The use of BSF (Black Soldier Fly) maggot in mini biopond as a solution for organic waste management on a household scale

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Abstract. Domestic waste which has a high protein content has the potential to be bio-converted using Hermetia illucens larvae which has 45-50% protein nutrition and 24-30% fat. So that it can be used as a source of high nutritious feed for fish, chickens and other livestock. This research studied H. illucens larvae, known as Black Soldier Fly (BSF) through the SiMalin process, USU's Waste Management System through Urban Farming. The first step as an axus study is done by collecting garbage (vegetables and fruits) in each household in USU's housing. by varying the feed rate of 150, 200, 250 mg / larva / day. The study was conducted for 21 day by analysing larvae weight, consuming the substrate and trying to feed fresh wet larvae to fish and chickens. The results of this study indicate that the waste is the most optimal way to produce larvae in this process is a mixture of fruit peels with a feed rate of 250 mg/larva/day or a total weight of 25.00 grams per feeding. BSF is an alternative to utilizing waste that is appropriate and environmentally friendly.

1. Introduction

The waste that is around us is dominated by organic waste or which decomposes quickly. These rubbish include food waste or food waste. This waste is organic waste that is disposed of from various sources such as food processing plants, canteens, commercial kitchens and domestic kitchens which we usually call household waste. The types of household waste produced include rice, leftover vegetables and fruit, nuts, kitchen spices and so on [1].

There have been many ways of processing waste, one of which is by using the waste to become a protein source for feed ingredients through a bioconversion process. As said [2] stated that in this process organic waste will be converted into simple compounds, both protein and fat, through a fermentation process that utilizes living organisms. This bioconversion process can be carried out by certain insects, one of which is the Black Soldier Fly (Hermetia illucens) have cellulotic activity in the presence of bacteria in their intestines [3]. The presence of bacteria in the larvae’s intestines helps the larvae convert organic waste in their intestines.
Based on research [4], black soldier fly larvae (*H. illucens*) contain a number of nutrients including 45- 50% protein and 24-30% fat. This is also in line with research [5] where the larvae of *H. illucens* contained 42.1% raw protein, 34.8% lipids, 14.6% ash, 7.9% moisture, 7.0% fiber, 5% calcium, 1.5% phosphorus and 1.4% nitrogen (NFE) and contains Omega-3. Therefore, the Black Soldier Fly larvae have started to be used as an ingredient in fish and poultry feed because they have a high protein content.

Organic waste that comes from canteens and housing in USU’s environment can be managed into compost, liquid fertilizer or biogas which is useful and economically valuable. The use of Black Soldier Flies (BSF) fly larvae has been widely used to speed up the composting process. In addition, the grown larvae can be used for chicken or fish feed. Adult flies lay their eggs near organic waste vegetables, fruit and food scraps/feces, and will die after that. Adult BSF flies (*H. illucens*) only consume water and are not harmful to humans because they do not sting and do not carry disease (vectors).

As one of the campuses that is dedicated as a Green Campus and is actively involved in the UI Greenmetric World University Ranking, there is a great need for a good waste management system within the USU campus. Properly managed organic waste will be able to produce products of economic value such as fertilizer, animal feed and biogas [6,7].

2. Materials and methods

Materials consisted of BSF larvae, vegetable waste, fruit waste, egg shells, leftover rice, and tea bags, trays, plastic gloves, rulers, stationery, cameras, hand sprayers, dry leaf calipers, net cages, wood. The raw materials needed are collected from household waste around the USU Campus (Case Study: Jalan Tri Dharma Kampus USU, Medan). Each household will collect as much as 250gr of household waste (remaining vegetables, fruits, rice, egg shells, tea bags). The collected household waste is placed in 1 mini biopond measuring 50x32x17 cm, starting with the placement of 25gr baby BSF in a 3 day old biopond then the larvae are fed using household waste as much as 250 grams per day until the age of 4 weeks.

To maintain adult flies which will lay eggs and produce larvae, 2 net cages are needed. One cage can hold 1.5 kg of pupae will fly. Furthermore, the necessary hatchery space/box is prepared to hatch the eggs into prepupa. Larvae are left for 7 days in the hatchery that is not exposed to sunlight. Then BSF, *H. illucens* was put into biopond which was 3 x 1 meter in size which was made 3 levels. At the lowest level is for rearing larvae for breeding purposes into new flies. While at level 2 and 3 to break down waste. Larvae break down waste up to 4 weeks of age. Then most of the larvae are harvested for fish/livestock feed and the decomposed waste can be dried and packaged into compost, while 20% of the larval population was moved to the bottom shelf to be raised as adults. From the results of decomposition of the waste, leachate is produced which is then collected in a vat for further fermentation into liquid fertilizer. In 1 of biopond used for BSF, it can produce 2.25 kg of BSF prepupa as fish feed. Since this process consumes 250g of waste per day, it is assumed that BSF can help decompose household waste every day.

3. Results and discussion

3.1. Description of rearing BSF

Maggots of *H. illucens* larvae can grow and develop on nutritious media according to their daily needs such as described into Figure 1. This research began with the preparation of the medium for hatching eggs of *H. illucens*. The media is a mixture of vegetables (carrots, long beans, mustard greens, cabbage). The eggs obtained from PJ Akar Rimba Kisaran, Medan were placed on a biopond tray media that had been prepared on a paper mat. The eggs hatch within 2-3 days. The larvae that appeared were cultivated for 6 days in the medium before being harvested. The 6 day old larvae are then used as bioconversion agents for organic domestic waste. During the larval cultivation process, the media for the material to be converted or the larva's feed substrate are also prepared. The media is in the form of domestic waste which consists of waste from rice, vegetables such as carrots, potatoes, shallots, mustard greens, kale,
cassava leaves compared to fruits of the types of oranges, mangoes, bananas, papayas, apples, and guavas (1:1). Larva obtained by 6 days of age given daily feed treatment using waste feed media that has been prepared for 21 days of maintenance. The treatment given to each feed medium was a variation of the feed rate of 150, 200, 250 mg larva/day with each treatment carried out 3 times. At the lowest level is for rearing larvae for breeding purposes into new flies. While at level 2 and 3 to break down waste. Larvae break down waste up to 4 weeks of age.

Figure 1. Procedure rearing BSF (*H. illuscens*) consist of (a) 25gr baby BSF; (b) Tray and biopond; (c) Rearing BSF with given vegetables and fruits wastes; (d) Urban farming; (e) Bioconversion; (f) hidropnic; (g) Fish pond; (h) Chicken feeding (Composter Building USU, 2020)

Maggot cultivation can be done in a degradation manner using organic materials and based on household and industrial waste [8]. Thus, maggot cultivation as a form of waste degradation has an
opportunity in bioconversion waste processing where BSF larvae consume and degrade organic matter up to 70% [9]. In addition, the use of H. illucen larvae has been shown to eliminate Salmonella bacteria. These flies are very easy to breed and easy to find around the house. The success of breeding this H. illucen fly is determined by the growing medium. When the fly reproduction process occurs, this type of fly will like a typical growing medium and special aroma, so that tiger flies live and develop in the media [10]. This fly is very fast growing and easy to grow in organic waste such as poultry manure. When H. illucen flies are ripe, it takes 3-4 days to be used as feed for processing drying and milling to be used as feed material [11].

Table 1a, 1b, and 1c showed the measured of length and width of BSF given food of vegetables waste and fruits waste during twelve days with simultaneously.

Larvae are placed in a uniform tray container and maintained at a temperature of 27-29℃ and a humidity of 58-70%. H. illucens larvae began to pupate on day 21, so the maintenance period was stopped. The larval growth rate is very rapid up to days 10th, where on the 10th to 21th day the increase in larval length tends to be less significant. Larval growth was also observed by adding larval weight. Larval weight measurements were carried out every 3 days at the same time replacement of feed according to treatment. A drastic increase in larval weight increased from day 3 to day 15. Table 1a, 1b, and 1c shows that each type of feed and type of treatment gave a uniform trend. At the stage the larvae have entered the prepupa phase, where the stage when feeding activities are no longer carried out, there is a tendency when in this prepupa phase the weight of the larvae tends to remain or even a little less [4].

Table 1a. Measurement of length and width of larva Black Soldier Fly, L=Length, W=Width

| No | 1 Recorded data 1st observation | 2 Recorded data 2nd observation | 3 Recorded data 3rd observation |
|----|---------------------------------|---------------------------------|---------------------------------|
|    | food of vegetables waste | food of fruits waste | food of vegetables waste | food of fruits waste | food of vegetables waste | food of fruits waste |
|    | L (cm) | W (cm) | L (cm) | W (cm) | L (cm) | W (cm) | L (cm) | W (cm) | L (cm) | W (cm) |
| 1  | 2     | 0.3   | 1     | 0.4   | 2     | 0.5   | 2.1   | 0.6   | 2     | 0.5   | 2.1   | 0.7   |
| 2  | 2.1   | 0.3   | 1.9   | 0.3   | 2     | 0.4   | 2.2   | 0.5   | 1.9   | 0.5   | 2     | 0.6   |
| 3  | 2.1   | 0.4   | 1.8   | 0.2   | 2.1   | 0.5   | 2.2   | 0.6   | 2     | 0.6   | 2.1   | 0.7   |
| 4  | 1.9   | 0.2   | 2     | 0.3   | 1.5   | 0.4   | 1.8   | 0.5   | 2     | 0.5   | 2.1   | 0.6   |
| 5  | 2     | 0.3   | 1.9   | 0.2   | 2     | 0.5   | 1.1   | 0.6   | 2.1   | 0.5   | 2.2   | 0.5   |
| 6  | 1.9   | 0.3   | 1.7   | 0.2   | 1.9   | 0.4   | 2.1   | 0.5   | 2.1   | 0.5   | 2.2   | 0.6   |
| 7  | 1.9   | 0.3   | 1.8   | 0.2   | 1.9   | 0.4   | 2.1   | 0.5   | 1.9   | 0.5   | 2     | 0.7   |
| 8  | 1.8   | 0.2   | 1.9   | 0.3   | 1.9   | 0.5   | 2.1   | 0.5   | 2.2   | 0.6   | 2.3   | 0.7   |
| 9  | 2     | 0.4   | 2     | 0.4   | 2     | 0.4   | 2.1   | 0.5   | 2.1   | 0.5   | 2.2   | 0.6   |
| 10 | 2     | 0.3   | 2.1   | 0.4   | 2.1   | 0.6   | 2.2   | 0.6   | 2     | 0.4   | 2     | 0.5   |
| 11 | 2     | 0.3   | 2     | 0.3   | 1.6   | 0.5   | 1.8   | 0.6   | 1.8   | 0.4   | 1.9   | 0.5   |
| 12 | 1.9   | 0.3   | 2     | 0.3   | 1.9   | 0.4   | 2.1   | 0.5   | 1.8   | 0.5   | 1.9   | 0.6   |
| 13 | 1.5   | 0.2   | 2     | 0.4   | 2     | 0.6   | 2.1   | 0.7   | 1.9   | 0.4   | 2     | 0.5   |
| 14 | 1.8   | 0.3   | 1.9   | 0.3   | 2     | 0.5   | 2.1   | 0.6   | 2     | 0.5   | 2.1   | 0.6   |
| 15 | 1.9   | 0.3   | 2     | 0.4   | 1.8   | 0.5   | 2     | 0.4   | 2.3   | 0.6   | 2.4   | 0.6   |
Table 1b. Measurement of length and width of larvae Black Soldier Fly, L=Length, W=Width (Continue).

| No | 4 Recorded data 4th observation | 5 Recorded data 5th observation | 6 Recorded data 6th observation |
|----|---------------------------------|---------------------------------|--------------------------------|
|    | food of vegetables waste | food of fruits waste | food of vegetables waste | food of fruits waste | food of vegetables waste | food of fruits waste |
|    | L (cm) | W (cm) | L (cm) | W (cm) | L (cm) | W (cm) | L (cm) | W (cm) | L (cm) | W (cm) | L (cm) | W (cm) |
| 1  | 2.1 | 0.6 | 2.2 | 0.7 | 2.2 | 0.7 | 2.3 | 0.8 | 2.3 | 0.7 | 1.9 | 0.6 |
| 2  | 2 | 0.7 | 2.2 | 0.6 | 2.1 | 0.7 | 2.3 | 0.6 | 2.2 | 0.7 | 2 | 0.7 |
| 3  | 2.2 | 0.7 | 2.3 | 0.5 | 2.3 | 0.8 | 2.4 | 0.6 | 2.1 | 0.6 | 1.9 | 0.6 |
| 4  | 2.1 | 0.7 | 1.9 | 0.8 | 2.4 | 0.8 | 2.1 | 0.8 | 2 | 0.7 | 2.2 | 0.6 |
| 5  | 2.3 | 0.8 | 2.2 | 0.6 | 2.4 | 0.8 | 2.3 | 0.6 | 2.3 | 0.7 | 2.2 | 0.7 |
| 6  | 2.3 | 0.8 | 2 | 0.7 | 2.2 | 0.7 | 2.1 | 0.7 | 2.2 | 0.6 | 2 | 0.6 |
| 7  | 2.1 | 0.7 | 2.1 | 0.6 | 2.4 | 0.7 | 2.2 | 0.7 | 2.1 | 0.7 | 2 | 0.6 |
| 8  | 2.3 | 0.8 | 2.1 | 0.6 | 2.3 | 0.8 | 2.3 | 0.6 | 2.3 | 0.7 | 2.1 | 0.6 |
| 9  | 2.2 | 0.7 | 2.2 | 0.7 | 2.4 | 0.7 | 2.3 | 0.7 | 2.4 | 0.7 | 2 | 0.6 |
| 10 | 2 | 0.6 | 2.3 | 0.8 | 2.2 | 0.6 | 2.4 | 0.8 | 2.3 | 0.6 | 2 | 0.7 |
| 11 | 1.9 | 0.6 | 2 | 0.6 | 2 | 0.6 | 2.2 | 0.6 | 1.9 | 0.6 | 2 | 0.6 |
| 12 | 2 | 0.6 | 2.2 | 0.7 | 2.1 | 0.6 | 2.2 | 0.7 | 1.8 | 0.6 | 1.9 | 0.5 |
| 13 | 1.9 | 0.6 | 2.1 | 0.7 | 2.1 | 0.6 | 2.2 | 0.7 | 1.9 | 0.6 | 2 | 0.6 |
| 14 | 2 | 0.6 | 2.1 | 0.6 | 2.5 | 0.7 | 2.1 | 0.6 | 2 | 0.6 | 2.1 | 0.7 |
| 15 | 2.4 | 0.7 | 2 | 0.6 | 2.5 | 0.7 | 2.1 | 0.6 | 2.1 | 0.7 | 2.1 | 0.7 |

7 Recorded data 7th observation
8 Recorded data 8th observation
9 Recorded data 9th observation

| No | 7 Recorded data 7th observation | 8 Recorded data 8th observation | 9 Recorded data 9th observation |
|----|---------------------------------|---------------------------------|--------------------------------|
|    | food of vegetables waste | food of fruits waste | food of vegetables waste | food of fruits waste | food of vegetables waste | food of fruits waste |
|    | L (cm) | W (cm) | L (cm) | W (cm) | L (cm) | W (cm) | L (cm) | W (cm) |
| 1  | 2.1 | 0.6 | 1.9 | 0.7 | 2.2 | 0.7 | 2 | 0.7 | 2.1 | 0.7 | 2.3 | 0.7 |
| 2  | 2 | 0.6 | 1.9 | 0.6 | 2.1 | 0.6 | 1.9 | 0.6 | 2 | 0.7 | 2.1 | 0.8 |
| 3  | 2.3 | 0.7 | 2 | 0.7 | 2 | 0.6 | 2.1 | 0.7 | 2 | 0.7 | 2 | 0.7 |
| 4  | 2.1 | 0.7 | 2 | 0.6 | 1.8 | 0.6 | 2.2 | 0.8 | 2.2 | 0.8 | 2 | 0.7 |
| 5  | 2.2 | 0.7 | 2 | 0.6 | 2 | 0.7 | 1.8 | 0.6 | 2.1 | 0.6 | 2.1 | 0.8 |
| 6  | 2 | 0.6 | 2.2 | 0.7 | 2.2 | 0.7 | 2.1 | 0.7 | 2 | 0.6 | 2.3 | 0.8 |
| 7  | 1.8 | 0.6 | 2.2 | 0.7 | 2.2 | 0.7 | 2 | 0.7 | 2 | 0.7 | 2 | 0.6 |
| 8  | 2.3 | 0.7 | 2.1 | 0.7 | 2 | 0.6 | 2 | 0.8 | 2.1 | 0.7 | 2 | 0.6 |
| 9  | 2.2 | 0.7 | 1.8 | 0.6 | 2.2 | 0.8 | 2 | 0.7 | 2.3 | 0.8 | 2 | 0.7 |
| 10 | 1.9 | 0.7 | 2.2 | 0.7 | 2 | 0.7 | 2.3 | 0.7 | 2.1 | 0.7 | 2.1 | 0.7 |
| 11 | 2.1 | 0.7 | 2 | 0.7 | 2.4 | 0.8 | 2 | 0.7 | 2 | 0.6 | 2.1 | 0.6 |
| 12 | 2.2 | 0.6 | 1.8 | 0.6 | 2.3 | 0.7 | 1.9 | 0.7 | 2 | 0.6 | 2.2 | 0.7 |
| 13 | 1.8 | 0.6 | 1.8 | 0.6 | 1.9 | 0.7 | 2.1 | 0.7 | 2.2 | 0.7 | 2 | 0.7 |
| 14 | 2 | 0.6 | 2 | 0.7 | 2.3 | 0.8 | 1.9 | 0.6 | 2.1 | 0.6 | 1.9 | 0.7 |
| 15 | 1.9 | 0.6 | 1.9 | 0.6 | 2.1 | 0.7 | 2.1 | 0.6 | 2 | 0.7 | 2 | 0.7 |
Table 1c. Measurement of length and width of larvae Black Soldier Fly, L=Length, W=Width (Continue).

| No | food of vegetables waste | food of fruits waste | L (cm) | W (cm) | L (cm) | W (cm) | L (cm) | W (cm) | L (cm) | W (cm) |
|----|--------------------------|---------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1  | 2                        | 0.6                 | 2.3    | 0.5    | 2.3    | 0.5    | 2.3    | 0.5    | 2.1    | 0.7    |
| 2  | 2.1                      | 0.6                 | 2.3    | 0.8    | 2.4    | 0.6    | 2.1    | 0.6    | 2.1    | 0.6    |
| 3  | 2.1                      | 0.7                 | 2.2    | 0.7    | 2.3    | 0.6    | 2.4    | 0.7    | 2.2    | 0.6    |
| 4  | 2                        | 0.7                 | 2.2    | 0.8    | 2.4    | 0.6    | 2.5    | 0.7    | 2      | 0.7    |
| 5  | 2.2                      | 0.7                 | 2.3    | 0.8    | 2.4    | 0.7    | 2.3    | 0.7    | 2      | 0.7    |
| 6  | 2.1                      | 0.6                 | 2.2    | 0.7    | 2.1    | 0.6    | 2.1    | 0.6    | 2.5    | 0.7    |
| 7  | 2.2                      | 0.7                 | 2.1    | 0.7    | 2.3    | 0.6    | 2.2    | 0.7    | 2      | 0.6    |
| 8  | 2.3                      | 0.6                 | 2.1    | 0.8    | 2.2    | 0.5    | 2.5    | 0.7    | 2.1    | 0.7    |
| 9  | 2.1                      | 0.6                 | 2      | 0.8    | 2.3    | 0.8    | 2.4    | 0.7    | 2      | 0.7    |
| 10 | 2                        | 0.7                 | 2.3    | 0.7    | 2.4    | 0.7    | 2.5    | 0.7    | 2.4    | 0.7    |
| 11 | 2.2                      | 0.6                 | 2.2    | 0.8    | 2.3    | 0.7    | 2.2    | 0.7    | 2.3    | 0.7    |
| 12 | 2                        | 0.6                 | 2      | 0.7    | 2.2    | 0.7    | 2      | 0.7    | 2.2    | 0.6    |
| 13 | 2.3                      | 0.7                 | 2.1    | 0.8    | 2.3    | 0.8    | 2.2    | 0.7    | 2.3    | 0.7    |
| 14 | 2                        | 0.8                 | 2.1    | 0.7    | 2.4    | 0.8    | 2      | 0.6    | 2.4    | 0.7    |
| 15 | 2.2                      | 0.7                 | 2      | 0.6    | 2.3    | 0.7    | 2      | 0.7    | 2.5    | 0.8    |

At this stage they will stop eating and will empty their intestines (self-cleansing). The mouth will turn into a climbing aid and they will move outward to find dry and protected areas to become pupae [12]. Larvae will use the energy in their bodies to undergo the metamorphosis process to become flies, therefore their body weight experience shrinkage. Larvae that have the greatest mass is on the eleventh day of measurement, in the treatment of using a mixture of vegetables with rice weighing 250 gr (1: 1). This is due to the nutrient composition of the media a more complete mixture than rice or vegetables or fruit only. On the media a mixture of rice-vegetables, there is a complete nutritional form in the form of macro elements sourced from rice in the form of carbohydrates and micro elements sourced from cassava leaves, kale or potatoes are vitamins A, B1, C, calcium, phosphorus and other substances iron. The relationship between nutrition and nutrition completeness with the production of this larvae weight corresponds to research conducted by [13] that generally substrates are quality will produce the maggot more because it can provide nutrients which is sufficient for the growth and development of maggot. Besides having acid, cassava leaves methionine which is relatively low in protein ones contained in cassava leaves is a protein and crude fiber and contains acid cyanide which is toxic.

4. Conclusions
The total of 2.25 kg in 1 biopond prepupa produced, it can be used as ornamental fish feed or chicken feed. From the results of this household waste processing to become prepupae, it can consume 250 grams of waste per day for each household. This can help process household waste into something more useful.

References
[1] Kiran EU, Trzcinski AP, Ng WJ and Liu Y 2014 Bioconversion of food waste to energy: a review Fuel 134 pp 389-99
[2] Newton L, Sheppard C, Watson W, Burtle G, Dove R, Tomberlin J and Thelen E 2005 The black soldier fly Hermetia illucens as a manure management/resource recovery tool. In Symposium on the state of the science of Animal Manure and Waste Management 1 pp 57

[3] Supriyatna A and Ukit 2016 Screening and Isolation of Cellulolytic Bacteria from Gut of Black Soldier Flies Larva (Hermetia illucens) Feeding with Rice Straw Journal of Biology & Biology Education Biosaintifikasi 8 (3) pp 314-20

[4] Fahmi MR 2015 Optimalisasi Proses Biokonversi dengan Menggunakan Mini Larva Hermetica illucens Untuk Memenuhi Kebutuhan Pakan Ikan [Optimalizing Bioconversion Process Using By Mini Larva of Hermetica illucens To Fulfilling Fish Feed Nutrition] Prosemnas Masy Biodev Indon 1(1) pp 139-44

[5] St-Hilaire S, Cranfill K, McGuire MA, Mosley EE, Tomberlin JK, Newton L, Sealey W, Sheppard C and Irving S 2007 Fish Offal Recycling by the Black Soldier Fly Produces a Foodstuff High in Omega3 Fatty Acids Journal of the World Aquaculture Society 38(2) pp 309-13

[6] Indriyanti DR, Banowati E and Margunani M 2015 Pengolahan Limbah Organik Sampah Pasar Menjadi Kompos [Market Waste Organic Management to Compost] Jurnal ABDIMAS 19 (1) pp 43–8

[7] Sunyoto S, Saputro DD and Suwahyo S 2016 Pengolahan Sampah Organik Menggunakan Reaktor Biogas di Kabupaten Kendal [Organic Waste Management Using Biogas Reactor on Kendal District] Jurnal Rekayasa 14(1) pp 29–36

[8] Silmina D, Edriani G and Putri M 2011 Efektivitas Berbagai Media Budidaya Terhadap Pertumbuhan Maggot Hermetia illucens [Effectivity of Maggot Media to Hermetia Illucens Growth] (Bogor, Indonesia: Institut Pertanian Bogor)

[9] Lalander CH, Fidjelan J, Diener S, Eriksson S and Vinneras B 2014 High waste-to Biomass Conversion and Efficient Salmonella spp Reduction using Black Soldier Fly For Waste Recycling Agron Sustain Development 36 pp 261–71

[10] Katayane FA, Bagau B, Wolayan FR and Imbar MR 2014. Produksi dan Kandungan Maggot (Hermetia illucens) Dengan Media Tumbuh yang Berbeda [Production and Maggot (Hermetia Illucens) Content with Different Media] Jurnal Zootek 34 pp 27-36

[11] Widjastuti T, Wiradimadja R and Rusmana, D 2014 The Effect of Substitution of Fish Meal by Black Soldier Fly (Hermetia illucens) Maggot Meal In The Diet On Production Performance of Quail (Coturnix coturnix japonica) Scientific Papers Series D Animal Science 57 pp 125 – 29

[12] Hall DC and Gerhardt RR 2002 Medical and Veterinary Entomology Flies (Diptera) [California: Academic Press San Diego] pp 127-61

[13] Mangunwardoyo WA and Hem S 2011 Penggunaan Bungkil Inti Kelapa Sawit Hasil Biokonversi Sebagai Substrat Pertumbuhan Larva Hermetia illucens (Maggot) [Utilizing Bioconversion Palm Kernel Meal as a Growth Substrat for Maggot Larva Hermetia illucens] Jurnal Biota 16 pp 166–72

Acknowledgements
I would like thanks to Zuah Eko Mursyid Bangun and Erwin as field assistant. I would like to express my highest appreciation to USU’s LPPM who gave field assistant. I would like to express my highest appreciation to the Chancellor of USU, USU’s LPPM who gave the Non-BNBP Campus Intellectual Product Development Fund (PPUPIK) Number 288 / UN5.2.3.2.1 / PPM / 2020, USU Green Metrics, TPS, UPT Lab. Integrated, PJ Akar Rimba, and any persons who help the continuity of activities.