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Difference of Salinity Requirements among the Three Estuarine Crab Species, *Chiromantes dehaani*, *Helice tridens* and *H. japonica* (Brachyura: Grapsidae)

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Summary

Although three grapsid species, *C. dehaani*, *H. tridens* and *H. japonica*, inhabit the estuary of the same river, their distributions are different from each other. The salinity requirement in adults and larvae were compared between the three species.

All or almost of the adults of the three species survived when they were placed at 35 ppt for 10 days, indicating a high tolerace to salinity in all three species. As salinity declined, the survival rate varied among species, specifically, in rank order, *C. dehaani* > *H. tridens* > *H. japonica*. All adults of *C. dehaani* survived in freshwater during 10 days, but only about one half of the adults of *H. tridens* survived, while all the adults of *H. japonica* died during the 10 days.

All the larvae of *C. dehaani* and *H. tridens* survived when they were placed in 35 ppt for 24 hours, indicating a high tolerance to high salinity in the larval stage of both species. As salinity declined, the survival rates differed. In *C. dehaani* more than 50% of larvae survived at 1 ppt and in freshwater, but all larvae of *H. tridens* died within one hour of the salinity less than 10 ppt. From the results, the distributions of the three species appeare to be closely related to their salinity requirements.

The three species of crabs, namely *Chiromantes dahaani*, *Helice tridens* and *H. japonica*, have commonly inhabited a river estuary in Japan. *C. dehaani* inhabits burrowing muddy banks of river from the mouth to the uppermost part of the estuary from the northern part of Honshu in Japan to Taiwan (1-3). *H. tridens* can be found in the swamp of the lower part of the estuary near the seashore from the northern part of Japan to Korea (2-4). *H. Japonica* can be found in burrowing muddy flats in the inland sea and the estuary from the southern part of Japan to Korea and Taiwan (1-4). Within the same river system, *C. dehaani* and *H. tridens* and *H. tridens* and *H. japonica* have been caught together, but their distributions in a single river estuary system are different. Such differences in distribution may be caused by physiological differences, especially salinity requirements.

Fidhiany *et al.* (5) showed the difference of adult salinity tolerance and larval salinity requirements between two genetically and reproductively isolated types of freshwater shrimp, *Palaemon paucidens* (6, 7), one of which inhabited the upperstream and the other downstream. They suggested that the difference of salinity tolerance and salinity requirements between them is one of the main factors dividing the habitat of the two types within the same river system. Mashiko (8) revealed the difference in reproductive traits of long-armed prawn, *Macrobrachium nipponense*, between the brackish and upper freshwater population within the same river system. The prawn collected from upper stream failed to reproduce in the experimental brackish water, and the survival and developmental responses of newly hatched larvae to extremes in salinity differed between them.

The aims of the present study are to examine the differences in salinity requirements among the three species, and to discuss the causes of the differences in their distribution within a single river estuary system.

Materials and Methods

1. Adult Salinity Requirements

As shown in Table 1, specimens were collected from three estuaries located in Miyagi and Ehime Prefecture. *C. dehaani* were collected from the Abukuma river (in Miyagi Prefecture) and Shigenobu river (in Ehime Prefecture), *H. tridens* from the Nanakita river (in Miyagi Prefecture) and the Shigenobu river and *H. japonica* from the Shigenobu river. Crabs were transported to the laboratory in bucket of damp mud from the collection site. All crabs were maintained in the laboratory in 20 ppt artificial sea water. Pre or post molt crabs and injured crabs were discarded from the samples in the present experiments.

Acclimation was done in 20 ppt for at least 24 hours. Each crab was then placed in a round plastic aquarium (10.5 cm in diameter with a depth of 11.5 cm) with 500 ml of artificial sea water of 35, 20, 10, 1 and 0.35 ppt, and of freshwater (distillated water : 0 ppt) without aeration. Experiment media were changed every two days. Survivors were checked in 12 hour intervals, up to 10 days. During acclimation and experiments, food was not given. Salinity requirement experiment was done at room temperature. Temperature of experimental media was checked wice a day. The range of temperature was 19.3 C to 25 C in September 1991, 15.7 C to 25 C in October 1991 and 7.9 C to 16.7 C in November 1991. Carapace width was measured at the end of the experiment for the survivors or after the crab died during the experiment. Sample size, mean and standard deviation of carapace width are shown in Table 1. Lack of response of antennae and eyestalk to mechanical stimulation (9) and lack of branchial movement indicated death.

TABLE 1. *Data of Specimens Used in the Salinity Requirements Experiment.*

Species	Locality (river)	No. of indiv.	Mean C.W. ± sd (mm)
Adult			
C. dehaani	Shigenobu	30 (18)	26.5±3.6
	Abukuma	118 (64)*	25.5±3.6
H. tridens	Shigenobu	30 (23)	27.1±1.9
	Nanakita	101 (61)**	26.5±4.7
H. japonica	Shigenobu	30 (19)	17.8±2.2
Larva			
C. dehaani	Abukuma	6***	
H. tridens	Nanakita	6***	

Number in parenthesis indicate the number of male; *two individuals are ambiguous; **one individual is ambiguous; ***number of dams.

2. *Larval Salinity Requirements*

Stage I zoea of *H. tridens* and *C. dehaani* were obtained from six ovigerous females. Fifty-five to 301 larvae from females of *C. dehaani* and sixty-five to 253 lervae from females of *H. tridens* were transferred to 50 ml of the experimental media. In one cases of *H. tridens*, larvae from two females were mixed; sixty-five to 174 larvae of dam 1 and 2, and 38 to 253 larvae of dam 3 and 4 were transferred to 50 ml of experimental media. The salinity of media was: 35, 20, 10, 1 and 0 ppt and the media were placed in an incubator at 25 C. Salinity requirement experiments were begun the same day of their hatching. Survival was monitored hourly for the first eight hours and then at 12 hour intervals, up to 24 hours. Absence of swimming activity was used to indicate behavioral death (9).

3. *Field observation*

To know the real ratio of occurrence of *C. dehaani* and *H. tridens* in the estuary of Nanakita river, field observations were done at 6 stations in July 1992. The stations of field observations in the Nanakita river are shown in Fig. 1. The number of crabs which appeared in the surface area were counted. Salinity and water temperature were measured, simultaneously with counting, at each station.

Results

1. *Adult Salinity Requirements*

Changes in survival during salinity requirement experiments are shown in Fig. 2. At the termination of the 10 day experimental period, all or most individ-

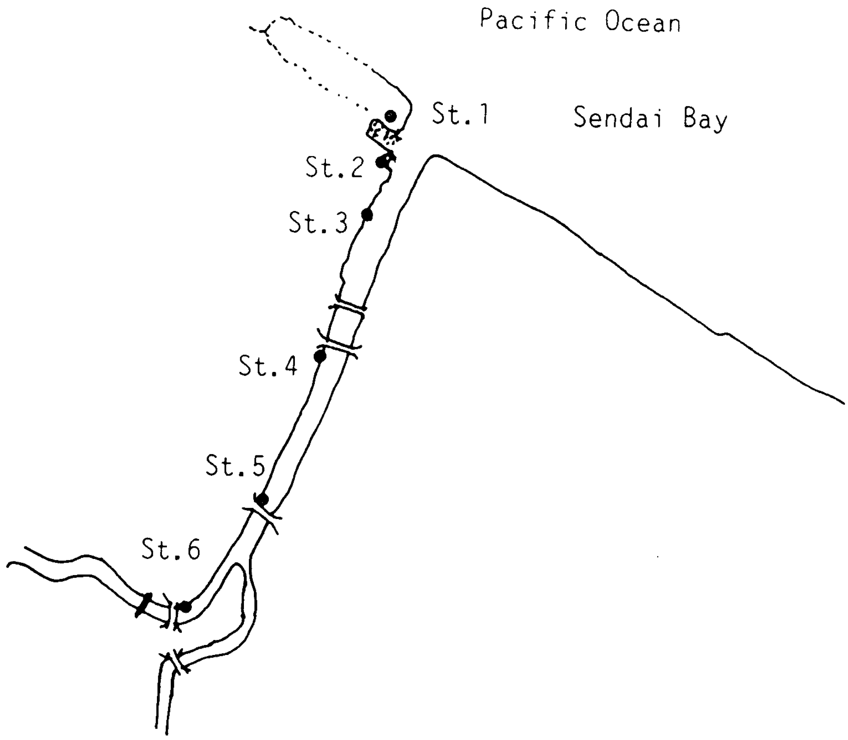

FIG. 1. Sketch-map of Nanakita river showing the station of field observations.

uals of the three species survived at 35, 20, 10, and 1 ppt. At a salinity of 0.35 ppt, all individuals of *H. japonica* died in less than 3 days, but all individuals of *C. dehaani* and *H. tridens* survived during the 10 days. In freshwater, all individuals of *H. japonica* died within one day, 56.5% of individuals of *H. tridens* died during the 10 days, but all individuals of *C. dehaani* survived during the 10 days. For all species, differences of survival were not observed between sexes, between months and between rivers. The final survival rates of the 10 day experiments are shown in Table 2. Resistance to high salinity was not different among the three species, but the salinity requirement was highest in *H. japonica*, followed by *H. tridens* with the lowest salinity requirement in *C. dehaani*.

2. *Larval Salinity Requirements*

Changes in survival of the larvae of *C. dehaani* and *H. tridens* during 24 hours are shown in Fig. 3. All larvae of both species survived during the experimental period at a salinity of 35 and 20 ppt. At a salinity of 10 ppt, all individual of *C. dehaani* survived during 24 hours, but all individual of *H. tridens* died within one hour. At a salinity of 1 ppt and 0 ppt, 73.3% and 49.0%, respectively, of individuals of *C. dehaani* survived during the experimental period, while all individuals of *H. tridens* died within only one hour. From this result, the larvae of *H. tridens*

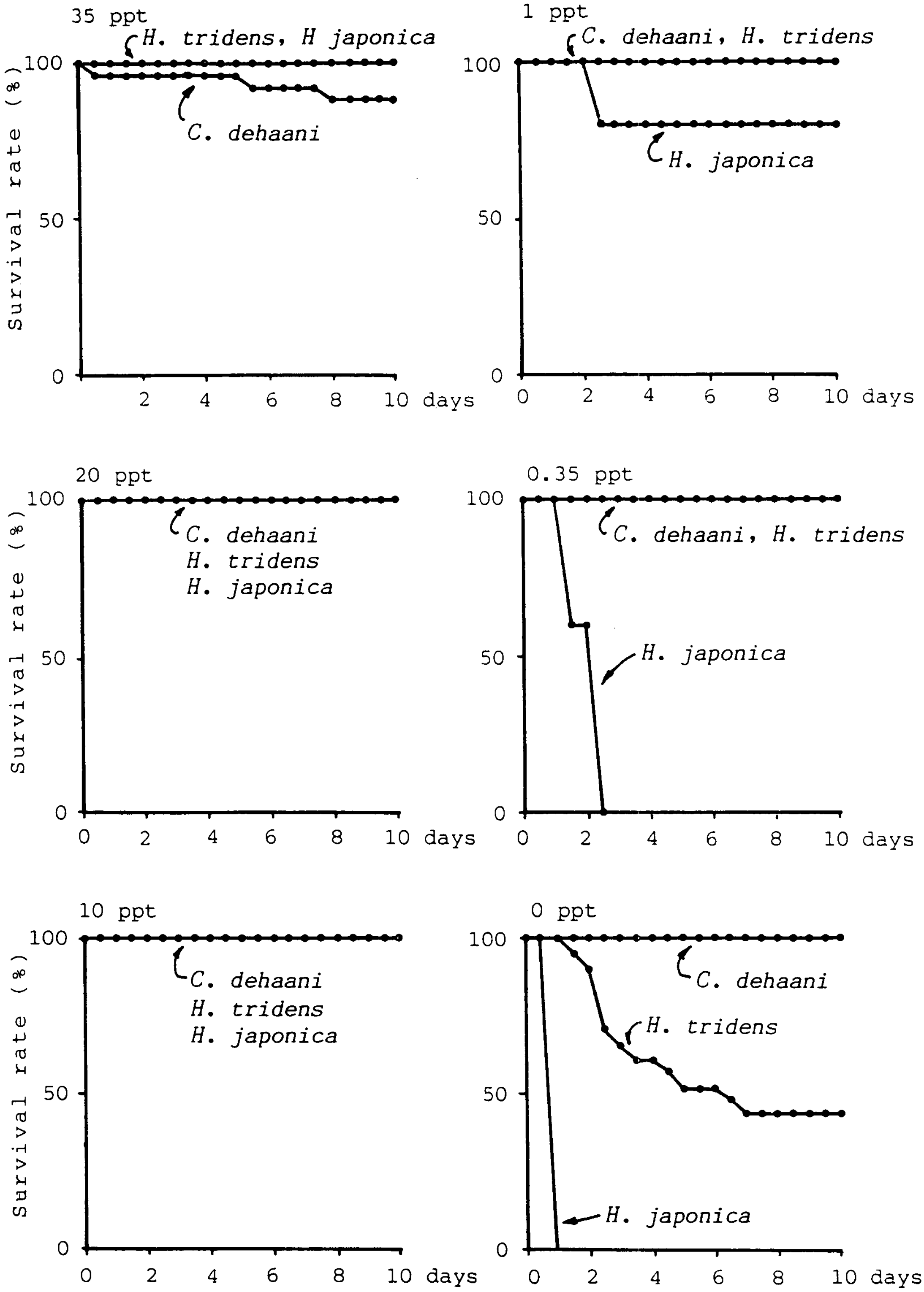

FIG. 2. Survival rate of adult crabs during salinity requirement experiments.

TABLE 2. *Survival rate (%) of Adult Crabs at Each Salinity.*

Species	Salinity (ppt)					
	35	20	10	1	0.35	0
C. dehaani	88.0% (25)	100% (25)	100% (24)	100% (25)	100% (24)	100% (25)
H. tridens	100 (23)	100 (20)	100 (19)	100 (23)	100 (23)	43.5 (23)
H. japonica	100 (5)	100 (5)	100 (5)	80.0 (5)	0.0 (5)	0.0 (5)

* The number in parenthesis shows the number of individuals used in the experiment.

would require that the salinity be more than 20 ppt. A higher salinity requirement was observed in *H. tridens* than in *C. dehaani*.

3. Field observation

In order to clarify the actual adult distributions and relative abundance in the estuary of the Nanakita river, the number of individuals were counted at the six stations (Fig. 1). The occurrence of individuals and the salinity measured at the time of counting (during low tide period) are shown in Table 3. Salinity was high level in station 1, middle in stations 2 and 3, low in stations 4 and 5, and almost freshwater in station 6. At stations 1 and 2, *H. tridens* were observed dominant, with a relative abundance of more than 97%. At station 3, both species were observed approximately even, and at stations 4 and 5, *C. dehaani* was observed dominant, with a relative abundance of more than 97%. Both species were not observed at station 6. From these results, it is notes that *H. tridens* inhabited the high salinity area while *C. dehaani* inhabited the low salinity area in the Nanakita river.

Discussion

The salinity level within an estuary system is not always uniform. Generally, salinity declines from the mouth to the uppermost part of the estuary. Also, the distribution of organisms are not always uniform within an estuary. When the species belonging to the same taxonomical group showed a different distribution from the mouth to the uppermost of the estuary, the limitation of the distribution would depend on the salinity requirement. Barnes (11) showed the effect of salinity upon five Australian grapsoid crabs exhibiting different distribution of an estuarine system. The distributions of *Macrophthalmus crassipes*, *M. setosus*, *Mictyris longicarpus* and *Australoplax tridentata* are limited by hyposaline

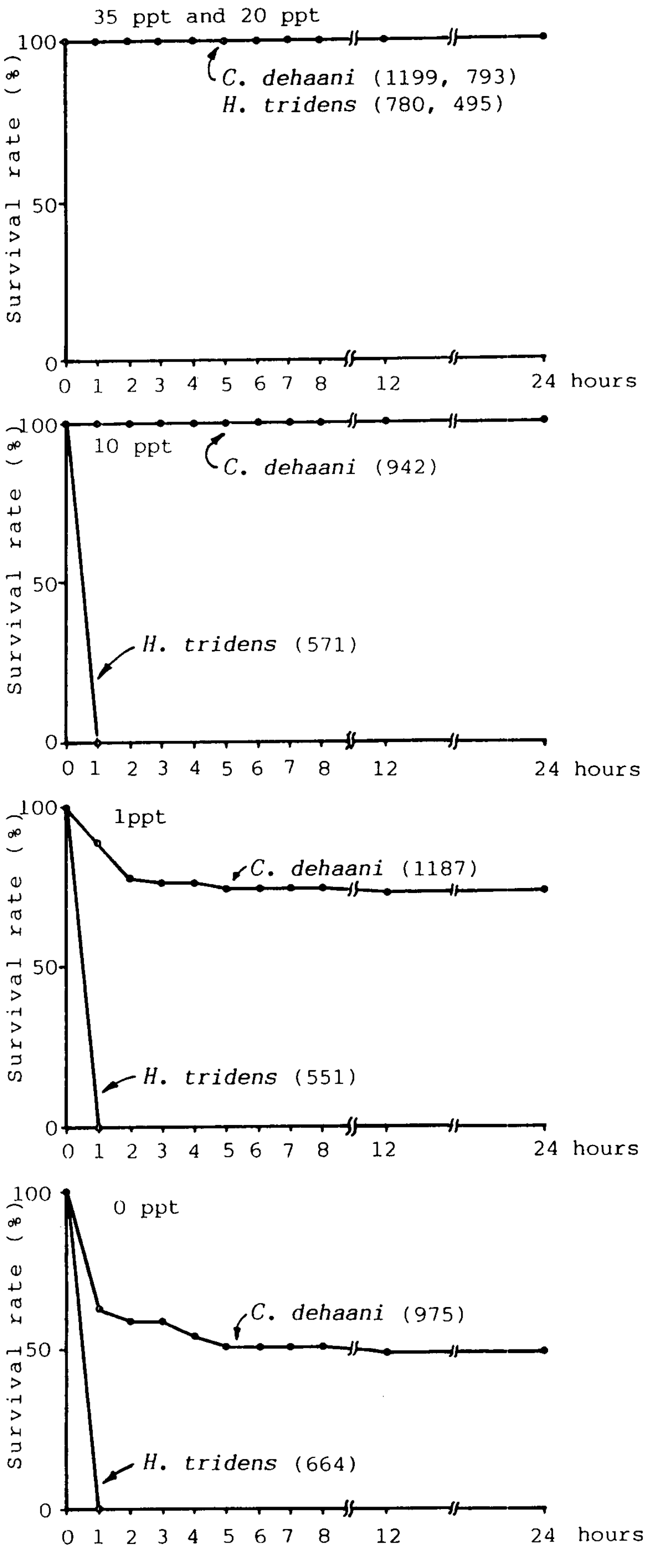

FIG. 3. Survival rate of larvae of *C. dehaani* and *H. tridens* during salinity requirement experiments.

TABLE 3. *Occurence of Individuals in Each Station in Nanakita River.*

Station.	Salinity average (ppt range)	*C. dehaani*	*H. tridens*
1	17.0 (12-23)	1 (0.2)*	639 (99.8)
2	4.3 (2- 7)	81 (2.3)	3472 (97.7)
3	5.2 (0- 9)	212 (61.3)	134 (38.7)
4	2.6 (0- 5)	180 (97.8)	4 (2.2)
5	2.3 (1- 4)	115 (99.1)	1 (0.9)
6	1.0 (0- 2)	0 (0.0)	0 (0.0)

* Number in parenthesis are the relative abundance (%).

conditions, while *Paracleistoma mcneilli* is limited by a hypersaline condition.

In the present study the differences of salinity requirements among the three grapsid species corresponded to the differences of their distribution along the river estuary system based on the field observation. *H. japonica*, which required a high salinity condition, was restricted in the mouth of the estuary. *H. tridens*, which also required a high salinity condition, especially in the larval stage, was also restricted in lower parts of the estuary. *C. dehaani*, which did not required a high salinity condition in adult and larval stages, inhabited the lower to the uppermost part of the estuary. Trerefore, the distribution of these three species appeared to be closely related to their required level of salinity.

It could be considered that the differential zonation up an estuarine reflects the differential penetration to the river. Ono (12) stated that upstream penetration of the crab is restricted generally by the effect of chlorinity diminution based on field observations and salinity/survival data. Barnes (11) showed the effect of salinity upon five Australian grapsoid crabs exhibiting differential penetration of an estuarine system. The upstream penetration would possibly be achieved due to their freshwater tolerance, or adecrease in the salinity requirement during the evolutionary process. The differential zonation in an estuarine among the three grapsid species surveyed in the present study is considered to be explained by the different levels of the upstream penetration. The level of upstream penetration is highest in *C. dehaani*, followed by *H. tridens* with the lowest in *H. japonica*.

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References

1) Dai, A and S. Yang, "*Crabs of the China Seas*"., Chine Ocean Press, Beijing (1991).
2) Miyake, S., "*Japanese Crustacean Decapods and Stomatopods in Color*" Vol. II Brachyura (Crabs). Hoikusha Pub., Co., Ltd., Osaka (1983). (In Japanese)
3) Sakai, T., "*Crabs of Japan and the Adjacent Seas*". Kodansha Ltd., Tokyo (1976).
4) Sakai, K. and K. Yatsuzuka, Notes on some Japanese and Chinese *Helice* with *Helice* (*Helicana*) n. subgen., including *Helice* (*Helicana*) *japonica* n. sp. *Senckenbergiana biologia* **60**, 393-411 (1980).
5) Fidhiany, L., A. Kijima and Y. Fujio, Adult salinity tolerance and larval salinity requirement of the freshwater shrimp *Palaemon paucidens* in Japan. *Tohoku J. Agri. Res.*, **42**, 17-24 (1991).
6) Fidhiany, L., A. Kijima and Y. Fujio, Premating and postmating isolation among local populations of freshwater shrimp *Palaemon paucidens* in Japan. *Nippon Suisan Gakkaishi*, **56**, 1407-1411 (1990).
7) Fidhiany, L., A. Kijima and Y. Fujio, Genetic divergence between two types in *Palaemon paucidens*. *Tohoku J. Agri. Res.*, **39**, 39-45 (1988).
8) Mashiko, K., Evidence of differentiation between the estuarine and upper freshwater population inhabiting the same water system in the long-armed prawn *Macrobrachium nipponense* (de Haan). *Zoological Magazine*, **92**, 180-185 (1983).
9) Jones, M.B., Effect of temperature, season, and stage of life cycle on salinity tolerance of the estuarine crab *Helice crassa* Dana (Grapsidae). *J. Exp. Mar. Biol. Ecol.*, **52**, 271-282 (1981).
10) Jones, M.B. and M.J. Simons, Habitat preferences of two estuarine burrowing crabs *Helice crassa* Dana (Grapsidae) and *Macrophthalmus hirtipes* (Jacquinot) (Ocypodidae). *J. Exp. Mar. Biol. Ecol.*, **56**, 49-62 (1982).
11) Barnes, R.S.K., The osmotic behaviour of a number of grapsoid crabs with respect to their differential penetration of an estuarine system. *J. Exp. Biol.*, **47**, 535-551 (1967).
12) Ono, Y., On the ecological distribution of ocypoid crabs in the estuary. *Mem. Fec. Sci. Kyushu Univ.* (E) **41**, 1-60 (1965).