

## The Asteroidea, Echinoidea, and Holothuroidea (Echinodermata) of the Mariana Islands

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**Abstract**— The asteroid, echinoid, and holothuroid faunas of the Mariana Islands are reviewed and 35, 53, and 47 species recorded, respectively. Four asteroids, 28 echinoids, and 9 holothuroids are newly recorded for the archipelago. Together with 21 crinoids (Kirkendale & Messing 2003) and 47 ophiuroids (Starmer 2003), the echinoderm fauna of the archipelago now stands at 202 species, with 196 of these known from Guam. That 41% of the echinoderms of the Marianas were hitherto undocumented demonstrates how poorly known even these large, popular, and much-studied marine invertebrates are in the tropical Pacific, even at extensively surveyed locations such as Guam. *Holothuria guamensis* Quoy & Gaimard, 1833 is placed in synonymy of *Actinopyga mauritiana* (Quoy & Gaimard, 1833).

### Introduction

The Mariana Islands are a chain of 15 major volcanic and limestone islands bordering the western margin of the Pacific plate between 13°N and 21°N latitude (see Paulay 2003 for a more detailed description of the area). The archipelago is a classic island arc, formed by volcanic eruptions initiated by subduction of the Pacific plate under the Philippine plate, on which the islands lie. The island group comprises two geologically distinct chains, the volcanically inactive and older islands of the Southern Mariana back-arc, extending from Guam to Farallon de Medinilla, and the volcanically active, younger islands of the Northern Mariana fore-arc, extending from Anatahan to Uracas. This geological separation should not be confused with the political division of the archipelago into the U.S. Territory of Guam, and the Commonwealth of the Northern Mariana Islands (CNMI) comprising all islands north of Guam.

The Southern Marianas were initiated ~43 Ma when the Pacific plate abruptly shifted spreading from NW to WNW; the archipelago has had a complex geological history since. The southern islands are composed of mixed volcanics and uplifted limestones. Volcanic shorelines are uncommon while karstic shores dominate. Limestone cliffs characterize large tracts of shore, and

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reefs are generally narrow. Large sections, especially along windward shores, lack reef protection, so that steep fore reefs abut limestone cliffs, often fronted with supratidal limestone benches. Shores elsewhere are fronted by narrow, largely intertidal reef flats or shallow, moderately wide (100-1000 m) fringing reefs. Deep moat and lagoonar habitats are uncommon, the only significant ones being Apra Harbor and Cocos lagoon on Guam, and Tanapag-Garapan lagoon on Saipan. Only Apra Harbor has substantial lagoonal habitats >10 m deep. Subtidal habitats are dominated by oligotrophic reefs. Limestones fronting and underlying recent reefs are riddled by caves and caverns both above and below water. Although marine caverns and crevices are fairly common, they are generally of limited horizontal extent. Large blocks fallen from cliff faces provide additional wall and crevice habitats.

The echinoderms of Guam have become fairly well known over the years, as these large and conspicuous animals have been popular subjects for a variety of biological studies. The first written record is by Quoy & Gaimard (1833), who described *Holothuria guamensis* (comment 20) and noted five holothurian species from the island. Brandt (1835) described *Holothuria maculata* (comment 28) from Guam soon after. A few echinoderms were recorded from Guam early in the 20<sup>th</sup> century, although some apparently erroneously (comment 29), after Guam passed into US hands (Fisher 1919, Clark 1920). Following World War II, Clark (1954) and Cloud (1959) reported on a number of species from Guam and Saipan. Numerous studies followed after the establishment of the University of Guam and the Marine Laboratory, especially in wake of a large outbreak of crown of thorns sea stars that devastated Guam's reefs in 1967. A major research effort on *Acanthaster* followed (see Eldredge 2003 for a brief historical review), that documented the outbreak and its impact on reef communities (Chesher 1969, Randall 1973a, 1973b, 1973c, Colgan 1987), and explored potential causes (Birkeland 1981, 1982), as well as *Acanthaster* life history (Yamaguchi 1973a, 1973b, 1974a, Cheney 1974), physiology (Yamaguchi 1974c), and control (Cheney 1973). Other echinoderms also received increasing attention, including life history (e.g. Yamaguchi 1974b, 1977a, 1977b, 1977c), ecological (e.g. Kropp 1982, Kerr et al. 1993), ecotoxicological (e.g. Rideout 1975, Heslinga 1976), and molecular genetic (e.g. Palumbi et al. 1997, Palumbi 1999, Williams 2000) studies.

Masashi Yamaguchi's extensive research on the life history of Guam's asteroids also led to a faunistic review of the class (Yamaguchi 1975a). Frank Rowe's visit to Guam led to a review of holothuroid fauna, a paper that served as a popular introduction to holothurian taxonomy in the Pacific for years, by virtue of numerous color plates it offered (Rowe & Doty 1977). The crinoids of Guam were briefly reviewed by Meyer & Macurda (1980). The echinoderms of Guam were checklisted in "A working list of marine organisms from Guam" (UOGML 1981), and numerous new records added subsequently by Kerr et al. (1992). Kirkendale & Messing (2003) and Starmer (2003) review the crinoids and

ophiuroids of the island in this volume, while this paper covers the remaining three echinoderm classes.

### Methods

This checklist is based on literature records and new collections. Most records are from Guam, although I added records from other Mariana Islands as encountered. Most species recorded in the literature were redocumented with new collections or photographs. New records and observations are based on both informal and formal biodiversity surveys. Informal surveys were carried out between 1991 and 2000 around Guam. Four formal biodiversity surveys were carried out, three for COMNAVMARIANAS (U.S. Department of Defense): at Apra Harbor (Paulay et al. 1997), southern Orote – North Agat Bay area (Paulay et al. 2001), and Puguia Patchreef (“Double Reef”) – Haputo area (Amesbury et al. 2001), and one funded by Sea Grant focused on non-indigenous species (Paulay et al. 2002). Most newly encountered species were photodocumented and collected. Vouchers were deposited in the University of Guam Invertebrate collections (UGI), Florida Museum of Natural History, University of Florida (UF), the California Academy of Sciences (CAS), and the US National Museum of Natural History (USNM). Photo vouchers are by Gustav Paulay (GP numbers, housed at the Florida Museum of Natural History), Robert F. Myers (RFM numbers), and John Starmer (JS numbers). Cited photographs (Appendix 1) are available online at <http://www.flmnh.ufl.edu/reefs>; they are also available on the Marine Biodiversity of Guam CD-ROM co-publication.

### Results and Discussion

Thirty-five asteroids, 53 echinoids and 47 holothuroids are recorded from the Marianas (Table 1, Appendix 1). Together with 21 crinoids (Kirkendale & Messing 2003) and 47 ophiuroids (Starmer 2003), the echinoderm fauna of the archipelago now stands at 202 species, with 196 of these known from Guam. This is more than double the 96 species recorded from Guam by the last checklist (UOGML 1981). Considering all literature records and changes in species status and identifications (see Appendix 1), 83 species represent new records for the region. New records are especially prevalent among small and cryptic taxa such as ophiuroids and irregular echinoids; 57% of all new records pertain to these groups. However large and conspicuous animals, such as species of *Chondrocidaris*, *Phyllacanthus*, *Leiaster*, *Echinaster*, *Thelenota*, and *Holothuria* are also among the new records.

Other than reef corals, which have been extensively surveyed on Guam over several decades by Randall (2003), echinoderms are probably the best known group of marine invertebrates on Guam. They qualify as charismatic megafauna among invertebrates and have received attention from numerous resident as well as visiting scientists at the University of Guam Marine Lab. The fact that 41% of

even this fauna has gone unrecorded until now, at one of the most thoroughly surveyed locations in the tropical Pacific, strikingly demonstrates our lack of knowledge of marine biodiversity. The necessarily brief taxonomic work that accompanied this checklist uncovered numerous taxonomic and nomenclatural issues, some of which are briefly mentioned as comments below Appendix 1. These show, that just as our exploratory knowledge of marine invertebrate biodiversity is inadequate, knowledge of already described diversity also is limited, even in this supposedly well known invertebrate taxon. Accurate identification of numerous species remain difficult or impossible, until revisionary treatments using morphological and genetic characters are completed.

Table 1. Echinoderm species richness

	Marianas	Guam	New records	% new
Asteroidea	35	33	4	11
Echinoidea	53	52	28	53
Holothuroidea	46	46	9	20
Crinoidea	21	18	14	67
Ophiuroidea	47	47	28	60
Total	202	196	83	41

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Appendix 1. Echinoderms of the Marianas

Voucher: specimens deposited at BPBM: Bernice P. Bishop Museum, Honolulu, CAS: California Academy of Sciences, UF: Florida Museum of Natural History, University of Florida, Gainesville, UGI: University of Guam Invertebrate Collections, USNM: US National Museum of Natural History, Washington DC

Refs: references listed at end of Appendix

Photo: vouchers by GP: Gustav Paulay, RFM: Robert F. Myers, and JS: John Starmer are available online at: <http://www.flmnh.ufl.edu/reefs>, and in the Marine Biodiversity of Guam CD-ROM co-publication.

Notes: listed at end of Appendix

D: depth: 1) marine, 0-60m, 2) marine, 60-200m, 3) marine, >200m

Is: island codes: Ag: Agrihan, Al: Alamagan, An: Anatahan, As: Asuncion, G: Guam, Gu: Guguan, M: Maug, P: Pagan, R: Rota, S: Saipan, Sa: Sarigan, T: Tinian, U: Uracas.

Taxon	Voucher	Refs	Photo	Notes	D	Is
ASTEROIDEA: ASTROPECTINIDAE						
<i>Astropecten polyacanthus</i> Müller & Troschel, 1842	UF 838, CAS 117906	1, 2, 3, 4	GP235-28	1	1	G
ASTEROIDEA: OREASTERIDAE						
<i>Bothriaster primigenius</i> Döderlein, 1916	USNM E47784, UF 169, CAS 106988, UGI 275	1, 2, 3, 5	GP839-16	1, 2	1	G
<i>Choriaster granulatus</i> Lütken, 1869	USNM E15878, CAS 108827, UGI 1189	1, 2, 3, 4	GP775-11		1	G
<i>Culcita novaeguineae</i> Müller & Troschel, 1842	USNM E49090, UF 369, CAS 117066, UGI 28	1, 2, 3, 4, 5, 6(S), 7, 8	GP775-12		1	G, S
<i>Pentaceraster</i> cf. <i>multispinus</i> (van Martens, 1866)	USNM E7716, UF 1251	1, 2, 3, 5, 9	RFM-194b, JS Mvc-007 (S)	1, 3	1	G, S
ASTEROIDEA: GONIASTERIDAE						
<i>Mediaster ornatus</i> Fisher, 1906	USNM E15871, UF 839, CAS 108821, UGI 1197	Y			3	G
ASTEROIDEA: OPHIDIASTERIDAE						
<i>Cisrina columbae</i> Gray, 1840	USNM E16434, UF 853, CAS 107017, UGI 280	1, 2, 3, 4	GP533-3		1	G
<i>Dactylosaster cylindricus</i> (Lamarck, 1816)	USNM E15864, CAS 107023, UGI 281	2, 3, 4			1	G

Appendix 1. Echinoderms of the Marianas / (continued)

Taxon	Voucher	Ref	Photo	Note	D	Is
<i>Fromia milleporella</i> (Lamarck, 1816)	USNM E15866, UF 828, CAS 108823, USNM E7865(S), UGI 271	1, 2, 3, 4, 5(S), 6(S)	GP516-12	4	1	G, S
<i>Fromia nodosa</i> A.M. Clark, 1967	USNM E47753, UF 153, UGI	1?, 2, 3, 4?	GP746-14	5	1	G
<i>Gomophia egyptiaca</i> Gray, 1840	USNM E15865, UF 860, CAS 106929, UGI 1111	1, 2, 3, 4, 11	GP515-32	6	1	G
<i>Heteronardoa carinata?</i> (Koehtler, 1910)	UF 826(R)	10		36	2	R
<i>Leiaster glaber</i> (Petets, 1852)	UF 1252	P	GP469-9	7	1	G
<i>Leiaster leachii</i> (Gray, 1840)	USNM E15881, UF 854(S), CAS 108836, UGI 1107	1, 2, 3, 4	GP582-23	7	1	G, S
<i>Linckia guildingi</i> Gray, 1840	USNM E15870, UF 843, CAS 117159, USNM E7866(S), UGI 214	1, 2, 3, 4, 6(S), 12	GP588-24	8, 16	1	G, S
<i>Linckia laevigata</i> (Linnaeus, 1758)	USNM 40409, UF 842, CAS 106964, UGI 2130	1, 2, 3, 4, 5, 6(S), 7, 12, 13, 14, 15, 16, 17, 18(P), 19	GP515-16, RFM 194a	9, 16	1	G, P
<i>Linckia multifora</i> (Lamarck, 1816)	USNM 40184, UF 553, CAS 106692, USNM E37233(S), UGI 45	1, 2, 3, 4, 5(S), 6(S), 12, 13, 18(Gu, P, Sa), 20	GP253-19	10, 16	1	G, Gu, P, Sa,
<i>Neoferdina cumingi</i> (Gray, 1840)	UF 437, UGI 222	1, 2, 3, 4	GP692-9		1	G
<i>Ophidiaster cribrarius</i> Lütken, 1871	USNM E15886, UF 863, CAS 107012, UGI 1122	1, 2, 3, 4		11	1	G
<i>Ophidiaster duncani</i> de Loriol, 1885	UF 846, UGI 6144	M	GP523-10		1	G
<i>Ophidiaster granifer</i> Lütken, 1872	USNM E15875, UF 856, CAS 107026, UGI 1175	1, 2, 3, 4, 21	GP776-29		1	G
<i>Ophidiaster hembrichii</i> Müller & Troschel, 1842	USNM E14041, UF 1152, CAS107024, UGI 226	1, 2, 3, 4, 5	GP-408-26	12	1	G
ASTEROIDEA: ASTEROPSEIDAE						
<i>Asteropsis carinifera</i> (Lamarck, 1816)	USNM E15876, UF 841, CAS 117081, UGI 6106	1, 2, 3, 4, 5	GP521-10	18	1	G
<i>Vahvaster striatus</i> (Lamarck, 1816)	UF 163, UGI 5718	9	GP411-5		1	G

Appendix 1. Echinoderms of the Marianas / (continued)

Taxon	Voucher	Ref	Photo	Note	D	Is
ASTEROIDEA: ASTERINIDAE						
<i>Asterina anomala</i> (H.L. Clark, 1921)	USNM E15884, UF 678, UGI 223	1, 2, 3, 4	GP396-22		1	G
<i>Asterinides cepheus</i> (Müller & Troschel, 1842)	USNM E15861, UF 894, CAS 107014, UGI 244	1, 2, 3, 4	GP692-27	13	1	G
<i>Disasterina</i> sp. 1 (n. sp.)	USNM E7801, UF 1253	5(S), 6(S), M	GP527-18	14	1	G, S
<i>Nepanthia briareus</i> (Bell, 1894)	UF 840(S), UGI 1195	10	GP753B-16		2	G, T
<i>Nepanthia</i> sp. 1 (aff. <i>maculata</i> Gray, 1840)		10			2	S
ASTEROIDEA: ACANTHASTERIDAE						
<i>Acanthaster planci</i> (Linnaeus, 1758)	USNM E14041, UF 835, CAS 102172, UGI 240	1, 2, 3, 4, 7, 18(P), 22, 23(G,S)	GP742-25	16, 37	1	G, P
ASTEROIDEA: MITHRODIIDAE						
<i>Mithrodia clavigera</i> (Lamarck, 1816)	USNM E15873, UF 830(S), CAS 106970, UGI 253	1, 2, 3, 4	GP516-14		1	G, S
<i>Thromidia catalai</i> Pope & Rowe, 1977	UF 370, BPBM W2507 (paratype)	4, 45	GP337-8		1	G
ASTEROIDEA: ECHINASTERIDAE						
<i>Echinaster callosus</i> von Marenzeller, 1895	UF 426	P	GP648-13		1	G
<i>Echinaster luzonicus</i> (Gray, 1840)	USNM E15882, UF 676, CAS 108828, USNM E7798(S), UGI 313	1, 2, 3, 4, 5(S), 6(S)	GP650-7	19	1	G, S
ASTEROIDEA: SPHAERASTERIDAE						
<i>Podosphaeraster pulvinatus</i> Rowe & Nichols, 1980	BPBM W2813 (holotype)	4, 10, 24, 25		15	3	G
ECHINOIDEA: CIDARIDAE						
<i>Actinoidaris</i> sp. 1 (n. sp.)	UF 719	P	GP409-1		1	G
<i>Chondrocidaris brevispina</i> (H.L. Clark, 1925)	UF 720	P	GP337-10		1	G
<i>Chondrocidaris gigantea</i> A. Agassiz, 1863	UF 143	9			1	G
<i>Euclidaris metularia</i> (Lamarck, 1816)	USNM E25660, UF 137, CAS 108829, UGI 2905	4, 5, 18(An), 26	GP382-8	16	1	An, G
<i>Phyllacanthus imperialis</i> (Lamarck, 1816)	USNM E32097, UF 367, CAS 108831, UGI 6137	P	GP389-13		1	G
ECHINOIDEA: DIAEMATIDAE						
<i>Centrostephanus</i> sp. 1	UF 1147	P	GP580-31		1	G

Appendix 1. Echinoderms of the Marianas / (continued)

Taxon	Voucher	Ref	Photo	Note	D	Is
<i>Diadema savignyi</i> Michelin, 1845		4, 7, 27, 28, 29	GP376-11	16	1	G
<i>Diadema setosum</i> (Leske, 1778)		4, 6?(S), 28, 29, 27	GP531-24	16	1	G, S
Diademataidae sp. 1	UF 1143	M			3	G
<i>Echinothrix calamaris</i> (Pallas, 1774)	USNM E27475, CAS 108770, UGI 2052	4, 27	GP596-27	16	1	G
<i>Echinothrix diadema</i> (Linnaeus, 1758)	USNM E27314	4, 5(G, S), 6(S), 14, 18(P), 28	GP648-26		1	G, P, S
<i>Lissodiadema lorioli</i> Mortensen, 1903	UF 199, CAS 161285, UGI 6675	M	GP816-5		1	G
ECHINOIDEA: TEMNOPLURIDAE						
<i>Mespilia globulus</i> (Linnaeus, 1758)	USNM E32083, UF 434, CAS 99732, UGI 4 1981				1	G
ECHINOIDEA: TOXOPNEUSTIDAE						
<i>Cyrtechinus verruculatus</i> (Lütken, 1864)	USNM E41797, UF 1080	P	GP646-19		1	G
<i>Nudechinus</i> sp. 1	CBM-ZE-31(Ag)	18(Ag)			1	Ag
<i>Pseudoboletia maculata</i> Troschel, 1869	UF 435, CAS 81252, UGI 1975	9	GP384-18		1	G
<i>Toxopneustes pileolus</i> (Lamarck, 1816)	UF 1141, UGI 2902	4	GP325-31		1	G
<i>Tripneustes gratilla</i> (Linnaeus, 1758)	USNM E41803, UGI 2412	4, 5, 6(S)	GP384-22		1	G, S
ECHINOIDEA: PARASALENIIDAE						
<i>Parasalenia gratiosa</i> A. Agassiz, 1863	USNM E32084, UF 1081, UGI 2413	9			1	G
<i>Parasalenia poehlili</i> Pfeffer, 1887	UF 151, UGI 6250	P	GP411-8		1	G
ECHINOIDEA: ECHINOMETRIDAE						
<i>Colobocentrotus mertensi</i> Brandt, 1835	USNM, UF 268, UGI 2015	5(G, S), 6(S), 18(Ag, Al, An, As, Gu, M, P, U)	GP583-11		1	Ag, Al, An, As, G, Gu, M, P, U, S
<i>Echinometra mathaei</i> (de Blainville, 1825)	USNM, UGI 1976	18(Ag, P), 28, 31	GP826-29	16, 17	1	Ag, G, P
<i>Echinometra oblonga</i> (de Blainville, 1825)	UF 156, UGI 6251	4, 34	GP843-12	17	1	G
<i>Echinometra</i> sp. A	USNM, UGI 1971	18(An, P), 30	GP578-20	16, 17	1	An, G, P
- <i>Echinometra mathaei</i> -complex (including 3 species above)		4, 5(G, S), 6(S), 7, 14, 32		17	1	G, S
<i>Echinostrephus aciculatus</i> A. Agassiz, 1863	USNM, UF 168, UGI 6249	4	GP781-13		1	G

Appendix 1. Echinoderms of the Marianas / (continued)

Taxon	Voucher	Ref	Photo	Note	D	Is
<i>Heterocentrotus mammillatus</i> (Linnaeus, 1758)	USNM E25721, UF 366	4, 5(S), 6(S)	GP648-27		1	G, S
<i>Heterocentrotus trigonarius</i> (Lamarck, 1816)	USNM E42782, UF 430, UGI 1969	5	GP615-31		1	G
ECHINOIDEA: ECHINOIDEAE						
<i>Echinoneus abnormalis</i> de Loriol, 1883	UF 267, UF 577(S), UGI 6676	P			1	G
<i>Echinoneus cyclostomus</i> Leske, 1778	USNM E37479, UF 139, CAS 118039, UGI 6668	4			1	G
ECHINOIDEA: CLYPEASTERIDAE						
<i>Clypeaster reticulatus</i> (Linnaeus, 1758)	USNM E35976, UF 141, CAS 117083, UGI 1988	4	GP523-26		1	G
	UF 1154	M			2	G
ECHINOIDEA: LAGANIDAE						
<i>Laganum</i> sp. 1	UF 820	M			2	G
<i>Peronella macroproctes</i> Koehler, 1922	USNM E36033, UF 810, CAS 161287	M			1	G
<i>Peronella minuta</i> (de Meijere, 1904)	UF 1153	M			1	G
ECHINOIDEA: FIBULARIIDAE						
<i>Echinocyamus crispus</i> Mazzetti, 1893	USNM E35779, CAS 108767, UF 803, UGI	M			1, 2	G
<i>Echinocyamus elongatus</i> H.L. Clark, 1914	USNM 38204, UF 1151	M			1, 2	G
<i>Echinocyamus megapetalus</i> H.L. Clark, 1914	UF 440, UF 439(T), UGI 6252	M			1	G
<i>Fibularia ovulum</i> Lamarck, 1816	USNM E35819, UF 687, UGI 2024	M			1	G
<i>Mortonia australis</i> (Desmoulins, 1835)	CAS 108769, UF 1147, UGI 1997	M	GP408-18		1	G
ECHINOIDEA: PERICOSMIDAE						
<i>Pericosmus</i> sp. 1	CAS 161283	M			2	G
ECHINOIDEA: SCHIZASTERIDAE						
<i>Paraster</i> cf. <i>compactus</i> Koehler, 1914	UF 1145	M			2	G
<i>Paraster gibberulus</i> (L. Agassiz, 1847)	UF 442, UGI 6720	P			1	G
<i>Prymnastr investigatoris</i> Koehler, 1914	UF 201	M	GP842-18		1	G
ECHINOIDEA: BRISSIDAE						
Brissidae sp. 1 (aff. <i>Rhynobrissus hemiasteroides</i> A. Agassiz, 1879)	UF 198	M	GP522-34		1	G
<i>Brissopsis</i> sp. 1	UF 1146, CAS 161284	M			2	G
<i>Brissus agassizii</i> Döderlein, 1885	UF 433	P			1	G

Appendix 1. Echinoderms of the Marianas / (continued)

Taxon	Voucher	Ref	Photo	Note	D	Is
<i>Brissus latecarinatus</i> (Leske, 1778)	USNM E37478, UF 259, UGI 2030	4, 14			1	G
<i>Eupatagus rubellus</i> Mortensen, 1948	UF 146, CAS 161282	P	GP842-19		1, 2	G
<i>Metalia dicrana</i> H.L. Clark, 1917	UF 181, CAS 81225, UGI 2039	9, 14, 35	GP541-7		1	G
<i>Metalia spatagus</i> (Linnaeus, 1758)	USNM E37477, UF 176, UGI 2034	4, 5, 14	GP540-27		1	G
ECHINOIDEA: SPATANGIDAE						
<i>Marelia planulata</i> (Lamarck, 1816)	USNM E43011, UF 1138, CAS 86760, UGI 6669	9, 35, 36	GP416-22		1	G
<i>Nacospatangus?</i> sp. 1	UF 1149	M			2	G
ECHINOIDEA: CASSIDULIDAE						
<i>Oligopodia epigonus</i> (van Martens, 1865)	UF 813	M			2	G
HOLOTHUROIDEA: STICHOPODIDAE						
<i>Stichopus chloronotus</i> Brandt, 1835	USNM E24585, UGI 2304	4, 14, 37, 38, 39, 46	GP378-28		1	G
<i>Stichopus horrens</i> Selenka, 1867	USNM E32417, UF 1136, UGI 2299	4, 37, 38, 39	GP648-24		1	G
<i>Stichopus monotuberculatus?</i> (Quoy & Gaimard, 1833)	USNM E24500	P		22	1	G?
<i>Stichopus noctivagus</i> Chéronnier, 1980	UF 1142	9, 40	GP223-3		1	G
<i>Thelenota ananas</i> (Jaeger, 1833)	UGI 2362	4, 37, 39	GP378-20		1	G
<i>Thelenotaanax</i> H. L. Clark, 1921	UGI 6681	4, 37, 39	GP380-9		1	G
<i>Thelenota rubralineata</i> Massin & Lane, 1991	UGI 6681	P	GP229-6	23	1	G
HOLOTHUROIDEA: HOLOTHURIIDAE				39		
<i>Actinopyga echinites</i> (Jaeger, 1833)	USNM E51767, UF 1139, UGI 2406	4, 37, 39	GP578-8		1	G
<i>Actinopyga mauritiana</i> (Quoy & Gaimard, 1833)	USNM E16720, UGI 210	4, 37, 39, 41, 42, 46	GP648-29	20	1	G
<i>Actinopyga palauensis</i> Panning, 1944	UF 237, UGI 5752	9, 39	GP648-11	24	1	G
<i>Bohadschia argus</i> Jaeger, 1833	USNM E31584, UGI 2348	4, 14, 37, 39, 46	GP376-4	31	1	G
<i>Bohadschia marmorata</i> Jaeger, 1833-complex	USNM E51759, UGI 2349	4, 37, 39	GP838-32	25	1	G
<i>Holothuria (Cystipus) rigida</i> (Selenka, 1867)	UF 183, UGI 2310	4, 37, 39	GP534-22		1	G
<i>Holothuria (Halodeima) atra</i> Jaeger, 1833	USNM E16601, UGI 2343	4, 6(S), 14, 37, 38, 39, 46	GP578-29		1	G, S
<i>Holothuria (Halodeima) edulis</i> Lesson, 1830	USNM E16602, UGI 2373	4, 37, 46	GP774-36		1	G
<i>Holothuria (Halodeima) signata</i> Ludwig, 1875	UF 173	P	GP823-35		1	G

Appendix 1. Echinoderms of the Marianas / (continued)

Taxon	Voucher	Ref	Photo	Note	D	Is
<i>Holothuria (Lessonothuria) hawaiiensis</i> Fisher, 1907	UF 250	P	GP589-35		1	G
<i>Holothuria (Lessonothuria) lineata</i> Ludwig, 1875	USNM E32178, UF 205, UGI 2384	4, 37	GP772-8	27	1	G
<i>Holothuria (Lessonothuria) sp. 1</i>	UF 192	P	GP381-24		1	G
<i>Holothuria (Mertensiothuria) leucospilota</i> Brandt, 1867	USNM E16798, UGI 13	4, 14, 37, 39	GP577-11		1	G
<i>Holothuria (Metriatyla) scabra</i> Jaeger, 1833?	USNM E9937	44		29	1	G?
<i>Holothuria (Microthele) fuscopunctata</i> Jaeger, 1833	UGI 2316	37	GP739-24	26	1	G
<i>Holothuria (Microthele) nobilis</i> (Selenka, 1867)	USNM E51762?, UGI 5712	9, 39, 43		28	1	G
<i>Holothuria (Microthele) whitmaei</i> Bell, 1887	UGI 2325	4, 37, 39	GP541-11	30	1	G
<i>Holothuria (Platyperona) difficilis</i> Sempér, 1868	USNM E16797, UF 213, UGI 2326	4, 37, 39	GP820-28		1	G
<i>Holothuria (Platyperona) excellens</i> (Ludwig, 1875)	UGI 5723	9	GP654-23		1	G
<i>Holothuria (Semperothuria) cinerascens</i> (Brandt, 1835)	USNM E16681, UGI 2335	4, 37, 38, 39, 46	GP780-36		1	G
<i>Holothuria (Semperothuria) flavomaculata</i> Sempér, 1868	USNM E32424, UGI 2368	9	GP521-30		1	G
<i>Holothuria (Staur-opora) pervicax</i> Selenka, 1867	USNM E24550, UF 193, UGI 2345	4, 37, 39	GP578-23		1	G
<i>Holothuria (Theleothuria) turriscelsa</i> Cherbonnier, 1980	USNM E51769, UGI 5720	9	GP648-12		1	G
<i>Holothuria (Thymiosycia) arenicola</i> Sempér, 1868	USNM E16796, UGI 2387	4, 37	GP399-17		1	G
<i>Holothuria (Thymiosycia) hilla</i> Lesson, 1830	USNM E16680, USNM E16865(S), UF 1137, UGI 2386	4, 37, 38, 39, 46	GP390-22	38	1	G
<i>Holothuria (Thymiosycia) impatiens</i> (Forsskål, 1775)	USNM E17059, UF 185, UGI 2333	4, 37, 39, 46	GP391-32		1	G
<i>Labidodemas semperianum</i> Selenka, 1867	USNM E53083, UF 1134, UGI 20	4, 37	GP538-11		1	G



Appendix 1. Echinoderms of the Marianas / (continued)

Taxon	Voucher	Ref	Photo	Note	D	Is
<i>Pearsonothuria graeffei</i> (Semper, 1868)	USNM E51761, UGI 2338	4, 37	GP378-18	32	1	G
HOLOTHUROIDEA: SYNAPTIDAE						
<i>Euapta godeffroyi</i> (Semper, 1868)	USNM E32418, UF 1135, UGI 2359	4, 37, 39	GP390-30	1	1	G
<i>Ophiodesoma grisea</i> (Semper, 1868)	USNM E49114?, UGI 207	4, 37, 39	GP694-22	33	1	G
<i>Patinapta</i> sp. 1	UF 224, USNM E49122	P	GP865-34	1	1	G
<i>Polyplectana</i> sp. 2	UF 219, UGI 2374?	4, 37	GP401-24	34	1	G
<i>Polyplectana galathea</i> Heding, 1928	UF 152	P	GP401-19	34	1	G
<i>Synapta maculata</i> (Chamisso & Eysenhardt, 1821)	UGI 2363	4, 14, 37, 39	GP577-36	1	1	G
<i>Synapta</i> sp. 1	UF 218	P	GP585-35	1	1	G
HOLOTHUROIDEA: CHIRIDOTIDAE						
<i>Chiridota hawaiiensis</i> Fisher, 1907	UF 160, USNM E49120?, UGI 2361	4, 37, 39	GP534-22	21	1	G
<i>Chiridota violacea</i> Müller, 1850	UF 154	P			1	G
HOLOTHUROIDEA: CUCUMARIIDAE						
<i>Thyone okeni</i> Bell, 1884		4, 37		35	1	G
HOLOTHUROIDEA: PHYLLOPHORIDAE						
<i>Afrocuemmis africana</i> (Semper, 1868)	USNM E31702, USNM 31691(S), UF 225, UGI 2366	4, 37, 39	GP543-14	1	1	G

References: 1) Yamaguchi, 1973a, 2) Yamaguchi, 1975a, 3) Yamaguchi, 1977a, 4) UOGML 1981, 5) Clark 1954, 6) Cloud 1959, 7) Rupp 1973, 8) Yamaguchi 1977c, 9) Kerr et al. 1992, 10) Grigg & Eldredge 1975, 11) Yamaguchi 1974b, 12) Williams 2000, 13) Fisher 1919, 14) Yamaguchi 1975b, 15) Yamaguchi 1977b, 16) Rideout 1975, 17) Strong 1975, 18) Irimura et al. 1994, 19) Williams & Benzie 1998, 20) Rideout 1978, 21) Yamaguchi & Lucas 1984, 22) Birkeland & Lucas 1990, 23) Benzie 1992, 24) Rowe & Nichols 1980, 25) Rowe et al. 1982, 26) Lessios et al. 1999, 27) Lessios et al. 2001, 28) Neill 1988, 29) Pearse 1998, 30) Palumbi et al. 1997, 31) Palumbi 1999, 32) Heslinga 1976, 34) Arakaki & Uehara 1999, 35) Norris 1991, 36) Warén et al. 1994, 37) Rowe & Doty 1977, 38) Kropp 1982, 39) Kerr et al. 1993, 40) Erhardt & Baensch 1998, 41) Quoy & Gaimard 1833, 42) Hopper et al. 1998, 43) Brandt 1835, 44) Clark 1920, 45) Pope & Rowe 1977. ‘?’ following reference denotes uncertainty in identification in reference.

Notes:

- 1) Clark's (1954) record of *Protoreaster nodosus* was based on USNM E-7476 (Guam, Oca Point, DH Johnson! May 1945), a lot that included one specimen of *Bothriaster primigenius* (as already indicated by Yamaguchi 1977a: 287) and five specimens of *Pentaceraster* cf. *multispinus* (since split to USNM 47784). *Protoreaster nodosus* proper is unknown in the Marianas, although common in Palau.

- 2) Yamaguchi (1975a) noted that *Bothriaster primigenius* may represent the juvenile stage of *Choriaster granulatus*; this remains to be tested.
- 3) Identification of this uncommon species remains tentative. It was misidentified (in part, see note 1) as *Protoreaster nodosus* by Clark (1954), a record questioned, but perpetuated, by Yamaguchi (1973a, 1975a, 1977a) who did not encounter the species. It was listed as a “new record” under the name *Pentacaster alveolatus* by Kerr et al. (1992) and is currently identified (L. Marsh in litt.) as *P. cf. multispinus*. This species is rarely encountered on reef flats; all known specimens are relatively small (R<8 cm) for genus, and the color is typically off-violet.
- 4) Previously identified as *F. hemioplata* (Yamaguchi 1973a, 1975a, but not 1977a, UOGML 1981).
- 5) Yamaguchi’s (1973a, 1975a, 1977a) and UOGML’s (1981) *Fromia* sp. likely corresponds to this species, as only the two *Fromia* species listed have been seen on Guam in recent years.
- 6) The color pattern of animals from Guam (dark violet with pastel pink tubercles) is distinctive and may indicate cryptic geographic differentiation in this putatively widespread species. Endemic color morphs characterize several other insular populations.
- 7) Although already once revised (Jangoux 1980), *Leiaster* deserves further scrutiny, as more forms are discernible on the basis of field characters in the Pacific than there are named taxa.
- 8) Juvenile *L. guildingi* on Guam typically have 6 mottled, thin, often unequal arms and appear to frequently undergo asexual reproduction by fragmentation. They are further characterized by conspicuous patches of orange-peach-colored ampullae. These distinctive juveniles (see photo GP234-29) are genetically indistinguishable from the uniformly tan to brown adults (S.T. Williams pers. comm.). Yamaguchi (1975a, 1977a) differentiated juvenile (as *L. guildingi*) and adult (as *L. pacifica*) forms, although noted that they may be conspecific.
- 9) *Linckia laevigata* occurs in two forms on Guam, a typical blue form, usually encountered on reef flats and moats (rarely on the fore reef) and a grayish-brown, larger form found on the fore reef usually at 8-20m depths (distinguished as *Linckia* sp. by Yamaguchi (1975a, 1977a)). The two differ physiologically (Strong 1975), but they are genetically indistinguishable (Williams 2000 pers. comm.).
- 10) Williams (2000) found *L. multifora* to be genetically indistinguishable from sympatric *L. laevigata*. Her study included material from many areas of the Indo-west Pacific, including material from Guam for both forms. These results may reflect a) incomplete sorting since speciation, b) introgression, or c) that *L. multifora* and *L. laevigata* represent ecophenotypic variants of a single species (Williams 2000). In SE Polynesia typical *L. multifora* coexist with putative juvenile *L. laevigata* distinguishable by a more elongate shape and brownish rather than rust-red spotting. On Guam I have only seen the latter, “classic” *L. multifora* form. In the northern Mariana Islands typical *L. laevigata* appear to be absent, and *L. multifora* grows to a much larger size. The status of *L. multifora* needs further study.
- 11) As *O. tortoli* in Yamaguchi (1973a) and as *O. robillardi* in Yamaguchi (1975a, 1977a) and UOGML (1981).
- 12) As *Ophiaster pustulatus* in Clark (1954), and as *O. squameus* in Yamaguchi (1975) and UOGML (1981).
- 13) As *Asterina* sp. in Yamaguchi (1973a, 1975a) and UOGML (1981); transferred to *Asterinides* by O’Loughlin (2002).
- 14) The new species of *Disasterina* collected on Guam and identified by Marsh, was compared and appears to be conspecific with Clark’s (1954) specimen (USNM 7801) of “*Disasterina spinulifera*” from Saipan.
- 15) As *P. polyplax* in Grigg & Eldredge (1975)

- 16) Specimens from Guam have been included in molecular genetic studies of species, see: Benzie 1992, Palumbi et al. 1997, Palumbi 1999, Lessios et al. 1999, 2001, Williams 2000
- 17) Recent work on the morphology, genetics, reproductive biology, and ecology of Indo-West Pacific *Echinometra* has shown that it includes a complex of closely related and morphologically similar species, previously lumped under *Echinometra mathaei* or under *E. mathaei* and *E. oblonga* (Palumbi et al. 1997). Three species in this complex are known in the Marianas: *E. sp. A*, characterized by white-tipped spines, *E. mathaei*, characterized by uniformly pastel and needle-shaped gonadal spicules, and *E. oblonga*, characterized by dark spines. Literature records that do not differentiate among these species are listed under a separate generic entry for the species complex.
- 18) As *Asterope carinifera* in Clark (1954)
- 19) As *Othilia lizonica* in Clark (1954) and Cloud (1959)
- 20) Cherbonnier (1952), in his review of Quoy & Gaimard's holothurians, considered *Holothuria guamensis* Quoy & Gaimard, 1833 to likely pertain to *Holothuria nobilis* Selenka, 1867. In contrast Rowe & Doty (1977) concluded that *H. guamensis* is synonymous with *Actinopyga mauritiana* (Quoy & Gaimard, 1833), a species described in the same publication. Although the type specimen of *H. guamensis* is lost, Quoy & Gaimard's excellent figure leaves little doubt that the species is *A. mauritiana*. *Actinopyga mauritiana* is characteristically reddish-brown and white, although the color pattern is polymorphic, ranging from almost pure white to almost pure reddish-brown on the dorsum. Although predominantly white specimens like the one illustrated by Quoy & Gaimard, are not common, they are not rare either. The elongate reddish-brown extensions that reach toward the middorsal line in Quoy & Gaimard's figure are also typical of *mauritiana*. Although juvenile animals of the *Holothuria nobilis*-complex are variable in color, I have never seen them to be this color. The shape depicted in the figure also matches *mauritiana* and not "*nobilis*", in being more elongated and flexible (note curvature of specimen in figure) and in lacking both the mammillae of mature *nobilis*, as well as the sharp, projecting papillae that characterize juvenile *nobilis*. Finally *A. mauritiana* is one of the most common holothurians on Guam, while the *nobilis* complex is much less common, although this may not have been the case before the trepang fishery hit the island. I am not aware of any use of the binomen *Holothuria guamensis* as valid since 1899, and neither is Claude Massin (pers. comm.). In contrast the binomen *Actinopyga mauritiana* is in common usage. As first reviser I select *Holothuria mauritiana* Quoy & Gaimard, 1833 as the senior synonym, and *Holothuria guamensis* Quoy & Gaimard, 1833 as the junior synonym (ICZN code 24.2.2).
- 21) Specimens from Guam match *Chiridota hawaiiensis* Fisher, 1907 closely and much better than *C. rigida* Semper, 1868. Although these two taxa have often been considered synonymous, they appear to be specifically distinct. All previous literature records from Guam have treated this species as *C. rigida*.
- 22) This record is based on a single lot (USNM E24500), with no indication as to provenance other than "Guam". Both specimens in the lot pertain to the *Stichopus "variegatus"* complex, potentially to *S. monotuberculatus*. The only other record of this species complex that I am aware of in the Marianas is a specimen, that appeared to be *S. monotuberculatus*, collected by Alex Kerr on Guam in the early 1990's. A slide, but no specimen of this animal may be in the UGI collection (A. Kerr pers. comm.).
- 23) The single known specimen in the Marianas was collected at 60 m at night off the Glass Breakwater in 1992 by A. Kerr et al..

- 24) Identified as *A. obesa* in Kerr et al (1992, 1993). Rowe & Gates (1995) have synonymized *Actinopyga obesa palauensis* Panning, 1944 under *A. obesa* (Selenka, 1867). *Actinopyga obesa* was described from Hawaii, and presumably refers to the common chocolate brown, wrinkled *Actinopyga* common in, and apparently endemic to, these islands. Only one other *Actinopyga*, *A. mauritiana* in known in Hawaii. I have not yet examined Selenka's type, but if it indeed pertains to the Hawaiian species, then the synonymy with *A. palauensis* is in error. *Actinopyga palauensis* is larger, less narrow, nearly black and has a smooth surface.
- 25) *Bohadrschia marmorata* belongs to a poorly understood species complex (see Rowe & Doty 1977). At least two forms occur in Guam, differing in fine details of the color pattern; we plan to investigate their distinction using mtDNA sequences.
- 26) As *H. axiologa* in Rowe & Doty (1977), see Rowe & Gates (1995) for synonymy.
- 27) *Holothuria lineata* is generally confused with *H. pardalis* in the literature, but Rowe (pers. comm. and unpublished MS) now recognizes them as separate. The two are also distinguishable in Hawaii (C. Pitman pers. comm.). All specimens on Guam available to me pertain to *H. lineata*, differentiated by having tapering front and back ends, subdivided papillae and smaller buttons (F.W.E. Rowe pers. comm.). Rowe (pers. comm.) also considers his previous record of *H. pardalis* from Guam (Rowe & Doty 1977, UOGML 1981) to be this species.
- 28) *Holothuria maculata* Brandt, 1835 (not *Holothuria maculata* Chamisson & Eysenhardt, 1821), described from Guam, appears to pertain to *H. nobilis*, as does *H. fuscogilva* Cherbonnier, 1980 (the identification used by Kerr et al. 1992, 1993) (see Rowe & Gates 1995 for synonymy). Note also that previous records of *H. nobilis* now pertain to *H. whitemaei* (see comment 30).
- 29) Record based on USNM E9937, a single specimen labeled as collected by the Albatross on shore on Guam, 27 February 1900, and so reported by Clark (1920). I have examined the specimen and it is indeed *H. scabra*, a species otherwise not known from Guam. Three possibilities are that 1) the species is rare / episodic / hard to find on Guam, 2) has been extirpated on Guam, or 3) the specimen was mislabeled. *Holothuria scabra* is usually common where it occurs and largely confined to shallow reef flats and moats, so the first hypothesis is unlikely. It is sought after by the beche-de-mer trade, which thrived on Guam during the first part of the 20<sup>th</sup> century (Rowe & Doty 1977), thus the second possibility has some support. However I find the third hypothesis most compelling, because the Albatross left Guam on 25 February 1900 (L. Eldredge pers. comm.), or two days before the specimen was supposedly collected.
- 30) Previously recorded as *H. nobilis* (Rowe & Doty 1977, UOGML 1981, Kerr et al. 1993); see Rowe & Gates (1995) for lectotype designation that altered common useage of this name, and synonymy.
- 31) As *Holothuria argus* in Domantay (1954) and Yamaguchi (1975b).
- 32) Previously known (Rowe & Doty 1977; UOGML, 1981) as *Bohadrschia graeffei*, see Rowe & Gates (1995).
- 33) Until further work resolves the confusion surrounding *Ophiodesoma* I retain Rowe & Doty's (1977) tentative identification of *O. grisea*.
- 34) At least two species of *Polyplectana* occur on Guam, one has small, irregularly-shaped military granules and scattered tubercles around the base of tentacles (visible on photo GP401-24), the other lacks or has very few military granules and also lacks the conspicuous tubercles on the tentacles. Given that only the former has military granules, it is likely that the records of *P. kefersteinii* on Guam (Rowe & Doty 1977, UOGML 1981, UGI 2374 - not reexamined) were based on this form. However this species does not match *P. kefersteinii* from the type locality (the

Hawaiian Islands), which lack the tentacle tubercles (UF 1085, pers. obs.). The second species is tentatively identified as *P. galathea*, previously known from a single specimen from Tahiti (Heding 1928).

- 35) This species was recorded from a single specimen 25 years ago (Rowe & Doty 1977); no additional material has come to light.
- 36) Listed as *Certonardoia squamulosa*? by Grigg & Eldredge (1975) based on identification by A.M. Clark; *Certonardoia squamulosa* was synonymized under *Heteronardoia carinata* by Rowe (1976).
- 37) There is a substantial literature on *Acanthaster* from Guam, see Introduction and Birkeland & Lucas (1990) for additional references.
- 38) As *Holothuria gyrfifer* in Domantay (1954), see Rowe & Gates (1995) for Indo-West Pacific synonymy.
- 39) One additional holothuriid, *Holothuria pulla*, is recorded from Guam by Domantay (1954). This record is likely a misidentification and is not included in the checklist.