Ecological Observation on the Appearance Frequency of the Bivalve Larvae in Sun-Jae Island

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仙才島產 二枚貝 幼生의 出現頻度에 關한 生態學的 觀察

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摘 要

우리 나라 西海岸인 京畿道 富川郡 仙才島에서 產出되는 二枚貝類의 出現 頻度 分布 狀態를 1959年 8月부터 1960年 10月에 걸처서 生態學的인 調査를 하였다.

1) Sampling은 motor pump를 使用하여 願하는 깊이에 따라 各各 plankton을 採集하여 顯微鏡으로 觀察하여 Larvae의 數를 調査하였다.

2) 각 stage의 larvae를 測定한 結果, 가장 어린 것은 60×54μ이었고, 가장 큰 것은 320×336μ이었다.

3) 二枚貝의 larvae들은 水中에서 不規則하게 分布하였다. 溫度의 上昇에 따라서 larvae의 分布는 增加되고, 反對로 溫度가 下降함에 따라서는 減少되었다.

4) 어린 stage의 larvae數는 7月~9月에 걸처 出現 頻度가 높았다. 이것은 이 時期가 仙才島에 있어서는 二枚貝類의 產卵時期라고 生覺된다.

5) 8月~9月에 걸처서 大型의 larvae의 出現 頻度가 減少되는데, 이것은 larvae가 着生되었기 때문이라 生覺된다.

INTRODUCTION

According to T. Nelson (1921b and annual reports 1922—1930, and T. Nelson & Perkins 1931) the horizontal distribution of oyster larvae has a direct bearing on the location of natural oyster beds and on the intensity of setting on planted grounds.

In 1917 Nelson showed that the larvae do rise during flood tide and sink during the ebb tide, thus migrating away from the ocean. Prytherch (1928) and Galtsoff, Prytherch, and McMillin (1930) found the abundance and distribution of oyster larvae to be extremely irregular.

In 1949 Loosanoff reported that, in general, he found no relation between the stratification of larvae and the stage of the tide, and no evidence that larvae in advanced stages of development were more numerous near the bottom.

Roughley (1933) described the younger larvae of oyster as moving continuously from the bottom to the surface, but as they become older generally remain in the lower strata of water.

An analysis of such factors as salinity, current velocity, temperature, light, and pH which may influence the distribution of oyster larvae has been attempted by various investigators in order to determine the fundamental biological conditions which govern larval behavior.

However, since the larvae are not distributed uniformly from the surface of the water to the bottom, the study of their horizontal distribution is considerably complicated and it discloses the need of more detailed observations on their vertical and horizontal movements and the effects of environmental factors on these migrations.

The writers sellected the Sun-Jae Island in Yellow Sea, where plenty habitat of *Tapes philippinarum* can be found, for ecological observations on the appearance frequency of the bivalve larvae. The observations were made during 1959 and 1960.

GENERAL METHODS

A) Geographical Location of Sun-Jae Island

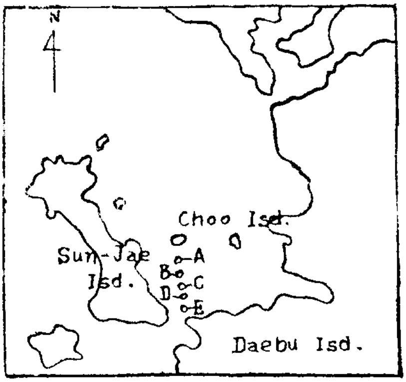

Fig. 1. Map showing the localities under investigation

Sun-Jae Island is located in Yeoheung-Myun, Buchun-Gun, Kyungki Province, adjacent to Daebu Island in Yellow Sea. The Island is approximately 3.5km long and 1 km² in area. The difference between the flood and ebb tides is around 8 meters.

B) Collecting Stations

The fixed plankton stations are situated about 1km from the Daebu Island to Choo Island. Five stations (A, B, C, D, and E), which are assumed to be the habitat of the *Types philippinarum*, were sellected taking the interval of each station 100m. The plankton sample collection was made from both surface and bottom of the each station.

C) Procedure of sampling

A motor pump was installed in the boat and hauled the water for 1 minute (100 liters of water) through a calibrated intake hose (4cm in dia.) from any desired depth. The collected water was introduced to pass the plankton net (25cm in diameter at the mouth, about 50cm deep, ending in a plankton-pail with a leaden weight; gauze No. 18 i. e., 18 meshes per mm) and the filtered quantity to be 10ml. A small detachable brass bucket closes the lower tapering end of the net and permits ready removal of the plankton samples to sample bottles. Plankton samples were preserved in approximately 4% formalin (as recommended by Stafford 1912) and then were ready for identification, counting and measuring.

D) Counting of the Bivalve Larvae

From the 10ml of the collected plankton sample, 1 ml were pipetted up and divided into 10 glass dishes. Each dish was observed with 100X microscope (Wetzler/Asslar) and measured the size of the larvae and also counted the total number of larvae. The external contours of the valves of the various stages of the larvae were drawn and the drawings were pictured with "Exakta" camera.

E) The depth of water was recorded in meter taken from the length of hose, at the end of which bound with a large stone.

The depth of each fixed plankton station under study at the flood tide were as follows:

A Station:	5 meters	D Station:	6.2 meters
B 〃	5.5 meters	E 〃	7 meters
C 〃	6 meters		

Temperatures of water and the time when samplings made were also recorded. Salinity of the water was measured with standard hydrometer and then converted into Baume.

pH of the water was measured with Beckman pH meter from the sample water carried to the laboratory.

RESULTS AND DISCUSSION

1. Identification of the bivalve larvae

Among the numerous papers on ***Crassostrea virginica***, the following include descriptions and/or illustrations of oyster larvae: Brooks (1880), Jackson (1888), Stafford (1905, 1909, 1912, 1913), J. Nelson (1909, 1910), Churchill (1920), T. Nelson (1921 b, 1923), Wells (1927), Prytherch (1934), Medcof (1939), and Sullivan (1948).

The illustrations are given in the form of photomicrographs, pencil or pen-and-ink drawings, and the majority of them are of the older stages of the larvae. J. Nelson (1909), the first to publish photomicrographs of oyster larvae, T. Nelson (1921b), Wells (1927) and Sullivan (1948) in photomicrographic form illustrate the various stages of the larvae, yet much of diagnostic detail is lost in such reproduction.

Stafford (1912) has drawn the various stages and included some internal structure; however, internal structure of ***Tapes philippinarum*** larvae is not always readily apparent in fresh sample or in formalized larvae.

Thus, comparing with ***gigas***, pen-and-ink drawings of the principal stages of the larvae which stress the diagnostic external contours of the valves were used to supplement photomicrographs in larvae identification.

Such an attempt has been made in Fig. 2, A-I, which were drawn from freshly preserved larvae under the camera "Exakta".

The veligers were collected in the summer of 1959 through October, 1960 in Sun-Jae Island.

In New Jersey waters the length of oyster larvae varies from approximately 60μ in the earliest stage at which the valves completely clothe the veliger to approximately 300μ at the time of setting, as also reported by T. Nelson (1921).

T. Nelson (1923,) gives a curve illustrating the rate of growth of oyster larvae in Barnegat Bay in June, in which the oldest larvae measured 248μ in length. Prytherch (1934) records an average dimension for fully grown larvae in Milford Harbor, Connecticut, of 330×220μ.

In Canadian waters Stafford records the maximum size of larvae at 358×365μ (1905) and later (1912) 369×384μ: J. Nelson (1917), at 320 to 400μ: and Medcof (1939) at 365μ.

Yoshita reported the maximum size of floating larvae at 215—225μ and the larvae in early stage of setting at 200—230μ.

Miyasaki recorded the largest size of larvae he found at 221—227μ (1936).

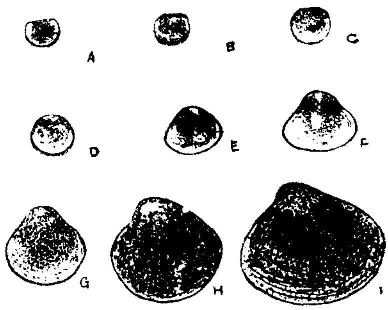

Fig. 2. Pen-and-ink drawings of various stages of the bivalve larvae

T. Nelson (1921 b) suggested the larger maximum size of the Canadian larvae is due to lower water temperature.

But the largest larvae obtained during this study was 336×320μ and the larvae at earliest stages 60×54μ.

Table 1 is given the range of measurement of bivalve larvae through the larval cycle, taken from several swarms in Sun-Jae Island from August 1959 through October 1960. Length and height are recorded.

Table 1. Range of measurements (Length × height, in μ) of the various stages of the bivalve larvae taken at the surface and bottom in Sun-Jae Is.

Straight Hinge	Early Umbo	Late Umbo	Mature	Eyed
60×54	112×96	160×161	224×218	288×272
80×70	128×112	176×170	240×223	304×288
96×80	144×130	192×180	256×241	320×303
		280×198	272×256	336×325

Larval Cycle of the Bivalve

A brief review of the prodissoconch period (taken principally from W. K. Brooks, Jackson, J. Nelson and T. Nelson) may make clearer the evidence for the native movements of the larvae.

It is thought that sexually matured oysters and clams spawn on the late flood tide (T. Nelson, 1921, 1922, 1927; Prytherch, 1928), the total annual production by one female being estimated at 50−60 million eggs. Sperm and ova are thrown into the bottom strata of the water where fertilization occurs. Ova sink at least an inch in 7 minutes after oviposition, and the early develop cilia in 4 or 5 hours. In currents of 13cm/sec. or more, they may be carried to some distance. After the cilia form, most of the embryos crowd to the surface of the water, in part pursuing an active spiral progression.

About a day after fertilization the embryos, now larvae with complete purse-shaped valves, are recognizable as straight hinge larvae; in Sun-Jae waters they measured approximately 60μ in length, swimming actively and soon become distributed vertically. In about 2 weeks from the time of fertilization, at a water temperature of approximately 27°C these veligers pass through the stages of early umbo, late umbo,mature and eyed larvae.

2. The larval appearance frequency of the surface and bottom in percentage.

From May, 1960 to October, 1960, the larval appearance frequency has been observed. Salinity and pH during the period were 2.61o/oo−3.20o/oo and 8.2±, respectively.

Total collected plankton sample number was 60 samples: During 6 months from the five fixed stations both from surface and bottom, the total counted larvae number in percentage was recorded and shown in Fig. 3.

As shown in Fig. 3, in the month of August the total larvae of bottom appeared notably numerous than that of surface.

The result of analysis of variance against this difference, the "F" value, was 1.94 (Tab. 2).

It is smaller than 5% value, 4.96 from the "F" value table. Therefore, the larvae distribution difference between surface and bottom has no significance.

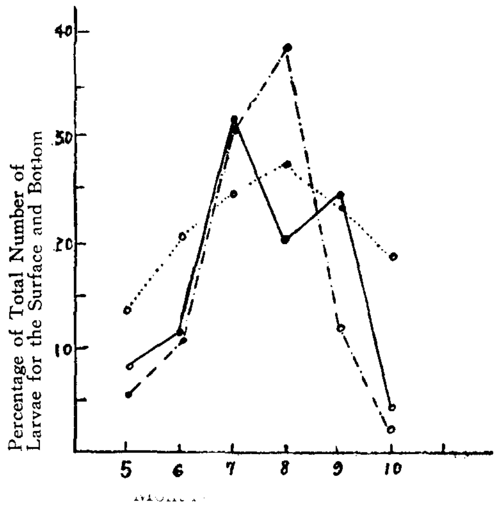

Fig. 3. Showing the percentage of larvae distribution of the surface and bottom in the plankton throughout the 6 months in Sun-Jae Is.
—— Surface —·—·— Bottom ······ Tem.

Table 2. Analysis of Surface & Bottom Frequency Distribution.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Value
Between sum of Squares	12674.9	1	12674.9	1.94
Within sum of Squares	65217.1	10	6521.71	
	77892	11		

It can be concluded that the larvae are not distributed uniformly in the water, from the surface to the bottom.

With regards to the effect of water temperature on the vertical distribution of larvae, J. Nelson (1908, 1916) thought the higher water temperatures cause larvae to rise to the surface and that cold weather drives them down. Perkins (1931) attributed no appreciable influence of temperature in bringing about larval distribution.

Fig. 3 shows that as temperature goes up, the total number of larvae increases and if temperature drops the total number of larvae decreased. When temperature was in maximum, the total number of larvae in bottom was increased while the surface larvae decreased. However, the correct temperature of bottom has not been measured during the sampling and thereby it was not possible to state the relation between temperature and the bottom larvae.

3. Larval distribution in various size by month

The size of larvae has been measured with 100X microscope and classified in three groups such as: small, medium and large. Small size of larvae combines the straight hinge and early umbo, medium larvae combines late umbo and part of mature, and the rest as large larvae. Small larvae ranges from 60μ to 144μ, medium from 154μ to 240μ, and large from 256μ to 336μ.

In July, larvae at setting period appeared numerously. And straight hinge and early umbo stage larvae were increasing from July, and showed maximum in August and September, then rapidly decreased in October. (Fig. 4.)

As samples of larvae in November were not available, it is difficult to discuss the appearance frequency distribution.

From the above fact the spawning period of *Tapes philippinarum* can be presumed.

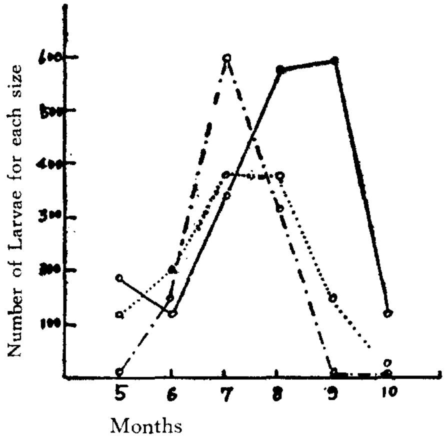

Fig. 4. Larval distribution of various size by Month
—— S (64–144μ)
—•—•— M (154–240μ)
······ L (256–336μ)

The spawning period of *Tapes philippinarum* in Ariake sea, Japan, is said twice a year, in spring and autumn, from March to July and September to November respectively. It has been reported that the maximum spawning occurs in May and from the end of October through November (Ikematsu 1957).

According to Korean Fisheries Experimental Station, it is reported that the maximum spawning period in Korea is from August to November (1939), and Kurashige reported from August to September (1943). The Fisheries Experimental Station also recorded that the maximum spawning period in Susan begins from June to the end of September, and in Ongjin from July through the beginning of September (1939).

By the habitants of Sun-Jae Island, the spawning periods are twice a year, from April to May in spring and from August to the end of September. Fig. 4 shows that early stage larvae were increasing from June to September. This states that the spawning has been occurred during the period, as reported by the Fisheries Experimental Station in 1939.

The decreasing curve of large size larvae in August and September can be illustrated that the larvae has set during the period.

The larvae appeared in May are not considered as *Tapes philippinarum* and may be other bivalve larvae. It is presumed that the peak of older stage larvae curve in July is considered as other bivalve larvae.

4. Vertical distribution of larvae

For the observation of vertical distribution of larvae, plankton samples were collected for three days, August 5, 6 and 7, 1960 at the five fixed stations with the depth interval of 1 meter. The average of the total number of larvae for three days were drawn in Fig. 5.

The larvae in each different stages are distributed vertically.

Prytherch (1928) reported that more larvae are found in bottom during the ebb tide while more larvae in surface during flood tide.

However, the younger stage of larvae were increasing by going deep into the bottom and showed a maximum value at the depth of 5 meters. And most of the older stage of larvae at setting period were found near the bottom.

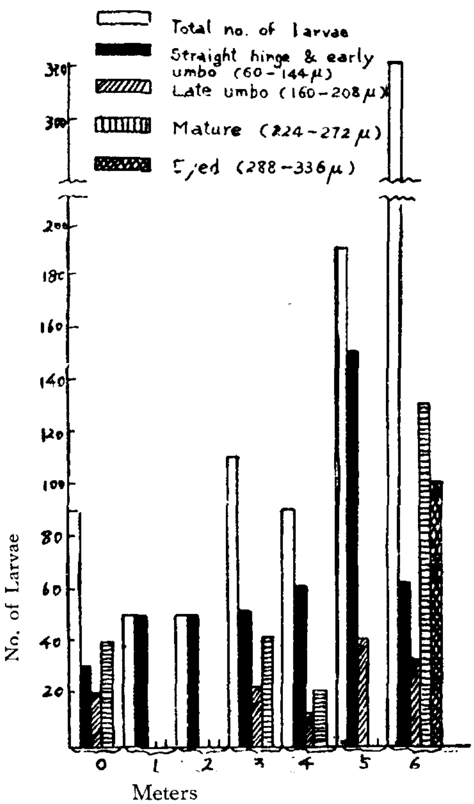

Fig. 5. Vertical distribution of larvae by larvae size in various depth.

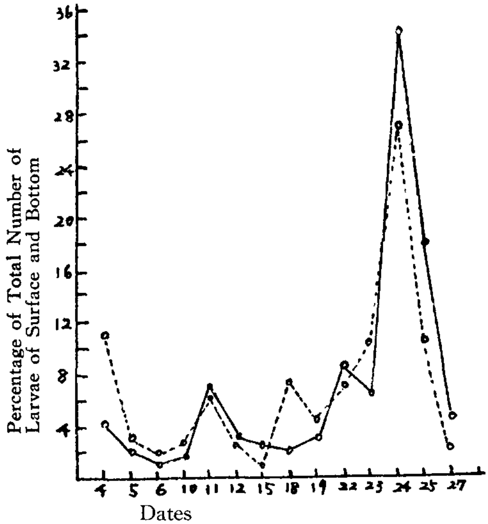

Fig. 6. Showing the percentage larvae distribution of the surface and bottom during the month of August 1959.
—— Surface ······ Bottom

5. Appearance frequency distribution during the month of August

Sampling has been made daily during the month of August 1959. The percentage of total number of larvae of surface and bottom were drawn in Fig. 6. Average water temperature of Sun-Jae Island in August was around 26°C, the average salinity 2.6o/oo, and pH was 8.2+.

The date of maximum larvae appearance was 24th August and larvae size of 96μ−112μ were found in the greatest number. It can be presumed that the spawning has been occurred about 4 or 5 days before.

The larval appearance of the bottom and surface were extremely irregular in numbers throughout the month. However, in general, more of the small size larvae were found during the month.

The reason for the decreasing of the number of larvae at 4th−5th August could not be known, however the curve might be connected to the month of July if the sampling had been made.

SUMMARY

The appearance frequency of the bivalve larvae collected in Sun-Jae Island has been observed during the summer of 1959 and 1960.

1. Using a motor pump, plankton samples have been hauled from any desired depth through a calibrated intake hose.
2. Pen-and-ink drawing of the principal stage of the bivalve larvae, stressing the diagnostic external contours, and measurements of the various stages of the larvae are included.
3. The largest larvae obtained during this study was $336\mu \times 320\mu$ and the earliest stages of larvae $60\mu \times 54\mu$.
4. The larvae are not distributed uniformly in the water, from the surface to bottom. As temperature goes up, the total number of larvae increased and if temperature drops the total number of larvae decreased.
5. Early stage larvae were increasing from June to September in Sun-Jae Island. This states that the spawning has

been occurred during the period. Large size larvae decrease in August and September and set during the period.

6. The larval appearance of the bottom and surface were extremely irregular in numbers throughout the month of August.

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