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ECHINODERMS OF TARUT BAY AND VICINITY, SAUDI ARABIA

BY AUSTIN H. CLARK

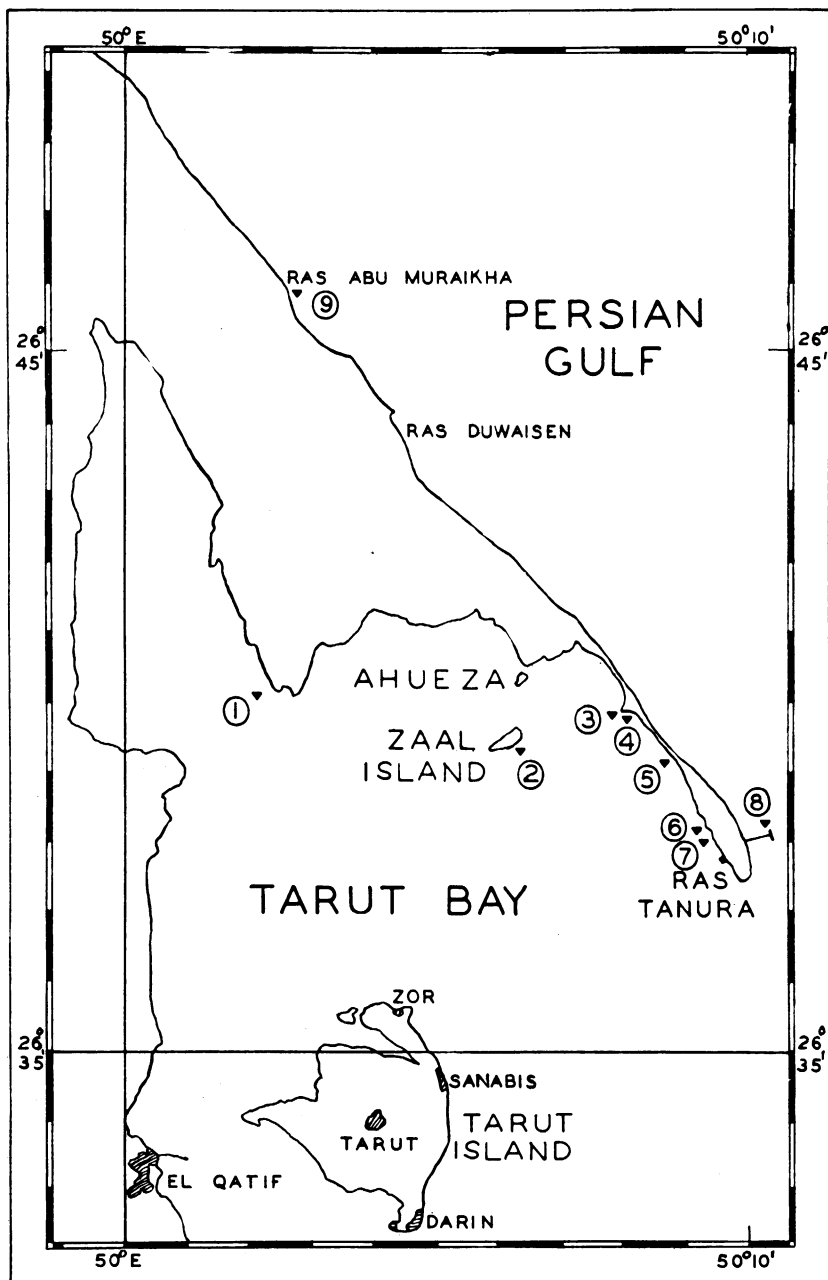
WITH NOTES ON THEIR OCCURRENCE

BY RICHARD LeBARON BOWEN, JR.

Between February 10, 1945, and August 30, 1947, Mr. Richard LeBaron Bowen, Jr., made a small but very interesting collection of echinoderms in Tarut Bay, Saudi Arabia, and vicinity. Tarut Bay, cut off from the Persian Gulf by the promontory of Ras Tanura (Tannura or Tannurah), lies in latitude $26^{\circ} 35' N.$, longitude $50^{\circ} 00' E.$ Its location on maps of Arabia is marked by the town of El Qatif (Katif or Kateef).

Although the number of species is small, including only three starfishes, six brittle-stars, and six sea-urchins, Mr. Bowen regards it as complete for the species living in the littoral fringe, except for the rarer or more elusive forms.

Of special interest in connection with this collection are Mr. Bowen's extensive notes on the occurrence of these animals. Noteworthy is the abundance of *Metalia townsendi*, *Clypeaster humilis*, and *Lovenia elongata* along the shores in this region. With these, and with the equally abundant *Echinodiscus auritus*, Mr. Bowen found the small symbiotic brittle-star *Amphilycus androphorus*, which has not been reported since its discovery at Lourenço Marquez. For the first time the needle-urchin (*Diadema*) was found in the Persian Gulf, though its occurrence there was to be expected. Just what species is represented must be left for future determination, as no specimens were collected.



STATION LIST

STATION ¹	LOCALITY	DATE
1	Tarut Bay, rocky bottom on upper Tarut Bay	March 7, 1947
2	Tarut Bay, approaches to Zaal Island	February 21, 1947
3	Tarut Bay, rocky point jutting off Ras Tanura Peninsula	May 25, 1945 December 13, 1946
4	Tarut Bay, rocky point jutting off Ras Tanura Peninsula	February 7, 1947
5	Tarat Bay, shores of Ras Tanura Peninsula	February 6, 1947 April 19, 1947 April 20, 1947
6	Tarut Bay, four sand bars off Ras Tanura Peninsula	January 10, 1947
7	Tarut Bay, sand bar off Ras Tanura Peninsula	December 23, 1946 December 27, 1946 February 4, 1947
8	Persian Gulf, in 40 feet of water	March 30, 1947
9	Persian Gulf, Rocky Point	May 30, 1947

ASTEROIDEA

***Astropecten polyacanthus* Müller and Troschel**

LOCALITY: Station No. 6A, buried in the sand; January 10, 1947. Two specimens.

NOTES: In these two specimens $R = 34$ and 30 mm. In both all the superomarginals carry a well-developed erect spine, that on the first largest, those from the second onward decreasing gradually and regularly in height to the end of the ray.

***Astropecten pugnax* Koehler**

LOCALITY: Station No. 6A, buried in the sand; January 10, 1947. One specimen.

NOTE: In this specimen $R = 47$ mm.

***Asterina cephea* var. *iranica* Mortensen**

LOCALITY: Station No. 5, on under side of rocks; February 6, 1947. Two specimens.

NOTES: The larger specimen has $R = 27$ mm., $r = 11$ mm. There are six spines on the oral surface of each jaw plate, in one case seven. In the smaller specimen $R = 23$ mm., $r = 10$ mm.

¹ For the location of these stations, see the map on opposite page.

OPHIUROIDEA

Ophiothrix hirsuta Müller and Troschel

LOCALITIES: Station No. 4, in pools under rocks; February 7, 1947. Two specimens.

Station No. 2, underneath rocks; February 21, 1947. Two large specimens.

NOTES: The larger specimen from Station No. 4 has the disk slightly stellate, 18 mm. in diameter, and the arms 270 mm. long. The arms above have a conspicuous median white stripe bordered with black; beyond these black borders there is, in the outer part of the arm, an indefinite light stripe on either side. Beneath the arms are dark brown becoming deep purple distally with a conspicuous median white stripe. The arm spines are short, not twice the width of the arm in length.

In a smaller specimen from the same locality the white median line above is indistinctly margined with dark and the arms below are white, the under arm plates in the outer part of the arm laterally clouded with dusky.

I follow Mortensen in referring these specimens from the Persian Gulf to *O. hirsuta*. They agree with Koehler's figure of a specimen in his collection from the Red Sea, though in color they agree well with Dr. H. L. Clark's *O. rhabdota* from the Murray Islands in Torres Strait. The hook formed by the first arm spine is variable, the type characteristic of *O. hirsuta* and that characteristic of *O. longipeda* being found in the same specimen. It seems doubtful if *hirsuta* and *rhabdota* are really distinct from *longipeda*.

Ophiothrix savignyi (Müller and Troschel)

LOCALITIES: Station No. 5, in pools under rocks; February 6, 1947.

Station No. 4, in pools under rocks; February 7, 1947.

Station No. 2, in pools under rocks; February 21, 1947.

Station No. 1, in pools under rocks; March 7, 1947.

Station No. 8, in 40 feet of water; March 30, 1947.

In all, 97 specimens.

NOTE: Like many of its relatives, this species is very variable in its color pattern.

Amphilycus androphorus Mortensen

LOCALITIES: Station No. 6A; January 10, 1947. One female.

Station No. 6D; January 10, 1947. One pair.

NOTES: The female of this small symbiotic species carries the dwarf male mouth to mouth, the arms of the male alternating with those of the female and wrapped around her disk.

This species was described by Th. Mortensen in 1933 from specimens taken by him at Polana Beach, Lourenço Marquez. He found it living on *Echinodiscus bisperforatus*, usually near the slits, more rarely near the mouth.

The specimens from Station No. 6D, a female with an attached male, are from the same station as some specimens of *Clypeaster humilis*, with which they were probably associated in life.

The specimen from Station No. 6A is a female from which the male has become detached. The disk is 3 mm. in diameter. This specimen is curious in having all the brilliancy of a glass model, appearing as if silicified. It was found on *Metalia townsendi*.

Ophonereis dubia (Müller and Troschel)

LOCALITY: Station No. 2, in pools under rocks; February 21, 1947. Three specimens.

Ophiactis savignyi (Müller and Troschel)

LOCALITY: Station No. 8, in 40 feet of water; March 30, 1947. One small specimen.

Ophiopezella fallax (Peters)

LOCALITY: Station No. 2, underneath rocks; February 21, 1947. Two specimens.

Station No. 1, underneath rocks; March 7, 1947. One specimen.

NOTES: The two specimens from Station No. 2 have the disk 14 mm. in diameter and the arms 40–45 and 50 mm. long. One shows small, bare, appleseed-shaped radial shields with usually three small bare plates arranged in a triangle between them; the center plate in the rows of enlarged marginal plates between the arms is bare.

The specimen from Station No. 1 has the disk 14 mm. in diameter and the arms 47 mm. long.

ECHINOIDEA

Temnopleurus toreumaticus (Leske)

LOCALITY: Station No. 7, buried in the sand; December 23, 1946. Two specimens 28 and 36 mm. in diameter.

Echinometra mathaei (De Blainville)

LOCALITIES: Station No. 3, on top of rocks; May 25, 1945. Three specimens.

Station No. 4, under rocks; February 7, 1947. Two small specimens.

Echinodiscus auritus Leske

LOCALITIES: Station No. 3, buried in muddy sand; May 25, 1945. Three specimens.

Station No. 6A, buried in the sand; January 10, 1947. One specimen.

Station No. 6D, buried in the sand; January 10, 1947. Two small purple specimens.

Clypeaster humilis (Leske)

Figure 1

LOCALITIES: Station No. 6A, buried in the sand; January 10, 1947. Three specimens.

Station No. 6B, buried in the sand; January 10, 1947. Four specimens.

NOTE: Some of the specimens have the petaloid areas outlined in deep purple.

Metalia townsendi (Bell)

Figure 2

LOCALITIES: Station No. 7, buried in the sand; December 27, 1946. Two specimens.

Station No. 6A, buried in the sand; January 10, 1947. One broken specimen and fragments.

NOTES: All the specimens of this very delicate species were more or less broken when received. The best, from Station No. 7, was 68 mm. long, 60 mm. broad, and 36 mm. high.



FIG. 1. *Upper:* Station No. 7, February 4, 1947; *Clypeaster humilis*, buried. *Lower:* Same, with the *C. humilis* dug out. Photographs by Richard LeBaron Bowen, Jr.

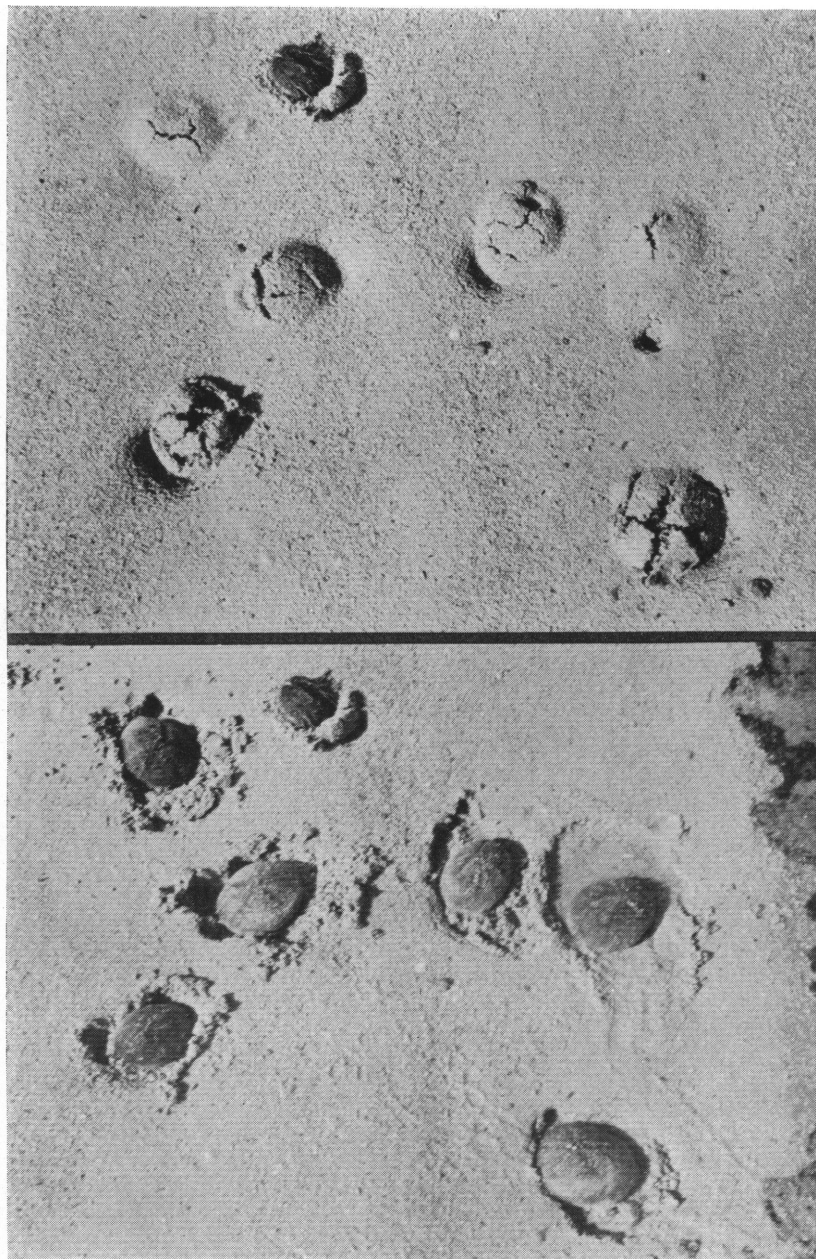


FIG. 2 *Upper*: Station No. 6C, January 10, 1947; doming bottom; six *Metalia townsendi*, buried; one *Lovenia elongata* emerging from the sand (upper left). *Lower*: Same, with the *M. townsendi* dug out. Photographs by Richard LeBaron Bowen, Jr.

Lovenia elongata (Gray)

Figure 2

LOCALITIES: Station No. 3, on top of sand; December 13, 1946. One specimen.

Station No. 7, buried in the sand; December 27, 1946. Two specimens.

NOTE: The two specimens from Station No. 7 are 72 and 52 mm. long.

NOTES BY RICHARD LEBARON BOWEN, JR.

RANGE

With the exception of the specimens collected on March 30, 1947, all the specimens came from the lower littoral fringes of the Persian Gulf and Tarut Bay. If it is assumed that the six-armed brittle-stars which were collected on May 30, 1947, are *Ophiactis savignyi*, the deep-water station produced only specimens found in the littoral fringe.

Early in the refinery construction program an arbitrary datum was selected on which to base all surveying. This datum was set at what was supposed to be Indian Spring High Tide; actually it was set a little low. The datum was defined as 0.00 feet; the refinery was built at +6.0 feet as finished grade. There were several tide boards set on this coordinate system with feet reading down to -7.0. There was a recording tide gauge at the West Pier. With this coordinate system at my disposal it was possible to estimate the relative elevation of any collecting station expressed as feet below the arbitrarily chosen datum.

From February 10, 1945, to August 30, 1947, the tides kept a characteristic seasonal pattern. In the summer the spring tide was about +1 foot, while the daylight spring low never went below -5 feet. The lowest tides were in January and February and reached a minimum of -7 feet in February. In February there would be two or three low tides 6 or 8 inches lower than any occurring in the rest of the year. The lowest tides on each side of these minima would probably be from -6 to -6.5 feet.

Looking back to the echinoderms as they occurred along the shores it appears that two starfishes (*Astropecten polyacanthus* and *A. pugnax*) and two sand dollars (*Echinodiscus auritus* and *Clypeaster humilis*) wander the highest, as they were found in sand bars as high as -5 feet. The upper range of the brittle-

stars seems to have been about -6 feet, as was that of the starfish *Asterina cephea* var. *iranica*. The upper range of the heart urchins (*Metalia townsendi* and *Lovenia elongata*) was just about the same. *Echinometra mathaei* gave itself a safe margin against exposure to the air by living generally at from -8 to -10 feet. *Diadema* was found in this same range.

It is interesting to speculate on the maximum exposure these animals can stand without extermination. It should be noted that the brittle-stars, even though their actual station may be above the tide level, were generally in pools of water under rocks. The starfishes *Astropecten polyacanthus* and *A. pugnax* apparently stood the exposure of their sand bars well. Many of the *Clypeaster humilis* turned green even when buried. Exposure was fatal to *Lovenia elongata* as it came up out of the sand and never got more than a foot in its dash for water. One could not tell about *Metalia townsendi*, as this species was very inactive. *Echinometra mathaei* died quickly on exposure and became matted.

OCCURRENCE

The number of specimens of each species that Mr. Clark received has no significance in the case of the starfishes and the sea-urchins, as only representative specimens were collected, and generally there were dozens of specimens of each to be had. But in the case of the brittle-stars the number of specimens that Mr. Clark received is of the utmost significance, as every one was collected that could be captured. *Ophiothrix savignyi* is by far the commonest brittle-star, as close to 100 specimens were collected; but the other five species turned up at isolated stations and were never found in numbers greater than six altogether.

When the marine fauna of the Persian Gulf at Ras Tanura is looked at as a whole, it is easily seen that the echinoderms form the most ubiquitous feature of the life in the lower littoral fringes in virtually every type of situation. Certainly they are predominant in sheer mass as well as in numbers. They appear to live in colonies, but it is more probable that a certain species is limited to certain types of situations and thus appears as colonial.

It is not easy to say just what the most frequently occurring echinoderm was, as it depended largely on the situation. But if one started out to see how many echinoderms one could collect

from everywhere one would probably end up with *Echinometra mathaei* and *Ophiothrix savignyi* in largest numbers, with *Metalia townsendi*, *Echinodiscus auritus*, and *Clypeaster humilis* next in frequency. Of the other species, *Astropecten polyacanthus*, *A. pugnax*, *Asterina cephea* var. *iranica*, and *Lovenia elongata* would be common; but *Ophiothrix hirsuta*, *Amphilycus androphorus*, *Ophionereis dubia*, *Ophiactis savignyi*, *Ophiopezella fallax*, *Temnopleurus toreumaticus*, and *Diadema* would be rare. This may be an injustice to *Amphilycus androphorus* as not all *Metalia townsendi* or *Clypeaster humilis* were examined for this brittle-star; its occurrence may well be common.

Several times before leaving Arabia I returned to the localities where the needle-urchin (*Diadema*, sp.) was first seen on May 25, 1945, and attempted to collect specimens of this urchin, but they were nowhere to be found. It seemed strange that they should be present in such numbers at first and then later totally absent. The sulphurous waste and gasoline that has been allowed to escape into Tarut Bay about 3 miles north of Station No. 3 since the refinery started in October, 1945, may have driven these fast-moving urchins away. *Echinometra mathaei* was still present in the same quantities as before.

GEOGRAPHICAL RANGE

One will notice that virtually all the stations listed are in Tarut Bay, but this by no means should imply that no collecting was done on the Persian Gulf side of the Ras Tanura Peninsula. Probably as many trips were made on the Persian Gulf side as were made on Tarut Bay, wherein mollusks and other animals were collected. With the exception of the six-armed brittle-stars [presumably *Ophiactis savignyi*—A.H.C.] found on May 30, 1947, the only echinoderm that was found in the littoral fringe of the Persian Gulf was *Echinometra mathaei*. This urchin was living either on the rocks or in little caves in the soft rock, from which it was impossible to remove it without breaking the rock. In general *Echinometra mathaei* tended to be ensconced in rock caves on the Persian Gulf side, while in Tarut Bay *E. mathaei* was simply found walking on top of rocks and on the bottom. This urchin was never seen in a rock cave in Tarut Bay.

Strong north winds (known as *shamal* to the Arabs) blow frequently in Arabia and produce relatively strong wave action along

the whole Arabian coast. Tarut Bay, in vivid contrast, is always sheltered, so that the wave action along the Ras Tanura shores is practically negligible. There were dozens of stations on the Persian Gulf that were identical in appearance with those in Tarut Bay, but none of the echinoderms that were common in Tarut Bay were found on the Persian Gulf. Presumably the stronger wave action along the shore has limited the animals to deeper water on the Persian Gulf side.

SUMMARY OF DATA OF OCCURRENCE

	Occurrence	Upper Range	Typical Station
ASTEROIDEA			
<i>Astropecten polyacanthus</i>	Common	—5 feet	Buried in sand bars
<i>Astropecten pugnax</i>	Common	—5 feet	Buried in sand bars
<i>Asterina cephea</i>	Common	—6 feet	On under side of rocks
OPHIUROIDEA			
<i>Ophiothrix hirsuta</i>	Rare	—6 feet	Underneath rocks
<i>Ophiothrix savignyi</i>	Extremely common	—6 feet	On under side of rocks and underneath rocks
<i>Amphilycus androphorus</i>	? Common	—6 feet	On heart urchins and sand dollars
<i>Ophionereis dubia</i>	Rare	—6 feet	On under side of rocks and underneath rocks
<i>Ophiactis savignyi</i>	Rare	? — 7 feet	In porous rocks
<i>Ophiopezella fallax</i>	Rare	— 6 feet	Underneath rocks
ECHINOIDEA			
<i>Echinometra mathaei</i>	Extremely common	—8 feet	On rocky bottom, many times near coral growth
<i>Temnopleurus toreumaticus</i>	Rare	—6 feet	Buried in the sandy bottom
<i>Echinodiscus auritus</i>	Very common	—5 feet	Buried in sand bars and in sandy bot- toms
<i>Clypeaster humilis</i>	Very common	—5 feet	Buried in sand bars and in sandy bot- toms
<i>Metalia townsendi</i>	Very common	—6 feet	Buried in the sandy bottom
<i>Lovenia elongata</i>	Common	—6 feet	Buried in the sandy bottom
<i>Diadema</i> , sp.	? Rare	—9 feet	On rocky bottom near coral

FIELD NOTES

TARUT BAY, STATION NO. 3, MAY 25, 1945: Station No. 3 is a point jutting into Tarut Bay. In the muddy area below the plunge point (between the end of the coral reef and the fish trap on the north side of the point) there were dozens of *Echinodiscus auritus* plowing along and leaving their characteristic mark just under the surface at elevation -6 and -7 feet. In going from the sandy beach to deeper water on the north side of this point I started running into brain corals. They were circular and about the size of very small melons. This was in about 3 feet of water at low tide.

I approached a dark spot some distance away in the water, and there was a small mound under water made up of branching, treelike coral and brain coral. All over this mound was *Echinometra mathaei*. Most of the individuals were crawling over it, but a few were in niches, apparently settled down. On one side of the mound, the top of which was 2 to 3 feet under water, was an echinoderm of a type I had never seen before. This needle-urchin (*Diadema*, sp.) had tremendously long spines about a foot long. The test was circular. I left it there, as I had nothing with which to lift it out and it appeared rather formidable. This mound was between a fish trap and the Ras Tanura Peninsula. There seemed to be three species of brain coral.

All around was *Echinometra mathaei*, walking on the mud-covered bottom, with bits of shells, corals, and other urchins on top of their spines. Some had one small piece covering perhaps 5 to 10 per cent of their outline, and one had six pieces covering maybe 30 to 40 per cent of its outline. It certainly was not very effective as a camouflage, as it seemed to "spotlight" them, where their dark form might well go unnoticed in the coral on the mud flats.

Farther down towards the end of the point a band of coral runs parallel to the shore on the north and forms a dark band in the water when seen from the shore. Here all the species of corals are stacked up with huge brain corals perhaps 2 feet in diameter. Here I picked up a needle-urchin (*Diadema*, sp.) with a stick. It had what looked like a purple anemone sticking out of the top of the test. The spines have thousands of barbs on them. If you are holding a spine and let it slip through your fingers the barbs break off and impart a purple color to your skin for days. When anything approached these needle-urchins, they waved all the

spines through a distance of perhaps half an inch to an inch in the area from which the disturbance came.

Just on the other side (south side) of the point a strange change takes place. There is also a coral band just off shore with the same types of coral, but there is a relative lack of *Echinometra mathaei*. *Diadema* is predominant and common here. As I walked across the sand spit which juts out from the point to the west and was just under water, I noticed that the north side was level with the spit, but the south side dropped off rapidly. At the shallowest point the water was very cool from evaporation.

The needle-urchins were not on the coral here as the average *Echinometra mathaei* were; they were on the mud-covered rock bottom between the coral and the shore. These urchins seemed to be in clusters of from three to eight with the spines almost touching. Occasionally there were stray single needle-urchins and *Echinometra mathaei*. On the north side I observed only two needle-urchins, but there were hundreds of *Echinometra mathaei*, mostly on the coral. The needle-urchins on the south were nowhere near as plentiful as was *Echinometra mathaei* on the north. As the top of the coral at Station No. 3 is just under water at the lowest tides, this would make the elevation about 3 feet below (as an average) for these urchins, or about -10 feet.

So far, I have noticed that sea-urchins and coral seem to go together. On the Persian Gulf side of the peninsula there were some brain corals in small bits on the rocks in which I found three *Echinometra mathaei* some time ago ensconced in holes in the soft limestone rock.

TARUT BAY, STATION NO. 3, DECEMBER 13, 1946: In a sandy lagoon at about elevation -6.4 feet I found a *Lovenia elongata* moving rapidly on the top of the sand in 6 inches of water. The lowest tides would drain this lagoon.

TARUT BAY, STATION NO. 7, DECEMBER 23, 1946: At Station No. 7 at low tide I found two interesting urchins, *Temnopleurus toreumaticus*. Station No. 7 was a long sand bar rising out of the semisandy surroundings about a foot and a half, with a top elevation of -5.3 feet. These urchins were buried under about 1 inch of sand at about elevation -6 feet. They were perfectly circular, 36 and 28 mm. in diameter, or, counting the spines, 55 and 40 mm. The spines were dark purple with half a dozen or so wide white bands. The test underneath was a light whitish color. These two were the only ones I have ever found in

shallow water. I have seen native divers bring up similar specimens in 30 feet of water about a mile away.

[Speaking of the eastern side of the Gulf, Dr. Th. Mortensen says that "This species appears to be the commonest Echinoid, outside the reefs, and seems to be common all over, on clay or sand bottom. Most of the specimens are quite small, and of very light colour. In the ecology of the sea it must evidently play a considerable rôle." Specimens from the Persian Gulf are almost all small and light colored. Dr. H. L. Clark wrote that a fine series which the Museum of Comparative Zoölogy received from Capt. F. W. Townsend in 1895 had the ground color very light, usually a pale cream color, in some with a more or less marked olive green cast, and primary spines very conspicuously banded with brownish or purplish red. He said that these specimens appear to be identical with those from the Arabian coast of the Red Sea described by Koehler as a new species, *Temno-pleurus perezi*. But both he and Mortensen point out that there seems to be no reliable difference between *perezi* and typical *toreumaticus*. Mortensen found in Dr. H. Blegvad's collection from the east side of the Persian Gulf a specimen with the spines much darker colored, and furthermore he has seen light-colored specimens from India, Singapore, and Indo-China. He says it seems that such light-colored individuals are those living on a white sandy bottom, whereas those that live on a grass bottom are much darker in color. The maximum size of this species in the Persian Gulf and Red Sea appears to be about 40 mm. in diameter. Elsewhere it reaches a diameter of 51-53 mm.—A.H.C.]

TARUT BAY, STATION No. 7, DECEMBER 27, 1946: While looking for giant olive shells in the sandy bottom off of Station No. 7, I played with a number of *Metalia townsendi* whose presence could be detected by little cone-shaped hollows in the sand with a movement of sand particles at the bottom, where the animal was apparently dredging its way through the sand. The bottom was made up of coarse sand with a little muddy substance to it. The elevation was probably -7 to -8 feet. Low tide reached -6 feet today.

At virtually every step you could feel the crunch of a test collapsing like an egg shell. When a *Metalia townsendi* is uncovered it shows little if any detectable action, but a *Lovenia elongata* immediately starts to burrow again if uncovered. So

active are the spines on these latter urchins that it is difficult to pick them up; I did succeed in pricking myself with one in water up to my armpits.

I turned up two *Metalia townsendi* which seemed to be different from the average. One was about 17 mm. long; the other was about 32 mm. long. It must be the juvenile state that makes the proportions of these urchins different from the adults.

Looking back on the specimen of *Lovenia elongata* found on December 13, 1946, it is difficult to understand why it was not buried.

TARUT BAY, STATION NO. 6A, JANUARY 10, 1947: This station was a sand bar jutting out from one wing of a fish trap about one-quarter of a mile from shore. The top of the bar is about -5.3 feet. It dropped off gradually all around until it reached the bottom 2 feet farther down all around. Today low tide reached -6.4 feet.

All over the bar were *Clypeaster humilis*. These were about 3 feet apart in any direction. Some had already started turning green from exposure to the air, although still buried in the sand. These were large ones, on the average about 4 inches in diameter, possessing a brown color when alive. I found only one large *Echinodiscus auritus* about 4 inches long. It was a characteristic dark purple color.

I found a few *Metalia townsendi*—maybe 10. These have a pinkish reddish tan color, with short stubby spines. I also found a few *Lovenia elongata*—maybe five. All had plowed up to the surface of the sand and some had traveled 6 inches or a foot. The *Metalia townsendi* were all buried.

I found a few *Astropecten polyacanthus* buried in the sand. They have a gray back with black dots and white spines sticking out and up. I also found a few *Astropecten pugnax*. These have a purplish top with a sort of reptilian pattern. These were likewise buried in the sand.

Later in the bottom of the look-box in which I had several *Metalia townsendi* I found an *Amphilycus androphorus*. I had noticed small brittle-stars living on *Metalia townsendi* on these bars before.

TARUT BAY, STATION NO. 6B, JANUARY 10, 1947: There are tens of big and little *Clypeaster humilis* here, but not an *Echinodiscus auritus* or other urchin evident. Station No. 6B was a bar 5 feet wide and 100 feet long with an elevation of -6.2 feet.

TARUT BAY, STATION No. 6C, JANUARY 10, 1947: While I was on the last bar it started to go under, so I hurried to the next in-shore sand bar, Station No. 6C. This turned out to be a part of the bottom gently doming up out of the water, with a maximum elevation of about -6.0 feet. It was composed of muddy coarse sand with lumps of coral. About every 8 inches or a foot over the whole area, which was perhaps 50 feet in diameter, was the mark of a *Metalia townsendi* moving under the surface. A few were attempting to reach water. Perhaps one out of every 20 heart urchins was a *Lovenia elongata*, which had pushed out and started crawling somewhere (see fig. 2). Many times it got no farther than just breaking out of the sand. There were also a few *Clypeaster humilis*, generally large. This is a part of the same bottom described on December 27, 1946, off Station No. 7.

TARUT BAY, STATION No. 6D, JANUARY 10, 1947: As the tide continued in I hurried to a last sandy bar, Station No. 6D, about 2 feet wide and perhaps 30 feet long. I found two of the smallest *Echinodiscus auritus* ever found, and also a few small *Clypeaster humilis*.

In the bottom of a jar of alcohol in which I had put these two very small *Echinodiscus auritus*, a few small *Clypeaster humilis*, and numerous mollusks I found an *Amphilycus androphorus*. It has a star pattern on its body [probably the attached male—A.H.C.]. It must have come from one of the *Clypeaster humilis*, as the two *Echinodiscus auritus* were so small and had such smooth surfaces that I would have noticed a brittle-star on them when I picked them up.

TARUT BAY, STATION No. 7, FEBRUARY 4, 1947: There were a couple of cracks in the sand at about elevation -6.1 feet. When I dug these out I found a large *Clypeaster humilis* and several mollusks (fig. 1).

TARUT BAY, STATION No. 5, FEBRUARY 6, 1947: We decided to take a quick run down to the Terminal to look at the tide at noon. To our amazement whole areas that we had never seen before were out. We stopped at a likely cowry station, probably about elevation -6.5 to -6.9 feet. The ground here consisted of flat rock ledges with porous rocks scattered at intervals. I found only three *Ophiothrix savignyi* under these rocks. Also under these rocks were individuals of *Asterina cephea* var. *iranica*, with mottled brown and red surfaces. These starfishes have a habit of absolutely assuming the contour of the rocks as if

they were glued to them. They even get themselves into small holes and almost turn themselves inside out in doing so. They are always found under rocks, clinging to the under side.

TARUT BAY, STATION NO. 4, FEBRUARY 7, 1947: I got down on the spit before low tide and found the same conditions as prevailed yesterday. I started on a rock ledge laid bare on the south side of Station No. 3, which was 4 inches out of water at elevation -6.5 feet. On the outside was the coral reef, a band about 20 feet wide on the edge of the dropoff. The tops of the branched corals were just under water.

Under porous rocks in little pools on the rock ledge I found 16 *Ophiothrix savignyi*. I studied these 16 brittle-stars for a long time and could not detect two of the same color or appearance. I also found two *Ophiothrix hirsuta* in pools under these same rocks. One was small, 3 inches in diameter; the other large, 12 inches in diameter.

On the under side of these rocks I found two baby *Echinometra mathaei*. The spines on one of these, 40 mm. in diameter, appeared proportionately longer than those in the fully grown ones, or on the smallest one, 15 mm. in diameter. The spines on neither of these matted as they do on the adult individuals. This must be characteristic of the young specimens.

TARUT BAY, STATION NO. 2, FEBRUARY 21, 1947: I went to Zaal Island today. The minimum water was -6.5 feet. We picked our way in through sand bars until we were in as far as we could go in the launch. We were face to face with a reef running parallel to the shore and indicating the start of a place where one could walk ashore. There were large flat rocks strung along, making a cliff. Covering this reef were hundreds of *Echinometra mathaei*, in a band 2 to 3 feet wide, running along the edge at a depth of from $1\frac{1}{2}$ to 2 feet below lowest water (elevation -8 to -8.5 feet). Among the rocks were scattered leafy weeds; no other forms of life could be detected among the urchins.

Farther in on a sand bar at an elevation of from -5 to -6 feet were two large *Echinodiscus auritus* and one large *Clypeaster humilis*. At elevation -5.5 feet several medium-sized *Echinometra mathaei* were found under rocks. These certainly had wandered far above their range.

The most prominent feature of the whole of the deeper water ground (now exposed) was the presence of brittle-stars. They

ranged from elevation -6 feet down into the water, always under flat and porous rocks in pools of water. There were but few rocks here the under side of which did not yield at least a couple of brittle-stars. One must move fast or they slide into a hole or under a rock. Generally they were attached to the bottom of the rocks, but sometimes they were in the water. They have an uncanny habit of sliding into the smallest hole of any kind. It is annoying to see how an animal with no sense of sight can pick a hole and disappear so quickly. Perhaps they do have a sensitivity to light. The moment a tip of an arm finds a shady spot, after they have been exposed to light, the rest of the animal quickly slides into it. This was true of a can I had them in, as they were always crowded in the shady edge.

I found two *Ophiothrix hirsuta*. Their arms were about 15 and 8 inches long, the animals being 30 and 16 inches in diameter. I put them in fresh water for 24 hours, then in alcohol for 24 hours, and then dried them, as I did all the other brittle-stars. I found four *Ophiopezella fallax*. These were always in the water under the rocks, never on the rocks themselves as was *Ophiothrix savignyi*. *Ophiopezella fallax* has tan and brown banded arms and a tan pentagonal body. The bands do not always stop on even plates, the average being three plates to a color. In fresh water they emitted a brown fluid from their mouths which discolored the body slightly. They have eight short stubs of spines at each plate junction on each side. The bands do not go all the way around the arms, as the under side is white.

I found five *Ophionereis dubia*. These have long thin arms with short spines and a circular smooth body. Although they look white, they have a decidedly green cast under a glass. I also found about 48 *Ophiothrix savignyi*. A study with a glass could not produce two alike so far as color and structure went.

Also under these rocks I found occasionally—perhaps 10 or 15 all told—*Asterina cephea* var. *iranica*. These have little protruding papulae all over their backs. One looks fatter than the others. They all have a greenish color with a little red in some cases.

TARUT BAY, STATION NO. 1, MARCH 7, 1947: On the bottom of flat rocks resting on rock ledges at elevation -6 to -6.5 feet I found six *Ophiothrix savignyi* and one *Ophiopezella fallax*, which was gray (whereas the ones from Station No. 2 were tan). The gray was immediately noticeable.

PERSIAN GULF, STATION No. 8, MARCH 30, 1947: The Marine Department raised a buoy and anchor that had been in 40 feet of water by the submarine loading lines off the East Pier on the Persian Gulf side of the Ras Tanura Peninsula for six years. I collected specimens from the concrete anchor block that was on the bottom and from a buoy that floated halfway up at 20 feet. I collected 20 *Ophiothrix savignyi* and one small *Ophiactis savignyi*.

TARUT BAY, STATION No. 5, APRIL 19, 1947: The wind of the present *shamal* was blowing in its second day. That the tide would be exceptionally low today could be guessed at 8:30 A.M. from the height of the water then, for even then it was low. It hit a low of -6.5 feet at 11:30 A.M., about 1 foot lower than would be expected. I stopped by a spot where there were rocks out in the water where old fish traps had been. The rocks were of the porous sea rock type with a hollow spongy structure, resting on a sandy bottom at elevation -6.5 to -7.0 feet. I found four *Ophiothrix savignyi* here.

TARUT BAY, STATION No. 5, APRIL 20, 1947: I went to the same station as yesterday, but the tide did not get so low. This time I covered deeper rocks which I missed yesterday. They were all in from 3 to 12 inches of water, so some specimens could have escaped in picking up the rocks. I found only one *Ophiothrix savignyi* at an elevation of from -7.0 to -7.5 feet.

PERSIAN GULF, STATION No. 9, MAY 30, 1947: I collected a lot of rocks for forms of life other than echinoderms from an elevation of from -6 to -10 feet and kept them in stale water. From the bottom of the pail I collected a lot of little six-armed brittle-stars [presumably *Ophiactis savignyi*—A.H.C.].