Pongener *et al.*
Bulletin of the National Research Centre (2023) 47:90
https://doi.org/10.1186/s42269-023-01067-0

Bulletin of the National Research Centre

RESEARCH

Open Access

Tessaratoma javanica and *Coridius singhalanus* in the practice of entomophagy in Nagaland: an assessment of their nutritional quality

Anungla Pongener[1], Bendang Ao[1], Sarat Chandra Yenisetti[1] and Amar Deep Soren[2*]

Abstract

Background A survey was executed to estimate the extent of entomophagy practiced by the tribal population in Nagaland. From the survey, two consumed stink bugs, namely *Tessaratoma javanica* and *Coridius singhalanus*, were assessed. Nutrient contents were assessed following the AOAC guidelines and elements were quantised using ICP-OES.

Results About 55% of the people surveyed consumed *T. javanica*, and 49% were consumers of *C. singhalanus*. The survey also indicated that the non-consumer respondents did not have any aversion towards the consumption of these insects. Biochemical analysis revealed that except for carbohydrate and moisture contents, all the other evaluated parameters (ash, crude fats, crude protein, and fibre content) were found to be comparatively higher in *C. singhalanus*, although the difference was significant ($p \leq 0.05$) only for crude fat, carbohydrate, and fibre content. Trace elements analysis revealed that calcium (107.74 ± 0.213 mg/100 g), iron (22.17 ± 0.080 mg/100 g), and sodium (120.34 ± 0.214 mg/100 g) contents were significantly higher in *T. javanica*, whereas magnesium (76.06 ± 0.166 mg/100 g) content was significantly higher in *C. singhalanus*.

Conclusions Both the bugs show good nutritive contents and are liked for their distinctive smell and flavour.

Keywords *Coridius singhalanus*, Entomophagy, Nutrient, Stink bug, *Tessaratoma javanica*

Background

Entomophagy is practised globally with the highest reports from Asia, Africa, and Latin America (van Huis et al. 2022). Globally, about 2000 different insect species are consumed as food across 113 countries (Jongema 2017). With increasing global food crisis, entomophagy can be an alternative (Aung et al. 2023) as recommended by the United Nations (FAO 2012). Several studied edible insects revealed rich contents of nutrients, vitamins, and elements (Ogidi et al. 2023; Oonincx and Finke 2023). Besides, insects are also known to be used in therapy to treat various ailments (Devi et al. 2023).

Among Asian countries, India has a significant place in the practice of entomophagy. Entomophagy practiced by the Negrito tribes of the Andaman Islands was recorded by Sharief (2007). Prevalence of this practice is most prominent in north-east India where Ayekpam et al. (2014) documented about 46 species consumed by tribes of Manipur and a study from Nagaland mentioned 82 insects from 28 families of 9 orders (Mozhui et al. 2017). Likewise in Assam, Borah et al. (2020) described about 17 insects used as food by the people

*Correspondence:
Amar Deep Soren
amar4deep@gmail.com
[1] Department of Zoology, Nagaland University, Lumami, Nagaland 798627, India
[2] PG and Research Department of Zoology, B. Borooah College, Guwahati, Assam 781007, India

Fig. 1 *Tessaratoma javanica* (Thunberg, 1783)

Fig. 2 *Coridius singhalanus* (Distant, 1900)

of the upper Brahmaputra valley and entomophagy among the Meiteis in Manipur and the Khasis in Meghalaya was recorded by Meyer-Rochow (2004). In the eastern most state of Arunachal Pradesh, about 158 insect species have been reported to be edible (Chakravorty et al. 2011a, 2013).

In Nagaland, this practice is widely prevalent. This study was performed to garner information on the practice of entomophagy and also to evaluate the nutritional contents of two most commonly consumed hemipteran insects, namely *Tessaratoma javanica* (Thunberg, 1783) (Fig. 1) and *Coridius singhalanus* (Distant, 1900) (Fig. 2). *T. javanica* (Pentatomidae) inhabits areas where climatic conditions are hot (24–40 °C), whereas *C. singhalanus* (Dinidoridae) is usually present in dry riverbeds and their consumption can cause intoxication in its consumers. They are also reported to be eaten by the tribals in Arunachal Pradesh (Gogoi et al. 2017). These stink bugs release an emission when agitated which can be very painful when it enters the eyes. It may cause burn like wounds in the skin, and hence, precautions must be taken while collecting them. This secretion has been reported to be used in the treatment of warts (Pongener et al. 2019).

Methods

Survey

A survey was conducted in 4 districts of Nagaland, viz. Dimapur (25° 38′ 32.699" N and 93° 32′ 25.55″ E to 25° 58′ 26.294″ N and 94° 2′ 34.937″), Kohima (25° 31′ 4.275"N and 93° 53′ 38.711″ E to 26° 1′ 16.014″ N and 94° 18′ 1.962″ E), Mokokchung (26° 10′ 40.65″ N and 94° 17′ 22.32″ E to 26° 45′ 50.32″ N and 94° 45′ 30.30″ E) and Zunheboto (25° 43′ 51.26″ N and 94° 12′ 38.946″ E to 26° 17′ 37.223″ N and 94° 42′ 47.976″ E). Coordinates were obtained from the Nagaland GIS and Remote Sensing Centre, Planning and Coordination Department, Kohima.

To carry out the investigation, photographs of *T. javanica* and *C. singhalanus* along with a semi-structured questionnaire were used. Photographs were shown to the respondents for easy identification so that precise information on the specific insect could be retrieved. The questionnaire was used to accumulate information about occurrence, vernacular names, habit and habitat, parts consumed, preparation, harvesting methods, and presumed nutritive and therapeutic values. Collection of insects from forests and local markets was assisted by locals and informants. Data were collected from 500 respondents mostly comprising of elderly persons with profound knowledge and experience in insect use. Accordingly, respondents were divided into three categories, namely frequent consumers (FC), infrequent consumer (IC), and non-consumers (NC). The insects were identified by an insect taxonomist, published keys (Atkinman 1974; Ghosh 2008; Hassan et al. 2014; Parveen et al. 2015) and published manuscripts (Mathew 1988; Distant 1902; Gogoi et al. 2017).

Nutrient analysis

The collected insects were washed and dried (55 °C) by placing them in a hot air oven for 3 days. The appendages, wings, and exoskeletal parts were detached, powdered, and then kept in airtight container at − 30 °C. The analyses were carried out in triplicate, and resulting data were converted to g/100 g. Nutrient analysis was evaluated as per the AOAC (2005) guidelines and formula.

For moisture content, dried sample (3 g) was heated in an oven (105 °C for 3 h), cooled, and weighted. Likewise, for ash content, an empty silica crucible was heated (600 °C for 12 h) and cooled and the initial weight was noted following which sample (2 g) was placed, heated (600 °C for 6 h), cooled, and weighed. For determination of crude protein, Kjeldhal method was carried out to first estimate the nitrogen content from which the protein content was quantified using a conversion factor of 6.25. For estimation of crude fibre, dried insect samples were initially digested using 1.25% sulphuric acid, filtered and washed, and later digested with 1.25% sodium hydroxide, filtered, washed, dried, and ignited. For crude fat estimation, 5 g of the sample was extracted in Soxhlet apparatus for 6 h using petroleum ether. Finally, the carbohydrate content was evaluated using the difference method (James 1995).

Determination of minerals

Minerals were determined using inductively coupled plasma optical emission spectrometry (ICP-OES) (Model: iCAP™0.7600ICP-OES), at SAIF, NEHU, Shillong, India. Samples were digested with nitric acid and the results were converted to mg/100 g.

Statistical analysis

The experimental results were analysed using ANOVA and expressed as mean of three replicates ± standard error of mean. Results were considered to be significantly different at p value ≤ 0.05.

Results

Survey

Tessaratoma javanica is usually consumed raw or roasted to make a chutney. They are collected from stems and leaves of lychee trees, whereas *C. singhalanus* are hand-collected from under the rocks on wet riverbeds. They are washed with cold water to kill it and to remove the chemicals secreted by them. These insects are eaten either fried or sometimes mixed with chutney. Another traditional method the tribals use is pounding the insects resulting in a liquid concentrate which is for flavouring other dishes. These cleaning, handling, and processing techniques for preservation are likely to influence the nutritional value and safety properties of the insects.

Though consumption is popular among the consumers with 55% and 49% for *T. javanica* and *C. singhalanus*, a large percentage, i.e. 45% and 51% of the tribals, do not consume them, respectively. The reasons include seasonal and market availability of the insects. They are foraged from their habitats only for personal consumption. Owing to the strong smell from these bugs, they are not used as food in several families. About 66% of the respondents were aware that *T. javanica* is used as a food. It was also reported during the survey that the chemicals secreted by the stinkbugs have therapeutic uses. About 81% of the respondents were aware about the use of *C. singhalanus* as food. Individuals who were aware of the value of these insects as food and medicine (FM) eclipse the percentage of consumers indicating that non-consumers (NC) are no strangers to these insects, and as evident, there is no averseness (Table 1). Both stink bugs are considered as delicacies as they are thought to have high fat content. They also have a distinct smell which is addictive as reported by the consumers making them to consume the insect more.

Nutrient contents

The carbohydrate (33.51 ± 0.056%) and moisture (3.72 ± 0.400%) contents in *T. javanica* were found to be higher than *C. singhalanus* (12.85 ± 0.180% and 6.54 ± 0.280%, respectively). On the contrary, protein (29.82 ± 0.230%), fat (43.64 ± 0.270%), ash (2.87 ± 0.280%), and fibre (7.1 ± 0.200%) contents in *C. singhalanus* were higher compared to *T. javanica* (13.13 ± 0.270%, 37.65 ± 0.062%, 2.47 ± 0.044%, and 6.7 ± 0.156%, respectively). The proximate contents are described in Table 2.

Mineral contents

Mg (76.06 ± 0.166 mg/100 g) was found in higher amounts in *C. singhalanus*, whereas Ca (107.74 ± 0.213 mg/100 g), Cu (8.18 ± 0.012 mg/100 g), K (106.78 ± 0.086 mg/100 g), and Zn (19.63 ± 0.019 mg/100 g) were found in higher amounts in *T. javanica*. Trace amount of Pb was found in

Table 1 Data collected during the survey

Scientific name	Common name	Vernacular name	Availability	Edible parts	Preparation	FC (%)	IC (%)	NC (%)	FM (%)
Tessaratoma javanica	Lychee Stink Bug	Ao: Tsüknü/ Tsüngi Sumi: Akhano/ Michika	Nov–Feb, Jun–Sep	Whole Body	Dried, Fried, Chutney	20	35	45	66
Coridius singhalanus	Stink Bug	Ao: Bholo Angami—Poluo Sumi: Akhano	Dec–Feb	Whole Body	Fried, Chutney, Fermented	17	32	51	81

FC frequent consumers, *IC* Infrequent consumers, *NC* non-consumers, *FM* consumers aware of food or medicinal value of the insect

Table 2 Proximate analysis (g/100 g dry weight)

	T. javanica	*C. singhalanus*
Ash (%)	2.47 ± 0.044	2.87 ± 0.280
Protein (%)	13.13 ± 0.270	29.82 ± 0.230
Fat (%)	37.65 ± 0.060*	43.64 ± 0.270*
Moisture (%)	6.54 ± 0.280	3.72 ± 0.400
Carbohydrate (%)	33.51 ± 0.056*	12.85 ± 0.180*
Fibre (%)	6.7 ± 0.156*	7.1 ± 0.200*

Data expressed as mean of 3 replicates ± standard error of mean

*The values are significant with their corresponding value at $p \leq 0.05$

Table 3 Mineral contents (mg/100 g of dry weight)

	T. javanica	*C. singhalanus*	Recommended intake for 25 year old male (mg/day)**
Fe	22.17 ± 0.080*	7.09 ± 0.082*	8
Ca	107.74 ± 0.213*	75.17 ± 0.195*	1000
Cu	8.18 ± 0.012	4.28 ± 0.017	0.9
Mg	27.29 ± 0.112*	76.06 ± 0.166*	400
K	106.78 ± 0.086	105.01 ± 0.116	4700
Na	120.34 ± 0.214*	70.20 ± 0.002*	1500
Zn	19.63 ± 0.019	7.65 ± 0.018	11
Pb	0.011 ± 0.008	0.011 ± 0.004	–

Data are expressed as mean of 3 replicates ± standard error of mean

*The values are significant with their corresponding value at $p \leq 0.05$

**DRIs (Dietary reference intakes): recommended dietary allowances and adequate intakes, minerals, Food and Nutrition Board, Institute of Medicine, National Academies

equal concentration in both the studied insects. The contents of essential elements are described in Table 3.

Discussion

The state of Nagaland in India is no stranger to entomophagy where it has been practiced since ancient times as revealed during the survey. It is usually the nutritional properties that motivate them to consume these insects which was also reported in a similar study in Myanmar (Aung et al. 2023). On the contrary, these nutritional aspects did not influence the consumption of insects in a similar study in the Danish population (Erhard et al. 2023). As seen in other communities as well (Aung et al. 2023), entomophagy is a part of the Naga lifestyle. Estimation of the nutritional properties of the insects is essential to determine its value in the diet and also to propose it as a substitute to other costly or unavailable foods.

Consumption of some insects could be toxic resulting in allergy (Papastavropoulou et al. 2022). Mpuchane et al. (2000) showed that consumption of male mopane worm causes an intoxicating reaction leading to headache, drowsiness, fever and ultimately vomiting. Similarly, a psychiatric disorder and seasonal ataxia caused by consumption of *Aspongopus nepalensis* was reported by Chakravorty et al., (2011b). When such symptoms are reported after consumption, some anti-allergic local medicines called *tangmo (Rhus semialata*), garlic or Avil tablet are taken as a cure (Pongener et al. 2019).

Insects are known to possess high nutritive contents and hence, several workers have carried out similar studies. Teffo et al. (2007) reported higher values of crude protein (35.2 g) and crude fats (50.5 g) and lesser content of carbohydrates (7.63 g) in *Encosternum delegorguei*. Similarly, Chakravorty et al. (2011b) recorded a value of 10.6 ± 0.6 g crude protein and 38.4 ± 1.1 g crude fat in *A. nepalensis.* They also recorded crude fibre with a value of 33.5 ± 1.1 g. In this study, *T. javanica* and *C. singhalanus* showed ash content of 2.47 ± 0.044 g and 2.87 ± 0.28 g, respectively, which was a little higher compared to the values obtained by the recorded value of 1.7 g by Teffo et al. (2007) and 2.2 ± 0.2 g by Chakravorty et al. (2011b). Soren et al. (2021) also reported high content of similar nutrients in *Tarbinskiellus portentosus* and *Schizodactylus monstrosus*.

Knowledge of mineral contents is essential and has been evaluated by several authors. Soren et al. (2021) reported high Mg in *T. portentosus* and *S. monstrosus*, whereas other minerals, namely K, Na, Ca, Mn, Cu, Fe, Zn, and B, were found in moderate quantities. Interestingly, they also reported the presence of toxic elements (As, Pb, and Cd) in them, which could serve as indicators of pollution or anthropogenic activities. Likewise, Choudhury et al. (2020) also assessed silk moth and diving beetle and reported high Mg, Na, Ca, Mg, Na, and K contents.

Conclusions

Insects are a major food source for people in countries with a large rural population. They act as an alternate source of food since they are cheap and easily available. This study also validates the use of *T. javanica* and *C. singhalanus* as food by the Naga tribe in Nagaland since they have shown to be rich in nutrient and mineral contents as evident by this study. Since insects are consumed widely, estimation of their proximate and mineral content is necessary.

Abbreviations

ANOVA Analysis of variance
AOAC Association of Official Agricultural Chemists
ICP-OES Inductively coupled plasma optical emission spectrometry

Acknowledgements

The authors acknowledge the staff at SAIF, NEHU for the metal analysis and also the Nagaland GIS and Remote Sensing Centre, Kohima, for providing

the geographical coordinates of the districts and the Nagaland Public Health Laboratory, Medical Department, Government of Nagaland, for the nitrogen content estimation. The authors also sincerely thank all the respondents from the four districts who cooperated and provided information about the insects' traditional uses and consumption habits.

Author contributions
BA and SCY conceptualised and supervised the study. AP carried out the analysis and ADS analysed the data. AP and ADS wrote the first draft. BA and SCY finalised the draft. All authors read and approved the manuscript.

Funding
This study did not receive any funding.

Availability of data and materials
All generated data are available in this manuscript.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
All the authors declare that they have no conflict of interests.

Received: 1 May 2023 Accepted: 17 June 2023
Published online: 26 June 2023

References

AOAC (2005) Official Method of Analysis, Method 920.39. Fat (crude) or ether extract in animal feed. (18th ed). AOAC International, Gaithersburg, MD
Atkinman ET (1974) Fauna of Himalaya. Cosmos Publications, Delhi
Aung MTT, Dürr J, Borgemeister C, Börner J (2023) Factors affecting consumption of edible insects as food: entomophagy in Myanmar. J Insects Food Feed. https://doi.org/10.3920/JIFF2022.0151
Ayekpam N, Singh NI, Singh TK (2014) Edible and medicinal insects of Manipur. Indian J Entomol 76:256–259
Borah S, Boruah A, Sonowal P, Bora D (2020) A study on prevalence of the practice of entomophagy in Upper Brahmaputra Valley of Assam, North-East India. J Entomol Res 44(1):135–140. https://doi.org/10.5958/0974-4576.2020.00025
Chakravorty J, Ghosh S, Meyer-Rochow VB (2011a) Practices of entomophagy and entomotherapy by members of the Nyishi and Galo tribes, two ethnic groups of the state of Arunachal Pradesh (North-East India). J Ethnobiol Ethnomed 7:5. https://doi.org/10.1186/1746-4269-7-5
Chakravorty J, Ghosh S, Meyer-Rochow VB (2011b) Chemical composition of *Aspongopus nepalensis* Westwood 1837 (Hemiptera; Pentatomidae), a common food insect of tribal people in Arunachal Pradesh (India). Int J Vitam Nutr Res 81(1):49–56. https://doi.org/10.1024/0300-9831/a000050
Chakravorty J, Ghosh S, Meyer-Rochow VB (2013) Comparative survey of entomophagy and entomotherapeutic practices in six tribes of eastern Arunachal Pradesh (India). J Ethnobiol Ethnomed 9:50. https://doi.org/10.1186/1746-4269-9-50
Choudhury K, Sarma D, Sapruna PJ, Soren AD (2020) Proximate and mineral compositions of *Samia cynthia ricini* and *Dytiscus marginalis*, commonly consumed by the Bodo tribe in Assam, India. Bull Natl Res Cent 44:152. https://doi.org/10.1186/s42269-020-00411-y
Devi WD, Bonysana R, Kapesa K, Mukherjee PK, Rajashekar Y (2023) Edible insects: as traditional medicine for human wellness. Future Foods 7:100219. https://doi.org/10.1016/j.fufo.2023.100219
Distant WL (1902) The fauna of British India, Ceylon and Burma. Rhynchota vol 1 (Heteroptera). Taylor and Francis, London, pp 257–285
Erhard AL, Silva MA, Damsbo-Svendsen M, Karpantschof BM, Sørensen H, Frøst MB (2023) Acceptance of insect foods among Danish children: Effects of information provision, food neophobia, disgust sensitivity, and species on willingness to try. Food Qual Prefer 104:104713. https://doi.org/10.1016/j.foodqual.2022.104713
FAO (2012) Assessing the potential of insects as food and feed in assuring food security. Presented at Tech Consult Meet, 23–25 January, FAO, Rome, Italy
Ghosh LK (2008) Handbook on Hemipteran pests in India. Zoological Survey of India, Kolkata
Gogoi H, Moyong B, Sonia K, Umbrey C (2017) Species of Tari in Arunachal Pradesh: morphology, ecology and toxicity of entomophagy. J Bioresour 4(2):50–57
Hassan ME, Chandra K, Biswas B (2014) Report of litchi stink bug, *Tessaratoma javanica* (Hemiptera: Tessaratomidae) on mahua tree in Chhattisgarh. Rec Zool Surv India 114(Part-2):263–268
James CS (1995) Analytical chemistry of foods. Chapman and Hall, New York
Jongema Y. List of edible insects of the world. www.wur.nl/en/Expertise-Services/Chairgroups/Plant-Sciences/Laboratory-of-Entomology/Edible-insects/Worldwide-species-list.htm. Accessed 1 September 2021 (2017).
Mathew K (1988) Tymphanal organs of pentatomidae (Hemiptera). Rec Zool Surv India 85(3):459–461
Meyer-Rochow VB (2004) Traditional food insects and spiders in several ethnic groups of Northeast India, Papua New Guinea, Australia, and New Zealand. In: Paoletti MG (ed) Ecological implications of mini-livestock: rodents, frogs, snails, and insects for sustainable development. Science Publishers Inc., USA, pp 385–409
Mozhui L, KakatiChangkija LNS (2017) A study on the use of insects as food in seven tribal communities in Nagaland, Northeast India. J Hum Ecol 60(1):42–53. https://doi.org/10.1080/09709274.2017.1399632
Mpuchane S, Gashe BA, Allotey J, Siame B, Teferra G, Dithlogo M (2000) Quality deterioration of phane, the edible caterpillar of an emperor moth *Imbrasia belina*. Food Control 11(6):453–458. https://doi.org/10.1016/S0956-7135(00)00010-4
Ogidi CO, Ogunlade AO, Bodunde RS, Aladejana OM (2023) Evaluation of nutrient contents and antioxidant activity of wheat cookies fortified with mushroom (*Termitomyces robustus*) and edible insects. J Culin Sci Technol. https://doi.org/10.1080/15428052.2023.2181253
Oonincx DGAB, Finke MD (2023) Insects as a complete nutritional source. J Insects Food Feed 9(5):541–543. https://doi.org/10.3920/JIFF2023.x002
Papastavropoulou K, Xiao J, Proestos C (2022) Edible insects: tendency or necessity (a review). eFood 4(1):e58. https://doi.org/10.1002/efd2.58
Parveen S, Choudhury JS, Thomas A, Ramamurthy VV (2015) Biology, morphology and DNA barcodes of *Tessaratoma javanica* (Thunberg) (Hemiptera: Tessaratomidae. Zootaxa 3936(2):261–271. https://doi.org/10.11646/zootaxa.3936.2.6
Pongener A, Ao B, Yenisetti SC, Lal P (2019) Ethnozoology and entomophagy of Ao tribe in the district of Mokokchung, Nagaland Indian. J Tradit Knowl 18(3):508–515
Sharief MU (2007) Plants folk medicine of Negrito tribes of Bay Islands. Indian J Tradit Knowl 6:468–476
Soren AD, Choudhury K, Sapruna PJ, Sarma D (2021) Nutrient and toxic heavy metal assessment of *Tarbinskiellus portentosus* and *Schizodactylus monstrosus* consumed by the Bodo tribe in Assam, India. Int J Trop Insect Sci 41:2001–2006. https://doi.org/10.1007/s42690-021-00439-1
Teffo LS, Toms RB, Eloff JN (2007) Preliminary data on the nutritional composition of the edible stink-bug, *Encosternum delegorguei* Spinola, consumed in Limpopo province, South Africa. S Afr J Sci 103:434–436
van Huis A, Halloran A, Van Itterbeeck J, Klunder H, Vantomme P (2022) How many people on our planet eat insects: 2 billion? J Insects Food Feed 8(1):1–4. https://doi.org/10.3920/JIFF2021.x010

Publisher's Note