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Hermaphroditism in the Sea Urchin, *Hemicentrotus pulcherrimus*

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It is rare to find hermaphrodites in sea urchins. In spite of the low incidence of the finding, hermaphroditism has been reported in several genera of echinoids, such as *Arbacia, Paracentrotus* and *Strongylocentrotus,* and also in *Dendraster, Echinocardium, Echinus, Psamechinus* and *Sphaerechinus* with lower frequency (Boolootian and Moore, 1956).

In Japanese sea urchins hermaphroditism has been reported mainly with the species commonly used in experimental works, including *Strongylocentrotus intermedius* (Tajima and Tomita, 1980), *Hemicentrotus pulcherrimus* (Okada and Shimoizumi, 1952; Ijiri, Ejima and Amemiya, 1981) and *Clypeaster japonicus* (Ijiri *et al.*, 1981).

We report in this paper on a case of hermaphroditism in an individual of *H. pulcherrimus* which had pure ovaries and testes in its own body.

The animal was found among those collected in April to May of 1985 from the shore at Shimokashiro, Iwaki, Japan. The external appearence was normal, with a size of ca. 5 cm in diameter. The tips of tube feet appeared slightly tinged with orange, which is a characteristic feature of the other normal females. When 0.55 M KCl was injected into the body cavity, the animal shed eggs from two gonopores and sperm from two other gonopores. No gamates was shed from one remaining gonopore.

After the eggs and sperm were ejected, the whole gonads were dissected from the shell and fixed in Bouin's solution. The overall view of the dissected gonads before fixation is shown in Fig. 1a. Three of five lobes appeared to be matured, from which gamates, eggs from one lobe and sperm from two of other lobes, came oozing out through the injured portions made during dissection. The two remaining lobes were smaller than these and appeared more darkened, from which no extrusion of gamates was observed by any further dissection.

For the microscopic observations, small pieces of gonads were excised and embeded in paraffin by a routine method. After sectioned at 5 to 10 μm thickness, samples were stained with hematoxilin and eosin. Histologically examined portions are indicated in Fig. 1b. The portion excised from

the gonad oozing eggs showed normal histological appearence of a pure ovary (Fig. 2a), and that from the gonad oozing sperm showed the appearence of a pure testis (Fig. 2b). Histlogy of the portion from the junction of the gonadal lobes revealed that many of the tubules contained exclusively either oocytes or sperm (Fig. 2c) but a few tubules contained both oocytes and sperm (Fig. 2d). The tubules showing the appearence of the ovotestis were found mainly on the boundary between the regions containing the tubules showing ovarian and testicular appearence.

Eggs exuded from the hermaphrodite were spontaneously fertilized with sperm from the same animal immediately after shed, with a fertilization ratio of about 80% by judging from the elevation of the fertilization membrane. Sperm swam normally (Fig. 3) with the normal flagellar beating (54.5 ± 4.0 Hz of beat frequency of five free swimming sperm at 25°C). Self-fertilized eggs proceeded with their normal cleavage (Fig. 4a, b) and developed to four-armed pluteus, feeding on algae (Fig. 4c).

It has previously been reported that in *H. pulcherrimus* there are several ovotestis in the body of a single hermaphrodite, while a few pure ovaries or testes may be found in the same body. However in the hermaphrodite described in the present report, there were at least one pure ovary and two testes, while ovotestes were found only in a limited region on the boundary between the ovary and testis. These findings may suggest that there is a variation in the type or degree of hermaphroditism in the sea urchin or that the ovotestis emerges in a region between the ovary and the testis in the process of its formation. These suggestions may stimulate one into experimental works on this phenomenon, hermaphroditism, in the sea urchin which is rather rare in the natural environment.

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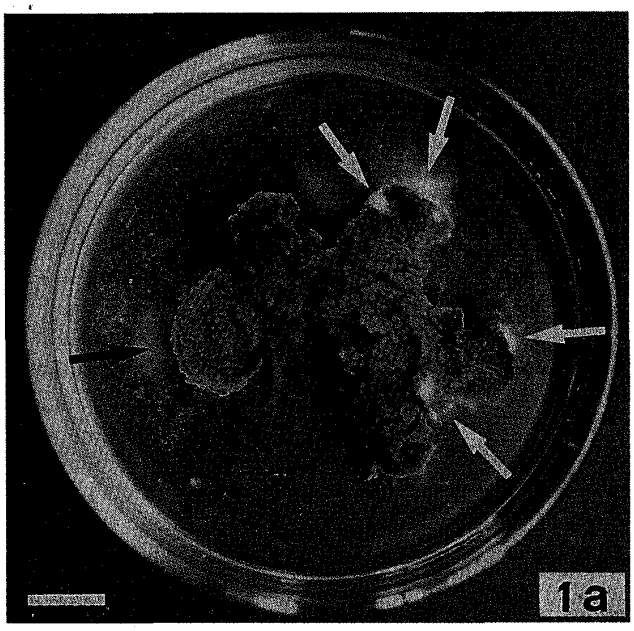
Explanation of Figs. 1-4

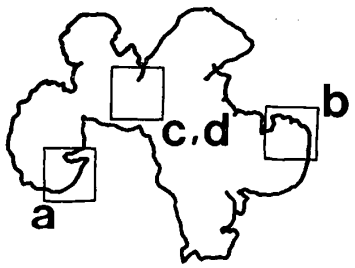
Fig. 1. Gonads from a hermaphrodite of *Hemicentrotus pulcherrimus*. a: an overall view of the dissected gonads. Black arrow indicates the portion from which eggs came oozing out. White arrows indicate the portions from which sperm came oozing out. Scale bar, 1 cm. b: a scheme of the gonads indicating the portions which were sectioned and examined. a to d correspond to those in Fig. 2.

Fig. 2. Histology of the gonads of a hermaphrodite of *Hemicentrotus pulcherrimus*. Sections of the normal ovary (a), testis (b), junction between the ovary and the testis (c) and the region containing ovotestis (d) are shown. O, ovary; T, testis; OT, ovotestis. Scale bar, 100 μm.

Fig. 3. Sequential photographs of the movement of the sperm exuded from a hermaphrodite of *Hemicentrotus pulcherrimus*. The sperm was swimming freely under the cover slip. The artificial sea water in which sperm were diluted contained 1% bovine serum albumin in order to avoid the adhesion of the sperm tail to the glass surface. Storoboscopic recording with flash intervals of 12.5 ms. 25°C. Scale bar, 10 μm.

Fig. 4. Development of the self-fertilized eggs from a hermaphrodite of *Hemicentrotus pulcherrimus*. a, 16 to 32 cell stage; b, mollula and c, four-armed pluteus, 8 days after fertilization. Each scale bar, 10 μm.





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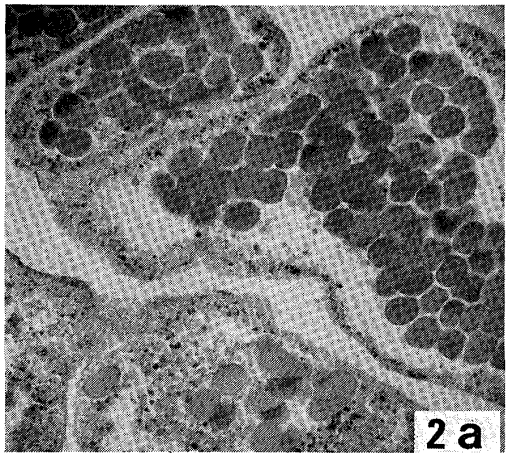
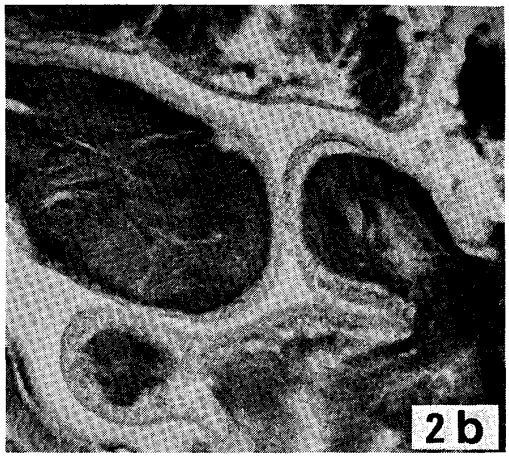
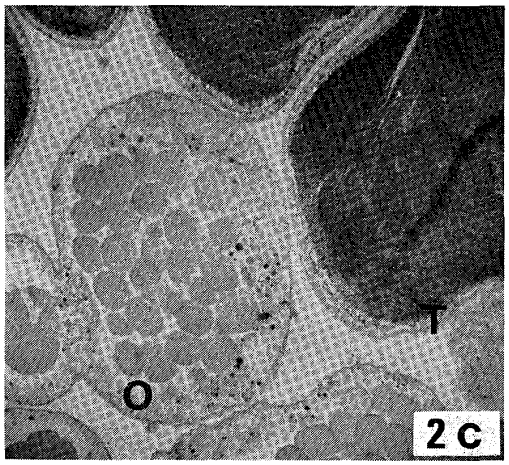
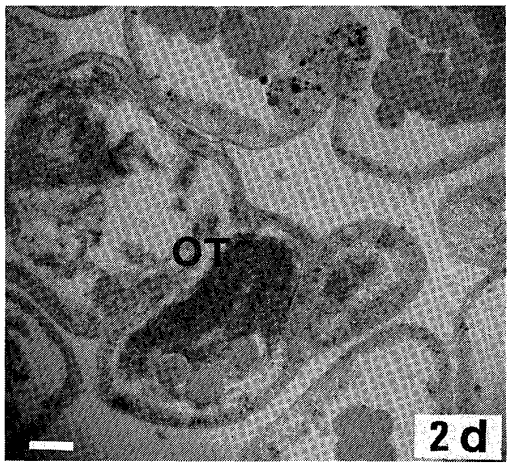
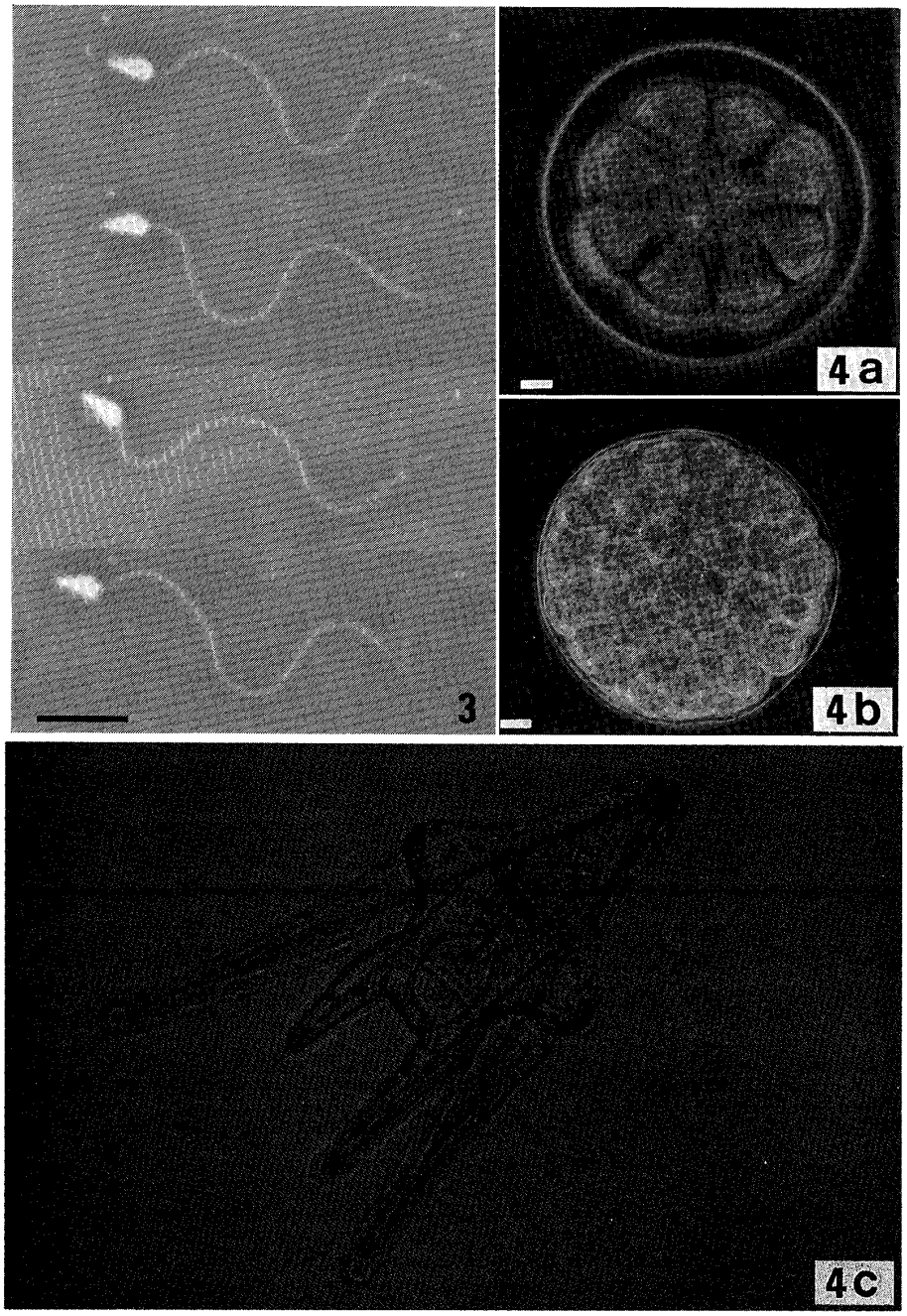








Figs. 1-2



Figs. 3-4