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Factors affecting consumption of edible insects as food: entomophagy in Myanmar

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RESEARCH ARTICLE

Abstract

With the world's population rapidly increasing, food security and malnutrition have emerged as critical issues. Edible insects offer an alternative protein source that requires less land and water than conventional livestock production and emits lower levels of greenhouse gases. Myanmar has a long history of consuming insects such as crickets, grasshoppers, palm weevil larvae, giant water beetles, stink bugs, honeybees, cicadas, and ants. Although insect consumption is common in Myanmar, very little is known about the factors that could potentially encourage or discourage people from consuming edible insects as an alternative meat protein. This study analyses data from 872 respondents to investigate consumer acceptance of entomophagy and the factors influencing edible insect consumption in Myanmar using descriptive statistics and Poisson regression model with sample-selection analysis. Results show that consumer acceptance towards edible insects as food is 67%; moderately high in Myanmar, but consumption frequency is occasional. Edible insect consumption is influenced by ethnicity, religion, opinion towards entomophagy, insect phobia, nutritional properties, social concerns, and discomfort. Meanwhile, consumption frequency is influenced by income, ethnicity, family size, taste, smell, and safety concerns. We find that negative opinions, insect phobia, safety concerns, social concerns, and discomfort are significant bottlenecks for insect consumption in Myanmar. In contrast, the nutritional properties of edible insects motivate individuals to consume them. This highlights the importance of increasing public awareness of the benefits of entomophagy, creating a favourable impression, and reducing social fears about insect consumption. Providing novel insect-based foods, such as flour, could boost consumption. The government should implement, monitor and communicate good manufacturing practices to ensure actual and perceived food safety.

Keywords: Poisson model, acceptance, insect consumption, consumption frequency, social concerns, discomfort

1. Introduction

With the world population rising rapidly, food security and malnutrition are becoming ever more critical challenges for sustainable development (FAO, 2017; FAO *et al.*, 2019; IFPRI, 2018). These problems are exacerbated by decreased arable land, water scarcity, and changing climatic conditions (Alexandratos and Bruinsma, 2012; Ebenebe *et al.*, 2017; Fitton *et al.*, 2019; Gomiero, 2016; Misra, 2014; Nam *et al.*, 2022; Sachs, 2009). Edible insects promise an alternative protein source with less land and water requirements and lower GHG emissions than conventional livestock production (FAO, 2017; Kinyuru *et al.*, 2015; Van Huis *et al.*, 2013). Nutritional content varies depending on the insect species, but generally, insects offer higher contents of proteins, fats, vitamins, and minerals than meat (Banjo *et al.*, 2006; Orkusz, 2021). Hence, edible insects may contribute to solving the undernutrition problems (Imathiu, 2020). Consumption of edible insects can positively impact food security, sustainable food production, vulnerable populations' livelihoods, economic opportunities, and the environment. However, consumers' negative perception of edible insects still poses a significant obstacle for them to becoming a meat protein alternative (Van Huis *et al.*, 2013).

Even though entomophagy is common in many parts of the world, it remains a peculiar practice for many consumers, particularly in Western societies (Shockley and Dossey, 2014; Sogari *et al.*, 2019b). Consumer studies on edible insects have primarily been conducted in Western (i.e. non-entomophagy) countries. Only a few studies focus on insect-eating countries (Hwang and Kim, 2021; Liu *et al.*, 2020;

Omemo *et al.*, 2021). Given that insect consumption in many entomophagous countries may have already decreased due to westernisation (Chakravorty *et al.*, 2013; Manditsera *et al.*, 2018; Pambo *et al.*, 2018), more consumer studies for traditional insect-consuming countries where malnutrition is chronic are needed to understand the associated driving forces (Meysing *et al.*, 2021). Investigating consumer acceptance is important for such countries, as people from traditional insect-eating areas may also reject insect consumption for various reasons (Ghosh *et al.*, 2019). Changes in farming techniques, westernisation, loss of traditional practises, particular eating habits, and a lack of indigenous knowledge transmission are all possible causes of this phenomenon (Ancha *et al.*, 2021; Bae and Choi, 2020; Ghosh *et al.*, 2019; Pambo *et al.*, 2016). For Southeast Asia, a traditional insect-eating region, previous research focused primarily on edible insect species, production and markets, but not on consumers (Sogari *et al.*, 2019a). Hence, Liu *et al.* (2020) stressed the need for analysing consumer acceptance towards insects as a protein source in less developed Asian nations.

Myanmar has been a diverse ethnic country with an 'insect-eating habit' for centuries. In eight out of fifteen regions, the Burmese form the country's largest ethnic group, while in the remaining seven regions other ethnic groups such as Kachin, Kayah, Kayin, Chin, Mon, Rakhine, and Shan are the majority (Myanmar embassy (Tokyo), 2003). Insects play an important role in the diet of some ethnic groups, primarily those from mountainous regions, such as the Kayin, Chins, Kachins, and Shans (Linn *et al.*, 2016). In contrast, entomophagy is not as common in the central part of Myanmar, where the Burmese people rarely consume insects (Nischalke *et al.*, 2020). Although insect consumption is not widespread everywhere in Myanmar, various edible insects are naturally abundant throughout the country (Yhoung-Aree and Viwatpanich, 2005). The well-known insects in Myanmar are crickets, grasshoppers, palm weevil larvae, giant water beetles, stink bugs, honey bees, cicadas, and ants (Spectrum, 2016). The annual value of wild-harvested insect value chains is approximately US$ 5 million (Spectrum, 2020).

About 30% of children under five in Myanmar face chronic malnutrition (USAID, 2020), and maybe surprisingly, many people from traditional entomophagous areas of Myanmar suffer from malnutrition, including due to the high poverty level in these parts of the country. Moreover, the COVID-19 pandemic and the recent military coup aggravated this situation even further (UNDP, 2021; UNHCR, 2021). Consuming insects is a recently proposed idea to help alleviate food shortages and famine (Belluco *et al.*, 2015). Because of their high protein content, insects are a good food source for countries like Myanmar, where meat protein consumption is traditionally low (Eurocham Myanmar, 2019; Smith *et al.*, 2021; Tuhumury, 2021).

Owing to a dearth of research, it is difficult to understand edible insect consumption as another source of protein in fighting food insecurity and malnutrition in Myanmar. Especially, data regarding the proportion of insect consumers, how much or how frequently they consume insects, and what factors influence their consumption is lacking. This research gap highlights the importance of edible insect consumer studies in Myanmar to identify the factors that may potentially promote or inhibit consumers from consuming edible insects as an alternative meat protein. Researching consumer acceptance could aid in exploring the business potential of edible insects (Van Huis *et al.*, 2013). By investigating consumer acceptance of edible insects and its main influencing factors, this study aims to better understand edible insect consumption as another source of protein in fighting food insecurity and malnutrition in Myanmar and beyond. This will provide valuable insights into promoting edible insect consumption and related market activities.

2. Factors affecting consumer acceptance and consumption frequencies

Consumer acceptance

Consumer acceptance is a complex phenomenon, and a single theory cannot adequately explain why individuals accept or reject a product (Lensvelt and Steenbekkers, 2014). Consequently, numerous indicators of consumer acceptance of foods have been proposed, including overall acceptance, attitude, willingness to pay/eat, buying intention, and actual consumption (Adámek *et al.*, 2018; Baker *et al.*, 2022). The definition of consumer acceptance and the results of studies on edible insects varied widely from country to country. Ancha *et al.* (2021) defined consumer acceptance as insect consumption and found that most respondents in Nigeria (82%) consume insects. Meanwhile, consumer acceptance in Korea, as measured by the willingness to buy and consume edible insects, is 64% (Bae and Choi, 2020). Interestingly, 63% of these consumers do not want to eat insects unless necessary. Ghosh *et al.* (2019) analysed consumer acceptance regarding individuals' attitudes towards using insects as food and feed in Korea and Ethiopia. Insect-containing meals are less acceptable to Ethiopians (11%) than they are to Koreans (46%), and male participants in both societies were more accepting than their female counterparts. Pambo *et al.* (2016) explored consumer acceptance, defined as eating insects as a regular part of people's diets, and found that this applied to 73% of respondents. Even though consumer acceptance is generally high according to these studies, in certain regions, for example, in Ethiopia, where malnutrition is prevalent, most consumers do not accept edible insects as food. Based on the definition of Pilgrim (1957), consumer acceptance in this research refers to the consumption of edible insects.

Frequency of edible insect consumption

As regular consumption of edible insects could reduce malnutrition problems in Myanmar, it is essential to know the consumption frequency and its driving factors. Only a few studies have explored the frequency of edible insect consumption in entomophagous countries. For instance, Barennes *et al.* (2015) conducted a national survey in Laos with 1,059 adult respondents from 30 different ethnic groups. They showed that nearly 97% were insect consumers, and consumption frequency varied by ethnicity, region, and season. About 13% of respondents consumed insects weekly or daily, 31% occasionally, and 56% very infrequently during a year. Manditsera *et al.* (2018) explored insect consumption frequency in Zimbabwe. The results showed that 80% of urban and 90% of rural residents were consumers, with rural residents consuming more frequently than urban ones.

Factors affecting the consumption of edible insects

Several factors that may influence the consumption of edible insects and the frequency of consumption have been proposed as one of them. Most of these factors are based on the models of Randall and Sanjur (1981) and Shepherd and Raats (1996). According to both models, individual, product-related, and environmental factors are the three main determinant groups. Individual factors include gender, age, education, income, and knowledge (Assegaff, 2017; Randall and Sanjur, 1981). Men engage in entomophagy more than women in Ghana and Kenya (Anankware *et al.*, 2017; Omemo *et al.*, 2021). However, why men are more willing to accept edible insects as food than women remain unclear. Women consume more edible insects than men in Liberia and China. Women, especially pregnant women, consume more insects because they are thought to be beneficial to their health (Castro and Chambers, 2019; Coley *et al.*, 2020). In China, age correlates positively with the consumption frequency of edible insects because older people are more familiar with them (Liu *et al.*, 2020). Young people in developing countries are increasingly turning away from insect-eating practises (Vantomme, 2015) by adopting Western food and abandoning their cultural habits (Hlongwane *et al.*, 2021). However, some younger generation members in Myanmar see edible insects as trendy food and are willing to try them (Nischalke, 2020). In South Africa, education is the strongest predictor of edible insect consumption, with people with less education consuming more insects (Egan, 2013). However, Anankware *et al.* (2017) detected positive relationships between education and insect consumption in Ghana and explained this by stating that well-educated people are more likely to travel and be open to new experiences. Furthermore, more educated people may be more aware of the nutritional benefits of edible insects and thus consume them more frequently (Liu *et al.*, 2020). Carolyne (2018) and Manditsera *et al.* (2018) revealed a negative relationship between income and edible insect consumption in Kenya and Zimbabwe; they explained that as income rises, people have more options for purchasing other animal proteins. Lower-income people in South Africa consume more edible insects, most likely because they save money on food when insects are readily available (Egan, 2013). Similarly, Dürr and Ratompoarison (2021) found no significant differences in insect consumption between poorer and wealthier families in Madagascar highlands because insects are not purchased but instead collected in the wild. Meanwhile, in China and Kenya, income does not affect the frequency of consumption of edible insects (Liu *et al.*, 2020; Carolyne, 2018).

Due to the inconsistency of the effect of individual characteristics, additional emotional factors, such as disgust, neophobia, familiarity, and opinions, may interfere with and influence acceptance (Hartmann *et al.*, 2015; Orsi *et al.*, 2019; Pambo *et al.*, 2016; Sogari *et al.*, 2019c). Disgust harms the acceptance of insects as food (Cicatiello *et al.*, 2016; Neves, 2015; Orsi *et al.*, 2019). About one-fourth of Nigerian respondents do not accept edible insects as food due to disgust, as insects are perceived as unclean and unsanitary (Ancha *et al.*, 2021). Similarly, insect phobia is the main barrier to consumer acceptance in non-entomophagous countries (Junges *et al.*, 2021; Moruzzo *et al.*, 2021; Sogari *et al.*, 2019c) and in traditional insect-eating countries like China (Hartmann *et al.*, 2015). Hartmann *et al.* (2015) showed that familiarity plays a crucial role in consumer acceptance. People familiar with edible insects indicate higher acceptance of edible insects in Kenya (Pambo *et al.*, 2016). Similarly, familiarity significantly affects insect consumption in Uganda (Olum *et al.*, 2020). Familiarity with a certain food type reduces fear and doubts about it (Aldridge *et al.*, 2009). For example, people who are familiar with edible insects regard them as food (Schardong *et al.*, 2019). Food preferences can also be predicted by considering the individual's attitude towards the food item (Steenkamp, 1993). In Western societies, an opinion as a way of verbally expressing one's attitude (Sundararaj and Rejeesh, 2021) towards entomophagy is often negative (Sogari, 2015; Videbæk and Grunert, 2020). Moreover, in South Africa, younger people have negative attitudes towards entomophagy, possibly as a result of globalisation (Egan, 2013). Besides, Shepherd and Raats (1996) mentioned negative effects on consumption behaviour caused by anticipated worry, concern, or regret. Some unpleasant feelings associated with insect consumption, including nausea, vomiting, diarrhoea, headaches, dizziness, difficulty breathing, allergic reactions, and an itchy rash, have been reported (Belluco *et al.*, 2015; Chomchai and Chomchai, 2018; Ribeiro *et al.*, 2021).

When selecting foods, customers must consider product-related factors, such as nutritional values, taste and smell, and safety (Adámek *et al.*, 2018). The nutritional value of

edible insects influences their consumption in Madagascar (Meysing *et al.*, 2021). Moreover, food safety concerns harm the frequency with which Chinese consumers consume edible insects (Liu *et al.*, 2020). Insects may be contaminated by pesticides, toxic elements, and heavy metals in their habitats in Laos (Barennes *et al.*, 2015). Similarly, respondents in a pre-survey conducted in Yangon, Myanmar, cited food safety concerns about chemical contaminations as the primary reason for decreasing and discontinuing insect consumption (Myint Thu Thu and Dürr, 2019). Finally, edible insect availability is critical for entomophagy (Hlongwane, 2021; Shelomi, 2015; Tan *et al.*, 2015). Non-availability appears to be a barrier to insect consumption in Laos and Kenya (Barennes *et al.*, 2015; Pambo *et al.*, 2016). According to Egan (2013), populations of edible insects in South Africa have declined due to overharvesting and climate change. In Myanmar, insect farming is still in its early stages, and the availability of edible insects is primarily dependent on seasonal wild collection (Nischalke *et al.*, 2020).

Household-level factors such as location, family size, ethnicity, and religion have also influenced individuals' particular actions (Yakut, 2019). In Ghana, consumption of insects is more common in rural than in urban areas (Anankware *et al.*, 2017). Also, Manditsera *et al.* (2018) discovered that in Zimbabwe, insect consumption frequency is higher in rural areas where insects are collected in the wild than in urban areas where most people have to buy them. According to Liu *et al.* (2020), family size does not affect the frequency of consumption of edible insects. Yet, Meysing *et al.* (2021) discovered that larger households in Madagascar have lower per capita insect consumption because more members share total amounts. In contrast, larger families in Kenya are more likely to adopt entomophagy (Omemo *et al.*, 2021), maybe because more family members increase the available time for insect collection in the wild, thereby expanding the insect harvest (Dürr and Ratompoarison, 2021). On the other hand, edible insect consumption frequency in Laos varies depending on ethnic differences (Barennes *et al.*, 2015). Finally, Dube *et al.* (2013) highlighted that religion significantly impacts the eating of insects because entomophagy is not practised by people whose religion forbids the consumption of foods derived from animals (Abdullahi *et al.*, 2021). As Myanmar is a multi-religious and ethnically diverse country, these factors may be crucial.

3. Material and methods

Questionnaire design

In this study, consumer acceptance is based on the actual consumption of edible insects. Insect consumers are individuals who have consumed insects in the past and continue to do so today. According to Agudo (2004), insect consumption frequency refers to the individual insect consumption times within a year. Based on the current literature, this study included individual factors such as gender, age, education, and income, emotional factors such as disgust, insect phobia, familiarity, opinions, and discomfort, product-related factors such as nutrition, taste, smell, availability and safety and household factors such as location, family size, ethnicity and religion as explanatory factors. Besides, willingness to eat naturalness was considered as one extra factor as people in Myanmar are often hesitant to eat farmed insects and prefer wild collection (Nischalke *et al.*, 2020). Furthermore, the availability of substitutes, such as fish and meat, is critical in understanding insect consumption behaviour (Van Huis, 2015), and it was counted as an additional factor. Finally, social concerns were incorporated in this study as Van Huis *et al.* (2022) and Egan (2013) mentioned that people today prefer to eat more meat than insects, and insects as a traditional food have been abandoned because insect consumption is seen as a symbol of poverty or illiteracy.

The analysis consisted of two stages: for the first stage, we explored the drivers of insect consumption and tested the following ten variables: gender, ethnicity, religion, opinion, disgust, insect phobia, familiarity, nutrition, discomfort, and social concerns. As the dependent variable is binary, '1' denotes 'consume insects in recent year' and '0' signifies 'do not consume insects in recent year.' For the second stage, we analysed the effects of 14 variables on the consumption frequency of edible insects per year (measured as count numbers). The variables were: gender, age, education, income, location, ethnicity, family size, naturalness, taste, smell, nutrition, food safety, availability of edible insects, and availability of fish and meat. As the data collection period coincided with the military coup in Myanmar, many individuals feared political unrest, and respondents were hesitant to provide precise information regarding age, income, and family size. Therefore, open-ended questions were replaced with multiple-choice questions to determine which groups respondents belonged to. Besides, this study used 'yes or no' and 5-point Likert scale questions. Afterward, all 5-point Likert scale variables were re-arranged into three groups: negative perception (strongly disagree + disagree), neutral and positive perception (agree + strongly agree). The description of each variable are described in the following Table 1.

Survey and sampling

Between March 2021 and June 2021, telephone surveys were used to gather the data. Participants were chosen at random from all areas of Myanmar. The minimum required number of respondents for each category was calculated according to Cochran (1963) as follows:

$$N = \frac{Z^2 \times p(1-p)}{e^2}$$

Table 1. Description of all independent variables to predict consumer acceptance and consumption frequency of edible insects.

Variables	Description	Expected sign	
		Consumption (consumer acceptance)	Consumption frequency
Gender	Sex of respondents (male = 1, female = 0)	+/-	+/-
Age	Chronological age (young (≤30 years) = 1, middle age (31-45) = 2, old age (>45) = 3)		+
Education	Education level (middle school = 1, high school = 2, undergraduate = 3, ≥bachelor = 4)		+
Income	Monthly income (low (<$200) = 1, others (≥$200) = 0)		+
Location	Geographic entity (urban = 1, rural = 0)		+/-
Ethnicity	Belonging to a particular ethnic group (Burmese = 1, Kachin = 2, Kayah = 3, Kayin = 4, Chin = 5, Mon = 6, Rakhine = 7, Shan = 8)		+/-
Religion	Practicing Buddhism = 1, others = 0		+/-
Family size	Total number of household members (small (≤3) = 1, medium (4-6) = 2, large (>6) = 3)		+
Opinion	Insect consumption is a good habit (positive = 1, negative = 0)	+	
Insect phobia	I am afraid of edible insects (no = 1, neutral = 2, yes = 3)	-	
Disgust	I feel disgusted with edible insects (no = 1, neutral = 2, yes = 3)	-	
Familiarity	I heard about edible insects (yes = 1, no = 0)	+	
Discomfort	The thought of eating insects makes me feel uncomfortable (disagree = 1, neutral = 2, agree = 3)	-	
Social concerns	Insect consumption is a symbol of lower status (disagree = 1, neutral = 2, agree = 3)	-	
Nutritious	Edible insects are nutritious foods (disagree = 1, neutral = 2, agree = 3)	+	+
Taste	Taste of the insects generally_ not for specific insect (normal = 1, good = 2, very good = 3)		+
Smell	Smell of the insects generally_ not for specific insect (disagree = 1, neutral = 2, agree = 3)		+
Naturalness	Willingness to eat wild edible insects (eat only wild insects = 1, otherwise = 0)		+
Safety concerns	Afraid of chemical contamination of edible insects (disagree = 1, neutral = 2, agree = 3)		-
Availability of edible insects	Edible insects are available in my area (yes = 1, no = 0)		+
Availability of fish and meat	Fish and meat are readily available in my town/village (disagree = 1, neutral = 2, agree = 3)		+

where: N = required minimum sample size; Z = Z score; p = expected consumer proportion; q = 1 – p; e = margin of error.

We used consumer proportion (p) = 0.5 at a 90% confidence level with a 3% margin of error since the proportion of the entire population was unknown. Hence, the required minimum sample size for this study was 752 participants.

Since no databases in Myanmar contain mobile phone numbers, a total of 18,694 numbers were generated randomly and then called. Of these numbers, 68% were unavailable or out of service. For the numbers that were dialled (5,981), 40% of persons did not answer the call, 45% declined to participate, and 15% (897) agreed. Despite some variation, the collected data represent the actual population of the 2014 census data (DOP, 2015) in terms of regions, gender, age, education, income, ethnicity, religion, and family size but do not represent the rural-urban population. Nevertheless, it must be considered as a convenience sample. After cleaning data and eliminating outliers, the number of valid respondents was reduced to 872.

Statistical analysis

Poisson regression with sample-selection analysis

When an individual never consumes insects, the consumption frequency is zero. Without knowing the exact reason for zero consumption frequencies, we must assume that our dependent variable is truncated. For truncated data, samples are taken from a subset of a larger sample of interest (Ao, 2009; Ilyas *et al.*, 2020). In this study we are only interested in people who eat insects. The bias resulting from this sample selection is referred to as sample selection bias (Heckman, 2010). The use of ordinary least squares regression analysis in the presence of such data is expected to be biased, inconsistent, and inefficient (Greene, 2012). Heckman (1977) claimed that estimation on the selected

subsamples leads to sample-selection bias because of the study's partially observable outcome of interest.

When normality and homoskedasticity assumptions were violated, the presence of discreteness and heteroskedasticity in count data motivate using a Poisson rather than a linear specification. The Heckpoisson model fits the dependent variable better with count data and corrects sample-selection bias (Kingsuwankul *et al.*, 2021; Waruingi *et al.*, 2021). Hence, we used Poisson regression with sample-selection (Heckpoisson model). It is divided into two stages: (1) a binary regression that shows whether respondents consume edible insects or not, with values of 0 or 1, and (2) a Poisson regression with count data for the frequency of edible insect consumption, which can be written as follows (Stata, 2021):

For the first step (selection model):

$$C_i = \beta_i X'_i + \varepsilon_1$$

$$\varepsilon_1 \sim N(0, 1)$$

$C_i = 1$ if $\beta_i X'_i + \varepsilon_1 > 0$, and 0 for otherwise.

For the second step (Poisson model):

$$E(CF_i / X'_j, \varepsilon_2) = \exp(\beta_i X'_j + \varepsilon_2)$$

$$\varepsilon_2 \sim N(0, \delta)$$

CF_i is only observed if $C_i = 1$

$$\rho = \text{corr}(\varepsilon_1, \varepsilon_2)$$

where: C_i is the binary dependent variable show whether consume edible insects or not; CF_i is the insect consumption frequency per year; X'_i and X'_j are the explanatory variables hypothesised to affect the dependent variables; β_i is the vectors of parameters to be estimated; ε_1 and ε_2 are the error terms with a mean of zero; δ is the standard deviation; ρ is the correlation between ε_1 and ε_2.

Diagnostic tests

Before starting the analysis, the basic assumptions of the econometric model were checked with various tests. Following Şanlı (2019) and Uzun *et al.* (2017), we first conducted Pearson correlation tests of the explanatory variables, resulting in generally weak relationships (r-values less than 0.5), except for disgust with a moderate correlation (r=0.54) with insect phobia (Supplementary Table S1 and S2). Thus, disgust was excluded from the model. According to descriptive statistics, familiarity, availability of edible insects, and availability of fish and meat occurred in more than 90% of cases; therefore, these three variables were omitted in the subsequent analysis.

Multicollinearity was checked using the variance inflation factor (VIF). Individual VIF values ranging from 1.02 to 1.36 do not indicate multicollinearity issues, given that they are smaller than the critical VIF value 10 (Hair Jr *et al.*, 2014) (Supplementary Table S3). The Breusch-Pagan/Cook-Weisberg test was used to examine heteroskedasticity under the null hypothesis that the variances of the error terms are constant. As both the consumption and consumption frequency chi-square values were large and significant at 0.001, heteroskedasticity issues exist (Supplementary Table S4). To resolve this issue, we performed a robust estimate of the Heckpoisson methods. The Wald test of the independent equation yielded a significant correlation estimate (ρ) of (-0.50) at (P=0.001), leading to a rejection of the null hypothesis of no sample-selection bias. Therefore, the error terms were associated, confirming the appropriateness of using the Heckpoisson model. The findings of the Heckpoisson model are robust against using a separate probit or logit for consumer acceptance, followed by a standard Poisson for consumption frequency.

4. Results

Descriptive analysis

Most respondents (72%) had consumed insects (Figure 1). People with insect consumption experience can be divided into two groups: (1) those who consumed insects only in the past (5%); and (2) those who consumed insects both in the past and present (67%). In this article, we referred to the second group as insect consumers. In terms of the frequency of insect consumption among those insect consumers, 25% of respondents consumed insects 1-2 times annually; 30%, 3-6 times annually; and 9%, 7-12 times annually. Only 3% of those surveyed reported eating insects on average at least once a month (>12 times per year). On average, general consumption frequency was around three per year and five times per year for consumers.

In terms of the individual characteristics of the respondents, which were then used as independent variables in the Heckpoisson models, the female/male ratio in the sample turned out to be nearly equal, and approximately half of the respondents were under the age of 30 (Table 2). The respondents' educational level was high, with roughly half of the respondents having bachelor's degrees. Approximately 85% of respondents earn <$200 per month, whereas 15% earn more >$200 per month. According to the Pearson chi-square test, except for gender, no significant differences in the number of insect consumers between individual factor groups were found. The percentage of consumers did not differ significantly by age, education, or income, though

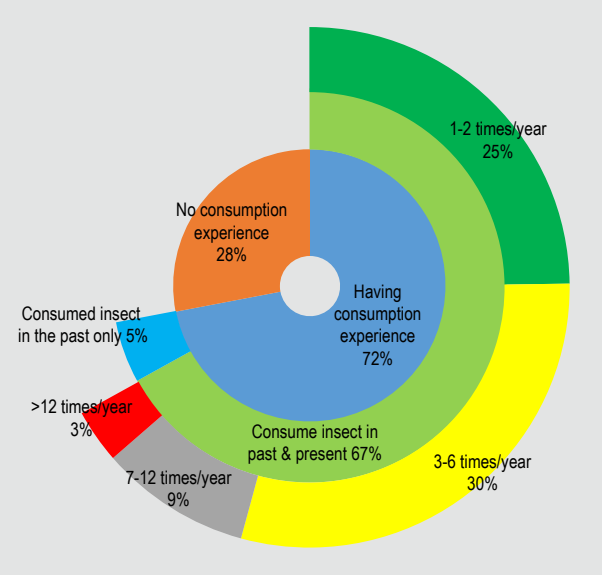

Figure 1. Consumption of edible insects in Myanmar.

the frequency of consumption varied significantly between the two income groups.

Regarding emotional factors, only 40% of respondents held a favourable view of entomophagy (Table 3). About 20% of respondents have insect phobias, and 16% are disgusted by them. Just <1% are unfamiliar with edible insects or have never heard of them, while 30% feel uncomfortable when consuming insects. About 32% of respondents do not believe that eating insects indicate a lower social status. In contrast to individual factors, the Pearson correlation test showed that all emotional factors influence consumer acceptance significantly, while consumption frequency was influenced by opinion, phobia, and discomfort.

Regarding the product-related factors, less than half of respondents (45%) thought edible insects were wholesome foods, and 33% of the individuals who recently consumed insects believed insects had good taste, with 13% rating the taste as excellent (Table 4). Approximately 88% of people believed that edible insects have a pleasant smell, but 83% of people said they would eat only wild insects, and 61% of the respondents expressed concerns about contamination by pollutants. With 93 and 96%, the vast majority of the respondents were sure of insects and meat and fish availability in their areas, respectively. The Pearson correlation test revealed that all product-related factors, except for safety issues, significantly varied across groups regarding insect consumers. There is a noticeable variation in consumption frequency regarding taste, smell, and safety issues.

Concerning the household-level factors, the rural-to-urban ratio in this study turned out to 30:70, as opposed to the 70:30 ratio in the 2014 census data (DOP, 2015) (Table 5). In terms of ethnicity, the majority of the samples were Burmese (68%), and 88% were Buddhists, with the remaining 12% practising other religions. Most people live in medium-sized families, with 26% belonging to small families and 14% to large families. Pearson correlation test revealed that consumer percentage and frequency differ significantly by ethnicity but not by location, religion, or family size.

Table 2. Distribution of insect consumers and their consumption frequency regarding the individual characteristics of the respondents.[1]

Individual characteristics		Total %	Insect consumers %	Pearson chi-square value	Average consumption time a year	Pearson chi-square value
Gender	Female	51.03	59.33	26.37***	5	38.46
	Male	48.97	75.64		5	
Age	Young (≤30)	48.97	66.28	5.45	5	62.77
	Middle age (31-45)	35.21	71.66		5	
	Old age (>45)	15.82	60.87		5	
Education	Middle school	12.16	67.92	4.13	4	83.20
	High school	19.95	73.56		5	
	Undergraduate	19.38	65.68		4	
	≥Bachelor	48.51	65.25		5	
Income	Low (<$200)	84.75	66.98	0.25	4	62.08***
	Others (≥$200)	15.25	69.17		6	

[1] *** = $P<0.001$.

Table 3. Distribution of insect consumers and their consumption frequency regarding the emotional characteristics of the respondents.[1]

Emotional characteristics		Total %	Insect consumers %	Pearson chi-square value	Average consumption time a year	Pearson chi-square value
Opinion	Negative	60.09	52.10	138.20***	4	64.49***
	Positive	39.91	90.23		6	
Insect phobia	No	61.58	83.05	199.82***	5	77.43*
	Neutral	18.01	59.87		4	
	Yes	20.41	26.40		4	
Disgust	No	58.49	83.53	253.41***	5	51.98
	Neutral	25.57	64.57		4	
	Yes	15.94	12.23		4	
Familiarity	No	0.80	0.00	14.53***	0	-
	Yes	99.20	67.86		5	
Discomfort (thought of eating insects makes me feel uncomfortable)	Disagree	52.52	82.97	145.70***	5	96.02**
	Neutral	17.55	68.63		4	
	Agree	29.93	39.08		5	
Social concerns (insect consumption is a symbol of lower status)	Disagree	32.00	61.29	7.32*	5	55.01
	Neutral	41.05	68.99		5	
	Agree	26.95	71.91		5	

[1] *** = $P<0.001$; ** = $P<0.01$; * = $P<0.05$.

Table 4. Distribution of insect consumers and their consumption frequency regarding product-related factors.[1]

Product characteristics		Total %	Insect consumers %	Pearson chi-square value	Average consumption time a year	Pearson chi-square value
Nutritious food	Disagree	18.35	47.50	91.15***	5	62.26
	Neutral	36.70	57.19		4	
	Agree	44.95	83.67		5	
Taste[2]	Normal	53.66	100.00		3	170.42***
	Good	33.05	100.00		7	
	Very good	13.29	100.00		7	
Smell[2]	Disagree	3.07	100.00		3	58.16
	Neutral	8.52	100.00		6	
	Agree	88.42	100.00		5	
Naturalness[2]	Eat only wild insects	82.96	100.00		5	46.53*
	Otherwise	17.04	100.00		6	
Safety (afraid of chemical contamination of edible insects)	Disagree	16.86	70.75	1.61	6	80.73*
	Neutral	22.48	64.29		4	
	Agree	60.66	67.49		4	
Availability of edible insects	No	7.00	18.03	72.41***	3	26.15
	Yes	93.00	71.02		5	
Availability of fish and meat	No	1.49	53.85	16.34***	3	24.42
	Neutral (Not sure)	1.95	23.53		5	
	Yes	96.56	68.41		5	

[1] *** = $P<0.001$; * = $P<0.05$.

[2] Data are only for those who have eaten insects recently (587 respondents)

Table 5. Distribution of insect consumers and their consumption frequency regarding the household-level factors.[1]

Household-level characteristics		Total %	Insect consumers %	Pearson chi-square value	Average consumption time a year	Pearson chi-square value
Location	Rural	33.26	69.66	1.08	4	35. 51
	Urban	66.74	66.15		5	
Ethnicity	Burmese	67.66	64.07	30.21***	4	311.18***
	Kachin	3.67	87.50		8	
	Kayah	2.41	95.24		2	
	Kayin	5.05	72.73		4	
	Chin	3.21	67.86		5	
	Mon	2.98	46.15		3	
	Rakhine	7.22	84.13		8	
	Shan	7.80	66.18		7	
Religion	Buddhism	88.30	67.79	0.68	5	42.06
	Others	11.70	63.73		6	
Family size	Small (≤3)	26.49	64.94	0.81	4	76.23
	Medium (4-6)	59.52	68.21		5	
	Large (>6)	13.99	68.03		6	

[1] *** = $P<0.001$.

Varieties of edible insects in Myanmar

Twenty-three edible insect varieties could be identified (Table 6). Around 54% of the people tried only one type of edible insects in a year, while the rest, 46%, tried two to six different species. Cricket consumers accounted for 80% of the total population, and 43% of respondents only tried crickets, but no other insects. Half of the respondents regarded crickets as their favourite. This was followed by bees (14%), bamboo worms (8%) and dung beetles (5%).

Result of the Heckpoisson model

Factors affecting insect consumption

The results of the first step (selection) of the Heckpoisson model, i.e. the binary regression model that determines whether or not respondents consume insects, are summarised in Table 7. Belonging to a particular ethnic and religious group but not gender influenced insect consumption significantly. Fear of insects, social concerns, and discomfort turned out to be the primary obstacles to consuming edible insects. Regarding ethnicity, the incidence-rate ratio (IRR) for Kachin, Kayah, and Rakhine are >1, indicating that these three ethnic groups are more likely to consume insects than Burmese, with likelihoods of 420, 312 and 76%, respectively. The likelihood of Mon ethnicity to consume edible insects was 52% less than that of Burmese ethnicity. Buddhists are 58% more likely to consume insects than adherents of other religions. The IRR of 2.33 for opinion indicates that insect consumption is 133% more likely for respondents with a positive compared to a negative attitude towards entomophagy. The likelihood of consuming edible insects is 73% lower for respondents with than without insect phobia, and individuals who believe edible insects are nutritious are 79% more likely to consume them. People who believe insect consumption indicates a lower social status are 34% less likely to consume edible insects, and those who are uncomfortable with insect consumption are 58% less likely to consume insects.

Factors affecting consumption frequency

In the second stage (frequency) of the Heckpoisson model, 12 elements were used to predict variables influencing the frequency of insect consumption (count data), as shown in Table 7. Income, race, family size, taste, odour, and safety concerns greatly impacted how frequently people consume edible insects. Respondents with higher incomes (≥$200) experience a 37% greater number of consumption events than those with lower incomes (<$200). Compared to other ethnic groups, Burmese people consume insects less frequently. Kayah ethnics consume them 43% less often, whereas Kachin, Rakhine, and Shan are predicted to consume 41%, 44%, and 55% more frequently than the Burmese. The annual insect consumption frequency increases by 21% when families grow from small to large, with family size significantly impacting the consumption frequency. Respondents who believe edible insects to be tasty foods are more likely to consume more edible insects than those who do not. A 68% increase in consumption frequency is found if the taste of edible insects improves from 'normal' to 'good,' while a 57% increase in consumption frequency with the decent from 'normal' to 'very good.'

Table 6. Lists of the common eating edible insects in Myanmar.

Sr.	English name	Scientific name	Burmese name
1	Backswimmer	*Notonecta gluca*	Nga Poe
2	Bamboo Worm	*Omphisa fuscidentalis*	Wah Poe
3	Banana leaf roller/ skipper	*Erionota thrax*	Ngapyaw Poe
4	Bee	*Apis* sp. *Linneaus*	Pyar
5	Cicada	*Tibicen purinosus*	Puzin Yin kwe
6	Common emigrant pupa	*Catopsilia pomona*	Mezali Poe
7	Cricket	*Brachytrupes portentosus/Gryllus assimilis/Acheta domesticus*	Pa Yit
8	Dinorid bug	*Coridius singhalanus*	Kyauk Poe
9	Diving Beetle	*Eretes sticticus*	Twin Poe
10	Dung Beetle	*Helicopris bucephalus*	Ecode
11	Giant water bug	*Lethocerus indicus*	Be-lar/ Palima
12	Grasshopper	*Oxya hyla*	Hnan Kaung
13	Hornet	*Vespa* sp.	Padu
14	Long horn beetle	*Batocera rufomaculata*	D n d lwan Poe/ Thit Poe
15	Predaceous diving beetle	*Dytiscus verticalis*	Yae Kyar
16	Red palm weevils	*Rhynchophorus* sp.	Thin Paung Poe
17	Rhinoceros beetle	*Oryctes rhinoceros*	Ohn Poe
18	Silkworm	*Bombyx mori*	Poe Zar
19	Termite	*Maacrotermesdarwiniensis*	Palu
20	Water beetle	*Aciliussulcatus*	Yae Poe
21	Water scavenger beetle	*Hydrophilus triangularis*	Ngape Poe
22	Weaver ant	*Oecophylla smaragdina*	Kha Gyin
23	White grub	*Phyllophaga* spp.	Thae Poe

The frequency of insect consumption rises by 69% when the smell perception changes from 'disagree' to 'neutral,' the latter pointing at am alluring scent. Concerns about food safety also play a significant role. One scale increase in doubts about the safety of edible insects is associated with a 19% decrease in the number of insects consumed during a year.

5. Discussion

Current situation of entomophagy

Entomophagy is common in Myanmar, with 67% of respondents eating insects. However, the proportion is quite low compared to Laos, where 97% of the population is said to be insect consumers (Barennes *et al.*, 2015). It appears that most consumers in Myanmar eat insects only occasionally rather than daily or weekly. Twenty-three varieties of edible insects were documented; among them, crickets ranked first as the preferable insect species, consistent with the findings of Spectrum (2016), while bees and bamboo worms were the second and third most popular insect species. These edible insects have also been listed as the preferred insect varieties in neighbouring countries such as Laos, Thailand, and Vietnam (Raheem *et al.*, 2019). A continuous supply of the preferred insect varieties could help increase consumption frequency.

Reasons for low insect consumption

Despite insect consumption is widespread in Myanmar, the question is why the consumption rates are relatively low. One reason could be the price of edible insects. Although they are not prohibitively expensive, the overall low wages and the current economic crisis may limit consumption for many people in Myanmar. Spectrum (2016) reported that insects are often considered luxury foods in Myanmar, with the price of insects having increased considerably in recent years. However, the latter does not apply to households that harvest insects in the wild for their own consumption, and one would expect low-income households to be more active in gathering nature's 'free lunch' (Dürr and Ratompoarison, 2021). Children are primarily wild insect harvesters, so the opportunity costs for those households are meagre.

Another reason for the observed low frequency of insect consumption could be seasonal availability. Barennes *et al.* (2015) mentioned the seasonal nature of edible insects makes it difficult to obtain them during the off-season. Although insects are available in almost all areas of Myanmar, they are not always available in markets or

Table 7. Results of Heckpoisson analysis of the factors influencing the consumption and consumption frequency of edible insects.[1]

Heckpoisson model	1st step (selection model)			2nd step (Poisson model)		
Variables	Coefficient		Incidence-rate ratio	Coefficient		Incidence-rate ratio
Gender (male)	0.115	(0.11)	1.121	0.082	(0.06)	1.085
Age (31-45)				0.038	(0.07)	1.039
Age (>45)				-0.16	(0.11)	0.852
Education (high school)				0.001	(0.10)	1.001
Education(undergraduate)				-0.062	(0.10)	0.939
Education (≥bachelor)				0.001	(0.10)	1.001
Income (≥$200)				0.315**	(0.10)	1.370
Location (urban)				-0.011	(0.07)	0.989
Family size (4-6)				0.123	(0.07)	1.131
Family size (>6)				0.192*	(0.09)	1.212
Ethnicity (Kachin)	1.648***	(0.43)	5.196	0.343*	(0.14)	1.410
Ethnicity (Kayah)	1.416**	(0.50)	4.122	-0.566***	(0.13)	0.568
Ethnicity (Kayin)	-0.092	(0.25)	0.912	0.134	(0.10)	1.144
Ethnicity (Chin)	0.485	(0.42)	1.624	-0.037	(0.27)	0.964
Ethnicity (Mon)	-0.725*	(0.30)	0.484	-0.288	(0.20)	0.75
Ethnicity (Rakhine)	0.568*	(0.25)	1.764	0.362**	(0.12)	1.437
Ethnicity (Shan)	-0.032	(0.19)	0.968	0.435***	(0.09)	1.546
Religion (Buddhism)	0.458*	(0.20)	1.581			
Opinion	0.846***	(0.14)	2.330			
Insect phobia (neutral)	-0.592***	(0.14)	0.553			
Insect phobia (yes)	-1.316***	(0.14)	0.268			
Nutritious food (neutral)	0.083	(0.14)	1.087			
Nutritious food (agree)	0.580***	(0.16)	1.785			
Social concerns (neutral)	-0.018	(0.13)	0.982			
Social concerns (agree)	-0.420**	(0.15)	0.657			
Discomfort (neutral)	-0.253	(0.15)	0.776			
Discomfort (agree)	-0.868***	(0.13)	0.420			
Naturalness (wild)				-0.143	(0.08)	0.867
Taste (good)				0.519***	(0.07)	1.680
Taste (very good)				0.454***	(0.09)	1.574
Attractive smell (neutral)				0.525**	(0.20)	1.69
Attractive smell (agree)				0.31	(0.17)	1.364
Nutritious food (neutral)				-0.159	(0.11)	0.853
Nutritious food (agree)				-0.137	(0.11)	0.872
Safety concerns (neutral)				-0.171	(0.10)	0.842
Safety concerns (agree)				-0.206*	(0.09)	0.814
Constant	0.249	(0.26)		0.998***	(0.23)	2.714
/athrho	-0.505***	(0.14)	0.603			
/lnsigma	-0.606***	(0.05)	0.546			
rho	-0.466	(0.11)				
sigma	0.546	(0.03)				

[1] *** = $P<0.001$; ** = $P<0.01$; * = $P<0.05$. Robust standard errors are described in the parenthesis.

shops. Seasonality affects availability and accessibility as prices rise in the off-season. What aggravates the problem is that important insect species, such as crickets, are declining in Myanmar, partly due to over-collection and partly due to pesticide use in agriculture (Spectrum, 2020b). As a result, commercial insect harvesters must move from one location to another in search of insects, and people who used to collect insects for home consumption can no longer

easily find them in their surroundings. Furthermore, we found that more than half of the people eat only one type/ species of edible insects, mostly crickets, while the rest consume two to six species. People who eat different types/ species of insects can consume insects for longer because the seasonal occurrence varies between species, while those who eat only one type/ species may not be able to eat them all year round. One potential solution would be to raise edible insects; however, insect farming is still in its infancy in Myanmar (Nischalke *et al.*, 2020).

Individual and household-level factors and insect consumption

Gender, age, education, and location appear to not affect the frequency of insect consumption, possibly because entomophagy is a family tradition that is often passed down from generation to generation (Nischalke, 2020). Most people eat insects in their social environment, regardless of gender, age, educational level, rural or urban location, in a society where entomophagy is widespread and is considered a normal habit. Furthermore, approximately 20% of Myanmar's total population has migrated partly due to the current political crisis (UNESCO, IOM, UNDP, 2018), implying that a possible locational effect may have become less pronounced. However, because people in rural areas typically harvest insects for their own consumption, whereas people in urban areas typically buy them, differences in insect consumption between rural and urban would be expected. Nonetheless, more research is needed to identify potential differences between rural and urban areas because of the rural-urban population's unrepresentative data. Regarding the representation of the rural-urban population, gender, age, and education level may also differ, and thus need to explore their potential causes. Although previous studies show that those factors often do not significantly affect insect consumption (Hartmann *et al.*, 2015; Manditsera *et al.*, 2018; Orsi *et al.*, 2019; Verbeke, 2015), there is no clear explanation or conclusion for those factors. The appearance of insects strongly influences men and women in Western society, with women generally showing a stronger aversion to insects than men when the insects are visible; however, this difference disappears when the insects are invisible (Lammers *et al.*, 2019; Orsi *et al.*, 2019). In our study, 74% of women were insect-phobic compared to only 26% of men. Such attitudes towards entomophagy are highly important for accepting or rejecting edible insects, underlining the importance of attitude in consumer behaviour (Ajzen, 2008). People with a favourable attitude towards edible insects are more likely to eat edible insects. This is hardly surprising. However, two startling facts merit further investigation: In our sample, 60% of respondents are opposed to entomophagy, and still, half of them consume insects. Even though 82% of the Kachin consumers oppose entomophagy, both consumer percentage and consumption frequency for Kachin turned out to be higher than the national average. The observed discrepancy between negative attitudes and consumption of edible insects might be due to the growing exposure to Western societal beliefs and related aversion against entomophagy and, at the same time, widespread poverty in Myanmar where insects collected in the wild can be a cheap source of food. Negative opinions may also be related to Buddhism, where killing of insects is considered a bad habit. Yet, in Myanmar living insects are often perceived more delicious than dead ones, thus people prepare and eat live insects despite knowing their actions are considered wrong by their religion.

The fact that insects have been eaten by some ethnic groups, such as the Kachin, Kayah, and Rakhine, since the time of their ancestors, but not by the Burmese, explains the significant difference in insect consumption and frequency observed in this study as well as in others (Nischalke, 2020; Tun, 2016). In contrast, Mon ethnic is less likely to consume insects, which may be due to the fact that 32% of Mon respondents who practiced Islam said they had never tried edible insects, which might be a combination of ethnic and religious factors here. Another element could be the location of ethnic groups. People who live in border areas consume insects more frequently than Burmese people (Nischalke *et al.*, 2020), possibly because of the greater abundance of wild edible insects in these areas and the more common harvesting practises. Thus, ethnicity plays a role in insect-eating, and intake levels vary from one ethnicity to the next, but more research is needed to determine the underlying reasons for this.

Our selection model revealed a significant positive association between Buddhism and entomophagy, possibly because eating foods that others have slain is not forbidden in Buddhism (Hays, 2008), whereas in Islam, entomophagy is not entirely forbidden, but is not a traditional habit (Rahim, 2018; Tajudeen, 2020). Eating insects has generally been considered acceptable by all faiths, including Christianity, Judaism, and Islam (Terrell, 2000). We found no differences between Buddhist versus non-Buddhist insect consumers (68 vs 64%), though Muslims in Myanmar clearly consume much less insects.

The consumption frequency of edible insects is positively and significantly influenced by family size. This means that people from larger families consume insects more frequently than others due to per capita consumption. It might also be related to poverty, as poorer households often have more family members (Kyaw, 2009; MPLCS, 2017) and are more vulnerable to food insecurity. Hence, such households use insects as food more frequently. In addition, larger families may be able to collect more insects than smaller households (Dürr and Ratompoarison, 2021). However, per capita consumption might be lower as the number of consumers in the family increases.

Emotional factors and insect consumption

We found that insect phobia negatively affects consumption, which is consistent with findings from other studies from entomophagous and non-entomophagous countries (Cicatiello *et al.*, 2016; Hartmann *et al.*, 2015; Phonthanukitithaworn *et al.*, 2021; Sogariet al., 2019a). Insect phobia is frequently associated with cultural issues and the perceived risk of such unfamiliar, novel, and unusual food (La Barbera *et al.*, 2018; Nyberg *et al.*, 2021; Sogari *et al.*, 2019b; Yen, 2009). This cultural phenomenon is more prevalent in non-entomophagous countries (Hartmann *et al.*, 2015; Moruzzo *et al.*, 2021; Sogari *et al.*, 2019a). However, in an insect-consuming country like Myanmar, at least 20% of the respondents in our study expressed insect phobia, and most were no longer insect consumers. One reason for this could be the different appearance of insects compared to other food products.

Furthermore, 'social concerns' can harm consumer acceptance of edible insects. In our study, 27% of people believe that eating insects denotes a lower social status and thus consume less. Similarly, Van Huis *et al.* (2022) in Niger observed that insects were regarded as poor men's food when living standards improved and consequently phased out of local diets. Whether this trend also exists in Myanmar is unclear; if so, promoting edible insects as healthy, nutritious, and fashionable food would be necessary to possibly counteract such a trend.

The consumption of edible insects can be associated with discomfort. On the one hand, 17% of the respondents in our study said they were hesitant to eat insects because they were concerned about them being unsanitary and containing unhealthy ingredients such as oil. Likewise, discomfort and fear reduced insect consumption frequencies by 36% in South Africa (Hlongwane *et al.*, 2021). On the other hand, 30% of people reported feeling discomfort after eating insects. Some people experience high blood pressure and/or headaches. These people generally avoid or reduce their consumption of insects. Studies in entomophagous countries such as Thailand, China, and Laos reported allergies, health problems, and other intolerance after insect consumption (Barennes *et al.*, 2015; Chomchai and Chomchai, 2018; Ji *et al.*, 2009; Taylor and Wang, 2018). However, those studies did not specify whether or not people who experienced such health issues continued to practise entomophagy.

Product-related factors and insect consumption

When people believe insects taste good or excellent, they are more likely to consume them. Hence, consumer preferences play an important role in the frequency of consumption in an entomophagous country like Myanmar. One of the primary motivations for consumers is the taste of insects (Barennes *et al.*, 2015; Dürr and Ratompoarison, 2021; Van Huis *et al.*, 2013). Deroy *et al.* (2015) argued that insects are not eaten out of necessity in Western countries but because they are considered delicious. Studies from Zimbabwe and the Netherlands came to the same conclusion that taste is a vital factor in determining the consumption frequency of foods (House, 2016; Manditsera *et al.*, 2018). Aside from taste, the frequency with which edible insects are consumed is influenced by smell, which, according to cricket traders, is the most convenient method of determining the freshness of insects (Spectrum, 2020b). The less smelly the insects are, the fresher they are. As a result, when people find insects to have no smell, they consume them more frequently.

We also found regarding food safety that persons concerned about chemical contaminations are more inclined to avoid higher consumption than those who are not. Consumers in Myanmar are becoming more aware of food safety, but this concept is still relatively new in the edible insect sector (Spectrum, 2021). Nonetheless, when people believe edible insects are safe to eat, they consume more of them, underlining the importance of food safety also for entomophagy as exemplified by a study from Zimbabwe where awareness of food safety issues turned out to be one of the most vital characteristics of insect consumers (Manditsera *et al.*, 2018).

In terms of nutritional value, those who believe insects are nutritious foods are more likely to consume them. A study conducted in Zimbabwe found that three-quarters of the urban population consumed insects due to their nutritional value (Manditsera *et al.*, 2018). Yet, only 45% of our respondents regarded insects as nutritious food; there appears to be a lack of consumer knowledge in Myanmar about the nutritional benefits edible insects can have.

In our analysis 'naturalness' had no significant impact on the frequency of consumption of edible insects, although a large majority of insect consumers prefer eating wild-harvested compared to (mass-) reared insects. Wild-harvested insects currently dominate the market, and insect rearing for human consumption is still in its infancy in Myanmar (Nischalke *et al.*, 2020). Some reared insect species, such as crickets, are imported into Myanmar from neighbouring countries, though the quantities are so far rather small (Nischalke, 2020). Hence, markets generally supply, and consumers typically consume wild insects. More research is needed to better understand consumer preferences in Myanmar vis-à-vis wild-harvested and (mass-) reared insects.

6. Conclusions

Before concluding, we note some research limitations to better evaluate the results. First, this study did not consider the effect of price on insect consumption frequency. Second,

it did not explore how people consume insects (e.g. as snacks or as part of a meal) and how they acquire them (by purchase or harvest), which might be important to better understand entomophagy in Myanmar. Third, there may be reporting bias. The proportion of Muslims and Hindus in the survey is small and most respondents are from urban areas, although in reality 70% of the population resides in rural areas. Results may differ if the sample is representative of the actual rural-urban population.

As one of Myanmar's first edible insect consumer studies, this article explored factors influencing consumer acceptance and consumption frequencies. Entomophagy is pervasive among all ethnic groups, including both urban and rural residents, and consumer acceptance of edible insects as food is moderately high. However, insects are rarely consumed, and the potential of edible insects to combat food insecurity and malnutrition remains challenging. Myanmar is rooted in malnutrition and food insecurity; regular consumption of edible insects could significantly improve the nutritional value of diets in malnourished populations. National nutrition programmes based on insects would be beneficial for promoting more frequent consumption in Myanmar. One of the key findings of this study is that social concerns, which are mentioned by Egan (2013) and Van Huis *et al.* (2022) but not investigated in any earlier studies, are crucial factors in determining insect consumption. Moreover, emotional factors, such as negative opinions, insect phobia, safety concerns, and discomfort, are major barriers to insect consumption. Providing new insect-based products or an invisible form, such as flour or a food additive, could help reduce insect phobia and discomfort. In contrast, the nutritional properties of edible insects motivate people to consume them. This emphasises the need to educate the public about the benefits of consuming edible insects, forming a favourable opinion and reducing social concerns about insect consumption. Thus, governments and non-governmental organisations should hold public forum to raise public awareness of the environmental benefits and health benefits of consuming edible insects. In addition, the government should set good manufacturing practices for edible insect food to ensure food safety and the value chain actors should priority food safety by following laid down policies.

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Conflict of interest

The author declares no conflict of interest.

Supplementary material

Supplementary material can be found online at https://doi.org/10.3920/JIFF2022.0151.

Table S1. Pearson correlation test result of the variables of consumption.

Table S2. Pearson correlation test result of the variables of consumption frequency.

Table S3. Multicollinearity tests.

Table S4. Breusch-Pagan / Cook-Weisberg test for heteroskedasticity.

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