

Studies on Ciliary Activity of Bivalve, *Tapes philippinarum*, During Developmental Stages

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成長段階에 따르는 二枚貝, *Tapes philippinarum*,의 纖毛 運動能에 關한 研究

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摘 要

바지락(*Tapes philippinarum*)의 纖毛運動能에 미치는 몇가지 重要한 環境 要因의 影響에 關하여 生理學的 方法으로 調査하였다.

1. 酸化還元電位 測定結果, 稚貝일 수록 成貝에 比하여 無氣狀態에 對한 抵抗性이 낮았다.
2. 稚貝의 纖毛運動能은 $17 \pm 1^\circ\text{C}$ 에서 酸素張力 低下狀態로 옮긴 20分後, 成貝의 約 1/2 以下로 減少되었다.
3. 한편 水溫 $13 \pm 1^\circ\text{C}$ 에서는 纖毛運動能이 같은 酸素張力の 低下에 依하여서도 成貝 稚貝 모두가 비슷한 傾向으로 急激히 抑制되었다.
4. 水溫 10°C 에서 20°C 로 옮겼을 때 成貝와 稚貝의 纖毛運動能은 高溫으로 因하여 거의 併行하게 最高值 約 230% 까지 促進되었다.
5. 特히 稚貝에 있어서는 浮游土分子의 낮은 混濁度에 依하여 纖毛運動能이 減少되었다.
6. 바지락은 廣鹽性動物임을 밝혔다.
7. 이들 결과로서 稚貝의 높은 致死率은 海底棲息地의 不利한 環境要因 特히 重疊要因에 左右되는 것이 確實하다. 致死率을 左右하는 가장 重要한 要因은 溶存酸素의 缺乏, 低溫 그리고 甚한 浮游土의 混濁度이며, 反하여 약간의 鹽度變動은 그리 致命的인 것이 아니다.

INTRODUCTION

Resistability of the bivalve, *Tapes philippinarum*, may be different according to the growing stages especially at the beginning of bottom life under unfavorable conditions after microscopical straight hinge and attached stages.

It has been reported that a high mortality of the scallop spat is ascertained to amount in many cases even to 82 to 100 per cent according to habitats (Yamamoto 1957).

When transferred into different salinities of sea water, the American oyster, *Crassostrea virginica*, adjusts fairly well over a range from 3 to 35 per mile in a few hours (Pearse and Gunter, 1956)

It was found that, in *Ostrea gigas* and *Mytilus edulis*, the rate of pumping was not reduced due to the high concentration of bentonite, and that the amount of feeding increased with the growing concentration of bentonite but the rate of its increment grew smaller (Chiba and Ohshima 1957). Some ciliary activities of the gill continued at temperature as low as 0.9°C for *Ostrea equestris* and 4°C for *Crassostrea virginica* (Menzel 1955).

As far as authors know, although many physiological phenomena in the bivalves have been investigated, there is little report as to ciliary activity in the bivalve, *Tapes philippinarum*, under environmental conditions.

In this paper it will be reported that results on the ciliary activities effected by most primary factors during developmental stages.

MATERIAL AND METHODS

The material used in this study was the bivalve, *Tapes philippinarum*, collected from Wolmi-Island, Kyungki Province, Korea. They were divided into three grades (young... 10~13mm, medium... 20~25mm and adult... 30~35mm in shell length) and used after physical recovery of disturbance in running sea water about one day long. Gill pieces (3×5mm) were cut from the gill lamella of fresh organism.

The redox potential of cilia was estimated by vital staining method. The rH value was calculated by formula as the following:

$$rH = (Eh + 0.0001983 T \text{ PH}) \frac{0.0001983 T}{2}$$

0.003 per cent solutions of Thionin (Lauth's violet), Methylene blue, Nile blue, Phenosafranine and Neutral red were prepared with sea water as vital staining dye, and the pH of them were adjusted to 7.0 by adding M/10 NaOH.

The ciliary activity was determined by the modified Nomura and Tomita's method (1933). The value of ciliary activity was calculated in percentage which is relative velocity of crawling of gill pieces.

Sea water of low oxygen tension was made by boiling two hours and then covered with liquid paraffin. The normal salinity was regulated with boiled distilled water. Various turbidities were admixed by dried fine silt collected from Sunjai-Island, Kyungki Province, Korea where is densely populated with *Tapes philippinarum*.

Various salinities of sea water were prepared by Herbst's artificial sea water, and regulated as high as pH 8.3.

The following is a salt mixture devised by Herbst:

	Grams		Grams
NaCl	26.3	CaCl ₂ 2H ₂ O	1.5
KCl	0.7	NaHCO ₃	0.45
MgSO ₄ 7H ₂ O	11.9	Water	1,000.00

Chlorinities and salinities of the sea water have been reported as follows (Yamamoto, 1957):

Table 1 Chlorinities and salinities of the sea water

Sea Water %	25	50	75	100	125	150	175	200
Cl %	4.47	8.73	12.99	18.11	21.49	25.62	29.81	34.08
S %	8.098	15.788	23.477	32.719	38.819	46.304	Ca 53.9	Ca 61.6

RESULTS

In this work for redox potential, ciliary motions were gradually slackened and finally stopped on account of oxygen consumption under anaerobic condition in the respiratory chamber.

As shown in table 2, there were gradual differences among three grades in shell length.

Table 2 Redox potential of gill pieces of *Tapes philippinarum* under anaerobic condition (Temp. 30°C)

Indicator	Size	Reduction and Time of stoppage			rH (pH 7.0)
		Young	Medium	Adult	
Thioin		+405'	+369'	+158'	16.1
Methylene blue		±195'	+188'	+94'	14.4
Nile blue		—	±331'	+109'	9.3
Phenosafranine		—	—	±296'	5.9
Neutral red		—	—	—	2.7

Decoloration of each gill pieces stopped respectively between rH value 16.1 and 14.4 (young), rH 14.4~9.3 (medium), and rH 9.3~5.9 (adult) along with their growing stages. Particularly young bivalve was not decolorized at high rH value, theoretically higher rH value indicates the low tolerance of animal.

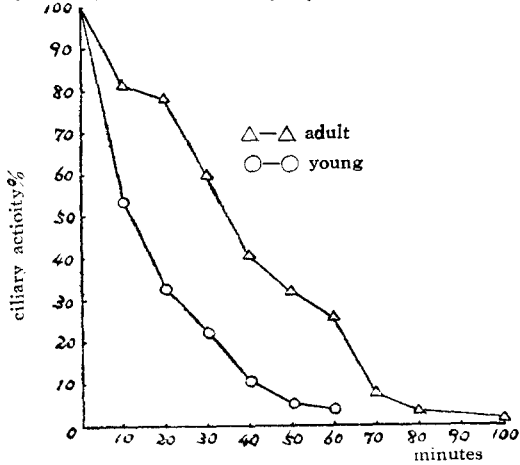


Fig. 1. Low oxygen tension-time relation at water temperature $17 \pm 1^\circ\text{C}$, pH 8.2

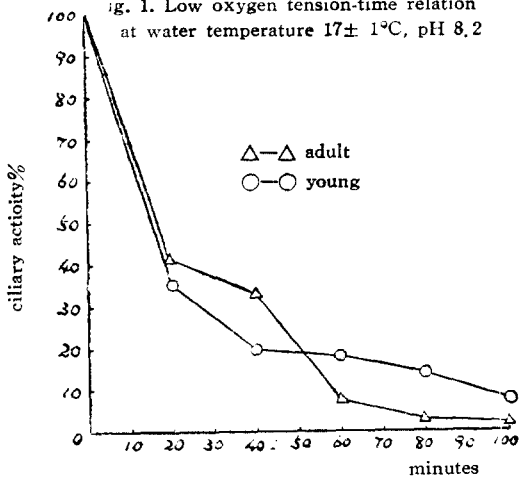


Fig. 2. The relation between low oxygen tension and time of treatment (pH 8.2, Tem. $13 \pm 1^\circ\text{C}$)

It was well known that oxygen tension of the boiled sea water is about 1/4 lower than that of normal sea water (Yamamoto 1957).

The effects of low oxygen tension, 1.51~1.79cc/l, on the ciliary activities were shown in Figures 1 and 2.

At water temperature $17 \pm 1^\circ\text{C}$, the ciliary activity of the adult was decreased to 78.6 per cent after 20 minutes and stopped after 100 minutes of immersion into medium, but that of the young was remarkably repressed even to 32.9 per cent and stopped after 60 minutes (Fig. 1).

At low temperature of $13 \pm 1^\circ\text{C}$, on the other hand, the ciliary activities were instantaneously decreased almost to 40 per cent in both, and their reduction continued irregularly a little (Fig. 2).

Temperature changes were controlled by thermostat. It may be noteworthy that ciliary activities were extremely risen up to maximum of 236.4 per cent in the young and 217.9 per cent in the adult when gill pieces were transferred from 10°C to 20°C in water temperature (Table 2). But young was stopped at temperature 35°C .

In contrast with the higher one, at the lower temperature of below 10°C their activities were rapidly fell down, for example even to 18.6 per cent at 5°C in the young (Table 3).

Table 3 Effect of high temperature on the ciliary activity in the bivalve, *Tapes philippinarum*

grade	temp.	Control 10 ($^\circ\text{C}$)	Temperature treated & ciliary activity					
			15	20	25	30	35	40
Adult		100 (%)	130.1	217.9	142.5	98.2	46.6	0
Young		100 (%)	133.8	236.4	159.7	114.4	0	—

Table 4 Effect of low temperature on the ciliary activity in the bivalve, *Tapes philippinarum*

grade	temp.	Control 15 $^\circ\text{C}$	Treatment	
			10 $^\circ\text{C}$	5 $^\circ\text{C}$
Adult		100%	57%	40.8%
Young		100%	65%	18.6%

Relative velocities of both were slackened to about 50 per cent by low turbidity of 0,05 per cent of silt and decreased to 25 per cent at the turbidity of 0,2 per cent (Fig. 3). Though activity of the adult has maintained about 25 per cent at 0,5 per cent turbidity, that of the young was decreased to 5 per cent. Afterwards, they could not move at all at turbidity of 0,8 per cent.

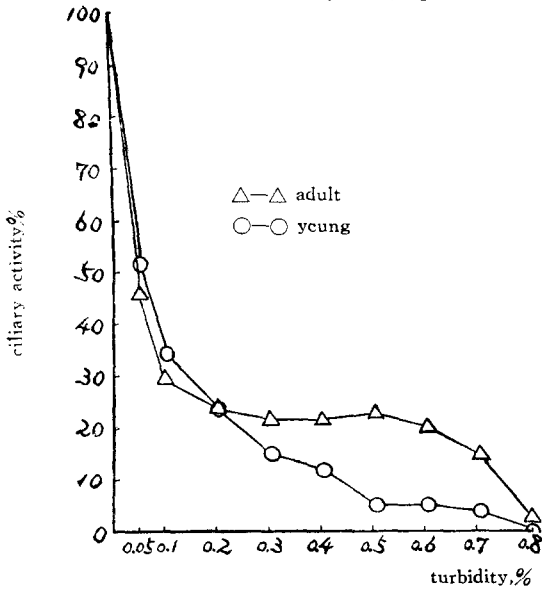


Fig. 3. Relative velocity under various turbidities
Temp.— $20 \pm 1^\circ\text{C}$, pH— 8.2

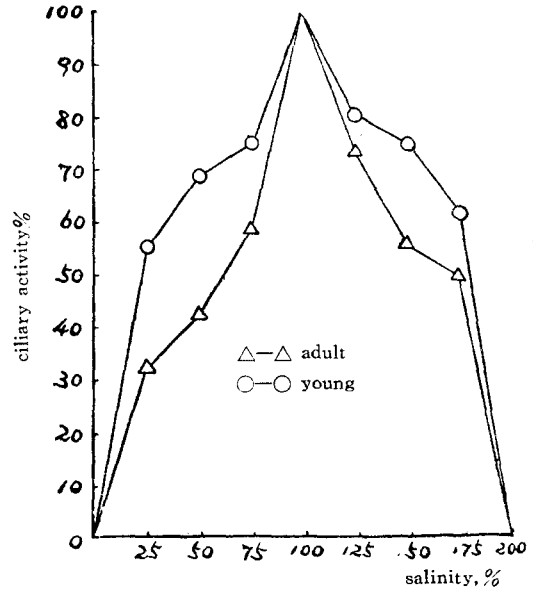


Fig.4. Ciliary activity under various salinities
Temp.— 15°C , pH— 8.2

The ciliary activities of adult and young showed a gradual reductional tendency along with the hypotonic and hypertonic sea water (Fig. 4). Ciliary activity of this species was active almost 70 per cent or more between 8,73 and 25,62 per mille in various salinities. It is very interest that ability of the young was more greater than that of the adult in sea water concentrations such very wide range as 25 per cent to 175 per cent.

DISCUSSION

It is well known that ciliary movement of the gill performs the role of paramount importance in physiological behavior, more over this activity always reveal metabolic pattern of the bivalves. From the result of redox potential, it is evident that resistability of the adult is the greatest among them and capacity of young is the weakest in comparison with others (adult > medium > young).

The tendency of this result was agreed with the one of scallop by Yamamoto (1957).

In a comparison between Fig. 1 and 2 which present the low oxygen tension and time-temperature relation, there was a difference in their physical capacity.

In treatment of low oxygen tension, it may be suggested that adult can control their physiological metabolism a little, because they have a peculiar ability to adjust for the unfavorable factors under warm condition of $17 \pm 1^\circ\text{C}$ or more only.

Young could not, however, tolerate for the same treatment as much as adult, for it may have not yet the active ability in order to adapt.

At low temperature of $13 \pm 1^\circ\text{C}$, all of them were greatly influenced by the same oxygen tension. It seems to confirm this phenomenon have been caused by injurious double inhibitors and temperature 13°C is too cold to control their resistability even in the adult one.

The water temperature is also an important factor to exist under nature, furthermore rate of spawning and development of larvae depend upon a particular temperature injuriousness which may be either higher or lower than optimum.

It is assumed, they might have been a peculiar specificity to react for the higher temperature with a active way when the maximum of ciliary activity was reached more over 217.9 per cent and 236.4 per cent and 236.4 per cent in Table 2. Though the temperature range, from maximum to minimum, is much wider than other species, it is considered that their optimum range able to spawn and grow may be little wide (Tables 3 and 4).

Great repression of the relative velocity of crawling was effected by the very low turbidity (Fig. 3). It seems this phenomenon is occurred by suspended silt particles that act on respirational and mechanical actions, therefore the turbidity factor is most important one on the crawling in bottom life.

And it has been reported that the pumping action of gill showed a reduction of 95 per cent in the low turbidity of silt as much 0.3g/l in the oyster, *Ostrea virginica* (LOOSANOFF and ENGLE 1947; LOOSANOFF and TOMMERS 1948).

Salinity of individual surroundings is not constant through the day and year, because it is influenced by rain fall and exposure. Loosanoff (1950) clarified that *Crassostrea virginica* is capable of withstanding sharp changes in various salinities.

The effects of various salinities in the bivalve reveal a very typical figure. Not only the adult is able to continue active motion in a much wide range, but also is the young able in a more wider range of various salinities. The low and high salinities do not bring any advantages but it is a biological richness of the bivalve *Tapes philippinarum*.

From the figure 4 it is demonstrated this species is a very euryhaline organism such as *Crassostrea virginica*. It may be safely concluded from this view that *Tapes philippinarum* has a osmoregulatory characteristics evidently.

SUMMARY

Effects of several environmental factors on the ciliary activity of gill in the bivalve, *Tapes philippinarum*, have been investigated by physiological methods.

1. Results obtained from redox potential suggested that younger have not yet undeveloped to unfavorable anaerobic condition in comparison with the adult.
2. Ciliary activity of the young was diminished below about 1/2 of the adult after 20 minutes of immersion to low oxygen tension at water temperature of $17 \pm 1^\circ\text{C}$.
3. Under water temperature of $13 \pm 1^\circ\text{C}$, on the contrary, ciliary activities were repressed rapidly with the same tendency in the both by low oxygen tension. It is considered, this phenomenon was caused by double treatments unfavorable.
4. Ciliary activities of both were accelerated vigorously up to maximum about 230 per cent in parallel with together by higher temperature effect when transferred from 10 to 20°C , which may be explained they have a peculiar physiological specificity to react for the higher temperature.
5. Perhaps, both of adult and young might have no capacity which is able to regulate the metabolism at low temperature.
6. Relative velocity of crawling was decreased by low turbidity factor, particularly in the young, which might be influenced in the mechanism of respiration and mechanical moving by silt particles.
7. It was demonstrated that *Tapes philippinarum* is a very euryhaline animal (poikilosmotic organism).
8. From these results, it is confirmed that high mortality of the young bivalve may depend upon the unfavorable environmental factors, particularly complexed one, in the bottom life.

The most important factors which have influence on the mortality were lack of dissolved oxygen, low temperature and heavy turbidity, whereas a little variety of salinity was not critical one.

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