SCALING UP INSECT FARMING IN KADUNA STATE: CHALLENGES, EVIDENCE-BASED PROSPECTS, AND ITS ROLE IN ENHANCING LIVELIHOODS IN URBAN AND RURAL AREAS

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Abstract

This paper analyzed the prospects of scaling up and the importance of insect farming- particularly honey bees and Black Soldier Fly (BSF) in the rural and urban areas of Kaduna State. This was done through secondary data review, application of participatory methods like focus group discussion, key informant interview, semi-structured interviews and participants' observation. A mixed-methods approach is employed, combining quantitative analysis of yield data, cost-benefit assessments, and qualitative interviews with poultry farmers and agricultural experts. The research aims to identify the barriers to the adoption of BSF, such as limited access to technology, knowledge gaps, and infrastructural challenges. It also seeks to evaluate the economic potential of BSF production within the local agricultural economy, assessing its effects on poultry growth rates, feed costs, and overall farm profitability. Preliminary findings indicate that BSF can significantly enhance the nutritional quality of poultry feed while reducing dependency on conventional feed sources, which are often subject to price volatility. Furthermore, the study reveals that successful BSF farming practices could lead to increased income for farmers, reduced environmental impact compared to traditional livestock farming, and improved food security. It was recommended that the Kaduna State and Nigeria government and other interested parties must create an enabling environment that supports the development of the insect-based feed value chain. Also, it is important to raise awareness among farmers, policymakers, and consumers about the advantages of insect farming for animal feed

production, to encourage its adoption and integration into Nigeria's agricultural system. Studies should be carried out on how insect farming particularly BSF and bee keeping, processing, marketing and exporting of honey products can be enhanced in the state.

Key Words:
Insect farming, Black Soldier Fly, Bee-keeping, Honey production, Kaduna State

INTRODUCTION

A plethora of literature has revealed that honey has played a prominent role in the history of human existence, serving both sacred and culinary purposes. In any part of the world, insects form an intergral part of the ecosystem. Instects provide immediate benefit like pollination. On the other hand, they constitute a nuisance in the environment, like the mosquitoes. Crane (1999) highlights its historical significance across various civilizations in The World History of Beekeeping and Honey Hunting. Furthermore, Ambrose (2002) discusses honey's medicinal applications in Honey: A Comprehensive Survey. The Bible (Exodus 3:8) refers to the land of Canaan as "flowing with milk and honey," illustrating its cultural importance in ancient texts. Additionally, Kidd (2002) explores honey's cultural relevance and symbolism in her novel The Secret Life of Bees. Hodge (2007) emphasizes its historical use as a natural remedy in Honey: The Gourmet Medicine. Finally, Jones (2005) provides insights into beekeeping practices and honey's role in diets in Apiculture: A Guide to Bees and Honey. Collectively, these works underscore honey's multifaceted significance throughout history (Crane, 1999; Ambrose, 2002; Bible; Kidd, 2002; Hodge, 2007; Jones, 2005). The ever-increasing world population raises essential questions about our future capacity to produce and provide access to adequate food (Madau et al., 2020). According to Food and Agricultural Organization (FAO), as of 2020, approximately 8.9% of the world's population, or about 690 million people, suffer from hunger and malnutrition (FAO, 2020), highlighting the urgent need for effective actions to address this growing crisis. Fears about global food security have arisen from food losses and waste across the entire supply chain, which accounts for about one-third of all food produced for human consumption (1.3 billion tons of edible food), having significant negative economic and environmental impacts. The estimated 70% increase in global food production by 2050 compared to 2009 to fulfill the additional need for food and feed (FAO, 2009) highlights the actual challenges that practitioners, researchers, and policymakers face.

In Sub-Saharan Africa, the majority of agricultural production relies on rainfall, making it susceptible to climate change's adverse impacts like frequent droughts. This is expected to lead to more food insecurity and malnutrition (Ringler et al., 2010). Simultaneously, Africa's rapid population growth is driving higher demand for nutritious and healthy foods (Alemu et al., 2023). To address this demand while combating climate change, sustainable and resilient agricultural practices need to be adopted which is crucial for safeguarding livelihoods and improving food security and nutrition in the long term (Parodi et al., 2018; Verner et al., 2021; McKenzie et al., 2015), especially for small farmers who need to adopt low-cost farming approaches with minimal land, water, and feed requirements (Verner et al., 2021; McKenzie et al., 2015).

According to the United Nations (UN), Nigeria's population is expected to surpass 330 million by 2050, placing it among the eight countries that will account for over half of the expected increase in the global population by 2050 (United Nations Department of Economic and Social Affairs [UNDESA], 2022). The rise in population coincides with a surge in food prices, which has been exacerbated by the growing competition between humans and livestock for plant and animal protein sources. The spike in the cost of fish and other feed protein sources has been one of the primary factors driving renewed interest in insects as alternative food and feed sources (Aigbedion-Atalor et al., 2024).

Insect farming can be considered an alternative to livestock production and has the potential to offer multiple benefits (Verner et al., 2021). Insects are generally rich in high-quality animal protein and essential micronutrients, which can help improve nutrition in food-insecure areas (Huis et al., 2021). Compared to other livestock production systems, insect farming results in lower greenhouse gas emissions. Moreover, it has the potential to produce food that is nutritionally equivalent to livestock while requiring fewer resources such as water and land (Halloran et al., 2016; Alexander et al., 2017).

This makes insect farming a resilient practice in the face of climate change and positions it as a climate-smart agricultural practice (Lipper et al., 2014). Insect farming can also create employment opportunities and generate cash income for households, which can support rural livelihoods in Africa (FAO, 2013).

The Insect-based Feed Value Chain

The insect-based feed value chain includes seven key stages, as shown in the figure below.

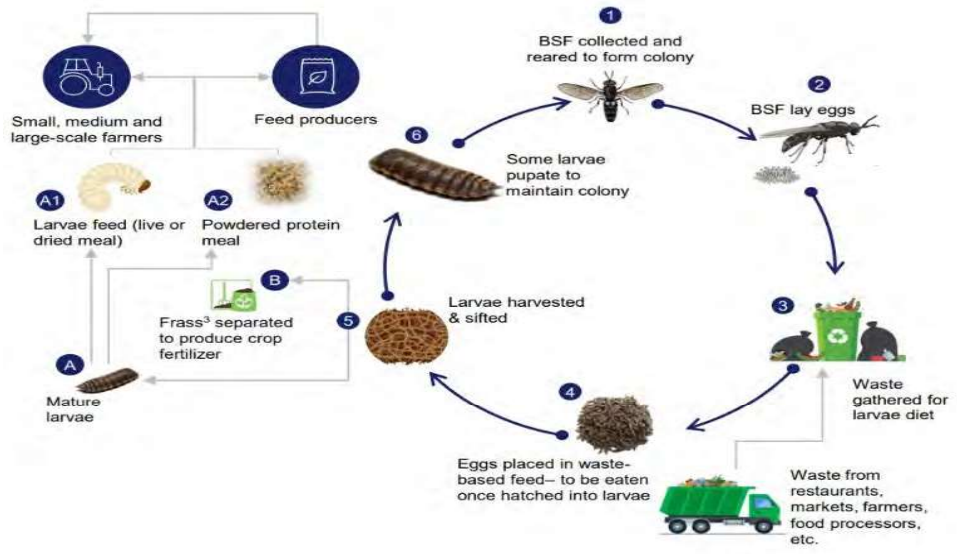

Figure 1: Insect-Based Value Food Chain
Source: Maritz, 2023.

Black Soldier Fly as Fish Feed in Kaduna State

We have few farmers of BSF in Kaduna. A residence in Barnawa and Climate-Smart Agric Center in Sabon-Tasha have been producing maggots from BSF farming with a number of challenges. The increasing demand for sustainable and cost-effective alternatives in aquaculture has led to growing interest in the use of Black Soldier Fly Larvae (BSFL) meal and oil as substitutes for traditional fish meal and fish oil. This case study explores the viability of BSFL in Kaduna State, Nigeria, where limited successful BSF farming has been reported.

BSFL are recognized for their high protein and lipid content, making them a promising alternative to fish-based feeds for aquaculture (Kroeckel et al., 2012). They can efficiently convert organic waste into protein-rich biomass, making them particularly valuable in regions with constraints on traditional fish sources. The significance of fish meal and oil in aquaculture is well-documented, but factors such as overfishing and a decreasing availability of fish have escalated costs and heightened the need for alternative feed sources. Given that BSFL thrive on organic waste streams, they represent an innovative solution for fish farmers

facing increasing feed prices. When BSFL are fed a lipid-rich diet, they accumulate oils in their bodies, offering a nutritional profile that is typically more favorable to fish than standard vegetable oils (Wang & Shelomi, 2017). For example, by supplementing the larval diet with fish offal, pre-pupae enriched with essential omega-3 fatty acids can be produced, which are highly beneficial for the growth and vision development of species such as rainbow trout (Sealey et al., 2011).

Research indicates that BSFL can partially replace fish meal in various fish diets. Although initial studies reported lower palatability and nutritive value, BSFL have been shown to be a feasible substitute, particularly when reared on local organic waste. In trials with turbot (Psetta maxima), researchers concluded that BSFL could serve as a partial replacement for fish meal, especially when cost considerations are critical (Kroeckel et al., 2012). Similar results were observed in experiments with African catfish (Clarias gariepinus), wherein total substitution of fish meal with BSFL comprising 25% of the diet did not adversely impact growth rate or nutrient utilization (Aniebo et al., 2009). The capacity of BSFL to produce protein-rich biomass from potentially protein-poor organic waste has prompted researchers to assert that BSFL can significantly contribute to sustainable aquaculture practices, potentially acting as either a partial or total meal replacement (Diener et al., 2009; Magalhães et al., 2017). This benefit extends not only to fish but could also encompass aquatic invertebrates such as shrimp (Cummins et al., 2017).

Despite the potential benefits, the adoption of BSFL farming in Nigeria has been sluggish, with only a few successful farmers operating at a small scale. In Kaduna State specifically, there are only two known BSF farmers actively involved in this innovative agricultural practice. The limited number of BSFL producers in the region may hinder broader acceptance and implementation within the local aquaculture industry. The challenges faced by these small-scale farmers include insufficient technical knowledge, lack of access to funding, and inadequate infrastructure to scale their operations. As found in broader research, effective extension services and support systems play a crucial role in the success of new agricultural practices (Ibitoye et al., 2021).

In conclusion, while BSFL meal and oil hold significant potential as substitutes for fish meal and oil in aquaculture, particularly in regions like Kaduna State, the current uptake is limited. The successful integration of BSFL into local aquaculture systems would require addressing the challenges faced by farmers, enhancing education and training, and providing adequate resources to facilitate broader implementation. By overcoming these barriers, Kaduna State could play a

pivotal role in the evolution of sustainable aquaculture practices in Nigeria, capitalizing on the advantages offered by BSFL.

Black Soldier Fly (BSF) as Poultry Feed in Kaduna State in Particular.

Less than five fewer persons are presently involved in Black Soldier Fly farming in Kaduna State despite several attempts of introducing through Ministry of Agriculture and some farms. The quest for sustainable and cost-effective poultry feeds has led to renewed interest in the potential use of Black Soldier Fly Larvae (BSFL) as a viable alternative in poultry nutrition. In Kaduna State, Nigeria, where poultry farming plays a critical role in the agricultural economy, the inclusion of BSFL in poultry diets offers numerous advantages, particularly in terms of nutrition and sustainability.

BSFL are recognized for their high protein content, essential fatty acids, vitamins, and minerals, making them a highly nutritious feed source for poultry. Research indicates that BSFL can contain up to 42% protein and 35% fat, depending on their diet during the larval stage (Bawa et al., 2021). This nutritional profile can significantly enhance the growth and overall health of poultry, especially in broilers and layers, where high protein intake is crucial for optimal performance. Additionally, studies have shown that the inclusion of BSFL can improve feed conversion ratios, allowing poultry to achieve better growth rates and feed efficiency compared to conventional feeds (Rintala & Järvisuo, 2018).

The use of BSFL as poultry feed also addresses several challenges currently facing the poultry industry, particularly the rising costs and scarcity of traditional feed ingredients such as soy meal and fish meal. Given the increasing competition for these resources, coupled with the impacts of climate change on agricultural production, farmers in Kaduna State are in search of alternative sources to maintain profitability and sustainability. By incorporating BSFL, which can be reared on organic waste and agricultural by-products, poultry farmers can lower their feed costs and diversify their feed resources, fostering a more resilient farming system (Ogunleye et al., 2019).

Moreover, BSFL cultivation contributes to effective waste management by converting organic waste materials, such as kitchen scraps, agro-industrial by-products, and animal manure—into high-quality protein for poultry. This process has significant environmental benefits, especially in urban and peri-urban areas of Kaduna State, where poultry farming is prevalent. The recycling of waste materials reduces landfill usage and lessens the carbon footprint associated with conventional feed production (Diener et al., 2009).

Despite its many advantages, the adoption of BSFL as poultry feed in Kaduna State faces several challenges. Currently, only a few farmers are engaged in BSFL production, and there is limited awareness about the benefits and practical applications of BSFL in poultry diets. Additionally, the regulatory frameworks and standards for the use of alternative proteins in animal feeds in Nigeria remain underdeveloped, which can hinder farmer confidence in transitioning to BSFL as a feed option (Adeniji & Adeyemi, 2021). The perceived safety and quality of insect-based feeds are crucial factors influencing farmers' acceptance, and a lack of standardized guidelines may create apprehension regarding the nutritional adequacy and safety of BSFL for poultry.

To fully realize the potential of BSFL in poultry feed, targeted initiatives are necessary. Educational programs aimed at poultry farmers are essential to raise awareness about the nutritional value of BSFL, practical approaches to integrating BSFL into existing feeding regimes, and the advantages of using such alternative protein sources. Collaborations with agricultural research institutes can help develop best practices and conduct further research to understand the long-term impacts of BSFL use in poultry farming (Barbosa et al., 2020).

Furthermore, establishing production facilities for BSFL is critical in scaling up adoption. Local governments and agricultural authorities in Kaduna State can support this transition by providing incentives for farmers to engage in BSFL production and use, as well as ensuring access to necessary resources and training (Ayub et al., 2021).

In conclusion, the incorporation of Black Soldier Fly Larvae into poultry feed in Kaduna State presents a promising opportunity to enhance the sustainability and profitability of the poultry industry. By leveraging the nutritional benefits of BSFL, addressing production challenges, and promoting effective education and resource systems, Kaduna State could establish itself as a leader in innovative poultry farming practices. This transition not only stands to benefit local farmers economically but also contributes to broader goals of environmental sustainability and food security.

BEEKEEPING IN KADUNA STATE

Bee keeping and production of honey is practiced in almost all the 23 LGAs of the state. The tendercy has more to do with traditional methods of keeing bees and using crude methods and implements to harvest it. Not many farmers are aware that the venom of bee costs more in the international market than the liquid. Beekeeping as a smart form of Agriculture is worth venturing. No short cuts and

can be the first industry to be set up in rural areas. From the selection of timber, leading to processing coupled with the knowledge of the precision of the "Bee Space" in all Hives produced by Bouston Honeywealth ltd, the Honey volume is at variant. Depending on source of nectar from flowers (Now encouraging sunflower planting) and closeness to water, tangible Honey crop is obtainable.

On the prospects of beekeeping in recent times the assertions made by a farmer is reported thus*:*

The beauty of this venture is not just the potential for profit but the sustainable practice of beekeeping itself. Beekeeping contributes positively to the environment by promoting pollination, which is crucial for the ecosystem. Plus, there is an increasing awareness about the benefits of natural honey compared to processed sugars, making this a perfect time to consider such an enterprise.

If you're hesitant about the initial investment, think of it this way: with an upfront cost of around 10k for the beehive and minimal ongoing expenses, the possibility of yielding high-quality honey could bring in returns that far exceed your initial input. For example, just one successful harvest can yield enough honey to reclaim your startup costs multiple times.

Moreover, the sense of accomplishment from nurturing these industrious creatures is a rewarding experience in itself. You are not just investing in a business; you are also partaking in a significant ecological endeavor that supports bee populations, which are vital to agricultural productivity.

In terms of logistics, the supply chain for beekeeping materials, like hives and attractants, is well-established. Local artisans, like the carpenter I mentioned, make it easy for new beekeepers to obtain quality equipment without excessive burden on the wallet. This accessibility is a key reason why aspiring beekeepers can confidently step into the field.

As I mentioned, just the other day, my consultant, a local clergyman with experience in beekeeping, emphasized the importance of patience and faith in this venture. It's encouraging to see that even with basic resources and a bit of dedication, remarkable things can happen. The vision of a flourishing beekeeping business becomes even more tangible when you witness the initial signs of success—like bees occupying your hives.

I encourage anyone considering this path to do thorough research, connect with local beekeeping associations, and visit those who are already in the trade. There's a community of beekeepers out there eager to share their knowledge and experiences. Whether for profit, personal enjoyment, or environmental stewardship, beekeeping offers a unique opportunity that is accessible to many.

In conclusion, while embarking on this journey may require some considerations and shared hopes, the pay-off, both financially and personally, can be immensely rewarding. Should you decide to take the plunge into beekeeping, I wish you the very best and may your hives flourish!

Remember, this isn't just about selling honey; it's about cherishing the art of beekeeping and understanding the immense value of bees to our planet. So let us nurture this age-old practice and reap its benefits for generations to come!
— Chief Mathias Kurah, mni, A retired CBN Director now a Farmer at Kenyi, Kagarko LGA on 06th Aprial, 2025.

THE ATTRACTION: Bees are kept for pollination to reproduce seed and organic products of 100% purity.
PRODUCTS:
Honey: N7500/Liter
Propolis: N500/Gram
Beeswax: N5000/Kg
Pollen: N10,000/100Gram
Bee Bread: Mixture of Honey and Pollen (N25, 000/1000Grams)
Royal Jelly (Yet to be extracted in commercial quantity in Nigeria), and Silk

TYPES OF BEE HIVE:

1. KENYAN TOP BAR (N35'000- Wooden Box, delivery, installation and Baiting (using attractant to invite the bees). Volume of Honey during harvest:10-12kg (Depending on nectar source and foraging ability of the Bees).
2. LANGSTROTH BEEHIVE (DOUBLE-DECKER) N75'000.With Queen Excluder. Honey Volume-18-22kg.
3. "CELL" COMBINATION BEEHIVE: N50'000 (Designed and developed by Bouston Honeywealth ltd in year 2020 (during the Covid 19 period). A unique and attractive hive depicting the comb cell. Honey Volume: 15-18kg.

4. POLLINATOR BEEHIVE(N18’500)-Portable and movable Beehive for Orchards and Green housing Farm. A replica of the Kenyan Top Bar with 7-9 top bars that can produce 5-6.5kg. Also to be used as “Catcher” Box for Swarms.
5. SINGLE CABIN LANGSTROTH: (N35’000). Honey Volume-8-12kg.
6. THE WARRE BEEHIVE: An interesting Beehive mimicking the tree trunk. To be handled by Professional Beekeepers. (N125’000). Honey Volume- 36-42kg.

Over the years, volume of Honey increases.

TIME FRAME:

A year is considered to be tolerable period for Hive occupation to establish colony with active Queen (producing 1000 plus eggs per day after mating with 10-15 male bees).

Worker Bee (Sterile female that constitute 98% of the colony).

Drone, the male bee responsible for mating the Queen Bee.

SECURITY:

Is of paramount importance to safeguard investment. Bee products translate to USD ($), EURO (€) and POUND (£). In an ideal situation, Bee Farm must be fenced with provision of entrance Gate at the back. Demonstration Bee Farm in communities can spark active involvement and participation

EQUIPMENT:

Beesuit/Face veil (Protective gear)
Smoker
Hand glove
Hive tool
Knife
Gum Boot
Cone
Sieve

MANAGEMENT: Least Management of hives remain our trade mark. We encourage and apply natural ways to keep Bees.Sequel to the formation of cooperative, registration is envisaged with CAC and NAFDAC certification for authenticity of products after assay reports

Source: Haruna Magaji Jirayi (Certified Beekeeper). VEA (Volunteer Exchange Ambassador). Hunan Agricultural Group. Changsha-China.

Plate 1: This is a Black Soldier Fly love cage constructed in Kaduna. The farm is owned by a practicing Medical Doctor in Barnawa.

Plate 3: This is a a wooden honey pressing machine in Care & Action Research CaRE-NGO, Kaduna. It was donated by the CBDD of DFID

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Plate 2:This is a Smoker for scaring bees away during harvest of honey from CaRE-NGO, Kaduna

Plate 4: Larvae of Black Soldier Flies weight billed from Abeokuta to Kaduna. Attempts to start BSF in CaRE-NGO have not produced the desired results. BSF are expected to produce maggots for poultry and fish feeds

Plate 5: This is the chaff or bee wax left after processing honey. It is used in candle making, shoe polish, furniture

making and pharmaceutical industries. It is used in blocking seepage from leaking roofs. It is very expensive when exported.

Plate 7: This is a metal press for processing honey. It was donated to CaRE-NGO, Kaduna by CBDD of DFID.

Plate 9: This is the box that contains the eggs hatched BSF in the love cage. The picture was taken in a BSF farm in Kaduna. There are few such farms in Kaduna.

Plate 6: This is raw honey that has not yet been filtered from Kagal, Zangon Kataf LGA, Kaduna State. Together with weight billing, this cost N10,000. A 25 litre jerry can of honey is now sold at N100,000 in Kaduna.

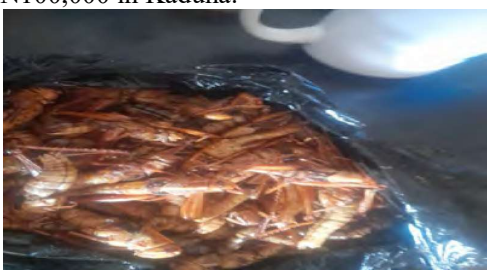

Plate 8: This wrap of locust delicacy (para) is N100. It was brought from Maiduguri area. It is a common delicacy in Kaduna. There was a time in the 1950s when locust wrecked farms. No attempt has been made to rear/farm locust in Kaduna.

Plate 10: 'Fried' maggots from BSF for feeding fish and poultry. When fully in operation, they are expected to bring down the cost of fish and poultry feeds in Kaduna

Plate 11: These are eggs of BSF laid in love cage. These will later

metamophorse into pupae and larva.

Plate 13: These are the pupae of BSF bought from Abeokuta. Apart from transportation, the cost stood at N20,000. It has been difficult trying to establish BSF farm in Kaduna.

Plate 12: This is local experiment made in CaRE-NGO to start a BSF farm.

Plate 14: Beehive Langstroth

Plate 15: Single Cabin Langstroth

The Black Soldier Fly lays eggs inside the edges of these separated sticks. The basins contains the substiate where the maggots transfor into pupae.

Plate 16: Kenyan Top Bar, Langstroth, and Cell Combination (clockwise)

This is the love cage in Sabon-Tasha, Kaduna where the BSF meet to lay eggs.

This is Black Soldier Fly . From this both the female and male meet in the love cage to form eggs. Attempt to produce light for the love cage led to an explosion. Due to inadequate light the attempt to collect the eggs did not produce good results

Study Area and Methodology

Kaduna State is made up of 23 LGAs and a report by AFEX indicates that 77.5% of the population of 9.02 million are active farmers. The state is situated in a tropical wet and dry climate, classified as Köppen Aw (Abdussalam, 2020). The wet season runs for about six to seven months, mostly between April and October with a peak in August, with an average rainfall of about 1400mm. The dry season denotes Harmattan, having severe dust haze, with northerly winds blowing from the desert. Maximum temperature in Kaduna North can be well over 30^0C, with the hottest months being March, April, and May. The relative humidity typically ranges from 25% and 90% depending on the month of the year, with the lowest humidity between December and February.

The study utilized various types of secondary data, including demographic information, economic statistics, and previous research findings related to the beekeeping and honey production sector. The research involved conducting eight Focus Group Discussions (FGDs) with two categories of participants: bee farmers and honey entrepreneurs. A total of ten Key Informant Interviews (KIIs) were conducted, with five beekeepers and five honey entrepreneurs participating.

In terms of respondent distribution, the study included 20 respondents in Location A, 15 respondents in Location B, and 25 respondents in Location C.

These methods were chosen to ensure comprehensive insights into the beekeeping industry. The participatory methods employed included Focus Group Discussions, Key Informant Interviews, semi-structured interviews, and participant observation, allowing for a rich understanding of community perspectives. In total, 198 respondents were contacted to provide information for the study. This number included participants from eight Focus Group Discussions (FGDs) as well as individuals involved in Key Informant Interviews (KIIs). The key informant interviews were conducted with beekeepers and honey business entrepreneurs across various local government areas (LGAs), including Kagal, Zangon-Kataf, Kagarko, Kajuru, Chikun, Kaduna South, and Zaria. This sample consisted of diverse stakeholders to ensure a comprehensive understanding of the beekeeping industry in the region.

Figure 2: Kaduna State showing the Study Areas
Source: Adapted from GRID[3] - Nigeria, 2022.

Results and Discussion

The relevant socio-economic and demographic characteristics of the respondents are shown in Table 1. Shows the results indicate a significant male dominance among the respondents, with 93.9% identifying as male and only 6.1% as female. This disparity may reflect cultural norms and societal barriers that limit women's participation in beekeeping and related activities.

Variable	Categories	Frequency	Percentage (%)
Sex	Male	186	93.9
	Female	12	6.1
	Total	**198**	**100.0**
Age	Less than 20 years	38	19.2
	20-29	20	10.1
	30-39	51	25.7
	40-49	33	16.7
	50-59	36	18.2
	60+	20	10.1
	Total	**198**	**100.0**
Marital Status	Single	38	19.2
	Married	121	61.1
	Widowed	39	19.7
	Total	**198**	**100.0**
Level of Education	No formal education	28	14.1
	Literacy classes	32	16.2
	Primary/Quranic	48	24.2
	Secondary school	49	24.7
	Tertiary Education	41	20.7
	Total	**198**	**100.0**
Occupation	Farmer only	87	43.93
	Civil servant	58	29.29
	Business	20	10.10
	Artisan/Others	33	16.66
	Total	**198**	**100.0**
Types of Insects Kept	Bee	190	96.0
	Black Soldier Fly	6	3.0
	Locust	2	1.0
	Total	**198**	**100.0**

Purpose for Keeing Insects	For commercial purposes only	180	90.90
	For both commercial and consumption in the family	10	5.05
	Other purposes	8	4.04
	Total	**198**	**100.0**

Source: Field Study (2024)

In terms of age distribution, the majority of respondents fall within the 30-39 age group, accounting for 25.7% of the total. This suggests that beekeeping is an activity predominantly engaged in by younger adults. Notably, nearly 29.3% of respondents are under the age of 30, indicating a potential for youth involvement in this sector. Conversely, the lower representation of individuals aged 60 and above (10.1%) may imply challenges for older populations in sustaining demanding agricultural practices. The marital status of respondents shows a predominantly married demographic, with 61.1% in this category. This points to the likelihood that beekeeping is viewed as a family-oriented venture, possibly emphasizing the importance of community and familial support in agricultural activities.

Education levels reveal that while a significant number of respondents have completed secondary education (24.7%) and tertiary education (20.7%), nearly a third of the sample (30.3%) lacks formal education. This educational disparity can potentially affect respondents' access to advanced beekeeping knowledge and business acumen, which are crucial for enhancing productivity and market competitiveness. Regarding occupation, nearly half of the respondents (43.9%) identify as farmers, highlighting the close relationship between agriculture and beekeeping in the region. Additionally, a substantial proportion of civil servants (29.3%) suggests that some may engage in beekeeping as a supplementary income source rather than their primary livelihood.

The results reveal that 96% of respondents primarily keep bees, indicating a strong focus on beekeeping as the main activity in the study. Furthermore, an overwhelming majority (90.9%) keep insects for commercial purposes only, emphasizing the economic importance of beekeeping in this community. Only a small percentage of respondents keep insects for family consumption or other purposes, reinforcing the notion of beekeeping as a significant source of income rather than a subsistence activity.

Overall, the profile of respondents illustrates a predominantly male, middle-aged population involved in beekeeping primarily for commercial gain, with varying levels of education that could influence their engagement in innovative practices. This understanding of socio-economic and demographic characteristics can inform targeted interventions and support programs aimed at enhancing the beekeeping industry in the region.

In Kaduna State, the challenges associated with insect farming are significant and multifaceted, severely limiting the growth potential of this sector. One of the primary hurdles is limited access to funding. Insect farming, particularly for human consumption, lacks widespread recognition among agricultural financing bodies in Nigeria. As Ayegba (2016) notes, agricultural credit providers typically prioritize traditional agriculture and staple crops such as livestock, cassava, and vegetables. Consequently, insect farmers face difficulties in securing necessary funding and often depend on personal finances, thereby restricting their ability to invest and expand their operations in a competitive market (Ibitoye et al., 2019).

Moreover, there is a critical issue regarding insufficient information and skills available to insect farmers in Kaduna State. Despite some research targeting select species like B. membranaceus, there remains a significant deficit in knowledge related to the benefits, technical rearing practices, and profitability of other edible insect species, such as Z. variegatus and M. bellicosus (Banjo et al., 2006; Okweche et al., 2022). This gap in data hinders farmers' ability to develop essential skills and access necessary training materials, consequently obstructing the promotion of insects as viable food sources (Aigbedion-Atalor et al., 2024).

The lack of advanced processing technology is another major barrier to sustainable insect production. Most insects consumed in Nigeria are prepared through traditional methods, which may not align with the safety and quality standards required for modern food production (Adeoye et al., 2014). Current processing techniques such as steaming, roasting, and sun-drying are inadequate for scaling production to meet market demand. Additionally, as van Huis et al. (2013) highlight, Nigeria lacks clear legislation governing the rearing, harvesting, and commercialization of edible insects, leading to substantial losses for farmers, particularly when products like roasted insects do not sell within specified time frames (Ebenebe et al., 2017).

The existing poor extension services further exacerbate these obstacles. The disconnect between research outcomes and practical farming applications is due in large part to a shortage of effective extension services (Ibitoye et al., 2021). Experts suggest that improving the competencies of extension officers and

offering targeted training for farmers on best practices could bridge this gap and promote sector growth (Ibitoye et al., 2019).

Additionally, in Kaduna State, insects are primarily collected from the wild, creating challenges related to seasonality. Variations in environmental conditions can disrupt the life cycles of these insects, resulting in supply fluctuations that complicate market dynamics (Ebenebe et al., 2020). This situation often leads to increased pricing and irregular supply, which negatively impacts both consumers and producers (Ibitoye et al., 2019).

Finally, the challenge of scaling production is crucial. Start-ups in the insect farming sector encounter difficulties in establishing reliable methods to increase their production capabilities. The demand for insects, particularly as feed, surpasses current production levels, necessitating improvements in farming practices, access to resources, and technology (Nolet, 2017; Yang and Cooke, 2021). Regulatory uncertainties compound these challenges, further stifling the sector's potential for growth.

Therefore, addressing the challenges of access to funding, knowledge gaps, processing technology, extension services, seasonality, and production scaling is essential for facilitating the growth of the insect farming industry in Kaduna State. By overcoming these obstacles, the sector may harness its potential as a sustainable and viable alternative protein source in the region.

CONCLUSION

The findings from the study in Kaduna State highlight a significant opportunity for the growth of the beekeeping industry and alternative insect farming, particularly given the socio-economic context of the region. With 77.5% of the state's population actively engaged in farming, there is a substantial base for expanding agricultural practices, including the incorporation of innovative insect farming techniques such as raising Black Soldier Fly Larvae (BSFL) for poultry feed.

Kaduna State's tropical climate supports diverse agricultural activities; however, the industry faces numerous challenges that need to be addressed to optimize the benefits of insect farming. The demographic profile of respondents indicates a predominantly male, middle-aged population primarily engaged in beekeeping for commercial purposes, suggesting a community ready to embrace new agricultural practices if provided with the right support and resources.

Barriers such as limited access to funding, insufficient knowledge and skills, the lack of advanced processing technologies, poor extension services, and the challenges of seasonality significantly hinder the growth potential of the insect

farming sector. Specifically, many farmers currently depend on traditional methods and face difficulties in securing financing from agricultural credit bodies, which often prioritize conventional crops over innovative approaches like insect farming.

To foster the growth of the insect farming industry in Kaduna, several targeted interventions are essential. These include enhancing access to financial resources for farmers, providing comprehensive training programs to bridge knowledge gaps, and developing advanced processing technologies that meet safety and quality standards. Furthermore, improving extension services to connect research outcomes with practical farming applications will be crucial in promoting best practices in insect farming.

Additionally, addressing the seasonal variability in insect supply through reliable farming methods will be vital for stabilizing the market. By overcoming these barriers, Kaduna State can capitalize on the potential of BSFL as a sustainable protein source, not only contributing to food security and economic stability for farmers but also positioning the state as a leader in innovative agricultural practices across Nigeria.

The integration of BSFL and the enhancement of the broader insect farming sector in Kaduna State hold significant promise for improving the livelihoods of local farmers and contributing to a more resilient agricultural economy. Efforts to support this transition should be prioritized to ensure that the region benefits from the full potential of innovative, sustainable farming practices.

RECOMMENDATIONS

Insect farming has the potential to offer several benefits but to take advantage of these benefits, the Kaduna State and Nigeria government and other interested parties must create an enabling environment that supports the development of the insect-based feed value chain. This can be accomplished by providing technical and financial assistance to farmers and entrepreneurs, encouraging research and development in insect farming, and implementing policies that promote investment in the sector. Additionally, it is important to raise awareness among farmers, policymakers, and consumers about the advantages of insect farming for animal feed production, to encourage its adoption and integration into Nigeria's agricultural system. Studies should be carried out on how insect farming particularly BSF and bee keeping, processing, marketing and exporting of honey products can be enhanced in the state.

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