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Research Article

Knowledge, management practices and benefits of using black soldier fly larvae in livestock feed among farmers' cooperative in Oyo state, Nigeria

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Abstract: Black Soldier Fly (BSF) (*Hermetia illucens*) larvae are recognized as a sustainable and cheap alternative source of protein for livestock feed because they are high in crude protein content, balanced amino acid, and ability to convert organic waste into nutritious organic matter. This study assessed farmers' knowledge, management practices, and benefits of BSF larvae utilization among selected cooperative societies in Oyo State, Nigeria. One hundred and twenty respondents were selected using a multi-stage sampling technique from six cooperative societies engaged in poultry, piggery, and aquaculture production. Semi-structured questionnaires were used to collect data and analyzed with descriptive statistics and logistic regression. Results showed that all respondents were aware of insect larvae as livestock feed, but only 48.3% could identify BSF specifically, and just 6.7% had reared them. Pit rearing (59.2%) was the predominant method, while both wet and dry larvae were applied depending on livestock type. Promoting BSF larvae use can enhance livestock productivity, foster waste recycling, and advance sustainable agricultural development. The study recommends targeted awareness campaigns, farmer training on mass production techniques, and supportive policies to scale adoption.

Keywords: Black Soldier Fly, livestock feed, benefits, alternative protein, farmers' cooperatives

1. Introduction

Insects are traditional feed and food sources for humans, poultry, pigs and fish and their use as a feed component has long been proposed (Seyedalmoosavi et al., 2022; Barragán-Fonseca et al., 2017), and there is a growing use of insects as feed ingredients due to their high nutritional content. Recently, scientists, academic institutions and policy makers have reviewed and recognized the role of insects as food and feed (Van Huis, 2020). Insects contain valuable proteins with well-balanced amino acid profiles, fats with rich fatty acid contents as well as micronutrients. Most insects' amino acid contents are comparable to fishmeal and soybean (Henry et al., 2015; Seyedalmoosavi et al., 2022). Edible insects have traditionally been part of livestock diets especially in the tropics and may provide an alternative source of protein and other nutrients in livestock and aquaculture feeds (Makkar et al., 2014; Limbu et al., 2022). The use of insects as an alternative protein source is advantageous because they can be sustainably mass reared on organic side streams and agro-industrial by-products (Rumpold & Schluter, 2013; Seyedalmoosavi et al., 2022; Akanda et al., 2025).

The Black Soldier Fly (BSF), *Hermetia illucens*, is being used commercially in livestock feed because of easy rearing, high yield, rich nutritional value and the ability to utilize organic wastes. BSF larvae, housefly larvae, and yellow mealworms are promising for industrial animal feed production, among which BSF

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larvae have superior properties for mass rearing for feed (Van Huis, 2020; Dzepe et al., 2021)). The BSF is a common and widespread fly in many tropical regions, but the BSF originates from South America. As a result of human actions, the fly was able to spread to other tropical, sub-tropical and warmer regions. The BSF has the ability to adjust to different circumstances very quickly. But, in contrast to the housefly, the BSF is not a pest, they do not bite, sting and are not able to transfer zoonotic diseases. The larvae of the BSF are able to convert organic waste to protein (Dzepe et al., 2021). The protein content of the dried BSF larvae is between 35 and 50 %. The adult flies are between 15 to 20 millimeters long. Adults do not have a mouth; therefore, the larvae consume a lot of organic substrates during their larval stages (Oonincx et al., 2016). The larvae are able to feed quickly and can reach their harvesting stage in 10 to 14 days (Van Huis, 2020).

The black soldier fly larvae (BSFL) can consume substrate 25 mg up to 500 mg fresh matter per larvae per day to produce body length around 27 mm, 6 mm wide and weight 220 mg at 14 days old (Park, 2016). The nutrient composition of BSFL reared with mixed organic wastes ranges from 42% to 47%, 11.8% to 34.8%, 7% to 9%, and 14.6% to 15.9% for crude protein (CP), fat, crude fiber (CF), and ash, respectively. Meanwhile if BSF are reared on palm oil meal, they contain 43% CP, 19.51% fat, 12.27% CF and 4.85% ash, also contain a variety of fatty acids and amino acids (Astuti & Komalasari, 2022). Based on the BSF nutrient content, they have great potential as feed ingredient for ruminants, especially to substitute soybean meal, fish meal and antimicrobial growth promoters.

Cooperatives are voluntary social enterprises established by members to collectively meet their economic needs and interests through shared resources and mutual support, thereby improving access to finance and other socio-economic opportunities (Ribas et al., 2022). Unlike Investor-Owned Firms (IOFs), cooperatives derive their capital primarily from member contributions or credit facilities and operate with the goal of enhancing members' businesses, promoting growth, and alleviating poverty. They are typically formed based on common business interests, location, professional goals, and the need for social interaction, enabling members to exploit shared resources through collective strategies (Onyeze et al., 2022; Ehiwario et al., 2024). Cooperatives play a vital role in economic development by providing access to affordable loans, encouraging savings, and facilitating the dissemination of innovations that enhance productivity and livelihoods (Ribas et al., 2022). In agriculture, farmer cooperatives enable smallholder farmers with limited resources and fragmented landholdings to pool assets for production and marketing, thereby improving income and living standards, and serving as an effective mechanism for rural transformation and inclusion of small-scale farmers (Zakayo et al., 2025; Ribas et al., 2022).

Increasing world population requires an increase of food production, including livestock production. Livestock products such as meat, milk or eggs as part of food production are the fastest growing agricultural sector (Stephens et al., 2026). The challenge in animal nutrition is the availability of sustainable feeds that enable farmers to meet the rising demand for highly nutritious animal products. Ingredients for animal feed include soybeans, fish oil, and several grains, with fishmeal being the major protein source. However, a major constraint to a sustainable production of the increasingly demanded fish and meat products is that, land for soybean cultivation is diminishing globally, while the marine overexploitation has continued to reduce the abundance of the small pelagic forage fish, from which fishmeal and fish oil are derived. The growing demand and scarcity of resources to produce fishmeal and soybean meal have led to increased prices of these ingredients, while feed cost, representing 60-70% of animal production costs is already prohibitive and cannot be afforded by resource-poor famers (Hossain et al., 2025; Van Huis, 2020). In order to improve the animal production, it is necessary to improve feed quality offered to the animals. This situation is also affecting the livelihoods of farmers in Nigeria, especially the livestock farmers. It will therefore, not be a sustainable option to continue to rely on fishmeal and soybean meal as protein sources in feed production (Van Huis, 2020). The Nigerian livestock industry is searching for alternative protein sources for its growing poultry, pig and fish sub-sectors and there is much interest in possible replacements for these expensive ingredients. Hence there is a need to assess farmer's knowledge, management practices and benefits of BSF. The main objective was to assess the knowledge, management practices and benefits of utilizing the black soldier fly larvae in livestock feed among farmers in cooperative societies in Ibadan, Oyo State. The specific objectives are:

i. To assess farmers' knowledge of BSF larvae in livestock feed
ii. To determine farmers' acceptance of BSF larvae as substitute for protein in livestock feed
iii. To determine the management practices employed in utilizing the BSF larvae in livestock feed

iv. To determine the benefits of utilizing the BSF larvae as alternative source of protein and other nutrients in livestock feed

2. Methodology

This study was carried out in Oyo State, an inland state in southwestern Nigeria with its capital in Ibadan, one of the most populous cities in the country (Nenge, 2021). The state is bordered by Kwara, Osun, Ogun States and the Republic of Benin, with a projected population of 7,840,864, making it one of the most populous states in Nigeria (Akinjogbin, 1966). Predominantly inhabited by the Yoruba people, Oyo State—popularly known as the "Pace Setter State"—has a rich historical background linked to the old Oyo Empire. The state also hosts the first university in Nigeria, the University of Ibadan, and its economy is largely agrarian, with crops such as cassava, cocoa, and tobacco playing significant roles (Adeogun et al., 2017). Oyo State covers about 28,454 square kilometres and features a landscape of old hard rocks and gently rising hills, with several rivers originating within the region. The climate is equatorial, characterized by distinct dry and wet seasons and relatively high temperatures throughout the year. Agriculture is the main occupation, supported by favourable climatic conditions and the presence of farm settlements, livestock ranches, and agricultural development programmes across the state. The area comprises both urban and rural communities with active economic activities and well-established cooperative societies that support members through resource pooling, access to inputs, and development initiatives

The data were collected from six (6) selected farmers' cooperative societies namely: Oyosowapo Multipurpose CICS Oyo; Anuoluwapo Farmers' Cooperative Otu, Itesiwaju LGA; Oyo-Ifelodun Cooperative and Credit Society Investment Aawe; Moniya Greenland Multipurpose CICS, Ibadan; Baomakii Agri Venture Cooperative, Idiya, Ido LGA and Fortunate Farmers' Cooperative Lanlate, Ibarapa East LGA. The selection of these stated cooperative societies was based on the fore-knowledge about their activities and with the support of Extension Officers working in the affected Local Government Areas. Twenty (20) respondents (who are members of these cooperative societies) each comprising of Pig, Fish and Poultry farmers were selected from each of the cooperatives and a total of one hundred and twenty (120) questionnaires were administered to them. A semi-structured questionnaire was used to collect the data through face-to-face interviews. In contrast to other techniques like mail and telephone surveys, which have the issue of a high non-response rate, face-to-face interviews offer the benefit of allowing for quick follow-up and clarifications (Hussain et al., 2013; Mackenzie & Knipe, 2006). The interviews were conducted only after consent forms had been signed, indicating the participants willingness to be part of the study.

The semi-structured questionnaire comprised four sections namely socio-demographic characteristics, enterprise characteristics of farmers with livestock, management practices and benefits of utilizing the black soldier fly larvae in livestock feed, Farmers' knowledge of BSFL as protein supplement in livestock feed which consisting of a 5-point summated likert rating scale format as strongly agree, agree, undecided, disagree and strongly disagree. With about ten (10) questions which dwelt comprehensively on the subject matter of the study. The field survey took place form March to June, 2023 with all questionnaire duly attempted.

Data obtained from this study were analyzed using descriptive statistics (frequency, percentage, mean) and binary logistic regression to determine the influence of knowledge, rearing experience, and education level on BSF larvae adoption. Binary logistic regression was used because the BSF larvae adoption is a dependent variable (yes/no) and is dichotomous, making the model appropriate for estimating the influence of categorical and ordinal predictors such as knowledge, rearing experience, and education level on the likelihood of adoption.

3. Results

The present study on knowledge, management practices and benefits of utilizing the black soldier fly larvae in livestock feed shows that most respondents were male (58.3%), reflecting the dominance of men in livestock production cooperatives. The majority (43.3%) were aged 36–50 years (mean = 41.0 years), suggesting that middle-aged farmers are most engaged in BSF-related practices. Education levels were generally high, with over 65% having OND/HND or higher, which implies strong capacity for adopting innovative practices such as insect-based feed technologies. Household sizes were moderate (mean = 5.5 persons), aligning with the economic role of cooperative farming in supporting family livelihoods (Table 1).

The study also reveals in Table 2 that poultry enterprises (33.3%) dominated the users of BSFL, followed by poultry–fishery operations (19.2%). Most enterprises had been running for 4–6 years (37.5%), reflecting stability and accumulated experience. The primary purpose of livestock rearing was for sale

(56.7%), underscoring the commercial orientation of respondents. This finding is significant because commercial orientation increases the likelihood of adopting cost-saving innovations such as BSF larvae. The feed sourcing was almost evenly split between already-formulated and self-formulated feeds (Table 3). Soybean was the dominant single protein source (26.7%), but 43.3% of respondents used combined protein ingredients, indicating cost-driven diversification. Strikingly, all respondents reported high protein ingredient costs, reinforcing the urgent need for cheaper and sustainable protein alternatives such as BSF larvae.

As shown in Table 4, awareness of insect larvae as feed was universal (100%), and most farmers had experience using them (73.3%). However, less than half (48.3%) could identify BSF specifically, and only 6.7% had reared BSF, indicating a significant knowledge gap. Housefly maggots were the most common larvae reared (64.2%). Most farmers applied larvae in wet form (75.8%), which is simpler and less costly than drying. These findings reveal that while general insect-larvae use is accepted, targeted extension is needed to promote BSF adoption.

The logistic regression results in Table 5 show that none of the predictors significantly influenced the likelihood of feeding insect larvae ($p > 0.05$). Although farmers who could identify BSF were 1.2 times more likely to feed larvae, this effect was statistically insignificant ($p = 0.666$). Similarly, prior rearing of BSF was associated with a lower likelihood of feeding larvae (OR = 0.32), though also not significant ($p = 0.139$). Education level showed no significant adoption ($p = 0.617$). The low pseudo-R^2 (0.018) suggests that the model explains only a small proportion of the variation

Table 1: Demographic characteristics of respondents (n = 120)

Variable	Category	Frequency	Percent (%)
Sex	Male	70	58.3
	Female	50	41.7
Age (Mean = 41.0 years)	20–25 years	10	8.3
	26–35 years	30	25.0
	36–50 years	52	43.3
	51+ years	28	23.3
Marital status	Single	23	19.2
	Married	81	67.5
	Widow/Widower	16	13.3
	Divorced	0	0.0
Household size (Mean = 5.5 persons)	1–3 persons	28	23.3
	4–6 persons	50	41.7
	7–9 persons	32	26.7
	10+ persons	10	8.3
Educational level	Primary	8	6.7
	Secondary	18	15.0
	OND/HND	37	30.8
	Bachelor	42	35.0
	Master	15	12.5

Source: Field Survey, 2023

Table 2: Enterprise characteristics of respondents (n = 120)

Variable	Category	Frequency	Percent (%)
Type of livestock	Poultry only	40	33.3
	Fishery only	10	8.3
	Piggery only	8	6.7
	Poultry & Piggery	20	16.7
	Poultry & Fishery	23	19.2
	Fishery & Piggery	9	7.5
	All of the Above	10	8.3
Years in operation	1–3 years	25	20.8
	4–6 years	45	37.5
	7–9 years	30	25.0
	10+ years	20	16.7
Purpose of rearing	Sale	68	56.7
	Consumption	7	5.8
	Both	45	37.5

Source: Field Survey, 2023

Table 3: Feed and protein ingredient use (n = 120)

Variable	Category	Frequency	Percent (%)
Type of feed used	Already-formulated only	42	35.0
	Self-formulated only	40	33.3
	Both	38	31.7
Protein Ingredient	Soybean only	32	26.7
	Fish meal only	10	8.3
	Groundnut cake only	6	5.0
	Blood meal only	2	1.7
	Combination	52	43.3
	Others	18	15.0
Protein prices high	Yes	120	100.0

Source: Field Survey, 2023

Table 4: Knowledge and management practices of black soldier fly larvae (n = 120)

Variable	Category	Frequency	Percent (%)
Awareness	Aware insect larvae can be used as feed	120	100.0
Experience	Ever fed insect larvae	88	73.3
Knowledge	Can identify BSF	58	48.3
Production	Ever reared BSF larvae	8	6.7
Type of larvae reared	Housefly maggots	77	64.2
	Mealworms	25	20.8
	BSF	8	6.7
Livestock fed	Poultry	89	74.2
	Fish	95	79.2
	Pigs	16	13.3
Production method	Pit	71	59.2
Application method	Wet	91	75.8
	Both wet and dry	50	41.7

Source: Field Survey, 2023

Table 5: Logistic Regression Predicting Ever Feeding Insect Larvae

Predictor	β	Std. Error	Z	p-value	Odds Ratio (OR)	95% CI for OR
Constant	0.692	0.700	0.989	0.323	1.998	0.51–7.87
Identify BSF (Yes)	0.183	0.423	0.432	0.666	1.20	0.52–2.75
Reared BSFL (Yes)	-1.129	0.763	-1.479	0.139	0.32	0.07–1.44
Education (ordinal)	0.098	0.196	0.500	0.617	1.10	0.75–1.62

in adoption behaviour, indicating that other factors not included in the model may be important determinants.

4. Discussion

The study examined farmers' knowledge, management practices, and benefits of Black Soldier Fly larvae utilization in livestock feed across selected cooperative societies in Oyo State, Nigeria. The results reveal several critical insights with important implications for both practice and policy. The universal awareness of insect larvae as potential livestock feed among respondents indicates that farmers are open to alternative protein sources. However, the finding that less than half (48.3%) could specifically identify BSF and only 6.7% had reared them highlights a significant knowledge gap. This aligns with earlier research by Barragán-Fonseca et al. (2017), Seyedalmoosavi et al. (2022) and Ambele et al., (2025), who emphasized that while awareness of insect-based feeds is growing globally, adoption at the farm level is constrained by limited technical knowledge and capacity. In addition, Nyamuhirwa et al., 2025 also reported that about 20 % of surveyed farmers were aware of BSFL as a protein source in animal feed, and the actual adoption rate of BSFL of 4%. Pit rearing emerged as the predominant method of larvae production, with most farmers applying larvae in wet form. This finding underscores the preference for low-cost, labor-efficient practices among smallholder farmers. Similar practices were reported in Sub-Saharan Africa, where farmers adopt simple and locally adaptable rearing methods rather than expensive technologies (Akanda et al., 2025; Limbu et al., 2022; Van Huis, 2020). The choice of wet application also reflects efforts to minimize processing costs, though it may pose challenges for storage and transport.

The economic motivations strongly drive farmer perceptions. Farmers consistently emphasized the cost-

saving potential of BSF larvae, describing them as an inexpensive and sustainable substitute for soybean meal and fishmeal. This is consistent with global evidence that BSF larvae can substantially reduce feed costs while maintaining or improving animal performance (Kazemi & Valizadeh, 2025; Henry et al., 2015; Makkar et al., 2014). In resource-constrained settings like Nigeria, where protein ingredients are expensive and supply chains unstable, BSF larvae provide a practical and scalable alternative. Logistic regression analysis revealed that factors such as education, ability to identify BSF, and prior rearing experience did not significantly predict adoption. This indicates that these individual level characteristics were not strong determinants of adoption among the respondents. This insight is critical, as it shifts the focus from farmer-level attributes to systemic interventions. Policies that strengthen cooperatives, improve access to training, and incentivize local BSF production could therefore yield greater adoption outcomes. Finally, cooperatives not only facilitate knowledge sharing but also reduce individual risk by pooling resources. As shown in similar studies (Ribas et al., 2022), cooperative structures are instrumental in promoting agricultural innovation, making them an ideal entry point for BSF larvae adoption in Nigeria. A successful awareness creation can boost the actual adoption of BSFL. The awareness creation should target educated livestock farmers with access to group membership, credit, extension services, and diversified income sources to influence their decisions to adopt BSFL as a source of protein in animal feed.

5. Conclusion

The study concludes that while the potential of BSF larvae as a sustainable protein source is widely acknowledged, actual adoption remains low due to inadequate awareness and technical capacity among farmers. Cooperatives provide an effective platform for scaling knowledge transfer and innovation adoption, positioning them as key drivers of sustainable livestock feed transformation in Nigeria. Based on the finding the study, the following recommendations were made:

i. Organize extension campaigns and capacity-building workshops to improve farmers' knowledge of BSF larvae rearing and application methods.
ii. Government and development partners should integrate insect-based feed into livestock development policies and provide incentives for adoption.
iii. Encourage adaptive research on large-scale BSF rearing technologies suitable for Nigerian farming systems.
iv. Strengthen farmer cooperatives as entry points for disseminating innovations and scaling adoption of BSF-based feeds.
v. Promote public–private partnerships to commercialize BSF production, ensuring consistent supply for livestock farmers.

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