American Journal of Animal and Veterinary Sciences

Research Article

Morphology of Female Adult Black Soldier Fly Under Slaughterhouse Waste and Rice Bran Growing Medium

Fadilla Rizkia Fasha, Dedes Amertaningtyas, Faizal Andri and Nurul Isnaini

Faculty of Animal Science, Universitas Brawijaya, Malang, Indonesia

Article history
Received: 24-02-2025
Revised: 16-05-2025
Accepted: 20-05-2025

Corresponding Author:
Nurul Isnaini
Faculty of Animal Science,
Universitas Brawijaya, Malang,
Indonesia
Email: nurulisna@ub.ac.id

Abstract: The effectiveness of Black Soldier Fly (BSF) farming within a sustainable waste management framework heavily depends on the choice of a suitable rearing substrate. This study aimed to assess the morphological characteristics of female adult BSF reared on growing media composed of slaughterhouse waste (SW) and rice bran (RB). This study was conducted at the Laboratory of Animal Reproduction, Faculty of Animal Science, Universitas Brawijaya, Indonesia. This study employed an experimental approach using a completely randomized design, consisting of five treatment groups with six replications each. The treatments used in this study T0: 100% SW (control), T1: 75% SW + 25% RB, T2: 50% SW + 50% RB, T3: 25% SW + 75% RB, and T4: 100% RB. The results demonstrated that antennae width, antennae length, head length, head width, wing length, wing width, front leg length, front leg width, middle leg width, middle leg length, back leg width, and back leg length did not significantly differ ($P>0.05$) among treatments. However, SW and RB growing medium significantly affect ($P<0.05$) body length, body width, abdomen width, and abdomen length. In conclusion, while the primary aim was to assess morphological variation, these results suggest that the composition of the growing medium can influence body size traits in female adult BSF. An increased proportion of RB led to improved body dimensions, particularly in the abdomen, which may have implications for future applications involving selective breeding or reproductive performance.

Keywords: Black Soldier Fly, Morphology, Rice Bran, Slaughterhouse Waste, Sustainable

Introduction

The swift growth of agri-food industries to meet the demands of the global population has brought about major challenges, including the generation of large volumes of organic waste. Slaughterhouses are among the facilities that generate substantial quantities of organic waste, presenting a serious environmental concern if not properly managed (Dada *et al.*, 2021; Ragasri and Sabumon, 2023). The Black Soldier Fly (BSF), a non-pest insect species, is increasingly acknowledged for its remarkable capacity to transform organic waste into valuable biomass. Its larvae effectively break down organic materials, converting them into nutrient-dense insect biomass (Salam *et al.*, 2022; Isnaini *et al.*, 2023). These larvae have diverse applications, including their use as animal and aquaculture feed (Bessa *et al.*, 2020). Moreover, the residue from the BSF growing medium can serve as a biofertilizer (Song *et al.*, 2021).

The effectiveness of BSF farming within a sustainable waste management framework largely depends on the choice of a suitable rearing substrate (Wiyoso *et al.*, 2023). The substrate should provide the necessary nutrients for the larvae and serve as a supportive environment for their optimal growth. Slaughterhouse waste (SW) contains a variety of nutrient-dense materials, such as rumen contents and leftover animal tissues, making it a promising resource for cultivating BSF larvae (Limeneh *et al.*, 2022; Fasha *et al.*, 2024). The potential of SW as a growing medium for BSF remains a compelling and largely unexplored avenue.

Rice bran (RB) is another viable substrate for BSF cultivation, offering vital proteins, fats, and carbohydrates necessary for the larvae's proper growth and development (Sapwarobol *et al.*, 2021). A well-balanced mixture of SW and RB may offer a more effective rearing medium than using either material

individually. Therefore, this study investigated the impact of using a combined SW and RB medium on the body morphological traits of adult female BSF.

Materials & Methods

Experimental Design

This study employed a completely randomized design with five treatments and six replicates. The treatments used in this study were T0: 100% SW, T1: 75% SW + 25% RB, T2: 50% SW + 50% RB, T3: 25% SW + 75% RB, and T4: 100% RB. SW was firstly fermented with EM-4 under room temperature for a period of 7 days. SW was then mixed with RB according to the treatments. The growing medium was fed after BSF reaching 7 days old. The growing medium was added weekly, with each replicate receiving 500 grams. Prior to feeding the BSF larvae, the medium was combined with clean water at a 1:1 ratio.

Measurement of Morphological Characteristics

Five females adult BSF per replicate (totaling 150 females adult BSF) were carefully collected for measurement of body morphological characteristics. The measurement including body length, body width, antennae length, antennae width, head length, head width, abdomen length, abdomen width, wing length, wing width, front leg length, front leg width, middle leg length, middle leg width, back leg length, and back leg width. Morphological measurements were obtained using a digital caliper.

Data Analysis

The data were analyzed using IBM SPSS Statistics version 25. A one-way ANOVA was conducted to evaluate the data, with a significance threshold set at $P<0.05$. When significant differences were detected, Duncan's post hoc test was used to compare the means among the treatment groups.

Results and Discussion

This study assessed the impact of differential formulations of rearing substrates composed of SW and RB on the morphometric parameters of adult female BSF. This study focused exclusively on female BSF due to their critical role in egg production, which directly influences the reproductive success and sustainability of BSF colonies in mass-rearing systems.

Table 1: Effects of slaughterhouse waste and rice bran medium on body morphological characteristics of female adult black soldier fly

Variables[1]	Growing Medium					SEM	P-value
	T0	T1	T2	T3	T4		
BL	10.98^{a}	11.34^{ab}	11.39^{ab}	12.23^{bc}	12.57^{c}	0.193	0.034
BW	2.50^{a}	2.57^{a}	2.47^{a}	2.72^{a}	3.11^{b}	0.061	0.001
AnL	2.32	2.93	3.02	3.09	3.34	0.160	0.351
AnW	0.31	0.32	0.32	0.35	0.34	0.009	0.737
HL	1.07	1.03	1.05	1.09	1.14	0.018	0.399
HW	2.55	2.68	2.92	2.50	2.93	0.101	0.561
AbL	5.29^{a}	5.55^{a}	5.68^{a}	5.68^{a}	6.17^{b}	0.079	0.004
AbW	2.38^{a}	2.57^{a}	2.51^{a}	2.58^{a}	3.07^{b}	0.057	0.001
WL	7.03	8.30	8.19	8.43	8.98	0.268	0.228
WW	2.60	2.61	2.72	2.75	2.95	0.048	0.134
FLL	4.32	4.43	4.64	4.53	4.88	0.085	0.291
FLW	0.29	0.34	0.32	0.36	0.37	0.014	0.425
MLL	6.05	6.07	6.16	6.04	6.34	0.092	0.851
MLW	0.36	0.36	0.33	0.39	0.34	0.020	0.952
BLL	7.57	7.77	8.02	7.85	8.28	0.093	0.145
BLW	0.34	0.35	0.35	0.39	0.36	0.020	0.970

$^{a-c}$Uncommon superscript within a row indicate a significant different ($P<0.05$)
[1]BL: Body Length (mm), BW: Body Width (mm), AnL: Antennae Length (mm), AnW: Antennae Width (mm), HL: Head Length (mm), HW: Head Width (mm), AbL: Abdomen Length (mm), AbW: Abdomen Width (mm), WL: Wings Length (mm), WW: Wings Width (mm), FLL: Front Leg Length (mm), FLW: Front Leg Width (mm), MLL: Middle Leg Length (mm), MLW: Middle Leg Width (mm), BLL: Back Leg Length (mm), BLW: Back Leg Width (mm)

The results in Table 1 indicate significant variations in some morphological parameters across treatments. Body length showed significant differences among treatments ($P<0.05$), with the highest value recorded in T4 and the lowest in T0 (Figure 1A). Body width also exhibited significant variation ($P<0.05$), where T4 flies had the highest width (Figure 1B), suggesting that increased RB content positively influenced overall body size. Abdomen length and abdomen width were significantly different across treatments ($P<0.05$), with T4 showing the highest values (Figure 1C and 1D), indicating potential enhancement in abdominal

development with increased RB proportion. However, other measured traits such as antennae length, antennae width, head length, head width, wing length, wing width, and leg measurements did not show significant differences ($P > 0.05$), implying that these characteristics might be less responsive to dietary modifications.

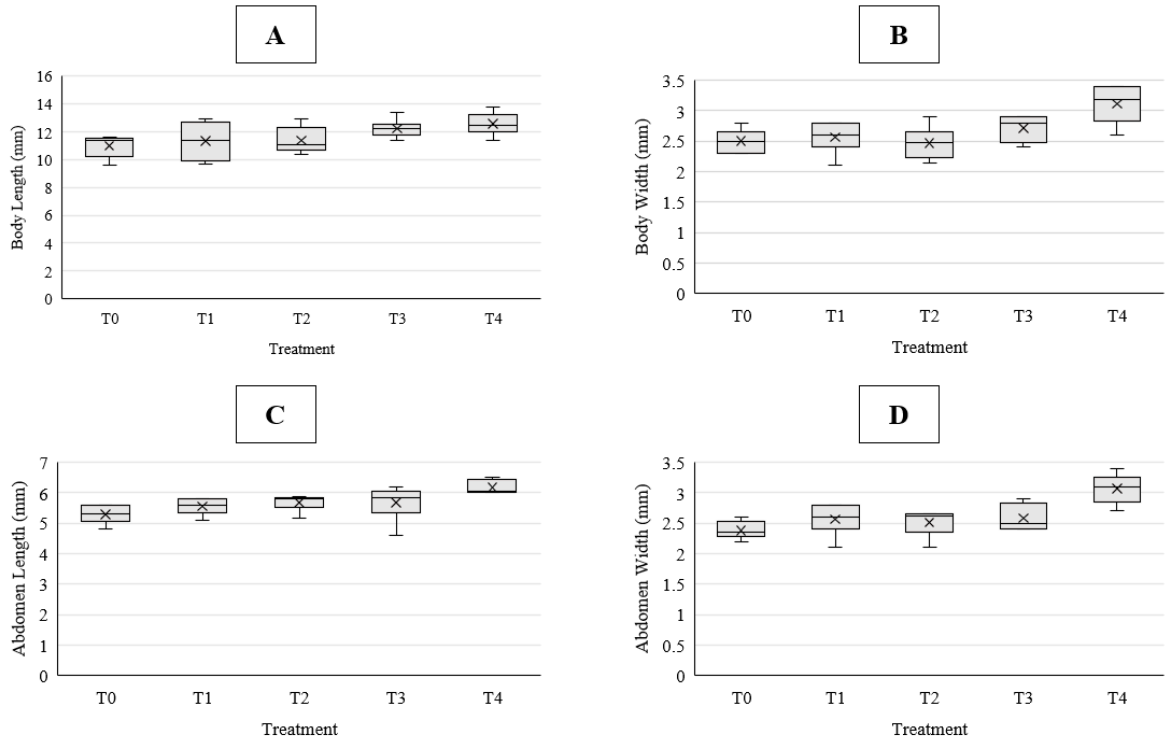

Fig. 1: Effects of slaughterhouse waste and rice bran medium on body length (A), body width (B), abdomen length (C), and abdomen width (D)

The findings suggest that an increased proportion of RB in the growing medium may contribute to improved overall body size in BSF, particularly in traits related to body length and width. The enhanced body dimensions observed in T4 could be attributed to the nutrient-rich nature of RB, which may have promoted better larval growth and development. The use of SW as growing medium has several obstacles, particularly due to the high lignocellulosic content. Total lignocellulose content in SW was 87% (Bai *et al.*, 2023). These lignocellulosic contents were difficult to digest by BSF larvae, so that it may compromise the growth of BSF (Gold *et al.*, 2020; Liu *et al.*, 2021). The use of RB can enhance the growth of BSF because this media could be used as a nitrogen source. RB contained 22,471 mg/kg nitrogen (Rashid *et al.*, 2023), while SW only had 2,083 mg/kg nitrogen (Bai *et al.*, 2023). Nitrogen availability plays a vital role in supporting microbial proliferation and the synthesis of enzymes involved in lignocellulose breakdown (Palma *et al.*, 2019). Therefore, the additional nitrogen provided by RB is expected to enhance the growth of Black Soldier Fly larvae.

Body dimensions play a crucial role in the productivity of adult female BSF, particularly in relation to their reproductive capacity. The abdomen part as a key morphological feature directly influences the egg-laying potential of the female. Since the black soldier fly does not feed as an adult, its reproductive potential largely depends on the nutrients accumulated during the larval stage. A broader and longer abdomen signifies a more energy reserve, which translates into higher reproductive efficiency in adulthood (Oliveira *et al.*, 2016; Cai *et al.*, 2022). Additionally, a larger abdomen length and width indicate greater space for egg development (Tomberlin *et al.*, 2002), potentially increasing fecundity. The relationship between body size and reproductive performance is vital in optimizing mass production of black soldier flies for industrial applications, including waste bioconversion and sustainable protein production for animal feed. Ensuring optimal dietary formulations that enhance abdomen dimensions can improve breeding efficiency, reduce generation time, and enhance sustainability in large-scale insect farming.

The use of SW as a growing medium for BSF farming also presents opportunities for economic viability and scalability. SW is abundantly available and often underutilized (Limeneh *et al.*, 2022; Ragasri and Sabumon, 2023), making it a low-cost and sustainable

input for large-scale BSF production. By diverting this waste from conventional disposal routes, producers may reduce operational costs associated with waste management while simultaneously generating high-value insect biomass.

Conclusion

In conclusion, the composition of the growing medium plays a critical role in influencing the morphological traits of female adult Black Soldier Flies. Increasing the proportion of RB was associated with larger body and abdomen dimensions, indicating that certain morphological parameters are responsive to substrate composition. While the primary aim of this study was to assess these morphological changes, the findings may offer valuable insights for future applications where body size traits are relevant, such as reproductive capacity or mass yield in BSF production systems. Future research should focus on understanding the biological mechanisms behind these morphological responses and explore whether they translate into functional advantages across the insect's life cycle.

Acknowledgment

The authors gratefully acknowledge the Faculty of Animal Science, Universitas Brawijaya, for providing the facilities that supported this research.

Funding Information

This research was funded by the Directorate of Research and Community Services, Universitas Brawijaya, through the Professor Research Ecosystem Strengthening Grant under contract number 1759.1.19/UN10.C20/2023.

Authors' Contributions

Fadilla Rizkia Fasha was participated in the conceptualization, investigation, data collection, writing of the original draft, and give final approval of the version of to be submitted and any revised version.

Dedes Amertaningtyas and **Faizal Andri** involved in the conceptualization, experimental design, data analysis, writing of the original draft, and give final approval of the version of to be submitted and any revised version.

Nurul Isnaini contributed in the conceptualization, experimental design, interpretation of data, critically reviewing and editing the manuscript for substantial intellectual content, and give final approval of the version of to be submitted and any revised version.

Ethics

The article presents original content that has not been previously published. All authors have reviewed and approved the version to be submitted and any revised version, and no ethical concerns are involved.

References

Bai, X., Grassino, M., & Jensen, P. D. (2023). Effect of alkaline pre-treatment on hydrolysis rate and methane production during anaerobic digestion of paunch solid waste. *Waste Management*, *171*, 303–312. https://doi.org/10.1016/j.wasman.2023.08.027

Bessa, L. W., Pieterse, E., Marais, J., & Hoffman, L. C. (2020). Why for feed and not for human consumption? The black soldier fly larvae. *Comprehensive Reviews in Food Science and Food Safety*, *19*(5), 2747–2763. https://doi.org/10.1111/1541-4337.12609

Cai, M., Li, L., Zhao, Z., Zhang, K., Li, F., Yu, C., Yuan, R., Zhou, B., Ren, Z., Yu, Z., & Zhang, J. (2022). Morphometric Characteristic of Black Soldier Fly (Hermetia illucens) · Wuhan Strain and Its Egg Production Improved by Selectively Inbreeding. *Life*, *12*(6), 873. https://doi.org/10.3390/life12060873

Dada, O. T., Odufuwa, B. O., Badiora, A. I., Agbabiaka, H. I., Ogunseye, N. O., & Samuel, O. S. (2021). Environmental hazard and health risks associated with slaughterhouses in Ibadan, Nigeria. *Environmental Hazards*, *20*(2), 146–162. https://doi.org/10.1080/17477891.2020.1747382

Fasha, F. R., Andri, F., & Isnaini, N. (2024). Morphometric traits of Black Soldier Fly larvae in slaughterhouse waste and rice bran growing medium. *BIO Web of Conferences*, *88*, 00035. https://doi.org/10.1051/bioconf/20248800035

Gold, M., Cassar, C. M., Zurbrügg, C., Kreuzer, M., Boulos, S., Diener, S., & Mathys, A. (2020). Biowaste treatment with black soldier fly larvae: Increasing performance through the formulation of biowastes based on protein and carbohydrates. *Waste Management*, *102*, 319–329. https://doi.org/10.1016/j.wasman.2019.10.036

Isnaini, N., Amertaningtyas, D., Sulistyo, H. E., Yekti, A. P. A., & Andri, F. (2023). Reproduction and Production Traits of Eggiest of Black Soldier Fly Reared in Different Enriched Media and its Potential as Poultry Feed. *Advances in Animal and Veterinary Sciences*, *11*(11). https://doi.org/10.17582/journal.aavs/2023/11.11.1905.1910

Limeneh, D. Y., Tesfaye, T., Ayele, M., Husien, N. M., Ferede, E., Haile, A., Mengie, W., Abuhay, A., Gelebo, G. G., Gibril, M., & Kong, F. (2022). A Comprehensive Review on Utilization of Slaughterhouse By-Product: Current Status and Prospect. *Sustainability*, *14*(11), 6469. https://doi.org/10.3390/su14116469

Liu, C., Wang, C., Yao, H., & Chapman, S. J. (2021). Pretreatment is an important method for increasing the conversion efficiency of rice straw by black soldier fly larvae based on the function of gut microorganisms. *Science of The Total Environment*, *762*, 144118. https://doi.org/10.1016/j.scitotenv.2020.144118

Oliveira, F., Doelle, K., & Smith, R. (2016). External Morphology of Hermetia illucens Stratiomyidae: Diptera (L.1758) Based on Electron Microscopy. *Annual Research & Review in Biology*, *9*(5), 1–10. https://doi.org/10.9734/arrb/2016/22973

Palma, L., Fernandez-Bayo, J., Niemeier, D., Pitesky, M., & VanderGheynst, J. S. (2019). Managing high fiber food waste for the cultivation of black soldier fly larvae. *Npj Science of Food*, *3*(1). https://doi.org/10.1038/s41538-019-0047-7

Rashid, M. T., Liu, K., Han, S., Jatoi, M. A., & Sarpong, F. (2023). Optimization of Extrusion Treatments, Quality Assessments, and Kinetics Degradation of Enzyme Activities during Storage of Rice Bran. *Foods*, *12*(6), 1236. https://doi.org/10.3390/foods12061236

Ragasri, S., & Sabumon, P. C. (2023). A critical review on slaughterhouse waste management and framing sustainable practices in managing slaughterhouse waste in India. *Journal of Environmental Management*, *327*, 116823. https://doi.org/10.1016/j.jenvman.2022.116823

Salam, M., Shahzadi, A., Zheng, H., Alam, F., Nabi, G., Dezhi, S., Ullah, W., Ammara, S., Ali, N., & Bilal, M. (2022). Effect of different environmental conditions on the growth and development of Black Soldier Fly Larvae and its utilization in solid waste management and pollution mitigation. *Environmental Technology & Innovation*, *28*, 102649. https://doi.org/10.1016/j.eti.2022.102649

Sapwarobol, S., Saphyakhajorn, W., & Astina, J. (2021). Biological Functions and Activities of Rice Bran as a Functional Ingredient: A Review. In *Nutrition and Metabolic Insights* (Vol. 14, p. 117863882110585). https://doi.org/10.1177/11786388211058559

Song, S., Ee, A. W. L., Tan, J. K. N., Cheong, J. C., Chiam, Z., Arora, S., Lam, W. N., & Tan, H. T. W. (2021). Upcycling food waste using black soldier fly larvae: Effects of further composting on frass quality, fertilising effect and its global warming potential. *Journal of Cleaner Production*, *288*, 125664. https://doi.org/10.1016/j.jclepro.2020.125664

Tomberlin, J. K., Sheppard, D. C., & Joyce, J. A. (2002). Selected Life-History Traits of Black Soldier Flies (Diptera: Stratiomyidae) Reared on Three Artificial Diets. *Annals of the Entomological Society of America*, *95*(3), 379–386. https://doi.org/10.1603/0013-8746(2002)095[0379:slhtob]2.0.co;2

Wiyoso, S. A., Sulistyo, H. E., Andri, F., & Isnaini, N. (2023). Effect of fermented laying hen manure and starter feed as growing media on black soldier fly larvae development. *BIO Web of Conferences*, *81*, 00021. https://doi.org/10.1051/bioconf/20238100021