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No. 271

Wildlife and Pollution: 1996/97 Annual Report

I. Newton, L. Dale, J.K. Finnie, P. Freestone,
H. Malcolm, D. Osborn, J. Wright, C. Wyatt & I. Wyllie

Centre for Ecology & Hydrology
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Institute of Terrestrial Ecology
(Natural Environment Research Council)
JNCC Project 018 (Contract F71-12-153)
ITE Project T08054c5

Annual report to Joint Nature Conservation Committee
Monks Wood
Abbots Ripton
Huntingdon
Cambs
PE17 2LS

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Contents

1 Preface and summary

1.1 Introduction

The Wildlife and Pollution contract covers a long-term monitoring programme to examine the levels of pollutants in some wildlife in Britain. The programme was started more than 30 years ago, when there were serious concerns over the effects of organochlorine insecticides and organomercury fungicides on several birds and mammals. This early work demonstrated the effects of the organochlorines, and eventually contributed to the ban on their use in this country and abroad. The programme has measured levels of these compounds in predatory and fish-eating birds since then. Investigations have also been made into the levels of industrial polychlorinated biphenyls (PCBs), following their identification as pollutants in 1966. Mercury levels, derived from both agricultural and industrial sources, have also been tracked. In addition, the contract supports a wildlife incident investigation service, which can examine the causes of unexpected mortality incidents (that are not obviously related to oil pollution or to farm chemicals). In recent years, investigations have been made into the effects of the newest generation of rodenticides on barn owls. Gannet eggs are regularly collected biennially from two colonies and, when available, from other sites; eggs were collected from three sites in 1996.

Annual reports give an interim summary of results. Every three years these annual results are gathered together into a more substantial report in which they are integrated with previous findings. In addition, results are published periodically in the scientific literature. Recent key papers are listed in this report under sub-project summaries.

The Wildlife and Pollution contract was the subject of scientific assessment within JNCC's rolling programme of peer review in autumn 1993, and was further assessed in 1996.

Each subproject within the Wildlife and Pollution contract is summarised below. Each is dependent on the provision of material from amateur naturalists and other interested parties, and it is not always possible to obtain desired material for analysis, especially from remote areas.

1.2 Organochlorines and mercury in predatory birds

The main objective of this work was to analyse the bodies of predatory and fish-eating birds, supplied by members of the public, in order to continue the monitoring of organochlorine and mercury residues in livers. This enables us to keep a watch on the effects of previous hard-won withdrawals of permitted uses of some of these chemicals, and to examine geographical variation in residues. For 1996 the livers from 124 birds were analysed, including those from 23 kestrels, 78 sparrowhawks, 8 herons, 3 kingfishers, 1 great-crested grebe and 11 birds of various other species. These birds came from various localities in England, Scotland and Wales. Over the whole monitoring period (1963-96), the overall data for most species have revealed significant long-term downward trends in residues (except for PCBs in three species). Declines may be levelling off for DDE (the main metabolite of DDT) and HEOD (derived from aldrin and dieldrin). There was one significant change in geometric mean levels between 1995 and 1996; this was an increase in HEOD levels in kestrels. It is impossible to say whether this difference reflected real year-to-year changes in exposure.

1.3 Organochlorines and mercury in peregrine eggs

Eggs from 13 peregrine clutches were analysed in 1996, from various parts of England, Scotland and Wales. The organochlorine levels in British peregrines continue to decline, and at least in inland areas, are unlikely now to cause breeding failures and mortality.

1.4 Organochlorines and mercury in merlin eggs

Eggs from 28 merlin clutches were analysed in 1996, from various parts of England and Scotland. The results confirm that the merlin remains the most contaminated of the British raptors, but residue levels are declining. Mercury in eggs from the Northern Isles continues to be at high levels, and some high PCB levels were found in some areas.

1.5 Organochlorines and mercury in golden eagle eggs

Eggs from ten clutches (nine from Scotland and one from England) were analysed. These confirm the low levels of contamination in eggs from inland districts found in recent years. The level of residues and shell index of the one coastal egg was not markedly different from the other eggs received in 1996.

1.6 Organochlorines and mercury in gannet eggs

Eggs from three colonies were analysed in 1996. Residue levels were low and within the range of previous eggs from these colonies. Over the long term (1971-96) HEOD showed a significant decline in eggs from Bass Rock, and DDE declined significantly in eggs from Bass Rock and Hermaness. However, eggs from St Kilda showed a significant increase in mercury levels. The gannet is the only British seabird in which residue levels have been monitored continuously over the past 25 years, so has become a key indicator species in marine pollution.

1.7 Rodenticide residues in barn owls

The aims of this study were to find (i) to what extent barn owls in Britain are contaminated with certain rodenticide residues, and (ii) whether such residues are likely to cause significant mortality. As barn owl numbers are thought to have declined this century, it is important to assess any role that secondary poisoning from rodenticides might have on the British population. The second-generation anticoagulant rodenticides (currently difenacoum, bromadiolone, brodifacoum and flocoumafen) are likely to pose the greatest threat. These are rapidly replacing warfarin and are both more toxic and more persistent. Due to the serious illness of the specialist analyst, no rodenticide analyses were included in the 1995/96 report. This report, therefore, contains the results of rodenticide analyses for carcasses received in 1995 and 1996. The residues of one or more rodenticides were found in the livers of 48 (35%) birds. A review of all rodenticide analyses carried out under this contract reveals that the proportion of birds containing detectable residues has increased more than 7-fold over the last 14 years. Still, however, only 2% of deaths recorded over 1983-96 were unequivocally attributed to rodenticide poisoning.

1.8 Lindane residues in predatory birds

Residues of the primary constituent of lindane, gamma-HCCH (formerly gamma-HCH), have been measured in the livers of predatory birds since the monitoring scheme began. This section of the report reviews these results to show long-term trends in the levels of residues found.

1.9 *Kittiwake mortality incident, Marsden, July 1996*

Only one mortality incident was investigated in 1996, namely the large kill of kittiwakes which occurred off the Northumbrian coast in August/September. Seven birds were analysed for organochlorine and mercury levels, none of which were out of the ordinary. From a similar incident in 1997, MAFF scientists diagnosed the mortality cause as dinoflagellate toxin poisoning, which would not have been detected in our analysis.

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Wildlife and pollution

Part 2 Organochlorines and mercury in predatory birds, 1996

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2 Organochlorines and mercury in predatory birds, 1996

2.1 Introduction

Thé main objective of this work was to analyse the carcasses of predatory birds, supplied by members of the public, in order to continue the monitoring of organochlorine and metal residues in livers. The chemicals of interest included DDE (from the insecticide DDT), HEOD (from the insecticides aldrin and dieldrin), PCBs (polychlorinated biphenyls from industrial products) and Hg (mercury from agricultural and industrial sources). Throughout this section, the levels of organochlorines are given as ppm in wet weight and of mercury as ppm in dry weight.

The main species involved included the sparrowhawk and kestrel, representing the terrestrial environment, and the fish-eating heron, kingfisher and great-crested grebe, representing the aquatic environment. The findings from various other species received during the year are also included. Findings from previous years are given in earlier reports in this series and in a published paper by Newton *et al* 1993.

2.2 Results from 1996

During the past year, the livers from 124 birds were analysed, including those from 23 kestrels, 78 sparrowhawks, 8 herons, 3 kingfishers, 1 great-crested grebe and 11 others. These totals included some birds which had died in earlier years, but which were analysed in the current year. The results from all these birds are listed in Table 1, and the geometric means for each chemical from the main species (1996 specimens only) are given in Table 2.

Several birds from 1996 had unexpectedly high levels of pollutants. They included a kestrel (from Lincolnshire) with 6 ppm DDE, 9 ppm PCB and 6 ppm mercury, another kestrel (from Merseyside) with 36 ppm PCB and a kestrel collected in 1995 with 11 ppm mercury; one sparrowhawk (from Dyfed) with 20 ppm DDE, 46 ppm PCB and 13 ppm mercury, another sparrowhawk (from Kent) with 19 ppm DDE, two other sparrowhawks with 6 ppm DDE, five with PCB levels of 11-21 ppm and three with mercury levels of 10-16 ppm. Amongst other species, mercury was found at high levels in a peregrine from Orkney with 16 ppm, a merlin from Orkney with 20 ppm, four herons with 21-28 ppm and a bittern from West Yorkshire with 34 ppm. None of these levels are thought to have caused the death of the birds concerned.

Another major change of recent years has been the increasing relative importance of PCBs. In some species these chemicals have not declined since the 1970s, so in many specimens they now predominate among organochlorine residues.

Out of 16 comparisons, one significant difference in geometric mean values was found between the 1995 and 1996 results. This was a significant increase in HEOD residues in kestrels (Table 3). It is impossible to say whether this difference reflected real changes in exposure, especially as levels were generally low. Because only one great-crested grebe was received in 1996, no comparisons between residues in 1995 and 1996 could be made for this species.

2.3 Reference

Newton, I, Wyllie, I. & Asher, A. 1993. Long term trends in organochlorine and mercury residues in some predatory birds in Britain. Environ. Pollut. 79: 143-151.

Table 1. **Levels of organochlorines (ppm wet weight) and mercury (ppm dry weight) in the livers of predatory birds analysed between April 1996 and March 1997**

ND=none detected; J=juvenile in first year; A=adult other than first year; M=male; F=female; D & G=Dumfries & Galloway; H & W=Hereford & Worcester.

Specimen no.	Date Found	County	Age	Sex	pp'-DDE	HEOD	PCB	Hg
Kestrel (*Falco tinnunculus*)								
12114	Sep-94	Strathclyde	J	F	0.090	0.466	2.244	4.571
12309	Jan-95	Gwynedd	J	F	0.140	0.066	0.180	0.685
12128	Oct-95	Shetland	J	F	0.115	0.123	2.095	11.361
12021	Nov-95	Essex	J	F	0.989	0.105	0.268	0.930
12013	Jan-96	Tayside	J	F	0.227	0.154	0.987	1.065
12227	Jan-96	North Yorks	-	-	0.052	0.191	4.877	0.348
12316	Jan-96	Lincolnshire	J	M	6.489	0.278	9.973	6.057
12043	Feb-96	Humberside	J	F	0.660	0.072	1.381	1.413
12048	Feb-96	Orkney	J	F	0.270	0.051	3.063	3.755
12066	Mar-96	Lancashire	A	M	0.089	0.132	1.595	3.024
12125	Jul-96	Suffolk	A	M	0.130	0.178	0.782	0.359
12322	Aug-96	Gwynedd	J	F	0.110	0.314	0.778	3.763
12158	Aug-96	Cheshire	J	F	ND	0.439	0.035	0.155
12162	Aug-96	Norfolk	J	F	0.088	0.832	0.385	0.613
12320	Aug-96	Gloucestershire	A	M	0.046	0.159	4.324	0.272
12305	Oct-96	Kent	J	F	0.023	0.906	0.160	0.684
12290	Oct-96	Essex	J	M	0.089	0.353	1.150	1.545
12360	Nov-96	Merseyside	A	M	1.512	0.401	36.743	1.466
12293	Nov-96	Essex	J	F	0.031	0.267	0.191	0.398
12302	Nov-96	Humberside	J	F	0.039	0.225	2.259	2.513
12338	Nov-96	Avon	J	F	0.144	0.120	2.075	1.072
12362	Nov-96	Northants	J	F	0.056	0.122	0.062	0.104
12358	Dec-96	Grampian	A	F	0.086	0.120	0.051	0.389
Sparrowhawk (*Accipiter nisus*)								
12216	May-95	Lancs	-	-	0.324	0.115	0.094	1.706
12217	May-95	Lancs	-	-	0.228	0.152	0.017	2.219
12310	Aug-95	Clwyd	A	F	0.218	0.128	0.128	2.895
12311	Sep-95	H & W	J	F	3.471	0.293	0.386	2.367
12095	Oct-95	Norfolk	J	F	4.181	0.142	0.371	ND
12053	Nov-95	North Yorks	J	M	0.123	0.024	0.122	0.569
12313	Nov-95	Essex	J	M	1.046	0.102	5.800	2.925

Specimen no.	Date Found	County	Age	Sex	pp'-DDE	HEOD	PCB	Hg
Sparrowhawk (*Accipiter nisus*) cont.								
12022	Jan-96	Cambs	J	F	0.160	0.042	0.644	1.951
12007	Jan-96	Hants	J	F	0.026	0.023	0.001	0.234
12035	Jan-96	Leics	J	M	1.292	0.138	2.585	1.585
12052	Jan-96	North Yorks	A	F	0.146	0.039	0.489	1.011
12024	Jan-96	W Midlands	A	M	0.134	0.096	3.448	0.302
12026	Jan-96	Dorset	J	F	0.158	0.137	0.253	0.755
12062	Jan-96	Tayside	J	F	0.045	0.017	ND	0.553
12126	Feb-96	D & G	A	M	1.780	0.077	7.852	16.665
12036	Feb-96	D & G	A	F	2.990	0.154	4.235	5.975
12039	Feb-96	Merseyside	J	M	2.540	0.051	4.854	1.961
12045	Feb-96	Kent	J	F	19.574	0.867	9.623	2.860
12046	Feb-96	Essex	J	M	3.708	0.053	0.682	1.220
12060	Mar-96	Wilts	J	M	0.441	0.047	0.676	2.775
12233	Mar-96	Glos	-	-	0.930	0.141	0.511	2.895
12234	Mar-96	Glos	-	-	0.487	0.076	1.948	2.367
12071	Mar-96	Bucks	J	F	2.108	0.105	13.516	3.018
12068	Mar-96	Humberside	J	M	0.207	0.050	0.356	1.137
12075	Mar-96	Glos	J	M	1.960	0.074	4.761	5.191
12070	Mar-96	Fife	A	M	1.174	0.113	1.996	2.585
12089	Apr-96	Kent	A	M	10.968	2.021	5.734	6.000
12084	Apr-96	Essex	J	M	17.120	0.819	24.784	5.500
12085	Apr-96	Herts	A	M	1.013	0.025	1.476	0.493
12102	May-96	Dyfed	-	-	20.253	1.305	46.715	13.665
12106	May-96	Strathclyde	A	F	3.326	0.773	3.042	7.855
12091	May-96	Sussex	A	F	4.776	0.316	21.140	9.175
12324	Jun-96	Gwynedd	A	F	0.986	0.448	0.804	3.097
12115	-	Northumberland	J	F	0.807	0.220	3.086	5.011
12140	Jul-96	Kent	J	M	0.310	0.062	ND	0.392
12135	Jul-96	W Midlands	J	F	3.652	0.414	1.335	ND
12323	Aug-96	Gwynedd	J	F	0.741	0.221	1.531	4.318
12143	Aug-96	Salop	J	F	0.036	0.027	ND	ND
12150	Aug-96	Isle of Man	J	F	1.070	0.584	1.081	2.564
12147	Aug-96	Northants	J	F	0.076	0.033	ND	0.384
12151	Aug-96	Herts	J	F	0.166	0.036	0.105	ND
12153	Aug-96	Oxon	J	M	0.529	0.060	0.199	0.568
12155	Aug-96	Herts	J	M	0.257	0.213	0.585	0.904
12154	Aug-96	Cambs	J	F	0.298	0.050	0.083	0.711
12159	Aug-96	Surrey	J	M	0.466	0.082	1.755	1.444
12156	Aug-96	Hants	J	F	0.064	ND	ND	1.068
12157	Aug-96	Northants	J	F	0.232	0.029	0.098	1.103

Specimen no.	Date Found	County	Age	Sex	pp'-DDE	HEOD	PCB	Hg
Sparrowhawk (*Accipiter nisus*) cont.								
12178	Aug-96	Strathclyde	J	F	0.082	0.009	ND	1.916
12163	Aug-96	Wilts	J	F	0.054	0.037	ND	0.687
12164	Aug-96	Lincs	J	F	0.631	0.075	0.274	0.745
12165	Aug-96	Lincs	J	F	0.065	0.026	0.062	0.476
12184	Aug-96	Derbys	J	F	0.143	0.029	0.085	1.706
12183	Aug-96	Lincs	J	M	0.869	0.105	1.605	1.134
12186	Aug-96	Devon	J	M	0.090	ND	ND	0.995
12187	Sep-96	Derbys	J	F	0.276	0.046	0.287	0.722
12185	Sep-96	Devon	J	M	0.123	0.056	0.029	1.055
12190	Sep-96	Essex	J	M	0.269	0.047	0.188	1.507
12194	Sep-96	Devon	J	F	1.269	0.113	1.940	1.342
12353	Sep-96	Strathclyde	A	F	4.426	0.536	14.211	10.364
12198	Oct-96	Devon	J	F	1.232	0.216	0.895	0.624
12201	Oct-96	Surrey	J	M	1.504	0.233	2.271	1.752
12255	Oct-96	Salop	J	F	0.272	0.061	0.435	0.396
12257	Oct-96	Clwyd	A	F	5.230	0.461	11.835	1.061
12292	Nov-96	Oxon	A	M	0.260	0.021	0.186	1.055
12304	Nov-96	London	A	F	0.266	0.069	0.381	0.650
12300	Nov-96	Humberside	J	M	3.863	0.185	3.414	1.064
12301	Nov-96	Somerset	J	M	0.179	0.049	0.175	1.468
12327	Nov-96	Cambs	J	F	0.535	0.229	0.034	1.571
12336	Nov-96	Essex	J	M	2.124	0.096	0.440	1.405
12337	Nov-96	Wilts	A	M	1.733	0.177	9.614	0.835
12344	Dec-96	North Yorks	J	M	0.375	0.214	0.542	3.174
12346	Dec-96	Surrey	J	F	1.572	0.040	0.890	0.308
12345	Dec-96	Essex	J	M	6.817	0.368	4.610	0.692
12348	Dec-96	Suffolk	J	M	0.263	0.033	ND	0.496
12351	Dec-96	Dorset	J	M	0.448	0.031	1.555	4.461
12352	Dec-96	Berks	J	F	0.235	0.041	0.141	0.306
12355	Dec-96	Middlesex	J	M	6.551	0.439	21.495	1.710
12354	Dec-96	Cambs	J	F	0.434	0.038	0.134	1.242
Peregrine Falcon (*Falco peregrinus*)								
12223	Nov-95	Cumbria	-	-	0.967	0.158	3.942	3.994
12285	Oct-96	Orkney	J	M	2.767	0.075	9.216	16.478
Merlin (*Falco columbarius*)								
12049	Feb-96	Orkney	J	M	0.063	0.030	0.924	20.509
12054	Aug-94	North Yorks	J	F	0.166	0.123	0.395	1.524

Specimen no.	Date Found	County	Age	Sex	pp'-DDE	HEOD	PCB	Hg
Buzzard (*Buteo buteo*)								
12107	Jun-96	Hampshire	A	F	0.060	0.090	0.191	0.683
Hen Harrier (*Circus cyaneus*)								
12020	Jan-96	Kent	A	M	3.096	0.106	0.542	1.034
Red Kite (*Milvus milvus*)								
12072	Mar-96	Dyfed	-	-	0.037	0.028	0.182	1.455
Long-eared Owl (*Asio otus*)								
12017	Jan-96	Norfolk	J	F	3.386	0.028	3.431	1.342
Short-eared Owl (*Asio flammeus*)								
12028	Jan-96	Cambs	A	M	0.048	0.036	0.063	0.376
12317	Mar-96	Highland	J	M	ND	ND	ND	0.069
Heron (*Ardea cinerea*)								
12016	Jan-96	Durham	J	F	0.013	0.021	0.052	5.068
12015	Jan-96	Durham	J	F	0.005	0.012	0.024	4.901
12019	Jan-96	Kent	A	F	0.626	0.025	0.740	4.315
12044	Feb-96	Tayside	J	M	1.664	0.046	1.791	58.847
12047	Feb-96	Cumbria	J	F	0.102	0.022	0.373	21.142
12129	May-96	Shetland	A	F	0.854	0.025	6.957	32.392
12347	Dec-96	Cumbria	J	F	0.496	0.105	1.179	21.527
12361	Dec-96	Humberside	J	F	0.191	0.117	1.214	7.339
Bittern (*Botaurus stellaris*)								
12027	Jan-96	West Yorks	J	F	0.536	0.006	1.892	34.352
Kingfisher (*Alcedo atthis*)								
12160	Aug-96	Salop	J	M	0.205	0.536	0.672	0.863
12161	Aug-96	Salop	J	M	0.677	0.339	2.875	0.933
12296	Nov-96	Suffolk	J	F	0.248	0.311	0.431	1.558
Great-crested Grebe (*Podiceps cristatus*)								
12359	Dec-96	Humberside	A	M	0.597	ND	1.229	5.394

Table 2. **Geometric mean levels of pollutants in the various species in Table 1, for 1996 specimens only.**

GSE=geometric standard error

	pp'- DDE	HEOD	PCB	Hg
Kestrel				
Mean	0.134	0.213	0.923	0.878
N	19	19	19	19
Range within 1 GSE	0.097-0.186	0.179-0.253	0.606-1.406	0.675-1.142
Sparrowhawk				
Mean	0.632	0.081	0.405	1.076
N	71	71	71	71
Range within 1 GSE	0.524-0.762	0.074-0.102	0.286-0.573	0.873-1.326
Heron				
Mean	0.165	0.034	0.530	12.713
N	8	8	8	8
Range within 1 GSE	0.071-0.385	0.027-0.045	0.249-1.124	8.543-18.919
Kingfisher				
Mean	0.325	0.384	0.939	0.927
N	3	3	3	3
Range within 1 GSE	0.224-0.471	0.324-0.454	0.530-1.669	0.896-1.298

Note: none detected values were taken as 0.001 for all residues

Table 3. **Comparison of geometric mean residue levels (log values) from birds collected in 1995 and 1996; t-values are shown. Minus values indicate a decrease and plus values indicate an increase from 1995.**

	pp'-DDE	HEOD	PCB	Hg
Kestrel	t_{43}=+0.70	t_{43}=+2.82**	t_{43}=-0.02	t_{43}=+1.83
Sparrowhawk	t_{129}=-0.80	t_{129}=+1.52	t_{129}=-1.34	t_{129}=-0.87
Heron	t_9=-0.91	t_9=-1.72	t_9=-0.95	t_9=+1.80
Kingfisher	t_4=+0.93	t_4=+1.11	t_4=-0.21	t_4=-0.51

Notes: None detected values taken as 0.001 for all residues
Significance of difference: **P<0.01; ***P<0.001.

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Annual report to the Joint Nature Conservation Committee

Wildlife and pollution

Part 3 Organochlorines and mercury in peregrine eggs, 1996

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October 1997

3 Organochlorines and mercury in peregrine eggs, 1996

3.1 Introduction

The findings from all peregrine eggs analysed between 1961 and 1986 were summarised in Newton *et al.* (1989); those from eggs analysed during 1987-95 are given in previous reports in this series, and those from 13 eggs (one per clutch) analysed in 1996 are given in Table 4. Unfortunately no coastal eggs were represented.

3.2 Results

The findings confirm continuing widespread contamination of British peregrine eggs with organochlorines and mercury. However, most of the residues were present at relatively low levels. The highest DDE level recorded in 1996 was 0.6 ppm wet weight (in an egg from Dyfed), the highest HEOD was 0.2 ppm (in an egg from Derbyshire), the highest PCB level was 1.45 ppm (in an egg from Gwent) and the highest mercury level was 1.28 ppm dry weight (in an egg from Dyfed), (Table 4).

There seems little doubt that organochlorine levels in British peregrines are continuing to decline. Over most of the country, the population recovered some years ago from its pesticide-induced decline. At least in inland areas, breeding failure and mortality from organochlorine pollution now seems unlikely.

3.3 Reference

Newton, I., Bogan, J.A. & Haas, M.B. 1989. Organochlorines and mercury in British Peregrine eggs. Ibis 131: 355-376.

Table 4. **Residue levels (organochlorine ppm wet weight (lipid weight); mercury ppm dry weight) and shell indices (SI) for Peregrine eggs received in 1996.**

ND=none detected.

Number	Year	County	SI	pp'-DDE	HEOD	PCB	Hg
CENTRAL AND EASTERN HIGHLANDS							
E6893	96	Tayside	1.73	0.17 (6.67)	0.01 (0.34)	0.48 (18.86)	0.58
E6894	96	Tayside	1.82	0.06 (2.28)	0.01 (0.56)	0.10 (4.21)	0.45
E6902	96	Tayside	-	0.14 (4.28)	0.01 (0.19)	0.86 (25.71)	0.32
E6903	96	Tayside	-	0.30 (11.69)	0.01 (0.32)	0.40 (15.65)	0.49
E7137	96	Grampian	2.16	0.26 (8.91)	0.04 (1.39)	0.35 (12.23)	0.14
E7138	96	Tayside	1.78	0.22 (5.13)	0.05 (1.16)	0.58 (13.62)	0.22
NORTHERN ENGLAND							
E6875	96	Cheshire	-	0.47 (20.22)	0.01 (0.39)	0.58 (25.32)	0.60
E6954	96	Cumbria	1.77	0.02 (0.64)	0.01 (0.18)	0.09 (3.32)	0.30
E6956	96	Cumbria	1.96	0.09 (3.44)	0.01 (0.41)	0.40 (15.12)	0.43
E7063	96	N'humberland	1.91	0.01 (10.38)	ND	ND	0.79
E7094	96	Derbyshire	-	0.52 (14.59)	0.20 (5.60)	0.50 (14.08)	0.19
WALES							
E6979	96	Dyfed	-	0.60 (24.39)	0.03 (1.14)	1.19 (48.63)	1.28
E7009	961	Gwent	1.6	0.46 (21.12)	0.14 (6.50)	1.45 (66.38)	0.25

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Wildlife and pollution

Part 4 Organochlorines and mercury in merlin eggs, 1996

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4 Organochlorines and mercury in merlin eggs, 1996

4.1 Introduction

The findings from most previous analyses of merlin eggs were given in Newton & Haas (1988), those from 1987-1995 in previous reports in this series, while those from 28 eggs (one per clutch) analysed in 1996 are summarised in Table 5.

4.2 Results

The results from these additional 28 merlin eggs serve to confirm the continuing widespread contamination of British merlins with organochlorines and mercury. Levels of all contaminants were generally higher than those in peregrine eggs, but levels of all chemicals continue to decline slowly. The highest DDE level was 14 ppm (an egg from Northumberland). The highest HEOD level was 4.5 ppm (an egg from North Yorkshire) and the highest PCB level was 16 ppm (an egg from Northumberland). As in previous years, the highest levels of mercury (2-7 ppm) were found in eggs from the Northern Isles.

Together with previous findings, these data indicate a continuing downward trend in organochlorine residues in merlins, but occasional high levels still occur, and mercury remains at high level in eggs from the Northern Isles. Decline in residues over the past 10-15 years has coincided with a substantial recovery in merlin numbers over much of the country.

4.3 Reference

Newton, I. & Haas, M.B. 1988. Pollutants in Merlin eggs and their effects on breeding. Brit. Birds 81: 258-269.

Table 5. Residue levels (organochlorine ppm wet weight (lipid weight); mercury ppm dry weight) and shell indices (SI) for Merlin eggs received in 1996.

ND=none detected.

Number	Year	County	SI	pp'-DDE	HEOD	PCB	Hg
CENTRAL AND EASTERN HIGHLANDS							
E7070	96	Tayside	1.26	3.48 (92.31)	3.19 (84.73)	0.86 (22.79)	1.02
NORTHERN ENGLAND							
E6908	96	North Yorks	-	4.78 (160.15)	4.52 (151.33)	15.65 (524.03)	2.39
E6909	96	North Yorks	-	2.20 (53.03)	0.05 (1.15)	3.00 (72.36)	3.21
E6958	96	Cumbria	1.16	1.61 (67.29)	0.04 (1.65)	1.61 (67.29)	1.90
E7041	96	Durham	1.17	2.93 (83.45)	0.31 (8.89)	2.83 (80.63)	1.37
E7047	96	N'humberland	1.33	4.39 (139.48)	0.42 (13.31)	2.40 (76.19)	1.02
E7048	96	N'humberland	1.24	6.18 (159.60)	0.16 (4.02)	5.90 (152.36)	1.01
E7050	96	N'humberland	1.12	7.79 (176.50)	0.15 (3.49)	6.73 (152.46)	0.96
E7051	96	N'humberland	1.28	1.78 (27.58)	0.14 (2.21)	2.32 (35.79)	0.70
E7052	96	N'humberland	1.09	0.77 (20.55)	0.05 (1.33)	1.05 (27.93)	0.70
E7053	96	N'humberland	1.31	3.90 (117.71)	0.20 (5.96)	3.10 (93.55)	2.07
E7054	96	N'humberland	-	3.40 (64.94)	0.17 (3.31)	4.31 (82.25)	2.37
E7055	96	N'humberland	1.14	14.01 (214.49)	1.11 (17.06)	5.15 (78.84)	0.91
E7056	96	N'humberland	0.96	3.36 (82.23)	0.85 (20.83)	2.79 (68.25)	5.09
E7057	96	N'humberland	1.18	3.54 (63.64)	0.19 (3.38)	5.55 (99.89)	ND
E7058	96	N'humberland	1.30	4.91 (93.88)	0.21 (4.09)	4.60 (87.85)	1.20
E7059	96	N'humberland	1.21	4.59 (156.94)	0.19 (6.64)	16.26 (555.51)	5.41
E7060	96	N'humberland	1.01	3.13 (83.75)	0.20 (5.34)	3.21 (85.89)	0.89
E7061	96	N'humberland	1.39	3.00 (50.85)	0.48 (8.05)	4.48 (75.91)	1.29
E7062	96	N'humberland	1.33	5.92 (129.95)	0.12 (2.71)	5.51 (120.92)	1.04
E7095	96	Derbyshire	1.14	6.24 (109.05)	0.57 (10.02)	9.92 (173.36)	0.92
E7096	96	Derbyshire	1.38	1.38 (57.70)	0.10 (4.03)	2.09 (87.12)	1.35
NORTHERN ISLES							
E6992	96	Shetland	-	2.11 (46.14)	0.12 (2.51)	4.18 (91.36)	2.97
E6993	96	Shetland	1.01	5.11 (107.95)	0.15 (3.26)	4.51 (95.25)	2.70
E6994	96	Shetland	1.30	1.35 (31.68)	0.09 (2.21)	1.38 (32.20)	3.46
E6995	96	Shetland	-	0.96 (36.44)	0.08 (2.86)	2.20 (83.03)	3.35
E7064	96	Orkney	1.06	1.42 (46.09)	0.23 (7.40)	2.07 (66.89)	6.72
E7065	96	Orkney	1.19	0.97 (63.89)	0.43 (28.18)	0.67 (44.01)	7.81

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Annual report to the Joint Nature Conservation Committee

Wildlife and pollution

Part 5 Organochlorines and mercury in golden eagle eggs, 1996

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5 Organochlorines and mercury in golden eagle eggs, 1996

5.1 Introduction

The findings from analyses of golden eagle eggs obtained during 1963-86 were given in Newton & Galbraith (1991), and from 1987-95 in previous reports in this series. Eggs from ten clutches were received in 1996, and the results are given in Table 6.

One coastal egg was received from the Isle of Lewis. Although the residue levels were above the geometric mean residue levels of the other eggs analysed in 1996, they were within the range of levels found in inland eggs.

5.2 Results

The new analyses serve to confirm the low levels of contamination found in recent years in golden eagle eggs (Table 6). All residue levels were low, and well within the range of previous values.

5.3 Reference

Newton, I. & Galbraith, A.E. 1991. Organochlorines and mercury in the eggs of Golden Eagles *Aquila chrysaetos* from Scotland. Ibis 133: 115-120.

Table 6. Residue levels (organochlorine ppm wet weight (lipid weight); mercury ppm dry weight) and shell indices (SI) for Golden Eagle eggs received in 1996

ND=none detected.

Number	Year	County	SI	pp'-DDE	HEOD	PCB	Hg
SOUTHERN SCOTLAND							
E6915	96	Strathclyde	3.33	0.01 (0.41)	0.01 (0.26)	0.06 (3.00)	0.35
E7030	96	Strathclyde	3.28	0.02 (14.47)	0.01 (6.00)	ND	0.47
E7031	96	Strathclyde	3.25	0.13 (4.84)	0.08 (2.97)	0.34 (12.86)	0.58
E7032	96	Strathclyde	2.94	0.11 (6.66)	0.05 (2.78)	0.30 (18.17)	0.70
E7033	96	Central	-	0.31 (6.25)	0.07 (1.38)	4.90 (99.94)	0.21
NORTHERN SCOTLAND							
E6874	96	Highland	3.01	0.00 (6.97)	0.00 (3.68)	ND	0.74
E6896	96	Highland	3.26	0.00 (0.16)	0.00 (0.17)	0.04 (1.64)	0.42
E7068	96	Grampian	3.49	ND	0.06 (2.45)	0.00 (0.00)	ND
WESTERN ISLES							
E6895	96	Lewis	3.22	0.11 (4.94)	0.01 (0.66)	2.38 (111.09)	0.62
NORTHERN ENGLAND							
E6953	96	Cumbria	2.88	0.02 (1.57)	0.00 (0.29)	0.17 (12.26)	0.14

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Annual report to the Joint Nature Conservation Committee

Wildlife and pollution

Part 6 Organochlorines and mercury in gannet eggs, 1996

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6 Organochlorines and mercury in gannet eggs, 1996

6.1 Introduction

The findings from all gannet eggs examined to 1987 were summarised in the report for 1989, and in published form in Newton *et al.* (1990). Subsequent results were given in previous reports in this series, and those for 30 eggs examined in 1996 are given in Table 7. They include 10 eggs from each of the three colonies at Hermaness, Bass Rock and St Kilda. Bad weather did not permit landing at Ailsa Craig during the 1996 breeding season. For eggs from each colony, mean residues are compared with previous eggs from that colony, both in the short term (comparing with Hermaness, Bass Rock and St Kilda in 1994 (Table 7)), and in the long-term (1971-96 and 1986-96) in Table 8.

6.2 Results

Low levels of DDE, HEOD, PCBs and mercury were found in all the eggs from the three colonies analysed in 1996. Although low levels were again confirmed, comparison with residues in the 1994 samples from the same colonies show significant increases in DDE, HEOD and PCBs in the samples from Hermaness and Bass Rock, and significant increases in mercury in the samples from Hermaness and St Kilda. There were also decreases (although not significant) in the shell indices of eggs from Hermaness and Bass Rock.

Over the longer term (1971-96), significant declines in DDE levels were apparent in eggs from Hermaness and Bass Rock and a significant decline in HEOD in eggs from Bass Rock, continuing the trend seen in previous years. However, eggs from St Kilda showed a significant increase in mercury. Since the monitoring programme started, mercury has always shown less consistent trends over time (Newton *et al.* 1990).

Over a more recent period (1986-96) there were no significant trends in residues. The low levels found are unlikely to have any adverse effects in the reproduction and survival of gannets.

The importance of continued monitoring of gannet eggs is that this is the only seabird of British coasts in which residue levels have been measured continuously over the past 25 years. It therefore provides a useful baseline, as well as revealing long-term trends.

6.3 Reference

Newton, I., Haas, M.B. & Freestone, P. 1990. Trends in organochlorine and mercury levels in Gannet eggs. Environ. Pollut. 63: 1-12.

Table 7. Residue levels (organochlorine ppm wet weight; mercury ppm dry weight) and shell indices (SI) for gannet eggs (*Sula bassana*) received in 1996

Colony	SI	pp'-DDE	HEOD	PCB	Hg
Hermaness	3.09	0.27	0.10	5.62	2.26
	2.97	0.17	0.07	1.98	3.11
	2.20	0.12	0.08	2.11	3.62
	3.27	0.25	0.09	3.46	2.96
	3.19	0.24	0.11	2.93	3.40
	3.20	0.17	0.09	2.25	3.17
	3.21	0.10	0.09	1.90	2.88
	-	0.27	0.11	3.28	2.58
	-	0.22	0.09	2.37	3.53
	-	0.16	0.04	1.21	3.70
Mean	3.02	0.00	0.00	0.00	0.00
SD	0.37	0.06	0.02	1.23	0.46
Range within 1 SE	2.88-3.16	0.17-0.21	0.08-0.09	2.11-2.89	2.94-3.24
Bass Rock	2.92	0.11	0.10	2.52	2.04
	2.88	0.11	0.09	2.65	5.72
	3.18	0.14	0.09	3.08	1.99
	2.56	0.26	0.15	5.55	2.13
	2.99	0.19	0.09	3.25	2.92
	3.13	0.24	0.18	4.01	3.04
	2.90	0.15	0.10	3.17	2.82
	2.67	0.19	0.10	2.57	2.13
	2.89	0.09	0.07	2.23	2.43
	-	0.38	0.20	8.53	3.11
Mean	2.90	0.00	0.00	0.00	0.00
SD	0.20	0.09	0.04	1.93	1.10
Range within 1 SE	2.83-2.98	0.16-0.22	0.07-0.10	1.89-3.11	2.74-3.44
St Kilda	3.18	0.05	0.06	1.28	3.40
	3.37	0.04	0.04	0.74	4.68
	3.57	0.04	0.03	0.85	3.88
	2.91	0.09	0.04	1.10	5.40
	2.98	0.09	0.05	1.80	2.70
	3.33	0.04	0.05	3.58	3.19
	2.68	0.11	0.04	1.57	3.10
	3.23	0.05	0.04	0.90	3.40
	3.01	0.06	0.03	0.88	3.12
	3.15	0.05	0.05	0.89	3.61
Mean	3.14	0.00	0.00	0.00	0.00
SD	0.26	0.02	0.01	0.85	0.82
Range within 1 SE	3.05-3.24	0.18-0.20	0.08-0.09	2.23-2.77	2.83-3.35

NB: Means are arithmetic for shell index; geometric for residues

Comparison of shell index and geometric mean residue levels from gannet eggs collected from Hermaness, Bass Rock and St Kilda in 1994 and 1996.

t values shown. Minus values indicate a decrease and plus values an increase from previous eggs from the same site.
* P<0.05 ** P<0.01 ***P<0.001

	Hermaness	Bass Rock	St Kilda
Shell index	t_{15}=-0.38	t_{16}=+0.69	t_{17}=+0.96
pp'-DDE	t_{18}=+5.04***	t_{18}=+2.30*	t_{17}=+0.40
HEOD	t_{18}=+4.20***	t_{18}=+5.94***	t_{17}=+0.53
PCB	t_{18}=+3.09**	t_{18}=+2.19*	t_{17}=+1.50
Hg	t_{18}=+3.79**	t_{18}=+1.94	t_{17}=+3.94**

Table 8. Long term trends in pollutants in Gannet eggs based on regression analyses of annual geometric mean values on year.

Figures show linear regression coefficients (b) based on log values regressed against year. *P=<0.05; **P=<0.01; ***P=>0.001; ns=not significant.

	1971 - 1996	1986 - 1996
Hermaness		
HEOD	-0.0379 ns	-0.0063 ns
pp'-DDE	-0.1829 *	0.0115 ns
PCB	0.0887 ns	0.3219 ns
Hg	0.0716 ns	-0.0471 ns
Bass Rock		
HEOD	-0.0157 *	-0.0100 ns
pp'-DDE	-0.0452 ***	-0.0168 ns
PCB	-0.1248 ns	-0.1509 ns
Hg	0.0263 ns	0.0775 ns
St Kilda		
HEOD	-0.0094 ns	-0.0806 ns
pp'-DDE	-0.0160 ns	-0.0284 ns
PCB	-0.0159 ns	-0.2988 ns
Hg	0.1402 *	0.1004 ns

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Wildlife and pollution

Part 7 Rodenticide residues in barn owls

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7 Rodenticide residues in barn owls

7.1 Introduction

The aims of this study were to find (1) to what extent barn owls *Tyto alba* in Britain are contaminated with certain rodenticide residues, and (2) whether such residues are likely to represent a significant source of mortality. As barn owl numbers are thought to have declined in Britain during the present century (Bunn *et al.* 1982, Shawyer 1987, Percival 1991), it is important to assess any role that secondary poisoning from rodenticides might have.

It is the so-called 'second-generation' anticoagulant rodenticides which are likely to pose the greatest threat, as these are rapidly replacing warfarin and other 'first generation' rodenticides, to which rats and mice in many areas have become resistant. Four second generation rodenticides are currently in use in Britain. Difenacoum was introduced in 1975, bromadiolone in 1980, brodifacoum in 1982 and flocoumafen in 1986. All these chemicals are more toxic than warfarin, and also more persistent, giving the possibility of secondary poisoning in rodent predators and scavengers. As the barn owl often nests and hunts around farm buildings where these chemicals are commonly used, it would seem to be at particular risk.

We began analysing barn owls for rodenticide residues in 1983, and the findings from 145 carcasses examined up to March 1989 were summarised in Newton *et al.* (1990), and from subsequent carcasses in previous reports in this series.

The purpose of this present report is to bring the findings up to date, first by presenting the results from 137 birds analysed over the past two years, and secondly by reviewing the results over the whole 14 year period, 1983-96.

7.2 Methods

To obtain carcasses for chemical analysis, we placed regular advertisements in ornithological magazines and journals asking for bodies of barn owls found dead. All carcasses were requested, regardless of the cause of death. On receipt, each carcass was catalogued, weighed and marked, and then stored at -20°C until it could be examined, up to several months later. Age classes (juvenile or adult) were distinguished from 1988 onwards, mainly on plumage (Newton *et al.*, in press), and birds of all ages were sexed by gonad inspection. Not all specimens could be aged or sexed, however, because some had been previously skinned or were badly damaged.

Many of the birds examined showed signs of haemorrhaging, which differed according to cause of death. Accident victims typically bled heavily around the site of impact, while some organochlorine victims showed haemorrhaging of certain internal organs, including brain, lungs, heart and foregut (Newton *et al.* 1982), although no such victims were found during the period considered here. Rodenticide victims typically showed faint subcutaneous bleeding along the keel and on the skull, and external bleeding around the leg joints, mouth and nostrils (Newton *et al.* 1990). However, some organochlorine and rodenticide victims showed no obvious bleeding. Haemorrhaging was therefore not used as the sole diagnosis of any mortality cause, only along with other evidence, including chemical analysis.

About half the liver was removed from each bird and analysed for residues of second-generation rodenticides, using the method of Hunter (1985), modified in minor respects (the other half of the liver was kept for possible future use). Liver samples were extracted with chloroform-acetone, and the extracts were cleared of fat using Bond-Elut NH_2 columns. The concentrated samples from the columns were then analysed against a standard for each compound by High Pressure Liquid Chromatography, using a 5 μm Hypersil ODS column and a Varian spectrofluorometer (to 1990) or a Shimadzu spectrofluorophotometer (from 1991). When an apparent rodenticide was detected, a recovery test was done from a spiked sample of solvent to validate the identification and to correct the estimate of mass present. Recoveries from most batches were in the range 75-95% and detection limits were estimated as 0.0025 μg for difenacoum, 0.004 μg for brodifacoum, 0.005 μg for flocoumafen and 0.01 μg for bromadiolone. From a liver sample weighing 1g, these values were the same as the concentration expressed as μg g^{-1} or mg kg^{-1}. However, because liver weights varied greatly between individuals, some liver samples that were analysed weighed around 2 g. This would have halved the residue concentration levels that could have been detected to around 0.0012 μg g^{-1} for difenacoum, 0.002 μg g^{-1} for brodifacoum, 0.0025 μg g^{-1} for flocoumafen, and 0.005 μg g^{-1} for bromadiolone. In practice, detection limits also varied slightly between batches, as did the water-content of liver samples, and in some specimens residue concentrations were detected as low as 0.001 μg g^{-1} for difenacoum, 0.002 μg g^{-1} for brodifacoum, 0.003 μg g^{-1} for flocoumafen and 0.004 μg g^{-1} for bromadiolone.

7.3 *Results*

(a) *Birds analysed over the past two years*

Of the 137 birds analysed (which included 29 which died before 1995), residues of one or more rodenticides were detected in 48 (35%) (Table 9). Difenacoum was found in 30 birds, bromadiolone in 22 birds, brodifacoum in 15 birds and flocoumafen in three. Of the 48 contaminated birds, two were diagnosed from haemorrhage symptoms as having died of rodenticide poisoning. These birds contained (1) 0.11 μg g^{-1} difenacoum and (2) 0.25 μg g^{-1} brodifacoum plus 0.14 μg g^{-1} bromadiolone in their livers. Other birds with residues of similar and lower levels were diagnosed as having died of other causes, mainly accidents or starvation (see below).

(b) *Review of birds analysed over the whole study period, 1983-96.*

In the period 1983-96, a total of 714 barn owls was received for analysis. They came from all major regions of Britain, and from all months of the year, with more from outside the main breeding season (September-March) than within it (April-August) (Newton *et al.* 1991). No ecological significance could be attached to the rise in numbers received per year over the study period, as this could have been due to greater advertising and publicity given to the species in more recent years. The sex ratio among 680 birds in which the gonads could be examined was 351 (52%) males to 329 (48%) females, not significantly different from equal. The age ratio among 658 birds was 186 adults to 472 (72%) first-year birds. As an estimate of first-year mortality, this latter figure is about 10% higher than that calculated by Glue (1971) from 320 ring recoveries in 1909-69.

The numbers of owls in different mortality categories are given in Table 10, along with the number in which rodenticides were detected. The main recorded causes were road accidents (48%), other accidents (8%) and starvation (31%), with various other causes accounting for the remainder.

(c) *Proportion containing residues*

Of the 714 birds analysed during 1983-96, 187 (26%) contained detectable residues of second generation rodenticides in the liver. Most specimens (149) had residues of only one chemical, but 31 birds had residues of 2 different chemicals, six birds had residues of three chemicals and one had residues of all four. No significant differences between age or sex groups were apparent, rodenticides being found in 30% of all adults compared with 25% of all first-year birds. and 24% of all males compared with 30% of females. Nor was there any obvious regional variation in the proportion of birds that contained detectable residues. Over the years, however, a marked increase was apparent in the proportion of owls in which residues were detected, from 5% in 1983-84 to 38% in 1995-96 (Table 11).

The different chemicals appeared in barn owl livers over the period 1988-96 roughly in proportion to their usage (Table 12). Questionnaire surveys of farms in England and Wales in different years gave information on the frequency with which the different chemicals were used (Olney *et al.* 1991a, 1991b, 1994, Olney & Garthwaite 1992, 1993, Thomas & Wild 1996). The overall figures matched fairly closely the relative frequencies with which we detected the same chemicals in barn owl livers during 1988-96 (Table 12). Of 177 birds in which residues were detected during 1988-96, difenacoum was found in 113 (64%) birds, bromadiolone in 76 (43%), brodifacoum in 23 (13%) and flocoumafen in 9 (5%). It seemed, therefore, that barn owls picked up a more or less representative cross-section of the second generation rodenticides in use.

Difenacoum was found in liver at concentrations of 0.001-0.512 $\mu g\ g^{-1}$ (mean 0.046 $\mu g\ g^{-1}$), bromadiolone at 0.004-1.720 $\mu g\ g^{-1}$ (mean 0.177 $\mu g\ g^{-1}$), brodifacoum at 0.002-0.515 $\mu g\ g^{-1}$ (mean 0.117 $\mu g\ g^{-1}$), and flocoumafen at 0.003-0.144 $\mu g\ g^{-1}$ (mean 0.045 $\mu g\ g^{-1}$) (Table 13). Because of the likely persistence of residues in the livers of contaminated birds, these owls could have been exposed for up to several months previously and on more than one occasion.

In total, only nine birds were diagnosed as having died of rodenticide poisoning. In the eight that showed typical haemorrhage symptoms, the following residues ($\mu g\ g^{-1}$) were detected in liver: (1) 0.11 difenacoum, (2) 0.17 difenacoum, (3) 0.33 bromadiolone, (4) 1.07 bromadiolone, (5) 0.44 brodifacoum, (6) 1.72 bromadiolone plus 0.07 brodifacoum, (7) 0.25 brodifacoum plus 0.14 bromadiolone, (8) 0.05 bromadiolone plus 0.002 brodifacoum plus 0.003 flocoumafen. All these birds showed extensive haemorrhaging of heart, lungs, liver, brain and subcutaneous areas which was not associated with any impact, and no other cause of death was apparent. The ninth bird, that showed no haemorrhage symptoms, contained 0.42 $\mu g\ g^{-1}$ brodifacoum. It was classed as a rodenticide victim because of the relatively high brodifacoum level present (consistent with lethal levels found in other barn owls (Newton *et al.* 1990), and because it showed no other obvious cause of death. In previous studies, various experimental owls which were known to have died of rodenticide poisoning contained after death around 0.20-1.72 $\mu g\ g^{-1}$ residue in their liver (Table 14). It seems, then, that despite the increasing occurrence of rodenticide residues in British barn owls, only 2% of our total sample for 1983-96 are likely to have died directly of rodenticide poisoning. Another 24% contained what were probably sub-lethal levels, or levels that would in time have become lethal, had the birds concerned not died of some other cause.

7.4 Discussion

About 26% of the 714 barn owls examined in 1983-96 had residues of one or more rodenticide in their bodies, but this sample may not reflect the true exposure of owls to rodenticides in the regions concerned. Almost certainly the owls in our sample did not form a representative cross-section of Barn Owl deaths. They were probably biased towards those forms of mortality most associated with people, accounting for the high proportion of accident victims. On the other hand, the sample may have under-estimated the proportion of deaths due to rodenticides because, some hours before death, affected animals become lethargic. Any affected owls are therefore likely to die on their roost sites, in tree holes or roof cavities, where they are less likely to be found by the casual observer than are birds that die in the open. This statement is entirely conjectural, however, and as yet there is no evidence one way or the other.

Despite any possible bias in the sampling procedure, it is clear that contamination of barn owls with second generation rodenticides is both widespread and increasing. Contaminated specimens came from all major regions of Britain, and were not restricted to the warfarin-resistance areas, as depicted by Shawyer (1987). The increasing contamination of barn owls with second generation rodenticides over the study period was expected from the increasing use of these chemicals, which are gradually replacing warfarin and other first generation rodenticides. By 1995-96, about 38% of all barn owls received contained measurable residues of one or more compounds, giving a clear indication that exposure of barn owls to second-generation rodenticides is widespread in Britain. However, only a small proportion of birds (up to 5% of contaminated owls, <2% of all owls) contained residues large enough to have killed them. With yet further increases in usage, however, these chemicals could become a more important cause of mortality in future.

One complication in assessing trends in contamination frequencies was that the analytical equipment was changed between 1990 and 1991 from a Varian spectrofluorometer to a Shimadzu spectrofluorophotometer. On the Varian, the lowest limits of detection on a 1g wet liver sample were calculated as 0.005 $\mu g\ g^{-1}$ for difenacoum, 0.008 $\mu g\ g^{-1}$ for brodifacoum, 0.01 $\mu g\ g^{-1}$ for flocoumafen and 0.02 $\mu g\ g^{-1}$ for bromadiolone, whereas on the Shimadzu these limits on a 1g sample fell to half these levels (see Methods). This meant that some trace residues which would have been detected in the 1991-96 samples could have been missed in the 1983-90 samples. If the detection limits had been the same in the latter period as in the earlier period the numbers of birds recorded as contaminated would have fallen by at most three in 1991-92 (bringing the total proportion of birds contaminated in those years to 30%), by at most one in 1993-94 (bringing the total contaminated to 29%) and by at most one in 1995-96 (bringing the total contaminated to 37%). This would clearly have had negligible effect on the upward trend. Many of the trace levels of residues given in Table 4 were from birds that also contained another compound at much higher levels, so those birds would have been recorded as contaminated at whatever date they were analysed.

Throughout the study, only part of the liver from each bird was analysed, and the rest was kept in deep freeze. As a further check on possible change in the sensitivity of analysis with time, we selected in 1994 some 25 frozen samples at random and re-analysed them on the replacement equipment. In no birds previously recorded as uncontaminated were residues detected on further analysis. It seems reasonable to conclude, therefore, that the apparent increase over the years in the proportion of owls containing rodenticide residues was a genuine trend and not an artefact of analytical procedure.

Of 28 owls containing residues of any rodenticide above 0.2 $\mu g\ g^{-1}$ (and hence within the lethal range), most had apparently died of accidents (12) or starvation (9). Rodenticides may have predisposed these birds to die from other causes or reduced the chance of recovery from accidents. Moreover, if they had not died from the recorded causes, they might later have succumbed to rodenticide poisoning. In any event, the maximum likely proportion of recorded deaths by rodenticides is still low. Currently, therefore, we have no evidence that second generation rodenticides contribute appreciably to the overall mortality in British barn owls, and hence no evidence that the use of these chemicals is seriously affecting population levels.

Work on mammals and birds has shown that rodenticide residues may persist in liver for up to several months after a single oral dose (Parmar *et al.* 1987, Huckle *et al.* 1989a, b). This means that owls in which residues were detected could have been exposed up to several months previously or on more than one occasion thereby explaining the presence of more than one rodenticide in the livers of some animals. On the other hand, it is unlikely that rodent prey species would not remain contaminated so long, because in these animals a single oral dose would normally be lethal. Trials have shown that mice and rats die some 2-14 days (mostly 3-8) after a single feed of any of the chemicals involved (Bajomi 1984, Hoppe & Krambias 1984, Newton *et al.* 1991 & unpublished).

The main prey of barn owls in Britain is the field vole *Microtus agrestis* (Glue 1974, Taylor 1994), which has not yet been subject to extensive control operations. Clearly, if the new rodenticides were ever used away from buildings (and contrary to current regulations), the potential for secondary poisoning of owls would greatly increase. A study of the foraging behaviour of barn owls on farmland in the United States (Hegdal & Blaskiewicz 1984, Hegdal & Colvin 1988) showed that owls seldom hunted close to farm buildings and would therefore be unlikely to ingest high levels of rodenticide when usage is restricted to those sites. In our sample, three out of four birds from the Isle of Man were contaminated, as were seven out of ten from the Channel Islands. On these islands, field voles are lacking, and barn owls feed much more heavily on commensal rats *Rattus norvegicus* and house mice *Mus musculus*, together with wood mice *Apodemus sylvaticus*. It would not be surprising, therefore, if a high proportion of owls on these islands were contaminated. The different diet of barn owls on the Isle of Man also led them to be more affected by dieldrin than mainland birds (Newton *et al.* 1991).

7.5 References

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Table 9. Levels of rodenticides (ppm in wet weight) in the livers of Barn Owls (*Tyto alba*) received in 1995 and 1996.

ND=none detected; J=juvenile in first year; A=adult other than first year; M=male; F=female; brod=brodifacoum; difen=difenacoum; brom=bromadialone; floc=flocoumafen; D & G=Dumfries & Galloway; H & W=Hereford & Worcester.

Specimen No.	Date	County	Age	Sex	brod	difen	brom	floc
12258	Sep-82	Cornwall	-	-	ND	ND	ND	ND
12259	Oct-84	Cornwall	-	-	ND	ND	ND	ND
12260	Oct-84	Cornwall	-	M	ND	ND	ND	ND
12261	Nov-85	Cornwall	-	M	ND	ND	ND	ND
12262	Feb-88	Cornwall	-	M	ND	ND	0.090	ND
12263	Feb-88	Cornwall	-	M	ND	0.160	ND	ND
12264	Nov-88	Cornwall	-	F	ND	0.050	ND	ND
11819	Dec 88	Suffolk	J	M	ND	ND	ND	ND
12265	Feb-89	-	-	F	ND	ND	ND	ND
12266	Jul-89	Cornwall	-	M	ND	ND	ND	ND
12267	Aug-89	Cornwall	-	M	ND	ND	ND	ND
12268	Oct-89	Cornwall	-	M	ND	ND	ND	ND
12269	Feb-90	Cornwall	-	F	ND	ND	ND	ND
12270	Sep-90	Cornwall	-	M	ND	ND	ND	ND
11821	Nov 90	Bedfordshire	J	M	ND	ND	ND	ND
12271	Mar-91	Cornwall	-	F	ND	ND	ND	ND
12272	Apr-91	Cornwall	-	-	ND	ND	ND	ND
12273	May-91	Cornwall	-	-	ND	ND	ND	ND
12282	Jul-91	-	-	-	ND	ND	ND	ND
12274	Oct-91	Cornwall	-	F	0.040	0.030	0.060	ND
12275	Nov-91	Cornwall	-	M	ND	ND	ND	ND
12276	Apr-92	Cornwall	-	M	ND	0.040	ND	ND
12277	Feb-94	Cornwall	-	F	ND	ND	ND	ND
12278	Mar-94	Cornwall	-	M	ND	0.180	ND	ND
12113	Mar 94	Strathclyde	A	F	ND	ND	ND	ND
12110	Aug 94	Cumbria	J	M	ND	ND	ND	ND
11735	Dec 94	Grampian	J	F	ND	ND	ND	ND
11969	Dec 94	Highland	J	M	ND	0.020	ND	ND
12279	Dec-94	Cornwall	-	F	ND	ND	0.030	ND
11723	Jan 95	Lothian	A	F	ND	0.006	0.216	ND
11724	Jan 95	Dorset	J	M	ND	ND	ND	ND
11727	Jan 95	Cambridgeshire	J	F	ND	0.037	ND	ND

Specimen No.	Date	County	Age	Sex	brod	difen	brom	floc
11728	Jan 95	Northamptonshire	J	F	ND	ND	ND	ND
11730	Jan 95	Bedfordshire	J	F	ND	ND	ND	ND
11731	Jan 95	Somerset	J	F	ND	ND	ND	ND
11732	Jan 95	London	J	F	ND	ND	ND	ND
11733	Jan 95	Cornwall	J	M	ND	ND	ND	ND
11734	Jan 95	Cumbria	J	M	ND	ND	ND	ND
11736	Jan 95	Hertfordshire	J	M	ND	ND	ND	ND
11738	Jan 95	Gwynedd	J	F	ND	ND	ND	ND
11739	Jan 95	Humberside	J	M	ND	ND	ND	ND
11740	Jan 95	Suffolk	A	F	ND	ND	ND	ND
11745	Jan 95	Cambridgeshire	J	F	ND	ND	ND	ND
11750	Feb 95	Kent	J	M	ND	ND	ND	ND
11754	Feb 95	Gloucestershire	A	F	ND	0.066	ND	ND
11755	Feb 95	Lincolnshire	A	F	ND	ND	ND	ND
11757	Feb 95	Northamptonshire	A	F	ND	0.007	ND	ND
11759	Feb 95	Northamptonshire	J	F	ND	0.011	ND	ND
11761	Feb 95	Oxfordshire	J	F	0.644	0.013	ND	0.053
11762	Feb 95	E.Sussex	A	M	0.183	0.010	ND	ND
11765	Feb 95	Norfolk	J	M	0.056	ND	ND	ND
11768	Feb 95	Gwynedd	J	F	ND	0.050	ND	ND
11771	Feb 95	Norfolk	J	M	ND	ND	ND	ND
11968	Feb 95	Highland	J	M	ND	ND	ND	ND
11770	Mar 95	Norfolk	A	F	ND	0.010	ND	ND
11779	Mar 95	Norfolk	A	M	ND	0.015	ND	ND
11780	Mar 95	Norfolk	J	M	ND	ND	ND	ND
11782	Mar 95	Essex	A	M	ND	0.022	ND	ND
11799	Mar 95	Grampian	J	F	ND	ND	ND	ND
11800	Mar 95	Wiltshire	A	F	0.250	ND	0.140	ND
11810	Mar 95	Essex	J	M	ND	ND	ND	ND
12112	Mar 95	Strathclyde	J	M	ND	0.030	0.070	ND
11798	Apr 95	Humberside	J	F	ND	ND	ND	ND
11813	Apr 95	Staffordshire	J	M	ND	ND	ND	ND
11831	Apr 95	Strathclyde	J	F	ND	ND	ND	ND
11861	Jun 95	Northumberland	A	M	ND	0.197	0.035	ND
12109	Jun 95	Strathclyde	A	F	ND	ND	ND	ND
11879	Jul 95	Bedfordshire	J	F	ND	ND	ND	ND
11880	Jul 95	-	J	M	ND	ND	ND	ND
11900	Aug 95	H & W	J	M	ND	0.110	ND	ND
11966	Aug 95	Highland	J	M	ND	ND	ND	ND
11925	Sep 95	Dyfed	J	F	ND	ND	ND	ND

Specimen No.	Date	County	Age	Sex	brod	difen	brom	floc
11932	Sep 95	Hampshire	J	M	ND	ND	ND	ND
11935	Sep 95	Highland	J		ND	ND	ND	ND
11939	Sep 95	E.Sussex	J	M	ND	ND	ND	ND
11965	Sep 95	Highland	J	F	ND	ND	ND	ND
12280	Sep-95	Cornwall	-	F	ND	0.020	ND	ND
11982	Nov 95	Suffolk	J	M	ND	ND	ND	ND
11983	Nov 95	D & G	J	M	ND	ND	ND	ND
11985	Nov 95	Oxfordshire	J	M	ND	0.010	0.040	ND
11989	Nov 95	Cumbria	J	M	ND	ND	ND	ND
11990	Nov 95	W.Sussex	J	F	ND	ND	ND	ND
11991	Nov 95	Northumberland	J	M	ND	ND	ND	ND
12281	Nov-95	Strathclyde	-	F	ND	0.010	ND	ND
12029	Nov 95	Essex	J	M	ND	0.008	ND	ND
11998	Dec 95	Northamptonshire	J	F	ND	ND	ND	ND
12000	Dec 95	Suffolk	J	M	ND	ND	0.160	ND
12002	Dec 95	Salop	J	M	ND	ND	ND	ND
12012	Jan 96	Surrey	J	M	ND	ND	ND	ND
12009	Jan 96	Bedfordshire	J	F	ND	ND	ND	ND
12018	Jan 96	Norfolk	J	F	ND	ND	0.060	ND
12023	Jan 96	Hampshire	J	F	ND	ND	0.060	ND
12040	Jan 96	Highland	J	M	ND	ND	ND	ND
12025	Jan 96	Powys	J	M	ND	ND	ND	ND
12041	Jan 96	Grampian	J	F	0.046	ND	0.064	ND
12031	Jan 96	Norfolk	J	F	ND	0.134	0.066	ND
12030	Jan 96	Essex	A	M	ND	0.027	ND	0.070
12032	Feb 96	Dyfed	J	M	ND	ND	ND	ND
12038	Feb 96	Oxfordshire	A	M	ND	ND	0.032	ND
12058	Feb 96	Suffolk	J	M	ND	ND	ND	ND
12063	Feb 96	Gwynedd	A	F	ND	ND	ND	ND
12067	Mar 96	Hampshire	J	F	ND	ND	ND	ND
12065	Mar 96	Cambridgeshire	A	F	ND	ND	ND	ND
12073	Mar 96	Merseyside	J	F	ND	ND	ND	ND
12074	Apr 96	Northamptonshire	J	F	ND	ND	ND	ND
12077	Apr 96	Middlesex	A	F	ND	ND	ND	ND
12078	Apr 96	Northumberland	J	F	ND	0.040	ND	ND
12086	May 96	Lincolnshire	J	M	ND	ND	0.170	ND
12098	May 96	Warwickshire	J	M	ND	ND	ND	ND
12104	May 96	Dorset	-	M	ND	ND	0.070	ND
12123	Jun 96	Wiltshire	J	M	ND	ND	0.140	ND
12121	Jun 96	Lincolnshire	J	M	ND	ND	ND	ND

Specimen No.	Date	County	Age	Sex	brod	difen	brom	floc
12136	Jul 96	Berkshire	J	F	ND	ND	0.110	ND
12142	Jul 96	Wiltshire	J	F	ND	ND	ND	ND
12145	Aug-96	Humberside	J	F	ND	ND	ND	ND
12146	Aug-96	Lincolnshire	A	M	ND	0.040	ND	ND
12111	Aug 96	Cumbria	J	M	ND	ND	ND	ND
12188	Sep-96	Cornwall	J	M	ND	ND	ND	ND
12196	Sep-96	Lincolnshire	J	F	ND	ND	0.050	ND
12199	Sep-96	Norfolk	A	M	0.120	ND	0.080	ND
12205	Oct-96	Kent	J	F	ND	ND	ND	ND
12340	Oct-96	Gwynedd	J	M	ND	ND	ND	ND
12253	Oct-96	Wiltshire	A	M	0.060	ND	ND	ND
12284	Oct-96	Suffolk	A	M	ND	ND	ND	ND
12299	Nov-96	Northamptonshire	J	M	ND	ND	ND	ND
12295	Nov-96	Northamptonshire	J	M	ND	ND	0.020	ND
12331	Nov-96	Cambridgeshire	J	M	ND	ND	ND	ND
12341	Nov-96	Gwynedd	J	F	ND	0.040	ND	ND
12342	Nov-96	Devon	J	F	ND	ND	ND	ND
12303	Nov-96	Hampshire	J	F	ND	ND	ND	ND
12328	Nov-96	Cambridgeshire	J	M	ND	0.010	ND	ND
12349	Dec-96	Leicestershire	J	F	ND	ND	ND	ND
12350	Dec-96	Lincolnshire	J	F	ND	ND	0.020	ND
12287	-	Lincolnshire	J	M	ND	ND	ND	ND
12288	-	Lincolnshire	J	M	ND	ND	ND	ND
11822	-	-	J	M	ND	ND	ND	ND
11967	-	-	J	F	ND	ND	ND	ND

Table 10. **Recorded causes of deaths in Barn Owls found dead in Britain during 1983-96.**

	Number	Percent of total	Number (%) in which rodenticide residue was detected
Natural causes	244	34.2	60 (24.6)
Starvation	221	31.0	57 (25.8)
Disease	11	1.5	1 (9.1)
Predation	12	1.6	2 (16.7)
Accidents	397	55.6	104 (26.2)
Road casualties	343	48.0	92 (26.8)
Other trauma	44	6.2	10 (22.7)
Drowned	7	1.0	2 (28.6)
Electrocuted	3	0.4	0 (0)
Other human-related causes	14	2.0	9 (64.3)
Poisoned	9	1.3	9 (100)
Shot	5	0.7	0 (0)
Unknown causes	60	8.4	15 (25.0)

Table 11. **Percentage of Barn Owls whose livers contained rodenticide residues in different periods.**

	Number of owls analysed	Number (%) in which rodenticide residues were detected
1983-84	20	1 (5)
1985-86	76	9 (12)
1987-88	64	11 (17)
1989-90	141	31 (22)
1991-92	162	52 (32)
1993-94	139	42 (30)
1995-96	109	41 (38)

Significance of variation between periods: $\chi^2_6 = 28.08$, $P<0.001$

Table 12. Rodenticide use and barn owl contamination in Britain.

	Arable Farms[1]	Livestock farms[1]	Barn owls
(a) 1988-89			
Number examined	565	459	103
Number with rodenticide	431	404	16
Difenacoum	62%	54%	75%
Bromadiolone	32%	37%	25%
Brodifacoum	5%	7%	31%
Flocoumafen	0.5%	1.5%	0.0%
(b) 1990-92, arable farms only			
Number examined	1696	-	233
Number with rodenticide	1387	-	75
Difenacoum	52%	-	64%
Bromadiolone	40%	-	37%
Brodifacoum	7%	-	15%
Flocoumafen	0.6%	-	8.0%
(c) 1993-94			
Number examined	1062	709	139
Number with rodenticide	904	606	42
Difenacoum	55%	59%	60%
Bromadiolone	37%	36%	50%
Brodifacoum	7%	5%	7%
Flocoumafen	0.9%	-	0.0%

[1]Based on questionnaire surveys of randomly selected farms, 1988-94 (Olney *et al*. 1991a, 1991b, 1994, Olney & Garthwaite 1992,1993, Thomas & Wild, 1996).

Table 13. **Frequency of Barn Owl contamination by second generation rodenticides at different levels, 1983-96. The total number of owls containing residues was 187, but some had residues of more than one compound (see text).**

Liver Residue range mg kg^{-1}	Number of owls containing residues of: Difenacoum	Bromadiolone	Brodifacoum	Flocoumafen
0.001-0.009	26	2	5	2
0.01-0.099	81	40	14	5
0.1-0.999	13	33	9	1
> 1.0	0	2	0	0

Table 14. **Summary details of four second generation rodenticides and warfarin.**

Chemical	Year of introduction to UK	LD_{50} (mg kg^{-1}) Rat	Mouse	Time (days) taken to kill laboratory mice after one-day dose	Liver levels (mg kg^{-1}) detected in poisoned non-target species	
Warfarin	1952	185	375	not recorded	none reported	
Difenacoum	1975	1.80	0.80	2-11	Tawny Owl[1] *Strix aluco*	<0.20
					Weasel[1] *Mustela nivalis*	0.40-4.00
Bromadiolone	1980	0.55	0.99	2-9	Barn Owl[2] *Tyto alba*	(not analysed)
					Barn Owl[3]	0.33-1.72
Brodifacoum	1982	0.26	0.40	3-8	Weasel[1]	0.20-0.80
					Barn Owl[4]	0.63-1.25
					Barn Owl[4]	0.52
					Barn Owl[5]	0.29-0.61
					Screech Owl[6] *Otus asio*	0.40-0.80
					Rabbit[6] *Oryetolagus cuniculus*	0.30
Flocoumafen	1986	0.25	1.13	2-12	Barn Owl[7]	0.93

1. Anon 1982
2. Mendenhall & Pank 1980
3. Newton *et al.* unpublished
4. Newton *et al.* 1990
5. Greig-Smith *et al.* 1989
6. Hegdal & Colvin 1988
7. Newton *et al.* 1994

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Annual report to the Joint Nature Conservation Committee

Wildlife and pollution

Part 8 Lindane residues in predatory birds, 1963-96

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8 Lindane residues in predatory birds

8.1 *Introduction*

Lindane is the name given to a form of 1,2,3,4,5,6-hexachlorocyclohexane (HCCH), which consists of not less than 99% of the gamma-HCCH isomer. This isomer was first found to have insecticidal properties in the 1940s (Hayes & Law 1991). Lindane is an active ingredient of several products available to the public or for professional use in insecticides, fungicides, fertilizers and wood preservatives. It is available in a number of forms both singly and in combination with other compounds. From 1963 the level of gamma-HCCH (active component of lindane) has been analysed in liver tissue from all species. The results from the three species of which we received the most carcasses, sparrowhawk, kestrel and heron, are reported here. They include results from 1633 sparrowhawks, 1417 kestrels and 774 herons.

8.2 *Results*

The trends for residues in the three species during 1963-96 are shown in figures 1 and 2. In all three species, the majority of specimens contained up to 0.5 parts per million of lindane in wet weight (Table 15). Only one specimen of each species contained more than 5 parts per million. All three species showed peaks in annual levels recorded, and proportion of specimens containing residues, in the years 1982-86 (Fig 1). Kestrels also showed a minor peak in levels during 1969-71, and herons around 1967. From 1976 to the present, sparrowhawks showed a higher five-year moving mean residue level than either kestrels or herons, although all three species followed a similar pattern (Fig.2). Prior to this period, kestrels appeared to show higher levels.

The significance of the trends over the last 15 years was assessed by regression analyses of individual residue levels on years. This covered the period of peak contamination through a rapid decline to the present. Kestrel ($b=-0.0105$, $p<0.001$) and sparrowhawk ($b=-0.0166$, $p<0.001$) showed greater and statistically more significant declines than heron ($b=-0.0137$, $p<0.05$).

Over the 34 year period, none of the birds examined under the monitoring scheme were thought to have died from lindane poisoning. However, lindane residue levels in avian liver have been found to decline rapidly within hours of ingestion, making it difficult to confirm death from lindane poisoning by detection of lethal levels in field samples (French & Jefferies, 1968). The Wildlife Incident Investigation Scheme, run by the UK's Agriculture Departments, has found gamma-HCCH to be responsible for the deaths of bats, exposed to the chemical in timber treatment, and of honeybees exposed either through timber treatment or crop spraying. There have been no recent reports of poisoning of wild birds by gamma-HCCH (Fletcher *et al.* 1996).

8.3 *References*

Hayes, W.J., & Laws, E.R. (eds) 1991. Handbook of Pesticide Toxicology. Vol. 2. Classes of Pesticides. Academic Press, San Diego.

Fletcher, M.R., Hunter, K., Barnett, E.A. & Sharp, E.A. 1996. Pesticide Poisoning of Animals 1995: Investigations of Suspected Incidents in the United Kingdom. London: MAFF.

French, M.C., & Jefferies, D.J. 1968. Disappearance of γ BHC from avian liver after death. Nature 219: 164-6

Table 15. Gamma-HCCH residues in predatory birds, in successive 5-year periods
ND=none detected

Sparrowhawk

Years	Number analysed	ND	Number (%) of specimens containing the following residue levels (ppm). 0-0.01	0.011-0.10	0.11-0.25	0.26-0.50	0.51-1.0	1-5	>5
1961-65	31	27 (87.10)	3 (9.68)	1 (3.23)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
1966-70	75	73 (97.33)	0 (0.00)	0 (0.00)	1 (1.33)	0 (0.00)	0 (0.00)	0 (0.00)	1 (1.33)
1971-75	113	112 (99.12)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.88)	0 (0.00)
1976-80	204	175 (85.78)	4 (1.96)	0 (0.00)	11 (5.39)	7 (3.43)	4 (1.96)	3 (1.47)	0 (0.00)
1981-85	304	108 (35.53)	65 (21.38)	2 (0.66)	51 (16.78)	59 (19.41)	12 (3.95)	7 (2.30)	0 (0.00)
1986-90	389	299 (76.86)	26 (6.68)	2 (0.51)	15 (3.86)	44 (11.31)	2 (0.51)	1 (0.26)	0 (0.00)
1991-95	517	265 (51.26)	107 (20.70)	134 (25.92)	1 (0.19)	6 (1.16)	2 (0.39)	2 (0.39)	0 (0.00)
Totals	1633	1059 (64.85)	205 (12.55)	139 (8.51)	79 (4.84)	116 (7.10)	20 (1.22)	14 (0.86)	1 (0.06)

Kestrel

Years	Number analysed	ND	Number (%) of specimens containing the following residue levels (ppm). 0-0.01	0.011-0.10	0.11-0.25	0.26-0.50	0.51-1.0	1-5	>5
1961-65	103	92 (89.32)	0 (0.00)	5 (4.85)	1 (0.97)	1 (0.97)	2 (1.94)	2 (1.94)	0 (0.00)
1966-70	147	115 (78.23)	0 (0.00)	11 (7.48)	7 (4.76)	11 (7.48)	3 (2.04)	0 (0.00)	0 (0.00)
1971-75	195	172 (88.21)	0 (0.00)	3 (1.54)	3 (1.54)	9 (4.62)	3 (1.54)	4 (2.05)	1 (0.51)
1976-80	178	167 (93.82)	1 (0.56)	1 (0.56)	3 (1.69)	4 (2.25)	0 (0.00)	2 (1.12)	0 (0.00)
1981-85	347	170 (48.99)	5 (1.44)	96 (27.67)	52 (14.99)	14 (4.03)	5 (1.44)	5 (1.44)	0 (0.00)
1986-90	214	170 (79.44)	5 (2.34)	14 (6.54)	21 (9.81)	2 (0.93)	1 (0.47)	1 (0.47)	0 (0.00)
1991-95	233	188 (80.69)	34 (14.59)	10 (4.29)	1 (0.43)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Totals	1417	1074 (75.79)	45 (3.18)	140 (9.88)	88 (6.21)	41 (2.89)	14 (0.99)	14 (0.99)	1 (0.07)

Heron

Years	Number analysed	ND	Number (%) of specimens containing the following residue levels (ppm). 0-0.01	0.011-0.10	0.11-0.25	0.26-0.50	0.51-1.0	1-5	>5
1961-65	60	52 (86.67)	1 (1.67)	7 (11.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
1966-70	149	127 (85.23)	6 (4.03)	14 (9.40)	2 (1.34)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
1971-75	100	99 (99.00)	1 (1.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
1976-80	71	67 (94.37)	4 (5.63)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
1981-85	154	80 (51.95)	6 (3.90)	22 (14.29)	30 (19.48)	12 (7.79)	2 (1.30)	2 (1.30)	0 (0.00)
1986-90	164	132 (80.49)	0 (0.00)	5 (3.05)	22 (13.41)	3 (1.83)	1 (0.61)	0 (0.00)	1 (0.61)
1991-95	76	67 (88.16)	8 (10.53)	1 (1.32)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Totals	774	624 (80.62)	26 (3.36)	49 (6.33)	54 (6.98)	15 (1.94)	3 (0.39)	2 (0.26)	1 (0.13)

Fig. 1. Percentage of carcasses analysed that contained detectable residues of gamma-HCCH

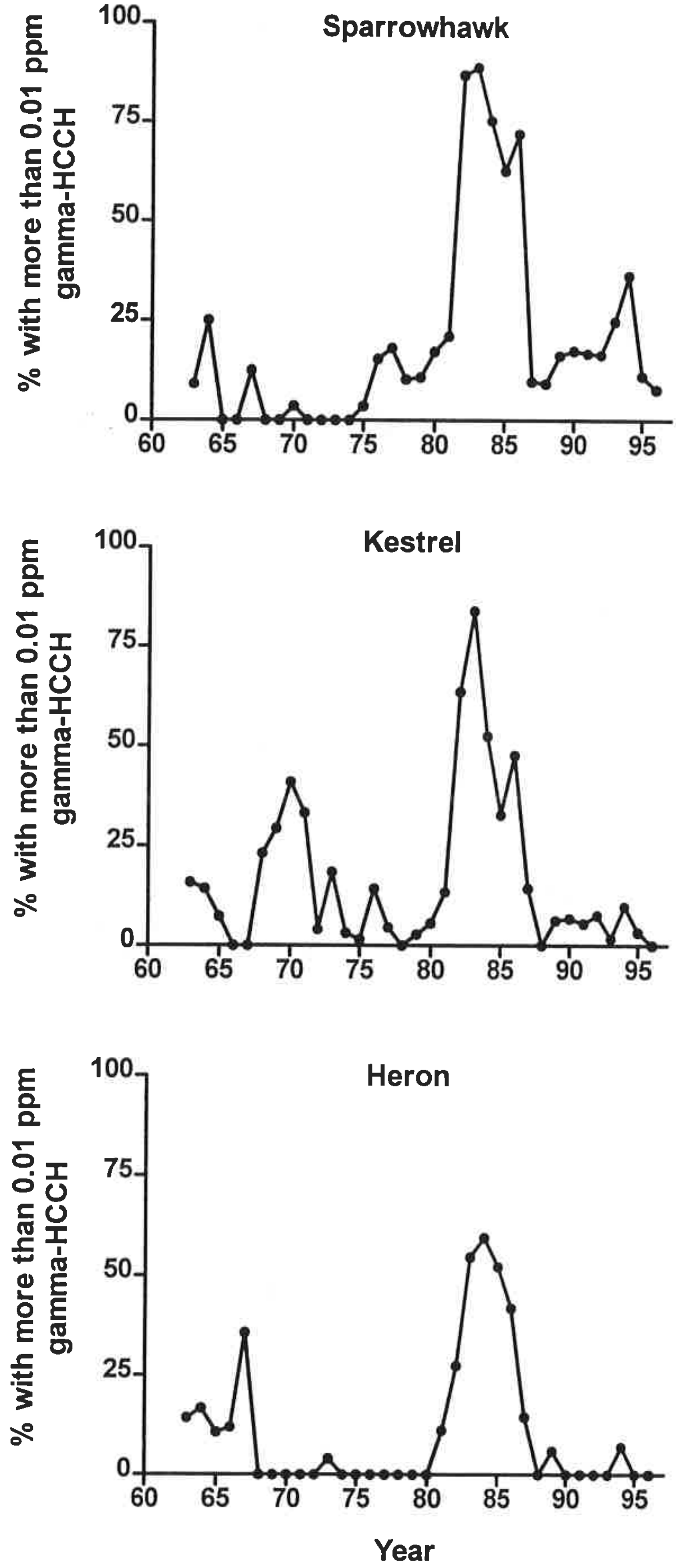
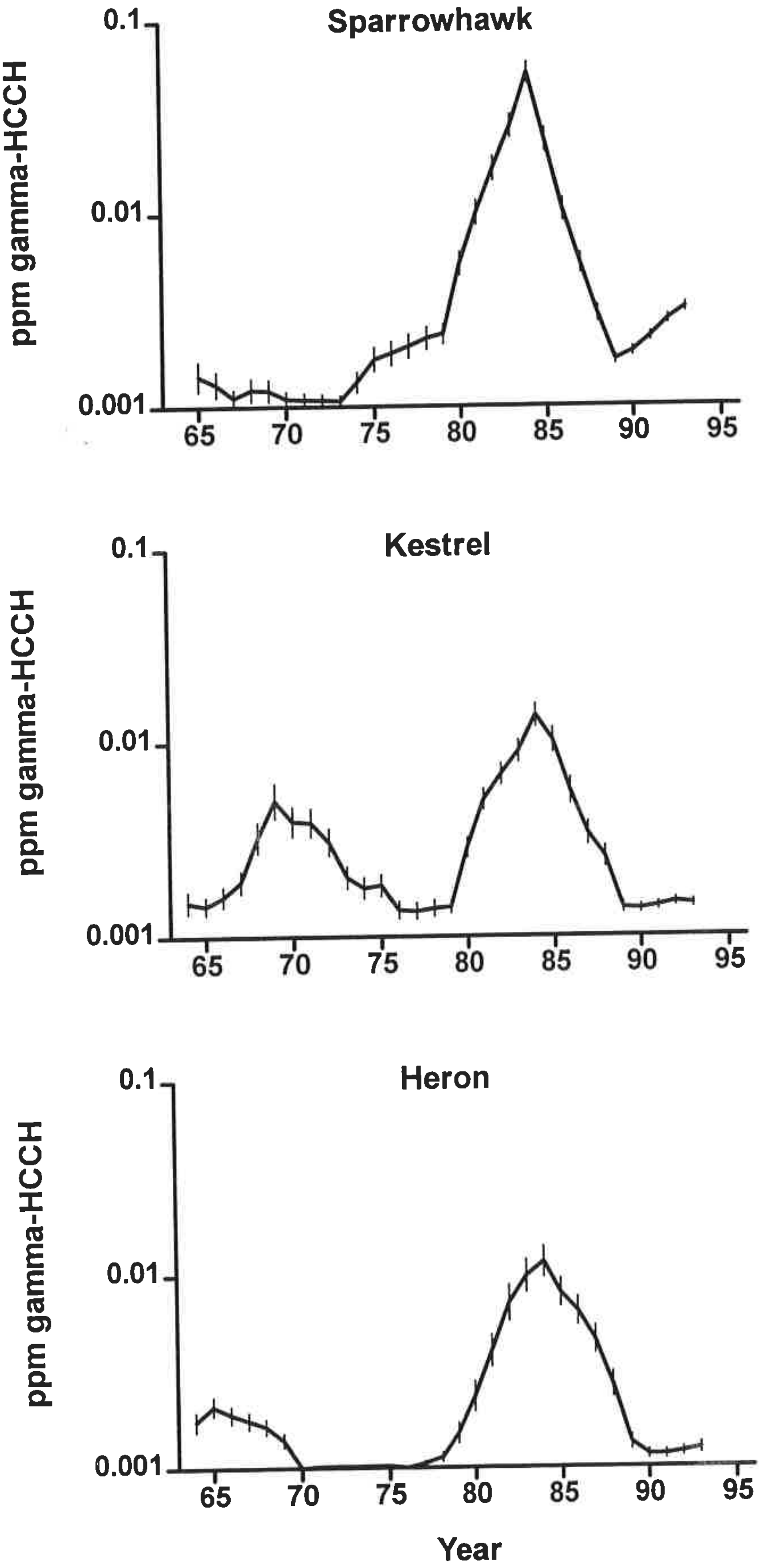


Fig. 2. Five-year rolling means of gamma-HCCH residues in carcasses analysed



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Annual report to the Joint Nature Conservation Committee

Wildlife and pollution

Part 9 Kittiwake mortality incident, Marsden, July 1996

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9 Kittiwake mortality incident, Marsden, July 1996

Only one mortality incident was reported to us during 1996. In July-August of that year, several hundred kittiwake *Rissa tridaclyla* carcasses were washed ashore along a short stretch of coast at Marsden, north-east England.

Superficially, the birds were in excellent condition, and freshly dead. Post-mortem analysis revealed that the intestines were inflamed but no other gross abnormalities were apparent. Liver samples from seven birds were analysed for organochlorine and mercury residues (Table 16). The levels of all residues were well below those thought to induce toxic effects, and were similar or lower than levels reported in various species of seabirds, including kittiwakes, in previous years.

Liver samples were also scanned for the presence of additional organic chemicals and heavy metals. Quantitative data are not available, but the scans suggested that neither industrial organochlorine compounds nor heavy metals had contributed to the mortality of these birds.

The cause of the mortality incident was not determined. MAFF laboratories analysed samples for relevant bacteria, viruses and dinoflagellates, but all tests proved negative. However, after another incident in July/August of 1997, and similar analyses by MAFF, the deaths in this year were attributed to dinoflagellate poisoning.

Table 16. Organochlorine and mercury residues in Kittiwake livers from Marsden, 1996

Figures show geometric means and the ranges within one geometric standard error. Organochlorine values are ppm wet weight, and mercury ppm dry weight

Chemical	Concentration
Lipid content	4.41 (4.04-1.82)
Hg	1.51 (1.10-2.08)
HCB	0.01 (0.01-0.01)
Lindane	<0.003
DDE	0.07 (0.04-0.12)
HEOD	0.03 (0.02-0.04)
TDE	<0.003
DDT	<0.004
Total PCBs	0.73 (0.65-0.82)
PCB 028	<0.011
PCB 031	<0.011
PCB 052	<0.026
PCB 077	<0.021
PCB 101	<0.011
PCB 118	0.02 (0.01-0.02)
PCB 126	<0.004
PCB 128	0.00 (0.00-0.00)
PCB 138	0.05 (0.04-0.05)
PCB 149	0.01 (0.01-0.02)
PCB 153	0.08 (0.08-0.10)
PCB 169	0.01 (0.01-0.01)
PCB 170	0.01 (0.01-0.01)
PCB 180	0.03 (0.02-0.03)

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