Implication of types of feeds combined goat manure for preference black soldier fly (BSF) : *Hermetia illucens* L.

I Indri, S Sjam, A Gassa and V S Dewi

Plant pest and Disease Department, Agriculture Faculty, Hasanuddin University, Makassar 90245, South Sulawesi, Indonesia

E-mail : sylviasjam@yahoo.com

**Abstract.** *Hermetia illucens* L. (Diptera: Stratiomydae) called black soldier fly (BSF) has an important role in the degradation of organic waste or bioconversion activity. The current study compared some types of feeds to preference BSF to eggs laid and the implication of the number of larvae and the size of pupae produced, the percentage of larvae that became adults. Type of feeds is rice bran, mixture of fruits waste, agricultural waste, vegetable waste and household waste. The type of feeds mixed with goat mature. The study reports that Black Soldier Fly (BSF) produced the highest number of egg colonies in household waste (6 colonies) then vegetable waste (5 colonies), bran (4.3 colonies), fruits waste (3.3 colonies) and the lowest on agricultural waste (1 colony). The highest number of larvae was in bran (4783), then household waste (1942), vegetable waste (1511), fruits waste (983) and the lowest in agricultural waste (276). The longest pupa size is in fruits waste (2 cm), household waste (1.96 cm), vegetable waste 1.84 cm), bran (1.51 cm), and the lowest is in agricultural waste (1.46). The highest number of imago was in the bran (2266 heads), vegetable waste (396 heads), fruits waste (95 heads), agricultural waste (674.3 heads) and the lowest was in household waste (661.3 heads)

1. **Introduction**

Garbage is a problem of concern because the production is so large every day. Based on the composition, waste is divided into 60% organic waste, 15% plastic, 10% paper, and 15% others (such as metal, glass, cloth, leather) [1]. Minimizing the pile of organic waste is the best option that can be done. Management of organic waste by utilizing microorganisms and insects today needs to be considered. The conversion of organic matter by black soldier fly (BSF) larvae or known as maggot is a recycling technology that is very attractive and has the economic potential [2].

Composting technology as well as the production of feed ingredients using BSF has the potential to be developed. Moreover, to do it in cities that have a very high and fast level of organic matter production, have limited land area, energy and time in managing urban organic waste [3]. The use of BSF as a waste management strategy/organic waste is an innovative strategy because it can produce animal feed containing abundant fat and protein and organic fertilizers [4].

Black soldier fly (*Hermetia illucens* L.; Diptera: Stratiomyidae) is an insect whose maggot is able to break down plant wastes up to 66.53%. Another study states that from the larvae stage to the prepupa stage, black soldier fly is able to reduce up to 55% of the waste given. Besides that, it is also not a vector that is a disease, so it is relatively safe for human health [2, 5]. BSF larvae in reducing waste, the final
stage of larvae called prepupa can be harvested alone (self-harvesting) resulting in high added value which contains 40% protein and 30% fat which is used as fish feed and fish meal livestock [6].

The growth of maggots is very much determined by the growing media, for example, the type of black soldier fly likes a distinctive aroma medium, but not all media can be used as a place to lay eggs for BSF flies [7]. In nature, female flies will be attracted to the smell of aromatic compounds from organic waste (attractants) so they will come to these locations to lay eggs. The nutrient content of the media is quite good but if the scent medium cannot attract flies to nest, maggots will not be produced [8].

BSF larvae are classified as immune and can live in quite extreme environments, such as in media/organic waste that contains lots of salt, alcohol, acid and ammonia. They live in a warm atmosphere, and if the surrounding air is very cold or lack of food, BSF larvae do not die but they become vacuum/inactive waiting until the weather warms up again or food is available again and can also live in water or in the atmosphere alcohol [9].

The feed medium used to attract black soldier fly is added with ripe goat manure to minimize the amount of air so that the air content in the media is not excessive which will affect the survival of the larvae up to the imago. In addition, it also adds nutrients from the feed media which can then be used as fertilizer if the eggs have become imago. The texture of goat manure is distinctive and has the nutrient content of N 0.7%, P₂O₅ 0.4%, K₂O 0.25% and CaO 0.4% [10].

2. Materials and methods

2.1. Preparation of feed media
The media is goat manure, vegetable waste, fruits waste, bran, agricultural waste, banana stalks, rice straw, household waste. All the main ingredients are 80% each plus 10% bran and 10% goat manure except 100% bran as a control. All ingredients are chopped and according to the treatment added with local microorganisms.

2.2. Preparation of local microorganism
The local microorganism (MOL) used was fermented pineapple MOL which added as much water 10 liters and 1 liter molasses.

2.3. Preparation of container
The mixed feed media is put into a stacked bucket that has been perforated at the bottom and the top of the bucket wall (near the lid). The lid of the lower bucket is perforated to be stacked with the top bucket. On the 6th day of fermentation, cardboard pieces were cut crosswise in the opposite direction to the cavity on the surface of the feed medium as a place to lay eggs.

2.4. Observation parameters
The observation parameters were the number of egg colonies, the number of larvae, the number of developing imago, and the length of the pupa. Observation of the number of eggs laid by BSF imago was carried out every day for 8 days after the media was put into the container. The calculation of the number of larvae was carried out 3 times on the 10th day after the eggs hatched by manually separating the feed and black soldier fly larvae. Pupa length was calculated on 20 pupae per treatment by measuring the length of the pupa using a ruler. Calculation of imago starts when the first pupa grows into imago for 14 days.

2.5. Data analysis.
Testing data using one-way ANOVA (analysis of variance with univariate).
3. Results and discussion

3.1. Result

The black soldier fly Imago is attracted to aromatic food so that it will lay its eggs in the food. The number of egg colonies laid by the BSF image is presented in figure 1. These results indicate that the household waste treatment has the highest number of colonies, namely 6 colonies. Next is the treatment of vegetables waste with 5 egg colonies for each replication group. Bran treatment with 4.3 egg colonies, and fruit waste treatment of 3 egg colonies. While the treatment with the lowest number of colonies was the treatment of agricultural waste with 1 egg colony.

![Figure 1. Production of black soldier fly egg colonies (Hermetia illucens) on feed media.](image)

BSF larvae count was carried out on the 21st day after the first egg was laid. The unloading of the feed is carried out 3 times to separate the larvae from the feed. The production of BSf larvae occurs in figure 2. These results indicate that the best bran treatment of all treatments with 4783 larvae. Furthermore, the highest average consecutively is household waste with a total of 1942 larvae, 1511 larvae of vegetable waste, then fruit waste as many as 983 larvae, and the lowest is agricultural waste with 276 larvae.

![Figure 2. Production of black soldier fly larvae (Hermetia illucens) in feed media.](image)

The pupa stage is calculated to determine its length with 20 samples of pupae taken randomly in each treatment. These results can be seen in figure 3 which shows that the treatment of bran has an average pupa length of 1.51 cm, treatment of fruit waste with an average length of 2 cm which is the treatment with the longest pupa. While the treatment of agricultural waste is 1.46 cm long. While. Treatment of vegetables waste with a pupa length of 1.84 cm and treatment of household waste with a length of pupa of 1.96 cm.
Figure 3. Pupae of black soldier fly (*Hermetia illucens*) in all feed media

The calculation of the imago of black soldier fly (*Hermetia illucens*) was carried out for 14 days from the time the first pupa metamorphosed into imago on the 48th day since the feed was placed in the container (figure 5). The results are presented in figure 5 which shows the number of imago in the bran treatment of 2266 individuals. Fruit waste treatment was 396 tails. Meanwhile, the lowest in the treatment of agricultural waste was only 95 tails. In the treatment of vegetable waste as many as 661 tails, and treatment of household waste as many as 742 heads.

Figure 4. The percentage of larvae that metemorphosed to adults.

Figure 5. Production of black soldier imago (*Hermetia illucens*) on feed media.

3.2. Discussion

Black soldier fly lay their eggs near food sources or in dry areas or in crevices of containers [11]. Figure 1 shows that the treatment with the highest number of colonies was the treatment of household waste with an average of 6 egg colonies, while the least was the treatment of agricultural waste with only 1
colony per replicate group. The household waste treatment has a strong aroma compared to agricultural waste. Female flies will be attracted by the smell of aromatic compounds from organic waste (attractants) so that they will come to that location to lay eggs [12].

Figure 2 shows that the treatment of bran is a treatment with an average of larvae of each group having the highest number of replicates, namely as many as 4783 individuals, while the lowest treatment is agricultural waste treatment with an average of only 276 larvae. Even though it can be seen in figure 1 that household waste treatment has the highest average number of colonies compared to bran treatment. This is because the number of eggs for each colony varies depending on the size of the colony. A normal BSF female fly is capable of producing eggs ranging from 185-1235 eggs. Black soldier fly that has a larger body size with larger wings also tend to be more fertile than those with smaller bodies [7, 13].

The fruit waste treatment was the longest pupa treatment with a length of 2 cm (figure 3). Whereas the treatment of agricultural waste and bran treatment was the treatment with the shortest pupae with an average length of 1.46 cm and 1.51 cm. The difference in pupa body length is influenced when it is still a larva. The pupa size of the bran treatment and the treatment of agricultural waste are small because when they are still larvae, they consume foods whose particle sizes are rather difficult to consume BSF maggots. Larvae do not have mouthparts to chew, so the nutrients will be easily absorbed if the substrate is in small pieces or even in a liquid or slurry form [14]. The nutritional content of the feed also affects the pupa size. Materials suitable for maggot growth are materials that contain many types of organic matter [15].

The most pupae that metamorphosed into imago were in the treatment of bran waste as much as 2266 imago, and the lowest was an agricultural waste as much as 95 imago. Meanwhile, the largest percentage of larvae metamorphosed into imago was in bran treatment of 47%, while the lowest was in the treatment of agricultural waste by 34% and household waste 38% (figure 4). The process of pupa metamorphosis into adult black soldier fly (Hermetia illucens) takes place within a period of 10 days to several months depending on environmental temperature conditions [14]. The treatment of bran, fruit waste, vegetables waste had a medium temperature of 30.2-32.5°C, while the media temperature for agricultural waste was 29.1-30.8% and household waste had a feed medium temperature of 27.7°C.

When the pupa is most active, it metamorphosed into an imago, which is during the day. BSF will stop eating and take advantage of the body’s existing fat reserves as a source of energy. Adult flies generally like warm temperatures in their life cycle. The optimum media temperature is in the range of 30-36°C. Black soldier fly maggots cultivated in media with a temperature of 27 °C grew slower than those of 30 °C [4, 9]. Apart from temperature, space also affects pupal hatchability. The space is narrow and contains many pupae that can cause stress. Even though they are not active, they will look for a drier, humus-textured, light-less place when entering the prepupa period [2].

4. Conclusion
There is a significant difference in the preference of black soldier fly (Hermetia illucens) to different feed media. Household waste treatment is the best treatment in attracting insects to lay eggs with 6 egg colonies. The treatment of bran had the highest number of larvae, namely 4783 tails and the highest number of imago that succeeded in metamorphosed from all treatments of 1606. Meanwhile, the longest pupa produced was fruit waste treatment with an average of 2 cm. In the waste degradation process, the larvae are used, so the best treatment that can be used to attract BSF is bran treatment because it produces the most larvae.

References
[1] KLHK 2015 Dialog Penanganan Sampah Plastik (Jakarta: Kementerian Lingkungan Hidup dan Kehutanan)
[2] Diener S 2010 Valorisation of Organic Solid Waste Using the Black Soldier Fly, Hermetia Illucens, In Low and Middle-Income Countries (Swiss: ETH Zurich)
[3] [BPTP] Badan Pengkajian Teknologi Pertanian 2016 Teknologi Pengomposan Limbah Organik Kota dengan Menggunakan Black Soldier Fly (Jakarta: Kementrian Pertanian)

[4] Gabler 2014 Using Black Soldier Fly for Waste Recycling and Effective Salmonella spp. Reduction (Swedish: Swedish University of Agricultural Sciences)

[5] Žáková M and Borkovcová M 2013 Hermetia illucens Application in Management of Selected Types of Organic Waste 2nd Electr. Int. Interdisciplinary Con. pp 367-370

[6] Diener S 2011 Valorisation of Organic Solid Waste Using the Black Soldier Fly, Hermetia illucens, In Low and Middle-Income Countries (Swiss: Eth Zurich)

[7] Tomberlin J K, Adler P H and Myers H M 2009 Development of the Black Soldier Fly (Diptera: Stratiomyidae) in Relation to Temperature Envirom. Entomol 38 930-934

[8] Suciati R and Faruq H 2017 Efektifitas media pertumbuhan maggots Hermetia illucens (Lalat Tentara Hitam) sebagai solusi pemanfaatan sampah organik BIOSFER J. Bio. Pend. Bio. 2 2549-0486

[9] Mudeng N E G, Mokolensang J F, Kalesaran O J, Pangkey H and Lantu S 2018 Budidaya maggot (Hermetia Illuens) dengan menggunakan beberapa media Budidaya Perairan 6 1 – 6

[10] Hartatik W and Widowati L R 2006 Pupuk Organik dan Pupuk Hayati (Jakarta: Balai Besar Litbang Sumberdaya Lahan Pertanian) pp 59–82

[11] Tomberlin J K and Sheppard D C 2002 Factors influencing mating and ovipositing of black soldier fly (Diptera: Stratiomyidae) in a colony J. Entolomogy Sci. 37 345-352

[12] Wardhana A H 2016 Black soldier fly (Hermetia illucens) sebagai sumber protein alternatif untuk pakan ternak WARTAZOA 26 69-78

[13] Gobbi P, Martinez-Sánchez A and Rojo S 2013 The effects of larval diet on adult life-history traits of the black soldier fly, Hermetia illucens (Diptera: Stratiomyidae) Eur. J. Entomol. 110 461-468

[14] Sipayung P Y E 2015 Pemanfaatan Larva Black Soldier Fly (Hermetia illucens) Sebagai Salah Satu Teknologi Reduksi Sampah di Daerah Perkotaan (Surabaya: Institut Teknologi Sepuluh Nopember)

[15] Duponte M W and Larish L B 2003 Orinetal Blow Fly. Livestock Management Insect Pest (Manoa: University of Hawaii)