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Density fluctuation of caprellid amphipods (Crustacea) inhabiting the red alga *Gelidium amansii* (LAMOUROUX) LAMOUROUX, with emphasis on *Caprella okadai* ARIMOTO*

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Abstract: Species composition and density fluctuation of caprellid amphipods inhabiting a red alga *Gelidium amansii*, which is a true-perennial alga, were investigated in a small inlet of the rocky shore facing the Pacific Ocean, at Amatsu-Kominato, Chiba Prefecture. Six caprellid species were found to be present. Among them *Caprella okadai* was the most dominant species. Its share in the caprellid fauna was more than 67 % throughout the year. The density during May to August was 10 times higher than that during September to March, and mature females were found almost all the time. Several species of *Caprella* which inhabit *Sargassum* spp. have been reported to exhibit different occurrence pattern, suggesting that life forms of algae influence the occurrence of caprellids. Review of distribution of *C. okadai* reveals that this species is restricted to calmer zones of rocky shore facing the open sea.

1. Introduction

Caprellid amphipods, as well as gammarid amphipods, represent an important component in the ecosystem of "Garamo-ba" (*Sargassum* zone) which flourishes on rocky shores of southern Japan, as these crustaceans are the major predated forms by rocky shore fishes (FUSE, 1962; HIRAYAMA, 1978; KANAMOTO, 1977, 1979; OMORI, 1980). Ecological studies on the caprellids on the "Garamo-ba" have mostly dealt with either substrate selection (HIRAYAMA and KIKUCHI, 1980; IMADA *et al.*, 1981; NORTON and BENSON, 1983; TAKEUCHI *et al.*, 1987; TAKEUCHI *et al.*, MS) or population dynamics (IMADA and KIKUCHI, 1984; AOKI, 1988). These studies, however, are usually restricted to animals collected from the *Sargassum* species which are larger algae among various kinds of algae found in "Garamo-ba". Only HIRAYAMA and KIKUCHI (1980) and TAKEUCHI *et al.* (1987) reported on caprellid species compositions on several species of smaller algae on the basis of seasonal collections.

In this study, we focus on species composition and density fluctuation of the Caprellidea inhabiting the red alga *Gelidium amansii* (LAMOUROUX) LAMOUROUX, which is a true perennial alga (KATADA, 1963).

2. Materials and Methods

This study was conducted in the innermost part of an inlet called "Jizogi" (Fig. 1) in the vicinity of the Kominato Marine Biological Laboratory of the Tokyo University of Fisheries (KMBL) (now the Kominato Marine Laboratory, Faculty of Science, Chiba University). This inlet is situated on the southwest of Uchiura Bay facing the Pacific Ocean. Sampling was carried out from the center of a thick community of *Gelidium amansii* at the depth of 1.3 m.

Duplicate samples of *G. amansii* from a quadrat of 20 × 20 cm were collected by skin diving at monthly intervals from April 1978 to March 1979. Algae were gently removed and quickly placed in a vinyl bag. In the laboratory, the algae were shaken in freshwater for dislodging free-living epifauna. Caprellids were carefully sorted out and preserved in 10

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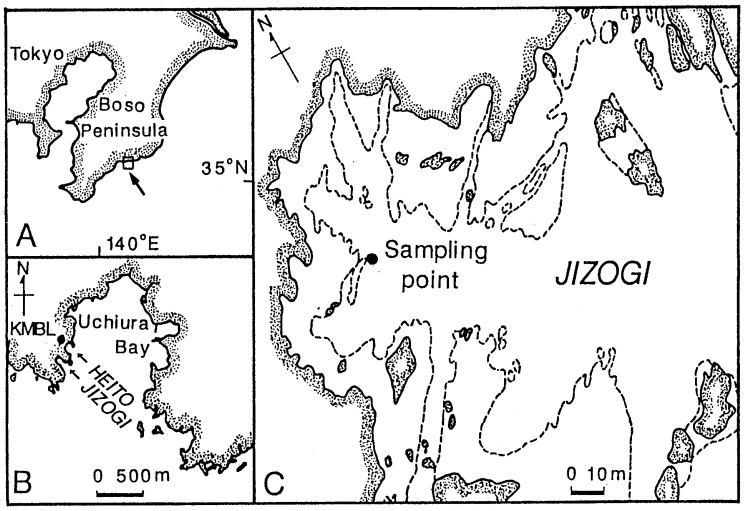

Fig. 1. Maps showing the study site. A. Boso Peninsula. Marked area (arrow) indicates the location of Uchiura Bay. B. Uchiura Bay. KMBL: Kominato Marine Biological Laboratory, Tokyo University of Fisheries. C. Map of Jizogi showing the sampling point. Broken lines indicate the highest low water during the neap tide.

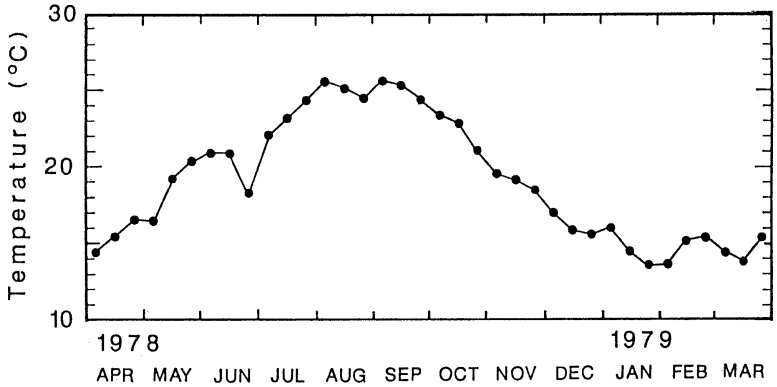

Fig. 2. Seasonal change of seawater temperature based on the daily observation records of the former Kominato Marine Biological Laboratory, Tokyo University of Fisheries. Each solid circle indicates the average temparature for the first, second and last 10 days in every month.

% buffered formalin. Caprellid species identification was conducted under a binocular microscope. Sex of *Caprella okadai*, the most dominant species, was determined from the development of gnathopod in males and the presence of oostegites in females. The other small individuals which did not possess the sexual characters were classified as juveniles. Furthermore, females were separated into two categories, i. e. immatures in which oostegites are without setae, and matures in which oostegites with long setae form a brood pouch. Wet weight of algae was measured to the nearest g after leaving them on papers for two hours.

Seawater temperature data based on the daily observation record of KMBL have been used in the present study. It ranged from 13.2 to 25.5℃ (Fig. 2). Salinity variation was restricted to 33.1-34.0‰ during the period of

the investigation (HAYASHI, 1989).

3. Results

The wet weight of *Gelidium amansii* per 400 cm² varied from 80 to 175 g and no seasonal fluctuation was recognized.

Six species of the Caprellidae were collected. All these six species belong to the genus *Caprella*; *C. okadai* ARIMOTO, 1930, *C. simia* MAYER, 1903, *C. kominatoensis* TAKEUCHI, 1986, *C. penantis* LEACH, 1814, *C. decipiens* MAYER, 1903 and *C. generosa* ARIMOTO, 1977. The last species is the same as *Caprella* sp. III reported from Amatsu-Kominato by TAKEUCHI *et al.* (1987).

C. okadai was the most dominant species throughout the year. The share of *C. okadai* to total number of caprellids varied from 67 to 100 % (Fig. 3). Its individual density per 100 g wet weight of the alga increased rapidly from April to May and was kept high until August (> 150 ind./ 100 g wet weight) (Fig. 4). In September, it decreased to 16.2 ind./ 100 g wet weight, and such a low density (< 50 ind./ 100 g wet weight) extended up to March. The density pattern based on their abundance per 400 cm² bottom area in the quadrat sample also showed a similar projection (Fig. 4).

Juveniles, i. e. those individuals which had a body length less than 4.0 mm, constituted the bulk of the population throughout the year except in August and November (Table 1). Mature females were also collected throughout the year, except during January 1979. This indicates that *C. okadai* could mature and produce eggs all the year round in this area, where seawater temperature varied between 13 and 26℃ (Fig. 2).

The second dominant species was *C. simia*. Its maximum share was only 33 % and was encountered in October 1978 (Fig. 3). In July and August, its density was relatively high (15.4 and 5.9 ind./ 100 g wet weight, respectively), but in other months it was less than 2.0 ind./ 100 g wet weight. Mature females were not found.

4. Discussion

In this study, *Caprella okadai* was found to be exclusively dominant throughout the year on the red alga *Gelidium amansii* in the inner part of the inlet (Fig. 3). Although we did not measure the length of algae, it is estimated to range from ca. 15 to 20 cm throughout the year. TAKEUCHI *et al.* (1987) report-

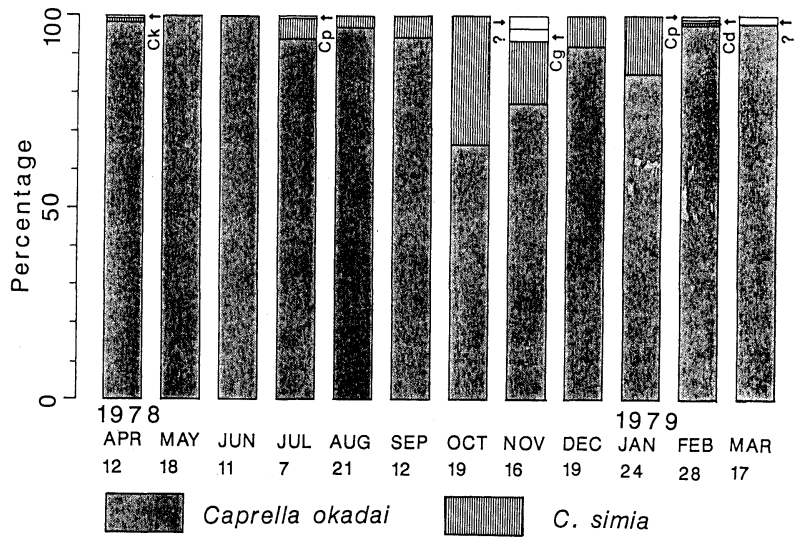

Fig. 3. Seasonal fluctuation in species composition of the Caprellidae associated with *Gelidium amansii* (LAMOUROUX) LAMOUROUX. Cd, *Caprella decipiens* MAYER; Cg, *C. generosa* ARIMOTO; Ck, *C. kominatoensis* TAKEUCHI; Cp, *C. penantis* LEACH; and ?, unidentified individuals due to damages.

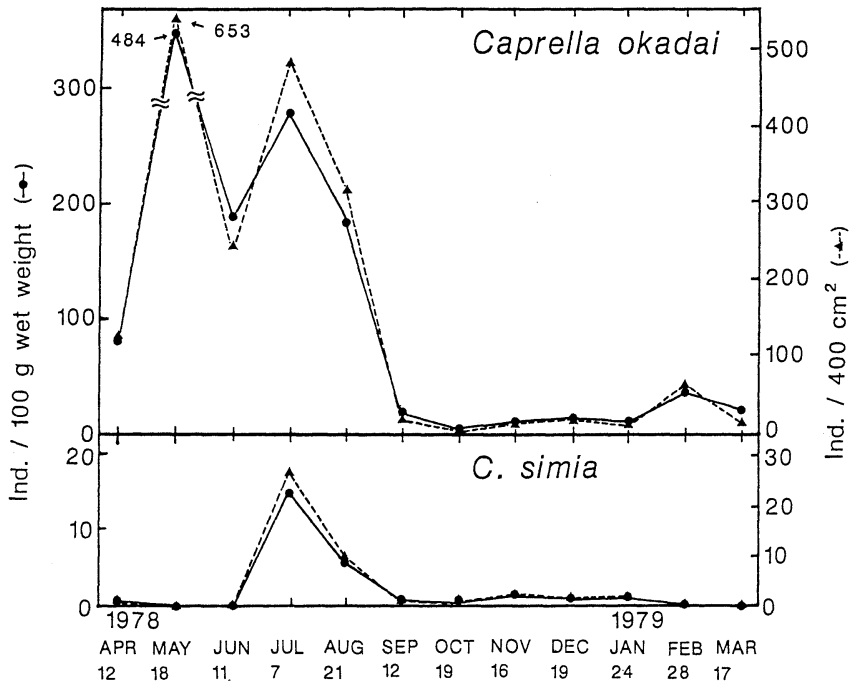

Fig. 4. Seasonal fluctuation in the density of *Caprella okadai* ARIMOTO and *C. simia* MAYER. Solid circle: the number of individuals per 100 g wet weight of *Gelidium amansii* (LAMOUROUX) LAMOUROUX. Solid triangle: the number of individuals per 400 cm² of bottom area.

Table 1. Seasonal variations in proportion (%) of juveniles, males, immature and mature females to the total individuals and sex ratio (males/females) of *Caprella okadai* ARIMOTO.

	1978								1979			
	12 Apr.	18 May	11 June	7 July	21 Aug.	12 Sept.	19 Oct.	16 Nov.	19 Dec.	24 Jan.	28 Feb.	17 Mar.
Juveniles	76.4	84.8	67.1	51.3	30.5	47.1	50.0	16.7	60.0	52.2	55.2	46.2
Males	11.8	5.7	14.0	17.6	28.6	26.4	25.0	41.7	25.7	21.7	15.2	28.8
Females												
immatures	10.0	4.9	10.2	20.3	17.9	14.7	0.0	33.3	2.9	26.1	18.4	17.3
matures	1.8	4.6	8.7	10.8	23.0	11.8	25.0	8.3	11.4	0.0	11.2	7.7
Sex ratio	1.00	0.60	0.74	0.57	0.70	1.00	1.00	1.00	1.80	0.83	0.51	1.15

Juveniles 1.5 - 4.0mm, males 4.0 - 8.5mm, immature females 3.5 - 6.0mm and mature females 4.5- 8.0mm in body length.

ed that *C. okadai* was the dominant species on such large algae (>10cm) as *G. amansii*, *Cladophora wrightiana* HARVEY and *Sargassum piluliferum* (TURNER) C. AGARDH, which were growing at the zones protected from wave exposure in the inlet "Heito". This inlet is located to the north of "Jizogi" (Fig. 1). The present results support their conclusion.

Year-round breeding in different species of *Caprella*, similar to the present observation on *C. okadai*, has been reported in studies carried out in the temperate region; *C. penantis* (BYNUM, 1978; CAINE, 1983), *C. laeviuscula* MAYER (CAINE, 1979), *C. californica* STIMPSON (KEITH, 1971), *C. equilibra* SAY (KEITH, 1971), *C. gorgonia* LAUBITZ and LEWBEL (LEWBEL, 1978), *C. tsugarensis* UTINOMI (IMADA and KIKUCHI, 1984), *C. decipiens* (IMADA and KIKUCHI, 1984) and *C. verrucosa* BOECK (AOKI, 1988).

The occurrence of caprellids is influenced by the life forms of algae with which caprellids are associated. In this study, *C. okadai*

was collected throughout the year, and the high density was recorded during May to August. However, the occurrence of *C. danilevskii* CZERNIAVSKI, *C. tsugarensis* and *C. decipiens*, which were associated with the brown alga *Sargassum horneri* (TURNER) C. AGARDH, was restricted from fall to early summer (IMADA and KIKUCHI, 1984). Similar seasonal fluctuation was also observed in the case of *C. verrucosa* on *S. patens* C. AGARDH (AOKI, 1988). *S. horneri* is an annual alga (TERAWAKI *et al.*, 1983b; TERAWAKI, 1986), and the entire thalli flowed away during spring to early summer (IMADA and KIKUCHI, 1984). The larger parts of *S. patens* thalli, which is a stem-survived perennial species (KATADA, 1963; TERAWAKI *et al.*, 1983a), also flowed away during late spring to early summer, leaving behind short round stems only (AOKI, 1988). TAKEUCHI *et al.* (1987) reported that *C. okadai*, *C. danilevskii*, *C. tsugarensis* and *C. decipiens* were mostly collected from large algae (> 10 cm) which possess filamentous or long thalli. All these four species of *Caprella* are typically similar in having an elongate body with a sharp and short basis of gnathopod II. They observed that these caprellids, except *C. decipiens*, clung the substrata by gnathopod I and pereopods V-VII with body straightened. This reveals a possibility that morphological characteristics of caprellids might have adapted to the feature of algae. Hence, the presence of suitable feature of algae for clinging is one of the most important factors which have influence on the occurrence of caprellid amphipods. Therefore, these species of *Caprella* associated with *S. horneri* and *S. patens* could not be collected during the summer.

This conclusion is also supported by the result of a comparative study on populations of *Caprella penantis* collected from two sites along the Atlantic Ocean of North Carolina (BYNUM, 1978). He compared the population structure of this caprellid from the estuarine site where hydroids and bryozoans were the most common substrate and that from the coastal site where red and green algae predominated. Population at each site peaked during July. During late August, the caprellid density at estuarine site rapidly decreased with disappearance of *Tubularia crocea*, a common hydroid, while the high density continued to prevail at the coastal site.

Caprella okadai was reported first from Tateyama, Chiba Prefecture (ARIMOTO, 1930, 1976) and then from Tomioka, Amakusa-Shimoshima Island, Kumamoto Prefecture (IMADA *et al.*, 1981) and Amatsu-Kominato (TAKEUCHI *et al.*, 1987). Besides these records, one of the authors (IT) has also found it on several occasions in coastal waters of Japan, i.e. Nabeta Bay of Izu Peninsula, Shizuoka Prefecture, Unose on Amakusa-Shimoshima Island and Magari on Notojima Island, Ishikawa Prefecture. In all these instances, *C. okadai* was collected from the rocky shore facing the ocean influenced by either the Kuroshio Current or Tsushima Current. Since this species of *Caprella* has never been found in eutrophic bays such as the Seto Inland Sea, Ise Bay, Tokyo Bay, etc. until now, it can be presumed that the distribution of *C. okadai* is restricted to the areas protected from wave exposure of rocky shore facing the open sea.

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マクサ上のワレカラ類，特にオカダワレカラの密度の周年変動

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要旨: 千葉県天津小湊町地先のガラモ場にて、真多年生海藻であるマクサに棲息するワレカラ類の種組成および密度の周年変動を調査した。オカダワレカラは，一年中，全個体の67%以上を占める優占種であり，密度は5月から8月に特に高く他の季節より10倍以上高い値を示した。成熟個体がほぼ一年中採集されたことから，繁殖期が周年にわたるものと推察された。従来のガラモ場のワレカラ類の研究によると，一年生あるいは茎部多年生海藻であるホンダワラ類の上では，ホソワレカラなどの出現は秋から初夏に限られることが報告されている。これらのことから，海藻の生活形がワレカラ類の出現に影響を及ぼすと考えられる。また，オカダワレカラの分布に関する知見を整理すると，本種の棲息域は外洋に面した岩礁域の波浪の影響の少ないところに限られるのではないかと推察される。