Community Structure of Caprellid Amphipods (Crustacea) on Seagrasses in Otsuchi Bay, Northeastern Japan, with Reference to the Association of *Caprella japonica* (Schurin) and *Phyllospadix iwatensis* Makino

Ichiro Takeuchi*¹ and Akinori Hino*²

*¹Otsuchi Marine Research Center, Ocean Research Institute, The University of Tokyo, Akahama, Otsuchi, Iwate, 028-11 Japan

*²Fisheries Laboratory, Faculty of Agriculture, The University of Tokyo, Maisaka, Shizuoka, 431-02 Japan

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The community structure of caprellids inhabiting 3 species of seagrasses was investigated at 6 stations of the sublittoral zone of Otsuchi Bay, northeastern Japan. Ten species of *Caprella* were collected from 5 stations, while no caprellids were collected from the estuary station where the salinity was 6.8 to 26.4 (PSU). The community structure of caprellids can be separated into two groups; *Caprella japonica* was strongly associated with *Phyllospadix iwatensis* which is distributed on rocky outcrops, while *C. tsugarensis* was with *Zostera marina* and *Z. caulescens* near the inner most part of the bay.

Key words: *Caprella japonica*, Caprellidea, community structure, epifauna, seagrass, *Phyllospadix iwatensis*

In the shallow water ecosystem, the caprellidean and gammaridean amphipods are considered to be one of the most important prey items for the fishes, especially small fish less than 10 cm in body length.¹⁾ About 100 species of caprellidean amphipods are currently recorded from Japanese waters.²⁾ With the progress in the taxonomy,^{2,3)} biological and ecological information has accumulated on caprellid community structure,⁴⁻⁸⁾ population fluctuations,⁹⁻¹²⁾ life-history,^{1,13-15)} and behavior.¹⁶⁻¹⁸⁾ Most of these studies have dealt with the caprellids inhabiting algae in the *Sargassum* zone. Although the seagrass prevails in muddy-sandy shallow waters along the Japanese coast as well as in other temperate regions of the world, the caprellids inhabiting on the seagrass are poorly documented at the species level.¹⁹⁻²¹⁾

Seven species of seagrasses in two genera are reported from the Japanese coast.²²⁾ Three of these species are confirmed to be distributed in Otsuchi Bay on the Sanriku ria coast of northeastern Japan. Two species of *Zostera*, i.e., *Z. marina* Linnaeus and *Z. caulescens* Miki, are luxuriant in estuaries and the inner part of the bay, and *Phyllospadix iwatensis* Makino flourishes on rocky coasts not so far from the *Zostera* zone.²³⁾ Thus, Otsuchi Bay was considered to be a suitable site to conduct a comparative study on the epifaunal community associated with *Zostera* and *Phyllospadix*.

The purpose of the present study is, first, to investigate the community structure of epifaunal caprellids living on the 3 species of seagrass distributed in the bay, and second, to describe the environmental conditions and features of their habitats.

Study Area, Materials, and Methods

This study was carried out in Otsuchi Bay (39°19'–22'N

141°54'–142°00'E), a semi-enclosed embayment of 8 km long and 2 km wide on Sanriku ria coast of the Pacific Ocean in north-eastern Japan. Six sampling stations were set up in the sublittoral zone around the bay (Fig. 1). Stations A to C are situated in rock areas within the *Phyllospadix iwatensis* zone. *Phyllospadix iwatensis* is most abundant around St. A in Otsuchi Bay.²³⁾ Station D is set in *Zostera marina* zone in the estuary of Otsuchi River. Stations E and F are located in *Z. marina* and *Z. caulescens* zones, respectively, near the innermost part of the bay. *Zostera caulescens* is distributed in a rather deeper water zone close to the *Z. marina* bed. *Phyllospadix iwatensis*

Fig. 1. Map showing the study area and sampling stations in Otsuchi Bay.

OMRC indicates the location of Otsuchi Marine Research Center, Ocean Research Institute, the University of Tokyo.

and *Z. caulescens* are endemic to the northwestern Pacific.

Duplicate or triplicate samplings of seagrasses were conducted during early summer, i.e., June 5–13, 1990. During SCUBA diving seagrasses were gently cut off near their base in a quadrat and quickly placed in a plastic bag (mesh size 0.16 mm). Sample area depended on the species of seagrasses: *Phyllospadix iwatensis* (Sts. A, B and C), 20 × 20 cm in quadrat size; *Zostera marina* (Sts. D and E), 25 × 25 cm; and *Z. caulescens* (St. F), 25 × 75 cm.

In the laboratory, seagrass samples were shaken in freshwater and detached animals were collected through a sieve with mesh size of 0.25 mm and preserved in 10% neutralized formalin. Organisms attached to the collecting bag were also carefully removed and preserved. Later, caprellid amphipods were sorted and identified to species level under a binocular microscope. A similarity index C_{π} ²⁴⁾ between stations was calculated as follows;

$$C_{\pi} = 2 \sum_k n_{ik} \cdot n_{jk} / (\pi_i^2 + \pi_j^2) N_i \cdot N_j$$

$$\pi_i^2 = \sum_k n_{ik}^2 / N_i^2, \quad \pi_j^2 = \sum_k n_{jk}^2 / N_j^2$$

$$N_i = \sum_k n_{ik}, \quad N_j = \sum_k n_{jk}$$

where n_{ik} and n_{jk} are individual number of species k in samples i and j , respectively. The index ranges from "0", no common taxa in two samples, to "1.0", perfect correlation of taxa in two samples.

Seagrasses were preserved in the formalin, and later weighed after laying them on newspaper for 20 minutes. The maximum length of leaves was measured on 5 to 8 selected plants from each sample. The width of leaves was also recorded from the top, middle and lower part of the same plant.

During the sampling period, temperature, salinity and water motion were measured. A STD with built-in memory (Alec Electronics Co. Ltd., Kobe, Japan; AST1000S) provided a vertical distribution of temperature and salinity at 0.2 m intervals on June 12, 1990. The degree of water motion was estimated as a time-averaged intensity using the plaster ball method.^{25),*3} Plaster balls with a diameter of 2.7 cm were weighed initially in a dry condition. A stand with 6 plaster balls was submerged at each station. After 2 hours of exposure the stands were recovered, and then the plaster balls were weighed again after being completely dried. The percentage of weight loss is regarded as an index of water motion.

Results and Discussion

Environmental Condition

Station D (Fig. 1), the estuary station, had 6.8 (PSU) at

the surface and 26.4 (PSU) at 0.8 m depth, but salinity at the other stations was never less than 27.8 (PSU) even within the surface layer (Fig. 2). Among the other stations, salinity of inner stations (Sts. E and F) was less in the surface layer than the outermost stations.

The existence of a steep thermocline decreasing by up to 4°C between surface and 2 m depth was observed except for the shallow stations (Sts. C and D). Kutsuwada²⁶⁾ also reported the occurrence of this thermocline from May to August at the center of Otsuchi Bay, especially a 5°C difference of temperature within the upper 2 m during June.

The circulation of water in Otsuchi Bay induced by changing wind direction could possibly lead to rapid changes of temperature and salinity, although no continuous measurement of the vertical profile were conducted. Strong westerly to northwesterly winds lead a vertical circulation of the water mass in Otsuchi Bay.²⁷⁾ The rapid change of seawater occurs several times during May to September.²⁶⁾ Consequently, the habitat of epifaunal caprellids in the present study has a possibility of undergoing rapid changes of temperature and salinity during summer.

The degree of water motion was higher at stations on bedrock (Sts. A, B and C) and at the estuary station (St. D) with a 3.93 to 4.84% reduction (Table 1). Those at the other two stations (Sts. E and F) have significantly lower values than Sts. A, C, and D (Mann-Whitney U test; $p < 0.05$) or nearby than St. B ($0.05 < p < 0.10$).

Feature of Substratum

Mean length of *Zostera caulescens*, 195.1 ± 38.5 cm, was over twice that of *Z. marina*, 73.4 ± 7.2 to 91.5 ± 20.8 cm (Table 2). *Phyllospadix iwatensis* showed an intermediate value between these two species of *Zostera*: 127.6 to 146.6

Fig. 2. Vertical temperature and salinity profile at Sts. A to F.

These data were recorded on June 12, 1990 using a STD with built-in memory (Alec electronics Co. Ltd., Kobe; AST 1000S).

Table 1. The degree of water motion measured by the weight reduction (%) of plaster balls at 6 stations in Otsuchi Bay recorded on June 12, 1990

	A	B	C	D	E	F
Degree of water motion (% + S.D.)	4.84 ± 1.63	3.93 ± 1.51	4.39 ± 0.79	4.59 ± 1.13	2.40 ± 0.87	2.72 ± 0.94
Temperature (°C)	12.8	12.2	18.0	18.6	12.9	14.8

*3 Modified by Hayashi and Yamakawa (unpubl.).

Table 2. Features of leaves and biomass of seagrasses collected from 6 stations. The mean and Standard deviation are expressed in the table

	A	B	C	D	E	F
Species	Pi	Pi	Pi	Zm	Zm	Zc
Length (cm)	136.7 ± 24.7	127.6 ± 21.2	146.6 ± 26.4	73.4 ± 7.2	91.5 ± 20.8	195.1 ± 38.5
Width; bottom (mm)	4.34 ± 0.28	4.09 ± 0.17	3.81 ± 0.34	5.88 ± 1.58	6.60 ± 1.46	2.68 ± 0.52
Width; middle (mm)	3.45 ± 0.32	3.18 ± 0.47	3.50 ± 0.43	6.23 ± 0.88	6.97 ± 0.82	11.94 ± 1.30
Width; top (mm)	3.24 ± 0.28	2.78 ± 0.51	3.29 ± 0.36	5.78 ± 0.79	6.58 ± 0.86	11.46 ± 1.12
No.*	16	16	15	10	11	15
wet weight (g/m ²)	11300 ± 5869	8413 ± 2351	8417 ± 1553	1062 ± 212	1336 ± 91	2523 ± 695
No.*	2	2	3	2	2	3
Depth (m)	5.0	4.6	0.8	0.6	1.8	3.8
Bottom condition	bedrock	bedrock	bedrock	mud	sandy mud	sandy mud

Abbreviations in the table as follows; Pi, *Phyllospadix iwatensis* Makino; Zm, *Zostera marina* Linnaeus; and, Zc, *Z. caulescens* Miki.

*; Number of samples.

Table 3. Density of the Caprellidea inhabiting three species of seagrasses collected from 6 stations

Species	A	B	C	D	E	F
<i>Caprella japonica</i> (Schurin)	103.75 ± 22.98	8.75 ± 1.77	10.80 ± 3.82	0	0	0
<i>C. tsugarensis</i> Utinomi	0	0	0	0	3.80 ± 0.29	4.09 ± 1.34
<i>C. danilevskii</i> Czerniavski	0	1.25 ± 1.77	0	0	0	0
<i>C. subinermis</i> Mayer	2.50 ± 3.54	0	0	0	0	0
<i>C. polyacantha</i> Utinomi	0	0	0	0	1.00 ± 0.29	0
<i>C. verrucosa</i> Boeck	0	1.25 ± 1.77	0	0	0	0
<i>C. scaura</i> Templeton	0	0	0	0	1.00 ± 1.41	0.71 ± 1.23
<i>C. bispinosa</i> Mayer	0	0	0	0	0.60 ± 0.85	0
<i>C. sp. aff. brevisrostris</i> Mayer	5.00 ± 7.07	1.25 ± 1.77	0	0	0	0
<i>C. sp.</i>	0	0	0	0	0	0.18 ± 0.31
Total	111.25 ± 19.45	12.50 ± 7.07	10.80 ± 3.82	0	6.40 ± 2.26	4.98 ± 0.62

Number indicates the mean with standard deviation in individuals per 0.10 m² bottom area. Species of seagrasses as follows; Sts. A–C, *Phyllospadix iwatensis* Makino; Sts. D & E, *Zostera marina* Linnaeus; and St. F, *Z. caulescens* Miki.

cm in average length.

The difference in width from top to bottom is relatively small except for *Z. caulescens* at st. F (Table 2). Width of leaves of *Phyllospadix iwatensis* (2.78 to 4.34 mm) is narrow, while *Z. marina* (5.78 to 6.97 mm) and *Z. caulescens* (2.68 to 11.94 mm) are broader (Table 2). The lower one-third of the stem of *Z. caulescens* is, thus, elongate and narrow.

Community Structure of the Caprellid Amphipods

A total of ten species of Caprellidea, all belonging to the genus *Caprella*, were collected except for St. D on the estuary of Otsuchi River (Table 3). The absence of caprellids at the estuarine station indicates that the relatively low level, less than 28 (PSU), is a salinity limit for caprellids.

Caprella japonica (Schurin) constituted more than 70% of the total number of caprellids sampled at Sts. A, B, and C. In contrast, *C. tsugarensis* Utinomi was consistently dominant (more than 60%) on *Zostera marina* and *Z. caulescens* from the inner part of the bay (Sts. E and F). Besides the difference of the major species, the non-dominant species of *Caprella* of each group also differed. The similarity index $\pi^{24)}$ within each group was more than 0.93 in each combination confirming marked similarity. Contrary to the previous records, *Caprella kroyeri* de Haan, which was dominant on *Z. marina*,^{19–21,28)} was not obtained during the present study.

Among the oceanographic factors between habitats of

Fig. 3. A, *Caprella japonica* (Schurin), dominant species on *Phyllospadix iwatensis* Makino; and B, *C. tsugarensis* Utinomi on *Zostera marina* Linnaeus and *Z. caulescens* Miki.

These are lateral views of typical mature male specimens. *Caprella tsugarensis* was redrawn from Takeuchi.²⁾ Bar indicates 5.0 mm.

Caprella japonica and *C. tsugarensis*, the difference of wave exposure is recognized (Table 1). However, the definitive morphological adaptation to wave exposure reported in Hirayama and Kikuchi⁵⁾ and Takeuchi *et al.*^{6,7)} was not observed between the two dominant species of *Caprella* (Fig. 3). Both species resemble each other in having elongated body somites, short basis of gnathopod II, forward-bent gills and grasping spines on pereopods V to VII.

Caprella japonica, as well as *C. tsugarensis*, was observed to hold seagrasses in a "parallel" posture; the terminology of the clinging behavior was defined by Takeuchi and Hirano.¹⁸⁾

The width of leaves in the middle and top parts also differs significantly in the habitats of the two species (Table 2; Mann-Whitney *U* test; $p < 0.05$). Edgar reported that small epifaunal amphipods were more likely to be present on filamentous algae rather than on other algae with wide thalli.²⁹⁾ However, his conclusion was not applicable to the habitat segregation of the two caprellid species, since *C. japonica* inhabiting the narrow width of seagrasses grows to a larger size than *C. tsugarensis*; *C. japonica*, 2.0 to 27.7 mm, and *C. tsugarensis*, 1.4 to 12.0 mm.

It is noteworthy that sizeable numbers of *Caprella japonica* were collected from *Phyllospadix iwatensis* on rocky shores in the ecological studies (Table 3). Prior to the present study, *C. japonica* has been recorded from the Maritime Province of Siberia facing the Sea of Japan to the central part of Pacific coast of Honshu Island, Japan.^{1,2,30-33)}

Phyllospadix iwatensis forms small patch-like zones, within or close to *Sargassum yezoense* (Yamada), along the rocky shore in the middle to outer part of Otsuchi Bay. Takeuchi conducted monthly sampling of *S. yezoense* at two stations over a year to investigate the species diversity and biomass of caprellid amphipods.³⁾ Contrary to the present study, only 2 individuals of *C. japonica* were found among 39,733 individuals examined. *Caprella penantis* Leach R-type,^{*4} *C. danilevskii* Czerniavski, *C. verrucosa* Boeck, and *C. subinermis* Mayer constituted more than 90% of epifaunal caprellids from the outer station in the bay, and *C. danilevskii* dominated more than 95% of total individuals from the inner station. Moreover, *C. japonica* was not recorded from either community investigations on *Sargassum* zone^{4-7,11,12)} or *Zostera marina*¹⁹⁻²¹⁾ from other regions of Japan.

Such a definitive species association with the substratum was not reported in epifaunal caprellids inhabiting the *Sargassum* zones.^{4-7,11,12)} A distinct morphological difference between the two species of *Caprella* is observed only in the mouthparts; in *C. japonica* the fourth segment of mandibular palp is vestigial, while in *C. tsugarensis* the fourth segment is large and claw-shaped as usual in the most species of *Caprella*.^{1,3)} This might reflect an adaptation of *C. japonica* to feed on a particular group of unicellular algae attached to *Phyllospadix iwatensis*, but remains unclear at present.

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*4 Same as the "*Caprella penantis* Leach R-type" in Takeuchi.²⁾

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