La mer 29; 170-173, 1991
Société franco-japonaise d'océanographie, Tokyo

Preliminary studies on the energy budget of a deep-sea nematode

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Abstract: Ingestion and absorption rates of a nematode, *Paramonohystera* sp., were measured to discuss the energy budget of meiofauna in the deep sea. Its respiration rate was estimated using a datum of the same species collected at another locality in another cruise. The ingestion rate measured was distinctively low, and the energy ingested did not balance with the energy respired. The absorption rate was found to be comparable to the ingestion rate. These results suggested that dissolved organic matter is as important as particulate organic matter as an energy source for the deep-sea nematode.

1. Introduction

The deep-sea environment has been believed as a food-limited world for a long time (THIEL, 1975, 1979). This idea has been strongly supported by the measurement of metabolism of deep-sea fishes (SMITH and HESSLER, 1974; SMITH and BROWN, 1983). In these studies, respiration rates of deep-sea species have been found to be one to two order of magnitude slower than their shallow-water relatives, and this reduction of the metabolic activity has been discussed as an adaptation to the energy-limited environment.

Recently, on the other hand, active respiration rates of deep-sea meiofaunal taxa have been measured by present author (SHIRAYAMA, 1992). The later results further lead to a question how meiofauna obtain enough energy in the deep-sea environment.

Ingestion rates of meiofauna have been measured using a radioactive substance as a tracer (MONTAGNA, 1984a). It is impossible to carry out such an experiment in the field due to the strict regulation for the use of radioactive material in Japan. However bathyal meiofauna is active under one atmospheric pressure even though they experienced rapid decompression, as proven in the respiration rate measurement (SHIRAYAMA, 1992). The present study is to add some information regarding the ingestion rates of a bathyal nematode *Paramonohystera* sp. obtained through the experiment carried out in a laboratory. It was also aimed to discuss about the balance of input and output of energy along the deep-sea nematode.

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2. Materials and Methods

Respiration rates of deep-sea nematodes were measured using the stoppered-diver method (HAMBURGER, 1981), a kind of Cartesian diver technique. Detail of the method as well as the materials used have been described elsewhere (SHIRAYAMA, 1992). *Paramonohystera* sp. used for the measurement of ingestion rate were collected from a bathyal depth of the Suruga Bay, central Japan using a box corer at station A3 of the R.V. Tansei-Maru cruise KT-86-01. The sampling station was situated at 35° 00.96′ N and 138° 41.18′ E at a depth of 1214 m. *Paramonohystera* sp. was by far more abundant than other nematode species at this station.

Immediately after the sampling, subsamples of the sediment were taken using acrylic-resin subcores (3.6 cm in inner diameter) on board ship. They were kept in cool (5° C), and transferred into a laboratory on land for the tracer experiments.

Tritiated thymidine or ^{14}C-amino acid

mixture was inoculated into the overlying water of each subcore and stirred gently. Then subcores were incubated at 5° C for 0, and 270 minutes, and finally formalin was added to stop the experiments.

An aliquot of sedment sample was taken and washed with sea water on the millipore filter of 0.2 μm opening. The radioactivity of the filter was measured using a liquid scintillation counter to measure the final radioactivity of the particulate organic matter in the sediment.

Another aliquot of the sediment was taken to count bacterial abundance. The microbes were stained with DAPI, and their number was counted under a fluorescent microscope. *Paramonohystera* specimens were sorted out under a binocular dissecting microscope from the sediment which was washed with 100 μm mesh sieve. After drawing its lateral view using camera lucida to measure the body mass, each individual was digested by soluene 100 in a scintillation vial. Liquid scintillator was added into each vial and the radioactivity was measured using a liquid scintillation counter.

3. Results

Respiration rate of the *Paramonohystera* species used in the ingestion rate measurement was not measured. To discuss the energy budget of the nematode, the value of the same species (0.78 nl O_2 hr^{-1}) collected at another area in another cruise will be used in the present study. It should be noticed that spatial difference is not very large for the respiration rate of the deep-sea nematodes (SHIRAYAMA, 1992). Above value was standardized for an individual of 1 nl in body mass using the method of HEIP *et al*, (1985). According to them, respiration of 1 ml oxygen is equivalent to consumption of 0.4 mg carbon. Using this conversion facter, the respiration rate of *Paramonohystera* was estimated as 0.31 ngC hr^{-1} ind^{-1}.

In the experriment using tritiated thymidine as a tracter, the ingestion rate of *Paramonohystera* sp. of the same body mass was measured as 1.4 nl sediment hr^{-1} ind^{-1}.

This result was not reasonable because it meant a nematode individual ingested more volume of sedment than its own every hour. On the basis of the abundance of bacteria in the sedment (3×10^9 cells cm^{-3} sediment) and the radioactivity of the sedimentary particles (3.7×10^5 DPM cm^{-3} sediment), the label of single bacterium was calculated as 1.2×10^{-4} DPM. Assuming the nematode ingested bacteria selectively, these value lead to the figure that *Paramonohystera* sp. ingested 7,400 bacterial cells hr^{-1} ind^{-1}. Assuming the amount of organic carbon in a single bacterium as 10^{-13}gC $cell^{-1}$, *Paramonohystera* sp. was estimated to ingest 0.74 ngc hr^{-1} ind^{-1}

When ^{14}C-amino acid was used as a tracer, the ingestion rate of the same animal was caculated to be as high as 35,000 cells hr^{-1} ind^{-1}. I assumed the difference of measured ingestion rate between the two experiments was a result of the direct absorption of the dissolved amino acid by the nematode from

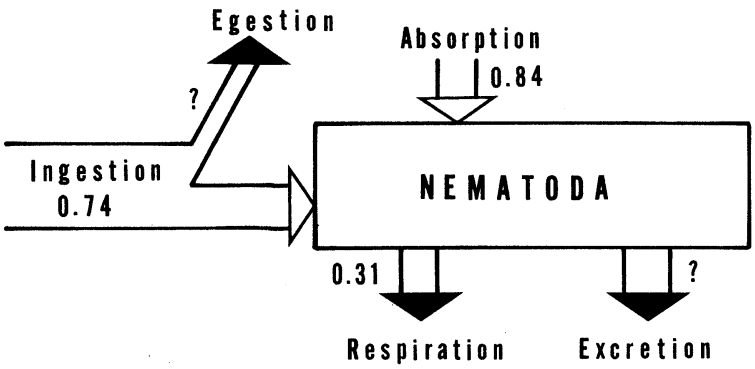

Fig.1. Diagram showing the energy balance of a deep-sea nematode.

the pore water. The radioactivity of DOC was estimated as 0.53 DPM ngC^{-1}. Assuming that DOC concentration was constant during the experiment, the absorption rate of *Paramonohystera* could be calculated as 0.84 ngC hr^{-1} ind^{-1}. The summary of measurements is shown in Fig. 1 schematically.

4. Discussion

The ingestion rates of a nematode measured using a ^{3}H- Thymidine as a tracer pointed out that *Paramonohystera* ingested about twice as much energy as they respired. This figure does not necessarily mean the nematode can obtain enough energy by means of ingestion, because it is impossible to assimilate all the ingested material, even though the animal seemed to feed on particulate organic matter selectively. When amino acid was used as a labeled substance, they seemed to obtain more energy which might be enough to balance their energy consumption by their active respiration. These results suggests that DOM plays important role as a energy source of deep-sea nematode.

MONTAGNA (1984b) has reported that shallow-water meiobenthos uses glucose as its energy source. Recently, the present author found numerous tubercles in the anterior region of other deep-sea nematode species belonging to the genus *Desmoscolex* (SHIRAYAMA, and Hope 1992) in the way of scanning electron microscopic observation. This ultrastructure may also suggest utilization of DOM by deep-sea nematodes.

Further studies are however clearly necessary to prove the above idea. It is especially desired to carry out *in situ* tracer experiments in the deep sea using a manned submersible.

Acknowledgments

The author would like to express his sincere gratitude to the officers and crew of .V. Tansei Maru of his institute and of manned-submersible "Shinkai 2000" of JAMSTEC for their help in sampling deep-sea sediments used in the pressent study. This research was partially supported by the grant-in-aid of the Ministry of Education, Science and Culture, Japan, No. 59480004, 61740371, 62740371 and 02740317.

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深海産線虫類のエネルギー収支に関する予備的研究

白山　義久

パラモノヒステリダ属の一種の線虫について，深海産メイオベントスのエネルギー収支を議論するために，摂食速度と吸収速度を計測した。またその呼吸速度は別の航海で別の海域から採集した同種のデータから推定した。計測された摂食速度は非常に低く，摂食によって得られるエネルギー量は呼吸によって消費されるエネルギー量とつり合わなかった。吸収速度は摂食速度と同じ程度であった。これらの結果は溶存態有機物が粒状有機物と同様に深海産の線虫類のエネルギー源として重要であることを示唆している。