Temperature profile and radiolarian fauna in surface waters off Tassha, Aikawa Town, Sado Island, central Japan

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Abstract

The water temperature profile in early September off Tassha, Sado Island, is well stratified. The uppermost 20-30 m layer in water column has a homogenous temperature of ca. 27° C. This layer corresponds to well mixed surface water. The surface layer is underlain by a water mass with a temperature gradient of ca. 1.6° C/10 m. This water mass corresponds to the upper part of thermocline. The temperature at the deepest (100 m) two sites was 15.3° C and 15.4° C, respectively. Radiolarian abundance correlates well with the water temperature profile. Few radiolarian individuals were obtained in surface (0-10 m) tows, while deep tow (up to 150 m deep) samples generally contained rich radiolarian faunas. The faunal association is similar to that of the Kuroshio Warm Current but species diversity is much lower. This may be the result of a sorting effect associated with branching of the Tsushima Current from the Kuroshio Current. No cold water species indigenous to deep waters in the Sea of Japan were recovered.

Key words: plankton, radiolaria, Sado Island, Sea of Japan, Tsushima Current, water temperature.

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Fig. 1. Research boat (IBIS 2000) in the Sado Marine Biological Station, Niigata University.

Introduction

Radiolarians are abundant in the pelagic environment but are generally believed to be uncommon in coastal waters. However, living radiolarians have been reported from surface waters off Okinawa Island, southwest Japan (Matsuoka, 1993) and off the Izu Peninsula, central Japan (Sashida and Uematsu, 1994; Sashida and Kurihara, 1999). These coastal faunas are rather rich and indicate radiolarians must play an important role even in near-shore ecosystems.

Radiolarians and other planktonic organisms around Sado Island have been reported briefly by Abe et al. (1984) and Abe (1993). In the present study, the senior author (A. M.) has attempted since 1992 to obtain radiolarians from surface waters off the coast of Niigata and near Sado Island but with little success. The Sado Marine Biological Station (SMBS) of the Faculty of Science, Niigata University has recently introduced a new research boat, IBIS 2000 (3.8 t) (Fig. 1), which now makes it possible to perform marine plankton research, including deeper tows in plankton sampling.

Upon introduction of the new boat, we began marine environmental research around the station. As a first step, we measured the temperature profile of the upper 100 m of the water column. Deep tows up to 150 m were carried out in the coastal area off Tassha (Fig. 2). This paper reports the temperature profile and radiolarian assemblages from the subsurface waters.

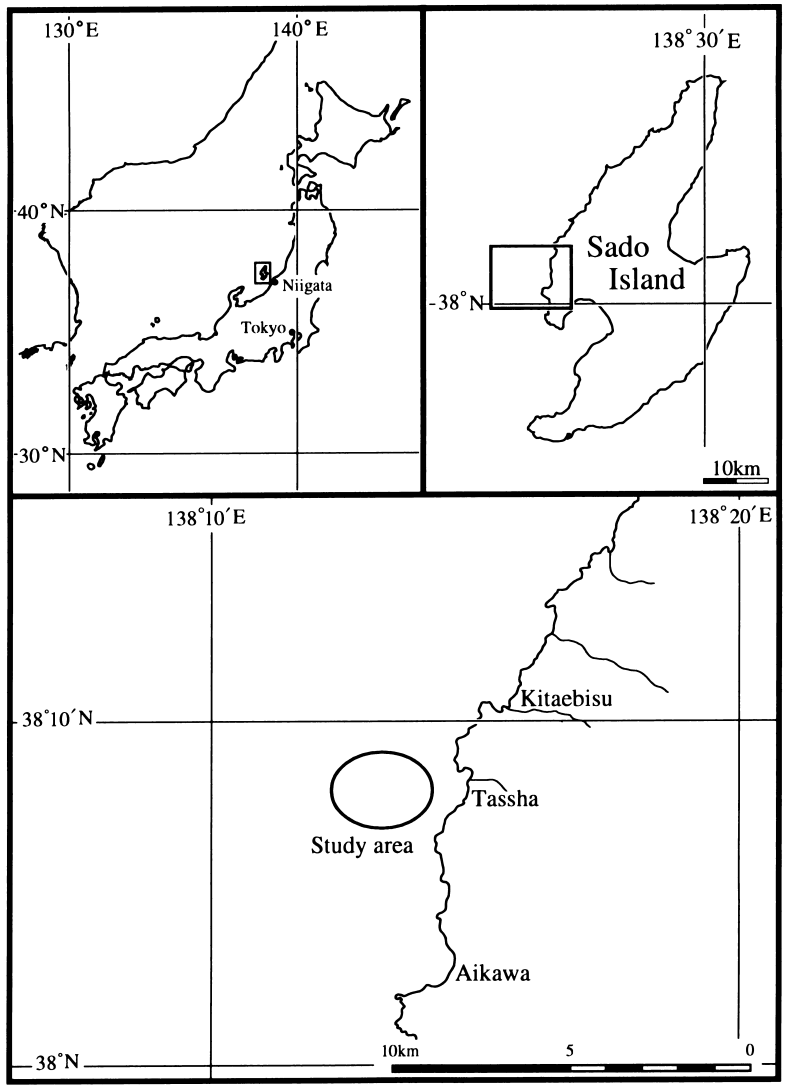

Fig. 2. Map showing the study area.

Materials and methods

Plankton samples were obtained at locations approximately 2-3 km west of Tassha, Aikawa Town, Sado Island, Niigata Prefecture, central Japan (Fig. 2). Sampling was performed in the morning and afternoon of September 6th and the morning of September 7th in 2000. Surface and subsurface tows were carried out in each sampling operation. A 46 μm mesh net with 0.5 x 0.5 m square opening and a 64 μm mesh net of the Marukawa type with a 0.5 m diameter mouth were used for surface and subsurface tows, respectively. Tow duration

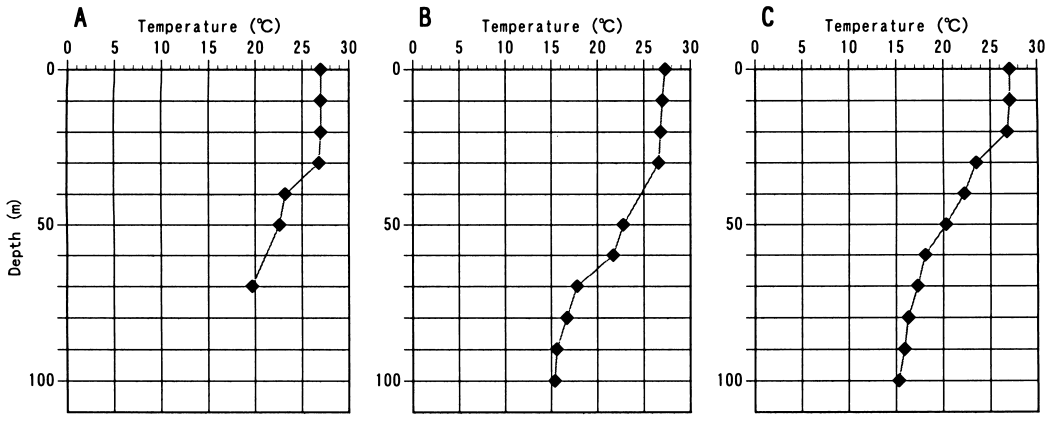

Fig. 3. Temperature profiles in the surface waters off Tassha, Sado Island.
A: morning of Sept. 6, B: afternoon of Sept. 6, C: morning of Sept. 7, 2000.

was usually ca. 5 min. At the sampling sites, we recorded temperatures with a digital thermometer.

On return to the laboratory, the plankton samples were allowed to settle for ca. 30 min. to condense planktonic organisms on the bottom of sampling containers. Small aliquots of the sample were placed in a dish, examined with a binocular microscope and individual radiolarian specimens were drawn into a Pasteur pipette and transferred to another dish containing seawater obtained at the collection site.

Images of living radiolarians and other organisms were taken with a CCD camera equipped with an inverted microscope Nikon Diaphot. Following observation of living organisms, all plankton samples were placed in 50 % sulfuric acid for a day to obtain silica skeletons of radiolarians. The residues were collected on a 46 μm mesh sieve, rinsed with water, and mounted in Canada balsam for light microscopic observation. Light microscopic images of radiolarian skeletons were taken by a digital microscope (Keyence VH-7000).

Results

1. Temperature profile

Temperature profiles at three sites are presented in Fig. 3. The water mass in the study area is well stratified. The uppermost 20-30 m in water column has a homogenous temperature of ca. 27° C. This layer corresponds to well mixed surface water. The surface layer is underlain by a water mass with a temperature gradient of ca. 1.6° C/10 m. This water mass corresponds to the upper part of thermocline layer. Temperatures recorded at the deepest two sites (100 m) were 15.3° C and 15.4° C, respectively.

Table 1. List of radiolarian species from the surface waters off Tassha, Sado Island.

SPUMELLARIA
***Dictyocoryne profunda* Ehrenberg**
***Didymocyrtis tetrathalamus tetrathalamus* (Haeckel)**
***Hymeniastrum euclidis* Haeckel**
***Spongaster tetras tetras* Ehrenberg**
***Spongodiscus biconcavus* Haeckel**
***Spongosphaera streptacantha* Haeckel**
***Tetrapyle octacantha* Müller**
NASSELLARIA
***Acanthodesmia vinculata* Müller**
***Lipmanella dictyoceras* (Haeckel)**
***Lophophaena hispida* (Ehrenberg)**
***Neosemantis distephanus* (Haeckel)**
***Pseudocubus obeliscus* Haeckel**
***Pseudodictyophimus gracilipes* (Bailey)**
***Spirocyrtis scalaris* Haeckel**
***Zygocircus productus* (Hertwig)**

2. Radiolarian faunas

The richness of radiolarian samples is highly variable. Few individuals were obtained in surface (0-10 m) tows. Whereas deep tow samples generally contained a fairly rich fauna. Fifteen radiolarian species were identified in the deeper tows (Table 1). Living radiolarians are illustrated in Plate 1 together with planktonic foraminifers. Plate 2 shows radiolarian skeletons of selected species. Dominant radiolarian species include *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel), *Tetrapyle octacantha* Müller, *Zygocircus productus* (Hertwig), *Neosemantis distephanus* (Haeckel), *Lophophaena hispida* (Ehrenberg), and *Pseudocubus obeliscus* Haeckel. All species are common in the Kuroshio Warm Current.

Discussion

Radiolarian abundance correlates well with the water temperature profile. The same is true for planktonic foraminifers. Surface waters from 0-10 m contain few radiolarians and plankton density is generally low. This is concordant with the high degree of transparency in the surface waters around Sado Island in summer. Waters below the surface mixed layer are rather rich in radiolarians and species composition is similar to that of the Kuroshio Warm Current. This suggests that the radiolarians may be derived from the Tsushima Current, a branch of the Kuroshio Current. However, species diversity is much lower than in surface waters of the Kuroshio Current around Okinawa Island (Matsuoka, 1993) and off the coast of Shimoda, Izu

Peninsula (Sashida and Uematsu, 1994; Sashida and Kurihara, 1999). This could result from a sorting effect associated with branching of the Tsushima Current from the Kuroshio Current.

Analysis on radiolarian assemblages from surface sediments (Motoyama, 1995; Itaki et al., 1997) and core samples (Itaki et al., 1996) in the Sea of Japan indicate that Japan Sea waters lying below the surface waters are characterized by cold water species such as *Larcopyle butschlii* Dreyer, *Cycladophora davisiana davisiana* Ehrenberg, and *Ceratospyris borealis* (Bailey). Recently, more direct evidence for the vertical distribution of these species has been clarified by using plankton tow samples at different levels of water column in the Sea of Japan (Itaki et al., 2000). We have not recovered any of the above species from the surface waters in the study area off Tassha. They probably cannot be transferred from deeper/colder parts of the water column in summer when the water is so well stratified in terms of temperature and density. Cold water species may occur in winter time when the stratification is disturbed.

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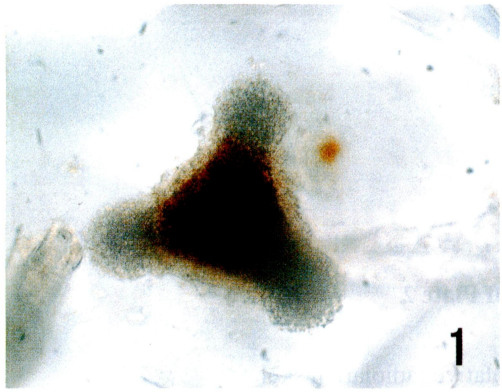
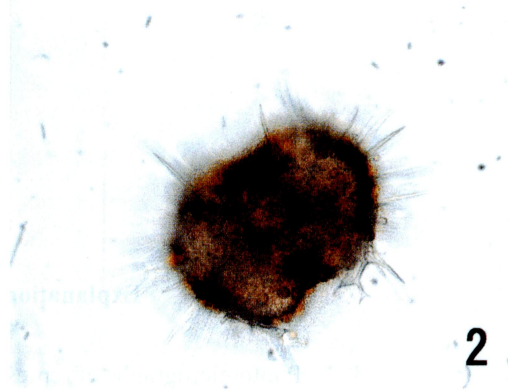
Explanation of Plate 1

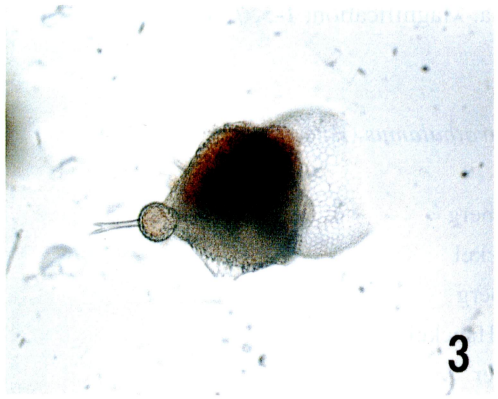
Light microscopic images of living Protista from surface waters off Tassha. Magnification; 1-4: × 180, 5-8: × 90.

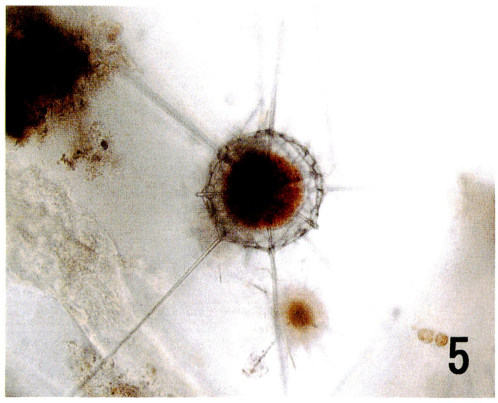
1. *Dictyocoryne profunda* Ehrenberg [Spumellarian Radiolaria]
2. *Tetrapyle octacantha* Müller [Spumellarian Radiolaria]
3. *Lipmanella dictyoceras* (Haeckel) [Nassellarian Radiolaria]
4. *Pseudocubus obeliscus* Haeckel [Nassellarian Radiolaria]
5. Acantharia gen. et sp. indet. [Acantharian Radiolaria]
6. Phaeodaria gen. et sp. indet. [Phaeodarian Radiolaria]
7. Planktonic Foraminifer
8. Planktonic Foraminifer

Plate 1









Explanation of Plate 2

Photomicrographs of representative radiolarian skeletons from the surface waters off Tassha. Magnification; **1-5, 7, 8: × 128, 6: × 64**

1. *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel)
2. *Tetrapyle octacantha* Müller
3. *Spongaster tetras tetras* Ehrenberg
4. *Spongodiscus biconcavus* Haeckel
5. *Dictyocoryne profunda* Ehrenberg
6. *Spongosphaera streptacantha* Haeckel
7. *Acanthodesmia vinculata* Müller
8. *Spirocyrtis scalaris* Haeckel

Plate 2