POLISH POLAR RESEARCH (POL. POLAR RES.) POLSKIE BADANIA POLARNE	4	1–4	135–141	1983

Aleksy B. ŁUKOWSKI

Department of Zoology and Ecology, Institute of Zoology, Warsaw University, Krakowskie Przedmieście 26/28, 00-927 Warsaw, Poland

DDT and its metabolites in the tissues and eggs of migrating Antarctic seabirds from the regions of the South Shetland Islands*)

ABSTRACT: Using gas chromatography methods the content of *DDT* residues was determined in the tissues of 4 species of Antarctic birds: *Oceanites oceanicus, Catharacta skua, Sterna vittata* and *Larus dominicanus*, and in the eggs of *Macronectes giganteus* and *Larus dominicanus*. Samples were collected on King George Island, in February and October 1978. The highest level of *DDT* and its metabolites concentration was observed in the tissues of *Oceanites oceanicus* and the lowest in the tissues of *Sterna vittata* and in the eggs of *M. giganteus* and *L. dominicanus*. The differences in *DDT* content between different species and within one species are associated with their food composition and winter migrations to the regions with higher degree of *DDT* pollution.

Key words: Antarctic, *DDT* contents, seabird

1. Introduction

The coasts of Antarctic islands are breeding grounds of many species of seabirds. During the Antarctic winter these birds migrate, reaching often subtropical regions of both hemispheres, and some of them go as far as the Temperate Zone of the Northern Hemisphere (Dorst 1962, and Watson 1975), spending the greatest part of the year away from the Antarctic. The chlorinated hydrocarbons content in the tissues of the birds is conditioned to a greater degree by the residues of these compounds in the food taken in the course of their migrations than the food found in the breeding grounds.

Only a few studies deal with the differences in the levels of biocides concentration in the tissues of the Antarctic birds taking simultaneously into consideration their migrations. One of them is the paper by Riesebrough and Carmignani (1972) who have reported that the eggs of *Oceanites*

*) This study was supported by the Polish Academy of Sciences, within the MR-I-29 Project.

oceanicus from two separate breeding colonies at Anvers Island and Cape Hallet had a completely different level of chlorinated hydrocarbons concentration. In the opinion of those authors this results from the different degree of the pollution of the grounds on which the two populations wintered.

The aim of this study is to examine thoroughly the quantitative differences in the picture of chlorinated hydrocarbons accumulated in the tissues and eggs of the birds in connection with their winter migrations.

2. Material and methods

All the birds and eggs were collected in close vicinity of the H. Arctowski Polish Antarctic Station on King George Island (Lat. 62 09′45′′S, Long. 58 27′45′′W). The following species of birds were examined: *Oceanites oceanicus* (Kuhl), *Larus dominicanus* Lichtenstein, *Catharacta* skua Brunn, *Sterna vittata* Gmelin, *Macronectes giganteus* (Gmelin). The birds were collected during the period from the 15th to 25th February and the eggs in October, 1978 (Table I).

The following samples were taken for analyses: 50 g of the pectoral muscle from *Larus dominicanus* and *Catharacta skua*, both pectoral muscles from *Sterna vittata*, *Oceanites oceanicus*, entire livers, subcutaneous adipose tissue (if there was any) — 10 g and in the case of *O. oceanicus* about 1 g. The samples were packed up in tinfoil previously washed with redistilled acetone and then frozen at the temperature of $-28°C$.

The analyses of the eggs were made immediately after collection.

The preparation of the samples for determinations with the gas chromatography method was made according to Thompson (1972) in the laboratory of the Arctowski Station. Till the time of the preparation of chromatograms the extracts were kept in glass ampoules in cold storage at the temperature of about $-10°C$.

The chromatographic analysis was made using a Pye Unicam, Series 104, gas chromatograph with a detector ECD Ni-63. Glass columns (5 feet in length, 4 mm in diametre) were used. The columns were filled with 1.5 OV 17/1.95 OV 210 on a WAW DMCS 80/100-mesh chromosorb. The carrier gas: argon. The presence of *pp′DDT*, *pp′DDD* and *pp′DDE* was identified in all the samples.

3. Results

All the samples of the tissues of the birds contained *DDT* residues (Table I). The levels of this compound concentration were different. The highest concentration of total *DDT* was recorded in the tissues of

Table I

Content of *pp'DDT* and its metabolites in the tissues of Antarctic sea birds (arithmetical mean values, standard deviations and variability range are given)

Species	Tissue	Number of samples	*pp'DDE* level	Number of samples containing *DDE*	*pp'DDD* level	Number of samples containing *DDD*	*pp'DDT* level	Number of samples containing *DDT*	*DDT*
Larus dominicanus	liver	12	0.057 ± 0.040 0.015 ÷ 0.156	12	0 ÷ 0.016	1	0.038 ± 0.064 0 ÷ 0.236	6	0.130 ± 0.115 0.015 ÷ 0.273
	pectoral muscle	13	0.0759 ± 0.033 0.027 ÷ 0.146	13	0.016 ÷ 0.022	2	0.029 ± 0.025 0 ÷ 0.070	8	0.113 ± 0.051 0.056 ÷ 0.254
	adipose tissue	1	1.888	1	0	0	trace	1	—
	eggs	5	0.007 ± 0.002 0.002 ÷ 0.010	5	0	0	0	0	
Catharacta skua	liver	10	0.153 ± 0.069 0.061 ÷ 0.213	10	0.025 ± 0.032 0 ÷ 0.083	4	0.102 ± 0.120 0 ÷ 0.379	9	0.280 ± 0.178 0.064 ÷ 0.589
	pectoral muscle	10	0.214 ± 0.123 0.051 ÷ 0.429	10	0.041 ± 0.062 0 ÷ 0.189	4	0.113 ± 0.157 0 ÷ 0.567	9	0.369 ± 0.302 0.079 ÷ 1.141
	adipose tissue	8	3.370 ± 2.012 0.988 ÷ 6.702	8	0.659 ± 0.775 0 ÷ 2.127	5	0.885 ± 0.488 0.163 ÷ 1.356	8	4.912 ± 2.906 1.255 ÷ 9.127
Sterna vittata	liver	8	0.053 ± 0.030 0.007 ÷ 0.118	8	0	5	0.254 ± 0.381 0 ÷ 1.028	5	0.308 ± 0.384 0.007 ÷ 1.086
	pectoral muscle	10	0.034 ± 0.016 0.014 ÷ 0.048	10	0	0	0.069 ± 0.116 0.0353	4	0.096 ± 0.107 0.016 ÷ 0.375
	adipose tissue	10	0.399 ± 0.307 0.084 ÷ 1.248	10	0	0	0.354 ± 0.389 0 ÷ 0.941	5	0.593 ± 0.438 0.084 ÷ 1.271
Oceanites oceanicus	liver	9	0.467 ± 0.165 0.176 ÷ 0.763	9	0.237 ± 0.074 0.110 ÷ 0.346	9	0.598 ± 0.237 0.338 ÷ 1.139	9	1.289 ± 0.363 0.647 ÷ 1.822
	pectoral muscle	10	0.718 ± 0.129 0.342 ÷ 1.171	10	0.421 ± 0.212 0.149 ÷ 0.783	10	0.381 ± 0.151 0.163 ÷ 0.659	10	1.430 ± 0.551 0.703 ÷ 2.528
	adipose tissue	10	8.388 ± 5.858 0.903 ÷ 2.085	10	4.856 ± 2.860 0.344 ÷ 9.144	10	3.184 ± 1.529 0.654 ÷ 5.382	10	16.427 ± 9.508 1.902 ÷ 32.973
Macronectes giganteus	eggs	5	0.025 ± 0.003 0.016 ÷ 0.036	5	0	0	0	0	

O. oceanicus. It was much higher than in the tissues of the remaining species.

A markedly lower level of the total *DDT* concentration was noted in *L. dominicanus* and *S. vittata*; it was much lower than in the tissues of *C. skua*.

In all the tested birds the highest level of the total *DDT* concentration was observed in the adipose tissues. In the muscles and liver within one species the *DDT* content was much alike.

The lowest level of *DDT* residues (only in the *pp'DDE* form) was noted in the eggs. In *M. giganteus* it was slightly higher than in *L. dominicanus*.

The obtained results are characterized by a wide range of the values not only between different species but also within one species. This is particularly evident in the comparison of the calculated index of variability, *V* (Table II). The *V* value calculated for the *pp'DDE* content in the tissues does not differ drastically between the species and does not exceed the value of the mean level of the *pp'DDE* concentration. In the case of the *pp'DDT* content the index of variability is distinctly the lowest for *O. oceanicus* and does not exceed the mean level of this compound concentration.

Table II

Values of variability index (*V*) for *pp'DDT* and its metabolites content in the tissues of Antarctic seabirds

Species	Tissue	*pp'DDE*	*pp'DDD*	*pp'DDT*
Larus dominicanus	liver	70,2	—	168,4
	pectoral muscle	43,5	—	86,2
	adipose tissue	—	—	—
	eggs			
Catharacta skua	liver	45.1	128.0	117.6
	pectoral muscle	57.5	151.2	138.9
	adipose tissue	59.7	117.6	55.1
Sterna vittata	liver	56.6	—	150.0
	pectoral muscle	47.1	—	168.1
	adipose tissue	76.9	—	109.9
Oceanites oceanicus	liver	35.3	31.2	45.7
	pectoral muscle	18.0	50.3	39.6
	adipose tissue	69.8	58.9	48.0

In the remaining species the *V* values exceed now and then considerably the mean levels of *pp'DDT* concentrations in the tissues.

The analysis of the quantitative composition of total *DDT* in the tissues of the birds (Table I) shows that *pp'DDE* occurs in the tissues of all the birds tested. In all the tissues of *O. oceanicus* and *C. skua* the presence of *pp'DDT* was also observed. In the remaining species this compound was observed in about 50% of the samples. The least persistent metabolite: *pp'DDD* was found in all the tissues of *O. oceanicus*, in about 50% of the *C. skua* tissue samples and sporadically in the tissues of *L. dominicanus*. It was not found at all in the tissues of *S. vittata*.

4. Discussion

The comparison of the content of *DDT* and its metabolites in the tissues of the examined birds with the data from earlier studies indicates that the actual values are similar to the values obtained by Georg and Frear (1966) in the Ross Sea region, Tatton and Ruzicka (1967) in the Signy Island region, Figge, Hoerschelmann and Polzhofer (1976) in the Falkland Islands region, and by Łukowski (1978) in the Palmer Island and King George Island regions.

The earlier studies in the Palmer Island and King George regions (ibid.) show that *L. dominicanus* and *S. vittata* had slightly lower content of total *DDT* in the tissues than the values recorded at present.

The actual values of *DDT* content in adipose tissue of *O. oceanicus* are comparable with the results of the studies by Riesebrough and Carmignani (1972), showing high concentration of total *DDT* in the lipids from the whole body of this species.

There are no available data in the literature concerning *DDT* content in the eggs of *L. dominicanus*. Yet, the values of the residues of this compound found in the eggs of *M. giganteus* are slightly lower than those obtained by Riesebrough and Carmignani (1972).

The level of chlorinated hydrocarbons accumulation, especially in adipose tissue, is conditioned by the length of the trophic chain of the consumer. The greater the number of indirect links the higher the level of these compounds concentration in the tissues of the terminal consumers. Hence, the high level of *DDT* and its metabolites residues in adipose tissues of *C. skua* is quite natural. The birds of this species feed on other birds and their eggs and the tissues of dead mammals (Watson 1975). The dietary composition of the food of *L. dominicanus* is much alike, especially in the breeding colonies. In one of the individuals of this species, having adipose tissue, *DDT* was found in quantities approximating the values recorded in the adipose tissues of *C. skua*.

The food of *O. oceanicus* in the feeding colonies does not differ much

from the food of *S. vittata* (Halba, personal information). These are, however, the species with extreme values of the *DDT* level in the tissues. It is suggested that this may result from the effect of a supplementary component of the food of *O. oceanicus*. The diet of *O. oceanicus*, consisting just as that of *S. vittata* of small aquatic animals, is, as reported by Watson (1975), supplemented now and then by a peculiar component, i.e. the fat leaking out from putrefying animal carcasses. Thus, these birds take additionnaly food which potentially, due to cumulative processes, should contain large quantities of chlorinated hydrocarbons.

Higher *pp'DDE* content in the eggs of *M. giganteus* than in the eggs of *L. dominicanus* is likewise due to the fact that *M. giganteus* are typically necrophagous birds, and consequently their food is much more strongly contaminated with chlorinated hydrocarbons than that of *L. dominicanus*.

It seems, however, that food found in the course of migrations during Antarctic winter is the decisive factor determining the level of *DDT* concentration in the migratory Antarctic birds, since the non-migratory species have as a rule lower chlorinated hydrocarbons content in their tissues (Georg and Frear 1966; Sladen, Menzie and Reichel 1966; Tatton and Ruzicka 1967; Riesebrough and Carmignani 1972; Conroy and French 1974; Riesebrough 1974).

O. oceanicus and *C. skua* migrate to the remotest places. *O. oceanicus* nest in large colonies in the Antarctic Peninsula region and pass the Antarctic wintertime in the Northern Hemisphere between Europe and Africa on the east and the Americas on the west (Dorst 1962) thence in the proximity of the Continents, where preparations containing *DDT* were most extensively used in the past.

As reported by Watson (1975), the two species of skua occurring in the Antarctic reach in their migrations as far as: California, India and Japan, thus the areas like-wise with undoubtedly higher degree of contamination with *DDT* residues than that in the Antarctic regions.

L. dominicanus and *S. vittata* remain in the Southern Hemisphere. As reported by Watson (1975), *L. dominicanus* nesting in the Antarctic Peninsula region spend the winter in the southern part of South America. *S. vittata* winter along the coasts of South America, South Africa and on the waters of the South Pacific Ocean (Watson, 1975). It may be suggested therefore that a lower level of *DDT* residuea concentration in the tissues of these both species, as compared with *O. oceanicus* and *C. skua*, is associated with their staying all the year round in the Southern Hemisphere. This hypothesis is substantiated by Riesebrough (1974), asserting that Southern Hemisphere is much less polluted with chlorinated hydrocarbons than the Northern one.

It seems that winter migrations of the birds have also an effect upon highly varied *DDT* content in the tissues within one species. Most probably some species of the birds forming breeding populations, or more generally

summer populations, on King George Island are dispersed in the wintertime, preying on the feeding grounds polluted with *DDT* residues in various degrees, Hence, the differences in qualitative composition of total *DDT* in the tissues observed within the species (occurrence or absence of *pp'DDE* and *pp'DDD*). The population of *O. oceanicus* seems to be the most homogeneous in this respect. This may be connected with more or less regular routes of their migrations (Dorst 1962).

5. Резюме

В районе польской антарктической станции им. Х. Арцтовского на острове Кинг Джордж с применением метода газовой хроматографии проводился анализ содержания *DDT* и метаболитов в тканях и яйцах: *Oceanites oceanicus*, *Larus dominicanus*, *Sterna vittata*, *Catharacta skua*, *Macronectes giganteus* (таблица I). Полученные результаты были дифференцированы как в количественном, так и в качественном аспекте. Вычисленные величины коэффициента изменчивости содержания *pp' DDT* и метаболитов в тканях птиц приведены в таблице II. Полученные результаты сравнивались с данными, приведенными в раньших работах. В случае *C. skua* содержание *DDT* сходно с раннее полученными данными. Результаты такого сравнения для *O. oceanicus* похожи. Высшее содержание общего *DDT* по сравнению с предыдущими данными было установлено в тканях *L. dominicanus* и *S. vittata*. Зато содержание *pp' DDE* в яйцах *M. giganteus* оказалось несколько ниже по сравнению с раннее полученными данными. Было установлено заметно высшее содержание *DDT* и метаболитов в тканях *O. oceanicus* и *C. skua* по сравнению с остальными видами. Эти разницы обусловлены качеством пищи и различными условиями зимовки. Разницы в качественном составе общего *DDT*, содержащегося в тканях в пределах вида, также объяснены зимней дисперссией.

6. Streszczenie

W rejonie Polskiej Stacji Antarktycznej im. H. Arctowskiego na wyspie King George określono metodą chromatografii gazowej zawartość *DDT* i metabolitów w tkankach i jajach: *Oceanites oceanicus*, *Larus dominicanus*, *Sterna vittata*, *Catharacta skua* i *Macronectes giganteus* (tablica I). Uzyskano zróżnicowane ilościowo i jakościowo wyniki. Obliczono wartości współczynnika zmienności zawartości *pp'DDT* i metabolitów w tkankach ptaków i podano go w Tabeli II. Uzyskane wyniki porównano z danymi zawartymi w pracach wcześniejszych. W przypadku *C. skua* zawartość *DDT* jest zbliżona do danych wcześniejszych. Podobnie kształtują się wyniki porównania dla *O. oceanicus*. Wyższą zawartość całkowitego *DDT* w porównaniu z danymi wcześniejszymi stwierdzono w tkankach *L. dominicanus* i *S. vittata*. Natomiast zawartość *pp'DDE* w jajach *M. giganteus* okazała się nieco niższa od danych wcześniejszych. Stwierdzono wyraźnie wyższą zawartość *DDT* i metabolitów w tkankach *O. oceanicus* i *C. skua* w porównaniu z pozostałymi gatunkami. Różnice te powiązano z rodzajem pobieranego pokarmu i odmiennymi terenami zimowania. Różnice w składzie jakościowym sumarycznego *DDT* zawartego w tkankach w obrębie gatunku wyjaśniono również dyspersją zimową.

7. References

1. Conroy I. W. H., French M. C. 1974 — Organochlorine levels in two species of Antarctic birds — Br. Antarct. Surv. Bull. 38: 43—47.

2. Dorst J. 1962 — The migrations of birds — Heineman, London, 476 pp.
3. Figge K., Hoerschelmann H., Polzhofer K. 1976 — Organochlorpestizide und polychlorierte Biphenyle in Vögeln aus den Gebieten südliches Südamerika, Falklandinseln und Norddeutschland (In: Hospital — Hygiene, Gessundheittswesen und Desinfektion 11, 12) — 1976/68 Jahrgang: 354—360, 367—374, 393—400, 403—410).
4. George J. L., Frear D. G. H. 1966 — Pesticides in the Antarctic — J. Appl. Ecol., Suppl: 155—167.
5. Łukowski A. B. 1978 — *DDT* and its metabolites in Antarctic Birds — Pol. Arch. Hydrobiol., 25: 729—737.
6. Riesebrough R. W. 1974 — Transfer of organochlorine pollutants to Antarctica (In: Adaptations Within Antarctic Ecosystems, Ed. G. Llano) — Smithsonian Inst, Houston; 1203—1210.
7. Riesebrough R. W., Carmignani G. M. 1972 — Chlorinated hydrocarbons in Antarctic birds — (In: Proceedings of the colloquium on conservation problems in Antarctica. Ed. B. C. Parker Lawrence, Kansas, Allen Press: 63—78).
8. Sladen W. J. L., Menzie G. M., Reichel W. L. 1966 — *DDT* residues in Adelie penquins and a crabeater seal from Antarctica — Nature, 210: 670—673.
9. Tatton J. O'G., Ruzicka J. H. A. 1967 — Organochlorine pesticides in Antarctica — Nature, 215: 246—348.
10. Thompson J. F. (Ed.). 1972 — Manual of analytical methods. Prepared by pesticides and toxic substances effects laboratory Triangle Parc, N. C., National Environmental Research Centr. Section 5, A(1): 1—9.
11. Watson G. E. 1975 — Birds of the Antarctic and Subantarctic — Richmond, Virginia, The William Byrd Press Inc., 350 pp.

Paper received 16 April 1982