ISSN:
Print - 2277 - 0755
Online - 2315 - 7453

Journal of Agricultural Science and Environment

AWARENESS, WILLINGNESS AND PERCEIVED BENEFITS OF BLACK SOLDIER FLY LARVAE IN AQUAFEED PRODUCTION AMONG OGUN STATE FISH FARMERS

[1]O.C., OJELADE, *[1]O.P. OYETADE, [1]I. ABDULRAHEEM, [1]A.O. AKINDE, [1]O.J., OLAOYE, [2]R.M. AKINBODE, [3]F.F. OYEBANJI, [1]T.O. AKINTADE, [1]H.T. AKINOLA AND [1]O.J. ADEKUNFE

[1]Department of Aquaculture and Fisheries Management, Federal University of Agriculture, Abeokuta.
[2]Animal Nutrition, Federal University of Agriculture, Abeokuta.
[3]Environmental Management and Toxicology, Federal University of Agriculture, Abeokuta.
*__Corresponding Author__: oyetadeop@funaab.edu.ng **Tel**:+2347031849361

ABSTRACT

Black Soldier Fly Larvae Meal (BSFLM) is a viable alternative to conventional fishmeal, offering a high-protein content that meets the nutritional needs of fish. This study assessed the awareness, willingness, and perceived benefits of BSFLM-based aquafeed to fish farmers in Ogun State. A multistage sampling technique was adopted. Ogun State Agricultural Development zoning system was adopted and blocks with prevalent fish farming activities were selected. Purposive selection was done to select 307 farmers within the study area. This ensured that only farmers relevant to the study's focus, who are capable of providing accurate and relevant information needed were selected. A structured interview guide was used to elicit information on socio-economic characteristics, awareness, willingness and perceived benefits of BSFLM. Data collected were analysed using descriptive and inferential statistical tools (SPSS, v25). Majority (87%) of the farmers were married; 88% were male. Average age was 39 years; household size – 6; years of farming experience – 13 and average monthly income was ₦279,511. BSFLM awareness rate of 82.4% was relatively high, and only 19.8% were aware of its use in aquafeed formulations. About 91% of the respondents showed willingness to adopt BSFLM. Willingness tested as the dependent variable indicated that years of experience ($p = 0.042$), average monthly income ($p=0.019$), number of ponds owned by farmers and the quantity of harvest, significantly influenced willingness to adopt BSFLM. Perceived benefits result indicated that about 89% of farmers perceived that BSFLM does not pose a potential risk to consumers, 94% perceived BSFLM-formulated feed is cheaper and 73% agreed that BSFLM in aquafeed does not affect consumer acceptability. Inadequate training ($x=2.23$) was identified as the highest barrier to the adoption of BSFLM while competition with other farmers ($x=1.74$) was the lowest ranked. The study concluded that majority of farmers have basic awareness of BSFL. Most farmers were noted to show a high level of willingness and they perceived the benefits of BSFLM. The study recommends that targeted educational programs be developed to bridge this knowledge gap, alongside policies that ensure the availability and affordability of BSFLM.

Keywords: Black soldier fly; fish farming; information; fishmeal; benefits

INTRODUCTION

The aquaculture sector plays a pivotal role in global food security, contributing significantly to the supply of high-quality protein and supporting the livelihoods of millions worldwide (FAO, 2022). However, as the demand for fish continues to rise, there is an increasing need for sustainable practices to address challenges such as resource depletion and environmental impacts. One critical area is the development of alternative feed ingredients to reduce reliance on conventional fishmeal, which is both costly and unsustainable (Amankwah *et al.* 2018; Zarantoniello *et al.*, 2019; Alhazzaa *et al.*, 2019). Feed accounts for at least 40-80% of the total variable cost of fish production (Chia *et al.* 2020). Fish meal and soya bean meal are the primary protein sources in aquafeed, but fishmeal is costly and unsustainable for smallholder farmers. To address the issue of pressure on land and water use by agriculture and depleted fish resources due to overfishing, there is an urgent need to explore alternative sustainable feed diets.

Insect meals are gaining interest as a potential feed alternative in fish farming due to their high energy conversion efficiency, nutritional value, benefits for fish development and health improvement (Mousavi *et al.,* 2020). Insects have been promoted as a beneficial source of protein for fish diets (Ouko *et al.*, 2023). Some insect species can be grown organically to reduce environmental contamination and transform waste into high-protein feed, which could replace fish meal in aquafeed. This approach is sustainable and can be done in warehouses, requiring less space and water compared to crops (Hamid *et al.,* 2022). However, not all insect species can be used as feed ingredients in aquaculture. Only a few can be produced on a large scale, depending on their protein, amino acid profile, fat, mineral, and raw material availability. The Black Soldier Fly Larvae (BSFL) is the most commonly farmed insect in the animal feed industry and is commonly used in organic waste treatment as a bio-convertor (Siva *et al.* 2022). There has been an increase in research and industrial-scale production of BSF as feed ingredients. Fish feeding trials have shown that replacing fish meal with BSFL meal in aquafeeds has no negative effects on growth or performance (Ouko *et al.*, 2022; Abd Hamid *et al.,* 2022).

The nutritional qualities of ingredients are crucial for fish growth as well as their perceived utility and acceptability by fish farmers (Brugere *et al.,* 2021). Farmer decision-making research often relies on economic models and socioeconomic considerations, but cognitive and socio-psychological factors can provide insights into individual decisions.

Objectives of the study

1. To determine the level of awareness and knowledge among fish farmers about BSFL as an alternative protein source.
2. To determine the factors that influence fish farmers' willingness to adopt BSFL as a feed ingredient.
3. To identify the perceived benefits associated with the use of BSFL in fish feed.
4. To identify the barriers to the adoption of BSFL among Ogun State fish farmers.

MATERIALS AND METHODS

Study Area and Sampling Technique

The study was conducted in Sagamu, Ijebu, and Ilase areas of Ogun State, Nigeria. These locations were chosen for their high concentration of fish farmers, providing a representative sample of the aquaculture community in the State. The targeted population comprised of registered and unregistered fish

farmers within the Ogun State Agricultural Development Program (OGADEP). A validated structured interview guide was used to elicit information on the socio-economic characteristics, awareness, willingness and perceived benefits of BSFLM in aquafeeds. A multistage sampling technique was employed for this study. Firstly, Ogun State was stratified based on her Agricultural Development Zones. Within each zone, 3 blocks with high concentrations of fish farming activities were selected purposively. In the selected blocks, 10% of the total number of registered farmers were randomly sampled to ensure adequate representation of the farming population. A total of 307 farmers were surveyed, with 102 respondents from Sagamu, 104 respondents from Ilase, and 101 respondents from Ijebu.

Measurement of Variables

The dependent variable, farmers' willingness to adopt BSFL- based feed was measured as a binary variable (1 = Willing, 2 = Not willing). Independent variables, including socio-economic characteristics such as age, sex, marital status, etc.as well as production related variables were measured using nominal or ordinal scales with most variables grouped into categories.

Analytical Technique

Data obtained were analysed using both descriptive and inferential statistics in Statistical Package for the Social Sciences (SPSS, v25). Farmers' level of awareness was measured as described in Ouko *et al.* (2023) and categorized as:

i. No awareness: Farmers who have never heard of BSFL as an option for aquafeed.
ii. Basic awareness: Farmers who have heard of BSFL but haven't adopted it yet.
iii. Informed awareness: Farmers who know about BSFL and its benefits, and might be considering adoption.
iv. Active awareness: Farmers who have used BSFL in their farming practices.

The awareness rate was calculated using:

$$Awareness\ Rate = \frac{Farmers\ with\ Awareness(Basic,\ informed,\ Active)}{Total\ farmers} X\ 100 \dots\dots\dots\dots (1)$$

Farmers' willingness to adopt BSFL was categorized into "willing" and "not willing." A Chi-square test was used to assess the relationship between farmers' socioeconomic characteristics and willingness to adopt BSFLM.

$$x^2 = \sum \frac{(O_i - E_i)^2}{E_i} \dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Where:

O_i = Observed frequency (The actual numbers of farmers who are willing and not willing in each socio-economic characteristic category).

E_i = Expected frequency

The x^2 measures how much the observed frequency deviates from the expected frequency.

The p-values derived from chi-square statistics were used to determine whether to accept or reject the null hypothesis (H_o).

The null hypothesis was rejected for $p \leq \alpha$ (the significance level, typically 0.05), vice versa.

A Linear regression model was used to identify the effect of production variables such as total stocking density, culture period, etc., on farmers' willingness to adopt BSFLM-based feed. Based on farmers' willingness (Y), the model is specified as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots\cdots + \beta_n X_n + \in \cdots\cdots\cdots (3)$$

Where:

Y = Farmers' willingness

β_0 = Constant

$\beta_1, \beta_2, \ldots\ldots, \beta_n$ = Coefficient that measures the effect of each independent variable

$X_1, X_2, \ldots\ldots, X_n$ = Independent variables (e.g., total stocking density)

ϵ = Error (Captures unexplained variability).

A Likert Scale analysis was employed to evaluate the severity of various factors influencing the adoption of BSFL by farmers. Each factor was rated on a three-point severity scale: Very severe (3 points), Severe (2 points) and Not severe (1 point). The total score for each factor was calculated as:

$$Fx = (n_{very\ severe} \times 3) + (n_{severe} \times 2) + (n_{not\ severe} \times 1) \ldots\ldots\ldots\ldots\ldots (4)$$

$n_{very\ severe}$, n_{severe} and $n_{not\ severe}$ represent the number of respondents choosing each severity level for a particular factor.

Mean score (X) for each factor was determined using:

$$X = \frac{Fx}{N} \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Fx = Total score

N = Total number of respondents

The factors were ranked based on the weight of their mean scores. The higher the mean score, the more severe the factor is considered (Roy *et al.* 2024).

RESULTS AND DISCUSSION

Farmers' Socio-economic Characteristics

The socio-economic characteristics of fish farmers showed a predominantly middle-aged individuals 30 – 39 years category comprising 39.2% of the total population (Table 1), moderately experienced which falls between 5 – 10 years (47.1%), and moderately literate community with nearly half (49%) having secondary education and a significant number (41.2%) holding tertiary qualifications. The entire population had a majority of male (89.2%) and married respondents (81.4%). The socio-economic profile of the farmers indicated a favourable environment for adopting innovative practices such as BSFL-based feeds. Middle-aged, moderately experienced, and literate farmers are more likely to adopt new technologies due to their exposure and adaptability (Asa *et al.*, 2022). Most farmers had secondary education (Figure 1) and belong to associations, which facilitate knowledge sharing and collaboration, a key factor in technology adoption (Han *et al,* 2022). Income levels varied significantly, but the majority earned between ₦100,000 and ₦199,999 monthly (Table 1). However, income disparities among farmers suggest that while some can invest in innovations, others may struggle due to financial constraints (Musa *et al.* 2023). Previous studies have shown that limited financial resources can hinder adoption of novel farming techniques (Anigbogu *et al.*, 2015). Therefore, targeted interventions, such as training programmes and financial incentives, could bridge this gap and enhance adoption rates (Boateng *et al.*, 2021). These attributes suggest that the farmers are well-positioned to adopt innovations like BSFL-based feeds, though targeted interventions addressing income disparities and enhancing training could further support adoption.

Table 1: Socio-economic Characteristics of Fish Farmers in Ogun State

Variables	Frequency (N = 307)	Percentage (%)	Mean ± Std.Dev
Age			
<30 years	21	20.6	
30 - 39 years	40	39.2	
40 - 49 years	21	20.6	39.44 ± 9.24
50 - 59 years	16	15.7	
60 years and above	4	3.9	
Household size			
<3	3	2.9	
3 – 5	59	57.8	5.55 ± 2.05
6 – 8	33	32.4	
9 – 11	7	6.9	
Years of farming experience			
<5 years	4	3.9	
5 - 10 years	48	47.1	
11 - 16 years	21	20.6	
17 - 22 years	17	16.7	13.80 ± 8.44
23 - 28 years	6	5.9	
29 - 34 years	3	2.9	
> 34 years	3	2.9	
Average monthly income			
< ₦100000	10	9.8	
₦100000 - ₦199999	26	25.5	
₦200000 - ₦299999	32	31.4	
₦300000 - ₦399999	24	23.5	279511 ± 273422
₦400000 - ₦499999	4	3.9	
₦500000 and above	6	5.9	
Sex			
Male	91	89.2	
Female	11	10.8	
Marital Status			
Single	17	16.7	
Married	83	81.4	
Widowed	2	2	
Religion			
Christianity	50	49	
Islam	49	48	
Traditional	3	2.9	
Level of education			
Primary	10	9.8	
Secondary	50	49	
Tertiary	42	41.2	
Primary occupation			
Agriculture	2	2	
Artisan	3	2.9	
Business	3	2.9	
Clergyman	2	2	
Fish farming	92	90.2	
Secondary occupation			
Agriculture	5	4.9	
Artisan	12	11.8	
Business	8	7.8	
Fish farming	77	75.5	
Association membership			
Actively involved	74	72.5	
Partially involved	23	22.5	
Not involved	5	4.9	

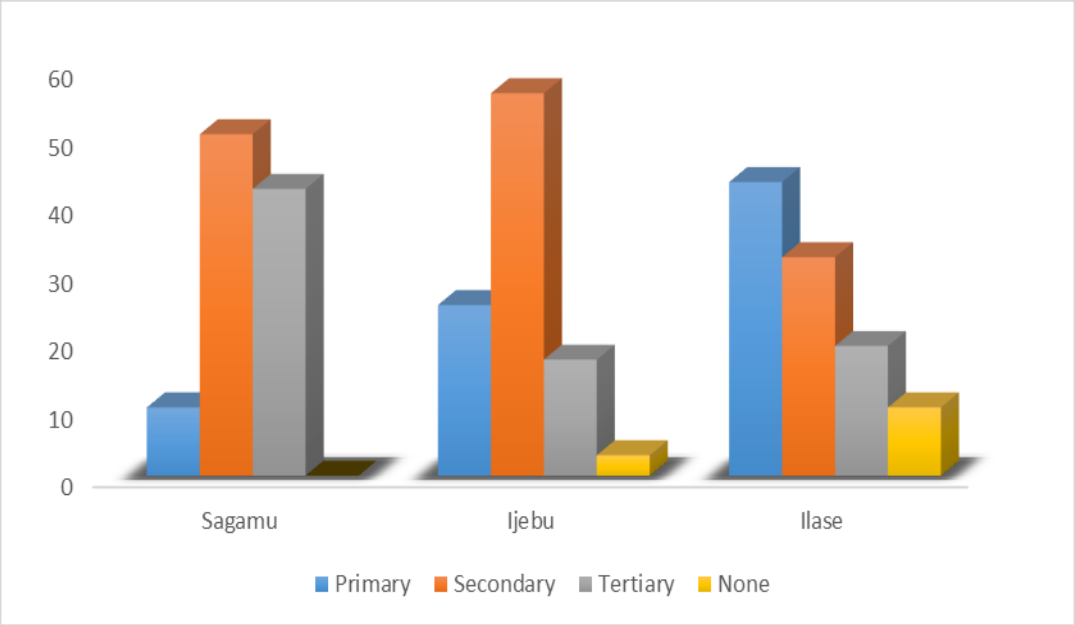

Figure 1: Fish farmers' educational background across the three locations

Notable disparity existed across the zones (Figure 2). Sagamu zone recorded the highest proportion of fish farmers with no awareness at 42.2%, indicating little or no exposure to information about BSFL as an alternative feed ingredient. This suggests a significant information gap in Sagamu, potentially due to limited extension services or lack of exposure to innovative practices. Ijebu zone recorded the highest percentages in both active (13.9%) and informed awareness (16.8%), implying a relatively stronger knowledge base and readiness to engage with the innovation. This could be attributed to better access to training or peer-to-peer knowledge sharing. Ilase zone had the highest concentration of fish farmers with basic awareness (58.6%), indicating that while many have heard about BSFL, their understanding might still be shallow. Only few had progressed to the stages of informed (12.5%) and active awareness (7.7%). This pattern across the three zones underscores the importance of location-specific awareness strategies, considering that fish farmers' exposure and understanding vary significantly. This observation is consistent with Ouko *et al.*, 2022 findings who emphasized that awareness is a critical precursor to adoption.

The study's findings revealed that the majority of 91.1% fish farmers in Ijebu, 57.8% in Sagamu and 78.8% in Ilase were in awareness of BSFLM level from basic awareness to activeness level (Figure 2). However, there was a notable gap in technical knowledge and confidence regarding its application as a feed ingredient. This limited understanding may stem from reliance on informal knowledge-sharing networks and insufficient exposure to structured extension programs (Brugere *et al,* 2021). About 91% of the fish farmers believed that insect meals like BSFL can be fed to fish, while 66% were unaware of its utilization in feed formulations (Table 2). It can be inferred from the result that farmers recognize the potential of BSFL, but

they lack comprehensive information and educational training on its broader applications and benefits in aquafeed production. These observations align with Ouko *et al.* (2023), who reported similar awareness levels among Kenyan fish farmers regarding BSFLM-based aquafeeds. Their study identified factors such as education level, access to training, and membership in farmer associations as significant determinants of awareness. The limited awareness of BSFLM's potential to replace traditional feed ingredients like fishmeal is a critical barrier to its adoption. Research indicates that BSFLM can effectively substitute fishmeal in aquafeeds without adverse effects on fish growth or health (Abd Hamid *et al.* 2022). However, lack of technical knowledge among farmers impedes the integration of BSFLM into their feeding practices. To bridge this knowledge gap, targeted interventions are essential. Implementing comprehensive training programs and strengthening extension services can enhance farmers' understanding of BSFLM's benefits and applications. Also, fostering collaboration through farmer associations can facilitate knowledge dissemination and support the adoption of innovative feed practices.

Table 2: Fish farmers' awareness of the use of BSFL

Variables	Yes (%)	No (%)
Do you have knowledge of components of feed ingredients?	256 (83.4%)	51 (16.6%)
Do you think that insect meal, such as BSF, can be fed to fish?	280 (91.2%)	27 (8.8%)
Are you aware of the utilization of BSF larva in feed ingredients?	203 (66.1%)	104 (33.9%)

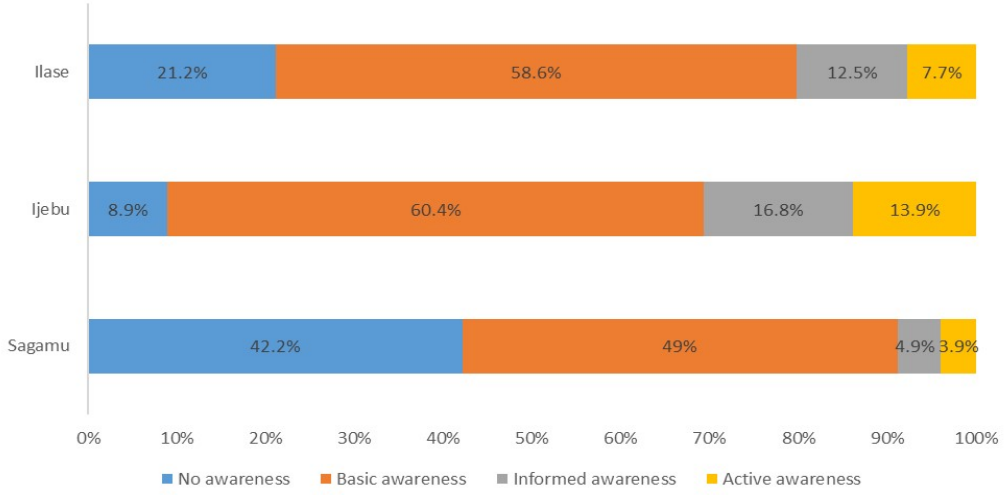

Figure 2: Varying levels of awareness among fish farmers in the study area

Factors affecting Fish Farmers' Willingness to adopt BSFLM

Farmers' willingness to adopt Black Soldier Fly Larvae (BSFL) as an innovative feed ingredient reflects their openness to alternative solutions that enhance aquaculture productivity. This willingness is influenced by various socio-economic factors, as farmers assess the perceived benefits, risks, and feasibility of integrating BSFL into their practices (Chie *et al,* 2020). A study by Ouko *et al.* (2022) in Kenya found that stakeholders perceived significant benefits in using BSFL meal in aquaculture, including its potential to provide a sustainable and cost-effective protein source. However, concerns regarding feed safety and environmental impacts were also noted, indicating that farmers weigh both advantages and potential risks when considering adoption. Similarly, research by Olutegbe and Ojuoluwa (2022) in Nigeria highlighted that farmers' acceptance of BSFL as a protein source in poultry feed was significantly influenced by factors such as income from poultry, farm size, perceived economic viability, and environmental friendliness. This suggests that socio-economic characteristics play a crucial role in the decision-making process for adopting BSFL.

Factors influencing willingness to adopt BSFL in aquafeeds

Socio-economic Factors

Responding to willingness to adopt BSFLM, it was revealed that the majority (91.0%) expressed their willingness to adopt BSFLM. Only 9.0% of the total population were not willing (Figure 3). A significant association was identified between farming experience and adoption willingness (χ^2 = 13.056, p = 0.042). Farmers with 5-10 years of experience exhibited the highest willingness (40.1%), followed by those with 11-16 years (21.5%) and 17-22 years (17.9%). Farmers with less than 5 years of experience were the least inclined (5.4%). This trend suggests that moderately experienced farmers are more receptive to innovative practices, possibly due to a balance between traditional knowledge and openness to new methods (Mwangi and Kariuki, 2015). In contrast, farmers with few years of experience may lack confidence, while farmers with more years of experience might prefer established techniques. This observation aligns with findings that social trust and networks significantly influence technology adoption among farmers, as they rely on trusted sources and peer experiences when considering new practices (Han *et al.* 2022). Income levels also demonstrated a significant correlation with BSFL adoption willingness (χ^2 = 13.501, p = 0.019). For instance, farmers earning ₦100,000–₦199,999 were the most willing (26.5%), whereas those earning ₦400,000–₦499,999 showed no willingness (Table 3). This pattern indicates that middle-income farmers perceived BSFL as a cost-effective innovation, potentially reducing feed costs and enhancing profitability. Higher-income farmers might have established supply chains and less incentive to alter existing practices, while lower-income farmers could face financial constraints hindering the adoption of new technologies (Mwangi and Kariuki, 2015; Ouko *et al,* 2022; Olutegbe and Ojuoluwa, 2022; and Roy *et al,* 2024). This is consistent with research highlighting that economic viability and perceived cost-benefit ratios are critical determinants in the adoption of sustainable agricultural innovations (Roy *et al.* 2024). Other factors, such as age, gender, and household size, did not exhibit a statistically significant impact on farmers' willingness to adopt BSFL. This suggests that while demographic characteristics are essential, socio-economic fac-

tors like experience and income play more decisive roles in influencing adoption decisions. Understanding these dynamics is crucial for developing targeted outreach and support strategies that address specific barriers and leverage motivators pertinent to different farmer segments.

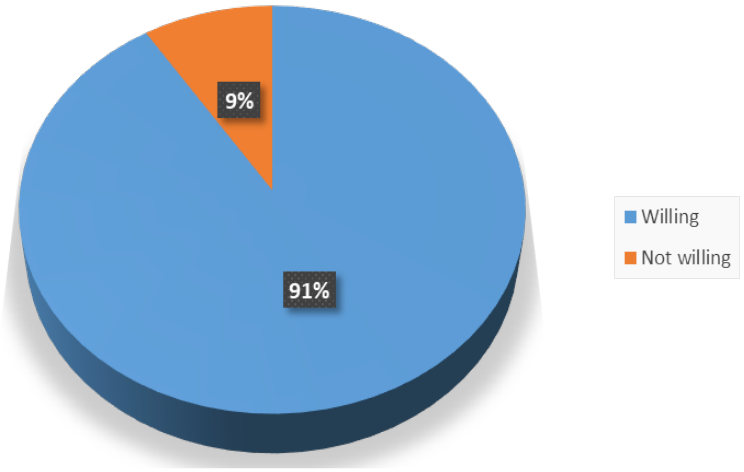

Figure 3: Proportion of Farmers Willing and Not Willing to Adopt BSFLM

Table 3: Chi-square result on the relationship between farmers' socio-economic characteristics and their level of awareness

Variables	x^2	df	p-value
Age	7.176	4	0.127
Sex	0.701	1	0.315
Household size	4.886	4	0.299
Years of experience	13.056	6	0.042*
Average monthly income	13.501	5	0.019*
Marital status	0.830	3	0.842
Religion	3.461	2	0.177
Level of education	2.553	3	0.466
Association membership	4.543	2	0.103

Culture period showed a marginally significant inverse relationship with willingness (Table 4). The β coefficient for culture period (B = -0.010, p = 0.056) suggests that for every additional month in the culture period, willingness to adopt BSFL decreases. Farmers engaged in longer culture cycles may view BSFL as a risky or complex innovation, especially if it requires additional management inputs. This suggests that farm-

ers engaged in longer cycles are less willing to adopt BSFL, possibly due to perceived risks and complexities, aligning with findings by Boateng *et al.* (2021) and Siva *et al.* (2022) on risk aversion in aquaculture. The significant negative β coefficient for the number of ponds (B = -0.005, p = 0.031) indicates that for every additional pond, willingness decreases. This is likely due to scalability challenges and disruption concerns, which corroborates the findings of Mwangi and Kariuki (2015). It also suggests that high-output farmers are more willing to adopt BSFL due to greater financial stability and growth-oriented mindsets (Asa *et al*, 2022). Farmers with larger pond systems may perceive BSFL adoption as challenging due to scalability concerns. They might also be hesitant to disrupt existing production practices that work for their extensive operations. The positive and significant β coefficient for the quantity of total harvest (B = 8.06E-06, p = 0.023) shows that for every additional kilogram of harvest, willingness increases. Farmers achieving higher harvest volumes are more willing to adopt BSFL, possibly due to their confidence in scaling innovative practices and their financial capability to experiment with new feeds. Other production variables such as the number of feedings, total stocking density, do not affect the farmers' willingness to adopt Black Soldier Fly Larvae based feed as farmers likely based their willingness on cost-effectiveness and efficiency rather than feeding schedules and stock densities (Table 4). Other variables, such as feeding frequency and stocking density, were insignificant, indicating that cost-effectiveness and productivity are prioritized over specific management practices (Musa *et al.* 2023). These findings highlight the need for targeted outreach strategies that address scalability concerns for large-scale farmers, emphasize productivity gains for high-yield farmers, and mitigate risk perceptions for those with longer culture cycles to enhance BSFL adoption in aquaculture.

Table 4: Regression analysis of production variables against farmers' willingness

Variables	B	Std. Error	t-value	p-value
(Constant)	1.085	0.094	11.518	0.000
Number of feeding times per day	0.026	0.038	0.672	0.502
Culture period	-0.01	0.005	-1.921	0.056
Number of ponds	-0.005	0.002	-2.174	0.031*
Total stocking density	-3.17E-06	0.000	-1.032	0.303
Quantity of the total harvest	8.06E-06	0.000	2.281	0.023*

* $p<0.05$

Perceived Benefits of utilization of BSFL to fish farmers in Ogun State

About 89% farmers recognized BSFL-based feed as safe, 93.8% as cost-effective, and 73% as largely acceptable to consumers considering the economic benefits and environmental sustainability (Table 5). Ouko *et al.* (2024) found that BSFL can reduce the unit price of diet rations, and 50% of fish meal protein can be replaced without affecting growth performance or economic efficiency. The high survival rates observed in *Clarias gariepinus* fed with BSFL further affirm its safety and concerns about health risks (Abd Hamid *et al.*, 2022). Acceptance of BSFL-fed fish is influenced by consumer awareness of sustainability and environmental responsibility as well as effective communication and transparency. The taste and quality of BSFL-fed fish remain unaffected, contributing to consumer trust and marketability (Asa *et al.*, 2022). Trust in the safety protocols and regulatory standards of insect-based feeds contributes to its market acceptance.

Table 5: Perceived benefit of the use of BSFL in aquafeeds

Variables	**Agree**	**Do not agree**
Potential risk to consumers	35 (11.4%)	272 (88.6%)
Cost effectiveness	288 (93.8%)	19 (6.2%)
Consumers' acceptability	224 (73%)	83 (27%)

Barriers to the Adoption of BSFL among Ogun State fish farmers

Adoption of BSFL in aquafeed practices faces several barriers, including a lack of proper training (16.21%), availability issues (15.84%), cost concerns (15.19%), and logistical challenges (14.75%) - Figure 4. Ouko *et al.* (2022) found that inadequate training significantly hinders the adoption of innovative agricultural technologies, as farmers are often unfamiliar with their benefits and integration methods. In the context of BSFL, this knowledge gap prevents farmers from understanding its nutritional advantages and cost-saving potential. Also, availability is a major concern, as inconsistent supply chains and limited distribution networks pose logistical challenges (Siva *et al.*, 2022). Solving these supply chain bottlenecks through improved infrastructure and strategic partnerships could enhance accessibility. Cost-effectiveness is another critical factor influencing adoption. Although BSFL is marketed as a cost-effective alternative to conventional feeds, farmers remain uncertain about its financial advantages (Chia *et al.*, 2020). However, competition with other feed types and consumer preferences are perceived as less severe barriers. This indicates that while traditional feed brands are well-established, consumer acceptance of BSFL- based feed in aquafeeds is relatively high, possibly due to increasing awareness of sustainable and environmentally friendly practices (Olutegbe and Ojuoluwa, 2022). Affordability ranked lower than accessibility, suggesting that logistical constraints are a more pressing issue than the direct financial cost of BSFL feed. Improving distribution networks and creating more access points could significantly enhance BSFL adoption rates. Addressing

these identified barriers through targeted education programs, supply chain improvements, and cost-effective demonstration could promote the wider acceptance of BSFL in the aquaculture sector for sustainability (Olutegbe and Ojuoluwa, 2022).

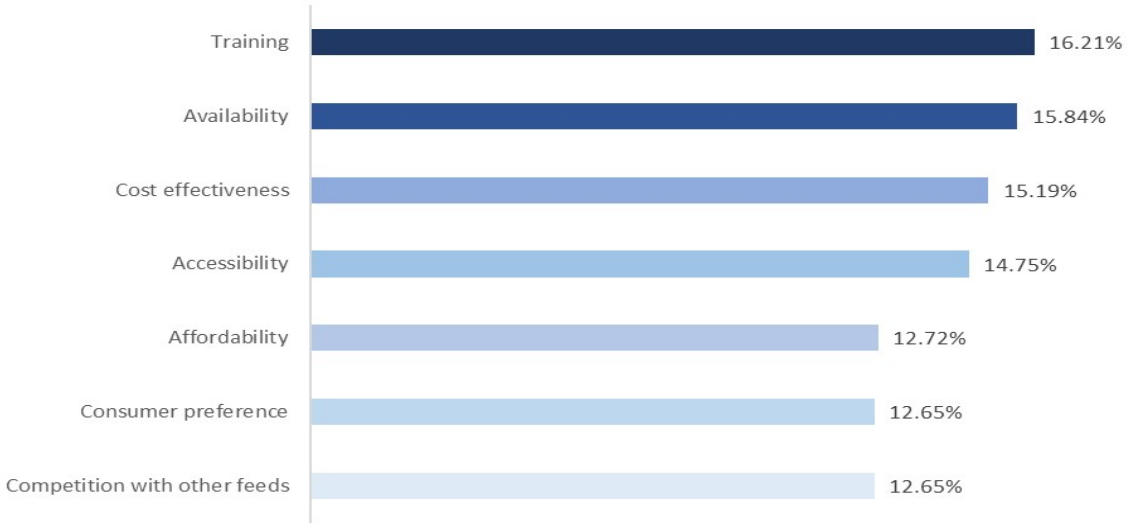

Figure 4: Barriers to BSFL adoption in descending order

CONCLUSION AND RECOMMENDATIONS

The study highlights the level of awareness, willingness, and perceived benefits of Black Soldier Fly Larvae (BSFL) in aquafeed production among fish farmers in Ogun State. While awareness of BSFL as an alternative protein source is growing, willingness to adopt remains influenced by factors such as farming experience, income level, and accessibility. Farmers recognized the cost-effectiveness, sustainability, and nutritional value of BSFL-based feed, yet barriers such as inadequate training and limited availability hinder widespread adoption. Addressing these challenges through targeted extension services, improved distribution channels, and policy support can enhance farmers' confidence in BSFL and promote its integration into aquafeeds to reduce reliance on conventional feed ingredients, lower production costs, and promote sustainable fish farming in the study area.

Acknowledgement

This work was supported by the Tertiary Education Trust Fund (TETFund) Intervention in Research Project under grant number FUNAAB/DRIP/40. The research team sincerely appreciate TETFund for the financial assistance, which significantly contributed to the successful completion of this research.

REFERENCES

Abd Hamid, N.A., Zakaria, N. F., and Mohamad Ali, N. A. L. Study on utilization of black soldier fly larvae (Hermetia illucens) as a protein substitute in the pellet diet of Clarias gariepinus fingerling. *Adv Agriculture Food Resources Journal* 2022 3(1): a0000258. https://doi.org/10.36877/aafrj.a0000258.

Alhazzaa, R., Nichols, P. D., Carter, C. G. 2019. Sustainable alternatives to dietary fish oil in tropical fish aquaculture. *Reviews in Aquaculture*, 11(4): 1195-1218.

Amankwah, A., Quagrainie, K. K., Preckel, P. V. 2018. Impact of aquaculture feed technology on fish income and poverty in Kenya. *Aquaculture Economics and Management*, 22(4): 410-430.

Anigbogu, T. U., Agbasi, O. E., Okoli, I. M. 2015. Socioeconomic factors influencing agricultural production among cooperative farmers in Anambra State, Nigeria. *International Journal of Academic Research in Economics and Management Sciences*, *4*(3): 43-58.

Asa, W. F., Amankwah, E., Quagrainie, K. K. 2022. Factors influencing the adoption of sustainable aquaculture practices among fish farmers in Ghana. *Journal of Applied Aquaculture*, 34(1): 1–20.

Boateng, D. O., Quagrainie, K. K., Amisah, S. 2021. Adoption of alternative fish feed technologies: A case of aquaculture farmers in Ghana. *Aquaculture Economics & Management*, 25(3): 243–261.

Brugere, C., Padmakumar, K. P., Leschen, W., Tocher, D. R. 2021. What influences the intention to adopt aquaculture innovations? Concepts and empirical assessment of fish farmers' perceptions and beliefs about aquafeed containing non-conventional ingredients. *Aquaculture Economics and Management*, *25*(3): 339-366.

Chia, S. Y., Macharia, J., Diiro, G. M., Kassie, M., Ekesi, S., van Loon, J. J., ... and Tanga, C. M. 2020. Smallholder farmers' knowledge and willingness to pay for insect-based feeds in Kenya. *PloS one*, 15(3): e0230552.

Food and Agriculture Organization of the United Nations. 2022. The State of Food and Agriculture 2022 (SOFA): Leveraging Agricultural Automation for Transforming Agrifood Systems. *Food and Agriculture Organization of the United Nations*.

Han, M., Liu, R., Ma, H., Zhong, K., Wang, J.and Xu, Y. 2022. The Impact of Social Capital on Farmers' Willingness to Adopt New Agricultural Technologies: Empirical Evidence from China. *Agriculture* ***12*** (9): 1368. https://doi.org/10.3390/agriculture12091368.

Mousavi, S., Zahedinezhad, S., Loh, J. Y. 2020. A review on insect meals in aquaculture: The immunomodulatory and physiological effects. *International Aquatic Research 12*(2): 100-115.

Musa, I. W., Yusuf, S. A., and Adenegan, K. O. 2023. Economic analysis of fish feed technology adoption among aquaculture farmers in Nigeria. *Aquaculture International* 31: 123–140.

Mwangi, M., Kariuki, S. 2015. Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. *Journal of Economics and Sustainable Development* 6(5); 208–216.

Olutegbe, N. S. and Ojuoluwa, O. 2022. Overcoming Social Barrier to Adoption of Black Soldier Fly (*Hermetia illucens*) as a Protein Source for Poultry: How Tall Is the Order? *Chemistry Proceedings 10*(1): 73. https://doi.org/10.3390/IOCAG2022-12321

Ouko, K. O., Mukhebi, A. W., Obiero, K.

O. Opondo, F. A. 2022. Using technology acceptance model to understand fish farmers' intention to use black soldier fly larvae meal in Nile tilapia production in Kenya. *All Life 15*(1): 884-900.

Ouko, K. O., Mboya, J. B., Obiero, K. O., Ogello, E. O., Mukhebi, A. W., Muthoka, M., Munguti, J. M. 2023. Determinants of fish farmers' awareness of insect-based aquafeeds in Kenya; the case of black soldier fly larvae meal. *Cogent Food and Agriculture 9*(1): 2187185.

Ouko, K. O., Mboya, J. B., Mukhebi, A. W., Obiero, K. O., Ogello, E. O., Munguti, J. M., and Tanga, C. M. 2024. Effect of replacing fish meal with black soldier fly larvae meal on growth performance and economic efficiency of Nile tilapia. *Fundamental and Applied Agriculture 9*(1): 1-9.

Raman, S. S., Stringer, L. C., Bruce, N. C., Chong, C. S. 2022. Opportunities, challenges and solutions for black soldier fly larvae-based animal feed production. *Journal of Cleaner Production*, 373, 133802.

Roy, J. K., Ahmed, J. U., Mannaf, M., Jannat, A., Islam, M. M. 2024. Assessing the economic viability and factors affecting farmer adoption of black soldier fly larvae as broiler feed in Bangladesh: a comparative analysis. Discover Agriculture, 2(1), 71. https://doi.org/10.1007/s44279-024-00064-9

Zarantoniello, M., Randazzo, B., Truzzi, C., Giorgini, E., Marcellucci, C., Vargas-Abúndez, J. A., and Olivotto, I. 2019. A six-month study on Black Soldier Fly (Hermetia illucens) based diets in zebrafish. *Scientific reports* 9(1): 8598.

(Manuscript received: 12th March, 2024 ; accepted: 10th June, 2025).