EDIBLE NON-MARINE MOLLUSCS OF INDIA

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Photographs: Surya Narayanan

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Dedicated to Fred Naggs, who was instrumental in reviving malacological studies in South Asia and N.A. Madhyastha, who popularised biodiversity science among public.

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Preface

Molluscs, the second most abundant phylum after arthropods, exhibit a remarkable diversity spanning many ecosystems. They range from the depths of the oceans to the Himalayan snow-clad mountains and from tropical rainforest to deserts and subarctic and subantarctic habitats. Notably, they are absent from the Antarctic landmass. With an estimated 86,436 species identified to date, molluscs are integral to ecosystems as water filters, nutrient recyclers, prey for numerous animals, a source of sustenance for humans, and a means of livelihood for millions of people across the globe.

India boasts a particularly rich molluscan fauna, housing nearly 5,000 species across its sea, land, and freshwater environments. This impressive biodiversity is a result of the country's wide-ranging habitats, encompassing high-altitude mountainous regions to expansive coastlines. Among these, non-marine molluscs, which include freshwater and terrestrial species, number around 1,500, which exhibit significant levels of endemism. In India, as in many other tropical regions around the world, molluscs play a pivotal role in supporting the livelihoods of impoverished communities. Much of the mollusc harvesting and consumption in the country takes place along the coastal regions and in the northeasten states. Coastal areas predominantly consume marine and brackish water molluscs, while freshwater molluscs play a more substantial role in other regions, with terrestrial molluscs having a lesser presence. It's worth noting that some tribal communities in Northeast India and parts of West Bengal utilised certain mollusc species for medicinal purposes.

However, non-marine molluscs face unprecedented challenges due to various anthropogenic pressures, leading to a drastic decline in their populations. Overharvesting from the wild is one of the prominent threats these species confront. The adoption of heliciculture, or mollusc cultivation methods, in backyard settings is proposed as a

solution. This approach not only helps alleviate the pressure on wild populations but also offers opportunities to enhance the livelihoods of impoverished communities.

The primary objective of this book is to provide a comprehensive account of all documented edible non-marine molluscs known in India. For this task, we undertook extensive literature reviews, conducted rigorous field studies, and engaged in interviews with communities dependent on these molluscs.

The book provides comprehensive detail on 41 species, of which nine are terrestrial and 32 are freshwater molluscs. The highest number of molluscs consumed is from Northeastern Indian states. Many western Indian states refrain from consuming land and

freshwater molluscs. Nevertheless, this list is preliminary, and the possibility of more cryptic species, particularly within genera like *Brotia*, *Paludomus*, *Idiopoma*, and *Filopaludina*, cannot be ruled out. Resolving these taxonomic challenges demands an integrative taxonomic approach, as many species within the *Brotia* genus, for example, exhibit significant intra-specific variation, rendering morphological characterisation alone insufficient for species delineation.

We anticipate that this book will serve as a valuable resource not only for students and teachers but also for conservationists and environmental managers. It aims to contribute to the knowledge and preservation of these important yet vulnerable non-marine molluscs in India.

Foreword

It gives me great pleasure to be given the opportunity to write this forward. I first met Aravind at a World Congress of Malacology in Perth, Australia, in 2004. I was struck by his enthusiasm and passion for malacology and we developed joint projects and an enduring friendship. I continued to be impressed by Aravind's growing expertise as his career developed and he pursued a multifaceted approach to his research. His broad approach is exemplified by this current book on non-marine edible molluscs, to which he brings a wide range of expertise to a neglected subject. Non-marine edible molluscs as an important source of nutrition are known to have existed for thousands of years, extending into the last ice age, as evidenced by shell middens, often found in caves inhabited by hunter gatherers. They remain a critically important rich protein source for many communities, particularly the poorest. However, in many parts of the World they can also be highly prized foods for middle income and wealthy consumers, such as *Helix pomatia*, the famous escargot of France and the giant African *Archachatina* of West Africa. Thus, in addition to an important source of nutrition, there is enormous economic potential in the cultivation of molluscs. This will be a standard work of reference for a wide range of applied disciplines, especially those related to nutrition and diets in subsistence economies. It will also be of value to a wide range of environmental subjects and as an identification guide to molluscs of economic importance.

Fred Naggs
Wallington, Surrey, UK
November 2023

Acknowledgements

The work presented in this book stands as a testament to years of dedicated effort, collaboration, and support from various quarters.

We take this opportunity to extend our heartfelt acknowledgements to all those who contributed to the realisation of this project. The research and data compiled in this book represent the culmination of five years of rigorous work. This effort involved extensive field surveys, engaging interviews with communities across India in general and Northeast India in particular, and a thorough review of existing literature.

We are immensely grateful to the Department of Biotechnology, Government of India (File no. B.T./01/17/NE/TAX), for their generous financial support for this work. Their backing was instrumental in making this project feasible. A special note of appreciation goes out to the communities across India who rely on molluscs for their livelihoods. Their willingness to share information regarding the collection and utilisation of molluscs played an invaluable role in our research and compilation of the data. Their insights were integral to the comprehensive understanding presented in this book.

The visual appeal of this book owes much to the exceptional photographs of molluscs provided by Surya Narayanan. His skill and artistry in capturing these intricate details added depth to our work, and we are deeply thankful for your contribution.

We sincerely thank Ravikanth, Nilanjan, Chinta and Nipu Kumar Das for dedicating time to review the book chapters meticulously. The critical comments and insightful suggestions were instrumental in enhancing the overall quality of this publication.

We also profusely thank Gokulapriya for creating beautiful distribution maps.

We thank Prof. Fred Naggs, for writing the foreward to this book and mentoring us in this endeavour.

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We are obliged to the curators, John Pfeiffer (Smithsonian Museum, Washington, USA) and Johnathan Ablett (Natural History Museum, London, UK), for providing us with the photographs of the type specimens for the book.

In conclusion, this book represents a collective effort, and it would not have been possible without the collaboration, expertise, and support of the individuals and institutions mentioned above.

Introduction

Phylum Mollusca represents one of the most diverse and ecologically significant groups within the animal kingdom. Characterised by their soft bodies, often protected by a calcareous shell, molluscs exhibit remarkable variation in form (shape), habitat, and behaviour. Molluscs are the second largest group of animals after arthropods in terms of number of species described. They are traditionally classified into seven classes: Gastropoda (snails and slugs), Bivalvia (clams, mussels, and oysters), Cephalopoda (squids, octopuses, and cuttlefish), Polyplacophora (chitons), Scaphopoda (tusk shells), Monoplacophora (a rare class of deep-sea molluscs), and Aplacophora (worm-like, shell-less molluscs). Currently, 86,436 species of molluscs (extant species) are described from marine, freshwater and terrestrial habitats. The highest diversity of molluscs is reported from marine environments, with 51,212 species, followed by terrestrial (28,536 species) and freshwater (6,688 species) (MolluscaBase 2023).

Molluscs exhibit a characteristic body plan with three main parts: the head-foot region responsible for locomotion and sensory perception, the visceral mass containing vital organs, and the mantle that encloses the body, secretes the shell (if present), and often helps in respiration. Many molluscs, other than bivalves, possess a radula, a specialised feeding organ equipped with tiny teeth, which varies in structure according to their diet. The presence and structure of the shell distinguish different mollusc classes. Gastropods typically have coiled shells, while bivalves exhibit hinged, two-part shells. Cephalopods possess internalised shells or, in some cases, none at all. The shells serve multiple functions, including protection, buoyancy, and support. Molluscs exhibit diverse feeding strategies. Herbivorous species graze on algae, carnivores hunt other invertebrates, and filter feeders extract plankton from the water column. The radula, jaws,

or specialised tentacles are adapted to these varied feeding habits. Some are hermaphrodites, but most molluscs have separate sexes, and many engage in complex courtship rituals. Fertilisation can be internal or external, depending on the species. Some molluscs produce planktonic larvae, while others have direct development without a larval stage.

Molluscs play crucial ecological roles as herbivores, decomposers, and prey for various predators; while some are voracious predators. They inhabit diverse ecosystems, from marine and freshwater environments to terrestrial habitats, contributing significantly to nutrient cycling and energy transfer. Molluscs face numerous threats, including habitat loss, pollution, overharvesting, and invasive species. Some species are highly endangered, emphasising the need for conservation efforts to protect them. Beyond their ecological importance, molluscs serve as valuable models for studying various biological phenomena, from evolutionary processes to neurobiology. The unique features of cephalopods, such as their complex behaviours and remarkable intelligence, have garnered particular scientific interest.

Thus, the phylum Mollusca represents a fascinating group of organisms comprising a wide array of species with diverse ecological roles and adaptations. Ongoing research continues to unravel the complexities of mollusc biology, contributing to our understanding of the broader natural world. As scientists delve deeper into the intricacies of this phylum, discoveries and insights are poised to emerge, further enriching our knowledge of life on Earth.

Taxonomy

Gastropods, a diverse class of molluscs, are primarily identified and classified based on a set of key shell characteristics. These shell attributes serve as fundamental taxonomic markers in the field of conchology. The diagram below provides a visual representation of the principal shell characteristics that are generally used in classifying and differentiating gastropods. These attributes include shell shape, size, colouration, ornamentation, sculpture, aperture, and distinctive spines or ridges. Conchological characteristics offer valuable insights into the taxonomic placement of gastropods and are widely employed for their systematic classification. However, it's important to note that internal anatomical structures play a pivotal role in precisely identifying gastropods beyond the external shell morphology. These internal structures include a range of features, such as the morphology of male and female reproductive organs and the structure of the radula, which comprises specialised teeth-like structures used in feeding.

In contrast, when dealing with bivalves, the primary character for identification shifts to internal shell structures. These internal attributes are often more conspicuous and definitive for bivalve taxonomy. While external characteristics are still relevant, internal features, such as hinge teeth, ligament structures, and muscle scar patterns, take precedence in the accurate classification of bivalves. Occasionally, certain internal traits beyond the shell are also considered in the taxonomic assessment of these organisms. Thus, the taxonomy of gastropods and bivalves relies on an integrated approach incorporating a wide array of conchological and internal anatomical characteristics. These combined features are essential for the rigorous scientific identification and classification of these molluscan taxa.

Shell forms and shape

Molluscs are characterised by their remarkable shells. These shells, typically composed of calcium carbonate, serve as protective exoskeletons for these soft-bodied creatures. The forms and shapes of molluscan shells exhibit an astonishing array of diversity, reflecting millions of years of evolution and adaptation to various ecological niches. The basic structure of a molluscan shell consists of three distinct layers: a) The outermost layer, known as the periostracum, is a thin and proteinaceous membrane. It protects the underlying shell layers and can vary in colour and texture, b) Beneath the periostracum lies the prismatic layer, which consists of densely packed calcium carbonate crystals organised into prisms. This layer contributes to the shell's strength and c) The innermost layer, the nacreous layer, is composed of thin, translucent calcium carbonate plates separated by organic material. It imparts the inner lustre and iridescence seen in many molluscan shells.

Molluscs have evolved a wide range of shell forms; each adapted to specific ecological roles and lifestyles. The most common shell forms:

Gastropod shells: Gastropods, the largest class of molluscs, possess coiled shells. These shells can range from flat and disc-like to tall and conical. Some, like snails, have dextral (right-coiling) shells, while others have sinistral (left-coiling) shells. The shape of gastropod shells can be broadly categorised into conical, globular, and limpet-like.

Bivalve shells: Bivalves, such as clams and mussels, are known for their two-part, hinged shells. These shells are typically flattened and bilaterally symmetrical. The shapes of bivalve shells vary from elongated and triangular to nearly circular.

Cephalopod shells: Cephalopods, including squids and nautilus, have unique shells. Nautilus retain a coiled, chambered shell, often resembling a coiled paper. Squids, on the other hand, have internal shells called pen and gladius, which provide support rather than protection.

Scaphopod shells: Scaphopods, also known as tusk shells, have slender, tubular shells open at both ends. They are often curved and resemble elongated elephant tusks.

Polyplacophoran shells: Chitons, or polyplacophorans, have segmented shells composed of eight overlapping plates. These plates give them a flexible, armour-like appearance.

Monoplacophoran shells: Monoplacophorans, ancient and rarely seen molluscs, have conical, cap-shaped shells reminiscent of limpets.

The diversity of molluscan shells serves various ecological, functional, and evolutionary purposes. The primary function of a shell is protection. It shields the soft, vulnerable body of the mollusc from predators, physical damage, and desiccation. The shape and thickness of the shell influence its protective capabilities. Some molluscs, like nautilus, use their gas-filled chambers for buoyancy control. By adjusting the gas-to-liquid ratio, they can move up or down in the water column. Shell shapes often align with a mollusc's lifestyle and habitat. For instance, flattened bivalves can easily bury themselves in sediment, while coiled gastropod shells provide greater mobility and space for visceral mass. Certain gastropods, like cone snails, have venomous harpoons, enabling them to capture prey. Their venomous strategy complements their cone-shaped shells. Some molluscs, such as cowries, have highly polished, smooth shells that aid in camouflage, making them resemble rocks or corals. In

many cases, shell forms play a role in mating rituals. Molluscs may use their shells to signal readiness or engage in courtship behaviours.

The forms and shapes of molluscan shells represent an astonishing spectrum of evolutionary solutions to life's challenges. These structures adapted over millions of years, are not merely protective coverings but also integral to the survival, ecological niche, and evolutionary success of this remarkable group. Whether coiled, bivalved, tubular, or segmented, molluscan shells continue to captivate scientists and enthusiasts, providing valuable insights into the intricacies of life on Earth.

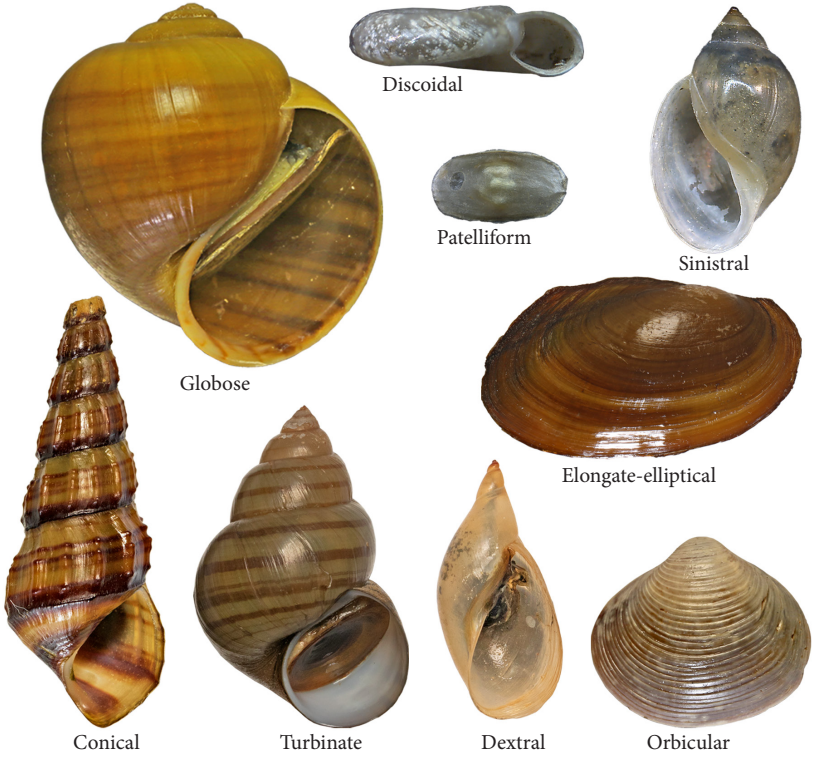


Figure: Shell shapes of non-marine molluscs

Non-marine molluscs of India

India is rich in molluscan fauna and is distributed in four biodiversity hot spots. Our knowledge of non-marine molluscs in this region owes much to the contributions of European malacologists such as William Benson, Theobald, Hanley, the Blanford Brothers, Godwin-Austen, Preston, and Annandale (Sen et al. 2012). Within the Indian political boundary, approximately 1,130 species of land snails (Ramakrishna et al. 2010) and 220 freshwater molluscs have been formally described (Aravind MS Under Preparation).

The Western Ghats, a biodiversity hotspot, harbours 350 non-marine mollusc species, comprising 300 land snails and 50 freshwater molluscs. Remarkably, 89 percent of land snails and 40 percent of freshwater molluscs in this region are endemic (Aravind 2005). In contrast, the Northeastern Indian states boast more than 750 species (Aravind MS Under Preparation). Since the year 2000, over 25 species of freshwater and land snails have been documented, with descriptions of several new genera and new records for India.

Despite this wealth of molluscan diversity in India, ecological and natural history studies concerning non-marine molluscs are quite limited. Many of these studies tend to be checklists or evaluations of distribution patterns. A few have attempted to discern how habitat and environmental factors influence species distribution on a local scale. Recently, some studies have delved into the impact of introduced species on native freshwater molluscs, primarily in laboratory settings.

However, field-based studies on this topic are scarce, with one study focusing on land snails' response to the invasive plant *Lantana camara* (Aravind and Sarma 2015).

Significant investigations into the systematics, population status, phylogeny, and taxonomic revisions of different families or genera of Indian non-marine molluscs are surprisingly rare. Such studies have only gained traction in recent years. Our comprehension of the biogeographic patterns of these molluscs remains incomplete, with foundational knowledge drawn from works dating back to the late 19th century by naturalists like Blanford and more recent works in the early 21st century. These works primarily revolve around assessing faunal similarities between Sri Lanka and India (Naggs and Raheem 2005).

Non-marine molluscan lineages in India, specifically Pulmonata and Caenogastropda, were believed to have diverged in the Devonian period, which occurred between 416 to 359.2 million years ago. The Indian subcontinent is home to numerous deep, independent lineages of ancient groups, some of which are unique and endemic to South Asia. These include *Corilla, Euplecta, Indrella, Cremnoconcus, Paracrostoma,* and others.

Recent advancements in molecular biology offer opportunities to unravel the taxonomic intricacies and better understand the phylogenetic relationships and biogeographic patterns within this taxonomic group. Recent studies have touched on the phylogeny and biogeography of freshwater molluscs such as *Paracrostoma* (Köhler and Glaubrecht, 2007), *Cremnoconchus* (Reid et al. 2013; Aravind et al. 2016; Saha et al. 2022), *Brotia* (Jadhav et al. 2023), Viviparids (Sil et al. 2019), *Pila* (2020, 2022), and *Indoplanorbis* (Sil et al. 2023). Nevertheless, for the majority of these taxa, evolutionary relationships among Indian non-marine molluscs remain unresolved despite their high diversity, endemism, and unique radiation.

A global perspective is essential for comprehending the relationships between Indian non-marine molluscs and other South and Southeast Asian regions. The lack of research into the phylogeny and biogeography of Indian non-marine molluscs is often attributed to a shortage of expertise in this region (Sen et al. 2012).

Edible non-marine molluscs

Traditional foods, encompassing wild plants and animals along with their derivatives, have been harnessed for centuries by local and indigenous communities across diverse regions of the world. This historical practice has not only served as an economic asset but has also played a vital role in ensuring food and nutritional security, especially among rural and underprivileged populations in developing and underdeveloped nations (Costa-Neto 2005; Sangma et al. 2016). Molluscs have been an integral part of human diets across the world for millennia.

Freshwater molluscs, in particular, hold a prominent place in the daily diets of tribal and economically disadvantaged communities in South and Southeast Asia. They present an advantageous and cost-effective source of protein compared to other conventional dietary choices (Karna and Shrestha 2006). Apart from their traditional culinary role, the resource potential of molluscs has gained increasing recognition in recent years. This emerging perspective not only benefits the socioeconomic status of local communities but also offers a compelling avenue for scientific exploration.

The utilisation of traditional knowledge by these communities, encompassing the multiple uses of molluscs, ranging from food to medicinal applications, has significantly contributed to the ongoing scientific research on their potential. Throughout history, molluscs have served as a dependable and nutrient-rich food source, with roots dating back to the existence of early hunter-gatherer societies (Rabett et al. 2011; Burgos et al. 2019). The earliest recorded instances of mollusc consumption as a food source date back to the Late Pleistocene and Holocene eras, notably in Vietnam, Spain, Benidorm and Malaga, where species belonging to the genera *Iberus*,

Cyclophorus, etc., were part of the diet (Serrano et al. 1997; Rabett et al. 2011; De Pablo et al. 2014).

Hence, molluscs have played a crucial role in providing highly nutritious sustenance to these hunter-gatherer communities (Waselkov et al. 1987; Cobbinah et al. 2008; Jerardino et al. 2017). Even today, molluscs remain a culinary delicacy in various European nations such as France, the Netherlands, Belgium, and Italy (Waselkov et al. 1987; Jerardino et al. 2017), as well as across the Mediterranean, Asia, and Africa (Yildirim 2004; Baby et al. 2010; Ivan et al. 2017; Jadhav et al. 2023). For instance, snail caviar, which comprises snail eggs, is a highly sought-after luxury food item, particularly popular in Europe (Ivan et al. 2017).

Furthermore, the practice of snail farming, known as heliciculture, has emerged as a burgeoning industry in both Europe and several Southeast Asian nations. Snail farming serves various purposes, including the production of snail flesh and eggs for consumption and the extraction of snail slime, which finds application in cosmetology.

However, it is crucial to recognise that in both less developed and developed regions of the world, wild populations of non-marine molluscs were extensively harvested and consumed as an affordable and accessible source of protein, particularly by communities facing economic and social marginalisation.

Edible non-marine molluscs from India

India has a long history of consuming molluscs, especially by the marginalised communities. Edible non-marine molluscs have been an essential part of Indian diets and culinary traditions for centuries. Almost all the tribe communities from Northeast India depend upon various natural resources for their survival and livelihoods. Among these bio-resources, they are highly dependent on freshwater molluscs to a greater extent and land snails to a lesser extent as a source of food and medicine (Betlu 2013; Chinlampianga et al. 2013; Jadhav et al. 2023). In many regions of India, molluscs are used as ingredients in traditional dishes. They are often cooked with spices, herbs, and local flavours to create unique delicacies. In some communities, land snails are considered a delicacy and are reserved for special occasions. Molluscs, like seafood, are a valuable source of protein for people in both rural and urban areas. They are especially important in diets where access to other protein sources is limited. In certain traditional medicinal practices, snail mucus and extracts were used for their perceived health benefits. They are believed to have properties that can alleviate some health issues. In regions where edible molluscs are abundant, such as Northeast India, they contribute to the livelihoods of local communities. Collection, processing, and sale of molluscs can provide a source of income for especially impoverished communities.

Comprehensive information and documentation regarding edible non-marine molluscs in India are regrettably scarce, with only a limited number of localised studies available, and these studies are by no means exhaustive (Subba Rao 1989; Jamir and Lal 2005; Borkakati et al. 2009; Betlu 2013; Chinlampianga et al. 2013; Jadhav et al. 2023). Of note, a study conducted by Jadhav et al. (2023) represents the initial comprehensive documentation on the diversity

and cultural utilisation of edible freshwater molluscs in northeastern India. This particular compilation stands out as it records the highest number of edible molluscs documented across all of Asia. A previous compilation by Tripathy and Mukhopadhyay (2015) compiled a list of 21 mollusc species from India, sourced from all published references. However, it is important to highlight that their compilation has taxonomy-related challenges. For example, both *Pila virens* and *Pila globosa* were previously reported as being present in Northeast India. Yet, recent investigations, as evidenced by Sil et al. (2020), have demonstrated that these two species are, in fact, restricted to Peninsular India and the Gangetic Basin, respectively. In essence, while the existing body of knowledge regarding edible non-marine molluscs in India is growing, issues related to the taxonomy and distribution of these species persist. Further research and study are necessary to both refine our understanding of these molluscs and to provide a comprehensive and accurate account of their diversity, distribution, and cultural uses.

Non-marine molluscs that are collected from wild populations are widely distributed and locally abundant. Freshwater gastropods are in great demand as they are easy to collect available most throughout the year and comprise some economic importance to the tribal community that sells them. *Filopaludina bengalensis* and *Pila* spp. are commonly consumed in many parts of India. However, the rate of consumption varied with the availability of the species and its abundance locally. The members of the families Viviapridae, Pachychilidae and Paludomidae are the most important freshwater molluscs, with the highest number of species consumed in Northeast India. In West Bengal, apart from the above commonly collected species from the northeast, *Indoplanorbis exustus, Cerasina luteola* and *Radix rufescens* were also used as food and medicine (Chattopadyay 1992).

The molluscs are boiled in water and cooked with spices and vegetables. In the case of *Brotia* spp., the shells are broken from the middle and the meat sucked is out, or the entire animal is removed through the shell aperture. *Pila maura* is usually consumed by first boiling, and then the entire animal is fried. In some cases, it was also recorded that communities prepare a traditional curry of snails (*Filopaludina bengalensis*) with black gram. Freshwater snails belonging to the genus *Pila* are known to be consumed for food as well as for medicinal purposes in various parts of India, but more frequently in states such as Bihar, West Bengal, Nagaland, Tripura, Mizoram, Manipur, Meghalaya and Assam (Borkakati et al. 2009; Betlu 2013; Chinlampianga et al. 2013; Jadhav et al. 2023).

Numerous studies have well-documented the utilisation of freshwater molluscs for medicinal purposes by indigenous tribal communities across regions (Chattopadhyay 1992; Jamir and Lal 2005; Borkakati et al. 2009; Tripathy and Mukhopadhyay 2015; Kakati and Doulo 2022). Particularly in Northeastern India and certain areas of West Bengal, freshwater molluscs hold a significant place in traditional medicine practices. Local communities residing in states such as Tripura, Nagaland, Manipur, Mizoram, and Assam attribute various health benefits to the consumption of snails. These perceived advantages include the improvement of eyesight, enhanced kidney function, and relief from joint pain. *Filopaludina bengalensis*, in particular, holds a prominent place in traditional Indian medicine. This species is harvested to address a spectrum of health issues, including conjunctivitis, vision problems, joint pain, spleen enlargement, gastritis, jaundice, asthma, and wound healing (Prabhakar and Roy 2009; Bhattacharya et al. 2014; Jadhav et al. 2023). The widespread employment of these molluscs in both healthcare and cultural contexts underscores their deep-rooted significance in the daily lives of these communities.

The applications of freshwater molluscs in traditional healthcare extend to other dimensions. In Nagaland, snails form part of the staple diet, especially in post-medical procedures. The belief is that consuming snails contributes to quicker recuperation after surgeries. Additionally, snail slime, collected from these molluscs, is directly applied to the eyes, showcasing their diverse roles in traditional medicinal practices. Species such as *Lamellidens marginalis*, *Filopaludina bengalensis,* and *Pila maura* are valued for their therapeutic potential. They are used for common ailments, including issues such as vomiting, anaemia, eye-related conditions, jaundice, and giddiness (Chattopadhyay 1992; Betlu 2013). In the context of women's health, *Lamellidens marginalis* is employed to manage menstrual concerns (Chattopadhyay 1992).

It is important to recognise that the usage of these molluscs extends beyond food and medicinal applications. They are integral to the daily lives and cultural practices of various communities, employed as utensils, totemic items, ritual objects, ornamentation, decorative elements, tools for recreational activities, and even materials for trade. This multifaceted role demonstrates the deep-seated significance of these molluscs in the lives of individuals from diverse backgrounds, transcending caste and creed boundaries.

Apart from human consumption, *Pila maura and Filopaludina bengalensis* are harvested commercially as fish feed for shrimp farms in certain areas of Bangladesh (Baby et al. 2010). In many parts of Northeast India, *Pila* spp. is used for purposes other than human consumption, such as poultry feed. According to local communities in Manipur, Assam and Tripura, feeding poultry with *Pila* and *Filopaludina* would increase egg production (Jadhav et al. 2023). Thus, there might be a great potential for the use of freshwater snails in enhancing egg production. The shells of these molluscs are used by the village people for different purposes, viz. as measuring pots, as collyrium preparation pots, and as jeweller's chemical containers.

The shell of *Lamellidens marginalis* is also used to cut the umbilical cord of the newborn baby in rural areas (Chattopadhyay 1992).

Ethnic groups: The prevalence of mollusc consumption within the scheduled castes and scheduled tribes of West Bengal, Assam, and Bangladesh, as noted in previous research (Chattopadhyay 1992; Baby et al. 2010), surpasses the rates observed within the general castes or higher casts. However, in the northeastern Indian states, a significant proportion of the population belongs to scheduled tribes. In West Bengal, studies showed that the frequency of mollusc consumption fluctuated not as much with caste but rather with the species preference and the geographic location of the villages and households (Chattopadhyay 1992). Interestingly, a recent study by Jadhav et al. (2023) aligns more closely with the variations related to preferred mollusc species rather than caste-related distinctions. This could be attributed to the relatively diminished emphasis placed on issues of caste within this specific context.

Collection: Non-marine molluscs are typically harvested from the wild using various methods. For instance, clams and mussels are commonly collected by either hand-picking or nets and gastropods by handpicking only. In certain regions of India, *Filopaludina* is harvested by setting traps made of palm leaves. These traps are submerged in ponds or tanks overnight and retrieved the following morning, with the molluscs then being hand-picked from the traps (Subba Rao 1989). The collection of freshwater molluscs occurs throughout the year, with a more frequent harvest during the monsoon season and a reduced rate during drier periods. In contrast, land snails are gathered only during the monsoon season.

Nutritive value: A handful of studies conducted in India and neighbouring countries such as Nepal and Bangladesh have looked into the nutritional aspects of only freshwater molluscs (Baby et al. 2010; Diarra 2015). These molluscs have garnered attention for their

potential as a source of mini livestock, particularly in addressing the nutritional needs of underprivileged communities (Ghosh-Jerath et al. 2015; Ghosh et al. 2016; FAO, 2018). While comprehensive data remains somewhat limited, several reviews substantiate the prevailing belief that mollusc meat is characterised by its high protein and low-fat content. Biochemical investigations have revealed that freshwater snails typically contain protein levels ranging from 4 to 70% of their total wet weight (see Table 2 for details). This protein content is on par with or even exceeds that of conventional meat sources like chicken, making it a substantial protein reservoir at a much cheaper cost. Thus, these molluscs are an affordable source of protein for impoverished and marginal tribal communities in developing or underdeveloped countries. Moreover, freshwater molluscs are notably rich in essential minerals such as calcium and substantial amounts of phosphorus, iron and zinc, especially in species like *Pila globosa, Filopaludina bengalensis* and *Lamellidens marginalis* (Baby et al. 2010).

The predominant fat content in freshwater molluscs comprises polyunsaturated fats. In particular, *Filopaludina bengalensis* and *Pila globosa*, two commonly studied species and extensively consumed, feature a fat composition consisting of saturated fatty acids (48-60%), monounsaturated fatty acids (18-30%), and polyunsaturated fatty acids (21-33%) (Misra et al. 2002). Polyunsaturated fatty acids (PUFAs) hold significant dietary importance due to their inclusion of what are commonly referred to as 'essential fatty acids,' including linoleic, linolenic, and arachidonic acids. The consumption of these molluscs can play a pivotal role in enhancing the nutritional well-being of communities.

Snail farming or heliciculture: Molluscs are one of the major groups being reared in aquaculture in Southeast Asia, especially marine or brackish water species (FAO 2018).

as several countries such as Mexico, Thailand, Phillippines and Taiwan have developed methods for the successful rearing of the snails (Ghosh et al. 2016; Flores-Garza et al. 2012; FAO 2018). In many parts of India, whjere rich traditional knowledge exists and people are dependent on freshwater molluscs, snail farming has great potential for securing nutritional security.

In the face of existing challenges related to food and nutritional scarcity, the time has come to explore the prospects of cultivating edible snails and treating them as a form of mini-livestock. To uplift the livelihoods and guarantee the food and nutritional security of economically disadvantaged communities, it is essential for both government institutions and civil society organizations to promote the practice of heliciculture or snail farming actively. This strategic approach not only contributes to the conservation of wild snail populations but also opens up significant employment opportunities, especially for marginalized communities. The adoption of snail farming not only aids in the conservation of natural mollusc populations but also mitigates the pressure exerted on these populations. Beyond heliciculture, there is a compelling need to advocate for alternative strategies, such as the cultivation of freshwater molluscs in backyard ponds or in tandem with rice paddies during the monsoon season. Certain hardy and generalist species, including *Pila, Filopaludina, Cipangopaludina,* and *Angulyagra*, exhibit characteristics that render them highly adaptable to farming. Notably, their prolific reproductive rates make them particularly suitable for breeding in artificial ponds in the homesteads or backyards.

By encouraging and facilitating these initiatives, governments and civil society organisations can make substantial contributions to poverty alleviation, fortify food security, and enhance the overall well-being of vulnerable populations. The dual benefits of conservation and livelihood improvement underscore the significance of these strategies as pivotal steps towards sustainable development. Both local and international studies, including research conducted in and outside India, have affirmed that snails are economically viable for rearing at the commercial level, requiring minimal maintenance and inputs while yielding high returns (Ivan et al. 2017; Ghosh et al. 2016). This underlines the potential for snail farming to be a transformative and sustainable practice with far-reaching benefits for communities and ecosystems alike.

Table 1: List of edible molluscs reported from India.

Family	Species	Endemic / Non-endemic	
Ampullaridae	*Pila globosa*	NEn	
Ampullaridae	*Pila saxea*	En	
Ampullaridae	*Pila malabarica*	En	
Ampullaridae	*Pila virens*	En	
Ampullaridae	*Pila maura*	En	
Ampullaridae	*Pila* sp.	En	
Viviparidae	*Filopaludina bengalensis*	NEn	
Viviparidae	*Idiopoma dissimilis*	NEn	
Viviparidae	*Angulyagra oxytropis*	NEn	
Viviparidae	*Angulyagra sp.*	En	
Viviparidae	*Cipangopaluidna lecythis*	NEn	
Viviparidae	*Cipangopaludina nagaensis*	En	
Pachychilidae	*Brotia costula*	NEn	

	Red list status	Habitat	Uses
	LC	Ponds, tanks, marshes, reservoirs	Food, Medicine, Poultry
	LC	Streams	Food
	NE	Ponds, tanks, marshes, reservoirs	Food
	LC	Ponds, tanks, marshes, reservoirs	Food
	NE	Ponds, tanks, marshes, reservoirs	Food, Medicine, Poultry
	NE	Ponds, tanks, marshes, reservoirs	Food
	LC	Ponds, tanks, marshes, reservoirs	Food, Medicine, Poultry
	LC	Ponds, tanks, marshes, reservoirs	Food, Medicine
	LC	Ponds, tanks, marshes, reservoirs	Food, Medicine
	NE	Ponds, tanks, marshes, reservoirs	"Food, Medicine
	LC	Ponds, tanks, marshes, reservoirs	Food, Medicine
	LC	Ponds, tanks, marshes, reservoirs	Food, Medicine
	LC	Streams, Rivers	Food, Medicine

Paludomidae	*Paludomus* sp.	En	
Paludomidae	*Paludomus* sp.	En	
Paludomidae	*Paludomus* sp.	En	
Paludomidae	*Paludomus* sp.	En	
Paludomidae	*Paludomus* sp.	En	
Paludomidae	*Paludomus reticulata*	En	
Lymnaeidae	*Radix rufescens*	NEn	
Lymnaeidae	*Racesina luteola*	NEn	
Bulinidae	*Indoplanorbis exustus*	NEn	
Unionidae	*Lamellidens marginalis*	NEn	
Unionidae	*Lamellidens corrianus*	NEn	
Unionidae	*Lamellidens* sp.	En	
Unionidae	*Parreysia corrugata*	NEn	
Unionidae	*Indonaia gratiosa*	NEn	
Unionidae	*Indonaia caerulea*	NEn	

	NE	Streams, Rivers	Food, Medicine
	NE	Streams, Rivers	Food, Medicine
	NE	Streams, Rivers	Food, Medicine
	NE	Streams, Rivers	Food, Medicine
	NE	Streams, Rivers	Food, Medicine
	LC	Streams, Rivers	Food, Medicine
	LC	Ponds, tanks, marshes, reservoirs	Food, Medicine
	LC	Ponds, tanks, marshes, reservoirs	Food, Medicine
	LC	Ponds, tanks, marshes, reservoirs	Food
	LC	Streams, Rivers	Food, Medicine
	LC	Streams, Rivers	Food, Medicine
	NE	Rivers	Food
	LC	Streams, Rivers, Tanks	Food, Medicine
	DD	Streams, Rivers	Food
	LC	Streams, Rivers	Food

Unionidae	*Balwantia soleniformis*	NEn	
Unionidae	*Trapezidens exolescens*	NEn	
Cyrenidae	*Corbicula striatella*	NEn	
Cyrenidae	*Villorita cyprenoides*	En	
Cyclophoridae	*Cyclophorus altivagus*	En	
Cyclophoridae	*Cyclophorus aborensis*	En	
Cyclophoridae	*Cyclophorus koboensis*	En	
Cyclophoridae	*Cyclophorus* sp.	En	
Cyclophoridae	*Pterocylcos aborensis*	En	
Cyclophoridae	*Spiraculum planum*	En	
Cyclophoridae	*Spiraculum kempi*	En	
Camaenidae	*Psuedotrachaea vittata*	En	
Achatinidae	*Lissachatina fulica*	NEn	

	LC	Streams, Rivers	Food, Medicine
	LC	Streams, Rivers	Food, Medicine
	LC	Streams, Rivers	Food
	LC	Brackish water	Food
	NE	Terrestrial	Food
	NE	Terrestrial	Food
	NE	Terrestrial	Food
	NE	Terrestrial	Food
	NE	Terrestrial	Food
	NE	Terrestrial	Food
	NE	Terrestrial	Food
	NE	Terrestrial	Food
	NE	Terrestrial	Food, Medicine
	LC	Terrestrial	Food

Legend: En: Endemic; NEn: Non-endemic
LC: Least Concern; NE: Not Evaluated

Table 2: Nutritive value (per dry mass in percentage) of different species of edible non-marine molluscs from Northeast India and Bangladesh.

Species	Protein	Fat	
Filopaludina bengalensis	8.79-35.67	0.984-4.83	
Idiopoma dissimilis	11.18±2.17		
Pila globosa	15.59-57.05	0.73-5	
Brotia costula	12.91-44.42	2.9	
Lamellidens marginalis	4.24-45.84	0.51-3.60	
Lamellidens corrianus	71.21%	5.43	

	Carbohydrates	Red list status
	4.31-22.54	Baby et al. 2010; Khaluala et al. 2014; Debnath et al. 2016; Chutia et al. 2020
	11.46±6.42	Debnath et al. 2016
	2.9-12.11	Baby et al. 2010; Ghosh et al. 2016; Debnath et al. 2016; Chutia et al. 2020
	9.12-21.89	Debnath et al. 2016; Chutia et al. 2020
	4.94	Baby et al. 2010; Sable and Vedpathak 2017; Ghosh et al. 2016
		Suryanarayanan and Alexander 1972

Conservation

Non-marine molluscs in India, which include land and freshwater molluscs, are currently facing significant threats from a variety of anthropogenic activities. These activities have collectively put the non-marine mollusc populations in a vulnerable position, and concerted efforts are required to address these issues.

Land use and land cover changes: One of the primary threats to non-marine molluscs in India is the alteration of land use and land cover. The conversion of natural habitats for agriculture, urbanization, and industrial development results in the loss and fragmentation of habitats that these molluscs depend on for their survival. As these landscapes are transformed, molluscs lose their habitats and are often unable to adapt to the new conditions.

Habitat loss and degradation: Habitat loss, often due to agriculture expansion, deforestation, and construction activities, directly impacts non-marine mollusc populations. In addition to outright habitat loss, degradation of the remaining habitats through activities like pollution and habitat modification further stresses these species and their population. The pollution of water bodies, for instance, can lead to declines in freshwater molluscs.

Urbanization: Rapid urbanization in India is a significant contributor to the decline of non-marine molluscs. Urban areas often have reduced green spaces and increased impervious surfaces, which limits the available habitats for these creatures. The alteration of water bodies within cities and towns also negatively affects freshwater molluscs.

Infrastructure development (dams, roads, railways): Infrastructure development, including the construction of dams, roads, and railways, disrupts the natural landscapes where non-marine molluscs reside. These structures fragment habitats and can directly lead to mortality as molluscs are unable to navigate these barriers.

Overharvesting: Overharvesting of non-marine molluscs, often for the pet trade or as a source of food in some communities, poses a significant threat. Excessive collection can lead to local extirpation of populations and impact the overall abundance of these species.

Increasing human population: The growing human population in India places added pressure on the land, leading to habitat transformation and increased demands on natural resources. This indirectly affects non-marine molluscs by reducing the available space and resources.

Conservation assessment and management of non-marine molluscs in India is a complex challenge due to the unique characteristics of each species and the varied threats they face. To date, there has been more focus on conserving freshwater molluscs, leaving land molluscs less studied and protected.

Basic information regarding the distribution, abundance, and specific threats for each non-marine mollusc species is often lacking. Even in cases where assessments exist, they may be outdated, failing to reflect current population trends and distribution ranges.

The situation is particularly dire for land molluscs, where comprehensive documentation and conservation efforts are notably lacking. A prime example of this is the limited number of assessments available for these species on the IUCN Red List, with a large proportion of species categorised as data deficient (DD). This DD status underscores the gaps in our understanding of population dynamics, distribution, and the specific threats these species encounter.

Therefore, future research, whether taxonomic or ecological, needs to emphasise documenting the threats faced by non-marine molluscs and gathering accurate data on population density and distribution. This information is essential for conducting robust conservation assessments and developing effective conservation strategies to safeguard these unique and often-overlooked components of India's freshwater biodiversity. Scientists, conservationists, and policymakers must work together to address these issues and protect the diversity of non-marine molluscs in India.

About the book

This book serves as a repository of knowledge encompassing 42 distinct species of land and freshwater molluscs utilised for sustenance and medicinal purposes across India. Within this compilation, 41 species are meticulously documented, with a composition of 32 falling within the category of freshwater molluscs while the remaining nine are terrestrial snails. The information presented in this book is the result of an extensive research effort, amalgamating our original findings with data synthesised from a myriad of other scholarly investigations.

Detailed descriptions are provided to aid in the identification and understanding of each species, offering insights into their ecological preferences, geographical distribution, uses, and any additional pertinent information. In light of the challenges encountered when distinguishing between species within the *Brotia* genus based on field observations, our documentation offers a holistic perspective by combining all five recognised species, given the considerable intra-specific variability present within this genus (Jadhav et al. 2023).

For each species, we provide distribution maps. It is important to acknowledge that while these maps are a valuable resource, they do not claim to encompass all available data and should not be regarded as exhaustive. Any given species might be more widely distributed, but the distribution data is scarce. We intend to offer a basis for further exploration and research. To facilitate ease of reference and identification, each species is accompanied by a set of images from three distinct angles, allowing for comparative analysis.

Moreover, we have incorporated an array of icons for each species, each connoting a different aspect of their nature. These include representations of their preferred habitat, whether lentic (stagnant water) or lotic (flowing water), IUCN Red List status, uses including food, medicinal, or poultry applications, endemic or non-endemic status, and finally, whether the species serves as a host for schistosomes. This approach aims to provide a comprehensive and readily accessible resource for both researchers and the wider public, fostering a deeper appreciation for the diversity and significance of these molluscs in the Indian context.

List of icons

IUCN Status

Data Deficient

Least Concern

Not Evaluated

Uses


Food


Medicine


Poultry

Status

Endemic

Non-endemic

Habitat


Lentic

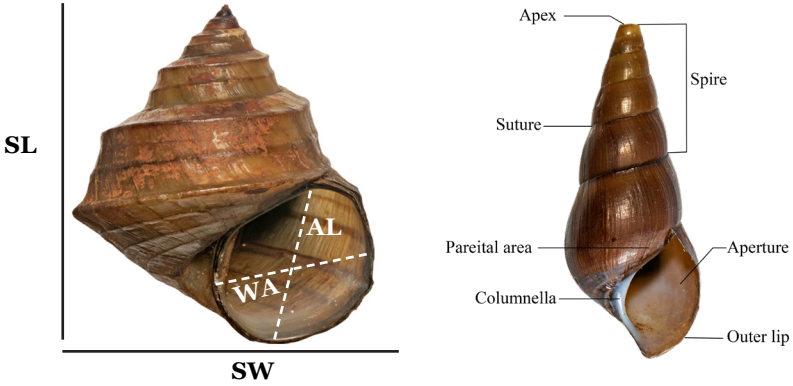

Lotic


Terrestrial

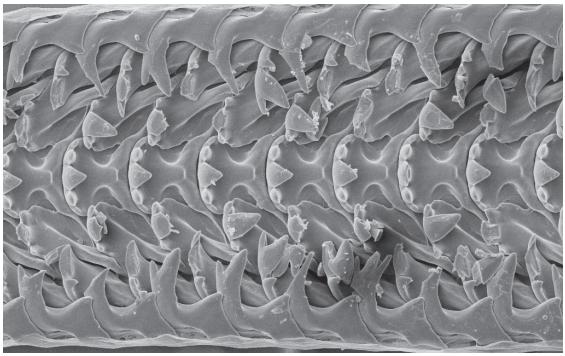
Abbreviations

H = Height if the shell
W = Width of the shell
Ap H = Aperture Height
Note: All the shell measurements are given in mm

Figure: Diagram showing the structure of a gastropod shell and terminologies used in taxonomy.

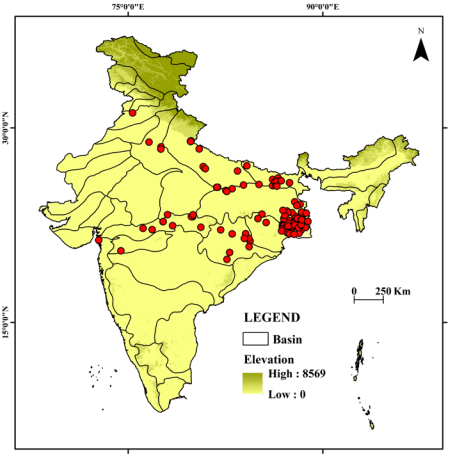


Scanning electron microscope image of radula of *Pila* sp.



Species Accounts

Freshwater Gastropods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Family: Ampullariidae
***Pila globosa* (Swainson, 1822)**

Common Name: Globose Apple Snail

Size: H = 56.20; W = 45.40; Ap H = 36.35; No. of whorls = 5

Identification: Shell is usually big and globular, smooth, olive in colour, body whorl is inflated with depressed spire, suture slightly impressed, aperture margin is thick, grooved and fulvous; umbilicus is open and narrow and contracted with horny, ovate and concentric operculum. Body whorl swollen with irregular dark spiral bands.

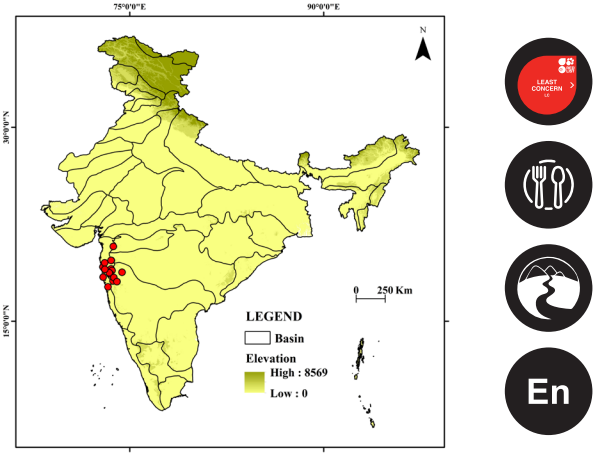
Distribution: Restricted to the Ganga River basin in India and Nepal. Probably also found in Bangladesh.

Ecology and Habitat: Found in marshes, paddy fields, tanks, and other lentic water bodies. It is also found in the stagnant section of rivers. This species can tolerate pollution to a certain extent.

Conservation status: Least Concern

Uses: It is extensively used as food and sometimes as medicine.

Remarks: This species is also used extensively in research related to biochemistry, physiology, toxicology, etc. Birds such as open-billed storks feed on this species. Largest of all Indian *Pila* species. It has good potential for heliciculture.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Family: Ampullariidae
***Pila saxea* (Reeve, 1865)**

Common Name: Mountain Apple Snail

Size: H = 29; W = 25; Ap H = 20; No. of whorls = 4-5

Identification: Shell oblong-ovate and olive in colour. Umbilicus is narrow, spire obtuse. Whorls are obtusely angled and rounded, with slight depression on the upper part. Aperture pear shaped and oblong, with dark brown-blackish margin. Collumellar lip slightly reflected. Operculum oval and concentric.

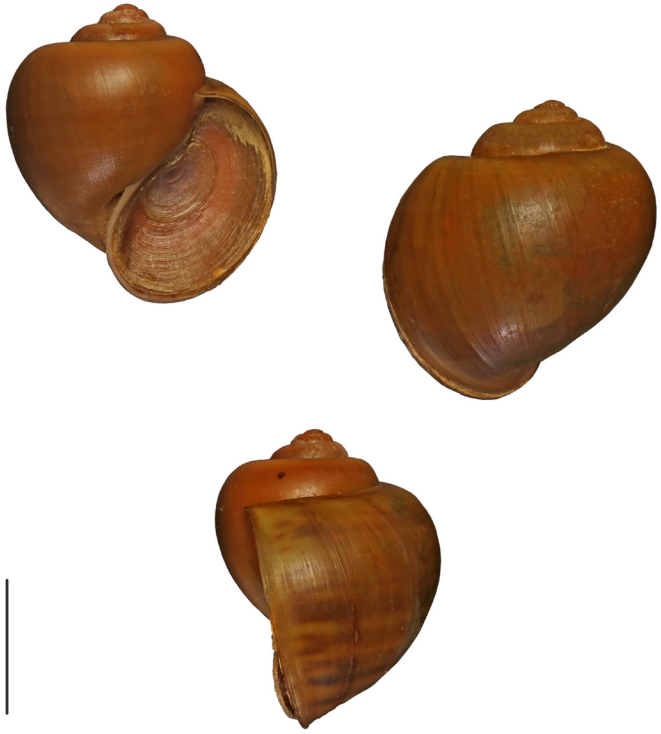
Distribution: Restricted to hill streams of Northern Western Ghats (above 16^{o} N latitude) in Maharashtra and Gujarat.

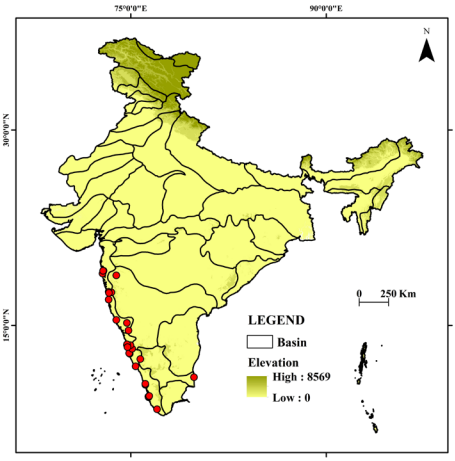
Ecology and Habitat: Abundant in rocky hill streams and small rivers, mostly riffles and at the base of the waterfalls. It is also found in the edges of paddy fields where there is water flow. Found above 200 m amsl. This species requires clear flowing water. Eggs are laid in clusters and are white in colour.

Conservation status: Least Concern

Uses: Consumed as food by *Kunbi* communities during *Rishipanchami* in Maharashtra parts of the Western Ghats during monsoon season when they are abundant (Aparna Watve *Pers Comm.*).

Remarks: There are no direct threats reported for this species, but changes in land use could be possible threats.

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Family: Ampullariidae
***Pila malabarica* (Philippi, 1852)**

Common Name: Malabar Apple Snail

Size: H= 36.25; W = 32; Ap H = 25.16; No. of whorls = 4-5

Identification: Shell medium size, ovate, uniformly olive with narrow umbilicus, suture impressed, body whorl angular. Aperture is ovate-oblong, callus absent. Spire distinct, one-third of shell height. Peristome strong and reflected on basal lip. Operculum oval and concentric.

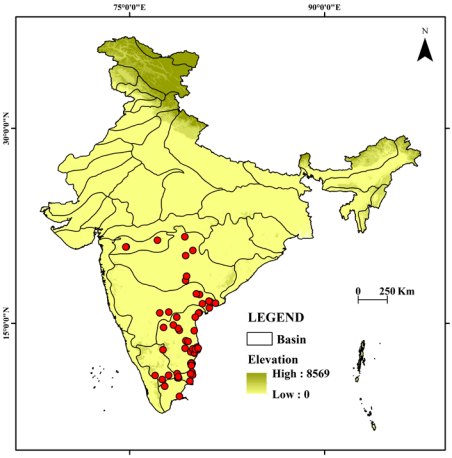
Distribution: Restricted to the west coast of India in the lower altitude.

Ecology and Habitat: It is found in marshes, paddy fields, tanks, ponds, etc. This species can tolerate habitat disturbance and pollution to a certain extent.

Conservation status: Not Evaluated.

Uses: Used as food by coastal communities during monsoon season when they are abundant.

Remarks: This species was synonymised with *Pila virens*, but recent molecular analysis and radular structure suggest this as a valid species (Sil et al. 2023). It has good potential for heliciculture.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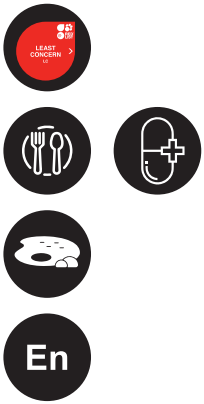
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Family: Ampullariidae
***Pila virens* (Lamarck, 1822)**

Common Name: Green Apple Snail

Size: H = 16.4; W = 12.5; Ap H = 10.9; No. of whorls = 5

Identification: Shell medium, globose, smooth. Body whorl oblique when viewed dorsally, relatively swollen. Suture deeply impressed and canaliculate due to which the whorls appear to regularly increase in size. Apex is obtuse. Spire is conical and takes 1/4th of the height of the shell. Aperture ovate and broad below. Peristome continuous with distinct lip that is tilted backwards and has a ridge for the operculum to fit in. Callus well developed. Umbilicus is very narrow as it is partly hidden by the retroverted inner lip. Operculum oval and concentric.

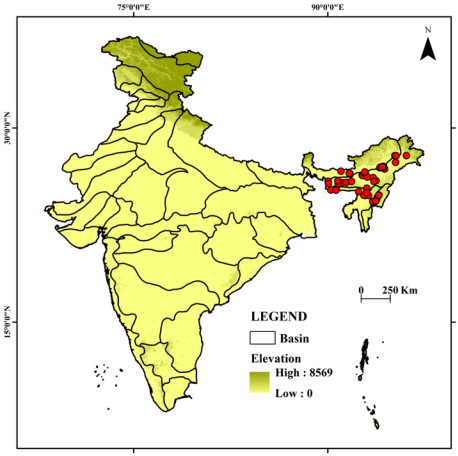
Distribution: Restricted to Peninsular India in the Deccan region South of River Krishna and Godavari, but absent in the west coast of India, where this species is replaced with *P. malabarica.*

Ecology and Habitat: This species is found in marshes, paddy fields, tanks, etc. Highly generalist species can tolerate moderate levels of organic pollution and habitat disturbance. Found abundantly. Restricted to Deccan region in the eastern parts of India up to 400 m amsl.

Conservation status: Least Concern

Uses: This species is extensively used as food and occasionally for medicinal purposes.

Remarks: Birds such as open-billed storks feed on this species. *Pila virens* was reported from Assam based on shell morphology. A recent molecular analysis showed that this species is restricted to Peninsular India (Sil et al. 2023). *Pila virens* is also used in research. It has good potential for heliciculture.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Family: Ampullariidae
***Pila maura* (Reeve, 1856)**

Common Name: Assam Apple Snail

Size: H = 31; W = 29; Ap H = 25; No. of whorls = 4

Identification: Shell nearly globose, umbilicus indstinct, spire is short, suture impressed. Whorls olive, rounded with longitudinal striations and encircled with two distinct linear, narrow blackish-red bands. Aperture is pyriformly ovate, lip thickened, and reflected on basal and columellar lips, callus indistinct.

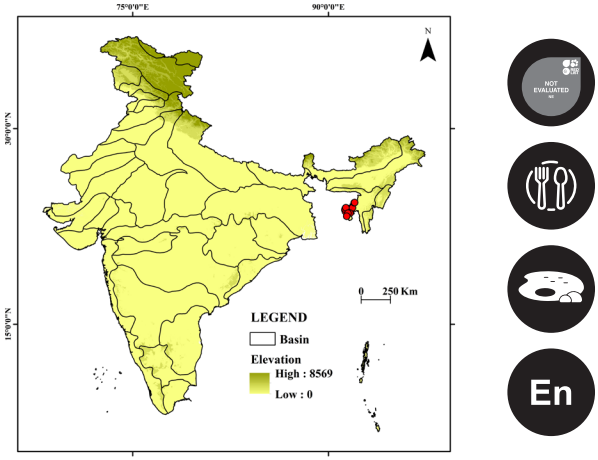
Distribution: Restricted to the Brahmaputra River basin in Northeast India. Found in lower altitudes in the states of Assam, Nagaland, Manipur, and Arunachal Pradesh. Not reported from Meghalaya.

Ecology and Habitat: This species is found abundantly in marshes, paddy fields, tanks, etc. Highly generalist species can tolerate moderate levels of organic pollution and habitat disturbance.

Conservation status: Not Evaluated

Uses: Communities in northeast India consume *P. maura* extensively. Also sold in the local market for INR 40-60. This species is also used in poultry to increase egg production. The communities in Northeast India use it as medicine for eye diseases like conjunctivitis. It is believed that consumption and use of "juice" cure eye disease and increase eyesight.

Remarks: Earlier, this species was synonymised with *P. virens*. But recent molecular and radular analysis suggest that this is a distinct species (Sil et al. 2023). It has good potential for heliciculture.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NOT EVALUATED
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Family: Ampullariidae
***Pila* sp.**

Common Name: Tripura Apple snail

Size: H = 38.25; W = 36.42; Ap H = 27.5; No. of whorls = 4

Identification: Shell medium, roundish with inflated body whorl, brownish in colour. Spire slightly depressed. Body whorl has fine longitudinal striations at regular intervals. Aperture big, ear shaped. Circumference of the aperture towards the body whorl from both sides is thicker. Umbilicus is small, deep and contracted. Circumference of the aperture slightly reflected.

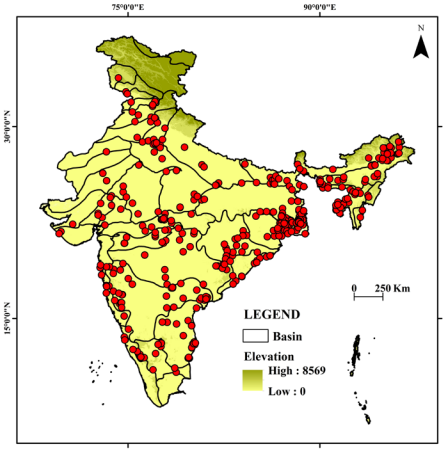
Distribution: Currently known only from Tripura state of Northeast India. This species might be found in Bangladesh as well.

Ecology and Habitat: This species is found abundantly in marshes, paddy fields, tanks, etc. It is a highly generalist species and can tolerate moderate levels of organic pollution and habitat disturbance.

Conservation status: Not Evaluated.

Uses: Communities in Tripura consume this species extensively.

Remarks: Taxonomic status of this species needs to be worked out. It has good potential for heliciculture.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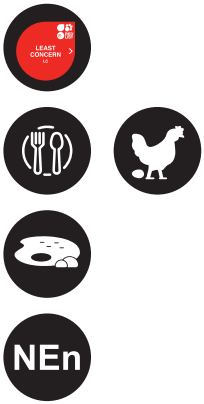
LEAST CONCERN
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Family: Viviparidae
***Filopaludna bengalensis* (Lamarck, 1822)**

Common Name: Banded Pond Snail

Size: H = 34.85; W = 24.25; Ap H = 18.92; No. of whorls = 6

Identification: Shell conical, thin, greenish, with fine growth lines, and linear narrow spiral dark green bands across shell. Spire conical, with pointed protoconch. Whorls convex, smooth with minor decussate striations. Sutures highly impressed, aperture sub-oval with thin lip. Embryonic shells are thin with three rows of chaetae and low ridges, with the lowermost being well developed. Operculum oval, brownish in colour.

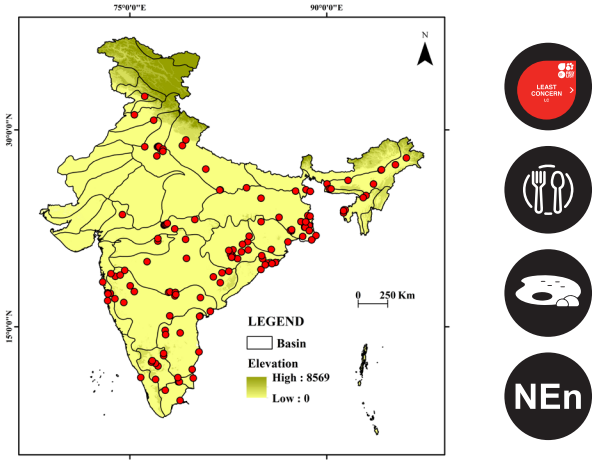
Distribution: This is one of the most common freshwater mollusc species that occurs all over India, Nepal, Bangladesh, etc.

Ecology and Habitat: This species is commonly found in all types of lowland lentic water bodies, lakes, ponds, marshes, channels and paddy fields. Highly generalist species can tolerate quite a high degree of habitat disturbance and pollution. This species can reproduce profusely and give birth to young ones

Conservation status: Least Concern

Uses: Studies have shown that this species is a good source of protein and calcium. *Filopaludna bengalensis* is the most widely consumed species among non-marine molluscs by the local communities across India.

Remarks: This species is extensively used in research related to biochemistry, physiology, toxicology, etc. Birds such as open-billed storks feed on this species. It has good potential for heliciculture.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LEAST CONCERN
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Family: **Viviparidae**
***Idiopoma dissimilis* (O.F. Müller, 1744)**

Common Name: Variable Pond Snail

Size: H = 36.00; W = 17.90; Ap H = 14.25; No. of whorls = 6

Identification: Shell small, globose, brownish in colour. Body whorl convex, shows slightly elevated ridge, which may be obscure in some specimens, pale spiral band may or may not be present. Spire is conical and swollen. Suture deeply impressed. Umbilicus indistinct. Aperture circular, lip or peristome of the aperture often black, less sharp with thick operculum exhibiting prominent muscular scar.

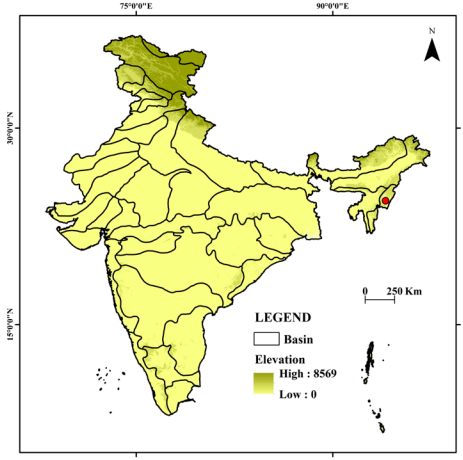
Distribution: This is one of the most common freshwater mollusc species that occurs not only all over India but also in Nepal, Bhutan, Bangladesh, etc.

Ecology and Habitat: This Viviparid species is usually found in lentic freshwater habitats such as small ponds, tanks, marshes and manmade habitats such as irrigation canals and paddy fields during monsoons. Highly generalist species can tolerate quite a high degree of habitat disturbance and pollution. This species can reproduce profusely.

Conservation status: Least Concern

Uses: This species is consumed as food by the local communities across India.

Remarks: This species is extensively used in research related to biochemistry, physiology, toxicology, etc. Birds such as open-billed storks feed on this species. *Idiopoma dissimilis* has a good potential for heliciculture.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Family: **Viviparidae**
***Angulyagra* sp.**

Size: H = 33.11; W = 29.35; Ap H = 18.24; No. of whorls = 7

Identification: Shell medium sized, sharply acuminate and angled. The shell extremely angular at the border of each whorl. The body whorl is much broader than the height of the shell and shows longitudinal striations. Apex is pointed. The base of the second and third whorl is slanting. The angle of the body whorl to the tip of the aperture is slightly slanted. Presence of three dark spiral brown bands (ribs), out of which two bands are on the angles of the body whorl. Bands are prominent on the ventral view of the shell. Four light brown fine bands seen in between the three dark bands as 1+3 on the body whorl if seen ventrally. After the second body whorl, fine single bands are present between each body whorl. Umbilicus open. Aperture circular and angled at the end of bands. Outer lip has angle and band like structure, which is seen in the aperture.

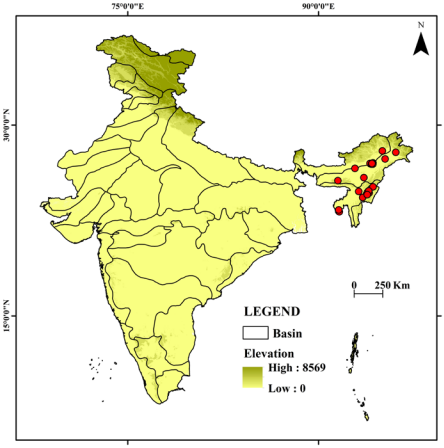
Distribution: This species is reported only from Imphal and Chandel districts of Manipur.

Ecology and Habitat: Found in all kinds of lentic water bodies, from artificial ponds to lakes, where they can be found attached to grass stems and longer parts of plants that float on the surface of water.

Conservation status: Not Evaluated

Uses: This *Angulyagra* species is consumed as food and used as medicine in Manipur. The powder of the shells is also used as poultry feed to enhance egg production.

Remarks: Taxonomic status needs to be assessed.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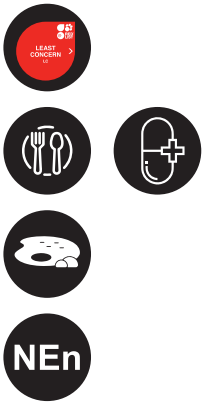
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Family: Viviparidae
***Angulyagra oxytropis* (W.H. Benson, 1836)**

Size: H = 42.7; W = 30.0; Ap H = 15.83; No. of whorls = 7

Identification: Shell large and thin, light brown to light olive-green in colour. Overall shape of shell slightly broad and conical, with acuminate apex. Shell shows prominent spiral angled ridges. The protoconch is minute, whorls increasing gradually, little flattened but oblique outside. Suture slightly impressed. The three last whorls of the spire have two smooth prominent dark spiral ridges, three on the upper part of body whorl and two each on the rest of the whorls. Oblique striae present all over the shell. Aperture is somewhat roundish, more wider than long. Columellar margin is prominent but narrow. Umbilicus is narrow but shows a deep depression with a continuous peristome. Outer lip is thin and slightly arched at regular intervals.

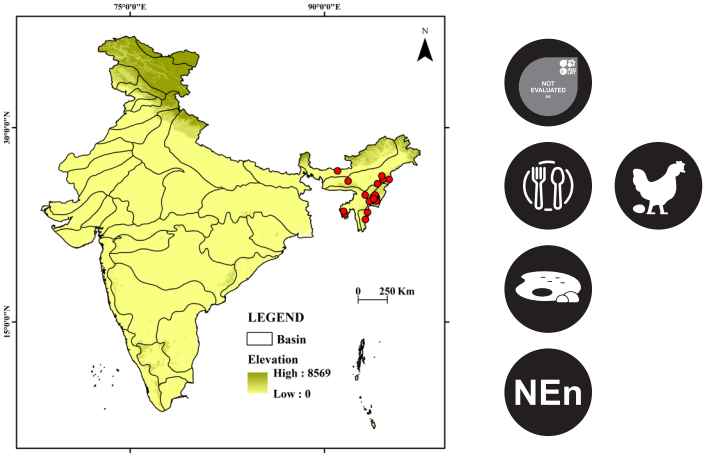
Distribution: Currently, this species is known only from a few states of Northeast India.

Ecology and Habitat: *Angulyagra oxytropis* is a very abundant species found in lentic aquatic ecosystems such as wetlands, freshwater lakes, marshes and also manmade habitats. Highly generalist species can tolerate quite a high degree of habitat disturbance and pollution.

Conservation status: Least Concern

Uses: Used as food and also this species is believed to have medicinal property. Extensively used by the tribal communities from Nagaland Manipur and Mizoram.

Remarks: This species is also reported to be used in the shell and jewellery industries by the locals. It has good potential for heliciculture.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Family: **Viviparidae**
***Cipangopaludina lecythis* (W. H. Benson, 1836)**

Size: H = 40.9; W = 32.65; Ap H = 22.5; No. of whorls = 5

Identification: Shell globose to conical in shape, thin, olive to dark brown in colour, feeble wrinkles present in some individuals. Whorls round in shape, fine longitudinal striations present. Sutures impressed. Aperture roundish oval in shape, dark-brownish peristome. Operculum oval, and concentric. Umbilicus not well developed.

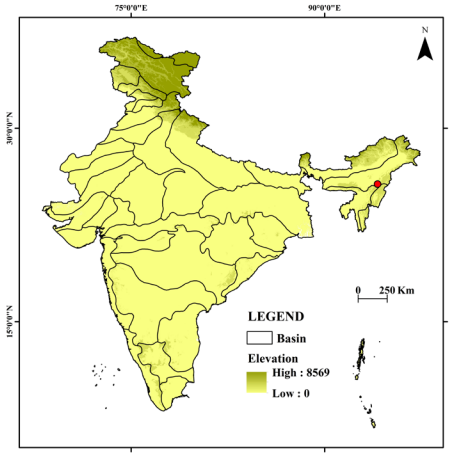
Distribution: This species is widely distributed in the northeast sates of India, such as Assam, Mizoram, Meghalaya, Manipur, Nagaland and Tripura.

Ecology and Habitat: It is found in lentic freshwater habitats such as ponds, marshes and rice fields. Highly generalist species can tolerate quite a high degree of habitat disturbance and pollution.

Conservation status: Least Concern

Uses: Used mainly as food in the Northeast India. In some states like Manipur and Nagaland, the shells are also used in poultry to increase egg production.

Remarks: Currently no threats are recorded for this species. It has good potential for heliciculture.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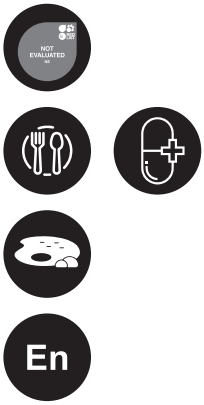
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Family: Viviparidae
***Cipangopaludina nagaensis* (Preston, 1914)**

Size: H = 28; W = 20; Ap H = 15; No. of whorls = 5

Identification: Shell small, dark olive in colour, globose, turbinate, fissured. Whorls globose, regularly increasing, sculptured with fine transverse striae. Suture is well developed. Umbilicus not very well developed. Circumference of the aperture encircled with a thin dark brown border. Columella descends to a slight curve. Aperture roundish and ovate in shape.

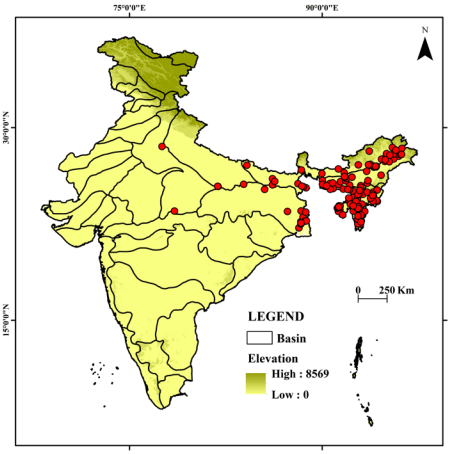
Distribution: Restricted to Naga Hills in the state of Nagaland. It might be found in other parts of Northeast India.

Ecology and Habitat: Found in stagnant freshwater bodies as well as man-made aquatic habitats.

Conservation status: Not Evaluated

Uses: *Cipangopaludina nagaensis* is commonly consumed in Nagaland for food and medicinal purposes and used as poultry feed.

Remarks: Nothing much is known about its ecology and distribution. Extensive surveys needed to assess the actual distribution of this species.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LEAST CONCERN
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NEn

Family: **Pachychilidae**
***Brotia* sp.**

Common Name: Cap Snail

Size: H =54.68; W = 17.17; Ap H = 16.42; No. of whorls = 6-12

Identification: Shell elongate, medium to large sized having uniform olive to green colour. Whorls 6 to 12, with spiral ridges or nodules along with prominent axial ribs. The axial ribs usually support small, spiny nodules that are arranged in a spiral band at the centre of the whorl. But some specimens are smooth. Tip of the spire is often eroded. Suture impressed. *Brotia costula* is known to exhibit lot of morphological variation of the shell. Aperture is wide and rounded at the base covering one fifth of the shell height.

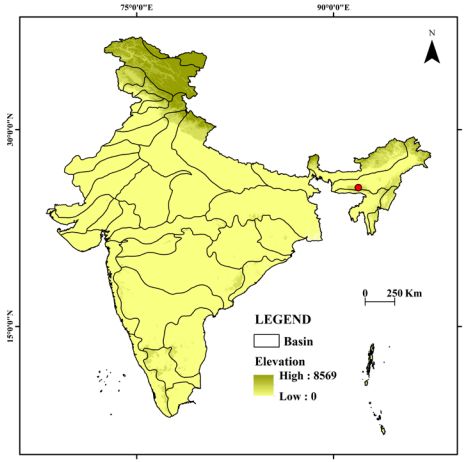
Distribution: Among all known *Brotia* species, *B. costula* is known to occur through the Gangetic plains and Brahmaputra River basin in the East and Northeast India and Nepal.

Ecology and Habitat: All *Brotia* species are predominantly found in slow to fast-flowing streams and rivers with sandy bottom and occasionally in rocky bottom. *Brotia costula* is found in both lentic as well as lotic habitats.

Conservation status: Least Concern / Not Evaluated

Uses: *Brotia* sp. is believed to be of medicinal importance and consumed on a large scale in East and Northeast India. The communities in Northeast India use the shells as poultry feed. Among all freshwater molluscs sold in the market, *Brotia* is of high value and preferred over other species.

Remarks: There are five known species in this genus. Given their high intra-specific variation and difficulty in species-level identification, we provide a general description for all five known species of *Brotia* in this genus. *Brotia* prefer clean water and cannot tolerate pollution.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NOT EVALUATED
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Family: Paludomidae
***Paludomus* sp.**

Size: H = 22.03; W = 19.26; Ap H = 14.68; No. of whorls = 4

Identification: Shell globose, with longitudinal fine striae. Body whorl inflated round, has dark brown band, out of which the first one is light and other two are dark. The bands are seen through the aperture. The aperture is thick and oval. Callus thick, white. Outer lip of the aperture shows brownish tinge.

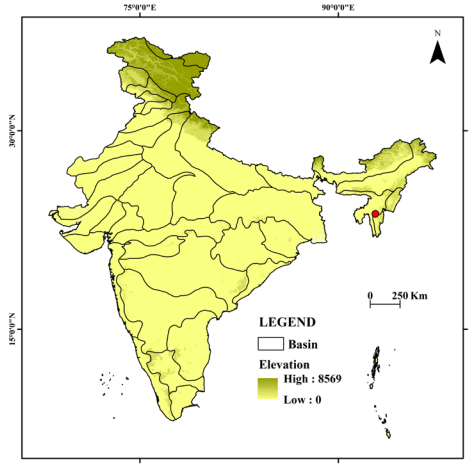
Distribution: Currently, this species of *Paludomus* is reported from Shillong in the East Khasi Hills district of Meghalaya.

Ecology and Habitat: This species inhabits flowing waters like streams and rivers. This species is usually attached to stones, boulders and leaves.

Conservation status: Not Evaluated

Uses: This species is used as food in Northeast India.

Remarks: Species belonging to this genus usually prefer clean waters. Deforestation, sedimentation, and hydropower projects are the potential threats apart from harvesting from wild.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Family: Paludomidae
***Paludomus* sp.**

Size: H = 17.49; W = 14.23; Ap H = 12.79; No. of whorls = 4-5

Identification: Shell oval, thick, chestnut brown in colour. Body whorl is timid and shows longitudinal lines, which are not very prominent. Body whorl has prominent black longitudinal lines in some individuals. Umbilicus absent. Apex often eroded. Aperture oval, white and columella very thick.

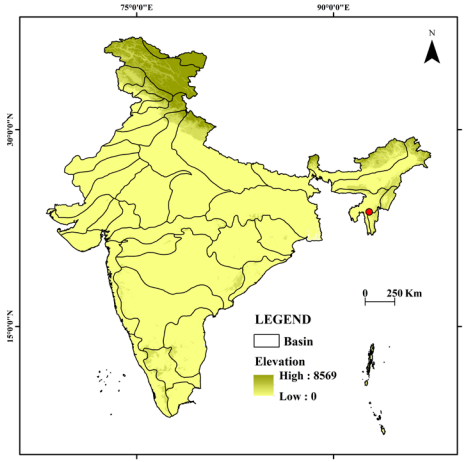
Distribution: Currently, this species is recorded only from Mizoram.

Ecology and Habitat: This species is usually found in flowing waters such as streams and slow flowing rivers.

Conservation status: Not Evaluated

Uses: This species is consumed on a large scale in Mizoram. The shells are sometimes powdered and given as poultry feed. Local communities believe this species has medicinal properties.

Remarks: This species is usually found in less polluted waters and requires sandy or rocky bottom.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Family: Paludomidae
***Paludomus* sp.**

Size: H = 23.03; W = 20.20; Ap H = 15.19; No. of whorls = 5-6

Identification: Shell conical, light brown in colour. Dark brown band on the body whorl, which starts from below the aperture and runs only dorsally. Fine longitudinal lines on the body whorl, which can be seen ventrally on the body whorl. Suture slightly impressed. One or two lines running below, radially along the suture. Aperture thick, whitish and broad towards the end. Columellar lip brownish. Umbilicus absent.

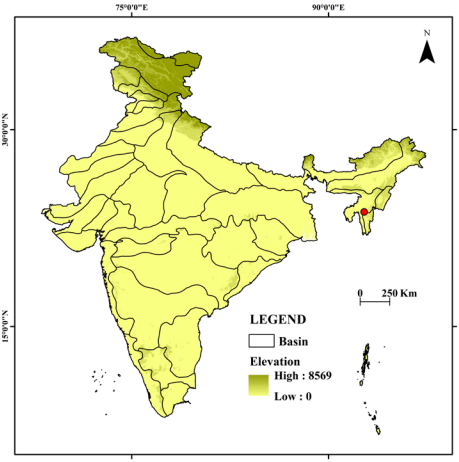
Distribution: This species is currently known from the Aizawl district of Mizoram.

Ecology and Habitat: This species inhabits streams and rivers and usually remains attached to stones, and boulders.

Conservation status: Not Evaluated

Uses: This species is commonly eaten in the Aizawl district of Mizoram.

Remarks: This species prefers clean and running water. Taxonomy needs to be worked out.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Family: **Paludomidae**
***Paludomus* sp.**

Size: H = 26.89; W = 22.89; Ap H = 17.51; No. of whorls = 4-5

Identification: Shell ovate but roundish, dark brown in colour throughout. Apex eroded. Longitudinal striations seen on the body whorl. Rows of minor reticulated lines on penultimate whorl which are present at regular intervals. Suture impressed with two lines running radially below the suture on the second body whorl. Aperture thick and whitish. Columella thick.

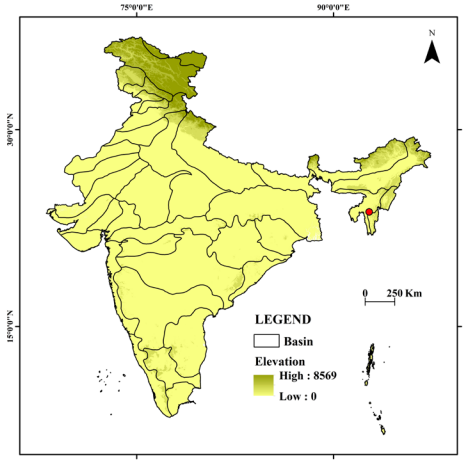
Distribution: This species is currently known to occur in the Aizawl district of Mizoram.

Ecology and Habitat: This species is found in streams and rivers.

Conservation status: Not Evaluated.

Uses: This particular species of *Paludomus* is widely consumed in Mizoram for food and medicinal purposes by the locals.

Remarks: This species is sold in the local markets of Aizawl and near nearby areas in Mizoram. The taxonomy of this species needs to be worked out.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Family: Paludomidae
***Paludomus* sp.**

Size: H = 24.53 ; W =17.05; Ap H = 14.36; No. of whorls = 5

Identification: Shell conical, ovate, brown in colour. Body whorl ovate roundish, shows presence of two thick dark brown band. Body whorl has longitudinal striations. Suture impressed. Two to three lines running radially below the suture from second to fourth whorl. Aperture thick, whitish. Outer lip of the aperture sharp.

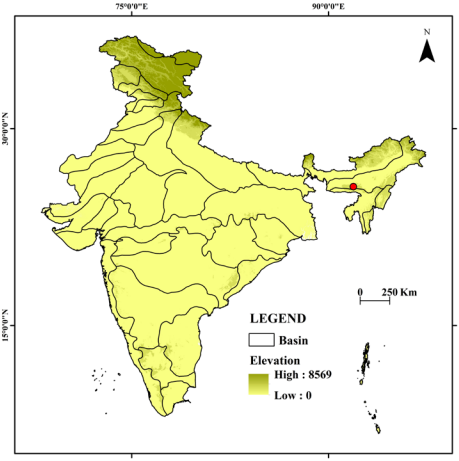
Distribution: Currently known to be distributed only from Aizwal district in Mizoram.

Ecology and Habitat: This species of *Paludomus* is known to occur in streams and rivers, inhabiting the substratum and is well camouflaged sometimes.

Conservation status: Not Evaluated

Uses: This species is sold in the local markets of Aizawl and surrounding areas in Mizoram.

Remarks: Taxonomy of this species needs to be worked out.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LEAST CONCERN
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Family: Paludomidae
***Paludomus reticulata* W.T. Blanford, 1870**

Common Name: Reticulate Paludomus

Size: H = 23.52; W = 20.42; Ap H = 15.78; No of whorls = 4-5

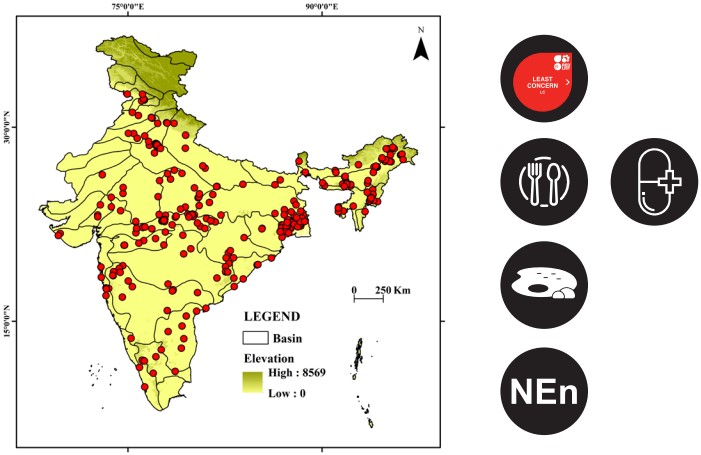
Identification: Shell globose, uniformly brown, umbilicus absent. The entire shell is sculptured with reticulated spiral and vertical lyres whose intersections give granule like appearance. Suture impressed with short and eroded apex. Aperture white, oval, posteriorly sub angulated. Callus whitish, thick. Outer lip of the shell minutely corrugated.

Distribution: This species is recorded from hill streams in Meghalaya. Probably have wide distribution.

Ecology and Habitat: Found in low to mid-altitude streams. They are usually found attached to rocks or large submerged leaves in the stream and seldom in the sandy or muddy substratum.

Conservation status: Least Concern.

Uses: *Paludomus reticulata* is extensively used as food and sold in local markets of Shillong in the East Khasi Hills district of Meghalaya.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Family: Lymnaeidae
***Radix rufescens* (J. E. Gray, 1822)**

Size: H = 13.25; W = 8.50; Ap H = 8.62; No. of whorls = 4

Identification: Shell dextral, elongated, thin, translucent, narrow, with long spire. Aperture large and long, 2/3rd of the shell height, oval, uniformly less expanded; columellar fold is feebly developed; reddish to brownish in colour; apex sharp, narrow.

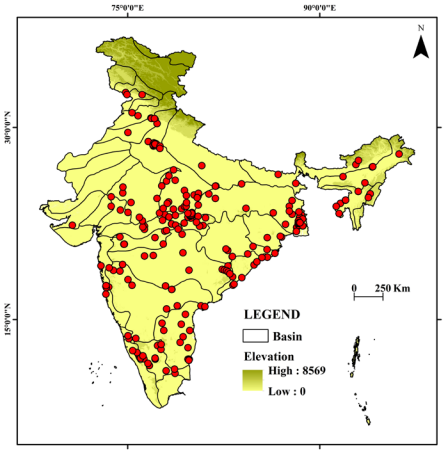
Distribution: This species is distributed almost all-over South and Southeast Asia. It is invasive in some other parts of the world.

Ecology and Habitat: It is commonly seen in high abundance in temporary or permanent and stagnant water bodies with abundant vegetation, including man-made habitats. They can survive in low dissolved oxygen conditions. They are found either attached to the aquatic vegetation or floating on the surface. They are very prolific breeders and are easily dispersed through aquatic vegetation and birds. Probably, eggs or young ones undergo dormancy during the dry season.

Conservation status: Least Concern

Uses: This species is widely used in West Bengal for food, ornamentation, for decoration purposes and as medicine. The locals all over West Bengal also use these snails as playing tools and trade materials (Chattopadyay 1992).

Remarks: This is one of the highly adaptive species and can survive in highly polluted waters with relatively low dissolved oxygen. This species is also known to carry Schistosomiasis parasites such as *S. incognitum, S. nasale* and *Orientobilharzia dattai* (Kali 2015), which infect humans and cattle. *Radix rufescens* is widely used in research on biochemistry, biology, toxicology, etc.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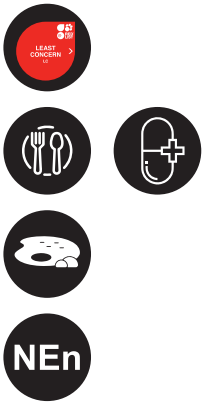
LEAST CONCERN
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Family: Lymnaeidae
***Racesina luteola* (Lamarck, 1822)**

Size: H =17.31; W = 10.87; Ap H = 11.08; No. of whorls = 4-5

Identification: Shell thin, glossy, body whorl less inflated and laterally compressed a little, spire pointed and comparatively longer and gradually tapering. Suture moderately impressed. Aperture oval and narrows above, nearly 2/3rd of shell height.

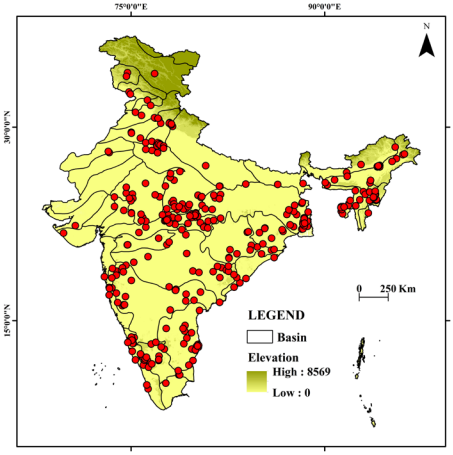
Distribution: This species is distributed throughout South and Southeast Asia.

Ecology and Habitat: It is commonly seen in high abundance in temporary or permanent and stagnant water bodies with abundant vegetation, including man-made habitats. They can survive in low dissolved oxygen conditions. They are found either attached to the aquatic vegetation or floating on the surface. They are prolific breeders easily dispersed through aquatic vegetation and birds. Probably, eggs or young ones undergo dormancy during the dry season.

Conservation status: Least Concern

Uses: *Racesina luteola* is widely used by the communities in West Bengal for food, medicine, trading, etc (Chattopadyay 1992).

Remarks: This is one of the highly generalist species and can survive in highly polluted waters with relatively low dissolved oxygen. This species is also known to carry *Schistosoma* parasites, which infect humans and cattle. *Racesina luteola* is widely used in research on biochemistry, biology, toxicology, etc.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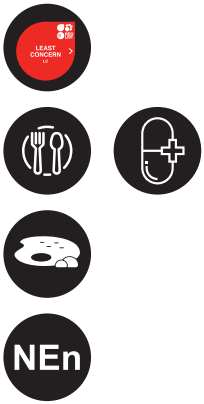

LEAST CONCERN
NEn

Family: Bulinidae
***Indoplanorbis exustus* (Deshayes, 1833)**

Size: H = 6.80; W =16.80; Ap H = 6.60; No. of whorls = 3

Identification: Shell sinistral, yellowish brown, translucent, finely ridged, flat disc like with deeply impressed sutures. Whorls three with the last one being large. Spire is flattened. Aperture ear-shaped, angularly raised but depressed and then broadens below.

Distribution: It is widely distributed in South and Southeast Asia and Middle-east.

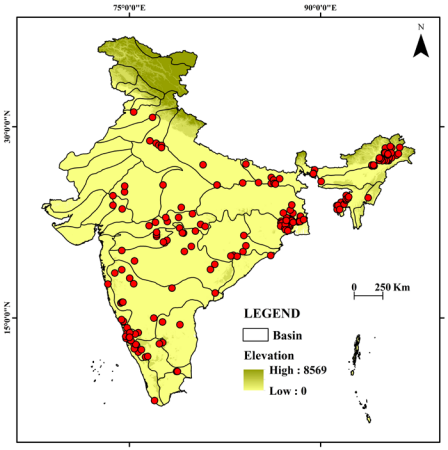
Ecology and Habitat: It is commonly seen in high abundance in temporary or permanent and stagnant water bodies with abundant vegetation, including man-made habitats. They are found either attached to the aquatic vegetation or floating on the surface. They are very prolific breeders and are easily dispersed through aquatic vegetation and birds. Probably, eggs or young ones undergo dormancy during the dry season.

Conservation status: Least Concern

Uses: *Indoplanorbis exustus* plays a significant role in the cultural and economic practices in certain states such as West Bengal. This species is utilised for various purposes such as food, medicine, ritual goods and ornamentation. The people of West Bengal use this species as a tool for playing and material for trade (Chattopadyay 1992).

Remarks: This is one of the highly adaptive species and can survive in highly polluted waters with relatively low dissolved oxygen. This species also carries Schistosomiasis parasites such as *Schistosoma indicum, S. spindalis, S. incognitum,* and *S. nasale,* which infect humans (Kali 2015) and cattle.

Freshwater Bivalves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LEAST CONCERN
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Family: Unionidae
***Lamellidens marginalis* (Lamarck, 1819)**

Size: H = 92.80; W = 48.85

Identification: Shell oblong-ovate, thin, slightly inflated, covered with blackish brown shining epidermis, which is lustrous within. Posterior side of the shell roundly angular with straight margin dorsally while lateral margin is oblique; ventral margin is elevated towards the end with slight contraction in the middle. The anterior part of the shell is stunted narrow. Dorsally the shell is sloped, deltoid and smooth.

Distribution: This species is widely distributed in South Asia.

Ecology and Habitat: This species inhabits both lentic and lotic water bodies. Found buried in the soft substratum of aquatic bodies. This species can tolerate organic pollution to a certain extent.

Conservation status: Least Concern

Uses: This species is widely consumed in many parts of India. It is believed to have medicinal properties and is extensively used to cure vomiting, anaemia, jaundice, eye-related diseases, giddiness, etc. *Lamellidens marginalis* is also economically important as it yields pearls and is used for pearl culture in the coastal regions of India and Northeast India. The shells are used in lime production in certain parts of India.

Remarks: This species is also used in research.


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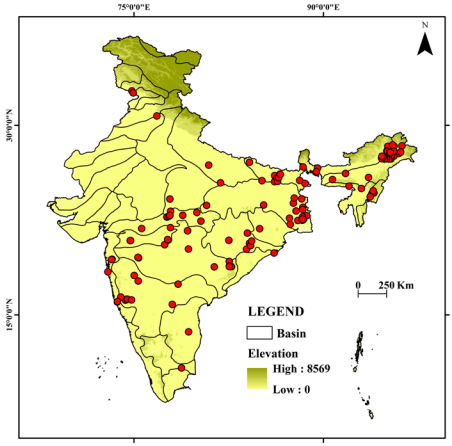
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LEAST CONCERN
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Family: Unionidae
***Lamellidens corrianus* (I. Lea, 1834)**

Size: H = 25.5; W = 53.5

Identification: Shell thick, slightly swollen on one side with slight depression in the middle, in equilateral and oblong. The ventral edge is retuse raised at the beginning. Umbonal ridge is elevated. Area behind the ridge is hollow and broad. Slanting primary teeth with distant lamellae present.

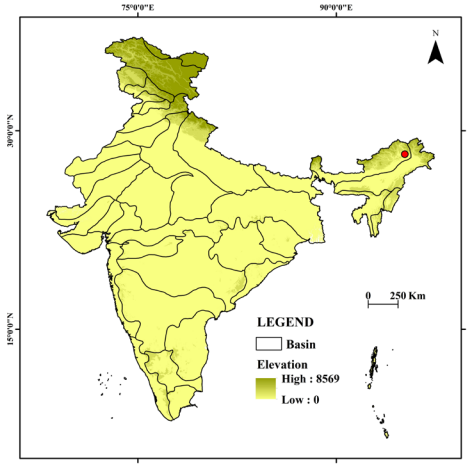
Distribution: This species is widely distributed in India, including the Andaman and Nicobar Islands.

Ecology and Habitat: This species prefers lotic water bodies and is found buried in sand, silt and mud substrates of large lowland rivers.

Conservation status: Least Concern

Uses: This species is widely consumed for food and believed to possess medicinal properties.

Remarks: *Lamellidens corrianus* has high demand in lime, jewellery and handicraft industry in the states of Bihar, Jharkhand and West Bengal.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Family: Unionidae
***Lamellidens* sp.**

Size: H = 36.94; W = 77.66

Identification: Shell large with overall dark brown glossy epidermis. Umbo slightly depressed and placed inequilateral. Anterior end of the shell rounded while posterior side of the shell slanting more than half of the width of shell and rounded later joining the base of the shell. Growth rings prominent towards the base of the shell. Inside of the shell lustrous off-white with prominent pallial lines.

Distribution: This species is recorded from the river near Sili village in the East Siang district of Arunachal Pradesh.

Ecology and Habitat: This species is found in slow-flowing stretches of rivers.

Conservation status: Not Evaluated

Uses: This species of *Lamellidens* is mainly used for food by the local communities in Arunachal Pradesh.

Remarks: The taxonomy of this species needs to be worked out.


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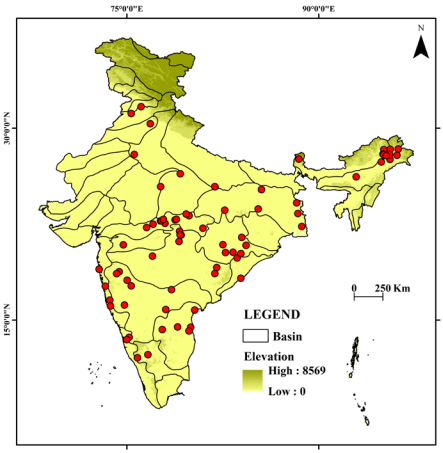
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LEAST CONCERN
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Family: Unionidae
***Parryesia corrugata* (O.F. Müller, 1774)**

Size: H = 42.28; W = 30.4

Identification: Shell green, elliptic to oval, scarcely inequilateral, smooth, umbones prominent, sculptured with somewhat radiating, oblique, linear, ridges, ventral margin convex, lunule well marked, cardinal teeth strong, not lamellar.

Distribution: This species is widely distributed all over India.

Ecology and Habitat: This species is found buried in substratum and inhabits both lentic and lotic water bodies. It can tolerate a certain degree of pollution.

Conservation status: Least Concern

Uses: The shells of *P. corrugata* are commonly used in handicraft industries and consumed as food by the local communities (Subba Rao, 1989).


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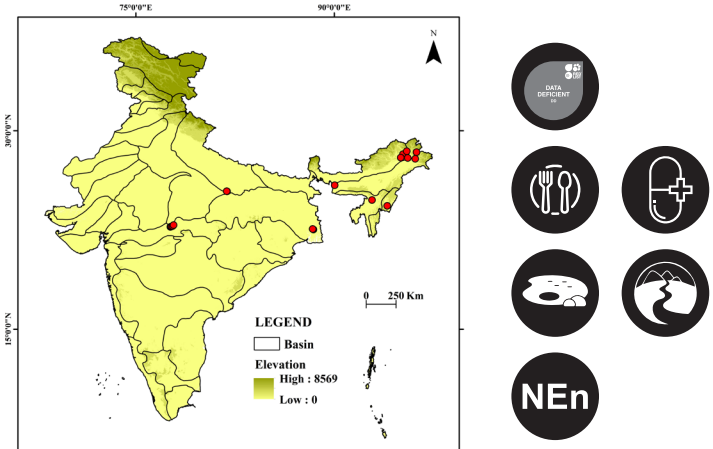
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Family: Unionidae
***Indonaia gratiosa* (R.A. Philippi, 1843)**

Size: H = 33; W = 20.4

Identification: Shell elliptical and and inequilateral appears folded, compressed, wrinkled-ovate, bi-angulate at the posterior end but rounded anteriorly showing prominent compression at the tips. Cardinal teeth small, compressed obliquely subcurved laterally.

Distribution: This species is recorded from Assam, Madhya Pradesh, Uttar Pradesh, Rajasthan, West Bengal, and Bangladesh. Probably this species is widely distributed in South Asia.

Ecology and Habitat: This species is found in permanent water bodies such as large wetlands, rivers, etc.

Conservation status: Data Deficient

Uses: This species is used for food.

Remarks: *Indonaia gratiosa* is threatened by fish poisoning and the water pollution that occurs due to agricultural runoff carrying pesticides.


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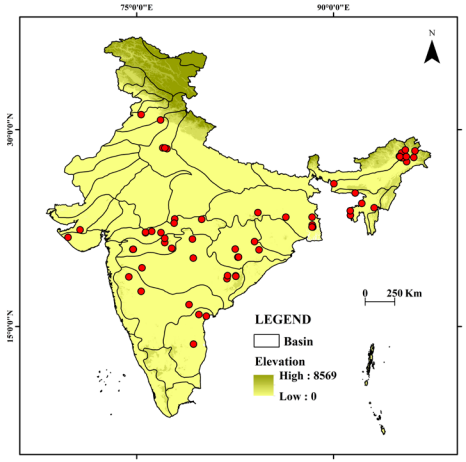
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Family: Unionidae
***Indonaia caerulea* (I. Lea, 1831)**

Size: H = 43.90; W = 22

Identification: Shell narrow-elliptical, transverse, inequilateral, subcylindrical, positioned as straight on the sides and basal margin. Beaks slightly elevated and rounded near the anterior margin and showing overall corrugation with diverging undulations. Ligament is short and straight. Rays very indistinct; posterior slope furnished with small undulations and two irregular rays on each side. Cardinal teeth lamelliform in shape and double in the right valve only. Lateral teeth straight and lamelliform with distinct anterior cicatrices. Posterior cicatrices show confluence. Cavity of the beaks wide and rounded with bluish white iridescent nacre.

Distribution: This species is distributed in Punjab, Uttar Pradesh, Orissa, Bihar, West Bengal, Tripura, Uttarakhand, Sikkim, Meghalaya, Assam and Mizoram.

Ecology and Habitat: This species is found buried under gravels, sand and mud substrates of lowland streams and wetlands such as permanent marshes, ponds, lakes and rivers. This species is usually found in less polluted waters.

Conservation status: Least Concern

Uses: Apart from being consumed in the northeast states as food, *I caerulea* is widely used in handicrafts, jewellery and cottage industry for the manufacturing of buttons and tiles and poultry feed (Subba Rao, 1989).

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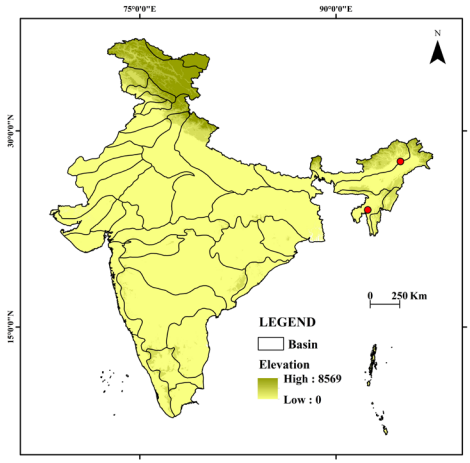
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LEAST CONCERN
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Family: Unionidae
***Balwantia soleniformis* Benson 1836**

Size: H = 45.5; W = 19.1

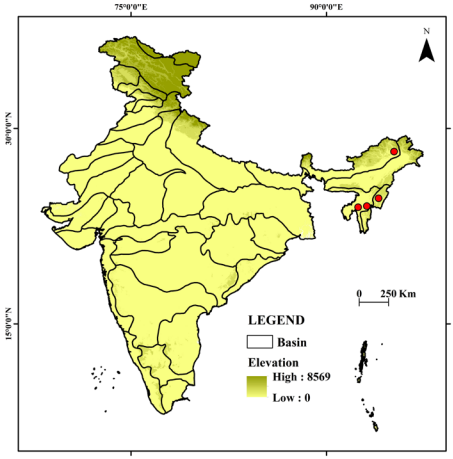
Identification: Shell protracted posteriorly narrow with strongly compressed valves and sharp margins. Shell broad at anterior end with rounded and obliquely truncated extremity. Extremity at juvenile stage flattened, inconspicuous. Corner of the umbone green which turns brown as the shell ages.

Distribution: Currently, this species is reported from Brahmaputra and Barak River basins, Mizoram and Tripura.

Ecology and Habitat: This species prefers rapid-running waters. They dwell in the burrows, which are usually outside the curves in the river where the water currents are moderately high.

Conservation status: Least Concern.

Uses: *Balwantia soleniformis* is harvested extensively for consumption and used in the making of jewellery, production of cement and animal feed (Subba Rao, 1989).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LEAST CONCERN
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Family: Unionidae
***Trapezidens exolescens* (A. Gould, 1843)**

Size: H = 37.8; W = 21.50

Identification: Shell very thin and compressed or inflated, umbones depressed, occasionally prominent, anterior end narrow or obliquely truncated, posterior side dilated, posterior wing not very distinct or narrow, periostracum greenish brown, or brownish yellow.

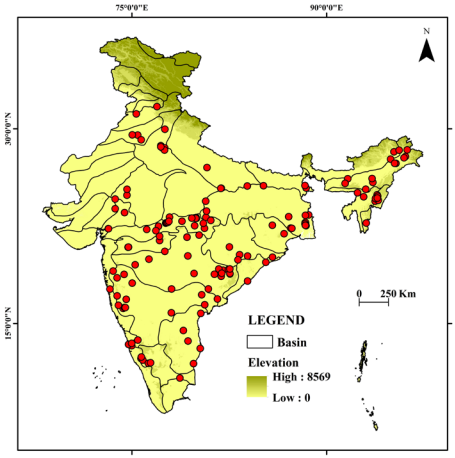
Distribution: It is known from Northeast India and Myanmar.

Ecology and Habitat: This species is reported from permanent lentic habitats such as ponds, lakes etc.

Conservation status: Least Concern.

Uses: It is used as food in Eastern and Northeast India.

Remarks: Harvesting from the wild could be a possible threat to this species.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LEAST CONCERN
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Family: Cyrenidae
***Corbicula striatella* Deshayes, 1855**

Size: H = 20.88; W = 18.25

Identification: Shell thick, medium size, tumid, triangular ovate to ovate, dorsal margin arched, more on the anterior side than on the posterior, umbones prominent, periostracum shining lemon yellow in young, darker and often brownish in full grown specimens, striae regular, concentric and raised into ridges, pallial line with a trace of sinus, muscle scars fairly deeply developed.

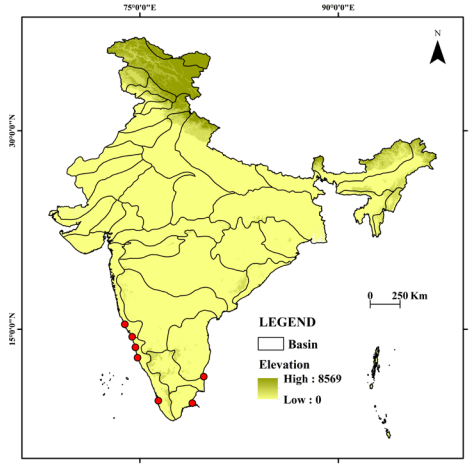
Distribution: One of the most common and widely distributed freshwater mollusc species of India.

Ecology and Habitat: It is found in rivers, streams and lakes, and it prefers fine gravel, sand or mud substratum. It is mostly confined to lowland rivers up to around 250 m amsl. It can also tolerate a certain degree of pollution and habitat disturbance like sand mining, changes in hydrology, etc.

Conservation status: Least Concern.

Uses: It is extensively harvested from the wild for food.

Remarks: This species is also used in research.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LEAST CONCERN
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Family: Cyrenidae
***Villorita cyprinoides* (Gray, 1825)**

Common Name: Black Clam

Size: H = 33; W = 23.16

Identification: Shell medium size, thick, anterior margin short, regularly curved above, almost straight in the middle, then with a rapid curve and meeting the ventral border, the latter curving upwards and meeting the posterior margin, the posterior margin nearly straight, much larger than the anterior, with thick concentric ridges, umbones prominent, near the anterior side, recurved, a large, thick external ligament posteriorly.

Distribution: It is endemic to India. It is a very common species in coastal brackish/saline backwaters of the west and east coasts of India.

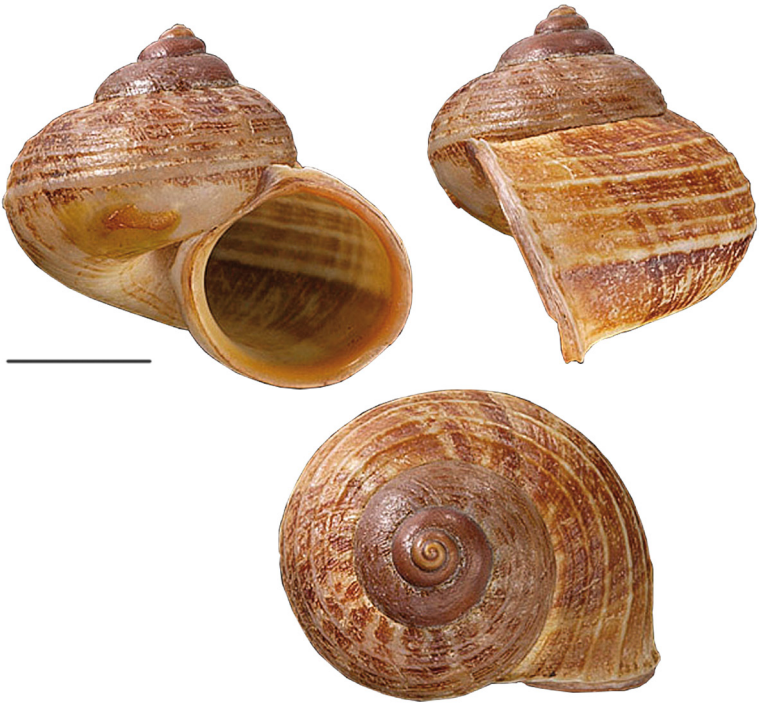
Ecology and Habitat: This species prefers brackish water and restricted to west and east coast of India. Shells are found buried in the substratum. This species is a generalist and can tolerate a salinity range of 3 ppt to 16 ppt, and a dissolved oxygen range from 2.8 to 6.5 ml/L.

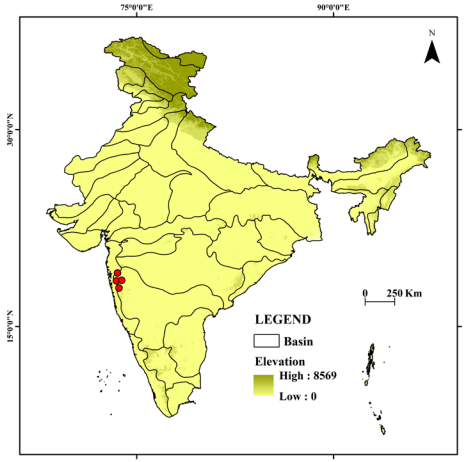
Conservation status: Least Concern.

Uses: Extensively harvested and consumed as food in coastal regions.

Remarks: There is a huge clam fishery society in the Vembanad backwaters of Kerala. It was estimated that about 25,000 tonnes of black clam is being harvested annually and over 4000 fishermen are involved in this activity (Suja and Mohamed 2010).

Land Snails

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NOT EVALUATED
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Family: **Cyclophoridae**
***Cyclophorus altivagus* Benson 1854**

Size: H = 26; W = 31; Ap H =17; No of whorls = 5

Identification: Shell globose-conical, solid, red above and chestnut below with white periphery. Spire raised, turbinate, suture strongly impressed. Body whorl has 5–6 spiral ridges which run circular to the body whorl. Umbilicus narrow. Aperture circular, angled at the top but rounded at the end. Peristome double and strongly reflected. Columellar margin minutely sinuate and narrow and reflexed above the umbilicus.

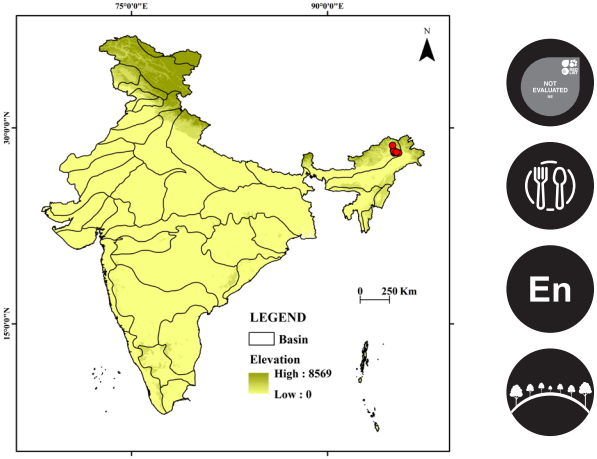
Distribution: It is known to occur in evergreen and semi-evergreen forests of the Western Ghats of Maharashtra.

Ecology and Habitat: *Cyclophorus altivagus* is found in the evergreen and semi-evergreen forests of northern Western Ghats.

Conservation status: Not Evaluated.

Uses: This species is consumed by the *Chandraseniya Kayastha Prabhu* (CKP) communities in the Tamhini region of Maharashtra.

Remarks: This species is not consumed on a large scale but only in the small pockets of Maharashtra by certain communities.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NOT EVALUATED
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Family: Cyclophoridae
***Cyclophorus aborensis* Godwin-Austen 1915**

Size: H = 44.13; W = 56.76 ; Ap H = 31.52; No. of whorls = 5

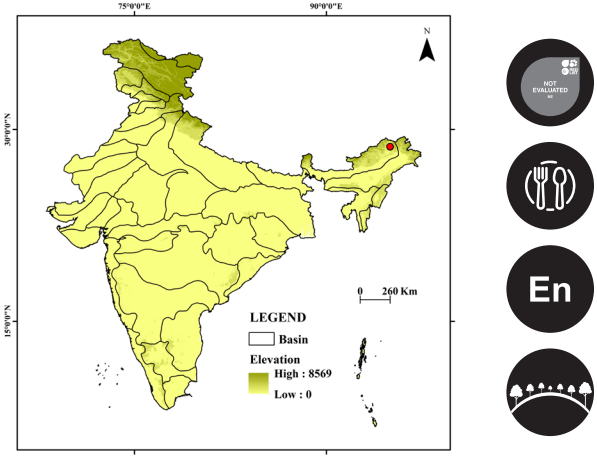
Identification: Shell globosely turbinate, openly umblicated, solid. Sculpture, carinate spiral, lirae wide apart, 5 conspicuous, the last peripheral, with much finer intermediate liration, not distinctly seen in old specimens. Colour (specimen from Renging) a rich ruddy brown over most of the surface, beneath pale ochracous, a few splashing of same colour next the suture; in the type and in most old shells much bleaching takes place. Spire fairly high, apex fine. Suture impressed. Whorls 5, rather rapidly increasing, rounded. Aperture circular, suboblique. Peristome white, solid, continuous, very slightly reflected. Columellar margin sub vertically curving.

Distribution: Endemic to northeast India. It is currently known from Pasighat, Rottung, Kaleg, Yemsing, and Renging in Siang Valley in Arunachal Pradesh.

Ecology and Habitat: Very common species, mostly found in the soil, leaf litter and under the rocks. Altitudinal ranges from 250 m amsl to 900 m amsl in the evergreen and semi-evergreen forests.

Conservation status: Not Evaluated.

Uses: This species is used predominantly for food by *Adi* tribes in Siang Valley in Arunachal Pradesh.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NOT EVALUATED
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Family: Cyclophoridae
***Cyclophorus* sp.**

Size: H = 40.18; W = 45.74; Ap H = 25.44; No. of whorls = 5

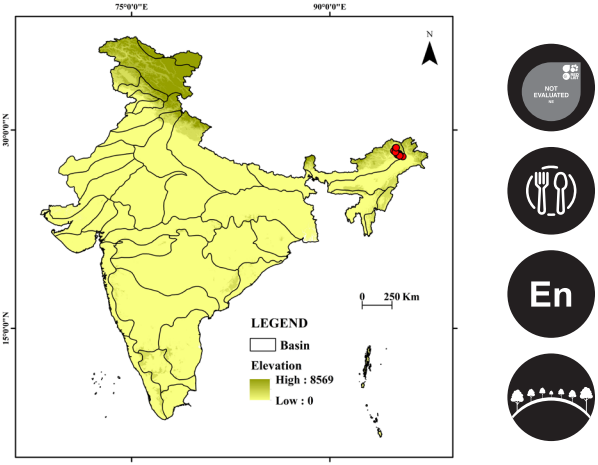
Identification: Shell globose, with spiral ridges, spiral, with an open umbilicus. No sculpture as such on the shell. Colour dark chocolate brown at most of the body whorl while lighten after second whorl. Distinct white band runs spirally starting from the mid of the aperture in ventral view and ends at the point where the aperture joins the body whorl in dorsal view. Spire not very high with fine apex. Whorls after the second one nearly flattened, neither concave nor convex in shape. Aperture circular. Peristome thick, white and strongly reflected.

Distribution: Endemic to Northeast India. It is currently known from Ramsing and Gobuk in Siang Valley in Arunachal Pradesh.

Ecology and Habitat: Very common species, mostly found in the soil, leaf litter and under the rocks. Altitudinal ranges from 250 m amsl to 900 m amsl in the evergreen and semi-evergreen forests.

Conservation status: Not Evaluated.

Uses: This species is used predominantly for food by *Adi* tribes in Siang Valley in Arunachal Pradesh.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NOT EVALUATED
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Family: Cyclophoridae
***Cyclophorus koboensis* Godwin-Austen 1915**

Size: H = 23.02; W = 31.94; Ap H = 18.83; No. of whorls = 6

Identification: Shell is turbinate with keeled body whorl, sculpture with darker zig-zag patterns giving the shell a mottled appearance. Umbilicus is open and partially concealed by the peristome. Colour brown, with a distinct dark brown band below the keel which is ochraceous white beneath. Spire conical but depressed with fine apex and impressed suture. Aperture spherical. Peristome double with a continuous inner lip, which is thick and very reflected. Columellar margin vertically rounded.

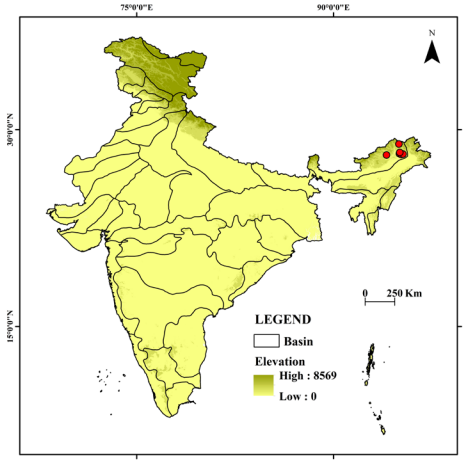
Distribution: Endemic to Northeast India. It is currently known from the Siang Valley of Arunachal Pradesh.

Ecology and Habitat: Very common species, mostly found in the soil, leaf litter and under the rocks. Altitudinal ranges from 150 m amsl to 1000 m amsl in the evergreen and semi-evergreen forests.

Conservation status: Not Evaluated.

Uses: This species is used predominantly for food by *Adi* tribes in Siang Valley in Arunachal Pradesh.

Remarks: This is smaller cyclophorid compared to other edible species found in Arunachal Pradesh.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NOT EVALUATED
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Family: **Cyclophoridae**
***Spiraculum planum* Godwin-Austen 1915**

Size: H = 16.77; W = 2; Ap H = 12.22; No. of whorls = 5-5.5

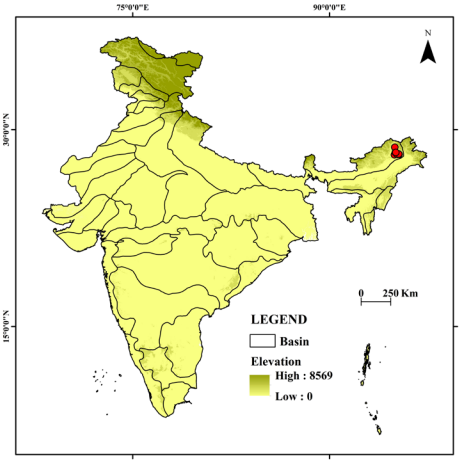
Identification: Shell in flat and disc shaped with coarse spiral ribs. Spire is low, shell similar to *S. kempi*. Colour brown. Spire very low, the apex scarcely showing above the last whorl. Suture deeper. Sutural tube recurved backward partially covering penultimate whorl. Aperture circular and oblique. Peristome double, thickened, outer lip expanding into a somewhat lengthened open wing, ascending on the whorl next to it, not descending as in previous species.

Distribution: Endemic to Northeast India. It is currently known from Siang valley and Miri Hills of Arunachal Pradesh.

Ecology and Habitat: Very common species, mostly found in the soil, leaf litter and under the rocks. Altitudinal ranges from 150 m amsl to 1000 m amsl in the evergreen and semi-evergreen forests.

Conservation status: Not Evaluated.

Uses: This species is used predominantly for food by *Adi* tribes in Siang Valley in Arunachal Pradesh.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Family: Cyclophoridae
***Spiraculum kempi* Godwin-Austen 1915**

Size: H = 17.45; W = 30.28; Ap H = 12.60; No. of whorls = 5

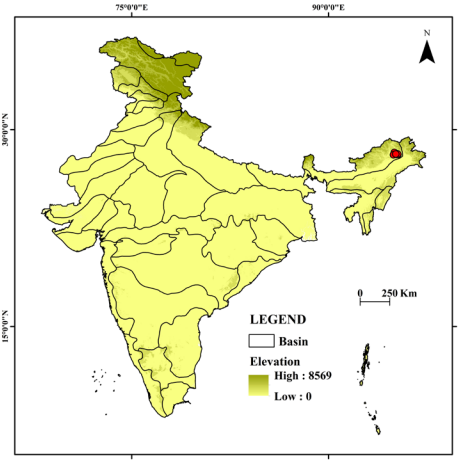
Identification: Shell flatly discoid, finely sculptured, umbilicus open and wide. Transverse epidermal lines both above and below the whorls. Colour dark brown, very indistinct transverse broad brown band. Spire very low just raised above the last whorl. Suture deeply impressed; the sutural arching over penultimate whorl. Whorls rounded on periphery. Aperture circular and oblique. Peristome white, thickened, double, reflected, the outer lip above forming the short open descending wing. Columellar margin rounded. Operculum roundly convex, the whorl in double filaments distantly raised, close and smooth at centre.

Distribution: Endemic to Northeast India. This species is currently known from central parts of Arunachal Pradesh.

Ecology and Habitat: Very common species, mostly found in the soil, leaf litter and under the rocks. Altitudinal ranges from 150 m amsl to 1000 m amsl in the evergreen and semi-evergreen forests.

Conservation status: Not Evaluated.

Uses: This species is used predominantly for food by *Adi* tribes in Siang Valley in Arunachal Pradesh.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Family: **Cyclophoridae**
***Pterocyclos aborensis* Godwin-Austen 1915**

Size: H = 20.87; W = 29.62; Ap H = 14.29; No of whorls = 5

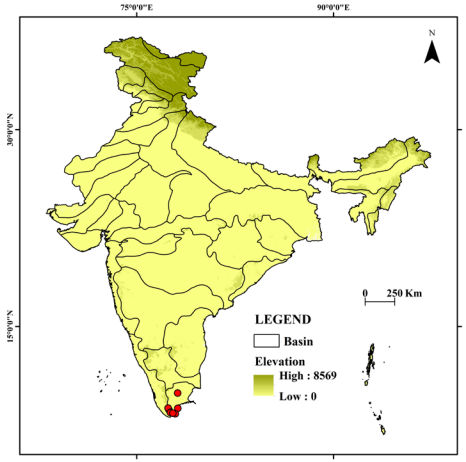
Identification: Shell subdepressedly turbinate, umbilicus open and wide. Sculpture prominant with strong epidermal growth lines. Well raised distant spiral lirae, both on upper and lower side. Colour dark brown. Spire subconoid, apex small. Suture deep. Whorls regularly increasing, angulately rounded on periphery. Aperture circular. Peristome double, not thickened, reflected, inner lip continuous, the outer expanded forward at inner angle into a half-closed, spout-shaped wing. Columellar margin sub-vertically curved.

Distribution: Endemic to Northeast India. This species is currently known from central parts of Arunachal Pradesh.

Ecology and Habitat: Very common species, mostly found in the soil, leaf litter and under the rocks. Altitudinal ranges from 150 m amsl to 1000 m amsl in the evergreen and semi-evergreen forests.

Conservation status: Not Evaluated.

Uses: This species is used predominantly for food by *Adi* tribes in Siang Valley in Arunachal Pradesh.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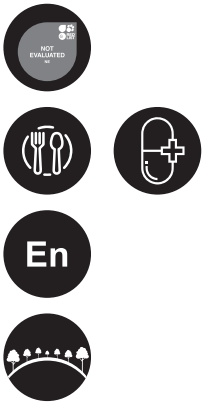
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Family: Camenidae
***Pseudotrachia vittata* (O.F. Müller, 1774)**

Size: H = 22.32; W = 26.66; Ap H = 15.10; No. of whorls = 4-5

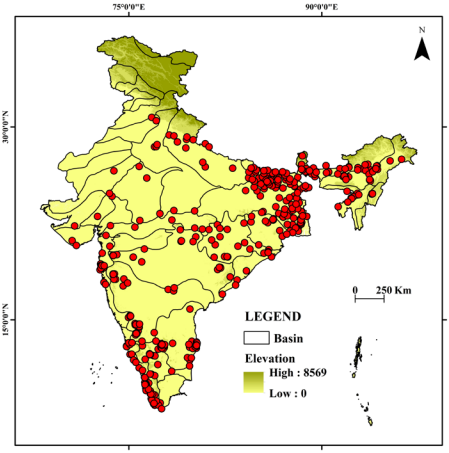
Identification: Shell discoid in shape with or without brown bands on the whorls. When present number and width vary to a great extent. Sutures of the last two whorls dark brown in colour and lightens as the whorls proceed towards the body whorl that is base of the shell. Aperture roundish, inside dark brown in colour and lip is reflexed. Umbilicus open, prominent and partially closed by the columellar lip.

Distribution: This species is restricted to drier parts of Tamil Nadu, Telangana and Andhra Pradesh in Peninsular India.

Ecology and Habitat: Endemic species to Peninsular India. It is a very common and locally abundant species of land snail among shrubs and bushes. Found attached to bushes during dry seasons. The shells exhibit differential banding patterns from almost no bands to several dark brown bands.

Conservation status: Not Evaluated.

Uses: This species is mainly used for medicine in certain parts of Tamil Nadu. No information is available on the exact medicinal use.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Family: Achatinidae
***Lissachatina fulica* (Bowdich, 1822)**

Common name: Giant African snail

Size: H = 103.93; W = 55.89; Ap H = 52.75; No. of whorls = 7-9

Identification: Shell large, smooth, thin, conical which is twice as high as it is broad. Shell with continuous bands which are reddish brown to dark brown which run around spirally. Body whorl moderately swollen with sharp conical spire. Whorls are convex with impressed sutures. Outer lip usually sharp and thin. Columella is more or less concave. Callus not prominent. Aperture elongate.

Distribution: Native of east Africa and introduced to many tropical and sub-tropical regions of the world. Widely distributed all over India, except in high altitude cold regions and desert.

Ecology and Habitat: The species is found in wide arrays of habitats such as agricultural lands, gardens, coastal areas, wetlands, disturbed areas, scrublands, natural and planted forests and urban areas as well. It prefers tropical climates with warm and humid environments. It is a highly invasive species and known to feed on more than 500 species of plants. High threat to native biodiversity and agriculture.

Conservation status: Least Concern

Uses: This species was used as a food source during the Bengal famine in 1943**.**

Remarks: Two specimens were taken from Mauritius to India by W.H. Benson in 1847 as curiosities. Before leaving India for the last time, Benson handed them to his neighbour who subsequently released them in his garden (Naggs 1997).

Glossary

Dextral: Right coiled gastropod shell

Sinistral: Left coiled gastropod shell

Umbo: Umbo or hinge area, where the valves are joined together, is the dorsal part of the animal

Aperture: The main opening in gastropod shells, scaphopod shells, and also for Nautilus and ammonite shells.

Apex: Tip of the gastropod shell

Suture: Depression between two whorls of a gastropod shell

Operculum: The operculum is a single lid that closes the aperture of the shell when the animal is retracted.

Whorls: Whorls come in contact with one another at the shell sutures.

Lentic: Lentic (from the Latin lentus, meaning slow or motionless), refers to standing waters such as lakes and ponds, swamps and marshes.

Lotic: Lotic (from the Latin lotus, meaning washing), refers to running water habitats such as rivers and streams.

Schistosomiasis: Schistosomiasis, also known as bilharzia, is a disease caused by parasitic worms.

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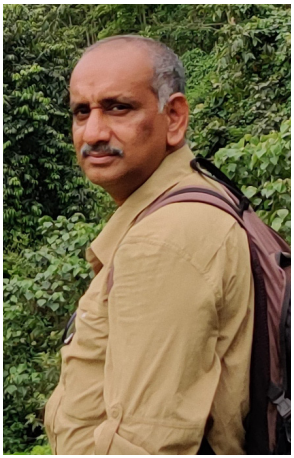
About the authors



Aravind N.A. is a senior fellow at ATREE. He has been working on non-marine molluscs of India for the last 25 years. His interests are in ecology, taxonomy, biogeography and conservation of non-marine molluscs and amphibians of India. He also utilises citizen science data to understand patterns and processes in nature. He published over 120 research and popular articles in national and international journals. He is an elected Fellow of the Linnean Society of London and a member of the IUCN SSC Amphibian and Mollusc specialist groups.

Anushree Jadhav is a graduate student at ATREE working on the systematics and ecology of freshwater molluscs of India. Apart from her PhD work, she was part of the Siang expedition in Arunachal Pradesh, funded by the National Geographic Society and conservation assessment of cliff snails of the Western Ghats. She is interested in integrative taxonomy of the freshwater molluscs of India.

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