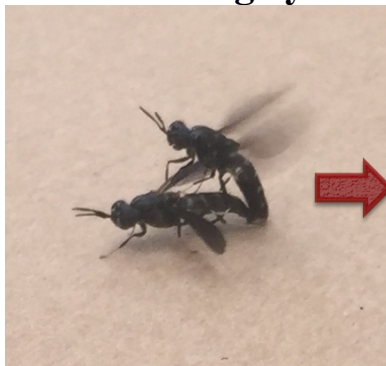
**a. 10-gal Rubbermaid Brute**



**b. Lid**



**4) BSF breeding cycle**



Aerial Questing



En Copula



Oviposit