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Organochlorines and Heavy Metals in Herring Gull (*Larus argentatus*) Eggs and Chicks from the Same Clutch

Peter H. Becker[1] and Hans Sperveslage[2]

[1]Institut für Vogelforschung "Vogelwarte Helgoland", An der Vogelwarte 21, D-2940 Wilhelmshaven 15, FRG and [2]Staatl. Veterinäruntersuchungsamt Oldenburg, Philosophenweg, D-2900 Oldenburg, FRG

In an earlier paper we investigated the intraclutch variability in levels of toxic pollutants and compared this contamination with that of the female Herring Gull (Larus argentatus) after production of the clutch in question (Becker et al. 1989). In the present study, we examine the concentrations of contaminants in chicks as compared with one egg of the same clutch. Such studies are important with regard to the question as to which ontogenetic stage is most endangered by toxic pollutants. Some investigations concerning this problem have already been carried out (e.g. Lukowski 1978, Lemmetyinen & Rantamäki 1980, Lemmetyinen et al. 1982, Custer et al. 1985), but they don't refer to samples taken from the same clutches, which materially improves comparability.

Chicks receive contaminants mainly from two sources: from the egg, which reflects directly the contamination of the breeding female (e.g. Vermeer & Reynolds 1970, Lukowski 1978, Ohlendorf et al. 1978, Fimreite 1979, Lemmetyinen et al. 1982, Becker et al. 1989) as well as from the food. Moreover the concentrations of pollutants in chicks vary with growth-dependent body distribution and with a decline of the lipid content (e.g. Charnetski 1976, Lemmetyinen & Rantamäki 1980, Custer et al. 1985).

MATERIALS AND METHODS

The samples were gathered in 1981 on the island of Mellum (53.43 N 06.54 E), where Herring Gulls were breeding in a colony of about 10.000 pairs (Becker & Nagel 1983). 44 3-egg clutches were chosen on an area in the south of the island. They were marked and checked daily so that laying and hatching dates and conse-

Send reprint requests to P.H. Becker at the above address

Table 1. Residues of organochlorines (mg/kg fat) and heavy metals (mg/kg wet weight) in eggs and 5d-old chicks from identical clutches of Herring Gulls ($\bar{x}$±sd, n= 21). p-values: t-test paired samples, * p< 0.05, ** p< 0.01, *** p< 0.001.

	egg	chick 5d	p
% fat	10.9 ± 1.9	2.3 ± 1.1	
β- HCH	0.059 ± 0.091	0.452 ± 0.326	***
γ- HCH	0.070 ± 0.058	0.450 ± 0.393	***
Σ DDT	5.500 ± 2.001	14.443 ± 6.622	***
Heptachlor	0.145 ± 0.088	0.383 ± 0.202	***
Dieldrin	2.109 ± 1.164	3.983 ± 3.616	*
HCB	0.206 ± 0.128	0.519 ± 0.848	
PCBs	47.457 ± 38.075	26.838 ± 12.428	*
Mercury	0.327 ± 0.099	0.356 ± 0.095	**
Lead	0.030 ± 0.016	0.055 ± 0.051	*
Cadmium	0.005 ± 0.0	0.018 ± 0.009	***

quently the age of the chicks were known. The third egg was collected three days after being laid and kept cool until egg sampling was completed. Then they were blown and the egg contents frozen. One of the marked chicks, preferably the first hatched, from the remaining two eggs of the clutch was collected at the age of 5d, the other one ten days later. The chicks were wrapped in aluminium foil and frozen. This way we obtained for our contamination studies from each of 21 clutches one egg and one 5d-old chick (in two cases the chicks were actually 6d); and 7 of the clutches each provided us additionally with a second chick of 13-15d.

The methods of the chemical analysis are described in detail by Becker et al. (1989). Egg contents and 5d-old chicks were analysed in their entirity; from the 15d-old chicks only the liver was investigated. We studied concentrations of selected organochlorines (mg/kg fat, see table 1;Σ DDT=p,p'-DDE + p,p'-DDD; p,p'-DDT and heptachlorepoxide were not detected) and heavy metals (Hg,Pb and Cd, mg/kg fresh weight).

RESULTS AND DISCUSSION

Most pollutants were found in higher concentrations in the chicks than in the eggs (table 1). The exception was PCBs: their concentrations while being the highest of the chemicals studied, were lower in the chicks than in the egg. If we take into consideration that several

Table 2. Estimated total body contents of organochlorines and heavy metals in Herring Gull eggs and chicks 5d-old from the same clutch (μg).

	egg	chick 5d
β- HCH	0.6	1.4
γ- HCH	0.7	1.4
Σ DDT	43.2	45.9
Heptachlor	1.4	1.2
Dieldrin	16.8	12.7
HCB	1.7	1.7
PCBs	443.7	85.3
Mercury	39.1	49.8
Lead	2.6	7.7
Cadmium	0.4	2.5

chlororganic compounds are present in higher concentrations in third eggs than in first ones (13 - 17%, see Becker et al. 1989), the difference between concentrations of the pollutants in eggs and chicks must in fact be even greater than observed. Concerning intraclutch differences in mercury, present in lower levels in the third egg than in the first (-28%, Becker et al. 1989), levels would have shown a slight drop (from 0.46 mg/kg in the egg to 0.36 in the chick) if it had been possible to make a direct comparison.

Compared with the pollutant levels found in the fat values of the 5d-old chicks (total body), those in the liver-fat of the 15d-old sibling were with the exception of the PCBs clearly lower (n=6, cf. table 1: β-HCH 0.215±0.156; γ -HCH 0.130±0.125; Σ DDT 8.120±3.003; heptachlor 0.278±0.148; dieldrin 1.835±0.949; HCB 0.270±0.204; PCBs 69.450±26.720). Heavy metal concentrations in the liver of the older chicks, however, showed increases as against the body levels of their younger siblings (n=7, cf. table 1: Pb 0.234±0.256; Cd 0.026±0.015; Hg not analysed). Nevertheless the comparability is restricted by the fact that we couldn't analyse total body contents of the older chicks, and so we dispense with a statistical test.

Concentrations alone, however, are insufficient as evidence of the total amount of the pollutants in an organism. Therefore on the basis of an average egg mass (86g, Schönwetter 1967, Möllering 1972), a 5d-old chick mass of about 140g (Spaans 1971), the fat contents (table 1) and the significant differences in concentra-

Table 3. Correlation coefficients (r, only decimal places) of residues of organochlorines and heavy metals in third eggs with residues in chicks of different ages from identical Herring Gull clutches. p-values as in table 1.

	egg/chick 5d	chick 5d/chick 15d
	n = 21	n = 6
β- HCH	.36	.98 ***
γ- HCH	.13	.99 ***
Σ DDT	.32	.98 ***
Heptachlor	.49 *	.92 **
Dieldrin	-.09	.97 **
HCB	.34	.85 *
PCBs	.38	-.35
	n = 21	n = 7
Mercury	.92 ***	-
Lead	.30	.47
Cadmium	.05	.46

tions between first and third eggs (see Becker et al. 1989, first eggs compared with third eggs: Σ DDT - 16%, dieldrin - 17%, HCB - 14%, Hg + 39%), we estimated the total amount of the residues in egg and chick (table 2). These calculations result in comparable levels in egg and 5d-old chick in the case of Σ DDT, heptachlor and HCB, in higher amounts in the chicks in the case of β- and γ- HCH, and in lower amounts of dieldrin and PCBs in the chicks. The chicks contained greater amounts of heavy metals than the eggs (table 2). Therefore the young received β- and γ-HCH as well as heavy metals through the food, whereas PCBs and dieldrin possibly become degraded or excreted.

Is a chick originating from a heavily contaminated clutch also highly polluted ? We went into this question by means of correlation coefficients (table 3). They were in fact positive but not significant, so that our answer to the question above, except with reference to mercury and - with reservations - to heptachlor, is in the negative. Thus the mercury concentration in the egg predetermined to a great extent the later pollution of the chick. The correlations between egg and liver of the 15d-old chick showed similar results: only HCB correlated significantly ($r = 0.55$, $n=6$, $p<0.05$; mercury not analysed).

In contrast, positive correlations between the siblings of different ages were found in the concentrations of all the organochlorines but the PCBs (table 3); the heavy metal levels were not correlated significantly. Thus younger chicks heavily contaminated with chlororganic residues will also be polluted comparatively highly at a more advanced age.

The investigations showed higher concentrations of contaminants in 5d-old chicks than in eggs of the same clutch, owing mainly to accumulation in the lower fat content of the chicks, but with some chemicals, also to additional ingestion with food. As the young during their embryonic development reduce fat for energetic requirements (e.g. Drent 1970), the lipophil pollutants accumulate in their remaining fat.

Higher contents of toxic substances in the young compared with the eggs were found also by Lemmetyinen & Rantamäki (1980) and by Lemmetyinen et al. (1982) in Herring Gulls and Artic Terns (Sterna paradisaea), as also by Custer et al. (1985) in Common Terns (Sterna hirundo). Owing to declining concentrations with increasing age of the chicks (see below), the young are most threatened by toxic chemicals during their first days of life (Koeman et al. 1967, Robinson et al. 1967, Lemmetyinen & Rantamäki 1980).

Mercury in particular is deposited in the egg, especially in the first laid (Becker et al. 1989, Fimreite 1979).Thus the Hg-amount in chicks is determined mainly by the levels in the egg (table 1-3). The heavy metals lead and cadmium, however, which are found only in traces in the eggs (Becker et al. 1985 b, 1989), reach the young chiefly through their food. We noted,too, a marked increase in β- and γ-HCH total masses in the chicks compared with the egg. The whole body totals of the most organochlorines reveal similarities between eggs and young (cf. Robinson et al. 1967, Phalacrocorax aristotelis), only the PCBs were detected in five times smaller quantities in the chicks, indicating degrading or excretion.

The significance of nutrition for the introduction of pollutants into the young is also clearly expressed in the weak correlations between egg- and chick values, as opposed to the good correspondence in the chlororganic substances between younger and older chicks (table 3). The difference between egg and chicks from the same clutch can be due to several factors: the eggs reflecting more directly the female's long-term contaminant load; the difference in food sources of adults before egg laying and during feeding the chicks, which are supplied mainly with small fish (e.g.Goethe 1980); the parents possibly differing a)in the exploitation of special food sources and b) in the degree of participation in feeding their chicks.

The fact that only the livers of the 15d-old chicks were investigated hampers considerably a comparison with the results obtained from the total body contents of the younger siblings. For according to Howarth et al. (1982) lead and cadmium contents in tissues of the Crested Tern (Sterna bergii) differ. In Artic Terns, chlororganic compounds were found in similar concentrations in liver and muscle (Lemmetyinen & Rantamäki 1980), but not in liver, ovary or body-fat of Herring Gulls (Vermeer & Reynolds 1970, Becker et al. 1989). Nevertheless, an increase in heavy metal and PCBs contamination and a decline in pollution with the other chlororganic compounds is indicated. Results obtained by Robinson et al. (1967), Koeman et al. (1967), Charnetski (1976), Lemmetyinen & Rantamäki (1980) and Lemmetyinen et al. (1982) support this conclusion, which is explainable by dilution and distribution throughout the growing body of the contaminants adopted mainly from the egg, and may possibly also be the consequence of degrading and excretion.

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