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Spatial and Temporal Distributions of the Limpet *Collisella heroldi* Population in an Intertidal Rocky Shore in Southern Hokkaido

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Abstract

The spatial and temporal distributions of the limpet *Collisella heroldi* were examined at Bentenjima rocky shore in Usujiri, southern Hokkaido. Quantification I analysis was applied to reveal relationships between environmental factors and distribution of the limpets. *C. heroldi* was mainly distributed in an area from the sea to 20 m towards the shore, a little above the mean low water tidal level. No distinct seasonal changes were found. There was little difference in the areas being occupied by the young limpets (0-2 years old) and the old ones. While the young limpets were distributed on the rock slopes with relatively strong wave action, the aged ones distributed on the boulder areas with weaker wave action. These results suggest that desiccation is the most important factor affecting the distribution of *C. heroldi*.

Introduction

The intertidal rocky shore community has attracted the interest of many ecologists currently, but few studies on benthic fauna inhabiting rocky shore platforms have been reported (Fuji and Nomura, 1990). The small limpet *Collisella heroldi* is a numerically dominant species and an important grazer in the intertidal rocky shore at Usujiri, southern Hokkaido (Fuji and Nomura, 1990; Fuji et al., 1991). Studies on ecology and bioenergetics of this population can provide valuable information to further studies on the rocky shore community. Until now, we have studied the reproductive cycle (Niu and Fuji, 1989) and growth, age structure and mortality of the *C. heroldi* population (Niu et al., 1992). The objective of this study is to provide detailed information on the distribution of the *C. heroldi* population for the ecological energetic study of this population.

Materials and Methods

Samples were collected using a $25 \times 25\ cm^2$ quadrate bimonthly at 44 stations from August 1986 to June 1989 on the intertidal sites at Usujiri, Hokkaido given in Niu et al. (1992). All the limpets collected were fixed in 10% sea water formalin

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and sorted into different age groups according to their year external rings on the shell (Niu et al., 1992). Then the limpets in each age group were counted.

Quantification I analysis was applied to investigate relationships between environmental factors and the distribution of *C. heroldi*. The environmental factors included distance from shore (m), degree of wave action (data from Fuji, 1988), height above datum (cm), and substratum in which three types were recognized; boulder, rock and sand.

Results and Discussion

The spatial and temporal distributions of different age groups of *C. heroldi* are as shown in Fig. 1. Clearly the animals show a contagious distribution pattern. Limpets were abundant only in the sea side where the substratum is rock slope or stack with relatively strong wave action (Fuji, 1988), especially for younger limpets. There were no distinct changes in seasonal distributions (Fig. 1) and also among different years based on the three years data from August 1986 to June 1989, in the spatial distribution of the animals. Mean densities of the whole sampling area in the periods of August 1986-June 1987, August 1987-June 1988 and August 1988-June 1989 are 339, 490 and 723 ind/m^2, respectively, indicating that the population size of the limpets in the study area increased during the study period.

To show the spatial distribution of the limpets more clearly, based on the data from Fig. 1, a spatial distribution in percentage (%) termed as the number of limpets of a certain age group collected from one station to the total number of the samples

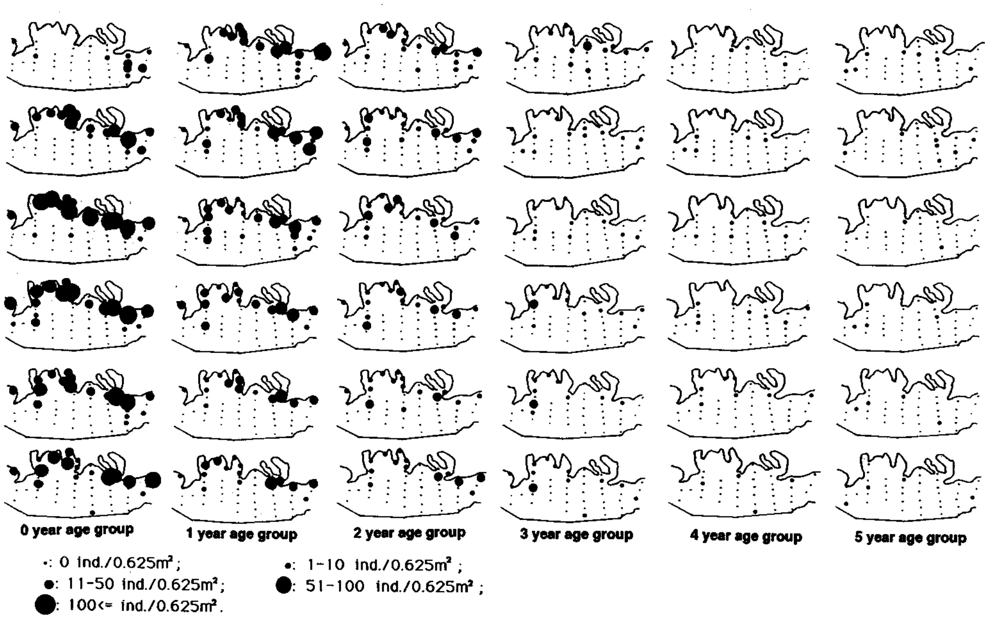

Fig. 1. Seasonal distribution of *C. heroldi* population in the intertidal zone, Usujiri, southern Hokkaido. Each figure indicates the densities in August, October, December, February, April and June from top to bottom, respectively.

of same age group collected from the whole study area is presented in Fig. 2. The black area on the map shows the places with the highest density, while the white area shows the places without *C. heroldi.* It can be understood that although the distribution pattern is similar among different age groups, there is a little difference among the distribution areas. Most of the young individuals (0-3 year groups) were distributed in the sea side places with strong wave action, while most of the older

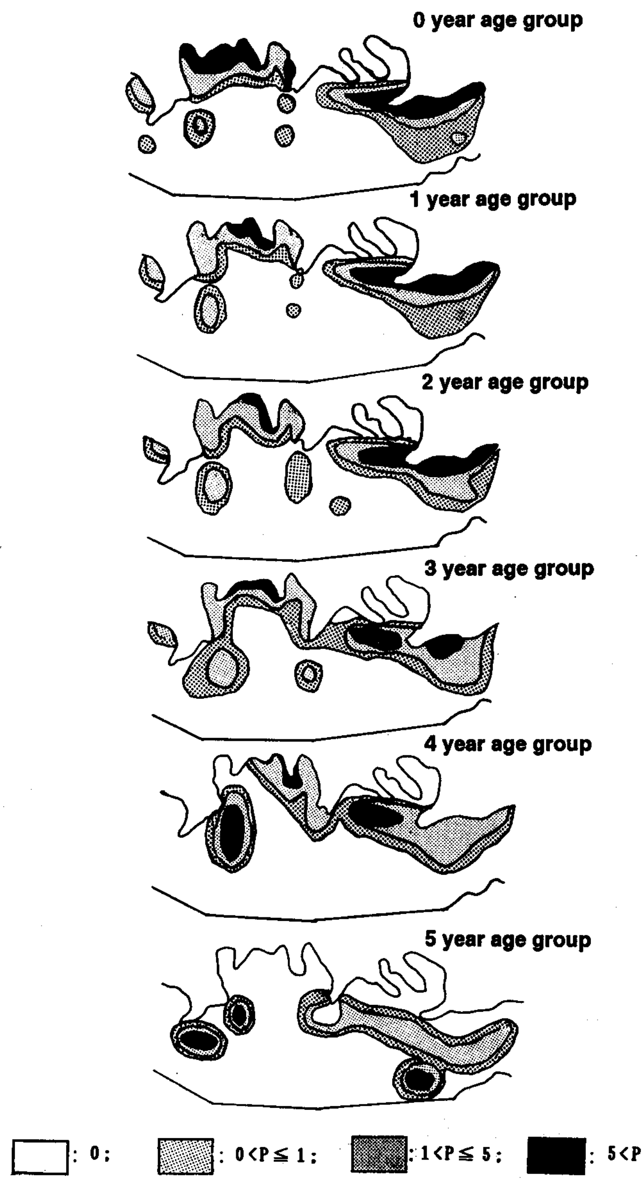

Fig. 2. Diagram showing the distribution of different age groups of the *C. heroldi* population. Drawing patterns show different percentages of individuals in each age group.

Table 1. Result of the quantification I analysis showing the effects of the environmental variables on the distribution of the *C. heroldi* population.

Age group	Factor	Category	Score	P.c.	M.c.	Age group	Factor	Category	Score	P.c.	M.c.
		0-10	463.44					0-10	14.56		
	Item 1	10-20	−136.28	0.98			Item 1	10-20	3.72	0.86	
		20-30	−227.09					20-30	−9.83		
		30-40	−238.17					30-40	−13.32		
		1	−416.35					1	−23.14		
	Item 2	2	16.19	0.89			Item 2	2	−3.99	0.75	
		3	30.11		0.98			3	3.86		
0		4	12.88			3		4	1.66		0.88
		0-25	−679.71					0-25	−17.86		
	Item 3	25-50	−21.20	0.96			Item 3	25-50	−8.97	0.84	
		50-75	56.29					50-75	5.14		
		75-100	55.83					75-100	3.29		
		B	43.94					B	1.55		
	Item 4	R	81.64	0.92			Item 4	R	1.89	0.63	
		S	−349.51					S	−9.69		
		0-10	194.79					0-10	3.77		
	Item 1	10-20	−45.57	0.98			Item 1	10-20	3.56	0.83	
		20-30	−88.29					20-30	−3.79		
		30-40	−117.55					30-40	−5.06		
		1	−0.20					1	−5.51		
	Item 2	2	−18.66	0.50			Item 2	2	−4.12	0.74	
		3	11.28					3	2.04		
1		4	−1.60		0.96	4		4	1.56		0.83
		0-25	−258.02					0-25	−1.21		
	Item 3	25-50	−38.50	0.96			Item 3	25-50	−4.16	0.74	
		50-75	36.98					50-75	1.79		
		75-100	23.53					75-100	1.18		
		B	29.18					B	0.54		
	Item 4	R	25.98	0.94			Item 4	R	0.22	0.45	
		S	−156.84					S	−2.19		
		0-10	40.89					0-10	−0.51		
	Item 1	10-20	4.43	0.91			Item 1	10-20	1.37	0.80	
		20-30	−25.56					20-30	−0.38		
		30-40	−33.05					30-40	−0.45		
		1	−3.56					1	−1.54		
	Item 2	2	−11.12	0.55			Item 2	2	−1.59	0.84	
		3	6.71					3	0.67		
2		4	−0.25		0.94	5≦		4	0.70		0.93
		0-25	−50.25					0-25	0.25		
	Item 3	25-50	−20.28	0.88			Item 3	25-50	−0.70	0.55	
		50-75	11.75					50-75	0.25		
		75-100	9.18					75-100	0.19		
		B	3.50					B	−1.20		
	Item 4	R	3.48	0.62			Item 4	R	1.10	0.86	
		S	−19.79					S	0.66		

Item 1 : Distance from shore (m) ; Item 2 : Degree of wave action ; Item 3 : Height above datum (cm) ; Item 4 : Substratum. M.c. : Multiple correlation coefficient ; P.c. : Partial correlation coefficient. Category from 1 to 4 in item 2 means the degree of wave from strong to weak. B, R and S in item 4 show boulder, rock and sand.

limpets stayed in places a little apart from the sea side with weaker wave action (Fuji, 1988).

The results of the quantification I analysis are shown as in Table 1. It is evident from the multiple correlation coefficient that the four environmental factors have a close relation with the distribution of the limpets. There is a trend where the multiple correlation coefficient becomes lower with age, perhaps, because the animals are less affected by environmental factors as they become bigger in size. From partial correlation coefficient and the score, it can be deduced that *C. heroldi* is mainly distributed in an area from the sea to 20 m towards the shore, a little above the mean low water tidal level.

While young animals (0-2 years old) are distributed on the rock slopes with relatively strong wave action, aged ones are distributed on the boulder area with weaker wave action. It is considered that desiccation is usually the most important physical factor affecting the distribution of intertidal limpets (Branch, 1981) and this seems to be true with *C. heroldi* in the present study. Three factors which are closely related with desiccation (distance from the sea, height and wave action) examined in the study had a strong influence on the spatial distribution of *C. heroldi*.

Blackmore (1969) and Thompson (1979) found that the greater number of small limpets were often distributed at the low tidal stations with strong wave action, while at the higher tidal levels on the more exposed shores, large limpets often occupied a greater proportion. This observation is similar to the result in the present study. The reason for this phenomenon is not yet clear, however perhaps this is because the young limpets have a weaker tolerance to desiccation than that of the older ones (Thompson, 1979; Branch, 1981), and the older ones can get more space and food by staying in the areas a little apart from the young limpets. However, no data concerning seasonal migration was obtained in the present study. More detailed investigations on the distribution of *C. heroldi* are expected.

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