

A new record of *Nerita nigrita* Röding, 1798 (Mollusca: Gastropoda: Neritidae) from India

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Many members of the family Neritidae display polymorphism as their shells can be highly variable in colour, which has sometimes led to confusion in the identification of closely related species. One such confusion in the taxonomic identification of two *Nerita* spp. currently exists in India. According to the literature and identification keys available, *Nerita nigrita* does not exist in the country (has not been reported), but the reason is that this species has thus far been misidentified as *Nerita maxima*. The key difference between these two species can be observed in their shell spire – *N. nigrita* consists a slightly elevated spire with distinguishable protoconch, whereas *N. maxima* has a depressed spire with indistinct protoconch. Other identification characters which separate these two species, such as shell texture, operculum structure and outer lips are also described. The present study reports *N. nigrita* as a new record from the Indian coast.

Keywords: Identification characters, *Nerita nigrita*, *Nerita maxima*, polymorphism.

NERITIDAE Rafinesque, 1815 is a large family of gastropods comprising approximately 14 genera and 200 species¹. These herbivorous snails are found in marine, brackish and freshwater habitats. In the marine environment, they usually inhabit the middle to upper intertidal zone and are known to be gregarious². Neritidae has a cosmopolitan distribution; however, majority of species occur in the Indo-Pacific region. About 44 species are reported from the marine habitat and freshwater streams along the coast of India³.

Neritids are often polymorphic with shells of the same species showing highly variable colouration, which has led to confusion in the identification of some closely related species. One such confusion involves the identities of *Nerita maxima* Gmelin, 1791 and *Nerita nigrita* Röding, 1798. Although the two species do not show striking similarity except for colouration (*N. maxima* is polymorphic in terms of colouration), *N. maxima* shows striking similarity to *N. polita* Linnaeus, 1758, while *N. nigrita* is often confused with *N. semirugosa* Récluz, 1841 (ref. 1). No reports have been published on the

occurrence of *N. semirugosa* in the Andaman and Nicobar (A&N) Islands. Therefore, *N. nigrita* stands out without any confusion whereas *N. polita*, which shows high resemblance with *N. maxima*, is highly abundant.

Based on the available literature and existing taxonomic keys^{3,4}, *N. nigrita* has thus far been identified as *N. maxima* and as of now, there is no report on the occurrence of the former species from India. However, during the survey of macrobenthic epifauna on the Port Blair coast of South Andaman between 2013 and 2015, both species were found to be equally well distributed with sizeable populations near the upper intertidal rocky shores. From the available literature, it is also apparent that due to this misidentification or confusion, there is no documentation of *N. nigrita* from the Andamans or India. Therefore, the resolution of this misidentification will also add one more species to the overall neritid list in the country. The collected specimen of *N. nigrita* was deposited under the National Zoological collections (No. ZSI/ANRC-18535, 16 January 2018) of the Zoological Survey of India, Andaman and Nicobar Regional Centre, Port Blair. Box 1 provides the taxonomy and description of *N. nigrita*.

The shell is large for the genus, up to 3.8 cm elongate and heavy. Low intact spire with small yet distinguishable yellowish protoconch (Figure 1 a and b). Shell furnished with broad spiral cords having narrow interstices. The spiral cords are normally broader near the spire region and become gradually narrow away from the spire after the mid-dorsal region. The outer lip margin is extremely thin, which extends beyond the thick aperture

Box 1. Taxonomy and description of *N. nigrita*

Taxonomy and description of *Nerita nigrita*:

Phylum: Mollusca
Class: Gastropoda
Order: Archaeogastropoda
Family: Neritidae
Genus: *Nerita*
Species: *N. nigrita* Röding, 1798



Figure 1. *Nerita nigrita*. a, Entire specimen; b, Aperture view with operculum.

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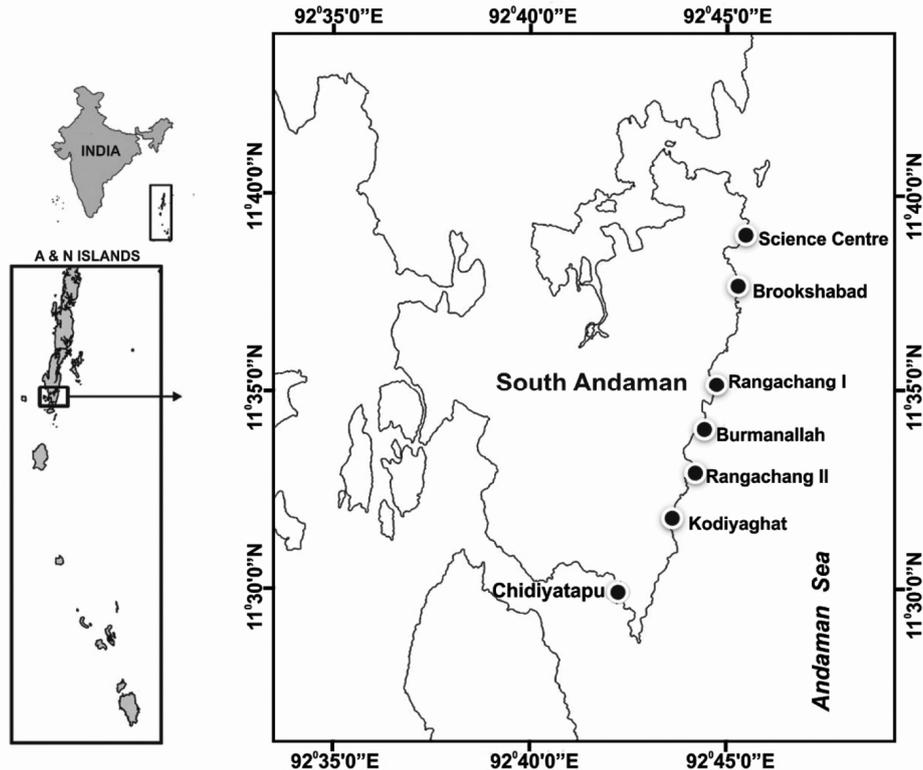


Figure 2. Study locations: distribution of *N. nigrita* along the south Andaman coast.

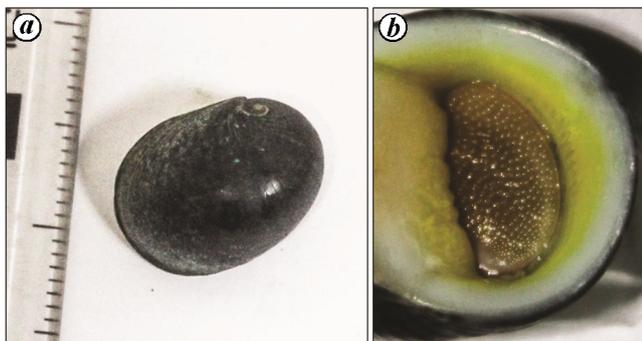


Figure 3. *Nerita maxima*: a, Entire specimen; b, Aperture view with operculum.

ridge. The flared outer lip is without the parietal sheath and is essentially an extended part of the spiral cord and periostracum, and therefore fragile and appears denticulate. The aperture and parietal sheath are pearly white. This species occurs in high abundance at the upper margins of rocky intertidal shores.

Colour: Dull black interposed with off-white interstices, operculum light grey and granular throughout.

Habitat: Widespread on the upper shores of rocky intertidal zone. In the Andamans, this species was recorded at Science Centre, Brookshabad (south of Carbyn's Cove), Rangachang, Burmanallah, Kodyaghat and Chidiyatapu (Figure 2). In India, this species has been

recorded from the west coast, but misidentified as *N. maxima*^{3,4}. Distribution of *N. nigrita* has also been recorded from Thailand, Indonesia, Sri Lanka, Maldives and Madagascar.

In the case of *N. maxima*, shell is solid, bulbous, slightly elongated and 2–4.1 cm in size. Appearance of shell is smooth and glossy, but usually comprises numerous fine, shallow spiral cords. Spire is small and depressed (Figure 3 a and b). Aperture is generally white with yellowish tinge on columella surrounding the operculum. Outer lip is thick with indistinct crenulation inside. Occasionally, the posterior-most tooth is more prominent compared to rest of the teeth. The parietal shelf is rather flat, smooth and glossy, usually wrinkled behind the lower teeth on the columella. There are generally 2–3 columellar teeth at the centre and a large squared tooth at the posterior end of the columella. Operculum is flat and granular, but the nuclear area is smooth.

Colour: The shell of *N. maxima* is highly variable in colour, but majority of specimens are dark brown and grey, although some specimens are brightly coloured. Operculum flat, pustulose and greenish-grey in colour.

Habitat: Widespread on the upper intertidal rocky shores beneath boulders. This species was collected from the south of Carbyn's Cove. However, distribution of the species was also observed at other rocky shores of the Port Blair coast. A careful examination is required because this species prefers to hide under rocks and

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Table 1. Comparative key characters, description and distribution of four highly similar neritid species

	<i>Nerita nigrita</i>	<i>Nerita maxima</i>	<i>Nerita polita</i>	<i>Nerita undata</i>
Size	2.5–4.1 cm	2–4.1 cm	2–3.9 cm	2–3.7 cm
Shell description	Large and heavy, elongated, slightly flared, sharp-edged lip. Shell furnished with broad spiral cords with narrow interstices.	Solid and bulbous, elliptical in juveniles, but elongated in adults. Smooth and glossy appearance, but consists of numerous fine shallow, spiral cords.	Solid, bulbous and elliptical; appearance is smooth and glossy, but with fine axial growth striae.	Solid and subglobose, sculptured with numerous narrow spiralling ribs which are smooth and regularly spaced.
Spire	Small and low, never decompressed. A small yet distinguishable yellowish protoconch.	Small and low, and sometimes depressed yet visible.	Spire flat and sometimes completely depressed.	Spire moderately high.
Columella	Straight with poorly defined round teeth. Generally apical tooth is square and the lower two teeth are rounded. Sometimes a hint of yellow staining around the columellar teeth.	Columella equipped with 2–3 Small, centred teeth. Usually wrinkled behind the lower teeth on the columella. Yellow staining around the columellar teeth.	Columella with thick and extensive callus, smooth and polished with two or three weak and small teeth at the centre.	Columella flat, sometimes bearing promiscuous wrinkles, equipped with 3–5 teeth; the uppermost tooth is square-shaped. Columella generally white with varying degrees of yellow staining.
Operculum	Pustulose with well-spaced granules. A narrow corneous lamella encircling the operculum. Greenish-grey with lighter grey staining around the nucleus.	Flat, pustulose and grey with greenish tinge. Area around the nucleus is smooth. A vestigial corneous lamella along the labral margin.	Flat, smooth and glossy. Outer margin with chestnut-brown zone traversed by numerous concentric ridges.	Operculum flat, grey with small granules over entire outer the surface.
Colour	Dull black, interposed with off-white interstices.	Extremely variable, but majority of specimens are dark brown and grey; sometimes mottled pattern of black and brown.	Highly variable, greenish-brown or yellowish-brown, with 2–3 narrow spiral bands of black or dull black, or white or reddish bands.	Variable colour, ash–white to light brown with varying amounts of random black blotches, stripes, or axial bands, sometimes with three indistinct darker spiral bands, and sometimes completely black.
Habitat	Upper shores (splash zone) of rocky intertidal area. Occupies highest landward zones among other neritids.	Intertidal area; generally remains hidden beneath rocks and boulders during the day and comes out during night.	Intertidal zone, sandy bottom covered with boulders.	Generally found at the upper shores beneath rocks during the day, emerging from the hiding place at dusk.
Distribution	Extremely common in Andaman & Nicobar islands. Slightly uncommon in mainland India. Reported from the coast of Andhra Pradesh as <i>N. maxima</i> . Also found in Thailand, Indonesia, Sri Lanka, Maldives and Madagascar.	Possibly identified as <i>N. polita</i> , so no authentic reports from mainland India. Present in the Andaman Islands. Also found in western side of central Pacific, Fiji to Guam and Australia.	East and west coasts of India, A&N Islands. Also, widely distributed in the Indo-Pacific from Africa to Hawaii, Australia to Japan.	Distributed along the west coast of India; reported from Gujarat, Maharashtra and Goa. However, absent from the east coast of India, including A&N Islands. Also found in the Indo-West Pacific; northeastern South Africa to Kenya, Indonesia, Philippines, southern Japan to northern Australia.

boulders, and shows striking similarity with *N. polita* (which is present in extremely high abundance in the Andamans). The species is also distributed at western side of central Pacific, Fiji to Guam and Australia.

N. nigrita and *N. maxima* are clearly two separate species and do not show much similarity with each other.

The current ambiguity in their identification may be due to the first unintended mistake while preparing the taxonomic key for Indian waters, which led to wrong identification of subsequent new reports from other regions of the country. As mentioned earlier, *N. nigrita* shows great degree of similarity with *N. semirugosa*, and *N. maxima*

is often confused with *N. polita*. Due to the striking similarity between *N. maxima* and *N. polita*, it may be possible that the real *N. maxima* was identified as *N. polita*, which consequently led to misidentification of *N. nigrita* as *N. maxima*. Interestingly, the distribution of *N. semirugosa* is restricted to the western Pacific from Queensland, Australia to the Solomon Islands¹. Therefore, *N. nigrita* clearly stands out in this region without any confusion. However, now as we resolve this problem, it is also important to provide details of *N. polita* and *N. undata* which may be confused with *N. nigrita* and *N. maxima*. Table 1 provides the detailed key characters, discriminating features and distribution of the above-mentioned species.

The distribution of *N. nigrita* ranges from Thailand, Indonesia, westward through Sri Lanka, Maldives and Madagascar. However, this species has never been documented from the Indian coast due to its misidentification as *N. maxima*. *N. nigrita* shares a great degree of similarity with *N. semirugosa*, which is restricted to the western Pacific. However, with this report we resolve the confusion of *N. nigrita* and *N. maxima*; simultaneously, the occurrence of this species also extends the geographical range of *N. nigrita* on the Indian coast. In order to avoid future confusion, we have also provided a comparative account of *N. maxima*, *N. polita* and *N. undata* which are similar to each other and have been documented from the Indian coast.

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Rice straw biomass to high energy yield biocoal by torrefaction: Indian perspective

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India is an agriculture based country and generates more than 600 million tonnes of biomass waste from different crops and produces 140 million tonnes of rice straw alone annually. To dispose the rice straw for making field ready for next crop, farmers are burning it in the fields. Burning of rice straw in agriculture fields poses lot of environmental, health and economic issues in various parts of the country. On one hand, rice straw is a good source of renewable energy but on the other hand it has some inherent problems. Therefore, to mitigate problems due to the burning of rice straw, in this study, an effort is made to convert rice straw into an useful product by torrefaction process, i.e. biocoal. The biocoal which has the calorific value equivalent to that of bituminous coal is used in thermal power plants. By optimizing the processing parameters of torrefaction process, desired calorific value of torrefied product has been archived. The 10% use of torrefied product with coal can consume 140 million tonnes of rice straw and as a consequence, it reduces the consumption of fossil fuels. This can greatly solve problems arising due to burning of rice straw and reduce greenhouse gas emission significantly.

Keywords: Calorific value, energy yield, pelletization, rice straw, torrefaction.

CLIMATE change and the inevitable depletion of fossil fuel reserves are among the major challenges the humanity is facing in the 21st century, which has led to a boom in research related to alternative energy sources and reducing greenhouse gas (GHG) emissions. Agricultural biomass rice straw, is a secondary lignocellulosic biomass abundantly available in many parts of the world and around 731 million tonnes are produced per year globally¹. Among the different countries, Asian countries produce 667 million tonnes of rice straw and India alone produces ~140 million tonnes² annually. In India, some of the rice straw used as roofing material, animal feed, fuel and packing material, while the rest is disposed by burning in the agriculture field itself. Burning agro-residues in the field is considered a cheap and easy way of disposal to

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