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## Notes on the correct taxonomic status of *Haliotis rugosa* Lamarck, 1822, and *Haliotis pustulata* Reeve, 1846, with description of a new subspecies from Rodrigues Island, Mascarene Islands, Indian Ocean (Mollusca: Vetigastropoda: Haliotidae)

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*Haliotis rugosa* Lamarck, 1822, and *H. pustulata* Reeve, 1846, have long been a source of confusion. Herbert (1990) suggested the synonymy of the two and designated the lectotype and type locality of *H. rugosa*. Examination of several hundred shells of each of the two taxa has demonstrated that the *H. rugosa* morphology is found only on Mauritius and Reunion, while the *H. pustulata* morph occurs at Madagascar and the east coast of Africa, from approximately Park Rynie, South Africa, to the Red Sea and east to Yemen. No specimens from the latter localities resemble *H. rugosa*; however, a very small number of specimens from Mauritius have an intermediate morphology between the two taxa. The two species-level taxa are here considered as subspecies of each other. They show some overlapping shell morphology, but are geographically isolated.

**Abbreviations of Collections:** BOC: Buzz Owen Collection, Gualala, California, USA; SBMNH: Santa Barbara Museum of Natural History, Santa Barbara, California, USA; RKC: Robert Kershaw Collection, Narooma, NSW, Australia; NGC: Norbert Göbl Collection, Gerasdorf near Vienna, Austria; HDC: Henk Dekker Collection, Winkel, The Netherlands; FFC: Franck Frydman Collection, Paris, France; MAC: Marc Alexandre Collection, Souvret, Belgium.

**Shells examined:** *H. rugosa rodriguensis* n. ssp., Anse Cotton, Rodrigues Island, 10; Saint François, Rodrigues Island, 3; Gran Baie, Rodrigues Island, 1. *H. rugosa rugosa*, Mauritius, >100; Reunion, >65. *H. rugosa pustulata*, Madagascar, >100; Park Rynie, South Africa to Fernão Veloso, Mozambique, >75; Zanzibar to Red Sea area, >50; Mukalla, Yemen, 25; Dahab, Sinai, Egypt, 22; Haifa, Israel, 2; Tobruk, Libya, 2.

### Genus: *Haliotis* Linnaeus, 1758

**Type species.** *Haliotis asinina* Linnaeus, 1758 (subsequent designation Montfort, 1810)

### *Haliotis rugosa rodriguensis* new subspecies

(Fig. 1.1–14)

**Type material:** Holotype: SBMNH 230926 (Fig. 1.1), 31.2 mm. Paratype: BOC 195233 (Fig. 1.2), 45.3 mm. Grande Baie, Rodrigues Island, Mascarene Islands.

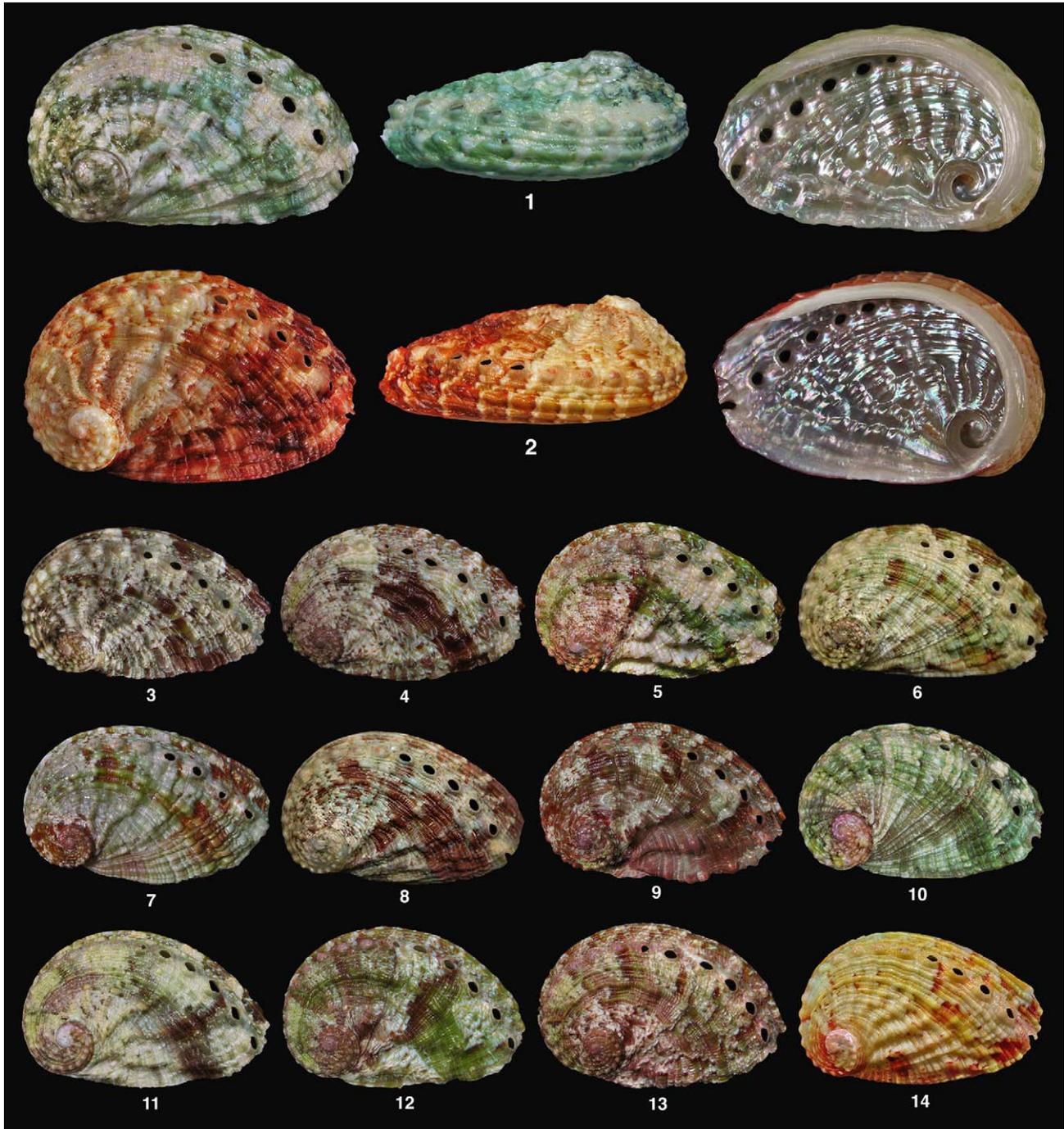
**Type locality:** Anse Cotton, Rodrigues Island, Mascarene Islands; 19°40'58"S, 63° 29'48"E.

**Etymology:** The subspecies is named for the type locality, Rodrigues Island.

**Distribution and habitat:** All 14 specimens were live taken by snorkeling in 1–3 m in December, 2011, by Bruno Mathé, and were found living under dead coral and stones. No animals were preserved.

**Description (diagnostic characters underlined):** Shell small (to ~50 mm), fairly light-weight, oblong, hardly arched, somewhat convex. Anterior margin straight to slightly curved. Spire somewhat elevated and tilted, located approximately 70% towards the posterior margin of shell; partially visible in ventral view (Fig. 1.1–1.2). Holes medium large, fairly elevated, somewhat elongate, usually 4–6 open. Dorsal surface usually with strong, bumpy spiral cords alternating with narrower ribs crossing deep, prominent lamellae-like folded ridges, giving shells very jagged irregular sculpture (ribs may appear slightly scaly on some specimens). Spiral ribs with bumps present on early portion of most specimens. Periphery between row of holes and columella with 2–3 very strong thick cords, occasionally with 1–2 weak threads immediately below holes. Central cord usually largest, often expanding to create a wide shelf-like ridge.

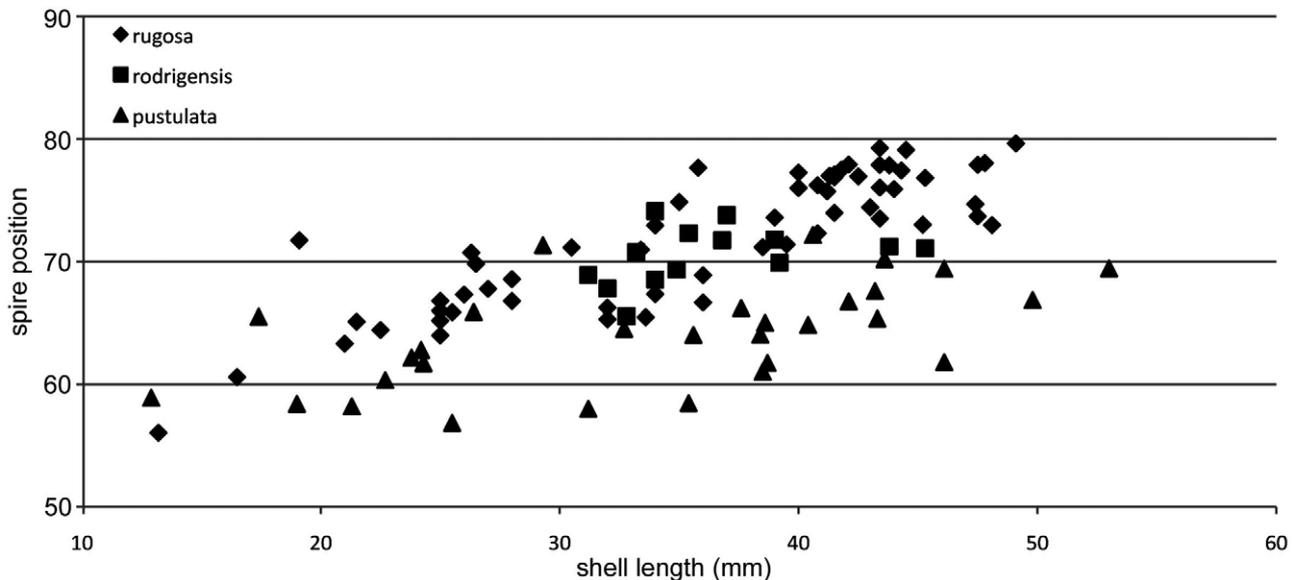
Columella quite narrow. Shell very brightly colored with lime-green, bright white, and purple-maroon brown. Occasional specimens almost entirely lime-green (Figs. 1.1, 1.10). Colors arranged as irregular banding or patches. Slight evidence of diet banding present on several specimens, especially early portion of shell. Occasional specimens have unusual “V” markings arranged in irregular patterns (Fig. 3.15). No prosocline rays. Ventral surface highly iridescent silver nacre with reflections of steel blue, pink, and green; usually highly irregular and lumpy due to very jagged sculpture on dorsum. No muscle scar.



**FIGURE 1.** *Haliotis rugosa rodriguensis* n. ssp. Rodrigues Island. 1. Anse Cotton. 31.2 mm. Holotype, SBMNH 230926. 2. Grande Baie, 45.3 mm, paratype, BOC 195233. 3. Anse Cotton, 39.2 mm, BOC. 4. Anse Cotton, 37.0 mm, BOC. 5. Anse Cotton, 36.8 mm, BOC. 6. Anse Cotton, 35.4 mm, NGC. 7. Saint François, 43.8 mm, BOC. 8. Saint François, 35.4 mm, HDC. 9. Anse Cotton, 34.0 mm, BOC. 10. Anse Cotton, 34.0 mm, MAC. 11. Anse Cotton, 33.2 mm, BOC. 12. Anse Cotton, 32.0 mm, BOC. 13. Anse Cotton, 32.8 mm, BOC. 14. Saint François, 34.0 mm, FFC.

**Comparisons.** *Haliotis rugosa rugosa* (Fig. 3.1–3.3) has wide spiral cords, sometimes interspaced with narrow ribbing, which are most often quite smooth, flat, and often have a squarish profile. Occasional specimens have folded ridges and rarely form strong lumpy sculpture. As a result, the dorsal surface is generally quite even, and lacking in jagged irregular sculpture. The ventral surface is marked with smooth but strong parallel ribs that normally show weakly developed irregular bumps or folded ridges. The colors of both subspecies are often quite similar, both being marked with irregular patches of white, red, maroon, green, and dull brown. Approximately 20% of the 165 specimens examined have weakly developed prosocline rays.

*Haliotis rugosa pustulata* (Fig. 3.4–3.6) has much weaker and narrower spiral ribs and lacks the much deeper (if present at all) somewhat lamellose folded ridges. It is usually less elongate, and has a less elevated and tilted spire, which is located more towards the center of the shell (Fig. 2). It usually has 4–5 somewhat narrow and shallow ribs in the periphery between the row of holes and columella. It is most frequently marked with dark brown to reddish-brown, dull green, and cream colors, and prosocline rays, especially in earlier stages of growth.

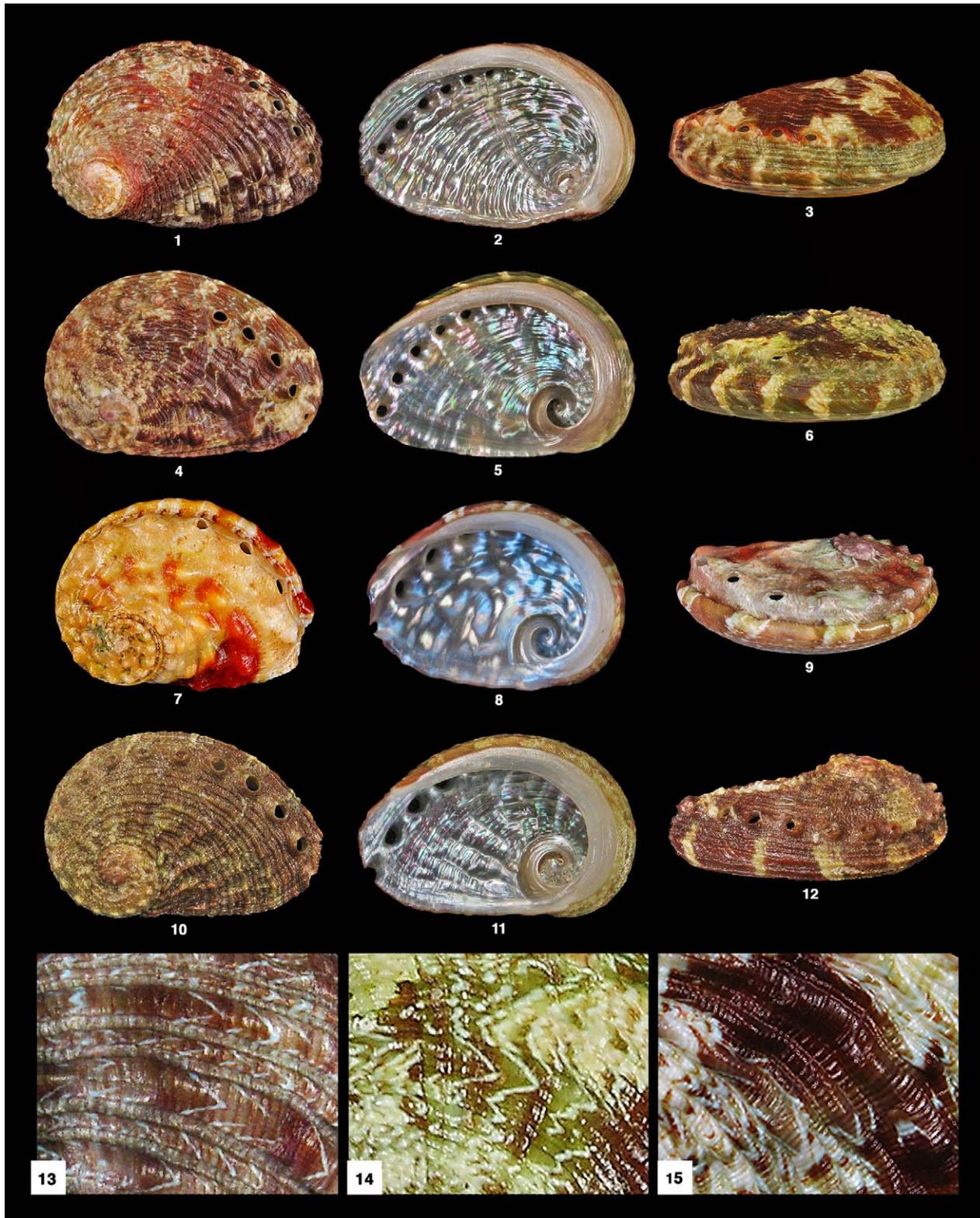


**FIGURE 2.** Spire position of the three *H. rugosa* subspecies as a function of size. Spire position in percent of shell length.

*Haliotis unilateralis* Lamarck, 1822 (Fig. 3.7–3.9) is more circular in shape, flatter, and has the spire positioned much closer to the center of the shell. Additionally, it is often smooth and lacks spiral ribs – frequently having a lumpy surface instead – these bumps often being arranged in several parallel rows. It usually has 3–4 rather large somewhat elevated open holes, and frequently has weak to moderate prosocline rays, especially in earlier stages of growth.

*Haliotis clathrata* Reeve, 1846 (Fig. 3.10–3.12) has narrow, often quite scaly spiral ribs intersected by closely spaced lamellae. The interior has narrow spiral ribs of uniform width frequently crossing numerous closely spaced lamellae, has the spire positioned more towards the center of the shell, and has 4–5 fairly large, round, and elevated open holes. The color is commonly reddish-brown to dark brown (specimens from Indian Ocean), often with white patches or prosocline rays.

*Haliotis rugosa rugosa* vs. *H. rugosa pustulata*. The dorsal surface of *H. rugosa rugosa* can be separated from *H. rugosa pustulata* by its ribbing, which is either deeply etched into the surface and often a bit rounded, or is so shallow and flat that it is barely visible. *Haliotis rugosa pustulata* often has no spiral ribs, and if present they are much narrower and rounded, not flat. Additionally, ribs may bear regularly spaced pustules; pustules may be lined up radially to form prosocline radial folds. These pustules are usually not seen in *H. rugosa rugosa*, except in some juveniles up to approximately 1 cm in length, which have particularly wide ribbing. The highly reflective nacreous ventral surface of *H. rugosa rugosa* has strong spiral ribbing, which is often somewhat undulating due to weakly developed folded ridges. The similarly nacreous interior of *H. rugosa pustulata* is often very lumpy due to interacting narrow rounded spiral ribs, pustules, and folded ridges, and lacks the strong and wide spiral ribbing that is so prevalent in the nominate subspecies. The spire position of *H. rugosa rugosa* generally lies closer to the posterior end of the shell than *H. rugosa pustulata* (Fig. 2).



**FIGURE 3.** 1–3. *Haliotis rugosa rugosa*. 1. 53.3 mm, Pereybere, Mauritius, BOC. 2. 53.3 mm, Pereybere, Mauritius, BOC. 3. 58.1 mm, La Gaulette, Mauritius, BOC. 4–6. *H. rugosa pustulata*. 4. 37.4 mm, Tulear, Madagascar, BOC. 5. 38.6 mm, Fernão Veloso, Nacala, Mozambique, BOC. 6. 38.6 mm, Fernão Veloso, Nacala Bay, Mozambique, BOC. 7–9. *H. unilateralis*. 7. 36.8 mm, Dahab, Sinai, Egypt, BOC. 8. 24.0 mm, South Island, Cargados Carajos Shoals, Mauritius, RKC. 9. 32.0 mm, South Island, Cargados Carajos Shoals, Mauritius, RKC. 10–12. *H. clathrata*. 10. 23.3 mm, Fernão Veloso, Nacala Bay, Mozambique, BOC. 11. 21.2 mm, North Pemba Island, Mozambique, BOC. 12. 22.6 mm, North Pemba Island, Mozambique, BOC. 13–15. Details of shell sculpture and coloration. 13. *H. rugosa rugosa*, 35.4 mm, Mauritius, RKC. 14. *H. rugosa pustulata*, 37.5 mm, Tulear, Madagascar, BOC. 15. *H. rugosa rodriguensis*, 37.0 mm, Anse Cotton, Rodrigues Island, BOC.

Subspecific status of the two taxa is also indicated by the presence of irregular V-shaped markings on the dorsal surface, which are also found on the new subspecies (Fig. 3.13–15). These markings are uncommon in other *Haliotis* spp.; somewhat similar patterns are occasionally observed in *H. ovina ovina* Gmelin, 1791, and a morph of *H. clathrata* found in the Olango Island area of the Philippine Islands.

Published scanning electron microscope images of the radula of *H. rugosa rugosa* by Herbert (1990) and *H. rugosa pustulata* by Geiger & Owen (2012) show no distinct differences.

The epipodia of five lots were compared by D. L. Geiger (pers. comm.). Four lots were indistinguishable, three of which were *H. rugosa pustulata* from the Sinai Peninsula (SBMNH 89241, 210504, 210510) and one lot of *H. rugosa rugosa* from Reunion (SBMNH 210501). Shared characters include a relatively narrow epipodium, dorsal portion one third of total width, ventral portion two thirds, dorsal margin with major tentacles at periphery, additional major tentacles on face of epipodium, many digitated processes along dorsal margin as well as on face, with digitated processes about 10% of length of major tentacles. One lot from Madagascar (SBMNH 210496) had a roughly one third wider epipodium compared to overall shell size, and the digitated processes were about as long as the major tentacles; morphologically the shell was typical *H. rugosa pustulata*.

Additional specimens of each species have been illustrated by Geiger & Owen (2012).

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