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## STUDIES ON THE BIOLOGY OF THE SEA URCHIN

### II. Size at First Maturity and Sexuality of Two Sea Urchins, *Strongylocentrotus nudus* and *S. intermedius*

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In a previous paper (Fuji, 1960) it has already been mentioned that most specimens of *S. intermedius* under 20 mm and of *S. nudus* under 30 mm in test diameter possess neuter gonads. This assessment has been concluded from arbitrary samples, but it is not based upon samples with variation of test diameter covering the whole range from large animals to small ones. Consequently, it may be highly necessary to make careful determinations on the biological minimum size, which is an important item of basic information for understanding the reproductive biology of these sea urchins.

To test the validity of this assessment, observations were made on the sexual composition and on the size at first maturity of these animals.

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#### Material and Method

The materials employed in this investigation consist of two series: (a) To test the sexual composition, regular samples covering the entire size range of the two sea urchins were taken from Muroran and Ishiya during the period from June to September 1958. (b) Other samples for determination of the size at first maturity in their life were arbitrarily selected from the samples of September, that is, at the period of maximum gonad development.

Total number of sea urchins examined was about 2,000 specimens.

These urchins were histologically examined on their gonad tissue and the histological criteria as reported in the previous paper were used for a careful determination of gonad maturity.

Histological techniques employed in this observation are the same as described in the previous paper.

#### Observation

The data are illustrated in histogram form (Figure 1), the frequencies being the percentages of neuter, male and female urchins for each 5 mm class interval of test

diameter. Figure 1(a) is based on the histological observation for gonads of 644 specimens of *S. intermedius* from Ishiya, (b) on 627 specimens of the same species from Muroran, and (c) on 477 specimens of *S. nudus* from Ishiya. During the period of June - September, the percentage of inactive gonads in the adult specimen is very low, consequently sea urchins with undeveloped gonads are predominantly neuter specimens.

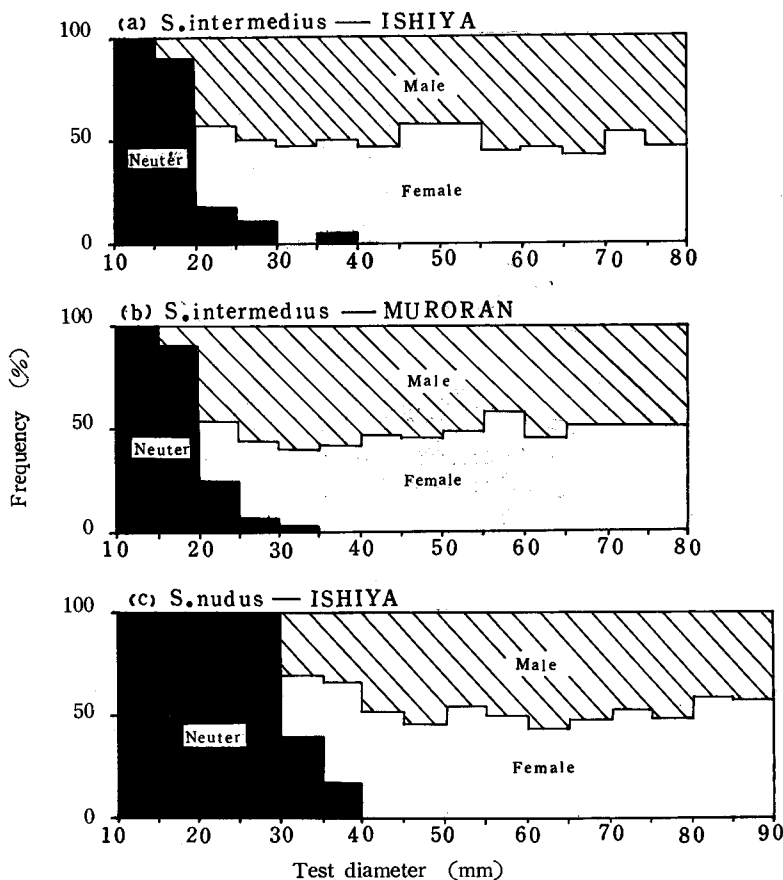


Fig. 1. The percentage frequency of the sexes in various size-groups (based on test diameter)

Figure 1 shows how sex composition varies with size (equatorial diameter, exclusive of spines). In *S. nudus*, almost all specimens of under 30 mm test diameter possess neuter gonads, while in *S. intermedius* neuter specimens were those under 15 mm in test diameter. The two sexes are approximately equal in number in *S. intermedius* having a test diameter over 15 mm; the same is found in *S. nudus* over 30 mm test diameter.

The histograms represented in Figures 2 and 3 are the frequencies in percentage of each gonadal stage for the two species of sea urchins collected in September corresponding to the term of maximum gonad development. In both species the frequency in each gonad

stage shows a considerable fluctuation with variation of test diameter; a significant difference between the two species is found at the size-group which represented a high frequency of Stage IV gonad. Specimens of *S. intermedius* of 25-35 mm in test diameter possess mature gonads (Stage IV) in excess of 50%. On the other hand, in *S. nudus* nearly all specimens of under 35 mm test diameter possess gonads belonging to Stage I, and the animals of Stage IV approach about 50% when they attain to size between 45 mm and 50 mm equatorial diameter.

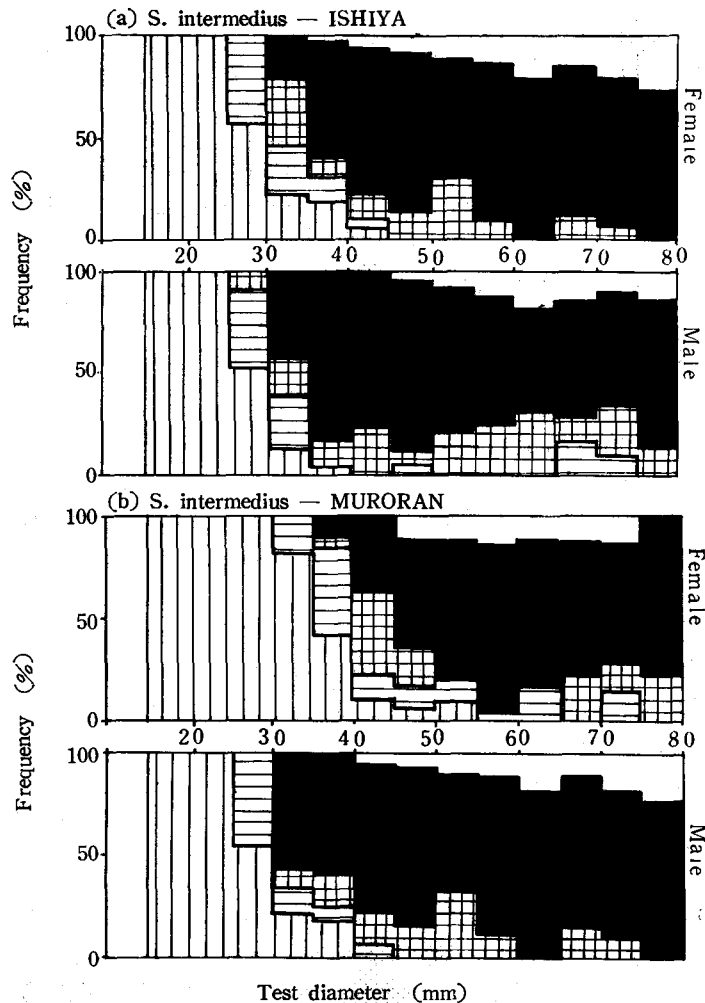
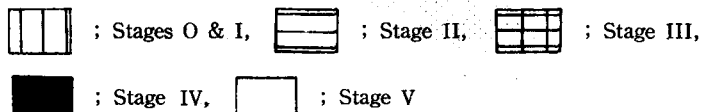


Fig. 2. Variation with size-group in the percentage frequency of the gonad stages in *S. intermedius*



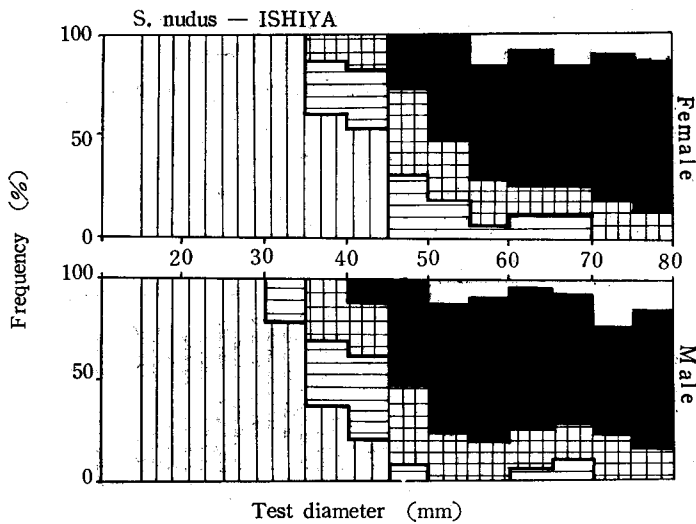


Fig. 3. Variation with size-group in the percentage frequency of the gonad stages in *S. nudus*. Each symbol is the same as those in Fig. 2

In regard to this matter, the most striking difference between male and female urchins is that the small size-group of the male population is preponderant in comparison with the same size-group of female ones in the occupancy of later gonad stages (Stages IV and V). The size-groups of 20-35 mm in *S. intermedius*, like *S. nudus* in size-groups of 30-45 mm, possess a high proportion (ca. 70% at least) of the early developing gonad (Stages I and II) even in September which is the period of maximum gonad development. Accordingly, it is extremely probable that the specimens of these size-groups remain virgin without developing to the later gonad stages till the following spawning season. From such considerations, it is concluded that the size at first maturity covers a test diameter of 30-35 mm in *S. intermedius* and of 40-45 mm in *S. nudus*.

#### Discussion

Very few statistical reports of hermaphrodite echinoids are available. The record that 20 hermaphrodites are yielded among 10,000 *Strongylocentrotus purpuratus* is the highest incidence so far reported (Booolootian & Moore, 1956). Giard (1900) has suggested that *Echinocardium cordatum* is normally a protandric hermaphrodite. Neefs (1937, 1938, 1952) used two lines of explanation for the seasonal change of sex. One is the presence of hermaphrodite specimens, in which one sexual phase is in perfect condition whilst the other shows degeneration. The other attempt has been made to account for the seasonal variation of sex composition; male urchins preponderate over female in summer

season, and vice versa in winter. The presence of degenerate gonads of two colours in an animal (Neefs, 1952) and of a perfectly functioned hermaphrodite (Shapiro, 1935; Harvey, 1939) may be interpreted as a presumable indication of sex reversal. Since the presence of such a sexual phenomenon is very rare (Shapiro found one individual among 2350 *Arbacia punctulata*), however, it may be an appearance of pathological gonads so called "pseudohermaphrodite".

If echinoids are normally a protandric hermaphrodite, it may be noticed that the great majority of small urchins are male, and that the large ones are preponderantly female. As illustrated in Figure 1, there is no significant change in the sex ratio over almost the entire range of size-groups except as the result of differential mortality and migration into two sexes. In the two sea urchins under consideration in the present investigation, a differential migration and mortality is unlikely between male and female population.

It has been already presumed that the first maturity in their life commences with a test diameter ranging between 30-35 mm in *S. intermedius* and between 40-45 mm in *S. nudus*. Of course, the size dimension is proportional to age; the size range may be regarded as corresponding to the lifetime of the species. However, there is no available data of growth rate in the two sea urchins up to the present time. Consequently, it may not be said with certainty that the difference in the size at first maturity between the two species is a direct indication of different ages. Such questions concerned with age and growth rate of the two species of sea urchins are left as unsolved problems.

### Summary

Observations have been made on the biological minimum size of two sea urchins, *S. intermedius* and *S. nudus*, by means of stained section of gonads.

Almost all specimens of *S. intermedius* ranging up to 15 mm test diameter and of *S. nudus* under 30 mm in test diameter were neuter, but in the specimens in excess of these sizes it is possible to differentiate the sexes. The size at first maturity covers a test diameter ranging between 30 and 35 mm in *S. intermedius* and between 40 mm and 45 mm in *S. nudus*.

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