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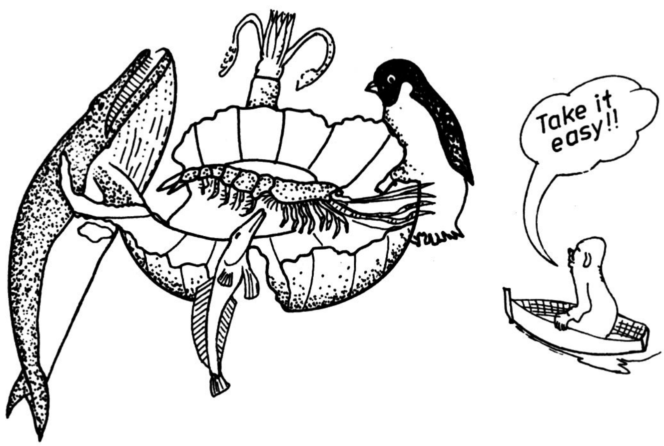

Trace metals, fluorine and radionuclides in antarctic krill *Euphausia superba* Dana

ABSTRACT: In 25 krill samples (*Euphausia superba*) collected at the Scotia Sea and in the area of South Georgia, South Orkney and South Sandwich Islands, Antarctic Peninsula and the eastern part of the Bellingshausen Sea the concentrations of Cd, Pb, Zn, F, ^{90}Sr, ^{137}Cs, U and ^{239,240}Pu has been determined. The corresponding average concentrations were found to be: Cd — 2.5, Pb — 3.4, Zn — 123.1, F — 50 (ppm dry weight), ^{90}Sr — 1.9, ^{137}Cs — 4.7 ($mBq\cdot^{-1}$ dry weight), U — 11.1 (ppb dry weight) and ^{239,240}Pu — 0.08 ($mBq\cdot g^{-1}$ dry weight).

Key words: Antarctic, krill, contamination

1. Introduction

The antarctic krill (*Euphausia superba* Dana) is an important link in the food chains of fish, calamaries, birds and mammals of the Antarctic. Krill is a planktonic filtrator and in certain situations it may be treated as a bioindicator. It is also important as a potential sources of protein. This paper is aimed at the determination of the Cd, Pb, Zn, F, ^{90}Sr, ^{137}Cs, U and ^{239,240}Pu content in krill from the regions of the Scotia Sea, Weddell Sea and Bellingshausen Sea.

2. Terrain, material and methods

The concentrations of krill were located in the following regions: South Sandwich, South Georgia, South Orkneys, Joinville, Elephant and King George Islands and in regions of the Palmer Archipelage, Bisco Archipelago and on the Bellingshausen Sea, between latitude 52—69°S and longitude 92—26°W (Fig. 1). The material was gathered during the IV Polish Marine Antarctic Expedition on r/v "Profesor Siedlecki" of the Sea Fisheries Institute in the period of 16 December 1978 to 30 March 1979 (Soszka 1979). The krill samples were collected by a bongo type plankton sampler and with a pelagic trawl with a krill adapter. A total of 25 samples, consisting of 500 individuals each, were analysed. Samples were dried in 105°C directly after collecting, on board. The ashing at 450°C and all chemical analyses were performed in the Central Laboratory for Radiological Protection (CLOR). Radiochemical methods described in the CLOR Report 110/D (Bilkiewicz, ed. 1978) were used for the determination of ^{90}Sr and ^{131}Cs. Samples of krill were analysed for fluoride using a selective fluoride electrode method. Concentration of Pb was determined colorimetrically on the Unicam SP-500 spectrophotometer after the ditizon extraction. Concentrations of Cd and Zn were determined by flame absorption atomic spectrophotometry (IL 353 spectrophotometer). The erros of determination were: Cd — 20%, Pb — 10%, Zn — 5%, F — 10%, ^{90}Sr — up to 100%, ^{137}Cs — 20—60%, U — 10% and ^{239,240}Pu — 10%. All results were above sensibility of methods. The obtained results for dry weight of samples were expressed as ppm and ppb and in $mBq \cdot g^{-1}$.

3. Results and discussion

The ranges of the heavy metals concentrations in krill were as follows: Cd 1.2—4.6 ppm, Pb 0.8—11.5 ppm and Zn 65.0—370,0 ppm, the average concentrations were: Cd — 2.5 ppm, Pb — 3.4 ppm and Zn — 123.0 ppm. Apart from few exceptions there was no geographical differentiation of the heavy metal concentrations in the studied regions in krill (Table I). A higher level of Pb was noticed only in the region of King George Island and Bellingshausen Sea, the Cd concentrations were slightly higher in the regions of Elephant Island, Peter I Island and Bellingshausen Sea. We found lower content of heavy metals in flesh of krill than in the chitin, the following values were, respectively: Cd — 0.7 and 1.9 ppm, Pb — 2.2 and 4.2 ppm, Zn — 26.9 and 46.3 ppm. The krill females had a little higher content of Pb, the same of Cd and lower one of Zn

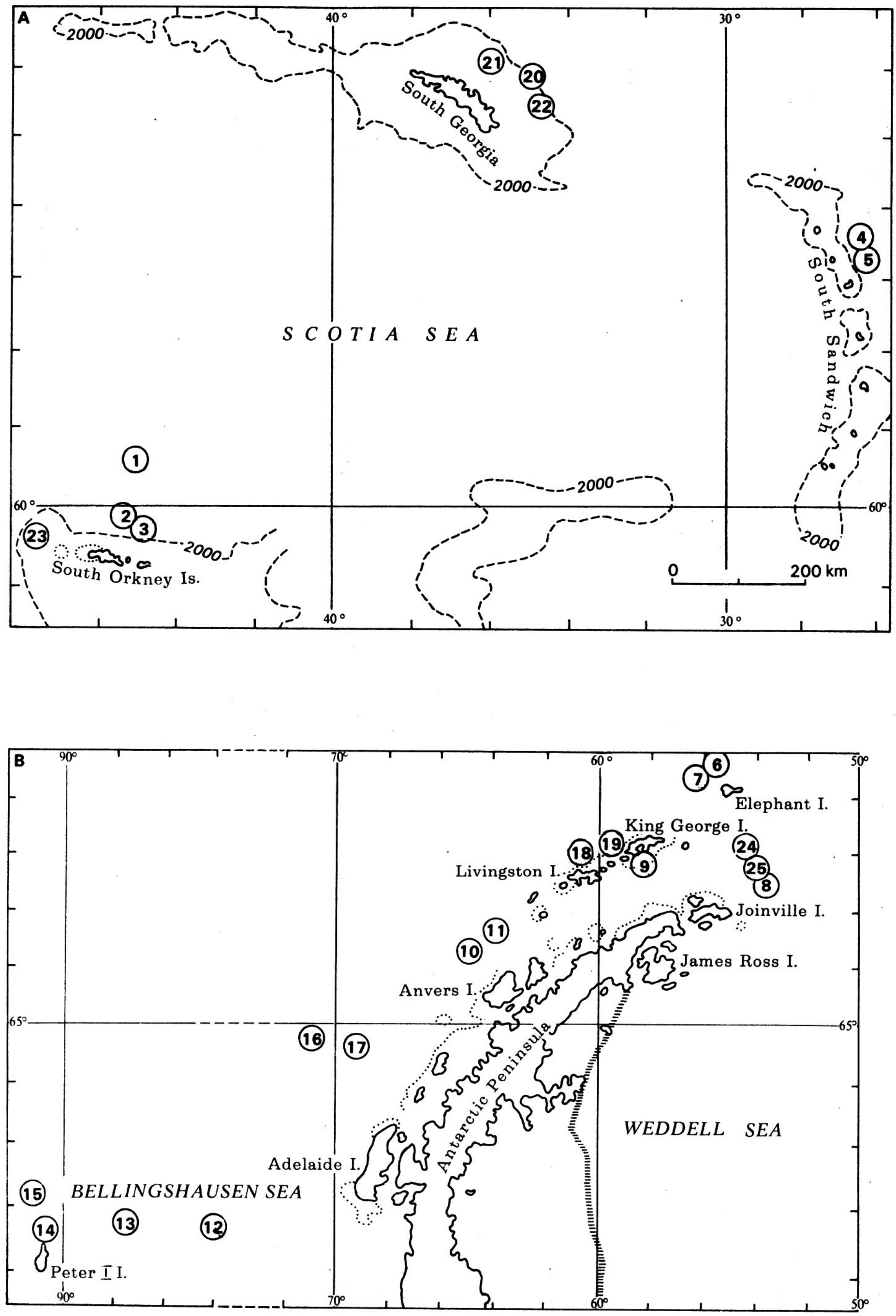

Fig. 1. The distribution of stations for collection the krill samples in Scotia Sea and adjacent waters in summer of 1978—1979; in circles numbers of stations

Table I.

Concentration of ^{90}Sr, ^{137}Cs ($mBq \cdot g^{-1}$ dry weight), U (ppb in dry weight), $^{239,240}Pu$ ($mBq \cdot g^{-1}$ dry weight) and Cd, Pb and Zn (ppm in dry weight) in the Antarctic krill in season 1978/1979

Region of studies and number of samples		^{90}Sr	^{137}Cs	U	$^{239,240}Pu$	Cd	Pb	Zn
South Sandwich Is.	2	2.7	5.8	—	—	2.4	0.8	81.0
South Georgia	3	2.0	4.3	8.7	0.04	1.5	1.8	65.0
South Orkney Is.	3	2.7	5.5	18.7	0.07	1.7	2.6	94.8
Joinville I.	2	1.0	4.4	—	0.11	1.4	2.3	107.5
Elephant I.	2	—	5.1	—	—	3.8	1.4	89.7
King George I.	3	1.9	6.5	11.5	0.15	1.3	5.2	370.0
Palmer Arch.	3	—	3.7	4.9	0.04	1.24	5.0	96.9
Bisco Arch.	3	2.2	4.9	11.4	0.01	1.6	1.3	107.5
Bellingshausen Sea	2	—	1.2	13.3	—	4.6	11.5	119.0
Peter I. I.	2	0.7	—	—	—	3.95	2.6	93.8
Average		1.9	4.7	11.1	0.08	2.5	3.4	123.1

^{90}Sr 9 samples
U, $^{239,240}Pu$ 8 samples

than the males. The ^{137}Cs concentration in krill varied from 1.2 to 6.7 $mBq \cdot g^{-1}$ dry weight, the mean was 4.7 $mBq \cdot g^{-1}$ dry weight, for ^{90}Sr these values were 0.7—2.7 $mBq \cdot g^{-1}$ and 1.9 $mBq \cdot g^{-1}$ dry weight, respectively. The content of U varied from 4.9 to 19.7 ppb, with mean of 11.1 ppb. Corresponding values for $^{239,240}Pu$ were 0.01 to 0.15 and 0.08 $mBq \cdot g^{-1}$ dry weight. The concentration of F in whole krill reached about 50 ppm dry weight.

The studies of heavy metal content in marine animals caught by industrial methods are carried out for a long time, already. Particular metals are elaborated in great details. However, these studies deal mainly with mercury, cadmium, lead and selenium, which receives much attention in the last years.

The studies of radioactive substances have much shorter tradition, although the fish and marine waters were relatively well known from this point of view (Polikarpov 1964, 1966, Duursma 1972 and Andrušajtis et al. 1973). The studies of the krill from this point of view were only fragmentary ones (Tolkač and Gromov 1975, Tolkač, Gromov and Spicyn 1975, Tolkač and Gromov 1976, Beasley et al. 1978, Jagielak and Pietruszewski 1979, Kucharczyk et al. 1979, Soszka, Grzybowska and Suplińska 1979, Soszka et al. 1980 a, 1980 b).

Comparing the mean content of Zn and Pb in krill with the Polish norm for meat (50 ppm and 2 ppm fresh weight, respectively)[1]) they were found to be small. The content of Cd is slightly higher when compared with the limit used in Poland (0.2 ppm fresh weight, Nabrzyski 1979). The mean Cd concentration in krill is lower than found previously by Polish workers (Table II, Soszka, Grzybowska and Suplińska 1979) the Pb concentrations are similar (Kucharczyk et al. 1979) and Zn — lower (Jagielak and Pietruszewski 1979, Kucharczyk et al. 1979, Soszka, Grzybowska and Suplińska 1979). It was found that the concentration of Cd, Pb and Zn in various species of pelagic antarctic crustaceans are different (Suplińska and Soszka, unpublished data). It was suggested that so low concentrations of Cd, Pb and Zn should have no toxic efect (Stoeppler and Brandt 1979).

The present data on the mean concentrations of radioisotopes in krill are higher for U than the previously obtained values (1.6 ppb, Soszka, Grzybowska and Suplińska 1979, Table II), similar for ^{137}Cs concentrations (4.7 $mBq \cdot g^{-1}$ dry weight and 3.3—3.4 $mBq \cdot g^{-1}$ dry weight) and higher for ^{90}Sr (1.9 $mBq \cdot g^{-1}$ dry weight and 0.7 $mBq \cdot g^{-1}$ dry weight). The concentrations of ^{90}Sr and ^{131}Cs in plankton of the Baltic Sea are an order of magnitude larger (Kuźma, Nakonieczny and Taper, unpublished data).

The interest in krill as a potential source of protein is thus reflected in papers on the level of toxic substances in it. In USA krill used for protein is treated in a specific way. There are four lines of preparation: krill must be prepared for further elaboration during the four hours after catching, — the chitin must be separated immediately, — krill flour for cattle

[1]) According to Regulations issued by Public Health Ministry of Poland, of Sept. 15, 1971.

Table II

Concentration of radioisotopes and heavy metals in krill (*Euphausia superba* Dana) and in the krill flour from the Antarctic region (1977*)

Comparison elements	Whole krill with shells			Fluor krill	Method of measurement
	ppm	ppb	$pCi \cdot 100\ g^{-1}$	$pCi \cdot g^{-1}$	
^{90}Sr				0.49—1.82	radiochemical
^{137}Cs				0.40—0.51	”
^{90}Sr			1.9 ± 4.7		”
^{137}Cs			8.8 ± 4.0— 9.2 ± 4.8		”
^{210}Pb			9.9 ± 4.2—41.8 ± 9.8		”
^{210}Po			5.5 ± 1.5—16.4 ± 3.1		”
^{226}Ra			44.2 ± 2.5		”
Th		7.93			fluorometric
U		1.58			”
Cd	1.66—9.00				atomic flame photometry
Pb	1.67—1.78				colorimetric
Zn	95.0				atomic flame photometry
Ca	8750.0				”

*) after Soszka, Grzybowska and Suplińska (1979).

is made from pure flesh, — the permissible contribution of krill meat in the food for human population is about 5% (Bogucki, personal communication). Soevik and Brackkan (1979) found the fluorine content in krill: whole krill — 2400 ppm dry weight, muscle — 570 ppm dry weight and carapace — 4260 ppm dry weight. The American Limit for meat for F is 100 ppm (Soevik and Brackkan 1979). Results of F determination in whole krill obtained by Soevik and Brackkan (1979) 2400 ppm dry weight are much higher than those obtained by us. Perhaps our results are lower because of methodological errors during digestion. Szewielow (1980) as well as Soevik and Brackkan (1979) found much higher F concentration in the shell (carapace) of krill in comparison with its muscle meat. Informations about the harmful effects of F in krill has been reported in literature unanimously (Szewielow 1980). The utilization of krill for our purposes is for us a complicated problem. However, it seems that the question should be: what is the way of krill utilization, but not: should we utilize it or not. The utilization must be safe from the point of view of fluorine, heavy metals and toxic organic compounds and some others contamination factors.

Numerous attempts of the utilization of krill in the diet of various animals have been made. E.g. in Poland krill was fed to the carp (Gacek 1979), to the carp fry (Dąbrowski and Dąbrowska 1978), to the salmonids (Trzebiatowski, Domagała and Filipiak 1979), to the poultry (Gawęcki et al. 1979), pigs (Horbowska and Dobrzycka 1979) and to rodents (Pastuszewska and Wyłuda 1979). Only the feeding of salmonids with krill was successful, in other species adverse effects were observed. There are certain problems which need to be explained: were all the experiments carried out properly, is it only the fluorine which influences the fed animals negatively, — did the chitin fragments of krill caused the negative effect, — is there a physiological barrier in domestic animals for assimilation of krill food?

It is commonly known that in the antarctic waters krill is a main food link for birds, mammals, fish and calamaries. It seems that the krill problem is still not answered and it needs further complex studies.

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4. Summary

The concentrations of Cd, Pb, Zn, F, ^{90}Sr, ^{137}Cs, U and $^{239,240}Pu$ were determined in 25 krill samples (*Euphausia superba*) collected at the Scotia Sea, Weddell Sea and Bellingshausen Sea. The average values of the above elements were, respectively: 2.5, 3.4, 123.1, 50.0 (ppm dry weight), 1.9, 4.7 ($mBq \cdot g^{-1}$ dry weight), 11.1 (ppb dry weight) and 0.08 ($mBq \cdot g^{-1}$ dry weight) (Table I).

The results of feeding krill to the vertebrates of our climatic zone were in the majority of cases not encouraging, except for the salmonides, although krill in the antarctic waters is the major food for mammals, birds, fish and calamaries. It seems, however, that the krill problem is still not answered and it needs further complex studies.

5. Резюме

Определено содержание Cd, Pb, Zn, F, ^{90}Sr, ^{137}Cs, U и $^{239,240}Pu$ в 25 пробах крыля (*Euphausia superba*) собранных в море Скотия, море Ведделла и море Беллингсхаусена. Средние величины в.у. элементов равняются: 2,5; 3,4; 123,1; 50,0 (ppb сухой массы) и 1,9; 4,7 ($mBq \cdot g^{-1}$ сухой массы), 11,1 (ppb сухой массы) и 0,08 ($mBq \cdot g^{-1}$ сухой массы) (таблица I).

Итоги кормления крылем позвоногных нашей климатической полосы в большинстве случаев были неудачными, за исключением лососёвых несмотря на то, что в антарктических водах крыть является главной пищей млекопитающих птиц, рыб и кальмаров. Затем, кьжется, вопрос крыля является всё время открытым и требует дальнейших комплексных исследований.

6. Streszczenie

Określono zawartość Cd, Pb, Zn, F, ^{90}Sr, ^{137}Cs, U i $^{239,240}Pu$ w 25 próbach kryla (*Euphausia superba*) zebranych na Morzu Scotia, Morzu Weddella i Morzu Bellingshausena. Średnie zawartości powyższych pierwiastków wynoszą odpowiednio: 2,5, 3,4, 123,1, 50,0 (ppb suchej masy), 1,9, 4,7 ($mBq.g^{-1}$ suchej masy), 11,1 (ppb suchej masy) i 0,08 ($mBq.g^{-1}$ suchej masy) (tabela I).

Wyniki skarmiania krylem kręgowców naszej strefy klimatycznej w większości przypadków były niefortunne, z wyjątkiem łososiowatych, mimo iż w wodach antarktycznych kryl jest głównym pokarmem ssaków, ptaków, ryb i kalmarów. Wydaje się zatem, że problem krylowy jest nadal otwarty i wymaga dalszych kompleksowych badań.

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