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The potential of black soldier fly (*Hermetia illucens*) as a biological control for the house fly, *Musca domestica*

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Abstract: The presence of black soldier fly (BSF) in livestock farms has been shown to reduce house fly populations. It is believed caused by the interspecific interaction between these two species. The objective of this project is to evaluate the potential of BSF larvae as biological control agents for house flies in livestock farms. In the bioassay treatment of the effects of repelling house fly oviposition, the effectiveness of each treatment was measured by the number of hatching house fly larvae in each treated chicken manure samples. The less the number of house fly larvae the higher the effectiveness of the treatment. The bioassay's results show that there were significant differences in the number of house fly larvae hatched between controls treatment with 40 BSF treatment ($F = 170.93$, $df = 3$, $P < 0.01$) and 80 BSF treatment ($F = 529.99$, $df = 3$, $P < 0.01$). Meanwhile, there was no significant difference between treatments with 20 BSF ($F = 4.19$, $df = 3$, $P < 0.05$). The reduction of the house fly population regarding to the increasing of BSF larvae number in the treatment suggested the density-dependant factor alongside with the depletion of the nutrient in the treated manure for house fly larvae to growth.

Keywords: black soldier fly, house fly, biological control, insect population, waste management

1. Introduction

Currently, black soldier fly (BSF), *Hermetia illucens*, has been used globally as a component in the management of organic waste such as livestock waste. Its use is not just to reduce the pollution effect caused by livestock manure but also helps in reduce the population of house flies in livestock farms. The house fly, *Musca domestica*, is a species of fly that has been a vector for many diseases such as diarrhea and food poisoning. These house flies are easy to breed in livestock manure such as poultry and cattle in just 5 to 8 days (Larrain & Sallas, 2008; Miranda et al., 2019). Besides being a vector of various pathogens, their presence can also disturb livestock production and farm income (Graczyk et al., 2001). For decades, house fly has just been controlled using pesticides and this practice has built up the resistance in house flies (Busvine, 1959; El Basheir, 1967; Georghiou & Hawley, 1971) Therefore, an integrated control approach must be used, which the combination of biological and chemicals methods such as the use of BSF in livestock farm (Axtell, 1999; Miranda et al., 2019).

BSF is a versatile insect with a capacity for 50% organic waste (Myers et al., 2008) and provides 42% protein source and 35% fat overall (Sheppard et al., 1994). The presence of BSF in the manure can reduced the house fly population up to 90% (Sheppard 1983; Furman et al, 1959; Kilpatrick & Schoof, 1959). However, some of the studies suggested it is because of microbial composition changes such as *Escherichia coli* used by house flies for the growth in the manure (Schmidtmann & Martin, 1992; Rochon, 2003). In addition, it is believed that there are olfactory interactions between BSF and house flies in this case. Bradley & Sheppard (1984) first suggested that the presence of BSF not only reduced the larval population of house flies through competition with food sources but also suppressed allelic material, which is an allomone that acts to thwart the feeding activity of house flies.

This study will evaluate the effect of house fly egg laying activity on chicken manure treated with BSF larvae. Both species use livestock manure as a medium for breeding and feeding for their larvae. In the event of competition interaction, one of these species will dominate the source, i.e. manure, causing its population to increase while the other

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species will have a population decline. Understanding this natural interaction in depth can be manipulated as one of the methods of biological control in the future.

2. Materials and Methods

2.1 Study location

This study was conducted at the Entomology Laboratory, Malaysian Agricultural Research and Delevopment Institute Institute (MARDI) located in Serdang, Selangor. This laboratory has a temperature range of 27-28oC and relative humidity (RH) of 60-80%.

2.2 Black soldier fly culture

Fruit residues, such as jackfruit and banana skins were used as oviposition substrates to obtain eggs from scavenging black soldier fly (BSF), Hermetia illucens. The food baits are placed in a plastic box (35 x 25 x 20 cm). A hole (4.8 cm diameter) was made at the top of the box cover and covered with a plastic mesh (0.5 mm mesh size) that serves as a place for BSF flies to lay eggs. Fresh chicken manure (60 g; 1- 2 days old) contained in a polyethylene container (30 x 30 x 10 cm) was used as a breeding medium and replenished every week. The container was then placed in a net cage (30 x 30 x 30cm) to prevent larvae from escaping.

2.3 House fly culture

Adult house flies were obtained from the Entomology Laboratory, Medical Research Center (IMR), Kuala Lumpur. All samples were reared in Entomology Laboratory, MARDI Serdang at 27-28oC and relative humidity (RH) at 60-80% and placed in a net cage (50 x 50 x 50 cm; 5.5 mesh) with dietary sugar and skim milk (Sawicki, 1964). 60 grams of 1-2-day-old chicken manure filled in a 100-gram polyethylene container were also placed in the cage as a medium of oviposition.

For bioassay purposes, male and female adult house flies emerging from the poultry were left together for 48 hours. After 48 hours, adult female flies used for bioassay purposes were transferred to a new cage. These flies were given a diet of sugar water and skim milk and were left in the cage for 24 hours before being used for bioassay studies. This period is taken following the findings from Grtibel & Cave (1998) which stated that the period for the house fly to lay egg is between 3 and 4 days after mating.

2.4 Chicken manure sampling

Chicken manure samples were obtained from two poultry farms in Semenyih, Selangor. Fresh chicken manure not more than 24 hours after being secreted by the chicken was used as a study sample. Chicken manure was collected using a hand scoop and filled in a 'ziplock' plastic. All the samples were placed in an insulation box along with ice cubes to slow down the gas evaporation process of the stool sample. The samples were then sent directly to the laboratory for weighing and separated into 100 grams of plastic cups.

2.5 Determination of the effect of the presence of BSF larvae on chicken manure against the population of house fly.

The bioassay was conducted to determine whether the house fly would lay eggs on chicken manure exposed to BSF fly larvae. The experiment was divided into 2 factors, namely the effect of the number of BSF larvae and the effect of the BSF larval stage on the oviposition activity of house flies on chicken manure. The experimental method was based on Tomberlin's (2001) method with little modification. Each treatment used about 60 grams of chicken manure samples. For the effect of BSF larvae quantities, a total of three sets of individuals were used, 20, 40 and 80 BSF larvae, and for BSF larval stage effects three stages were used which were, 1-2, 3-4, and 5-6. These two factors were carried out simultaneously with each bioassay repeated 3 times. For the control, zero (0) BSF larvae were placed on the chicken manure.

Each treatment was placed separately in a polyethylene container (30 x 30 x 10 cm) which was inserted into a net cage (50 x 50 x 50 cm, 5.5 meshes). All BSF larvae were left for 24h on chicken manure before bioassay was initiated. During bioassay, 5 gravid adult female house flies were released into cages undergoing different treatments and left for 24 hours before re-release.

At the end of the bioassay, the number of house fly larvae obtained for each treatment was recorded. The number of larvae determines the degree of evasion of BSF larvae to the house fly larvae.

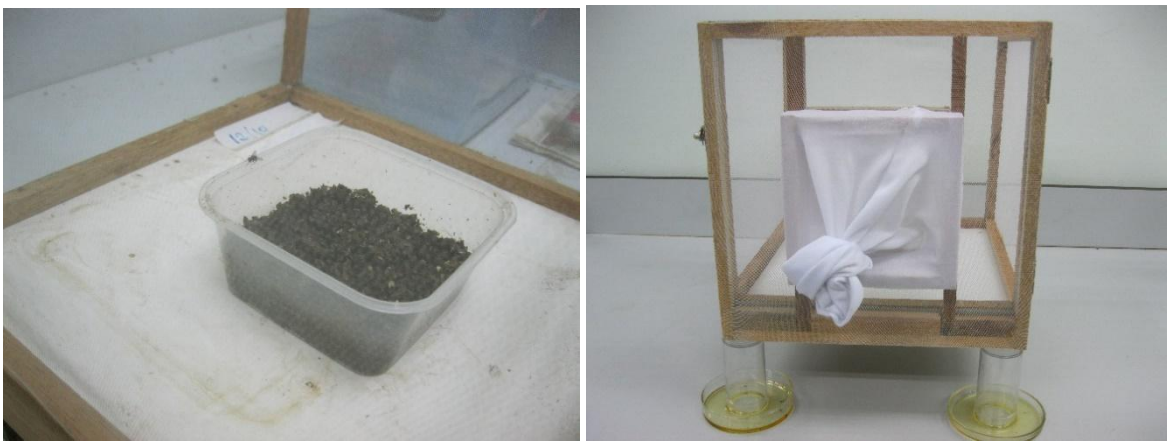

Fig. 1: All the treatments were placed separately in a polyethylene container (30 x 30 x 10 cm) and inserted into a net cage (50 x 50 x 50 cm, 5.5 meshes) to avoid contamination.

2.5 Statistical analysis

Data from the treatment of effects of BSF 20, 40 and 80 larvae and different larval stages and controls were analyzed using two-way analysis of variance (ANOVA). Tukey test of mean comparison was performed for significance ANOVA results (P = 0.05).

3. Results and Discussion

3.1 Determination of the effect of the presence of BSF larvae on chicken manure against the population of house fly.

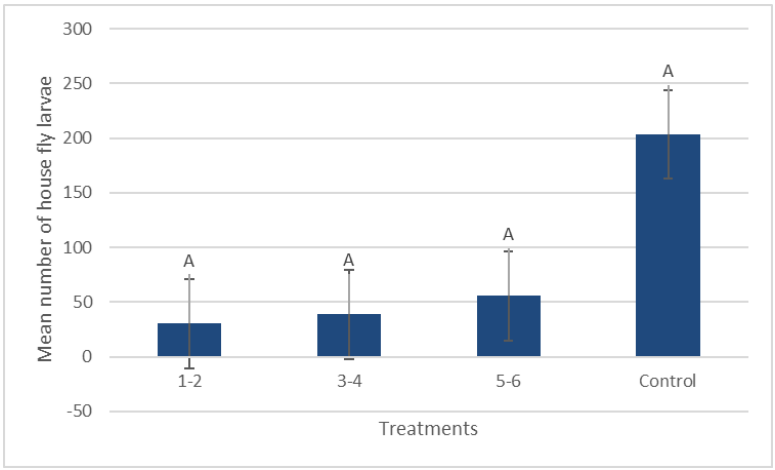

Fig. 2: The mean number of house fly larvae in chicken manure samples for 20 BSF treatment

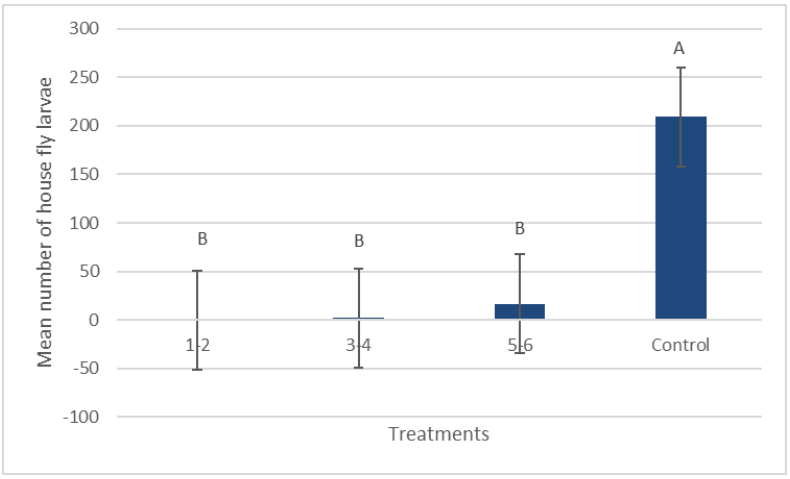

Fig. 3: The mean number of house fly larvae in chicken manure samples for 40 BSF treatment

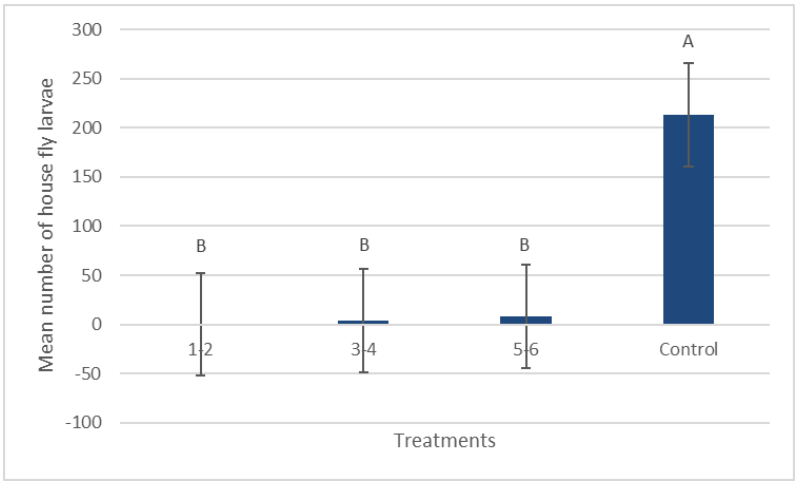

Fig. 4: The mean number of house fly larvae in chicken manure samples for 80 BSF treatment

In this bioassay treatment, the effectiveness of each treatment was measured by the number of hatching house larvae on each chicken manure sample. The less the number of house fly larvae the higher the effectiveness of the treatment. In Figure 2, the results showed that there were no significant differences ($F = 4.19$, $df = 3$, $P < 0.05$) in the number of house fly larvae hatched between controls, instar 1-2, instar 3-4 and instar 5-6 for 20 BSF treatment. Control treatment showed the highest mean number of house fly larvae (203.5 ± 114) followed by instar 5-6 (55.8 ± 3.53), instar 3-4 (38.7 ± 67) and instar 1-2 (30.2 ± 18.7). Meanwhile, in Figure 3, the results showed that there were significant differences ($F = 170.93$, $df = 3$, $P < 0.01$) in the number of house fly larvae hatched between control and other instar stages of BSF for 40 BSF treatment. The number of house fly larvae for control (209.40 ± 23.30), was the highest followed by instar 5-6 (16.78 ± 13.28), instar 3-4 (2.22 ± 2.55) and instar 1-2 (0.00 ± 0.00). There were also significant differences ($F = 529.99$, $df = 3$, $P < 0.01$) shown between the control and other instar stages in the treatment of 80 BSF in Figure 4. Control treatment showed the highest mean number of house fly larvae (213.44 ± 13.62) followed by instar 5-6 (8.11 ± 7.17), instar 3-4 (3.89 ± 3.4) and instar 1-2 (0.00 ± 0.00).

From the bioassay, the presence of BSF larvae in chicken manure can reduce the house fly population. The higher the number of BSF larvae, the more effectively the number of house flies is reduced. This may be due to the presence of volatile organic compounds (VOC) which disturbed the oviposition activity by house flies. As suggested by Bradley & Sheppard (1984) the presence of BSF reduced the larval population of house flies through the suppressed allelic material, which is an allomone that acts to prevent the feeding activity of house flies. They also suggested the decreased in the number of house flies reduced due to a decrease in the quality or lack of some nutrients in the manure due to the presence of BSF and the competition for food and space between the two species. From this experiment, it was found that the density of BSF larvae in the manure significantly affected the number of hatched house flies' larvae. This is in line with the findings reported by Furman et al. (1959) in the study. In the study, observations were made on 2 containers containing

poultry manure treated with 500 BSF larvae and without BSF larvae and exposed to gravid female house flies. It was found that containers containing manure with BSF larvae did not show the presence of house fly larvae. He suggested that this reaction was due to the effect of density on the manure medium.

There is also a suggestion linking the decline of house fly to the treated manure with BSF larvae due to the moisture content in the manure. The presence of BSF larvae causes higher moisture content and is not suitable for house flies to grow (Fatchurochim et al., 1989).

In addition, there has been a report from previous studies suggesting that the decline in house fly populations is due to the lack of nutrients in manure treated with BSF larvae. A study by Erickson et al. (2004) found that the presence of BSF larvae caused a decrease in *E. coli* content in the chicken manure in just 3 days. Bacteria of *E. coli* was one of the essential nutrients that house fly larvae need to grow (Schmidtmann & Martin, 1992).

Comparison for the different instar levels showed no significant differences. This can be explained by the biological properties of BSF and house fly. BSF larvae have a longer shelf life than house fly larvae of about 16 - 20 days compared to house fly of only 6 days (Ong et al., 2017). The biological nature of adult BSF that do not need food (Sheppard et al., 2002) causes them to use more digestive enzymes to feed more efficiently during larval stages (Gobbi et al., 2013). This makes every stage of the BSF larvae feed actively and contributes to the faster and more efficient manure decomposing process.

4. Conclusion

This preliminary study shows the potential of BSF larvae to reduce the house fly population. The number of BSF larvae exposed to the manure plays an important role in ensuring better results. In addition, to get a better effect the BSF larvae should also be exposed to the fresh manure to avoid the house fly laying the eggs first on the manure.

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Conflict of Interest

The authors declare no conflicts of interest.

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