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The toxicological importance of chemical pollution for marine birds in the Netherlands *)

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In the past period of 10 years a number of studies were made on the effects of chemical pollution on birds living in the coastal area of the Netherlands. These studies started in 1964 when it was discovered that the tissues of various species of birds, including sandwich terns (*Sterna sandvicensis*), eider ducks (*Somateria mollissima*), common terns (*Sterna hirundo*), and spoonbills (*Platalea leucorodia*) contained high levels of chlorinated hydrocarbon pesticides (Koeman & van Genderen 1966).

The finding of dead cormorants (*Phalacrocorax carbo*) in the tidal zone of the river Rhine in 1970 and the discovery of high levels of polychlorinated biphenyls (PCB's) in the tissues of these birds urged us to consider the possible toxicological effects of the PCB's. More recently some observations were made on the concentrations of mercury and selenium in liver and brain tissue of marine birds (guillemot *Uria aalge* and razorbill *Alca torda*) in order to compare these with the high levels found in marine mammals. The results of the studies referred to above will be summarised briefly in the present paper.

1. Effects of chlorinated hydrocarbon pesticides on sandwich terns and eider ducks

In 1964 and 1965 sandwich terns died with conspicuous symptoms in the Dutch Wadden Sea. In the tissues of the birds several chlorinated hydrocarbon pesticides were found in lethal concentrations. Comparable effects were observed in female eider ducks, which were found dying in the period from 1964 to 1967 It could be shown that the pesticides were mobilised from fat and other tissues during the incubation period which explained that only female birds were affected in this species. Incidental mortality caused by pesticides also occurred in a few other species

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Table 1: Numbers of breeding pairs of the sandwich tern in the Netherlands from 1965 onwards[1]). – Brutpaarzahlen der Brandseeschwalbe (*Sterna sanvicensis*) in den Niederlanden ab 1965.

year Jahr	n	year Jahr	n
1965	650	1970	2500
1966	1700	1971	2900
1967	1000	1972	3400
1968	1500	1973	4000
1969	2000	1974	± 4000

[1]) data from ROOTH & JONKERS (1972) and ROOTH, personal communication (1974).

Table 2: Annual mortality rate of female eiders ringed as breeding ducks (after SWENNEN 1972). – Jährliche Mortalitätsrate weiblicher als Brutvögel beringter Eiderenten (*Somateria mollissima*).

year Jahr	mortality rate (%) Mortalitätsrate in %
1964	35
1965	61
1966	33
1967	17
1968	15
1969	8
1970	2
1971	3

including the spoonbill, the common tern, the arctic tern *Sterna macrura*, the herring gull *Larus argentatus* and the grebe *Podiceps cristatus*. The compounds of major importance were telodrin, dieldrin and endrin. It could be demonstrated that most of the pesticidal material originated from a pesticide manufactory near Rotterdam. Consequently elaborate measures were made by this industry in order to limit any further pollution as much as possible. From 1967 a new purification plant was started and thereafter the concentrations of the compounds have shown a gradual decrease in the marine biota. Based on data from the literature and the recovery data of banded juvenile terns collected by the Bird migration Station at Arnhem it could be shown that excessive mortality of sandwich terns very probably also occurred in several years before 1965. The conclusion was drawn that pesticide pollution was one of the major causes for the observed decline of the sandwich tern from 40 000 breeding pairs in 1954 to 650 breeding pairs in 1965. The numbers of breeding pairs in the Netherlands from 1965 onwards are presented in table 1. It can be seen that the population shows a slow steady increase.

In the period from 1960 to 1968 the numbers of nests in the eider duck colonies in the Netherlands dropped from 5756 to 1329 (SWENNEN 1972). The first signs of recovery were noted in 1970 when 1919 nests were counted. The total number of nests did not increase after that date. In 1974 the number was estimated to be between 1000 and 1500 (SWENNEN). SWENNEN (1972) calculated the annual mortality rate of female eiders ringed as breeding ducks on the island Vlieland from the number of ring recoveries. These data are presented in table 2. The mortality rate has dropped markedly after 1968.

Table 3: Residual levels of chlorinated hydrocarbon compounds and mercury in the tissues of cormorants. – Rückstandshöhe von chlorierten Kohlenwasserstoff-Verbindungen und Quecksilber in den Geweben von Kormoranen (*Phalacrocorax carbo*).

No. Tissue Nr. Gewebe	Level of residue in ppm (wet weight) Rückstandshöhe in ppm (Feucht-Gewicht) HCB[1]	DDE	PCB	Hepo[2]	Dieldrin	Hg	MeHg
Birds found dead Tot gefundene Vögel							
1 Liver – Leber	14	n.a.	470	0.27	1.7	33	5.8
Brain – Gehirn						1.5	1.7
Total body – gesamter Körper	11	n.a.	280	0.07	0.85	4.7	3.6
2 Liver – Leber	11	5.5	93	0.12	0.25	18	6.2
Brain – Gehirn						2.0	1.6
Total body – gesamter Körper	25	14	460	0.14	1.9	4.4	3.4
3 Liver – Leber	6.2	29	300	0.10	0.79	52	1.4
Brain – Gehirn						2.0	1.9
Total body – gesamter Körper	3.4	13	150	0.225	0.24	7.0	3.8
4 Liver – Leber	2.5	30	350	n.a.	5.0	22	5.9
Brain – Gehirn						0.87	0.90
Total body – gesamter Körper	< 0.39	3.4	29	0.017	0.26	2.6	1.7
5 Liver – Leber	3.7	15	450	0.25	1.4	14	3.3
Brain – Gehirn						0.96	0.84
Total body – gesamter Körper	< 1.0	11	280	0.20	0.74	2.4	1.4
6 Liver – Leber	28	17	250	0.097	1.5	24	6.0
Brain – Gehirn						1.6	1.8
Total body – gesamter Körper	17	14	414	< 0.028	1.7	3.8	1.2
Mean brain level Durchschnittliche Rückstands-höhe im Gehirn	18	13	190	0.14	1.7	3.50	1.46

[1] Hexachlorobenzene
[2] Heptachloroepoxide

However, the excessive mortality rate of adult female birds in former years was still noticeable from an unbalanced sex ratio in 1974. 70 % of the population consists of male bird as compared to 50 % in the period before the female part of the population became affected (SWENNEN personal communication).

Eggshell measurements were made in both sandwich terns and eiderducks. In both species the relative shell weight (calculated by measuring the eggshell index, e. g. shell wt (mg)/length (mm) × width (mm)) appeared to be 5 % lower in the period from 1964 to 1970 as compared to the period before 1950. There were no indications that the eggshell changes coincided with a reduction in the reproductive potential of the birds (KOEMAN et al. 1967, 1972; KOEMAN 1971; KOEMAN & VAN GENDEREN 1972).

2. Effects of PCB and DDE in cormorants

The finding of a number of dead cormorants in the early spring of 1970 focussed our attention to the possible effects of persistent chemicals on this species. The PCB (polychlorinated biphenyls) residues in the tissues ot these birds appeared to be very high. The residue levels of PCB, total mercury, methyl mercury and chlorinated hydrocarbon pesticides found in dead cormorants are presented in table 3. In order to assess the toxicological implications of PCB's on cormorants, an experiment was carried out with 5 cormorants which were taken from main breeding colony in the

Table 4: Residue levels in tissues of cormorants poisoned with PCB (Clophen A 60) under experimental conditions. – Rückstandshöhe in Geweben von Kormoranen, die unter experimentellen Bedingungen mit PCB (Clophen A 60) angereichert wurden.

No.	Sex Geschlecht	Total dose (g) Gesamtdosis (g)	Survival time (days) Überlebensdauer in Tagen	Residue in level in ppm (wet weight) Rückstandshöhe in ppm (Feucht-Gewicht)				Total body content (g) Gehalt in g im gesamten Körper	% of dose % der Dosis
				Brain Gehirn	Liver Leber	Fat Fett	Total[1]) body gesamter Körper		
1	♀	2.8	55	115	210	n. a.[2])	850	1.12	49
2	♂	3.5	75	160	230	n. a.	1820	2.75	79
3	♀	6.7	106	76	245	10,300	2750	4.85	72
4	♀	7.1	110	180	290	20,500	2150	3.34	47
5	♂	9.1	124	120	285	n. a.	2580	4.15	46

[1]) Calculated for total body minus feathers, bill, feet and intestines. – Geschätzt für den gesamten Körper abzüglich Federn, Schnabel, Füße und Eingeweide.
[2]) n. a. = not analysed – nicht analysiert.

Netherlands. The animals were dosed with a technical PCB mixture (Clophen A 60) for a period of 14 weeks. The PCB's were administrated by injecting the material in the fish which served as food (Common roach *Leuciscus rutilus*). Further details about this experiment were published elsewhere (KOEMAN et al. 1972; 1973 a). It can be seen from table 4 that the PCB's are absorbed very efficiently by the birds. Average levels of 130 and 252 ppm PCB were detected in the brains and livers respectively. No correlation was found between the concentrations in these tissues and the time of survival, which strongly suggests that these represent threshold concentrations for the cormorant. The mean PCB concentrations measured in brain and liver of cormorants found dead were 190 ppm and 319 ppm respectively, and are slightly higher than those found in the experimental study. It is highly probable, therefore, that the birds had died from PCB poisoning. It is not possible here to evaluate the possible contribution of the chlorinated dibenzofurans know to be present in the Clophen A 60 mixture used, which also could be a consistent of the PCB residues found in nature (see VOS et al. 1970).

A comparison of shell thickness (actual thickness measured with a specially adapted micrometer) of cormorant eggs collected in 1971 with eggs from the period 1906 to 1937 showed a significant decrease of 9.8 %. In the 1971 sample the residue content of DDE and PCB tends to rise in association with declining shell thickness. It is most likely that DDE was the main factor responsible for the observed change in eggshell thickness.

In spite of the findings reported in the present study the population of the cormorant seems to be fairly stable in the Netherlands.

3. Mercury and selenium in marine birds

Various species of seals and whales appear to be able to concentrate larger amounts of mercury in their tissues than any other species studied sofar. The high mercury levels in marine carnivores are supposed to be related to one or more of the following factors:

(a) their end position in the food-chain
(b) a relative low rate of mercury excretion
(c) the possible existence of a protective mechanism which is able to convert the highly toxic methylmercury to less harmful compounds.

Table 5: Concentrations of mercury and selenium in livers and brain of marine birds (expressed in ppm on a wet weight basis). – Quecksilber- und Selenkonzentration in Leber und Gehirn von Seevögeln (ausgedrückt in ppm auf Feucht-Gewichts-Basis).

No.	Species Art	Date Datum	Tissue Gewebe	Mercury Quecksilber	Selenium Selen
1	Guillemot Trottellumme (*Uria aalge*)	19. Dec. 1971	Liver Brain	2.1 0.58	2.4 0.46
2	Guillemot	19. April 1973	Liver Brain	1.8 0.36	4.6 1.1
3	Guillemot	28. Sept. 1973	Liver Brain	2.1 0.35	3.4 0.83
4	Razorbill Tordalk (*Alca torda*)	27. Nov. 1972	Liver Brain	2.4 0.48	3.6 0.69

The latter factor finds support by the following scientific data. In tissues of marine mammals a 1 1 Hg/Se molecular increment ratio was found and an almost perfect linear concentration between mercury and selenium (KOEMAN et al. 1973 b). It is suggested that marine mammals are able to detoxify methyl-Hg by a specific chemical mechanism in which selenium is involved.

Some data on concentrations of mercury and selenium in marine birds are presented in table 5.

These data indicate that mercury does not accumulate to the same extent in these marine birds as it does in seals. Moreover no clearcut correlation was found between mercury and selenium. Further information on marine birds can be derived from british data showing that in 28 guillemots mercury concentrations in the liver did not exceed a level of 5 ppm (HOLDGATE 1971). The data on these marine birds strongly suggest that the fate of methyl mercury in fisheating marine birds differs fundamentally from that in marine mammals (KOEMAN et al., 1975).

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Zusammenfassung

Die toxikologische Bedeutung von chemischen Verunreinigungen für Seevögel in den Niederlanden

Während der letzten 10 Jahre hat man in den Niederlanden Untersuchungen über den Einfluß der Meerwasserverschmutzung auf verschiedene Arten von Küstenvögeln gemacht. Bis 1967 Maßnahmen gegen eine weitere Umweltverschmutzung getroffen wurden, hatte man Todesfälle bei Brandseeschwalben und bei weiblichen Eiderenten festgestellt, die auf eine industrielle Verseuchung mit Pestiziden (chlorierte Kohlenwasserstoffe) zurückzuführen gewesen waren. Die Anzahl der Brutpaare der Seeschwalben, die 1965 ein kritisches Minimum erreicht hatte, hat seither eine zwar langsame aber gleichmäßige Zunahme erfahren. Die recht erhebliche Sterblichkeit bei den weiblichen Eiderenten hörte auf. Es besteht jedoch bei dieser Art immer noch ein bemerkenswertes zahlenmäßiges Mißverhältnis der Geschlechter.

Weitere Chemikalien, die im Gewebe verschiedener Küstenvogelarten nachgewiesen werden konnten, sind die polychlorierten Biphenyle. Es ist mit großer Wahrscheinlichkeit anzunehmen, daß in den Niederlanden gelegentlich Kormorane durch diese Stoffe vergiftet werden, wenn es auch bisher keine Anzeichen dafür gibt, daß die Vermehrung bei dieser Art dadurch beeinträchtigt wurde.

Zur Zeit ist es schwierig, die toxikologische Bedeutung des Vorhandenseins von Quecksilber in der maritimen Zone im Hinblick auf Vögel und Säugetiere zu beurteilen. Ein sehr hoher Quecksilbergehalt ist in Robben, Tümmlern und Delphinen nachgewiesen worden. Die Konzentration im Gewebe von Lummen und Alken ist bedeutend geringer, woraus sich schließen läßt, daß sich das Schicksal des Methyl-Quecksilbers in Seevögeln nicht unwesentlich von dem mariner Säuger unterscheidet.

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Neue Ringfunde vom Eleonorenfalken *(Falco eleonorae)*

Von Dietrich Ristow

1. Einleitung

Das Verbreitungsgebiet des Eleonorenfalkens erstreckt sich von Zypern nach Westen über das ganze Mittelmeergebiet bis zur Atlantikküste in Marokko und den Kanarischen Inseln (Lovegrove 1971, Schmalfuss 1972, Vaughan 1961, Walter & Deetjen 1967). Der Bestand wird insgesamt auf weniger als 3000 Brutpaare geschätzt (Walter 1968), die in Kolonien meist auf unzugänglichen Felsinseln brüten. Infolgedessen werden kaum Vögel beringt, und es gibt entsprechend wenige Rückmeldungen: ein Nestling aus Marokko wurde ein Jahr später in Spanien wiedergefunden, ein weiterer nach anderthalb Jahren im Januar in Madagaskar (Terrasse 1963); ein Nestling aus Zypern wurde im selben Jahr Ende November ebenfalls auf Madagaskar getötet (Bannerman & Bannerman 1971). Weitere Ringfunde liegen jetzt von der Insel Paximada bei Kreta vor, wo ich 1965 mit H. Walter, 1969 mit