

Note on a 4-rayed Specimen of *Clypeaster*
japonicus DÖDERLEIN.

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With Plate XXV.

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In May 1928, after a heavy storm, I found several specimens of *Clypeaster japonicus* DÖDERLEIN on the shore close to the Seto Marine Biological Laboratory, Seto, Prov. Kii; and among them a 4-rayed individual was discovered. This specimen had apparently been so subjected to the action of the waves since its death, that all the spines, as well as the inner soft parts, were gone. Therefore, my description of the present specimen will be confined to the external structures, in comparison with the normal materials collected in the same locality.

DESCRIPTION OF THE TEST.

The outline of the ambitus is a rhomboid with rounded corners; it is slightly sinuated in the right anterior and the left posterior inter-radii, while smoothly convex in the right posterior and nearly straight in the left anterior interradius (Figs. 2, 3). The perradial sutures of each petal of ambulacrum cross at almost a right angle, so that there

is shown an apparent biradial symmetry on the aboral surface. The test is composed of elements of four in number, instead of five, viz. 4 ocular plates and genital pores, 4 petals, 4 sets of ambulacral and interambulacral plates. The outline of the petal is nearly oval and its distal part is obtuse, while in the normal example it is much more elongated and has a more or less pointed end. The peristome sinks deeply, with four ambulacral furrows radiating outward. The jaws are incomplete, but these also may not be an exception to the tetramerism. Below the ambitus, in the right posterior interradius, is the periproct, quite apart from the usual position (Figs. 1, 3).

The sutures of the individual plates are very indistinctly shown. However, careful examination under a lens has revealed that all the shell-plates are regularly arranged (Fig. 4). The madreporite is rectangular in outline, though nearly pentagonal in the normal specimen. The genital pores are situated at the corners of the madreporite. The madreporite gives attachment at the middle of each margin to a perforated ocular plate, from which originates a double column of the ambulacral plates of the petaloid region. Each of these plates produces a demi-plate in the poriferous zone, as usual. The latter, except at the distal parts of the petal, is so arranged that the transverse sutures of the opposite plates are convergent to the perradial suture, and the sutures of the demi-plates of the whole surface form concentric rings, though in a normal example these plates are placed oblique to the perradial axis, the sutures of the opposite plates forming a concave arc. It is highly probable, that this abnormal arrangement of the demi-plates has been brought about by the uniform elongation of the individual plates in the tangential direction, to fill up the space of the missing ray (see also later). Simultaneously, this compensatory growth of the plates probably has made the outline of the petal wider and shorter, as stated above. In other respects the arrangement of the shell-plates is identical with that in a normal test.

TABLE I.

Dimensions of the test, in comparison with normal young specimens.

	4-rayed specimen	Normal young specimens	
		A	B
Length mm.	68.2	60.8	75.6
Width mm.	60.4	49.4	60.7
Height mm.	21.8	16.5	19.5
Ratio $\frac{\text{Width}}{\text{Length}}$ %	88	81	80
Ratio $\frac{\text{Height}}{\text{Length}}$ %	32	27	26

TABLE II.

Measurements of the petal of the tetramerous specimen.

The length is measured from the ocular pore to the line bound together between the distal ends of a pair of poriferous zones, along the perradial suture.

Petal of ambulacrum	Width mm.	Length mm.	Number of ambulacral pore-pairs in each poriferous zone	
			right	left
anterior	15.2	22.0	33	34
right	15.0	20.0	33	33
posterior	16.0	24.0	37	37
left	15.2	20.8	32	35

Some remarkable features of the specimen are seen in Table I, that is, the specimen is relatively wider and higher as compared with normal young individuals, and the test has a somewhat rounded appearance.

The number of ambulacral pore-pairs is the least among the two hundred and more specimens of my collection. This fact may be partly due to its immaturity, because there is a tendency of increase in the

number of the ambulacral pore-pairs (or in other word, demi-plates) with the growth of the test, in fact I could count as many as 66 pore-pairs in a larger specimen. However, this alone does not explain the smallness of the number of the ambulacral pore-pairs in this specimen, because even the smallest individual I could secure (Fig. 5, and measurements given in column A of the Table I) has more (34-41) pore-pairs. Perhaps this peculiarity is due to some extent, to the suppression of the growth of the corona.

DETERMINATION OF THE MISSING PART.

Of the four petals, one is open at the anterior extremity, showing that this is the anterior petal. The remaining three rays, therefore, must represent the other four rays of the normal specimens; but the question arises as to which ray of the former corresponds with which ray of the latter. The number of ambulacral pore-pairs gives the clue to the answer. Both lateral petals have almost the same number of pore-pairs (Table II), which number is less than that of the pore-pairs of the posterior petal. In a normal individual the pair of posterior petals always have the largest number of pore-pairs, and this is the case with the posterior unpaired petal of the present specimen (see Table II). It is thus obvious that this petal corresponds to one of the posterior petals of a normal individual, and the two lateral petals to the same of the latter. Consequently, it is certain that one of the pair of the posterior radii is missing in this specimen. Next, the position of the periproct shows that the missing part is probably the right posterior ray (namely Ambulacrum I of LOVÉN'S system). If we suppose that, after the removal of the right posterior radius from a normal test, a harmonic compensation has occurred, viz. both the lateral rays were shifted backward, and the left posterior to the right, the present case may be plainly interpreted. It must be added however, that the right half of the periproct is derived from the interambulacrum of the right anterior ray, as the anus lies between the pair of interambulacral plates.

REMARKS.

BATESON (1894) has divided the cases of meristic variation of Echinoidea into four classes, of which the present case belongs to class I, "cases of total variation to a 4-rayed form, with 4 ambulacra and 4 interambulacra". Several tetramerous examples in the irregular echinoids in genera such as *Echinobryssus*, *Pyrina*, *Discoidea*, *Hemiaster*, *Echinocomus*, *Echinolampas*, etc. have been reported by previous writers. COTTEAU (1862-'67) among others described in *Discoidea cylindrica* a symmetrical fossil specimen. He says, "L'ambulacre antérieur est complètement atrophié et les quatre autres, un peu plus espacés qu'ils ne le sont ordinairement, présentent cependant dans leur disposition une régularité parfaite. La plaques ocellaire antérieure, correspondant à l'ambulacre qui fait défaut, manque également" (p. 31). Although this explanation is plausible, yet it is insufficient for the determination of the missing part, because there is no statement in regard to the symmetry of the apical system and no differentiation occurs in the ambulacra in this species. ROBERTS (1891) reported an *Echinocomus subrotundus*, which lacks the parts "which lie on the left side of a line drawn through the middle of the anterior single ambulacrum and the posterior unpaired interambulacrum" (p. 117), but the precise determination of the missing part was impossible in this case. Both these specimens agree with mine in having a regularly-constructed test, but the marked difference in the ambulacral system makes detailed identification impossible.

A number of cases of a similar character among the regular echinoids are mentioned by BATESON (*l. c.*), HAMANN (1904), and RITCHIE and McINTOSH (1908). VERRILL (1909) illustrates a 4-rayed specimen of *Arbacia equituberculata* in his paper on the starfish, without any description in regard to the coronal structure. This specimen is from the Azores, and is preserved in the Museum of Yale University. The photograph (fig. 1 *b* on p. 546) shows that the madreporic plate is unusually large, and apparently provided with two openings of unequal

size, and that the interambulacral area of the same radius as the madreporite is irregularly swollen. These abnormal features of the test suggest that in consequence of abortion of the right anterior ambulacrum, union of the neighbouring interambulacral areas has taken place.

SUMMARY.

1. The regularly tetramerous specimen described above differs from the normal one in that (a) the outline of the ambitus is more rounded, (b) the test is higher, (c) the number of ambulacral pore-pairs is smaller, (d) the outline of the petal is oval, and (e) the direction of the transverse sutures of the demi-plates is almost tangential.

2. The tetramerism of the present specimen has been brought about apparently by the complete abortion of the right posterior ambulacrum and the adjacent interambulacra.

The specimen described above is now deposited in the collection of the Seto Marine Biological Laboratory.

I wish herewith to express my thanks to Prof. T. KOMAI, the director of the Laboratory, who gave valuable advice and expressed much interest in regard to the present report.

LIST OF REFERENCE.

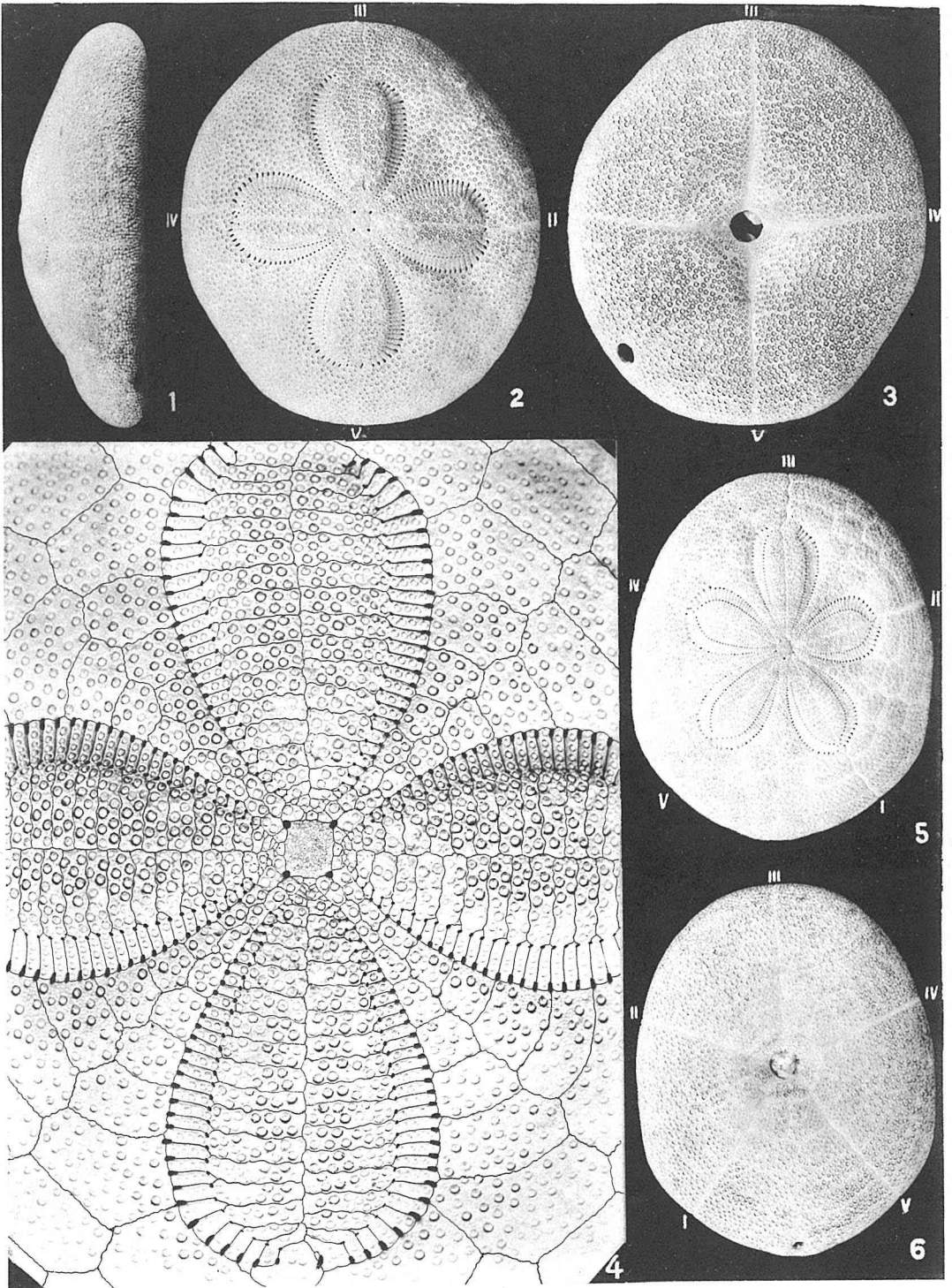
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EXPLANATION OF PLATE XXV.

The denuded test of *Clypeaster japonicus* DÖDERLEIN.
4-rayed specimen.

- Fig. 1. View from right side. Fig. 2. Aboral view.
Fig. 3. Oral view. Fig. 4. Central part of adapical surface, magnified. The suture-lines are drawn with black ink.
Normal young specimen.

- Fig. 5. Aboral view. Fig. 6. Oral view.
(The numbering of the ambulacra is given after LOVÉN'S nomenclature).
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I. TAKI photo.

TAKI: 4-rayed Specimen of *Clypeaster japonicus*.