Acta Scientific Veterinary Sciences (ISSN: 2582-3183)

Volume 6 Issue 3 March 2024

Research Article

Improving Breeding Efficiency of Local Population of Black Soldier Fly (*Hermetia Illucens*) (Stratiomyidae: Diptera) by Crossing with a Distant Thrissur Population and Evaluation of the Progeny

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DOI: 10.31080/ASVS.2024.06.0841

Received: January 22, 2024

Published: February 25, 2024

Abstract

The black soldier fly, *Hermetia illucens* is a much sought after insect now a days for waste management and also as an alternative source of proteins for animals, poultries and fish. It is being reared on large scale in commercial farms in various parts of the world including Africa to cater to the needs of the poultries, piggeries, protein processing units or waste management units. However, with increase in the commercial value of the insect, breeding programs have been focusing on populations that have shorter life cycles and robust larvae. Moreover, there is every possibility of gene transfer between populations thriving in close proximity and this could lead to changes in the physiology and life cycle durations which may further influence production procedures in commercial rearing units. Hence, detailed studies were carried out in the laboratory to study the possibility of improving breeding efficiency of locally available Medipalle population by crossing it with a distant Thrissur populations and understand the effects of cross mating on the progeny also.

Keywords: Black Soldier Fly; Cross Mating; Progeny; Waste Management; Breeding Efficiency

Abbreviations

BSF: Black Soldier Fly; ^{0}C: Degree Centrigrade; %: Percentage; DOL: Day old Larvae; Kg: Kilogram; g: Gram

m^3: Cubic Metre; Cm: Centimetre

Introduction

Globally, one-third of all food produced is wasted, amounting to 1.3 billion tons per year. At the same time, there is a constant search for sustainable solutions to mitigate climate change, rejuvenate soils, bolster food production, and provide people with healthy, nutritious diets. Waste disposal is also a big problem in many parts of the world. However, a number of insects, e.g., larvae of the black soldier fly (Hermetia illucens), the common house fly (Musca domestica), and certain mealworm species, can also be used for this purpose [1]. As the world grapples with challenges of sustainable agriculture, food security, and climate resilience, the black soldier fly offers a compelling solution. It is native to many regions of Africa and offers solution for problems cited here as it has the potential to convert organic wastes to nutrient rich manure, while the larva accumulates good amounts of crude protein and crude fat and served as an important source of proteins. Its commercial cultivationhas become popular among the farmers and entrepreneurs of various countries of the world. African farms grow the insect for the larvae and frass which can serve as an additive to vermicompost or farm yard manure due to its nitrogen, phosphorus and potassium. The larvae have an outstanding ability to convert organic waste (consisting of mixed or separate waste) into biomass rich in fat and protein [2] and have good nutritional potential [3,4]. Larvae can ingest a range of organic wastes including animal manure [5], municipal organic waste [6], food waste [7], crop straw [8] and empty fruit bunches [9]. Crude protein and crude lipid contents of BSFL meal range between 40%-44% and 15%-49%, respectively, depending on the processing methods and substrates used [10]. BSFL cannot transmit parasites or diseases when used in feed, despite feeding on waste, spoiled feed, and manure [11].

This species is native to the Neotropical realm, but in recent decades has spread across all continents, becoming virtually cosmopolitan [12] and has been recorded throughout the world, in both tropical and temperate climates across the Americas, Europe, Africa, and Asia [13]. Made a phylogenetic analysis and showed that specific haplotypic populations from the Palearctic Oriental, Afrotropic, Australasian, and Nearctic biogeographic realms have a closer relationship or a single ancestral origin with Indian haplotypes, which is likely due to anthropogenic factors, resulting in the cosmopolitan distribution of this new world originated spectrum fly. In India, presence of the fly has been recorded from all the states. Populations that occur close to each other or are more alike, linkedby greater amounts of gene exchange, than populations that occur farther apart, the probability of causing gene flow by dispersion decreases with distance between the source and recipient populations (sink) [14]. Hence, in the present study the impact of cross mating of two geographically distant populations and their progeny characteristics was studied in detail and this helps to explore the possibility of enhancing production levels through breeding programmes.

Materials and Methods

Collection and maintenance of Black soldier fly populations of Medipalle and Thrissur

Black soldier fly population was collected from a farmer from Medipalle village in Rangareddy district of Telangana state and this was designated as "Medipalle population". Rearing methods were adopted mainly from [15] and [16] with some modifications. Similarly, Thrissur population was collected from a commercial rearing unit in Thrissur, Kerala.

Rearing and maintenance of black soldier fly stock cultures

The insects were maintained at 26-28^{0}C temperature and 70 % relative humidity in a glass house attached to the laboratory. Maintenance of the larvae is discussed under four side heads as below.

Nursery

Eggs collected were incubated in open petridish placed above nursery feed (Gainesville diet 70% moisture) in plastic trays. Standard diet used was Gainesville diet for rearing of BSF larvae for scientific experiments in laboratory condition. Constituents of Gainesville diet were Alfalfa meal (30%), wheat bran (50%) and Corn meal (20%). To incubate 1 g of egg, 200 g GV diet (70% moisture) was prepared by mixing 30g of wheat bran, 18 g of alfalfa meal and 12g of cornmeal in 140 ml ofwater [17]. After 5 days of hatching, 6 day old larvae were separated and the average weight of 6 day old larvae were recorded.

Stock larvae maintenance

For maintaining larval stock, Gainesville diet was prepared and placed in plastic trays (50cm × 30cm × 15cm). In each tray 3 kg of feed were placed and 3000 6-day old larvae were released for feeding. After 5 days again 3 kg of feed was added. When 90 % population transformed into pre- pupae, the frass and undigested material were separated [18,19].

Maintenance of pupae in net cages

Separated pre-pupae were pupated in moist cocopeat placed in plastic trays and kept inside cages made of mosquito nets.

Maintenance of adults in cage

After adults emerged, water trays (for moisture and humidity), attractant (mixture of 100g dead flies, 200g nursery residue, 200g of old attractant residue in 1 L of water) and egg collecting devices (Eggies) were kept for oviposition [20]. After egg laying, eggies were removed from the love cage net cages), eggs were scrapped and incubated for next generation.

For the experiment, male and female of the adult stages were separated based on genital dimorphism given by [21], 100 females of Thrissur population and 100 males of Medipalle population were placed in a mating cage along with decaying matter as an oviposition stimulant and wooden egg holders to facilitate egg laying by the female. 7 such mating cages were set up. Also, 100 males of Thrissur population and 100 females of Medipalle population were placed in a mating cage along with decaying matter as an oviposition stimulant and wooden egg holders to facilitate egg laying by the female. 7 such mating cages were set up and observations on number of egg clutches laid in each cage were recorded daily.

Observations on Incubation period (days), larval period (days), pre-pupal period (days), pupal period (days), adult longevity (days), fecundity, Adult emergence (%), Hatching percentage (%), No of egg clutches laid by the female and total life period of progeny were recorded of Medipalle male x Thrissur female and Thrissur male x Medipalle female populations. Morphometric observations on the following parameters were taken for the progeny of Medipalle male x Thrissur female and Thrissur male x Medipalle female. Further, the robustness of the larvae, pre-pupae and pupae were also recorded in terms of length and weight of larvae and pupae at 6 DOL,10 DOL,14 DOLand 18 DOL using ZEISS Stemi 508 Stereo Zoom Microscope and Analytical balance of Medipalle malex Thrissur female and Thrissur male x Medipalle female.

Results and Discussion

Results revealed that incubation period of eggs, prepupal and pupal durations, total life cycle and number of eggs in each cage did not differ significantly between progeny of Medipalle male x Thrissur female (4.57 ± 0.79 days, 10.71 ± 0.95 days, 9.43 ± 0.79 days, 61.57 ± 3.31 days and 7.79 ± 4.42 respectively) and Thrissur male x Medipalle female (4.86 ± 0.90 days, 11.43 ± 0.53 days, 8.57 ± 0.79 days, 60.86 ± 1.07 days and 7.07 ± 3.54 respectively) and they were on par (Table.1.). Larval duration was significantly higher in Thrissur male x Medipalle female offspring (25.60 ± 0.79 days) compared to Medipalle male x Thrissur female offspring (22.60 ± 0.79 days) implying that the former completes life cycle early and suits the needs of a commercial farm. Adult duration was significantly higher in Medipalle male x Thrissur female progeny (14.80 ± 0.84 days) compared to Thrissur male xMedipalle female progeny (11.00 ± 1.87 days) indicating that it could be highly preferred in commercial farms than Thrissur male x Medipalle female cross. Moreover, adult emergence and hatching percentage were also significantly higher in Medipalle male x Thrissur female progeny (84.00 ± 16.73% and 42.00 ± 9.00 % respectively) compared to Thrissur male x Medipalle female progeny (56.00 ± 16.73% and 28.00 ± 10.00% respectively), which made the latter a better choice compared to the former for units which rear the larvae for commerce. [16] studied the life history parameters of Black soldier fly progeny populations under five breeding densities. Oviposition periods were much smaller (11 ± 0.7 days) for the lowest density (500 individuals/m^3) than for the higher densities (2500 individuals/m^3 (16.5 ± 0.6 days), 4500 individuals/m^3 (15.3 ± 0.3 days), 6500 individuals/m^3 (16.2 ± 0.6 days), 8500 individuals/m^3 (15.8 ± 0.6 days) [5]. observed female adult longevity of 13.17 ± 0.86 days, 12.68 ± 0.23 days, 10.09 ± 0.23 days respectively and male adult longevity of 13.20 ± 0.61 days, 12.73 ± 0.90 days,10.13 ± 0.56 days respectively Wuhan, Guangzhou and Texas Black soldier fly strains when reared on Gainesville diet.

[22] observed that in 100% homogenous populations of Black soldier fly, hatching level of large males mated with large females was 43.00 ± 31.28 %. Similarly, when small males mated with small females hatching was to an extent of 47.00 ± 20.16 % [23]. Observed that hatchability of black soldierfly eggs was higher in F4 than F1 generation [24]. Showed that fertility level (%) of Black soldier fly egg clutches PRST colony was 91.4 ± 5.3 %, 13 % and 5 % respectively when the adults were exposed to the BSFLED, HALO, LEDUV lights.

Length and weight of the larva

Results revealed that lengths of 6,14,18 DOL and prepupae were significantly higher in Medipalle male x Thrissur female offspring (0.48 ± 0.05 cm, 1.66 ± 0.04 cm, 1.81 ± 0.05 cm respectively) compared to those in Thrissur male x Medipalle female offspring (0.39 ± 0.01 cm, 1.55 ± 0.05 cm, 1.74 ± 0.07 cm respectively), whereas at 10 DOL length was significantly higher in Thrissur male x Medipalle female offspring (1.35 ± 0.05 cm) compared to Medipalle male x Thrissur female offspring(1.14 ± 0.05 cm). A quick increase in length was observed in Thrissur male x Medipalle female progeny from 6^{th} to 10^{th} day (Table 2). Similar results were obtained by [25] who observed that in the Wuhan and Inbred Black soldier fly strains larval body length increased quickly from 6^{th} day to 12^{th} day but reduced after the 14^{th} day. Larval body length reached maximum at 22.0 ± 1.2 mm for the Wuhan strain and 21.4 ± 1.0 mm for the inbred strain.

Weight of 6 and 10 DOL and pupa was significantly higher in Thrissur male x Medipalle female progeny (0.004 ± 0.0004 g per larvae and 0.07 ± 0.006 g per larvae, 0.10 ± 0.007g respectively) compared to Medipalle male x Thrissur female progeny (0.002 ± 0.001g per larvae and 0.04 ± 0.004 g per larvae and 0.09 ± 0.007g respectively). However, the weight of 14 and 18 DOL did not differ significantly between Medipalle male x Thrissur female progeny (0.15 ± 0.02 g per larvae) and 0.14 ± 0.01g per larvae respectively) and Thrissur male x Medipalle female progeny (0.15 ± 0.03 g per larvae, 0.13 ± 0.02 g per larvae respectively) (Table 3). However, no significant difference was observed between Medipalle male x Thrissur female progeny (0.11 ± 0.01 g per prepupae) andThrissur male x Medipalle female progeny (0.12 ± 0.01 g per prepupae).

[5] observed that weights of final instar larvae of Wuhan, Guangzhou and Texas Black soldier fly strains when reared on Gainesville diet were 0.1701 ± 0.0013 g, 0.1456 ± 0.0078 g, 0.1071 ± 0.0022 g respectively and those of pre-pupae were 0.1100 ± 0.0058g, 0.0876 ± 0.0037g, 0.0766 ± 0.0049g respectively [26]. investigated the outcome of the selected body weight line against the basic population line through six experimental rounds under various environmental conditions. The selected line exceeded the base population line by 39% in larval weight per crate under automated production settings [25]. Observed that body weights of prepupa of Wuhan and Inbred Black soldier fly strains were 18.5 g per 100 prepupae in Wuhan strain, 19 g per 100 prepupae in Inbred strain) which was higher than body weights of pupae of Wuhan strain (18 g per 100 pupae) and Inbred strain (17 g per 100 pupae).

Conclusion

Thus, from the present study it could be concluded that progeny of the Medipalle male x Thrissur female were found to be more robust compared to Thrissur male x Medipalle female progeny and had longer larvae and prepupae and heavier pupae. Such progeny may be better preferred for commercial farms as separation process of the larvae from the substrate is easy for larger larvae.

Acknowledgements

The authors are thankful to the Department of Entomology, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad and AICRP on Biological Control of Crop Pests and Diseases, ARI, Rajendranagar, Hyderabad for providing necessary infrastructural facilities and financial support to conduct this research work. Help with black soldier fly cultures from the ICAR-NAHEP Project on Black soldier fly operating at PJTSAU, Rajendranagar is gratefully acknowledged.

Conflict of Interest

The authors declare that there are no financial interests or any conflict ofinterests from the work.

Bibliography

1. Oonincx DGAB., *et al.* "Feed Conversion, Survival and Development, and Composition of Four Insect Species on Diets Composed of Food By-Products". *PLoS One* 10.12 (2015): 2015.
2. Gao Z., *et al.* "Bioconversion performance and life table of black soldier fly (Hermetia illucens) on fermented maize straw". *Journal of Cleaner Production* 230.1 (2019): 974-980
3. Zozo B., *et al.* "The Nutritional Quality and Structural Analysis of Black Soldier Fly LarvaeFlour before and after Defatting". *Insects* 13 (2022): 168.
4. Bessa LW., *et al*. "Why for feed and not for human consumption? The black soldier fly larvae". *Comprehensive Reviews in Food Science and Food Safety* 19.5 (2020): 2747-2763.
5. Zhou F., *et al.* "Developmental and Waste Reduction Plasticity of Three Black Soldier FlyStrains (Diptera: Stratiomyidae) Raised on Different Livestock Manures". *Journal of Medical Entomology* 50 (2013): 1224-1230.
6. M Kalova and M Borkovcova. "Voracious larvae Hermetia illucens and treatment of selected types of biodegradable waste". *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis* 61 (2013): 7.
7. Salomone R., *et al.* "Environmental impact of food waste bioconversion by insects: Application of Life Cycle Assessment to process using *Hermetia illucens"*. *Journal of Cleaner Production* 140.2 (2017): 890-905.
8. R Manurung A., *et al.* "Bioconversion of rice straw waste by black soldier fly larvae (*Hermetia illucens* L.): optimal feed rate for biomass production". *Journal of Entomology and Zoology Studies*4.4 (2016): 1036-1041.
9. Dickinson E., *et al.* "From waste to food: optimising the breakdown of oil palm waste to provide substrate for insects farmed as animal feed". *PLoS One* 14.11 (2019): e0224771.
10. Makkar HPS., *et al.* "State-of-the-art on use of insects as animal feed". *Animal Feed Science and Technology* 197 (2014): 1-33.
11. Van Huis J., *et al.* "Edible insects - Future prospects for food and feed security". FAO ForestryPaper 171.Food and Agriculture Organization of the United Nations, Rome (2013).
12. Marshall SA., *et al.* "The historical spread of the Black soldier Fly, *Hermetia illucens* (L.) (Diptera, Stratiomyidae, Hermetiinae), and its establishment in Canada". *The Journal of the Entomological Society of Ontario* 146 (2015): 51-54.
13. Ebeneezar S., *et al.* "Nutritional evaluation, bioconversion performance and phylogenetic assessment of black soldier fly (Hermetia illucens, Linn. 1758) larvae valorized from food waste". *Environmental Technology and Innovation* 23 (2020): 1017-1083.
14. Bayne BL. "Developments in Aquaculture and Fisheries Science". *Biology of Oysters* 41 (2017): 89-138.
15. Sheppard DC., *et al.* "Rearing methods for the black soldier fly (Diptera: Stratiomyidae)". *Journal of Medical Entomology* 39.4 (2002): 695-698.
16. Hoc B., *et al.* "Optimization of black soldier fly (*Hermetia illucens*) artificial reproduction". *PloS One* 14.4 (2019): e0216160.
17. Hogsette JA. "New diets for production of house flies and stable flies (Diptera: Muscidae) in the laboratory". *Journal of Economic Entomology* 85.6 (1992): 2291-2294.
18. Diener S., *et al.* "Conversion of organic material by black soldier fly larvae: establishing optimal feeding rates". *Waste Management and Research* 27.6 (2020): 603-610.
19. Yang F and Tomberlin JK. "Comparing selected life-history traits of black soldier fly (Diptera: Stratiomyidae) larvae produced in industrial and bench-top-sized containers". *Journal of Insect Science* 20.5 (2020): 25.

20. Dortmans., *et al.* "Black Soldier Fly Biowaste Processing - A Step-by-Step Guide". second ed. Swiss Federal Institute of Aquatic Science and Technology, Dübendorf, Switzerland, Eawag (2021).

21. Julita U., *et al.* "Mating success and reproductive behaviour of black soldier fly *Hermetia illucens* L. (Diptera, Stratiomyidae) in tropics". *Journal of Entomology* 17.3 (2020): 117-127.

22. Jones BM and Tomberlin JK. "Effects of adult body size on mating success of the black soldier fly, *Hermetia illucens* (L.) (Diptera: Stratiomyidae)". *Journal of Insects as Food and Feed* 7.1 (2021): 5- 20.

23. Badenhorst R. "Genetic diversity in a commercial black soldier fly, *Hermetia illucens* (Diptera:Stratiomyidae), population". (Doctoral dissertation, Stellenbosch: Stellenbosch University) (2017): 134.

24. Liu Z., *et al.* "Mating success of the black soldier fly, *Hermetiaillucens* (Diptera: Stratiomyidae), under four artificial light sources". *Journal of Photochemistry and Photobiology B: Biology* 205 (2020): 111815.

25. Cai M., *et al.* "Morphometric Characteristic of Black Soldier Fly (*Hermetia illucens*). Wuhan Strain and Its Egg Production Improved by Selectively Inbreeding. *Life* 12.6 (2022): 873.

26. Facchini E., *et al.* "Long-term artificial selection for increased larval body weight of *Hermetia illucens* in industrial settings". *Frontiers in Genetics* 13 (2022): 1503.