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RESEARCH ARTICLE

Education: an efficient tool to increase the willingness of children to consume farmed crickets in Madagascar

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Abstract

Insects are increasingly promoted as a sustainable protein alternative for human consumption. Yet consumers have shown varied levels of acceptance, especially in countries without a tradition of eating insects. Even in countries where people traditionally eat insects, farmed insects might be considered novel foods if they are not the same species locals traditionally consume. In this work, we measured acceptance of a farmed cricket (*Gryllus madagascariensis*) as food at eight primary schools in the central highlands of Madagascar, a country with a long tradition of eating insects but not this species. We evaluated the role of education as a strategy to increase acceptance of insects as food. We also assessed whether education interventions affect children's willingness to try cricket-based products, comparing three five-minute education interventions: historical overview of entomophagy in Madagascar, nutritional benefits of consuming insects, and preparation of cricket-based meals. Out of the 483 children, 73% had consumed insects in the past. The percentage of children willing to eat novel farmed crickets in school meals jumped from 16% before the education sessions to 87% after the education sessions. Education based on preparation of cricket-based meals was the most effective, as 86% of the reluctant children changed their minds. Finally, we found strong evidence that males were more willing to try insects than females before and after education. Our results are in line with past studies, and underscore the importance of education in promoting insect consumption. The drastic increase in the proportion of children willing to try insects suggests that barriers to consuming farmed insects are low in countries with a tradition of insect consumption and can be overcome through education. Our study supports the acceptability of novel farmed insects as an alternative protein solution to combat malnutrition in children in developing countries like Madagascar.

Keywords

acceptance – farmed insects – promoting – strategy

1 Introduction

While the growth in human population is expected to make consuming protein from a sustainable source a challenge in developed countries, access to protein is already an issue in developing countries (Dury *et al.*, 2019; FAO, 2017). Introducing and increasing the scale of entomophagy, the human consumption of insects, is an interesting alternative to meat consumption (DeFoliart, 1992; van Huis *et al.*, 2013). Insects are easy to farm, less harmful to the environment, and highly nutritious (van Huis *et al.*, 2021; Vantomme and Halloran, 2013). For the last decade, insect farming activities have proliferated in both developed and developing countries. Yet, even though edible insects are available through farming, whether people will accept and include them in their diet remains uncertain (van Huis *et al.*, 2013).

Studies have found that the proportion of people willing to try consuming edible insects and insect-based products can vary greatly from 5% to 95% (Manditsera *et al.*, 2018; Verbeke, 2015). Numerous and complex factors influence acceptance of insects as food (Hartmann and Siegrist, 2016; Kröger *et al.*, 2022; van Huis *et al.*, 2021). At a global level, a recent review underscored the contextual difference between countries with and without a tradition of eating insects (Florença *et al.*, 2022). At the population level, the percentage of individuals consuming insects varied by region, ranging from 28% in Kwazulu-Natal to 95% in Limpopo within South Africa (Hlongwane *et al.*, 2020). At the individual level, male, young, educated, and environmentally conscious people were more likely to try eating edible insects (Hartmann *et al.*, 2018; Schardong *et al.*, 2019; Verbeke, 2015; Videbæk and Grunert, 2020). In Belgium willingness to try insect-based food increased over a two years period (19% to 32%), as people became more familiar with the concept (Van Thielen *et al.*, 2019). Importantly for the present work, this highlights the benefits of education on entomophagy as a means to increase its acceptance. However, the majority of the studies have investigated acceptance in places without a tradition of eating insects, such as Western countries (Kröger *et al.*, 2022). For countries with a tradition of entomophagy, the focus has been on the loss of traditional consumption patterns due to western influence (Dube *et al.*, 2013; Manditsera *et al.*, 2018; Meyer-Rochow and Chakravorty, 2013; Obopile and Seeletso, 2013; Riggi *et al.*, 2016). Therefore, even in countries with a tradition of eating insects, there is no guarantee that people will accept farmed insects, especially if the farmed species is not traditionally consumed.

Education is one strategy that could increase the acceptance of insects as food (Rumpold and van Huis, 2021; van Huis and Rumpold, 2023). For instance, in Italy and Denmark, information on social benefits effectively stimulate people's intention to consume insects (Verneau *et al.*, 2016). In Minnesota, information on nutritional and environmental benefits is also effective at convincing consumers to eat insects (Petersen *et al.*, 2020). In Germany, 75% of participants unwilling to try insects changed their minds when informed about the practice (Rumpold and Langen, 2019). However, most studies of the efficacy of education have been conducted in Western countries without a tradition of eating insects (Hémar-Nicolas *et al.*, 2022; Jones and Beynon, 2021; Petersen *et al.*, 2020; Verneau *et al.*, 2016). To the best of our knowledge, only one study has examined the impact of education in changing the perception of farmed insects in an insect-eating country (Pambo *et al.*, 2018). This research found that participants in Kenya rated the cricket-based product higher after information about its nutritional benefits were given.

In Madagascar, the majority of the population has limited access to conventional meats. The diet is composed primarily of rice, resulting in nutrient and protein deficiencies (Rakotonirainy *et al.*, 2018). This is particularly alarming among Malagasy children, an estimated 47% of whom suffer from chronic undernutrition (Unicef Madagascar, 2017). Madagascar has a tradition of eating insects; over 100 different insect species are consumed across the island (Fisher and Hugel, 2020; Randrianandrasana and Berenbaum, 2015; Van Itterbeeck *et al.*, 2019). In the order Orthoptera, 37 edible species have been inventoried, 27 of which were grasshoppers and locusts, and 11 crickets (Van Itterbeeck *et al.*, 2019). Traditionally, after harvesting, the locusts are put into boiling water, dried in the sun, ground into a powder, cooked in hot water, and served with rice or sauce (Decary, 1937; Fisher and Hugel, 2020). *Brachytrupes membranaceus* and *Gryllus madagascariensis* both belong to the Grylloidea superfamily. The former is a wild cricket and is accepted as edible, the latter, though nutritious and easy to farm, is not traditionally consumed (Van Itterbeeck *et al.*, 2019). Because upscaling insect farming is ongoing in Madagascar with the goal of fighting child malnutrition, it is important to understand how acceptance for farmed insect consumption can be increased. In this work, we assessed the acceptance of farmed crickets at eight primary schools in the central highlands of Madagascar, and the effectiveness

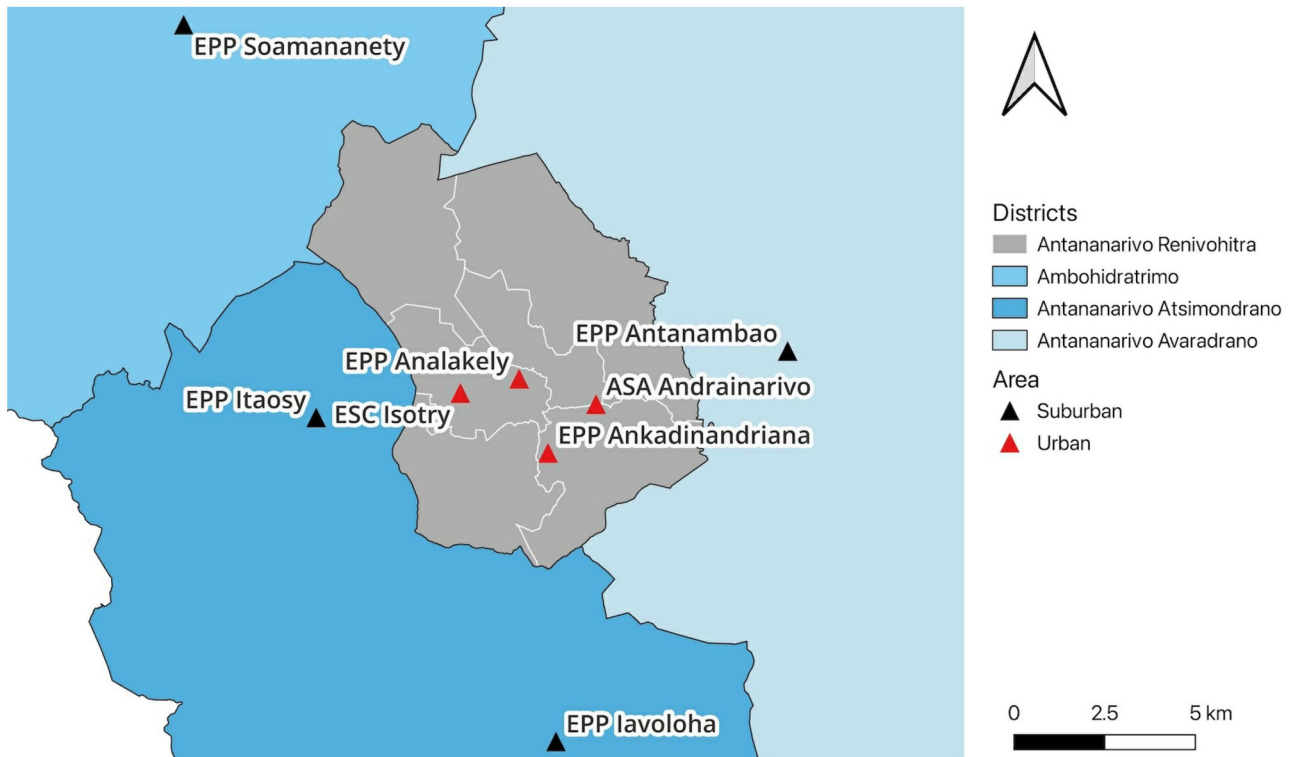


FIGURE 1 Location of the eight primary schools surveyed. Urban area in gray and suburban area in blue. Black icon: school in suburban area, red icon: school in urban area.

of various education topics at convincing reluctant consumers.

2 Materials and methods

This study was conducted in and around the city of Antananarivo, Analamanga region, Madagascar, in February 2019. We surveyed children in eight primary schools in urban and suburban areas. The urban area is part of the city that has a high population density. The suburban area is located outside or around the city and has a lower population density. These schools participate in feeding programs that provide daily meals supported either by the government or non-governmental entities. The rationale was that farmed insects could be added to their lunch programs in the future. The study was developed in collaboration with the CISCO (“Circonscription Scolaire”), the representative of the Ministry of Education responsible for coordinating and supervising the education system at the district level (administrative level 2). In the district of Antananarivo, we selected four schools in the urban area of Antananarivo Renivohitra: EPP (“Ecole Primaire Publique”) Analakely, EPP Ankadinandriana, ASA (“Ankohonana Sahirana Arenina”) Andrainarivo, and Ecole des Soeurs

de la Charité; and four schools in the suburban area of Atsimondrano: EPP Itaosy and EPP Iavoloha, Avaradrano: EPP Antanambao, and Ambohidratrimo: EPP Soamananety (Figure 1). The University of Antananarivo, the heads of the CISCOS, and the director of each school approved and signed the survey request. The survey was conducted when the children had no classes.

Prior to the survey, the director of each school, the head of the cafeteria, and the teachers were asked to form three groups of 20 children each aged 7–14 with an equal number of males and females within a uniform age distribution. The visit consisted of three phases: interviews prior to education intervention, education intervention, and follow-up interviews post-education intervention.

The first phase of the research (before educational intervention) consisted of a structured interview. For each school, 60 children were interviewed by six interviewers including the first author (10 children per interviewer). The same person conducted and interviewed the same children for the first and the third phases. Each child was asked whether they have eaten insects or not in the past. We designated children who already consumed insects as consumers and children who never consumed insects as non-consumers. After viewing a photo of the whole cricket on a white background (Sup-

plementary Figure S1), each child was asked about his or her willingness to try farmed crickets (*Gryllus mada-gascariensis*) in the school cafeteria, and reasons for his or her decision, Table A1. The children responded freely without having to choose from predetermined answers. Their responses were subsequently grouped into the following categories: fear, disgust, dislike, ignorance, and forbidden.

For the second phase, we gathered a group of 20 children in the classroom and conducted a brief education program. Each group was presented with concise education interventions on one of three educational topics on insect consumption: historical overview of entomophagy, nutritional benefits of consuming insects or preparation of cricket-based meals. Each time the educator presented a point, she showed a related picture to aid understanding. For the historical overview of entomophagy, children were informed about prehistoric consumption (Supplementary Figure S2), references in the Bible (Supplementary Figure S3), how insects were a delicacy during the monarchy in Madagascar (taken before 1896; Supplementary Figure S4) and the use of insect-based products as a pigment in candy (Supplementary Figure S5). For the nutritional benefits of insect consumption, children were informed about the calcium, protein, and vitamin content of insects, and told that eating insects makes a child stronger and taller (Supplementary Figures S6–S8). For the preparation of cricket-based meals, children were told how insects are cleaned (i.e. washing, Supplementary Figures S9 and S10) and fried (Supplementary Figure S11) before being served, and were shown different traditional Malagasy meals made with whole insects (Supplementary Figures S12–S15) and insect powder (Supplementary Figures S16–S19). Each education intervention lasted about 5 minutes and was conducted by the first author. For each topic, photos were shown to each child and displayed as visual aids afterwards. A photo of a whole cricket on a white background was shown to all three education groups (Supplementary Figure S1).

For the third and final phase, we conducted a follow-up, post-education structured interview where each child was asked if their willingness to try meals with farmed crickets at the school cafeteria had changed, and the reasons for their decision, Table A2. The children responded freely without having to choose from predetermined answers. Their reasons were subsequently grouped into the following categories: curiosity, less fear, appetizing, nutritious, edible, and clean. All interviews were conducted in simple Malagasy. The teacher was not present during the interviews to avoid biased answers.

We encouraged the children to provide honest answers by reassuring them that there were no right or wrong responses.

We compared how the number of consumer children (those who had experience consuming insects) varied by area (urban vs suburban) and sex (male vs female). We tabulated the number of children who were willing to try farmed crickets before and after education based on area, sex, and past consumption (consumers vs non-consumers). To assess which education topic was more effective, we compared the number of children who changed their minds after the education (i.e. reluctant before education, becoming willing to try after education) and investigated if the number depended on area, sex, and past consumption. For reluctant children who changed their minds, we compared the reasons mentioned by the children for their reluctance before and willingness after, and how it varied among education topic groups. We compared the number of children who did not change their minds after education (i.e. reluctant and willing before and after education) and their reasons for this decision.

We used a chi-square test of independence to determine if there is evidence for such dependence. Chi-square tests were performed on the absolute number but results are given in percentages for ease of comparison. Use of the P -value = 0.05 as a threshold for statistical significance has been criticized (Amrhein *et al.*, 2019; Berkson, 1942; Cohen, 1994; Cox, 1982; Ioannidis, 2005; Rozenboom, 1960; Wasserstein and Lazar, 2016). Below, we reported the results in term of degree of evidence: little or no evidence when P -value > 0.05, moderate evidence when $0.05 > P$ -value > 0.01, strong evidence $0.01 > P$ -value > 0.001, and very strong evidence when P -value < 0.001 (Muff *et al.*, 2022). We have incorporated Cramer's V into the analysis of Chi-square tests in cross-tabulations to complement the P -values and provide a measure of the strength of associations (Cohen, 1988). Statistical analyses were performed in R software version 4.2.3 (R Core Team, 2015).

3 Results

Insect consumptions and profile of consumers

A total of 483 children were surveyed across the eight schools (Table 1). About 73% of the children had consumed insects in the past (Figure 2a, Table 2). The highest proportion of consumers were males in urban areas (80%) whereas the lowest proportion was among females in urban areas (60%) (Figure 2b). There was no

TABLE 1 Distribution of age and sex of the 483 children

Age	Sex	
	Female	Male
7–10 years	127	117
11–14 years	111	128
Total	238	245

evidence that area (74% for urban vs 70% suburban) influenced past consumption ($\chi^2 = 0.86$, $df = 1$, P -value = 0.353, Cramer's $V = 0.047$) (Supplementary Table S1). There was strong evidence that sex influences past consumption, (79% for male vs 67% for female, $\chi^2 = 8.716$, $df = 1$, P -value = 0.003, Cramer's $V = 0.14$) (Table 2).

Before the education sessions, only 16% of the children were willing to try farmed crickets (Figure 2a). The percentage was highest among males in urban areas (6%) and lowest for females in suburban areas (2%) (Figure 2c). There was no evidence that area (18% for urban vs 13% suburban) influenced willingness to try crickets ($\chi^2 = 1.88$, $df = 1$, P -value = 0.17, Cramer's $V = 0.068$) (Supplementary Table S1). There was moderate evidence that sex (20% for male vs 11% for female) influenced willingness to try farmed crickets ($\chi^2 = 5.64$, $df = 1$, P -value = 0.017, Cramer's $V = 0.113$) (Table 2). Likewise, there was moderate evidence that past consumption influenced willingness to try farmed crickets ($\chi^2 = 3.89$, $df = 1$, P -value = 0.048, Cramer's $V = 0.096$). Indeed, 10% of children who had never consumed insects were willing to try farmed cricket whereas 18% of children who consumed insects in the past were willing to try farmed crickets.

After the education sessions, 87% of the children were willing to try farmed crickets (Figure 2a). All children willing to try crickets before education were still willing to try crickets after the education sessions (Figure 2a). Males and females in suburban areas were most and least likely to try farmed crickets, 93% and 71%, respectively (Figure 2d). There was moderate evidence that area (91% for urban vs 82% for suburban) influenced willingness to try farmed crickets ($\chi^2 = 6.379$, $df = 1$, P -value = 0.011, Cramer's $V = 0.12$) (Table 2). There was very strong evidence that sex (male 93% vs female 80%) influenced willingness to try farmed crickets ($\chi^2 = 14.894$, $df = 1$, P -value < 0.001, Cramer's $V = 0.182$) (Table 2). Finally, there was strong evidence that past consumption (89% for consumers vs 80% for non-consumers) influenced willingness after education intervention ($\chi^2 = 6.813$, $df = 1$, P -value = 0.008, Cramer's $V = 0.125$) (Table 2).

Effectiveness of each education topic among reluctant children

From the first phase, out of 483 children, 408 were reluctant to try crickets before education intervention but 343 (84% of reluctant children) changed their minds after the education sessions. There was very strong evidence that different educational programs had a different degree of effectiveness ($\chi^2 = 18.971$, $df = 2$, P -value < 0.001, Cramer's $V = 0.198$). The most effective was the education on preparation of cricket-based meals, where 86% of the reluctant children changed their minds. The percentage of reluctant children who changed their minds for the nutritional benefits and historical overview of entomophagy were 63% and 62%, respectively. There was moderate evidence that children in suburban areas are less likely to change their minds compared to children in urban areas (82% vs 91%, $\chi^2 = 6.379$, $df = 1$, P -value = 0.012, Cramer's $V = 0.12$) (Table 2, Figure 3a). There was very strong evidence that females were less likely to change their minds (80% vs 93%, $\chi^2 = 14.894$, $df = 1$, P -value < 0.001, Cramer's $V = 0.181$), (Table 2, Figure 3b). There was moderate evidence that non-consumers were less likely to change their minds, (80% vs 89%, $\chi^2 = 6.831$, $df = 1$, P -value = 0.008, Cramer's $V = 0.125$), (Table 2, Figure 3c). These patterns were consistent across the three education topics (Figure 3).

Reasons for reluctance and willingness

Among the reluctant children who changed their minds, the main reason given for not trying crickets was fear (69%). In all the three education programs, fear was cited: 69% for historical overview, 62% for nutritional benefits, 73% for preparation of cricket-based meals (Table 3). Disgust was second (21%), with 24% having received the historical overview education, 24% the nutritional benefits education, and 16% the preparation of cricket-based meals education. Dislike, ignorance of edibility, and forbidden by parents were also mentioned by 18%, 14%, and 11% of the children, respectively.

After the education sessions, the reasons driving willingness to try crickets were more diverse and equitably distributed: curiosity (33%), less fear (29%), appetizing (20%), nutritious (12%) (Figure 4, Table 4). The least mentioned reasons were edible (5% ~ 16 children), and clean (1% ~ 4 children) (Figure 4). Curiosity was the most common reason mentioned in the historical overview (59%). Curiosity was frequently mentioned post-education. Nutritional benefits was second (37%), and went down (11%) with the intervention on preparation of cricket-based meals. Less fear (29%) was

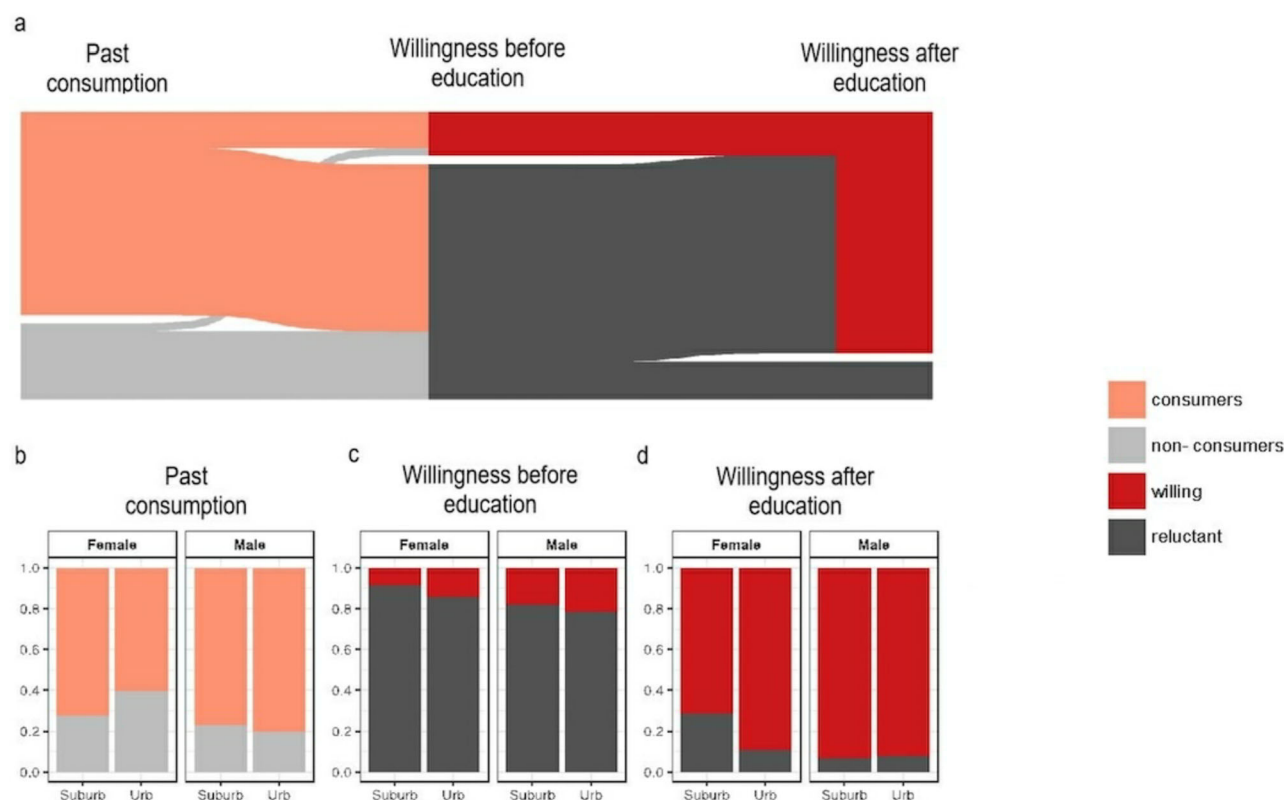


FIGURE 2 (a) Alluvial plot showing (left column) the proportion of consumers and non-consumers who were willing or reluctant to eat crickets before (middle column) and after education (right column). Proportion of children that (b) consumed insects, (c) were willing to eat crickets *Gryllus madagascariensis* before education, and (d) were willing to eat crickets after education as a function of sex (male and female) and area (suburban and urban). Orange: children who already consumed insects; gray: children who never ate insects; red: children who were willing to eat crickets before or after education, and dark gray: children who were reluctant to eat crickets before or after education.

TABLE 2 Numbers of children who had consumed insects in the past, and those who were willing to try farmed cricket before and after education, by sex and area

		Past consumption		Willingness to try before education		Willingness to try after education	
		Consumers	Non-consumers	Willing	Reluctant	Willing	Reluctant
Sex	Female	158 (73%)	80 (34%)	27 (16%)	211 (89%)	191 (80%)	47 (20%)
	Male	193 (79%)	52 (21%)	48 (20%)	197 (80%)	227 (93%)	18 (7%)
Area	Suburban	178 (75%)	60 (25%)	31 (13%)	207 (87%)	196 (82%)	42 (18%)
	Urban	173 (71%)	72 (29%)	44 (18%)	201 (82%)	222 (91%)	23 (9%)
Past consumption	Consumers	NA	NA	62 (18%)	289 (82%)	313 (89%)	38 (11%)
	Non-consumers	NA	NA	13 (10%)	119 (90%)	105 (80%)	27 (20%)

the second most common reason in all education topics, with 40%, 21%, and 27% for historical overview, nutritional benefits, and preparation of cricket-based meals education programs, respectively. Nutritious was the most common reason (41%) in the nutritional benefits session but was not mentioned by children in the other programs. Likewise, appetizing (49%) was the feature most commonly mentioned in preparation of

cricket-based meals. Interestingly, edible was only mentioned by one child in both the historical overview and nutritional benefits programs, whereas 14 children mentioned it in the preparation of cricket-based meals program. Finally, clean was mentioned by four children in the preparation of cricket-based meals program.

Out of 483 children, 65 were not willing to try farmed crickets either before or after education. Their reasons

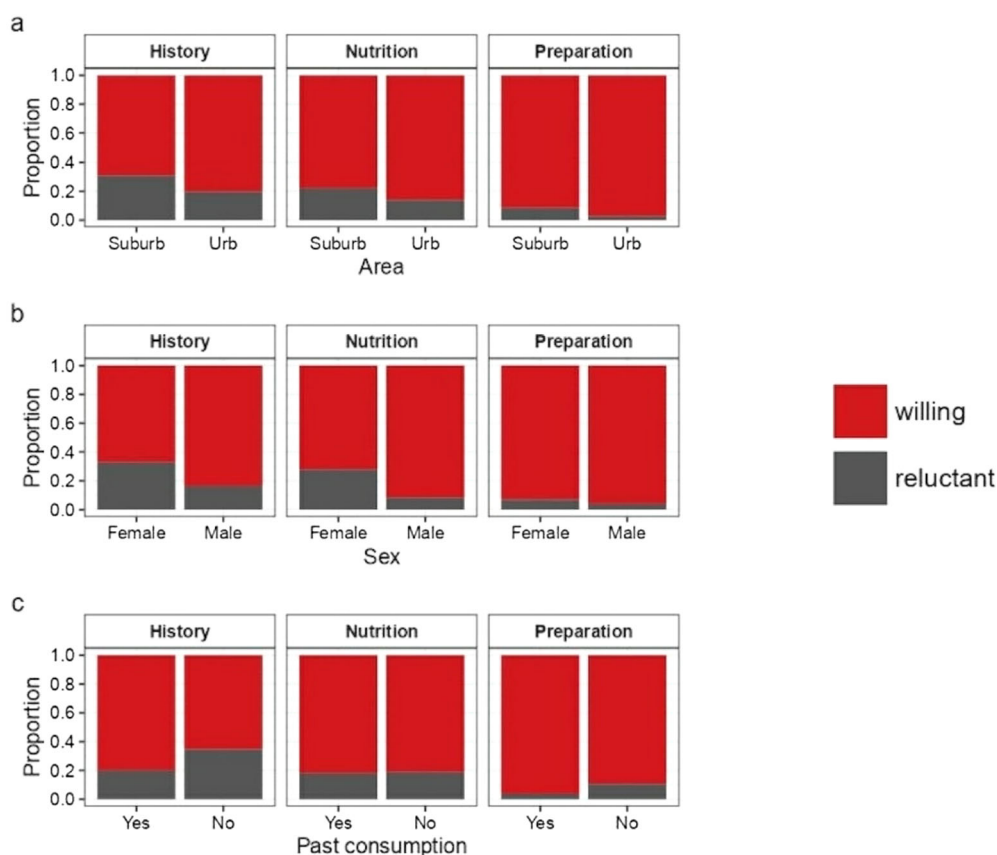


FIGURE 3 Proportion of reluctant children before education who (red) were willing to eat crickets *Gryllus madagascariensis* after education and (dark grey) remained reluctant after education. Rows represent profile (a) area (suburb: suburban, urb: urban), (b) sex and (c) past consumption (Yes: consumers, No: non-consumers), and columns represent the education topic: history of entomophagy, nutritional benefits, and cricket-based meal preparation.

TABLE 3 Reasons for reluctance to try crickets for each education topic, for children initially reluctant who became willing after the education sessions

Reasons for reluctance	History of entomophagy n = 100	Nutritional benefits n = 103	Cricket-based meal preparation n = 140	Total n = 343
Fear	69 (69%)	64 (62%)	102 (73%)	235 (69%)
Disgust	24 (24%)	25 (24%)	23 (16%)	72 (21%)
Dislike	3 (3%)	5 (5%)	10 (7%)	18 (5%)
Ignorance*	3 (3%)	7 (7%)	2 (2%)	12 (3%)
Forbidden**	1 (1%)	2 (2%)	3 (2%)	3 (2%)

* that cricket can be consumed, ** by parents or religion.

were the same pre- and post-education: religion (Adventist), disgust, taboo, and fear. There were 75 children willing to try farmed crickets before and after education. No one changed their mind after the education but some changed their reasons after the education. Indeed, only curiosity and past cricket consumption (had already eaten cricket) were mentioned in the first survey. After education, in addition to curiosity and past

cricket consumption, children also mentioned appetizing, clean, less fear and nutritious.

4 Discussion

This work assessed the willingness of primary school children in Madagascar to try a novel farmed cricket

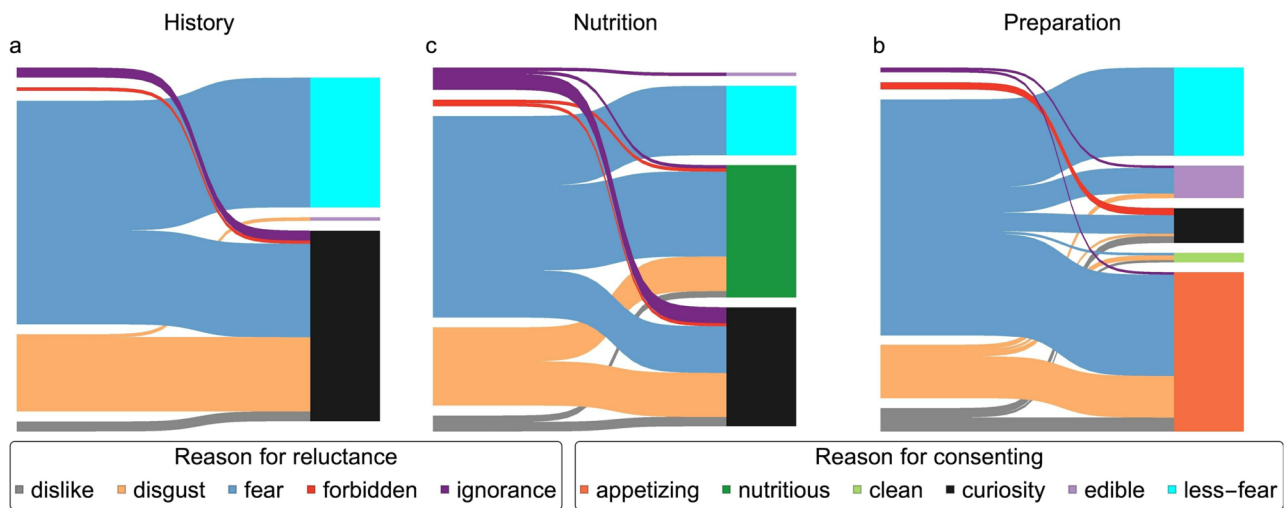


FIGURE 4 Alluvial plots showing why children were reluctant to consume crickets *Gryllus madagascariensis* before education (see legends) and why they changed their minds and were willing to consume crickets after different types of education: (a) history of entomophagy, (b) nutritional benefits, and (c) cricket-based meal preparation.

TABLE 4 Reasons for the willingness to try farmed crickets for each education topic, for children initially reluctant who became willing after the education sessions

Reasons for consent	History of entomophagy n = 100	Nutritional benefits n = 103	Cricket-based meal preparation n = 140	Total n = 343
Curiosity	59 (59%)	38 (37%)	15 (11%)	112 (33%)
Less fear	40 (40%)	22 (21%)	38 (27%)	100 (29%)
Appetizing	0 (0%)	0 (0%)	69 (49%)	69 (20%)
Nutritious	0 (0%)	42 (41%)	0 (0%)	42 (12%)
Edible	1 (1%)	1 (1%)	14 (10%)	16 (5%)
Clean	0 (0%)	0 (0%)	4 (3%)	4 (1%)

(*Gryllus madagascariensis*) if it were included in cafeteria meals, and the effectiveness of three education topics on willingness to consume the insect. Overall, we found that 73% of the children had already consumed insects but only 16% were willing to try the novel cricket. However, after a five-minute presentation, 87% were willing to try the novel cricket. The presentation about preparation of cricket-based meals was the most efficient and convinced 86% of the reluctant children. Finally, we found strong evidence that male and past consumers were more likely to try crickets before and after education. Although the cricket *Gryllus madagascariensis* is not among the species of insect traditionally consumed in Madagascar (Van Itterbeeck *et al.*, 2019), these results indicate that initial reluctance to eat this species could largely be addressed with education. Our findings support the idea that cricket farming can be an acceptable and pragmatic solution for feeding children in developing countries that, like Madagascar, have a tradition of eating insects.

Only sixteen percent of the primary school children were initially willing to try farmed cricket (*Gryllus madagascariensis*) if it were included in school cafeteria meals. That number is surprisingly low for a country with an extensive tradition of insect consumption like Madagascar. Even in Western countries, about a quarter of the population is willing to eat novel insect-based food (van Huis and Rumpold, 2023). The different attitudes towards entomophagy between countries with and without a tradition of eating insects were recently reviewed (Florença *et al.*, 2022). A handful of studies explicitly compared and found differences between Ethiopia and Korea (Ghosh *et al.*, 2020), China and Germany (Hartmann *et al.*, 2015) and the Netherlands and Thailand (Tan *et al.*, 2015). A comparative study between a country without a tradition of eating insects (the Netherlands) and a country with a tradition of eating insects (Thailand) showed that mealworms were accepted in the former but not in the latter (Tan *et al.*, 2015). It is worth mentioning the silk moth (*Bom-*

byx mori), an introduced species farmed primarily for silk, is consumed in Madagascar and sold in markets in the capital Antananarivo (Dürr *et al.*, 2020). The cricket *Gryllus madagascariensis* is not consumed in Madagascar, possibly because of low abundance compared to other species like grasshoppers, and because of their presence (or that of similar-looking species) in many houses. Another plausible reason is the specific species of insects available and traditionally consumed, which can impact willingness. For example, while *Brachytrupes membranaceus* is traditionally consumed, *Gryllus madagascariensis* is not part of the traditional diet in the central highlands of Madagascar, which might be perceived as unfamiliar (Van Itterbeeck *et al.*, 2019). These results (including ours) underscore that not all edible insects are valued equally and cultural context matters.

With more study (including ours), similarities emerge. Males were more willing to try farmed crickets. This was consistent across past consumption, willingness to try before, and willingness to try after education intervention groups. To the best of our knowledge, only one study in Benin found no evidence of increased male willingness, although the sample size was small (Ghosh *et al.*, 2021). Boys are considered more adventurous, more likely to accept insects as food, and more apt to be “early adopters” (Verbeke, 2015; Verneau *et al.*, 2016). Girls are reported as being more disgusted with the idea of tasting insects (Verbeke, 2015) and more affected by the insect’s visual aspect (Alhujaili *et al.*, 2023; Caparros Megido *et al.*, 2016). Our work shows that children who consumed insects in the past were more willing to try farmed crickets. This is consistent with previous studies where people who have already eaten or tasted insects have a more positive attitude towards entomophagy than people who have never eaten insects (Lensvelt and Steenbekkers, 2014; Verbeke, 2015). Various methods can be used to increase familiarity with insect consumption: tasting, presentation, information to counter disgust and neophobia (Tan *et al.*, 2015; Wansink, 2002; Woolf *et al.*, 2021). Familiarity of Belgian consumers to edible insects increased after two years on the market (Van Thielen *et al.*, 2019). Familiarity is fundamental for increasing the acceptance of eating insects.

In this study, education based on the preparation of cricket-based meals was effective (86% “converted”) because the historical overview and nutritional benefits were more distant and less concrete. In contrast, the materials in preparation of cricket-based meals were familiar: children could easily imagine cleaning the crickets and saw images of the prepared meals. One of

the cricket recipes shown to the children follows the traditional locust recipe, where insect powder is added to rice (Decary, 1937; Fisher and Hugel, 2020). The degree of visibility of insects could influence their acceptance: the less visible the insect, the more it is accepted as food. For example, insects can be served as a powder, as in our education intervention based on the preparation of cricket-based meals with recipes for powdered cricket (Duda *et al.*, 2019; Kröger *et al.*, 2022). Studies on the effectiveness of education to enhance the willingness of children to try insects were conducted in Western countries where entomophagy is not a tradition (Rumpold and van Huis, 2021). For instance, about half of the children were willing to choose insect-based products for lunch (Jones and Beynon, 2021) and up to 75% of participants in Germany were willing to try crickets after a single information session was provided (Rumpold and Langen, 2019). The findings are based on different cultural contexts, modes and topics of education (for example, education was spread over 18 months in Finland (Mustonen and Tuorila, 2010), as well as response variables (willingness or reluctance vs attitude towards entomophagy or its drivers measured on a continuous scale). Our study recorded the highest percentage of change in acceptance post-education. We posit that the success of education in convincing children is driven by the familiarity of Malagasy people with insect consumption.

5 Caveats and next steps

We suspect that the results might be less pronounced if the study includes schools where there is less of a tradition of eating insects, such as wealthy private schools with a tendency to embrace Western culture. Regardless, these results are important in Madagascar, where 47% of children are malnourished (Unicef Madagascar, 2017) and where enhancing acceptance of insects as food is vital to improve nutrition.

The willingness to try to eat insects may not necessarily translate into a willingness to consume (Szczepanski *et al.*, 2022). However, this study represents a first step towards understanding the role of education to improve acceptance of farmed insects among children in Madagascar. Future research will assess whether this initial willingness translates into regular consumption and will identify potential barriers to consumption as well as possible solutions.

Our study was conducted in and around Antananarivo: the capital of Madagascar. It would be interest-

ing in future studies to compare urban and rural areas, expanding the geographic scope of the study to include additional ethnic groups on the island, since Madagascar has rich cultures and traditions that differ across the 23 regions. Another suggestion is to compare the acceptance of a farmed cricket that is not traditionally consumed with acceptance of a locally consumed species such as sakondry, *Zanna tenebrosa* (Borgerson *et al.*, 2021, 2022).

Logic is not necessarily the best way to convince participants. In our case, although malnutrition is the main problem, explaining nutritional benefits was not as effective as showing how cricket-based meals are prepared. Malnutrition is not necessarily the primary factor in determining acceptance. Ethiopians with histories of food insecurity were less willing than Koreans to try insects (Ghosh *et al.*, 2020). However, children might not be able to fully grasp such concepts, and images of preparation already evoke nutritional benefits. Various factors come into play for acceptance, such as emotional attitudes towards foods (King and Meiselman, 2010), the appearance of the insects, taste, and familiarity with insect foods (Wendin and Nyberg, 2021). Arguments are not sufficient to convince children to eat insects; children take into account the visual aspect of the insect (Hémar-Nicolas *et al.*, 2022).

Diverse strategies have been used to promote entomophagy (van Huis and Rumpold, 2023) such as food tastings and product design; we see those as avenues for future studies. Another strategy is the visual aspect of the insect (van Huis and Rumpold, 2023). Reducing insects to powder that is incorporated into usual dishes can also promote acceptance of the insect as food (Caparros Megido *et al.*, 2016; Sogari *et al.*, 2017). Organizing exposure and tasting sessions can help to promote familiarity and acceptance of insects (Beans, 2022; Maya *et al.*, 2023). Education combined with a tasting session is more likely to convince reluctant consumers. These Western strategies should be adapted so that they align with Malagasy culinary and culturally practices.

6 Conclusion

This work touches on two main themes: willingness to try a novel insect that is not traditionally consumed and the effectiveness of education to increase willingness. We showed that in urban and suburban schools, a low initial willingness (16%) to consume a novel insect increased to 87% after a five-minute education intervention. Though novel farmed insects are not necessarily

accepted in countries with a tradition of eating insects (Tan *et al.*, 2015), it may be easier to reverse initial reluctance to try insects in such instances because cultural barriers to entomophagy are weaker.

Our results are encouraging for countries like Madagascar, where 47% of children are undernourished and acceptance is key to reversing population-scale malnutrition. Education can be an efficient tool at acceptance (Rumpold and van Huis, 2021). We support the idea of including insects in the curricula of African schools because such education offers multifaceted benefits and helps combat undernourishment (DeFoliart, 1992; Dürr and Ratompoarison, 2021; Nadeau *et al.*, 2015). Overall, demystifying and making entomophagy common place is a step toward the food revolution and a solution for environmental problems and malnutrition.

Supplementary material

Supplementary material is available online at: <https://doi.org/10.6084/m9.figshare.26572312>

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Appendices

TABLE A1 Survey sheet

Name:			
Age:			
Sex:			
Group:			
Have you already eaten insects?			
Yes	No		
Look at this insect, would you try to eat it in the school cafeteria later?			
Before education		After education	
Yes	No	Yes	No
Reasons		Reasons	

TABLE A2 Overview of children who have consumed insects in the past, and the percentage willing to try farmed cricket before and after education, by sex and area

	Category	Percentage	X-square	df	P-value
Past consumption	Urban vs suburban	74% vs 70%	= 0.86	= 1	= 0.353
	Male vs female	79% vs 67%	= 8.716	= 1	= 0.003
	Female urban vs suburban	60% vs 72%	= 3.182	= 1	= 0.074
	Male urban vs suburban	80% vs 77%	= 0.150	= 1	= 0.697
Willing to try before education	Urban vs suburban	18% vs 13%	= 1.88	= 1	= 0.17
	Male vs female	20% vs 11%	= 5.647	= 1	= 0.0174
	Female urban vs suburban	14% vs 8%	= 1.503	= 1	= 0.22
	Male urban vs suburban	21% vs 18%	= 0.341	= 1	= 0.559
Willing to try after education	Urban vs suburban	91% vs 82%	= 6.349	= 1	= 0.011
	Male vs female	93% vs 80%	= 14.894	= 1	<0.001
	Consumer vs non-consumer	89% vs 80%	= 6.831	= 1	= 0.008
	Female urban vs suburban	89% vs 71%	= 10.605	= 1	= 0.001
	Male urban vs suburban	93% vs 92%	= 0.014	= 1	= 0.905