POLLUTANTS IN GUILLEMOT AND KITTIWAKE EGGS FROM LUNDY

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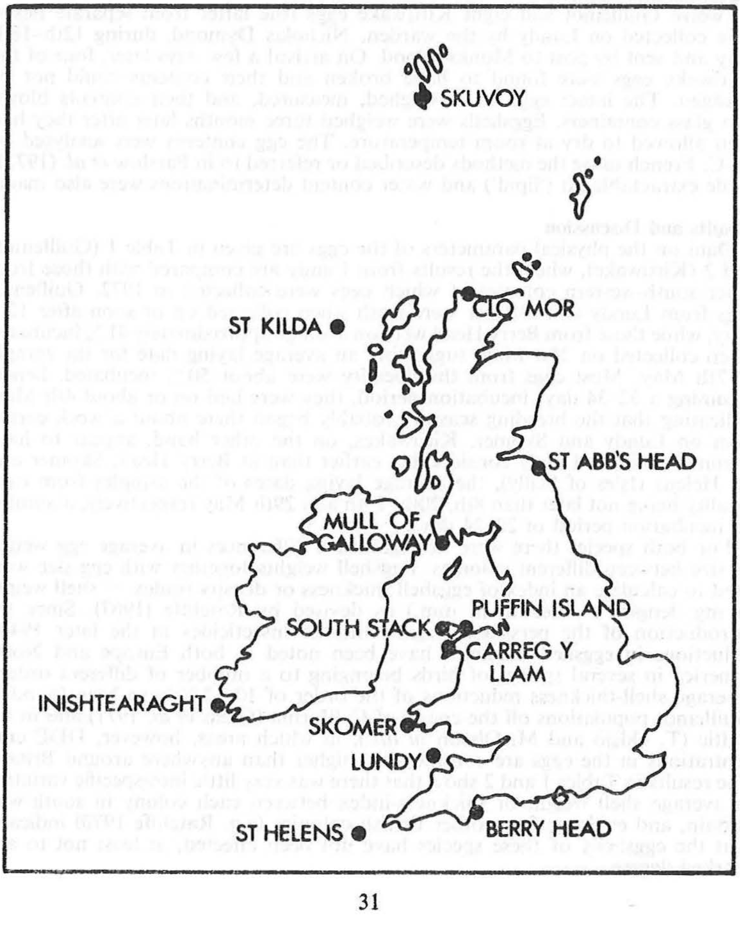
Introduction

As part of a survey of the occurrence of various marine pollutants in seabirds nesting on different parts of the coasts of the British Isles, small batches of eggs of Guillemots *Uria aalge* and Kittiwakes *Rissa tridactyla* were collected on Lundy in May 1972 and sent to Monks Wood Experimental Station for analysis. The main aim of the survey is to provide information on geographical and inter-specific variations in the levels of these pollutants in a number of seabird species so that contaminated populations can be identified and studies made on the possible effects of the pollutants on the birds. The two species mainly involved in this study were selected as representing seabird species, living on small fish or other live pelagic animals, whose populations are generally increasing (Kittiwake) or decreasing (Guillemot) in the British Isles as a whole (Coulson 1963, Parslow 1973). Sites at which samples of eggs have been collected in recent years (mostly 1971 and 1972) are shown in Fig. 1.



At present the pollutants being studied are the organochlorine insecticides (notably DDT and its principle metabolite, pp'-DDE, and dieldrin), polychlorinated biphenyls (PCB) and certain toxic metals (notably mercury, cadmium and lead; also copper and zinc). The synthetic insecticides are used mainly in agriculture, while PCBs have a number of industrial uses, many of which, however, have recently been stopped owing to the recognition of the risk of environmental contamination. The toxic metals are of course present naturally in the environment—indeed copper and zinc are essential to most forms of life—and locally high concentrations can occur in aquatic ecosystems as the result of natural leaching and run-off from base-rich soils, as well as from mining activities, refining and manufacturing industry, and in some cases from agricultural use.

Because of the possibility of locally high pollution, particularly of certain toxic metals, originating from industry higher up the Bristol Channel, Lundy provided a key site in the survey. The purpose of this paper is to present the results of the analyses of eggs collected there and to comment briefly on their significance. Full data from the survey are being published elsewhere.

Materials and Methods

Twelve Guillemot and eight Kittiwake eggs (the latter from separate nests) were collected on Lundy by the warden, Nicholas Dymond, during 12th–18th May and sent by post to Monks Wood. On arrival a few days later, four of the Kittiwake eggs were found to have broken and their contents could not be salvaged. The intact eggs were weighed, measured, and their contents blown into glass containers. Eggshells were weighed three months later after they had been allowed to dry at room temperature. The egg contents were analysed by M. C. French using the methods described or referred to in Parslow *et al.* (1972); crude extractable fat ('lipid') and water content determinations were also made.

Results and Discussion

Data on the physical parameters of the eggs are given in Table 1 (Guillemot) and 2 (Kittiwake), where the results from Lundy are compared with those from other south-western colonies at which eggs were collected in 1972. Guillemot eggs from Lundy and Skomer were fresh when collected on or soon after 12th May, while those from Berry Head were on average approximately 41% incubated when collected on 21st May, suggesting an average laying date for the sample of 7th May. Most eggs from this locality were about 50% incubated, hence, assuming a 32–34 days incubation period, they were laid on or about 4th May, indicating that the breeding season probably began there about a week earlier than on Lundy and Skomer. Kittiwakes, on the other hand, appear to have begun to nest on Lundy considerably earlier than at Berry Head, Skomer and St. Helens (Isles of Scilly), the average laying dates of the samples from each locality being not later than 8th, 20th, 25th and 29th May respectively, assuming an incubation period of 22–24 days.

For both species there were no significant differences in average egg weight or size between different colonies. Eggshell weights together with egg size were used to calculate an index of eggshell thickness or density (index = shell weight in mg./length × breadth in mm.) as devised by Ratcliffe (1967). Since the introduction of the persistent organochlorine insecticides in the later 1940s, reductions in eggshell thickness have been noted in both Europe and North America in several species of birds belonging to a number of different orders. Average shell-thickness reductions of the order of 10–12% have been found in Guillemot populations off the coasts of California (Gress *et al.* 1971) and in the Baltic (T. Odsjö and M. Olsson *in litt.*), in which areas, however, DDE concentrations in the eggs are considerably higher than anywhere around Britain. The results in Tables 1 and 2 show that there was very little intraspecific variation in average shell weight or thickness-index between each colony in south-west Britain, and evidence from other British colonies (e.g. Ratcliffe 1970) indicates that the eggshells of these species have not been affected, at least not to any marked degree.

Table 1

Physical parameters of Guillemot *Uria aalge* eggs from Lundy compared with other south-western colonies

	Lundy (*N. Devon*)	*Skomer* (*Pembroke*)	*Berry Head* (*S. Devon*)
No. of eggs	12	5	8
Date collected	12–18.5.72	12.5.72	21.5.72
Mean embryo development (%)	4	0	41
Egg weight (g)	106 ± 3	100 ± 3	100 ± 3
Egg length (mm)	83·0 ± 0·9	80·6 ± 0·8	82·8 ± 2·0
Egg breadth (mm)	50·0 ± 0·5	50·8 ± 2·1	49·0 ± 0·6
Shell weight (g)	12·5 ± 0·3	12·1 ± 0·4	12·3 ± 0·7
Eggshell index	3·01 ± 0·04	2·95 ± 0·07	3·04 ± 0·11
'Lipid' (%)	11·8 ± 1·0	11·6 ± 0·9	14·2 ± 0·5
Water content (%)	74·0 ± 1·8	75·5 ± 1·5	72·9 ± 0·8

NOTES: For calculation of eggshell index see text. In Tables 1–4, figures following '±' denote standard errors.

Table 2

Physical parameters of Kittiwake *Rissa tridactyla* eggs from Lundy compared with other south-western colonies

	Lundy (*N. Devon*)	*Skomer* (*Pembroke*)	*Berry Head* (*S. Devon*)	*St. Helens* (*Is. of Scilly*)
No. of eggs	4	6	8	6
Date collected	12.5.72	27.5.72	23.5.72	31.5.72
Mean embryo development (%)	19	8	12	8
Egg weight (g)	(45·1)	45·2 ± 1·4	45·7 ± 1·2	46·8 ± 1·9
Egg length (mm)	55·6 ± 0·7	53·8 ± 1·4	55·5 ± 0·6	56·5 ± 1·2
Egg breadth (mm)	40·1 ± 0·4	40·4 ± 0·3	40·5 ± 0·5	40·3 ± 0·4
Shell weight (g)	2·72 ± 0·03	2·55 ± 0·04	2·67 ± 0·07	2·70 ± 0·08
Eggshell index	1·22 ± 0·02	1·18 ± 0·02	1·17 ± 0·02	1·19 ± 0·03
'Lipid' (%)	9·28 ± 0·53	9·39 ± 0·42	8·06 ± 0·62	9·38 ± 0·15
Water content (%)	77·0 ± 0·7	77·2 ± 0·4	79·0 ± 0·9	77·0 ± 0·5

See footnote to Table 1.

Lipid and water content determinations of the egg samples also show little intraspecific variation between colonies. The organochlorine substances are stored in lipids, amounts of which in eggs vary from species to species. Guillemot eggs, for example, have proportionately larger yolks (and hence more lipid) than do Kittiwake eggs. Interspecific differences in organochlorine residue concentrations are therefore best indicated by the amounts in egg lipids rather than whole egg contents. Water contents of eggs are inversely related to lipid levels and provide an indication of water loss between collection and processing for analysis.

Analytical results have been converted to concentrations (in parts per million) in lipid in the case of the organochlorine residues and ppm dry weight in the case of the toxic metals. These results are summarised in Tables 3 and 4 for Guillemot and Kittiwake respectively, and are discussed below.

PCB Concentrations

Levels of PCB in Guillemot eggs from Lundy were on average higher than those from Skomer but were appreciably and significantly lower than in those from Berry Head, where the population would appear to be exposed to relatively high levels of PCB contamination either locally or in its winter quarters. On average, the levels of PCB in the Guillemot eggs from Berry Head were 2·4 times higher than in those from Skomer and 1·6 times higher than in those from

Lundy. Indeed the residues found approach those of the most heavily contaminated Guillemot population yet examined, at the Mull of Galloway in the northern part of the Irish Sea.

At Lundy, Skomer and Berry Head, mean concentrations of PCB in Kittiwake eggs were slightly but consistently higher than in Guillemot eggs from the same localities (and were also relatively high in the Kittiwake eggs from Scilly), but only at Skomer was the interspecific difference statistically significant. Between the different colonies there was much less variation in mean residues in Kittiwake eggs than in Guillemots', the difference in mean PCB residues between the most (Berry Head) and least (Skomer) contaminated populations being only 40% and not statistically significant.

Table 3

Mean concentrations of certain organochlorine substances and toxic metals in Guillemot *Uria aalge* eggs from three south-western colonies

	Lundy (*N. Devon*)	*Skomer* (*Pembroke*)	*Berry Head* (*S. Devon*)
Organochlorine residues (*ppm in lipid*)			
PCB	81·5 ± 6·6	56·0 ± 6·9	133·6 ± 9·5
DDE	10·84 ± 0·63	10·68 ± 0·83	14·64 ± 0·57
dieldrin	*c.*0·61 ± 0·23	*c.*0·17 ± 0·07	*c.*0·31 ± 0·18
Toxic metals (*ppm dry weight*)			
mercury	5·35 ± 0·46	4·61 ± 0·43	6·25 ± 0·35
copper	10·24 ± 1·36	4·64 ± 0·37	5·11 ± 0·23*
zinc	86 ± 6	104 ± 16	100 ± 13

* Copper mean in eggs from Berry Head excludes a single high value, 11·5 ppm; including this sample, the mean at this locality is 5·90 ± 0·82 (standard error).

Table 4

Mean concentrations of PCB, DDE and three toxic metals in Kittiwake *Rissa tridactyla* eggs from four south-western colonies

	Lundy (*N. Devon*)	*Skomer* (*Pembroke*)	*Berry Head* (*S. Devon*)	*St. Helens* (*Is. of Scilly*)
Organochlorines (*ppm in lipid*)				
PCB	115 ± 17	100 ± 7	141 ± 18	131 ± 15
DDE	2·71 ± 0·40	4·17 ± 0·75	2·79 ± 0·44	7·13 ± 0·98
Metals (*ppm dry weight*)				
mercury	1·73 ± 0·19	1·45 ± 0·08	2·32 ± 0·23	2·78 ± 0·38
copper	4·04 ± 0·06	3·64 ± 0·22	4·41 ± 0·24	3·62 ± 0·25
zinc	113 ± 5	83 ± 2	109 ± 6	82 ± 2*

* Zinc mean in eggs from St. Helens excludes a single high value of 151 ppm; including this sample the mean at this locality is 94 ± 12 (standard error).

Most surveys of organochlorine residues in marine ecosystems have shown that PCB is present in greater concentrations than the organochlorine insecticides. Levels of DDE (and dieldrin) tend to be low in British seabirds in comparison with PCB levels and with DDE levels in the same or similar species in some other parts of the northern hemisphere, for example in coastal waters off California and and in the Baltic. PCB levels, on the other hand, appear to be at least as high in Guillemots and their eggs from some parts of the British coast (notably the

Irish Sea, also Berry Head) as in the same species from California and the Baltic. An important source of PCB in certain British coastal areas is dumped sewage sludge (Holden 1970). Particularly high levels of PCB were present in the livers of birds found dead during the massive Guillemot wreck in the Irish Sea in autumn 1969 (Anon. 1971, Parslow and Jefferies in press) and in several Gannets *Sula bassana* involved in a wreck in the Irish Sea region in 1972 (Parslow *et al.* 1973). In both instances, and particularly the first, it was possible that PCB was a contributory cause of the mortality. Laboratory experiments have shown that PCB can also have sublethal effects on seabirds, notably on the endocrine system (Jefferies and Parslow 1972).

DDE Concentrations

Mean residues of DDE in Guillemot eggs were almost identical at both Lundy and Skomer but were slightly (35–40%) and significantly higher at Berry Head. Residues in Kittiwake eggs were more variable within each colony and there were no significant differences in mean concentrations between Lundy, Skomer and Berry Head. Rather surprisingly, however, the sample from the Isles of Scilly had average residues that were significantly higher than those from both Lundy and Berry Head. In contrast to PCB residues, DDE levels were much higher in Guillemot than Kittiwake eggs at all colonies, as shown in Table 5.

Table 5

Ratio of PCB to DDE in Guillemot *Uria aalge* and Kittiwake *Rissa tridactyla* eggs.

		P C B / D D E		
	Lundy	*Skomer*	*Berry Head*	*St. Helens*
Guillemot eggs	7·2	5·0	8·9	
Kittiwake eggs	40	23	50	18

Fig. 1. Survey of pollutants in eggs of Guillemots *Uria aalge* and Kittiwakes *Rissa tridactyla.* Map shows sites from which samples of eggs of one or both species have been collected and analysed in recent years (mostly 1971 and 1972).

The difference in the proportionate amounts of DDE and PCB in the eggs of the two species is presumably related to differences in the birds' feeding ecology and consequently to different levels of exposure to each of these organochlorine materials. Throughout virtually the whole year, Guillemots feed in the inshore marine zone on small fish, notably young herrings and sprats (*Clupea* spp.) and sand-eels (*Ammodytes* spp.). Analyses of such fish from the Irish Sea region indicate that they contain of the order of two to ten times more PCB than organochlorine residues (DDE and dieldrin) (data from Holdgate 1971). Kittiwakes, on the other hand, feed mainly on macrozooplankton living on or near the surface in the offshore and pelagic zones. Zooplankton samples from the North Atlantic examined by Risebrough *et al.* (1972) contained very much more PCB than DDE, particularly those from the open ocean, where PCB concentrations were 30000 or more times higher than DDE concentrations. The data imply that the source and transportation of PCB reaching the Kittiwakes (via their pelagic, plankton diet) is different to that reaching the Guillemots (via their inshore, fish prey); in all probability the former is likely to have arisen through aerial pollution and the latter from water-borne effluent or sewage dumping in coastal waters.

Dieldrin

On the analytical methods employed, the lowest concentrations of dieldrin that could be measured were about 0·3 ppm (lipid basis). Only three of the Guillemot eggs from Lundy contained concentrations greater than this (0·85, 1·95 and 2·71 ppm) as did only one from Skomer (0·46 ppm) and two from Berry Head (0·33 and 1·52 ppm). None of the Kittiwake eggs contained measurable residues of this insecticide.

Mercury

In the eggs of both species, concentrations of total mercury were significantly greater at Berry Head than Skomer, with Lundy intermediate between the two. On average, Guillemot eggs contained concentrations of mercury that were about three times higher than in Kittiwake eggs from the same localities. The source of this mercury, and in particular whether most of it was of natural or industrial immediate origin, is not known. The concentrations found are high by comparison with eggs of the same species nesting in northern Britain and the Faeroes but low in comparison with some Irish Sea colonies, where the influence of industrial pollution appears to be an important factor. The significance of the concentrations in relationship to their possible effects on the birds themselves is not known.

Copper and Zinc

Copper and zinc occur naturally in seabirds and their eggs and such data that exist suggest that these essential elements are regulated metabolically. With a few individual exceptions, there is generally relatively little interspecific or geographical variation in concentrations of either copper or zinc in seabird eggs. The results in Tables 3 and 4 indicate that this general principle holds good for zinc: mean levels in Kittiwake and Guillemot eggs were closely similar between species and localities, except that levels in the small sample of Kittiwake eggs from Lundy were rather higher than in Guillemot eggs from the same locality and from Kittiwake eggs from Skomer.

At Skomer and Berry Head mean copper concentrations in Guillemot eggs were slightly (but not significantly) higher than in Kittiwake eggs. At Lundy, however, although there was considerable variation between individual eggs, the mean levels of copper in Guillemot eggs were appreciably and significantly greater (about twice as high) than in Kittiwake eggs from the same locality, and indeed were appreciably higher than in the eggs of either species from each of the south-western colonies. The reasons for these higher copper levels in the Lundy Guillemots are not known.

Cadmium and Lead

Analyses for these metals were carried out on all eggs. Except that two of the Kittiwake eggs from Scilly contained 1·3 and 1·7 ppm cadmium, all eggs examined contained less than 1 ppm cadmium or lead.

Conclusions

For various reasons, for example possible differences in the winter movements and age structure of each population sampled, the analytical results reported in this paper cannot necessarily be used for the direct comparison of potential pollution hazards within the immediate neighbourhood of the individual colonies. This is particularly so in the case of such a wide-ranging, pelagic species as the Kittiwake. Nevertheless, the results do indicate that in general the Guillemot and Kittiwake populations on Lundy contain similar levels of most of the pollutants studied as do the same species on Skomer, the nearest locality for which comparable data are available. The main exception is that copper levels in Guillemot eggs at Lundy are much higher, and indeed are higher than in Guillemot eggs from any other colony yet studied. By comparison with Berry Head (and incidentally some Irish Sea colonies) levels of PCB and, to a lesser extent, DDE in Guillemot eggs from Lundy are relatively low, though they are still much higher than the levels found in the eggs of the same species from colonies in northern Scotland and the Faeroes, in areas remote from industry. Full discussion of these results and, in particular, their significance in relation to possible hazards to the birds themselves, are deferred until the full results of the wider survey are available.

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