Shallow-Water Holothuroids (Echinodermata) of Yap, Federated States of Micronesia[1]

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Abstract: In December 2002, July 2007, and December 2009, we surveyed the sea cucumber fauna of the western Caroline Island of Yap (Federated States of Micronesia). We collected 37 species of holothuroids, including 32 species of aspidochirotes and five species of apodans. We found all 13 of the previously reported species and 24 new records for the Islands: 19 aspidochirotes and five apodans. At least two of the new records appear to be previously undescribed species. Types of microhabitats and reef zonation were closely correlated with the species distributions of Yapese holothuroids.

Coral reefs are among the most biologically diverse marine ecosystems, yet they are threatened by climate change, overexploitation, eutrophication, and ocean acidification (Hughes 1994, Reaka-Kudla 1997, Bruno et al. 2009). The currently known 93,000 coral reef–associated species are estimated to represent only a small portion of the actual diversity (Reaka-Kudla 1997). In addition, many species have not been seen since their original descriptions, often over a century ago, causing ongoing taxonomic confusion. This taxonomic confusion is not limited to rare species; statuses of even some common species remain in flux. We clearly have much to learn about the alpha diversity of coral reefs (Reaka-Kudla 1997, Bouchet et al. 2002, Michonneau et al. 2013).

Holothuroids are one of the more poorly studied, yet abundant animals on shallow reefs of Micronesia. Only a handful of reports describe the holothuroid fauna of that region, and there are no published accounts of the holothuroids from the islands of Yap, Federated States of Micronesia. The earliest reports of Yapese echinoderms (Hayashi 1938, Clark 1954) do not include holothuroids. The more recent reports (Amesbury et al. 1976, 1977, Grosenbaugh 1978, 1981) record a total of 15 species, but many of the identifications

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remain uncertain because of a lack of voucher material. In December 2002, July 2007, and December 2009, we surveyed the reefs and adjacent habitats around the main islands of Yap and collected 37 species of holothuroids, 24 of which are new records for the island, including two potentially undescribed species.

MATERIALS AND METHODS

Study Sites

Yap State comprises the main island group and 14 outer atolls. The main island group (9° 32′ N, 138° 07′ E, 100 km^2) consists of four closely situated volcanic islands surrounded by fringing and barrier reefs, with a variety of shallow-water marine habitats (Figure 1). The inner reef flats are silty and support beds of the sea grasses *Thalassia hemprichii*, *Enhalus acoroides*, and *Zostera* spp. The middle reef flats are inhabited by large colonies of the corals *Acropora* spp., *Pocillopora* spp., and *Porites* spp. Outer reef flats and crests are covered by a large amount of coral rubble and loose rocks but far fewer and smaller living corals. The reef flats are often interrupted by deep "blue holes," areas to 20 m depth with high coral cover. Few sites differ from the described common reef flat topography. The southernmost site, Rull, is a wide sand flat with several massive *Porites* spp. colonies and rubble. Balabat, farther north, is also sandy, but the bottom is covered with the sea grasses *T. hemprichii* and *E. acoroides*, and the outer reef flat has abundant colonies of *Porites* spp. and *Acropora* spp. The two sites located between the islands, Fanif and O'Keefe's Island, both have soft substrate with copious beds of *T. hemprichii* and a few massive *Porites* spp. colonies. The fore-reef near Colonia is a gradual slope with high coral cover.

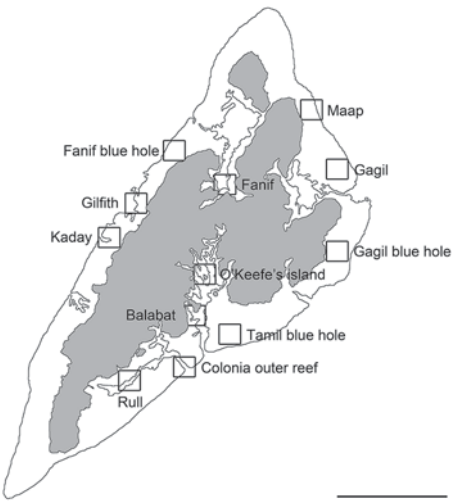

FIGURE 1. Map of Yap proper and sampling sites. Scale indicates 5 km.

Sampling Methods

Specimens were collected over 5 days in December 2002, 9 days in July 2007, and 8 days in December 2009 from a total of 12 different sites (Figure 1). Specimens were captured by hand while snorkeling or using SCUBA at depths up to 20 m. Specimens were often collected at night because many holothuroids are exclusively nocturnal. Depth, time of day, global positioning system (GPS) coordinates, and microhabitat were noted for each specimen. Most collected specimens were also measured for length and photographed in situ. In the laboratory, all specimens were first relaxed in a solution of $MgCl_2$, $MgSO_4$, or chloretone. Relaxed specimens were then photographed, and a small portion of tissue was sampled and stored in 95% ethanol for molecular analyses. In addition, further subsamples of the dorsal and ventral body walls were excised for ossicle preparations. These were initially dissolved in household bleach and then rinsed in water and with an increasing concentration gradient of ethanol (60%, 80%, and 100%). The ossicles were spread onto a microscope slide for morphological examination. Whole specimens were initially fixed in 70% ethanol and are now deposited in the Florida Museum of Natural History.

RESULTS

Annotated Species List

A total of 37 holothuroid species was recorded including 32 species of aspidochirotes and

five species of apodans. Ossicle micrographs are shown in Figures 2, 3, 4, and 5. Abbreviations used throughout are as follows: FSM, Federated States of Micronesia; NSF, U.S. National Science Foundation; UF, Florida Museum of Natural History; YAPCAP, Yap Community Action Program. Field numbers of the form YAP-SK-000 indicate material that is curated at UF but for which museum accession numbers are currently pending.

Class Holothuroidea
Order Aspidochirotida
Family Holothuriidae
Genus *Actinopyga* Bronn, 1860

Actinopyga mauritiana (Quoy & Gaimard, 1833)
Figure 2*A*, *B*

Holothuria guamensis Quoy & Gaimard, 1833:137.
Holothuria mauritiana Quoy & Gaimard, 1833:138.
Mülleria mauritiana: Selenka, 1867:315; Semper, 1868:76.
Microthele guamensis: Cherbonnier, 1952:40, Pl. II, fig. 1.
Actinopyga mauritiana: Panning, 1929:128, fig. 11; Panning, 1944:55, fig. 24; Cherbonnier, 1952:41, figs. 16*a–o*; Domantay, 1954:349; Rowe, 1969:131; A. M. Clark and Rowe, 1971:176–177, pl. 27, fig. 3; Rowe and Doty, 1977:228, 247, figs. 3*f*, 6*d*, 9; Cherbonnier, 1988:16–17, fig. 2; Kerr, 1994:166.

material examined: UF5881, Colonia, Woneeday Channel, 5 m depth during the day at outer reef near crest, 2 August 2007. UF11392, Balabat, <1 m depth during the day on reef crest, 14 December 2009.

remarks: This species is a new record for Yap. The species was common at the eastern sites and much less common on western reefs. Specimens were found in higher-energy zones, from the outer reef flat to the shallow reef front.

Actinopyga ?palauensis (Panning, 1944)
Plate I*A*

Actinopyga obesa palauensis Panning, 1944:57–58, fig. 26.
Actinopyga palauensis: A. M. Clark and Rowe, 1971:176–177; Kerr et al., 1992:206–208, fig. 3*a*, non *A. obesa* (Panning).

material examined: No voucher specimen, Gagil-Tamil, <1 m depth in sea grass during the day, inner reef flat, 21 September 2009. Photo record (Plate I*A*), Maap, <1 m depth in sea grass during the day, inner reef flat, 16 September 2009.

remarks: This species is a new record for Yap. We found several deep brown to nearly black *Actinopyga* sp(p)., which we were not permitted to collect. Six of the specimens appear closest to *A. miliaris* (Quoy & Gaimard, 1833). These were smaller, averaging 15 cm in length, rounder and with an arched dorsum and occurring in sea grass on the inner reef flat, often quite near the mangrove fringe of the islands. Two specimens that resembled *A. palauensis* were found farther seaward on the reef flat in deeper water on a silty sand bottom; they were larger, up to 28 cm in length, and more oblong.

Actinopyga sp.
Figure 2*C*, *D;* Plate I*B*, *C*

Actinopyga echinites: Grosenbaugh, 1981:50–53.
Unidentified species (Holothuriidae?): Allen and Steene, 1996: unnumb. fig., 245.

material examined: UF5848, 5868, 5870, 5884, 5887, Fanif, <1 m depth during the day in sea grass, inner reef flat, 30 July 2007. UF11290, 11310, Gagil, 25 September 2009. YAP-SK-047, 048, 049, 050, O'Keefe's Island, Fanif, <1 m depth during the day in sea grass on inner reef flat, 12 December 2009.

remarks: This form of *Actinopyga* sp. seems to be restricted to the tropical western Pacific Ocean, only reported from New Guinea and Palau (G. Paulay, pers. comm.). Its distribution in Yap was quite patchy, with a high abundance at only two sites, Tomil and Fanif, where the inner reef flat was silty and the bottom was covered with sea grass. Animals were striped, or uniformly tan to dark

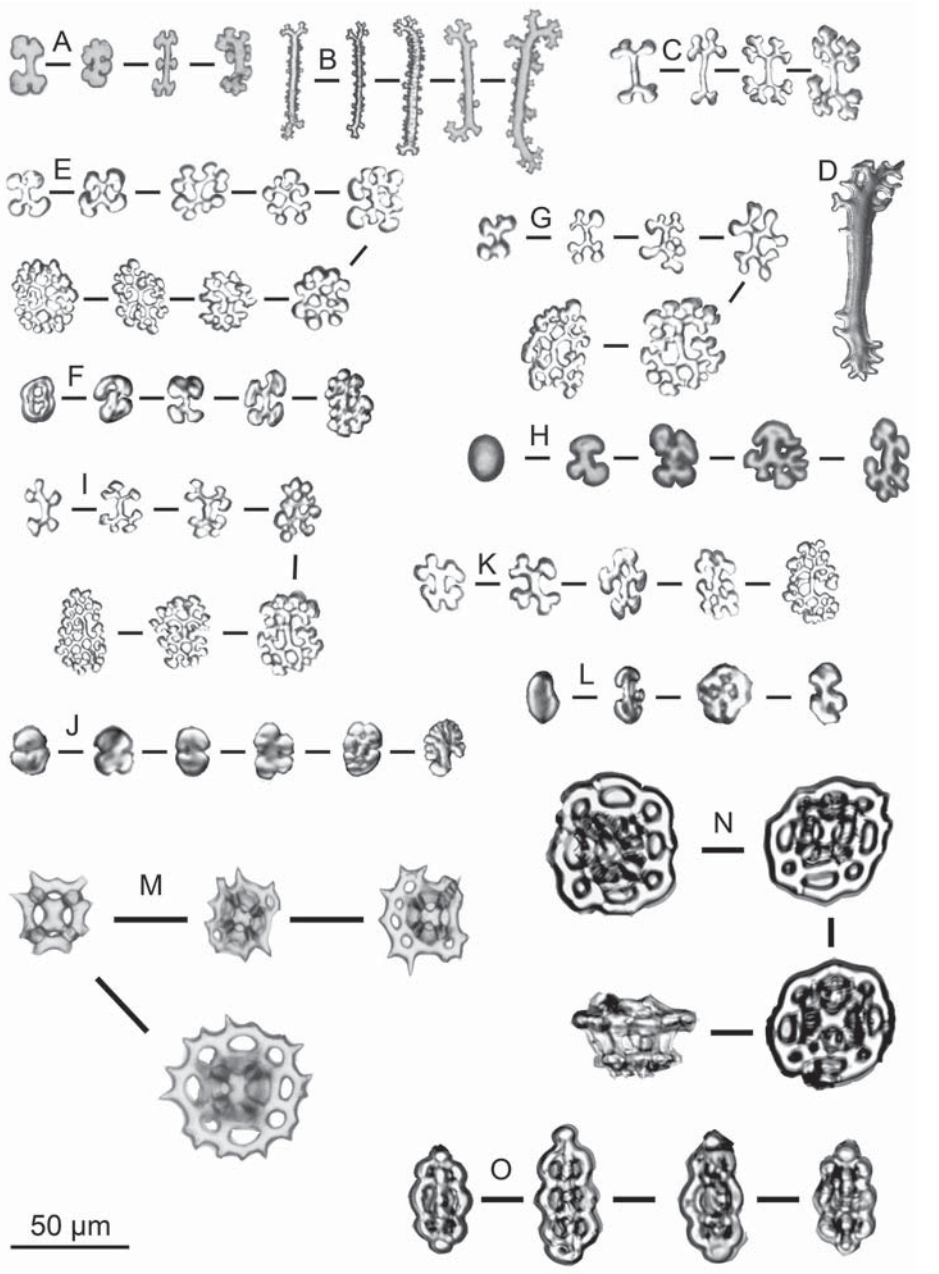

FIGURE 2. Ossicle micrographs of collected specimens. *A*, *Actinopyga mauritiana* (UF11392): rosettes from dorsal body wall; *B*, *A. mauritiana* (UF11392): rods from dorsal body wall; *C*, *Actinopyga* sp. (YAP-SK-049): rosettes from dorsal body wall; *D*, *Actinopyga* sp. (YAP-SK-049): rod from ventral body wall; *E*, *Bohadschia argus* (UF11417): rosettes from dorsal body wall; *F*, *B. argus* (UF11417): grain-rosettes from ventral body wall; *G*, *B. marmorata* (UF11401): rosettes from dorsal body wall; *H*, *B. marmorata* (UF11401): grain-rosettes from ventral body wall; *I*, *B. koellikeri* (UF11420): rosettes from dorsal body wall; *J*, *B. koellikeri* (UF11420): grain-rosettes from ventral body wall; *K*, *B. vitiensis* (UF11394): rosettes from dorsal body wall; *L*, *B. vitiensis* (UF11394): grain-rosettes from ventral body wall; *M*, *Holothuria* (*Acanthotrapezia*) *coluber* (UF11419): tables from dorsal body wall; *N*, *H.* (*Cystipus*) *inhabilis* (UF5861): tables from dorsal body wall; *O*, *H.* (*C.*) *inhabilis* (UF5861): irregular buttons from dorsal body wall.

brown (Plate I*B*, *C*). Amesbury et al. (1976, 1977) and Grosenbaugh (1981) reported "*A. echinites*" as very common and occurring in small groups from several shallow sea grass beds in Yap. Given their abundance, restricted microhabitat, and density, the animals they mention are almost certainly the species considered here, *Actinopyga* sp. Recently, Michonneau et al. (2013) reported two black *Actinopyga* species from Guam based on genetic data and identified one of them as "*A. miliaris?*." Given the morphological similarity, *Actinopyga* sp. recorded here could be the same taxon that Michonneau et al. (2013) reported from Guam.

Genus *Bohadschia* Jaeger, 1833

Bohadschia argus Jaeger, 1833
Figure 2*E*, *F*

Bohadschia argus Jaeger, 1833:19, pl. *A*, figs. 1–1*b;* Panning, 1944:36, figs. 7–8; Rowe, 1969:130; A. M. Clark and Rowe, 1971:176–177, pl. 27, fig. 6; Rowe and Doty, 1977:233, 229, figs. 2*h*, 6*f;* Grosenbaugh, 1981:51; Cherbonnier, 1988:34–35, fig. 10; Kerr, 1994:166–167; Kim et al., 2013:86, fig. 3*A*, *B*.
Holothuria (*Bohadschia*) *argus:* Panning, 1929:121, fig. 50*a–c*.

MATERIAL EXAMINED: UF5873, Maap, <1 m depth during the day on sand on inner reef flat, 29 July 2007. UF11417, Kaday, <1 m depth during the day on sand on inner reef flat, 11 December 2009.

REMARKS: This species was found at all but two sites located between the volcanic islands, Fanif and O'Keefe's Island, where the bottom consisted of soft mud and sea grass. The most common color pattern observed in Yap was a gray background with dark ocellations, and others were dark brown or, rarely, pure white with only faint gray ocellations.

Bohadschia marmorata Jaeger, 1833
Figure 2*G*, *H*

Bohadschia marmorata Jaeger, 1833:18, pl. 3, fig. 9; Brandt, 1835:56; A. M. Clark and Rowe, 1971:176–177, 209, pl. 27, fig. 8; Rowe and Doty, 1977:229–230, figs. 3*a*, 6*g*, *h;* Cherbonnier, 1988:36, fig. 11*a–l;* Kim et al., 2013:88–89, fig. 3*K*.
Sporadipus ualanensis Brandt, 1835:46.
Holothuria ualensis Selenka, 1867:341.
Holothuria marmorata: Semper, 1868:79, pl. 80, fig. 10, pl. 35, fig. 3, pl. 36, fig. 8, pl. 37, figs. 1–4; Lampert, 1885:36, 86–87; Théel, 1886:202–203; H. L. Clark, 1938:523.
Holothuria (*Bohadschia*) *marmorata:* Panning, 1929:120, fig. 1.

MATERIAL EXAMINED: UF5856, 5859, 11401, Kaday, <1 m depth at night in sea grass near mangroves, and on sand on middle reef flat, 5–6 August 2007, 11 December 2009.

REMARKS: This species is a new record for Yap. This species was most frequently observed at night in sea grass and sand flats of the inner and middle reef flats. *Bohadschia marmorata* has frequently been referred to other species within the genus in the literature. However, a recent study by Kim et al. (2013) revealed that *B. marmorata* sensu Jaeger is genetically distinct from other species frequently misidentified as *B. marmorata*. In addition, *B. marmorata* can be easily distinguished by its dorsolateral markings and relatively small size (Kim et al. 2013).

Bohadschia koellikeri (Semper, 1868)
Figure 2*I*, *J;* Plate I*D*, *F*

Holothuria koellikeri Semper, 1868:86, pl. 30, fig. 25, pl. 35, fig. 7; Lampert, 1885:36, 86–87; Théel, 1886:204; Rowe and Gates, 1995:351.
Bohadschia koellikeri: Rowe, 1969:130; A. M. Clark and Rowe, 1971:194, 209; Kim et al., 2013:86–88, figs. 3*E*, *F*.

MATERIAL EXAMINED: UF11420, Kaday, <1 m depth at night on sand on inner reef flat, 10 December 2009.

REMARKS: This species was nocturnal and only found in Kaday. *Bohadschia koellikeri* has been frequently misidentified as *Bohadschia vitiensis*, a morphologically similar but genetically distinct species (Kim 2010, Kim et al. 2013). Fine lineation and light brown

blotches on the dorsal body wall clearly separate *B. koellikeri* from *B. vitiensis*, which possesses a smooth dorsum, often with solid transverse bands (see Plate I*D*, *E*, *F*, *G*). The overall color pattern of *B. koellikeri* observed in Yap was creamy beige with light brown blotches on the dorsum (Plate I*D*).

Bohadschia vitiensis (Semper, 1868)
Figure 2*K, L;* Plate I*E*, *G*

Holothuria vitiensis Semper, 1868:80, pl. 30, fig. 12; Lampert, 1885:89; Théel, 1886:203–204; Pearson, 1913:57–60, pl. VII, fig. 6; Domantay, 1933:76, pl. 1, fig. 2; Domantay, 1953:119.
Holothuria similis Semper, 1868:85–86, pl. 25, 30.
Holohuria clemens Ludwig, 1875:107, fig. 49.
Holothuria bivittata Mitsukuri, 1912:68–71, pl. 3, fig. 75.
Bohadschia marmorata vitiensis: Panning, 1944:40, fig. 11*a–y*.
Bohadschia vitiensis: Pearson, 1914:170; Rowe, 1969:130; A. M. Clark and Rowe, 1971:194; Rowe and Doty, 1977:229–230; Cherbonnier, 1988:42–44, fig. 14*a–i*; Kerr, 1994:167–168; Rowe and Richmond, 2004:3300; Kim et al., 2013:89, fig. 3*G–J*.

MATERIAL EXAMINED: UF5852, 5853, 5914, Colonia, 1 m depth in sea grass at edge of mangroves, 5 August 2007. UF5891, 5915, Tamil, 2 m depth on sand on middle reef flat, 31 July 2007. UF11394, Kaday, <1 m depth at night on sand on inner reef flat, 10 December 2009.

REMARKS: This species was found in Kaday and Tamil at night. The specimens were buried in sand during the day and emerged during the late afternoon. They were mostly found on inner reef flats in sea grass or sand flats in large numbers. *Bohadschia vitiensis* showed a wide variation in shading. The background coloration varied from creamy white to brown, and the two dorsal transverse bands could be absent or quite distinct (Plate I*E*). *Bohadschia vitiensis* has frequently been misidentified as *B. marmorata;* however, a study by Clouse et al. (2005) revealed that specimens referable to *B. bivittata* Mitsukuri, 1912, were genetically distinct and deserved species status. A recent study by Kim et al. (2013) added that color forms matching the description of *B. bivittata* fell within the *B. vitiensis* clade, in which the members show variable color and banding patterns.

Genus *Holothuria* Linnaeus, 1767

Holothuria (*Acanthotrapezia*) *coluber* Semper, 1868
Figure 2*M*

Holothuria coluber Semper, 1868:90, pl. 28, pl. 30, fig. 28*a*, *b*, pl. 34, fig. 5; Panning, 1944:62, fig. 30*a–i*.
Holothuria (*Holothuria*) *coluber:* Panning, 1934*a*:35, fig. 30*a*, *b*.
Holothuria (*Acanthotrapezia*) *coluber:* Rowe, 1969:138–139; A. M. Clark and Rowe 1971:176–177, fig. 85*c*, pl. 27, fig. 13; Levin, 1979:20; Cherbonnier, 1980:636, fig. 11*A–H;* Tan Tiu, 1981:74, pl. 16, figs. 1–3; Cannon and Silver, 1986:21, fig. 6*c*; Féral and Cherbonnier, 1986:80–81, fig. 40*f*; Kerr, 1994:168, fig. 4; Rowe and Gates, 1995:290.

MATERIAL EXAMINED: UF5888, 11419, O'Keefe's Island, <1 m depth during the day under a massive *Porites* sp. on inner reef flat, 30 July 2007, 13 December 2009.

REMARKS: This species was found only near O'Keefe's Island. During the day, the observed specimens were less active, often hiding under rocks or coral heads. The specimens extended their anterior end to feed at night. This may be the "*Holothuria leucospilota*" of Amesbury et al. (1977) and Grosenbaugh (1981), who noted a species in identical habitat also extending its anterior end to feed, especially in the evening.

Holothuria (*Cystipus*) *inhabilis* Selenka, 1867
Figure 2*N, O;* Plate I*H*

Holothuria inhabilis Selenka, 1867:333, pl. 19, figs. 73–74.
Jaegerothuria inhabilis: Deichmann, 1958:323–324, pl. 8, figs. 14–19.

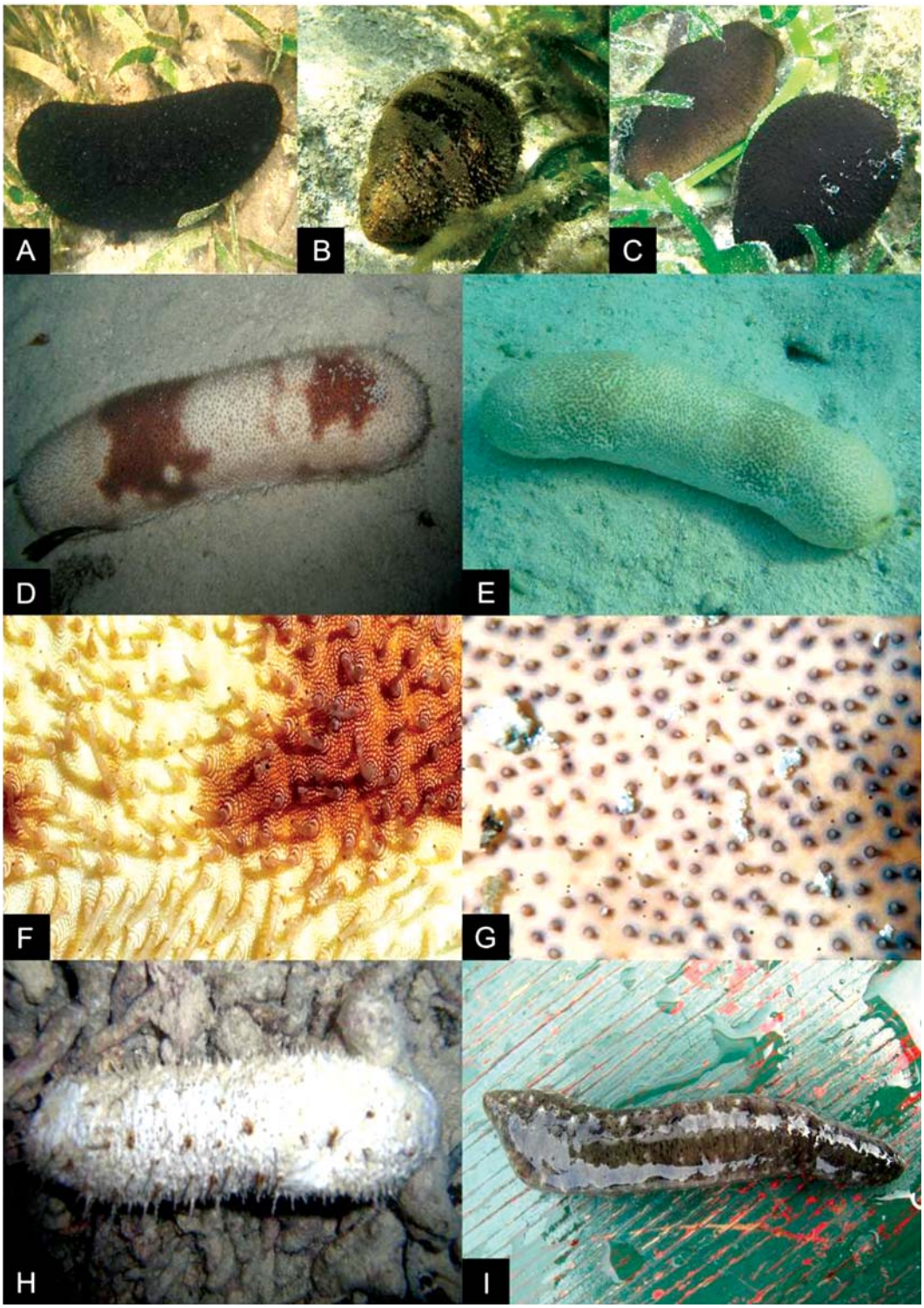

PLATE 1. Conspicuous color patterns of selected new records including potential new species. *A*, *Actinopyga ?palauensis; B*, *Actinopyga* sp.; *C*, *Actinopyga* sp.; *D*, *Bohadschia koellikeri; E*, *B. vitiensis; F*, close-up of *B. koellikeri* body wall; *G*, close-up of *B. vitiensis* body wall; *H*, *Holothuria (Cystipus) inhabilis; I*, *H.* ?*(Lessonothuria) cavans*.

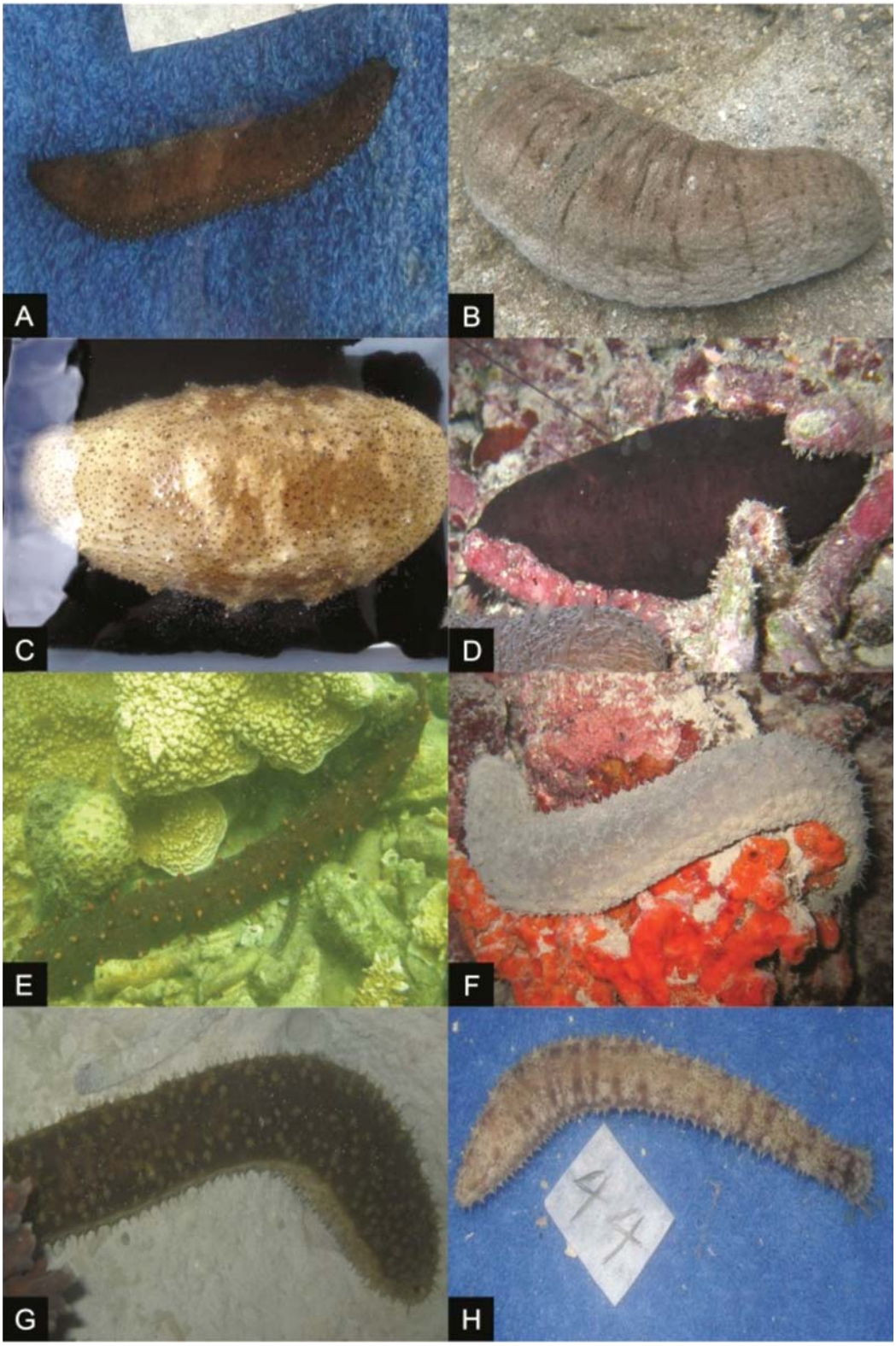

PLATE II. Conspicuous color patterns of selected new records including potential new species. *A*, *Holothuria (Mertensiothuria) leucospilota; B*, *H. (Metriatyla) ?lessoni; C*, *H. (Microthele) fuscogilva; D*, *H. (Platyperona) excellens; E*, *H. (Semperothuria) roseomaculata; F*, *H. (Theelothuria)* sp.; *G*, *H. (Theelothuria)* sp.; *H*, *H. (Thymiosycia) impatiens.*

PLATE III. Conspicuous color patterns of selected new records including potential new species. *A*, *Holothuria (Thymiosycia) impatiens; B*, *Holothuria* (?*Thymiosycia*) sp.; *C*, *Thelenota rubralineata; D*, *Chiridota* sp.; *E*, *Synapta maculata; F*, *Opheodesoma grisea; G*, *O. grisea; H*, *O. grisea*.

Holothuria (*Cystipus*) *inhabilis:* Rowe, 1969:156–157; A. M. Clark and Rowe, 1971:176–177, 194, 209, pl. 28; Michonneau et al., 2013.

MATERIAL EXAMINED: UF5861, Fanif blue hole, 10 m depth at night in blue hole, 3 August 2007.

REMARKS: This species is a new record for Yap. The sole specimen encountered had a white dorsum and ventrum with two rows of dorsolateral brown papillae and was exposed on coralline rubble at night (Plate I*H*).

Holothuria (*Halodeima*) *atra* Jaeger, 1833
Figure 3*A*, *B*

Holothuria atra Jaeger, 1833:22.
Holothuria (*Holothuria*) *atra:* Panning, 1934*a*:30, fig. 22*a–f*.
Holothuria (*Halodeima*) *atra:* Rowe, 1969:137, fig. 7; A. M. Clark and Rowe, 1971:176–177, pl. 27, fig. 11; A. M. Clark and Taylor, 1971:91; Liao, 1975:210, fig. 10; Rowe and Doty, 1977:230–231, 247, figs. 3*d*, 7*a;* Grosenbaugh, 1981:51–53; Tan Tiu, 1981:73, pl. 15, figs. 1–3, pl. 29, figs. 1–2*e;* Cherbonnier, 1988:73, fig. 28*a–j;* Kerr, 1994:168.

MATERIAL EXAMINED: UF5875, 5897, Colonia, <1 m depth in sea grass near mangroves, 5 August 2007. UF11402, Kaday, <1 m depth during the day in sea grass bed on inner reef flat, 11 December 2009.

REMARKS: This species was ubiquitous at all reef flat sites, occurring in practically all types of microhabitats from inner to outer reef flats. *Holothuria atra* was the most common species observed during the surveys.

Holothuria (*Halodeima*) *edulis* Lesson, 1830
Figure 3*C*, *D*

Holothuria edulis Lesson, 1830:125, pl. 46, fig. 2.
Holothuria (*Holothuria*) *edulis:* Panning, 1934*a*:43–44, fig. 36*a–d*.
Holothuria (*Halodeima*) *edulis*: Rowe, 1969:138; A. M. Clark and Rowe, 1971:176–177, pl. 27, fig. 14; Rowe and Doty, 1977:231, figs. 3*e*, 7*b;* Levin, 1979:20; Cherbonnier, 1980:632, fig. 9*A–L;* Liao, 1980:115; Grosenbaugh, 1981:51–53; Liao, 1984:222; Cannon and Silver, 1986:22, fig. 6*f*, text fig.; Cherbonnier, 1988:75, fig. 29*A–I;* Kerr, 1994:168; Rowe and Gates, 1995:291.

MATERIAL EXAMINED: UF5889, 5912, Colonia, <1 m depth in sea grass with patch reefs nearby, 30 July 2007. UF11404, Kaday, <1 m depth at night on sand near a massive *Porites* sp. on middle reef flat, 11 December 2009.

REMARKS: This species was commonly found in Kaday. This species displays geographic variation in its color (O'Loughlin et al. 2007). In Yap, the specimens possessed a black to dark gray dorsum and a pink ventrum.

Holothuria ?(*Lessonothuria*) *cavans*
Plate I*I*

MATERIAL EXAMINED: Photo record (Plate I*I*), site unrecorded, <1 m depth in sea grass collected by E. Tardy, 22 September 2009.

REMARKS: This species is a new record for Yap. The uncollected photographed specimen showed a dark green background with dark brown blotches and white spots (Plate I*I*). This species is frequently misidentified as a darker form of the closely related *H.* (*L.*) *lineata;* however, *H.* (*L.*) *lineata* is dark brown to gray in background and does not display the greenish hue. This species has also been observed in Okinawa and Palau (G. Paulay and F. Michonneau, pers. comm.).

Holothuria (*Mertensiothuria*) *hilla* Lesson, 1830
Figure 3*E*, *F*

Holothuria hilla Lesson, 1830:226, pl. 79.
Holothuria (*Thymiosycia*) *hilla:* A. M. Clark and Rowe, 1971:178–179; Rowe and Doty, 1977:232–233, 247, figs. 4*b*, 8*b;* Grosenbaugh, 1981:51–53; Cherbonnier, 1988:85–87, fig. 34*3a–l;* Kerr, 1994:169–170; Rowe and Gates, 1995:372.
Holothuria (*Mertensiothuria*) *hilla:* Samyn and Massin, 2003:2500; Rowe and Richmond, 2004:3301.

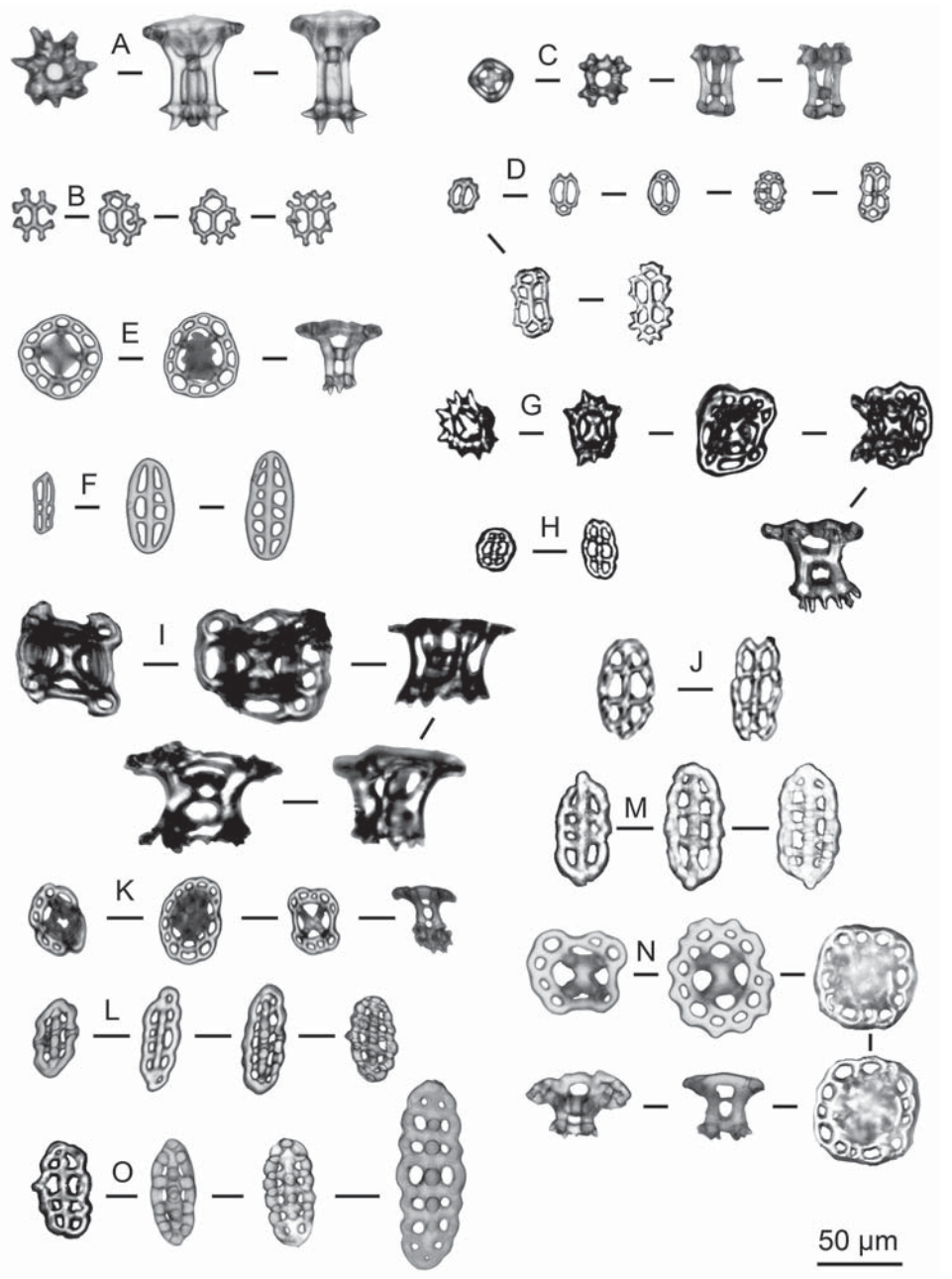

FIGURE 3. Ossicle micrographs of collected specimens. *A*, *Holothuria* (*Halodeima*) *atra* (UF11402): tables from dorsal body wall; *B*, *H.* (*H.*) *atra* (UF11402): rosettes from body wall; *C*, *H.* (*H.*) *edulis* (UF11404): tables from body wall; *D*, *H.* (*H.*) *edulis* (UF11404): rosettes from body wall; *E*, *H.* (*Mertensiothuria*) *hilla* (UF11426): tables from dorsal body wall; *F*, *H.* (*Mertensiothuria*) *hilla* (UF11426): buttons from body wall; *G*, *H.* (*Metriatyla*) ?*lessoni* (UF5880): spiny and irregular tables from body wall; *H*, *H.* (*Metriatyla*) ?*lessoni* (UF5880): buttons from body wall; *I*, *H.* (*Metriatyla*) *scabra* (UF5851): tables from body wall; *J*, *H.* (*Metriatyla*) *scabra* (UF5851): buttons from body wall; *K*, *H.* (*Microthele*) *fuscogilva* (UF11414): tables from body wall; *L*, *H.* (*Microthele*) *fuscogilva* (UF11414): irregular buttons from body wall; *M*, *H.* (*Microthele*) *fuscopunctata* (UF11390): irregular buttons from body wall; *N*, *H.* (*Microthele*) *whitmaei* (UF11389): tables from body wall; *O*, *H.* (*Microthele*) *whitmaei* (UF11389): irregular buttons from body wall.

MATERIAL EXAMINED: UF5871, Colonia, <1 m depth in sea grass with patch reefs nearby, 30 July 2007. UF11426, Rull, 2 m depth during the day on sand under a rock on inner reef flat, 12 December 2009.

REMARKS: Specimens recorded in this survey were found only during the day hiding under rocks on inner and middle reef flats. *Holothuria hilla* is a nocturnal species, commonly found exposed on reef flats at night.

Holothuria (*Mertensiothuria*) *leucospilota* Lesson, 1830
Plate II*A*

Holothuria (*Gymnochirota*) *leucospilota* Brandt, 1835:51.
Holothuria leucospilota: Ludwig, 1881:595; H. L. Clark, 1921:179.
Holothuria (*Mertensiothuria*) *leucospilota:* Rowe, 1969:149; A. M. Clark and Rowe, 1971:176–177; Amesbury et al., 1977:13–16; Rowe and Doty, 1977:234, figs. 4*g*, 8*c;* Grosenbaugh, 1981:51–53; Cherbonnier, 1988:112–114, fig. 45*a–p;* Kerr, 1994:168; Rowe and Gates, 1995:358; Rowe and Richmond, 2004:3301.

MATERIAL EXAMINED: Photo record (Plate II*A*), Gagil, <1 m depth under exposed coral rubble on the outer reef flat at low tide, 28 November 2002.

REMARKS: Although often abundant on other islands of Micronesia (e.g., Kerr et al. 1993, Kerr 1994), this species was seen in Yap only as a few small individuals under exposed coral rubble on the outer reef flat at low tide at Gagil.

Holothuria (*Metriatyla*) *?lessoni* Massin, Uthicke, Purcell, Rowe, & Samyn, 2009
Figure 3*G*, *H;* Plate II*B*

Holothuria timama Lesson, 1830:118, pl. 43; Lampert, 1885:94; Théel, 1886:240; A. M. Clark, 1963:383; Opinion 762, 1966:15; Melville and Smith, 1987:301.
Holothuria (*Metriatyla*) *timana:* Rowe and Gates, 1995:295; Marsh and Morrison, 2004:339.
Holothuria (*Metriatyla*) *scabra:* VandenSpiegel et al., 1992:168, figs. 2, 3*A–E*, 4*A–G*, non *H.* (*M.*) *scabra* Jaeger, 1833.
Holothuria scabra var. *versicolor* Conand, 1986:19; Conand, 1991:170; Conand and Byrne, 1993:3ss; Forbes et al., 1999:38; Hamel et al., 2001:146, fig. 4*B;* Uthicke et al., 2005:261ss, fig. 1*B–D*.
Holothuria aculeate: Cherbonnier, 1951:298, non *H. aculeata* Semper, 1868; Catala, 1979:245, fig. 91, non *H. aculeata* Semper, 1868; Rowe and Gates, 1995:295 (cited as a synonym of *H. timana*).
Holothuria (*Metriatyla*) *aculeate:* Rowe, 1969:160; A. M. Clark and Rowe, 1971:176.
Holothuria (*Metriatyla*) *lessoni* Massin, Uthicke, Purcell, Rowe, & Samyn, 2009:41–47, figs. 1, 3, 4, 5, table 1, 2.

MATERIAL EXAMINED: UF5880, Gagil, <1 m depth during the day in mangrove habitat near corals and sea grass, 6 August 2007.

REMARKS: This species is a new record for Yap. One specimen was found in shallow water at the boundary between mangrove forest and sea grass bed with small, scattered *Porites* sp. The color pattern was gray with several small, black blotches (Plate II*B*). This species has been frequently misidentified as *H. scabra* (see following species); however, the recent description of *H. lessoni* (Massin et al. 2009) clarified the diagnostic morphological characters, such as size, color, and ossicles, to eliminate frequent confusion between the two species. When describing, the authors were not able to use the name *H. timama* because it has been suppressed by ICZN Opinion 762 (1966). We are unable to confidently identify the collected specimen because it shows mixed characters of *H. lessoni* and *H. scabra*. The collected specimen shows the diagnostic morphology of *H. scabra* including transverse grooves, lack of blotches, and general color pattern; however, the specimen also shows the characteristic, spiny table ossicles of *H. lessoni* (Figure 3*G*, Plate II*B*).

Holothuria (*Metriatyla*) *scabra* Jaeger, 1833
Figure 3*I*, *J*

Holothuria scabra Jaeger, 1833:23.
Holothuria (*Holothuria*) *scabra:* Panning, 1934*b*:80, fig. 66*a–f*.
Holothuria (*Metriatyla*) *scabra:* Rowe, 1969:160–161, fig. 20*a–c;* A. M. Clark and Rowe, 1971:178–179, fig. 871, pl. 15, fig. 15; Cherbonnier, 1980:647, fig. 16*A–L;* Liao, 1980:116; Tan Tiu, 1981:83, pl. 25, figs. 1–3; Féral and Cherbonnier, 1986:86–87; Cherbonnier, 1988:135–137, fig. 55*a–o;* Kerr, 1994:168, fig. 4*c;* Rowe and Gates, 1995:294.

MATERIAL EXAMINED: UF5851, O'Keefe's Island, <1 m depth during the day in sea grass at the edge of mangroves, 5 August 2007.

REMARKS: This species is a new record for Yap. Several specimens were observed during this survey at a depth of about 1 m during the daytime. They all occurred on the inner reef flat, adjacent to mangroves, and in sea grass and on silty sand.

Holothuria (*Microthele*) *fuscogilva* Cherbonnier, 1980
Figure 3*K, L;* Plate II*C*

Holothuria (*Microthele*) *fuscogilva* Cherbonnier, 1980:628, fig. 7, pl. C; Féral and Cherbonnier, 1986:88–89; Kerr et al., 1992:208, fig. 4*d*, pl. 1*b*.

MATERIAL EXAMINED: UF11163, 11414, Kaday, <1 m depth, one specimen collected during the day and one collected at night; both were in sea grass beds on the middle reef flat, 11 December 2009.

REMARKS: This species is a new record for Yap. *Holothuria fuscogilva* is usually found at depths below 10 m; however, most of the specimens in Yap were observed at depths of less than 2 m in sea grass. *Holothuria fuscogilva* specimens in the western Pacific frequently display color patterns that are mixtures of black and white, hence the common name, white teatfish. Specimens seen in Yap showed a rather uniform beige background with dark brown mottling (Plate II*C*). This color form has also been observed in other localities, such as Moorea (G. Paulay, pers. comm.), Guam (Kerr et al. 1992), Australia, and the Southwest Pacific (Uthicke et al. 2004).

Holothuria (*Microthele*) *fuscopunctata* Jaeger, 1833
Figure 3*M*

Holothuria fuscopunctata Jaeger, 1833:23; Semper, 1868:86, 277, pl. 30, fig. 29; Théel, 1886:235; Lampert, 1885:79; Ludwig, 1882:136.
Holothuria axiologa H. L. Clark, 1921:175, pl. 38; Grosenbaugh, 1981:51.
Holothuria (*Microthele*) *fuscopunctata:* Cherbonnier, 1980:623, fig. 5; Rowe and Gates, 1995:361.

MATERIAL EXAMINED: UF11390, Balabat, 3 m depth during the day on sand on middle reef flat, 14 December 2009.

REMARKS: This large and distinctive species was observed occasionally on sandy middle reef flats at depths between 1 and 3 m.

Holothuria (*Microthele*) *whitmaei* Bell, 1887
Figure 3*N, O*

Holothuria (*Bohadschia*) *whitmaei* Bell, 1887:532–533, pl. 45, fig. 4.
Holothuria mammifera Saville-Kent, 1890:4, pl. 1, fig. 3.
Holothuria (*Microthele*) *nobilis* Selenka, 1867:313, pl. 17, fig. 16; Rowe, 1969:162, 164, fig. 21; A. M. Clark and Rowe, 1971:178–179, fig. 87*m*, pl. 27, fig. 10, pl. 28, fig. 20; Rowe and Doty, 1977:231, figs. 3*f*, 7*d;* Grosenbaugh, 1981:51–53; Cherbonnier, 1988:142–144, fig. 58*a–l*.
Holothuria (*Microthele*) *whitmaei:* Rowe and Gates, 1995:362.

MATERIAL EXAMINED: UF5866, Tamil, 1 m depth on rubble on middle reef flat, 31 July 2007. UF11389, Gilfith, 3 m depth during the day on rubble on middle reef flat, 13 December 2009.

REMARKS: This species was commonly found on the eastern outer reef flats and the western reef edges. This species tends to inhabit high-energy habitats with strong wave action. Adults of this species resemble *H. fus-*

cogilva in shape and size but have a uniformly black dorsum.

Holothuria (*Platyperona*) *excellens* (Ludwig, 1875)
Plate II*D*

Mülleria excellens Ludwig, 1875:98, fig. 32*a–c;* Lampert, 1885:97.
Holothuria (*Microthele*) *excellens:* Panning, 1929:132, fig. 16.
Holothuria (*Platyperona*) *excellens:* Théel, 1886:199; Cherbonnier, 1988:94–95, fig. 37*a–n;* Kerr et al., 1992:209–213, pl. 1*e–f*, figs. 3*g–h*, 4*a–c*, 5*a–e*.

MATERIAL EXAMINED: UF5879, Tamil blue hole, 15 m depth at night, 30 July 2007.
REMARKS: This species is a new record for Yap. One specimen was seen at night in an area with high coral cover. This species is uniformly brown with a purplish tinge, has a smooth body wall, and ejects numerous fine Cuvierian tubules when handled (Plate II*D*).

Holothuria (*Semperothuria*) *roseomaculata* Kerr, 2013
Plate II*E;* Figure 4*A*, *B*

Holothuria flavomaculata: Yamanouti, 1939:604–634; Yamanouti, 1956:361; Amesbury et al., 1977:14–16; Grosenbaugh, 1981:51–53; Colin and Arneson, 1995:260, fig. 1232.
Holothuria (*Semperothuria*) *flavomaculata:* Féral and Cherbonnier, 1986:90–91, fig. 40*D*, unnumb. fig. (p. 90); Conand, 1989:27 et non seq., figs. 18–19; Purcell et al., 2013:50–51, unnumb. figs.
Holothuria (*Semperothuria*) sp.: Kerr et al., 2007:15, 31, fig. 3*b*.
Holothuria (*Semperothuria*) non *flavomaculata:* Friedman et al., 2008:8, 12; Tardy and Pakoa, 2009:10, 49–50.
Holothuria (*Semperothuria*) *roseomaculata* Kerr, 2013:384–394.

MATERIAL EXAMINED: UF5849, 5850, 5872, 5890, 5911, O'Keefe's Island, <1 m depth in sea grass near patchy massive *Porites* sp., 30 July 2007. UF11397, 11403, Fanif, <1 m depth during the day under a massive *Porites* sp. on inner reef flat, 12 December 2009.
REMARKS: This species was locally abundant near O'Keefe's Island and Fanif in sea grass. This species has been misidentified as *H. flavomaculata*, of which the color and form are consistently different from those of this species. *Holothuria flavomaculata* possesses yellow papillae, whereas *H.* (*S.*) *roseomaculata* has larger, rose-colored papillae (Plate II*E*). We found this species on silty sand, under massive *Porites* spp. colonies near O'Keefe's Island, at Fanif, and in the Colonia harbor. Based on the similarity in abundance and habitat, it appears to be the "*Holothuria moebii*" mentioned in Amesbury et al. (1976).

Holothuria (*Stauropora*) *pervicax* Selenka, 1867
Figure 4*C*, *D*

Holothuria pervicax Selenka, 1867:327, pl. 18, fig. 54; A. M. Clark, 1952:204.
Holothuria depressa Ludwig, 1875:108, fig. 44.
Holothuria (*Mertensiothuria*) *pervicax:* Rowe, 1969:149; A. M. Clark and Rowe, 1971:176–177; Rowe and Doty, 1977:234, figs. 4*g*, 8*c;* A. M. Clark, 1984:99; Cherbonnier, 1988:107–108, fig. 43*a–k;* Kerr, 1994:168.
Holothuria (*Stauropora*) *pervicax:* Rowe and Gates, 1995:368; Rowe and Richmond, 2004:3303.

MATERIAL EXAMINED: UF11425, Kaday, <1 m depth at night on sand under a coral head on middle reef flat, 11 December 2009.
REMARKS: This species is a new record for Yap. *Holothuria pervicax* was an uncommon nocturnal species on Yap and seen only in Kaday. Specimens occurred under rocks and coral heads during the day and were seen exposed on sand and rubble at night.

Holothuria (*Theelothuria*) sp.
Plate II*F*, *G;* Figure 4*E*, *F*

MATERIAL EXAMINED: UF5892, Tamil blue hole, 15 m depth at night in blue hole among dead coral rubble, 31 July 2007. UF5893, Gagil blue hole, 12 m depth at night in blue hole, 6 August 2007. UF5896, Fanif

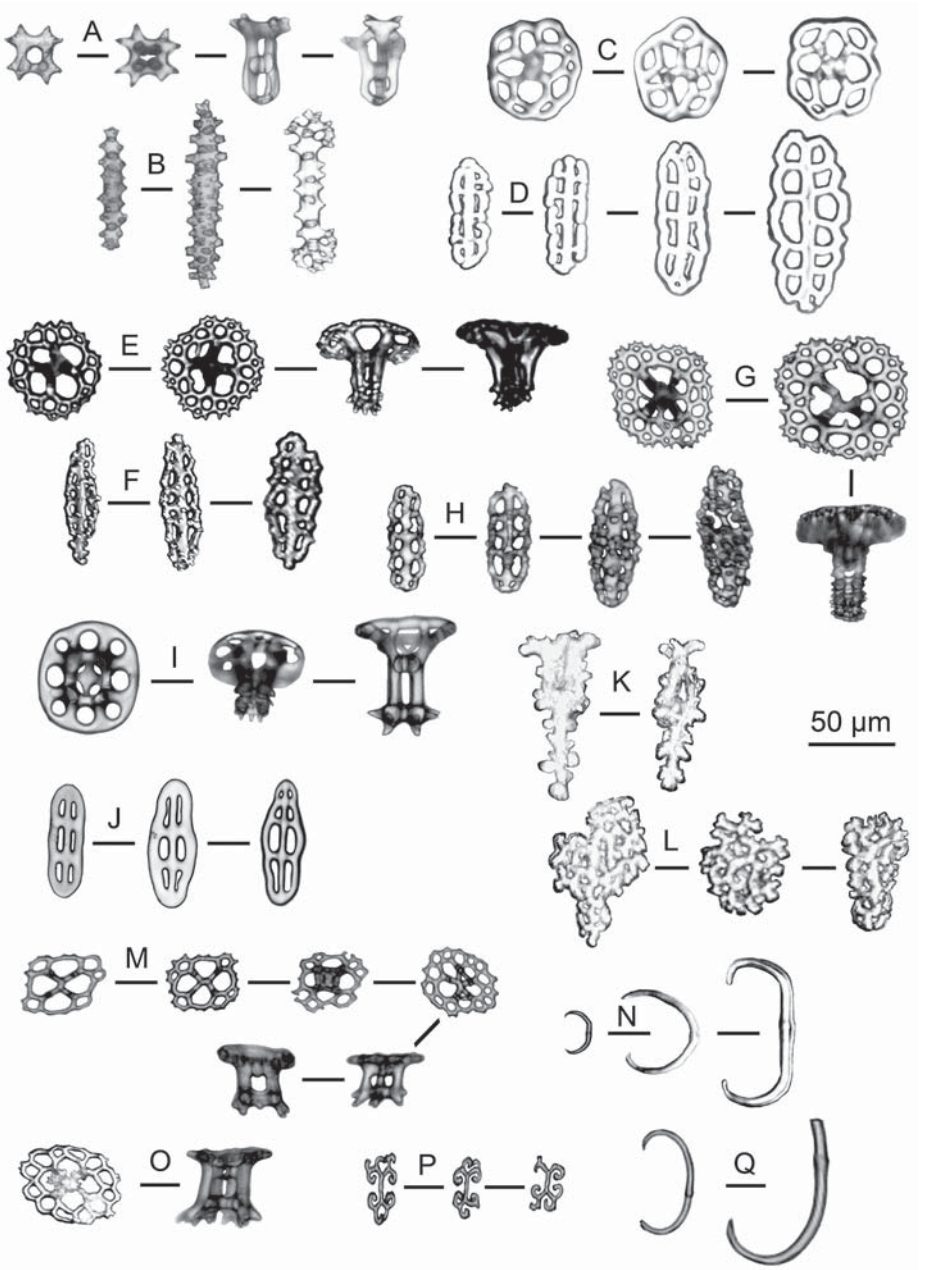

FIGURE 4. Ossicle micrographs of collected specimens. *A*, *Holothuria* (*Semperothuria*) *roseomaculata* (UF11403): tables from body wall; *B*, *H.* (*Semperothuria*) *roseomaculata* (UF11403): spiny rods from body wall; *C*, *H.* (*Stauropora*) *pervicax* (UF11425): tables from body wall; *D*, *H.* (*Stauropora*) *pervicax* (UF11425): buttons from body wall; *E*, *H.* (*Theelothuria*) sp. (UF5896): tables from body wall; *F*, *H.* (*Theelothuria*) sp. (UF5896): buttons from body wall; *G*, *H.* (*Theelothuria*) *turriscelsa* (UF11396): tables from body wall; *H*, *H.* (*Theelothuria*) *turriscelsa* (UF11396): buttons from body wall; *I*, *H.* (*Thymiosycia*) *impatiens* (UF11427): smooth tables from body wall; *J*, *H.* (*Thymiosycia*) *impatiens* (UF11427): buttons from body wall; *K*, *Pearsonothuria graeffei* (UF11393): pin-shaped irregular tables; *L*, *P. graeffei* (UF11393): complex rosettes from body wall; *M*, *Stichopus chloronotus* (UF11407): tables from body wall; *N*, *S. chloronotus* (UF11407): C-shaped ossicles from body wall; *O*, *S.* cf. *monotuberculatus* (UF11415): tables from dorsal body wall; *P*, *S.* cf. *monotuberculatus* (UF11415): rosettes from ventral body wall; *Q*, *S.* cf. *monotuberculatus* (UF11415): C-shaped ossicles from body wall.

blue hole, 15 m depth at night in blue hole, 3 August 2007.

REMARKS: This species is a new record for Yap. It is a relatively common holothuroid at night in the blue holes on the western reefs (Plate II*F*, *G*). Most specimens possessed a gray dorsum with many raised tubercles and a slightly lighter ventrum (Plate II*F*). A less-common color morph also seen had an olive green dorsum (Plate II*G*) but was otherwise identical in form, habitat, and behavior. Dorsal and ventral body wall ossicles consist of tables and buttons. Tables have flattened, lacelike disks with spiny margins and a large central hole in which the four tiers form a distinctive cross. Buttons are variably developed and often knobby. When disturbed, specimens readily ejected many long translucent Cuvierian tubules, most resembling those of *H.* (*Theelothuria*) *turriscelsa* and *H.* (*Stauropora*) *pervicax*.

Holothuria (*Theelothuria*) *turriscelsa* Cherbonnier, 1980
Figure 4*G*, *H*

Holothuria (*Theelothuria*) *turriscelsa* Cherbonnier, 1980:644; pl. 1*e*, fig. 15*a–l;* Féral and Cherbonnier, 1986:92–93; Kerr et al., 1992:209.

MATERIAL EXAMINED: UF5878, Tamil, 15 m depth at outer reef slope, 2 August 2007. UF11396, Kaday, <1 m depth at night under a coral head on middle reef flat, 11 December 2009.

REMARKS: This species is a new record for Yap. It was found under coral heads and rubble on middle reef flats in Kaday. At night, *H. turriscelsa* was often seen roaming on the reef flat. Specimens readily ejected thick, transparent Cuvierian tubules when disturbed.

Holothuria (*Thymiosycia*) *impatiens* (Forsskål, 1775)
Plate II*H;* Figure 4*I*, *J;* Plate III*A*

Fistularia impatiens Forsskål, 1775:121, pl. 39*b*.
Holothuria impatiens: Haacke, 1880:46; H. L. Clark, 1921:178, pl. 19, figs. 3, 5; Panning, 1935:86–88, fig. 72; Panning, 1941:7, figs. 5–6.
Holothuria impatiens concolor H. L. Clark, 1921:179.
Holothuria impatiens lutea H. L. Clark, 1921:179.
Holothuria impatiens pulchra H. L. Clark, 1921:179, pl. 19.
Holothuria impatiens bicolor H. L. Clark, 1938:522.
Holothuria (*Thymiosycia*) *impatiens:* Rowe, 1969:146–147, fig. 13*a–c;* A. M. Clark and Rowe, 1971:178–179, fig. 85*a–a′*, pl. 26, fig. 2, pl. 28, fig. 8; Rowe and Doty, 1977:233, figs. 4*c*, 7*e;* Cherbonnier, 1988:88–89, fig. 35*a–k;* Kerr, 1994:170; Rowe and Gates, 1995:372–373; Rowe and Richmond, 2004:3303–3304.

MATERIAL EXAMINED: UF5877, Kaday, blue hole, 4 August 2007. UF11427, Kaday, <1 m depth during the day on sand under a rock on middle reef flat, 11 December 2009.

REMARKS: This species is a new record for Yap. This cryptic species was found infrequently under rocks at the western sites Kaday and Gilfith. As for many other holothuroids, the taxonomic status of *H. impatiens* has been debated for years because of its color and morphological variation. It is likely a complex of several species (F. Michonneau, pers. comm.). We found at least three distinct color variants with morphology and ossicle variation currently assignable to *H. impatiens* (Plates II*H*, III*A*). One of the forms was nearly all white and inhabited the blue holes of the reef flat. It was nocturnally active and retracted into its shelter at even the slightest exposure to light, making it difficult to photograph in situ. Hence, we do not have a photo record of this variant.

Holothuria (?*Thymiosycia*) sp.
Plate III*B*

MATERIAL EXAMINED: Photo record (Plate III*B*), site unrecorded, <1 m depth in sea grass, collected by E. Tardy, 16 September 2009.

REMARKS: This species is a new record for Yap. The uncollected photographed

specimen's mustard color, sparsely placed papillae, and habitat resemble those of a form of *H.* (*Thymiosycia*) *impatiens* that has also been observed in Palau (A. M. Kerr, unpubl. obs.).

Genus *Pearsonothuria* Levin, Kalinin, & Stonik, 1984

Pearsonothuria graeffei (Semper, 1868)
Figure 4*K*, *L*

Holothuria graeffei Semper, 1868:78, pl. 30, fig. 9*a–b*.
Bohadschia drachi Cherbonnier, 1955:134, pl. 24*a–n*.
Bohadschia graeffei: Panning, 1929:124, fig. 5; Panning, 1944:44, fig. 13; A. M. Clark and Rowe, 1971:176–177, pl. 27, fig. 7; Rowe and Doty, 1977:229, figs. 2*g*, 6*e*.
Pearsonothuria graeffei: Levin et al. 1984:33–38, figs. 1, 2; Cherbonnier, 1988:49–50, fig. 17*a–f*; Kerr, 1994:170; Rowe and Gates, 1995:376.

MATERIAL EXAMINED: UF5895, Kaday, 15 m depth at outer reef slope, 2 August 2007. UF11393, Colonia outer reef, 10 m depth on coral on reef slope, 15 December 2009.

REMARKS: This species is a new record for Yap. In this survey, this species was found only at the Colonia outer reef slope around 10 m in depth, but it is a conspicuous and abundant species in other locations in the western Pacific (Massin 1999).

Family STICHOPODIDAE
Genus *Stichopus* Brandt, 1835

Stichopus chloronotus Brandt, 1835
Figure 4*M*, *N*

Stichopus (*Perideris*) *chloronotos* Brandt, 1835:50.
Stichopus hirotai Mitsukuri, 1912:161, fig. 28.
Stichopus chloronotus: Lampert, 1885:107; Théel, 1886:159, pl. 7, fig. 6; Sluiter, 1887:196; Ludwig, 1888:812; H. L. Clark, 1946:417; A. M. Clark and Rowe, 1971:178–179, pl. 27, fig. 18; Grosenbaugh, 1981:51–53; Cherbonnier, 1988:146–147, fig. 60*a–o;* Kerr, 1994:170; Rowe and Gates, 1995:377–378; Rowe and Richmond, 2004:3304.

MATERIAL EXAMINED: UF5867, Colonia, 1 m depth on sand and rubble, 31 July 2007. UF11407, Kaday, <1 m depth during the day on rubble on middle reef flat, 11 December 2009.

REMARKS: This species was common in almost all types of habitats from sea grass to inner and middle reef flats with high coral cover. It was also encountered on reef slopes at deeper depths, where individuals were often larger.

Stichopus cf. *monotuberculatus* (Quoy & Gaimard, 1833)
Figure 4*O*, *P*, *Q*

Holothuria monotuberculata Quoy & Gaimard, 1833:131, pl. 432, fig. *I*.
Stichopus monotuberculatus: Cherbonnier, 1952:23, pl. 3, fig. 4, text fig. 8*a–t;* Rowe and Gates, 1995:325; Samyn, 2000:15.
Stichopus cf. *monotuberculatus:* Samyn and Vanden Berghe, 2000:31, pl. 2*F–H*.

MATERIAL EXAMINED: UF11415, Kaday, <1 m depth during the day under rubble on middle reef flat, 11 December 2009.

REMARKS: This species is a new record for Yap. This nocturnal species displayed an array of color patterns, also seen in other locations in the Indo-Pacific (Byrne et al. 2010, Michonneau et al. 2013). The background varies from beige to camel with green and dark brown mottling. This species was commonly observed under rocks and coral heads during the day and exposed on sand or coralline rock at night. Recent genetic work by Byrne et al. (2010) revealed that *S. horrens* and *S. monotuberculatus* share similar sets of variable color patterns. The two species are distinguished by ossicle morphology: *S. horrens* possesses tacklike body wall ossicles, whereas *S. monotuberculatus* does not (Byrne et al. 2010). The collected specimen was devoid of tacklike ossicles (Figure 4*O*, *P*, *Q*); however, ubiquity of the shared color forms in Yap suggests that *S. horrens* may also inhabit Yapese reefs.

Stichopus vastus Sluiter, 1887

Stichopus vastus Sluiter, 1887:198–199, pl. 2, figs. 46–48; Sluiter, 1895:79; Rowe and Gates, 1995:381–382; Forbes et al., 1999:14; Massin, 1999:71–77, figs. 57*a–l*, 58*a–m*, 59*a–g*, 60*a–d*, 61, 112*d–e*.
Stichopus sp.: Allen and Steene, 1996:246; Gosliner et al., 1996:282, fig. 1039.

MATERIAL EXAMINED: UF5367, 5869, 5913, O'Keefe's Island, <1 m depth during the day in sea grass bed near patchy reef, 30 July 2007.

REMARKS: This species is a new record for Yap. It was uncommon and seen during the day and night on silty sand near mangroves and in the inner harbor.

Genus *Thelenota* H. L. Clark, 1921

Thelenota ananas (Jaeger, 1833)

Trepang ananas Jaeger, 1833:24, pl. 3 fig. 1; H. L. Clark, 1922:48.
Holothuria ananas: Quoy & Gaimard, 1833:110, pl. 6, figs. 1–3.
Holothuria (*Thelenota*) *ananas:* Brandt, 1835:53.
Stichopus ananas: Semper, 1868:75; Ludwig, 1882:133; Sluiter, 1901:30, pl. 2, fig. 1; Mitsukuri, 1912:150–155, pl. 1, figs. 6–8, text fig. 25.
Thelenota ananas: A. M. Clark and Rowe, 1971:178–179, fig. 87*a;* Rowe and Doty, 1977:227, figs. 2*b*, 5*e;* Grosenbaugh, 1981:51–53; Cherbonnier, 1988:152–153, fig. 63*a–k;* Rowe and Gates, 1995:382.

MATERIAL EXAMINED: UF5857, Balabat, 5 m depth during the day on pavement, 2 August 2007.

REMARKS: This survey suggests that *T. ananas* is uncommon in Yap, relative to other locations in the western Pacific. It was occasionally seen exposed during the day and night on the outer reef slope on coralline rock or sand to at least 20 m deep.

Thelenota rubralineata Massin & Lane, 1991
Plate III*C*

Thelenota rubralineata Massin & Lane, 1991:57–64, figs. 1–8; Kerr et al. 2007:21–22, fig. 4.

MATERIAL EXAMINED: Photo record (Plate III*C*), Ulithi Atoll, 25 m depth. Picture from Vanessa Fread, 27 July 2007.

REMARKS: This species is a new record for Yap. Several specimens of this unmistakable and striking species have been seen by Brian Greene (University of Hawai'i at Mānoa, Honolulu, pers. comm., 2007) around Yap and other islands in Yap State, on the deep outer reef slopes to at least 60 m depth.

Order APODIDA
Family CHIRIDOTIDAE
Genus *Chiridota* Eschscholtz, 1829

Chiridota sp.
Plate III*D*

MATERIAL EXAMINED: Photo record (Plate III*D*), site unrecorded, exposed near coral rubble on middle reef flat, 28 November 2002.

REMARKS: This species is a new record for Yap. This species usually takes shelter under rubble, often near sandy areas. *Chiridota* sp. often cleaves its body transversely when disturbed, as shown in Plate III*D*. This is likely either *C. rigida* Semper, 1868, or *C. hawaiiensis* Fisher, 1907, two widespread and poorly characterized species in the Pacific (A. M. Clark and Rowe 1971, Paulay 2003).

Family SYNAPTIDAE
Genus *Euapta* Oestergren, 1898

Euapta godeffroyi (Semper, 1868)
Figure 5*A*, *B*, *C*

Synapta godeffroyi Semper, 1868:231, pl. 39, fig. 13.
Euapta godeffroyi: Oestergren, 1898:113; H. L. Clark, 1907:72; H. L. Clark, 1921:158; Cherbonnier, 1955:172, pl. 48, figs. *a–j;* A. M. Clark and Rowe, 1971:185–186, pl. 30, fig. 8; Rowe and Doty, 1977:235–236, figs. 5*c*, 8*h;* Cherbonnier, 1988:249–251, fig. 111*a–j;* Kerr, 1994:171; Rowe and

Gates, 1995:338; Rowe and Richmond, 2004:3307–3308.

MATERIAL EXAMINED: UF11413, Gilfith, <1 m depth at night on rubble on middle reef flat, 14 December 2009.

REMARKS: This species is a new record for Yap. The few other specimens of *Euapta* seen in this survey also all appear to be this species, rather than the closely related *E. tahitiensis* Cherbonnier, 1955, which also occurs in Micronesia (Michonneau et al. 2013). This species was active at night on rubble and sand. Specimens seen during the day were hidden under rocks and rubble.

Genus *Opheodesoma* Fisher, 1907

Opheodesoma grisea (Semper, 1868)
Plate III*F*, *G*, *H;* Figure 5*D*, *E*, *F*

Synapta grisea Semper, 1868:11, pl. 4, figs. 6, 7.
Opheodesoma grisea: Fisher, 1907:723; Heding, 1928:129, figs. 4.7, 7.3, 9; Cherbonnier, 1955:171, pl. 49, figs. *k–t;* A. M. Clark and Rowe, 1971:186, pl. 30, fig. 11; Rowe and Doty, 1977:235, figs. 5*a*, 8*g;* Cherbonnier, 1988:244–246, fig. 109*a–f;* Rowe and Gates, 1995:340; Rowe and Richmond, 2004:3308.

MATERIAL EXAMINED: UF5862, 5876, Fanif, 10 m in blue hole, 3 August 2007. UF5885, 5886, O'Keefe's Island, 1 m depth in sea grass near massive *Porites* sp. colonies, 30 July 2007. UF5855, 5900, O'Keefe's Island, 1 m depth in sea grass near mangroves, 5 August 2007. UF11406, Kaday, <1 m depth during the day in sea grass bed on inner reef flat, 11 December 2009.

REMARKS: This species is a new record for Yap. We found diverse color patterns among specimens referable to *O. grisea* (Plate III*F*, *G*, *H*). This species was frequently observed in sea grass on inner reef flats, as well as at night in areas with high coral cover in the blue holes.

Genus *Polyplectana* H. L. Clark, 1907

Polyplectana sp.
Figure 5*G*, *H*

MATERIAL EXAMINED: UF5874, Maap, 2 m depth during the day in sea grass bed on inner reef flat, 29 July 2007.

REMARKS: This species is a new record for Yap. This is a small species found in large numbers in sea grass, bordering a patch reef of *Acropora* spp. Absence of miliary granules and branched ossicles suggests that this species is *P. kerfersteini.*

Genus *Synapta* Eschscholtz, 1829

Synapta maculata (Chamisso & Eysenhardt, 1821)
Plate III*E*

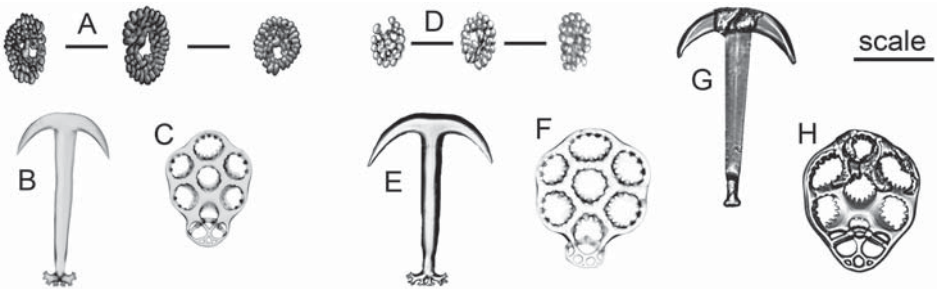

FIGURE 5. Ossicle micrographs of collected specimens. *A*, *Euapta godeffroyi* (UF11413): miliary granules from body wall; *B*, *E. godeffroyi* (UF11413): anchor from body wall; *C*, *E. godeffroyi* (UF11413): anchor plate from body wall; *D*, *Opheodesoma grisea* (UF5855): miliary granules from body wall; *E*, *O. grisea* (UF5855): anchor from body wall; *F*, *O. grisea* (UF5855): anchor plate from body wall; *G*, *Polyplectana* sp. (UF5874): anchor from body wall; *H*, *Polyplectana* sp. (UF5874): anchor plate from body wall. Scale indicates 50 μm for *A* and *D*, and 100 μm for *B*, *C*, *E*, *F*, *G*, *H*.

Holothuria maculata Chamisso & Eysenhardt, 1821:352, pl. 25; H. L. Clark, 1907:78, pls. 1, 4, figs. 17–19, 26; H. L. Clark, 1921:160; A. M. Clark, 1952:204; Cherbonnier, 1955:170, pl. 47, figs. *a–d;* A. M. Clark and Rowe 1971:186–187, pl. 30, fig. 9.

Synapta maculata andreae: Heding, 1928:115, text fig. 3, fig. 2.

Synapta maculata sundaensis: Heding, 1928:116, text fig. 3, figs. 3–5.

Synapta maculate: Heding, 1928:113, fig. 2; Rowe and Doty, 1977:234–235, figs. 5*a*, 8*e;* Cherbonnier, 1988:107–108, fig. 43*a–k;* Kerr, 1994:171; Rowe and Gates, 1995:343–344; Rowe and Richmond, 2004:3308.

MATERIAL EXAMINED: Photo record (Plate III*E*), Gagil, 1.5 m depth in grass flats mixed with corals, 26 November 2002. UF5894, Balabat, 15 m on sandy bottom of channel, 2 August 2007. UF11424, Kaday, <1 m depth during the day in sea grass bed on inner reef flat, 10 December 2009.

REMARKS: This species is a new record for Yap. This large, diurnally active species was commonly found in sea grass. Specimens were also found rarely in silty sites, scattered with occasional coral colonies.

DISCUSSION

Despite the rich fauna, only a handful of accounts report the holothuroids of Micronesia. The most recent and comprehensive account from Guam (Michonneau et al. 2013) enumerated 64 species of sea cucumbers, including 18 new records. The 37 species recorded in this study is comparable to the diversity known from Guam before the recent update (46 species) and makes Yap the best-documented Micronesian island after Guam. The known species composition of Yap is similar to that of Guam; the aspidochirotes dominate the reefs and adjacent habitats in Yap (86%) and Guam (81%), and the dendrochirotes are the most poorly reported group in Yap (0%) and Guam (5%).

Of the 37 holothuroid species recorded in this study, 24 (19 aspidochirotes and five apodans) are new records. At least two species, *Actinopyga* sp. and *Holothuria* (*Theelothuria*) sp., appear to be undescribed. One of the species we collected, *H.* (*Semperothuria*) *roseomaculata*, was also undescribed at the time of the surveys but was recently described (Kerr 2013). A few of the species were reported only as photo records because we lacked permission to collect during one visit. Two of these species, *H.* aff. (*Lessonothuria*) *cavans* and *H.* (?*Thymiosycia*) sp., may represent rare species; however, we cannot make confident identifications because we lack voucher specimens.

The small-scale distribution patterns of holothuroids are closely related to microhabitat and reef zonation (Levin 1979, Sloan 1979, 1982, Kerr et al. 1993, Kerr 1994). The distribution of Yapese holothuroids also varied considerably between reef zonations (Table 1). Sea grass beds on the inner reef flats were inhabited by the largest diversity of apodans, *Opheodesoma grisea*, *Polyplectana* sp., and *Synapta maculata*, as well as small cryptic aspidochirotes *H.* aff. (*Lessonothuria*) *cavans* and *H.* (?*Thymiosycia*) sp., and the commercially valuable aspidochirotes *Holothuria* (*Metriatyla*) ?*lessoni* and *H.* (*Metriatyla*) *scabra*. The diurnally burying *Bohadschia* species, *B. marmorata*, *B. vitiensis*, and *B. koellikeri*, were also frequently observed in sea grass beds and near mangroves during the late afternoon and at night. Diurnally cryptic species, *H. coluber*, *H. hilla*, *H. impatiens*, *H. pervicax*, *H. turriscelsa*, *Chiridota* sp., *Euapta godeffroyi*, and *Stichopus* cf. *monotuberculatus*, were recorded on middle reef flats, where numerous coral colonies and rubble covered the bottom. Blue holes hosted an interesting set of less-common species, such as *H.* (*Cystipus*) *inhabilis*, *H.* (*Theelothuria*) sp., and *H.* (*Platyperona*) *excellens*. The most common species encountered in the surveys, *H. atra*, was found at nearly all sites on inner and middle reef flats, and its large biomass was unrivaled by other species. Another common species, *B. argus*, was widespread at the western sites but was found less frequently at the more wave-exposed eastern sites. On the other hand, species that withstand higher wave energies, such as *H. whitmaei* and *A. mauritiana*, were found mostly on outer reef flats and edges at the eastern sites. In particular, *A. mauritiana*

was absent at the relatively calm western sites. Table 1 summarizes the distribution pattern of Yapese holothuroids.

The O'Keefe's Island and Fanif sites were unique in having large sea grass beds and lacking middle and outer reef flats. The silty bottom of both sites was inhabited by *Actinopyga* sp. and *Holothuria* (*Semperothuria*) *roseomaculata*. O'Keefe's Island was also home to other cryptic species, such as *H. coluber*, *B. vitiensis*,

TABLE 1

List of Shallow-Water Holothuroids of Yap and Their Reef Zone Distributions

	Microhabitat						
Species	Inner Reef–Mangrove and Sea Grass	Inner/Middle Reef–Sand Flat with Patchy Corals	Middle Reef–Rubble and Loose Rocks	Outer Reef–Wave-Washed Zone	Outer Reef–Reef Slope with High Coral Cover	Blue Hole	Other Studies[a]
Actinopyga mauritiana				X			
Actinopyga ?*palauensis*	X						
Actinopyga sp.	X						X
Bohadschia argus		X	X		X		X
Bohadschia koellikeri		X					X
Bohadschia marmorata	X	X					
Bohadschia vitiensis	X	X					X
Euapta godeffroyi		X	X				
Holothuria (*Acanthotrapezia*) *coluber*	X						
Holothuria (*Cystipus*) *inhabilis*						X	
Holothuria (*Halodeima*) *atra*	X	X	X	X			X
Holothuria (*Halodeima*) *edulis*		X	X				X
Holothuria ?(*Lessonothuria*) *cavans*	X						
Holothuria (*Mertensiothuria*) *billa*		X	X				X
Holothuria (*Mertensiothuria*) *leucospilota*			X				X
Holothuria (*Metriatyla*) ?*lessoni*	X						
Holothuria (*Metriatyla*) *scabra*	X						
Holothuria (*Microthele*) *fuscogilva*	X						
Holothuria (*Microthele*) *fuscopunctata*		X					X
Holothuria (*Microthele*) *whitmaei*				X			X
Holothuria (*Platyperona*) *excellens*						X	
Holothuria (*Semperothuria*) *roseomaculata*	X						X
Holothuria (*Stauropora*) *pervicax*			X				
Holothuria (*Theelothuria*) sp.							
Holothuria (*Theelothuria*) *turriscelsa*		X	X				
Holothuria (*Thymiosycia*) *impatiens*			X				
Holothuria (*?Thymiosycia*) sp.	X						
Opheodesoma grisea	X						
Pearsonothuria graeffei					X		
Chiridota sp.			X				
Polyplectana sp.	X						
Stichopus chloronotus	X	X	X		X		X
Stichopus cf. *monotuberculatus*		X	X				
Stichopus vastus	X						
Synapta maculata	X	X					
Thelenota ananas					X		X
Thelenota rubralineata					X		

[a] Includes combined past data from technical reports by Amesbury et al. (1976), Amesbury et al. (1977), and Grosenbaugh (1978, 1981).

and *B. koellikeri*. When these sites were visited in the late afternoon, nocturnal species *B. vitiensis* and *B. koellikeri* had begun to emerge from the sand.

Holothuroid taxonomy is being revised frequently with the publication of molecular analyses (Uthicke et al. 2004, Byrne et al. 2010, Uthicke et al. 2010, Honey-Escandón et al. 2012). Several taxa in this survey are also in need of review. For example, *H. impatiens* is certainly a species complex including several forms, all distinct in color or morphology (F. Michonneau, pers. comm.). In contrast, the color variation of *Opheodesoma grisea* has been suspected to indicate an unrecognized complex; however, color morphs appear mixed within a single clade in molecular analyses, suggesting extensive color polymorphism (G. Paulay, pers. comm.).

Time constraints and limited microhabitat coverage often hamper comprehensive biodiversity documentation. For example, a recent study by Michonneau et al. (2013) showed a consistent increase in species diversity even after nearly 200 yr of surveys. Similarly, the short time spent collecting on Yap suggests that the 37 species listed here are undoubtedly an underrepresentation of the Yapese holothuroid fauna. For example, among specimens housed at the U.S. National Museum and collected during the Fourth Pacific Atoll Survey (unpubl. data) from nearby Ifalik Atoll, Yap State, FSM, E. Deichmann and C. Ahearn have identified several often-widespread species that likely also occur in the main islands of Yap: *Afrocucumis africana* (Semper, 1868), *Holothuria* (*Semperothuria*) *cinerascens* (Brandt, 1835), and *H.* (*Platyperona*) *difficilis* (Semper, 1868). They also identified two species from Ifalik not previously reported in Micronesia: *Polycheira rufescens* and an unidentified *Synaptula* sp. Also we were unable to explore several habitat types on Yap, such as the wider sand flats and steep slopes to the south; these areas may host additional species.

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