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RESEARCH ARTICLE

EFFECT OF FEED TYPE ON THE NUMBER AND HATCHABILITY OF EGGS BLACK SOLDIER FLY (*Hermetia illucens L.*)

S. Sukarsono, H. Rusda Kumalasari, L. Waluyo, H. Husamah and M. Mirza Nuryadi
Department of Biology Education, Faculty of Teacher Training and Education, Universitas MuhammadiyahMalang, Jl. Raya Tlogomas 246 Malang, East Java 65144, Indonesia.

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Abstract

The increase in the rate of population growth and people's consumption patterns causes the amount of waste to accumulate, one of which is organic waste. One alternative for reducing landfills is by using the Black Soldier Fly (Hermetia illucens L.). H. illucens L plays an important role as a decomposer of organic waste. This research aims to determine the effect of various types of feed on the number and hatchability of H. illucens L eggs. Type of experimental research. The research was conducted at TPA Tlekung Batu in June 2023. The types of treatment were various types of feed including A (leaf waste), B (rice waste), C (pineapple waste), D (withered vegetable waste, carrots and mustard greens). The number of eggs and the hatchability of Black Soldier Fly eggs were measured with six repetitions. The research procedure began with preparing tools and materials, placing 14-day-old pupae in a cage, preparing organic feed and placing egg-laying wood on top of the feeder, and spraying water into the cage, collecting and analyzing data. The sampling technique used simple random sampling with a sample size of 24 pairs per cage. Data analysis used One Way Anova and Duncan. The research results showed that various types of feed influenced the number and hatchability of Black Soldier Fly. The type of feed that has a higher influence is on pineapple waste because the water content is very high and for the type of feed the influence is very low on leaf waste. The conclusion of the research is that the type of feed influences the number and hatchability of Black Soldier Fly eggs. The best type of feed is found in pineapple waste which has quite a significant difference.

Introduction:-

Population density and changes in people's lifestyles have caused the amount of landfill to increase. Based on data from the Ministry of Environment and Forestry's National Waste Management Information System (SIPSN), in 2022 the amount of waste accumulated will be 23,510,341.07 tons/year, the largest source of waste is household waste, one of which is organic waste. Organic waste is dominated by food waste, vegetables, fruit, leaves. One alternative that can be done to reduce waste accumulation is by using the Black Soldier Fly (*Hermetia illucens* L.) (Wardhana, 2017). *H. illucens L* has an important role as a decomposer of organic waste. According (Lalander et al., 2015), *Black Soldier*

Corresponding Author:- S. Sukarsono
Address:- Department of Biology Education, Faculty of Teacher Training and Education, Universitas MuhammadiyahMalang, Jl. Raya Tlogomas 246 Malang, East Java 65144, Indonesia.

Fly can reduce the amount of organic waste by 70%. The ability to degrade waste from *Black Soldier Fly (Hermetia illucens L)* larvae is better than other insects(Fitriyah & Syaputra, 2022).

The high environmental benefits and economic value prospects of Black Soldier Fly are very important for cultivation. The Black Soldier Fly business has great business prospects and promising potential and requires further development, but in the Black Soldier Fly business there are also obstacles, namely in selecting superior Black Soldier Fly seeds (Alizahatie, 2019). Black Soldier Fly's business potential can be reviewed and studied in more depth from all aspects including the environment, internal factors and external factors that influence the business to see how big its economic potential(Nurdi et al., 2023). The success of cultivation is greatly influenced by the egg production produced and insect egg production is influenced by the type of feed given (Solon-Biet et al., 2015).

The feed given to BSF comes from organic waste itself. The type of feed must have sufficient nutritional content otherwise it can affect insect fitness and reduce the nutritional value of the Black Soldier Fly (Wardhana, 2017). When laying eggs, the aromatic smell of organic waste attracts the Black Soldier Fly so that the fly will find a place for its eggs. The number of eggs in a female Black Soldier Fly is more than one, and in the same place usually more than one female fly lays eggs. This is because female flies will provide chemical markers to attract other females to lay eggs in the same place (Wardhana, 2016). Female Black Soldier Fly will not be attracted by types of food that do not have a distinctive aroma even though they have high nutritional content (Suciati & Faruq, 2017). A warmer temperature of maximum 36°C makes adult flies more active and productive.

In previous research, the type of feed that influenced the number of Black Soldier Fly egg colonies was rice and fruit waste ((Indri, 2021). Results(Fahmi, 2015), the successful use of Black Soldier Fly is the production of Black Soldier Fly eggs in large quantities using the bioconversion process. In cultivation, maximizing egg production depends on the nutritional quality of Black Soldier Fly feed which affects body mass and size (Gobbi et al., 2013). The importance of the type and characteristics of feed and the magnitude of its influence on BSF means that it is important to carry out research on the influence of type of feed on the hatchability and number of BSF eggs.

Methodology:-

This type of research is experimental. Black Soldier Fly (BSF) pupae and organic waste were obtained from maggot cultivation at TPA Tlekung Batu in collaboration with PT. Arta Asia Putra. The time of the research is June 2023. The equipment used in the research includes digital gold scales, hatching cages, ponds, and wood for laying eggs. BSF fly samples were obtained from maggot cultivation at TPA Tlekung Batu. The sampling technique uses simple random sampling. Fly samples were tested to determine the effect of different feeding on the number and hatchability of Black Soldier Fly, so the sample unit used was adult Black Soldier Fly. The types of treatment were various types of feed including A (leaves waste), B (rice waste), C (pineapple waste), and D (withered vegetable waste, carrots, and mustard greens) which affected the number of eggs (in grams) and egg hatchability (in tail) Black Soldier Fly with 6 repetitions. The sampling technique used simple random sampling with a sample size of 24 pairs per cage and data analysis using the One Way ANOVA test.

Research procedures include: placing the pupae in a cage, the Black Soldier Fly pupae used are 14 days old and will be ready to hatch into flies. The pupa that will hatch is black and no longer eats. The pupae are placed in a cage and will hatch into adult flies within 7 days. Prepare the type of feed, the type of feed used comes from organic waste consisting of pineapple waste, rice waste, wilted vegetable waste, and leaf waste. Food is placed in the pond and put in the cage to lure the Black Soldier Fly to lay eggs.

The next activity is to prepare the wood to lay eggs. Black Soldier Fly flies will lay eggs in narrow places, crevices, and close to organic waste. A piece of wood for laying eggs, called an aegis, will be placed on top of the bio pond to make it easier for the flies to lay their eggs, then spray water in the cage because the flies that will lay their eggs need to drink. Water is sprayed once every 2 days to ensure survival, and then the eggs with a digital gold scale and moved to a hatching rack with feed underneath. Black Soldier Fly eggs that have hatched are calculated within 3-4 days. Eggs are counted by pinching them one by one to determine the number of hatching eggs.

Data collection was carried out using experimental observations complete with observation data tables on Black Soldier Fly eggs and larvae. The treatment for the hatchability of Black Soldier Fly eggs will be seen from the high, medium, and low hatchability of the eggs. Data analysis used One-way ANOVA and Duncan's advanced test with a significance level of 5% using SPSS version 24.

Resultsand Discussion:-

Results:-

Data on Number of Black Soldier Fly Eggs

The results of observing the type of feed on the number of Black Soldier Fly eggs produced varied in each treatment. The data results for the highest number of Black Soldier Fly eggs in the pineapple treatment were 1 gram in the 2nd and 3rd replications and the data for the lowest number of Black Soldier Fly eggs in the leaf treatment was 0.01 grams in the 1st and 5th replications. The data results were average. The highest average results were shown by the pineapple feed type treatment with a total of 0.93 grams, while the lowest average results were shown by the leaf feed type treatment with a total of 0.02 grams (Table 1).

Table 1:- Data on Number of *Black Soldier Fly* Eggs (Grams).

Feed type treatment	Test						Average
	1	2	3	4	5	6	(Grams)
A	0.01g	0.02g	0.03g	0,02g	0,01g	0,03g	0,02g
B	0.77g	0.85g	0.85g	0,75g	0,73g	0,77g	0,78g
C	0.89g	1g	0.91g	1g	0,87g	0,91g	0,93g
D	0.55g	0.59g	0.60g	0,62g	0,62g	0,60g	0,59g

Description: A (leaf waste), B (rice waste), C (pineapple waste), D (withered vegetable waste, carrots and mustard greens).

Data Black Soldier Fly Egg Hatchability

Data on the influence of feed type on the hatchability of the Black Soldier Fly eggs produced varied for each treatment. Based on research data in Table 2 regarding hatchability, the highest category hatchability is 39.86% and the lowest category is 0.85%. Treatment A has very low egg hatchability with a percentage of 0.85%, treatment D has low egg hatchability with a percentage of 25.56%, treatment B has high egg hatchability with a percentage of 33.72% and Treatment C has the highest egg hatchability with a percentage of 39. .86%. The results of data on the hatchability of Black Soldier Fly eggs were highest in the pineapple treatment, namely 3448 in the 2nd replication, and data on the number of Black Soldier Fly eggs was the lowest in the leaf treatment, namely 35 grams in the 1st replication. The average results for the entire sample showed that there is an influence on feeding differently. The data results with the highest average were shown by the pineapple feed type treatment with a total of 39.86%, while the lowest average results were shown by the leaf feed type treatment with a total of 0.85% (Table 2).

Table 2:- Hatchability of Black Soldier Fly eggs (In Tail).

Feed type treatment	Test						Average (%)
	1	2	3	4	5	6	
A	35	69	102	65	38	102	0,85%
B	2655	2931	2925	2586	2517	2650	33,72%
C	3068	3448	3138	3440	3000	3130	39,86%
D	1896	2034	2069	2138	2127	2065	25,56%

Description: A (leaf waste), B (rice waste), C (pineapple waste), D (withered vegetable waste, carrots and mustard greens).

Effect of Feed Type on the Number of *Black Soldier Fly* Eggs

Table 3:- One Way Anova Test Results on the influence of feed type on the number of Black Soldier Fly eggs.

Number of Eggs					
Sum of Squares		df	Mean Square	F	Sig.
Between groups	2.874	3	.958	586.585	.000
In groups	.033	20	.002		
Total	2.907	23			

Based on the results of the One Way Anova test, the treatment of the influence of the type of feed on the number of Black Soldier Fly eggs obtained a significant value of less than 0.05 (0.00 < 0.05). It can be concluded that the type of feed treatment on the number of Black Soldier Fly eggs has a significant influence.

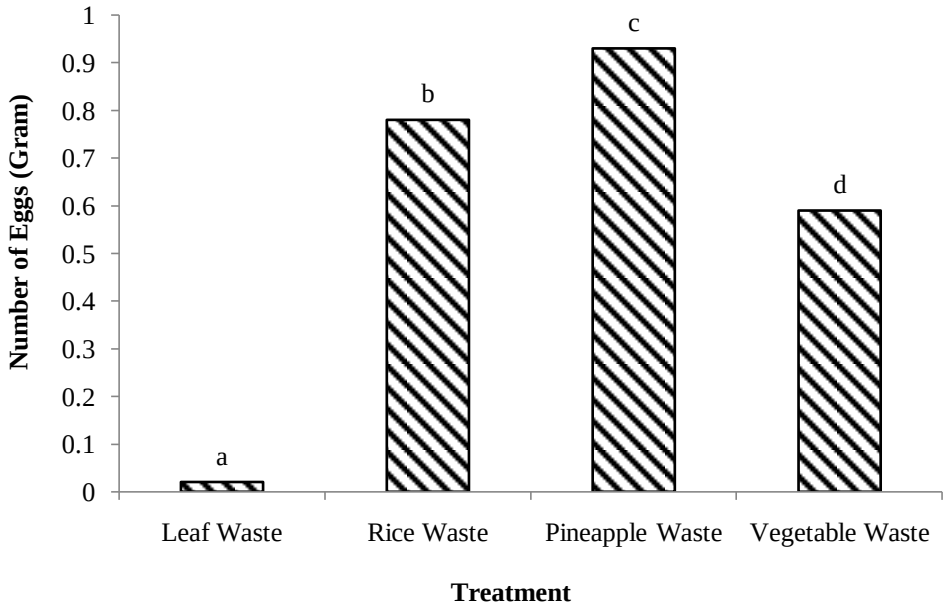

Figure 1:- Results of the Duncan Test on the effect of feed type on the number of BSF eggs.

Based on Figure 1, the average of 4 variances for each treatment has a significant difference in the number of Black Soldier Fly eggs. Based on Duncan's test results, shows that the treatment that has the most influence on the number of Black Soldier Fly eggs is the treatment of pineapple waste. This shows that the number of eggs in pineapple waste has a significant difference compared to other treatments. The treatment that had the smallest effect was leaf waste treatment. There are differences in the effects of rice waste treatment and pineapple waste treatment. The effects on the number of Black Soldier Fly eggs are pineapple waste, rice waste, vegetable waste, and leaf waste, respectively.

Effect of Feed Type on Hatchability of Black Soldier Fly Eggs

Table 4:- Effect of Feed Type on Hatchability of Black Soldier Fly Eggs.

Number of eggs hatched					
Sum of Squares		df	Mean Square	F	Sig.
Between Groups	34128006	3	11376002.11	595.774	.000
In Group	381889.667	20	19094.483		
Total	34509896.00	23			

Based on the results of the One Way Anova test, the treatment of the effect of type of feed on the hatchability of Black Soldier Fly eggs obtained a significant value smaller than 0.05 (0.00 < 0.05). accepted. It can be concluded that the type of feed treatment has a significant influence on the hatchability of Black Soldier Fly eggs.

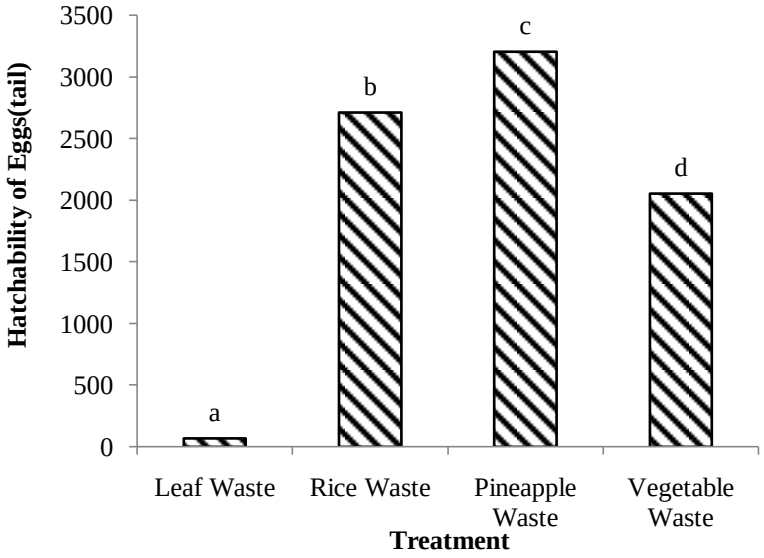

Figure 2:- Duncan continued test results on the effect of feed type on the hatchability of Black Soldier Fly eggs.

Based on Figure 2, the average of 4 variances for each treatment has a significant difference in the hatchability of Black Soldier Fly eggs. Duncan's test results showed that the treatment that had the most influence on the hatchability of the Black Soldier Fly was the pineapple waste treatment. This shows that the hatchability of eggs in pineapple waste has a significant difference compared to other treatments. There are differences in the effects of rice waste treatment and pineapple waste treatment. The effects on the number of Black Soldier Fly eggs are pineapple waste, rice waste, vegetable waste and leaf waste, respectively. The treatment that has the smallest effect is leaf waste treatment.

Discussion:-

Effect of Feed Type on the Number of Black Soldier Fly Eggs

Based on the data results in Table 1. the highest average is for pineapple waste and the lowest average is for leaf waste. The results of the one-way ANOVA test showed a significant difference in the type of feed that influenced the number of Black Soldier Fly eggs with a sig value < 0.05. The results of the Duncan test showed that the treatment that had the most influence on the number of Black Soldier Fly eggs was the treatment of pineapple waste. This shows that the number of eggs in pineapple waste has quite significant differences. Pineapple waste has a high impact because the water content in pineapples is very high, reaching 46-52% (Ibrahim et al., 2015). The second waste that was influential was leftover rice with an average of 0.78 grams, then wilted vegetable waste (carrots and mustard greens) with an average of 0.59 grams, and the lowest average was leaves, namely 0.02 grams. This difference is because each waste has different criteria, apart from that the number of eggs is also influenced by temperature, maggot food, and mating time(Dewi et al., 2021) .

Pineapple waste has a high average value which can be seen in Table 1. This is because the black soldier fly likes fruit-scented media, apart from that, the texture of pineapple which has a bright or striking color is also liked by the Black Soldier Fly (Lamin et al., 2022). According to(Lamin et al., 2022)Diptera insects prefer bright colors and do not like dark colors. Pineapples have a strong aroma compared to other foods. According to(Fatmasari, 2017)Pineapple waste contains 82.22% carbohydrates, 2.2% fat and 8.81% protein.

Based on the data in Table 1. the second highest average is for leftover rice waste. Leftover rice can attract the attention of Black Soldier Fly flies when they are about to lay their eggs, because this waste has a very strong odor because it has been fermented using EM4 or sugar. According to (Zahriani & Sutjahjo, 2017)Leftover rice has good nutritional content to feed the larvae that hatch later. The rest of the rice has a carbohydrate content of 40.6%, protein 2.1%, fat 0.1%. Rice waste gets the second highest average after pineapple waste because the criteria for attracting flies are almost the same, rice waste produces a foul smell that attracts flies. (Zahriani & Sutjahjo, 2017b).

The next waste that attracts the attention of Black Soldier Fly flies that lay their eggs are vegetables. All types of vegetables can be used as feed for Black Soldier Fly lures. The results of this research, researchers focused on wilted mustard greens and carrots. Wilted vegetables have a lower average value compared to pineapple waste and rice waste. Vegetables rot with the help of bacteria so that the rot produces a pungent odor. The pungent smell makes Black Soldier Fly flies want to lay eggs(Augusta et al., 2021). This vegetable waste also has sufficient water content to feed the eggs which will hatch into larvae (Pardede, 2013).

The last waste is leaves, this waste has the lowest average value compared to other waste. Based on researchers' observations, the leaves do not attract the attention of Black Soldier Fly flies to lay their eggs so few eggs are produced. The color of the leaves is striking at first, then the leaves will dry and smell unpleasant but not too strong. Based on table 1. research data, the number of eggs has a different number variant for each repetition, this is due to weather and sunlight factors. Light intensity and temperature are factors that influence mating activity. According to Zhang et al (2010) Generally, adult flies require high lighting to trigger Black Soldier Fly mating activity. In the research treatment, the weather at the Tlekung landfill when the flies were mating was cloudy and there was a lack of sunlight. Not all cages get direct sunlight, so the number of eggs produced is not large. A good cage must receive sufficient sunlight (Siagian et al., 2021). In the observation data table, there are several treatments that have a large number of eggs in each replication, this is because the cage receives sufficient sunlight.

The optimal temperature for maggot maintenance is 30°C which affects maggot growth. Rearing maggots at a temperature of 27°C causes maggot growth to be slower than at a temperature of 30°C (Ayu et al., 2023). In a period of 2 to 4 days, the egg will break into a baby maggot and develop into a young maggot in 22 to 24 days with an average of 18 days (Barros-Cordeiro et al. 2014).

Effect of Feed Type on Hatchability of Black Soldier Fly Eggs

Based on the data from Table 2. The highest hatchability was in pineapple waste with an average of 39.86% and the lowest hatchability was in leaf waste with an average of 0.85%. This data was then subjected to a one ANOVA test in Table 5. The results showed that there were significant differences in the type of feed that influenced the hatchability of Black Soldier Fly eggs with a sig value < 0.05. The next data will be tested by Duncan in Figure 2. with the results of the treatment that has the most influence on the hatchability of the Black Soldier Fly being the treatment of pineapple waste. This shows that the number of eggs in pineapple waste has quite significant differences.This research is in line with research Hermansyah et al. (2023) that the use of growth media from pineapple peel waste can increase the growth productivity of Black Soldier Fly. The water content of pineapple skin is very high, reaching 46 - 52%. Pineapple skin contains nutrients such as 8.78% crude protein and 17.09% crude fiber, 1.15% crude fat, 3.82% ash and 66.89% BETN. However, the use of pineapple waste, including the skin, crown and leaves of pineapple in feed at the same time, must be in a certain amount and balance (Raguati et al., 2018)

The factor of egg hatchability which is categorized from very low to very high is the quality of the eggs produced by the Black Soldier Fly. Apart from that, temperature also influences the hatchability of the eggs. Warm temperatures tend to encourage eggs to hatch more quickly than cold temperatures (Wardhana, 2016). Egg hatching media greatly influences the perfect hatchability of *Hermetia illucens* eggs, because good media does not contain pathogenic bacteria that can damage the eggs before they hatch. The larvae that have just hatched from the eggs are very small, around 1.8 mm. In contrast to adult flies, hatched larvae are photophobic(Gunawan et al., 2022). Newly hatched larvae live optimally at a temperature of 28-35°C with humidity of around 60-70% (Holmes et al., 2013).

Another factor that is thought to influence egg hatchability is humidity (Fahrizal, 2019). The cage used during the research was placed in a semi-enclosed room and the weather was very unstable, which affected the hatchability of the Black Soldier Fly. The best egg hatchability with an average of 39.86%. Eggs will hatch if the feed medium has sufficient water content. In leaf feed, the media lacks water content so few eggs hatch. In contrast pineapple waste, which has a water content of 85.78% (Khoirotun, 2017) and other feeds are comparable to pineapple waste. Black Soldier Fly eggs hatched and then counted at the age of 7 day larvae by pinching them one by one.

Conclusion:-

The conclusion of this research is that giving different types of feed affects the number of eggs and egg hatchability. The type of feed that has a higher influence on the number of eggs and hatchability of *Black Soldier Fly* eggs is pineapple waste and feed that has less influence is vegetables and leaves.

Conflicts of Interest
The authors declare no conflict of interest

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