

Determination of selected minerals and antioxidant properties of six edible aquatic insect species of Bajali region, Assam, India

Arundhati Gogoi*, Arnabjan GK Kashyap and Daisy Sarma

Department of Zoology, Bhattadev University, Pathsala:781325, Assam, India.
Email: arundhatigogoi27@gmail.com*

ABSTRACT: This work aims to fill the gap by determining the mineral composition and antioxidant properties of selected six commonly available edible aquatic insect species. *Lethocerus indicus* (Lepeletier and Serville, 1825), *Diplonychus rusticus* (Fabricius, 1781), *Laccotrephes ruber* (Linnaeus, 1764), *Cybister tripunctatus* (Olivier, 1795), *Hydrophilus olivaceus* (Fabricius, 1781) and *Sympetrum* sp. (Newman, 1833) were sampled from different freshwater bodies located within the Bajali region of Assam, India. Quantitative analysis of selected minerals (Ca, Mg, Fe, Mn, Zn and Cu) alongside with the evaluation of antioxidant properties (total phenol and total flavonoid content) were assessed. The results showed that among all the selected insect species, *L. ruber* showed the maximum amount of Ca content (58.23 mg 100g⁻¹). *H. olivaceus* showed the maximum amount of Mg (80.25 mg 100g⁻¹), while *L. indicus* showed the highest Fe content (98.36 mg 100g⁻¹), *H. olivaceus* showed highest Zn (mg 100g⁻¹) and *C. tripunctatus* showed highest amount of Cu content (5.28 mg 100g⁻¹). Total phenolic content ranged 102 to 152.30 mg 100g⁻¹ and total flavonoid content ranged from 28.79 to 53.52 mg 100g⁻¹. The current findings highlight that the selected aquatic insects are promising resource for food and feed, contributing to improved nutrition, food security and livelihood generation in this region. © 2026 Association for Advancement of Entomology

KEY WORDS: Biochemical, entomophagy, nutrition, food and feed

INTRODUCTION

Entomophagy practice in the world has been passing through since ancient times. From delicacy to lack of other food availability, entomophagy practices have always been supporting the people. Globally, people mostly consume insect species of orders Isoptera, Lepidoptera, Orthoptera, and Hymenoptera (Van Huis, 2013). These insects are consumed as a delicacy or substitute for food, used during periods of droughts, scarcity, or floods

(Sutton, 1988; De Foliart, 1992; Adedire and Aiyesanmi, 1999; Vantomme *et al.*, 2013). However, some societies recognize entomophagy as culturally inappropriate or as disgusting, especially in urban areas (Van Huis *et al.*, 2013). Despite some societal perception, insects are gaining recognition as a food source of high nutritional value. The Entomophagy practice has been proposed to fight with the deficiencies of minerals in developing countries (Christensen *et al.*, 2006). For instance, the approximately 3.5 billion

* Author for correspondence

global populations are at risk of Calcium deficiency (Mohammed and Wimalawansa, 2025), along with that, 23.2 per cent suffer from iron deficiency, 15.3 per cent suffer from zinc deficiency, 8.7 per cent suffer from copper deficiency and 0.4 per cent suffer from magnesium deficiency (Albalawi *et al.*, 2022).

Minerals are usually divided into two classes based on amount to meet dietary requirements. The first class is macro-minerals such as calcium, magnesium etc. and the second class is micro or trace minerals such as zinc, copper, iron, manganese, etc. (Oonincx and Finke, 2021). It is identified that insects potentially provide a large amount of micro and macro minerals such as Ca, Mg, Zn, Cu, Fe and Mn (Latunde-Dada *et al.*, 2016). Edible insects are also rich in anti-oxidant properties such as phenol and flavonoid (Shantibala *et al.*, 2014). Recent development shows an increase of use of the natural and synthetic antioxidants in nutritional supplements as a functional food (Rietjens *et al.*, 2002). Antioxidants are compounds which protect cells from the oxidative stress produced by free radicals, which are some unstable molecules and can harm cells that lead to development of chronic diseases and aging (Erhirhie and Paul, 2019). In the present study, we tried to record a good amount of minerals in some commonly available edible aquatic insect species consumed by the Bodo community of Bajali region of Assam, India. The basic mineral analysis along with their anti-oxidant properties were carried out to explore their potential role in enhancing the food security of this region. By doing so, the study aims to fill up the knowledge gap related to nutritional value of edible insects of this region.

MATERIALS AND METHODS

The current study was carried out from August 2024 to September 2025. Six edible aquatic insect species, viz., *Lethocerus indicus* (Lepeletier and Serville, 1825), *Diplonychus rusticus* (Fabricius, 1781), *Laccotrephes ruber* (Linnaeus, 1764), *Cybister tripunctatus* (Olivier, 1795), *Hydrophilus olivaceus* (Fabricius, 1781) and *Sympetrum* sp. (nymph) (Newman, 1833) respectively were

chosen for the present study. These insects were selected based on their availability and consumption by the local communities of this region. The sampling sites for this aquatic insect's collection were randomly selected from various freshwater bodies of Bajali district (26.5439°N; 91.1870°E). These insects were collected using the "1 minute kick net method" (Brittian, 1974) where the vegetation was disturbed and the net was dragged through the system for a unit of time (Macan and Maudsley, 1968). Three such drags constitute a sample. The aquatic insect species were identified with the help of standard taxonomic keys and further killed and processed following standard methods (Singh and Sachan, 2006). For biochemical analysis, the insect powders were preserved in sealed plastic containers.

Analysis of mineral composition: Ca, Mg, Fe, Mn, Zn and Cu were analyzed by following the methodology of Perkin Elmer (1996). At room temperature, the samples were digested with nitric acid (HNO₃) and perchloric acid (HClO₄) in the 2:1 ratio, filtered with distilled water, and made up to a final volume of 50ml, and then the filtrate was analyzed by ZEE nit700P Atomic Absorption Spectroscopy (AAS).

Analysis of antioxidant properties: Flavonoid content of the methanolic extract of the sample (1 mg ml⁻¹) was analysed spectrophotometrically following the modified protocol (Nooman *et al.*, 2008; Stankovic *et al.*, 2014; Martínez-Morales *et al.*, 2020).

All the experiments were conducted in triplicate. The statistical data was obtained using MS Excel. The values were expressed as mean ± standard deviation of three replicates. One- way ANOVA was performed using SPSS software version 25 to check the significant differences in their mineral and antioxidant content between the insect samples at 5 per cent level.

RESULTS AND DISCUSSION

Mineral assessment: Among the aquatic edible insects analyzed for six minerals, *L. ruber* had the highest amount of Ca content (58.23 mg100g⁻¹)

followed by *L. indicus* (49.33 mg100g⁻¹), *D. rusticus* (41.82 mg100g⁻¹), *C. tripunctatus* (40.45 mg100g⁻¹), *H. olivaceus* (38.71 mg100g⁻¹) and *Sympetrum* sp. (30.75 mg100g⁻¹). While *H. olivaceus* showed the maximum amount of Mg (80.25 mg100g⁻¹), Fe (101.96 mg100g⁻¹) and Zn (11 mg100g⁻¹). In contrast *D. rusticus* exhibited the highest Mn (5.45 mg100g⁻¹) content among all the species. *C. Tripunctatus* showed the highest content in Cu (5.28 mg100g⁻¹) among all. Studies have shown that all the mineral composition in the aquatic edible insect species were found to display considerable variation from one another at the 5% level of one-way ANOVA.

Analyzing edible insect's mineral content is crucial, since it informs consumers about the quality and quantity of nutrients they are consuming. The body cannot synthesize minerals; thus, a daily intake is necessary to sustain a number of physiological and biochemical functions (Soetan *et al.*, 2010). These trends are compatible with earlier work showing that insect mineral content varies widely by species, developmental stage, and ecological conditions (Oonincx and Finke, 2021; Sarmah *et al.*, 2022). The particularly high Fe and Zn levels in *H. olivaceus* are of nutritional relevance given that iron and zinc deficiencies remain global public health challenges (Hess *et al.*, 2023; Latunde-Dada, 2024). Likewise, the elevated Ca in *L. ruber* highlights its potential role in supporting bone health,

though the bioavailability of insects-derived Ca may be influenced by the chitinous exoskeleton (Ojha *et al.*, 2021). The amount of Ca content in the present study (30.74 to 58.23 mg 100g⁻¹) is relevant with the results of Shantibala *et al.* (2014) and Sarmah *et al.* (2022), which ranged from 24.3 to 96 and 32.09 to 56.15 mg 100g⁻¹, respectively. In comparison to terrestrial insects, aquatic insects have a significantly higher Ca content (Adeduntan, 2005). As Ca is important for bone health, aquatic insects can serve as a great source. The current study's Mg content ranged from 38.30 to 80.25 mg 100g⁻¹, which is comparable to the range of 33.6 to 99 mg 100g⁻¹ found in Manipur's aquatic insects (Shantibala *et al.*, 2014). Banjo *et al.* (2006) reported lower Mg levels (0.09 to 8.2 mg 100g⁻¹) compared to the present investigation. Mg is associated with the regulation of numerous vital processes such as blood pressure, glycemic control and neuromuscular function (Bertinato *et al.*, 2015; Grober *et al.*, 2015). The Fe content of the present analysis is compatible with the aquatic insects ranging from 25.30 to 112.10 mg 100g⁻¹ (Sarmah *et al.*, 2022). Identical results were detected in Manipur (Shantibala *et al.*, 2014). In comparison to red meats, insects are superior source of iron (Williams, 2007). From the current analysis the amount of Mn, Zn and Cu were found to be present in a lesser amount than the other minerals. The concentration of Mn identified in the present study is very low. Higher Mn contents were detected in

Table 1. Mineral composition of six edible aquatic insect species (mg 100 g⁻¹).

Insect species	Ca	Mg	Fe	Mn	Zn	Cu
<i>Lethocerus indicus</i>	49.33 ± 0.95	65.34 ± 2.63	98.36 ± 0.96	2.97 ± 0.36	10.77 ± 0.78	2.18 ± 0.15
<i>Diplonychus rusticus</i>	41.82 ± 0.92	40.74 ± 0.56	76.29 ± 2.45	5.46 ± 0.38	8.73 ± 0.52	3.32 ± 0.74
<i>Laccotrephes ruber</i>	58.23 ± 0.32	51.18 ± 3.55	89.74 ± 2.37	3.06 ± 0.73	7.82 ± 0.56	2.67 ± 0.29
<i>Cybister tripunctatus</i>	40.45 ± 0.22	38.30 ± 1.50	33.24 ± 0.24	4.26 ± 0.28	6.57 ± 0.48	5.28 ± 1.00
<i>Hydrophilus olivaceus</i>	38.71 ± 1.78	80.25 ± 0.11	101.96 ± 1.14	3.42 ± 0.21	11.00 ± 0.67	1.71 ± 0.99
<i>Sympetrum</i> sp. (Nymph)	30.75 ± 0.75	40.31 ± 1.74	19.74 ± 0.26	2.37 ± 0.36	1.08 ± 0.15	1.90 ± 0.10

Data represents mean ± SD of three replicates; p < 0.05 significant difference present among species

Table 2. Phenol and flavonoid content of six edible insect species (mg 100 g⁻¹).

Species	Phenol	Flavonoid
<i>Lethocerus indicus</i>	125.23±2.36	53.52±1.18
<i>Diplonychus rusticus</i>	152.30±2.18	40.36±0.80
<i>Laccotrephes ruber</i>	108.20±1.35	33.46±0.63
<i>Cybister tripunctatus</i>	208.06±0.98	45.21±0.76
<i>Hydrophilus olivaceus</i>	118.60±1.42	28.79±3.02
<i>Sympetrum</i> sp. (Nymph)	102.20±1.00	30.13±2.29

Data represents mean ± S.D of three replicates; $p < 0.05$ significant difference present among species

sundried edible black ants (Bhulaidok *et al.*, 2010). Zn is instrumental in preserving the stability of genetic material and regulating gene activity, as it participates in processes such as DNA transcription, chromatin organization, replication and repair (Dreosti, 2001). The Zn concentration levels in this investigation fall comfortably within the FAO (2001) mean range of 0.22-2.10 mg 100g⁻¹. The Zn content from the present study ranged from 1.08 to 11mg/100 g is uniform with the earlier findings, 4.98 to 7.22 mg 100g⁻¹ (Sarmah *et al.*, 2022). A higher amount for Zn was detected in Manipur (Shantibala *et al.*, 2014). A higher Zn content was reported in previous researches on terrestrial edible insects that ranged from 11.9 to 22.7 mg 100g⁻¹ (Bhulaidok *et al.*, 2010).

Antioxidant properties: In the current analysis, the *C. tripunctatus* displayed the highest phenol content (208.06 mg 100g⁻¹). The highest amount of flavonoid content (53.52 mg 100g⁻¹) was noted in *L. indicus*. In all the aquatic insect species, the antioxidant properties have demonstrated a notable variation. A high amount of phenol can have critical health effects, including decreased fertility, decreased young survival rate, growth inhibition (Babich and Davis, 1981). According to ATSDR (Agency for Toxic Substances and Disease Registry), 2008, adults require a minimal lethal oral dose of phenol of about 70 mg kg⁻¹. The phenol content from the current study is less than the lethal

dose. So, consumption of these edible aquatic insects is safe. Flavonoids play a significant role in regulating cell cycle, inducing apoptosis, and inhibiting the growth of cancer cells (Rue *et al.*, 2018). The current results are pertinent with the earlier findings, with phenol content ranging 117.39 to 363.80 mg 100g⁻¹ and flavonoid ranging from 17.70 to 50.82 mg100g⁻¹ (Sarmah *et al.*, 2022). Recent reports revealed differences in the content of phenolics and flavonoids in insects and were associated with diet, habitat, processing technology and are progressively being acknowledged for their bioactive and antioxidant characterization (Torres-Castillo and Olazarán-Santibáñez, 2023; Ruiz *et al.*, 2025). Additionally, insect-derived edible items have been found to retain phenolics bio-accessibility during digestion, contributing measurable antioxidant activity (Rocchetti *et al.*, 2024). These edible aquatic insects exhibit significant mineral and antioxidant activity, highlighting their potential as valuable food sources. In order to promote both environmental balance and nutritional well-being, it is imperative that these insects be conserved and used sustainably as alternate food sources. The inclusion of these insects in wider dietary and health-related applications is supported by this study, which also lays the groundwork for more thorough biochemical studies. Ensuring their conservation and sustainable management is essential to maximizing their micronutrient potential. The results also serve as valuable information for the local communities of Bajali region of Assam enhancing awareness of the dietary and health benefits associated with insect consumption. Future studies should concentrate on establishing standardized processing methods to maintain nutritional quality, evaluating environmental sustainability, and evaluating nutrient bioaccessibility using in vitro and in vivo digestion models. Food security and resilience could be significantly enhanced by raising public awareness and incorporating edible aquatic insects into nutritional policies.

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