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Residues of chlorinated hydrocarbons in the adipose tissue of the Antarctic pinnipeds

ABSTRACT: In 1979—1981 at the King George Island samples of adipose tissue of 5 pinniped species (*L. carcinophagus*, *L. weddelli*, *H. leptonyx*, *M. leonina* and *A. gazella*) were collected and the contents of chlorinated hydrocarbons (CHs) were determined with the gas chromatography method. The highest values were recorded in the leopard seal (432.3—614.7 ppb DDT), the second highest values in the mature elephant seal (73.4 ppb DDT) and the third in the Weddell seal (54.4—69.1 ppb DDT). In the Weddell seal the highest level of HCH content (23.3—32.1 ppb) was recorded. A decrease in the content of pp'DDE in the adipose tissue of crabeater seal in successive years was recorded, the values being 36.8 ppb in 1979, 24.4 ppb in 1980 and 15.3 ppb in 1981, as well as an increase in the concentration of HCH (15.3 ppb in 1980 and 27.4 ppb in 1981). The contents of CHs in the adipose tissue of Antarctic pinnipeds are 100—1000 times lower than those in the Arctic seals.

Key words: Antarctica, Pinnipedia, chlorinated hydrocarbons.

1. Introduction

Only few studies on the contents of chlorinated hydrocarbons in the tissue of Antarctic Pinnipedia have so far been carried out. Detailed data on the contents of these compounds in the tissue of the Weddell seal were presented only by Georg and Frear (1966) and Brewerton (1969). Data concerning single specimens of the Weddell seal and other Antarctic seal species are given by Sladen, Menzie and Reichel (1966), Riesebrough et al. (1976), Hidaka, Tanabe and Tatsukawa (1983). Recent investigations of the contents of CHs in more ample material, comprising the Weddell seal and the crabeater seal, were conducted by Schneider, Steinhagen-Schneider and Drescher (1985).

As it was proved by the studies by Tanabe, Kawano and Tatsukawa (1982) there occurs a constant transport of CHs in the region of the Antarctica, and their presence is commonly recorded in the atmosphere

and hydrosphere of this region (Tanabe, Kawano and Tatsukawa 1982, Tanabe, Hidaka and Tatsukawa 1983). The presence of chlorinated hydrocarbons was also recorded in the food of the seals—in krill (Łukowski 1978), in Antarctic fishes (Subramanian et al. 1983) and in penguins (Norheim, Sømme and Holt 1982, Łukowski 1983).

The present investigations aimed at monitoring the tendency of changes in the contents of chlorinated hydrocarbons in the adipose tissue of crabeater seal in successive years and at determining the actual levels of contents of chloroorganic biocides in the adipose tissue of species so far not investigated.

2. Material and methods

In 1979—1981 in the region of the “H. Arctowski” Polish Antarctic Station on King George Island (South Shetlands) there were collected samples of the adipose tissue of 26 specimens of crabeater seal (*Lobodon carcinophagus* Hombron et Jacquinot), 2 specimens of Weddell seal (*Leptonychotes weddelli* Lesson), 2 specimens of leopard seal (*Hydrurga leptonyx* de Blainville), 2 specimens of elephant seal (*Mirounga leonina* Linne) and 1 specimen of the fur seal (*Arctocephalus gazella* Gray). The animals were shot (crabeater and Weddell seals) or found dead (others).

Samples of the adipose tissue of the weight of about 10 g were taken for the analysis. The samples were wrapped in aluminium leaf washed in redistilled acetone and then frozen at -20°C . They were kept at this temperature till the contents of chlorinated hydrocarbons were determined. For the chromatographic analysis the samples were prepared according to the method given by Thompson (1972).

Qualitative and quantitative contents of chlorinated hydrocarbons residues in a sample was determined using the gas chromatography method (Pye Unicam, series 104, with a ECD Ni—63 detector). Glass columns (5 feet in length, 4 mm in diameter) filled with a 1.5% OV 17+1.95% OV 210 on 80/100 mesh of the WHP chromosorb were used. Argon was the carrier gas and its flow rate was $60\text{ ml}\cdot\text{min}^{-1}$. The temperature of the column was 215°C ; the ECD temperature 260°C . In the samples α , β and γ HCH, pp'DDT, pp'DDD and pp'DDE were identified.

3. Results

The presence of pp'DDE (metabolite of DDT) was found in the adipose tissue of all the investigated seals. The presence of the active form,

Table 1
 Contents of chlorinated hydrocarbons in the adipose tissue of Antarctic Pinnipedia (values in ppb) (for crabeater seal the means, standard deviations and variability ranges are presented)

Species	Year	N	HCH	pp'DDT	pp'DDE
<i>Hydrurga leptonyx</i>	1980	1	14,3	164,4	267,9
	1981	1	25,9	158,4	456,3
<i>Mirounga leonina</i> (juv.) (ad.)	1980	1	8,0	0,0	7,5
	1980	1	10,9	0,0	73,4
<i>Leptonychotes weddelli</i>	1980	2	23,3	0,0	54,4
			32,1	0,0	69,1
<i>Lobodon carcinophagus</i>	1979	10	—	0,0	36,8 ± 16,7
	1980	8	15,3 ± 9,2	0,0	13,9 – 98,1
			5,6 – 36,6		24,4 ± 14,8
1981	8	27,4 ± 18,1	0,0	5,4 – 77,2	
			15,9 – 71,9		15,3 ± 2,8
<i>Arctocephalus gazella</i>	1981	1	118,5	0,0	10,2 – 19,0
					22,7

Table 2

Results of various investigations on the DDT contents in the adipose tissue of Antarctic Pinnipedia

Species	Locality	Year	N	DDT (ppb)	Authors
<i>Lobodon carcinophagus</i>	Ross Island	1964	1	39 ^{xx}	Sladen, Menzie and Reichel 1966
	Gould Bay (Weddell Sea)	1980/81	2	53 ^{xx}	Schneider, Steinhagen-Schneider and Drescher 1985
	Atka Bay (Weddell Sea)	1980/81	3	77 ^{xx}	Schneider, Steinhagen-Schneider and Drescher 1985
	Ross Island	1964	15	18 ^{xx}	Georg and Frear 1966
<i>Leptonychotes weddelli</i>	McMurdo Station	1965	5	0-120 65 ^{xx}	Brewerton 1969
	McMurdo Station	1967	15	40-115 57 ^{xx}	Brewerton 1969
	Syowa Station	1981	1	30-100 17 ^{xx}	Hidaka, Tanabe and Tatsukawa 1983
<i>Hydrurga leptonyx</i>	Gerlache Strait	1975	1	81 ^x	Rieseborough et al. 1976

x — only pp'DDE

xx — pp'DDT and pp'DDE

xxx — pp'DDE, pp'DDT and pp'DDD

i.e. DDT, was found only in leopard seals, in quantities much lower than those of pp'DDE. In all investigated samples of the adipose tissue of seals and fur seal the occurrence of HCH isomers (α and γ) was also recorded (Table 1).

The highest value of the total DDT was recorded in the adipose tissue of leopard seal. It was about 10 times higher than in other investigated species. A relatively high content of DDE was also recorded in the tissue of the Weddell seal and mature elephant seal. The contents of HCH isomers in the adipose tissue of the investigated pinniped species were similar, excepting the fur seal, in which the recorded level of HCH was many times (by an order of magnitude) higher.

In subsequent years a decrease in the pp'DDE contents in the adipose tissue of crabeater seal was observed (Table 1). It was proved that the differences between the mean CHs values in materials from 1979 and 1980, and 1979 and 1981 (Table 1) are statistically significant, at significance level values $p = 0.05$ and $p = 0.001$ (t Student test), respectively. On the other hand, difference between mean values recorded for animals in 1980 and 1981 remained on the edge of significance.

4. Discussion

Few informations on the contents of chlorinated hydrocarbons (CHs) in pinniped species tissues from the region of Antarctica may be found in the literature of the subject (Table 2). Most ample data concern the Weddell seal. Georg and Frear (1966) and Brewerton (1969) carried out their investigations in the region of the McMurdo Station. Their results are very close to the values presented in this work. On the other hand, data obtained by Hidaka, Tanabe and Tatsukawa (1983) for the Weddell seal from the vicinity of the Japanese Syowa Station are lower from those presented in the present paper.

Somewhat higher values of the total DDT were recorded by Schneider, Steinhagen-Schneider and Drescher (1985) for seals from the Weddell Sea, although amounts of pp'DDE are similar to those from the King George Island region. The other species of Antarctic seals were so far sporadically investigated. Available data concern a single young leopard seal (Rieseborough et al. 1976), one specimen of crabeater seal (Sladen, Menzie and Reichel 1966) and 6 crabeater seals from the Weddell Sea, in which Schneider, Steinhagen-Schneider and Drescher (1985) recorded 2–3 times higher content values of CHs than in crabeater seals from the King George Island region studied in the same period, 1980–1981 (Table 1 and 2).

The highest contents of chlorinated hydrocarbons in the adipose tissue

of the leopard seal proves the generally recorded phenomenon that the content of CHs in the adipose tissue of animals is determined by their trophic level and length of the food chain. Leopard seals are at the top of one of the longest Antarctic food chains, because a large share of their food constitute penguins, and periodically also seal pups. Therefore it is a food type of a relatively high level of CHs pollution, because, as it was proved by Hidaka, Tanabe and Tatsukawa (1983), in the period of lactation, females of the seals transfer to their progeny about 50% of CHs cumulated in their tissues. As it follows from other investigations (Łukowski 1983), penguin tissues are to a large degree polluted with chlorinated hydrocarbons residues. Also, the adipose tissues of piscivorous Weddell seal (that closes an equally long trophic chain as in the case of leopard seal) have a significantly higher level of CHs content in comparison with the krill-eating crabeater seal.

Differences in the content level of chlorinated hydrocarbons in the adipose tissue connected with animal age are illustrated by the results obtained for the elephant seal (ten times higher values for the mature male than for the juvenile one). Similarly, higher values of CHs in mature individuals (16.9 and 47.3 ppm) than in young ones (8.5 and 29.8 ppm, respectively) were recorded by Reijnders (1980) for seals from the Northern Hemisphere.

A high level of HCH content values in the adipose tissue of the fur seal, much differing from data obtained for other pinniped species, may be either accidental or may be related to the penetration by this species of other regions of higher pollution with these compounds in comparison with breeding areas where the samples were collected.

Statistical comparison of pp'DDE and HCH values in the adipose tissue of crabeater seal shows that there is a trend of decrease in the DDE values and trend of increase in the HCH values in their tissue from year to year. This corresponds to a world wide tendency to substitute the insecticides containing DDT by other chloroorganic biocides, including HCH.

It is worth mentioning that the level of CHs content values in the adipose tissue of the investigated pinniped species from Antarctica is low and remain between several and several dozens ppb (excepting the leopard seal, in which it amounts to several hundred ppb). This level is many times (100—1000 times) lower than the values given by authors studying pinniped species in the Northern Hemisphere, including the Arctic species (Holden and Marsden 1967, Frank, Ronald and Braun 1973). Contents of CHs in the northern seals remain within the limits ranging between several and several dozens ppm: 3.6—22.6 ppm (Addison et al. 1973); 0.6—1.3 ppm (Addison and Smith 1974); 4.6—10.0 ppm (Drescher, Harms and Huschenbeth 1977); 8.5—47.3 ppm (Reijnders

1980). Very high differences in the contents of CHs between Arctic and Antarctic animals were also pointed out by Schneider, Steinhagen-Schneider and Drescher (1985). It seems that this situation remains in close relation with uneven distribution of chlorinated hydrocarbons in the world ecosystem and uneven burdening of both hemispheres (higher in the northern one) by the residues of these compounds (Rieseborough 1974). This is also connected with a low and highly specific transport of CHs via the atmosphere to the Antarctic regions.

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6. Streszczenie

W rejonie Polskiej Stacji Antarktycznej im. H. Arctowskiego na wyspie King George (Szetlandy Południowe) zebrano w latach 1979—81 próbki tkanek tłuszczowych 5 gatunków zwierząt pletwonogich: *L. carcinophagus* (26), *L. weddelli* (2), *M. leonina* (2), *H. leptonyx* (2) i *A. gazella* (1). Metodą chromatografii gazowej oznaczono w nich zawartość chlorowanych węglowodorów (CHs) (Tabela 1). Najwyższą zawartość CHs stwierdzono w tkankach drapieżnych fok lampartów (432,3—614,7 ppb), rybożernych fok Weddella (54,4—69,1 ppb) oraz dorosłego samca słonia morskigo (73,4 ppb). Stwierdzono obniżanie się poziomu pp'DDE w tkankach *Lobodon carcinophagus* w kolejnych latach: 1979 (36,8 ppb) — 1980 (24,4 ppb) — 1981 (15,3 ppb) oraz tendencję do wzrostu zawartości HCH (1980 — 15,3 ppb: 1981 — 27,4 ppb). Stwierdzono też stosunkowo wysoki poziom zawartości HCH w tkance tłuszczowej fok Weddella (23,3—32,1 ppb). Uzyskane wyniki porównano z danymi z literatury (Tabela 2). Różnice w poziomie zawartości CHs w tkankach poszczególnych gatunków powiązane z wiekiem zwierząt bądź z kumulowaniem się tych związków w kolejnych ogniwach łańcucha pokarmowego i osiągnięciem maksymalnych wartości w tkankach szczytowych konsumentów. Różnicujący wpływ na zawartość CHs, oprócz zajmowanego poziomu troficznego, może mieć także długość łańcucha pokarmowego — różna dla różnych gatunków Pinnipedia. Zmniejszanie się poziomu kumulacji pp'DDE w tkance tłuszczowej foki krabojada i tendencje do wzrostu w tkankach HCH, jak również zwiększony poziom HCH w tkankach fok Weddella i wysoki w tkankach uchatki, wyjaśniono ogólnosiwiatową tendencję do wycofywania z użycia DDT, a zastępowanie go preparatami zawierającymi HCH. Zawartość CHs w tkankach Pinnipedia z Antarktyki jest 100—1000 razy niższa, niż ich poziom w fokach z Półkuli Północnej, w tym arktycznych.