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Late spring radiolarian fauna in the surface water off Tassha, Aikawa Town, Sado Island, central Japan

Takuya ITAKI*, Atsushi MATSUOKA**, Kazuhiro YOSHIDA***, Satoru MACHIDORI***, Midori SHINZAWA*** and Takashi TODO****

Abstract

Fifteen radiolarian species were found in a plankton sample collected from surface water shallower than 10 m at the eastern margin of the Japan Sea off Tassha, Aikawa Town, Sado Island, central Japan in late May 2002. The late spring fauna was characterized by *Lithomellisa setosa*, *Tetrapyle octacantha*, *Stylodictya* spp., *Spongodiscus* spp. and *Larcopyle butschlii*. It is similar to that reported in late June 2001, but is different from that in early September 2000. Most individuals of warm-water species such as *T. octacantha*, *Didymocyrtis tetrathalamus* and *Euchitonia furcata* were juveniles.

Key words: Japan Sea, plankton, Radiolaria, Sado Island, Tsushima Warm Current, water temperature.

Introduction

Radiolaria are planktonic protists with opaline skeletons distributed in the world oceans. Their fossil records in marine sediments have been widely used as paleoceanographic indicators. In the Japan Sea, radiolarian faunal changes during the late Quaternary were used for reconstructing paleoceanographic conditions (Sakai, 1984; Morley et al., 1986; Itaki, 2001). However, radiolarian ecology in the sea is not yet well understood. Our knowledge of seasonal change in particular is very limited.

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* Institute for Marine Resources and Environment, Geological Survey of Japan, AIST, Tsukuba 305-8567 Japan
** Department of Geology, Faculty of Science, Niigata University, Niigata 950-2181, Japan
*** Graduate School of Science and Technology, Niigata University, Niigata 950-2181, Japan
**** Sado Marine Biological Station, Faculty of Science, Niigata University, Aikawa, Sado, Niigata 952-2135, Japan
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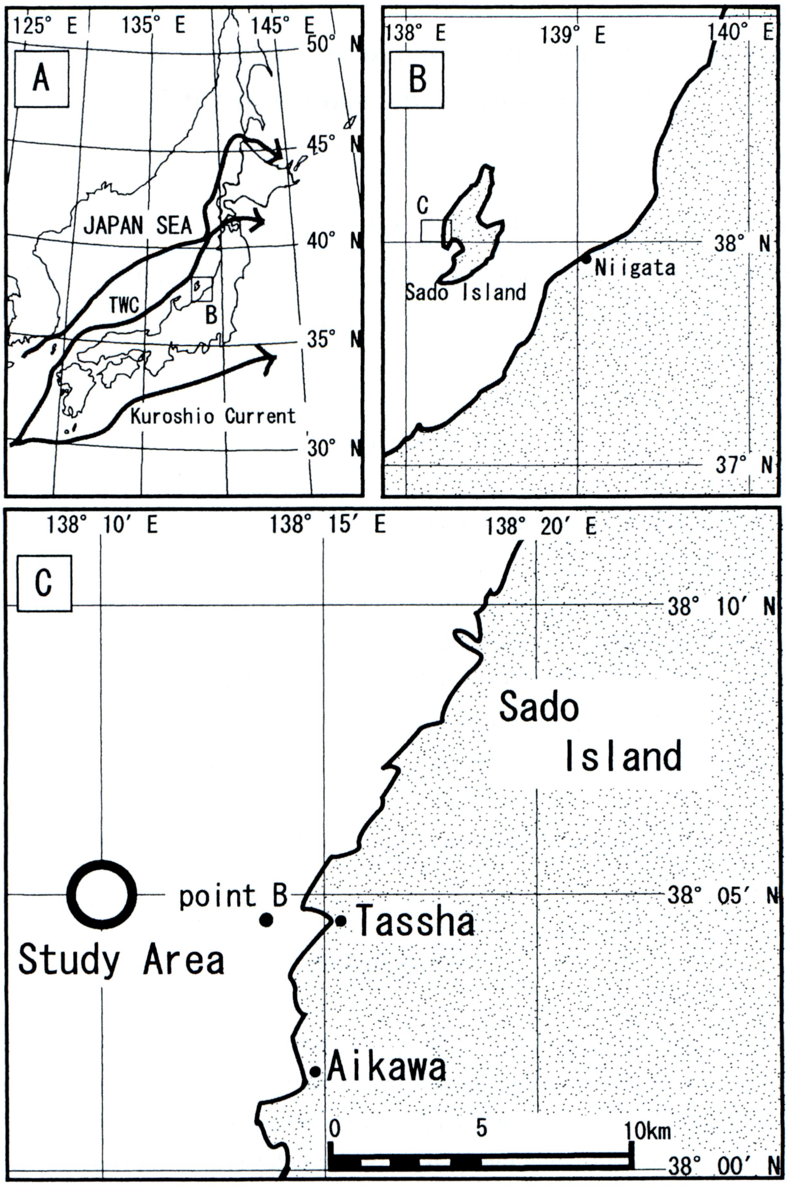

Fig. 1. Map showing the study area. Arrows indicate warm water currents such as the Tsushima Warm Current (TWC) and the Kuroshio Current (After Naganuma, 1977).

The Sado Marine Biological Station of Niigata University at Tassha, Aikawa Town, Sado Island, Niigata Prefecture, central Japan, is one of the best places for studying seasonal change in planktonic organisms of the Japan Sea because the Tsushima Warm Current (TWC), a branch of the Kuroshio Current, flows to the north of Sado Island along the eastern margin of the

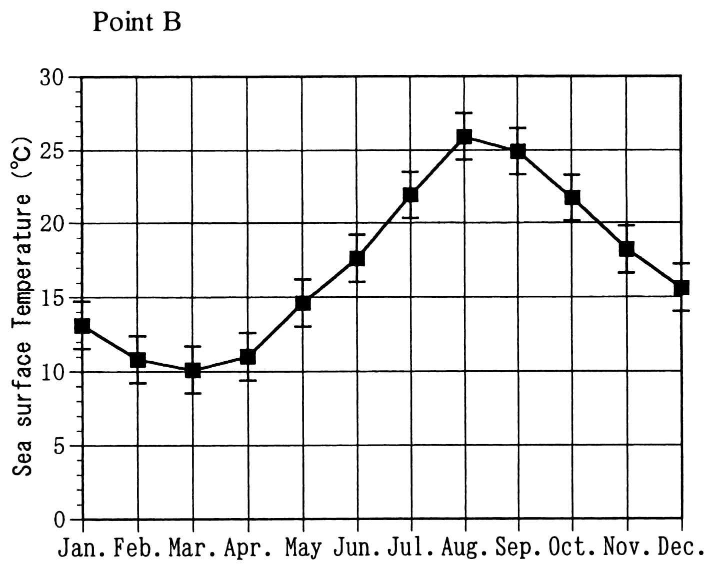

Fig. 2. Annual change in the sea-surface temperatures (SST) at Point B approximately 3 km west of Tassha, Sado Island. Solid-square plots and error bars indicate the mean SST and their standard deviation (data from 1995-2000; Sado Marine Biological Station, 1997, 1998, 1999, 2000, 2001).

Japan Sea (Fig. 1). The sea-surface temperature (SST) off Tassha annually ranges from 10 to 26 °C (Fig. 2). Abe et al. (1984) reported seasonal variations in planktonic organisms including some radiolarian species in Tassha Bay from January 1982 to January 1983 and showed that the plankton community is strongly affected with the TWC.

Radiolarian faunas in surface waters off Tassha have been studied continuously since 2000. Matsuoka et al. (2001) and Matsuoka et al. (2002) have reported radiolarian faunal compositions in early September 2000 and late June 2001, respectively. This is a first report on faunal analysis of the late spring (May 2002) off Tassha, Sado Island and is compared with our previous results on summer radiolarian assemblages.

All authors participated in the sampling on board and engaged in net towing, temperature measurement and sea condition observations. Radiolarian faunal analysis was carried out by the first author (T.I.).

Materials and methods

The plankton sample was obtained from 0-10 m depth at a location approximately 6 km west of Tassha (Fig. 1). Sampling was carried out by the vessel "Iwayuri" in the afternoon of 20 May, 2002, using a 44 μm opening net with a 0.5 x 0.5 m mouth (no. 3 net of Matsuoka, 2002). The volume of towed water estimated by a flow meter was 5.5 m^3. At the sampling site,

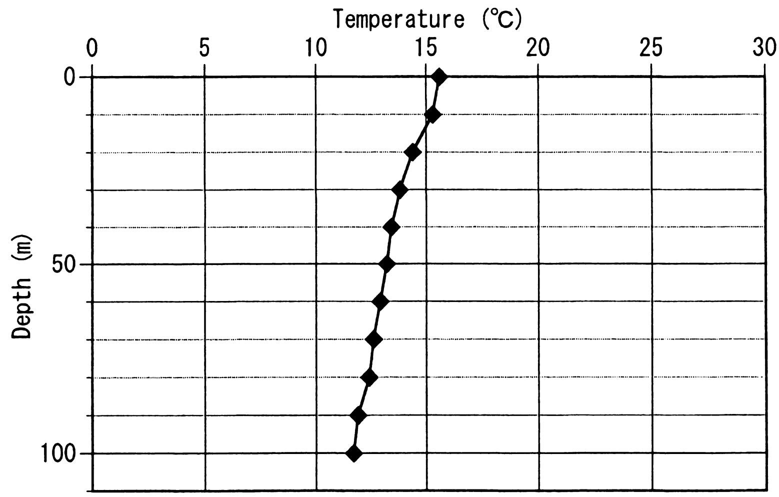

Fig. 3. Temperature profile at the sampling location off Tassha, Sado Island on 20 May, 2002.

we recorded a temperature profile of the upper 100 m of the water column. The water temperature decreased gradually from 15.6°C at sea-surface to 11.7°C at 100 m water depth (Fig. 3).

The plankton sample was placed in ca. 50 % sulfuric acid for a half day to obtain silica skeletons of radiolarians. Residues were collected on a 45 μm opening sieve and rinsed with water. After drying, materials were mounted in Canada balsam for microscopic observation. All radiolarian specimens were identified and counted under an optical microscope at 100 x or 200 x magnification. Light microscopic images of radiolarian skeletons were taken by a digital camera system (Microscope Network, NY2000S) equipped to a light microscope.

Results and discussions

A total of 116 radiolarian tests were encountered in the plankton-net sample (Table 1). The standing stock was 21 shells/m^3. Previous studies in summer season off Tassha showed that radiolarian density in surface water is less than that in deeper waters (Matsuoka et al., 2001, 2002). Compared with results in July 1999 off Hokkaido (Itaki, 2003), the standing stock is more than twice that in surface water (0-40 m; 9 shells/m^3), but is much less than that in sub-surface water (40-80 m; 220 shells/m^3).

The radiolarian assemblage is composed of fifteen species, twelve spumellarians and three nassellarians. Phaeodarian Radiolaria were not found in the sample. *Lithomellisa setosa* Jørgensen, *Tetrapyle octacantha* Müller, *Stylodictya* spp., *Spongodiscus* spp. and *Larcopyle butschlii* Dreyer constituted 78 % of the total assemblage (Fig. 4). This radiolarian assemblage is similar to that in late June 2001 (Matsuoka et al., 2002), but is quite different from that in early September 2000 which is dominated exclusively by warm-water species (Matsuoka et al., 2001).

Lithomellisa setosa, one of the most dominant spring species, constituted 21 % of the total assemblage in this study (late May). It was not found in early September 2000 (Matsuoka et al., 2001) and was minor in late June 2001 (Matsuoka et al., 2002). This species was recorded as "unknown Radiolaria" in March 1983 in Tassha Bay (Abe, 1993, Plate 11, Figs. A-C). The rarity or absence of this species in summer season could result from the dilution by other more abundant radiolarians. *Lithomellisa setosa* has been also reported from the equatorial Pacific (Yamashita et al., 2002) and the fjords of Norway (Bjørklund, 1974; Swanberg and Bjørklund, 1987). According to Yamashita et al. (2002), this species is abundant in surface waters of upwelling areas of the equatorial Pacific but is rare in the western Pacific warm pool (WPWP) in January 1999.

Tetrapyle octacantha, *Euchitonia furcata* Ehrenberg and *Didymocyrtis tetrathalamus* (Haeckel) in the plankton sample are generally known as warm-water species, based on their geographic distribution in surface sediments from the Japan Sea (Motoyama, 1995). Most individuals of these three species are juvenile forms with an immature or small-sized shell. In Tassha Bay, the SST rapidly increases during late spring to early summer from 11°C in April to 22°C in July (Fig. 2) and the increase in the number of plankton organisms relating to the warm water in May is remarkable (Abe et al., 1984). The SST at our sampling location was 15.6°C (Fig. 3), corresponding to the earliest increase in the SST (Fig. 2). The occurrence of warm-water radiolarians in the plankton sample is probably related to TWC water. The dominance of juvenile forms in warm-water radiolarian faunas may result from early phase reproduction.

Larcopyle butschlii constituted 9 % of the total assemblage. This species comprised more than 40 % of the total assemblage in late June 2001 (Matsuoka et al., 2002), but was not found in early September 2000 (Matsuoka et al., 2001). This species is the most dominant radiolarian in modern Japan Sea sediments (Motoyama, 1995; Itaki, 2003). Almost all *L. butschlii* with immature skeletons in the surface plankton sample are probably juveniles. Results from depth-stratified sampling of vertical plankton-tows in the Japan Sea show that juvenile forms of this species live mainly in shallow waters, but adults live deeper (Itaki, 2003). The occurrence of juvenile forms in the late spring assemblage is concordant to the vertical distribution obtained from depth-stratified sampling.

Concluding remarks

The late spring (May) radiolarian fauna in surface waters off Tassha is characterized by abundant *Lithomellisa setosa* Jørgensen, *Tetrapyle octacantha* Müller, *Stylodictya* spp., *Spongodiscus* spp. and *Larcopyle butschlii* Dreyer. The assemblage is similar to that in late

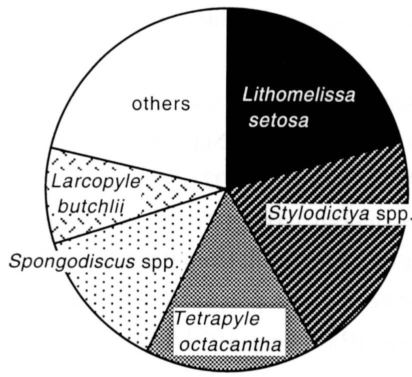

Fig. 4. Faunal composition of late spring surface water radiolarians off Tassha, Sado Island.

June 2001, but quite different from that in early September 2000. We report only surface water assemblage in this paper. Seasonal changes in radiolarian faunas will be discussed in more detail when microscopic observations are completed in the near future.

Taxonomic remarks

***Didymocyrtis tetrathalamus* (Haeckel)** (Plate 1, Figs. 14-16): All three specimens of *D. tetrathalamus* are juveniles similar to those shown in Takahashi (1991, Plate 21, figs. 1-7).

***Euchitonia furcata* Ehrenberg** (Plate 1, Figs. 12-13): In well developed specimens of *E. furcata*, a patagium is recognized between the arms (e.g., Itaki, 2001, Plate 1, figs. 2-3). This feature is not observed in our specimens.

***Larcopyle butschlii* Dreyer** (Plate 1, Fig. 24): This species has an immature cortical shell with short radial spines and has been identified as a juvenile (Itaki, 2003).

***Spongodiscus* spp.** (Plate 1, Figs. 1-5): *Spongodiscus* spp. are characterized by having a discoidal, spongy shell without spines. Two morphotypes are included: *Spongodiscus* sp. A (Plate 1, Figs. 1-2) and *Spongodiscus* sp. B (Plate 1, Figs. 3-5). *Spongodiscus* sp. B is very similar to *Spongodiscus* sp. A, but the spongy lattice shell is slightly rougher than that of *Spongodiscus* sp. A.

***Stylodictya* spp.** (Plate 1, Figs. 6-9): Two morphotypes are recognized in the genus *Stylodictya*, i.e., *Stylodictya* sp. A (Plate 1, Figs. 6-7) and *Stylodictya* sp. B (Plate 1, Figs. 8-9). *Stylodictya* sp. A has a shell with unclear concentric rings lacking radial spines. *Stylodictya* sp. B has a shell with more pronounced concentric rings and short radial spines.

***Tetrapyle octacantha* Müller** (Plate 1, Figs. 17-22): Most specimens of this species are less than 100 μm in size. This is remarkably small compared with specimens collected in summer off Tassha shown in Matsuoka et al. (2001, 2002).

Table 1. List of radiolarian species from the surface water off Tassha, Sado Island on 20 May, 2002.

Taxa	Shell No.	%	Plate 1 Fig. #
Suborder SPUMELLARIA Ehrenberg			
Family COCCODISCIDAE Haeckel			
Didymocyrtis tetrathalamus (Haeckel)	3	2.6	14-16
Family SPONGODISCIDAE Haeckel			
Spongodiscus sp. A	8	6.9	1-2
Spongodiscus sp. B	7	6.0	3-5
Stylodictya sp. A	16	13.8	6-7
Stylodictya sp. B	8	6.9	8-9
Spongodiscidae gen. et sp. Indet.	5	4.3	
Family PORODISCIDAE Haeckel			
Euchitonia furcata Ehrenberg	4	3.4	12-13
Euchitonia (?) sp.	2	1.7	10-11
Family PYLONIIDAE Haeckel			
Tetrapyle octacantha Müller	18	15.5	17-22
Octpyle stenozona Haeckel	1	0.9	23
Family LITHELIIDAE Haeckel			
Larcopyle butchlii Dreyer	10	8.6	24
Litheliidae gen. et sp. Indet.	1	0.9	25
other spumellarians	5	4.3	
Suborder NASSELLARIA Ehrenberg			
Family PLAGIACANTHIDAE Hertwing			
Lithomellisa setosa Jørgensen	24	20.7	27-32
Family ACANTHODESMIIDAE Haeckel			
Tholospyris sp.	1	0.9	26
Family PTEROCORYTHIDAE Haeckel			
Pterocorys sp.	1	0.9	33
other nassellarians	2	1.7	
Total	116	100	

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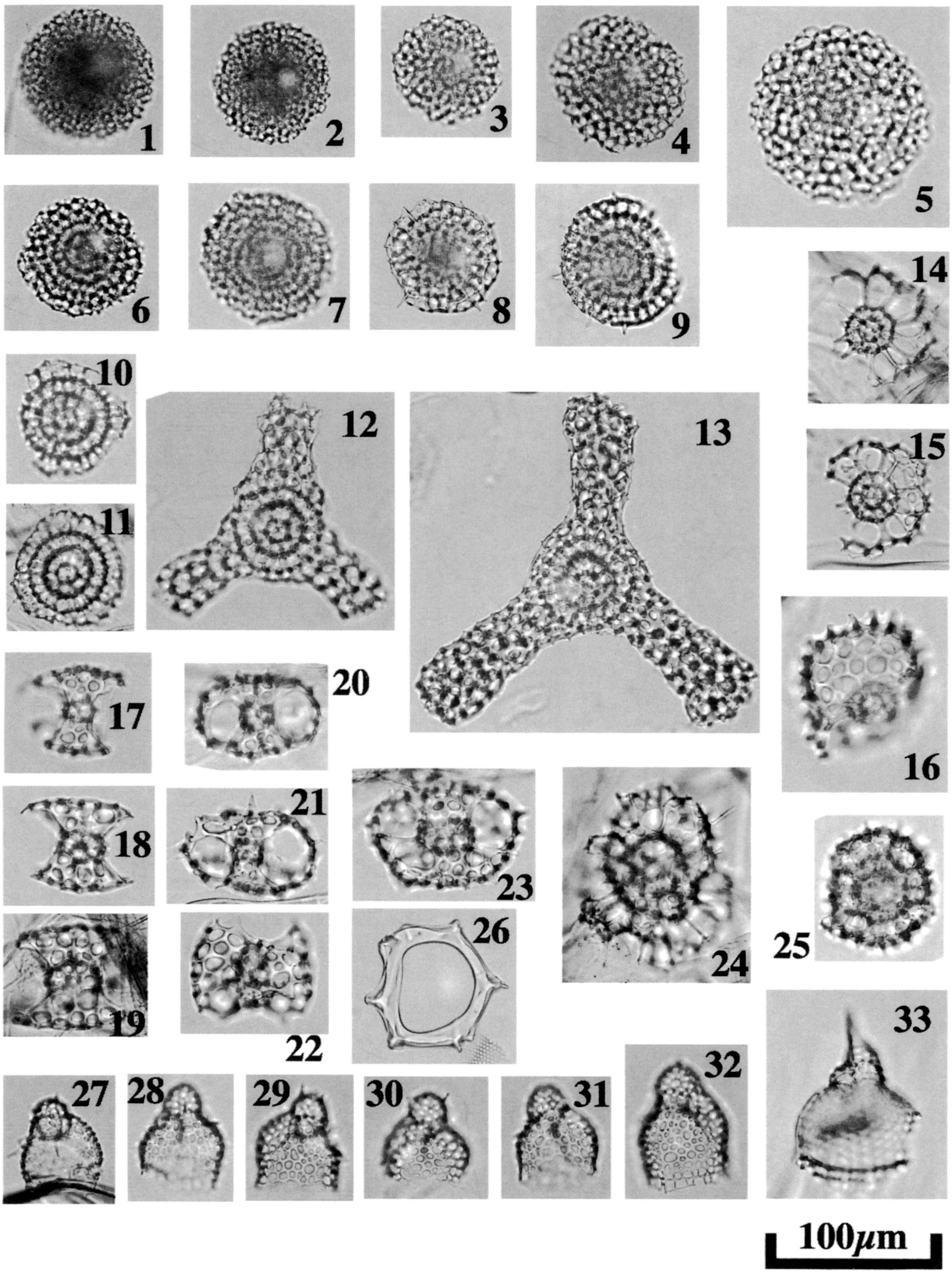
Explanation of Plate 1

Photomicrographs of radiolarian skeletons from the surface water off Tassha on 20 May 2002. The scale bar in the right bottom corner of Plate equals 100 μm.

1-2. *Spongodiscus* sp. A
3-5. *Spongodiscus* sp. B
6-7. *Stylodictya* sp. A
8-9. *Stylodictya* sp. B
10-11. *Euchitonia* (?) sp.
12-13. *Euchitonia furcata* Ehrenberg
14-16. *Didymocyrtis tetrathalamus* (Haeckel)
17-22. *Tetrapyle octacantha* Müller
23. *Octpyle stenozona* Haeckel
24. *Larcopyle butschlii* Dreyer
25. Litheliidae gen. et sp. indet.
26. *Tholospyris* sp.
27-32. *Lithomellisa setosa* Jørgensen
33. *Pterocorys* sp.

Plate 1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