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The Caprellidea (Crustacea: Amphipoda) inhabiting the green alga *Cladophora wrightiana*: The influence of wave exposure on the species composition*

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Abstract: The influence of wave exposure on caprellid fauna inhabiting the green alga *Cladophora wrightiana* was investigated. Algal samples were collected at four stations in a small inlet located on the Pacific coast of Boso Peninsula, Japan. The sampling stations were separated into two groups, *i.e.* the exposed site and the sheltered sites, according to the degree of wave exposure measured by the plaster ball method. Dominant species were *Caprella danilevskii* and *C. polyacantha* in the exposed site and *C. okadai* in the sheltered sites. Distributional difference of these caprellid species may be attributed to the differences in robustness of the body somites and appendages.

1. Introduction

Caprellid amphipods are one of the dominant epifaunal crustaceans inhabiting macroalgae in the *Sargassum* zone called "Garamo-ba" on the rocky coasts of southern Japan. Distribution of epifaunal caprellid (and/or gammarid) amphipods is affected by the following environmental factors: wave exposure (DOMMASNES, 1968; FENWICK, 1976; HIRAYAMA and KIKUCHI, 1980; TARARAM and WAKABARA, 1981; WAKABARA *et al.*, 1983; TAKEUCHI *et al.*, 1987), turbidity (MOORE, 1973, 1978), quantity of epiphytes (KITA and HARADA, 1962; NAGLE, 1968; NORTON and BENSON, 1983),and presence, size and features of substrata (CAINE, 1978; EDGAR, 1983a, b; GUNNILL, 1982; STONER, 1980, 1983; TAKEUCHI *et al.*, 1987). Rocky coasts facing the open sea provide suitable fields for studying the influence of wave exposure on epifaunal crustaceans, because the degree of wave exposure varies widely due to the complicated topography even within a small stretch. Recently TAKEUCHI *et al.* (1987) reported the caprellid fauna collected from the exposed and sheltered sites located within the small inlet "Heito" on the Pacific coast of Boso Peninsula. Although the species of algae in both areas in their study were different from one the other, no specific connection of caprellid to the algal species was recognized. They inferred that the wave exposure is one of the most dominant factors affecting the occurrence of caprellids.

The green alga *Cladophora wrightiana* HARVEY, as well as *Sargassum macrocarpum* C. AGARDH, grow mostly as in a bush-like manner on the medium size rocks around the center of the inlet Heito (KONNO, 1985). This area corresponds to the sheltered site in TAKEUCHI *et al.* (1987). In the inlet "Jizogi" next to Heito, *Cl. wrightiana is* distributed not only on the rocks and stones around the center but also the rock base near the entrance of the inlet where waves break. The occurrence in the entrance of Heito might be a rare case for this species.

Thus, in order to elucidate the influence of wave exposure on the caprellid fauna, we focus on the species composition of the Caprellidea on *Cl. wrightiana,* which was collected from the several localities within the small inlet Jizogi.

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2. Study area, materials and methods

This study was carried out in a small inlet called "Jizogi" located in the sanctuary of the Kominato Marine Laboratory, Faculty of Science, Chiba University (formerly Kominato Marine Biological Laboratory, Tokyo University of Fisheries). Jizogi is surrounded by rock bases, and rocks and stones are scattered on the bottom. Four sampling stations were set up in the sublittoral zone of the inlet (Table 1, Fig. 1). St. A is situated near the rock base at the entrance of the inlet where waves break upon. Sts. B, C and D are located on the rock or stones in the deepest point of the entrance, middle and inner part of the inlet, respectively. According to the measurements of wave exposure by the plaster ball method (Table 1), St. A was regarded as exposed site and Sts. B, C and D as sheltered sites.

Table 1. Depth, substratum and degree of wave exposure at four stations in the inlet "Jizogi". The degree of wave exposure was referred to our unpublished data. The measurements were conducted twice in February 1986 by the plaster ball method (Muus, 1968; Hayashi and Yamakawa, unpubl.). Plaster balls with diameter of 2.7 cm were weighed initially in the dry condition. Two bricks with styrol on the upper surface were set at each station, and six plaster balls were attached to the styrol surface. After three hours of exposure *in situ*, the plaster balls were weighed again in the completely dry condition. The percentage of weight loss was regarded as the degree of wave exposure. The degree of wave exposure at St. A was significantly higher than those of Sts. B, C and D ($P < 0.01$; *t*-test) during both measurements.

St.	Depth (m)	Substratum	Degree of wave exposure (%+S.D.)	
			Calm Weather	Stormy Weather
A	1.0	Rock base	14.3±4.16	21.4±8.35*
B	8.5	Rock with drift sand	5.3±0.34	12.5±0.24
C	6.0	Rock and stone	5.2±0.82	10.7±1.36
D	3.5	Stone	4.7±0.08	10.6±0.37

*Two plaster balls were flown off due to the stormy weather.

Sampling was conducted three times during late spring to early summer, *i.e.* 15-18 May, 11-16 June, and 8-12 July, 1978. Algal samples were cut off near the substrata and gently deposited in vinyl bags *in situ*. In the laboratory, they were shaken in freshwater and detached animals were collected through a sieve with mesh size of 0.3 mm. Caprellids were carefully removed from these animals, and preserved in 10 % neutralized formalin. These caprellids were identified to species level under the binocular microscope. Algae were weighed after placing them on paper for two hours.

The similarity of caprellid species composition among sampling stations was presented as the $C\pi$ index (Kimoto, 1967; Omori and Ikeda, 1984). The similarity matrix of caprellid fauna was converted into a dendrogram following Mountford's clustering method (Omori and Ikeda, 1984).

3. Results

Nine species from two genera of the Caprellidea were collected from *Cladophora wrightiana* (Table 2). Eight of these species belong to the genus *Caprella*.

The classification of stations by the similarity index correlated well with that by the degree of wave exposure. Figure 2 shows dendrograms of the similarity index on the sampling stations and the species composition of the Caprellidea. It indicates that the caprellid fauna could be separated into the same two groups every time: the exposed site (St. A) and the sheltered sites (Sts. B, C and D); the similarity index is higher than 0.80. The density of caprellids in the exposed site is generally higher than that in the sheltered sites.

In the exposed site, *Caprella danilevskii* Czerniavski and *C. polyacantha* Utinomi dominated and constituted more than 80 % of the total individuals (Table 2, Fig. 2). *C. verrucosa* Boeck was the third dominant species, being less than 20%.

In the sheltered sites, *C. okadai* Arimoto was consistently dominant and contributed more than 50% of the total caprellid fauna (Table 2, Fig. 2). *C. danilevskii* (2-26%) and

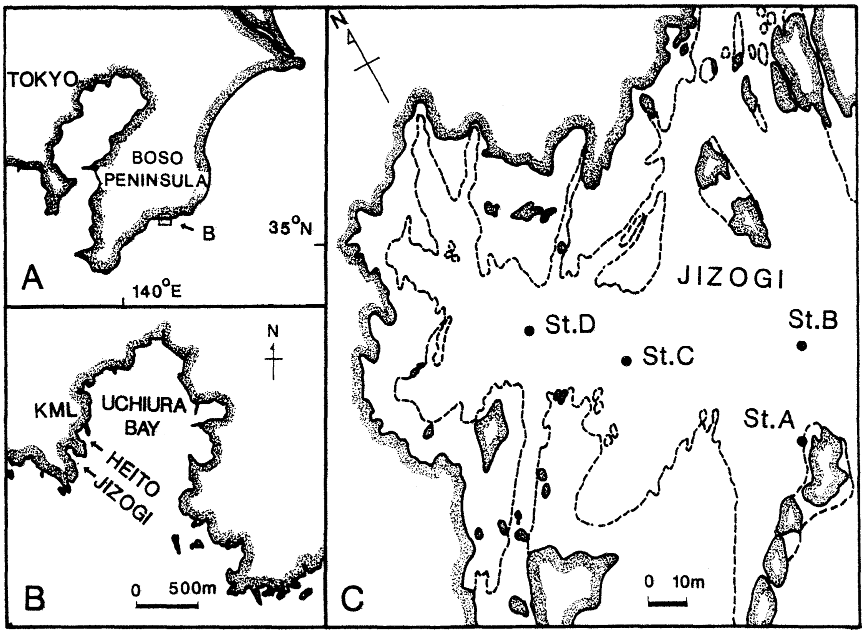

Fig. 1. Study area and stations. A. Boso Peninsula. B. Uchiura Bay. KML; Kominato Marine Laboratory, Faculty of Science, Chiba University (formerly Kominato Marine Biological Laboratory, Tokyo Unviersity of Fisheries). C. Sampling stations in Jizogi. Broken lines indicate the highest low water at the neap tide.

Table 2. Species compositions of the Caprellidea inhabiting *Cladophora wrightiana* Harvey. The number in parentheses indicates the percentage to the total number of individuals.

Species	May*			June				July			
	St.A	St.C	St.D	St.A	St.B	St.C	St.D	St.A	St.B	St.C	St.D
Caprella okadai		79(89.8)	91(100)	3(1.3)	10(52.6)	309(98.1)	124(96.1)	2(0.3)	175(73.5)	212(96.4)	158(89.3)
C. danilevskii	43(50.0)	2(2.3)		96(39.8)	5(26.3)	1(0.3)		321(48.3)	14(5.9)	4(1.8)	2(1.1)
C. subinermis		2(2.3)							2(0.8)		
C. kominatoensis		4(4.5)			3(15.8)			22(3.3)	37(15.6)	1(0.5)	2(1.1)
C. penantis	4(4.7)	1(1.1)		2(0.8)	1(5.3)				9(3.8)	1(0.5)	
C. verrucosa	7(8.1)							93(14.0)			
C. polyacantha	29(33.7)			139(57.7)				226(34.0)	1(0.4)		
C. simia						4(1.3)	5(3.9)			2(0.9)	15(8.5)
Paracaprella crassa	3(3.5)										
unidentified				1(0.4)		1(0.3)					
Total	86(100)	88(100)	91(100)	241(100)	19(100)	315(100)	129(100)	664(100)	238(100)	220(100)	177(100)
ind./alga (g)	0.56	0.10	0.36	0.36	0.04	0.44	0.17	1.09	0.26	0.23	0.21

*Algae of St. B could not be collected because of stormy weather.

C. kominatoensis Takeuchi (0−16%) were the next dominant species at Sts. B and C, while *C. simia* Mayer was the second dominant species at St. D, but contributing less than 10%.

4. Discussion

Of the chemical and physical factors, wave exposure could be considered to be the most important factor which influences the occurrence of epifaunal amphipods in a small stretch of rocky coast. Komatsu *et al.* (1982) demonstrated that difference of temperature in a 150 m stretch of rocky coast was less than 2° C, which was smaller than that of

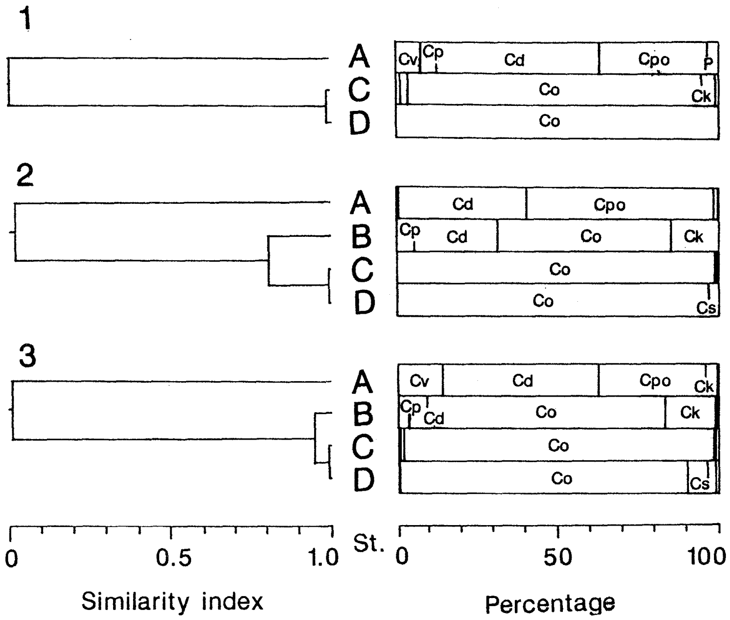

Fig. 2. Dendrograms of sampling stations by the similarity index and the species compositions of the Caprellidea at each station. The similarity is presented by Kimoto's C_π index. 1. May 1978. 2. June 1978. 3. July 1978. Abbreviations of the species of the Caprellidea are as follows: Cd, *Caprella danilevskii*; Ck, *C. kominatoensis*; Co, *C. okadai*; Cp, *C. penantis*; Cpo, *C. polyacantha*; Cs, *C. simia*; Cv, *C. verrucosa*; P, *Paracaprella crassa*. Occurrences less than 3.0% are omitted in the right part.

daily fluctuation (Komatsu, 1985). Hayashi (1989) reported that the salinity of the surface waters at middle part of "Heito" was limited between 33.0 and 35.0‰ throughtout the year. Hence, one may assume that in a small stretch of rocky coast the quality of seawater does not vary much spatially. Topography, however, chages drastically, which

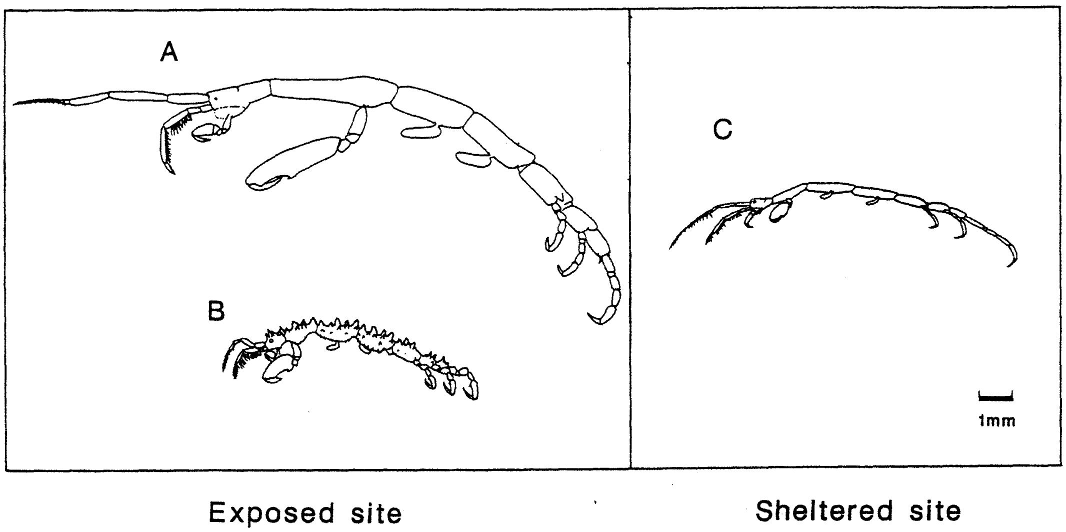

Fig. 3. Caprellid amphipods inhabiting the green alga *Cladophora wrightiana* Harvey. A, *Caprella danilevskii*; B, *C. polyacantha*; C, *C. okadai*. All species were drawn from a typical male.

in turns determines the degree of wave exposure, as shown by the present study and TAKEUCHI *et al.* (1987).

The Caprellidea associated with the green alga *Cladophora wrightiana* was clearly different in species composition between the exposed and the sheltered sites (Table 2, Fig. 2). Among the caprellid amphipods inhabiting this alga, *Caprella danilevskii* and *C. polyacantha* have much more robust body somites and appendages than *C. okadai* (Fig. 3). As already discussed by many researchers (DOMMASNES, 1968; FENWICK, 1976; HIRAYAMA and KIKUCHI, 1980; WAKABARA *et al.*, 1983; TAKEUCHI *et al.*, 1987) robust appendages seem to be suitable for grasping substrata in the exposed sites where waves splash strongly.

The present study revealed that the habitat of *C. polyacantha* was *Cl. wrightiana* of the exposed site among the *Sargassum* zone off Amatsu Kominato. In the exposed sites of the closed inlet "Heito", this caprellid was not recorded from any algae, whereas *C. danilevskii* has been found to inhabit *Sargassum yamadae* YOSHIDA and T. KONNO and *S. hemiphyllum* (TURNER) C. AGARDH (TAKEUCHI *et al*, 1987). Moreover, *C. polyacantha* was not recorded from *Cl. wrightiana* of the sheltered sites of "Heito" (TAKEUCHI, 1985; TAKEUCHI *et al.*, 1987).

The association of *C. polyacantha* to *Cl. wrightiana* might be partially explained by the morphological adaptation of this caprellid to the filamentous thalli of the alga. EDGAR (1983a,b) demonstrated a strong positive relationship between the size of epifaunal amphipods and the width of thalli. Thalli of *Cl. wrightiana* are like grass with width of 1-2 mm, while the above two *Sargassum* species have thalli which range from 5 to 10 mm in maximum width. Body length of *C. danilevskii* reaches 11 mm in mature male and 8 mm in mature female (TAKEUCHI and HIRANO, 1988), while *C. polyacantha* is a relatively small caprellid with body length of 6 mm in mature male (Fig. 3). Thus, *C. polyacantha* tends to inhabit selectively on algae, such as *Cl. wrightiana*, with filamentous thalli in the exposed area.

This study, together with DOMMASNES (1968), FENWICK (1976), HIRAYAMA and KIKUCHI (1980), and TAKEUCHI *et al.* (1987), ensures the influence of wave exposure on the occurrence of epifaunal amphipods on seaweeds.

Among those studies, only a few studies have represented quantitatively the degree of wave exposure. This study, as well as TAKEUCHI *et al.* (1987), bases the degree of wave exposure on the results obtained by the plaster ball method (MUUS, 1968; HAYASHI and YAMAKAWA, unpubl.). HIRAYAMA and KIKUCHI (1980) referred to the maximum height of waves from the unpublished report of Miyagi Prefecture. In this study, the weight loss of plaster balls at the exposed site was 2.82 times as much in the calm weather and 1.90 times in the stormy weather as that at sheltered sites (Table 1). In TAKEUCHI *et al.* (1987), the increase of the degree of wave exposure in the exposed sites from the sheltered sites were 58% in the calm weather and 61 % in the stormy werther. MUUS (1968) showed that the weight loss of plaster balls per current velocity increased as the velocity increased. Thus, if wave exposure could be converted into the current velocity equivalent to steady flow, it might be estimated that at least 1.6 times difference of the current velocity influences the occurrence of caprellid amphipods.

On the other hand, TARARAM and WAKABARA (1981) reported that the wave exposure did not affect the species composition of epifaunal gammarid amphipods, and WAKABARA *et al.* (1983) mentioned that common species of epifaunal amphipods were present in both the exposed and the sheltered shores. In these reports, however, quantitative data of the wave exposure are lacking. Thus it is inferred that in their sites the degree of wave exposure might not be so much different as to cause sufficient difference of epifaunal communities between the exposed and the sheltered shores.

Further detailed studies are needed to elucidate the critical degree of wave exposure which influences the occurrence of each species of caprellid and gammarid amphipods.

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チャシオグサ上のワレカラ類、特に種組成に対する波浪の影響について

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要旨: 房総半島の太平洋岸に位置する小湾内の4ヶ所からチャシオグサを採集し，ワレカラ類の種組成について調査研究した。調査地点の波浪の強弱を石膏玉法により測定した結果、各地点は2つのグループに分けることができた。波浪の影響の強い湾口部ではホソワレカラとイガワレカラが、波浪の影響の弱い湾奥部ではオカダワレカラが優占していた。湾口部に出現するワレカラ類の方が湾奥部の種より体節や付属肢が頑強であるため、波浪の影響により出現種が異なるものと推察された。