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Assessment of Entomophagy by Households in Kananga

Kapemba A. Mujinga[1], Mukenge J. C. Nkashama[2*], Nkoy R. Bongondedji[3]

[1]Department of Economic Sciences, Center for Research in Human Sciences (CRESH), Protestant University of the Congo (UPC), Kinshasa, Democratic Republic of the Congo
[2]Department of Economic Sciences, Protestant University of the Congo (UPC), National Pedagogical University (UPN), Kinshasa, Democratic Republic of the Congo
[3]Department of Economic Sciences, Notre Dame University of Kasayi (UKA), Kananga, Democratic Republic of the Congo
Email: mujinga.alain@upc.ac.cd, *jean-claude.nkashama@student.upc.ac.cd, richboongondedji@gmail.com

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Abstract

This study confirms that the majority of surveyed households (94%) consume insects in the city of Kananga, with the most commonly consumed insects being termites and crickets (93% each) according to their consumption frequency. The degree of appreciation, defined as the overall satisfaction level and acceptance of households regarding insect consumption, is rated as very good by most households. This high level of consumption is primarily explained by the availability of insects in the market as well as factors associated with their consumption, such as nutritional and cultural perceptions.

Keywords

Entomophagy, Insects, Households, Kananga, Probit

1. Introduction

It is commonly accepted that the planet Earth will host 9 billion human beings by 2050. Feeding a growing global population with more demanding consumers will require an increase in food production, which will inevitably put significant pressure on already limited resources such as arable land, oceans, water, and energy. If production remains in its current form, the increase in greenhouse gas (GHG) emissions, as well as deforestation and environmental degradation, will continue (Bonneau & Nakaa, 2020).

According to the FAO report published in 2011, this organization estimates that it will not be possible to feed everyone through traditional livestock farming of cows, pigs, chickens, etc. There is not enough space to produce the cereals needed

to feed the livestock, and this farming has always been accused of its significant greenhouse gas emissions. Therefore, it is urgent to find alternative solutions to conventional sources of animal protein in our diet, and edible insects are identified for humans and animals as an alternative source of interesting proteins and high-quality nutrients compared to meat and fish. Additionally, the production of greenhouse gases by most insects is likely to be lower than that of conventional livestock farming; for example, pigs produce 10 to 100 times more greenhouse gases per kilogram than insects (Khelouat, 2021).

Entomophagy, which is the consumption of insects by humans, has seen its importance recognized by the FAO in recent years to address the major challenge of feeding the current and future population in sufficient quantity and quality while respecting the environment and integrating sustainability aspects.

Despite the reported benefits of entomophagy, it is also necessary to note that the perception of the taste of food is a subjective perception influenced by multiple factors, both physiological (taste, retronasal olfaction, trigeminal chemical sensitivity) and psychosocial (culture, hedonic messages, representations...) (Scheidegger, 2018).

The consumption of insects in European countries is considered a threat to their psychological and cultural identity. Eating insects is seen as becoming contaminated, subhuman, and becoming someone else (Ouellet, 2018). Insect eaters are considered primitive, barbaric, and desperate (Gallen & Pantin-Sohier, 2015).

With globalization and civilization, the influence of Western culture is considered one of the factors responsible for the decline of entomophagy in several parts of the world (Ouellet & Bradley, 2017). This phenomenon is part of a generalized trend: the globalization of lifestyles, which is defined as the adoption of a universal cultural system largely based on Western values and customs; it therefore encompasses eating habits that increasingly tend towards the consumption of fast or packaged food to the detriment of traditional foods.

This trend would be associated, among other things, with the increase in income and urbanization, which bring changes in lifestyle and new food needs such as faster-to-prepare food. Consequently, traditional eating habits like entomophagy are generally better preserved in rural than urbanized areas (Ouellet & Bradley, 2017). They are often abandoned when people migrate to the city (DeFoliart, 1992), and some cultures turn to another way of life and new eating practices with the hope of discarding local practices.

The city of Kananga, being a city that hosts several ethnic groups that either favor or do not favor entomophagy, faces the threat of Western culture, especially among the youth who, for them, being fashionable simply means behaving like civilized, evolved people. This practice is nothing more than dressing like white people, eating, and doing everything like white people. This can be facilitated by media culture (use of social networks, television...). Imported products thus become more valuable than those produced locally. On one hand, we witness the effects of globalization with new technology influencing the eating habits of young

people, but also in the menus of various renowned restaurants in the said city, insects have an insignificant or even non-existent part. This highlights that entomophagy (culture or ancestral heritage) is increasingly losing its place in urban food plans, despite its health, environmental, and especially sustainable development benefits. On the other hand, we note that the ruralization of urban areas can in turn favor this practice as we observe in the city of Kananga, where rural areas tend to preserve ancestral practices. Villagers who leave their villages to live in the city often bring their habits with them (even if they often tend to forget them, while wanting to conform to the lifestyle of city dwellers considered better).

Given this observation, the existing empirical literature review indicates that apart from cultural aspects, insect consumption is influenced by other factors such as age, level of education, knowledge of the advantages of these insects... (Lisingo, Wetsi, & Ntahobavuka, 2010; Nsevolo Miankeba, 2012; Maxime, Eunice, & Sansan, 2022). Following the divergence of results observed in the literature as well as the lack of empirical studies on the Greater Kasai area, this study aims to examine the different motivations related to insect consumption by households, the main difficulties limiting their consumption, as well as the most consumed species. To achieve this, the following main question is raised:

- What are the determining factors of insect consumption by households in the city of Kananga? particularly caterpillars, winged termites, weevil larvae, locusts, and crickets.

Specifically, the following questions will be addressed:

- What is the proportion of households that consume insects in the city of Kananga?
- What is the most consumed species?

2. Literature Review

Entomophagy is a common practice in more than 130 countries. This diet is mainly found in Latin America, Asia, Africa, and Oceania (DeFoliart, 1992). It is important to note that urbanization provides a conducive environment for the advent of Western culture. Thus, the acceptance or rejection of entomophagy is a matter of culture. This reflection is supported by DeFoliart (1992), who believes that there are significant cultural barriers that prevent the expansion of edible insects, as each ethnic group is very specific about the species of insects to eat. According to DeFoliart (1992), entomophagy is often abandoned when people migrate to the city, and some cultures turn to another way of life and new dietary practices with the hope of discarding local practices. For him, entomophagy is not practiced by the majority of the population, and many feel a certain aversion to the idea of eating insects, even in areas where entomophagy is practiced. In several African populations, the consumption of insects is also decreasing. The insect-free diet of Western countries is gaining popularity (Van Huis & Oonincx, 2017).

The literature notes a decrease in entomophagy again associated with the Westernization of the diet, the importation of low-cost ultra-processed foods, and the

projected image of insect consumption as a primitive practice (Bourgault, 2019). However, this reflection is not supported by Mabossy-Mobouna et al. (2013), as their study conducted in Brazzaville shows that the consumption of Imbrasia truncata caterpillars is practiced by more than half of the population (65.8%). A similar figure is also mentioned by the study conducted by Lisingo, Wetsi, & Ntahobavuka (2010), their results show that 71.6% of households consume insects; also for the study conducted by Maxime, Eunice, & Sansan (2022), which attests that 60.46% of respondents are entomophagous. Tsafo, Meutchieye, & Manjeli (2016) also affirm in their study that 97.6% of households consume weevil larvae, 63.97% consume various caterpillars, 77.94% consume winged termites, 34.56% consume locusts, and only 10.29% consume crickets. The study conducted by Mabossy-Mobouna, Latham, & Malaisse (2020) also attests that 82.71% of households consume termites in the Republic of Congo.

Regarding the factors motivating the consumption of insects, knowledge about the nutritional value of insects by households is the main motivation (Mabossy-Mobouna, Kinkela, Lenga, & Malaisse, 2013; Tsafo, Meutchieye, & Manjeli, 2016; Lisingo, Wetsi, & Ntahobavuka, 2010). But also taste, dietary habits. Not to mention certain therapeutic reasons, for example, weevil larvae are used to combat acute respiratory distress in infants, red ants are incorporated into dishes consumed to combat, among other things, sexual weakness in men (Tsafo, Meutchieye, & Manjeli, 2016).

Among the factors limiting the consumption of insects, many studies identify seasonality or scarcity, as mentioned by (Mabossy-Mobouna, Kinkela, Lenga, & Malaisse, 2013; Tsafo, Meutchieye, & Manjeli, 2016; Mabossy-Mobouna, Latham, & Malaisse, 2020). Regarding the factors limiting the consumption of weevil larvae, the sale price and unavailability are noted in the study by Mabossy-Mobouna, Latham, & Malaisse (2020). For households that do not consume insects, the main reasons mentioned are mainly dietary habits, fear, custom, disgust according to the study conducted by Mabossy-Mobouna, Kinkela, Lenga, & Malaisse (2013), and the same study confirms that dietary prohibitions have a negligible influence on the consumption rate of caterpillars, religious prohibitions or other types of ethnic prohibitions are also mentioned (Nsevolo Miankeba, 2012).

Regarding the factors determining the consumption of insects, the study conducted by Nsevolo Miankeba (2012) attests that gender, age, and level of education have no influence on whether or not to consume insects.

All social categories consume caterpillars. In Latin America (Mexico, Brazil, Colombia, and Ecuador), people have extensive knowledge of insects with which they traditionally compose their meals (Bourgault, 2019). In Mexico, for example, fried grasshopper is a very popular food consumed by everyone (Rad). For some Amazonian communities, during the rainy seasons, 60% of their protein intake comes from insects (Van Huis et al., 2013). In Asia (South Asia and Southeast Asia), insects are consumed both in urban and rural areas (Van Huis et al., 2013). In Japan, several insect-based dishes are regularly consumed, such as "hachi-no-

ko," a dish containing grilled bee larvae placed on a bed of rice (Bourgault, 2019). On the African continent, insects are abundantly found in family gastronomy.

Insects represent between 10% and 15% of the diet in certain regions of Africa (Lavalette, 2013). In Australia, Aboriginal communities use insects for their sweet flavor (e.g., ants) and for the fat they add to recipes and dishes (e.g., larvae) (Bourgault, 2019). Additionally, insects account for up to 30% of the protein intake for some tribes (Bourgault, 2019). Thus, insects are a staple food in local diets. They are consumed for their taste and texture, not due to a lack of other food sources.

In countries where insects are consumed, they are considered tasty and nutritious. They are seen as a pleasure. It is reported that they are viewed not only as food but also as a delicacy (Bourgault, 2019). Some species of insects (e.g., mopane caterpillars) can fetch high prices and are considered luxury items. The regions with the highest number of edible insects are Mexico, northern South America, Africa, Asia, and Oceania. However, a decrease in their consumption is observed globally.

Over the past 200 years, the consumption of insects among Australian Aboriginals has decreased due to the arrival of the Western diet (changes in their diet), changes in social structures (the respective roles of men and women within their group have changed), and demographic changes (Bourgault, 2019).

Europe and North America are the continents where entomophagy is least present (MacEvilly, 2000), and the negative attitude of eaters towards insect consumption is cultural. However, following the publication of the FAO report in 2013, the idea of insect consumption began to emerge in Europe and North America.

There are now more and more businesses, restaurants, and food trucks offering insects to consumers. For example, in London, the Archipelago restaurant serves fried crickets with quinoa and spinach. In 2015, a grocery chain in the Netherlands, with more than 500 stores, integrated burgers and croquettes made from worms (Van Huis, 2016). In New York, Toloache offers grasshopper tacos, and in California, the Don Bugito food truck offers a menu composed entirely of insects. In the United States, interest is mainly in the private sector, where a large number of cricket-based products are being developed, such as protein bars, flour, and cookies (Van Huis, 2016). In supermarkets, there are also more and more insect-based products such as cricket powder, cricket pasta, insect bars, and insect crackers.

Providing definitive figures on the number of edible insect species worldwide is difficult for several reasons. First, an uninitiated person cannot describe an insect according to Linnaeus' classification, making official evaluations difficult. Things are complicated by the use of several vernacular names for the same insect species in many cultures. By using only Latin names and making the necessary corrections for synonyms, Yde Jongema from WUR undertook a global inventory using literature, including in Western countries and temperate zones. In April 2012, his list included 1900 edible insect species, with the most important being

in the orders of Coleoptera (beetles), Lepidoptera (butterflies and moths), Hymenoptera (bees, wasps, and ants), Orthoptera (grasshoppers and crickets), Isoptera (termites), Heteroptera (true bugs), and Homoptera (cicadas) (Monzenga Lokela, 2015).

Lower estimates exist. DeFoliart (1997) counted "less than" 1000 species, while Ramos-Elorduy (2005) counted "at least" 1681 species. Regional and national estimates have also been made: Yen (2009) identified 250 edible species in Africa; Ramos-Elorduy (2005) noted 549 species in Mexico (although Cerritos, 2009, noted only 177 in that country); in China, Chen, Feng, & Chen (2009) listed 170 species; Sessouma (2021) noted 164 species in the Lao People's Democratic Republic, Myanmar, Thailand, and Vietnam; finally, Paoletti (2005) estimated that 428 species were consumed in the Amazon basin.

In their introduction, Van Huis, Van Gurp, & Dicke (2014) state that edible insects for humans represent an alternative source of protein that is environmentally interesting, as they are associated with low greenhouse gas emissions, high food conversion efficiency, and the ability to transform organic waste into high-value protein. This is supported by Bourgault (2019), who argues that the benefits of insects in terms of sustainable development will be highlighted and will represent an opportunity to present this food as a substitute for conventional animal proteins. The consumption of insects by humans, or entomophagy, thus contributes positively to the preservation of the environment and livelihoods.

Mabossy-Mobouna, Latham, & Malaisse (2020) conclude that edible insects contribute to the diet of various rural and urban populations and constitute a very important potential in the fight against hunger and malnutrition in the world. They are also a very important potential for income and job creation for rural communities who collect, process, and market them. The economic benefits are remarkable in both rural and urban areas, as their sale allows many poor households to diversify their economic income. In this regard, Nsevolo Miankeba (2012) emphasizes that edible insects contribute to the empowerment of women and the reduction of poverty and hunger among rural populations, thus meeting at least two Millennium Development Goals.

However, the seasonality of these insects, as mentioned by Mabossy-Mobouna, Latham, & Malaisse (2020), is an obstacle that does not allow collectors to consume them all year round and to regularly supply urban communities. This is why Barennes, Phimmasane, & Rajaonarivo (2015) point out that edible insects are sometimes dried to be preserved and stored in large quantities by villagers. This traditional practice thus promotes a more stable supply according to the availability of species worldwide.

Some researchers raise concerns about the safety of insects regarding the risks of inorganic contamination, infections caused by microorganisms, the transmission of zoonoses, the toxicity of certain species, the development of allergies, or others. Marion et al. (2014) state that some species are toxic, even deadly for humans.

Similarly, Van Huis et al. (2013) report cases of constipation that can lead to intestinal obstructions. To circumvent this situation, Bonneau & Nakaa (2020) note that inhabitants of rural areas who traditionally collect edible insects know very well the places and times to collect them, the plants they feed on, the dangers associated with the activity, the tools to use, and the methods for capture, preparation, storage, or transport that vary according to species and mode of exploitation. Choo, cited by Van Huis et al. (2013), notes that the collection of edible insects can also have negative impacts on their habitat by influencing the ecological interactions between these different species. Trees are sometimes cut down entirely to facilitate the laying of larvae by female palm weevils, for example, which disrupts palm populations.

A study conducted in Hidalgo, Mexico, in 2009 revealed that 14 out of 30 consumed species were likely to disappear due to overexploitation, as mentioned by Ramos-Elorduy (2005). Here, it is now important to mention the notion of sustainability, which can only be applied by resorting to the domestication of edible insects, as stated by Ouellet & Bradley (2017).

Examples from the Democratic Republic of Congo, a study conducted by Kitsa (1989), show that in the capital Kinshasa, caterpillars are the most consumed insects with an average weekly consumption of 300g per household. The author also notes that the main supply provinces for the capital are Equateur (64%) and Bandundu (24%). Four main species of caterpillars are consumed there: Cirina Forda, Imbrasia epimethea, Imbrasia ertli, Imbrasia oyemensis. In the Kwango district, caterpillars are part of the choice dishes. For local tribes (Kiyaka, Kikongo, Tchokwe), mingolo ("caterpillar") is one of the main sources of protein in their diets. On the other hand, from an economic point of view, the trade of caterpillars to major urban centers such as Kinshasa and Kikwit provides a source of income for the inhabitants of the region, especially the most vulnerable. In this area of the DRC, the main caterpillar present is Cirina Forda. It invades wooded savanna areas between September and December (FAO, n.d.).

Caterpillars are not only consumed in the Democratic Republic of Congo, but they also play the role of medicine in certain provinces of the country. For example, the Sani caterpillar (Bas-Congo), called Mibamba in Bandundu, is a species appreciated by diabetics for its bitter taste. Its host plant is *Caloncoba welwitschii*. This species of caterpillar can be considered a medicine. Species of the genus *Linocodidae* sp. and *Tagoropsis jlavinata*, rich in calcium, and *Imbrasia epimathea*, *Imbrasia dione*, *Antheua insignata*, rich in proteins, can be recommended in the diet of pregnant and breastfeeding women. The species *Cinabra hyperbius* and *Imbrasia macrothyris*, rich in iron, can be recommended for anemic people and breastfeeding women (Malaisse, 1997). It should also be noted that, in general, the Congolese of the Yombe ethnic group from Bas-Fleuve (Bas-Congo) do not consume caterpillars and consider them a taboo food. Some are even afraid to touch them. During the caterpillar harvesting period in their villages, the Bayombe even avoid going to the forest for fear of seeing caterpillars along the way. Among the

Luba, the Tumpekete caterpillar is forbidden because it transmits diseases. According to Rega tradition in Maniema, a pregnant woman cannot consume Misaba, as it gives children large teeth. In the province of Equateur, Batikatike and Mpofumi are two species of caterpillars forbidden respectively to children and women. Malnutrition is a situation that concerns humanity today; seeking to eradicate this scourge leads to the depletion of available resources and especially goes against sustainable development. The advantages provided by insects position them as alternatives to conventional proteins. Thus, the need to promote this culture.

3. Conceptual Framework and Hypothesis

The following Figure 1 presents the conceptual framework of this study on the consumption choice of insects by households in Kananga.

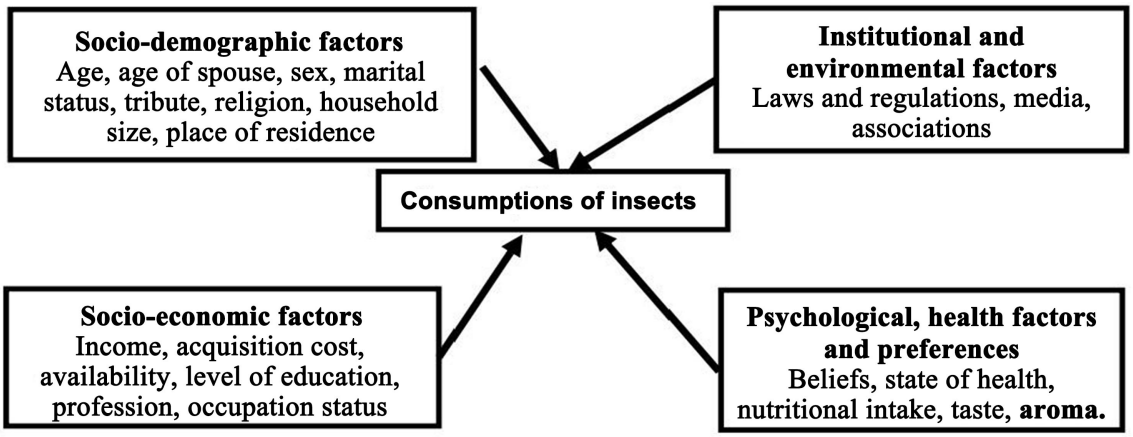

Figure 1. Conceptual framework. Source: Authors' own construction.

Based on the questions raised in the problem, the following hypotheses are put forward:

H1: The determining factors of insect consumption by households in Kananga are as follows:

H1a: Socio-demographic factors such as age, marital status, gender, religion, household size, and tribe are determining in the choice of insect consumption among households in Kananga.

H1b: Socio-economic factors, namely education level, occupation, income of the household head, and market availability, affect the choice of insect consumption among households in Kananga.

H1c: Health factors, such as knowledge about the nutritional benefits of insects by the household head, are very determining in the choice of insect consumption among households in Kananga.

H2: The majority of households under study consume insects.

H3: The most consumed species would be caterpillars, due to their availability on the market.

4. Materials and Methods

4.1. Study Context

Formerly known as Luluabourg, Kananga is a city with nearly 2,000,000 inhabitants, located in the center of the Democratic Republic of Congo. It is the capital of the Kasaï-Central province and the seat of the high bishopric of Kananga. The city of Kananga has a total area of 743 km^2, with a density of 1334.24 inhabitants/km^2. The commune of Kananga, with 300 km^2, is its largest commune, while Katoka is the smallest with 24 km^2.

The city of Kananga is mainly inhabited by the Lulua. It also includes the Luba. Generally, in this part of the Democratic Republic of Congo (DRC), there are evolving ethnic groups such as the Lulua, the Luntu, and the Luba coexisting with other groups that have maintained their traditional way of life, such as the Kuba, the Tetela, the Leele (Bashilele), the Ndengese, and the Salampasu. The languages spoken in this city are Tshiluba (most used), Swahili, Lingala, French, and some dialects like Tetela, Kikuba, etc.

Agriculture remains the main activity of the city, often oriented towards self-consumption. The main food crops are maize, cassava, rice, and peanuts. Despite the high agricultural potential, there is no agro-industry, although some bases are in place (coffee, oil palm). Industrial crops remain underdeveloped and have no significant impact on the city's economy or household income. However, there is the development of maize and cassava mills. The city has a few bakeries, including Monalux Bakery.

Kananga is not a productive center, even though there are some agricultural activities (maize, cassava, and rice cultivation), some local initiatives (e.g., agro-food products), small artisanal production units, and informal small livestock and poultry farming activities.

The main activities revolve around the retail trade of agricultural, manufactured, and imported products from Kinshasa, Ilebo, and Lubumbashi. It positions itself as a true commercial hub connecting Mbuji-Mayi and Tshikapa, serving as the marketing center for all agricultural production in the province (maize, cassava, coffee, rice, tomatoes, pineapples, etc.).

The main agricultural products are cassava, maize, rice, peanuts, beans, palm oil, pineapples, table bananas, plantains, onions, etc. The main non-agricultural products are matches, fuel, cement, cosmetics, second-hand clothes, clothing, school supplies, motorcycles, foam, stationery, toilet paper, paint, sheets, etc. These products are sold in various markets.

4.2. Data Collection

In this study, a non-probability sampling method was used due to the unavailability of a sampling frame that would allow for systematic identification of households. However, a multi-stage sampling technique was necessary. At the first stage, a simple random sampling was conducted among the five communes that make up the city of Kananga. This approach enabled access to crucial information

in the three selected communes, namely: Kananga, Ndesha, and Nganza. This initial selection ensures geographic and social diversity.

At the second stage, a random sampling was carried out to select a few neighborhoods within each selected commune. And at the third and final stage, households were randomly selected within some avenues of each neighborhood in the chosen communes.

Survey subjects were selected arbitrarily and subjectively. This choice was motivated by the need to ensure that the targeted households were accessible and willing to participate in our survey. Moreover, the arbitrary approach allows for including households representative of various socio-economic groups, although it introduces a risk of selection bias. This bias refers to the possibility that the chosen households may not be representative of the entire population, which could distort the results obtained. For example, if certain socio-economic groups are systematically excluded or underrepresented in the sample, this could influence the conclusions and limit the generalizability of the findings.

The survey was conducted from July 15 to September 22, 2022, resulting in a final sample of 250 households within the three communes of Kananga. It is essential to consider these methodological limitations when interpreting the results.

It should be noted that the concept of appreciation in this study refers to the overall perception of insect consumption. Its operationalization was carried out using a questionnaire with several items aimed at capturing household attitudes and perceptions regarding insect consumption. Appreciation was measured based on the level of satisfaction using a three-point Likert scale (very good, good, somewhat good). Households were asked to assess their level of satisfaction concerning various aspects of insect consumption, such as taste, protein contribution, aroma, and eating habits. Questions were also posed about their willingness and/or reasons justifying their current consumption, in order to evaluate qualitative dimensions of their appreciation.

4.3. Analysis Model

The nature of the dependent variables being binary qualitative, the use of the probit regression technique is recommended for multivariate analysis. But before that; a univariate analysis will be done to describe the variables individually.

The specification of the probit model for each insect is given below:

$$Y:\begin{cases}1=\text{consumption of insects}\\0=\text{no consumption of insects}\end{cases}$$

$$\text{Probit } Y_i=\beta_0+\beta_i X_i+\varepsilon_i$$

with:

X_t : The explanatory variables;

B: The estimated parameters of the probit model;

Y_t : The study variable (insect consumption);

u_t : The error term.

The use of distinct probit regression models for each type of insect is explained

by several key reasons: (1) heterogeneity of preferences: different insects may evoke varying levels of appreciation and consumption among households depending on cultural, nutritional, and sensory factors. By employing separate models, we can capture these specific differences and better understand individual preferences; (2) variability of explanatory factors: the determinants of consumption may differ from one insect to another; (3) robustness of results: separate analysis enhances the robustness of findings by preventing complex interactions between insect types from complicating the interpretation of coefficients. Each model can thus be interpreted independently, providing clearer and more targeted conclusions; (4) ease of communication of results: having distinct models facilitates the presentation of findings, allowing for better contextualization of conclusions for each insect type and guiding practical recommendations.

5. Results

Table 1 shows that overall, 94% of households consume insects. Termites (93%) are eaten more than caterpillars (89%) in Kananga. Among households that do not consume entomophagy, religious belief is the main cause for both termites and caterpillars. Regarding those who consume entomophagy, availability is the main reason for this consumption depending on whether it is termites or caterpillars. The households surveyed who consume entomophagy have a very good assessment of what generally comes from taste; but concerning the caterpillar, it is the consumption habits which are the main reason for this appreciation; and regarding the termite, it is always the taste which is the main reason.

Table 1. Characteristics linked to entomophagy consumption.

Variables	Consumption					
	Insects		Caterpillars		Termites	
	n_i	f_i	n_i	f_i	n_i	f_i
Consumption per household						
Yes	236	94	222	89	233	93
No	14	6	28	11	17	7
Causes of non-consumption						
Religious or cultural	14	100	14	50	14	82
Not accustomed	0	0	1	4	0	0
Disgusted	0	0	6	21	3	18
Fear of appearance	0	0	7	25	0	0
Reasons associated with this high consumption						
Availability	167	74.55	1	100	82	83.67
Affordable price	57	25.45	0	0	16	16.33
Reasons associated with this assessment						
The taste	154	65	37	17	65	48.14

Continued

Protein intake	74	31	76	34	6	4.46
Aroma	8	4	2	1	0	0
Eating habits	0	0	106	48	64	47.40
Appreciation						
Very good	231	97	116	52	169	73
Good	1	1	97	44	64	27
A little good	4	2	9	4	0	0

Source: Results from surveys.

Table 2 shows that the consumption of larvae, locusts, and crickets are respectively 87%, 26%, and 93% in Kananga households. Among households that do not consume insects, the majority do not consume larvae, locusts and crickets for religious, habitual and religious reasons respectively. The availability of insects is the main reason for consumption of larvae, locusts, and crickets. Concerning the assessment of the consumption of insects, it is very good for households which consume the larvae; but good for households that consume locusts and crickets. This appreciation is due to taste, eating habits, and liking for larvae, locusts, and crickets respectively.

Table 2. Characteristics linked to entomophagy consumption (continued).

Variables	Consumption					
	Larvae		Locusts		Crickets	
	n_i	f_i	n_i	f_i	n_i	f_i
Consumption per household						
Yes	217	87	64	26	233	93
No	33	13	186	74	17	7
Causes of non-consumption						
Religious or cultural	15	54	14	8	14	82
Not accustomed	0	0	159	86	3	18
Disgusted	2	7	11	6	0	0
Fear of appearance	11	39	0	0	0	0
Reasons associated with this high consumption						
Availability	78	66.10	61	100	25	100
Affordable price	40	33.90	0	0	0	0
Reasons associated with this assessment						
The taste	122	60	1	2	89	56
Protein intake	14	7	0	0	10	6
Aroma	0	0	0	0	0	0
Eating habits	67	33	63	98	59	38

Continued

Appreciation						
Very good	154	71	18	28	104	45
Good	57	26	41	64	116	50
A little good	6	3	5	8	13	5

Source: Results from surveys.

Table 3. Probit model results and marginal effects.

Variables	Consumption					
	Caterpillars		Termites		Larvae	
	$\frac{dy}{dx}$	p_i	$\frac{dy}{dx}$	p_i	$\frac{dy}{dx}$	p_i
Marital status	0.1046	0.000***	0.0387	0.002***	0.0634	0.024**
Age of head of household	0.0007	0.755	−0.0000	0.994	0.0016	0.633
Gender of head of household	0.0970	0.064*	0.0793	0.041**	0.1849	0.016**
Education level of head of household	0.0319	0.267	−0.0209	0.227	−0.1003	0.031**
Household size	−0.0071	0.157	−0.0031	0.313	−0.0079	0.287
Profession of head of household	−0.0074	0.298	−0.0063	0.175	0.0120	0.260
Religion of head of household	−0.0417	0.001***	−0.0228	0.007***	−0.0466	0.007***
Household occupancy status	0.0095	0.531	0.0034	0.658	0.0030	0.889
Tribute of the head of household	−0.0111	0.254	−0.0040	0.552	−0.0015	0.919
Number of years lived in the city	−0.0008	0.600	−0.0012	0.333	−0.0031	0.231
Main sources of information	−0.0192	0.189	−0.0055	0.548	−0.0387	0.057*
Possession of a social media account	0.0425	0.286	0.0096	0.712	0.0917	0.208
Knowledge of nutritional intake	0.1095	0.002***	0.0892	0.001***	0.1097	0.021**
Income of head of household	1.34^{E}−07	0.075*	−4.6e−08	0.282	−6.8e−09	0.950

Legend: ***significant at 1%, **significant at 5%, *significant at 10%. Source: Results from Stata 15 software analyses.

The results of the Probit regression show in Table 3 attest that caterpillar consumption increases with the variables marital status, sex of the head of household, knowledge of nutritional intake, and income of the head of household. And it decreases with the religion variable.

Concerning the consumption of termites, it increases with the variables marital status, sex of the head of household, and knowledge of nutritional intake. And it decreases with the religion variable.

Regarding the consumption of larvae, it increases with the variables marital status, sex of the head of household, and knowledge of nutritional intake. And it decreases with the variables level of education of the head of household, religion, and main source of information.

The results of the Probit regression show in Table 4 below attest that the con-

sumption of locusts increases with the variables marital status, gender of the household head, number of years lived in the city, and having a social media account. It decreases with the variables religion, household occupation status, and the tribe of the household head. However, the consumption of crickets increases with the variables marital status and knowledge of nutritional benefits. It decreases with the variable religion.

Table 4. Probit model results and marginal effects (continued).

Variables	Consumption			
	Locusts		Crickets	
	$\frac{dy}{dx}$	p_i	$\frac{dy}{dx}$	p_i
Marital status	0.1799	0.001***	0.0271	0.010**
Age of head of household	−0.0021	0.589	−0.0010	0.411
Gender of head of household	0.1760	0.016**	−0.0149	0.415
Education level of head of household	−0.0391	0.586	−0.0126	0.419
Household size	−0.0063	0.634	−0.0004	0.897
Profession of head of household	0.0155	0.368	−0.0045	0.317
Religion of head of household	−0.0556	0.057*	−0.0334	0.000***
Household occupancy status	−0.0856	0.014**	0.0035	0.652
Tribute of the head of household	−0.0433	0.081*	−0.0014	0.789
Number of years lived in the city	0.0086	0.001***	0.0001	0.912
Main sources of information	−0.0077	0.811	−0.0141	0.150
Possession of a social media account	0.1629	0.031**	0.0297	0.276
Knowledge of nutritional intake	−0.0107	0.864	0.0778	0.003***
Income of head of household	−1.99e−07	0.252	−5.76e−08	0.180

Legend: ***significant at 1%, **significant at 5%, *significant at 10%. Source: Results from Stata 15 software analyses.

6. Discussion and Implications

Entomophagy is a current topic worldwide, with several studies conducted in various contexts. Despite the lack of research in the DRC, particularly in the Greater Kasai area, most studies in the African context have shown that the majority of respondents are entomophagous (Nsevolo Miankeba, 2012; Maxime, Eunice, & Sansan, 2022; Lisingo, Wetsi, & Ntahobavuka, 2010; Mabossy-Mobouna, Latham, & Malaisse, 2020; Mabossy-Mobouna, Kinkela, Lenga, & Malaisse, 2013). These studies primarily highlight dietary habits, knowledge of nutritional values, and taste as the main motivations for households to consume insects. The findings of this study align with those of previous researchers, as it shows that the majority of surveyed households (94%) in Kananga are entomophagous, and the main motivations for this consumption are the same as those mentioned by these researchers.

Unlike the study conducted by Mabossy-Mobouna, Kinkela, Lenga, & Malaisse (2013), which cites dietary habits as the primary reason for non-consumption of insects, this study identifies religious prohibitions as the main reason for non-consumption of insects. This reason was also found by Nsevolo Miankeba (2012), who notes that a portion of his respondents primarily cite religious, customary, or other ethnic prohibitions that exclude the consumption of insects.

It is also noted that households from certain tribes surveyed in Kananga do not consume locusts, and the reason is nothing other than ethnic prohibitions, as confirmed by the last researcher mentioned above.

Regarding factors limiting insect consumption, market unavailability or seasonality, and high purchase prices (especially insects like weevil larvae and caterpillars) are mentioned. These results were also found by Mabossy-Mobouna, Kinkela, Lenga, & Malaisse (2013); Mabossy-Mobouna, Latham, & Malaisse (2020); and Lisingo, Wetsi, & Ntahobavuka (2010). Unlike the latter, the consumption of insects such as weevil larvae is limited due to various doubts about their source, as there are numerous rumors circulating regarding the origin of these larvae. Some believe that they are toilet maggots that are transformed using a well-established technique by vendors. This situation mainly highlights the impact of perception on the consumption of weevil larvae and underscores the need to act accordingly to improve food safety and promote sustainable eating practices.

Among the most consumed insects, the results of this study show that caterpillars and winged termites are the most consumed. The study conducted by Kitsa (1989) found the same results, showing that in Kinshasa, the capital of the DRC, caterpillars are the most consumed insects. This was also found by Nsevolo Miankeba (2012).

The factors determining insect consumption in Kananga are generally: the marital status of the household head, the religion of the household head, the income of the household head, but especially the knowledge of the household head about the nutritional benefits of insects. In his study, Nsevolo Miankeba (2012) also found that insects are consumed equally by men and women, and that the age and education level of the household head have no influence on insect consumption. The results found by Lisingo, Wetsi, & Ntahobavuka (2010) also show that insect consumption is independently related to gender, education level, or social status of the subjects.

In contrast, this study shows that marital status, gender of the household head, and income of the household head influence the consumption of caterpillars. Households headed by widows or widowers are more likely to consume caterpillars, as are households headed by men.

Among the factors limiting insect consumption in Kananga, the majority of surveyed household heads mentioned the unavailability of these insects in the market, which has led most of them to go more than 5 years without consuming insects such as crickets, locusts, and especially weevil larvae. The latter, being more appreciated by households, see their consumption decrease day by day,

caused not only by their unavailability but also by doubts about their source.

Based on the results found in this study, some recommendations can be made:

- Mistrust of the origin of weevil larvae may limit their consumption, which could restrict food options, especially in regions where protein sources are limited. This highlights the need to assess how this perception affects not only household food security but also the sustainability of local food systems. Given its real impact on food security, it is crucial to raise awareness among the population so that they can consume this insect without hesitation.
- Conduct research on domestication or breeding techniques for insects such as: weevil larvae, crickets, locusts, etc., this can create jobs and reduce financial and food dependence, but also allow for the population to consume them throughout the year;
- Invest in equipment that can help conserve periodic insects such as winged termites, this will allow the population to consume them at any time;
- Promote and above all raise awareness among the population, especially young people, who are likely to be influenced by European culture, to preserve the culture of entomophagy left by our ancestors;
- Educate and above all raise awareness among the population who collect insects, in the use of techniques aimed at the sustainability of this sector.

7. Conclusion

This study aimed to assess the consumption of entomophagy among households in the City of Kananga, identifying the factors associated with this consumption and identifying the most consumed insect by households. After analysis, the results show that nearly 94% of the surveyed households consume insects, confirming the second hypothesis. As for the determining factors of insect consumption, the Probit regression estimation reveals the following:

For caterpillars: the following hypotheses were confirmed: marital status, gender, religion of the household head, as well as the income of the household head and the knowledge of the nutritional value of insects by the household head. Other hypotheses were rejected.

Regarding winged termites, the following hypotheses were confirmed: marital status, gender of the household head, religion of the household head, and the knowledge of the nutritional value of insects by the household head. Other hypotheses were rejected.

Concerning weevil larvae, the following hypotheses were confirmed: marital status, gender of the household head, education level of the household head, religion of the household head, main source of information, and the knowledge of the nutritional value of insects by the household head. Other hypotheses were rejected.

Furthermore, for locusts, the following hypotheses were confirmed: marital status, gender, religion of the household head, possession of a social media account, and the income of the household head. Other hypotheses were rejected.

However, for crickets, the following hypotheses were confirmed: marital status, religion of the household head, and the knowledge of the nutritional value of insects by the household head. Other hypotheses were rejected.

According to survey results in Kananga, the most commonly consumed insects are termites and crickets (93% each). The main reason for this high consumption, unlike other insects, is their availability on the market. This allows us to reject the third hypothesis.

Kananga, being one of the cities in the Democratic Republic of Congo with a high rate of malnutrition, studies on entomophagy should be valued, especially research on techniques for farming edible insects, as the collection and farming of insects can offer important strategies for diversifying livelihoods and provide a source of valuable nutritional benefits.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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