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BY

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INTRODUCTION.

ALTHOUGH the collection of Galapagos echinoderms made by the Hopkins Stanford Expedition is small, and contains no new species, it nevertheless adds something to our knowledge of the marine fauna of those islands. Most of the specimens were collected in shallow water at Tagus Cove, on the west side of Albemarle Island, or at Iguana Cove, at the southwest end of the same island. A few brittle stars were taken at Narboro. A few species were collected only with the dredge, in Tagus Cove. Previous knowledge of the Galapagos echinoderms has been very scanty, for although a number of collecting expedi-

tions have visited the islands, little attention was given to the shallow-water fauna. The *Hassler* expedition collected a few species in 1872, and the *Albatross* visited the islands in 1888, and again in 1891. Most of the latter's collecting, however, was with dredge or trawl in deep water. References to the marine fauna of the islands are comparatively few, and are widely scattered in the literature of marine zoölogy, but it appears that up to the present time 3 species of crinoids (*Calamocrinus diomedeæ* A. Ag., *Antedon agassizii* Hartlaub, and *Antedon bigradata* Hartlaub, all collected by the *Albatross* in deep water), 5 species of Asteroids, 8 of Ophiuroids, 12 of Echinoids and 3 of Holothurians have been reported from the Galapagos. It is probable that of these 31 species, not less than 7 are incorrectly reported or are not valid species. The Hopkins Stanford collection contains 146 specimens, representing 24 species; 9 Asteroids, 4 Ophiuroids, 8 Echinoids and 3 Holothurians. Of these, 7 star fishes, 1 brittle star, 3 sea urchins and 1 holothurian, 12 species in all, were not previously known from the islands, so that the Hopkins Stanford Expedition has increased our knowledge of Galapagos echinoderms at least 50 percent.

In the following pages special note is made of any peculiarities of size, color or other characters, in which the Galapagos specimens differ from those from other localities. The previously known geographical range of each species is also added, to show how much that range has been extended by their occurrence at the Galapagos. For the pleasure of examining the collection, I am indebted to Mr. R. E. Snodgrass, by whom it was sent to me.

ASTEROIDEA.

Luidia bellonæ Lütken.

There is a single dry and much broken specimen of a *Luidia* from Tagus Cove, which answers well to the description of this species, except that the paxillæ have more than twelve papillæ. The ray is 100 mm. long, and the color dull yellow marked above with olive green much as in *L. alternata*. The species has been previously reported from Panama, Guayaquil and Callao.

Luidia columbiæ (Gray).

There are two large dry specimens of a *Luidia* from Tagus Cove.

These agree well with Verrill's description of *L. tesselata*, which Sladen considers a synonym of *columbiæ*. One specimen has rays 215 mm. long and the other 170 mm. The color is dull bluish or greenish above, and yellow beneath. In the larger specimen one of the granules on the paxillæ is often much larger than the others, and rather spine-like. This species is known from various points along the western coast of Mexico and Central America from San Blas to Panama.

Pentaceros occidentalis (Verrill).

The rays are 140 mm. long, and R : r = 2.15 : 1. One large specimen was taken at Tagus Cove; is also found on the western coast of Mexico and Lower California.

Nidorellia armata (Gray).

The collection contains thirteen dried specimens of this species, all from Tagus Cove. The largest is 122 mm. across, the smallest 90. There is great diversity in the number of spines and marginal plates; one specimen has only 60 superior marginal plates, while all the rest have from 70 to 74. In one specimen every superior marginal plate bears a stout spine, while in another there are only eleven such spines altogether. Common on the Pacific Coast, from southern California to Ecuador.

Paulia horrida Gray.

There are 5 dried specimens, collected at Tagus Cove in from 5 to 50 feet of water. The largest has rays 66 mm. long. Also known from the coast of Ecuador.

Pharia pyramidata (Gray).

Of this species there are 5 dry specimens from Tagus Cove, and 1 alcoholic from Iguana Cove. The largest has rays 180 mm. long. Previously known from the west coast, from Margarita Bay to Colombia.

Phataria unifascialis (Gray).

One dry specimen from Tagus Cove, with rays 98 mm. long. Has been collected along the coast from Margarita Bay to Zorritas, Peru.

Heliaster cumingi (Gray).

Of this curious starfish, there are 6 dry specimens from Tagus Cove and one alcoholic specimen from Iguana Cove; one has 32, one has 33, two have 34, one has 35, one has 36, and one has 37 rays; the last is the largest, about 140 mm. across. R : r = 7 : 6. Color purplish black above, with pale yellow spines, and on the oral surface dirty yellowish. Easily distinguished from the following species, not only by its color, but by the very short rays, and numerous equal

spines. Previously reported from Peru and also from Hood and Chatham Islands in the Galapagos.

Heliaster multiradiata (Gray).

There are 2 specimens in alcohol from Iguana Cove, one with 21 and one with 25 rays, and 2 dry specimens from Tagus Cove, one with 23, and one with 26 rays; the last is the largest, about 170 mm. across. R : r = 7 : 4. The alcoholic specimens are, on the aboral side, blue-black marked with pale yellow; spines yellow; oral side pale dirty brown. The dry specimens are yellow, irregularly marked with black; oral side yellow, but the basal half of the adambulacral spines, and the oral spines, are black. Previously reported from the Hawaiian Islands, California, Mexico and the Galapagos Islands.

The following Asteroids have been previously reported, but all are of questionable standing and are therefore not counted as properly belonging in this list.

Culcita schmideliana (Retzius).

A species of the western Pacific and the Indian Oceans, reported by Gray from the Galapagos, but perhaps his specimen was incorrectly labelled.

Gymnasterias valvulata Perrier.

A species based on a young individual which may be a young *Nidorellia* or possibly an immature *Gymnasterias carinifera*, a well-known Panama species.

Ancanthaster ellisii (Gray).

Another western Pacific species, the occurrence of which at the Galapagos is probably based on an incorrectly labelled specimen.

OPHIUROIDEA.

Ophiura teres Lyman.

The collection contains a single dry specimen from Narboro Island. It is notable for its large size, the disc being 35 mm. in diameter, and the rays 135 mm. long. The disc is closely and uniformly granulated, the radial and oral shields being completely concealed. The arm spines are 12 for some distance out on the arm, and the upper arm plates are often broken into 2 pieces, or less commonly 3, or even 4, but some are unbroken. This species is known from Lower California, from the west coast of Central America, and was taken at the Galapagos Islands by the *Hassler* Expedition.

Ophionereis albomaculata E. A. Smith.

Of this species, peculiar to the Galapagos, the collection contains one dry specimen from Narboro, and 22 alcoholic specimens from Iguana Cove. There are always four arm-spines for some distance out on the arms, and in one specimen five. Color somewhat variable; in the dry specimens olive-green marked with yellowish-white, especially on the upper arm-plates; in the alcoholic specimens, the prevailing tint is

brown, but in some specimens the upper side of the disc is light; in one specimen pale yellowish-white; in the smallest specimens, the upper side of the arms is more or less clearly banded with dull purplish, brownish-olive, and yellowish. The largest specimen has the disc 16 mm. across, and arms 105 mm. long; the smallest is 7 mm. across, and has arms 45 mm. long. Easily distinguished from any of its near relatives by its color and arm-spines.

Ophiocoma æthiops Lütken.

Of this huge species, the collection contains a single dry specimen from Narboro and five alcoholic specimens from Iguana Cove. The dry one is the largest ophiuran known to me, the disc being 40 mm. in diameter; unfortunately all the arms are broken. It resembles the common West Indian species, *O. echinata*, superficially, but is easily distinguished by its finer disc granulation, the wider arms, and the difference in shape of the oral shields and upper arm plates. Previously reported from Lower California and the west coast of Central America; it was collected at the Galapagos by the *Hassler* Expedition.

Ophiothrix spiculata LeConte.

There are two dry specimens from Narboro and three alcoholic from Iguana Cove. The disc of the largest one is 12 mm. across and and the arms less than 50 mm. long. The diversity of color is very remarkable. One of the dry specimens is dark purplish-blue, with the under arm-plates marked with yellowish-white, and the arm-spines dark dull purple. The other has the disc and basal half of arms yellowish, the center of disc, interbrachial spaces, and upper arm-plates clouded with dark blue; the arm-spines are light and clear, and just tipped with purple; the terminal half of the arms is dark blue as in the first specimen and the transition from yellow base to blue tip is very abrupt. The alcoholic specimens are intermediate in color between these two, but approach much more nearly the dark one. This also is a western Central American species.

The following species previously taken at the Galapagos, are not in the Hopkins Stanford collection.

Ophionereis annulata Lütken.

A western Central American species.

Ophionereis nuda Lütken and Mortensen.

Collected near Chatham Island by the *Albatross*, and not known from any other station.

Amphiura verticillata Ljungman.

Peculiar to the Galapagos.

Ophiothrix magnifica Lyman.

A western Central American species.

The brittle star which Lütken and Mortensen describe under the name *Ophiothrix galapagensis* seems to be, without much doubt, the young of *O. spiculata*.

ECHINOIDEA.

Cidaris thouarsii Valenciennes.

This species, common from Guayamas to Panama and the Pearl Islands, and previously known from the Galapagos, is represented in the collection by 17 specimens, 11 dry ones from Tagus Cove, 1 small one from Narboro, and 5 alcoholics from Iguana Cove.

Diadema mexicanum A. Agassiz.

The collection contains 4 dry specimens, all from Tagus Cove, the largest 100 mm. in diameter and 48 high. Previously known from the Pacific coast from Acapulco to Puget Sound.

Strongylocentrotus gibbosus (Valenciennes).

There are 11 dry specimens of this interesting urchin, from Tagus Cove. They range in diameter from 16 to 40 mm. The color is a distinct reddish-brown, the spines very dark olive, tipped with purplish; specimens from Chile and Peru, whence the species was previously known, are said to be gray. All but the smallest of the shells before me are distorted by the presence of the parasitic crab so generally found in this urchin, and in all but 3 the crab is present. This species has been previously reported from the Galapagos.

Toxopneustes semituberculatus (Valenciennes).

There are 4 dry specimens from Tagus Cove, and 8 alcoholics from Iguana Cove, ranging in diameter from 27 to 50 mm. They agree well with Agassiz's description except in color; the test is light brownish-green, the numerous pedicellariæ purple and the spines bright yellowish-green, less yellow in alcoholic specimens. Previously recorded from Cape San Lucas, Central America and the Galapagos.

Hipponœ depressa A. Agassiz.

There is a single fine specimen of this species, 118 mm. in diameter, from Tagus Cove. Previously reported from the Gulf of California and west coast of Central America.

Clypeaster rotundus A. Agassiz.

There are 5 very handsome dry specimens in the collection, dredged in 50 feet of water in Tagus Cove. All are dull purple in color, but differ considerably in shape; one is 160 × 135 mm. while another is 145 × 138 mm., the largest is 162 × 150 mm. They are easily dis-

tinguished from *C. subdepressus* from Jamaica, by the thicker edge of the test, by the shape of the rosette, and by the shorter, broader and blunter petals. This species occurs along the coast from San Diego to Acapulco.

Encope micropora Agassiz.

There are 7 fine, large, dry specimens, dredged on the sand in Tagus Cove in 50 feet of water. They vary considerably in proportions, one being 138 × 125 mm. and another 142 × 140 mm., the largest is 152 × 148 mm. The color is light brown, the margin and edges of the lunules dark purple. This species occurs from Guayamas to Panama, and has been previously reported from the Galapagos.

Rhynchopygus pacificus A. Agassiz.

The most beautiful object in the collection is a nearly perfect test of this spatangoid, 70 × 58 × 30 mm., bleached perfectly white. There are two other broken tests. This species is known from Panama, Acapulco, and Cape San Lucas, and has been previously reported from the Galapagos.

The following echinoids have been previously taken at the Galapagos:

Arbacia stellata (Blainville).

An urchin, ranging from Puget Sound to Peru.

Mellita stokesii Agassiz.

A sand dollar, known from Punta Arenas, Panama and Guayaquil.

The *Albatross* took two other species (*Porocidaris cobosi* A. Ag. and *Salenia miliaris* A. Ag.) in deep water in the vicinity of the islands, but they are not littoral forms, and so are not listed here.

The following species are reported from the Galapagos, but the first is of doubtful standing, and the other two are Western Pacific species, whose occurrence in the Galapagos is more than doubtful:

Pleurechinus bothryoides Agassiz.

Amblypneustes formosus Valenciennes.

Strongylocentrotus tuberculatus (Lamarck).

HOLOTHURIOIDEA.

Holothuria fusco-rubra Théel.

Of this species, previously known only from the Hawaiian Islands, there are two good specimens from a reef near Tagus Cove. They are about 125 mm. long, light reddish-brown, and answer perfectly to Théel's description and figures, except for some minor differences in the supporting plates of the pedicels.

Holothuria impatiens (Forskal).

The collection contains 3 much contracted specimens, from 60 to 120 mm. in length, of this almost cosmopolitan species, collected at Tagus Cove. The Galapagos specimens are distinguishable at a glance from those from the West Indies, which also seem to answer the description, and I feel reasonably sure that the specimens from the Caribbean, which have been referred to this species, are really perfectly distinct. The Galapagos specimens seem to resemble the East Indian form. They are brownish-gray, with large papillæ, many of which are almost white. The skin is very rough. Théel has reported this species from Charles and James Islands, in the Galapagos.

Holothuria marenzelleri Ludwig.

There are eleven specimens from the reef near Tagus Cove, which agree admirably with Théel's description of specimens from Charles and James Islands. This species was originally described from Nangkauri, and may therefore be regarded as an East Indian form. The individuals before me are from 60 to 100 mm. long, and have a stone-canal 25 to 30 mm. long.

The only other holothurian known from the Galapagos is

Holothuria arenicola Semper.

An East Indian species collected by the *Hassler* expedition.

COMPARISON OF GALAPAGOS AND BERMUDAN ECHINODERMS.

It is interesting to compare the Galapagos fauna with that of the Bermudas, since the latter islands are similarly isolated from the mainland. Leaving out of account the crinoids and deep water forms, 40 species of echinoderms are known from the Bermudas, and only 31 from the Galapagos. The four classes are represented as follows:

	Asteroids.	Ophiuroids.	Echinoids.	Holothurians.	Total.
Bermudas	4	18	8	10	40
Galapagos	9	8	10	4	31

Viewed thus, the most interesting differences between the two faunæ are to be found among the Asteroids and Holothurians. Starfishes are noticeably uncommon in the Bermudas, while they are very common in the Galapagos; exactly the reverse conditions exist among the Holothurians. In the latter case, however, the real explanation may lie in our imperfect knowledge, for Holothurians are easily overlooked, and, even when found, are difficult to preserve, so that few

would be brought home from the Galapagos unless they were specially sought for. As regards Ophiuroids, it is only by very recent and diligent search that such a large number of species has been found at the Bermudas. It is highly probable that similar diligent search would largely increase the number of species from the Galapagos.

By comparing the faunæ of the two regions, with respect to the origin of the Echinoderms, it appears that the Bermudan species are chiefly West Indian, while the Galapagos species are South American, with a few noteworthy exceptions:

Bermudas.					Galapagos.				
	Asteroids.	Ophiuroids.	Echinoids.	Holothurians.		Asteroids.	Ophiuroids.	Echinoids.	Holothurians.
West Indian.	3	18	8	7	Central and S. American.	9	5	10	—
Northern or E. Atlantic.	1	—	—	2	Pacific and East Indian.	—	—	—	4
Local.	—	—	—	1	Local.	—	3	—	—

The most important point, brought out by this table, is that the holothurians of the Galapagos have apparently had an entirely diffreent origin from the other echinoderms. Only one of the four species (*H. impatiens*) has been reported from east of the islands and that record (Panama) is open to suspicion; but even if correct, it does not alter the fact that the species is an oriental one. This peculiar difference between the holothurians and other echinoderms offers considerable opportunity for speculation. For example, the question arises whether it indicates that holothurian larvæ are more hardy than those of the other classes, and that they alone survived the long journey across the Pacific; and having once become established in the Galapagos, have they crowded out or kept out American species, which must have been brought there along with the larvæ of other groups? Only a thorough study of the holothurians of all the islands of the Archipelago, and of the whole Pacific coast of tropical America, can answer these questions, for it is entirely possible that this apparent peculiarity in the echinoderm fauna of the Galapagos may be due simply to our ignorance of Pacific holothurians. These 4 species may prove to be very widely ranging species, occurring on the American coast also, and if that is so, their occurrence in those islands is not so remarkable. But it is curious that no American holothurians have yet been found in the Galapagos. In this connection, it is interesting to note that in the Bermudas 3 holothurians occur, which are not West Indian, while there is only one other echinoderm of which this is true.

Another point shown by the table is that while the Bermudas have among their 18 known species not one peculiar ophiuroid, the Galapagos, with less than half as many species, have three peculiar forms. This may illustrate, what there is some reason to believe is the case, that the ophiuroids are more variable than any other class of echinoderms, and that "new species" are now forming under the influence of isolation or other suitable conditions, more rapidly than in the other classes. Or it may simply emphasize the fact that our knowledge of West Indian ophiuroids is far in advance of our knowledge of eastern Pacific forms. But whatever the explanation, these facts, though so few, seem worthy of special note.

THE HOLOTHURIANS OF CLIPPERTON ISLAND.

With the echinoderms from the Galapagos, Mr. Snodgrass sent me 26 holothurians taken at Clipperton Island. This island lies in latitude 10° north, and near longitude 109° west. It is the easternmost of the Pacific coral islands. These holothurians represent only two species, nine of them being large black individuals, the others small and reddish-brown. The former answer well to the descriptions of *Holothuria atra* (Jäger), especially as regards the calcareous deposits, but the specimens do not look at all like Semper's figure nor do they resemble specimens from the West Indies, with similar calcareous bodies. At present, however, there seems to be no recourse but to call them *H. atra*, though I am confident that no less than three distinct species are now included under that name. The case is very similar to that of *H. impatiens* and like that will require an abundance of material from all parts of the globe to make a proper assortment possible. The small holothurians from Clipperton Island seem to represent a new species allied to *H. captiva* Ludwig and *H. difficilis* Semper, the former from the West Indies, the latter from Samoa. For this species I propose the name *Holothuria frequentiamensis*.

HOLOTHURIA FREQUENTIAMENSIS sp. nov.

Dorsal surface somewhat arched, sparsely covered with papillæ; ventral surface flat, closely covered with pedicels, which show no evidence of arrangement in longitudinal rows; line between dorsal and and ventral surfaces quite clearly marked. Tentacles 20, not peculiar. Polian vessels, 3 or 4. Stone-canal small, single. Calcareous ring not peculiar, similar to that of *H. captiva*. Cuvier's organs very noticeable, brownish or purplish (in alcohol). Reproductive organs wanting in all but one specimen; some had evidently eviscerated while

others were probably immature. In the one specimen, they were very small but seemed to be present only on the left side of the mesentery. Calcareous deposits, very regular tables, the bases perforated by a central, and 8 or 9 peripheral holes, the rather low spires surmounted by 20–30 teeth; underneath the layer of tables are numerous buttons, most of which are not symmetrical, and have 8–12 holes, though many have only six; in and about the pedicels the buttons increase in size and gradually become transformed into curved supporting plates with four or more longitudinal series of holes; in the papillæ, are curved, rough supporting rods; the holes in the buttons and plates are not large nor of uniform size, but are quite irregular. The tables are very closely crowded in the outer layer of the body wall so that they form a rough, crisp layer, though very delicate, over the whole surface; it is because of this that the name *frequentiamensis* has been selected. Color light brown, with a distinctly reddish tinge; the tentacles and pedicels darker. Length of largest specimen about 40 mm.

Although this species is undoubtedly closely related to *captiva* and resembles it in some respects, it is distinguished from that species by the shape and arrangement of the calcareous particles, especially the buttons. In these respects also it differs from *difficilis* although it may be even nearer this latter species. Semper's description is very brief and he gives the figure of only one table and two buttons, so it is possible the Clipperton Island specimens are really nearer those from Samoa than would appear from the descriptions. But they differ in size, color and number of Polian vessels, as well as in the calcareous particles. Moreover, the genital gland is attached to the dorsal mesentery near the middle of the body in *frequentiamensis*, and not close behind the calcareous ring as Semper says it is in *difficilis*.