Open Access Library Journal
2025, Volume 12, e13682
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Entomophagy Factors: The Consumption of Palm Weevil Larvae in Maniema Households

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How to cite this paper: Chérif, A.Y., Jean-Berckmans, M.B., Joseph, M.T., Cikwanine, D. and Bertin, M.C. (2025) Entomophagy Factors: The Consumption of Palm Weevil Larvae in Maniema Households. *Open Access Library Journal*, **12**: e13682.
https://doi.org/10.4236/oalib.1113682

Received: May 28, 2025
Accepted: July 26, 2025
Published: July 29, 2025

Abstract

This is an investigation of the factors that influence the consumption of palm weevil larvae (*Rhynchophorus*) and other insects, as well as related practices in the Maniema region, Eastern DRC. These insect larvae are preferred fresh (90.3%) and eaten mainly with cornmeal (69%), and cassava pasta or rice (28.8%). Besides palm weevils, other insects are also eaten, to a much lesser degree; notably termites (84.7%), caterpillars (75.3%), rhinoceros beetles (14.7%), crickets (0.7%), and grasshoppers (4%). There is a correlation between the consumption of various insects and meats, as well as notable geographical disparities between the urban municipalities, particularly in terms of sourcing patterns and the intensity of entomophagy and meat consumption, both of which are expensive commodities. A more favorable socio-economic situation in the city center is accompanied by more intense insect-consumption, and purchasing (84.9%) vs. gathering (15.1%). Gathering is also typical of rural and suburban communities in this forest environment. In contrast with findings elsewhere, insect-eating in Kindu city is more intensive among the rich and the middle class and the more educated people, as well as in wealthier neighborhoods.

Subject Areas

Entomoculture, Entomophagy and Diversity of Edible Insects

Keywords

Palm Weevils, Entomophagy, Factors

1. Introduction

Entomophagy, or the consumption of insects by humans [1] [2] is currently posi-

tioned as an important option for addressing the world's nutritional and environmental problems [3]. By 2050, the world's population will reach around 9.7 billion, leading to a significant increase in food demand. At the same time, conventional livestock farming is responsible for 14.5% of greenhouse gas emissions and consumes large quantities of water and land, which poses limits in terms of sustainability. Insects, in particular *Rhynchophorus* spp., offer a viable alternative with a high protein, lipid, iron and zinc content, while requiring fewer resources for their production [4]. Many cultures around the world traditionally eat insects, but this habit is also gaining popularity in Western countries [5]. Disparities exist in insect consumption and preferences among given populations [6]. Acceptance of insects as food is strongly influenced by cultural context and beliefs [7].

Insects are an alternative and sustainable source of protein, meeting the challenges of food security and environmental sustainability [3]. The high nutritional value of insects, particularly their protein, vitamin and mineral content, is a key argument for promoting their consumption [8]. However, the nutritional profile varies considerably depending on the species and preparation methods [9]. Although insects are generally considered nutritious, certain health concerns, such as potential allergies or the presence of contaminants, need to be addressed to boost consumer confidence [10].

Among more than 1900 species of edible insects, beetles are the species most eaten by humans [2]. This preference is thought to be due to their delicious taste and high fat content [11] [12]. Beetle larvae are high in fat, protein, vitamins, fiber and minerals [6] [13] [14]. Their food value varies according to species, metamorphic stage, habitat and diet [2]. Palm weevils are an important food source in many parts of the world, including the Democratic Republic of Congo [13] [15]-[18].

Entomophagy is deeply rooted in the culinary traditions of many cultures in Asia, Africa and Latin America, where insects have been consumed for centuries. In contrast, Western cultures often show a strong aversion to insect consumption, due to cultural norms and perceptions [19]. The adoption of Western dietary habits and lifestyles has led to a decline in insect consumption in some regions [9]. Entomophagy is common in many cultures in Asia, Africa and Latin America, in contrast to cultures in Europe and North America [19]. In Africa, the Democratic Republic of the Congo (DRC) stands out for its great diversity of insect species. Southern Africa (Zambia, South Africa, Zimbabwe and Botswana) also boasts a high diversity of insects. In Asia, Thailand, India and China are the main consumers of insects [20]. The Thai insect industry is particularly well developed. Parts of Latin America, particularly Mexico, have a long tradition of insect consumption and a wide diversity of edible species [19].

Despite the socio-economic benefits [21], human consumption of edible insects remains marginal and is resisted by many, motivated by cultural aspects, food safety and traceability concerns [22] [23]. While insect consumption is less widespread in North America and Europe [20], there is growing interest in these re-

gions due to sustainability and nutrition concerns. However, cultural barriers and negative perceptions remain significant obstacles [19].

Worldwide, in Africa and in the Democratic Republic of Congo, several studies have been carried out on palm weevil consumption [1] [5] [12] [24]-[30]. Maniema province, located in the East of the Democratic Republic of Congo, is renowned for its biological diversity, including edible insects [31]. Yet, no research on palm weevil entomophagy has been carried out in this region. It is crucial to understand the factors behind insect consumption and to identify the levers to encourage this practice. Especially as a suitable technique for rearing *Rhynchophorus spp* in this environment has just been established by [32]. The scarcity of in-depth studies on the consumption of insects of the genus *Rhynchophorus* and on eating habits in Maniema province justifies the relevance and originality of our study.

This paper aims to explore the different aspects of edible insect consumption, focusing on nutritional benefits, environmental impact and socio-cultural issues. By understanding the motivations and barriers to insect consumption, it will be possible to propose recommendations to foster acceptance of this practice and encourage a transition towards more sustainable and nutritious diets. Thus, studying the consumption and preference of palm weevil larvae will make it possible to valorize this local food resource and improve food security in the region. Understanding the motivations behind the choice of edible insects by the local community can help promote a more sustainable and ecologically viable diet. By identifying the factors that influence the acceptability of palm weevil larvae, it will be possible to propose strategies to increase their consumption and raise awareness of the nutritional and environmental benefits of these insects.

2. Environment, Materials and Methods

2.1. Environment

The present study was carried out in the city of Kindu, Maniema province in the East of the Democratic Republic of Congo. The city of Kindu (See **Figure 1**) has an area of 101,295 km^2 with an estimated population of 719,895 inhabitants [33].

Social Presentation of Kindu City

Kindu, the capital city of Maniema Province is an important cultural, economic and social center. The main ethnic groups are: the Balega, the Bazimba, the Bakusu, the Basongola, the Bangubangu and others. These communities have distinct cultural practices, but they often coexist peacefully in an intercultural dynamic. The population is predominantly Catholic, but there are also Muslims, Protestants and revivalist churches. The way of life in the municipalities of Kindu is traditionally agrarian, with a heavy reliance on agriculture for subsistence. However, as urbanization has progressed, the way of life has evolved to include modern elements. These include the increasing use of communication technologies, limited access to education and healthcare, and the gradual transformation

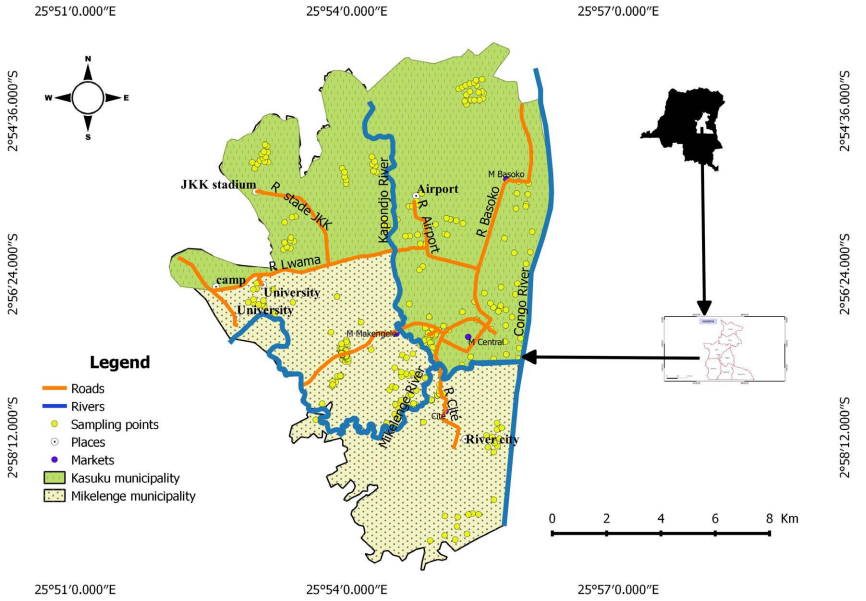

Figure 1. The city of Kindu, study area.

of local business practices. Families are generally extended, and respect for elders and traditional customs is a fundamental aspect of community life. Weddings, births and funerals are often celebrated with traditional rites and festivities. In the rural areas around Kindu, traditional dwellings are often built from local materials such as wood, straw and clay. In the city, on the other hand, modern houses made of concrete and metal are increasingly common.

The diet of Kindu's inhabitants, as in the majority of the DRC, relies mainly on local agricultural produce, including cereals (maize and rice), tubers and roots (yams, cassava, and sweet potatoes), vegetables (cassava leaves, amaranth and sweet potato leaves) and fruits (bananas, papayas, oranges and mangoes). Inhabitants consume protein from fish, poultry, goats and cattle, although this is more common in urban than in rural areas. As in many forest parts of Africa, entomophagy is common. Palm weevils and other edible insects are locally gathered and eaten [32].

Kindu's economy is largely based on agriculture (cassava, corn, rice, beans, peanuts and tubers), livestock (goats and poultry), mining (gold, coltan and cassiterite) and trade in local goods. Often, imported goods are traded by non-natives (Nande from North Kivu, Indians, Lebanese and others). The town serves as a regional commercial center, where numerous transactions take place between agricultural producers, traders and consumers. The town has several lively markets, where agricultural produce, fish, handicrafts and manufactured goods are traded.

2.2. Materials and Methods

Surveys were carried out in 2 urban municipalities using the Kobo-collect application, between November 3, 2024 and February 9, 2025; and using the random

ballot box method. Two boxes were produced, each representing a municipality. These boxes contained sub-boxes representing the Districts, and in each sub-box the names of the streets were marked. Four districts per municipality and five streets per District were randomly selected by a child. The use of a child for sorting through the ballot boxes (neutral and unbiased) enabled a simple random selection of neighbourhoods, ensuring the absence of influence from the research team. This strengthened the objectivity and impartiality of the sample, especially in a context where certain areas might be unconsciously favoured. Inclusion criteria were insect consumers and non-consumers, while people with no knowledge of edible insects were excluded. A total of 300 heads of household were interviewed individually [34]. The study variables in the questionnaire included: the respondents' profile (municipality, age, gender, marital status, Education level, profession, monthly income, household size, religion); the consumption status (yes/no), and motivations for not eating palm weevil larvae; the quantity consumed, the menu of palm weevils larvae and the preference level for recipes; the supply modes, the availability and causes of shortage; Seasonality of larvae availability; insect habitats, picking and packaging modes.

2.3. Archiving and Statistical Analysis

The data collected were typed into an Excel 2013 spreadsheet, then exported and analyzed using Jamovi 2.6.19, Jasp 0.18.3 and Past 4.11 free softwares. Descriptive statistics were computed to determine the frequencies, the extent of entomophagy, the intensity of other insects, and other animal protein sources. The chi-square test was used to compare proportions between qualitative variables. The Kruskal-Wallis test was used to compare the means of the numbers of weekly meals of palm weevil larvae according to the characteristics of the respondents. Principal component analysis (PCA on Past 4.11) was also used to show geographical disparities between the municipalities, while path diagrams on JASP were used to relate all the parameters.

3. Results

3.1. Characteristics of Respondents

Table 1. Respondents' profile.

Age	Frequency	Profession	Frequency
18 - 30 years	230	NGO worker	12
31 - 40 years	47	Farmer	69
>40 years	23	Unemployed	133
gender		Retailer	76
Female	177	Public employee	10
Male	123	**Monthly income (US $)**	
Marital status		50 - 200	262

Continued

Married	204	201 - 300	31
Single	85	>301	7
Divorced	3	**Household size (persons)**	
Widowed	8	06-janv	223
Education level		10-juil	56
None	8	>11	21
Primary	8	**Religion**	
Secondary	233	Catholic	54
University	51	Kimbanguist	18
		Muslim	27
		Protestant	80
		Revival churches	121
		Total	300

Young adults predominate in the population (18 - 30 years) vs. those over 40. Women predominate in food choices (59.0% women vs. 41.0% men). As for marital status, married respondents predominate as they keep families. These households, dominated by young adults, typically encompass 2 - 6 people. In fact, secondary education, whether achieved or incomplete, is predominant. Unemployment is high. Trade and agriculture are equally represented. A few jobs are offered by NGOs, and there are relatively few salaried employees. Declared incomes are generally low ($50 - 200) (See Table 1).

3.2. Extent of Entomophagy on Palm Weevil Larvae

Table 2. Consumption status, and motivation for not eating palm weevil larvae.

Consumption status of palm weevils larvae	Frequency	%
no	29	9.7
yes	271	90.3
Total	300	100
Motivation for eating palm weevils larvae		
Edible	107	39.5
Available	1	0.4
Delicious	16	5.9
nutritious	147	54.2
Total	**271**	**100**
Reasons for not eating palm weevils larvae		
Not eating by habits	2	6.9
Not interested	10	34.5

Continued

Phobia	13	44.8
Tasteless	4	13.8
Total	**29**	**100**

Our results (See Table 2) show that the vast majority of households (90.30%) consume palm weevil larvae vs. 9.70% who do not. Among consumers, 54.60% are motivated by the nutritional value, 39.50% know that palm weevil is just edible, and therefore one among several accessible foods; 5.90% eat them because they are delicious. For non-consumers of palm weevil, 44.80% argue that they are afraid to eat it because of larval contortion, 34.50% are not interested; 13.80% find it tasteless and 6.90% are not used to eating insects since childhood. As for the motivation for eating palm weevil larvae, 99.60% of respondents said they ate them out of habit.

Table 3. Quantity consumed, Menu of palm weevils larvae and preference level.

Quantity consumed per day	Frequency	%
>2 kg	1	0.4
0.1 - 1 kg	263	97.0
1.1 - 2 kg	7	2.6
Menu of grilled palm weevil larvae		
Banana	5	1.8
Fries	1	0.4
Maize and cassava pasta	187	69.0
Rice	78	28.8
Preferred recipe		
Dry	29	9.7
Fresh	271	90.3

Table 3 shows that consumers prefer fresh palm weevil larvae. The quantity consumed per day is less than or equal to 1000 g per day. The menu that accompanies the grilled larvae is mainly cornmeal (69%), followed by far with rice (28.00%); rarely banana (1.80%), and potato fries (0.40%).

3.3. Supply Modes, Availability and Causes of Shortages

Market purchases are the main mode of supply (81.20%) vs. 18.80% for gathering in the wild (See Table 4). The shortage of larvae in the city markets is strongly perceived (99.30%). As for the causes of the scarcity of larvae, people feel that little effort is made to gather larvae in the wild, because of insufficient manpower for the purpose. However, 3.30% mentioned a high demand on the markets, and 0.40% spoke of the scarcity of the palm tree, the main host plant.

Table 4. Modes of supply, availability and causes of shortage.

Supply	Frequency	%
Purchase	220	81.2
Gathering in the wild	51	18.8
Availability		
Abundance	2	0.7
Scarcity	269	99.3
Causes of deficiency		
High market demand	9	3.3
Few operators	261	96.3
Shortage of palm trees	1	0.4

3.4. Seasonality of the Consumption of Larvae

Table 5. Seasonality of larvae availability.

Availability by season	Frequency	%
Rainy (Aug, S, O, N, D)	267	98.5
dry	4	1.5
Months		
Aug, S, O, N, D	224	82.7
January, February, March, April	42	15.5
May, June, July	5	1.8

Table 5 shows that palm weevil larvae are most abundant during the rainy season. In terms of monthly larval availability, they are most abundant in August, September, October, November and December (rainy season).

3.5. Environment, Method of Collection and Storage of Collected Larvae

Table 6. Habitats, picking and packaging modes.

Pick-up location	Frequency	%
Cultivated palm	10	3.7
Wild palm	261	96.3
picking environment		
Forest	9	3.3
Field	260	95.9
Fallow land	2	0.7
Packaging mode		
Wrapped in *Megaprynium* leaves	202	74.5

Continued

Larvae placed in a container free of dead palm debris	1	0.4
Larvae mixed with dead palm debris in a container	68	25.1
Picking method		
Palm tree felling	15	5.5
Palm tree felled during field opening	246	90.8
Palm tree felled for wine production	10	3.7

Larvae are collected from wild palms and, rarely, from cultivated palms (3.7%). The larvae are collected in cultivated fields (95.9% vs. 3.3% in forests) from palms felled during the opening of fields (90.8%). Larvae are wrapped in *Megaprynium macrostachyum* (Mangungu) leaves (74.5%) or mixed with dead palm debris in a container (25.1%) (See Table 6).

3.6. Determinants of Weekly Larvae Consumption Frequency

Table 7. Weekly larvae consumption frequency by Commune.

		Municipality		
Frequency of larva meal		Kasuku	Mikelenge	Total
1	Frequency	23	167	190
	%	35.90	90.30	76.3
2		41	18	59
	%	64.10	9.7	23.7
Total		64	185	249

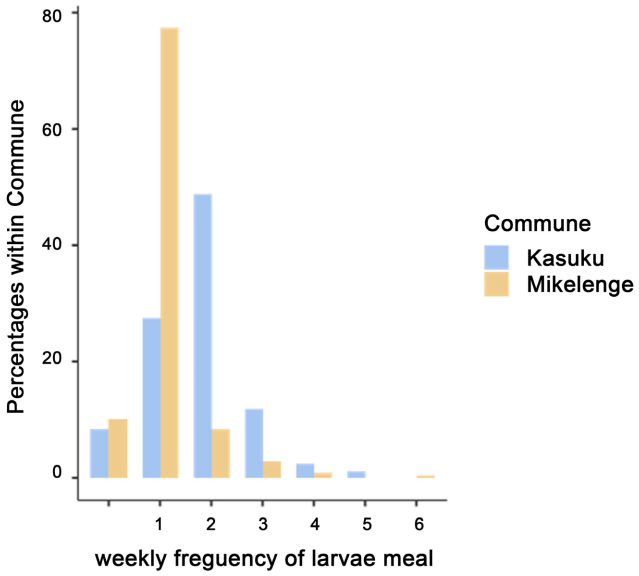

Figure 2. Weekly frequency of palm weevil larvae consumption by Municipality.

Consumption of larvae (See Table 7 and Figure 2) is more frequent in the Kasuku municipality vs Mikelenge (2 times a week 64.1% vs. 9.7%; $X^2 = 77.6$, dl = 1; $p \leq 0.001$), which shows only one meal of larvae per week (90.3%).

Table 8. Weekly frequency of consumption of palm weevil larvae by respondent gender.

Frequency of palm weevil larvae meal	Female	Male	Total
1	122	68	190
	81.90	68.0	76.3
2	27	32	59
	18.10	32.0	23.7
Total	149	100	249

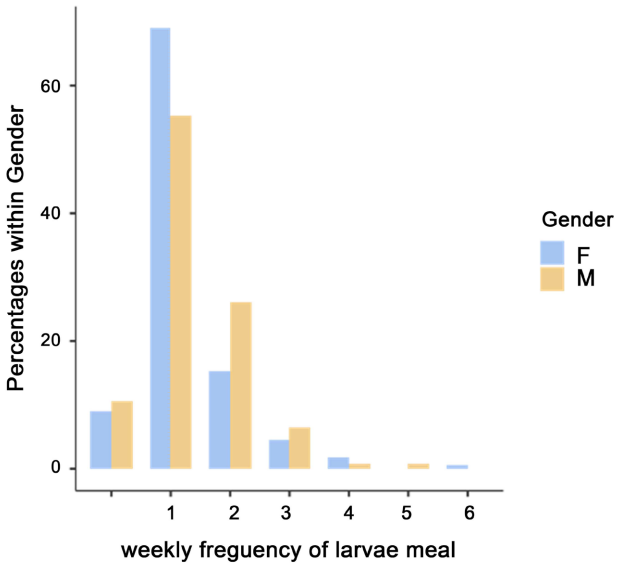

Figure 3. Weekly frequency (%) of consumption of palm weevil larvae by respondent gender.

Overall, both men and women report a weekly frequency of once a week (68.0% men vs. 81.9% women), although men more strongly perceive a frequency of 2 times a week (32% M vs. 18.1% F; $X^2 = 6.38$, dl = 1; $p = 0.01$) (See Table 8 and Figure 3).

Table 9. Weekly frequency of palm weevil larvae consumption by level of education.

FHCR	Frequency	Secondary school	University
1		162	23
	%	82.7	56.1
2		34	18
	%	17.3	43.9
Total		196	41

The level of education is also a source of variation in the frequency of palm weevil larvae consumption (See Table 9). Frequency 1 is cited by 82.70% of those with secondary school education vs. 56.10% of university graduates. Also, frequency 2 is cited at 17.30% by those with secondary school education vs. 43.90% among university level respondents, showing that frequency 2 is higher among university degree holders (X^2 Tests, $X^2 = 14$, dl = 1; $p \leq 0.001$). University degree holders can access to higher-paying jobs and, therefore, higher incomes.

Table 10. Weekly frequency of palm weevil larvae consumption by religion.

Frequency of palm weevil larvae meal		Catholic	Protestant
1	Frequency	28	58
	%	60.9	87.9
2		18	8
	%	39.1	12.1
Total		46	66

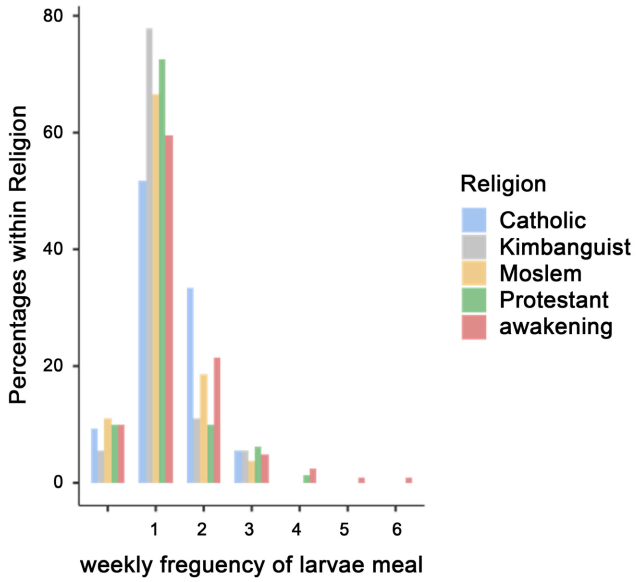

Figure 4. Weekly frequency of consumption of palm weevil larvae by religion.

Even religion, as a cultural factor, has its effects. This is in favor of Catholics (See Table 10 and Figure 4). At larvae consumption frequency 1, Catholic devotees expressed 60.90% vs. 87.90% among Protestants. Subsequently, at larvae consumption frequency 2, Catholic devotees expressed themselves at 39.10% vs. 12.10% among Protestants ($X^2 = 11.1$, dl = 1; $p \leq 0.001$). Here, it is assumed that religion has an indirect influence, since we're not talking about dietary prohibitions or taboos.

3.7. Geographical Disparities: Variations by Municipality

Figure 5 shows the main components of the extent of palm weevil consumption by commune and its factors. Kasuku commune shows higher values of number of meals per day, frequency of palm consumption, palm weevil consumption status (Yes/No), larvae supply per purchase, consumption of caterpillars, termites, poultry, fish, beef, goat meat, and weekly frequency of meat consumption. The commune of Kasuku is more urbanized and wealthier. The commune of Mikelenge dominates only in terms of intensity of rhinoceros beetle (*Oryctes*) and pork consumption. Although income classes show no significant difference between communes, the results indicate greater food security in Kasuku in terms of access to meals and animal proteins, as well as procurement by purchase rather than by gathering, the latter being a sign of poverty, especially for urban households. While the commune of Kasuku shows great homogeneity in this more intense consumption of palm weevil, that of Mikelenge is subdivided into two sub-groups. On the one hand, low consumers of caterpillars, poultry, fish, beef, goats and smoked meat; on the other, older people, low consumers of Oryctes, high consumers of termites, and low consumers of pork. The Mikelenge commune is poorer and forms the suburbs and outskirts of Kindu.

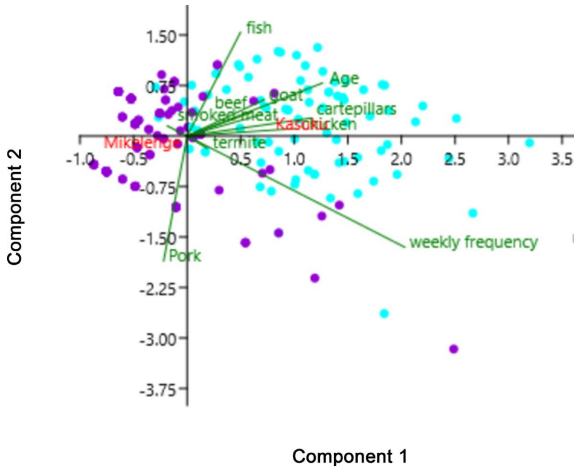

Figure 5. Main components of the extent of palm weevil consumption by commune and their factors.

Table 11. Geographical distribution of Menus.

Menu		Kasuku	Mikelenge
Banana	Frequency	4	1
	%	5.2	0.5
Fries		1	0
	%	1.3	0.0
Pastas		71	116
	%	92.2	59.8
Rice		1	77
	%	1.3	39.7
Total		77	194

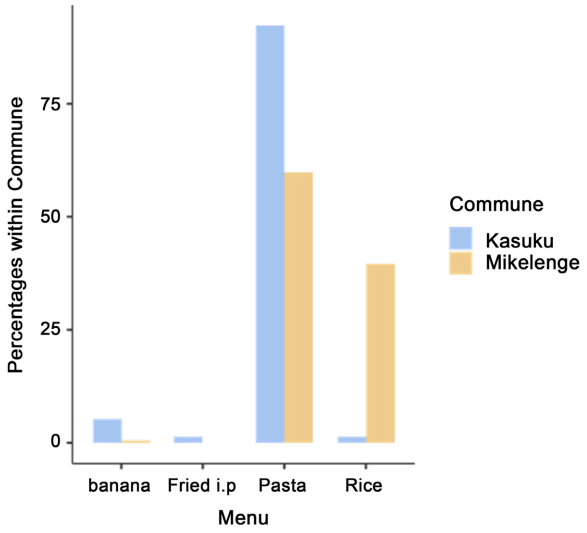

Figure 6. Menu disparity by commune.

Palm weevil larvae (See **Figure 6**) are consumed up to 92.20% in the commune of Kasuku with pastas vs. 59.80% in Mikelenge, where Rice is consumed more often with the larvae (39.70% vs. 1.3%) (See **Table 11**).

Table 12. Geographical disparities in supply mode.

		Municipality	
Supply		**Kasuku**	**Mikelenge**
Purchase	Frequency	72	148
	%	93.5	76.3
Gathering in the wild		5	46
	%	6.5	23.7
Total		77	194

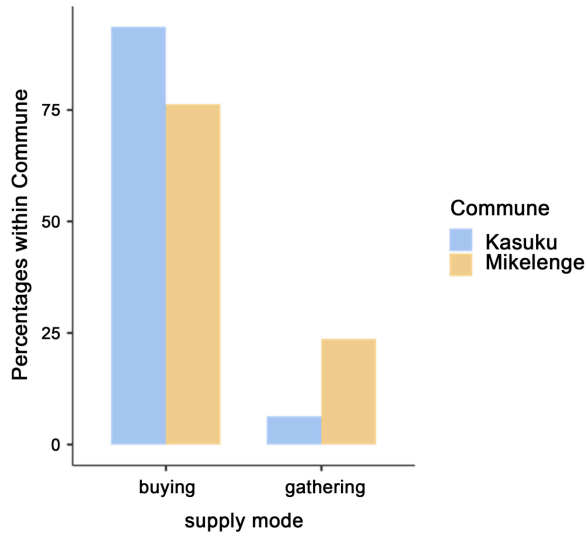

Figure 7. Geographical disparities between supply modes.

Gathering (See Figure 7) is rarely practiced in Kasuku; 6.5% vs. 23.7% in Mikelenge commune. Buying, on the other hand, predominates in Kasuku commune at 93.5% vs. 76.3% in Mikelenge (X^2 = 10.7, dl = 1; p = 0.001) (See Table 12).

3.8. The Intensity of Other Animal Protein Sources in the Diet

Table 13. Other insects consumed together with palm weevil larvae.

Caterpillars	Number	%
No	226	75.3
Yes	74	24.7
Rhinoceros beetles		
No	256	85.3
Yes	44	14.7
Termites		
No	46	15.3
Yes	254	84.7
Crickets		
No	298	99.3
Yes	2	0.7
Grasshoppers		
No	288	96.0
Yes	12	4.0

Among the other insects consumed together with palm weevil larvae, termites prevail (84.7%), followed by caterpillars (75.30%) and by far with rhinoceros beetles (14.7%). Grasshoppers swarm occasionally (4%) (See Table 13).

Table 14. The frequency of consumption of various meats in Maniema province.

Poultry	Frequency	%
No	241	80.3
Yes	59	19.7
Fish		
No	165	55.0
Yes	135	45.0
Pork		
No	170	56.7
Yes	130	43.3
Beef		

Continued

No	230	76.7
Yes	70	23.3
Goat		
No	249	83.0
Yes	51	17.0
Smoked meat		
No	264	88.0
Yes	36	12.0
Total	**300**	**100**

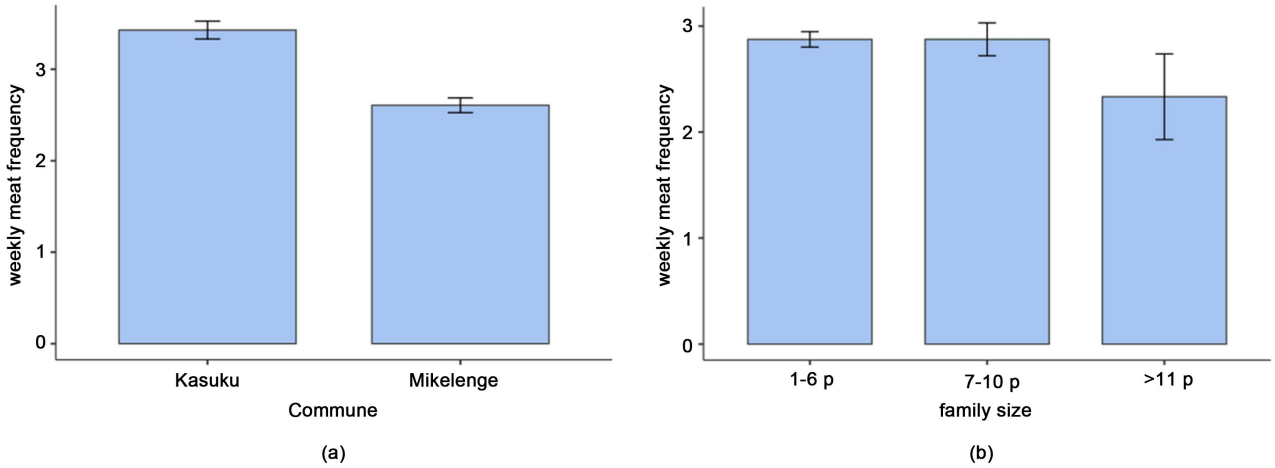

Figure 8. Proportion of meat consumption by municipality and household size class.

Poultry is expensive in Kindu, therefore it is scarce in the diet (19.7%). Fish also accounts for only 45.0% of meat consumption, along with pork (43.3%), beef (23.3%), goat meat (17.0%) and smoked game meat (12%) (See **Table 14**). Large households encompassing beyond 11 people eat meat less frequently than households of 1 - 6 people (See **Figure 8(b)**). Meat is typically eaten once a week in large households (46%) vs. 2 - 4 times in smaller households. Meat is indeed expensive to be accessible to large households (1 kg beef $8, 1 kg pork $7 and 1 kg local poultry $10). **Figure 8(a)** shows that meat consumption is higher in the commune of Kasuku than in the commune of Mikelenge.

3.9. Interactions between Entomophagy Factors

The interaction between caterpillar and rhinoceros beetle (*Oryctes*) consumption (**Figure 9(a)**) is significant (X^2 Tests, $X^2 = 3.38$, dl = 1; $p = 0.06$). Thus, caterpillar eaters also consumed *Oryctes spp.* In the rare cases where grasshoppers were eaten, caterpillars were also consumed (**Figure 9(b)**; $X^2 = 6.15$, dl = 1; $p = 0.001$).

Path Diagram

The principal components model was highly significant (Bartlett test $P < 0.001$) and it explained 58.9% of the variances. The variances of caterpillars, chicken,

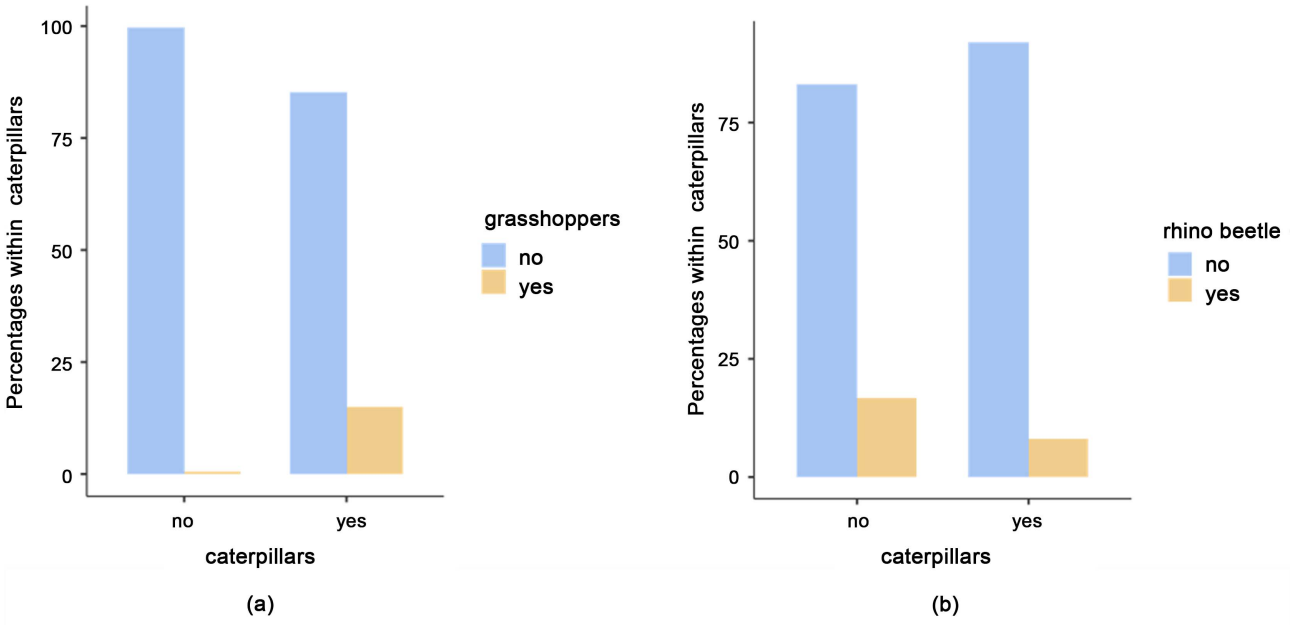

Figure 9. Interactions between entomophagy factors.

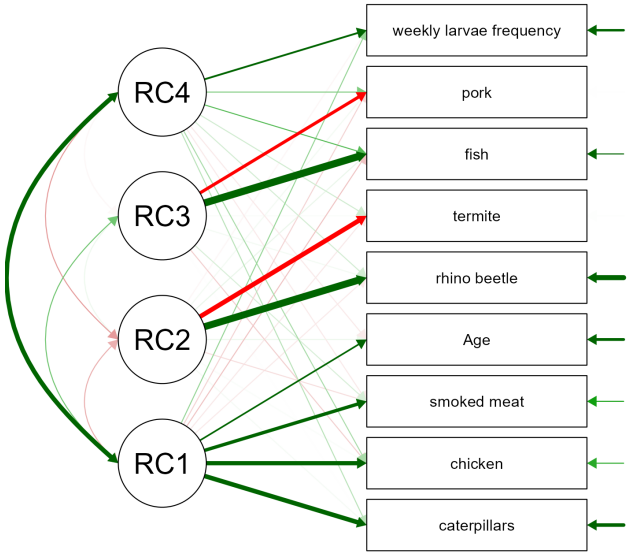

Figure 10. The principal components of palm weevil consumption.

smoked meat, and consumer's age were positively explained in the first component (**major insect and meats; r = 0.46 to −0.75**). The variances of rhino beetles (r = 1.0) and termites (r = −0.76) were explained in component 2. Fish was strongly tied to component 3 (r = 1.0) where pork was negatively linked (r = −0.61). Weekly consumption of palm weevil larvae was apart in component 4 (r = 0.48). The frequency of consumption of palm weevil larvae was significantly correlated with **major insect and meats; r = 0.51)**. So, entomophagy for the two most frequently consumed insect groups, palm weevil larvae and caterpillars, goes hand in hand. Those who eat palm weevil larvae also eat caterpillars and consume

more meat. Households that eat fish eat less pork. Similarly, those who eat more termites do consume less rhinoceros beetles. Crickets and grasshoppers are consumed more scarcely in Kindu (See **Figure 10**).

4. Discussion

4.1. Scope and Motivation of Palm Weevil Entomophagy

Insect consumption is an existing and popular practice among several ethnic groups in Kindu city. Palm weevil larvae are eaten for several reasons: cultural, nutritional and economic. They represent an important source of protein in this region, where agriculture and food resources are limited. The ease with which they can be harvested, their nutritional value, and their role in local culinary traditions make them a much-appreciated foodstuff. Moreover, marketing them generates income for rural and sub-urban communities. Their consumption continues to play a crucial role in the daily lives of Kindu's inhabitants. In fact, 90.30% of our respondents eat insects, compared with 9.70% who do not. This rate is higher than that of [3] who obtained 60.46% insect-eaters in the study area in Ivory Coast. [30] indicated that 66.3% of respondents in the study area in the Republic of Congo eat palm weevil larvae, while 33.7% did not. Here, 78% of insect-eaters preferred fresh palm weevil larvae among insects. [35] showed instead that 62.1% of respondents eat caterpillars. Beetles are reported to be the most widespread order of edible insects worldwide. Specific examples include the palm weevil (*Rhynchophorus* species). Our results confirm the great importance of the palm weevil in Maniema. Hymenoptera (bees, wasps, ants) are also frequently eaten. Lepidopteran caterpillars (butterflies and moths) are an important source of edible insects, particularly in Africa. Orthopterans (grasshoppers, locusts, crickets) are also widely eaten, particularly in Africa and Asia [19]. Among other orders, termites are particularly important in some parts of Africa [36] [37] stated that the United Nations has recommended entomophagy as a solution to the world's food shortage.

In Kindu, insect eaters are motivated by habits. [25] found that taste, nutritional value and the culture of origin of respondents are the main reasons for eating palm weevil. [3] in Ivory Coast, presented more detailed motivations, showing that most insect eaters are attracted by aroma and taste (38%), curiosity (22%), while others eat out of habit (15%) or because of knowledge of the nutritional value (14%). Only 1% were forced to eat insects for lack of food. [38] found that insect consumption is justified by their organoleptic quality and availability. [19] have wisely proposed the promotion of processing to increase the acceptance of insects in the diet, masking the appearance of the insect by modifying its texture.

The main obstacles to insect consumption in Kindu city are: the high price, the limited availability of larvae in markets and the dietary habits of some people. [39] concluded that the main barrier to insect consumption is individual rather than cultural experience. Conversely, "entomophobia" is justified by eating habits, religion, the bitter taste, the presence of hairs or spines in certain species and the way insect menus are presented. [3] indicate that the main reasons given by those

who no longer eat insects include the unavailability of insects (42.51%), age (28.94%) and allergies (9.78%) experienced after consumption, such as itching, diarrhea and nausea. [10] indicated that disgust is a major obstacle to insect consumption in Western cultures. This "disgust factor" is a powerful psychological deterrent. [7] points out that concerns about potential disease or contamination associated with insects also contribute to negative perceptions. Other authors mentioned cultural beliefs and insect availability as influencing entomophagy intensity [19]. Some religions in Africa discourage entomophagy [19]. Psychological factors such as disgust [10], food neophobia, fear of (allergic) diseases and the appearance of insects also influence entomophagy [19]. Excessive prices can discourage insect consumption [41].

4.2. Supply Methods, Availability and Causes of Shortages

Buying palm weevil larvae at the market is the main way of obtaining them in Kindu city, rather than gathering them in the wild. Buying palm weevil larvae at markets enables consumers to acquire them without having to painfully collect them in the wild. Harvesting palm weevil larvae involves a considerable amount of physical labor and special knowledge of where infested palms are located. Buying at the market, on the other hand, simplifies this process, making supply easier for consumers who may not have the time or skills to harvest them. In urban areas like Kindu, markets are central trading points offering a wide range of food products, including palm weevil larvae. This makes them easily accessible to locals without having to travel to remote rural areas or into the forest. For urban consumers or people with jobs or day-to-day responsibilities, buying at the market is a quick way of obtaining larvae without having to invest a lot of time in gathering. This time saving is crucial in an urban context where people prefer practical solutions to their food needs. [30] indicated that 90.95% of people surveyed in the Republic of Congo buy their food from markets. [25] also pointed out that markets are the main places for sourcing insects, but they can also be collected in the forest, in the savannah or on the soil surface, depending on the species.

In the wild, larvae are collected from wild palms felled during the opening of fields and from palms felled for palm wine production. They are then stored, either on rolled *Megaprynium macrostachyum* leaves, or in a container mixed with dead palm debris. According to [30], palm weevil larvae are collected from felled palms in village and forest areas, and are mainly preserved on dead organic palm debris. In addition, according to [3], all insects consumed in Ivory Coast are also collected in the wild and are not farmed.

Palm weevil larvae are most abundant during the rainy season in Maniema province, according to 98.50% of consumers surveyed. Regarding their monthly availability, 82.70% said that larvae were easier to find in August, September, October, November and December. These results are consistent with those [30].

There is a serious shortage of larvae in the markets of Kindu city. Regarding the causes of the shortage of larvae, people feel that the manpower of gatherers and

the effort to collect larvae in the wild is insufficient. On the other hand, the cutting down of palm trees for other uses (extraction of palm oil and palm kernel oil, production of artisanal building materials, manufacture of vegetable salt, source of firewood, etc.), reduce the number of palm trees. Palms are essential to the life of palm weevil larvae, so their reduction naturally leads to a reduction in the supply of larvae. Excessive collection of larvae, regardless of sustainable practices, will harm insect reproduction and population. If harvesters do not respect a balance in the quantity and size of larvae collected, this will lead to their decline in their habitats and, subsequently, a drop in the quantities available on the market. Climate changes such as drought or excessive rainfall can also disrupt the weevils' natural habitat, reducing the quantity of larvae produced and available for harvest. These factors can create temporary shortages, affecting the regularity of larvae supply to markets. As a result, larvae prices fluctuate, sometimes rising, in a context where demand outstrips available supply. Consumers then find themselves in a situation where they must either look for alternatives, or accept higher prices, making the supply of larvae more difficult or even inaccessible for some people. According to [41], there is a shortage of palm weevil larvae on markets in Cameroon. Although there are insufficient quantities on the market, palm weevil larvae are unquestionably the most prized by consumers. [19] noted that the unavailability of insects in a given environment is a major obstacle to their effective use in households. To remedy the problem of the lack of larvae on the markets of Kindu city, the promotion of rearing is crucial [32].

4.3. Perception and Determinants of *Larval Consumption Frequency*

Depending on gender, men and women may perceive and consume these larvae differently, influenced by social and family norms. This precious and expensive larvae menu is offered relatively more to men than to women in the Kindu household. In this society, it is not uncommon for a man to claim the best dish. These results corroborate the findings of [42] who agree that gender plays a role in increasing positive attitudes towards edible insects.

Religious beliefs can also affect attitudes towards entomophagy, but these perceptions vary according to local practices and interpretations of religious dietary rules. Thus, even religion, as a cultural factor, has its effects in Kindu city, in favor of Catholics. Here, we can say that religion has an indirect influence, since it's not a question of dietary prohibitions or taboos. [7] indicated that, religious beliefs can favor or forbid insect consumption. For example, some Muslim scholars consider that the consumption of insects other than locusts is not halal, as these insects are perceived as impure. However, these positions may vary according to religious interpretation. The level of education is also a source of variation in the frequency of consumption of palm weevil larvae. Consumption is high among university graduates in Kindu city. Academics have access to higher-paying jobs and, subsequently, higher incomes. These results concur with those of [37] stipulating that education plays a role in increasing positive attitudes towards edible

insects. [19] showed that socio-demographic factors play an important role in the choice of entomophagy practice. Consumer education and public awareness campaigns on the nutritional and environmental benefits of entomophagy are essential to increase acceptance [19]. In many parts of Asia, Africa and Latin America, the weekly frequency of insect meals can be high, even daily in some cases, and represent a primary source of protein. In regions where insects are readily available and harvested, consumption frequency tends to be higher [19]. Seasonal variations in insect availability also affect consumption patterns [7].

In regions where insects are a cheaper source of protein, consumption frequency could be higher, particularly in low-income groups [7]. However, in regions where insect foods are more expensive, alike Kindu, consumption could be limited to occasional treats or special occasions [9].

In many rural communities, the harvesters of these insects do not eat everything they collect. Instead of consuming their entire harvest, they often choose to sell part of it to buy other essential goods or services. This is a way of maximizing the benefit derived from a locally available resource. The sale thus enables reinvestment in other needs, such as education, health, or other necessary food products. Indeed, palm weevil larvae are consumed more in the Kasuku municipality than Mikelenge. Palm weevil gatherers in Mikelenge prefer to sell rather than eat the larvae. This disparity between communes is justified by the fact that palm weevil gatherers, whose income is lower than that of their customers, prefer to sell rather than consume.

The main supply circuit for palm weevil larvae in Maniema province follows a well-structured path from the forest to urban markets. This circuit connects rural harvesters to urban consumers, through a series of logical and economic stages (**Figure 11**):

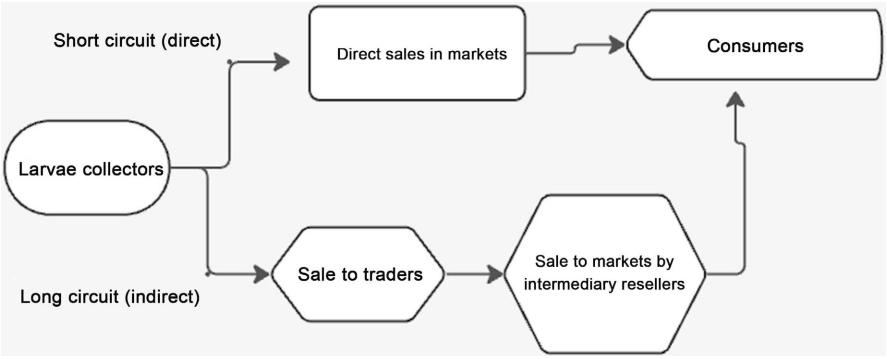

Figure 11. Supply and trade pathway of palm weevil larvae in Maniema province.

It is important to note that when larvae are sold by local harvesters on markets, they are less expensive. On the other hand, when they are sold by intermediate resellers, the price of larvae is higher. This can be explained by the additional costs associated with transport, selling as an intermediary, and market demand and supply.

Insects represent an essential source of income for many rural families, especially in forest areas, where the sale of edible insects such as Palm Weevil is a means of meeting urgent economic needs while tapping into demand on local markets. This choice is motivated by the possibility of increasing family income, diversifying funding sources and maximizing the profitability of insect harvesting. [21] noted that insects are not only a source of nutrients for local communities, but also a significant source of income. The price of insect-based foods compared with conventional protein sources influences consumer demand [19] and excessive prices can discourage consumption [40].

4.4. Geographical Disparities: Variations by Municipality/Commune

Results on geographical disparities reveal that gathering is less common as a supply strategy for consumers in Kasuku than in Mikelenge municipality. On the other hand, buying is predominant in Kasuku commune at the rate of 93.5% versus 76.3% in Mikelenge commune. This disparity is explained by the concentration of palm wine and larvae harvesters, palm wine outlets and farmers in the commune of Mikelenge, which is sub-urban and encompasses almost the entire outskirts of the city of Kindu. Their standards of living indicators are lower. Entomophagy is more intense in Kasuku than in Mikelenge. [43] assumed that the food system of each ethnic group is established on the basis of certain social, economic and environmental factors. [30] observed variations in beetle consumption rates from one commune to another. The highest rates were observed in Madibou (82.86%), Makékélé (74.30%), Djiri (77.27%), Talangai (77.14%) and Moungali (71.43%), while the lowest rates were recorded in Commune de Kintélé (51.43%) and Bacongo (54.30%) in Congo Brazzaville.

Rice is more frequently consumed with palm weevil larvae in Mikelenge commune than in Kasuku commune. This disparity can be explained by the fact that the commune of Mikelenge is influenced by the Kusu community, which prefers rice as a staple food. On the other hand, the consumption of pasta (a corn and cassava flour molding) accompanied by palm weevil in the commune of Kasuku can be explained by the diversity of tribal communities present, notably whose staple food is pasta; *i.e.* the Zimba, Basongola, Babangubangu and others. The commune of Kasuku, the urban core, is more cosmopolitan, with pasta as their staple food. [3] found that insects are generally eaten grilled with cassava semolina, but some people preferred dishes with insects alone (unaccompanied).

4.5. The Place of Other Insects and Animal Protein Sources in the Diet

Other insects consumed together with palm weevil larvae in the town of Kindu include termites, followed by caterpillars, distantly followed by rhinoceros beetles. Grasshoppers do occasionally swarm. In addition to insects, other sources of animal protein include fish, pork, beef, chicken, goat meat and smoked game meat.

[35] found that 62.1% of respondents eat caterpillars. The study also showed that the further away from the harvesting site, the lower the consumption rate. [25] found that *Cirina forda* is the most consumed insect in all of their study areas, with a consumption rate of 95.8%. Other insects such as *Imbrasia truncata* (81.8%), *Ruspolia differens* (71.4%), *Gryllus campestris* (56.8%) and *R. phoenicis* (42.5%) are also consumed in the study areas. Boko *et al.* (2021) observed that the most commonly consumed species are winged termites *Macrotermes subhyalinus* (29.79%), crickets *Acheta domesticus* (19.81%) and *Rhynchophorus phoenicis* (14.63%) in their study area in Ivory Coast. In Burkina Faso, on the other hand, the most consumed insect is the shea caterpillar (*Cirina butyrospermi*), which is considered a pest of tree plantations grown for the production of shea butter [44]. According to [41], Lepidopteran caterpillars and Isopteran larvae are the most traded insects on Cameroonian markets.

5. Conclusion

The study explored the consumption of edible insects, highlighting the socio-cultural issues, motivations and obstacles associated with this practice, as well as the factors influencing the acceptability of palm weevil larvae. The majority of respondents consume palm weevil larvae as a dietary habit. They prefer them fresh, mainly with maize or cassava pasta or rice. The consumers purchase larvae on markets and less by gathering in the wild. The availability of larvae on markets is notoriously low. In addition to palm weevil larvae, other insects; including termites, followed by caterpillars, and distantly followed by rhinoceros beetles. Grasshoppers are eaten occasionally when they swarm. Other sources of animal protein include fish, pork, beef, poultry and smoked meat. Geographical disparities between the municipalities of Kasuku and Mikelenge indicate differences in eating habits and sourcing patterns, highlighting the impact of the communes' socio-economic level on the intensity of consumption of palm weevil larvae and meat, two types of expensive commodities. Gathering in the wild is also a feature of rural and suburban communities in this forest environment. The findings of this paper demonstrate the importance of analyzing the multiple socio-cultural, economic and individual influences that shape the consumption of edible insects, offering avenues for a deeper understanding of this practice. In contrast with findings elsewhere, insect-eating in Kindu city is more intensive among the rich and the middle class and the more educated people, as well as in wealthier neighborhoods. The promotion of processing is necessary to solve the problem of some people's refusal to eat insects. The plan is to train the local community in the proper technique for domesticating *Rhynchophorus*. This will ensure the availability of larvae on the markets in the town of Kindu. This initiative will contribute to the development of local resources and the diversification of food sources in the city. Future studies will also target the nutritional composition of palm weevil larvae and other insects consumed, and analyze the consumption habits of various insects and meats within different socio-economic groups. Our recommendations

include the need to: a) Inform communities about the nutritional value of insects (rich in proteins, minerals, essential fatty acids) and their role in food safety; b) Include entomophagy in school and university curricula to familiarize young people with the practice from an early age; c) Organize fairs or workshops where insects are cooked in an attractive way. This will help to overcome the 'disgust' factor by showing that insects can be tasty; d) Involve community and religious leaders and local influencers in promoting the message, to legitimize the consumption of insects; e) and Offer insect-based products in the form of powder, nutritional bars or food mixes to get round the visual aspect that can put people off.

Conflicts of Interest

The authors declare no conflicts of interest.

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