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Some Aspects of Large-Scale Rearing of Larvae and Post-Larvae of the King Crab (*Paralithodes camtschatica*)

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Abstract

Large-scale rearing of larvae and post-larvae of the king crab was studied in 30*l* and 500*l* tanks. When the water temperature was maintained under 3°C, egg-bearing females reared for one year and could hatch out larvae normally. The best survival ratio at the first stage young crab was 38.8% in 30*l* tank and 16.62% in 500*l* tank. There was a lot of cannibalism even at the larval stage.

I. Introduction

The king crab (*Paralithodes camtschatica*) fishery of the North Pacific was one of the most important fisheries in Japan. The Japanese king crab catch had declined from 1,823 tons in 1975 to 130 tons in 1978 (FAO 1978). After setting of the 200 Mile Exclusive Economic Zones, Japan lost many fishing grounds for this crab. Such a decline, coupled with increased demand for this much-desired crustacean, has led to attempt to cultivate it artificially.

There are many studies on rearing larvae of the king crab (KAAI, 1940 and SATO, 1949). KURATA (1959, 1961) reared larvae from the first zoeal stage to the ninth post-larvae stage in a laboratory. His studies outlined a rearing method of larva and post-larva of the king crab.

Meanwhile, the larvae of the Kuruma prawn (*Penaeus japonicus*) and Japanese blue crab (*Portunus trituberculatus*) are both cultured on a large scale in the western Japan. Such large-scale rearings demonstrate the possibility of similar large-scale rearing of king crab larvae.

Studies on aquaculture of larvae and post-larvae of the king crab began in Hokkaido 1970. There are a lot of reports about large-sacle rearing at this project (NAKANISHI 1976, SASAOKA 1978, OMI 1980). This study is one part of this project.

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II. Materials and methods

Experiments were carried out from February to June, 1979, at the Hokkaido Regional Fisheries Research Laboratory, Kushiro, Hokkaido.

Three types of egg-bearing females were used for this study. (1) Egg-bearing females that were caught in May, 1978, and reared until the next spring when larvae were hatched out (Female No. I, II, III, and IV). (2) Matured female that was coupled with male in the laboratory in April, 1978, and reared for one year and larvae were hatched out in the next spring (Female No. V). (3) Egg-bearing females that were caught in April, 1979, with larvae hatched out one or two weeks later (Female No. VI and VII). These females had already hatched out 50–70% zoeae.

Egg-bearing females were caught near Nemuro with crab-pots. These egg-bearing females were transported to the laboratory and reared in tanks (2×1×0.7m) with a sand bed (5mm diameter) in 1978. These females were fed on squid, shrimps, sardines and mackerel pike with running sea water at a rate of 1 *l*/minute. Food was always given in excess of the amount expected to be eaten. The water temperature was controlled at under 3°C. Further analysis of the rearing method of these females and their egg development will be reported elsewhere. Soon after some zoeae emerged from eggs, these females were placed in a tank (1 m in diameter with 1 m depth). Egg-bearing females that were caught in spring, 1979, were also placed in this tank. These larvae, which are phototactic, were gathered by attracting them to a light and put into rearing tanks.

Rearing tanks at zoeal stage were 30*l* and 500*l* tanks. From the zoeal fourth stage, larvae were reared in net-cages (90×90×50 cm). The residual food and moulted shells were removed and half of the water in 30*l* tank was changed once a day. The water was always kept well aerated. The running sea water was supplied in 500*l* tanks at a rate of 1 *l*/minute. Residual food and moulted shells were removed once a day. These rearing tanks are shown in Fig. 1. Zoeae were fed on newly hatched out *Artemia salina* nauplii. Rotifer (*Brachionus plicatilis*) once every two days and *Phaeoductylum* sp. once per three days were used as food in order to balance nutrition. In net-cages, minced clam meats were given once per four days. There were two types of net-cages. One type of net-cage had benthic diatoms and the other net-cage did not.

Survival numbers were calculated by the sampling method. In the net-cages, these numbers were counted visibly. The water temperature was measured once a day (Fig. 2). The dead cause in 30*l* tanks was identified by the following method. A larva without tail and/or eye was considered to die of a cannibalism. A dead larva with a old exoskeleton was considered to die of a fail of moulting. Another dead larva was considered to die of unknown cause.

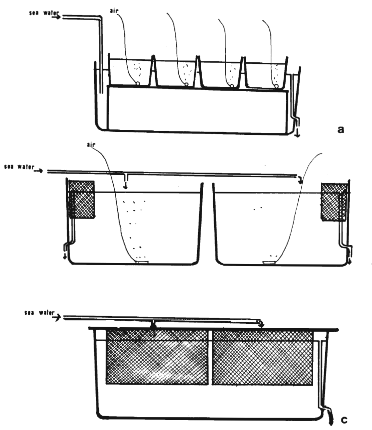

Fig. 1. Apparatus for rearing larvae and post-larvae of king crab.
a. 30 *l* tanks in water bath.
b. 500 *l* tanks with running sea water.
c. net-cage rearing at post-larvae stage.

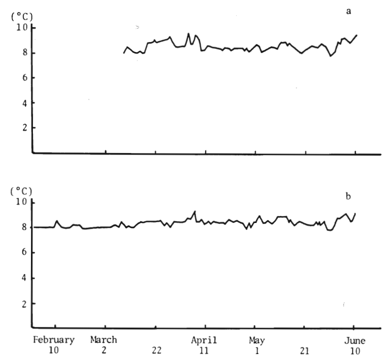

Fig. 2. The daily means of water temperature.
a. in 30 *l* tank.
b. in 500 *l* tank.

III. Results

The zoeal stage is abbreviated as Z, the glauchothoe stage as G, and the young crab stage as C. Total zoeae from each female fluctuated between 9,790 and 140,300 (Table 1). The release of eggs from egg-bearing females during rearing was the main reason for this fluctuation. All attached eggs that were not released were hatched out normally.

The survival numbers in 30 *l* tanks are shown in Table 2 and the survival ratios are shown in Table 3 and Fig. 3. The daily temperature mean in 30 *l* tanks are shown in Fig. 2–a.

Larvae in tank-a and -b were hatched out from female No. III. The survival ratio in tank-a was 73.8% at Z-4 and 38.8% at C–1. These zoeae were transferred to a net-cage with benthic diatom at the end of Z–4. The term from Z–1 to C–1 was 46 days. Eighty percent of zoeae died from cannibalism and 20% from failure to moult. The survival ratio in tank-b was 47.25% at Z–4 and 26.9% at C–1. These zoeae were

Table 1. Number of first-stage zoeae and the date of the hatching out of zoeae from each female.

Female No.	500 *l* tank	30 *l* tank	Date of H. O.	Total number of 1st zoea
I	A B	—	Jan. 31 1979	100769
II	C	—	Feb. 23 1979	9790
III	D E	a b	Mar. 8 1979	87877
IV	F G	c	Mar. 17 1979	16800
V	H I	d	Apr. 6 1979	140300
VI	J	e f g h i	Apr. 17 1879	46954
VII	K	—	Apr. 20 1979	21759

Table 2. Survivals of larva and post-larvae of king crab in 30 *l* tanks.

	Z_1	Z_2	Z_3	Z_4	G	C_1
a	500	485	393	369	203	194
b	2000	1565	1084	895	701	538
c	1500	1465	1210	945	503	515
d	1300	861	766	370	205	109
e	350	342	330	318	} 305	285
f	750	725	644	524		
g	854	815	734	535		
h	1500	1440	1001	711	} 250	259
i	3500	3034	1776	626		
Total	12254	10732	7938	5293	2167	1900

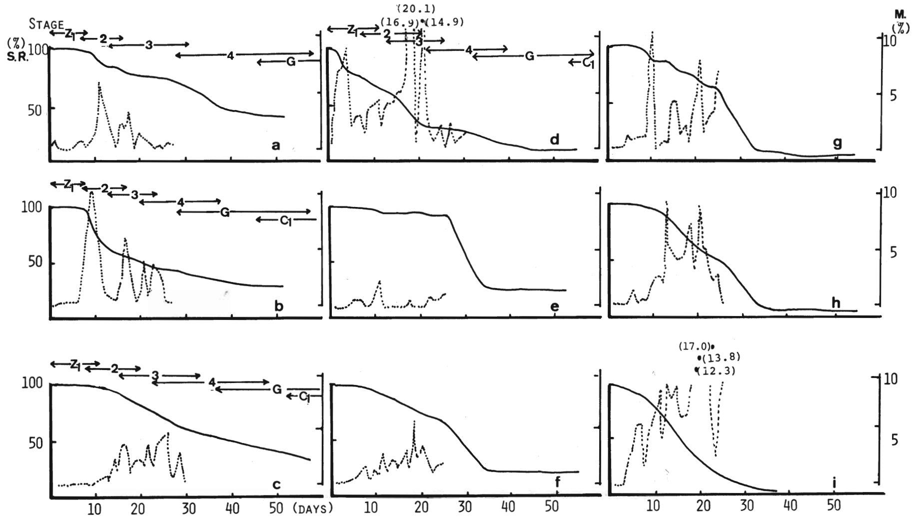

Fig. 3. Survival ratios and daily mortality in 30 *l* tank. a–i are the tanks numbers of 30*l* tanks.
—— survival ratio ······ mortality

Table 3. Survival ratios of larvae and post-larvae of king crab in 30 *l* tanks.

	Z_1	Z_2	Z_3	Z_4	G	C_1
a	100	97	78.6	73.8	40.6	38.8
b	100	78.25	54.2	47.25	35.05	26.9
c	100	97.66	80.66	63.00	33.53	34.33
d	100	66.23	58.92	28.46	15.77	8.38
e	100	97.71	94.29	90.85	} 27.73	25.90
f	100	96.67	85.86	69.87		
g	100	96.45	85.95	62.65		
h	100	96.00	66.73	47.40	} 4.27	4.42
i	100	86.69	50.74	17.89		
mean	100	87.58	64.78	43.19	17.68	15.50

transferred to a net-cage with benthic diatom at the end of Z-4. The term from Z–1 to C–1 was 46 days. The daily mortality during the moulting period from Z–1 to Z–2 (9 days from hatching out) was very high. Half of the zoeae died from cannibalism and 50% died from failure to moult.

The survival ratio in tank-c was 63.0% at Z–4 and 34.33% at C–1. These zoeae were transferred to a net-cage without benthic diatom at the beginning of Z–4. The term from Z–1 to C–1 was 52 days. Eighty percent of the zoeae died from cannibalism, 10% died from failure to moult and 10% from unknown causes. The survival ratio in tank-d was 28.46% at Z–4 and 8.38% at C–1. The daily mortality increased rapidly at the moulting period from Z–3 to Z–4. These zoeae were transferred to a net-cage with benthic diatom. The term from Z–1 to C–1 was 53 days. Thirty percent of the zoeae died from cannibalism and 70% from unknown causes.

Larvae in tank-e, -f, -g, -h and -i were hatched out from female No, VI. The survival ratio in tank-e was 90.85% at Z–4. Thirty percent of zoeae died from cannibalism and 70% died from failure to moult. The survival ratio in tank-f was 69.87% at Z–4. These zoeae in tank-e and -f were transferred to the same net-cage with benthic diatom at the beginning of Z–4. The daily mortality increased rapidly for one week after this transfer. The survival ratio at C–1 was 25.90%. The survival ratio in tank-g was 62.65% at Z–4. The daily mortality was 10% at 10 days from hatching out. Eighty percent of the zoeae died from cannibalism, 20% died from failure to moult. The survival ratio in tank-h was 47.4% at Z–4. Eighty percent of the zoeae died from cannibalism, 10% died from failure to moult and 10% from unknown causes. The survival ratio in tank-i was 17.89% at Z–4. The highest daily mortality was 17.0% during the moulting period from Z–3 to Z–4. The daily mortality continued at 10% for 7 days. Eighty percent of the zoeae died from cannibalism and 20% died from failure to moult. But some dead zoeae in this tank were attacked by other ones, so it was difficult to identify the cause of death whether cannibalism or failure to moult. These zoeae in tank-g, -h and -i were transferred to the same net-cage with benthic diatom at the beginning of Z–4 in tank-g and -h and during the moulting period from Z–3 to Z–4 in tank-i. The survival ratio at C–1 was 4.42%. The term from Z–1 to C–1 was 48 days.

The survival numbers in 500 *l* tanks are shown in Table 4. These survival ratios are shown in Table 5 and Fig. 4. The daily temperature means in 500 *l* tank are shown in Fig. 2–b.

Larvae in tank-A and -B were hatched out from female No. 1. The survival ratio in tank-A declined to 49% at Z–2 and all the zoeae died 3 days later during the moulting period from Z–1 to Z–2. The survival ratio in tank-B was 14.53% at Z–4 and 1.3% at C–1. These zoeae were transferred to a net-cage with benthic diatom at the middle of Z–4. The term from Z–1 to C–1 was 69 days. The survival ratio in tank-C was 12.87% at Z–4. These larvae were transferred to a net-cage with benthic diatom during the moulting period from Z–4 to G. The term from Z–1 to C–1 was 69 days.

Table 4. Survivals of larvae and post-larvae of king crab in 500 *l* tanks.

Stage	Z_1	Z_2	Z_3	Z_4	G	C_1
A	78154	38000	0			
B	22615	21462	10000	3285	1684	300
C	9790	4241	1665	1260	1000	700
D	15377	14462	13308	10615	3282	2555
E	70000	63636	48863	18461	18000	0
F	10000	2600	2000	2000	850	775
G	5300	5000	3000	1500	279	195
H	70000	59000	27897	9846	1480	596
I	69000	27273	19743	3250	2500	346
J	40000	32820	34461	14000	2812	2672
K	21759	21538	15000	11794	3555	1817
Total	411995	290305	175937	70611	33288	9570

Table 5. Survival ratios of larvae and post-larvae of king crab in 500 *l* tanks.

Stage	Z_1	Z_2	Z_3	Z_4	G	C_1
A	100	49.00	0			
B	100	94.90	42.22	14.53	7.45	1.30
C	100	43.04	17.01	12.87	10.21	7.15
D	100	94.08	86.57	69.05	21.35	16.62
E	100	90.91	69.80	26.37	25.71	0
F	100	26.00	20.00	20.00	8.50	7.75
G	100	93.34	56.60	28.30	5.20	3.60
H	100	59.00	39.80	14.06	2.10	0.80
I	100	39.50	28.60	4.70	3.60	0.50
J	100	82.05	86.15	35.00	7.03	6.68
K	100	98.90	68.90	54.20	16.00	8.35
mean	100	70.46	42.07	18.44	8.08	2.32

Larvae in tank-D and -E were hatched out from female No. III. The survival ratio in tank-D was 69.05% at Z–4 and 16.62% at C–1. These zoeae were transferred to a net-cage without benthic diatom at the middle of Z–4. The term from Z–1 to C–1 was 63 days. The survival ratio in tank-E was 26.37% at Z–4. There were a lot of zoeae, so these zoeae were transferred to two net-cages without benthic diatom at the middle of Z–4. All larvae in these net-cages died before moulting to C–1.

Larvae in tank-F and -G were hatched out from female No. IV. The survival ratio in tank-F was 20.00% at Z–4 and 7.75% at C–1. These zoeae were transferred to a net-cage without benthic diatom at the middle of Z–4. The term from Z–1 to C–1 was 54 days. The survival ratio in tank-G was 28.30% at Z–4 and 3.60% at C–1. These larvae were transferred to a net-cage without benthic diatom when 80% of larvae moulted to G. The term from Z–1 to C–1 was 45 days.

Larvae in tank-H and -I were hatched out from female No. V. The survival ratio in tank-H was 14.06% at Z–4 and 0.80% at C–1. These zoeae were transferred to a net-cage with benthic diatom. The term from Z–1 to C–1 was 45 days. The

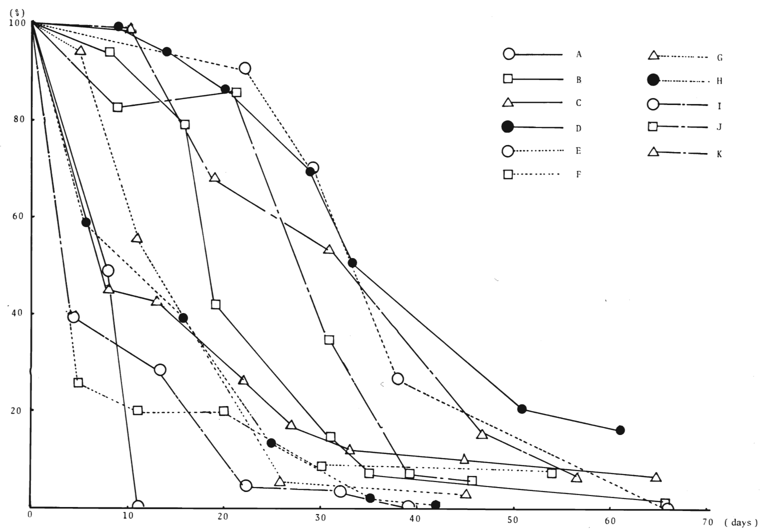

Fig. 4. Survival ratios of larvae and post-larvae in 500 l tanks. A–K are the tank numbers of 500 l tanks.

survival ratio in tank-I was 4.07% at Z–4 and 0.50% at C–1. These zoeae were transferred to a net-cage with benthic diatom at the middle of Z–4. The term from Z–1 to C–1 was 57 days.

The survival ratio in tank-J was 35.00% at Z–4 and 6.68% at C–1. These zoeae were transferred to a net-cage without benthic diatom at the end of Z–4. The term from Z–1 to C–1 was 54 days. The survival ratio in tank-K was 54.20% at Z–4 and 8.35% at C–1. These zoeae were transferred to a net-cage with benthic diatom at the middle of Z–4. The term from Z–1 to C–1 was 58 days.

IV. Discussion

The means of survival ratios of larvae which were hatched out from the three types of egg-bearing females are shown in the next line. (1) The means of survival ratio at C–1 from egg-bearing females that were caught in May, 1978, and reared for about one year and hatched out in the next spring were 33.34% in 30 l tank and 5.2% in 500 l tank. (2) The survival ratio at C–1 from the female that was coupled with a male in the laboratory and reared for one year and hatched out the next spring was 8.34% in 30 l tank and 0.60% in 500 l tank. (3) The means of survival ratios at C–1 from egg-bearing females that were caught by crab pots and hatched out one or two weeks later were 15.16% in 30 l tank and 7.52% in 500 l tank. Survival ratios in small tanks with static sea water higher than those in large tanks with running sea water. The mean of term from Z–1 to C–1 in 30 l tank was 49.0 days and 57.2 days in 500 l tank. The temperature in 30 l tank differed little from that in 500 l tank (Fig. 2). In small tanks it was easy to take care of and check the water quality. In running water, larvae have less chance to catch food than those in static sea water.

These differences may have an effect on the survival ratio and term during zoeal stages.

Females No. I–V that were reared in the laboratory for one year released a lot of eggs but hatched out normally. The means of survival ratio at C–1 in 30 *l* tanks was 27.1% and 4.72% in 500 *l* tank. The effect of long term reared egg-bearing females in a laboratory on eggs is little. The survival ratios in 30 *l* tank and in 500 *l* tank showed the same tendency with each female. The tendency is not dependent on the rearing method of the egg-bearing females but on another cause, such as the quality of eggs or the treatment during the hatching out period.

There was a lot of cannibalism, even at the zoeal stage. At the zoeal stage, tails and/or eyes were eaten by other larvae, but the whole body was eaten at the post-larvae stage. If cannibalism occured one time, it continued every day afterword. There were fewer zoeae that died from cannibalism in the smaller density of zoeae than in the bigger density. The prevention of cannibalism is one important factor for the large-scale rearing of larvae and post-alrvae of king crab.

The means of survival ratio of larvae that were reared in 30 *l* tanks and then in net-cages with benthic diatom from Z–4 to C–1 was 37.8% and 54.50% without benthic diatom. This mean of larvae that were reared in 500 *l* tank and then in net-cages with benthic diatom is 19.36% and 18.98% without benthic diatom. Benthic diatom has no actual effect on the survival ratios of post-larvae. But at the end of G, the benthic diatom disappeared around the post-larvae, so these post-larvae might have eaten this benthic diatom.

There may be a group effect on the survival ratio. A detailed study on this effect will be discussed with other data elsewhere.

The survival ratio of this study in 30 *l* tanks is the same as those in the study in 1978 (Sasaoka 1978). This shows that rearing larvae and post-larvae in 30 *l* tank can be repeated successfully. The best survival ratio at C–1 in 500 *l* tank was 16.62%. This is one sign of progress in large-scale rearing of larvae and post-larvae of king crab.

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タラバガニ幼生の大量飼育

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要　旨

タラバガニ幼生を30ℓと500ℓ水槽中で飼育した．30ℓ水槽は止水，500ℓ水槽は流水（1ℓ/分）とした．アルテミアのノープリウスを主として与え，シオミズツボワムシ等を副次的に投与した．ゾエア4期の後半頃からは、ネット生簀で飼育した．アサリ貝のむき身の細片を投与した．水温は8℃前後であった．30ℓ水槽で飼育していた幼生の稚ガニ1期における最も高い生残率は38.8%，そして500ℓ水槽で飼育していた場合は16.62%であった．1年間腹肢付着卵を持った雌ガニを飼育し、この親から大量の幼生を得ることが出来た．この幼生の生残率は，天然から採捕されたふ化直前の腹肢付着卵を持った雌ガニから得られた幼生の生残率と違わなかった．ゾエア期においても共喰が見られた．