

Shallow-water Holothuroids (Echinodermata) of Kosrae, Eastern Caroline Islands¹

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ABSTRACT: Line transects and qualitative surveys were used to determine species composition and abundance distributions of holothuroids on the fringing coral reefs of Kosrae, Federated States of Micronesia. On the reef flats, in a total sample area of 2982 m², 9383 holothuroids, comprising 13 species, were recorded. An additional 13 species were recorded off the transects between depths of 0 and 30 m. Species richness varied considerably between sites and physiographic zones and was significantly correlated with reef-flat width. *Holothuria (Halodeima) atra* Jaeger was the most abundant species recorded, composing 92.1% of the holothuroids on the transects. Other species were considerably less abundant: *H. (Platyperona) difficilis* Semper, *H. (Thymiosycia) hilla* (Forsskål), *Afrocucomis africana* Semper, and *Actinopyga mauritiana* Quoy & Gaimard were 6.1, 0.8, 0.3, and 0.2% of the enumerated taxa, respectively. For all other species, each composed $\leq 0.1\%$ of the fauna. Kosrae had very low densities of most commercially valuable holothuroids; only two marketable species, *Actinopyga mauritiana* and *H. (Metriatyla) scabra* Jaeger were found there in relative abundance. Twenty-eight species of holothuroids are now reported from Kosrae.

HOLOTHUROIDS ARE a conspicuous component of the reef flats of Kosrae, but there are no comprehensive published accounts of the island's holothuroid fauna. The most complete coverage is by Eldredge et al. (1979), who, in a technical report, reported observing 16 species and an unidentified synaptid on a northern reef flat. In another report, Birke-land (1991) listed three species on the reef slopes in an island-wide diurnal census. I conducted an extensive quantitative and qualitative survey of the island in July and August 1992, examining both the reef flat and reef slope to depths of 30 m during day and night, and found 26 species of holothuroids. Two other species not found in this survey are also reported from Kosrae (Eldredge et al. 1979).

MATERIALS AND METHODS

Study Site

Collections were made on several reefs on Kosrae (109 km²; 5° 20' N, 165° 00' E), a young (1 to 3 million yr old), volcanic island in the tropical western Pacific Ocean (Figure 1). Fringing reefs rim the island and vary in width from <100 m on southern to eastern shores to 1.6 km wide on western exposures. Shorelines are generally sandy on northern to eastern shores at Sialat, Pukusruk Te, and Leluh, whereas southeastern shorelines at Foko Yewak and Foko Mosral are more rocky. Western shores from Tafowan and Foko Saoksa northward to Foko Kiul and Okat are covered in mangroves, primarily *Bruguiera gymnorrhiza* Linnaeus and *Rhizophora* spp. The inner reef flats of reefs > 500 m wide, beginning at the edge of the mangroves (if present), are generally sandy to silty, from 0.5 to 1.0 m depth, and support extensive beds of the seagrass *Thalassia hemprichii* (Ehrenb.) Ashers. The middle reef flats

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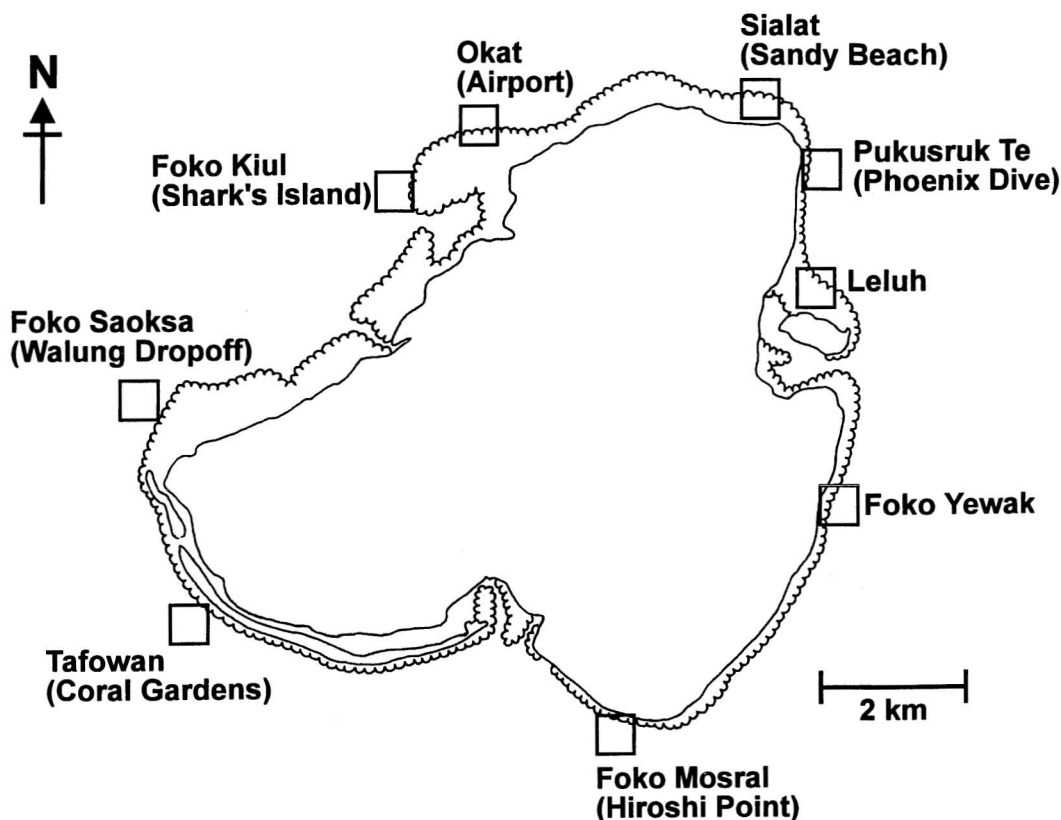


FIGURE 1. Map of Kosrae, showing sites mentioned in the text (popular English names in parentheses).

on wide reefs have coarser sediments, are about 0.5 m deep, and often have microatolls of *Porites* spp. This zone at Leluh also has extensive colonies of *Psammocora contigua* (Esper) and *Pavona* spp. Outer reef flats are 0 to 0.5 m deep and have few corals but much rubble. The reef edge, or reef margin, is mostly bare coralline limestone or encrusting coralline algae with a few low-growing, wave-resistant corals. Surge channels cut through this zone to the gently sloping reef front, which extends seaward to about 7 to 10 m depth. The reef front has abundant coral cover only along western reefs from Okat westward to Tafowan. Seaward of this reef zone, the reef slope is very steep and heavily populated by corals, with *Galaxea astreata* (Lamarck), *Diploastrea heliophora* (Lamarck), and massive *Porites* spp. dominating.

Surveys

To determine the abundance distribution of the holothuroids, during June to August 1992 I ran diurnal line transects on reef flats at Okat, Sialat, Pukusruk Te, Foko Yewak, and Foko Mosral and conducted diurnal searches at those sites and at Foko Saoksa outside the transects and nocturnal searches on reef flats at Sialat and Leluh. During the day, the reef front was investigated at all sites to a depth of at least 4 m, and reef slopes at Leluh, Tafowan, Foko Saoksa, and Foko Kiul from 10 to 30 m depth (Figure 1). The number of each species was recorded at 10-m intervals within 1 m of both sides of the transect line (10 by 2 m quadrats). Because of its abundance at Okat and Sialat, *Holothuria atra* Jaeger was counted only in 10-m² quad-

TABLE 1

ABUNDANCE OF HOLOTHUroids ON 2-M-WIDE TRANSECTS AND QUALITATIVE ASSESSMENTS OUTSIDE THE TRANSECTS

| FAMILY GENUS AND SPECIES | TRANSECTS | | | | | QUALITATIVE ASSESSMENTS ^a | | | |
|--------------------------------|--------------------|--------------------|----------|----------------|-----------|--------------------------------------|---------|-----------|---------|
| | SIALAT | OKAT | PUKUSRUK | F. YEWAK | F. MOSRAL | LELUH | TAFOWAN | F. SAOKSA | F. KIUL |
| Holothuriidae | | | | | | | | | |
| <i>Actinopyga echinites</i> | 0 ^b | 0 | 1 | 0 | 0 | R | A | A | A |
| <i>A. mauritiana</i> | 3 | 13 | 0 | 0 | 1 | C | A | A | A |
| <i>A. miliaris</i> | 0 ^b | 0 | 0 | 0 | 0 | R | A | A | A |
| <i>Bohadschia argus</i> | 0 ^b | 0 | 0 | 0 | 0 | C | A | A | A |
| <i>B. marmorata</i> | 0 ^b | 0 | 0 | 0 | 0 | C | A | A | A |
| <i>Holothuria arenicola</i> | 0 | 0 | 1 | 0 | 0 | A | A | A | A |
| <i>H. atra</i> | 6,350 ^c | 2,290 ^c | 9 | 1 | 0 | C | A | A | A |
| <i>H. coluber</i> | 0 | 0 | 0 | 0 | 0 | C | A | A | A |
| <i>H. difficilis</i> | 572 | 0 | 0 | 0 | 0 | A | A | A | A |
| <i>H. hilla</i> | 1 | 78 | 0 | 0 | 0 | C | A | A | A |
| <i>H. impatiens</i> | 5 | 0 | 1 | 0 | 0 | C | A | A | A |
| <i>H. leucospilota</i> | 3 | 3 | 1 | 1 | 0 | C | A | A | A |
| <i>H. nobilis</i> | 0 | 0 | 0 | 0 | 0 | R | A | A | A |
| <i>H. pervicax</i> | 10 | 0 | 0 | 0 | 0 | A | A | A | A |
| <i>H. scabra</i> | 0 | 0 | 0 | 0 | 0 | C | A | A | A |
| ? <i>Holothuria</i> sp. | 1 | 0 | 0 | 0 | 0 | A | A | A | A |
| <i>Labidodemas semperianum</i> | 3 | 0 | 0 | 0 | 0 | A | A | A | A |
| <i>Pearsonothuria graeffei</i> | 0 | 0 | 0 | 0 | 0 | A | R | R | R |
| Stichopodidae | | | | | | | | | |
| <i>Stichopus chloronotus</i> | 0 | 4 | 0 | 0 | 0 | C | A | A | R |
| <i>S. horrens</i> | 2 | 0 | 0 | 0 | 0 | R | A | A | A |
| <i>Thelenota ananas</i> | 0 | 0 | 0 | 0 ^b | 0 | A | A | A | R |
| Phyllophoridae | | | | | | | | | |
| <i>Afroccumis africana</i> | 17 | 4 | 8 | 0 | 0 | A | A | A | A |
| Chiridotidae | | | | | | | | | |
| <i>Chiridota rigida</i> | 1 | 0 | 0 | 0 | 0 | A | A | A | A |
| Synaptidae | | | | | | | | | |
| <i>Euapta godeffroyi</i> | 0 ^b | 0 | 0 | 0 | 0 | A | A | A | A |
| <i>Opheodesoma grisea</i> | 0 | 0 | 0 | 0 | 0 | C | A | A | A |
| <i>Synapta maculata</i> | 0 ^b | 0 | 0 | 0 | 0 | A | A | A | A |
| Depth range (m) | 0–1 | 0–1 | 0–1 | 0–1 | 0–1 | 0–10 | 10–30 | 10–30 | 10–23 |
| Transect length (m) | 550 | 500 | 200 | 180 | 60 | | | | |
| Dates (d.mo.1992) | 01.07 | 24.08 | 23.08 | 23.08 | 23.08 | 01.07 | 30.06 | 30.06 | 30.06 |
| | 21.08 | | | | | 21.08 | 22.08 | 22.08 | 22.08 |

^a C, common (≥ 10 holothuroids); R, rare (< 10); A, absent.^b Species occurred at the site, but was seen only outside the transect.^c Estimated for entire transect from 10-m² quadrats placed 40 m apart.

rats placed 40 m apart on the transects. The transects began on shore at the water's edge and extended perpendicularly from there to the reef-flat margin. At Okat, however, only the northern reef flat seaward of the airport was examined. Reef fronts and reef slopes had very few holothuroids, so only presence or

absence of species in these zones for each site was noted. I examined crevices, turned over rocks, and searched through stands of macroalgae within the sampled areas. In addition to the transect and qualitative surveys, the catch per unit effort of commercially valuable species at all sites was estimated by noting the

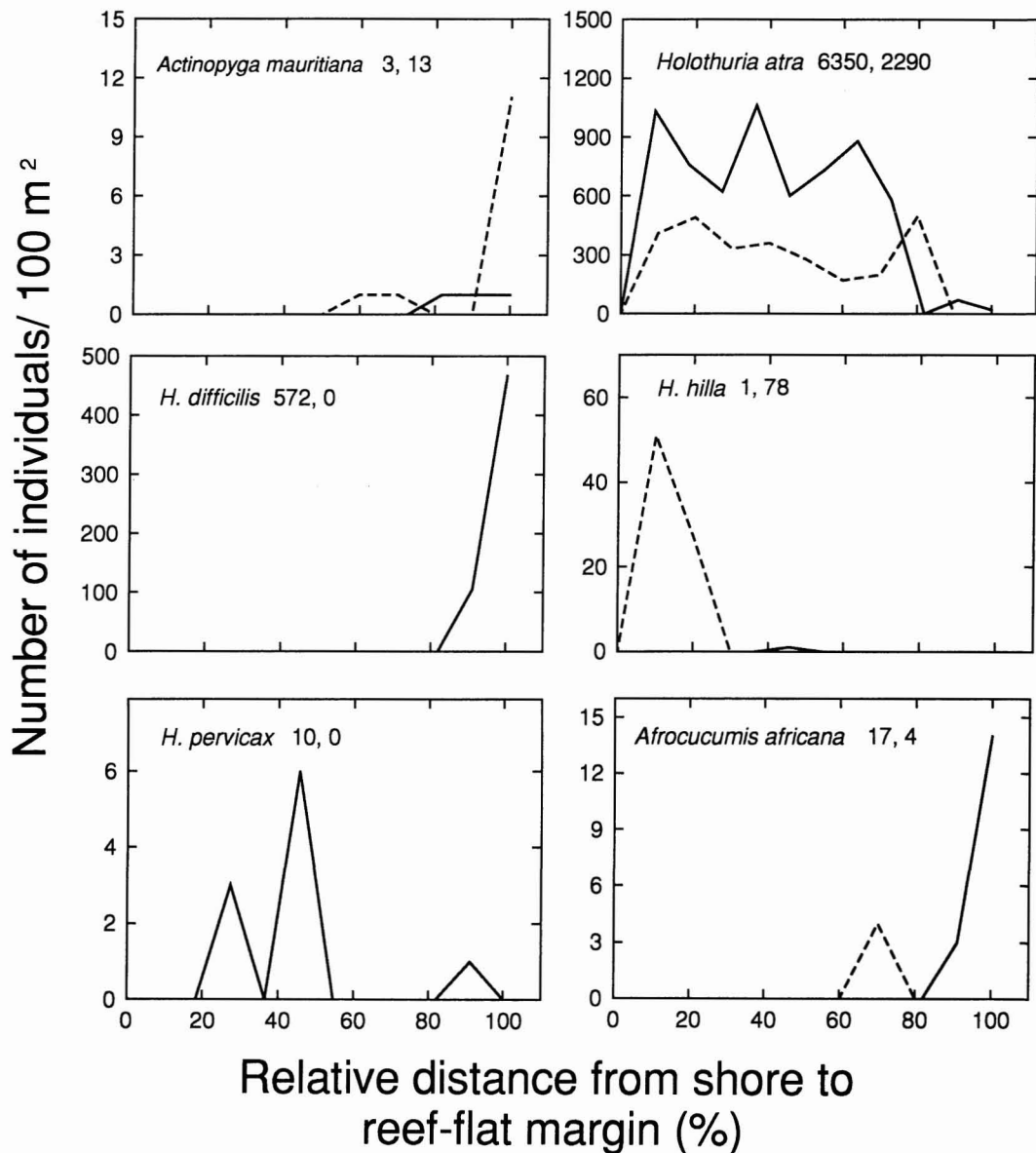


FIGURE 2. Distribution of abundant holothuroids on reef flats at Sialat (solid line) and Okat (dashed line). Numbers following species names are sample sizes for Sialat and Okat, respectively.

numbers of each species observed in 0.5- to 1-h surveys.

Holothuroids that could not be determined in the field were collected and preserved for later identification. Holothuroids were first relaxed for 30 min in seawater to which several drops of chloretone (1,1,1-trichloro-2-methyl-2-propanol) and 70% ethanol had been added, before being preserved in denatured ethanol buffered with sodium bicarbonate. The ossicles were prepared as permanent microscope slides following the procedures found in Rowe and Doty (1977) and using low-viscosity Cytoseal 60 mounting medium (Stephens Scientific, Riverdale, New Jersey).

RESULTS

Surveys

In a sample area of 2892 m², a total of 9383 holothuroids (numbers of *Holothuria atra* estimated for total sample space) comprising 13 species was seen on the transects (Table 1). An additional 13 species were found during the qualitative surveys. The six most abundant species on the transects were *Actinopyga mauritiana* (Quoy & Gaimard), *Afrocumis africana* (Semper), *H. atra*, *H. difficilis* (Semper), *H. hilla* (Forsskål), and *H. pervicax* Selenka, *Bohadschia argus* Jaeger, *B. marmorata* Jaeger, *H. coluber* Semper, and *Stichopus chloronotus* Brandt were also very abundant on the reef flat at Leluh. *Holothuria atra* was the most abundant species, composing 92.1% of all holothuroids on the transects. Other species were considerably less common: *H. difficilis*, *H. hilla*, and *A. mauritiana* were 6.1, 0.8, and 0.2% of the enumerated fauna, respectively. All other species were each $\leq 0.1\%$ of the fauna.

Most species of holothuroids (92.9%) occurred on the reef flat, where they were often found contagiously distributed (Figure 2). Conversely, only five species were found on the reef front and reef slope, at least during the day: *A. mauritiana*, *H. nobilis* (Selenka), *Pearsonothuria graeffei* (Semper), *S. chloronotus*, and *Thelenota ananas* Jaeger. Of these deeper-water species, *A. mauritiana*, *H. nobilis*, and *S. chloronotus* also occurred on the

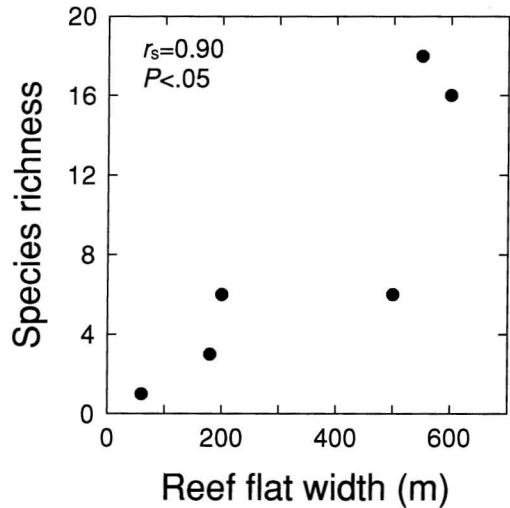


FIGURE 3. Species richness of reef flats on Kosrae. Data are combined from transects and qualitative surveys.

reef flat. Species richness varied considerably between sites and was significantly correlated with reef-flat width (Figure 3).

Kosrae had very low densities of commercially valuable holothuroids (Table 2); *A. mauritiana* was the most abundant. From 0 to 58 individuals of this species were seen per hour of observation along the reef margins and reef fronts to 4 m depth. Other species of *Actinopyga* were considerably less common (Table 2). Another marketable holothuroid, *H. scabra* Jaeger, was seen only on the reef flat at Leluh, where it occurred infrequently in small, dense aggregations. The remaining commercial species, *T. ananas* and *H. nobilis*, were rare to absent at all sites.

ANNOTATED SPECIES LIST

For each species, information on habitat, locality, and behavior, if known, is given. Remarks on biogeography are included for species showing considerable range extensions. An abbreviated synonymy giving the original name and currently accepted name is provided, as well as important references listing complete synonymies and further information on biology and biogeography. Collection numbers are for voucher specimens being

TABLE 2
COMMERCIALY VALUABLE HOLOTHUROIDS SEEN PER HOUR OF OBSERVATION

| HOLOTHUROID | SITE | | | | | | | | | |
|-----------------------------|------|--------|----------|-------|----------|----------------|---------|-----------|---------|--|
| | OKAT | SIALAT | PUKUSRUK | LELUH | F. YEWAK | F. MOSRAL | TAFOWAN | F. SAOKSA | F. KIUL | |
| <i>Actinopyga echinites</i> | 0 | 0 | 1 | 2 | 0 | 0 | ND | ND | ND | |
| <i>A. mauritiana</i> | 21 | 58 | 0 | 12 | 0 | 20 | ND | ND | ND | |
| <i>A. miliaris</i> | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | |
| <i>Holothuria nobilis</i> | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | |
| <i>H. scabra</i> | 0 | 0 | 0 | 10 | 0 | 0 | ND | ND | ND | |
| <i>Thelenota ananas</i> | 0 | 0 | ND | 0 | 0 | 1 ^a | 0 | 1 | 2 | |

NOTE: Data were estimated from 0.5- to 1.0-h counts using one to two observers. ND, reef zone inhabited by holothuroid was not surveyed.

^aJ. Sigrah, pers. comm.

curated in the invertebrate collection at the University of Guam Marine Laboratory (UGI).

Class HOLOTHUROIDEA
Order ASPIDOCHEIROTIDA
Family HOLOTHURIIDAE
Genus *Actinopyga* Bronn, 1860

Actinopyga echinites (Jaeger, 1833)

Mulleria echinites Jaeger, 1833: 17.

Actinopyga echinites, Clark and Rowe, 1971: 176-177, fig. 85b, pl. 27 fig. 1; Rowe and Doty, 1977: 228, 247, figs. 3e, 6c, 9; Cherbonnier, 1988: 31-32, fig. 9a-p.

UGI 5750, 1 specimen, Sialat, exposed on sand in seagrass on the inner reef flat < 1 m deep during the day; 1 July 1992.

REMARKS: This species occurred occasionally on the reef flat at Sialat and at Leluh.

Actinopyga mauritiana (Quoy & Gaimard, 1833)

Holothuria mauritiana Quoy and Gaimard, 1833: 138.

Actinopyga mauritiana, Clark and Rowe, 1971: 176-177, pl. 27 fig. 3; Rowe and Doty, 1977: 228, 247, figs. 3f, 6d, 9; Cherbonnier, 1988: 16-17, fig. 2.

UGI 5751, 1 specimen, Sialat, exposed on pavement on the reef-flat margin < 1 m deep during the day; 1 July 1992.

REMARKS: This species was abundant at

nearly all sites, from the outer reef flat to about 5 m depth on the reef front.

Actinopyga miliaris (Quoy & Gaimard, 1833)
Figure 4a

Holothuria miliaris Quoy and Gaimard, 1833: 137.

Actinopyga lecanora miliaris, Panning, 1944: 47-48, fig. 16a-u.

Actinopyga miliaris, Clark and Rowe, 1971: 176-177, pl. 27 fig. 4; Cherbonnier, 1984: 667-668, fig. 4a-j; Ferál and Cherbonnier, 1986: 74-75, fig. 40b.

UGI 5752, 1 specimen, Leluh, on sand on the inner reef flat < 1 m depth; 1 July 1992.
UGI 5753, one specimen, Sialat, on sand on the inner reef flat < 1 m depth; 1 July 1992.

REMARKS: Animals are uniformly dark brown or black and were covered with a fine layer of sand. This species was uncommon on the inner reef flats at Leluh and Sialat.

Genus *Bohadschia* Jaeger, 1833

Bohadschia argus Jaeger, 1833

Bohadschia argus Jaeger, 1833: 19, pl. A figs. 1-1b; Clark and Rowe, 1971: 176-177, pl. 27 fig. 6; Rowe and Doty, 1977: 223, 229, figs. 2h, 6f; Cherbonnier, 1988: 34-35, fig. 10.

UGI 5754, 1 specimen, Leluh, on sand on the inner reef flat < 1 m depth; 1 July 1992.

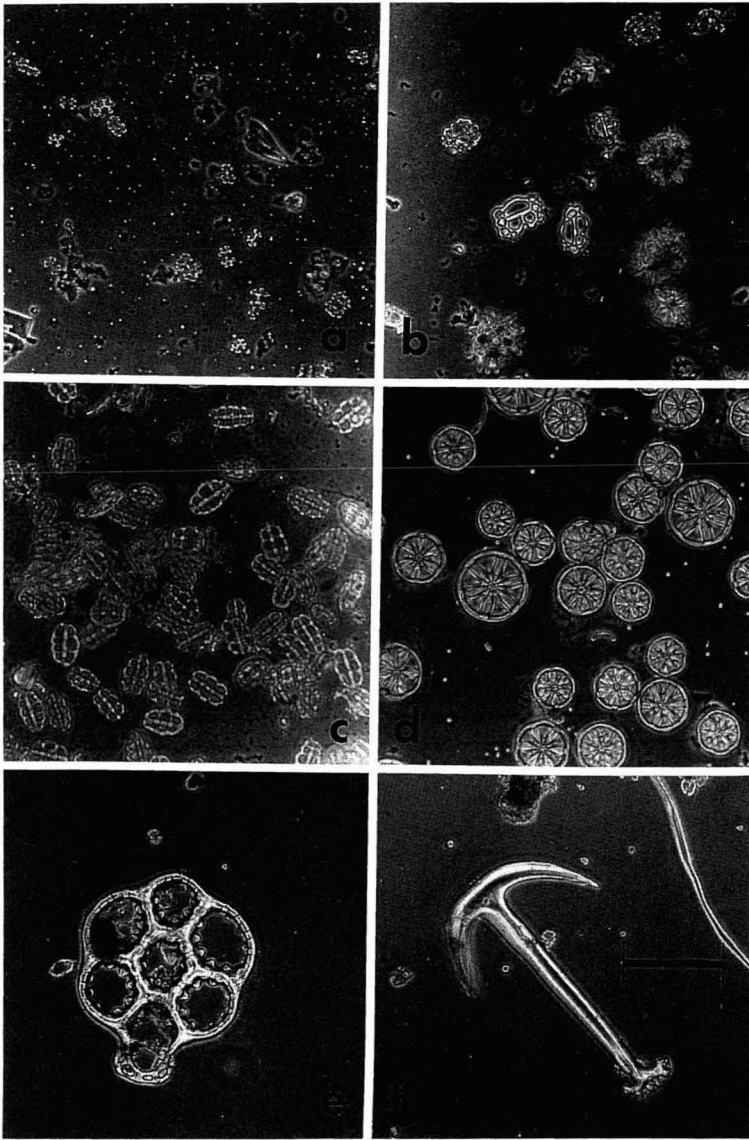


FIGURE 4. Photomicrographs of holothuroid spicules taken from middorsal body wall. Scale bar = 100 μm . *a*, *Actinopyga miliaris* (Quoy & Gaimard), dichotomously branched rods, UGI 5752. *b*, *Holothuria* (*Acanthotrapezia*) *coluber* Semper, tables and buttons, UGI 5756. *c*, *H. (Metriatyla) scabra* Jaeger, buttons, UGI 5759. *d*, *Chiridota rigida* Semper, wheels and curved rods, UGI 5769. *e*, *Opheodesoma grisea* (Semper), anchor plate, UGI 5768. *f*, *Opheodesoma grisea* (Semper), anchor, UGI 5768.

REMARKS: The dorsum of this specimen is gray with numerous dark brown spots bordered with white. Some uncollected specimens at Leluh were dark brown with brownish orange ocelli.

Bohadschia marmorata Jaeger, 1833

Bohadschia marmorata Jaeger, 1833: 18, pl. 3 fig. 9; Clark and Rowe, 1971: 176–177, pl. 27 fig. 8; Rowe and Doty, 1977: 229–230,

figs. 3a, 6g–h; Cherbonnier, 1988:36, fig. 11a–1.

UGI 5755, 1 specimen, Leluh, on sand on the inner reef flat <1 m depth; 1 July 1992.

REMARKS: Specimen is cream with two wide, dark brown, transverse bands. Patterns on the dorsa of uncollected specimens matched those described for several forms considered as color morphs of *B. marmorata* by Rowe and Doty (1977): *B. koellikeri*, *B. tenuissima*, *B. marmorata*, *B. similis*, and *B. vitiensis*.

Genus *Holothuria* Linnaeus, 1767

Holothuria (Acanthotrapezia) coluber Semper, 1868

Figure 4b

Holothuria coluber Semper, 1868:90, pl. 28, pl. 30 fig. 28a–b, pl. 34 fig. 5.

Holothuria (Acanthotrapezia) coluber, Rowe, 1969:138–139; Clark and Rowe, 1971:176–177, fig. 85c, pl. 27 fig. 13; Cannon and Silver, 1986:21, fig. 6c; Féral and Cherbonnier, 1986:80–81, fig. 40f.

UGI 5756, 1 specimen, Leluh, on the inner reef flat under live coral on sand <1 m depth at night; 1 July 1992.

REMARKS: This species was nocturnal and extended its anterior end from rocks and coral to feed. It was seen only on the inner reef flat at Leluh, where it was common. This holothuroid is found from the Malaysian Archipelago to the western Pacific (Clark and Rowe 1971, Levin 1979) and is known in Micronesia from Palau and Pohnpei (unpublished data).

Holothuria (Halodeima) atra Jaeger, 1833

Holothuria atra Jaeger, 1833:22.

Holothuria (Halodeima) atra, Rowe, 1969:137, fig. 7; Clark and Rowe, 1971:176–177, pl. 27 fig. 11; Rowe and Doty, 1977:230–231, 247, figs. 3d, 7a; Cherbonnier, 1988:73, fig. 28a–j.

UGI 5757, 1 specimen, Sialat, on sand on the inner reef flat <1 m depth; 1 July 1992.

REMARKS: This is the most common holothuroid of Kosrae. This species occurred on inner and outer reef flats at all sites.

Holothuria (Halodeima) edulis Lesson, 1830

Holothuria edulis Lesson, 1830:125, pl. 46 fig. 2.

Holothuria (Halodeima) edulis, Rowe, 1969:138; Clark and Rowe, 1971:176–177, pl. 27 fig. 14; Rowe and Doty, 1977:231, figs. 3e, 7b.

VOUCHER SPECIMEN: None.

REMARKS: I did not see this species, but it was reported from the channel near Foko Kiul on sand by Eldredge et al. (1979).

Holothuria (Mertensiothuria) leucospilota (Brandt, 1835)

Holothuria (Gymnochirota) leucospilota Brandt, 1835:51.

Holothuria (Mertensiothuria) leucospilota, Rowe, 1969:149; Clark and Rowe, 1971:176–177; Rowe and Doty, 1977:234, figs. 4g, 8c; Cherbonnier, 1988:107–108, fig. 43a–k.

UGI 5758, 1 specimen, Sialat, <1 m depth under rock on sand on the inner reef flat; 1 July 1992.

REMARKS: This species was uncommon; it fed by extending its anterior end from under coral or coralline rock during the day and night.

Holothuria (Mertensiothuria) pervicax Selenka, 1867

Holothuria pervicax Selenka, 1867:327, pl. 18 fig. 54.

Holothuria (Mertensiothuria) pervicax, Rowe, 1969:149; Clark and Rowe, 1971:176–177; Rowe and Doty, 1977:234, figs. 4g, 8c; Cherbonnier, 1988:107–108, fig. 43a–k.

UGI 5783, 2 specimens, Walung, <1 m depth during the day under rocks on the outer reef flat; 5 June 1993.

REMARKS: This species was seen under rocks on the reef flats at Sialat and Leluh. At night it was occasionally seen in the open on sand or sandy rubble.

Holothuria (Metriatyla) scabra Jaeger, 1833
Figure 4c

Holothuria scabra Jaeger, 1833:23.

Holothuria (Metriatyla) scabra, Rowe, 1969:160–161, fig. 20a–c; Clark and Rowe,

1971: 178–179, fig. 871, pl. 15 fig. 15; Féral and Cherbonnier, 1986: 86–87; Cherbonnier, 1988: 135–137, fig. 55a–o.

UGI 5759, 3 specimens, Leluh, < 1 m depth at night exposed on sand in stand of seagrass, *Thalassia hemprichii*, on the inner reef flat; 1 July 1992.

REMARKS: A large (21 cm) individual has a light gray dorsal surface with scattered dark brown spots; smaller (< 15 cm) specimens have occasional irregular transverse stripes. This species lay exposed in seagrass beds on the inner reef flat at Leluh during the day and night. *Holothuria scabra* is known in Micronesia from Palau (Panning 1944) and Yap (unpublished data) and was incorrectly listed from the latter island as *Bohadschia* sp. by Grosenbaugh (1981).

Holothuria (Microthele) nobilis (Selenka, 1867)

Mulleria nobilis Selenka, 1867: 313, pl. 17 figs. 13–15.

Holothuria (Microthele) nobilis, Rowe, 1969: 162, 164, fig. 21; Clark and Rowe, 1971: 178–179, fig. 87m, pl. 27 fig. 10, pl. 28 fig. 20; Rowe and Doty, 1977: 231, figs. 3f, 7d; Cherbonnier, 1988: 142–144, fig. 58a–1.

VOUCHER SPECIMEN: None.

REMARKS: This species is large and completely black with a thick, rigid body wall, a thin covering of sand, and often several enlarged ventrolateral papillae. *Holothuria nobilis* was seen only at Leluh on the outer reef flat and reef front to 10 m depth during the day and night.

Holothuria (Platyperona) difficilis Semper, 1868

Mulleria difficilis Semper, 1868: 92, pl. 30 fig. 21.

Holothuria (Platyperona) difficilis, Rowe, 1969: 138–139, fig. 12; Clark and Rowe, 1971: 178–179, fig. 87h, pl. 27 fig. 9; Rowe and Doty, 1977: 232, fig. 3h; Cherbonnier, 1988: 99–101, fig. 40a–k.

UGI 5760, 3 specimens, Sialat, < 1 m depth during the day under loose rubble on the outer reef flat; 1 July 1992.

REMARKS: This species was very common

under loose cobbles on the outer reef flat from Sialat. Specimens readily ejected numerous fine Cuvierian tubules when disturbed.

Holothuria (Selenkothuria) moebii Ludwig, 1883

Holothuria moebii Ludwig, 1883: 171.

Holothuria (Selenkothuria) moebii, Clark, 1938: 525–526; Clark and Rowe, 1971: 176–177.

VOUCHER SPECIMEN: None.

REMARKS: I did not see this species, but it was reported from the reef flat from “rock and/or rubble” at Okat by Eldredge et al. (1979). This species may have been confused with a superficially similar, but more widespread Indo-Pacific species, *H. (Semperothuria) cinerascens*. *Holothuria moebii* has been reported from Australia, northward to Japan and China (Clark and Rowe 1971), and was previously not known from Micronesia.

Holothuria (Thymiosycia) arenicola Semper, 1868

Holothuria arenicola Semper, 1868: 81, pl. 20, pl. 30 fig. 13, pl. 35 fig. 4.

Holothuria (Thymiosycia) arenicola, Clark and Rowe, 1971: 178–179, pl. 28 fig. 3; Rowe and Doty, 1977: 232, fig. 4a.

UGI 5761, 1 specimen, Sialat, < 1 m depth during the day under coralline rock on sand on the outer reef flat; 21 August 1992.

REMARKS: Specimen is creamy white with seven pairs of dark brown spots arranged longitudinally along the dorsum in two parallel rows.

Holothuria (Thymiosycia) hilla Lesson, 1830

Holothuria hilla Lesson, 1830: 226, pl. 79.

Holothuria (Thymiosycia) hilla, Clark and Rowe, 1971: 178–179; Rowe and Doty, 1977: 232–233, 247, figs. 4b, 8b; Cherbonnier, 1988: 85–87, fig. 343a–1.

UGI 5762, 1 specimen, Leluh, on the inner reef flat under live coral on sand < 1 m depth at night; 1 July 1992. UGI 5782, 2 specimens, Walung, < 1 m depth under coral in seagrass on the inner reef flat; 5 June 1993.

REMARKS: This specimen was found during the day under coral or loose cobbles on the

inner reef flat at Leluh, Sialat, and Okat, where it was very abundant. At night, it was seen extending its anterior end from its refuge to feed.

Holothuria (Thymiosycia) impatiens (Forskål, 1775)

Fistularia impatiens Forsskål, 1775:121, pl. 39b.

Holothuria (Thymiosycia) impatiens, Rowe, 1969:146, fig. 13a-c; Clark and Rowe, 1971:178-179, fig. 85a-a', pl. 26 fig. 2, pl. 28 fig. 8; Rowe and Doty, 1977:233, figs. 4c, 7e; Cherbonnier, 1988:88-89, fig. 35a-k.

UGI 5763, 6 specimens, Sialat, <1 m depth during the day under coralline cobbles and live colonies of *Porites lutea* on sand or sandy pavement on the reef flat; 22 August 1992.

REMARKS: Specimens were variable in color. Some were rough to touch, gray, banded transversely in black, with yellow tentacles and papilliar tips. Others were light brown and banded in dark brown, and a few were purplish brown and lacked distinct stripes.

?*Holothuria* sp.

VOUCHER SPECIMEN: None.

REMARKS: One specimen was seen at <1 m depth on sand under a coralline rock on the outer reef flat at Sialat. It was smooth, light gray, ca. 15 cm long, with light gray peltate tentacles and tube feet (arrangement uncertain). It readily ejected numerous fine Cuvierian tubules when handled.

Genus *Labidodemas* Selenka, 1867

Labidodemas semperianum Selenka, 1867

Labidodemas semperianum Selenka 1867:309, pl. 17 figs. 1-3; Clark and Rowe, 1971:176-177, pl. 28 fig. 12; Rowe and Doty, 1977:230, figs. 3b, 5g.

UGI 5764, 1 specimen, Sialat, <1 m depth during the day on sand under coralline rock on the outer reef flat; 22 August 1992.

REMARKS: This species was seen only at Sialat. This species has been found on Guam

(Rowe and Doty 1977) and Eniwetak, Marshall Islands (Cutress and Rowe 1986), in Micronesia.

Genus *Pearsonothuria* Levin, Kalinin & Stonik, 1984

Pearsonothuria graeffei (Semper, 1868)

Holothuria graeffei Semper, 1868:78, pl. 30 fig. 9a-b.

Bohadschia graeffei, Clark and Rowe, 1971:176-177, pl. 27 fig. 7; Rowe and Doty, 1977:229, figs. 2g, 6e.

Pearsonothuria graeffei, Levin et al., 1984:33-38, figs. 1-2; Cherbonnier, 1988:49-50, fig. 17a-f.

VOUCHER SPECIMEN: None.

REMARKS: This species was an uncommon inhabitant of the reef slope from 10 to at least 30 m depth, where it was seen on sand or coralline rock between live coral colonies. *Pearsonothuria graeffei* has been recorded from the Red Sea (Clark and Rowe 1971), westward to Guam (Rowe and Doty 1977) in Micronesia.

Family STICHOPODIDAE

Genus *Stichopus* Brandt, 1835

Stichopus chloronotus Brandt, 1835

Stichopus (Perideris) chloronotus Brandt, 1835:50.

Stichopus chloronotus, Clark and Rowe, 1971:178-179, pl. 27 fig. 18; Cherbonnier, 1988:146-147, fig. 60a-o.

UGI 5765, 2 specimens, Leluh, <1 m depth at night exposed on sand on the inner reef flat; 1 July 1992.

REMARKS: This species occurs on the reef flat and reef front to depths of 10 m.

Stichopus horrens Selenka, 1867

Stichopus horrens Selenka, 1867:316, pl. 18 figs. 27-29; Clark and Rowe, 1971:178-179, 201, pl. 27 fig. 19; Rowe and Doty, 1977:227, figs. 2d, 6b; Cherbonnier, 1988:147-148, fig. 61a-p.

UGI 5766, 1 specimen, Leluh, < 1 m depth at night exposed on sand on the inner reef flat; 1 July 1992.

REMARKS: Individuals were usually gray to greenish gray, though one small, dull pink specimen was seen. This species was exposed only at night; it hid under coral and rocks during the day.

Genus *Thelenota* H. L. Clark, 1921

Thelenota ananas (Jaeger, 1833)

Trepang ananas Jaeger, 1833: 24, pl. 3 fig. 1.
Thelenota ananas, Clark and Rowe, 1971: 178–179, fig. 87a; Rowe and Doty, 1977: 227, figs. 2b, 5e; Cherbonnier, 1988: 152–153, fig. 63a–k.

VOUCHER SPECIMEN: None.

REMARKS: This species occurs on the reef slope from depths of 10 to at least 30 m.

Order DENDROCHIROTIDA

Family PHYLLOPHORIDAE

Genus *Afrocucumis* Deichmann, 1944

Afrocucumis africana (Semper, 1868)

Cucumaria africana Semper, 1868: 53, pl. 15 fig. 16.

Afrocucumis africana, Clark and Rowe, 1971: 182–183, fig. 95g, pl. 30 fig. 3; Rowe and Doty, 1977: 226, fig. 2a; Cannon and Silver, 1986: 32, figs. 2k, 8d.

UGI 5767, 3 specimens, Sialat, < 1 m depth during the day on rubble under coralline rocks on the outer reef flat; 1 July 1992.

REMARKS: This species was found attached to the undersides of loose rubble in the turbulent water near the reef margin.

Order APODIDA

Family SYNAPTIDAE

Genus *Euapta* Oestergren, 1898

Euapta godeffroyi (Semper, 1868)

Synapta godeffroyi Semper, 1868: 231, pl. 39 fig. 13.

Euapta godeffroyi, Clark and Rowe, 1971: 185–186, pl. 30 fig. 8; Rowe and Doty, 1977: 235–236, figs. 5c, 8h; Cherbonnier, 1988: 249–251, fig. 111a–j.

UGI 5793, 1 specimen, Sialat, reef flat under rock < 1 m depth; 17 June 1993.

REMARKS: One specimen was seen on rubble on the inner reef flat at Sialat.

Genus *Opheodesoma* Fisher, 1907

Opheodesoma grisea (Semper, 1868)

Figure 4e–f

Synapta grisea Semper, 1868: 11, pl. 4 figs. 6, 7.

Opheodesoma grisea, Clark and Rowe, 1971: 186–187, pl. 30 fig. 11; Rowe and Doty, 1977: 235, figs. 5d, 8g; Cherbonnier, 1988: 244–246, fig. 109a–f.

UGI 5768, 1 specimen, Leluh, < 1 m depth at night in branches of live coral on the inner reef flat; 1 July 1992.

REMARKS: This and uncollected specimens were seen at night entwined and feeding among the branches of the live corals *Psammocora* and *Pavona*.

Genus *Synapta* Eschscholtz, 1829

Synapta maculata (Chamisso & Eysenhardt, 1821)

Holothuria maculata Chamisso and Eysenhardt, 1821: 352, pl. 25.

Synapta maculata, Clark and Rowe, 1971: 186–187, pl. 30 fig. 9; Rowe and Doty, 1977: 234–235, figs. 5a, 8e; Cherbonnier, 1988: 107–108, fig. 43a–k.

VOUCHER SPECIMEN: None.

REMARKS: One specimen of a *Synapta* sp. was seen during the day on coralline rubble on the inner reef flat at Sialat. This individual was provisionally identified as *S. maculata* based on the animal's previous record on Kosrae (Eldredge et al. 1979) and its widespread distribution in the western Pacific (Clark and Rowe 1971).

Family CHIRIDOTIDAE

Genus *Chiridota* Eschscholtz, 1829*Chiridota rigida* Semper, 1868

Figure 4d

Chiridota rigida Semper, 1868: 18, pl. 3 fig. 3, pl. 5 figs. 3, 13, pl. 6 fig. 4, pl. 8 fig. 14; Clark and Rowe, 1971: 188–189, pl. 13 fig. 9; Rowe and Doty, 1977: 234, figs. 4h, 8d; Cannon and Silver, 1986: 43, fig. 8k.

UGI 5769, 1 specimen, Sialat, < 1 m depth during the day partially buried in sand under coralline rock on the outer reef flat; 21 August 1992.

REMARKS: Spicule and tentacle morphology of this specimen are within the range described for *C. rigida* by Heding (1928) and Semper (1868).

DISCUSSION

Of the 28 species of holothuroids now reported from Kosrae, 11 are new records for the island. Two species, *Holothuria edulis* and *H. moebii*, previously reported from Kosrae (Eldredge et al. 1979), were not found during this survey. Most species in this census are widely distributed in the Indo-West Pacific region. *Holothuria coluber*, however, is only reported from the Australo-Malayan region and the Philippines (Clark and Rowe 1971). Previously, *Pearsonothuria graeffei* was known from the Pacific Ocean only as far eastward as Guam (Rowe and Doty 1977).

The distribution of holothuroids on Kosraean reef flats was similar to that found on other fringing and seaward atoll reefs in the western Pacific. Patterns of holothuroid abundance are often associated with the presence of certain physiographic zones on coral reefs (Levin 1979, Kerr et al. 1993), probably because microhabitats are clustered within those areas (Sloan 1979, 1982). The distributions of common taxa on Kosrae were also associated with reef zonation (Figure 2). *Actinopyga mauritiana*, *Afrocucumis africana*, and *H. difficilis* were concentrated along the outer reef-flat margin; other species inhabited less-turbulent areas of the reef flat. The cryptic

holothuroids *H. coluber*, *H. hilla*, *H. impatiens*, *H. pervicax*, and *Stichopus horrens* were limited to portions of the reef flat with rubble or coral colonies. *Holothuria atra* is the most common holothuroid on shallow reefs in the western Pacific Ocean (Lawrence 1979, Massin and Doumen 1986, Kerr et al. 1993). This holothuroid also composed 92.1% of the enumerated individuals on Kosrae. By contrast, the next two most abundant species, *H. difficilis* and *H. hilla*, composed only 6.1 and 0.8% of the individuals, respectively.

The holothuroid community at Okat appeared to have changed little since the construction of an airport runway across the reef in 1980. *Holothuria atra* and *H. hilla* were the two most abundant holothuroids recorded during a survey of the reef flat in 1978 (Eldredge et al. 1979) and were also dominant in the study reported here (Table 1).

Community diversity is a function of several factors, including habitat area (Abele 1984). In the study reported here, species richness varied considerably between the sampled locations and was significantly positively correlated with reef-flat width (Figure 3). This relationship is perhaps a result of the wider reef flats at Sialat and Leluh providing more protection from recent typhoon-generated waves (USNOCC/JTWC 1991) and more microhabitats than the narrower reefs. I was, however, unable to sample the widest reef flats (to 1.6 km) between Foko Kiul and Foko Saoksa and, thus, determine if the correlation had an asymptote.

Kosrae had low densities of commercially valuable holothuroids (Table 2), and, therefore, there appears to be little opportunity to develop an industry based on this resource. The most abundant marketable variety was *A. mauritiana*. Other, more-desirable taxa were considerably less numerous. Two of these, *H. nobilis* and *Thelenota ananas*, are relatively common on other islands with moderately inclined reef slopes or in lagoons on coarse coralline sand (Conand 1981, Kerr et al. 1993). These two species may not prefer the steep, rocky reefs surrounding Kosrae. The abundance of *H. scabra*, another marketable species, may be greater than reported here, because I did not investigate the extensive

seagrass beds, a preferred habitat of this species (Cannon and Silver 1986, Vandenspiegel et al. 1992), on the reef flats between Foko Kiul and Foko Saoksa (Figure 1).

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