

Taxonomy and Distribution of the Neritidae (Mollusca: Gastropoda) in Singapore

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Siong Kiat Tan and Reuben Clements (2008) Taxonomy and distribution of the Neritidae (Mollusca: Gastropoda) in Singapore. *Zoological Studies* 47(4): 481-494. Molluscs from the gastropod family Neritidae are primarily found in marine habitats, but they are also known from brackish and freshwater systems. In Singapore, there is a paucity of information on the diversity of Neritids in all 3 aquatic environments. Herein, we provide taxonomic descriptions and distributional data for locally occurring Neritids. Surveys of 31 sites over a period of 10 yr yielded a total of 19 species, of which 6 species are considered new records for Singapore. <http://zoolstud.sinica.edu.tw/Journals/47.4/481.pdf>

Key words: *Clithon*, Estuarine, *Nerita*, *Neritina*, Snail.

Gastropods from the family Neritidae Rafinesque, 1815 occur in marine, brackish, and freshwater systems. Along the coast, these herbivores usually inhabit the middle to upper intertidal zones and are known to be gregarious. Neritids are generally euryhaline; species from the genus *Nerita* are more closely associated with the marine environment, while species from *Neritina* and *Clithon* prefer to inhabit brackish or freshwater habitats.

Neritids can be extremely polymorphic as the shells of some species possess a wide variety of colors and patterns. As such, multiple names have been created and many are now considered synonyms; this situation has complicated efforts to revise the entire family. Despite several attempts to resolve the taxonomy of species within the Neritidae (e.g., Mienis 1973, Vermeij 1984, Krijnen et al. 1996, Haynes 2005), inconsistencies still remain over the use and validity of its representatives. Such taxonomic irregularities have, in part, resulted in the lack of comprehensive

papers on Neritids, especially in the tropics.

On the tropical island of Singapore, Neritids are poorly represented in the malacological literature (e.g., Tweedie 1967, Tan and Chou 2000), despite being considered one of the more-conspicuous mollusc groups above the waterline. In one of the first attempts to document Singapore's entire biodiversity, Chou et al. (1994) listed only 11 species of Neritids, of which 2 were known synonyms. The inclusion of such obsolete names and the lack of taxonomic and distributional data on local Neritids highlight the need for a more-accurate account of the Neritidae in Singapore.

Herein, we report 19 species from the family Neritidae occurring in marine and brackish waters of Singapore. We include notes on their taxonomy, distribution, and status in relation to historical checklists (e.g., Purchon and Purchon 1981). This report represents part of our ongoing efforts to revise and document the malacofauna of Singapore.

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MATERIALS AND METHODS

During the period of 1996 to early 2007, monthly surveys were conducted in marine and mangrove habitats (including monsoon canals and drains near the coast) around Singapore (Fig. 1). The following sites were sampled: Sarimbun (1), Lim Chu Kang Road end (2), Kranji (3), Sungei China (4), Tanjong Irau (5), Sungei Simpang (6), Sungei Khatib Bongsu (7), Seletar Dam (8), Sungei Punggol (9), Punggol (10), Pulau Ubin (11), Pulau Ketam (12), Pasir Ris (13), Sungei Loyang (14), Sungei Changi (15), Tanjong Changi (16), Changi North Bay (17), Tanah Merah (18), South Changi (19), Sungei Bedok (20), Marina East (21), Kallang Basin (22), Marina South (23), Berlayer Canal (24), Sentosa (25), Pulau Sakijang Bendera/St. John's I. (26), Pulau Hantu (27), Pulau Semakau (28), Pulau Salu (29), Tuas (30), and Tuas South (31).

Neritids were sampled from habitats such as intertidal rocks, breakwaters, mangrove tree

trunks and roots, canal walls, and submerged plant debris. Except for *Nerita albicilla*, *Nerita planospira*, and *Neritina* spp., measurements of shell heights were taken from the apex to the anterior of the shell in line with its coiling axis, and shell width refers to the widest distance perpendicular to the shell height. Due to their nearly flat or sunken apex, shell lengths for *Nerita albicilla*, *Nerita planospira*, and *Neritina* spp. were defined as the distance from the anterior edge to the posterior end of the shell placed flat with the aperture down, while shell width refers to the widest point perpendicular to the shell length. The sizes indicated represent the minimum and maximum dimensions of our examined specimens. Observations of the animal refer to color and patterns (if any) on the upper part of the foot.

Synonyms in local checklists and literature were reviewed and are discussed under "Remarks", but an attempt to provide an exhaustive list of all known synonyms was not

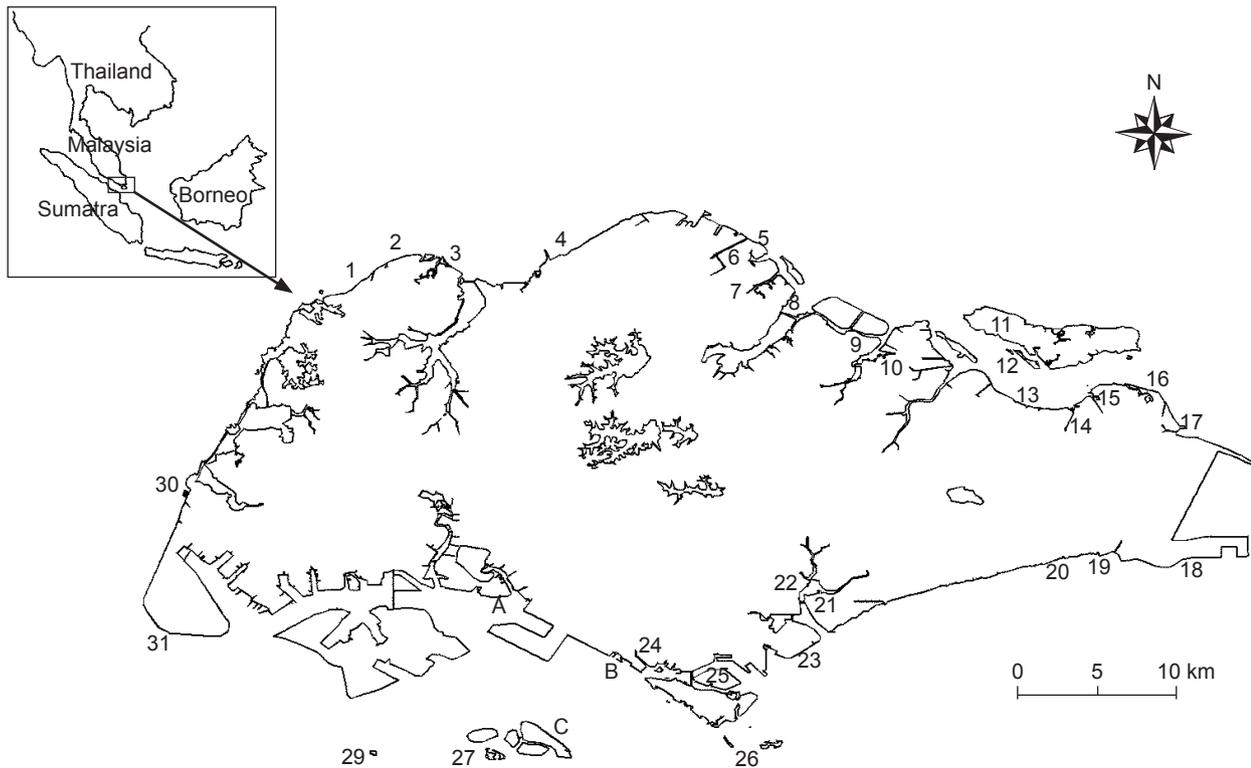


Fig. 1. Distribution of sampling sites throughout Singapore: (1) Sarimbun; (2) Lim Chu Kang Road end; (3) Kranji; (4) Sungei China; (5) Tanjong Irau; (6) Sungei Simpang; (7) Sungei Khatib Bongsu; (8) Seletar Dam; (9) Sungei Punggol; (10) Punggol; (11) Pulau Ubin; (12) Pulau Ketam; (13) Pasir Ris; (14) Sungei Loyang; (15) Sungei Changi; (16) Tanjong Changi; (17) Changi North Bay; (18) Tanah Merah; (19) South Changi; (20) Sungei Bedok; (21) Marina East; (22) Kallang Basin; (23) Marina South; (24) Berlayer canal; (25) Sentosa; (26) Pulau Sakijang Bendera/St. John's Island; (27) Pulau Hantu; (28) *Pulau Semakau; (29) Pulau Salu; (30) Tuas; (31) Tuas South. Sampling sites mentioned in Purchon and Purchon (1981): Tanjong Penjuru (A), Labrador (B), Pulau Bukom (C), *Pulau Sudong (D), *Raffles Light (E). * Indicates sites not visible on the map.

made. Nomenclature follows Abbott (1994) and references therein. Additional nomenclatural issues were discussed with and obtained through personal communication with local and foreign malacologists. Species were classified as new records based on historical local data from Chuang (1973), Way and Purchon (1981), Chou et al. (1994), and Tan and Chou (2000). Sampling sites mentioned in Purchon and Purchon (1981) that were not surveyed in this study are as follows (Fig. 1): Tanjong Penjuru (A), Labrador (B), Pulau Bukom (C), Pulau Sudong (D), and Raffles Light (E). Abbreviations used in the text are as follows: Is., island; Sg., sungei (= river); P., pulau (= island); SH, shell height; SL, shell length; SW, shell width; and Tg., tanjong (= cape or projecting land mass along the coast line). All measurements are in mm. Voucher specimens of species sampled from Singapore were deposited in the Zoological Reference Collection (ZRC.MOL.002776-002807), Raffles Museum of Biodiversity Research, National Univ. of Singapore, Republic of Singapore.

SYSTEMATICS

Nineteen species belonging to the family Neritidae are presently known from Singapore and 6 are considered new records. The species are listed as follows (* indicates a new record): *Nerita albicilla* Linnaeus, 1758, *Nerita articulata* Gould, 1847, *Nerita chamaeleon* Linnaeus, 1758, **Nerita costata* Gmelin, 1791, *Nerita grayana* Recluz, 1844, *Nerita histrio* Linnaeus, 1758, *Nerita planospira* Anton, 1839, **Nerita plicata* Linnaeus, 1758, *Nerita polita* Linnaeus, 1758, *Nerita signata* Lamarck, 1822, *Nerita undata* Linnaeus, 1758, **Neritina auriculata* Lamarck, 1816, **Neritina coromandeliana* (Sowerby, 1836), *Neritina cornucopia* Benson, 1836, **Neritina siquijorensis* (Recluz, 1843), **Neritina sulculosa* (von Martens, 1879), *Neritina violacea* (Gmelin, 1791), *Clithon faba* (Sowerby, 1836), and *Clithon oualaniensis* (Lesson, 1831).

Genus *Nerita* Linnaeus, 1758

Description: Shell solid, generally globular; dorsal surface smooth, spirally ribbed or with axial sculpturing; ventral side with large columellar callus or parietal wall, usually sculptured with wrinkles or small pustules; spire generally low. Columellar edge and aperture usually dentate, sometimes with small serrations. Operculum thick,

calcareous, either smooth or granose, with a peg.

Remarks: Several subgenera have been proposed, but the placement of many species has not been consistent in the opinions of various authors. Subgeneric placements within the genus *Nerita* were revised by Vermeij (1984), but a subgeneric classification is not adopted here (see Wilson 1993, Abbott and Dance 1982).

Nerita albicilla Linnaeus, 1758

(Figs. 2-1, -2)

Material examined: SINGAPORE: SL 22-22, SW 17-17 P. Salu (ZRC.MOL.002776); SL 21-32, SW 18-24 Tanah Merah (ZRC.MOL.002777); SL 28-29, SW 22-22 Tanah Merah.

Description: SL 19-32, SW 15-24. Shell sculptured with closely set rounded spiral ribs; spire sunken. Color white with varying amounts of black blotches and fine axial lines between blotches, all black, or alternating black and orangish-red spiral bands. Parietal shield pale yellow with rounded pustules becoming smaller near columellar teeth. Columellar edge with small teeth on central part. Outer lip dentate with 1st teeth at 2 ends largest. Operculum yellowish-pink with small granules over entire surface. Animal sand-colored with black lines.

Distribution: 11, 16-19, 23, 25-27, 29, 31, B, E.

Habitat: On rocks, breakwaters, and seawalls in lower to middle intertidal zone.

Remarks: Spiral sculpture may be indistinct or missing in eroded shells, which often appear as solid black bands or patches on a white ground color, making the shell appear rough in texture.

Nerita articulata Gould, 1847

(Figs. 2-3, -4)

Material examined: SINGAPORE: SH 25-29, SW 25-29 Berlayar Canal (ZRC.MOL.002778); SH 30-36, SW 30-35 Sg. Punggol (ZRC.MOL.002779); SH 27-27, SW 28-28 P. Ketam.

Description: SH 20-36, SW 21-35. Shell sculptured with numerous raised spiral cords; older specimens usually with finer spiral threads between main cords. Color relatively constant; grayish to pinkish-brown with black spiral cords. Columellar edge with several teeth, usually 3 on center part. Parietal wall white with yellowish tinge, usually smooth, sometimes with slightly raised cords at edge adjoining body whorl. Outer lip crenulate. Operculum grayish, generally darker

on central part, granular over entire outer surface.
Animal sand-colored with black lines.

Distribution: 1-15, 17, 18, 20-22, 24, 28.

Habitat: On mangrove tree trunks and roots, monsoon canal walls, muddy banks, and rocky

areas in or near mangroves.

Remarks: This species is often known as *Nerita balteata* Reeve, 1855 in the literature or as *Nerita lineata* Gmelin, 1791 (not *Nerita lineata* Muller, 1774). *Nerita birmanica* "Philippi" was

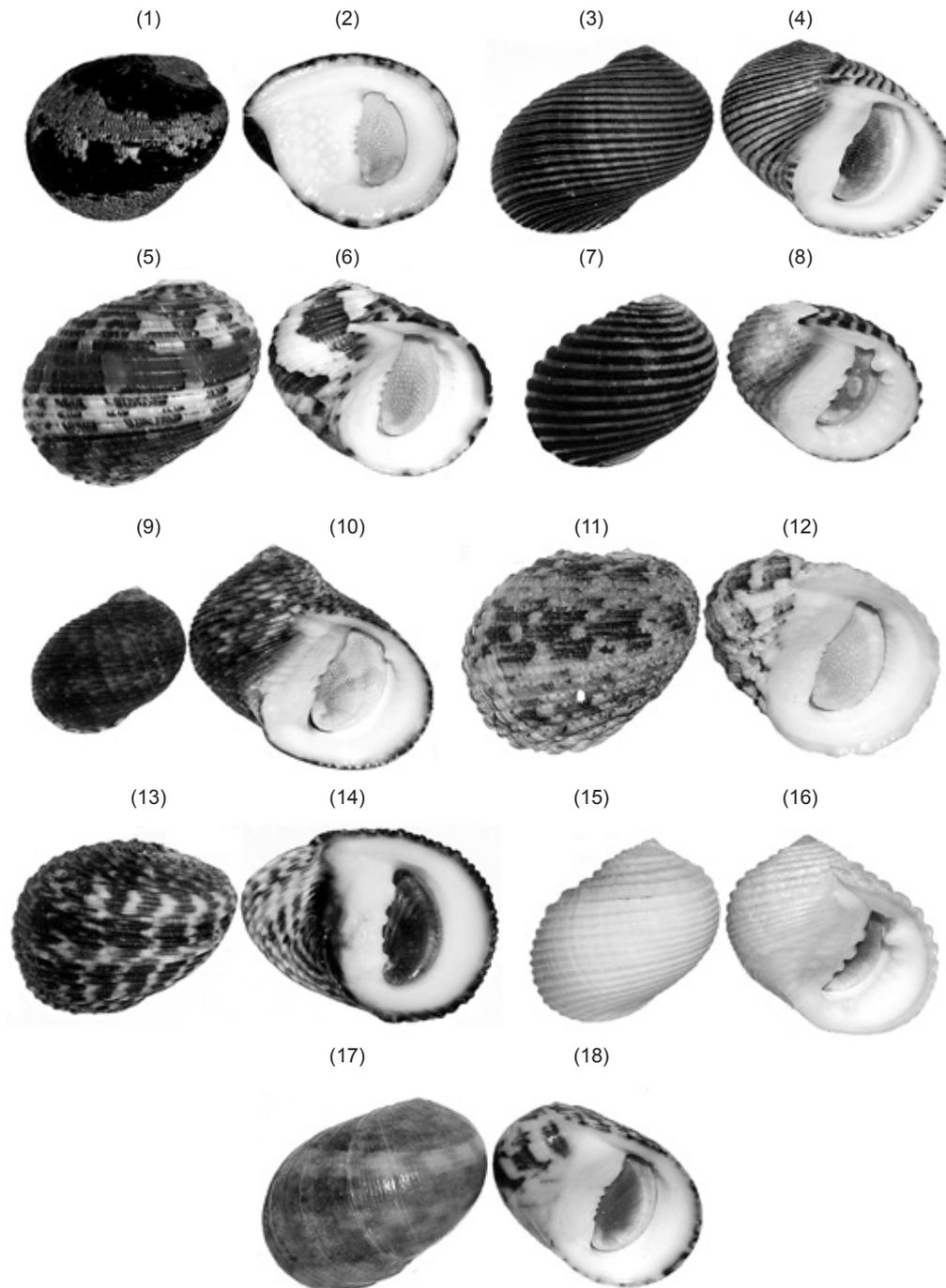


Fig. 2. (1, 2) *Nerita albicilla* Linnaeus, 1758; (3, 4) *Nerita articulata* Gould, 1847; (5, 6) *Nerita chamaeleon* Linnaeus, 1758; (7, 8) **Nerita costata* Gmelin, 1791; (9, 10) *Nerita grayana* Recluz, 1844; (11, 12) *Nerita histrio* Linnaeus, 1758; (13, 14) *Nerita planospira* Anton, 1839; (15, 16) **Nerita plicata* Linnaeus, 1758; (17, 18) *Nerita polita* Linnaeus, 1758. * Indicates a new record for Singapore.

also used for this species, but according to Mienis (1973), Philippi never described such a taxon. Krijnen et al. (1996) considers *Nerita articulata* and *Nerita balteata* as distinct species based on minor conchological differences, but we provisionally treat them as conspecifics, with *Nerita articulata* being the earliest name available.

***Nerita chamaeleon* Linnaeus, 1758**

(Figs. 2-5, -6)

Material examined: SINGAPORE: SH 25-26, SW 24-25 P. Sakijang Bendera (ZRC.MOL.002780); SH 22-23, SW 23-23 P. Salu (ZRC.MOL.002781); SH 22-24, SW 22-25 Tanah Merah.

Description: SH 18-28, SW 17-27. Shell with numerous raised smooth spiral ribs and very fine indistinct axial sculpturing; spire low. Periostracum thin, straw-colored. Color highly variable; ranging from black and white to a combination of 2 or more shades of gray, brown, orange, and red in random arrays of spiral bands, wavy blotches, or axial bands. Parietal shield white with several small pustules and ridges on side adjoining body whorl. Columellar edge with 2-4 small teeth on center part. Outer lip dentate, usually with 1 distinctly larger tooth at upper corner. Operculum grayish with small granules over entire outer surface. Animal light grayish with black lines.

Distribution: 11, 16-19, 23, 25-29, 31, A-D.

Habitat: Intertidal, on rocks, breakwaters, and seawalls.

Remarks: Very similar to *Nerita histrio*, but *Nerita chamaeleon* can be diagnosed by the higher spire, smoother ribs, more-distinct teeth in the outer lip and the consistently smoother and more regularly rounded outline of the peristome.

****Nerita costata* Gmelin, 1791**

(Fig. 2-7, -8)

Material examined: SINGAPORE: SH 18-20, SW 19 Tanah Merah (ZRC.MOL.002783).

Description: SH 13-30, SW 13-31. Shell form and color relatively consistent, sculptured with thick, raised, widely spaced grayish-black spiral cords; spire low. Outer lip strongly dentate, uppermost largest. Columellar edge with 3 strong teeth, 2nd tooth most prominent and squarish. Parietal shield white, smooth in juveniles, coarsely wrinkled in large individuals. Operculum pinkish-gray, slightly concave, covered with granules; lower end smooth, glossy near nucleus. Animal jet

black.

Distribution: 18, 28, 29.

Habitat: Boulders, rocks, seawalls, and breakwaters in middle to high intertidal zone, usually in crevices and hollows.

Remarks: Superficially similar to *Nerita articulata*, but differs by having thick spiral cords and a distinct aperture.

***Nerita grayana* Recluz, 1844**

(Figs. 2-9, -10)

Material examined: SINGAPORE: SH 15-24, SW 15-21 Seletar Dam (ZRC.MOL.002784); SH 15-17, SW 15-17 Sg. Khatib Bongsu (ZRC.MOL.002785); SH 20-22, SW 19-20 Lim Chu Kang road end; SH 19-22, SW 18-20 P. Ketam; SH 24, SW 24 Punggol.

Description: SH 8-31, SW 8-31. Shell with well-developed thin spiral ridges and axial sculpturing between ridges; spire relatively high. Color purplish-brown, variably patterned with dark dashes on spiral ribs or wavy dark axial patches, often with 3 indistinct darker spiral bands. Columellar edge with 3 or 4 teeth, uppermost squarish. Parietal shield smooth to strongly wrinkled, color varying from white with yellowish tinge to yellow with orangish tinge. Outer lip dentate with prominent last tooth at upper end. Operculum grayish, usually with patchy beige coloration, with small granules over entire surface. Animal creamy-white.

Distribution: 1-9, 11, 12, 14, 15.

Habitat: On tree trunks and roots and among or under rocks in interior or coastal fringes of mangroves.

Remarks: Spire more prominent than those of other local *Nerita* species. Some forms of *Nerita grayana* have a superficial similarity to *Nerita undata*, but the latter was not found in the same habitat during our surveys, and the animals rather differ. This species is also similar to *Nerita helicinoides* Reeve, 1855, which Mienis (1992a) listed as a junior synonym of *Nerita guamensis* Quoy and Gaimard, 1834. *Nerita guamensis* is apparently confined to the western Pacific Ocean and has not been recorded in this region. Vermeij (1973) mentioned the presence of *Nerita striata* (probably *Nerita grayana*) in Singapore. However, we were unable to find descriptions for *Nerita striata*, which is usually listed as a synonym of *Nerita undata*, and we therefore treat it as such. There are a few forms of *Nerita grayana* among

local populations, and we may actually be looking at a species complex. Until further studies show otherwise, we are provisionally regarding them as conspecifics.

***Nerita histrio* Linnaeus, 1758**

(Figs. 2-11, -12)

Material examined: SINGAPORE: SH 21, SW 23 Sarimbun (ZRC.MOL.002790); SH 14-17, SW 15-19 Tuas South (ZRC.MOL.002791); SH 24-25, SW 24-27 South Changi.

Description: SH 14-26, SW 15-28. Shell sculptured with rough, unevenly raised spiral cords, usually stronger at base of body whorl; axial sculpturing prominent, appearing scale-like in uneroded specimens; spire low to nearly flat. Color and markings variable; white or light yellow to gray and orange with random patterns of dark blotches, axial patches, or spiral bands. Few small obsolete teeth at center of columellar edge, sometimes with reddish stain around parietal teeth in juveniles. Parietal shield white or pale yellow, smooth or with small wrinkles. Outer lip with small teeth. Operculum flesh-colored, granulate, somewhat convex, sometimes with varying degrees of dark blotches. Animal sand-colored with black lines.

Distribution: 1, 11, 13, 14, 16-20, 22, 23, 25-27, 31.

Habitat: On mangrove tree trunks and stilt roots; muddy rocks at coastal fringes of mangroves; among rocky rubble along edge of muddy sand flats; on breakwater rocks.

Remarks: This species when found in mangroves appears to be rather drab (usually white with some black markings) compared to those found along the open sea. We speculate that this phenomenon may be driven by environmental factors, but further studies are required to confirm this. Usually known as *Nerita squamulata* Le Guillou, 1841 (e.g., Springsteen and Leobrera 1986, Tan and Chou 2000), *Nerita histrio* was treated by Mienis (2004) as a senior synonym and a figure of a specimen illustrated in Rumphius (1705: plate 22, Fig. 5) was proposed as the lectotype.

***Nerita planospira* Anton, 1839**

(Figs. 2-13, -14)

Material examined: SINGAPORE: SL 20-24, SW 16-20 Marina East (ZRC.MOL.002786); SL 28-29, SW 21-22 P. Ubin (ZRC.MOL.002787), SL

26-28, SW 20-22 Pasir Ris.

Description: SH 18-27, SW 18-30. Shell sculptured with raised spiral ridges and smaller cords between primary ones; spire sunken. Periostracum thin, brown. Color pink with somewhat axially aligned dark-violet patches and bands. Aperture light beige to white, peristome black with a black blotch at parietal shield edge. Four or 5 teeth present on columellar edge extending over 1/2 of septum as folds and pustules. Outer lip with very fine indistinct serrations. Dark gray to blackish operculum, entirely smooth and glossy. Animal black.

Distribution: 1-3, 11-13, 15, 21, A.

Habitat: On mangrove tree trunks and roots, muddy rocks, trash (e.g., discarded rubber tires and wooden planks), and monsoon canal walls.

Remarks: This species was tentatively identified as *Nerita* sp. in Lim (1963), and the *Nerita plancapira* mentioned in Chou et al. (1994) is probably a typographical error.

****Nerita plicata* Linnaeus, 1758**

(Figs. 2-15, -16)

Material examined: AUSTRALIA: SH 21-23, SW 20-22 Langford Is., Queensland; SH 22-27, SW 23-25 Dirk Hartog Is., western Australia. INDONESIA: SH 16-21, SW 16-21 Bali; SH 21-24, SW 22-25 Baron, south-central Java; SH 20-21, SW 18-20 Kabaena, southeast Sulawesi. PHILIPPINES: SH 12-24, SW 12-23 Sulu Archipelago.

Description: SH 15-21, SW 16-21. Shell with numerous widely spaced, regularly rounded spiral cords; spire low to moderately high. Color consistently pale creamy-pinkish, ribs sometimes with a darker tone or black markings. Columellar edge with 3 or more strong squarish teeth. Parietal shield white, wrinkled. Outer lip bordered by a yellow line, strongly dentate, teeth at both ends most prominent. Operculum pink, concave, glossy, smooth, finely granulated along border. Animal not observed.

Distribution: 28.

Habitat: Observed in holes and crevices in rocks, boulders, hollows, and crevices around supralittoral zone of sandstone and limestone boulders, and cliffs facing the open surf of Pulau Langkawi, Malaysia and in Java, Indonesia.

Remarks: This species has a wide Indo-Pacific distribution and is generally restricted to the high intertidal zone. Interestingly, Mienis (1992b)

noted that this species reached the Galapagos Islands by hitchhiking on transoceanic vessels.

***Nerita polita* Linnaeus, 1758**

(Figs. 2-17, -18)

Material examined: SINGAPORE: SH 19-22, SW 20-24 Sentosa (ZRC.MOL.002788); SH 15-21, SW 15-22 South Changi (ZRC.MOL.002789); SH 37, SW 38 Sg. Bedok; SH 19-20, SW 20-21 South Changi.

Description: SH 15-36, SW 17-40. Shell generally smooth without raised spiral cords or other prominent sculpturing, sometimes with fine spiral grooves in juveniles, larger specimens usually with fine axial striae; spire very low, sometimes nearly flat. Color highly variable; markings including shades of white, gray, brown, orange, and red, zigzag markings, spiral or axial bands, or blotches with specks and dots. Columellar edge with a few fine teeth at center extending into small ridges on parietal shield, which is otherwise smooth, glossy. Aperture white or with some yellow around edges. Outer lip with fine obsolete crenulations. Operculum greenish-gray, smooth, glossy except for fine transverse lines along border. Animal yellowish with black lines.

Distribution: 19, 20, 25, 26, 30, B.

Habitat: Intertidal rocks. Nocturnal in habit and frequently found shallowly buried in sand against base of rocks during the day.

Remarks: All examined shells found locally belong to what was formerly known as *Nerita polita* form *rumphii* (e.g., Abbott and Dance 1982), which is now often referred to as *Nerita litterata*. Krijnen et al. (1999) regarded *Nerita litterata* as a valid species in the *Nerita polita* complex, and the main conchological differences with *Nerita polita* are its generally smaller size, the flat to concave parietal area, and fine spiral striae that are obvious in smaller shells but obsolete in larger shells. However, both shell forms are often barely distinguishable, and forms of both *Nerita litterata* and *Nerita polita* were observed occurring sympatrically among the same boulders at Teluk Burau in Langkawi, West Malaysia. This suggests that they are polymorphic variations of a single species. We are provisionally treating *Nerita litterata* as a form of *Nerita polita*, and further studies on both of these closely related species are required to determine their actual relationships within the *Nerita polita* complex.

Another commonly used taxon, *Nerita doreyana*, is a junior synonym of *Nerita litterata* according to Krijnen (1999). Species in the *Nerita polita* group are often incorrectly placed in the subgenus *Amphinerita* (e.g., Dharma 2005), which has a granulated operculum as one of its characteristics (Mienis 2000b).

***Nerita signata* Lamarck, 1822**

(Figs. 3-19, -20)

Material examined: INDONESIA: SH 18-18, SW 17-18 P. Semata, Maluku; SH 15-16, SW 16 Lampung, Sumatra. PHILIPPINES: SH 13, SW 13 Olango Is., Cebu; SH 15-18, SW 15-20 Manila Bay, Luzon.

Description: SH 15-18, SW 16-18. Shell sculptured with spiral cords crossed by axial sculpturing, appearing scaly in uneroded shells; spire low. Color and markings variable; white to brown with black or brown maculations. Columellar edge with several small teeth in center extending into small ridges. Parietal shield with distinct reddish-brown blotch from parietal teeth extending to upper part. Aperture white. Outer lip dentate. Operculum slightly convex, pinkish-flesh color, minutely granulated. Animal not observed.

Distribution: E.

Habitat: On intertidal rocks under shade.

Remarks: Recorded as *Nerita reticulata* Karsten, 1789 in Way and Purchon (1981), but this name should not be used as Karsten's non-binomial work (Museum Lekeanum) has been suppressed by the ICZN (Opinion 1877; ICZN 1997) for nomenclatural reasons (Mienis 2000c).

***Nerita undata* Linnaeus, 1758**

(Figs. 3-21, -22)

Material examined: SINGAPORE: SH 28-29, SW 26-27 P. Salu (ZRC.MOL.002792); SH 15-33, SW 14-29 South Changi (ZRC.MOL.002793); SH 29-30, SW 27-28 South Changi; SH 14-16, SW 13-16 Sg. Bedok (ZRC.MOL.002794); SH 29-30, SW 27-28 P. Hantu.

Description: SH 17-37, SW 16-38. Shell spirally sculptured with numerous low rounded ribs; spire moderately high. Color variable; white to light brown with varying amounts of random black blotches, stripes, or axial bands, often with 3 indistinct darker spiral bands, sometimes all black. Parietal shield wrinkled, white with varying degrees of yellow staining around aperture. Columellar

edge with 3-5 teeth, uppermost 1 squarish. Outer lip dentate with a distinctly larger tooth at upper end. Operculum flat, gray with small granules over entire outer surface. Animal gray with black lines.

Distribution: 11, 16-20, 23, 25-27, 29-31, B, E.

Habitat: In crevices and under rocks of breakwaters and rocky shores of middle to upper intertidal zones. Nocturnal, emerging from their hiding places at dusk.

Remarks: There are many known synonyms

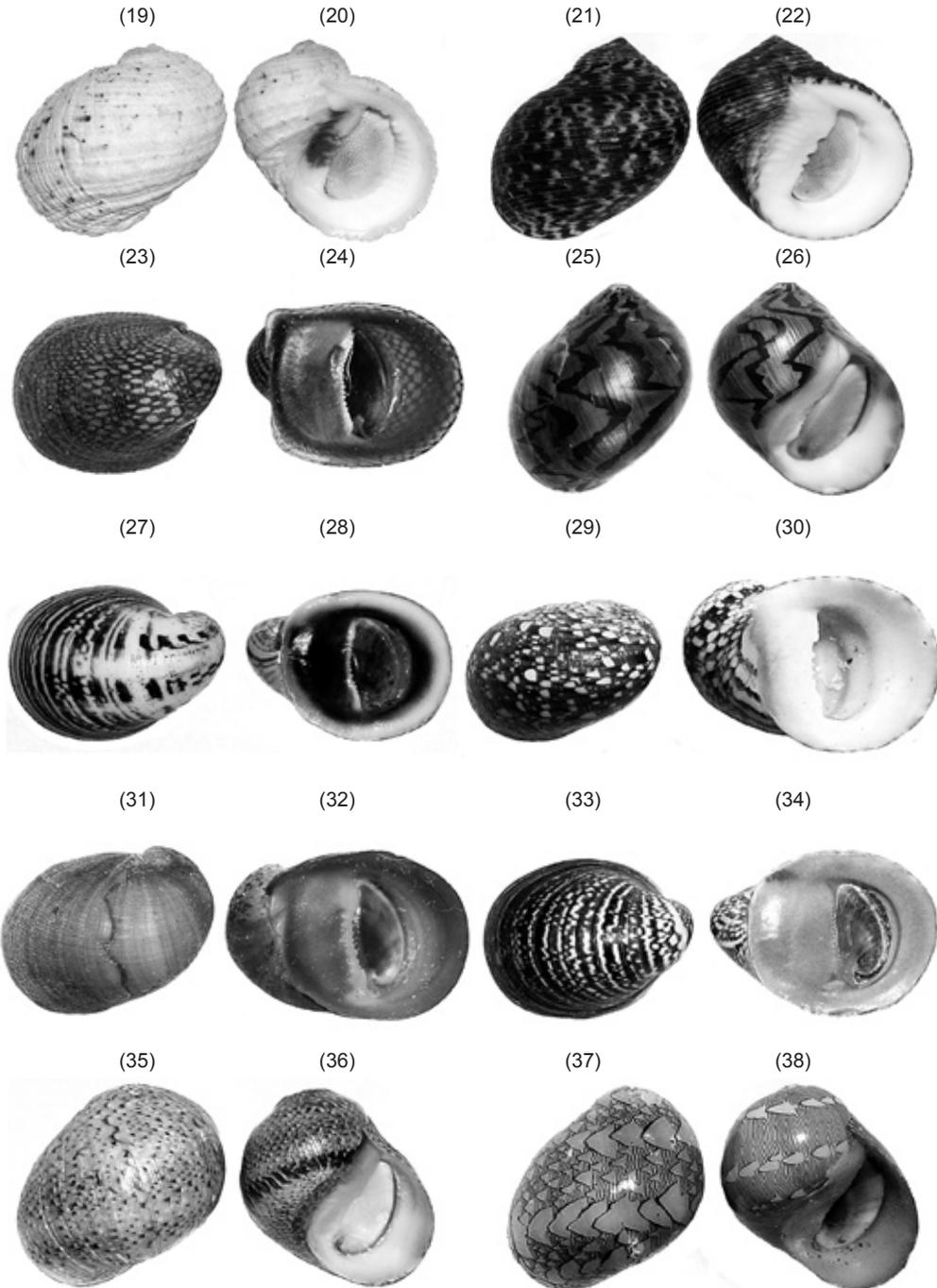


Fig. 3. (19, 20) *Nerita signata* Lamarck, 1822; (21, 22) *Nerita undata* Linnaeus, 1758; (23, 24) **Neritina auriculata* Lamarck, 1816; (25, 26) **Neritina coromandeliana* (Sowerby, 1836); (27, 28) *Neritina cornucopia* Benson, 1836; (29, 30) **Neritina siquijorensis* (Recluz, 1843); (31, 32) **Neritina sulculosa* (von Martens, 1879); (33, 34) *Neritina violacea* (Gmelin, 1791); (35, 36) *Clithon faba* (Sowerby, 1836); (37, 38) *Clithon oualaniensis* (Lesson, 1831). * Indicates a new record for Singapore.

(e.g., *Nerita quadricolor* Gmelin, 1791; *Nerita striata* Burrow, 1815; and *Nerita longii* Recluz, 1842), and several have been consistently treated as valid species in recent work (e.g., Krijnen et al. 1997 2001). Although Neritids are known to be polymorphic, the presence of cryptic species is highly likely within the *Nerita undata* complex. Local populations do not show clear intraspecific variation and probably consist of a single species. Krijnen et al. (2006) stabilized the taxonomical status of *Nerita undata* with the designation of a neotype, which agrees with the description of shells examined in this study.

Genus *Neritina* Lamarck, 1816

Description: Shells cap-shaped, globular, or semiglobose, generally thinner than shells of *Nerita* spp.; surface generally smooth. Columellar edge smooth or with fine denticulations. Operculum smooth with thin horn border.

Remarks: Many genera and subgenera have been designated mainly based on shell form, but much confusion still remains regarding respective specific placements and the validity of some of the generic and subgeneric names. We concur with the opinion of Haynes (2005) in regarding the division of *Neritina* into various subgenera (e.g. *Neripteron*, *Neritona*, and *Vittina*) as unnecessary and unjustifiable based on shell shape and radular differences.

**Neritina auriculata* Lamarck, 1816 (Figs. 3-23, -24)

Material examined: SINGAPORE: SL 8-13, SW 6-9 Berlayar Canal (ZRC.MOL.002795); SL 9-13, SW 7-10 Sg. Punggol (ZRC.MOL.002796); SL 13, SW 10 Sg. Punggol.

Description: SL 8-13, SW 6-10. Shell semiglobular or bean-shaped; spire sunken. Greenish-brown with darker brown, violet reticulations or flames. Aperture large, surrounded by a broad peristome ending in a point on upper columellar side, sometimes with slight protrusion at lower end. Operculum with reddish horn border. Animal black.

Distribution: 9, 24.

Habitat: On stones submerged in mangrove streams in running water.

Remarks: Local shells were not found to have the large extended “wings” or “ears” seen on some specimens from Indonesia and Peninsula Malaysia. Considerable variation in

the development of the “ears” was noted by van Benthem Jutting (1956). This species is easily mistaken for juvenile shells of *Neritina cornucopia*, to which it bears a strong resemblance, and juveniles can be difficult to identify with certainty. *Neripteron* is usually used for this species, either with full generic status or as a subgenus of *Neritina* (e.g., Komatsu 1986, Swennen et al. 2001). Dharma (2005) placed this species in the genus *Clypeolum*.

**Neritina coromandeliana* (Sowerby, 1836) (Figs. 3-25, -26)

Material examined: INDONESIA: SH 19-28, SW 17-24 Tg. Berlangkap, P. Bintan, Riau, Sumatra (ZRC.MOL.002797). SINGAPORE: SH 15, SW 13 Marina East.

Description: SH 15, SW 13. Shell smooth, somewhat conoidal; spire moderately elevated. Pinkish with black stripes, appearing brown with black stripes if periostracum intact. Parietal region grayish-white, smooth with tiny dentition at center of columellar edge. Operculum smooth, grayish-brown with reddish horn border. Animal not observed.

Distribution: 21.

Habitat: In seepholes of small tributary drains of monsoon canals. This species has been observed on fallen leaves and branches submerged in stagnant pools in mangroves of Pulau Bintan, Riau, Indonesia, and on submerged trunks of *Nipah* palms in Pahang, W. Malaysia.

Remarks: This species has often been confused with *Neritina zigzag* Lamarck (Brandt, 1974). As such, it is likely that the *Neritina zigzag* mentioned in van Benthem Jutting (1956) and Way and Purchon (1981) referred to this species. This species has also been placed in many different genera and subgenera, e.g., *Neritina* (*Vittoidea*) *coromandeliana* (Brandt 1974); *Neritina* (*Provittoidea*) *coromandeliana* (Springsteen and Leobrera 1986); and *Vittina coromandeliana* (Swennen et al. 2001). *Vittina* (*Provittoidea*) *parallela*/*Neritina* (*Vittina*) *parallela* in a number of Japanese publications (e.g., Komatsu 1986) is a misidentification of this species (Mienis 2000a).

Neritina cornucopia Benson, 1836 (Figs. 3-27, -28)

Material examined: SINGAPORE: SL 11-24, SW 9-18 Marina East (ZRC.MOL.002798); SL

19-21, SW 14-15 Marina East; SL 12-16, SW 9-12 Sg. Punggol (ZRC.MOL.002799); SL 13-16, SW 9-10 Berlayar Canal; SL 12-13, SW 9-10 Punggol.

Description: 9-24, SW 6-17. Depressed shell with rapidly expanding body whorl, nearly symmetrical when viewed from dorsum; spire sunken. Color white with purplish axial lines and "tent" markings, spiral bands often devoid of markings. Periostracum usually covering dorsum, brown, with algae or silt. Peristome ovate, continuous. Parietal shield and aperture white with grayish shades or very dark gray throughout. Small whitish denticulations along edge of columellar, usually along entire length. Operculum color similar to parietal area with an orangish-red horn border. Animal black.

Distribution: 1-3, 7, 9-11, 13, 15, 21, 24.

Habitat: Usually submerged; on mud, plant matter (e.g., fallen leaves and braches in stagnant pools), on and under stones in streams, and on concrete banks of drains.

Remarks: Very similar to *Neritina violacea* in terms of shell shape and is usually considered a variation of *Neritina violacea* (e.g., Ng et al. 1999b), but our study of conchological characters of the collected material largely agree with that of Huang (1997), and we are provisionally regarding the 2 species as distinct due to the different ventral colors.

****Neritina siquijorensis* (Recluz, 1843)**
(Figs. 3-29, -30)

Material examined: SINGAPORE: SL 5-7, SW 4-6 Pasir Ris (ZRC.MOL.002800); SL 9-11, SW 6-7 Sg. Bedok; SL 6-6, SW 5-5 Pasir Ris.

Description: SL 5-7, SW 4-6. Shell smooth with very fine axial striae; spire very low or flat. Periostracum thin, brownish. Color purplish with white tongue-shaped patterns and darker-toned shading somewhat aligned in a spiral pattern. Parietal shield grayish with 4-6 small teeth at center of columellar edge. Operculum smooth, gray with a reddish horn border. Animal not observed.

Distribution: 13, 20.

Habitat: On submerged fallen leaves in pools and stones on mudflats.

Remarks: *Neritina guerini* is a very similar species and could be conspecific (T. Eichhorst pers. comm.), but we have been unable to verify this due to a lack of available references for *Neritina guerini*. It was placed in the genus

Puperita by Dharma (2005).

****Neritina sulculosa* (von Martens, 1879)**
(Figs. 3-31, -32)

Material examined: SINGAPORE: SL 8, SW 6 Berlayar Canal (ZRC.MOL.002801); SL 12, SW 8 Sg. Punggol.

Description: SL 8-12, SW 6-8. Shell with very fine spiral striae; body whorl rapidly expanding; spire low. Periostracum olive-green. Peristome large, ovate, continuous, somewhat ridge-like where it meets body whorl. Parietal region light gray to brown, finely textured on parietal shield. Operculum smooth, dark gray, darker centrally with a red horn border. Animal not observed.

Distribution: 9, 24.

Habitat: In mangrove streams, on stones submerged in running water.

Remarks: Apparently rare, this species was not featured in our available references and was positively identified by Henk Mienis.

***Neritina violacea* (Gmelin, 1791)**
(Figs. 3-33, -34)

Material examined: SINGAPORE: SL 18-27, SW 13-20 Marina East (ZRC.MOL.002802); SL 24-25, SW 18-18 Marina East; SL 11-16, SW 9-13 Sg. Punggol (ZRC.MOL.002803).

Description: SL 11-26, SW 9-20. Depressed shell; body whorl rapidly expanding, nearly symmetrical when viewed from dorsum; spire sunken. Color white with dark-purplish often solidly banded axial bands and coarse "tent" markings. Periostracum brown, usually covered with silt or algae. Peristome ovate, continuous. Parietal shield and aperture color varying from whitish with orange tinge to brick-red. Denticulations along columellar edge variable, often only in central part, sometimes nonexistent. Operculum smooth; color similar to parietal area, usually darker with varying numbers of dark blotches. Animal orange with some black patches.

Distribution: 1-4, 6-13, 15, 21, 24.

Habitat: Similar to that of *Neritina cornucopia*.

Remarks: Shell very similar to that of *Neritina cornucopia*, mainly differing in having an orangish-red parietal region, lacking the spiral bands that are sometimes seen in *Neritina cornucopia*, and generally attaining a larger size. A well-known synonym, *Neritina crepidularia*, was listed in Chou et al. (1994). *Dostia* is usually used as the genus

or subgenus for this species (e.g., Hill 1977, Haynes 2001), but some authors (e.g., Swennen et al. 2001) place this under *Neripteron*.

Genus *Clithon* Montfort, 1810

Description: Subglobose shells similar to some *Neritina* spp., generally roughened with wrinkles, ridges, or spines. Columellar edge with a large tooth, followed by smaller teeth on central part. Operculum smooth with a narrow horn border and curved ridge; indentation occurring where large tooth of columellar edge fits.

Remarks: Smooth glossy shells within this genus are often placed in the separate subgenus, *Pictoneritina*.

Clithon faba (Sowerby, 1836)

(Figs. 5-35, -36)

Material examined: SINGAPORE: SH 10-19, SW 10-17 Marina East (ZRC.MOL.002804); SH 9-16, SW 9-15 Sg. Bedok (ZRC.MOL.002805); SH 11, SW 11 Punggol; SH 14-17, SW 14-17 Berlayar.

Description: SH 11-19, SW 11-17. Shell smooth; body whorl either regularly round, or possessing an angular "shoulder" with a slight concavity beyond suture; spire low to turreted. Color variable; pale yellow, yellowish-green, very dark green, pink, or gray with variable patterns of reddish to whitish, black-shaded spots, zigzag or triangular-shaped markings, usually with darker indistinct spiral bands, but spiral bands of large blotches or bands not uncommon. Periostracum greenish-brown. Parietal shield thick, white to grayish with a single large tooth, 5-7 smaller sometimes obsolete teeth on central part of columellar edge. Operculum smooth, yellow to grayish with a red horn border. Animal yellowish with white lines and flecks.

Distribution: 7, 10, 20-22, 24.

Habitat: On sandy banks of mangrove streams, on sand, stones, and concrete surfaces of drains and canals near sea.

Remarks: Two specimens collected from P. Bintan, Indonesia were found to have a single protruding spine on the edge of the "shoulder". Apart from the presence of the spines, all other conchological aspects agree with the specimens from Singapore, which is incidentally the type locality of the species. Van Benthem Jutting (1956) remarked that *Clithon faba* is never ornamented with spines and *C. faba* from Singapore was indeed never found with spines. Brandt (1974)

remarked that *C. faba* of van Benthem Jutting is not this species, but he does not justify his claims.

Clithon oualaniensis (Lesson, 1831)

(Figs. 3-37, -38)

Material examined: SINGAPORE: SH 4-11, SW 4-10 Kallang Basin (ZRC.MOL.002806); SH 6-11, SW 6-10 Sg. Bedok (ZRC.MOL.002807).

Description: SH 5-10, SW 5-9. Shell smooth, glossy; spire low or conical, appearing increasingly conical in larger shells. Color generally yellow or greenish with highly variable patterns of triangular markings, zigzag lines, spiral bands, and axial lines. Parietal shield relatively small, yellow or white with a larger tooth and ~4 min teeth at columellar edge. Operculum greenish-gray, somewhat lighter at edge with a red horn border. Animal greenish-gray with black lines.

Distribution: 1, 10, 11, 13, 15, 17-22, 31.

Habitat: On sandy banks of mangrove streams, on sand in drains and canals, intertidal muddy sand banks, and on mud in mangroves.

Remarks: Unmistakable colorful glossy little shells. Grüneberg (1978 1982) studied the shell color and pattern variations in several populations of this species and found that its axial and spiral patterns were not entirely discontinuous among individuals and used the term "pseudopolymorphism" for this category of variation.

DISCUSSION

Neritids typically found in brackish waters include *Nerita articulata*, *Nerita grayana*, and *Nerita planospira*. These species usually occur in mangroves along the northern coastline (e.g., Sarimbun and Sg. Simpang). From our sampling results, *Nerita grayana* appears to be largely confined to the Johor Straits, while the other 2 species have been found or reported from other locations further south. *Nerita planospira* was often associated with trunks and roots of *Rhizophora* trees, but further studies are needed to elucidate potential habitat affinities. *Nerita planospira* appears to be moderately uncommon and occurs in relatively low densities. The largest local population of *Nerita planospira* appears to be located in the mangroves of P. Ubin. It was also reported by Way and Purchon (1981) to occur at Tg. Penjuru, which is incidentally the last remaining extensive mangrove forest of the southern coastline, but that location was not sampled in this

study. The most widely distributed local species is probably *Nerita articulata*, a species commonly sighted on monsoon canal walls and mangrove trees, sometimes numbering in the hundreds in a single location and which was found in more than 70% of the sampling sites. Although *Nerita articulata* has been found on breakwater rocks and seawalls facing the open coast (e.g., Tanah Merah), individuals attain a much smaller average adult size and never reach the abundance levels of populations in mangroves.

All of the 8 local *Neritina* species appear to be restricted to brackish habitats. Although many freshwater species of *Neritina* are known throughout Southeast Asia, no true freshwater species have been found in Singapore. From our observations, *Neritina auriculata*, *Neritina cornucopia*, *Neritina sulculosa*, and *Neritina violacea* were found sympatrically on stones in streams of Sungei Punggol and Berlayar Canal. *Neritina auriculata* and *Neritina sulculosa* appear to have a preference for running water, as neither species has been found in stagnant pools or mud banks (e.g., Sarimbun and Kranji), where the other 2 species have been found. Among the *Neritina* species sampled, *Neritina coromandeliana* was the rarest with only a single specimen found at Marina East. Subsequent trips to the same location did not yield more samples and unfortunately, construction activities have destroyed and altered much of the original sampling location. *Neritina siquijorensis* has only been found in Pasir Ris and Sungei Bedok, but it may have been overlooked by earlier workers due to its small size. It would not be surprising if increased sampling efforts reveal the occurrence of this species at other locations. Local *Clithon* species are common in brackish canals and drains near the coast, and can also be found in muddy sand areas of lagoons and estuarine areas with little tidal influence. Both species were found on the sandy banks of a creek in a mangrove forest at Punggol. *Clithon faba* seems to prefer a sandier substratum and is probably more confined to brackish conditions. This species was not found on slightly muddy intertidal sand flats, nor did it occur on mud among mangroves where *Clithon oualaniensis* occurs.

Eight species of Neritids are typically associated with marine environments. *Nerita albicilla*, *Nerita chamaeleon*, *Nerita costata*, *Nerita polita*, and *Nerita undata* are generally found on rocky shores and breakwaters directly facing the surf (e.g., Tg. Changi and Tanah Merah). Although *Nerita histrio* is often found

sympatrically, it probably favors a slightly muddier habitat and usually occurs near estuaries (e.g., Sungei Bedok), or on muddy sand and rocks of lagoons (e.g., Tanah Merah and Pulau Sakijang Bendera). Two other marine species, *Nerita plicata* and *Nerita signata*, are known to occur in Singapore but were not found in our surveys. Nevertheless, they were included in this study and described based on specimens from Indonesia and Malaysia. *Nerita signata* (as *Nerita reticulata* in Way and Purchon 1981) was collected from Raffles Light circa 1950-1960 (Purchon and Purchon, 1981). Some juveniles of *Nerita histrio* bear a strong resemblance to *Nerita signata*, which begs the question of whether it could have been a misidentification. It also seems suspect that *Nerita histrio*, a common species in local waters, was not listed by Way and Purchon (1981). However, another reason for *Nerita histrio* not being listed may be the lumping of this species with that of another notoriously similar species: *Nerita chamaeleon*. As the geographical position of Singapore is within the known distribution range of *Nerita signata*, the occurrence of this species is provisionally treated as valid until proven otherwise. Although *Nerita plicata* was not found in our surveys, we came across a single lot of 7 specimens of *Nerita plicata* from a private collection. The shells were collected around the late 1970s and early 1980s from Pulau Semakau, which is an island within the geographical boundaries of Singapore. Since this species was not recorded in the literature to occur in local waters, we consider this species a new record for Singapore.

CONCLUSIONS

In total, 19 Neritid species were recorded from the waters of Singapore. Overall, 8 species are usually associated with marine habitats, while 11 are typically found in mangrove/brackish waters. Two marine and 4 brackish water species were recorded for the 1st time, comprising nearly 30% of the total number of sampled species. All the sampled species are believed to be native because Singapore is within their known geographical distribution range. The high proportion of new records may be attributed to the lack of taxonomical work and undersampling of the local malacofauna, which was evident throughout the available literature. Future surveys, particularly of other locations not covered in this

study may reveal species yet to be recorded and increase the distribution ranges of known species. Observations have shown that local Neritids do not appear to be under threat from exotic species or collection. Although major reclamation works over the past few decades have drastically changed the coastal environments of Singapore, populations of most marine Neritids do not appear to be under threat and have rapidly colonized artificial habitats such as breakwaters and seawalls. Increased habitat alteration, however, may have a disastrous effect on resident populations of *Neritina auriculata*, *Neritina coromandeliana*, and *Neritina sulculosa* as they appear restricted to certain niches within their sampled localities. As such, the conservation of remaining coastal habitats may be vital to the survival of these species in Singapore.

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