GROWTH AND BREEDING SEASON OF THE BRACKISH-WATER BIVALVE, *CORBICULA JAPONICA*, IN ZYUSAN-GATA INLET

Akira FUJI
Faculty of Fisheries, Hokkaido University

In some lamellibranchial bivalves, as a sign of their growth, the annual rings were shown on the surface of their valves, transverse section of shells and adductor muscle scars, and these are helpful in determining the age and growth rate of the clam. It is believed that these marks are made in any stagnating seasons of conchiolin secretive ability in the mantle margins. According to this supposition, the determination of age and growth rate in many marine bivalves have been studied by means of the shell reading method (Orton, 1926 ; Stephen, 1929 ; Yamamoto, 1947 ; Coe, 1947 ; Nayar, 1955 ; Cassei, 1955). In bivalves which have no distinct growth marks, size frequency distribution has been often employed for the presumption of age and growth rate. On *Corbicula sandai*, Furukawa (1953) has presumed age and growth rate by the shell reading method, however, in *Corbicula japonica* no growth marks, as concentric circular resting zones, appear on the surface of their valves and other parts, and information available on the growth of this economically important clam is scanty at present.

This study was initiated in order to gain some information on the growth rate of *Corbicula japonica* in natural population, and in addition such information was used as a presumption on the breeding seasons of the clam in Zyusan-gata Inlet.

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Method

Random sampling of the clam, *Corbicula japonica*, was made once a month for the period from June 1954 to October 1955, from various main clam fields (viz., Okinose, Est. Iwaki, Est. Yamada and Est. Imaizumi) in Zyusan-gata Inlet. All animals were sampled every time by means of a hand dredge with sieves of 1 mm square mesh.

Growth rate is determined by the size frequency method. Thus, as the standard of measuring size, shell height was measured with sliding calipers on a unit of one-tenth of a mm and measurements were grouped into sizes according to 1 mm intervals. Then the percentages of different size groups to the total number of clams measured for each month were represented by graphs. The polymodal frequency distributions obtained by observation were graphically analysed making use of probability graph paper devised by Harding (1949). Each normal distribution, which was separated from the polymodal frequency distribution, was compared with ordinal frequency under the statistical treatment of chi-square test, and was tested for the goodness of fit. The shifting of the mean values in each normal distribution for different months was taken to indicates the average growth rate of the different year-classes from month to month.

The spawning period of the clam was presumed from monthly size frequency distribution and from determining the annual variations in nutrition and meat weight coefficient of the clams. The size of clams used in this analysis was 18 mm or more in shell height. The valves were carefully opened without any damage to flesh, most of the adhering water in body surface and gill capillaries was removed by absorbent papers, then each clam was weighed with and without the valves. The meat weight coefficient of the clams was derived following formula;

$$\frac{\text{wet weight without valves}}{\text{total wet weight with valves}} = \text{meat weight coefficient of clam}$$

The flesh was dried to constant weight in an electric oven at 105±3°C; the loss of weight represented the water contents of each sample. Total nitrogen in dried sample was analysed by Kjeldahl method.

Water filtration was applied as an available index of physiogical activity of the clams. As shown in a previous paper (Fuji, 1957), the removal of particles from the suspension of acid earth was measured by the optical density of photoelectric colorimeter, and water filtration was calculated from the formula derived by Jφrgensen (1949). In the experiments of water filtration, all aquaria were continuously aerated with air bubbles, and experimental water was adjusted to 0.6% Cl.

Result and Discussion

The size frequency distribution in each mm interval is represented in Figure 1. From this figure, it is pointed out that three or four size groups were separated from the frequency distribution in each month. In the month of July 1954 the samples observed consisted of four size groups: the mean value of the first group, in which it is assumed the larval population is only shifting in bottom life, is estimated at 2.5 mm; in the second, the third and the fourth groups the mean value of each separate group is appraised at 8.4, 15.5 and 21.2 mm respectively. The shifts of these mean values of each size group, as given in Figure 1, increase steadily with the progress of months. For example, in the second group the gradual and steady increment of mean value is represented by the movement from 8.4 mm to 10.3, 11.2. 11.7, 11.8 and 12.0 mm in successive months. In July 1955 the mean values of four size groups separated were represented at 2.1, 7.5, 14.7 and 21.0 mm in shell height, and these values coincide with the one in the month of July 1954. From the results of above observations, it is strongly suggested that the three or four different size groups separated from the frequency distribution correspond with each different age-class. If this presumption is admitted, it may be concluded that the values of each different age class demonstrated

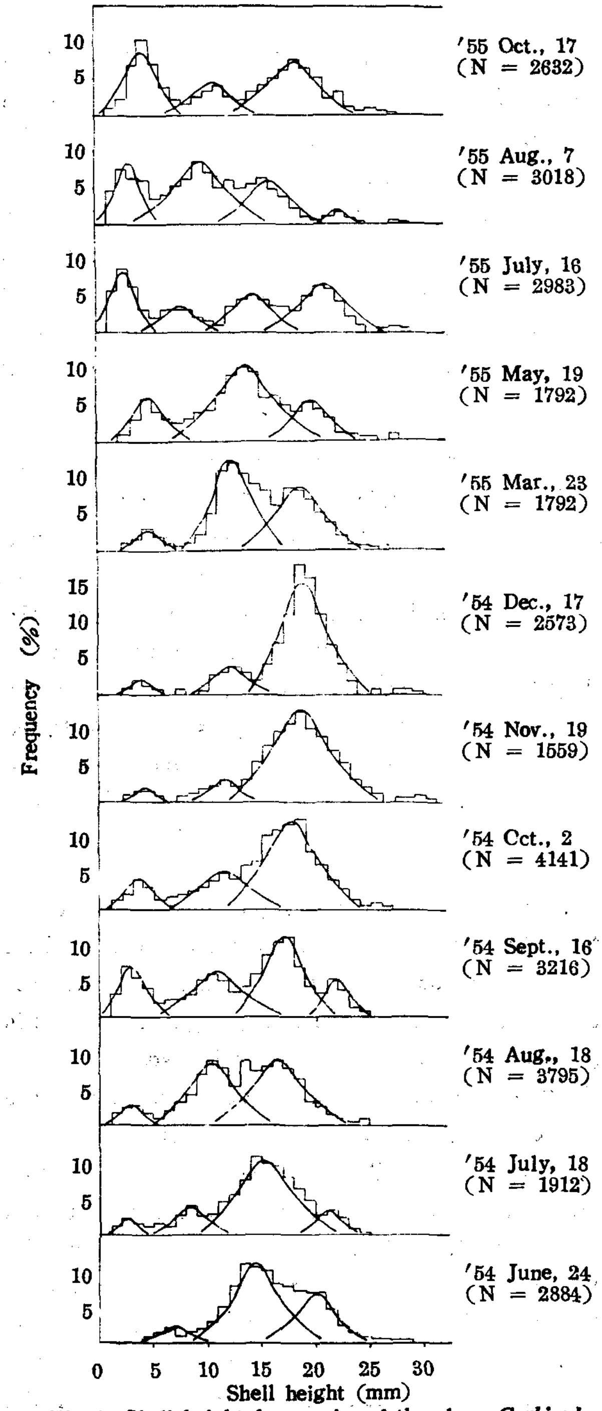

Fig. 1. Shell height frequencies of the clam, *Corbicula japonica*, caught in Zyusan-gata Inlet
Histogram : Shell height frequency distribution obtained by observations. Curve : Shell height groups estimated by fitting normal curves.

an approximate value of 9,15 and 21 mm in shell height at the ages of full 1, 2 and 3 years.

The correlation between the growth and the temperature in successive months is represented in Figure 2. The growth of the clam started in April when water temperature attained to approximately 10°C, a rapid increase of growth showed in May (temperature about 15°C) and in the season between June and August showing temperature of over 25°C, it was very vigorous. Their growth continues until November when the temperature was about 5°C, although in September and October the degree of increment in growth falls off. However, it is distinct that the augmentation of shell height ceases in the season between December and March.

The fact that the growth and breeding in aquatic animals are influenced to a considerable extent by fluctuations of environmental factors such as water temperature, salinity and others has been well recognized. Especially, in the shallow waters, in such clam fields as in Zyusan-gata Inlet, water temperature changes markedly between summer and winter resulting in rapid growth of clam shell height in the former season and less or negligible growth in the latter. In many marine bivalves, Orton (1926) on *Cardium*

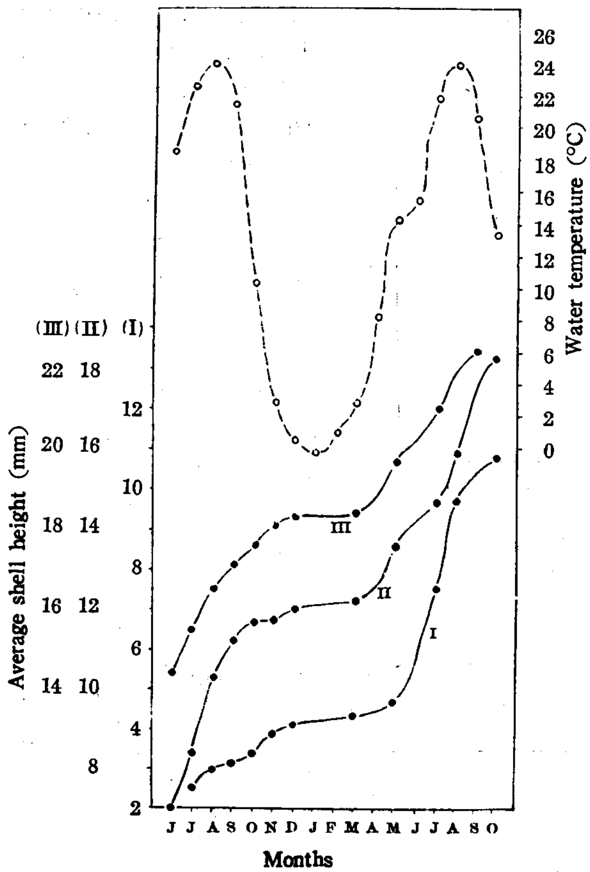

Fig. 2. Diagram showing the average growth rate of clams belonging to each year-class with water temperature in successive months

edule, Naito (1930) on *Mertirix mertrix* and Yamamoto (1947) on *Mactra sachalinensis* have furnished detailed information on such tendency of growth rate. It is believed that such annual variation of growth rate is influenced by the physiological activity of the clam resulting from the seasonal cycle of water temperature.

The influences of temperature on water filtration which is useful as an available measurement of physiological activity are given in Figure 3. From inspection of this figure, it can be stated that the value of water filtration under various temperatures increases linearly with the rise of temperature. In view of the fact that the measurement of filtration rate gives a reliable measure of current flow, it may be suggested that the feeding rate of the creature in higher temperatures shows more activity than in lower one, and the rate is closely comparable with the seasonal vicissitudes of growth rate.

In the monthly size frequency distribution (shown in Figure 1), a fresh year-class has commenced entering the population is revealed by the appearance of very small individuals of 1 to 2 mm height in mid-July of both years, and the occurence of the major set larval population is found still in September. A margin of about 2 to 3 weeks is allowed for embryonic, larval life, setting and growing to 1 or 2 mm in height, moreover, the most of samples used to prepare the size frequency distribution consisted of various sized clams left in the sieve of 1 mm square mesh. Consequently, it is assumed that the occurring period of set larvae lies in a few weeks before the middle of July.

Variation in tissue contents such as nitrogen, ash and moisture represents an annual cycle influencing the maturity and breeding. Sekine *et al.* (1929) on oyster, Ashikaga

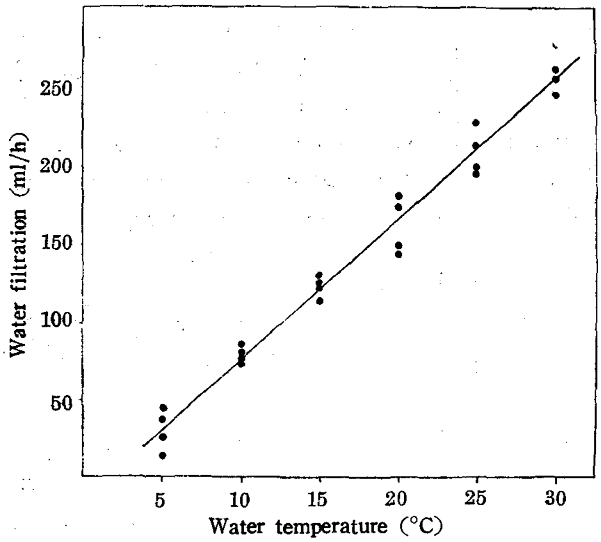

Fig. 3. Relation between water filtration of clam and water temperature

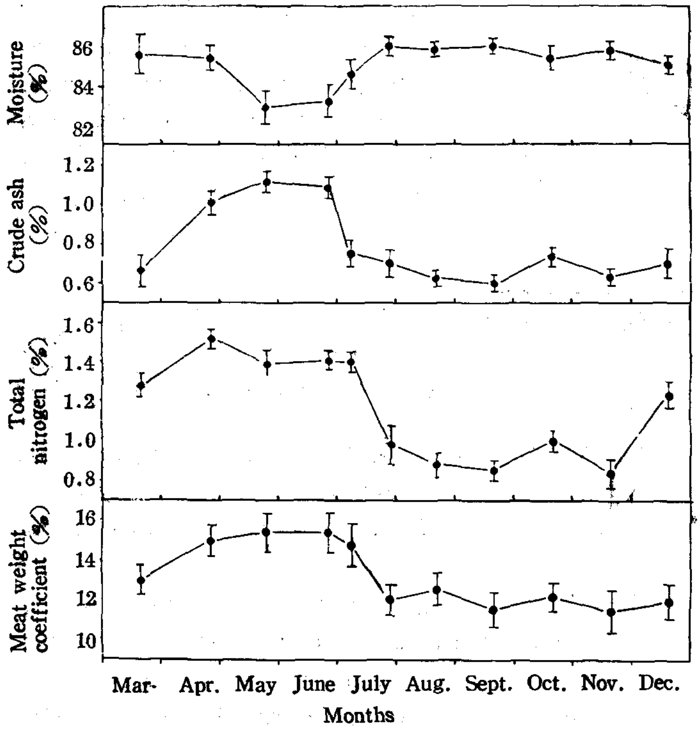

Fig. 4. Seasonal variation in the flesh components of clam (per cent in row material)
In this figure the vertical lines indicate a range of standard error of mean.

(1948) on pearl-oyster have reported detailed information in relation to the above problems. The samples obtained regularly by present author once a month during ten months between March 1955 and December 1955 were analysed in order to determine the annual variation in nitrogen, ash, moisture and mest weight coefficient of the adult clam (18–22 mm in shell height). The results are plotted in Figure 4. The peak values of meat weight coefficient, nitrogen and ash contents were attained during late May and late June, but in early and middle July they decreased strongly. On the other hand, moisture showed seasonal variation contrary to other elements. From these results, it may be assumed that the period between late May and middle June corresponds to the most maturating term of this clam and occurs just before the breeding.

According to Asahina (1941), in Mokoto-numa, Hokkaido, almost all females were spent individuals in middle July. Kokubo & Sato (1947) have reported that the major planktonic larvae of clam were found in plankton samples in August in Zyusan-gata Inlet. In view of these items of information, it is concluded that the breeding seasons of the clam in Zyusan-gata Inlet appear to be prolonged, extending from late August, and the majority of the individuals spawn in early July, although the breeding would be commenced at different times to some extent in various clam fields.

Summary

Monthly distributions of shell height frequency of the clam were analysed using a probability graph paper, covering the period from June 1954 to October 1955. Then they were separated into three or four normal distributions which correspond to the different year-classes. The growth rate of the different year-classes in successive months indicated the shifting of the mean values in each normal distribution for different months.

The growth of the clams in each different year-class commenced in April, and in the summer seasons showing the water temperature over 25°C, the growth was rapid. After this season, the gradual growth continued until November, but in the winter season between November and March the clam showed a less or a negligible growth.

A fresh year-class consisting of the very small individuals of 1 to 2 mm in height commenced entering the population in middle July. Moreover, the nutrient variation of clam tissues demonstrated considerable fluctuations in early and middle July. Thus it is shown from the above information that the breeding season extends from late June to late August, and the majority of individuals spawn in early July.

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