Studies on Feeding and Growth of the Oriental Brown Shrimp, *Penaeus japonicus* Bate

by

Sang CHOE

(Fishery Resources Lab., Korea Institute of Science and Technology, Seoul, Korea)

보리새우의 攝餌와 成長

崔 相

(韓國科學技術研究所 · 水產資源研究室)

보리새우(*Penaeus japonicus* Bate)의 攝餌量, 晝間, 夜間 攝餌率과 日間 攝餌率, 餌料의 種類에 따른 攝餌率의 差異, 보리새우의 成長과 餌料의 轉換効率등에 관해서 시험한 결과를 요약하면 다음과 같다.

1. 보리새우의 攝餌率은 水溫範圍 19~30°C, 體重範圍 1.6~14.9g에서 水溫이 높을수록, 또 새우의 크기가 작을수록 커지며, 평균 日間 攝餌率은 18~44%에 달한다.
2. 항상 夜間 攝餌率이 晝間 攝餌率보다 크나, 無底質, 暗狀態 또는 直接光線을 피한 飼育狀態에서는 晝間에도 日間 攝餌率의 22~37%의 攝餌를 이룩할 수가 있어, 그만큼 보리새우의 成長을 促進시킬 수가 있겠다.
3. 멸치와 바지락의 두가지 餌料에서는 晝夜의 區別없이 멸치를 한층 더 많이 攝取하였으며, 日間 攝餌率중에서 멸치 및 바지락肉의 攝餌率은 각각 12.9%, 10.3%이었다.
4. 보리새우의 體重(W;g)과 日間 成長率 (DGR;%) 사이에는 $\log \mathrm{DGR}=0.7035-0.7864 \log W$의 關係式이 成立되고, 새우의 크기에 比例하여 日間 成長率은 작아진다.
5. 보리새우의 餌料의 轉換効率은 새우의 크기에 따라 큰 差異가 없이 平均 2.8~7.8%의 範圍로 變動하며, 지금까지 알려진 魚類(문치가재미, 고등어, 방어 등)와 참오징어의 그것에 比較하면 매우 작은 값을 취한다.

Introduction

All species of the large size shrimp are prospective objects of cultivation because of their rapid growth and their outstanding commercial value. Particularly, *Penaeus orientalis* (closely resembling the white shrimp, *P. setiferus*) and *P. japonicus* (closely resembling the brown shrimp, *P. aztecus*) are important brands whose large scale cultivation has recently begun in Korea. However, fundamental studies for their cultivation are still poor, and it is essentially necessary now to study the aquacultural conditions of these important species of shrimp.

In the cultivation of shrimps, there are many tasks to resolve. For example, the general food habits of shrimp are still largely unknown. Feeding ecology, food requirements, feeding formulations and resulting growth, and other related matters are the topics of concern. These matters are all directly related to the cultivation management of the shrimp.

It is well known that the oriental brown shrimp *Penaeus japonicus* has nocturnal habits. In the daytime the shrimp remains in a quiet state buried in the sand, and seldom emerges from that positions. But when they meet environmental oxygen deficiency, they creep out of the sand (Egusa and Yamamoto, 1961). If feeding can be done during the daytime, the shrimp's growth can be accelerated considerably. Their cannibalism during cultivating period can be confined to a minimum through improvement of the cultivation method.

It is essential in all intensive cultivation to produce results in the shortest possible period of time through the most effective method. This offers one of the basic reasons for the production of artificial feedstuff for shrimp cultivation.

There have been few studies on growth of the oriental brown shrimp; Seno (1910) on the cultivated shrimp, Kajiyama (1935) and Kubo (1955) on the mass-growth of natural populations, and Hudinaga (1942) on the Zoea and Mysis stages. According to these works, growth of the oriental brown shrimp moderately varies in different districts. Generally, however, the body length grows to 10cm after one year, to 15cm after one and half years and to 19cm after two years. No definite data are yet available on their growth after two years. Also little is known on the moulting cycle in connection with the growth, or growth rate in conjunction with moulting of the shrimp.

The following experiments were designed to learn the feeding rate, as related to the size of the shrimp, the difference in feeding in the daytime and nighttime, the feeding rate by kinds of food, the efficiency of food conversion, and the growth of the shrimp.

Material, Devices and Methods

The oriental brown shrimp used for these studies were those which are 3. 4 to 10. 0 centimeters long (weighing 0. 45 to 10. 80 grams each) in various stage of growth, lured by a lamp and caught at night off the coast of an estuary. In the initial stage, they were put into large concrete water tanks (each with a base area of 3. 3 square meters) indoors for one to three days almost without feeding. The most lively individual shrimp among them were selected for the actual study.

The feeding experiment with the shrimp was conducted from August 19 to October 12. Oblong bamboo frames, each 30cm long, 15cm wide, and 15cm high were manufactured. The bottom of each frame was covered with synthetic fiber net with meshes of one millimeter and the upper portion with the similar net but with meshes of approximately three millimeters. Each frame was used as a feeding cage holding one shrimp for separate feeding to allow accurate observation. The feeding cages were turn placed in a concrete water tank (2 meters long, 0. 6 meter wide, and 0. 5 meter deep) situated outdoors. Approximately 40 liters of sea water was circulated in the water tank every minute.

This device enabled the author to easily estimate the unconsumed quantity of food in each feeding cage. Although the living space and the activity of the shrimp were limited in the feeding cages, the space of 30cm long, 15cm wide and 15cm high was not considered inadequate for the moult of the shrimp. A space slightly smaller than this caused the shrimp to suffer injuries during the moult, thereby obstructing their growth.

An over-ample amount of food was given twice a day, once in the morning (8 to 9 a.m.) and once at sunset. At each feeding, the unconsumed quantity of the food in each feeding cage was collected and recorded. Thus, the consumption of food was calculated by daytime and nighttime, and for each day. A tin-plate cover with wooden frame was placed on top of the concrete water tank kept outdoors so as to keep its inside dark even during the daytime. Shrimp were therefore raised in an almost non-sediment and dark condition.

The raising experiment of shrimp was conducted from September to the end of October. A total of 166 shrimps in various stages of growth were raised in outdoor concrete water tanks (each 1.8 meters long, 1.8 meters wide, and 0.5 meter deep) shielded from direct sunshine. They were raised under non-sediment conditions, and approximately 30 liters of sea water were circulated in the tank per minute. More than an ample amount of food was supplied to the shrimp twice a day, in the morning and at sunset.

In the feeding and raising experiments of the shrimp, sliced anchovy (*Engraulis japonica*) meat and whole short-necked clam (*Tapes japonica*) meat were used.

The temperature range of the rearing sea water was from 18.0° to 30.2°C, and its chlorinity range was from 13 ‰ to 16 ‰.

The daily feeding rate (or feeding rate for daytime and nighttime), the efficiency of food conversion, and the daily growth rate were calculated in accordance with the following equations:

Average weight of shrimp: $W=\frac{w+w_o}{2}$

Daily feeding rate: $r=\frac{f}{tW}$

Efficiency of food conversion: $e=\frac{w-w_o}{f}$

Daily growth rate: $g=\frac{w-w_o}{tW}$

where w_o indicates the initial weight of shrimp; t the number of days of feeding; f the quantity of food eaten during the feeding period; and w the weight of the shrimp after the quantity of food (f) was eaten and after (t) number of feeding days.

Results

Amount of Food Intake

Through out the feeding experiment involving 12 series of individual shrimp, the feeding status, broken down into daytime and nighttime, of six individual shrimp which underwent three to four rounds of successive moult and were considered to have made normal growth without injury during the moult, is indicated in Fig. 1. Fluctuations in their feeding rate during the daytime and at nighttime during the feeding period are shown in Table 1.

As indicated in Fig. 1, the feeding rate of the shrimp fluctuated extensively depending on the size of the shrimp and the temperature of the sea water in which the shrimp were raised. The results also indicate that a considerable quantity of food was consumed even during the daytime in the non-sediment and dark condition.

The temperature of the sea water was highest in August at 27.8° to 30.2°C, and gradually decreased to 22.2° to 29.2°C in September, and then to 19.4° to 25.6°C in October. Daily fluctuation in the temperature of the sea water sharply affected the food intake of the shrimp. When the water temperature was high, the amount of food intake was increased, while it was low, the amount of food intake was decreased. When the temperature was continuously low, the consumption of food gradually increased to a limited extent. This apparently indicated that the shrimp adapted themselves to the continuous low temperature.

It had generally been understood that the oriental brown shrimp take no food at all during moult. However, the results of this experiment showed that a considerable quantity of food was consumed in moulting day. Food consumption decreased approximately 14 to 16 percent during moult below the normal level in the case of small shrimp each weighing up to 10

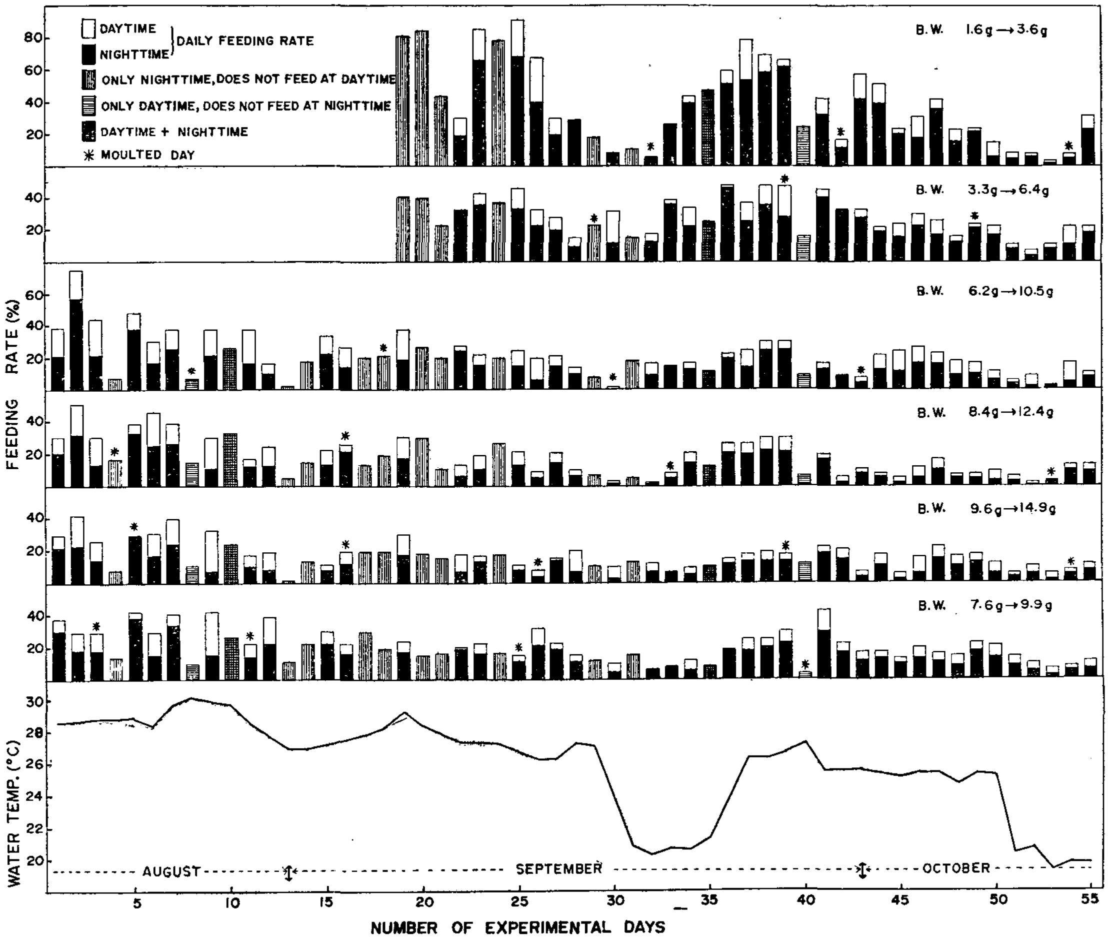

Fig. 1. Water temperature and daytime, nighttime, and daily feeding rates under each feeding of satiated amount for *Penaeus japonicus*.

Table 1. Daytime, nighttime and daily feeding rates of *Penaeus japonicus* fed on anchovy and short-necked clam meats (Aug. 19—Oct. 12)

Initial Body Weight (g)	Final Body Weight (g)	Aug. 19–31 (27.8–30.2°C)					
		Daytime (D)		Nighttime (N)		Daily Feeding Rate (%)	D/N+D (%)
		Range (%)	Mean (%)	Range (%)	Mean (%)		
1.6	3.6	—	—	—	—	—	—
3.3	6.4	—	—	—	—	—	—
6.2	10.5	5.6—22.7	14.8	1.4—57.2	21.3	36.1	41.0
7.6	9.9	5.1—22.5	11.5	13.5—37.2	20.6	32.1	35.8
8.4	12.4	4.5—20.0	12.9	4.3—33.6	19.1	32.0	40.3
9.6	14.9	0—18.9	12.3	1.4—24.2	12.5	24.8	49.6
Initial Body Weight (g)	**Final Body Weight (g)**	**Sept. 1–30 (22.2–29.2°C)**					
		Daytime (D)		Nighttime (N)		Daily Feeding Rate (%)	D/N+D (%)
		Range (%)	Mean (%)	Range (%)	Mean (%)		
1.6	3.6	0—27.5	10.8	6.5—81.2	41.7	52.5	20.1
3.3	6.4	0—20.2	8.6	9.8—43.0	28.5	37.1	23.2
6.2	10.5	0—18.6	5.2	1.7—27.0	15.9	21.1	24.6
7.6	9.9	0—23.4	6.9	4.5—29.6	16.7	23.6	29.2
8.4	12.4	0—17.4	5.5	0.9—30.5	13.8	19.3	28.5
9.6	14.9	0—12.7	5.6	4.5—19.9	12.3	17.9	31.3
Initial Body Weight (g)	**Final Body Weight (g)**	**Oct. 1–12 (19.4–25.6°C)**					
		Daytime (D)		Nighttime (N)		Daily Feeding Rate (%)	D/N+D (%)
		Range (%)	Mean (%)	Range (%)	Mean (%)		
1.6	3.6	1.4—12.9	5.9	2.9—40.0	17.0	22.9	25.8
3.3	6.4	0.9—14.4	5.7	4.9—28.2	15.0	20.7	27.5
6.2	10.5	0—12.4	6.7	3.4—16.3	9.0	15.7	42.7
7.6	9.9	1.5—6.8	4.6	3.1—17.8	9.9	14.5	31.7
8.4	12.4	0—6.4	3.3	0.4—10.6	5.7	9.0	36.7
9.6	14.9	0—8.9	3.9	1.4—11.2	6.7	10.6	36.8

grams. In the case of the large shrimp, however, little difference was noted in food consumption during moult as compared with the normal level. The night after each moulting, the normal consumption of food was recovered almost completely.

As shown in Table 1, the daily feeding rate of the oriental brown shrimp in the non-sediment and dark conditions was higher when the temperature of the sea water was higher as in the case of the smaller shrimp. The average daily feeding rate of shrimp weighing 1.6 to 3.0 grams reached 53 percent when the temperature of the sea water ranged from 22.2° to 29.2°C.

A greater quantity of food was consumed during the nighttime than during the daytime. In both cases, however, the consumption of food increased if the temperature of the sea water

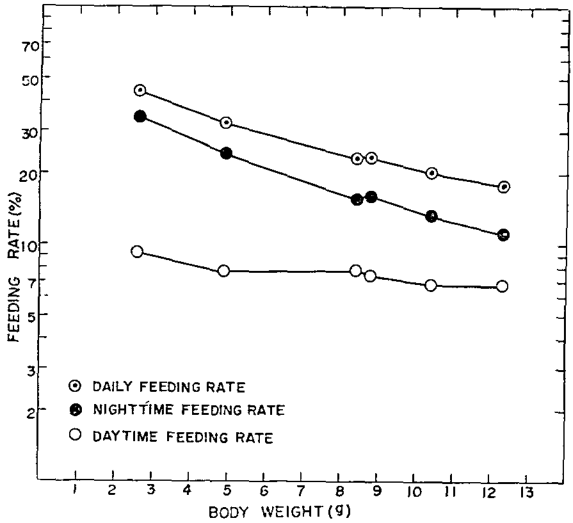

Fig. 2. Relationships between the body weight and the daily, nighttime, and daytime feeding rates of *Penaeus japonicus*.

increased and if the size of the shrimp was smaller. In some extereme instances, the daytime feeding rate reached nearly 50 percent of the daily feeding rate.

The daily, daytime and nighttime feeding rates for the 56-day period of August 19 to October 12 (with a sea water temperature range of from 19.4° to 30.2°C) are indicated in Fig. 2. The average daytime feeding rate was 6.8 to 9.4 percent, the average nighttime feeding rate was 11.1 to 34.6 percent, and the average daily feeding rate ranged from 17.9 to 44.0 percent. The ratio of daytime feeding rate to daily feeding rate stayed between 21.8 percent and 36.9 percent.

Feeding Rate by Kinds of Food

During the 25-day period from September 16 to October 10, over-ample amounts of anchovy and short-necked clam meats were simultaneously fed. The differences of consumption during the daytime and at nighttime by kinds of food were calculated as shown in Table 2.

Table 2. Change of feeding rates upon the bait kind for the shrimp, *Penceus japonicus*

Body Weight (g)		Daytime Feeding Rate (%)					Nighttime Feeding Rate (%)					Daily Feeding Rate (%)		
		No of Obs.	Anchovy		Clam*		No of Obs.	Anchovy		Clam*		Anchovy	Clam*	Total
Initial	Final		Range	Mean	Range	Mean		Range	Mean	Range	Mean			
2.2	3.5	13	1.4-25.0	7.6	0-5.9	2.8	19	2.3-42.6	16.9	0-28.3	12.9	24.5	15.7	40.2
4.1	6.2	13	0.8-13.7	5.5	0-5.3	2.0	19	1.6-28.9	13.0	3.3-33.4	11.6	18.5	13.6	32.1
8.5	10.4	13	0.5-6.5	2.8	0-6.1	2.6	19	1.0-15.2	5.5	1.0-13.6	6.7	8.3	9.3	17.6
8.8	9.8	13	0.5-6.5	3.2	0.5-5.0	2.4	19	0.5-18.5	7.2	0.5-15.6	6.6	10.4	9.0	19.2
10.4	12.3	13	0-5.0	2.4	0-5.5	2.4	19	0-17.0	5.5	0-12.8	4.4	7.9	6.8	14.7
12.4	14.7	13	0-4.6	2.3	0-11.9	2.8	19	0.7-14.4	5.8	0.7-10.3	4.6	8.1	7.4	15.5
Mean				4.0		2.5			9.0		7.8	12.9	10.3	23.2

* Short-necked clam

The daytime feeding rate of anchovy meat was 2.3 to 7.6 percent (4.0 percent in average), and that of short-necked clam meat 2.0 to 2.8 percent (2.5 percent in average). On the other hand, the nighttime feeding rate of anchovy meat was 5.5 to 16.9 percent (8.0 percent in average) and that of short-necked clam meat 4.4 to 12.9 percent (7.8 percent in average). Both during the daytime and the nighttime, the shrimp ate more anchovy meat than short-necked clam meat. Different kinds of food have a direct bearing on the growth of the oriental brown shrimp (unpublished).

Growth Rate and Efficiency of Food Conversion

The daily growth rate (in body weight) and the efficiency of food conversion of the shrimp each raised separately in different feeding cages, on over-ample amounts of anchovy and short-necked clam meats, are shown in Table 3. The relation between the weight of the individual shrimp and their daily growth rate in sea water the temperature of which was 19.4° to 30.2°C was indicated in a logarithmic cuive as shown in Fig. 3. Therefore, the following equation is formed on the relation between the daily growth rate (DGR in percent) and the body weight (W in gram): log DGR=0.7035−0.7864 log W.

Table 3. Values of growth rate (body weight) and efficiency of food conversion of *Penaeus japonicus*

Raising Period	W.T. (°C)	Exp. Series		A	B	C	D	E	F
		Body Weight (g)	Initial	1.6	3.3	6.2	7.6	8.4	9.6
			Final	3.6	6.4	10.5	9.9	12.4	14.9
Aug. 19–31	27.8～30.2	Mean Body Weight (g)		—	—	6.7	7.9	8.9	10.2
		Daily Growth Rate in Body Weight (%)		—	—	1.15	0.58	0.95	0.90
		Efficiency of Food Conversion (%)		—	—	3.70	2.04	2.75	3.79
Sept. 1–30	22.2～29.2	Mean Body Weight (g)		2.3	4.3	8.4	8.8	10.4	12.3
		Daily Growth Rate in Body Weight (%)		2.43	1.86	0.95	0.45	0.71	0.79
		Efficiency of Food Conversion (%)		5.13	5.56	5.01	2.34	4.21	5.23
Oct. 1–20	19.4～25.6	Mean Body Weight (g)		3.3	5.9	10.1	9.7	12.0	14.3
		Daily Growth Rate in Body Weight (%)		1.52	1.55	0.74	0.77	0.63	0.70
		Efficiency of Food Conversion (%)		6.78	7.82	4.80	2.99	7.35	6.59
Aug. 19–Oct. 12	19.4～30.2	Mean Body Weight (g)		2.6	4.9	8.4	8.8	10.4	12.3
		Daily Growth Rate in Body Weight (%)		2.08	1.70	0.93	0.48	0.70	0.78
		Efficiency of Food Conversion (%)		5.54	6.19	4.59	2.36	4.11	5.04

The efficiency of food conversion appeared great in the case of the small shrimp and small in the case of the large shrimp. But this tendency was not definite. The efficiency of food conversion ranged from 2.8 to 7.8 percent in the case when the weight of the individual shrimp was between 2 to 14 grams.

In order to study the survival, cannibalism, and growth of the oriental brown shrimp during the raising period, a total of 166 shrimp of various sizes (each 3.2 to 10.8 centimeters in length, and

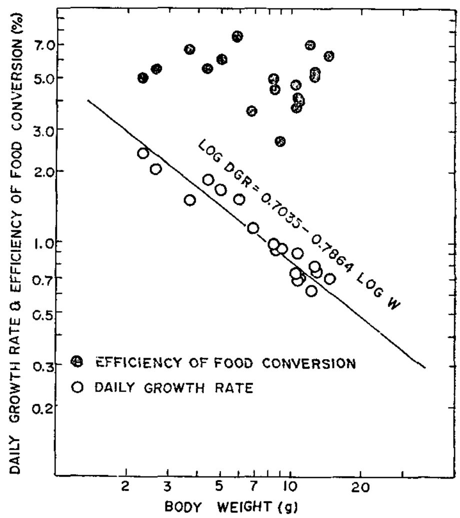

Fig. 3. Relationships between the body weight and the mean daily growth rate, and mean efficiency of food conversion of *Penaeus japonicus*.

0.4 to 16.5 grams in weight) were collectively raised in a large concrete water tank with a base area of 3.3 square meters. The weight of each shrimp per square meter of base area was 94 grams. Approximately 30 liters of sea water per minute was circulated in the tank. Anchovy and short-necked clam meats were given in over-ample amounts twice daily, once in the morning and the other time at sunset during a 46-day period from September 14 to October 30.

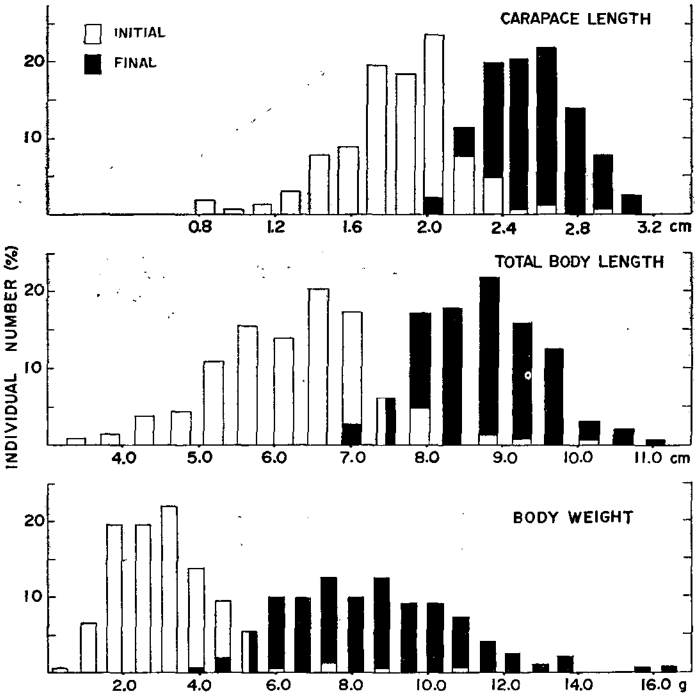

Fig. 4. Increase in carapace length, total body length and body weight of *Penaeus japonicus* raised for 46 days (14, Sept. to 30, Oct.).

The growing status of the carapace length, body length and body weight of shrimp is shown in Fig. 4. After 46 days of raising, 155 shrimp weighing a total of 1,322 grams (approximately 400 grams per square meter) were harvested. The growth rate during the feeding period was 38.0 percent for the carapace length, 39.4 percent for the body length, and 178.2 percent for the body weight of shrimp. During the raising period, 11 shrimps died, showing a mortality of 6.7 percent, which was in turn broken down as follows: One shrimp (9.1 percent) was assumed to have died immediately before moult in view of the ecdysis crust formed. Three shrimps (27.3 percent) died during or before the completion of moulting. Another three shrimps (27.3 percent) died after moult and without any apparent physical damage. Yet another three shrimps (27.3 percent) were killed as the result of cannibalism as their eyes, gills, pleopods, and other soft parts of their bodies were bitten off. One shrimp (9.1 percent) died for an unknown reason not related to moulting.

Thus, only three shrimps were killed as the result of cannibalism during the 46-day period of raising. They constituted only 1.2 percent of the total number of shrimps raised. Throughout the raising period, a total of 204 rounds of moult were made as confirmed by means of the moulted crusts of the shrimp. Each shrimp thus performed an average of 1.3 rounds of moult.

Discussion

Little is known at present about the relationship between the growth of the oriental brown shrimp and the sea water's temperature and salinity. According to Zein-Eldin (1963), however, strong resistance was shown by the fry of *Penaeus setiferus* (white shrimp), *Penaeus aztecus* (brown shrimp), and *Penaeus duorarum* (pink shrimp). He reported that their fry were raised well in sea water of salinity from 2 to 40 o/oo. It may be tentatively suggested that food requirements may be of more importance than the purely physical factors. According to Zein-Eldin and Griffith (1966), the growth rate of *Penaeus aztecus* increased as the temperature of the sea water increased to 32.2°C. With the mortality taken into consideration, however, the gross production was greatest when the temperature of the sea water was 22.5° to 30.0°C, according to them. Shrimp belonging to the family *Penaeus* apparently have a rather extensive scope of adaptability to the salt content of the sea water in which they grow. They also appear to grow faster if the temperature of sea water rises up to a limit of about 30°C.

In various kinds of fish culture, feeding technology, including such factors as an amount of food applied, and the number of times of feeding has great influence on the growth of fish, the supply and demand of food, and their economy.

According to Dawes (1930, 1931), the efficiency of food was higher in the case of optimum frequency of feeding than in the case of excessive increase in the frequency of feeding through a raising experiment on *Pleuronectes platessa* (a kind of flat fish) with the blue mussel meat. According to Probst (1939), growth status was better when food was given twice a day than when given six to seven times a day as the results of a comparison of the increase in the weight of fish and the total efficiency of the food conversion of 0 to 1-year-old rainbow trout raised on the combined food.

According to Pentelow (1939), the rate of increase in the weight of fish increased almost in proportion to the feeding rate in sea water whose temperature was 4° to 10°C as the result of raising O-year-old brown trout (*Salmo trutta*) on *Gammarus pulex*. He said that the gross efficiency of food in proportion to the growth of fish did not show an indication of decline even when a great quantity of food was given. He further reported that similar trends appeared also when the temperature of the sea water was 10°C or more excepting slight irregular phenomena.

Referring to the above works, Ishiwata and Kohno (1968) reported that a nearly straight line relationship existed between the daily feeding rate and the daily growth rate as long as the food was given once a day in an amount below satiation. They asserted, however, that the total efficiency of food conversion showed a tendency to approach a certain limit as the daily feeding rate increased.

According to Ishiwata (1969), satiated feeding two times daily ensured the most effective growth of fish as the results of the raising experiment on the filefish, puffer, yellowtail and rainbow trout etc., fed with satiated amount of food once, twice, and three times daily.

In the non-sediment, dark or direct-sunshine-shielded conditions, the oriental brown shrimp weighing 1.6 to 14.9 grams each always ate more food during the nighttime than during the daytime. During the daytime, however, they showed a feeding rate of 3.3 to 14.8 percent, or 20 to 50 percent of the daily feeding rate. Therefore, the raising of the oriental brown shrimp in that condition is considered to accelerate the growth of shrimp to that extent.

The daily feeding rate of the oriental brown shrimp increased as the temperature of the sea water increased, but the rate was greater when the size of the shrimp was smaller. When the temperature of the sea water was 22° to 29°C, each shrimp weighing 1.6 to 3.6 grams showed a maximum daily feeding rate of 53 percent. During a 56-day period of raising, each shrimp weighing 1.6 to 14.9 grams, showed an average daily feeding rate of 18 to 44 percent. The average ratio of daytime feeding rate to daily feeding rate reached from 22 to 37 percent.

A slight difference was noted in the feeding rate depending on the kind of food (anchovy and short-necked clam meats were used in this experiment). Both during the daytime and nighttime, more anchovy meat was eaten than short-necked clam meat.

The daily growth rate of the oriental brown shrimp varied depending on their size. The larger the shrimp were, the smaller the daily feeding rate was. The following equation is applicable to the relation between body weight (W in gram) and daily growth rate (DGR in percent): $\log DGR = 0.7035 - 0.7864 \log W$.

The efficiency of food conversion of the oriental brown shrimp showed a tendency to slightly decrease as their size increased. But this tendency was not conspicuous, and rather fluctuated generally between 2.8 and 7.8 percent. This is a somewhat small figure as compared with 10.4 to 18.2 percent for *Limanda yokohamae* (Hatanaka, et al., 1956), 9.5 to 19.9 percent for *Scomber japonicus* (Hatanaka, et al., 1957), 12.9 to 34.0 percent for *Seriola quinqueradiata* (Hatanaka and Murakawa, 1958) and 38.7 percent for *Sepia esculenta* (Choe, 1966). This indicates that the efficiency of food conversion is not very good in the raising of the oriental brown shrimp.

Under adequate raising conditions, the cannibalism of the oriental brown shrimp can be almost completely prevented.

Summary

1. The higher the temperature of the sea water, and the smaller the size of the oriental brown shrimp, the higher the feeding rate of the shrimp will be as long as the temperature ranges from 19° to 30° C, and each shrimp weighs from 1.6 to 14.9 grams. The average daily feeding rate is between 18 to 44 percent.
2. The nighttime feeding rate is always higher than the daytime feeding rate. However, the daytime feeding rate can be raised to from 22 to 37 percent of the daily feeding rate in the non-sediment, dark or direct-sunshine-shielded conditions. Growth can thus be accelerated to that extent under such conditions.
3. When anchovy and short-necked clam meats were simultaneously used as food, a greater quantity of anchovy meat was consumed than short-necked clam meat both during the daytime and nighttime. When anchovy and short-necked clam meats were simultaneously given, the averaged daily feeding rates of anchovy and short-necked clam meats were 12. 9 percent and 10. 3 percent, respectively.
4. The following equation applies to the relationship between the weight of the oriental brown

shrimp (*W* in grams) and their daily growth rate (DGR in percent): log DGR=0.7035−0.7864 log *W*. The daily growth rate is in inverse proportion to the size of the shrimp.

5. The efficiency of food conversion of the oriental brown shrimp fluctuates between 2.8 and 7.8 percent without extensive difference depending on the size of the shrimp. This was very small as compared with the corresponding figures so far known for fish and cuttlefish.

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