Three tiny new costellarids (Gastropoda: Costellariidae) from the eastern Caroline Islands

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ABSTRACT. *Vexillum (Pusia) oteroi* new species and *Thala turneri* new species are described from the islands of Kosrae and Pohnpei, and *Vexillum (Pusia) beitzi* is described from Kosrae. A list of other Costellariidae collected in the Caroline Islands and a short biogeographical note is given.

INTRODUCTION

The Caroline Islands, together with Mariana and Marshall Islands form Micronesia and consist of five fringing or barrier reef-enclosed high islands, 43 atolls or low coral islands, and numerous shallow sunken atolls and approximately eight banks spanning some 3260 km from the Palau Archipelago in the west to Kosrae in the east.

The Carolines are an archipelago in the northwestern Pacific Ocean, formed by 963 islands, mostly of volcanic origin, and small atolls and extend from 132° to 163° East with a prevailing direction W-E. From an administrative point of view, the Carolines are divided into the states of Palau and the Federated States of Micronesia [FSM], that includes the states of Yap, Chuuk, Pohnpei and Kosrae.

Faunistically, the Carolines can be conveniently divided into three regions: the western Carolines from Tobi to Fais (Republic of Palau and Western Yap State of the FSM); the eastern Carolines from Eauripik to Kosrae (Eastern Yap, Chuuk, Pohnpei and Kosrae State of FSM) and the isolated outpost of Kapingamarangi (Ponhpei State).

The Carolines consist entirely of tropical oceanic islands that rise steeply from the deep ocean floor with their upper slopes constantly bathed in warm and clear waters far from the influence of any continental coast. Oceanic conditions are almost quite uniform, with the equatorial current that flows from east to west in the northern Carolines and from west to east in the southern Carolines. Sea surface ranges from 27/28° C in February to 30° C in August while subsurface temperature generally remains above 26° C in the upper 100 m although periodically upwelling along the steep leeward walls of some reef may result in sudden drops of temperature (personal observation in Palau)(Myers 1999).

Kosrae, 162°59'E-05°19'N, an island of volcanic origin with a surface area of 109 square kilometers, lies about 590 km north of the equator, 5,000 km west of Hawaii and is the easternmost point of the archipelago. Kosrae is the third largest of Carolines and is called "The Sleeping Lady" because of the shape of one of its picturesque mountains. It is covered with dense tropical jungle and high volcanic peaks. The island is surrounded by very healthy fringing reefs, especially off the south coast, which slopes steeply into the blue depths. The coast alternates between sandy beaches and mangrove swamps (Segal 1989).

Pohnpei, 158°13'E-06°54'N, like Kosrae, is of volcanic origin, has a surface area of 345 square kilometers and is the capital of the Federated States of Micronesia. Called "The Garden Island" because everything is so lush and green, it lies about 3,500 km east of the Philippines and 660 km northeast of Kosrae. It is the second largest island in the archipelago. It is considered one of the wettest places on earth due to the rain that creates more than 40 rivers. The coral reefs all around the island form a vast lagoon, which is intersected by numerous channels that carry nutrients inside. These nutrients attract marine life and make Pohnpei one of the most varied marine lagoons in the Carolines. Most of the shoreline is covered by mangrove swamps (Ashby 1983).
The classical Darwin subsidence theory of atoll development, the volcanic island that subsides into the sea and leaves the reefs surrounding the island, is the best general explanation of the origin of these lagoons.The most common corals found are Acropora, Pocillopora and Porites (personal observation).

Material and methods

This faunal report is the result of investigating accumulations of dead shells and other animals (tanatocoenosis) collected by scuba in coralline habitat, in small sandy caves or sand patches and at the base of Acropora and Porites from a depth of 8.5 m to 40 m. Shell measurements are displayed by shell length, shell width and aperture length in millimeters.

Abbreviations

Repository

ANSP: Academy of Natural Sciences, Philadelphia, USA

Individual collections

DB: Doug Beitz, Kosrae Island, Caroline Islands
GP: Gianni Pellifroni, Porto Ceresio, Italy
HT: The late Hans Turner, Rovio, Switzerland
JLP: Jean Paul Lefort, Huahine, French Polynesia
RAS: Richard Salisbury, Meridian, Idaho, USA
SG: Sandro Gori, Livorno, Italy
MH: Manfred Herrmann,Rosdorf,Germany
IP: Ivan Perugia,Ravenna,Italy

SYSTEMATICS

Family **COSTELLARIIDAE** MacDonald, 1860
Genus ***Vexillum*** Röding 1798
Subgenus ***Pusia*** Swainson 1840
Type species by monotypy: *Mitra microzonias* Lamarck = *Vexillum* (*Pusia*) *microzonias* (Lamarck 1811). Caribbean, Recent.

Vexillum (Pusia) oteroi n. sp.
Figs 1-3

Type material. Holotype (Figs 1-3): Walung drop-off, Kosrae Island, Caroline Islands, 05°18'17''N-162°53'51''E, in sand in a small coral cave,13 November 2007, 33 m, collected by SG, ex SG collection, 3.2 mm x 1.4 mm x 1.4 mm. ANSP 451639.

Paratypes: Pehleng Pass, south ocean side drop-off, Pohnpei, Caroline Islands, 06°51'29"N-158°06'24"E, on sand in a small coral cave,17 November 2007, 40 m, collected by SG. Paratype 1. SG collection, 3.2 mm x 1.5 mm x 1.4 mm; paratype 2. SG collection, 3.2 mm x 1.5 mm x 1.5 mm; paratype 3. RAS collection, 3.0 mm x 1.3 mm x 1.3 mm; paratype 4. SG collection, 3.0 mm x 1.5 mm x 1.4 mm.
Walung drop-off, Kosrae Island, Caroline Islands, 05°18'17''N-162°53'51''E, in sand in a small coral cave, 13 November 2007, 33 m, collected by SG. Paratype 5. SG collection, 3.1 mm x 1.5 mm x 1.4 mm; paratype 6. SG collection, 3.0 mm x 1.5 mm x 1.4 mm; paratype 7. SG collection, 3.0 mm x 1.5 mm x 1.4 mm; paratype 8. SG collection, 3.0 mm x 1.5 mm x 1.4 mm; paratype 9. SG collection, 3.0 mm x 1.5 mm x 1.4 mm; paratype 10. SG collection, 3.2 mm x 1.5 mm x 1.5 mm.
South Trochus Sanctuary, Kosrae Island, Caroline Islands, 05°20'416''N-162°56'665''E, on sand, December 2008, 25 m, collected by DB. Paratype 11. SG collection, 3.1 mm x 1.5 mm x 1.4 mm.

Type locality. Kosrae Island, Caroline Islands

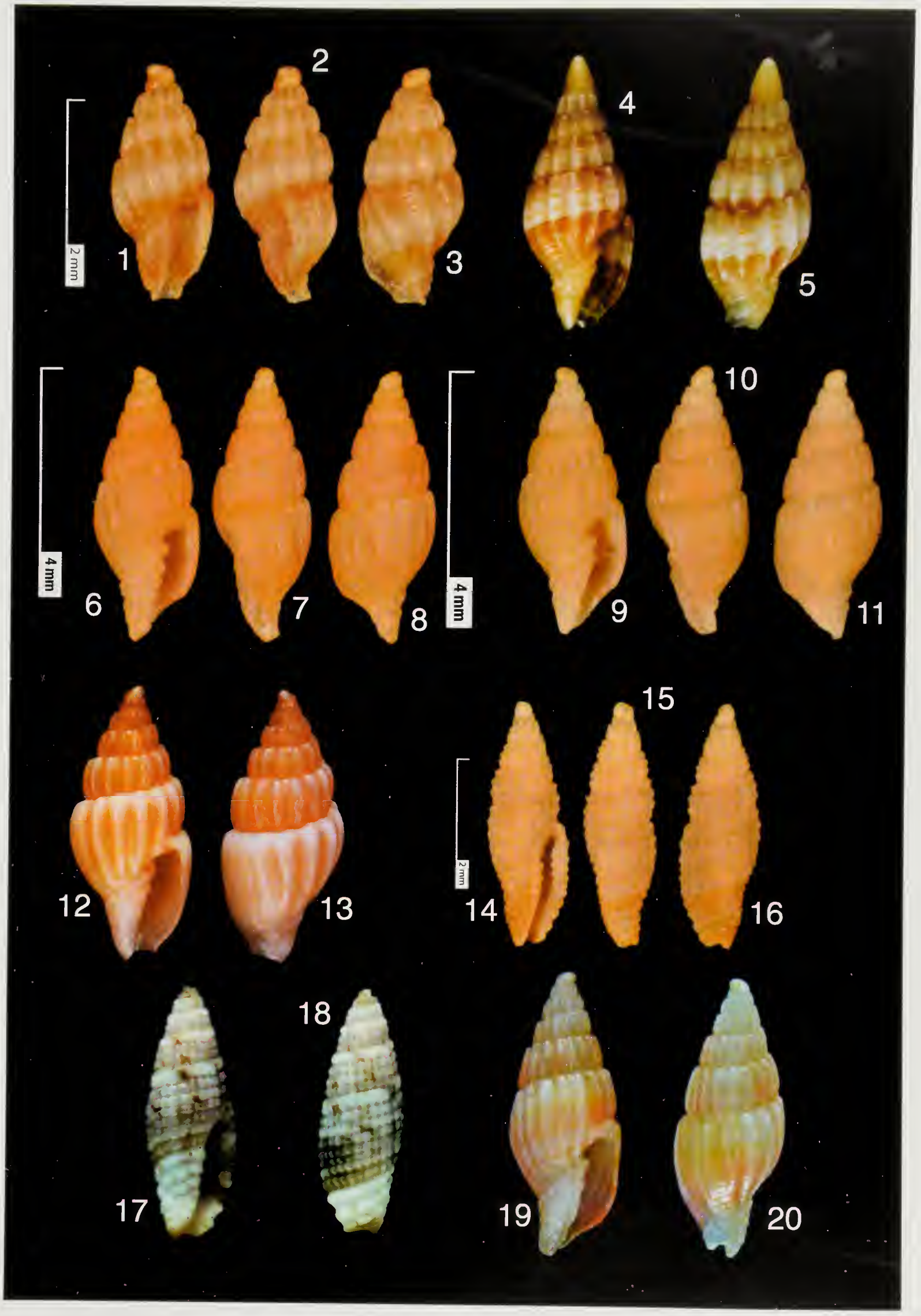
Habitat. In sand in small coral caves from 25 to 40 m

Range. Known only from Kosrae Island and Pohnpei Island, Caroline Islands

Description. Shell tiny, to 3.2 mm in length, 1.5 mm in width, elongate–ovate, opaque, some areas almost transparent. Protoconch, involute, mammillate, paucispiral of 2 glassy whorls. Teleoconch of 3 convex whorls, suture distinct and deeply incised.

Figures 1-20

1-3. *Vexillum* (*Pusia*) *oteroi* n. sp., holotype ANSP 451639, Walung drop off, Kosrae Island, Caroline Islands, in sand in small coral cave, 33 m. Size: 3.2 x 1.4 x 1.4 m.. Photo by Paul Callomon, ANSP; **4-5.** *Vexillum* (*Costellaria*) *diutenerum* (Hervier, 1897), Kepuhi Point, Makaha Beach, Oahu, Hawaii, in sand at base of a cliff line, 200 feet, Scuba. Size: 5.2 x 2.1 x 2.2 mm. RAS collection; **6-8.** *Vexillum* (*Pusia*) *beitzi* n. sp., holotype ANSP 451635, Walung drop-off, Kosrae Island, Caroline Islands, in sand, in a small coral cave, 38 m. Size: 6.0 mm x 2.3 mm x 3.3 mm. Photo by Paul Callomon, ANSP; **9-11.** *Vexillum* (*Pusia*) *beitzi* n. sp., paratype 1, . ANSP 451641,Trochus Sanctuary, Kosrae Island, Caroline Islands, in sand in a small coral cave, 33 m, Size: 5.2 mm x 2.1 mm x 2.9 mm. Photo by Paul Callomon, ANSP; **12-13.** *Vexillum* (*Pusia*) *salisburyi* Cernohorsky, 1976, paratype, Pupukea Beach, Oahu, Hawaii, in beach drift. Size: 6.1 x 2.4 x 2.5 mm. RAS collection; **14-16.** *Thala turneri* n. sp., holotype ANSP 451637, North Coral Gardens, Kosrae Island, Caroline Islands, in coral sand, 25 m. Size: 4.8 x 1.6 x 2.2 mm. Photo by Paul Callomon, ANSP; **17-18.** *Thala gorii* Rosenberg & Salisbury, 2003, holotype, North Male Atoll, Maldive Islands, in coral caves, 30 m. Size: 5.1 x 1.8 x 1.7 mm. ANSP 410282; **19-20.** *Vexillum* (*Pusia*) sp., Walung drop-off, Kosrae Island, Caroline Islands, on sand, 20 m. Size: 6.3 x 2.5 x 3.0 mm. SG collection.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Early whorls with 9-10 axial ribs, interspaces with 5-6 fine spiral grooves which do not intersect the axial ribs; Body-whorl with 9-10 strong axial ribs, interstices sculptured with 6-7 fine spiral grooves which may intersect the axial ribs near the suture, axial ribs and spiral grooves terminate about mid whorl; as the axial ribs terminate, there is a shallow flat area with some macroscopic axial and spiral sculpture; lower body whorl with 4-5 round, raised spiral cords, the first and largest spiral cord is pustulate, Aperture narrow; outer lip simple and smooth, slightly curved; inside the posterior aperture angle a small callus protuberance; 4-5 slender and smooth lirations within the aperture in some distance from the margin of outer lip; columella with 4 plaits decreasing in size anteriorly; very short siphon, siphonal notch very shallow or lacking. Color variable, embryonic whorl on protoconch white, second glassy whorl is brown or tan in color, shell white, early whorls light yellow with white band near suture, rarely with brown spots, body whorl with 2 brown bands separated by a wide white band, lower fasciole brown, first spiral cord is pustulate, with the pustules being faint white. Columellar folds are brown in fresh specimens, interior of aperture reflects the brown and white banding seen on the exterior of the shell.

Discussion. *V. (P.) oteroi* n. sp. is one of the smallest *Pusia* species described. It could be confused with juvenile shells of the larger species *Vexillum (Costellaria) diutenerum* (Hervier, 1897) (Figs 4-5). The protoconch of this new species is of a different form. The adult shell of *Vex. oteroi* being nearly the same size as the protoconch of *V. diutenerum*.

Etymology. Named in honor of the late José Maria Hernandez Otero, from Galdar, Gran Canaria, Spain, a dear friend of the junior author and unforgettable companion of many shelling expeditions.

Vexillum* (*Pusia*) *beitzi n. sp.
Figs 6-11

Type material. Holotype (Figs. 6-11): Walung drop-off, Kosrae Island, Caroline Islands, 05°18'17''N-162°53'51"E, in sand, in a small coral cave, November 13, 2007, 38 meters, collected by DB, ex SG collection, 6.0 mm x 2.3 mm x 3.3 mm. ANSP 451635.

Paratypes: Trochus Sanctuary, Kosrae Island, Caroline Islands, 05°21'195''N-162°53'915"E, in sand in a small coral cave, November, 2009, 33 meters, collected by DB. Paratype 1, 5.2 mm x 2.1 mm x 2.9 mm. ANSP 451641; paratype 2. SG collection, 4.5 mm x 2.0 mm x 2.6 mm; paratype 3. SG collection, 3.9 mm x 1.9 mm x 2.1 mm; paratype 4. SG collection, 3.1 mm x 1.5 mm x 2.0 mm (immature); paratype 5. SG collection, 4.6 mm x 2.5 mm (width) (fragment).
South Trochus Sanctuary, Kosrae Island, Caroline Islands, 05°20'416''N-162°56'665"E, in sand, December 2008, 25 meters, collected by DB. Paratype 6. SG collection, 5.00 mm x 2.1mm x 2.6 mm

Type locality. Kosrae Island, Caroline Islands

Habitat. In sand in small coral caves from 25 to 38 m

Range. Known only from Kosrae Island, Caroline Islands.

Description. Shell tiny, to 6.0 mm in length, elongate-fusiform, protoconch involute-mammilate-paucispiral of 1 ½ to 2 glassy pink whorls. Teleoconch of 4 slightly convex whorls, sutures distinct, Early whorls with 12-13 axial ribs, interspaces with 4-5 fine spiral grooves which do not intersect the axial ribs; sculpture of 4th whorl changes to axial ribs with a small but distinct subsutural bead; on later whorls, the bead becomes larger and more prominent. Body whorl with 13-14 strong axial ribs, interstices sculptured with 16-18 fine spiral grooves which may weakly intersect the axial ribs below the bead near the suture; axial ribs and spiral grooves terminate about mid-whorl, as the axial ribs terminate, there are 2-3 spiral rows of minute beads, lower body whorl with 3-4 round, raised spiral cords, the first and second spiral cords are pustulate, Aperture narrow; outer lip simple and smooth, slightly curved; inside the posterior aperture angle a small callus protuberance; inside the aperture there are numerous slender smooth lirations; columella with 4 plaits decreasing in size anteriorly; siphon short, siphonal notch very shallow or lacking. Color uniform, protoconch pink or faded white, shell red to reddish-pink, beginning with whorl 4, there is a light-purple to white subsutural bead on each axial rib, lower fasciole and aperture red to reddish-pink.

Discussion. *Vexillum (Pusia) beitzi* n. sp is similar to *Vexillum (Pusia) salisburyi* Cernohorsky, 1976 (Figs 12-13). It differs in being smaller with a much more sculptured shell, has a row of subsutural beads as each axial rib terminates at the suture. This new species could also be confused with *Vexillum (Pusia) pilsbryi* (Hedley, 1899). It differs in being much more sculptured, with a less elongate protoconch and the presence of rows of subsutural beads. The recently described species *Vexillum (Pusia) unicolor* Herrmann, 2012 is sculpturally similar but has a more bulbous protoconch, lacks the subsutural beads and is beige in overall color.

Etymology. Named in honor of Doug Beitz, owner and director of Kosrae Nautilus Resort, whose patience and skill were of much help during the research dives of the junior author in Kosrae.

Genus **Thala** H. & A. Adams, 1853

Type species by subsequent designation: *Mitra mirifica* Reeve, 1845.

Thala turneri, n. sp.
Figs 14-16

Type material. Holotype (Fig. 8): North coral gardens, Kosrae Island, Caroline Islands, in coral sand, 25 m, September 2008, collected by DB, ex SG collection, 4.8 x 1.6 x 2.2 mm. ANSP 451637.

Paratypes: Walung drop-off, Kosrae Island, Caroline Islands, 05°18'17''N-162°53'51''E, in sand in a small coral cave at 33 m, November 13, 2007, collected by SG. Paratype 1. SG collection, 5.3 mm x 1.7 mm x 2.7 mm; paratype 2. SG collection, 4.7 mm x 1.6 mm x 2.6 mm; paratype 3. SG collection, 4.3 mm x 1.4 mm x 2.2 mm.
Walung drop off, Kosrae Island, Caroline Islands, in coral sand, 25 m, September 2008, collected by DB.
Paratype 4. RAS collection, 5.1mm x 1.7 mm x 2.4 mm.
Walung drop off, Kosrae Island, Caroline Islands, 05°18'469''N-162°53'915''E, in sand patches, 25 m, September 2008, collected by DB. Paratype 5. GP collection, 3.3 mm x 1.5 mm x 2.1 mm; paratype 6. JPL collection, 3.9 mm x 1.6 mm x 2.4 mm; paratype 7. SG collection, 4.2 mm x 1.5 mm x 2.4 mm; paratype 8. SG collection, 4.0 mm x 1.5 mm x 2.3 mm; paratype 9. SG collection, 4.5 mm x 1.5 mm x 2.4 mm.
South Trochus Sanctuary, Kosrae Island, Caroline Islands, 05°20'416''N-162°56'665"E, on sand, December 2008, 25 meters, collected by DB. Paratype 10. MH collection, 5.2 mm x 1.7 mm x 2.6 mm; paratype 11. IP collection, 4.8 mm x 1.5 mm x 2.6 mm; paratype 12. SG collection, 5.0 mm x 1.6 mm x 2.6 mm; paratype 13. SG collection, 5.3 mm x 1.7 mm x 2.7 mm.
Pehleng Pass, south ocean side drop-off, Pohnpei, Caroline Islands, 06°51'29"N-158°06'24" on sand in a small coral cave,17 November 2007,40 m, collected by SG. Paratype 14. SG collection, 4.3 mm x 1.6 mm x 2.3 mm; paratype 15. SG collection, 5.1 mm x 1.7 mm x 2.6 mm; paratype 16. SG collection, 4.8 mm x 1.5 mm x 2.6 mm; paratype 17. SG collection, 5.2 mm x 1.7 mm x 2.6 mm; paratype 18. SG collection, 5.4 mm x 1.8 mm x 2.9 mm; paratype 19. SG collection, 4.3 mm x 1.6 mm x 2.3 mm; paratype 20. HT collection. 5.3 mm x 1.7 mm x 2.5 mm.

Type locality. Walung drop off, Kosrae Island, Caroline Islands, 05°18'469''N-162°53'915''E

Habitat. In coral sand from 25 to 40 m

Range. Known from Kosrae and Pohnpei Islands, Caroline Islands

Description. Shell tiny to approximately 5.4 mm, elongate-fusiform, protoconch involute paucispiral of 1.5 embryonic white whorls. Teleoconch of 4-5 whorls, early spire whorls with 3-4 beaded spiral cords, slightly convex in outline, beads on the spiral cords align axially to form 16 to 17 beaded axial ribs, beads on the spiral cords are close-set but not fused, suture shallow and not well defined, body whorl with 12-13 spiral cords, beads on spiral cords are set apart and connected by round threads, with 17-18 beaded axial ribs which become smaller, less beaded and more rounded on the lower body whorl, aperture nearly equal to half of the length of the shell, very narrow as is typical of many Thala species, with a slight anal depression reminiscent of a turrid's notch, outer lip undulate with 8 to 9 denticles along the inner lip becoming obsolete at the siphonal canal, interior of the aperture without lirations, siphonal canal open and short, siphonal notch shallow, columella with 4 folds, base color tan to brown with faint yellow bands of beads on the whorls, beads on siphonal fasciole slightly darker brown.

Etymology. Named in honor of the late Hans Turner, friend of both authors and well known malacologist whose great knowledge of Mitroidea is known all over the world.

Discussion. Is similar to *Thala gorii* Rosenberg and Salisbury, 2003 (Figs 17-18). *T. turneri* differs in being smaller, protoconch of one less whorl, beading much finer and more widely spaced. *T. gorii* has fewer rows of spiral beads, despite being larger. *Thala gorii* is light in color with brown spots, interrupted brown bands on the body whorl with a few pearl-white beads. *Thala turneri* is yellowish, light brown to dark brown in color with very faint bands of light yellow beads.

Additional species found in the same habitat

Vexillum (Costellaria) aureolineatum Turner 1988: Only from Kosrae.
Vexillum (Costellaria) cosmani (Kay 1979): Only from Kosrae.
Vexillum (Pusia) diutenerum (Hervier 1897): From both islands.
Vexillum (Pusia) emiliae (Schmeltz 1874): Only from Kosrae.
Vexillum (Pusia) exquisitum (Garrett, 1873) = *Vexillum (Pusia) suave* (Souverbie 1875): Only from Kosrae.
Vexillum (Pusia) fortiplicatum (Pease 1868): Only from Kosrae.
Vexillum (Pusia) gagei Salisbury in Severns, 2011: Only from Pohnpei.
Vexillum (Pusia) goubini (Hervier 1897): Only from Kosrae.
Vexillum (Pusia) kuiperi Turner 2006: Only from Pohnpei.

Vexillum (Pusia) loyaltiensis (Hervier 1897): Only from Kosrae.
Vexillum (Costellaria) micra (Pilsbry 1921): Only from Kosrae.
Thala mirifica Reeve 1845: Only from Kosrae.
Vexillum (Costellaria) modestum (Reeve 1845): Only from Kosrae.
Vexillum (Pusia) piceum (Pease 1860): From both islands.
Vexillum (Pusia) pluriuotatum (Hervier 1897): Only from Kosrae.
Vexillum (Pusia) roseotinctum (Hervier 1897): Only from Kosrae.
Vexillum (Pusia) rubrum (Broderip 1836): Only from Kosrae.
Vexillum (Pusia) tusum (Reeve 1845): From both islands.
Vexillum (*Pusia*) sp. (Figs 19-20): Only from Kosrae.

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