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Grasshopper production in Nigeria: Prospects, challenges, and future directions: A reviewed

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Abstract

The growing demand for sustainable protein sources has intensified interest in edible insects, particularly grasshoppers (Orthoptera), in Nigeria. This review aims to evaluate the potential of grasshoppers as an alternative protein source for food and feed systems. A comprehensive synthesis of existing literature was conducted, focusing on grasshopper biology, nutritional composition, production systems, economic relevance, and environmental sustainability. The findings indicate that grasshoppers are rich in high-quality protein, essential amino acids, lipids, and micronutrients, making them suitable for both human consumption and animal feeding. However, production remains largely dependent on seasonal wild harvesting, which limits scalability and commercialization. Key constraints identified include the absence of standardized domestication technologies, inadequate policy frameworks, and socio-cultural barriers affecting widespread adoption. Despite these challenges, significant opportunities exist for integrating grasshopper farming into Nigeria's agricultural systems to enhance food security, generate income, and promote environmental sustainability. In conclusion, the development of a sustainable grasshopper production industry in Nigeria requires targeted research on mass rearing techniques, supportive policies, and increased public awareness to facilitate acceptance and commercialization.

Keywords: Grasshopper Production; Edible Insects; Nigeria; Entomophagy; Sustainable Protein

1. Introduction

The global demand for sustainable protein sources is increasing due to rapid population growth and the environmental limitations associated with conventional livestock production. Edible insects have gained attention as promising alternatives because of their high feed conversion efficiency, low greenhouse gas emissions, and minimal land requirements [1,2]. In Nigeria, meeting the protein needs of a growing population remains a significant challenge, as conventional livestock systems are constrained by rising feed costs, climate change, and environmental pressures [3].

In sub-Saharan Africa, edible insects particularly Orthopteran species such as grasshoppers play an important role in traditional diets, with over 126 species consumed. In Nigeria, species such as *Zonocerus variegatus* are widely consumed, especially during the rainy season, highlighting their nutritional and cultural relevance. However, current supply systems rely largely on seasonal wild harvesting, resulting in inconsistent availability and limiting opportunities for large-scale production and commercialization.

Therefore, this study aims to evaluate the potential of grasshoppers as a sustainable protein source by examining their production systems, nutritional value, and prospects for integration into structured farming and feed applications.

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2. Biology and Species of Edible Grasshoppers

Grasshoppers belong to the order Orthoptera and are characterized by a hemimetabolous life cycle consisting of egg, nymph, and adult stages, as well as predominantly herbivorous feeding behavior [4,5]. Their developmental pattern allows for gradual morphological changes without a pupal stage, which is advantageous for controlled rearing systems. In addition, grasshoppers exhibit relatively high reproductive potential, with many species capable of producing multiple egg pods under favorable environmental conditions [6,7]. In Nigeria, several species are widely recognized as edible and culturally accepted, including *Zonocerus variegatus, Oedaleus senegalensis,* and *Ornithacris cavroisi* [3,8]. A comprehensive understanding of the biology, ecology, and reproductive dynamics of these species is essential for their successful domestication and large-scale production, particularly in the context of developing sustainable alternative protein sources [9,10].

The variegated grasshopper (*Zonocerus variegatus*) is the most studied species in Nigeria. It is polyphagous and feeds on a wide range of crops and weeds. Seasonal abundance is strongly influenced by rainfall patterns, with peak populations occurring during the late rainy season. Egg diapause and synchronized hatching contribute to seasonal availability, which directly affects supply for consumption and trade.

3. Nutritional Composition

Grasshoppers are recognized as highly nutritious, containing substantial levels of crude protein (40–70%) and lipids (10–30%), alongside a favorable profile of essential amino acids such as lysine and methionine, which are often limiting in conventional cereal-based diets [11,9]. In addition, they are rich in essential micronutrients, particularly iron and zinc, contributing to their value in addressing micronutrient deficiencies in developing regions [8,12]. Specifically, *Zonocerus variegatus* has been reported to possess high nutritional quality, with significant protein content and mineral composition, making it suitable for both human consumption and as an alternative ingredient in animal feed formulations [3,13]. These attributes highlight the potential of grasshoppers as sustainable and nutrient-dense food sources in emerging food systems.

Processing methods such as boiling, roasting, and frying have been shown to significantly influence nutrient retention, lipid stability, and the reduction of anti-nutritional factors in edible insects, with variations depending on species and processing conditions [11,14]. Thermal processing can improve digestibility and microbial safety, although excessive heating may reduce heat-sensitive nutrients. Across Africa, edible insects are widely recognized not only for their nutritional value but also for their ethnomedicinal and therapeutic significance in traditional diets [8,9]. Their high-quality protein, characterized by a balanced essential amino acid profile, makes them suitable for incorporation into both human diets and livestock feed formulations, offering a sustainable alternative to conventional protein sources such as soybean meal and fishmeal [12,15].

4. Traditional Harvesting and Utilization

Grasshopper consumption in Nigeria is predominantly dependent on wild harvesting practices, including hand picking, sweep netting, and light trapping, which are commonly employed in rural and peri-urban communities [8,9]. Once collected, these insects are typically processed through traditional methods such as roasting, frying, or sun-drying to enhance shelf life, palatability, and safety [3,16]. However, reliance on wild collection systems presents several limitations, including strong seasonality linked to ecological cycles, lack of standardized quality control measures, and inconsistent supply chains that hinder large-scale commercialization and industrial utilization [17, 9]. These constraints underscore the need for domestication and controlled production systems to ensure year-round availability and product standardization.

5. Grasshopper Production Systems

5.1. Wild Harvesting

Currently, the dominant system in Nigeria is wild collection. This method is seasonal, had low capital requirement, unsustainable with increasing demand and may affect biodiversity if overexploited.

5.2. Semi-Intensive and Intensive Farming

Emerging studies have demonstrated the feasibility of controlled rearing of grasshoppers under managed conditions, highlighting their potential for scalable production [9.17]. Grasshoppers can be successfully reared on a range of low-cost substrates, including agricultural by-products such as cassava peels, maize residues, and vegetable wastes, thereby reducing feed costs and enhancing sustainability within circular bioeconomy frameworks [15,10]. Various production systems have been proposed and tested, including cage-based systems, controlled indoor rearing units, and semi-intensive outdoor systems, each offering different advantages in terms of environmental control, labor efficiency, and productivity [9]. Furthermore, experimental evidence indicates that diet composition plays a critical role in influencing growth performance, survival rates, and reproductive output in grasshoppers, emphasizing the importance of optimized feed formulation for successful domestication [7,18]. These findings collectively support the viability of grasshopper farming as a sustainable alternative protein production system.

6. Production Systems in Nigeria

6.1. Traditional System

- Wild harvesting (dominant)
- Seasonal availability
- Minimal input

6.2. Emerging Farming Systems

- Cage-based rearing
- Semi-intensive systems
- Waste-fed insect production

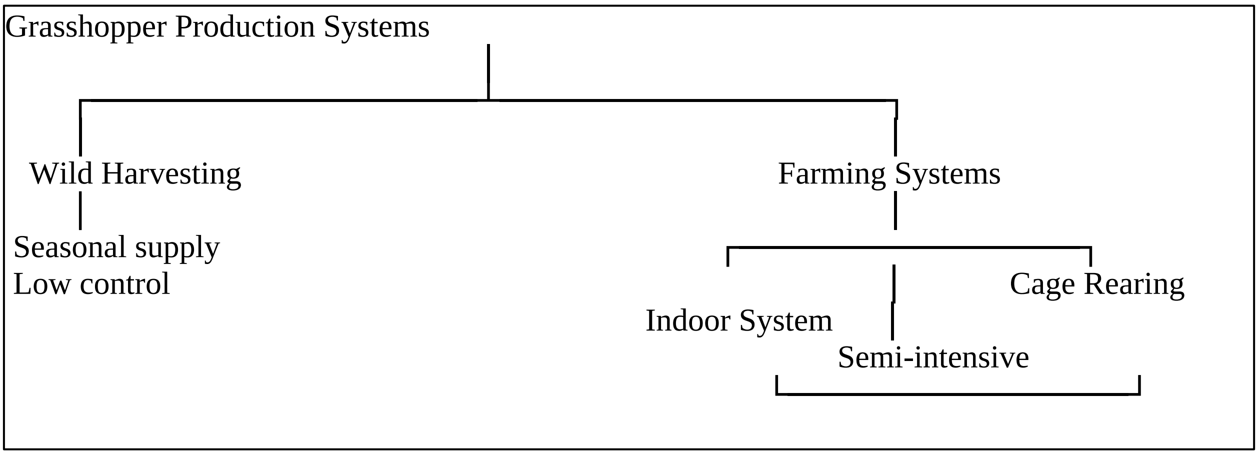

Figure 1 Grasshopper Production Systems (Conceptual Framework)

7. Value Chain of Grasshopper Production

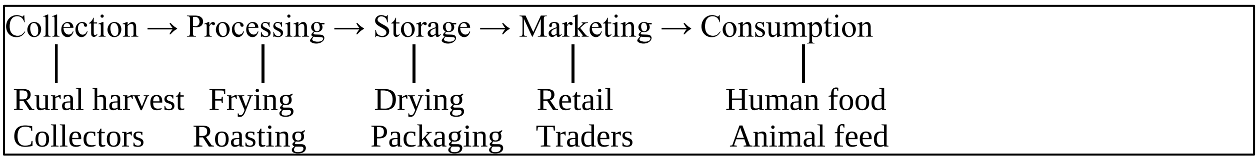

Figure 2 Grasshopper Value Chain in Nigeria

Grasshopper marketing contributes to rural livelihoods and provides income opportunities, especially for women and youth.

Breeding Stock → Egg Collection → Nymph Rearing → Feeding (Agro-waste)
↓
Growth Monitoring → Harvesting → Processing → Packaging → Distribution

Figure 3 Grasshopper Production System

Integrate insect production into agricultural extension programs

8. Economic Importance and Value Chain

Grasshopper trade contributes significantly to rural livelihoods by supporting income generation, employment creation, and the development of localized value chains [8,9]. In East Africa, particularly in Uganda and Kenya, commercialization of edible grasshoppers has evolved into a profitable seasonal enterprise, demonstrating strong economic viability and scalability [19]. Comparable opportunities exist in Nigeria, where marketing systems involve collectors, wholesalers, and retailers, thereby generating income and supporting household economies in rural communities [3,20].

Recent studies (2020–2025) further reinforce the potential of insect-derived meals as sustainable feed ingredients in poultry production. Insect meals, including those derived from Orthoptera and black soldier fly larvae, have been successfully used to partially or completely replace conventional protein sources such as fishmeal and soybean meal without adverse effects on growth performance, feed conversion ratio (FCR), or carcass quality in broiler chickens [21, 22, 23, 24, 25, 26]. Although insect meal inclusion at 5–10% consistently improves performance, digestibility, and gut morphology, variability exists across studies due to differences in insect species, processing methods (defatted vs full-fat), and diet formulation. For instance, the magnitude of FCR improvement (3–8%) and villus height enhancement (8–18%) may be influenced by chitin content, which can either stimulate gut health or reduce nutrient digestibility at higher inclusion levels. Furthermore, while immune responses (e.g., IgG increases of 8–20%) are generally enhanced, these effects are often context-dependent and may vary with bird age, health status, and environmental stressors.

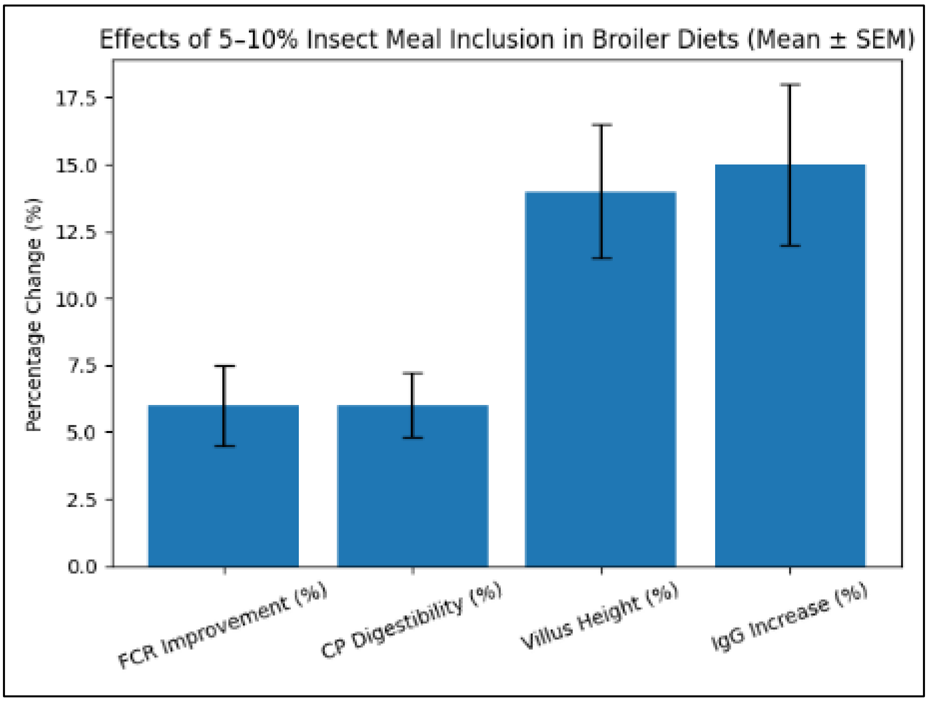

Figure 4 Effects of 5–10% insect meal inclusion in broiler diets on feed conversion ratio (FCR), crude protein (CP) digestibility, intestinal villus height, and immunoglobulin G (IgG) levels. Values represent mean percentage change relative to control diets (soybean/fishmeal-based), with error bars indicating standard error of the mean (SEM). Data synthesized from multiple studies (2020–2025)

Importantly, inclusion levels approaching 15% tend to show diminishing returns or neutral effects on growth performance, suggesting a threshold beyond which nutrient imbalances or reduced palatability may occur. Economic benefits are also highly location-specific, as profitability depends on the scalability and cost-efficiency of insect production systems. Therefore, while insect meals demonstrate strong potential as sustainable protein sources, optimization of inclusion levels, processing techniques, and diet formulation remains essential for consistent results.

Table 1 Comparison Table (5–15% Inclusion Levels)

Parameter	5% Inclusion	10% Inclusion	15% Inclusion
Feed Conversion Ratio (FCR)	↓ 3–5% improvement	↓ 5–8% improvement	≈ unchanged or ↓ 0–5%
Body Weight Gain	↑ 2–4%	↑ 4–7%	≈ similar (±2%)
Protein Deposition (CP)	↑ 3–6%	↑ 5–9%	↑ 2–5%
Breast Yield	↑ 2–4%	↑ 3–6%	≈ stable
CP Digestibility	↑ 3–5%	↑ 5–7%	↑ 2–4%
Fat Digestibility	↑ 4–7%	↑ 6–10%	↑ 5–8%
Villus Height	↑ 8–12%	↑ 10–18%	↑ 8–15%
Villus:Crypt Ratio	↑ 10–15%	↑ 12–20%	↑ 8–15%
Immune Response (IgG, IgA)	↑ 8–12%	↑ 10–20%	↑ 8–15%
Feed Cost Reduction	↓ 5–8%	↓ 8–12%	↓ 6–10%
Overall Performance	Improved	Optimal	Safe upper limit

From an economic perspective, insect meal production offers substantial cost-saving potential, particularly when insects are reared on low-cost organic substrates such as agricultural by-products and food waste. Feed typically accounts for 60–70% of total poultry production costs; thus, partial replacement of expensive ingredients like fishmeal can significantly reduce overall production expenses. Studies indicate that incorporating insect meal can lower feed costs while maintaining or improving growth performance, thereby increasing gross profit margins in poultry systems. Additionally, insect farming systems are characterized by relatively low land requirements, rapid biomass conversion, and the ability to utilize waste streams, contributing to improved resource efficiency and circular economy benefits [17].

Despite promising economic indicators, several constraints may affect ROI in insect farming systems. Feedstock availability and consistency remain critical, as nutrient variability in organic substrates can lead to 5–20% variation in larval crude protein content and up to 10–15% differences in growth rates across production batches [27, 28]. While the present study (Table 1) demonstrated improved feed efficiency and protein utilization at moderate inclusion levels, previous studies have reported neutral or slightly reduced performance (0–5% decline in weight gain or FCR) at higher inclusion rates (>15–20%), often attributed to elevated chitin levels and reduced nutrient digestibility [29, 21]. Similarly, although we observed enhanced gut morphology (Figure 4), the magnitude of villus height improvement reported in the literature varies widely (+5% to +25%), depending on insect species, processing method (defatted vs full-fat), and diet formulation [25, 30].

Initial capital investment for controlled production systems (e.g., climate regulation, drying, and processing infrastructure) remains a significant barrier, with setup costs varying by 20–40% across production scales, potentially limiting adoption in resource-constrained settings [31, 2]. In addition, regulatory frameworks governing insect use in animal feed are still evolving in many regions, including parts of Nigeria, which may restrict market access and commercialization [32, 33]. Reported profitability also shows notable variability, with return margins ranging from 5% to 18%, reflecting differences in production scale, insect species, feedstock sourcing, and processing efficiency [34, 35].

Furthermore, while insect-derived proteins are generally rich in essential amino acids, digestibility coefficients may vary by 3–10%, particularly for lysine and methionine, depending on processing conditions and chitin content [36, 37, 27]. Some studies have also highlighted potential palatability issues or reduced feed intake at higher inclusion levels, although these effects are inconsistent. Therefore, although our findings support the growing body of evidence that insect meals can enhance performance and sustainability, their long-term viability in Nigeria will depend on optimizing inclusion levels (as reflected in Table 1), improving substrate standardization, reducing production costs, and strengthening policy and value chain development [24, 38].

Table 2 Quantitative Ranges of the Effects of integration of grasshopper meal and other insect-based proteins into poultry feeding systems

Parameter	Reported Range Across Studies	Key Supporting References
CP content variability	5–20%	[15, 11, 27]
Growth performance variation	−5% to +10%	[25, 21, 29]
FCR change	−8% to +5%	[37,25, 34]
Villus height improvement	+5% to +25%	[25, 30]
Digestibility variation	3–10%	[15, 36, 37]
Profit margin (ROI)	5–18%	[9, 34, 32]
Capital cost variation	20–40%	[9, 38]

Overall, the integration of grasshopper meal and other insect-based proteins into poultry feeding systems presents a viable pathway for reducing feed costs, enhancing sustainability, and creating new economic opportunities within Nigeria's agricultural sector.

9. Food Security and Environmental Sustainability

Edible insects contribute significantly to food security in Nigeria by providing affordable, high-quality protein, reducing reliance on conventional livestock, and efficiently utilizing organic waste streams as feed substrates [9, 8]. Their ability to convert low-value biomass into nutrient-dense protein makes them particularly relevant in addressing protein deficiencies and improving resilience in food systems. In addition, insect farming systems support circular bioeconomy principles by transforming agricultural by-products and organic waste into valuable feed and food resources [39].

Table 3 Comparison Insects vs Conventional Livestock

Parameter	Insects (e.g., grasshoppers, crickets)	Poultry (chicken)	Pigs	Cattle
Feed Conversion Ratio (kg feed/kg gain)	~2:1	~2–3:1	~3–5:1	~8:1
Greenhouse Gas Emissions	Very low (up to 10–100× lower than livestock in some cases)	Moderate	High	Very high
Land Requirement	Very low	Moderate	High	Very high
Water Requirement	Low	Moderate	High	Very high
Edible Portion (%)	Up to ~80–100%	~55–65%	~55%	~40–50%
Waste Utilization	Can convert organic waste into protein	Limited	Limited	Limited
Production Cycle	Short (weeks)	Moderate (6–8 weeks)	Medium	Long (months–years)

From an environmental perspective, insect production offers substantial advantages over conventional livestock systems. Insects exhibit high feed conversion efficiency due to their poikilothermic nature, requiring significantly less feed to produce equivalent biomass. For example, insects may require approximately 2 kg of feed to produce 1 kg of body mass, compared to about 8 kg for cattle [40]. Furthermore, insects generate considerably lower greenhouse gas emissions and require less land and water, making them a more sustainable protein source [41, 17]. Recent studies also indicate that insect-based systems can reduce emissions by up to 50–90% when integrated into livestock feeding systems and waste bioconversion pathways [39]. Compared to conventional livestock, insect farming demonstrates superior resource-use efficiency, including higher edible yield (often approaching 100% of body mass) and the ability to utilize organic waste streams effectively. These attributes position grasshopper production as a viable component of climate-smart agriculture and sustainable livestock systems in Nigeria, contributing to reduced environmental footprints while enhancing food and feed security [9, 17]

10. Challenges Limiting Grasshopper Production in Nigeria

10.1. Challenges Limiting Grasshopper Production in Nigeria

Despite the growing interest in grasshopper farming, several challenges constrain its commercialization and scalability in Nigeria. These limitations span biological, technical, socio-economic, and policy-related factors.

10.1.1. Dependence on Wild Populations

Current grasshopper production largely relies on wild harvesting, which is inherently seasonal and unpredictable [8, 9]. This dependence leads to supply inconsistency, limiting year-round availability and the ability to scale operations. Seasonal fluctuations also affect prices, market stability, and income reliability for rural collectors.

10.1.2. Lack of Standardized Rearing Protocols

There is a shortage of species-specific rearing guidelines, including optimal diet formulation, environmental control, and breeding strategies [10, 7]. Grasshoppers, like other Orthoptera, exhibit sensitivity to temperature, humidity, and population density, which can impact growth, survival, and reproductive performance under controlled conditions [18]. The absence of standardized protocols limits successful domestication.

10.1.3. Feed and Nutritional Challenges

While grasshoppers can utilize agricultural by-products, not all locally available substrates provide complete nutrition, and feed formulation for optimal growth and reproduction remains under-researched [15, 10]. Nutrient deficiencies can reduce survival rates, fecundity, and biomass yield, impacting the economic viability of farming.

10.1.4. Disease and Pest Management

Insects, including grasshoppers, are susceptible to microbial infections, parasites, and cannibalism under intensive production conditions [17]. Limited knowledge of insect-specific disease management and biosecurity practices increases mortality risks in farmed populations.

10.1.5. Technical and Infrastructure Limitations

Controlled indoor rearing requires cages, ventilation, temperature regulation, and lighting systems. In rural Nigeria, lack of access to such infrastructure and technical expertise hinders large-scale adoption [9]. Additionally, post-harvest processing facilities for drying, roasting, or milling are often inadequate, affecting product quality and market acceptance.

10.1.6. Socio-Economic and Policy Constraints

There is limited awareness among farmers and investors regarding the profitability of insect farming and its potential role in agribusiness [8]. The absence of formal policy support, regulation, and market integration further discourages entrepreneurship. Consumer acceptance, while growing, remains influenced by cultural perceptions and limited value-added products [9].

10.1.7. Market and Supply Chain Issues

Unlike poultry or fish, grasshopper value chains are fragmented, with weak linkages between collectors, processors, and retailers [3, 19]. This fragmentation affects price stability, product standardization, and large-scale commercialization potential.

11. Opportunities and Future Directions in Grasshopper Production

Grasshopper farming in Nigeria presents significant opportunities for sustainable protein production, rural development, and climate-smart agriculture. Leveraging the biological and economic potential of these insects can contribute to national food security, environmental sustainability, and the growth of agribusiness.

11.1. Domestication and Controlled Rearing

Advances in controlled rearing techniques provide the foundation for commercial-scale grasshopper production. Cage-based systems, semi-intensive outdoor units, and controlled indoor environments have been shown to improve survival, growth, and reproduction, enabling predictable year-round supply [17]. Optimization of feed formulations using agricultural by-products such as cassava peels, maize residues, and vegetable wastes reduces production costs and supports circular bioeconomy models [15, 10].

11.2. Nutritional and Feed Applications

Grasshoppers provide high-quality protein, essential amino acids, and micronutrients suitable for both human consumption and livestock feed [3, 26]. Recent poultry feeding trials demonstrate that insect meals can partially or fully replace fishmeal or soybean meal, reducing feed costs while maintaining growth performance and feed conversion efficiency [26, 39]. This dual application increases demand and creates commercial opportunities across both human nutrition and animal agriculture sectors.

11.3. Economic and Agribusiness Potential

Grasshopper production can generate income and employment across rural communities through collection, processing, and marketing activities [8, 19]. Value-added products such as dried grasshopper powder, protein-rich snacks, and feed supplements further enhance market opportunities. Cost-benefit analyses indicate that small- to medium-scale insect farming can achieve favorable returns on investment (ROI), particularly when integrated with low-cost feed substrates and efficient production systems [17, 9].

11.4. Environmental Sustainability

Grasshopper farming aligns with climate-smart agriculture goals by reducing greenhouse gas emissions, minimizing land and water use, and promoting efficient feed conversion [41, 17]. Insect production can be integrated into waste management strategies, converting organic residues into protein and reducing environmental pollution, which complements national sustainability agendas.

11.5. Policy and Institutional Support

Scaling grasshopper production requires supportive policies, regulatory frameworks, and extension services to encourage entrepreneurship and adoption. Government incentives, farmer training programs, and investment in processing infrastructure can accelerate the transition from wild harvesting to commercial farming.

11.6. Research and Innovation Opportunities

Future research should focus on:

I. Species-specific rearing protocols for key Nigerian species such as *Zonocerus variegatus*, *Oedaleus senegalensis*, and *Ornithacris cavroisi* [7].
II. Genetic improvement and selective breeding to enhance growth, survival, and reproductive performance.
III. Feed formulation optimization using locally available agro-industrial by-products.
IV. Value chain development and market integration, including post-harvest processing, quality control, and commercialization strategies [8].

Collectively, these opportunities position grasshopper farming as a strategic, sustainable, and economically viable protein production system in Nigeria. With continued research, investment, and policy support, grasshopper production has the potential to enhance food security, promote environmental sustainability, and stimulate rural livelihoods.

12. Conclusion

Grasshopper production in Nigeria presents a promising pathway toward sustainable food systems. However, transitioning from wild harvesting to commercial farming requires coordinated efforts in research, policy, and capacity building to unlock its full potential.

Compliance with ethical standards

Disclosure of conflict of interest

There is no conflict of interest among the authors.

Statement of Informed consent

Informed consent was obtained from all individual participants included in the study.

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