# RECOVERY OF THE *ECHINOMETRA* POPULATION IN THE INTERTIDAL ZONE IN THE VICINITY OF SETO, WITH A PRELIMINARY NOTE ON THE MASS MORTALITY OF SOME SEA URCHINS IN THE SUMMER SEASON*

TAKASI TOKIOKA

Seto Marine Biological Laboratory

*With 4 Tables*

I reported[1] the mass mortality of *Echinometra mathaei* (BLAINVILLE) occurred in the winter 1962–63 and suggested that the unusual cold weather of that winter was responsible for it, but I could not affirm this at that time. However, several papers reporting the biological effects of that severe winter have been published in Japan[2,3] and Europe[4–7], and these seem to justify my supposition in a way. Since I wrote that report, I have tried to visit the shores whenever there are any chances, especially in the season from spring to summer when the tide is bigger in the daytime, to know how the *Echinometra* population has recovered in the intertidal zone. At the same time I have endevoured to get any informations concerning the occurrences of striking tropical or subtropical invertebrates in this vicinity in these two years, during this period the winter was never so severe as in 1962–63. The results of those sporadic observations and the fragmental knowledges obtained are here arranged in a form of a short note as seen next. In addition, a brief note is given as to the mass mortality of some echinids in the summer season.

## The outline of the steady recovery of populations of some subtropical to tropical invertebrates in the intertidal zone

Excluding the census of the echinid population made at the fixed station on the shore of Hatakezima, fourteen visits were made to the shores of the vicinity; eight in 1964 and six in 1965, and three in the spring and eleven in the summer season, as shown below.

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| Visit | 1964 | 1965 |
|---|---|---|
| to Hatakezima, in spring. | 2 | 1 |
| in summer. | 1 | 3 |
| around the Bansyosaki Cape to the Tôsima region. | 2 | 1 |
| to Sisôzima, a rocky islet several hundred meters off the end of the cape. | 1 | 1 |
| to Ezura reef. | 1 | |
| to Torinosu, a rocky shore at the head of Tanabe Bay just opposite Hatakezima. | 1 | |

*1) Echinometra population*: *Echinometra mathaei* which once disappeared wholly from the intertidal zone of Hatakezima began to appear again in its former habitat. On March 31, 1964, Mr. T. YAMAMOTO found two small individuals near the north-west corner of the seaward rocky reef on which I made my first echinid census; they were less than 14 mm in long diameter excluding spines*. On May 27, nine specimens up to 15 mm and on June 24 seventeen specimens up to 20 mm were found in the same area. In the latter case ten specimens were found gathered just near the echinid colony, the population of which was examined in detail in 1963, but at a little higher level. Then on April 5, 1965, a considerable number of this sea urchin up to 35 mm were met with in the lower part of the intertidal zone of this island, although it was hardly possible to see the density exactly as the area was thickly covered by *Hijikia fusiforme* (HARVEY) OKAMURA at that time. Ten specimens up to 40 mm were found under the stones in the shallow parts of the sublittoral zone during the same observation. And on June 17, thirty-two specimens were noticed during the tour for shore animal observation. They were mostly 30 mm or thereabout and 35 mm at the maximum, and found most densely near the north end of the seaward rocky reef. At some place about ten specimens were found gathered. The existence of a considerable number of this echinid on Hatakezima was again ascertained on July 14, both in the lower part of the intertidal zone and under the stones in the shallow parts of the sublittoral zone.

On the rocky shore around the distal end of the Bansyosaki Cape, where the laboratory is located, and in the Tôsima region, respectively six and three specimens of *Echinometra* were found on June 11, 1964; the specimens were all smaller than 20 mm. Again on July 9, seven specimens less than 20 mm were met with in the same area. Mr. Ch. ARAGA, the curator of the laboratory aquarium, also noted that *Echinometra* less than 30 mm had begun to appear on the southern rocky shore of the distal part of the Bansyosaki Cape in that summer season. And the shore observation made on July 11, 1965, revealed that *Echinometra* was increased much in the same area. They were mostly less than 30 mm and much smaller specimens were included.

* All measurements given in this note were made along the long diameter excluding spines.

Some specimens were appearing again in the echinid colony at the northern end of the Tôsima region as before.

There are four observations as to other places in this vicinity. The *Echinometra* population on Sisôzima, which is a rocky islet situated several hundred meters off the distal end of the Bansyosaki Cape, was found considerably recovered on July 25, 1964, though the specimens were still fewer and smaller. A small specimen was discovered even in the intertidal zone of Torinosu, a rocky shore at the head of Tanabe Bay just opposite Hatakezima, on July 26, 1964. On the Ezura reef, about ten specimens up to 25 mm were met with on August 24, 1964; five of them were found in a very small limited sphere.

All these observations seem to show that the noticeable recovery of the *Echinometra* population has taken place in the spring of 1964 and then been proceeding steadily as seen in the increase of observed number of specimens and of the body size of examined specimens.

*2) Mespilia population*: *Mespilia globulus* (LINNAEUS) was much decreased by the severe winter of 1962-63, and there were but only a small number of specimens available for the egg studies in the summer season of 1963. On March 31, 1964, only a few specimens were found by students in the intertidal zone of Hatakezima during the field observation. On May 27 of the same year, however, a considerable numer of small individuals were observed there, and on June 24 the population of this sea urchin in the lower part of the exposed intertidal zone of Hatakezima was surprisingly dense and we could not walk around there without crashing some of them under our soles. Indeed, *Mespilia* was quite abundant in the summer of 1964 throughout all the observed places in this vicinity. It was very common on the rocky shore around the distal end of the Bansyosaki Cape and in the Tôsima region, especially in the latter area, on June 11 and July 9. This was true in other places such as Sisôzima (July 25), Torinosu (July 26) and Ezura reef (August 24).

While, it was a great surprise to see that *Mespilia* was rather scarce in the summer of 1965. On the shore of Hatakezima, it was quite absent in the intertidal zone on April 5. It appeared in the summer season, but was seen only sparsely in the lower part of the intertidal zone on June 17 and rather rarely on July 14. It was scarce, too, around the distal end of the Bansyosaki Cape and in the Tôsima region. The paucity of this sea urchin seemed to be a general feature prevailing in this vicinity in this year.

It is quite unknown what caused this sharp depletion in 1965 and either what was the mechanism of so remarkable increase of *Mespilia* in this vicinity in the summer of 1964. Apart from the exact explanation of the phenomenon, only it is evident that the *Mespilia* population in the intertidal zone may be

recovered in this vicinity in only a single year.

*3) Other echinids*: *Echinostrephus aciculatus* A. AGASSIZ was found commonly in 1964 and 1965 as in 1963. However, this sea-urchin is rather scarce on the Ezura reef and it seems to show a sign of decrease in some parts of the intertidal zone of Hatakezima, which are topographically protected rather strongly. *Diadema* does not show any sign of increase, rather it becomes more and more scarce in the intertidal zone; this is evidently due to overfishing for commercial purpose and to meanless killing by shore hoverers for only curiosity. The same is to *Toxopneustes pileolus* (LAMARCK) and *Tripneustes gratilla* (LINNAEUS). The rich occurrence of the latter in 1965 was ever predicted by Mr. Ch. ARAGA who observed abundant small individuals of this species in the sublittoral zone of this vicinity in March of 1964, and as was expected, some fishermen got a big catch of this sea urchin in the area along the north shore of the laboratory and Ezura reef in the summer of 1965. Probably, however, such uncontrolled fishing will lead to the complete depletion of these large-sized sea urchins. *Stomopneustes variolaris* (LAMARCK) was observed in 1964–1965, one small individual with a 30 mm diameter was found by Mr. ARAGA at the night of December 20, 1964 near the low water mark on the southern shore of the Bansyosaki Cape and the other specimen was found during my echinid census made on Hatakezima on July 29, 1965.

*4) Holothurians*: *Holothuria pervicax* SELENKA was found but very sparsely in this vicinity up to the spring of 1965, but since it has never been observed in the intertidal zone of the vicinity. No specimen of *Holothuria leucospilota* (BRANDT) was met with near the low water mark on Hatakezima on March 31, 1964, but two specimens were found by myself on May 27 and also on June 24 when Mr. S. SAKAI of the laboratory mentioned that five individuals were observed in the shallow parts of the sublittoral zone of that island. In 1965, four specimens were found there on April 5, twenty on June 17, five on July 14 and two on August 11. At least in 1965, the appearance of this sea cucumber was most remarkable in June. High water temperature will favour the life of *H. leucospilota*, but probably the animals will be driven into the underside of stones under the strong sun shine of the mid-summer. The above observations seem to show a tendency to a slow increase of population. In other places of the vicinity, a single specimen was caught by Mr. MORIYAMA of the laboratory aquarium on the Ezura reef in March 1965 and two specimens were met with on the shore around the Bansyosaki Cape and in the Tôsima region on July 9, 1964. After these, no specimens have been met with in these areas. When I wrote my previous note, I thought that the disappearance of this sea cucumber in this vicinity was caused by that severe winter of 1962–63. On the other hand, this sea cucumber was found thriving in the waters adjacent to this vicinity by Mr. ARAGA who observed

the population of the density of about ten individuals/$(5m)^2$ in Hukuro Inlet of Tonda, just south of Sirahama, in the summer of 1964. The abundant occurrence of this sea cucumber in the sublittoral zone of Tanami, a fishing village near Kusimoto, was ascertained, too. Learning these facts, I am now inclined to consider that the overcatch was responsible for the depletion of *H. leucospilota* in this vicinity. This sea cucumber had been used at the laboratory as the material for the anatomical and embryological practices, in addition a great number of specimens had been treated in the earlier stages of the studies to extract the toxious substance from this sea cucumber. It is improbable that this sea cucumber with a capacity of hibernating under the stones or in rock crevices was affected to death by that severe winter, though it is not impossible. While, it is very probable that the recovery of the population from the density below a certain level is not achieved easily.

*5) Some mollusks*: Of mollusks, a small number of *Planaxis sulcatus* (BORN) were observed on March 31, 1964, in the colony of *Clypeomorus humilis* (DUNKER) formed at the spot in the upper intertidal zone of Hatakezima (Pl. in Text-fig. 2, TOKIOKA 1963) where the *Planaxis* colony had ever been observed. Its population was found recovered to a considerable density on May 27 and this was confirmed again in 1965. The occurrences of this snail in a moderate density were observed, too, on the southern shore of the Bansyosaki Cape and in the Tôsima region on June 11 and July 9 and on Sisôzima on July 25 in the summer of 1964. Thus, the recovery of this snail seemed to be achieved in a year. *Gonomurex luhuanus* (LINNAEUS) does not seem to be increased; this may be attributable to the fishing by persons who take the meat of this strombid snail as a kind of delicacy. *Saxostrea mordax* (GOULD) does not show any sign of recovery, although some of them were found survived at some special spots on Sisôzima (on July 25, 1964 and July 28, 1965). *Chama* (*Pseudochama*) *retroversa* LISCHKE shows no sign of recovery, either; only a few of small shells were met with near the low water mark of Sisôzima on July 25, 1964. *Gafrarium divaricatum* (GMELIN) and *Amphidesma* (*Atactodea*) *striatum* (GMELIN) are becoming fewer and fewer by careless digging made quite freely in this vicinity.

## The results of the echinid census made at the fixed station on Hatakezima

*1) The census of 1964*: On July 10, an examination was made in the same manner as it was done in 1963 and being helped by Mr. S. NISHIMURA of the laboratory who took charge of a half of the work. It was fine, and the water was lowest at 11. 55. The sudden appearance of a large number of *Mespilia* in the colony was very impressive. Eleven *Echinometra* were observed, but

Table 1. Composition of the examined echinid colony in 1964.

| | Section 1 | Section 2 | Section 3 | Section 4 | Total | Percent |
|---|---|---|---|---|---|---|
| *Echinostrephus aciculatus* | 37 | 93 | 93 | 67 | 290 | 46.5 |
| *Anthocidaris crassispina* | 47 | 54 | 97 | 59 | 257 | 41.2 |
| *Mespilia globulus* | 15 | 20 | 15 | 9 | 59 | 9.5 |
| *Echinometra mathaei* | 2 | 1 | 4 | 4 | 11 | 1.8 |
| *Hemicentrotus pulcherrimus* | 2 | | 2 | 2 | 6 | 0.9 |
| *Pseudocentrotus depressus* | | | | 1 | 1 | 0.1 |
| | | | | | 624 | 100.0 |

Table 2. Fluctuation of long diameter in observed specimens of *Echinometra mathaei*.

| Long diameter in mm | Number of individuals in 1964 | Number of individuals in 1965 |
|---|---|---|
| 35 | | 1 |
| 34 | | 2 |
| 33 | | 2 |
| 32 | | 2 |
| 30 | | 4 |
| 29 | | 1 |
| 27 | | 1 |
| 25 | | 3 |
| 21 | | 2 |
| 20 | 2 | 1 |
| 19 | | 1 |
| 18 | 1 | |
| 17 | 1 | |
| 16 | 2 | |
| 13 | 1 | |
| 12 | 2 | |
| 11 | 2 | |

they were all smaller than 20 mm. Small specimens of *Echinometra* less than 20 mm in long diameter were found at levels higher than that of the examined colony, too. For instance, five specimens were found in a 60 cm long crevice in the *Hijikia*-belt just above the colony, at the level about 30 cm higher.

*2) The census of 1965*: The examination was made on July 29, when it was fine and calm, and the water was lowest at 12. 30. The whole population seems superficially to grow denser year by year. This may be true to some extent. But actually it is very difficult to define the colony very strictly. Slight extension of the sphere along the periphery will cause a striking in-

crease of the number of individuals. The composition of the population is here to be noticed. The sharp decrease of *Mespilia* and the steady increase of *Echinometra* were remarkable in this survey. *Echinometra* were, then, 19 to

Table 3. Composition of the examined echinid colony in 1965.

| | Section 1 | Section 2 | Section 3 | Section 4 | Total | Percent |
|---|---|---|---|---|---|---|
| *Echinostrephus aciculatus* | 61 | 133 | 101 | 112 | 407 | 50.3 |
| *Anthocidaris crassispina* | 64 | 106 | 119 | 83 | 372 | 46.0 |
| *Echinometra mathaei* | 4 | 4 | 4 | 8 | 20 | 2.5 |
| *Mespilia globulus* | 2 | 3 | 2 | 1 | 8 | 1.0 |
| *Hemicentrotus pulcherrimus* | 1 | | | | 1 | 0.1 |
| *Stomopneustes variolaris* | 1 | | | | 1 | 0.1 |
| | | | | | 809 | 100.0 |

35 mm in long diameter, and the mode of the body size seemed evidently moved towards the bigger side as compared with that seen in the 1964 observation. The specimens with a 35 mm long diameter may be considered to be nearly in a matured state. However, I am not assure whether the *Echinometra* population observed in the summer of 1965 has already attained the level maintained before the winter of 1962–63 or not, as no reliable numerical data of the echinid population in this vicinity are available and thus any comparison is quite impossible. The Table 2 seems, however, to imply some possibilities about the recruitment of *Echinometra* in the echinid colonies in the lower intertidal zone of this vicinity. If the recruitment were made by individuals survived in the sublittoral zone, then a few to several large *Echinometra* would appear in the echinid colonies or nearby in the lower intertidal zone in the summer of 1963 or at least in the warm season of 1964. Really, however, none of this echinid was observed there in the 1963 summer and only a small number of small specimens appeared for the first time in the 1964 summer. The recruitment must be made in the same sphere by newly settled imagoes or by individuals grown up to a considerable size at some higher levels and then moved down there. Generally, larger specimens are seldom found at higher levels. Thus it is urged to know whether the individuals grown up to a certain body size at higher levels move down or the circumstances at higher levels do not allow them to live out there beyond a certain body size. More fundamentally, the distribution of very young *Echinometra* or the range of actually effective imago settling must be cleared out exactly. The paucity of small specimens of *Echinometra* in the 1965 population (Table 2) is very strange. This can be understood only under the supposition that the 1965 *Echinometra* population in this colony consisted of individuals grown up in this limited sphere and those came down there from

higher levels and the settlement of imagoes in 1964 in the area comprising this colony was unsuccessful. More crucial observations are needed to make these points clear.

### Mass mortality of some echinids in the summer season

On August 5, 1965, I happened to hear Messrs. S. URA and S. SAKAI of the laboratory speaking of the unusual heaps of washed shells of *Hemicentrotus pulcherrimus* formed at a certain spot near the middle of the beach between the northern shore of the laboratory and the Ezura reef. Unfortunately, the heaps were quite destroyed and shells were broken into pieces by big swells and waves raised by approach of a typhoon before I visited the situation. Then on August 27, I visited that situation being taken by Mr. SAKAI, affirmed the environmental aspects and confirmed that the echinid shells were not of *Hemicentrotus*, but consisted of shells of *Mespilia* and *Anthocidaris* up to 30 mm in diameter. According to Messrs. URA and SAKAI, such a heap of different scales will be met with once or twice at that situation and another spot near the Ezura reef every summer. There are maintained populations of *Mespilia* and *Anthocidaris* of a considerable density in the intertidal zone of the area comprising these situations. *Hemicentrotus* hides itself usually under the stones when the habitat is exposed and thus it is protected from the sun shine and drying up, while *Mespilia* and some *Anthocidaris* are left exposed in the lower intertidal zone in spring tides. Messrs. URA and SAKAI insist that *Mespilia* will remain exposed in the lower intertidal zone during low water on calm day, but submerge in the sublittoral zone in rough weather. As *Mespilia* has only a poor adhesive power, it may be washed down into the deeper water by waves in rough weather. It is uncertain if *Mespilia* moves up and down actively according to the condition of the sea. Anyhow, it is seen frequently that some echinids left in the intertidal zone are dried up to death by being exposed to the strong sunshine for a long time in spring tides. Next, the weather conditions at the time of low water of spring tides from the end of June to the beginning of August are picked up from the weather records and compared with the corresponding data from the tide table. If the water is low enough to leave the lower intertidal zone exposed for a long time over a certain limit, and there are no clouds screening the strong summer sun shine of midday, no wind to agitate the water to raise waves and no swells which will wash the lower intertidal zone at intervals, a considerable number of *Mespilia* and *Anthocidaris* will be killed in a day. The low water on July 2 seems to fit the above-mentioned conditions. Further, the low waters repeated during the period from July 27 to 31 seem to be responsible for the most part of the mass mortality occurred recently.

Table 4. Conditions of weather and tide in the days of spring tide from June 27 to August 1, 1965.

| Date | | Time of lowest water | Level of lowest water | Weather | Wind | Maximum atmospheric temperature |
|---|---|---|---|---|---|---|
| June | 27 | 10.26 | 20 cm | rainy | SE 1 | 25.2°C |
| | 28 | 11.10 | 4 | rainy | S 2 | 25.2 |
| | 29 | 11.55 | −6 | cloudy | S 1 | 26.2 |
| | 30 | 12.40 | −11 | cloudy | S 1 | 26.9 |
| July | 1 | 13.25 | −8 | rainy | S 2 | 25.7 |
| | 2 | 14.10 | 0 | fine | 0 | 24.5 |
| | 3 | 14.57 | 15 | fine | N 2 | 25.2 |
| | 12 | 11.24 | 24 | cloudy | S 2 | 28.1 |
| | 13 | 11.58 | 19 | fine-cloudy | SW 2 | 28.0 |
| | 14 | 12.29 | 17 | fine | S 1 | 29.1 |
| | 15 | 12.59 | 18 | fine-cloudy | S 1 | 30.2 |
| | 16 | 13.28 | 22 | fine | S 1 | 29.4 |
| | 17 | 13.57 | 28 | cloudy | S 2 | 30.2 |
| | 26 | 10.12 | 26 | fine | S 1 | 30.4 |
| | 27 | 11.02 | 9 | fine | 0 | 31.0 |
| | 28 | 11.48 | −1 | fine | 0 | 32.3 |
| | 29 | 12.31 | −5 | fine | S 1 | 32.5 |
| | 30 | 13.31 | −1 | fine | 0 | 32.4 |
| | 31 | 13.56 | 9 | fine | S 1 | 32.0 |
| August | 1 | 14.37 | 26 | fine | W 1 | 32.3 |

All the conditions in these days exactly agree those for destroying the exposed echinids, but the breeze from the south on 29th and 31st, which won't affect much on the leeward shore.

Before closing the present note, I wish to express here my hearty thanks to every person who helped me to carry out these observations or gave me various kinds of important informations.

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