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Fluoride Content of Antarctic Marine Animals Caught off Elephant Island*

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Summary. A number of marine animals were collected off Elephant Island (South Shetland Islands) and analyzed for fluoride (mg/kg wet weight). In fish muscle from six Antarctic species the content was low (approx. 2) not exceeding the content of fishes from other waters. In bone-tissue a concentration of 616 – 1207 was found. In some benthic living animals the amount of fluoride (determined in the whole body) was different depending on the species investigated. Low amounts of approx. 10 were encountered in a pycnogonid, an octopodid and a polychaet. Very high values of 200 – 600 were determined in isopods, amphipods, ophiuroids and asteroids, these concentrations exceeded sometimes the value found in Antarctic krill.

Introduction

Since the first report on considerable amounts of fluoride in Antarctic krill (Soevik and Braekkan 1979) a number of publications appeared dealing with and confirming these findings (Christians et al. 1981, Christians and Leinemann 1980, Szewielow 1981). Hempel and Manthey (1981) showed that larval krill is rich in fluoride too (even 50% higher than adult krill). Schneppenheim (1980) and Manthey (1980) investigated other Antarctic animals as fish, seal and penguin for their fluoride content showing that in almost all animals the major amount of fluoride is located in bones and connective tissue while the muscles contain less fluoride. No values were reported hitherto which exceed the unusual high fluoride concentrations found in Antarctic krill. In this investigation a number of Antarctic animals, especially fishes and benthic living species collected from bottom trawls off Elephant Island in March 1981, were analyzed for their fluoride content.

* Results of the Antarctic Expedition 1981 of the Federal Republic of Germany with *FRV Walther Herwig*

Materials and Methods

The animals investigated were collected during the second leg of the Antarctic Expedition 1981 of the Federal Republic of Germany on *FRV Walther Herwig* from hauls made with a 200′ bottom trawl off Elephant Island (South Shetland Islands) on 17 – 19 March 1981 in depths from 100 m to 500 m (Kock 1982).

Fishes were sacrificed immediately after hauling and subsequently filleted and eviscerated. Muscles, emptied stomachs, emptied gastric tracts and vertebrae were collected and separately frozen to −35 °C and stored at the same temperature until analysed. All other specimen were separately frozen without further treatment. After determination of the species – if possible – all samples were analyzed for fluoride.

Fluoride Determination

All solutions were stored and measurements performed in polyethylene tubes. Analyses were carried out at least twice. The following procedure was used: samples were thawed and homogenized in a blender. Amounts of 1 g – 10 g depending on the fluoride content supposed were ashed in nickel crucibles protected by a nickel lid in a muffle furnace at 550 °C for approximately 15 h. It was proved that the recovery-rate of fluoride was quantitative under the conditions employed. After ashing 5 g sodium hydroxide were added and fused with the sample to a semi-solid mass which was cooled and subsequently dissolved in distilled water at 70 °C. The clear solution was brought to a pH of approximately 5 with hydrochloric acid and diluted to volume. An aliquot was buffered to pH 5 – 5.5 by addition of the same volume of TISAB-buffer (Frant 1968). Fluoride concentrations were measured with a fluoride-specific electrode (ORION 94-0900) and a reference electrode (ORION 90-0100) connected with an ionometer (pMX 500, Wissenschaftlich-technische Werkstätten, Weilheim). The amount of fluoride was calculated from the potential change while adding known amounts of fluoride-standards (Selig 1973). A blank test was carried out with the same reagents, and the results of it taken into account in the calculations. The coefficient of variation of the fluoride determination method was 3% at fluoride concentrations of approx. 500 mg/kg. If concentrations were lower (1 – 20 mg/kg) the coefficient increased to 5%.

Results

The fluoride contents of some tissues of six Antarctic fish species are given in Table 1.

In all muscle samples the fluoride level is low ranging from 1.3 to 2.2 mg/kg. The components of the digestive

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Table 1. Fluoride content in different tissues of six Antarctic fish species (gastric tracts and stomachs were pooled and homogenized prior to analysis). Length is total length in centimetres, weight mean weight in grammes

Species	*n*	Length/ weight	Sample	Sex m/f[a]	Fluoride (mg/kg wet weight)
Micromesistius australis	1	nd	Muscle	nd	1.4
(Gadidae, pisces)	1		Vertebra		1207
Notothenia gibberifrons	1	39 cm	Muscle	−/1	1.3
(Nototheniidae, pisces)	1		Vertebra		1156
Notothenia rossii marmorata	1	45 cm	Muscle	nd	2.2
(Nototheniidae, pisces)	1		Vertebra		964
Notothenia (coriiceps) neglecta	1	33 cm	Muscle	1/−	3.7
	1		Vertebra		865
(Nototheniidae,	3	8.7 g	Gastric tract	3/−	6
pisces)	3	10.1 g	Stomach	3/−	3.7
Chaenocephalus aceratus	1	48 cm	Muscle	−/1	1.8
	1		Vertebra		1143
(Channichthyidae,	5	20.2 g	Gastric tract	2/3	2.9
pisces)	5	49 g	Stomach	2/3	1.8
Champsocephalus gunnari	1	44 cm	Muscle	−/1	1.9
	1		Vertebra		616
(Channichthyidae,	3	5.4 g	Gastric tract	−/3	4.5
pisces)	3	8.9 g	Stomach	−/3	4.3

nd = not determined
[a] male/female

Table 2. Fluoride content of benthic living Antarctic species (analyses from whole animals)

Species	*n*	Weight (g)	Fluoride (mg/kg wet weight)
Serolis cornuta (Isopoda, Crustacea)	2	8.8/5.3	183/268
Glyptonotus antarcticus (Isopoda, Crustacea)	1	2.8	332
Paraceradocus (miersii?) (Amphipoda, Crustacea)	2	3.1/2.4	544/624
Pontaster sp. (Asteroidea, Echinodermata)	1	0.5	388
Ophiurolepis (martensi?) (Ophiuroidea, Echinodermata)	1	0.9	347
Pycnogonid sp. (−, Pycnognida)	1	6.4	7.7
Laetmonice producta (Aphroditidae, Polychaeta)	1	13.4	7.9
Paraeledone charcoti (Octopoda, Cephalopoda)	1	5.1	17

tract, emptied stomachs and emptied gastric tracts, exhibit a somewhat higher content, the gastric tracts containing more fluoride than the stomachs. High fluoride values were found in the vertebrae only (about 1000 mg/kg). The figures in Table 2 demonstrate that the amount of fluoride in the benthic living Antarctic animals differs from species to species. Pycnogonid, octopodid and polychaet contain relative low amounts of fluoride though the whole bodies were analyzed. In contrast to these low concentrations amphipods, isopods, asteroids and ophiuroids exhibit a 20–60-fold higher level of fluoride varying from approx. 200 to 600 mg/kg.

Discussion

The fluoride concentrations found in the Antarctic fishes investigated are comparable to the values reported by Schneppenheim (1980) and Manthey (1980). Higher levels are found only in vertebrae, the muscle tissues containing amounts which are similar to those found in fish from other waters [Atlantic or Pacific (Sidwell 1981), Baltic Sea (Nuurtamo 1980)].

Fluoride contents within the six species are nearly independent of the species. Muscles and digestive organs (stomachs and gastric tracts) have amounts which are low and in a narrow range, the vertebrae, however, contain a high and varying content of fluoride. No difference could be found between the fish feeding on krill (e.g. *Champsocephalus gunnari* and *Micromesistius australis*) and fish feeding mainly on fish (e.g. *Chaenocephalus aceratus*) (Kock 1975; Kock 1981; Basalaev and Petuchov 1969). *Micromesistius australis, N. neglecta* and *Ch. gunnari* which are analysed for fluoride the first time contain the same amounts of fluoride like the other fishes from Antarctic waters. During emptying the stomachs and gastric tracts krill was found in the stomachs of *N. neglecta* and *Ch. gunnari*, while the stomachs of *Ch. aceratus* contained fish. Hence this prey caught by the fishes immediately before trapped had no influence on the fluoride content of the digestive tract. From the high fluoride level in the vertebrae of all fishes it can be concluded that fish consuming krill take up fluoride directly from krill and fish feeding on fish from fish prey, which is feeding itself on krill.

The results found in the benthic living specimen are very inhomogeneous. Low fluoride values are found but high values as well. The high fluoride levels reported for whole krill (800 mg/kg dry weight: Szewielow 1981; 2000 mg/kg dry weight: Schneppenheim 1980; 2400 mg/kg dry weight: Soevik and Braekkan 1979; and 1500 mg/kg dry weight: Christians and Leinemann 1980) are equaled by the amounts found in *Ophiurolepis* sp. (approx. 1400 mg/kg dry weight), *Pontaster* sp. (approx. 1500 mg/kg dry weight), and *Serolis* sp. (approx. 900 mg/kg dry weight). They were exceeded by *Paraceradocus* sp. with approx. 2200 mg/kg and 2500 mg/kg dry weight, respectively.

These high fluoride concentrations led to the conclusion that the isopods, amphipods, asteroids and ophiuroids (Dearborn 1977) are directly or indirectly involved in the Antarctic food chain which contains krill as the main source of fluoride.

The very low fluoride levels found in the whole bodies of pycnogonid, octopodid and polychaet could be an indication that these species did not feed on krill and are not or only to a low extent involved in food chains containing krill. Pycnogonids for example were reported to feed among others on sponges and sea anemones (Fry 1964).

The extremely different fluoride concentrations in the benthic Antarctic species seem to depend on different food chains they are belonging to. More investigations on species from different trophic levels, on age, maturity, sex etc. are necessary to clarify the fluoride concentrations and their distribution through food chains in Antarctic animals.

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