Longevity and Fecundity of Female Black Soldier Fly (*Hermetia illucens* L.) Maintained with Honey Solution at Different Concentrations

Nada Nisrina Amri[1], Syafitriani Ardiasani[2], Nabilah Elvira[3], Lily Surayya Eka Putri[4], Bandung Sahari[5]

{nadanisrina@apps.ipb.ac.id[1], syafitrianiardiasani@gmail.com[2], bandung27@yahoo.com[3]}

Natural Resources and Environmental Management, Graduate Study Program, IPB University, Bogor[1], Departement Biology Science, Faculty of Science and Technology, State Islamic University Syarif Hidayatullah, Jakarta[2,3,4], Center for Transdisciplinary and Sustainability Science, IPB University[5]

Abstract. Females of Black Soldier Fly (BSF) play an important role in ensuring the sustainability of their generation in mass rearing program for the grassroot community. This study aims to evaluate effects of honey solution at different concentrations combined with fish waste on longevity and fecundity of BSF females. Females of BSF are maintained with 8 combination feed treatments. Each treatment is consisted of five repetitions and every single unit contains 10 pairs of BSF females. The results show females maintained with 10% honey solution combined with or without waste can live longer compared to other treatments. The lowest and highest egg weight was recorded to be 0.01 grams and 0.2 grams. The weight of laid eggs is affected by the number of surviving females. The highest weight of eggs was recorded on the 5th day after females hatched from pupae with a 3-day preoviposition period.

Keywords: Imago BSF, fecundity, longevity, supplementary food

1 Introduction

Black soldier fly (*Hermetia illucens* L.) is currently being developed for various purposes because of the many benefits that can be obtained [1], including as animal feed because it has a fairly high protein content [2]. On the other hand, because BSF lives by consuming organic materials, it can be used to convert waste such as industrial, agricultural, and livestock waste [3]. The mass breeding of BSF as an agent for decomposing organic waste is strongly influenced by the survival of the imago [4]. BSF imago lives by consuming a liquid substrate, and will even survive without food [5]. BSF flies really like organic food that has a distinctive aroma. A study by Suciati et al., 2017 [6] revealed that although the nutrient content of the media is quite good, if the aroma of the media is unattractive and does not have a pungent or odorless smell that is typical for nesting, BSF flies will not be reproduced. 18.26% of the flies found in laying hens were BSF flies and poultry manure, which is one of the main feeds of BSF flies [7]. According to a study [8], temperature also affects the incubation period of eggs. Warm temperatures tend

RESILIENCE 2023, November 24, Jakarta, Indonesia

DOI 10.4108/eai.24-11-2023.2346489

to trigger eggs to hatch faster than low temperatures. BSF are important contributors to nutrient cycling, waste management, and as a food source for various organisms, thereby playing a significant role in sustaining the food chain and ecosystem balance. This study was focused on looking at several alternative combinations of additional feed for imago associated with aroma as a stimulant to lay eggs with the addition of additional feed in the form of catfish waste (organic waste) as an attractant.

2 Research method

2.1 Time and place of research

This research was conducted in December 2020–February 2021. The location for data collection is in the area of Mutiara Bogor Raya Integrated Waste Processing Site, Katulampa area, East Bogor Distric, Bogor City, West Java, Indonesia.

2.2 Procedure

The study was structured with the supplementary feed treatment and 5 repetitions as described in Table 1. Each unit consisted of 20 pairs of BSF imago.

Table 1. Research design

Number	Treatment	Number of imago (10 males and 10 females)
A	Water + Fish Waste	20
B	No Water + Fish Waste	20
C	Water without Fish Waste	20
D	No Water without Fish Waste	20
E	5% Honey + Fish Waste	20
F	5% Honey without Fish Waste	20
G	10% Honey + Fish Waste	20
H	10% Honey without Fish Waste	20

A total of 80 females BSF were reared with 8 combination feed treatments including an additional 5% honey solution, 10% honey, water, and fish waste (organic waste). Imago obtained from pupae reared in Mutiara Bogor Raya Integrated Waste Processing Site. The imago that appears and has performed mating activities are collected, and then the female imago is separated to see their egg-laying activity. The media for laying eggs in the form of wooden sheets with small gaps in between (eggies) is prepared and then put into a plastic container measuring 15 cm x 15 cm. The feed was sprayed on the sides of the cage using a sprayer in the morning and evening and fish waste (organic waste) was placed in the plastic container provided. Imago that has experienced death is recorded every day and the length and width of the body are measured. After 3-4 days the imago eggs produced in each treatment were harvested every day and then weighed and recorded.

2.3 Data analysis

The data obtained were compiled using *Microsoft Excel* and variance (ANOVA) was carried out to see the effect of treatment on the evaluated parameters. If it is found that there is an effect of treatment, further tests are carried out using the Tukey test at a 5% significance level. Statistical analysis using STATISTIKA 7.0 software. If the P value > 0.05 then the treatment given has no significant effect (H0 is accepted). If the P value < 0.05 then the treatment given has a significant effect (H0 is rejected). Simple linear regression was carried out to see the relationship between surviving females and egg weight produced.

3 Result and discussion

3.1 Environment factor Imago Black Soldier fly (BSF)

Based on the results of measurements in the field, temperature ranges from 26.6-30.2℃ with an average of 27.9℃ and relative humidity ranges from 59-71% with an average of 64.4% (Table 2). The results of the observations showed an increase and decrease in temperature and humidity. During the day, especially at 1.00 PM it is not always hot, but sometimes it is also cloudy. Therefore, the recorded data shows a fairly high fluctuation of temperature increase and decrease. BSF insects are very tolerant of humidity and temperature. In general, BSF imago mating and laying eggs at a temperature of 24-37℃ [5]. Stable BSF colonies are achieved at a temperature of 31.8℃ and at that temperature is a very good temperature to be able to reproduce BSF eggs [9].

Table 2. Measurement of temperature and humidity during development of imago BSF

Day (age)	Temperature (℃)	Humidity (%)
1	27.6	65
2	30.2	57
3	26.6	67
4	26.5	69
5	29.1	59
6	27.6	71
7	28	63

3.2 Effect of supplementary feed longevity of the Black Soldier Fly (BSF)

BSF was able to live up to 7 days after leaving the pupa, and death began to occur on the 4th day. The results showed a significant effect of the combination treatment of additional feed and the interference of fish waste aroma on the mortality rate and longevity of BSF female imago on the 5th day of observation ($F_{7.39} = 2.637$; $P = 0.029$; $n = 40$), day 6 ($F_{7.39} = 4.390$; $P = 0.002$; $n = 40$), and day 7 ($F_{7.39} = 6.612$; $P < 0.001$; $n = 40$). In general, it was seen that feeding supplementary honey 10% either with fish waste or not gave the best results for all observations compared to other treatments. On the other hand, 5% honey using fish waste gave poor results on the 6th and 7th day observations, although not on the 5th day.

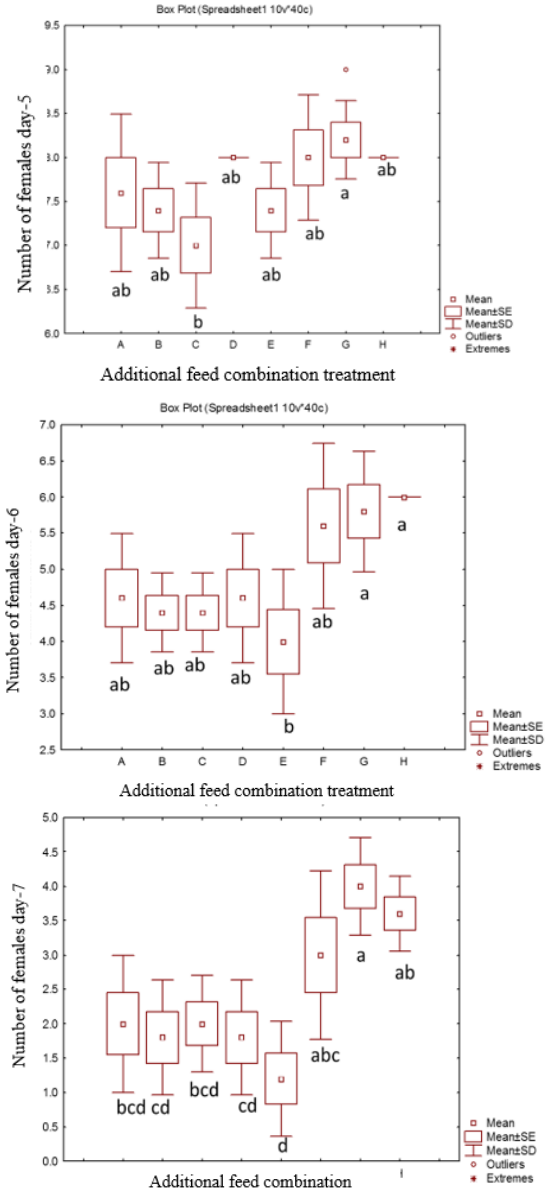

Fig. 1. The number of females who survived the combination treatment of additional feed and scent interference from fish waste on the 5, 6, and 7 days of observation. The same letter in the Whisker Boxplot Graph shows no significant difference with the Tukey test; A. Water + Fish Waste; B. No Water + Fish Waste; C. Water Without Fish Waste; D. No Water without Fish Waste; E. Honey 5% + Fish Waste; F. Honey 5% without Fish Waste; G. Honey 10% + Fish Waste; H. Honey 10% without Fish Waste

3.3 Female imago survival effect of supplementary feed longevity on BSF

Eggs laid were counted cumulatively from 10 females for each replication and daily based on weight. Overall, the lowest egg weight was 0.01 g and the highest production was 0.2 g. The death of the female was recorded starting on the 4th day and the eggs laid as a whole were only seen on the 4th day, while the imago that had come out of the pupa until the 3rd day was not recorded any eggs were laid. This is related to the preoviposition period. A study [10], stated that the preoviposition period is the period from when a new imago is formed until the imago releases eggs. Generally, the preoviposition period is short and lasts for several days, i.e., 0-3 days.

The number of females that managed to survive on the day of observation was related to the weight of the eggs recorded each day. The more the number of surviving females, the egg weight also increases. This is indicated by the R^2 value of the relationship between females that survived well on the 5th, 6th, and 7th days with egg weights approaching 1, meaning that the number of females that survived the more would affect the weight of the eggs produced (**Figure 2**). The death rate that increases every day will affect the weight of the eggs. On day 4, 400 females were still alive and had a chance to lay eggs, however on day 7, only 97 females survived, and on day 8 all females died.

Table 3. The value of the coefficient of determination and the regression equation of the relationship between the number of surviving females and the weight of the eggs laid.

Observation day	Female (N) endure	Regression equation	Score R^2
Day-4	400	-	-
Day-5	308	Y = 0.0142X	0.8177
Day-6	197	Y = 0.0205X	0.8941
Day-7	97	Y = 00376X	0.0766

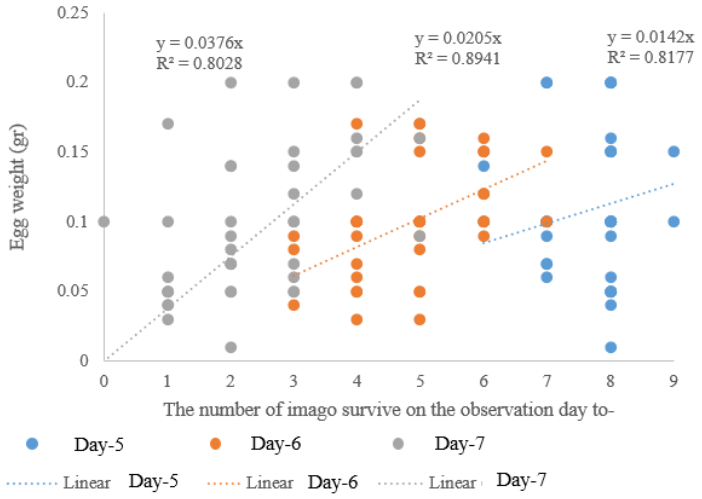

Fig. 2. The relationship between the number of surviving female imago and the weight of the eggs produced

Although egg weight tends to decrease with the number of surviving females, the female mortality rate does not necessarily reduce egg weight. Egg weight increased on day 5 of observation resulting from 308 individuals, and was higher than observations on day 4 of 400 females. However, it decreased on subsequent observation days following the number of dead females (**Figure 3**). This indicates that egg production reached its peak on the 5th day of observation and decreased thereafter.

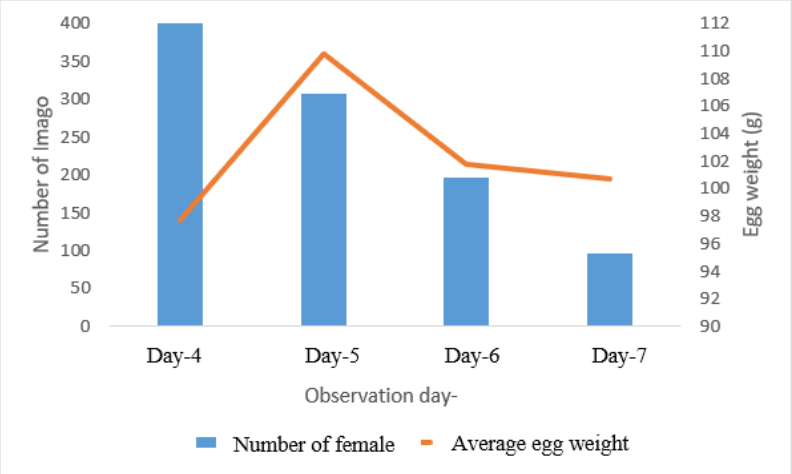

Fig. 3. Observation of daily egg production with the number of female imago BSF

The production of eggs is strongly influenced by the number of female imago that can survive. A long life span will produce a higher number of eggs compared to a short life span [11]. A study [12], that the adult phase has a fairly short life span of 6-8 days and only focuses on breeding activities. BSF imago requires a sufficiently moist water source to keep the body hydrated [13]. This is because the BSF imago only uses their body fat reserves obtained during the larval stage, if their body fat reserves are depleted, the imago will die [14]. During one month of observation, the average number of eggs produced from the cage reached 50 grams and the number obtained from eggs that were successfully collected in the provided place [15]. The highest egg production was because the imago used in the cage was only slightly from the amount that had been carried out by previous studies and the cage used in this study was quite narrow and the capacity was not so wide. The small number of eggs produced from imago fed other than 10% honey was thought to be due to the lack of energy needed by BSF imago. Imago BSF also really needs energy to be able to oviposit and produce eggs [11]. The main energy source for imago is sugar in the form of honey [16]. The results of the research of [17], stated that the imago of *Spodoptera exigua* which was given additional feed during the imago phase also showed a high level of personality and length of life when fed 10% honey compared to the imago which was only given additional food in the form of water only.

4 Conclusion

The provision of additional types of feed in the form of water, 5% honey, 10% honey and fish waste had a significant effect on the treatment of the combination of additional feed and interference with the aroma of fish waste on the mortality rate and longevity of BSF female imago. Good supplementary feeding, namely 10% honey + fish waste with the highest egg weight of 0.2 grams.

References

[1] Monita, L., Sutjahjo, S. H., Amin, A. A., & Fahmi, M. R.: Municipal organic waste recycling using Black Soldier Fly Larvae *(Hermetia illucens*). Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan, vol. 7, no. 3, pp. 227–234 (2017).

[2] Amandanisa, A , & Suryadarma, P.: Kajian nutrisi dan budi daya maggot (*Hermentia illuciens l* .) sebagai alternatif pakan ikan di RT 02 Desa Purwasari, Kecamatan Dramaga, Kabupaten Bogor [nutrition and aquaculture study of maggot (*Hermentia illuciens l* .) as fish feed alternative in RT]. Jurnal Pusat Inovasi Masyarakat, vol. 2, no. 5, pp. 796–804 (2020).

[3] Supriyatna, A., & Ukit, U.: Screening and isolation of cellulolytic bacteria from gut of Black Soldier Flys larvae (*Hermetia illucens*) feeding with rice straw. Biosaintifika: Journal of Biology & Biology Education, vol. 8, no. 3, pp. 314 (2016).

[4] Sipayung, P. Y. E.: Utilization of Black Soldier Fly (*Hermetia illucens*) larvae as a waste reduction technology utilization of the Black Soldier Fly (*Hermetia illucens*) larvae as a technology option for urban solid waste reduction. Final Project for the Department of Environmental Engineering, Faculty of Civil Engineering and Planning, Sepuluh Nopember Institute of Technology, Surabaya, 130 (2015).

[5] Sheppard et al.: Rearing black soldier fly to supplement natural populations in waste composting systems. 51 (2002).

[6] Suciati, R., Faruq, H., Biologi, J. P., & Timur, J.: Effectiveness of maggot growth media *Hermetia illucens* (Black Soldier Flies) as a solution for waste utilization. vol. 2, no. 1, pp. 0–5 (2017).

[7] Tumiran et al.: *Hermetia illucens*. Journal of Chemical Information and Modeling, vol. 53, no. 9, pp. 1689–1699 (1981).

[8] Tomberlin, et al.: Intra-puparial development of the black soldier-fly, Hermetia illucens. Journal of Insect Science, vol. 14, no. 83, pp. 1–10 (2014).

[9] Diener, S., Studt Solano, N. M., Roa Gutiérrez, F., Zurbrügg, C., & Tockner, K.: Biological treatment of municipal organic waste using black soldier fly larvae. Waste and Biomass Valorization, vol. 2, no. 4, pp. 357–363 (2011).

[10] Rustam, R.: Parasitoid Potential Opius sp. (Hymenoptera; Liriomyza Leaf Morder sp. Diptera), vol. 13 (2004).

[11] Nelly, N., & Buchori, D.: The effect of food on the length of life and fitness of Eriborus argenteopilosus Cameron (Hymenoptera: Ichneumonidae) imago. Indonesian Journal of Entomology, vol. 5, no. 1, pp. 1 (2017).

[12] Fahmi, M. R.: Optimization of the bioconversion process by using *Hermetia illucens* mini-larvae to meet fish feed needs. 1(Fao 2004), pp.139–144 (2015).

[13] Dortmans, B., Diener, S., Verstappen, B., & Zurbrugg, C.: Organic waste processing process with Black Soldier Fly (BSF): Complete Step-by-Step Guide (2017).

[14] Tomberlin.: Hermetia illucens. Journal of Chemical Information and Modeling, vol. 53, no. 9, pp. 1689–1699 (2002).
[15] Rachmawati et al.: Development and nutritional content of Hermetia illucens (linnaeus) larvae (Diptera: Stratiomyidae) in palm oil cake. Indonesian Journal of Entomology, vol. 7, no. 1, pp. 28 (2010).
[16] Fadamiro, H. Y., & Heimpel, G. E.: Effects of partial sugar deprivation on lifespan and carbohydrate mobilization in the parasitoid Macrocentrus grandii (Hymenoptera : Braconidae). pp. 909–916 (2001).
[17] Tisdale, R. A., & Sappington, T. W.: Realized and potential fecundity, egg fertility, and longevity of laboratory-reared female beet armyworm (Lepidoptera: Noctuidae) under different adult diet regimes. Annals of the Entomological Society (2001).