Ecological Studies on the *Penaeus orientalis* KISHINOUE Cultured in a Pond Filled with Sea Water

1. Growth Rate as Related to the Substrate Materials, Survival Rate, Predator of *P. orientalis*, and Water Conditions of Culturing Pond

by

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海水池에서 飼育되는 大蝦의 生態學的 硏究

1. 底質에 따른 成長率, 天敵 및 水質條件에 關한 硏究

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해수지에서 대하를 사육한 경우 저질의 종류에 따른 대하의 성장도, 생잔율, 포식자, 그리고 못 속의 수질 변화 등을 1968년 6월 25일부터 동년 10월 18일까지 조사 연구하였다. 조사한 결과는 아래와 같다.

1. 대하의 체장과 체중의 성장도는 투이의 여부와는 관계없이 저질이 모래인 경우보다는 개흙인 경우에 더 높았다.
2. 사육 기간 (X)과 체장 (Y)의 회귀 관계식은;
   저질이 개흙이고 투이를 한 경우 : $Y=0.58497X+25.05210$
   저질이 모래이고 투이를 한 경우 : $Y=0.51030X+26.57900$
   저질이 개흙이고 투이를 하지 않은 경우 : $Y=0.22352X+32.79360$
   저질이 모래이고 투이를 하지 않은 경우 : $Y=0.11418X+31.20740$이었다.
3. 사육 기간 (X)과 체중 (Y)의 회귀 관계식은
   저질이 개흙이고 투이를 한 경우 : $Y=0.09062X-2.11140$
   저질이 모래이고 투이를 한 경우 : $Y=0.06992X-1.19640$
   저질이 개흙이고 투이를 하지 않은 경우 : $Y=0.01615X+0.51150$
   저질이 모래이고 투이를 하지 않은 경우 : $Y=0.00495X+0.56150$ 이었다.
4. 투이를 하는 경우 포식자의 침입을 방지하면 투입된 치하의 생잔율을 80% 이상 높일 수 있다.
5. 문절망둑(*Acanthogobius flavimanus* TEMMINCK)은 대하의 주요 포식자이다.
6. 월 평균 12회 환수한 해수지내에서 일어나는 수질 변화는 대하의 생잔율에 크게 영향을 미치지는 않는 것으로 생각된다.

INTRODUCTION

Penaeus orientalis (KISHINOUE) is a species of crustacean which is distributed in the Yellow

Sea, South Sea of Korea, and in the coastal sea of China. Hudinaga (1962) studied the development of *P. japonicus* BATE. Yasuda et al. (1957) studied the culture of *P. japonicus*. Yoshida (1949) reported the study about the life cycle of *P. orientalis*. Kim (1967), Okamoto (1967) studied the artificial fertilization of *P. orientalis*. Reports of method for culturing *P. orientalis* were made by Kim (1967), and Yoo (1967). In each study it was reported that a sandy bottom was the only appropriate substratum for their culture. None of the studies reported detailed data which represented the difference in growth rate of *P. orientalis* in situations which compared specimens grown in sandy bottom vs muddy bottom habitats. The western coast of Korea, it was hoped, would be a good place for controlled culturing of *P. orientalis* in spite of the fact that is predominantly a muddy bottom coast-line. Too much expense would be involved in covering a muddy bottom area with sand.

The present study then attempted to compare the growth rate of those cultured in an area with a sandy bottom. The survival rate of *P. orientalis* during culture and the predator of *P. orientalis* were observed. The water conditions of experimental regions during the experimental period were also determined.

MATERIAL AND METHODS

The juvenile prawn used in the study were purchased from a commercial producer which is located at Asan-kun Choongnam, Korea. These juvenile prawn were incubated on June 4, 1968 and were cultured for 16 days with brine shrimp (*Artemia* sp.). And they were held in the contemporary culture depot on June 20. It took 8 hours to transfer to the experimental region. At that time, the mean body length of them was 9.2*mm* (S.D. = ±0.04*mm*) and the mean body weight was 0.022*g* (S.D. = ±0.004*g*).

The different experimental areas were constructed in a *P. orientalis* culturing pond which is located at Yungjong-myun Boochun-kun Kyunggi-do, Korea. Four experimental regions (A, B,C, and D) and one control region (E) were constructed. Each region was constructed by enclosing it in a nylon net, mesh 2 *mm*. The bottom of regions B and C were covered to a depth of 10*cm* with sand. Schematic representations of the experimental regions and the numbers of larvae cultured are shown in Fig. 1 and Table 1.

Smashed bivalves (*Tapes* sp., *Meretrix* sp.) were fed to the growing larvae in regions A and B in the early stages of the experiment. Amounts of food were reached 200% of total body weight in each experimental region from June 27 to July 20 during which their mean body weight were below 1*g*. During succeeding periods miscellaneous fish (*Harengula* sp., *Platycephalus* sp.) were

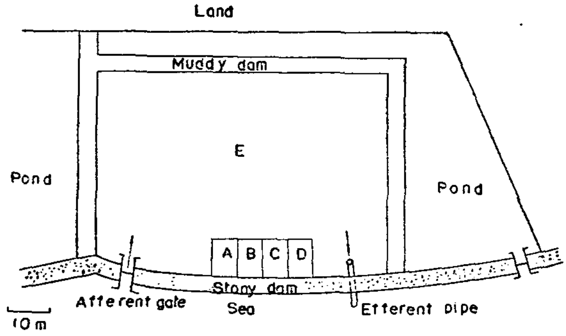

Fig. 1. Location of each experimental region in a pond filled with sea water.

Table 1. Conditions of Each Experimental Region

Region	Volume (m^3)	Mean depth (*cm*)	Water capacity (*t*)	Decline of bottom (°)	Bottom material	No. of larvae	Artificial food
A	10×9×2	132	11.88	30	mud	1,200	with food
B	10×9×2	132	11.88	30	sand	1,200	with food
C	10×9×2	132	11.88	30	sand	1,200	without food
D	10×9×2	132	11.88	30	mud	1,200	without food
E	180×80×2	132	12,464.00	10	mud	11,000	without food*

* without food during 68 days, later with food.

fed to the prawn in regions A and B for an amount of 30% of total body weight. No food other than naturally occurring forms were added to regions C and D. Region E was left in its natural condition until September 1. And then it was found that the growth of *P. orientalis* in region E had been nearly stopped during the period of August 9 and August 29. Smashed fish was put in region E for food from September 1 to August 16. It was provided for an amount of 30% of total body weight.

Five individuals were collected by random sampling from each experimental region. Samples were taken at ten-day intervals. Growth rate was estimated by measuring body weight of the samples.

Survival rate was determined by comparing total numbers of individuals stocked as larvae to the total numbers of adults in each region at the time of final harvest (Oct. 18). It was necessary to adjust the data by taking into account those individuals removed from the population during random sampling for length and weight studies.

The intestine of other fishes which ware caught through the experimental period and on the harvesting day was dissected. Stomach analyses from all species of fish in the experimental area were made. Mainly the predator of *P. orientalis* was investigated.

Certainph ysico-chemical factors in the experimental regions were investigated. Data were collected each day duiing the study.

RESULTS AND DISCUSSION

Yasuda et al. (1957) reported that the increasing amount of mud is not favorable for the life of *P. japonicus* post-larvae but the sandy bottom is not effective for them. Yoo (1967) also stated that the bottom material of culturing pond should be sand for *P. japonicus* culture. If the culturing pond had muddy bottom materials, it is good for culture to cover the bottom with sand of 10*cm* depth. But they did not show the detailed data which represent the difference of the growth rate as related to the substrate materials.

Data collected in this study indicated that *P. orientalis* grown in the experimental regions with a muddy bottom produce an increase in body length at a more rapid rate than specimens of *P. orientalis* grown in the experimental regions with a sandy bottom (Fig.2). This same comparative relationship exists for the comparison of increase in body weight (Fig.3).

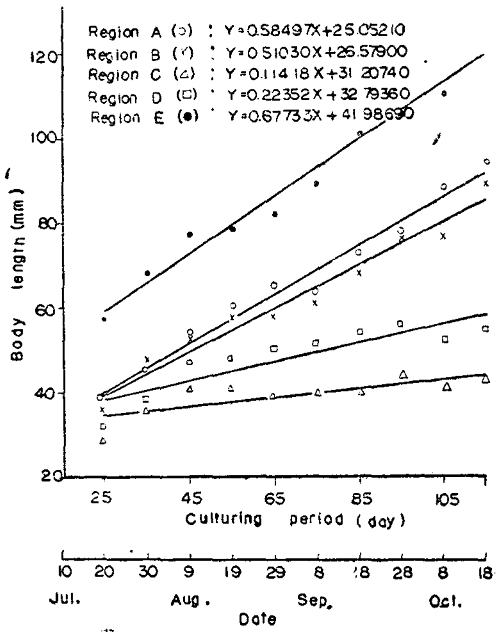

Fig. 2. Relationship between the culturing period and the body length of *P. orientalis*.

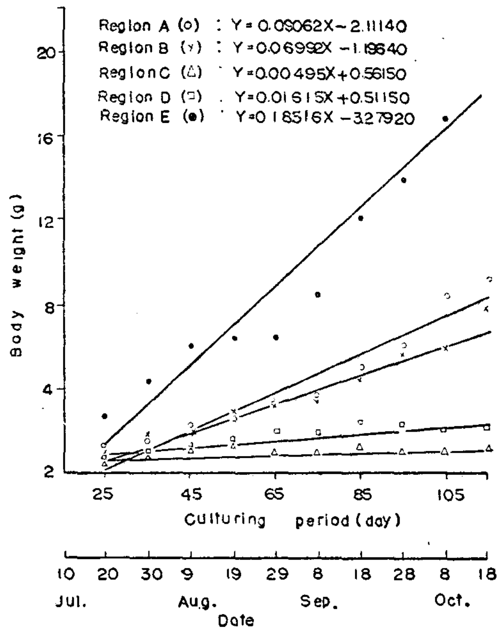

Fig. 3. Relationship between the culturing period and the body weight of *P. orientalis*

The growth of body length of *P. orientalis* in each region was indicated with regression line equation as follows:

Region A: $Y=0.58497X+25.05210$

Region B: $Y=0.51030X+26,57900$

Region C: $Y=0.11418X+31.20740$

Region D: $Y=0.22352X+32.79360$

Region E: $Y=0.67733X+41.98690$

The growth of body weight of *P. orientalis* in each region was indicated with regression line equation as follows:

Region A: $Y=0.09062X-2.11140$

Region B: $Y=0.06992X-1.19640$

Region C: $Y=0.00495X+0.56150$

Region D: $Y=0.01615X+0.51150$

Region E: $Y=0.18516X-3.27920$

In both regions where food was provided the rate of increase of body weight and body length was greater than in those regions where no food was provided. The best combination of factors to produce the greatest increase in body length and body weight of the larvae of *P. orientalis* was a region with muddy bottom and provision for artificial feeding of the larvae. But the growth of *P. orientalis,* even in region E, was represented at lower rate than the result of

Kim (1967). Comparison of the growth of *P. orientalis* with the result of Kim (1967) are shown in Fig.4.

Yoo (196) reported that survival rate would be above 50% and differ on their occassion. In this study the survival rate was above 80% when they were fed during experimental period. The survival rate in each region are shown in Table 2. Comparing region A and B with E, we could predict the higher survival rate could be reached by protecting predator of *P. orientalis* and feeding them. Several species of miscellaneous fish seemed to pass through the mesh of net early in experiment (Table 3).

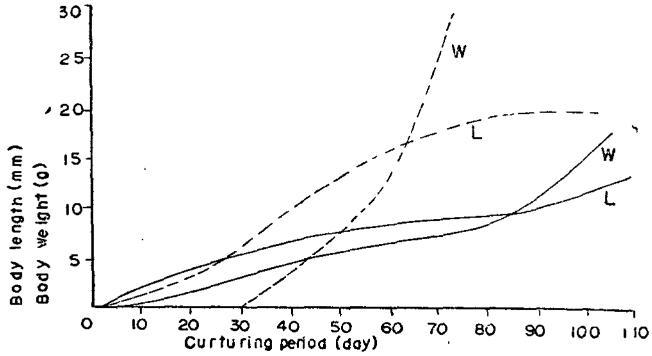

Fig. 4. The growth of the body length (L) and the body weight (W) of *P. orientalis* during culturing period. ——, data obtained — — —, data of Kim (1967).

Table 2. Survival Rate of *P. orientalis* in Each Experimental Region

Region	No. of larvae	No. of specimen collected during experimental periods	No. of actually cultured individuals	No. of individuals at harvesting day	Survival rate (%)
A	1,200	115	1,085	886	81.7
B	1,200	115	1,085	941	86.7
C	1,200	115	1,085	382	35.2
D	1,200	115	1,085	457	42.1
E	11,000	89	10,911	4,542	41.6
Total	15,800	549	15,251	7,208	47.3

Table 3. Number of Other Species Which was Caught in Each Experimental Region

Scientific name \ Region	A	B	C	D	E
Acanthogobius flavimanus Temminck	—	—	—	—	35
Anguilla japonica Temminck	—	—	—	—	1
Clupanodon punctatus Temminck	8	6	12	1	313
Eriocheir sinensis H. Milne-Edwards	—	—	—	—	1
Harengula zunsai Bleeker	—	—	18	5	3,500
Lateolabrax japonicus Cuvier	—	—	—	—	6
Mugil cephalus Linnaeus	—	—	—	—	155
Penaeopsis joyneri Miers	—	—	—	—	300
Platycephalus indicus Linnaeus	—	—	8	1	40
Sproeroides pardalis Temminck	—	—	—	—	1
Total	8	6	38	7	4,352

Table 4. Number of Collected *Acanthogobins flavimanus* and Number of Them Whose Intestine Have the Remains of *P. orientalis*

Date	No. of collected *A. flavimanus*	No. of *A. flavimanus* whose intestine has the remains of *P. orientalis*	Date	No. of collected *A. flavimanus*	No. of *A. flavimanus* whose intertine has the remains of *P. orientalis*
Aug. 2	3	—	Sep. 2	1	—
3	2	—	3	5	1
6	1	—	4	1	—
14	3	1	12	2	—
19	2	—	13	1	—
23	3	—	21	2	—
24	1	—	22	1	—
25	2	—	23	1	—
31	4	1	Oct. 16	35	3
Sep. 1	2	—			
Total				72	6

Table 5. Physico-chemical Water Conditions of the Pond During Experimental Period

Date	Factor	Air temp. (°C)	Surface water temp. (°C)	Underneath water temp. (°C)	Max. water temp. (°C)	Min. water temp. (°C)	pH	Surface sea water specific gravity	Underneath sea water specific gravity	Oxygen contents (cc/1)	Water depth (*cm*)	water transparency (*cm*)
Jun. 25–30 (6 days)	Max.	32	29	28	29	25	8.40	·	·	5.2	75	·
	Min.	28	28	28	28	22	8.25	·	·	5.2	67	·
	Mo.	31	28	28	28	22	8.35	·	·	5.2	74	·
	M.	30	28	28	29	24	8.35	·	·	5.2	74	·
Jul. 1–31 (31 days)	Max.	35	33	31	33	29	8.50	1.0203	1.0173	6.6	140	120
	Min.	21	23	23	25	23	8.10	1.0127	1.0130	4.7	69	40
	Mo.	32	31	30	31	25	8.35	1.0140	1.0165	5.6	94	90
	M.	24	29	28	29	26	8.35	1.0158	1.0155	5.6	94	87
Aug. 1–31	Max.	35	33	32	33	29	8.50	1.0185	1.0187	6.7	141	140
	Min.	25	25	25	27	23	8.10	1.0085	1.0144	4.8	123	50
	Mo.	32	29	29	31	26	8.35	1.0147	1.0160	5.6	133	100
	M.	30	29	29	30	37	8.33	1.0148	1.0164	5.5	132	97
Sep. 1–30 (30 days)	Max.	31	30	30	30	27	8.60	1.0185	1.0185	7.5	143	135
	Min.	19	20	19	20	17	8.20	1.0135	1.0144	5.1	118	70
	Mo.	30	22	28	28	26	8.50	1.0150	1.0163	6.0	129	90
	M.	27	26	25	27	23	8.36	1.0159	1.0149	6.2	130	99
Oct. 1–13 (13 days)	Max.	26	21	21	22	20	8.35	1.0198	1.0203	7.7	130	110
	Min.	16	17	16	16	14	8.00	1.0181	1.0184	6.4	117	70
	Mo.	22	19	18	21	16	8.15	1.0190	1.0195	6.6	122	87
	M.	21	19	18	19	17	8.20	1.0191	1.0191	6.8	124	88
Total period (111 days)	Max.	35	33	32	33	29	8.60	1.0203	1.0203	7.7	143	140
	Min.	16	17	16	16	14	8.00	1.0085	1.0144	4.7	69	40
	Mo.	30	29	29	29	26	8.35	1.0166	1.0166	5.9	135	90
	M.	24	27	24	27	24	8.34	1.0159	1.0166	6.3	119	94

Max.: Maximum, Min.: Minimum, Mo.: Mode, M.: Mean.
· : not estimated.

Acanthogobius flavimanus was single species which contain remains of *P. orientalis*. All of them were found only in region E(Table 4). Physico-chemical water conditions of the pond during experimental period are shown in Table 5.

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SUMMARY

The difference in growth rate of *P. orientalis* cultured on muddy bottom region and sandy bottom region in a pond filled with sea water were studied. For the investigation of the growth rate, the body length and the body weight were determined. Five individuals from each experimental region were sampled in random. The samples were collected at ten-day intervals. The survival rate, the qredator of *P. orientalis*, and the water conditions during the experimental period were also determined. The results in this study are summerized as follows:

1. The growth rate of *P. orientalis* which was cultured in the muddy bottom region was greater than that in the sandy bottom region. This is attributable in either case regardless of whether they were cultured with or without food,

2. The relationship between the culturing period (X) and the body length (Y) is:

Muddy bottom,	Food	$Y=0.58497X+25.05210$
Sandy bottom,	Food	$Y=0.51030X+26.57900$
Muddy bottom,	No food	$Y=0.22352X+32.79360$
Sandy bottom,	No food	$Y=0.11418X+31.20740$

3. The relationship between the culturing period (X) and the body weight (Y) is:

Muddy bottom,	Food	$Y=0.09062X-2.11140$
Sandy bottom,	Food	$Y=0.06992X-1.19640$
Muddy bottom,	No food	$Y=0.01615X+0.51150$
Sandy bottom,	No food	$Y=0.00495X+0.56150$

4. When the predator is not present, 84% of *P. orientalis* may survive.

5. *Acanthogobius flavimanus* is one of the predator of *P. orientalis*.

6. It is considered that the variation of water conditions of the pond, in which water had been exchanged 12 times per month, did not affect to the survival rate of *P. orientalis*.

LINTERATURE CITED

Hudinaga, Moto-saku (1942): Reproduction, development and rearing of *Penaeus japonicus* Bate. Jap.

Jour. Zool., 10 (2), 305-393.

Kim, Kwon Doo (1967): Studies on the artificial culture of *Penaeus orientalis* K. Indo-pacific Fisheries Council proceedings. 1nth. Session. 253-257.

Kim, Kwon Doo (1968): Studies on the Propagation, of a prawn, *Penaeus orientalis*. Bull. Korean Fish. Soc. 1 (1), 9-18.

安田治三郎・鈴木正也・篠岡久夫 (1957)： 瀬戸内海のエビ漁業の合理化に関する研究， 日本内水研研究報告, 10, 20-36.

Okamoto (1967): Studies on the culture of *Penaeus orientalis* K. II. Cultures in Fisheries 15 (2), 7-32.

柳晟奎 (1967)：대하의 養殖, 부산수산대학, 증식학과. 海馬 8.

吉田裕 (1949):：コウライエビの生活史について, 日本学誌, 15(5), 245—248.