Feeding of Copepods on Natural Suspended Particles in Tokyo Bay*

Atsushi Tsuda† and Takahisa Nemoto‡

Abstract: Community grazing rates of copepods were estimated from data taken during three cruises in Tokyo Bay, based on bottle incubations and a temporal variation of gut fluorescence. Special attention was paid to the feeding selectivity in the estimations. Differential grazing was observed in the copepod communities: Acartia omorii, abundant in February, selectively fed on the particles of dominant size classes, while Oithona davisae, dominant throughout the year, and Centropages abdominalis selected large particles (>20 μm). The maximum filtering rates on certain size classes were several times the average. In addition, a 34-hr investigation of the gut fluorescence of copepods revealed nocturnal feeding in Paracalanus spp., Pseudodiaptomus marinus and Oithona davisae.

Copepod communities collected with a net (95-μm mesh opening) were estimated to graze, in February 3.0%, in August 3.1-4.5% and in November 4.2-11.9% of the standing crops of phytoplankton or suspended particles per day.

1. Introduction

Inner Tokyo Bay is a temperate, semi-closed bay connected with the offshore waters by Uraga Strait. Eutrophication in the bay began in the 1960's and increased until the early 1970's to the level sustained at present (Unoki and Kishino, 1977; Anonymous, 1984; Han, 1988) with drastic changes in the phytoplankton community (Marumo and Murano, 1973). Excess of nutrients brings a high standing crop and photosynthetic activity of phytoplankton throughout the year (Shibata and Aruga, 1982; Brandini and Aruga, 1983; Han, 1988). Chlorophyll a concentration rarely falls below 10 mg m⁻³ even during winter, and often exceeds 100 mg m⁻³ in summer (Taga and Kohori, 1978; Shibata and Aruga, 1982; Anonymous, 1984). Red tides were observed for a period of over 100 days in 1982, which consisted of Skeletonema costatum, Prorocentrum spp., Heterosigma akashiwo and other diatom species (Anonymous, 1984).

Copepods are the dominant zooplankton in the bay. A small cyclopoid copepod Oithona davisae, formerly identified as O. brevicornis or O. aruensis (Nishida, 1985), is the most dominant species throughout the year, especially between July and September, while a calanoid copepod Acartia omorii, formerly identified as A. clausi (Ueda, 1986) is abundant from February to June (Anakubo, 1982). Little is known of the impact of zooplankton grazing on phytoplankton communities in Tokyo Bay. Uchima and Hirano (1986a, b) intensively studied the feeding behavior of O. davisae by laboratory experiments. They presented many interpretations of copepod ecology, however, information about the in situ grazing rates of dominant herbivorous and omnivorous zooplankton is needed to understand the interactions between primary producers and consumers. In addition, simultaneous measurements of the filtering rate, standing stock, and feeding selectivity of each species are required to obtain better estimates of the in situ feeding rates of natural assemblages (Thompson et al., 1982). It should be noted that most studies have ignored the feeding selectivity in evaluating the in situ feeding rate of zooplankton assemblages.

The present study estimated the in situ grazing rates of herbivorous and omnivorous copepod communities by bottle incubations on cruises in the inner part of Tokyo Bay. Special
attention was paid to their size selectivity in the estimation of community grazing rates. Furthermore, the community grazing rate was also evaluated based on a temporal variation of the gut fluorescence.

2. Materials and methods

Sampling and experiments were carried out on three cruises of the R/V Tansei Maru, of the Ocean Research Institute, University of Tokyo in the northern part of Tokyo Bay (Fig. 1). During the KT-83-13 cruise, in vivo chlorophyll fluorescence at the surface was monitored with a continuous water-sampler attached to a Turner model 111 fluorometer (Lorenzen, 1966). The area with the highest concentration was selected as the sampling station. The vessel was anchored over 14 to 34 hr for sampling and experiments.

2.1. Ingestion rate

Copepods were collected with a Norpac net (45 cm mouth diameter; 95-μm mesh opening) hauled vertically from near bottom to the surface, and then transferred to 5-1 containers filled with surface seawater and kept at ambient temperatures. Food media were prepared by passing surface seawater through a 63-μm mesh to remove large particles and zooplankton. Numerically abundant copepods were sorted into filtered seawater under a dissecting microscope, and after determining species, sex and developmental stages, active and undamaged individuals were injected into glass bottles (140-650 ml) filled with the food medium. Only adult females were used in experiments on Acartia omori, whereas for other copepods species copepodites were sorted in each species from the samples regardless of developmental stages and sex. Duplicate bottles of each species were placed on a cell roller to prevent the particles from settling (2 rpm). The incubation lasted for about 6 hr during the night, in darkness at ambient temperatures (Table 1). Size distributions of the suspended particles in the bottles were measured at the beginning and end of the incubations with a Coulter Counter model TAI attached to a 140-μm aperture which covered particles between 2.52 and 64.0 μm. Two bottles without copepods were used as controls. Copepod density during the incubations and other experimental conditions are summarized in Table 1. Ingestion rates and filtering rates on each size class of particles were calculated using the equations of Frost (1972).

![Fig. 1. Sampling stations in Tokyo Bay. Station T3: KT-83-1 cruise, 18-19 February 1983. Stations 2 and 9: KT-83-13 cruise, 1-9 August 1983. Station 1: KT-85-16 cruise, 6-8 November 1985.](image)

Table 1. Experimental conditions of the two cruises in Tokyo Bay.

<table>
<thead>
<tr>
<th>Cruise No.</th>
<th>KT-83-1</th>
<th>KT-83-13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station No.</td>
<td>T3</td>
<td>2, 9</td>
</tr>
<tr>
<td>Date</td>
<td>11-13 February 1983</td>
<td>1-9 August 1983</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>10-11</td>
<td>26-28</td>
</tr>
<tr>
<td>Volume of bottle (ml)</td>
<td>350</td>
<td>140</td>
</tr>
<tr>
<td>Copepod density in bottle (inds 1⁻¹)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acartia omori</td>
<td>50-200</td>
<td></td>
</tr>
<tr>
<td>Centropages abdominalis</td>
<td>94-116</td>
<td></td>
</tr>
<tr>
<td>Oithona davisiae</td>
<td></td>
<td>200-400</td>
</tr>
</tbody>
</table>

a Adult females.
b Copepodites and adults.
For estimating the standing stock, copepods were collected with the same net equipped with a flowmeter, hauled from nearbottom to the surface. They were preserved in 5% (v/v) buffered formalin seawater soon after the collection. Copepods were identified and counted under a microscope for an appropriate aliquot (1/32–1/64). The estimated abundances of the copepod were combined with the filtering rates of the copepod on each size class of food particles to obtain a community grazing rate (Thompson et al., 1982).

2.2. Gut fluorescence

Sampling was sustained for 34 hr at a hourly interval, between 6 and 8 November 1985 at Station 1 (Fig. 1). A collection of copepods was accomplished by vertical hauls with the Norpac net from near bottom (17-m depth) to the surface. Soon after sampling, the copepods were narcotized with a drop of chloroform (Gannon and Gannon, 1975) and collected on a glassfiber filter (46-mm diameter, GF/C). The filters were frozen at −20°C in darkness within 20 min after sampling, and used for pigment analysis ashore.

Gut fluorescence of the copepods was measured within two months after the sampling the procedure of Mackas and Bohrer (1976). The samples were re-suspended into cold (5°C), filtered seawater. The copepods were sorted under a dissecting microscope with a dim light and rinsed twice with filtered seawater. For each species, duplicate subsamples of 10 to 100 individuals each were put in screw-capped vials with 90% (v/v) acetone, and were allowed to extract a day and night in a dark freezer. Over 95% of the extraction yield was obtained by the same procedure, with 90% acetone for small copepods (Pleuromamma gracilis, Paracalanus spp.) and over 85% for large copepods (Calanus sinicus, Scolecithrix danae and Pleuromamma ziphias) in a study in Sagami Bay (Tsuda, unpublished). Simard et al. (1985) found no difference between samples ground and unground with 100% methanol extraction. Therefore, the grinding step was eliminated. Chlorophyll a and phaeopigment were measured with a Turner model 111 fluorometer.

Grazing rates were estimated from the gut pigment content assuming a 1.0 and 0.5 hr as the gut clearance time for Pseudodiaptomus marinus and smaller copepods (Oithona davisae and Paracalanus spp.), respectively, based on the body size and ambient temperature (Dagg and Grill, 1980; Kiørboe et al., 1982; Tsuda and Nemoto, 1987). Since some residual chlorophyll a was present, gut pigment content was shown as chlorophyll a+phaeopigment. The pigment content and the estimated ingestion rate were expressed as chlorophyll-a-equivalent weight. Measured pigment was considered to originate from only phyttoplankton cells, since no other pigment fluorescing was detected at the wavelength of chlorophyll a and its derivatives in the starved copepods (Baars and Helling, 1985).

The gut fluorescence method is useful to investigate the natural feeding rates of herbivorous copepods since short-term ingestion rates can be estimated without artificial effects. Wang and Conover (1986) pointed out that grazing rates estimated by the gut fluorescence method were underestimated due to pigment loss caused by destruction and assimilation of pigment through the gut passage. Usually, gut passage time has been estimated from the exponential decrease of the gut fluorescence of previously satiated copepods. Although Wang and Conover (1986) assumed that the estimated gut passage time consisted only of the defecation of fecal pellets, the decrease of copepod gut fluorescence in filtered seawater should include the defecation of and also the destruction of pigment. Moreover, the assimilation of pigment should be accompanied by its destruction, since the fluorescence in starved copepods was very small. Thus, gut passage times, which have been estimated actually included not only the defecation but also the destruction and assimilation of pigment. A more appropriate term is "fluorescence residence time". Furthermore, linearity is present between the gut pigment content and the ingestion rate estimated from bottle incubations (Tsuda and Nemoto, 1987; Wang and Conover, 1986). Therefore, we concluded that the gut fluorescence method is still valid for the estimation of natural feeding rates of copepods.

Water samples for chlorophyll a and phaeopigment were taken from three depths (0, 5, 10 m) with a Van Dorn sampler, and analyzed fluorometrically after Strickland and Parsons (1972).
3. Results

3.1. Plankton composition

Copepod fauna was dominated by only a few species through the three cruises (Table 2). *Oithona davisae* was dominant throughout the samplings and comprised 99% of the total number of copepods in summer. *Acartia omorii* and *Centropages abdominalis* occurred abundantly in February 1983, and *Pseudodiaptomus marinus* and *Paracalanus* spp. in November 1985.

The size spectrum of the suspended particles had three peaks in February (Fig. 2). According to the microscopic observations, the peak at the smallest size was comprised mainly of *Prorocentrum minimum*, that for the middle

| Table 2. Numerical abundance of copepods (inds \(^{-1}\)) collected with a Norpac net (95-\(\mu\)m mesh opening) in Tokyo Bay. nc: not counted |
|---|---|---|---|
| Date | 1983 | 1983 | 1985 |
| Local time | 18 February  | 1 August | 6-7 November |
| | 17:20 | 21:04 | night 18-04 |
| | | | day 06-10 |
| *Paracalanus* spp. | 0.03 | nc | 0.42 |
| *Centropages abdominalis* | 1.20 | 0 | 0 |
| *Acartia omorii* | 13.17 | nc | 0.02 |
| *Pseudodiaptomus marinus* | 0 | 0 | 0.17 |
| CVI | 0 | 0 | 0.49 |
| CIV-V | 0 | 0 | 0.69 |
| CI-III | 0 | 0 | 0.31 |
| *Oithona davisae* | 60.88 | 275.0 | 34.10 |
| Other copepods | 0.02 | 2.0* | 0.02 |

* Paracalanus* spp. and *Acartia omorii* are included.

![Graphs](image)

Fig. 2. Particle concentration, ingestion rate and filtering rate of *Acartia omorii* females feeding on natural suspended particles in Tokyo Bay on 18 February 1983. A: 50 inds \(^{-1}\), B: 100 inds \(^{-1}\), C: 200 inds \(^{-1}\).
size consisted of *Thalassiostra rotula*, and *Ditylum brightwellii* and tintinnids made up the largest peak. Two peaks were observed in the August size spectrum (Fig. 5), the smaller peak being comprised of Cryptophyceae and larger one of diatoms *T. rotula*, *Leptocylindrus danicus* and *Cerataulina pelagica*. In November, *Chrytomonas/Chromonas*, *Prorocentrum triestinum*, *Gymnodinium* sp. and *L. danicus* were abundant in the water column as also reported in Han (1988).

### 3.2. Grazing of copepods

*Acartia omorii* in February showed high ingestion rates at the peaks of the size distribution of suspended particles (Fig. 2). High filtering rates were also found at the size forming peaks or slightly larger sizes, although selective feeding was not clearly observed at the peak of the middle size. Since the filtering spectrum was depressed at the highest copepod density, the filtering spectra of the lower density (<100 copepods l⁻¹) was used to estimate the community filtering rate. A positive correlation (r=0.74) was found between the ingestion rate and particle concentration (Fig. 3).

*Centropages abdominalis* in February scarcely fed on particles smaller than 20 µm in diameter, including the smaller peaks (*P. minimum* and *Th. rotula*), and showed a high ingestion rate at the peak of the largest size (Fig. 4). The filtering rate increased rapidly in the size range of 20 to 64 µm.

Similar results were obtained for *Oithona*

![Figure 3](image1.png)

**Fig. 3.** Relationships between the particle concentration and the ingestion rate of *Acartia omorii* (February; solid circle), *Centropages abdominalis* (February; open circle) and *Oithona davisae* (August; solid triangle).

![Figure 4](image2.png)

**Fig. 4.** Particle concentration, ingestion rate and filtering rate of *Centropages abdominalis* feeding on natural suspended particles in Tokyo Bay. A: 18 February, B: 19 February 1983.

![Figure 5](image3.png)

**Fig. 5.** Particle concentration, ingestion rate and filtering rate of *Oithona davisae* feeding on natural suspended particles in Tokyo Bay. A: 1 August, B: 8 August 1983.
davisaet as for C. abdominalis. They had high ingestion rates, not on particles smaller than 10 \( \mu m \), but on larger particles (Fig. 5). The filtering rate increased rapidly with particle size in the size range from 20 to 64 \( \mu m \). Significant positive correlations were not observed between the particle concentration and the ingestion rate for either O. davisaet or C. abdominalis (Fig. 3).

3.3. Community grazing

In February the filtering spectra of Acartia omorii and Centropages abdominalis were used to estimate a community grazing rate, and in August only those of Oithona davisaet were used since their numerical abundance accounted for 99\% of the total copepods. In February the filtering spectrum of the copepod community largely reflected that of A. omorii (Fig. 6). The copepods did not feed on particles smaller than 5 \( \mu m \) and increased their filtering rate at about 10 and 50 \( \mu m \), which correspond to the dominant size classes of phytoplankton. The copepod community was estimated to consume 2.4\% and 10.3\% of the standing stock of suspended particles per day at the peaks of 10 and 50 \( \mu m \), respectively, assuming that their feeding continued from dawn to dusk. With the same assumption, 3.0\% of the total suspended particles measured (2.52-64.0 \( \mu m \)) were estimated to be grazed by the copepod community.

In August the community filtering rate increased rapidly in the particle size-range of 20 to 64 \( \mu m \). Especially with sizes greater than 40 \( \mu m \), a filtering rate as high as 40 ml l\(^{-1}\) hr\(^{-1}\) was observed, which indicated that the community filtered about the half of the water column between dusk and dawn at the above particle size range with the maximum filtering rate (Fig. 7). The community was estimated

![Fig. 6. Estimated community filtering spectrum of copepods (dotted area: Acartia omorii, open area: Centropages abdominalis) in Tokyo Bay on 18 February 1983.](image)

![Fig. 7. Estimated community filtering spectrum of Oithona davisaet in Tokyo Bay on 1 August (solid circle) and 8 August (open circle) 1983.](image)

![Fig. 8. Temporal variation of tidal height (upper), chlorophyll a (middle) and phaeopigment (lower) in the water column at Station 1 during a 34-hr sampling period between 6 and 8 November 1985.](image)
to graze 4.5 and 3.1% of the total suspended particles measured (2.52-64.0 μm) per day on 1 and 8 August, respectively.

3.4. Feeding rhythms

Chlorophyll a concentration at Station 1 varied with time and depth, but neither a diel rhythm nor tidal effect was observed (Fig. 8). The maximum concentration appeared at the upper 5-m depth. Integrated chlorophyll a concentration throughout the water column (0-10 m) was higher on the first night than on the second. Phaeopigment concentration was less variable in time and space.

Female *Pseudodiaptomus marinus* were collected by vertical hauls from the near bottom to the surface between dusk and just before dawn but not during the daylight. The gut fluorescence of *P. marinus* increased with time after dusk, and the maximum value was observed at midnight (Fig. 9). Since the gut fluorescence is considered to be partly affected by the variation at food environments, we estimated the filtering rate of *P. marinus* as an index of feeding activity, assuming that they grazed at the depth of the maximum chlorophyll concentration and their gut clearance time was 1 hr. The filtering rate had a similar fluctuation on each night (Fig. 9). The filtering rate of 0.3 ml copepod^{-1} hr^{-1} just after dusk increased to 0.8 ml copepod^{-1} hr^{-1} just before dawn. The gut fluorescence and filtering rate of copepodites IV and V of *P. marinus* showed parallel fluctuations to those of the adult females (Fig. 9).

Nocturnal feeding was also observed in *Oithona davisae* and *Paracalanus* spp. (Fig. 10). The gut fluorescence of *O. davisae* was high at night, although the peak appeared at different times during the two nights. The gut fluorescence of *Paracalanus* spp. increased after dusk and remained relatively constant until before dawn. These fluctuations correspond with those of the filtering rates estimated with the same assumptions as in *P. marinus* (Fig. 10).

3.5. Estimate of community grazing rate from gut fluorescence

The chlorophyll consumption by *Oithona davisae*, the numerically dominant copepod in November 1986, was estimated to be 3.60 mg Chl. m^{-2} day^{-1}, accounting for 74% of the total consumption by the copepod community (Table 3). The chlorophyll consumption by the copepod community during night was 4.81 mg Chl. m^{-2} day^{-1} on the first day and 3.03 for the second, if it was assumed that *Paracalanus* spp. would graze the same amount of phytoplankton in the first night as in the second. The average daily consumption by the copepod community was

![Fig. 9. Temporal variations of gut pigment content (solid circle) and estimated filtering rate (open circle) of *Pseudodiaptomus marinus* female (A) and CIV-CV (B) in Tokyo Bay. The night period is indicated by shaded bars on time axis.](image1)

![Fig. 10. Temporal variations of gut pigment content (solid circle) and estimated filtering rate (open circle) of *Paracalanus* spp. (A) and *Oithona davisae* (B) in Tokyo Bay. The night period is indicated by shaded bars on time axis.](image2)
Table 3. Chlorophyll consumption by copepods
(Paracalanus spp., Pseudodiaptomus marinus
and Oithona davisae) in Tokyo Bay, 7-9 No-

vember 1985. nd: not determined

<table>
<thead>
<tr>
<th></th>
<th>Local time</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>19-06</td>
</tr>
<tr>
<td>Paracalanus spp.a</td>
<td>nd</td>
</tr>
<tr>
<td>P. marinus female</td>
<td>0.117</td>
</tr>
<tr>
<td>CIV-V</td>
<td>0.274</td>
</tr>
<tr>
<td>O. davisaea</td>
<td>2.81</td>
</tr>
<tr>
<td>Total</td>
<td>3.20</td>
</tr>
</tbody>
</table>

a Copepodites and adults.

estimated to be 5.36 mg Chl. m\(^{-2}\) day\(^{-1}\). Integrated chlorophyll \(a\) concentration varied from 45.2 to 141.1 mg m\(^{-2}\), and consequently the copepod community was estimated to graze 3.5 to 4.8% of the phytoplankton standing crop during a night and 4.2 to 11.9% during a night and day.

4. Discussion

Nival and Nival (1976) showed that size selection of particles by Acartia clausi depended on the mesh size of their filtering basket. Active selection of abundant particle sizes, which could not be explained by a passive selection model, have been reported in the Acartia species (Wilson, 1973; Poulet and Marsot, 1978; Donaghay and Small, 1979) and other copepods (Richman et al., 1977; Poulet, 1978). In the present study, Acartia ormorii showed selective feeding on abundant particles, although it was not clear on the peak at the middle size. Breakage of larger particles was considered to occur during the feeding experiments since many cells of Thalassiosira rotula which the peak at middle size consisted of, were detected in the fecal pellets of A. ormorii (Tsuda, unpublished). Moreover, on the same cruise, peak tracking feedings were observed by A. ormorii on cultured red-tide phytoplankton, Prorocentrum minimum and Heterosigma akashiwo (Tsuda and Nemoto, 1984). These selective feedings on abundant particles, presumably active growing cells, are considered to be advantageous for copepod nutrition and also have effects on the composition of the phytoplankton assemblages. Oithona davisae and Centropages abdominalis scarcely fed on small particles but preferred large particles (>20 \(\mu m\)). Uchima and Hirano (1986a) demonstrated by laboratory experiments that O. davisae never fed on diatoms regardless of their size, but on dinoflagellates, ciliates and other motile organisms. By contrast, in the present study, the peaks at the large size (>20 \(\mu m\)) were composed mainly of diatoms and accounted for the major portion of food eaten by O. davisae and other copepods. Since the experiments using a particle counter as well as gut content fluorescence did not reveal whether copepods fed on diatoms or not, further study is needed to determine the composition of the food of the natural population of Oithona davisae and other copepods.

Abundant copepods in Tokyo Bay were classified as omnivores except for Paracalanus spp. These copepods showed high filtering rates on large particles (>20 \(\mu m\)). Consequently, the community filtering spectra were also high in the larger size range of particles. This size range corresponds with where the phytoplankton dominates in the biomass as well as the productivity in neritic waters (Malone, 1971). The maximum filtering rates of copepod communities, observed at dominant size classes or large particles, were several times that of the average rate. This result emphasizes the importance of estimating the food selectivity by copepods. Differential grazing observed in the copepod communities probably affects on the species composition of phytoplankton in nature, which has been reported for experimental conditions (Sonntag and Parsons, 1979; Ryther and Sanders, 1980). The feeding impact of copepod communities on small particles was lower than that on large particles for every season, especially in the summer. Since the dominant copepod (Oithona davisae) preferred large particles, microzooplankton such as ciliates and heterotrophic flagellates are presumably important as grazers on nanoplankton and also as food for omnivorous copepods.

Nocturnal feeding by herbivorous copepods is a commonly observed phenomenon (Mackas and Bohrer, 1976; Kiörboe et al., 1982; Simard et al., 1985). A classical explanation for nocturnal feeding is that copepods migrate daily through the water column between phytoplankton-rich and poor layers with a constant filtering rate (Gauld, 1953). This explanation partly fits the
results for *Pseudodiaptomus marinus* which showed a clear diel vertical migration between the near-benthic layer and the upper water column. However, a constant filtering rate was not observed during the night in the present study. Although the diel vertical migration of *Oithona davisae* has not been studied in Tokyo Bay, a high biomass was observed in the daytime in shallow waters where the chlorophyll *a* concentration was high (Anakubo, 1982). Therefore, other explicable models (e.g., the hunger-satiation model of Pearre, 1973) are needed to explain the feeding rhythm of non-migrating copepods.

Daily community grazing rates were calculated from the results of bottle incubations, assuming that the feeding period lasted from dusk to dawn, based on the time series observations of gut fluorescence. However, weak fluorescence was observed even in the daytime for *O. davisae* and *Paracalanus* spp. This result suggested that a part of the population continued to graze during the daytime, and/or different types of functional response to food concentration existed in copepods between night and day as in cladocerans (Haney, 1985). The community grazing rate estimated by the bottle incubation method might be somewhat low, since daytime feeding was ignored. On the other hand, the gut fluorescence method disregarded feeding selectivity and could not evaluate the ingestion rate on microzooplankton and pigment-free particles but only on phytoplankton cells. Accordingly, ingestion rates of omnivorous copepods are underestimated. However, it would be advantageous to understand the interactions between primary producers and copepods as primary consumers.

From bottle incubations the copepod communities were estimated to graze 3.0% and 3.1–4.5% of the standing crops of suspended particles per day in February and August, respectively. In November the gut fluorescence method estimated that the copepod community grazed 4.2–11.9% per day. The estimate in February by bottle incubations might be considerably low, since the ingestion rate of the numerically abundant copepod *Oithona davisae* was not measured. The reported part of the primary production consumed by zooplankton grazing ranged from less than 1% to over 100% (Menzel and Ryther, 1961; Taguchi and Fukuchi, 1975; Malone and Chervin, 1979; Sonntag and Parsons, 1979; Dagg *et al.*, 1982; Joris *et al.*, 1982; Dagg and Turner, 1982; Nicolajsen *et al.*, 1983; Tsuda *et al.*, 1985). Although we did not measure the primary production, high photosynthetic activity has been reported in Tokyo Bay (Funakoshi *et al.*, 1974; Shibata and Aruga, 1982; Brandini and Aruga, 1983). If we assumed that the primary productivity in Tokyo Bay is 2 gC m⁻² day⁻¹ (Funakoshi *et al.*, 1974, Yamaguchi and Shibata, 1979), the copepod community will graze, at most, about 10% of the primary production.

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**References**


東京湾における棲息類群集の天然懸濁懸粒子に対する摂餌

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東京湾内湾部における3回の航海で、棲息類群集の摂餌速度をパーティクルカウンターを用いた飼育実験および消化管内色素量の時間変動から求めた。棲息類群集には懸濁粒子による選択性の違いが認められた。すなわち2月に卓越した Acartia omori 須肌懸懸粒子サイズスペクトルで卓越した粒子を選択的に摂餌し、周年卓越した Oithona davisae および2月に出現した Centropages abdominalis は20μm以上の大型の粒子を選択的に摂餌した。この結果、懸濁類群集の特定の懸濁サイズに対する懸濁速度は全懸濁サイズでの平均懸濁速度の数値に達した。また、Paracalanus spp., Pseudodiaptomus marinus および Oithona davisae については消化管内色素量の時間変動から夜間に摂餌速度が高いことが明らかになった。

現場懸濁類群集の観察および実験結果から懸濁類群集の日間摂餌速度を求めた結果、2月には懸濁懸懸粒子現存量の3.0％、8月には3.1-4.5％、また11月には4.2-11.9％が懸濁類群集に摂餌されると推定された。

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