

# Prevalence and cluster effect of self-reported allergic reactions among insect consumers: An internet survey from Thailand

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## Abstract

**Background:** Entomophagy is a common practice in many parts of the world. Allergic symptoms after insect consumption have been reported in healthcare literature and in the news.

**Objectives:** We evaluated prevalence and association of allergic history and self-reported allergic reactions after entomophagy.

**Methods:** We conducted a cross sectional internet-based survey. Participants were people who have consumed insects. Collected information included demographic data, the practice of entomophagy, allergic history and self-reported allergic symptoms.

**Results:** During May to October 2017, 140 people completed the survey. Median and range of age are 27 and 18-64 years. Ninety-two (65.7%) were female. Thirty-seven (26.4%) and 13 (9.3%) participants had history of allergy and seafood allergy, respectively. Eighteen (12.9%; 95% confidence intervals (CI) 7.3-18.4) participants reported allergic reactions after insect consumption. Nine symptomatic participants reported other people who partook insects to have allergic symptoms. Reported factors with significant association with allergic reactions were history of allergy and seafood allergy with prevalence ratios of 4.83 (CI 1.83-10.44) and 3.76 (CI 1.59-8.87), respectively.

**Conclusion:** The prevalence of self-reported allergic reactions after entomophagy is 12.9%. Clusters of people with post-entomophagy allergic symptoms are found. History of allergy and seafood allergy are associated with post-entomophagy allergic reactions.

**Key words:** Entomophagy, histamine, scombroid, anaphylaxis, silkworm, grasshopper, cricket, bamboo caterpillar

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## Introduction

Entomophagy is a common practice for cultural, economic, and environmental reasons.<sup>1-3</sup> While the consumption of silkworm pupae is found among silk-production cultures because the pupae are by-products from silk spooling, grasshoppers caught from herds of migrating locusts in the field, are a naturally-found, seasonal source of protein. Crickets and bamboo caterpillars, on the other hand, are especially farmed for their economical values as specialty food items and are otherwise known as six-legged livestock.<sup>2</sup> Worldwide, contemporary reasons supporting entomophagy in human are mainly nutritional and sustainability as food security to mankind. Insects contain high protein, minerals and vitamins with relatively low fat

contents. Production of insects as livestock are more environmentally friendly since it requires significantly less feed, water and space, while emitting less greenhouse gases, as compared with poultry and cattle.<sup>2,3</sup> However, with entomophagy being on the rise both as small domestic, and large-scale commercial productions, safety cannot be overlooked.<sup>3</sup>

Allergy from insect consumption is reported intermittently in the news in countries where entomophagy are common, for example, in Southeast Asia with symptoms such as urticarial rash, bronchospasm and anaphylaxis.<sup>4-7</sup> Cases are often isolated and sporadic, occurring in small clusters, with infrequent reports of large scale outbreaks that involve anywhere from 27

to 118 patients.<sup>1,4-9</sup> Considering the scarcity of epidemiologic information, no public awareness has been raised considering the prevalence and risk of allergic symptoms which can occur from insect consumption.<sup>1,10</sup> And while public health agencies often caution against insect consumption in individuals with allergic illness, there are as yet no scientific evidence to support susceptibility to allergic symptoms among patients with allergic history after consumption of insects.<sup>11,12</sup> This study aims to assess the prevalence and to fill in the knowledge gap regarding the relationship between underlying allergic disease and the development of allergic symptoms after insect consumption.

## Methods

### Study design

This was an internet-based cross-sectional survey of people who practiced entomophagy. The study was conducted from May 1, 2017 to October 31, 2017. The survey questions and utilization of data received approval from Siriraj Institutional Review Board (SIRB) prior to study commencement. Recruitment was done through 2 venues. Poster advertisements were placed in and around Bangkok's Khaosan Road area where tourists and backpackers frequently come in contact with several fried insect vendors. Recruitment information was also posted in popular Thai social network websites Pantip (<https://pantip.com/>) and KhonkaenLink (<https://www.khonkaenlink.info/>) websites. In both settings, potential participants would encounter the first page of the online questionnaire containing an informed consent form and participant information sheet and were asked to leave the survey if they are under 18 years of age.

### Subjects

A history of insect ingestion was the only inclusion criteria. Participants were excluded from the final analysis if they did not specify the type of insect consumed or the symptoms experienced. Targeted sample size for the study was 113 subjects, based on calculated sample size of 94 for chi-square goodness-of-fit tests, 20% contingency, alpha 0.05, beta 0.80 and effect size 0.41 (chi-square value 7.06, sample size 42).<sup>5</sup> In addition, sample size for prevalence study was estimated using known prevalence value of 7.6%, precision value of 5% and confidence level of 95%. The required sample size is 101 cases.<sup>1,13</sup>

### Data collection

Content of the questionnaire was reviewed and commented by allergist and clinical epidemiologists for validity. The online questionnaire was piloted on Windows, iOS and Android operating systems, on personal computers, tablets and smart phones to ensure that it is user-friendly and precise. Participants were told the questionnaire was to assess "any illness or discomfort after insect consumption" and had the choice of questionnaire in either the Thai or English languages. The questionnaire contained 23 items including demographic information, gender, nationality, place of residence, and past medical history, including that of allergic diseases, irritable bowel disease and inflammatory bowel disease, and presence of specific food allergies. Specific details regarding the participant's experience with entomophagy were obtained such as the type of

insect ingested, source and form of insect ingested, frequency and reasons of entomophagy. In order to ascertain the occurrence of true allergic reaction to insects and reduce participant bias, a 17-item symptom list was formulated which included both allergy-associated and non-allergy associated symptoms involving the skin, respiratory, gastrointestinal and general symptoms. If participant report having symptoms after insect ingestions, they were asked secondary questions such as if they suspected a specific insect to be the cause, the time lapse between consumption and development of symptom, if they know of other people who consumed the same batch of insects who also developed symptoms and if the participant sought medical attention. No personal identification data was collected in this study.

### Classification of symptoms

Using criteria derived from a well-referenced research in food allergy, a set of symptoms were used to initially classify the self-reported symptoms as allergic or no allergic reactions.<sup>14</sup> Participant are considered to have 'allergic reactions' if at least one of the symptoms of skin rashes, swollen eyes, wheeze, difficulty breathing are reported with onsets less than 2 hours after insect ingestion. A secondary classification of allergic reactions was used to further identify those with wheezing, breathing difficulty, hypotension or fainting as 'severe allergic reaction' due to their life-threatening nature. Participants whose answers only included non-specific symptoms, such as headache, dizziness, vomiting, pruritus and diarrhea, were classified as 'no allergic reactions'. Participant are classified as having 'respiratory allergy' if they report history of allergic rhinitis or asthma and 'skin allergy' if history of eczema or urticaria are reported. Participants who specifically reported having allergy to sea fish, prawn, shrimp, lobster, crab, crayfish and mollusks were classified as having 'seafood allergy'.

### Statistical analyses

Descriptive data were presented with frequency, percentage, and mean with standard deviation (SD) and median with interquartile range (IQR) where appropriate. Continuous variables were compared with Student's t-test or Mann-Whitney U test. Associations were tested with chi-square test or Fisher's exact test when appropriated. Prevalence ratio (PR) and 95% confidence intervals (CI) were estimated. Alpha of 0.05 was used to determine statistical significance.

## Results

From May 1 to October 31, 2017, 140 people responded to the online questionnaire. The range and median (IQR) of age are 18-64 and 27 (23-37) years. Forty-three percent of the respondents were young adult (18-25 years), with 33% adults (26-39 years), 23% middle age (40-59 years), and only 1% elderly ( $\geq 60$  years). Ninety-two (65.7%) respondents were female. One hundred and thirty-six respondents (97.1%) were from Thailand and four were foreigners (two Americans and two Taiwanese). The largest proportion of Thai participants were from Central (48.6%) and Southern (23.6%) Thailand. Allergic history were reported in 37 (26.4%) participants, 18.6% being respiratory allergy, 12.9% having skin allergy and 2.9% having eye allergy.

**Table 1. Characteristics of the participants (n = 140)**

Characteristics	Values
Age (median, IQR) (year)	27.0 (23.0-37.0)
Gender (female, %)	92 (65.7)
<b>Hometown, Origin</b> (count, %)	
Northern Thailand	13 (9.3)
Northeastern Thailand	22 (15.7)
Central Thailand	68 (48.6)
Southern Thailand	33 (23.6)
Others	
Taiwan	2 (1.4)
USA	2 (1.4)
<b>Ethnicity</b> (count, %)	
Thai	135 (96.5)
East Asian	2 (1.4)
Caucasian	2 (1.4)
Indian	1 (0.7)
<b>Allergic history and other medical history</b> (count, %)	
Allergic history	37 (26.4)
Skin allergy	18 (12.9)
Eye allergy	4 (2.9)
Respiratory allergy	26 (18.6)
Seafood allergy	13 (9.3)
Irritable bowel syndrome	10 (7.1)
Inflammatory bowel disease	0

**Table 2. Insect consumption behaviors among participants (n = 140)**

Characteristics	Values
<b>Sources of insects consumed</b> (count, %)	
Market	7 (5.0)
Convenient store	48 (34.2)
Street vendor	109 (77.9)
<b>Presentation of insect products</b> (count, %)	
Pre-package	50 (35.7)
Ready-to-eat cooked food	121 (86.4)
Raw insect for self-cooking	5 (3.6)
<b>Types of insects consumed</b> (count, %)	
Bamboo caterpillars	100 (71.4)
Cricket	68 (48.6)
Silkworm pupa	90 (64.3)
Giant water bug	25 (17.9)
Grasshopper	64 (45.7)
Scorpion	3 (2.1)
Spider	4 (2.9)
Dung beetle	3 (2.1)
Queen ant	1 (0.7)
Termite	3 (2.1)
Jewel beetle	1 (0.7)
<b>Reason of insect consumption</b> (count, %)	
Curiosity	96 (68.6)
Peer influence	38 (27.1)
Taste	83 (59.3)
Nutritional values	13 (9.3)
<b>Frequency of insect consumption</b> (count, %)	
Regularly (few times a week)	3 (2.1)
Often (few times a month)	14 (10.0)
Some times (few times a year)	43 (30.7)
Rarely, once	80 (57.1)

**Table 3. Symptoms after insect consumptions and clinical details (n = 140)**

Characteristics	Values
<b>Participants with allergic reactions</b> (count, %)	18 (12.9)
<b>Symptoms</b> (count, %)	
Skin rashes and pruritus	14 (10.0)
Wheezing or difficulty breathing	6 (4.3)
Rhinoconjunctivitis	22 (15.7)
Vomiting	14 (10.0)
Fainting	2 (1.4)
Headache or dizziness	18 (12.9)
Hypotension	2 (1.4)
<b>Cluster of people with allergic symptoms</b> (count, %)	9 (6.4)
<b>Onset of symptoms</b> (count, %)	
Less than 2 hours	20 (14.3)
2 to 10 hours	5 (3.6)
More than 10 hours	2 (1.4)
<b>Severe symptoms</b> (count, %)	4 (2.9)
<b>Insect associated with the allergic reactions</b> (count, %)	
Silkworm larva	8 (44.4)
Grasshopper	4 (22.2)
Cricket	3 (16.7)
Bamboo caterpillar	3 (16.7)
<b>Duration of symptoms</b> (count, %)	
Less than 1 hour	2 (11.1)
2-3 hours	6 (33.3)
Half a day	4 (22.2)
One day	3 (16.7)
More than one day	3 (16.7)
<b>Management for symptoms</b> (count, %)	
Self-medication	8 (44.4)
Sought medical care	10 (55.6)
Hospitalized	5 (27.8)

Thirteen (9.3%) participants reported seafood allergy (Table 1). Ten (7.1%) participants reported a history of irritable bowel syndrome and none reported inflammatory bowel. Most participants (77.9%) bought insect products from street vendors or convenient stores (34.2%). A small proportion (5.0%) bought their insects from the markets. Most insect products consumed by participants were from ready-to-eat, roadside stalls (86.4%), or as pre-packaged products (35.7%). The frequency of insect being consumed, from the highest to lowest, were bamboo caterpillar (71.4%), silkworm pupa (64.3%), cricket (48.6%), grasshopper (45.7%), giant water bug (17.9%), spider (2.9%), scorpion (2.1%), termite (2.1%), dung beetle (2.1%), jewel beetle (0.7%) and queen ant (0.7%). Most participants reported practicing entomophagy out of curiosity and rarely ate it more than once. Only 12.1% reported consuming insects at least few times a month and 13% reported eating insect for their nutritional values (Table 2).

Of the 140 participants, 114 (81.4%) reported having no symptom after insect consumption. And while 26 participants reported experiencing symptoms, 18 (12.9%; 95%CI 7.3-18.4) had self-reported symptoms that fit the classification for allergic reactions. Of those classified as having allergic reaction, 9 (6.4%) reported others who consumed insects from the same

**Table 4. Association of variables and allergic reactions after entomophagy (n = 140)**

Factors	Allergic symptoms (n = 18)	No allergic symptoms (n = 122)	PR (95% CI)	p value
Age (mean (standard deviation)) (year)	29.1 (9.1)	31.5 (11.1)	-	0.105
Female (count (%))	11 (61.1)	81 (66.4)	1.3 (0.45-3.5)	0.86
Allergic history (count (%))	11 (61.1)	26 (21.3)	4.83 (1.83-10.44)	0.001*
History of respiratory allergy (count (%))	8 (44.4)	18 (14.8)	3.51 (1.54-8.02)	0.007*
History of skin allergy (count (%))	5 (27.8)	13 (10.7)	2.61 (1.06-6.44)	0.043*
Seafood allergy (count (%))	5 (27.8)	8 (6.6)	3.76 (1.59-8.87)	0.014*
Irritable bowel syndrome (count (%))	2 (11.1)	8 (6.6)	1.62 (0.43-6.09)	0.834

PR, prevalence ratio; CI, confidence interval; \*  $p < 0.05$

**Table 5. Review of clinical features, allergic and medical history and cluster effects of reported cases of post-entomophagy allergic reactions in English publications**

Number of cases, Gender (age (years))	Allergic, medical history	Insect	Symptoms after ingestion	Onset (hours)	Cluster, cluster size	Treatment	Ref.
14 cases, 9 males, 5 females (20-54)	Allergic rhinitis	SP	A, AP, D, F, FS, H, HA, P, U, UC, V	0.5-4	No	HD epinephrine, IV hexadecadrol, IM Chlorphenamine, IV Cetacort	6
2 cases 2 Males, (18, 44)	Latent tuberculosis, hypertension	SP	F, FE, FS, H, U	1	Yes, 2	AI, IM, IV epinephrine, IV diphenhydramine	9
5 Cases (22-40)	Asthma, allergic rhinitis, urticarial, food allergy	VW	P, R, U	0.5-2	No	No information	4
118 cases (1-70)	No information	SP	B, C, CJ, DZ, F, FE, FV, MS, N, NM, P, T, U,	0.25-22	Yes, 118	IV fluid, antihistamines	7
27 cases (13-19)	None	SP, GH	BS, D, DR, Dz, HA, N, NM, P, V	0.5-7	Yes, 27 cases	IV chlorpheniramine, domperidone, nebulized salbutamol	5

A, angioedema; AI, autoinjector; AP, abdominal pain; B, blurred vision; BS, bronchospasm; C, chill; CJ, conjunctivitis; D, dyspnea; DR, diarrhea; DZ, dizziness; F, fainting; FE, facial edema; FS, flushed skin; FV, fever; GH, grasshopper; H, hypotension; HA, headache; HD, hypodermic injection; IM, intramuscular injection; IV, intravenous injection; MS, muscle spasm; N, nausea; NM, numbness; P, pruritus; R, rhinitis; SP, silkworm pupa; T, tremor; U, urticaria; UC, unconsciousness; V, vomiting; VW, vegetable worm

batch and had reactions as well. As a whole, symptoms being reported were skin rashes and pruritus (10.0%), wheeze and difficulty breathing (4.3%), rhinoconjunctivitis (5.7%), vomiting (10.0%), fainting (1.4%), headache and dizziness (12.9%) and hypotension (1.4%). And all participants with self-reported allergic reactions experienced these symptoms within 2 hours of ingesting the insects. The types of insects associated with allergic reaction were silkworm pupa, grasshopper, cricket and bamboo caterpillar. Duration of symptoms were mostly half a day or shorter. The majority of people who experienced the allergic symptoms sought medical care with 5 (27.8) being hospitalized (Table 3). Severe allergic reaction were found in 2 participants. Both of them were hospitalized and implicated silkworm pupae, crickets and grasshoppers as being the cause of the symptoms.

Age and gender were not associated with allergic symptoms after insect ingestion. Allergic symptoms after insect consumption were associated with a history of allergy (PR 4.83, 95%CI 1.83-10.44,  $p$  value 0.001), history of respiratory allergy (PR

3.51, 95%CI 1.54-8.02,  $p$  value 0.007), history of skin allergy (PR 2.61, 95%CI 1.06-6.44,  $p$  value 0.043) and history of seafood allergy (PR 3.76, 95%CI 1.59-8.87,  $p$  value 0.014). Association with eye allergy history was not analyzed because the number of cases was small (Table 4).

## Discussion

The population in our study is predominately from Central and Southern Thailand, are relatively young, and carries comparable prevalence of respiratory and skin allergy to those previously reported in predominantly young Thai adults by Uthaisangsook in 2007 and Vichyanond in 2002.<sup>15,16</sup> The majority of the study population consumes insects sporadically and infrequently, out of curiosity or peer influence.

Prior to our study, the only reported prevalence of insect allergy comes from Barennes et al in the Laos PDR where a randomized national survey is conducted on 1,099 participants who are insect consumers. In that study, 7.6% of people who consume insects experience allergic symptoms.<sup>1</sup> This is slightly



smaller than the 12.9% being reported in our study. The allergic reactions, and in severe cases, anaphylaxis-like symptoms reported by our subjects are very similar to those being reported in the literature (Table 5).<sup>4-7,9,17,18</sup> Ji et al in 2008 reported 1 case and reviewed 13 previously reported cases of anaphylaxis after silkworm pupae ingestion.<sup>6</sup>

It is significant that our study also exhibits the same cluster phenomenon seen in other studies elsewhere in the world.<sup>5,7,9</sup> Symptoms of allergy are reported in a cluster of 2 patients from the USA who have ingested silkworm pupae.<sup>9</sup> In Thailand, 2 separate patient clusters with severe allergic symptoms after insect ingestion exist, one involving 118 patients who have consumed silkworm pupae and the second involving 27 patients who have consumed silkworm pupae and grasshoppers.<sup>5,7</sup> Previously, only consumption of silkworm pupae, grasshoppers and vegetable worms have been associated with allergic reactions.<sup>4-7,9,17,18</sup> The types of insects being reported by this study, namely crickets and bamboo caterpillar, add to the armamentarium of possible insects which can cause allergic reactions.

Currently, there are two mechanisms that may explain the occurrence of allergic symptoms from entomophagy. Type 1 hypersensitivity to the allergen tropomyosin has been proposed in cases where workers develop allergic symptoms after exposure to the allergen in cricket farm or through recreational exposure to pet crickets.<sup>10,19,20</sup> Tropomyosin is a protein found in shrimp, crustaceans and dust mites and it is reported that these cricket-allergic patients also have hypersensitivity to shrimp, crustaceans and dust mites.<sup>19-22</sup> This mechanism can help explain the association between pre-existing allergic history and the development of allergic symptoms after entomophagy in our study. However, it does not fully explain why these allergic reactions happen in clusters.

On the other hand, poisoning from histamine contained in the insects can account for the occurrence of mass allergic reactions after consumption of silkworm pupae and grasshoppers. Histamine poisoning, known more widely as scombroid poisoning, is a well-described food-borne illness associated with fish consumption. Histamine, a heat-stable amine, can be produced through bacterial decarboxylation of histidine, an amino acid contained in meaty fish such as tuna.<sup>23</sup> Insects are postulated to cause histamine poisoning through a similar pathway.<sup>5,7</sup> In the 2 outbreaks of allergic reactions after consumption of insects in Thailand, toxic histamine concentrations are detected in the implicated insects for both outbreaks.<sup>5,7</sup> Additionally, in one of the outbreak reported by Chomchai et al., patients with severe symptoms are reported to have normal serum tryptase concentrations.<sup>5</sup> In an outbreak reported from the US, allergic reactions among a family members after consumption of the same batch of silkworm pupae are described as having symptoms of "familial anaphylaxis".<sup>9</sup> In particular, those members who are already sensitive to histamine from their underlying allergic disease may experience more severe symptoms. This serves to further highlight the theory that histamine intolerance, may play a role in the manifestation of allergic reaction in patients exposed to external histamine from food, as is also found in this study. Histamine intolerance is a condition that the body develops symptoms and signs because of imbalance between accumulated histamine and histamine degradation within the body. In one way, histamine

intolerance may be an overlapping condition with histamine poisoning. To account for this effect, our questionnaire intentionally include irritable bowel syndrome and inflammatory bowel disease in the medical history because these conditions may be associated with histamine intolerance.<sup>24</sup>

There are major limitations in this study. The subject number in our study is small, however this number fulfills the sample size requirements for both the association and prevalence study. The study is conducted using internet-based survey with self-reported allergic symptoms and convenient subject recruitment for feasibility reasons since patients with sicknesses after consumption of insects present sporadically to clinics and emergency departments all over Thailand. Thus, there are no specific institutions where case numbers would be large enough to obtain via a prospective study. The main limitations for such approach are generalizability, reliability and validity of the results.<sup>25</sup> Generalization of information obtained from internet-based questionnaire survey needs special precaution. People who respond to internet surveys are usually young, with ready access to the internet, are well-educated and are employed.<sup>26</sup> This is also true for our population. Thus, they represent more of the adventurous foodies who experiment with exotic foods rather than the typical traditional population in rural areas where entomophagy is a way of life. Therefore, these participants may not be representative of the general population who practice entomophagy. Data obtained from internet-based survey can also be associated with inaccuracies. The prevalence rate of a condition or disease obtained through internet-based survey tends to overestimate the true prevalence in the population. Likewise, people who have experienced allergic reactions after insect ingestion may be more likely to participate in the survey, thus leading to over-estimation of the prevalence in this case.<sup>27-30</sup> Although, the prevalence being reported here is well within range of previously reported number. Over-detection of cases with allergic symptoms may occur due to self-reported allergic symptoms without a confirmatory diagnosis by the physician.<sup>31</sup> Overall, these factors may result in overestimation of the prevalence of post-entomophagy allergic symptoms. We suggest that prevalence, cluster effects and factors associated with post-entomophagy allergic reactions should be further investigated by studies with larger sample sizes and more objective confirmation of allergic manifestations and risk factors for allergic reactions after insect ingestion.

## Conclusion

Allergic symptoms can be found with a significant prevalence in people who consume insects. People with allergic history, respiratory allergy, skin allergy and seafood allergy have higher risk of developing allergic symptoms from insect ingestion.

## Conflict of interest

The authors declare no conflict of interest.

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