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RESEARCH ARTICLE

# From crop pest to plate: the potential of giant long-horn beetle larvae (*Tithoes confinis*) as a sustainable food and nutrition resource in Eastern Tanzania

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## ABSTRACT

Food insecurity remains a persistent challenge in rural Tanzania, particularly in Morogoro Rural District, where seasonal food shortages and limited access to affordable, nutritious food threaten household well-being. This study explored the contribution of edible giant longhorn beetle larvae (*Tithoes confinis*) to household nutrition and food security in selected villages across the district. Data were collected through household surveys, key informant interviews, and focus group discussions conducted in three purposively selected villages: Mazizi, Maseyu, and Mgodini. A total of 385 households participated in the study, representing a cross-section of food security statuses and insect consumption practices. Quantitative data were analyzed using descriptive statistics and chi-square tests to determine the relationship between food security levels and insect consumption, while qualitative data provided insights into advantages of consumption. The results showed that food insecurity was prevalent, with a notable percentage of households categorized as moderately or severely food insecure. Households experiencing higher levels of food insecurity were more likely to consume *T. confinis* larvae as coping strategy during food shortage. The larvae were recognized for their high nutritional value, ease of accessibility, and cultural acceptance among the Luguru people. However, consumption was declining due to changing dietary norms, negative perceptions, and lack of policy support. The study concludes that integrating edible insects like *T. confinis* into local diets and nutrition programme could enhance dietary diversity and resilience among rural populations. Policy support and public education on insect-based value chains are recommended to reposition this food source as part of sustainable nutrition strategies.

***Keywords:*** edible insects; entomophagy; food security; giant long-horn beetle; household nutrition; sustainable food.

## INTRODUCTION

Food insecurity remains a pressing issue in many developing countries, with disproportionate impacts on women and children. Women continue to face systemic barriers such as limited access to income, productive land, agricultural inputs, and education, which hinder their ability to secure adequate nutrition for themselves and their families (FAO, 2021; UN Women, 2022). According to the FAO (2020), nearly 60% of those experiencing chronic hunger globally are women and girls. The concept of food security is currently defined as a situation where all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life (FAO, IFAD, UNICEF, WFP & WHO, 2023). Despite ongoing global and regional interventions, hunger and malnutrition remain persistent challenges. In 2022, an estimated 735 million people were chronically undernourished, with rural women continuing to bear a disproportionate share of the burden due to gender-based disparities in access to resources, services, and decision-making (FAO et al., 2023; UN Women, 2022). Sub-Saharan Africa remains particularly vulnerable, with nearly one in five people facing undernourishment and food insecurity continuing to rise due to conflict, climate change, and economic instability (FAO et al., 2023). This escalating demand for nutritious and sustainable food sources has sparked global interest in alternative protein options, including edible insects, recognized for their high nutrient density and low environmental footprint (van Huis & Oonincx, 2017; Halloran et al., 2016).

Currently, over 2 billion people worldwide incorporate insects into their diets, highlighting their cultural and nutritional significance (FAO, 2021). Insect farming offers ecological advantages, including lower greenhouse gas emissions and reduced land and water use compared to conventional livestock (Dobermann et al., 2017; Payne et al., 2016). Initiatives such as Kenya and Uganda's INSFEED project have promoted the use of insects in food and feed systems, demonstrating the sector's potential to enhance food security in Sub-Saharan Africa (Mottet et al., 2020). Among the diverse edible insect species, the larvae of the giant longhorn beetle (*Tithoes confinis*), traditionally regarded as pests, are increasingly recognized in countries such as Tanzania, Gabon, Senegal, and Congo for their nutritional value and role in traditional diets (Araujo et al., 2021; Kelemu et al., 2015).

In Eastern Tanzania, especially among the Luguru people in the Uluguru Mountains, food insecurity remains a persistent challenge, driven by erratic rainfall patterns, soil degradation, and limited access to agricultural innovations (Mkonda & He, 2018; URT, 2021). Seasonal food shortages intensify during the rainy months, with studies indicating that a significant proportion of rural households up to 80% may experience food insecurity during this period (FAO et al., 2023; WFP, 2020). In response, some communities have adopted entomophagy as a sustainable and culturally rooted coping strategy. Among the Luguru, the larvae of *Tithoes confinis* are seasonally harvested and consumed as a nutritional buffer. These larvae are locally abundant, relatively easy to harvest, and nutritionally dense offering high levels of protein, unsaturated fats, and key micronutrients such as iron, zinc, and magnesium (Kelemu et al., 2015; Araujo et al., 2021).

Although insect consumption has long-standing cultural relevance in Tanzania, its practice is waning under the influence of urbanization, Western dietary trends, and evolving food preferences (van Huis & Oonincx, 2017; Dzerefos et al., 2021). Younger generations, particularly those with formal education and urban exposure, are increasingly distancing themselves from traditional insect-based diets, contributing to a generational erosion of indigenous food knowledge (Ayieko et al., 2016; Tchibozo et al., 2016). Preserving and promoting this knowledge is crucial, as it represents a culturally acceptable, locally available, and nutritionally valuable food resource for vulnerable populations (Mujuru et al., 2021). However, several barriers impede the wider integration of beetle larvae into food systems. These include a lack of standardized harvesting and processing techniques, risks associated with microbial contamination due to inadequate preparation, and the labor-intensive nature of larval cleaning (FAO, 2021; Alemu et al., 2022). In rural areas where refrigeration or solar drying technologies are unavailable, spoilage is a frequent issue. Moreover, persistent cultural stigmas particularly among youth linked to texture, appearance, and misconceptions around insects continue to limit wider acceptance (Kinyuru et al., 2021; Meyer-Rochow et al., 2021). At the policy level, the limited integration of edible insects into national food and nutrition strategies further hampers their formal recognition and promotion as a sustainable food source (FAO et al., 2021; Niassy et al., 2018). Despite being historically regarded as pests, *Tithoes confinis* larvae possess considerable potential as a sustainable, underutilized food resource. Their integration into local diets addresses nutritional deficiencies and supports environmental

conservation through reduced ecological impact. Advancing safe preparation methods, documenting indigenous entomophagy practices, and implementing public awareness campaigns could help reposition edible insects from marginal status to a central role in achieving food security and dietary resilience in Tanzania and beyond.

## MATERIAL AND METHODS

### Study area

This study was conducted in Morogoro Rural District, located in the eastern region of Tanzania. According to the National Bureau of Statistics (NBS, 2022), the district has a population of 387,736, marking a significant increase from 286,248 in the 2012 census. The district spans a wide ecological range, lying between latitudes 6°30′ and 8°00′ S and longitudes 37°30′ and 39°00′ E, with elevations ranging from 300 to 2,000 meters above sea level (URT, 2021). This geographical diversity contributes to a broad array of habitats, supporting both agricultural activity and a rich diversity of insect fauna, including longhorn beetle. Morogoro Rural experiences a bimodal rainfall pattern characteristic of eastern Tanzania, with short rains from October to December and long rains from March to May. Annual rainfall varies from approximately 800 mm in the lowlands to over 1,200 mm in the uplands (Mashauri & Majule, 2017). This climatic variation supports a mosaic of ecosystems, from miombo woodlands to cultivated landscapes, which serve as suitable environments for various edible insect species, notably the giant longhorn beetle (*Tithoes confinis*). The research focused on three villages; Mazizi, Maseyu, and Mgodini strategically selected for their low- to mid-altitude positioning, ecological relevance, and proximity to natural habitats conducive to beetle life cycles. These areas are predominantly inhabited by the Luguru people, a Bantu ethnic group native to the Uluguru Mountains and surrounding lowlands. The Luguru possess a rich tradition of ecological knowledge, including the practice of entomophagy, the cultural consumption of insects. Among their dietary practices is the seasonal harvesting and consumption of *T. confinis* larvae, a tradition rooted in ancestral knowledge and cultural norms (Van Huis et al., 2017). This ethnographic and ecological context made Morogoro Rural District an ideal location for exploring the transition of *T. confinis* from an agricultural pest to a sustainable food resource.

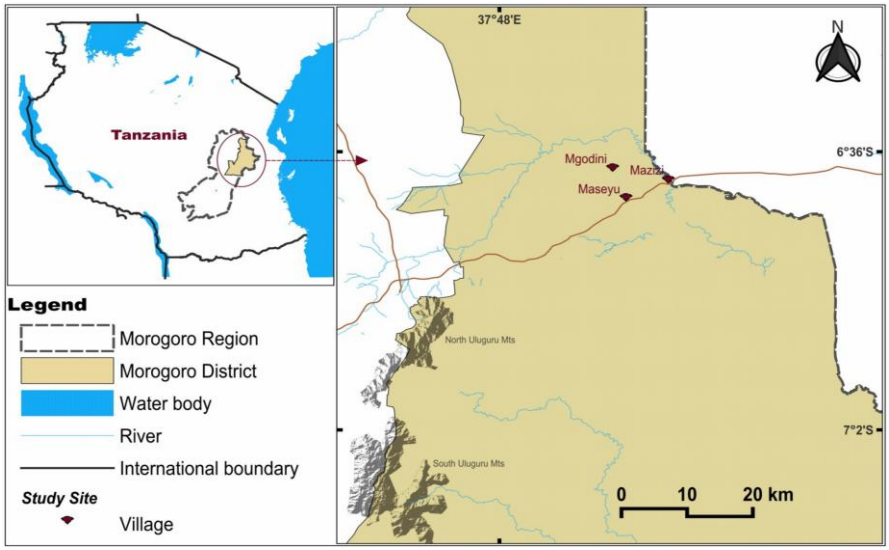



**Figure 1.** Map of Eastern Tanzania: Morogoro Rural District (NBS, 2022)

### Research Design

This study adopted a mixed-methods research design, combining qualitative and quantitative approaches to comprehensively investigate the cultural and nutritional dimensions of *Tithoes confinis* larvae consumption in Morogoro Rural District. Qualitative data were collected through Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs), which explored local cultural beliefs, harvesting and preparation techniques, and the symbolic significance of giant longhorn beetle larvae in indigenous food systems. These methods provided nuanced insights into community perceptions and social norms that influence entomophagy. Concurrently, quantitative data were gathered using structured questionnaires to quantify consumption frequency, duration, demographic correlations, and nutritional awareness across a broad sample of households. This approach

enabled statistical analysis of patterns and factors associated with larva consumption. By integrating both qualitative and quantitative data, the mixed-methods design enabled the triangulation of findings, ensuring a more comprehensive and valid understanding of the role of edible insects in food security and cultural practices. This approach aligns with contemporary mixed-methods research frameworks that advocate for integrating numerical data with rich contextual insights to address complex research questions. Creswell and Plano Clark (2018) emphasize the value of convergent designs, where quantitative and qualitative data are collected simultaneously and merged to enhance understanding. O'Cathain et al. (2015) further highlight integration strategies like connecting, building, and merging data throughout various research phases. Recent guidance from the Joanna Briggs Institute (JBI, 2020) also introduces the convergent integrated approach, which involves transforming qualitative data into quantitative form or vice versa, allowing for seamless synthesis and interpretation. These modern frameworks stress the importance of designing studies that intentionally bridge qualitative and quantitative paradigms to produce findings that are both statistically sound and contextually meaningful.

### Sampling Design

To investigate the cultural and nutritional role of *Tithoes confinis* larvae in Morogoro Rural District, a multistage sampling design was employed. The first stage involved purposive selection of wards and villages with a documented history of insect consumption, particularly those near ecologically rich areas like the Uluguru Mountains. In the second stage, systematic random sampling was used to select households within the chosen villages, ensuring equal representation across the community. Additionally, key informants, including village elders, foragers, and traditional food vendors, were purposively selected to provide deeper insights into the cultural context of beetle larva consumption. These informants contributed to interviews and focus group discussions, enriching the ethnographic understanding of how *T. confinis* transitions from pest to valued food source. This combined approach ensured both quantitative representation and qualitative depth, capturing community-wide practices and cultural significance surrounding edible insects.

### Study Population

The study population comprised residents of Morogoro Rural District, with a particular focus on communities located near forested landscapes such as the Uluguru Mountains areas, where traditional insect foraging remains a common practice. Primary attention was given to household members actively or indirectly involved in the collection, preparation, and consumption of giant longhorn beetle larvae (*Tithoes confinis*), a seasonal food resource culturally valued in the region. In addition to household respondents, the study incorporated key community stakeholders, including village elders, traditional insect gatherers, food vendors, and local health and agricultural officers. These individuals provided critical insights into the cultural, nutritional, and socio-economic dimensions of beetle larvae utilization. Particular emphasis was placed on the Luguru ethnic group, the predominant indigenous community in the area, known for their rich ecological knowledge and long-standing engagement with entomophagy. This inclusive population was selected to ensure a holistic understanding of how *T. confinis* is integrated into local food systems, reflecting its transformation from a perceived agricultural pest into a culturally embedded and nutritionally significant food resource.

### Target population and Sample sizes calculation

Morogoro Rural District, located in Eastern Tanzania, is one of the six districts within Morogoro Region. It covers a large rural area characterized by agriculture, forest reserves, and scattered settlements. According to the 2022 Population and Housing Census conducted by the National Bureau of Statistics (NBS), Morogoro Rural District had a total population of 387,736 people, showing a notable increase from the 2012 census figure of 286,248 (NBS, 2022). This population growth reflects both natural increase and internal migration patterns as people seek agricultural land and economic opportunities. The district is predominantly inhabited by the Luguru ethnic group, who have rich cultural traditions, including the consumption of edible insects such as giant longhorn beetle larvae (*Tihoes* spp.). The practice of entomophagy among the Luguru community represents both a cultural food preference and an adaptive strategy to enhance household nutrition and food security, particularly in rural and resource-constrained settings.

### Sample size determination and sampling procedure

In planning research studies involving human populations, especially for surveys and interviews, it is important to determine a sample size that provides valid and statistically significant results (Casteel and Bridier, 2021)

To determine the sample size for a population-based study in Morogoro Rural District, a sample size of 384 rounded to 385 respondents was selected using KREJCIE -MORGAN FORMULA from Morga (1970);

n= [ x^2Np(1-p)]/[e^2(N-1) +x^2p(1-p)]

Chi-square =3.841

ē-Margin of error = 0.05

The Krejcie-Morgan formula is used to determine the required sample size for a given population size with a desired level of precision, given the margin of error, confidence level, and the proportion of the population with a certain characteristic. In this case, the population size was N= 387,736, and we wanted to calculate the sample size using the formula, assuming a proportion of p=0.5 (maximum variability).

The formula for calculating the sample size using the Krejcie-Morgan formula is:

n = [Z^2 * N * p * (1 - p)] / [e^2 * (N - 1) + Z^2 * p * (1 - p)]

Where:

- n is the required sample size
- Z is the critical value for the desired confidence level (at 95% confidence level, Z=1.96)
- N is the population size
- p is the proportion of the population with the characteristic of interest (assumed to be 0.5 for maximum variability)
- e is the desired margin of error

Substituting the given values into the formula, we get:

n = [(1.96) ^2 * 387,736 * 0.5 * (1 - 0.5)] / [(0.05) ^2 * (387,736 - 1) + (1.96) ^2 * 0.5 * (1 - 0.5)]

Simplifying this expression, we get:

n = 384 ≈385

## Data collection

### *Questionnaire Method and Procedures*

To assess the consumption of *Tithoes confinis* larvae and related cultural practices in Morogoro Rural District, structured questionnaires were used as the primary data collection tool. This method enabled the efficient gathering of standardized information across a large and geographically dispersed rural population. The questionnaire captured both quantitative and qualitative data on demographics, dietary habits, cultural perceptions, and attitudes toward edible insect consumption. To ensure inclusivity and clarity, the questionnaire was translated into Kiswahili and Luguru, allowing respondents to fully understand and engage with the content. Trained enumerators administered the surveys face-to-face to reduce misinterpretation and accommodate participants with limited literacy. This approach enhanced data reliability and respondent honesty, especially on culturally sensitive topics. The field team consisted of five trained personnel three research officers and two field supervisors. Research officers conducted interviews and managed data accuracy, while fieldworkers facilitated household engagement. Supervisors ensured adherence to protocols and maintained overall data quality through regular oversight and support. This systematic approach ensured the collection of credible, culturally relevant data on how giant longhorn beetle larvae are perceived and used as a sustainable food resource within local communities.

### *Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs)*

To complement the structured questionnaires and provide deeper ethnographic insight, the study incorporated Key Informant Interviews (KIIs), Focus Group Discussions (FGDs), and direct field observations. These qualitative methods were essential in capturing the cultural context, community perceptions, and local knowledge surrounding the consumption of *Tithoes confinis* larvae. KIIs were conducted with local leaders, agricultural extension officers, traditional elders, and nutrition specialists. These interviews provided expert

perspectives on the nutritional value, cultural significance, and socio-economic aspects of giant longhorn beetle larvae consumption offering context that structured surveys could not fully capture. FGDs were organized with diverse community members, including men and women from various age groups, to explore shared experiences, beliefs, and social norms influencing entomophagy. These discussions highlighted gendered roles, intergenerational knowledge transfer, and seasonal consumption patterns. Additionally, direct observations of larval harvesting, preparation, and consumption practices were conducted in the field. This approach offered firsthand verification of reported behaviors and practices, enriching the study's reliability and helping illustrate the transformation of *T. confinis* from pest to valued food source. Together, these methods deepened the understanding of how edible insects are embedded in local food systems and traditions strengthening the evidence for their potential as sustainable nutritional resources.

### *Household Nutrition and Food Insecurity Access Scale (HFIAS) Method*

This study also used the Household Food Insecurity Access Scale (HFIAS) to assess the impact of giant longhorn beetle larvae consumption on household food security in Morogoro Rural District. The HFIAS evaluates food insecurity through nine standardized questions reflecting the severity of food access challenges over the previous 30 days. Each question was first posed as an occurrence inquiry ("Did this condition happen?") with binary responses coded as "0" for No and "1" for Yes. If the response was "Yes," a follow-up frequency question determined how often the event occurred: "rarely" (1–2 times), "sometimes" (3–10 times), or "often" (more than 10 times), scored 1, 2, and 3 respectively. Based on the responses, households were classified into four categories: Food secure: Rarely worried about food sufficiency, with negative responses to conditions 2–9. Mildly food insecure: Sometimes or often worried about food availability; may consume less preferred or monotonous diets, rarely eating undesirable foods. Moderately food insecure: Frequently reduce food quality and occasionally decrease meal size or frequency. Severely food insecure: Often reduce meal size, skip meals, or experience extreme conditions such as running out of food, going to bed hungry, or fasting for a whole day and night. This tool provided a standardized measure of household food security status, allowing the study to explore the potential role of *Tithoes confinis* larvae as a supplemental food source in mitigating food insecurity.

### Data Analysis

The study used a mixed-methods approach to analyze both quantitative and qualitative data on the consumption of giant longhorn beetle larvae in Eastern Tanzania. Quantitative data from structured questionnaires were first cleaned in Microsoft Excel and then analyzed using SPSS version 25. Descriptive statistics such as frequencies, percentages, means, and standard deviations were used to summarize key variables including demographic characteristics and consumption patterns. Pearson's Chi-square tests were employed to assess associations between insect consumption and factors like age, gender, education, and occupation, with statistical significance set at $p < 0.05$. This analytical approach enabled the identification of key determinants of insect consumption while supporting the interpretation of broader cultural and nutritional patterns.

## RESULTS AND DISCUSSIONS

### Socio-Demographic Descriptive Results

This section summarizes the socio-demographic profile of the 385 respondents who participated in the questionnaire survey. Of these, 47.27% (n = 182) were male and 52.72% (n = 203) were female. Respondents were drawn from three villages: Mazizi (53.76%, n = 207), Mgodini (27.01%, n = 104), and Maseyu (19.23%, n = 74). The majority of participants were aged 21–30 years, followed by those aged 31–40 years. In terms of education, 64.67% (n = 249) had attained primary education, 19.22% (n = 74) had secondary education, and 16.36% (n = 63) had informal or no formal education. Regarding occupation, the vast majority (90.91%, n = 350) were self-employed, while 7.27% (n = 28) held formal employment, and 1.82% (n = 7) were unemployed (Table 1).

**Table 1.** Socio-demographic characteristics of the study respondents, Eastern Tanzania (n=385)

| Characteristics | Category | Male (N) | Male (%) | Female (N) | Female (%) | Total (N) | Total (%) |
|---|---|---|---|---|---|---|---|
| Village | Mazizi | 109 | 52.65% | 98 | 47.34% | 207 | 53.76% |
| | Mgodini | 38 | 36.53% | 67 | 64.42% | 104 | 27.01% |
| | Maseyu | 35 | 47.29% | 39 | 52.70% | 74 | 19.22% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Age group | <21 | 0 | 0.00% | 4 | 100.00% | 4 | 0.91% |
| | 21–30 | 49 | 36.84% | 84 | 63.16% | 133 | 34.55% |
| | 31–40 | 28 | 34.56% | 53 | 65.22% | 81 | 20.91% |
| | 41–50 | 32 | 91.42% | 3 | 10.00% | 12 | 9.09% |
| | 51–60 | 31 | 52.54% | 28 | 47.45% | 59 | 17.27% |
| | 61–70 | 14 | 100.00% | 0 | 0.00% | 14 | 3.64% |
| | 71–80 | 18 | 54.55% | 15 | 45.45% | 33 | 8.57% |
| | >80 | 0 | 0.00% | 49 | 100.00% | 49 | 12.73% |
| Education | Primary school | 119 | 47.89% | 130 | 52.11% | 249 | 64.55% |
| | Secondary | 49 | 66.67% | 24 | 33.33% | 73 | 19.09% |
| | Informal level | 14 | 22.22% | 49 | 77.78% | 63 | 16.36% |
| Occupation | Unemployed | 0 | 0.00% | 7 | 100.00% | 7 | 1.82% |
| | Self-employed | 175 | 50.00% | 175 | 50.00% | 350 | 90.91% |
| | Employed | 7 | 25.00% | 21 | 75.00% | 28 | 7.27% |

### Gender-Related Patterns in Giant Longhorn Beetle Larvae Consumption

The findings showed that a relatively small proportion of respondents (27.3%, n = 105) reported having consumed giant longhorn beetle larvae, while the majority (72.7%, n = 280) had no such experience. Among male respondents, 28.83% (n = 111) reported prior consumption, compared to 25.97% (n = 100) of female respondents. Conversely, 71.15% (n = 274) of males and 74.14% (n = 285) of females reported no experience with consuming the larvae. Overall, a slightly higher number of female respondents (n = 151, 53.8% of total respondents) lacked experience with beetle larvae consumption compared to males (n = 130, 46.3%). However, statistical analysis revealed no significant association between gender and consumption experience of giant longhorn beetle larvae ($\chi^2 = 0.123$, df = 1, p = 0.726) (Table 2).

### Age-Related Patterns in Giant Longhorn Beetle Larvae Consumption

In contrast to gender, a significant association was found between respondents' age and their experience with consuming giant longhorn beetle larvae ($\chi^2 = 24.034$, df = 7, p = 0.001). Older individuals were more likely to have consumed the larvae compared to younger age groups. Among those with consumption experience, 33.3% (n = 128) were aged 51–60, followed by individuals aged 41–50. In contrast, the majority of younger respondents 41.3% of those aged 21–30, as well as many aged 31–40 reported no experience consuming the beetle larvae. These results suggest that larval consumption is more common among older generations, possibly due to cultural continuity or greater exposure to traditional dietary practices (Table 2).

### Education-Related Patterns in Giant Longhorn Beetle Larvae Consumption

The analysis revealed a significant association between respondents' education level and their experience with consuming giant longhorn beetle larvae ($\chi^2 = 6.637$, df = 2, p = 0.036). Among those who had consumed the larvae, the majority (76.7%) had attained primary education, followed by 20% with informal education (no formal schooling), and only 3.3% had reached secondary education. These findings suggest that individuals with lower levels of formal education were more likely to consume the larvae, possibly reflecting stronger ties to traditional food practices (Table 2).

### Occupation-Related Patterns in Giant Longhorn Beetle Larvae Consumption

A significant association was observed between respondents' occupation and their experience with consuming giant longhorn beetle larvae ($\chi^2 = 6.217$, df = 2, p = 0.045). The majority of those who had consumed the larvae (90%) were self-employed, followed by a smaller proportion of unemployed individuals. Interestingly, none of the unemployed respondents reported having no experience with consuming the larvae, suggesting that individuals outside formal employment may be more engaged in traditional or subsistence food practices (Table 2).

**Table 2.** Social demographic factors affecting choice to consume giant long horn beetle larvae, Eastern Tanzania

| Social Cultural Factors | Response | Chi-Square | df | p Value |
|---|---|---|---|---|
| Gender/sex | Male | 0.123 | 1 | 0.726 |

| | | | | |
|---|---|---|---|---|
| | Female | | | |
| Age of Respondents | <21<br>21-30<br>31-40<br>41-50<br>51-60<br>61-70<br>71-80<br>>80 | 24.034 | 7 | 0.001 |
| Educational background | Primary school<br>Secondary school<br>Informal education | 6.637 | 2 | 0.036 |
| Occupation status | Unemployed<br>Self-employed<br>Employed | 6.217 | 2 | 0.045 |

### Perceived Benefits and Reasons behind the Consumption of Giant Longhorn Beetle Larvae

The study identified several key factors that encourage the consumption of giant longhorn beetle larvae among respondents. The most frequently cited reason was the perceived nutritional benefits, reported by 50.9% of respondents (n = 196), who recognized the larvae as a rich source of protein and other essential nutrients. Food insecurity also played a significant role, with 49.1% (n = 189) indicating that they consumed the larvae due to shortages of other food sources, particularly during lean seasons. Additionally, traditional beliefs and cultural practices were noted by 24.5% (n = 95), with some respondents stating that consumption of the larvae is embedded in ancestral customs and rites. A smaller proportion, 20.9% (n = 80), mentioned ease of access and affordability, highlighting that the larvae are readily available in the wild and require minimal cost to obtain (see Figure 2).

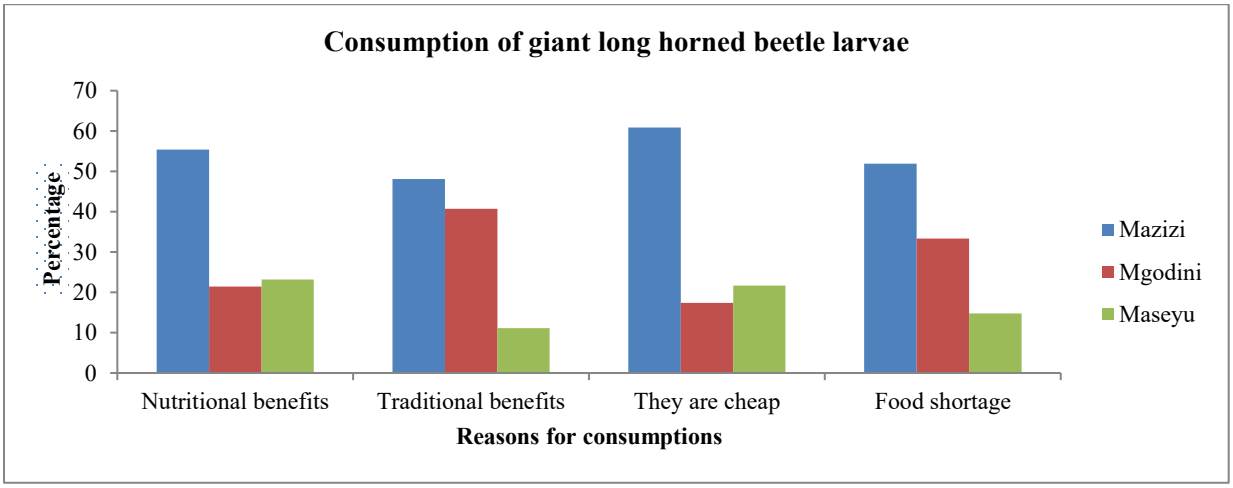
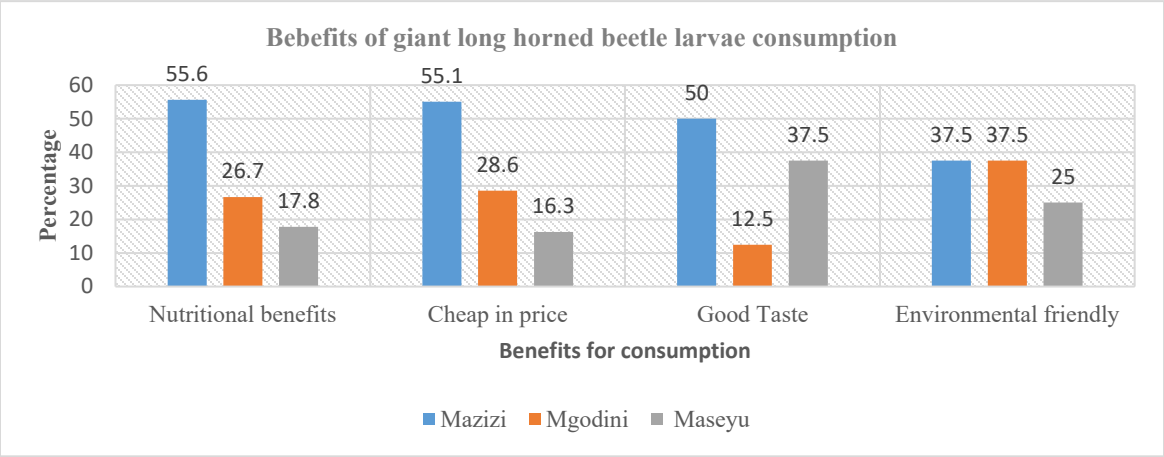



**Figure 2.** Reasons for consumption of the giant longhorn beetle larvae

In a separate set of questions addressing the perceived benefits of consuming giant longhorn beetle larvae, 44.5% of respondents reported that they were economically accessible, as they could be collected from nearby forests or obtained from neighbors without purchasing. Additionally, health and nutritional value was reiterated by 40.9% (n = 158), affirming the larvae's role in supplementing dietary needs. Taste was another factor, cited by 7.3% (n = 28), with some describing the larvae as flavorful when roasted or boiled. Another 7.3% (n = 28) highlighted the environmentally friendly nature of larval harvesting, stating that it has minimal ecological impact compared to conventional livestock farming. These findings underscore that the decision to consume giant longhorn beetle larvae is multifaceted, driven by nutritional, economic, cultural, and environmental considerations (Figure 3).

**Figure 3.** Benefits for consumption of the giant longhorn beetle larvae




## Potential of Giant Long-horn Beetle Larvae (*Tithoes confinis*) as a Sustainable Food and Nutrition Resource

### *Household Food Insecurity Status and Prevalence*

The study assessed household food security using the Household Food Insecurity Access Scale (HFIAS), categorizing households into four levels: food secure, mildly food insecure, moderately food insecure, and severely food insecure.

**Table 3.** Household food insecurity status/prevalence in the last four weeks (n=385)

| Food security status | | Edible Insect Consumption | | | |
|---|---|---|---|---|---|
| | | (N) | % | $\chi^2$ | p-value |
| Prevalence | Food secure | 106 | 27.5 | 6.636 | 0.015 |
| | Mildly food insecure | 21 | 5.5 | | |
| | Moderately food insecure | 49 | 12.7 | | |
| | Severely food insecure | 209 | 54.3 | | |
| Total | | 385 | 100 | | |

The study found that 72.5% of households in Morogoro Rural District experienced some level of food insecurity, with 54.3% classified as severely food insecure, and 5.5% as mildly food insecure (Table 10). A majority of severely food-insecure households had not consumed *Tithoes confinis* (giant longhorn beetle larvae), suggesting missed nutritional opportunities. The data indicate that food scarcity may encourage the adoption of edible insects as alternative food sources. A statistically significant association was found between food insecurity and beetle larvae consumption ($\chi^2$ = 6.636, df = 1, $p$ = 0.015), supporting the idea that households facing food shortages were more open to entomophagy (Figure 4).

**Table 4.** Association between food security status and edible insect consumption in Eastern Tanzania (N = 385)

| Food Security Status | N (Households) | Percentage (%) | Interpretation |
|---|---|---|---|
| Food secure | 106 | 27.5 | Lower reliance on insect consumption due to dietary sufficiency (Van Huis et al., 2017). |
| Mildly food insecure | 21 | 5.5 | Minimal use, possibly reflecting transitional food stress (FAO, 2021). |

| Food Security Status | N (Households) | Percentage (%) | Interpretation |
|---|---|---|---|
| Moderately food insecure | 49 | 12.7 | Moderate use, potentially for dietary diversification (Rumpold & Schlüter, 2013). |
| Severely food insecure | 209 | 54.3 | High reliance on edible insects as a coping strategy (Kelemu et al., 2015). |
| Total | 385 | 100 | $\chi^2 = 6.636$, $p = 0.015$ |

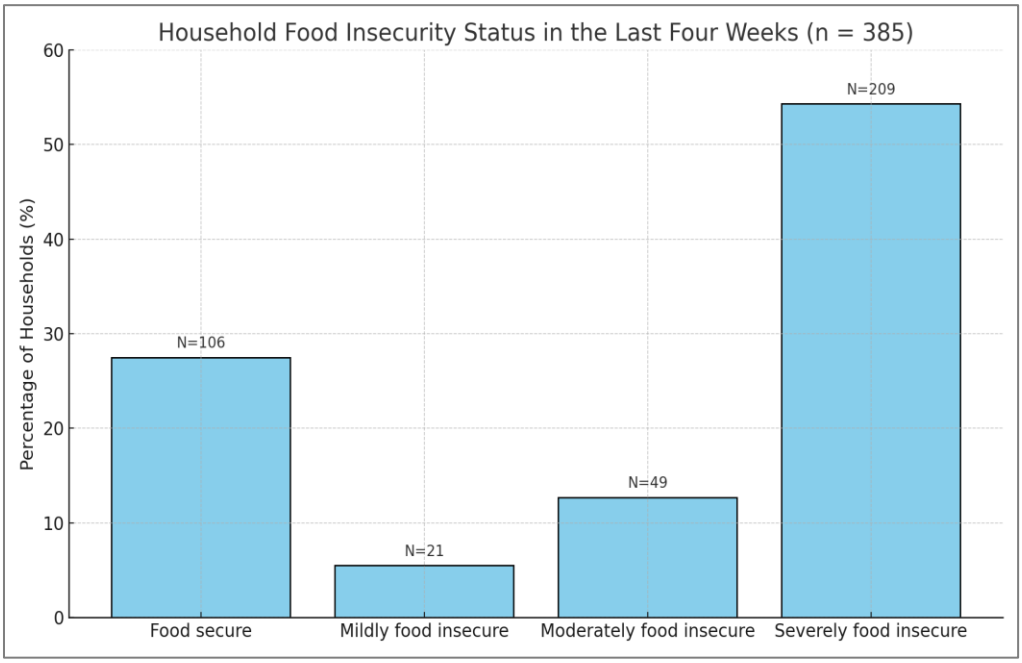



**Figure 4**. Household food insecurity status/prevalence in the last four weeks

### Prevalence of Missed Meals as an Indicator of Household Food Insecurity

The respondents were asked to indicate the frequency of missed scheduled meals. The findings are presented in (Table 5). Out of the 385 respondents surveyed, the majority (226 households or 58.9%) reported that they missed meals several times, while 12.2% (48 households) indicated they never missed meals, suggesting some level of food security within these groups. However, the remaining 40% of households experienced varying levels of meal deprivation, which reflects considerable food insecurity. Specifically, 15.1% (58 households) missed meals once a week, and 10.2% (39 households) indicated recurring food shortages. Alarmingly, 3.6% (14 households) missed meals every day, a clear indicator of severe food insecurity and potential nutritional vulnerability (Table 18). The frequency of missed meals aligns with the broader food security patterns observed, supporting the use of missed meal prevalence as a practical indicator for assessing household vulnerability and coping mechanisms in rural Eastern Tanzania (Figure 4)

**Table 5.** Frequency of Missed Meals among Surveyed Households (N = 385)

| How often? Response Category | Frequency (N) | Percentage (%) |
|---|---|---|
| Every day | 14 | 3.6% |
| Several times a week | 226 | 58.9% |
| Once a week | 58 | 15.1% |
| Rarely | 39 | 10.2% |
| Never | 48 | 12.5% |
| Total | 385 | 100% |

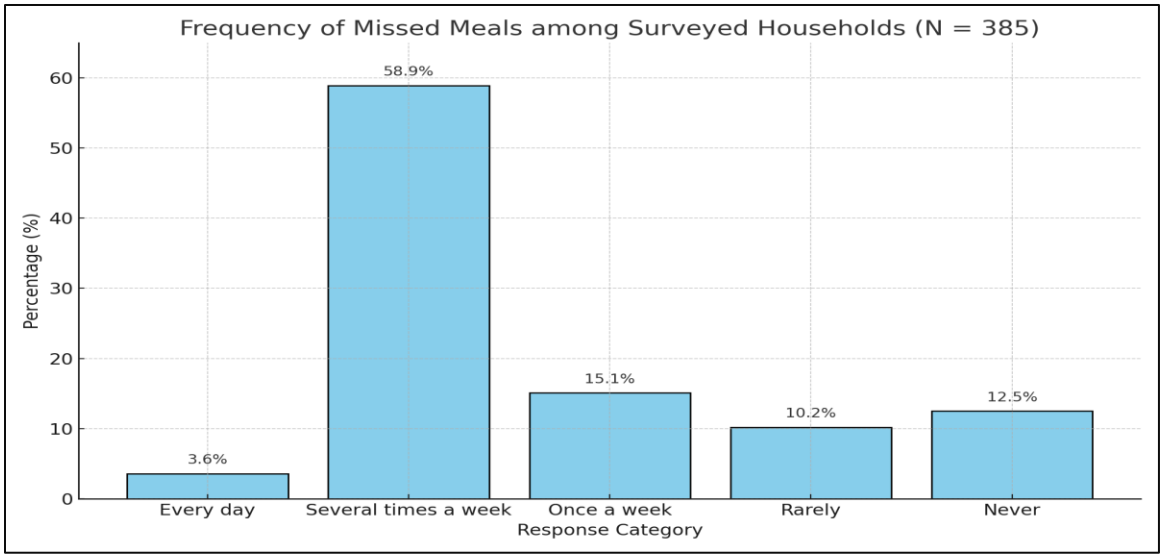



**Figure 5.** Frequency of missed meals among surveyed households/respondents

### Viability of Edible beetle larvae for household nutrition and Food Security

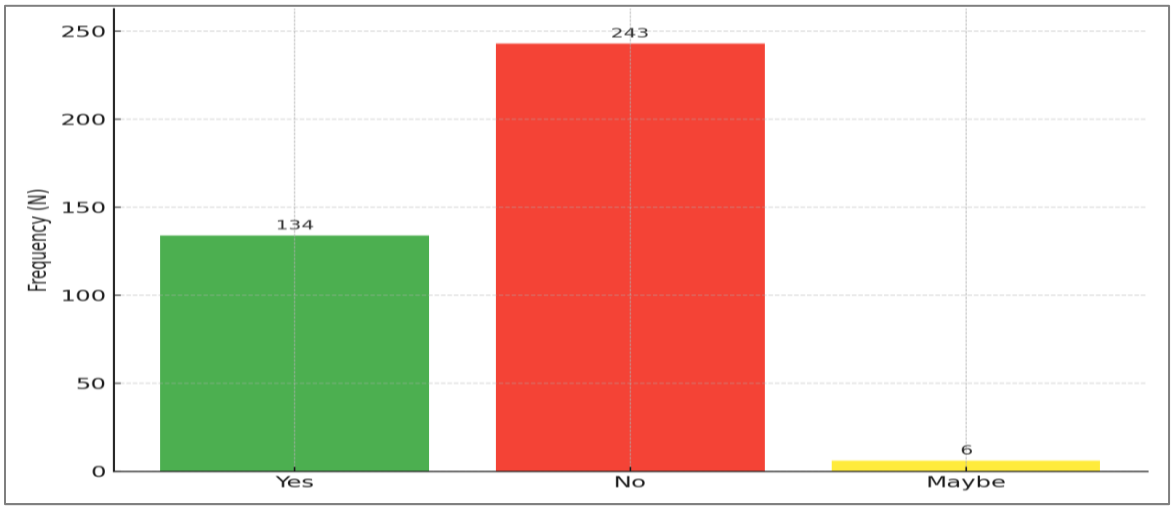



**Figure 6.** Respondents' perception of beetle larvae against household nutrition and food security

Table 6 shows that the majority of respondents (n=243, 63.12%) did not consider edible beetle larvae a viable solution for improving household nutrition and food security. In contrast, (n=34, 34.8%) believed insects could serve as a viable nutritional option, while a marginal (n=6, 1.55%) remained undecided. Findings from FGDs and KIIs revealed that many respondents who disagreed with the viability of edible insects viewed them primarily as pests rather than beneficial food sources. This perception made insects undesirable as a source of nutrition. Participants also noted that beetles can damage household materials and crops, reinforcing the belief that they pose a threat to food security. Furthermore, collecting insects in sufficient quantities, especially for large households, was seen as time-consuming, with respondents preferring to spend that time on other activities like farming. The limited availability of edible insects also contributed to their perceived ineffectiveness in alleviating hunger, as they were not consistently accessible in sufficient quantities to satisfy household needs. Insect farming, according to respondents, is not widely practiced or commercialised, making it difficult to purchase insects when needed. This lack of accessibility further reduced their perceived viability. Additionally, insects were often regarded as complementary rather than primary food items, diminishing their

role in the household diet. Finally, the absence of universally accepted safety standards for insect consumption discouraged people outside of traditional insect-eating communities from including them in their meals.

**Table 6**. Respondents' perception on Beetle larvae vs Household nutrition and food security

| Beetle larvae vs Household nutrition and food security? | Frequency | Percentage |
|---|---|---|
| Yes | 134 | 34.8% |
| No | 243 | 63.12% |
| Maybe | 6 | 1.55% |
| Total | 385 | 100 |

### Adaptive Responses and Strategies to Household Nutrition and Food Insecurity

Short term; several strategies were employed by respondents concerned about food availability in their households. As shown in Table 3 above, 54.3% (n=209/385) of households were classified as severely food insecure, 12.7% (n=49/385) as moderately food insecure, and 5.5% (n=21/385) as mildly food insecure. To cope with these challenges, households adopted various approaches. Some borrowed food from neighbours to meet their immediate needs (15.45%, n=60), while others borrowed food to store for future use (7.27%, n=28). A few households managed to purchase and store food (1.82%, n=7), while others relied on picking food from nearby farms (14.55%, n=56) or eating at neighbours' homes (9.09%, n=35). Notably, more than half of the households (51.82%, n=199) turned to collecting edible insects, specifically giant long-horned beetle larvae, as a coping strategy to address food shortages within their homes

Long term: Households were also asked about the long-term strategies they used to cope with food insecurity. The results revealed that 61.82% (n=238/385) purchased food on credit, while 50.91% (n=196/385) relied on borrowing food or receiving assistance from friends or relatives. Other strategies included reducing the number of meals consumed per day (39.09%, n=151), decreasing meal portions for each household member (19.09%, n=74), prioritizing food for working members of the household while excluding non-working individuals (16.36%, n=63), and withholding food from adults to ensure children had enough to eat (25.45%, n=98). A small proportion of households (7.27%, n=28) reported sending their children to beg for food as a last resort. Additionally, 35.45% (n=137/385) identified the collection of wild edible insects, specifically giant long-horned beetle larvae, as another important strategy during periods of moderate to severe food insecurity

## DISCUSSION

### Perceived Benefits and Reasons behind the Consumption of Giant Longhorn Beetle Larvae

The transformation of *Tithoes confinis* larvae from a notorious crop pest into a valued food resource in Eastern Tanzania's rural communities is driven by multiple perceived benefits. Notably, over half of survey respondents (50.9%) cited the larvae's high content of protein and essential micronutrients, consistent with recent findings showing edible insects are rich in iron, zinc, and high-quality proteins vital for addressing nutritional deficiencies (Ghosh et al., 2017; Melgar-Lalanne et al., 2019; Mwanri et al., 2020). Almost as many respondents (49.1%) identified the larvae as a critical coping mechanism during food shortages, reflecting evidence that insect consumption provides accessible and cost-effective nutrition in times of scarcity (Ayieko et al., 2016; Baiyegunhi & Oppong, 2016). Cultural factors also play a role: approximately 24.5% consume the larvae as part of ancestral traditions, underscoring entomophagy's role in reinforcing community identity and food heritage (Kelemu et al., 2015; Dzerefos et al., 2021). Accessibility further enhances their appeal, as larvae are harvested directly from wild host trees with minimal tools or cost, offering a no-cost food source for economically marginalized households (Raheem et al., 2019). Additionally, respondents noted both health and nutritional benefits (40.9%) and economic advantages (44.5%) aligned with evidence of insects' affordability, ease of access, and high nutrient density (Sogari et al., 2019; Oronje et al., 2023). Although taste preference was less commonly cited (7.3%), it remains relevant, especially among individuals familiar with insect consumption since childhood (Tan et al., 2015). A similar proportion also emphasized the environmental advantages of entomophagy, recognizing that insect farming and foraging produce fewer greenhouse gases and require less land and water than livestock production (Halloran et al., 2016; van Huis & Oonincx, 2017). Altogether, the

consumption of *T. confinis* larvae in Eastern Tanzania is driven by a complex interplay of nutritional need, economic necessity, cultural identity, sensory appeal, and ecological sustainability. This integrated perspective supports the broader global recognition of edible insects as a viable, resilient component of future food systems in the face of climate change and food insecurity.

### Efficacy of giant longhorn beetle larvae as a household nutrition and food security resource

Food security exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and preferences, enabling an active and healthy life a definition reaffirmed in FAO reports since 2015 (FAO, IFAD, UNICEF, WFP & WHO, 2018; Pérez-Escamilla, 2017). At the household level, food insecurity arises when families lack reliable access to adequate and nutritious food, compromising healthy living (Tarasuk et al., 2019). This multidimensional challenge impacts health, economic stability, and well-being. Severe food insecurity is consistently linked to hunger, undernutrition, and adverse health outcomes (Black et al., 2013; Owino et al., 2014). In this study, households in Eastern Tanzania were classified as food secure, mildly, moderately, or severely food insecure. Several families reported total food shortages over the prior four weeks, placing them in the severely insecure category. These households typically lack the income or mean to purchase or produce sufficient food (Si & Turpin, 2015). Interestingly, many of these severely food-insecure households still did not utilize locally available, traditionally important alternative foods like *Tithoes confinis* larvae.

In Morogoro Rural District, Eastern Tanzania, food insecurity remains a critical challenge. Households in the region often suffer from inconsistent access to affordable, nutritious food, exacerbated by seasonal shortages, erratic rainfall, limited farm inputs, inadequate market infrastructure, and poverty (FAO, 2021; Tarasuk et al., 2019). Most families rely on rain-fed agriculture, making them vulnerable to crop failures and price spikes. During lean seasons, common coping mechanisms include skipping meals, reducing meal frequency, or consuming less-preferred foods (Si & Turpin, 2015; Barrett, 2010). While these strategies may delay hunger, they often worsen malnutrition particularly for children and the elderly (Black et al., 2013; Owino et al., 2014). Thus, food insecurity in this region is not only about calorie shortages but also involves poor dietary quality and nutritional instability, with significant public health consequences.

In this context, integrating giant longhorn beetle larvae (*Tithoes confinis*) into household diets offers a practical, sustainable solution to food insecurity and nutritional deficiencies. These larvae are rich in protein, essential fatty acids, iron, zinc, and other key micronutrients—particularly crucial in areas with limited access to animal-source foods (Melgar-Lalanne et al., 2019; Ghosh et al., 2017). Found in forested and agroforestry settings, they require minimal harvesting effort, making them ecologically sustainable and economically viable animal-protein sources (Kelemu et al., 2015; Mwanri et al., 2020). Their collection and consumption are deeply rooted in indigenous knowledge especially among the Luguru people, who practice sustainable harvesting techniques passed down through generations. Promoting *T. confinis* consumption could help mitigate hunger during shortages while promoting dietary diversification and local resilience. Educational outreach, school-feeding initiatives, and community programs can help reduce stigmas around entomophagy and facilitate its integration into broader diets (Sogari et al., 2019; Oronje et al., 2023). Edible insects, now gaining global recognition for their sustainability and nutritional benefits, may play a key role in addressing food insecurity in low-income and rural contexts (Halloran et al., 2016; van Huis & Oonincx, 2017).

Findings from this study reveal that food-insecure households in Eastern Tanzania often turned to *T. confinis* larvae during severe food shortages. A clear correlation emerged between food insecurity levels and insect consumption: mildly insecure families opted for less-preferred foods; moderately insecure households reduced meal size or frequency; and severely insecure families frequently endured extended hunger. For many, foraging for and consuming *T. confinis* larvae provided immediate nutritional relief and temporary resilience. The larvae's seasonal abundance, easy harvesting, and low input support food sovereignty by reducing reliance on unpredictable food markets (Si & Turpin, 2015; Kelemu et al., 2015). Nevertheless, usage is declining due to stigma, hygiene concerns, allergy fears, and Western dietary influences, which marginalize traditional foods (Dobermann *et al.,* 2017; Imathiu et al., 2020; Barennes et al., 2015). Despite this, respondents showed openness to eating insect-based foods when incorporated into mixed dishes. Product innovation such as blending insect flour into staples could enhance acceptance (Melgar-Lalanne et al., 2019; Salinas-Castro, 2019). Realizing the full potential of edible insects like *T. confinis* requires a multi-faceted strategy: nutrition education; preservation of indigenous knowledge; improved hygiene and processing; and developing harvest–

supply chain infrastructure (Lange & Nakamura, 2021). Including edible insects in national food policies could strengthen long-term food and nutritional security strategies in vulnerable regions.

## CONCLUSION

Transitioning *Tithoes confinis* from a perceived crop pest to a valued food source represents a powerful paradigm shift with far-reaching implications for food security, nutrition, and sustainability in Eastern Tanzania. This study has shown that despite being traditionally regarded as an agricultural pest, the giant longhorn beetle larvae are deeply embedded in local food cultures and offer substantial nutritional benefits, particularly for food-insecure households. Their richness in protein, essential fats, and micronutrients, along with their ecological availability and low-cost harvesting, makes them a highly promising alternative to conventional animal-sourced foods, especially in rural and low-income settings where food insecurity is most acute. Moreover, the larvae's role as a seasonal, accessible food source aligns with both traditional knowledge systems and modern sustainability goals, demonstrating how indigenous practices can inform solutions to contemporary challenges like hunger, malnutrition, and environmental degradation. However, as dietary preferences shift and traditional food practices decline under the influence of globalization and stigma, the need to revitalise and revalue such local resources becomes urgent. Promoting the edible use of *Tithoes confinis* through education, food product development, and supportive policy frameworks can transform this once-overlooked pest into a vital component of resilient, locally anchored food systems. This "pest-to-plate" transition not only helps alleviate nutritional gaps and seasonal hunger but also empowers communities to reclaim control over their food resources in a way that honours both biodiversity and cultural heritage. As Tanzania and other nations seek sustainable pathways to food security, embracing insects like *T. confinis* offers a compelling, homegrown solution that bridges tradition and innovation.

*Recommendation:* The findings suggest many ways to sustain this insect species as a food and nutrition resource. First, public awareness initiatives should emphasise Tithoes confinis' nutritional, safety, and environmental benefits. These programs should lessen insect consumption stigma, especially among younger generations and urbanites who may perceive entomophagy as outmoded or unclean. Educational efforts, especially in schools and community health programs, can help promote edible insect consumption. Second, government agencies, NGOs, and research institutions should document and conserve Tithoes confinis harvesting, preparation, and seasonal availability knowledge systems. Knowledge is essential for promoting cultural heritage and ensuring sustainable harvesting that does not harm wild populations or host tree species. Third, national food and nutrition strategies should include Tithoes confinis. This could involve adding larvae to school food programs, dietary requirements, and agricultural extension services. Policymakers can legitimise and scale up their use across areas by recognising its food security benefits. Fourth, value chain development—processing, storage, and market access—requires investment. Developing dried larvae, insect-based flours, or ready-to-cook mixtures could increase shelf life, hygiene, and consumer appeal, expanding consumption beyond traditional ways. Supporting insect food businesses and community-based organisations could boost rural livelihoods and economic empowerment. Finally, more research should examine Tithoes confinis' long-term nutritional and health effects and ecological impact in agroecosystems. Evidence is needed to educate policy, scale up actions, and enhance public trust in insect consumption's safety and benefits. Tithoes confinis can be transformed from a crop pest to a vital part of sustainable diets and resilient food systems in Tanzania and beyond with cross-sector collaboration.

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## AUTHORS CONTRIBUTIONS

I hereby verify that all authors mentioned on the title page have made substantial contributions to the conception and design of the study, have thoroughly reviewed the manuscript, confirm the accuracy and authenticity of the data and its interpretation, and consent to its submission. All the authors equally contributed to this work.

## CONFLICT OF INTERESTS

The authors declare no conflict of interest.

## ETHICAL APPROVAL

Ethical approval for this research, conducted from June 2023 to April 2024, was obtained from the Ethics Review Committee of Jaramogi Oginga Odinga University of Science and Technology (JOOUST). Additional authorization was granted by the Department of Pest Management and Technology Development, Pest Management Centre of Sokoine University of Agriculture; Reference No: DPRTC/R/186 VOL IV.


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## AVAILABILITY OF DATA AND MATERIALS

All datasets analyzed and described during the present study are available from the corresponding author.

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