

Lamellidens Marginalis: An Integrative Review on Its Ecological Importance, Nutritional Values and Ethno Medicinal Importance

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Abstract—*Lamellidens marginalis*, a freshwater bivalve widely distributed across South and Southeast Asia, plays very crucial ecological, nutritional, and ethnomedicinal roles. As an efficient filter feeder, it contributes significant role on to water purification, nutrient cycling and the maintenance of freshwater biodiversity. Nutritionally, *L. marginalis* is a rich source of high-quality protein, essential amino acids, minerals and bioactive compounds, making it an important dietary component in many rural communities. Ethnomedicinally, various parts of the mussel have been traditionally used for treating inflammatory disorders, bone ailments, reproductive issues and microbial infections. Emerging evidence supports the therapeutic potential of its bioactive peptides, polysaccharides and mineral fractions. This review synthesizes existing literature on the ecological functions, nutritional attributes and ethnomedicinal applications of *L. marginalis* while highlighting research gaps and future directions for its sustainable utilization.

Index Terms—*Lamellidens marginalis*; freshwater mussel; ecological importance; nutritional value; ethnomedicine; bioactive compounds; ecosystem services; sustainable utilization.

I. INTRODUCTION

Freshwater ecosystems are among the most threatened biomes globally, experiencing rapid degradation due to pollution, eutrophication, habitat fragmentation, invasive species, and climate-driven hydrological shifts (Oberdorff, T. 2022.). Within these vulnerable systems, freshwater bivalves serve as ecological engineers whose functional roles are disproportionately large relative to their biomass. Among them, *Lamellidens marginalis*, a dominant unionid mussel distributed across the Indian

subcontinent and Southeast Asia, represents a species of considerable ecological and socio-economic interest (Ali, S., & Rawat, R. S. 2023). Despite its wide distribution and historical relevance in traditional food and health systems, *L. marginalis* remains critically understudied, with fragmented literature that inadequately reflects its ecological and nutritional value or its potential for therapeutic applications.

Ecologically, *L. marginalis* contributes extensively to freshwater ecosystem functioning through its filter-feeding activity, which regulates suspended particulates, enhances water quality, modulates nutrient cycling, and stabilizes benthic substrates (Chakraborty, A et al. 2024). These functions, position freshwater mussels as natural bioremediators. Nevertheless, populations of *L. marginalis* are declining in many regions, driven by deteriorating water quality and unsustainable harvesting, yet comprehensive ecological evaluations remain sparse (Mondol, M. M. R., et al., 2025). A critical reassessment of its functional ecology is therefore essential for informing conservation and freshwater resource management.

Nutritionally, *L. marginalis* represents a high-quality, low-cost protein source, rich in essential amino acids, bioavailable minerals, omega-3 fatty acids, and bioactive compounds (Lucakova, S., Branyikova, I., & Hayes, M. 2022.). While freshwater mussels hold promise for addressing protein insecurity and micronutrient deficiencies in rural and low-income populations (Kilemile, W et al., 2024). Systematic nutritional profiling of *L. marginalis* is limited with significant variation in methodologies across reported studies. Rigorous, standardized analysis is needed to validate its dietary potential and position it within

sustainable aquaculture and nutrition strategies (Mondol, M. 2025).

Ethnomedicinally, *L. marginalis* has a long history of use in traditional healing systems, where its flesh, liquid extracts and shell-derived preparations are used for treating inflammatory conditions, reproductive ailments, bone-related disorders, and general fatigue (Jadhav, A. et al., 2023; Mondol, M. M. R., et al., 2025; Estari, M., et al., 2011; Chakraborty, M et al., 2010). Preliminary pharmacological investigations have identified antioxidant, antimicrobial, immunomodulatory and wound-healing activities, aligning with some of its traditional uses (Elmahaishi, L. M., et al., 2025; Tiwari, R et al., 2018; Dwivedi, J et al., 2025). However, these studies remain mostly exploratory, lacking dose-response analyses, standardized extraction protocols, and mechanistic insights. This disconnect between traditional knowledge and scientific validation underscores a critical research gap.

This review critically examines available evidence on the ecological functions, nutrient composition, and therapeutic prospects of *L. marginalis*, while highlighting methodological gaps, inconsistencies and the urgent need for multidimensional research. By adopting a cross-disciplinary approach, the review aims to provide a consolidated foundation for conservation planning, sustainable utilization, and future biotechnological innovations centered on this ecologically significant freshwater mussel.

1.1 Taxonomic position and Distribution

- Kingdom: Animalia
- Phylum: Mollusca
- Class: Bivalvia
- Order: Unionida
- Family: Unionidae
- Genus: *Lamellidens*
- Species: *Lamellidens marginalis* (Lamarck, 1819)

Common name: Indian freshwater mussel

Distribution: Widely found in rivers, ponds, lakes, and marshes across India, Bangladesh, Nepal, Myanmar, and other South-Asian freshwater habitats (Mondol, M. M. R et al., 2025). Morphologically, *L. marginalis* possesses a thick, elongated shell with a smooth surface and varying hues of yellowish-brown to black.

Its soft tissues include the mantle, gills, digestive gland, adductor muscles and gonadal tissues each with distinct biochemical profiles.

1.2 Rationale for the Review: ecological, nutritional, and therapeutic interest

Lamellidens marginalis, a freshwater bivalve widely distributed across South and Southeast Asia, represents a biologically and socio-economically valuable molluscan species whose importance remains largely underexplored in mainstream scientific literature. As an ecosystem engineer, this mussel plays a pivotal role in maintaining aquatic ecosystem integrity by contributing to water filtration, nutrient cycling, sediment stabilization and habitat structuring for associated biotic communities (Hunt, D. S., & Kashian, D. R. 2026). Considering the rapid degradation of freshwater systems due to pollution, eutrophication, and anthropogenic disturbances, understanding the ecological contributions of *L. marginalis* is essential for biodiversity conservation and sustainable aquatic resource management (Bablee, A. L et al., 2026).

Beyond its ecological relevance, *L. marginalis* offers substantial nutritional benefits, being a rich source of high-quality protein, essential amino acids, omega-3 fatty acids, vitamins, and bioavailable minerals (Maity, S., & Yadav, A. K. 2026). With increasing global emphasis on affordable, high-protein alternative food sources, this species holds promise for supporting nutritional security, particularly in resource-limited regions. Comprehensive evaluation of its nutrient profile and food safety parameters can further enhance its potential inclusion in sustainable dietary frameworks.

Ethno-medicinally, *L. marginalis* has been traditionally used across indigenous and rural communities for treating ailments such as inflammation, joint pain, and reproductive disorders (Bablee, A. L. et al., 2026). Recent studies indicate that its tissue extracts exhibit antioxidant, antimicrobial, immunomodulatory and wound-healing activities, suggesting possible applications in modern drug discovery and nutraceutical development (Télessy, I. G. et al., 2026). However, scientific validation of these properties is limited and fragmented.

Given its multifaceted importance, a consolidated review is imperative to synthesize existing evidence on the ecological functions, nutritional attributes, and

therapeutic potentials of *L. marginalis*. Such a holistic analysis will not only bridge current knowledge gaps but also provide a foundation for future research, conservation strategies and biotechnological exploitation of this ecologically and economically significant freshwater mussel.

II. OBJECTIVES AND SCOPE OF THE REVIEW

The primary objectives of this integrative review are:

1. To synthesize current knowledge on the ecological functions of *Lamellidens marginalis*, including its role in water filtration, nutrient cycling, sediment stabilization and maintenance of freshwater biodiversity.
2. To critically evaluate the nutritional composition of *L. marginalis*, focusing on its macro- and micronutrient content, bioavailability and potential contributions to sustainable and affordable nutrition.
3. To examine the ethnomedicinal uses of *L. marginalis* across traditional healthcare systems and assess scientific evidence supporting its therapeutic properties including antioxidant, antimicrobial and immunomodulatory activities.
4. To identify research gaps, methodological limitations, and future directions necessary to advance ecological conservation, nutritional exploitation and biomedical applications of this species.

III. SCOPE OF THE ARTICLE

This review encompasses a comprehensive and interdisciplinary assessment of *Lamellidens marginalis* by integrating findings from ecology, nutritional science, ethnobiology and pharmacology.

The scope includes:

- **Ecological Dimension:** habitat characteristics, population distribution, ecosystem services, environmental stress responses and conservation status.
- **Nutritional Dimension:** biochemical composition, nutrient density, comparative evaluation with other freshwater mussels and its relevance to food security.
- **Therapeutic/ Ethnomedicinal Dimension:** traditional applications, bioactive components,

experimentally validated pharmacological effects and their potential in drug discovery or nutraceutical development.

- **Cross-cutting Issues:** threats from pollution and habitat degradation, sustainability of harvesting practices and implications for aquaculture and resource management.

By integrating these dimensions, the review aims to provide a holistic understanding of the ecological, nutritional, and therapeutic significance of *L. marginalis* and establish a foundation for future research, policy development and sustainable utilization.

IV. ECOLOGICAL IMPORTANCE

1. **Role in Water Filtration:** As filter feeders, *L. marginalis* removes suspended particles, phytoplankton, detritus, and microbial contaminants, thus improving water quality. A single mussel can filter several liters of water per hour, influencing turbidity and nutrient dynamics (Isibor, P. O. et al., 2026).
2. **Contribution to Nutrient Cycling:** Through bioturbation and biodeposition, mussels enhance nitrogen and phosphorus cycling. Their excreta and pseudofeces contribute to sediment enrichment, supporting benthic primary production (Fedarick, J. et al., 2026).
3. **Habitat Modification and Biodiversity Support:** Mussel beds stabilize sediments, create microhabitats, and enhance species richness of benthic invertebrates. They also serve as hosts for the larval stages (glochidia) of certain fish, indicating their importance in sustaining fish populations (DiNicola, M. E. 2026).
4. **Bioindicator of Environmental Health:** Due to their sensitivity to pollutants, *L. marginalis* is an effective sentinel species for monitoring heavy metals, pesticides and other contaminants in freshwater systems (Kumar N, et al., 2017).

V. NUTRITIONAL VALUES

Proximate Composition: *Lamellidens marginalis* is widely recognized for its rich and balanced nutritional profile, making it an important and affordable protein source in many freshwater-dependent communities. Its flesh contains a wide range of macro- and

micronutrients including essential amino acids, polyunsaturated fatty acids and biologically important minerals, contributing to its status as a high-value aquatic food organism (Sarma KA et al., 2022). Studies on freshwater mussels consistently show that *L. marginalis* possesses a favourable proximate composition that supports adequate energy and protein intake (Mondol MM et al. 2025).

Typical proximate values include:

- Moisture: 72–80%
- Protein: 12–20% (wet weight) / 50–65% (dry weight)
- Lipids: 1.5–4.0%
- Carbohydrates: 3–6%
- Ash: 2–4%

High protein/low fat composition classifies *L. marginalis* as a lean animal protein source. The low-fat content enhances its digestibility and suitability for cardiovascular-friendly diets. The mussel contains all essential amino acids needed for human nutrition.

Major essential amino acids present in the mussel are Lysine, Leucine, Isoleucine, Valine, Threonine, Phenylalanine, Methionine and Tryptophan.

High levels of lysine and methionine complement plant-based diets, which commonly lack these amino acids. The amino acid score (AAS) indicates that *L. marginalis* provides a high-quality, complete protein, comparable to other mollusks and some fish species.

Although total lipid content is low, the quality of fats present in *L. marginalis* is nutritionally valuable.

Predominant fatty acids include:

✓ Polyunsaturated fatty acids (PUFAs):

- EPA (Eicosapentaenoic acid)
- DHA (Docosahexaenoic acid)
- Linoleic acid
- α -Linolenic acid

✓ Monounsaturated fatty acids (MUFAs):

- Oleic acid
- Palmitoleic acid

Saturated fatty acids (SFAs):

- Palmitic acid
- Stearic acid

The presence of omega-3 PUFAs (EPA/DHA) supports cardiovascular health, cognitive functions, and anti-inflammatory activity. Balanced PUFA:SFA

ratio makes *L. marginalis* suitable for individuals needing lipid-controlled diets (Şereflişan H et al., 2025). *L. marginalis* is a rich source of several bioavailable minerals essential for metabolic and physiological functions.

Major minerals:

- Calcium (40–120 mg/100 g) bone development, shell-derived calcium used traditionally
- Iron (6–12 mg/100 g) prevents anemia
- Zinc (0.8–2.5 mg/100 g) immune and reproductive health
- Magnesium nerve and muscle function
- Phosphorus energy metabolism
- Sodium & Potassium electrolyte balance

Trace elements:

- Manganese
- Copper
- Selenium

Calcium and iron levels in *L. marginalis* surpass those of many freshwater fishes, making it a potent supplement for mineral-deficient diets (Tan K et al., 2022).

Although data vary across regions and seasons, *L. marginalis* contains:

- Vitamin A (retinol equivalents)
- Vitamin D
- B-complex vitamins: B1, B2, B6, B12
- Vitamin C (small quantities)
- Vitamin E (tocopherols)

Presence of vitamin B12 makes it particularly valuable for vegetarian communities with limited B12 sources. B-complex vitamins aid energy metabolism and neurological health.

Apart from basic nutrients, *L. marginalis* contains several biologically active compounds:

- Carotenoids
- Flavonoids
- Phenolics
- Glycoconjugates
- Enzymatic antioxidants: SOD, CAT, GPx

These compounds contribute to antioxidant, anti-inflammatory, and antimicrobial properties observed in experimental studies.

Table 1: Nutritional Composition of *Lamellidens marginalis* (Haldar A et al., 2014)
(Values are approximate ranges; expressed per 100 g edible portion unless specified)

Nutrient Category	Components	Typical Values
Proximate Composition	Moisture	72–80%
	Protein	12–20% (wet weight) / 50–65% (dry weight)
	Lipids	1.5–4.0%
	Carbohydrates	3–6%
	Ash	2–4%
Amino Acids (Essential)	Lysine	1.6–2.4 g/100 g protein
	Leucine	1.4–2.2 g/100 g protein
	Isoleucine	0.8–1.4 g/100 g protein
	Valine	0.9–1.5 g/100 g protein
	Threonine	0.7–1.2 g/100 g protein
	Methionine	0.4–0.7 g/100 g protein
	Phenylalanine	0.8–1.4 g/100 g protein
	Tryptophan	0.15–0.30 g/100 g protein
Fatty Acids	Total PUFA	20–35% of total lipids
	EPA (C20:5n3)	2–6%
	DHA (C22:6n3)	1–4%
	Linoleic acid	8–14%
	α -Linolenic acid	3–7%
	MUFA (mainly oleic acid)	15–25%
	SFA (palmitic, stearic acids)	30–45%
Minerals	Calcium	40–120 mg
	Iron	6–12 mg
	Zinc	0.8–2.5 mg
	Magnesium	20–40 mg
	Phosphorus	80–140 mg
	Sodium	50–90 mg
	Potassium	180–250 mg
Vitamins	Vitamin A	20–60 μ g
	Vitamin D	Trace–moderate
	Vitamin B1 (Thiamine)	0.02–0.06 mg
	Vitamin B2 (Riboflavin)	0.05–0.12 mg
	Vitamin B6	0.05–0.10 mg
	Vitamin B12	1.5–4.0 μ g
	Vitamin C	1–3 mg
	Vitamin E (Tocopherols)	0.2–0.6 mg
Bioactive Compounds	Phenolics	2–5 mg GAE/100 g
	Flavonoids	1–3 mg QE/100 g
	Carotenoids	Trace–moderate
	Enzymatic antioxidants (SOD, CAT, GPx)	Present (qualitative)

Table 2. Proximate and Mineral Nutritional Composition of *Lamellidens marginalis*

Component	Value (Approx.)	Remarks
Protein	45–58%	High-quality animal protein
Lipids	6–12%	Contains PUFA and omega-3 fatty acids
Carbohydrates	15–20%	Energy source
Iron (Fe)	12–18 mg/100g	Helps prevent anemia
Zinc (Zn)	2–4 mg/100g	Supports immunity
Calcium (Ca)	150–200 mg/100g	Bone health
Magnesium (Mg)	40–60 mg/100g	Metabolic function

VI. ETHNOMEDICINAL IMPORTANCE

6.1 Traditional Uses

In various indigenous communities across India, Bangladesh, Nepal and Myanmar, *L. marginalis* is traditionally used for (Ojha SN et al., 2022):

- Enhancing bone strength (shell-calcium preparations)
- Treating inflammation and joint pain
- Improving reproductive health and vitality
- Managing chronic infections
- Healing wounds and ulcers

6.2 Bioactive Components and Mechanisms

- Calcium carbonate from shells supports bone mineralization.
- Protein hydrolysates show anti-inflammatory and antioxidative activities.
- Polysaccharides exhibit immunostimulatory effects through macrophage activation.
- Lipid extracts possess antimicrobial effects against Gram-positive bacteria.

6.3 Evidence-Based Therapeutic Insights

Recent in vitro and in vivo findings suggest potential therapeutic roles in:

- Oxidative stress regulation
- Anti-inflammatory pathways (COX/LOX inhibition)
- Antidiabetic activity (via α -amylase and α -glucosidase inhibition)
- Hepatoprotection (modulating liver enzymes)

VII. ECONOMIC AND SOCIO-CULTURAL SIGNIFICANCE

L. marginalis supports rural livelihoods through fisheries, handicrafts (shell-based ornaments) and nutraceutical applications. Its cultural significance is notable in traditional diets and folk medicine (Simard NS et al., 2019).

Table 3. Ecological Roles of *Lamellidens marginalis*

Ecological Function	Description
Water Filtration	Removes suspended particles, algae, bacteria, improving water clarity.
Nutrient Cycling	Releases nutrients through biodeposition and bioturbation.
Bioindicator Role	Sensitive to pollutants, used in environmental monitoring.
Habitat Enhancement	Stabilizes sediment and improves microhabitats.

Conservation Status and Threats

Despite its ecological value, populations are declining due to:

- Habitat degradation
- Pollution and eutrophication
- Overharvesting
- Climate-induced hydrological changes

Sustainable harvesting protocols, habitat restoration, and community-level conservation initiatives are urgently needed.

VIII. FUTURE RESEARCH DIRECTIONS

- Genomic and proteomic profiling to identify novel bioactive molecules
- Standardization of mussel-derived nutraceutical formulations
- Evaluating pharmacological potential through in vivo and clinical studies
- Ecotoxicological studies under climate change scenarios
- Development of sustainable aquaculture systems for species conservation

IX. CONCLUSION

Lamellidens marginalis is a keystone freshwater mussel with multifaceted ecological, nutritional, and ethnomedicinal importance (Verma AK et al., 2025).

Modern scientific investigation combined with traditional knowledge highlights its potential in environmental management, nutrition security, and therapeutic development. Strengthening research, conservation and sustainable utilization strategies can ensure its long-term ecological and socioeconomic benefits (Fariha F et al., 2025).

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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