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ORIGINAL PAPER

Consumption patterns of edible insects in rural and urban areas of Zimbabwe: taste, nutritional value and availability are key elements for keeping the insect eating habit

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Abstract
Edible insect consumption is a traditional practice in many countries and has the potential to contribute to food security. The aim of this study is to obtain insight into insect consumption patterns amongst rural and urban populations, and into factors that may influence these patterns. For this purpose, a case study was made in Zimbabwe. A literature-based conceptual model indicated that motives for consumption, individual characteristics, consumer environment, availability, food characteristics, and indigenous knowledge could affect edible insect consumption. A survey amongst 200 urban and 175 rural respondents showed that insect consumption was significantly higher in rural (89.7%) than in urban (80.0%) areas. Rural respondents (63.9%) consumed insects more than three times a week on average as compared to urban (14.5%) respondents. Quantities consumed as snacks are significantly different between urban and rural respondents. Taste was the main motive of respondents in both the rural (89.2%) and urban areas (74.4%). Respondents in urban areas more often reported nutritional value (74.4%) and medicinal properties (28.1%) as important motives for consumption compared to rural respondents (51.0% and 15.3%, respectively). For rural areas, socio-demographics did not relate to consumption of edible insects whereas in urban areas, insect consumption was negatively related to education, main livelihood source and monthly income. Availability of edible insects influences both urban (64.0%) and rural (83.0%) respondents' consumption of insects. The lower consumption of specific insect species in urban areas could hamper the potential contribution of insects to food security in these areas. Therefore, promotion of entomophagy by marketing and maintaining traditional knowledge on insect processing should target urban people through provision of tasty products, communicating nutritional value.

Keywords Entomophagy · Consumption motives · *Henicus whellani* · *Eulepida species* · Indigenous knowledge

1 Introduction

Consumption of edible insects is a traditional practice in many African (Van Huis 2003), Asian (Yen 2015) and Latin American (Costa-Neto 2016) communities. More than 2000 species of insects are suitable for human consumption worldwide (Jongema 2017). Edible insects have the potential to contribute to food security (Belluco et al. 2013; Ghaly 2009). FAO is therefore promoting the consumption of insects from wild harvest or insect farming (Gahukar 2011; Hanboonsong et al. 2013; van Huis et al. 2013). The proportional contribution of edible insects to the diets of insect-eating populations ranges from minor to substantial and there can be variation in the contribution to different groups within communities (Raubenheimer and Rothman 2013; van Huis et al. 2013).

However, the potential contribution of edible insects to food security in continents such as Africa and Asia is under threat. A decrease in prevalence of traditional practices of entomophagy has been reported in communities in developing countries where insect consumption used to be common (Dube et al. 2013; Meyer-Rochow and Chakravorty 2013; Obopile and Seeletso 2013; Riggi et al. 2016; Yen

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2009). Reasons for this decrease include adoption of Western foods (Dube et al. 2013; Looy et al. 2014; Mlcek et al. 2014; Obopile and Seeletso 2013; Yen 2009) and decreased knowledge of preparation practices (Riggi et al. 2016). Other reported reasons include unavailability of the edible insects (Looy et al. 2014), uncontrolled harvesting (Ramos-Elorduy 2006), and loss of habitats leading to extinction of some species (Dube et al. 2013; Meyer-Rochow and Chakravorty 2013).

In developing countries, especially in urban areas and younger populations, there is a tendency to abandon the practice of entomophagy due to westernisation of traditional diets (van van Huis and Vantomme 2014; Vantomme 2015). Also a common belief is that traditional foods, like edible insects, are considered to be primitive and are not accepted by Western communities. This thinking leads to unwillingness of people to share experiences of these foods (Looy et al. 2014).

Multiple studies stress the importance of documenting traditional knowledge of edible insects to restore and promote entomophagy (Riggi et al. 2016; van van Huis 2015; Yen 2009) and to disseminate information to new consumers, especially in urban areas (Gahukar 2011). Traditional communities are well-enriched with local knowledge of the occurrence, methods of collection, processing and consumption (Riggi et al. 2016).

Many developing countries are still facing food insecurity despite an abundance of natural resources that can help to alleviate the problem. An estimated prevalence of 11.0% of the global population is undernourished and a higher 12.9% is observed in developing countries (FAO 2015). Food insecurity is not only limited to rural areas but is also observed in urban areas (Frimpong 2013; Tawodzera 2011). Rural to urban migration is usually associated with change consumption habits (Frimpong 2013; Puoane et al. 2006). The consumption of edible insects in many developing countries is documented for specific insect species. However, to the best of our knowledge, it is not yet known how edible insect consumption differs between urban and rural areas.

The aim of the study was to obtain insight into the insect consumption patterns among rural and urban populations and to study the factors that influence these patterns. For this purpose, a case study was made in Zimbabwe. Although mopane worms and termites are the most popularly consumed edible insects in Zimbabwe (Gardiner and Gardiner 2003; Onigbinde and Adamolekun 1998), *Eulepida* species (Dube et al. 2013; Musundire et al. 2016; Onigbinde and Adamolekun 1998) and *Henicus whellani* (Musundire et al. 2014a, b) are also commonly consumed in some regions of the country. The current study, next to overall insect consumption, focused on *Eulepida spp.* and *Henicus whellani*, because of their specific cultural value to local consumers and potential to contribute substantially to human nutrition.

2 Methodology

2.1 Study design

Data on consumption patterns and traditional processing of edible insects was collected through a survey. A questionnaire was administered in three urban towns and five rural districts of Zimbabwe through face-to-face interviews between July and October 2015. The questionnaire was based on a conceptual model that presents factors influencing consumption patterns of edible insects as described in the literature.

2.2 Questionnaire design

2.2.1 Conceptual model used to design the questionnaire

Figure 1 shows a conceptual model presenting possible factors influencing the consumption patterns of edible insects. The model is based on common food preference studies and literature on insect consumption. Food preferences play an important role in food consumption (Sijtsema et al. 2002) and can affect consumption patterns (Becker et al. 2000; Gerbens-Leenes and Nonhebel 2005), which are defined as repeated arrangements in the food consumption of a population group (Gerbens-Leenes and Nonhebel 2005). In the current study, consumption patterns refer to which insects are consumed, how much and when. Food preference can be affected by characteristics of the food itself (such as taste, flavour, appearance), consumer characteristics, such as gender, age and education (Han and Powell 2013), and characteristics of the consumer's social environment such as individual upbringing and religion (Sijtsema et al. 2002). Particularly, religion can play an important role in the consumption of insects, and in some religious practices, entomophagy is strictly forbidden (Dube et al. 2013).

Important reasons for consuming insects are sensory/pleasure considerations and health (van van Huis 2013), nutritional value (Kinyuru et al. 2010; Obopile and Seeletso 2013) and medicinal properties (Ayieko and Oriaro 2008; Musundire et al. 2014a). Other studies indicate that insect availability influences preferences and consumption of edible insects (Chakravorty et al. 2013; Meyer-Rochow and Chakravorty 2013; Obopile and Seeletso 2013; Raubenheimer and Rothman 2013). Also, indigenous knowledge on harvesting and processing have been mentioned as factors influencing the adoption and consumption of insect-based food (Gahukar 2011; Kinyuru et al. 2010; Obopile and Seeletso 2013), and this factor is included in the model as well.

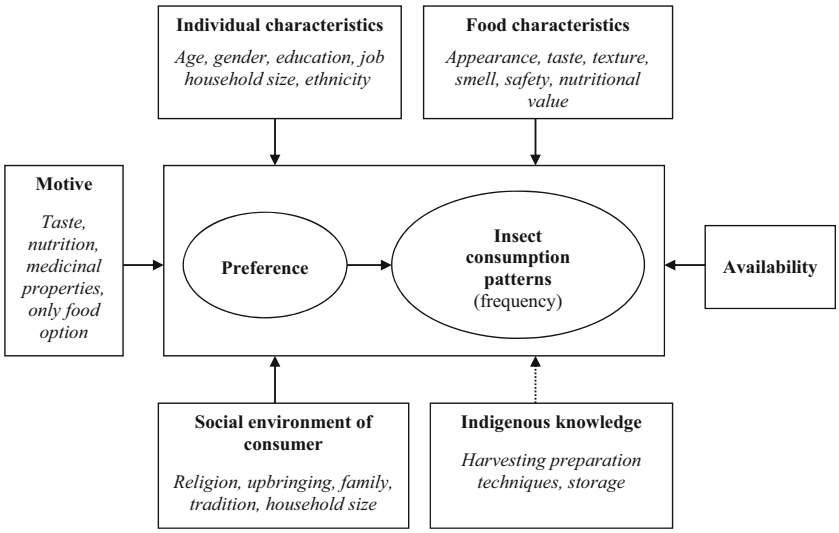

Fig. 1 Framework for the design of the questionnaire on possible factors that can influence insect consumption patterns

2.2.2 Questionnaire

The questionnaire was divided into seven sections. In the first section socio-demographic information was collected. The second section contained close-ended questions related to consumption patterns (frequency of consumption, quantity, and form of consumption) and possible motives (reasons) for consuming insects. The third section contained questions about how characteristics of the consumer's social environment, including religion, individual upbringing, family habits, and edible insects' availability influenced respondents' behaviour towards entomophagy. Section 4 includes questions related to the insects' characteristics. Respondents rated the importance they assigned to the various characteristics affecting their decision to eat insects on a five point hedonic scale. Moreover, consumers had to rate appreciation of different sensory attributes (taste, texture, smell and appearance). In the fifth section, questions on consumptions patterns were asked particularly for *Eulepida spp.* and *Henicus whellani*. Only those who actually consumed the two species completed these questions. The last two sections solicited indigenous knowledge on harvesting and traditional processing techniques of these two insect species.

2.3 Study area and respondents

Questionnaires were administered to 200 individuals who were randomly selected and had agreed to be interviewed at several market places and shopping centres in three urban areas: Harare ($n = 80$), Masvingo ($n = 60$) and Marondera ($n = 60$). Masvingo and Marondera were purposively selected because these towns are close to rural areas where *Henicus whellani* and *Eulepida species* are commonly found. The assumption is that people living in these cities are embedded in a culture where these insects are considered a local speciality.

Questionnaires were also administered in five rural areas in the Zaka, Bikita, Mhondoro, Seke and Zvimba districts, to a total of 175 respondents. One adult per randomly selected household from a list of households provided by traditional leaders was interviewed. The rural areas were purposively selected based on where either *Henicus whellani* or *Eulepida species* were commonly found and consumed. Zaka and Bikita districts were considered to be areas in the Southern Eastern region of Zimbabwe where *Henicus whellani* is found and consumed. Mhondoro, Seke and Zvimba were selected where *Eulepida spp.* are found and consumed.

2.4 Data analysis

Data from the questionnaire were coded and entered into IBM SPSS Statistics (Version 22, 2013). The data of the respondents who actually consume edible insects was used for calculating the (relative) frequencies of consumption and to discover consumption patterns. A Chi-square test of independence was performed to determine if there was any significant difference between consumption patterns of rural versus urban respondents and any relationship between consumption and demographics characteristics.

3 Results and Discussion

3.1 Insect consumption patterns

A greater percentage of the rural respondents (89.7%) compared to urban respondents consumed at least one type of edible insect. However, the consumption habit was also high among urban respondents (80.0%) ($\chi 2 = 6.736$, $df = 1$, $p = 0.009$) (Table 1). This suggests that most respondents consumed at least one edible insect species, but not necessarily

Table 1 Frequencies (as percentage) of the edible insect consumption patterns of urban and rural during insect harvest season[a]

	Urban	Rural
Overall consumption patterns*	$n = 200$	$n = 175$
Consumers	80.0	89.7
Non-consumers	20.0	10.3
Frequency of consumption*	$n = 159$	$n = 155$
Greater than 3 times/week	14.5	63.9
1–2 times/ week	37.1	29.7
1–4 times a month	24.5	5.2
Less than once a month	23.9	1.3
Meal type[b]	$n = 160$	$n = 157$
As relish*	61.9	77.1
In combination with other relish*	31.6	48.4
Snack	70.0	79.0
Quantities consumed		
As relish	$n = 99$	$n = 121$
Less than 1 cup	21.2	33.9
Equivalent to 1 cup	55.6	46.3
More than one cup	23.2	19.8
As combination with other relish	$n = 49$	$n = 76$
Less than 1 cup	63.3	72.4
Equivalent to 1 cup	24.5	17.1
More than one cup	12.2	10.5
*As snack**	$n = 112$	$n = 124$
Less than 1 cup	52.7	55.6
Equivalent to 1 cup	37.5	16.1
More than one cup	9.8	28.2

[a] All values represents %, [b] more than one answer possible, * significantly different between urban and rural

different types of insects. The results are in line with previous research, which observed that entomophagy is a common practice in Zimbabwe (DeFoliart 1997; Dube et al. 2013; Musundire et al. 2016). The data on consumption frequencies shows that a significantly higher percentage (63.9%) of the rural respondents consumed edible insects more than three times a week on average when it is insect harvest season compared with urban respondents (14.5%) ($\chi^2 = 101.766$, $df = 3$, $p < 0.001$).

The difference in frequency of consumption and quantities consumed between urban and rural respondents was expected since most of the edible insects are harvested in the wild and availability is an important factor in their consumption (Meyer-Rochow and Chakravorty 2013). Rural communities have greater access to insects, especially to species harvested exclusively from the forests. On the other hand, urban people obtain most of their edible insects from markets. Harvesting and marketing edible insects are contributing to the improvement of livelihoods for some rural communities. Van van Huis (2013) highlighted that collection of insects from the wild will not sustain entomophagy and suggested a need for considering rearing of targeted species.

Table 1 also shows how insects are consumed (meal type) and quantities consumed. The most common way of consuming edible insects in both rural and urban areas is as a relish and/or as a snack. Relish refers to a side dish taken together with the staple food (such as thick maize porridge called sadza). In this study, a snack refers to consumption of insects as a leisure activity rather than as a meal. More rural (77.1%) than urban (61.9%) respondents consumed insects only as a relish ($\chi^2 = 8.616$, $df = 1$, $p = 0.003$). Most of the insect consuming respondents in the urban (70%) and rural (79%) areas eat edible insects as snacks. Although there was no significant difference in consuming edible insects as snacks ($\chi^2 = 3.360$, $df = 1$, $p = 0.067$), the consumed quantities as snacks differed significantly between the rural and urban respondents ($\chi^2 = 20.552$, $df = 2$, $p < 0.001$). Amongst the urban and rural respondents who eat insects as a relish, 55.6% and 46.3%, respectively, eat one cup. The quantities were lower when respondents consumed insects in combination with other relishes for both urban (63.3%) and rural (72.4%) respondents. However, there was no significance difference between urban and rural for quantities consumed as a relish ($\chi^2 = 4.325$, $df = 2$, $p = 0.115$) and also when consumed in combination with other relishes ($\chi^2 = 1.250$, $df = 2$, $p = 0.535$). A cup contains between 50 and 75 g approximately of dried insects, depending on the type of insect.

Tables 2 and 3 show that in both the urban and rural areas, fewer than 50% of the respondents consumed *Eulepida spp.* and *Henicus whellani. Eulepida spp.* are consumed to a greater extent in both the urban (35.5%) and rural (48%) areas than *Henicus whellani* in urban (8.5%) and rural areas (41.1%). The frequency of consumption of *Eulepida sp*ecies is 1–2 times a week for the urban (45.7%) and rural (42.0%) respondents. In the rural areas, 67.6% of the respondents eat *Henicus whellani* more than three times a week, whereas, 46.7% of the urban consumer respondents consume this insect 1–2 times a week. *Eulepida species* are mostly consumed as snacks in both urban (80.0%) and rural (83.8%) areas. A different pattern exists for *Henicus whellani,* which are mainly consumed as a relish and snack in both urban (53.3%: 53.3%) and rural (83.1%; 88.7%, respectively) areas. Consumers of *Eulepida* species mostly take quantities of less than one cup for all meal types.

Differences in the consumption of *Eulepida* species and *Henicus whellani,* as compared to general consumption, could be attributed to people preferring different insect species and ease of access. Differences in preferences and prevalence of consumption of specific species have also been attributed to availability (Niaba et al. 2012; Obopile and Seeletso 2013; van van Huis 2013), ethnicity (Chakravorty et al. 2011; Obopile and Seeletso 2013; Riggi et al. 2016), palatability (Chakravorty et al. 2013) and seasonality (Kinyuru et al.

Table 2 Frequencies (as percentages) of consumption patterns for *Eulepida species* of urban and rural during insect harvest season

	Urban	Rural
Overall consumption patterns for *Eulepida species**	$n = 200$	$n = 175$
Consumers	35.5	48.0
Non-consumers	64.5	52.0
Frequency of consumption*	$n = 70$	$n = 81$
Greater than 3 times	22.9	42.0
1–2 times a week	45.7	42.0
1–4 times a month	20.0	6.1
Less than once a month	11.4	9.9
Meal type[b]	$n = 70$	$n = 81$
As relish	15.7	15.0
In combination with other relish	32.9	33.8
Snack	80.0	83.8
Quantities consumed:		
As relish	$n = 11$	$n = 12$
Less than 1 cup	63.6	75.0
Equivalent to 1 cup	27.3	25.0
More than one cup	9.1	0
As combination with other relish	$n = 23$	$n = 27$
Less than 1 cup	69.6	85.2
Equivalent to 1 cup	13.0	11.1
More than one cup	17.4	3.7
*As snack**	$n = 56$	$n = 67$
Less than 1 cup	58.9	58.2
Equivalent to 1 cup	33.9	14.9
More than one cup	17.2	26.9

* significant difference between urban and rural, [b] more than one answer possible

N.B Except in overall consumptions, n represents the number of consumer respondents in each category given

Table 3 Frequencies (as percentage) of consumption patterns for *Henicus whellani*of urban and rural during insect harvest season

	Urban	Rural
Overall consumption patterns for *Henicus whellani**	$n = 200$	$n = 175$
Consumers	8.5	41.1
Non-consumers	91.5	58.9
Frequency of consumption*	$n = 15$	$n = 71$
Greater than 3 times	26.7	67.6
1–2 times a week	46.7	25.4
1–4 times a month	13.1	4.2
Less than once a month	13.1	2.8
Meal type[b]	$n = 15$	$n = 71$
As relish*	53.3	83.1
In combination with other relish*	20.0	29.6
Snack*	53.3	88.7
Quantities consumed		
As relish	$n = 8$	$n = 59$
Less than 1 cup	25.0	39.0
Equivalent to 1 cup	37.5	40.7
More than one cup	37.5	20.3
As combination with other relish	$n = 3$	$n = 21$
Less than 1 cup	63.3	71.4
Equivalent to 1 cup	24.5	23.8
More than one cup	12.2	4.8
*As snack**	$n = 8$	$n = 63$
Less than 1 cup	52.7	63.5
Equivalent to 1 cup	37.5	15.9
More than one cup	9.8	20.6

* significant difference between urban and rural, [b] more than one answer possible

N.B Except in overall consumptions, n represents the number of consumer respondents in each category given

2010; Kinyuru et al. 2013). Hanboonsong et al. (2013) reported different insect eating habits due to availability of different species in different regions. Likewise, in the current study, the higher prevalence of consumption of *Eulepida* species is probably because this species is prevalent in many regions of Zimbabwe. *Henicus whellani* is commonly present only in the South Eastern region of Zimbabwe. *Eulepida species* is therefore consumed more than *Henicus whellani* in the urban areas. Urban consumers usually obtain these insects from informal markets and as gifts from rural folk, who harvest and prepare the insects and market them dried or ready to eat.

This study revealed that overall the consumption of insects in urban and rural areas is relatively high (>80%) although consumption patterns vary with species. The significant (but small) differences in percentage of respondents consuming insects in urban and rural areas can be an indication that entomophagy is not declining in either urban or rural areas in Zimbabwe, as suggested by other authors for other countries (Obopile and Seeletso 2013; Riggi et al. 2016). Likewise, the expectation that due to increased migration from rural to urban areas the consumption of traditional foods (under which edible insects are classified) would be abandoned, was not confirmed. Puoane et al. (2006) argued that people do not completely lose their culture but adhere to old traits, despite adoption of Western diets. However, a lower frequency of consumption in urban areas could be pointing to a decline of entomophagy, a trend that may continue if not addressed.

3.2 Motives for consuming edible insects

Table 4 shows that the major motives for consuming edible insect for both urban and rural respondents are taste (74.4% and 89.2%, respectively) and nutrition (74.4% and 51.0% respectively). Various studies in other developing countries report that taste is as a major motive for insect consumption (Ayieko and Oriaro 2008; Obopile and Seeletso 2013).

Table 4 Frequencies (%) of different motives for edible insect consumption in urban and rural areas of Zimbabwe (more than one answer category was possible)

Motive	Urban ($n = 160$)	Rural ($n = 157$)
Taste*	74.4	89.2
Nutrition*	74.4	51.0
Medicinal properties*	28.1	15.3
Only food option*	3.1	14.0
Other reasons*	6.9	14.6

*Significance difference between urban and rural

However, Obopile and Seeletso (2013) found, in their study in Botswana, that nutritional value was not the major reason for consuming insects since only 5% of their respondents indicated this motive. It is relevant to note that whilst respondents consume insects for their nutritional value, they do so because they perceive insects as high value nutritional food. They do not know exact nutritional values, rather they generalise that insects are rich in protein and health promoting components. Respondents in urban areas more often (74.4%) reported nutritional value ($\chi 2 = 18.600$, $df = 1$, $p < 0.001$) and medicinal properties (28.1%) as important motives compared to respondents from the rural areas (51.0% and 15.3%, respectively). In the rural areas, 14.0% of the respondents consume insects because they are the only food option. This percentage is relatively low and confirms that respondents did not perceive entomophagy as necessary because of lack of food but rather as a tradition. Furthermore, in rural areas, consumption of insects is an opportunity to break the monotony of available relishes. Some respondents considered certain types of insects, such as mopane worms and termites as delicacies.

3.3 Influence of characteristics of the consumers on consumption patterns

All socio-demographic characteristics, except gender, differed significantly between the urban and rural respondents (Table 5). Most of the respondents in urban (54.5%) and rural (62.3%) areas were female. In Zimbabwe, the male to female ratio is 48.1 to 51.9 both in rural and urban areas (ZIMSTAT). The respondents that consumed insects most were older than

Table 5 Characteristics of the urban and rural respondents

	Urban: $n = 200$ ($n = 160$)[a]	Rural: $n = 175$ ($n = 157$)[a]
Age group*		
≥ 18	0 (0)	0.6 (0.6)
19–29	21.5 (20)	12 (11.5)
30–39	30.5 (28.1)	21.7 (21.0)
40–49	32.0 (35.6)	13.1 (12.7)
> 50	16 .0(16.3)	52.6 (54.1)
Gender		
Males	45.5 (46.3)	37.7 (40.1)
Females	54.5 (53.8)	62.3 (59.9)
Level of education*		
No education	1.0 (1.3)	8.6 (8.9)
Primary level	9.0 (7.5)	40.6 (41.4)
Secondary level	44.5 (40.0)	45.1 (44.6)
Vocational training	8.0 (7.5)	0.6 (0.6)
Tertiary	37.5 (43.8)	5.1 (4.5)
Main source of livelihood*		
Formal employment	43.5 (46.3)	7.4 (7.0)
Informal	34.0 (35.0)	12.0 (11.5)
Subsistence farming	3.5 (3.8)	69.7 (70.1)
Commercial farming	4.5 (5.6)	1.1 (1.3)
Casual labour	2.5 (2.5)	2.3 (1.9)
Remittances	1.5 (0.6)	0 (0)
Petty trade	5.0 (1.3)	1.1 (1.3)
Pension	0 (0)	1.7 (1.9)
Other	5.5 (5)	4.6 (5.1)
Monthly income (US$)*		
< 100	9.5 (9.4)	64.0 (65.0)
100–199	19.5 (14.4)	20.0 (19.0)
200–350	22.5 (23.1)	9.1 (8.9)
351–450	13.5 (15)	4.0 (3.2)
451–600	13.5 (16.9)	1.7 (1.9)
601–800	9.0 (7.5)	0.6 (0.6)
801–1000	6.5 (8.1)	0.6 (0.6)
> 1000	6.0 (5.6)	0 (0)

[a] The values between brackets represents characteristics of the respondents who actually consume edible insects

*Significance difference between urban and rural

50 years in rural areas and they were between 40 and 49 years in urban areas. The majority of the respondents in rural areas depend on subsistence farming (69.7%) with a monthly income of less than US$100 (64.0%).

For the respondents in the rural areas, no significant associations between consumption of edible insects and socio-demographic variables were found. For urban areas, there was a significant negative association between consumption and education ($\chi 2 = 14.724$, $df = 4$, $p = 0.005$), main source of livelihood ($\chi 2 = 30.966$, $df = 7$, $p < 0.001$), and monthly income ($\chi 2 = 24.449$, $df = 7$, $p = 0.001$). The three characteristics were closely related. In urban areas there was a tendency for higher consumption of meat as a source of protein-rich foods with higher income (Puoane et al. 2006).

3.4 Characteristics of the social enviroment of consumers

Religion can play an important role in preference and consumption of insects (Chakravorty et al. 2013; van Huis et al. 2013). About 21.7% of urban and 8.7% of rural respondents are strictly forbidden from eating edible insects by their religion. On the other hand, 6.1% of the urban and 22.1% of the rural respondents' religion make them selective of the edible insects they eat. In Zimbabwe, 84% of the population are Christian (ZIMSTAT) and in this study 91.9% and 94.2% of urban and rural respondents, respectively, were Christian, although they belonged to different churches. The churches have different doctrines and differ in their views on the consumption of insects. While most traditional and pentecoastal churches are not prohibitive of insect consumption, the Apostolic churches strictly or selectively forbid consumption of insects. These sects believe that some insects are 'unclean', hence shouldn't be consumed. However, some respondents do not strictly adhere to their church's doctrines and do consume some edible insects. About 64% of the urban and 83% of the rural respondents reported that availability of edible insects influenced consumption, but most of the urban (>80%) and rural (>80%) respondents believed that their upbringing was the major influence and that eating insects was a family habit.

3.5 Rated importance of food characteristics of edible insects

Taste was the most important attribute of edible insects that the urban (95.6%) and rural (92.3%) respondents considered in deciding to consume them (Table 6) and this was true for consumers of *Eulepida* spp. and *Henicus whellani* as well, who particularly appreciated taste and texture (Table 7). For both insect species, salty taste and dry and crunchy texture were preferred. Moreover, urban respondents rated nutritional value (88.5%) as an important attribute. The results complement those on motives for consumption, which showed taste and nutritional value being major motives for consuming edible insects in urban areas.

Table 6 Frequencies (%) of respondents rating the importance of food characteristics in deciding to eat edible insects

Food characteristic	Urban	Rural
Taste	95.6	92.3
Texture	76.8	79.8
Apperance	54.9	76.8
Smell	56.6	71.8
Safety	61.5	61.3
Nutritional value	88.5	60.7

3.6 Traditional knowledge of harvesting and processing techniques for *Eulepida species* and *Henicus whellani*

About 35% of the urban and 39% of the rural respondents indicated that they had knowledge of harvesting and processing techniques for *Eulepida spp*. and 42% of rural but only 3% of urban respondents knew how to harvest and process *Henicus whellani* for consumption. The number of respondents with knowledge of insect processing was comparable with the number of consumers of the specific species. The similarity in percentage of the knowledgeable urban compared with rural respondents can be attributed to the former having a rural background and family habits of consuming such insect species. The lower percentage of respondents with knowledge of processing might be because of lack of traditional knowledge or because they were not used to consuming insects at all. Yen (2009) proposed that obtaining knowledge and support from traditional societies is important to advancing entomophagy. Knowledge of traditional systems can contribute to improvement of food and nutrition security (Alonso 2015).

The preferred method of harvesting *Eulepida spp.* is by shaking host trees on which they are found and picking them from the ground by hand into harvesting containers. The

Table 7 Frequencies % of consumers appreciating the food characteristics of edible insects, *Eulepida* species and *Henicus whellani* when eating

Food Characteristic	Edible insects		Eulepida species		Henicus whellani	
	Urban	Rural	Urban	Rural	Urban	Rural
Taste	98.8	98.7	97.1	93.1	93.8	97.1
Texture	75.6	78.7	81.4	82.7	87.5	74.3
Smell	62.0	82.6	52.9	75.0	75.0	70.0
Apperance	61.9	78.7	67.1	72.5	81.3	68.6

common methods for harvesting *Henicus whellani* is collecting the insects after rains or by digging them from their burrows. In general, there is considerable variation in the processing of species before consumption. Boiling and roasting are common but there is variation in the time of boiling and amount of water used. For long storage, such as required for marketing, sun drying is the common method.

3.7 Conclusions and recommendations

Consumption of edible insects is still prevalent in both urban and rural areas of Zimbabwe, although consumption of particular species such as *Eulepida spp.* and *Henicus whellani* is low compared to other more popular insect species such as mopane worms and termites. The most common way of eating insects is as a relish or snack. Frequency of consumption is higher in the rural than urban areas. Edible insects are not "just eaten" when it is the only food option. Taste and nutritional value are the major motives for consuming edible insects in both urban and rural areas. For respondents in urban areas, there is a significant negative association between consumption of edible insects and the socio-demographic variables education, main source of livelihood, and monthly income. For respondents from rural areas, no significant associations were found. Differences in consumption patterns for specific insect species are likely due to individual preferences, specific availability in different geographic locations, and religious beliefs. Individual characteristics, availability, and the greater importance of nutritional value for urban consumers might explain the observed differences in the insect consumptions patterns between respondents from urban and rural areas. The environment of the consumer and indigenous knowledge of insect preparation do not seem to play important roles in the different consumption patterns.

In general, the observed high consumption of insects in rural as well as urban areas indicates that entomophagy is still dominant in Zimbabwe. To promote consumption of certain insect species with high nutritional potential, particularly in urban areas, lessons can be learnt from the mopane worm value chain. Mopane worms are now widely eaten across Southern Africa and have become a trading commodity (Stack et al. 2003). Likewise, in Thailand, insect consumption is no longer considered as food for rural or poor people, but has become common for urbanites (Hanboonsong et al. 2013). There, they commonly market both wild-harvested and farmed insects. Rearing insects is a strategy that can be used to improve availability of seasonal insects and can contribute to the development of insect value chains (Hanboonsong et al. 2013; Raubenheimer and Rothman 2013). Such strategies could be useful in Zimbabwe because entomophagy is already common. Development of insect rearing farms and insect value chains, combined with development of attractive tasty products and communication of the nutritional value of *Eulepida spp.* and *Henicus whellani* could support the promotion of their consumption.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

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