JNCC Report
No. 305

Wildlife and pollution:
1998/99 Annual Report

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This report should be cited as:
Newton, I, Afsar, A, Dale, L, Finnie, J, Shore, R F, Wright,
J, Wyatt, C & Wyllie, I, 2000
Wildlife and Pollution: 1998/99 Annual Report
JNCC Report, No.305

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ISSN 0963-8091

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1. Preface and Summary

1.1 Introduction

The Wildlife and Pollution contract covers a long-term monitoring programme aimed to examine the levels of pollutants in selected wildlife species in Britain. The programme was started more than 35 years ago, when there were serious concerns over the effects of organochlorine insecticides and organomercury fungicides on various species of 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 agricultural pesticides. 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 1998.

As this programme is now the longest running of its kind anywhere in the world, the findings stimulate considerable interest internationally, as well as in Britain. Annual reports (like the present one) 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 1997.

Each sub-project 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. No major incidents were investigated in 1998.

1.2 Organochlorines and mercury in predatory birds

The main objective of this work is to analyse the bodies of certain predatory and fish-eating bird-species, 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 1998 the livers from 132 birds were analysed, including those from 13 kestrels, 63 sparrowhawks, 3 herons, 7 kingfishers, 3 great-crested grebes and 43 birds of various other species. These birds came from various localities in England, Scotland and Wales.

Over the whole monitoring period (1963-98), the overall data for most species have revealed significant long-term downward trends in residues (except for PCBs in kestrels and mercury in kingfishers). Declines may be levelling off for DDE (the main metabolite of DDT) and HEOD (derived from aldrin and dieldrin). There were two significant changes in geometric mean levels between 1997 and 1998, with decreases in DDE levels in kestrels and sparrowhawks. It is impossible to say whether these differences reflect real year-to-year changes in exposure.

1.3 Organochlorines and mercury in peregrine eggs

Single eggs from 8 peregrine clutches were analysed in 1998, from various parts of England, Scotland and Wales. The levels of organochlorine pesticides in British peregrine eggs 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

Single eggs from 26 merlin clutches were analysed in 1998, from various parts of England and Scotland. The results confirm that the merlin remains the most contaminated of the British raptors.

1.5 Organochlorines and mercury in golden eagle eggs

Single eggs from seven clutches from Scotland were analysed in 1998. These confirm the low levels of contamination in eggs from inland districts found in recent years.

1.6 Organochlorines and mercury in gannet eggs

Eggs from three colonies, namely Ailsa Craig, Bass Rock and St Kilda, were analysed in 1998. Residue levels were low and within the range of previous eggs from this colony. Over the long term (1971-98), eggs from Ailsa Craig showed declines in all residues, those from Bass Rock showed declines in DDE and HEOD and an increase in mercury, and those from St Kilda showed a decline in DDE and an increase in mercury**.** The gannet is the only British seabird in which residue levels have been monitored continuously over the past 28 years, so has become a key indicator species of marine pollution.

1.7 Organochlorines and mercury in sea eagle eggs

One egg was received in 1998 from Mull. Relatively high levels of PCB were found, presumably a reflection of the high proportion of marine food in the diet.

1.8 Rodenticide residues in barn owls

The second-generation anticoagulant rodenticides (currently difenacoum, bromadiolone, brodifacoum and flocoumafen) were considered a potential threat to barn owls. These rodenticides are rapidly replacing warfarin and are both more toxic to vertebrates and more persistent. Fifty-four birds were examined in 1998. The residues of one or more rodenticides were found in the livers of 28 (52%) birds and six (11%) of these had levels likely to be associated with mortality. Although results from a single year should be treated cautiously the proportion of contaminated owls in the 1998 sample was significantly higher than in previous years, as was the proportion with multiple residues. Despite widespread exposure, there is yet no evidence that these chemicals have had any serious impact on barn owl numbers in Britain. However, the evidence from this year's study would suggest that a significant proportion of the barn owl population may potentially suffer mortality due to this exposure.

2. Organochlorines and mercury in predatory birds

2.1 Introduction

The 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

During the past year, the livers from 132 birds were analysed, including those from 13 kestrels, 63 sparrowhawks, 3 herons, 7 kingfishers, 3 great-crested grebe and 43 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 predominant species (1998 specimens only) are given in Table 2. As usual, mercury levels were higher in the aquatic than in the terrestrial species.

Several birds had unexpectedly high levels of pollutants. They included a sparrowhawk (from West Sussex) with 90 ppm DDE, 12 ppm HEOD and 17 ppm PCB, another sparrowhawk (from the Highlands) with 19 ppm DDE and 36 ppm PCB and 16 ppm mercury, one (from the West Midlands) with 32 ppm PCB, and one (from the Highlands) with 16 ppm mercury. There was also a heron (from Norfolk) with 51 ppm DDE, 10 ppm HEOD, 7 ppm PCB, and 15 ppm mercury, and a kingfisher (from Buckinghamshire) with 3ppm HEOD and 91 ppm PCB. Amongst other species, a peregrine (from Lancashire) had DDE levels of 15 ppm and PCB levels of 11 ppm, and a long-eared owl (from Grampian) had 5 ppm DDE, 8 ppm HEOD and 7 ppm mercury**.** Two bitterns (from Suffolk) had 19 ppm and 28 ppm mercury respectively.

Out of 16 comparisons, two significant differences in geometric mean values were found between the 1997 and 1998 results. These were significant decreases in DDE in kestrels and sparrowhawks (Table 3). It is impossible to say whether these differences reflected real changes in exposure, especially as levels were generally low. Because only one great-crested grebe was received in 1997, no comparisons between residues in 1997 and 1998 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 1998 and March 1999

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*)								
12674	97	Warwickshire	J	M	0.014	0.259	0.183	0.381
12675	98	Norfolk	A	M	0.253	0.177	1.114	8.806
12690	98	Rutland	A	M	0.033	0.164	1.308	0.0333
12744	98	East Yorks	A	M	0.048	0.359	0.764	1.572
12769	98	Essex	J	M	1.710	0.121	0.707	4.002
12772	98	Nottinghamshire	J	F	0.035	0.167	0.999	0.597
12794	98	Northamptonshire	J	M	0.042	0.459	2.911	1.52
12802	98	Ayrshire	A	F	0.011	0.125	1.135	0.334
12827	98	Isle of Wight	J	F	0.115	0.219	1.680	1.052
12831	98	North Yorks	J	M	0.070	0.092	2.904	1.82
12832	98	Kent	A	M	5.356	0.531	2.796	0.849
12834	98	Cornwall	J	M	0.027	0.135	0.563	1.618
12836	98	Norfolk	J	F	0.377	0.769	1.467	0.991
Sparrowhawk (*Accipiter nisus*)								
12656	98	Strathclyde	J	F	0.201	0.060	1.375	3.326
12658	98	Cambridgeshire	A	M	1.322	0.092	4.075	1.147
12660	98	Surrey	J	F	0.093	0.036	0.469	2.214
12665	98	Berkshire	J	M	1.280	0.105	7.977	ND
12670	98	Oxfordshire	J	F	1.993	0.171	6.624	5.498
12672	98	West Glamorgan	A	F	0.425	0.089	2.430	2.011
12678	98	East Sussex	J	M	0.363	0.058	1.077	1.490
12682	98	Shropshire	A	M	2.329	0.638	11.943	5.577
12686	98	Highland	J	M	0.193	0.033	0.518	7.187
12689	98	Mid Glamorgan	J	M	0.235	0.029	0.479	7.126
12692	98	Greater Manchester	J	F	0.202	0.062	0.002	1.218
12693	98	Kent	J	M	1.180	0.042	1.491	2.935
12697	98	Hampshire	J	M	2.485	0.417	18.205	13.253
12699	98	West Sussex	J	F	90.744	12.167	17.511	9.928
12704	98	East Sussex	J	M	9.701	0.459	6.098	3.453
12705	96	Highland	J	M	0.348	0.001	0.117	1.774
12706	96	Highland	A	M	19.441	1.068	36.544	16.682
12707	97	Highland	A	M	2.905	0.133	8.348	3.889
12709	98	Derbyshire	A	M	0.361	0.005	1.687	1.031
12712	98	H&W	J	F	4.196	0.356	10.283	6.820
12717	98	Avon	A	M	0.750	0.059	1.393	1.696
12718	97	Hampshire	-	F	0.132	0.001	1.096	0.810
12720	98	Kent	J	M	3.718	0.087	2.916	5.418
12722	98	Dyfed	J	M	0.534	0.158	1.128	6.032
12727	98	Gwynedd	A	F	1.859	0.106	3.770	2.227
12728	98	Cheshire	A	M	1.690	0.241	11.532	5.809
12734	98	West Midlands	A	M	4.458	0.230	32.390	2.021

Specimen no.	Date Found	County	Age	Sex	pp'-DDE	HEOD	PCB	Hg
Sparrowhawk (*Accipiter nisus*) cont.								
12741	98	Dorset	J	M	3.534	0.135	7.404	2.302
12753	98	Highland	J	M	5.429	0.086	8.455	16.823
12754	97	Highland	A	F	5.893	0.282	5.774	5.275
12757	98	Devon	A	F	0.544	0.104	3.043	3.610
12763	98	Strathclyde	A	F	0.498	0.174	5.103	1.819
12765	98	D&G	J	F	0.289	0.051	1.167	4.395
12773	98	Dyfed	J	M	0.157	0.036	1.123	1.571
12774	98	West Sussex	J	F	0.173	0.029	2.493	1.186
12776	98	Bedfordshire	J	F	0.094	0.046	0.260	1.011
12777	98	Wiltshire	J	M	0.078	0.025	0.246	1.301
12779	98	Hampshire	J	M	0.517	0.058	1.847	0.677
12781	98	Hertfordshire	J	F	0.325	0.040	0.891	1.191
12783	98	Suffolk	J	M	3.728	0.170	2.502	1.708
12784	98	Essex	J	M	0.177	0.029	0.081	0.852
12785	98	Lincolnshire	J	M	0.280	0.136	1.321	1.561
12787	98	Derbyshire	J	F	0.079	0.020	0.121	0.950
12791	98	Berkshire	J	F	2.428	0.167	5.283	1.545
12795	98	H&W	J	F	2.140	0.153	2.236	1.086
12798	98	Dyfed	J	F	0.076	0.020	1.699	0.812
12807	98	Highland	J	F	0.693	0.126	3.839	2.262
12808	98	Orkney	J	F	0.129	0.023	0.556	ND
12810	98	Norfolk	J	F	0.052	0.012	0.992	1.978
12816	98	Cambridgeshire	J	M	3.495	0.135	1.706	2.773
12817	98	Hampshire	J	M	0.141	0.030	0.449	0.985
12825	98	H&W	J	M	1.069	0.269	1.227	1.412
12828	98	Clwyd	A	M	0.143	0.058	4.935	0.895
12833	98	North Yorks	J	M	0.265	0.058	2.103	1.852
12838	98	Dyfed	J	M	0.181	0.033	1.203	1.645
12840	98	Strathclyde	A	F	2.859	0.240	5.421	0.685
12842	98	Kent	J	M	1.663	0.110	0.914	0.546
12843	98	Northamptonshire	A	M	0.365	0.067	2.307	0.493
12846	98	Wiltshire	J	F	1.350	0.068	0.756	0.954
12848	98	Essex	J	M	1.358	0.057	0.836	0.813
12849	98	Hampshire	-	F	1.214	0.198	2.218	0.579
12854	98	Norfolk	A	M	18.832	0.132	32.689	1.687
12855	98	Northamptonshire	J	M	2.881	0.149	6.537	2.340
Peregrine Falcon (*Falco peregrinus*)								
12677	98	Lancashire	A	M	15.451	0.504	11.326	1.505
12687	98	Staffordshire	A	F	0.218	0.166	12.561	1.145
12716	98	D&G	A	M	6.653	0.636	2.689	6.709
12738	98	Lancashire	J	F	0.167	0.030	4.456	0.378
Merlin (*Falco columbarius*)								
12700	98	Highland	J	F	9.172	0.884	25.348	6.508
12750	98	Highland	J	M	1.091	0.083	4.019	1.596
12768	98	D&G	A	F	0.391	0.139	0.805	2.85

Specimen no.	Date Found	County	Age	Sex	pp'-DDE	HEOD	PCB	Hg
Hobby (*Falco subbuteo*)								
12823	98	Northamptonshire	J	F	0.343	0.139	0.948	0.558
Golden Eagle (*Aquila chrysaetos*)								
12708	98	Western Isles	A	M	0.021	0.190	0.224	2.036
Buzzard (*Buteo buteo*)								
12387	97	Dyfed	-	-	0.044	0.032	0.644	0.394
12392	97	Dyfed	-	F	0.014	0.026	0.546	0.134
12393	97	Dyfed	-	M	0.005	0.019	0.357	0.142
12456	97	Cumbria	J	F	0.084	0.094	0.612	1.049
12459	97	H&W	A	F	ND	0.144	0.259	0.774
12484	97	Dyfed	-	-	ND	0.073	3.353	1.496
12561	97	Somerset	J		ND	0.470	8.960	2.177
12572	97	Devon	A	M	ND	0.148	0.169	0.331
12574	97	H&W	J	F	ND	0.023	0.156	0.196
12647	98	Kent	J	M	0.108	0.128	0.003	1.122
12695	98	H&W	J	M	0.025	0.132	6.564	0.429
12715	98	Highland	A	M	ND	0.206	0.494	0.543
12736	98	H&W	J	M	0.263	3.295	0.470	4.637
12762	98	Somerset	J	M	ND	0.123	0.110	0.31
12841	98	Derbyshire	A	F	0.052	0.164	10.389	0.268
Hen Harrier (*Circus cyaneus*)								
12822	98	Tyne & Wear	J	-	0.462	0.135	1.479	5.608
Long-eared Owl (*Asio otus*)								
12537	97	Scilly Isles	A	M	0.105	0.052	2.049	0.173
12735	98	Grampian	A	F	5.748	8.325	1.968	7.49
Short-eared Owl (*Asio flammeus*)								
12538	97	H&W	A	F	2.699	0.010	0.779	1.132
12839	98	Lincolnshire	A	F	1.516	0.128	40.263	1.473
12847	98	Bedfordshire	A	F	10.160	0.101	15.028	1.7
Little Owl (*Athene noctua*)								
12510	97	Norfolk	A	M	0.306	0.038	0.823	0.295
12725	98	Hampshire	A	M	0.044	0.068	2.836	0.458
12755	98	Oxfordshire	J	M	0.035	0.071	2.440	0.152
12780	98	Somerset	A	F	0.468	0.061	0.869	0.45
Heron (*Ardea cinerea*)								
12669	96	Suffolk	A	M	0.368	0.097	0.801	6.432
12711	98	Norfolk	A	F	51.849	10.535	7.640	14.792
12748	98	Devon	J	F	0.144	0.211	0.737	4.011
12749	98	Highland	J	M	0.059	0.014	0.470	7.958

Specimen no.	Date Found	County	Age	Sex	pp'-DDE	HEOD	PCB	Hg
Bittern (*Botaurus stellaris*)								
12649	97	Suffolk	J	F	ND	0.032	0.939	5.201
12650	98	Suffolk	J	F	0.083	0.039	0.366	13.744
12683	98	Suffolk	-	-	ND	0.036	0.537	28.103
12723	98	Suffolk	J	F	ND	0.039	0.354	2.424
12724	98	Suffolk	J	-	ND	0.023	0.256	3.055
12733	98	Suffolk	J	M	ND	0.025	0.026	1.995
12737	98	Suffolk	J	F	ND	0.026	0.125	1.033
12850	98	Suffolk	J	-	ND	0.025	0.397	3.064
Kingfisher (*Alcedo atthis*)								
12731	98	Buckinghamshire	A	M	4.079	3.200	91.075	3.761
12742	98	Suffolk	J	M	0.086	0.181	0.369	1.462
12756	98	Kent	J	M	0.775	0.604	2.626	1.54
12759	98	Cambridgeshire	J	M	0.154	0.443	0.175	2.777
12761	98	Berkshire	J	F	0.121	0.326	0.400	1.925
12782	98	Isle of Wight	J	F	0.169	0.458	0.931	0.846
12801	98	Wiltshire	J	M	0.131	0.136	0.712	2.145
Great-crested Grebe (*Podiceps cristatus*)								
12851	98	Staffordshire	A	F	2.540	0.025	21.795	4.183
12853	98	Shropshire	J	F	0.026	0.026	0.330	2.542
12856	98	North Yorks	J	F	0.019	0.017	0.524	0.902
Little Grebe (*Tachybaptus ruficollis*)								
12721	98	Essex	A	M	0.332	0.116	5.930	11.042

Table 2. Geometric mean levels of pollutants in the various species in Table 1, for 1998 specimens only (units as in Table 1).

GSE=geometric standard error

	pp'-DDE	HEOD	PCB	Hg
Kestrel				
Geometric mean	0.097	0.2233	1.138	0.955
N	13	13	13	13
Range within 1 GSE	0.058-0.162	0.187-0.267	0.920-1.407	0.659-1.387
Sparrowhawk				
Geometric mean	0.786	0.080	1.964	1.638
N	63	63	63	63
Range within 1 GSE	0.644-0.960	0.067-0.095	1.604-2.404	1.340-2.003
Heron				
Geometric mean	0.761	0.315	1.383	7.7868
N	3	3	3	3
Range within 1 GSE	0.091-6.380	0.046-2.151	0.583-3.283	5.342-11.351
Kingfisher				
Geometric mean	0.273	0.439	1.223	1.877
N	7	7	7	7
Range within 1 GSE	0.162-0.460	0.298-0.647	0.57-2.686	1.565-2.252
Great-crested Grebe				
Geometric mean	0.108	0.022	1.556	2.125
N	3	3	3	3
Range within 1GSE	0.022-0.525	0.019-0.026	0.413-5.863	1.352-3.338

Note: nil detected values were taken as 0.001 for all residues

Table 3. Comparison of geometric mean residue levels (log values) from birds collected in 1997 and 1998; t-values are shown. Minus values indicate a decrease and plus values indicate an increase from 1997.

	pp'-DDE	HEOD	PCB	Hg
Kestrel	t_{37}= -2.38*	t_{37}= +0.18	t_{37}= -0.20	t_{37}= +0.95
Sparrowhawk	t_{123}= -3.16**	t_{123}= -1.35	t_{123}= -0.59	t_{123}= +1.73
Heron	t_9= +0.21	t_9= +0.85	t_9= -0.58	t_9= -0.62
Kingfisher	t_{12}= -0.29	t_{12}= +0.92	t_{12}= +0.29	t_{12}= -0.64

Notes: None detected values taken as 0.001 for all residues
Significance of difference: *P<0.05; **P<0.01; ***P<0.001.

Table 4. **Trends in pollutant levels in livers of predatory birds during 1963-1998 and 1993-1998. Figures show sample sizes (N) and linear regression coefficients (b) based on log values regressed against year.**
*P=<0.05; **P=<0.01;***P<0.001; ns=not significant

		1963-1998		1993-1998	
		N	b	N	b
Kestrel					
	pp'-DDE	1417	-0.0425 ***	174	0.0063 ns
	HEOD	1388	-0.0326 ***	172	0.0434 *
	PCB	1276	0.0022 ns	175	-0.0676 **
	Hg	1081	-0.0317 ***	171	-0.0403 ns
Sparrowhawk					
	pp'-DDE	1794	-0.0349 ***	452	0.0070 ns
	HEOD	1795	-0.0345 ***	452	-0.0500 **
	PCB	1750	-0.0127 ***	452	-0.0684 **
	Hg	1546	-0.025 ***	449	-0.0338 *
Heron					
	pp'-DDE	802	-0.0434 ***	55	0.0170 ns
	HEOD	792	-0.0503 ***	55	-0.0391 ns
	PCB	668	-0.0241 ***	55	-0.1060 ns
	Hg	505	-0.0214 ***	55	0.0046 ns
Kingfisher					
	pp'-DDE	223	-0.0467 ***	34	-0.0183 ns
	HEOD	222	-0.0245 ***	34	-0.0172 ns
	PCB	217	-0.0172 **	34	-0.1178 ns
	Hg	144	0.0014 ns	34	-0.0244 ns
Great-crested Grebe					
	pp'-DDE	187	-0.0281 ***	14	-0.0800 ns
	HEOD	166	-0.0298 ***	14	-0.0055 ns
	PCB	174	-0.0275 **	14	-0.0230 ns
	Hg	106	-0.0324 ***	14	-0.0748 ns

Notes: Analyses for Hg in Sparrowhawk, Kestrel and Heron were started in 1970, in Kingfisher in 1980 and in Great-crested Grebe in 1979.
Analyses for PCBs in sparrowhawk, Kestrel and Heron were started in 1967,

3 Organochlorines and mercury in Peregrine eggs

3.1 Introduction

The findings from all peregrine eggs analysed between 1961 and 1986 were summarised in Newton *et al.* (1989), which was updated in the 1997-98 report in this series. The results from eight eggs (one per clutch) analysed in 1998 are given in Table 5. Unfortunately no coastal eggs were represented.

3.2 Results

The findings confirm continuing contamination of British peregrine eggs with organochlorines and mercury. However, most of the residues were present at relatively low levels. The highest residue levels in 1998 were all found in one egg from Lancashire, which contained 2.73ppm DDE, 0.16ppm HEOD and 5.32 ppm PCB (wet weight) and 1.86 ppm mercury (dry weight) (Table 5). 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 seem unlikely.

3.3 References

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

Table 5. Residue levels (organochlorine ppm wet weight (lipid weight); mercury ppm dry weight) and shell indices (SI) for Peregrine eggs received in 1998.

ND = none detected.

Number	Year	County	SI	Pp'DDE	HEOD	PCB	Hg
CENTRAL AND EASTERN HIGHLANDS							
E7380	98	Fife	-	0.36 (7.72)	ND	0.758 (16.21)	0.29
NORTHERN ENGLAND							
E7362	98	Lancashire	2.02	0.11 (2.04)	ND	1.08 (19.18)	0.12
E7369	98	Lancashire	1.82	2.73 (57.42)	0.16 (3.35)	5.32 (111.78)	1.86
E7372	98	Cheshire	1.96	0.28 (14.89)	ND	1.04 (54.56)	0.32
E7490	98	Durham	1.91	0.32 (6.13)	0.04 (0.69)	2.39 (45.55)	0.22
E7517	98	Derbyshire	2.02	0.16 (2.98)	0.01 (0.27)	0.80 (14.77)	0.10
SOUTHERN ENGLAND							
E7373	98	Sussex	1.71	0.37 (8.09)	ND	1.59 (38.63)	0.28
WALES							
E7385	98	North Wales	1.71	0.74 (15.48)	0.02 (0.45)	1.90 (39.75)	1.00

4 Organochlorines and mercury in Merlin eggs

4.1 Introduction

The findings from previous analyses of merlin eggs were given in Newton & Haas (1988) and Newton *et al.* (1999) and also in previous reports in this series. Those from 26 eggs (one per clutch) analysed in 1998 are summarised in Table 6.

4.2 Results

The results from the 26 merlin eggs collected in 1998 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 7 ppm (in an egg from Durham), the highest HEOD level was 1.9 ppm (in an egg from Tayside) and the highest PCB level was 16.9 ppm (in an egg from Durham). As in previous years, the highest levels of mercury (3-7 ppm) were found in eggs from the Northern Isles, and eggs that were high in DDE tended also to be relatively high in HEOD and PCB. Shell-indices were available for 16 eggs in 1998, and averaged 1.21, some 4% less than the pre-DDT value.

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 relatively high levels in eggs from the Northern Isles. Declines in residues over the past 10-15 years have coincided with a substantial recovery in merlin numbers over much of the country.

4.3 References

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

Newton, I Dale, L & Little, B (1999) *Trends in organochlorine and mercurial compounds in the eggs of British Merlins Falco columbarius*. Bird Study **46**, 356-362.

Table 6. Residue levels (organochlorine ppm wet weight (lipid weight); mercury ppm dry weight) and shell indices (SI) for Merlin eggs received in 1998.

ND=none detected.

Number	Year	County	SI	pp'-DDE	HEOD	PCB	Hg
CENTRAL AND EASTERN HIGHLANDS							
E7422	1998	Grampian	1.18	4.59 (73.78)	0.17 (2.75)	3.05 (48.92)	1.19
E7423	1998	Grampian	1.20	2.25 (41.84)	0.14 (2.51)	1.97 (36.74)	1.46
E7424	1998	Grampian	1.46	3.74 (56.06)	0.15 (2.26)	7.07 (106.11)	1.13
E7425	1998	Grampian	1.16	4.01 (70.53)	1.70 (29.86)	1.87 (32.95)	1.55
E7450	1998	Tayside	-	3.36 (47.12)	0.12 (1.63)	3.95 (55.40)	1.70
E7451	1998	Tayside	-	6.87 (96.71)	1.26 (17.72)	3.25 (45.67)	2.39
E7453	1998	Tayside	-	3.43 (50.04)	0.20 (2.87)	3.54 (51.62)	1.18
E7454	1998	Tayside	-	6.67 (86.34)	0.30 (3.88)	3.03 (39.19)	2.09
E7455	1998	Tayside	-	4.14 (74.78)	0.23 (4.06)	2.32 (41.90)	1.49
E7456	1998	Tayside	-	4.56 (91.24)	0.28 (5.52)	2.59 (51.86)	1.75
SOUTHERN HIGHLAND FRINGE							
E7394	1998	Tayside	-	2.28 (46.84)	1.99 (40.84)	1.95 (40.08)	1.58
SOUTHERN SCOTLAND							
E7388	1998	Borders	1.17	3.78 (51.02)	0.22 (2.98)	8.62 (116.52)	2.78
E7392	1998	Borders	1.23	1.61 (14.69)	0.59 (5.39)	7.77 (70.86)	0.99
E7393	1998	Borders	1.09	3.27 (52.44)	0.12 (1.94)	1.89 (30.41)	1.99
NORTHERN ENGLAND							
E7368	1998	Lancashire	1.26	1.50 (18.74)	0.16 (2.00)	4.62 (57.75)	2.77
E7401	1998	North Yorks	1.25	2.25 (33.46)	0.34 (4.99)	4.19 (62.20)	1.65
E7403	1998	West Yorks	1.15	4.73 (71.18)	0.36 (5.44)	5.18 (77.93)	1.39
E7482	1997	Durham	1.26	2.96 (38.34)	0.34 (4.44)	16.90 (218.81)	4.39
E7483	1997	Durham	1.38	2.25 (35.64)	0.20 (3.10)	4.32 (68.25)	1.22
E7484	1997	Durham	1.00	7.03 (122.21)	0.19 (3.35)	1.95 (33.92)	1.28
E7485	1998	N'humberland	1.21	4.17 (67.23)	0.26 (4.23)	12.06 (194.24)	2.79
E7486	1998	N'humberland	-	3.17 (34.85)	0.13 (1.46)	2.06 (22.60)	2.04
E7487	1998	N'humberland	-	2.10 (34.91)	0.09 (1.49)	1.51 (24.98)	2.45
NORTHERN ISLES							
E7395	1998	Shetland	-	0.85 (15.72)	ND	5.57 (47.50)	5.35
E7399	1998	Shetland	1.13	4.73 (83.02)	0.17 (3.01)	2.07 (36.33)	7.02
E7415	1998	Orkney	1.21	1.41 (23.51)	0.06 (1.06)	2.46 (40.96)	3.08

5. Organochlorines and mercury in Golden Eagle eggs

5.1 Introduction

The findings from analyses of golden eagle eggs obtained during 1963-86 were given in Newton and Galbraith (1991), and from 1987-97 in previous reports in this series. Eggs from seven clutches were received in 1998, and the results are given in Table 7. There were no eggs from coastal areas.

5.2 Results

The analyses for the seven 1998 eggs served to confirm the low levels of contamination found in recent years in golden eagle eggs from inland areas. 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 7. Residue levels (organochlorine ppm wet weight (lipid weight); mercury ppm dry weight) and shell indices (SI) for Golden Eagle eggs received in 1998.

ND=none detected.

Number	Year	County	SI	pp'-DDE	HEOD	PCB	Hg
SOUTHERN SCOTLAND							
E7491	1998	Borders	2.88	ND	0.03 (0.79)	1.30 (37.55)	ND
CENTRAL AND EASTERN HIGHLANDS							
E7374	1998	Highland	3.19	0.01 (0.19)	ND	0.07 (1.72)	0.02
E7375	1998	Highland	3.25	0.05 (1.66)	0.03 (1.07)	0.07 (2.35)	0.06
SOUTHERN HIGHLAND FRINGE							
E7416	1998	Strathclyde	-	0.09 (4.14)	0.02 (0.72)	4.09 (183.44)	ND
E7512	1998	Tayside	-	0.02 (0.43)	0.03 (0.52)	3.60 (67.78)	0.09
E7513	1998	Tayside	-	0.01 (0.02)	0.01 (0.02)	1.70 (3.30)	0.07
E7514	1998	Tayside	-	0.07 (1.48)	0.03 (0.51)	0.56 (11.08)	0.06

6. Organochlorines and mercury in Gannet eggs

6.1 Introduction

The findings from all gannet eggs examined to 1988 were published in Newton *et al.* (1990) and to 1997 in the report for 1998. Results for 29 eggs examined in 1998 are given in Table 8. They include 10 eggs each from colonies at Bass Rock and St Kilda, and nine eggs from Ailsa Craig. For eggs from each colony, mean residues are compared with previous eggs from that colony, both in the short term (comparing with Bass Rock and St Kilda in 1996 (Table 9)), and in the long-term (1971-98) and shorter term (1988-98) in Table 10.

6.2 Results

Low levels of DDE, HEOD, PCBs and mercury were found in all the eggs from the three colonies analysed in 1998. Although low levels were again confirmed, comparison with residues in the previous samples collected from the same colonies show significant increases in PCBs in eggs from St Kilda, and significant in mercury in eggs from Ailsa Craig. There were significant decreases in DDE levels in eggs from Ailsa Craig and in mercury levels in eggs from Bass Rock and St Kilda. There were also non-significant decreases in the shell indices of eggs from Bass Rock and St Kilda (Table 9).

Over the longer term (1971-98), eggs from Ailsa Craig showed significant declines in all residue levels; eggs from Bass Rock showed significant declines in levels of DDE and HEOD, but significant increases in mercury levels; while eggs from St Kilda showed significant declines in DDE and a significant increase in mercury (Table 10). Since the monitoring programme started, mercury has always shown less consistent trends over time (Newton *et al*. 1990).

Over the more recent period (1988-98) eggs from Ailsa Craig have shown significant increases in PCB and mercury residues; eggs from Bass Rock significant declines in HEOD but significant increases in mercury residues; and eggs from St Kilda significant increases in HEOD and PCB residues and significant declines in mercury (Table 10). 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 27 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 8. Residue levels (organochlorine ppm wet weight; mercury ppm dry weight) and shell indices (SI) for Gannet eggs (*Morus bassanus*) received in 1998

Colony	SI	pp'-DDE	HEOD	PCB	Hg
Ailsa Craig	2.96	0.082	0.034	1.916	2.09
	3.11	0.041	0.037	2.038	2.14
	3.05	0.046	0.290	2.572	3.04
	3.07	0.046	0.038	2.087	1.27
	3.04	0.046	0.039	2.031	1.23
	2.89	0.046	0.039	1.712	1.85
	2.59	0.053	0.038	2.326	1.82
	2.81	0.030	0.036	1.802	2.27
	3.01	0.033	0.028	1.625	2.14
Mean	2.95	0.05	0.05	1.99	1.92
SD	0.17	0.12	0.31	0.06	0.12
Range within 1 SE		0.04-0.05	0.04-0.06	1.91-2.09	1.74-2.09
Bass Rock	2.98	0.041	0.036	1.613	1.47
	3.01	-	-	-	-
	3.10	0.179	0.082	13.070	1.51
	2.76	0.198	0.121	7.987	1.69
	2.55	0.086	0.068	2.821	1.83
	2.91	0.078	0.065	4.968	1.50
	2.52	0.158	0.102	6.477	1.30
	2.91	0.160	0.158	0.197	1.54
	3.37	0.130	0.113	6.346	1.70
	2.72	0.072	0.077	2.602	1.47
Mean	2.88	0.11	0.08	3.33	1.55
SD	0.26	0.23	0.19	0.54	0.04
Range within 1 SE		0.09-0.13	0.07-0.10	2.19-5.01	1.51-1.58
St Kilda	2.97	0.119	0.071	2.427	1.84
	2.87	0.067	0.030	5.762	2.32
	2.65	0.108	0.064	2.018	1.80
	3.02	0.082	0.049	4.324	1.37
	3.02	0.051	0.040	3.597	2.36
	3.23	0.053	0.039	1.739	2.53
	3.18	0.049	0.036	2.457	1.63
	2.97	0.032	0.031	1.780	1.44
	3.14	0.087	0.037	1.125	1.86
	3.03	0.670	0.047	2.691	1.52
Mean	3.01	0.08	0.04	2.51	1.83
SD	0.17	0.36	0.12	0.21	0.09
Range within 1 SE		0.06-0.11	0.04-0.05	2.14-2.95	1.70-1.95

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

Table 9. Comparison of shell index and geometric mean residue levels from Gannet eggs collected from Ailsa Craig in 1997 and 1998; and Bass Rock and St Kilda in 1996 and 1998

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

	Ailsa Craig	**Bass Rock**	**St Kilda**
Shell index	t_{17}= +0.130	t_{17}= -0.18	t_{18}= -1.38
pp'-DDE	t_{17}= -2.210*	t_{17}= -1.93	t_{18}= +1.28
HEOD	t_{17}= -2.000	t_{17}= -1.49	t_{18}= -0.14
PCB	t_{17}= +0.340	t_{17}= -0.08	t_{18}= +3.44**
Hg	t_{17}= +2.14*	t_{17}= -5.23***	t_{18}= -7.11***

Table 10. 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 = <0.001; ns = not significant

	1971 - 1998	**1988 - 1998**
Ailsa Craig		
pp'-DDE	-0.0687 ***	0.0392 ns
HEOD	-0.0465 ***	0.0356 ns
PCB	-0.0283 ***	0.1340 ***
Hg	-0.0151 ***	0.0201 **
Bass Rock		
pp'-DDE	-0.0334 ***	0.0061 ns
HEOD	-0.0159 **	-0.0482 ***
PCB	0.0075 ns	0.0046
Hg	0.0075 ***	0.0162 *
St Kilda		
pp'-DDE	-0.338 ***	0.0209 ns
HEOD	-0.0183 ns	0.0911 ***
PCB	0.0140 ns	0.0759 ***
Hg	0.0340 ***	-0.0162 *

7 Organochlorines and mercury in Sea Eagle eggs

7.1 Introduction

So far, the sea eagles *Haliaetus albicilla* introduced to western Scotland in the period 1976-85 have bred with poor success. Most breeding attempts have failed completely. One of the possible problems might be contamination with organochlorine and mercury residues, which the birds could acquire particularly from the marine component of their diet, various fish and seabirds. Some of the nests have been on inaccessible sea-cliffs, and in 1998 only one unhatched egg was obtained for analysis, from a nest on Mull. This made a total of six eggs obtained so far, with no more than one per year.

7.2 Results

The 1998 egg contained low values of DDE, HEOD and mercury (Table 11). The PCB level was quite high but gives no cause for concern.

Table 11. Residue levels (organochlorine ppm net weight (lipid weight); mercury ppm dry weight) and shell indices (SI) for a Sea Eagle (*Haliaeetus albicilla*) egg collected on Mull in 1998

Number	SI	pp'-DDE	HEOD	PCB	Hg
E7420	3.33	0.89 (17.45)	0.03 (0.53)	12.65 (247.93)	0.11

8. Rodenticide residues in Barn Owls

8.1 Introduction

The aim of this work was to screen barn owl *Tyto alba* carcasses for residues of 'second-generation' rodenticides. The carcasses were supplied by members of the public, and included birds which had died from various causes, mainly accidents. The chemicals of interest included difenacoum, bromadiolone, brodifacoum and flocoumafen. The findings from all barn owls analysed in previous years were given in Newton *et al.* (1997), and in previous reports in this series, while those from 54 birds examined in 1998 are given in Table 12.

8.2 Methods

Analysis of rodenticides in liver tissue was carried out by the same methods as in previous reports and described by Newton *et al.* (1991), but using new HPLC and detection equipment (Hewlett Packard LC-MS Series 1100). The new LC system enhanced the chromatography of the analysis, giving improved peak shape and separation and a more stable baseline. Quantification was carried out on the basis of peak areas on the chromatograms instead of the peak height method used previously. Mass spectrometry was not used to assign peak identity.

8.3 Results

This change in analytical equipment was coincident with the occurrence of a high proportion of birds examined in 1998 containing detectable residues of rodenticides. Of 54 birds analysed, 28 (52%) contained detectable residues, the highest proportion in an annual sample ever recorded in the history of barn owl rodenticide analysis at Monks Wood. Six birds (11%) had levels likely to be associated with mortality. It was possible that the improved chromatography associated with the change in analytical equipment may have been at least partly responsible for the increased detection rate for rodenticides in 1998. In particular, the improved peak shape and separation may have increased the certainty of peak identification and improved limits of detection. To determine whether this was likely, the data were examined in three ways:

(a) *The change in the frequency of detected residues in birds between 1990 and 1997 was examined for each rodenticide separately in order to determine which compounds had increased in frequency over this period (Figure 1a).* On this basis, the percentages of birds that contained bromadiolone (16%) and flocoumafen (2%) in the 1998 sample were similar to those in birds from previous years. The proportion of birds that contained difenacoum (33%) was considerably higher than in 1996 and 1997, but was only slightly greater than in 1995. In contrast, there was a marked increase in 1998 in the proportion of birds that contained brodifacoum (24%) compared with earlier years, although this may have continued a trend that started in 1996.

(b) *A stratified random sub-sample of the extracted owl livers were simultaneously re-analysed on the old and new analytical equipment.* Comparisons of the number of detected residues using both sets of analytical equipment were confined to difenacoum and brodifacoum. This was because none of the sub-sample of extracted livers contained flocoumafen and because deterioration of the sample extract between the initial analysis and re-analysis resulted in the bromadiolone peak being obscured, irrespective of the analytical equipment used. Analysis by the LC-MS equipment indicated that 13 of the re-analysed 19 samples contained difenacoum compared with 11 of these on the old HPLC equipment. Equivalent findings for brodifacoum were five on the new equipment and one on the old. There were no false negatives using the new LC-MS and all non-detected values on the new system were also non-detected on the old system.

If this small data set is representative of the differences between detection rates in 1998 and earlier years, resulting from the change in analytical equipment, it would suggest that in the 1998 sample, approximately 1 of the 6 birds that contained difenacoum alone and 5 of the 6 birds that contained brodifacoum alone would not have been detected as contaminated with rodenticide using the old HPLC equipment. Thus, the total number of positive birds would have been approximately 22 (40%) out of 54, instead of the recorded 28 (51%) out of 54. On either measure, the proportion of contaminated owls was greater in 1997-98 than in any previous year. Figure 1b data have been averaged over each pair of years since the programme began and show the increasing trend in contamination since 1983-99

(c) *The frequency distributions of detected residues in the 1998 sample were compared with those for birds examined between 1983 and 1997*. It was hypothesised that any change in the analytical equipment that improved chromatography and reduced baseline noise might improve the limits of detection in the analysis and result in a large proportion of low level residues being detected in the 1998 sample. This could potentially increase the frequency with which rodenticides might be detected. The frequency distributions for residues below 0.1 µg/g of brodifacoum and difenacoum, the two compounds detected frequently in the 1998 sample, were examined for birds analysed in 1998 and compared with the distribution for all owls analysed between 1983 and 1997. It was apparent that there was no increase in the preponderance of low-level residues in the 1998 sample. Thus, it would appear that the increase in detection rates that occurred, most markedly for brodifacoum, was a result of improved certainty in peak identification.

8.4 Conclusions

The implementation of new analytical equipment has resulted in an improvement in detection rates for certain rodenticides in barn owl livers. A detailed cross-validation exercise is needed using the old and new analytical equipment. However, it seems likely that the analysis carried out on birds killed during 1998 gives a truer picture of the actual extent of exposure of barn owls to second generation compounds, and that earlier analyses may have slightly underestimated the proportion of birds that contained residues, especially of brodifacoum. This does not alter the conclusion that the proportions of contaminated birds have risen steadily over the period 1983-98 covered by the survey (Figure 1b).

8.5 References

Newton, I Wyllie, I & Freestone, P (1990) *Rodenticides in British Barn O*wls. Environ. Pollut. **68**, 101-117.

Newton, I Wyllie, I Gray, A & Eadsforth, C V (1994) *The toxicity of the rodenticide flocoumafen to Barn Owls and its elimination via pellets*. Pestic. Sci**. 41**, 187-193.

Newton, I Wyllie, I & Dale, L (1997) *Mortality causes in British Barn Owls* (*Tyto alba*) *based on 1,101 carcasses examined during 1963-1996*. Pp. 299-307 in 'Biology and Conservation of Owls of the Northern Hemisphere'. eds. J.R. Duncan, D H Johnson & T H Nicholls. Second International Symposium, February 5-9, 1997. Winnipeg, Manitoba, Canada, United States Department of Agriculture.

Postscript

During the post mortem examination of Kestrels, one bird had bled in the manner expected of a rodenticide victim. Analysis of its liver revealed 0.014 ppm of difenacoum and 0.082 ppm of bromadiolone. This is the fourth species of predatory bird examined at Monks Wood which may have died of rodenticide poisoning.

Table 12. Levels of rodenticides (ppm in wet weight) in the livers of Barn Owls (*Tyto alba*) received in 1998.

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

Specimen No.	Date	County	Age	Sex	brod	difen	brom	floc
12474	Apr-97	West Sussex	-	-	0.015	ND	ND	ND
12639	Dec-97	Essex	A	M	0.014	0.035	ND	ND
12641	Mar-97	Northumberland	J	F	ND	ND	ND	ND
12642	Nov-97	Northumberland	J	F	ND	ND	ND	ND
12644	Dec-97	Gwynedd	J	M	ND	ND	ND	ND
12645	Jan-98	Lincolnshire	J	M	ND	ND	ND	ND
12646	Jan-98	Bedfordshire	J	F	ND	ND	ND	ND
12648	Jan-98	D & G	J	M	ND	ND	ND	ND
12651	Jan-98	Highland	J	M	ND	ND	ND	ND
12652	Jan-98	Lincolnshire	A	F	0.022	ND	ND	ND
12654	Jan-98	Berkshire	A	M	0.093	ND	0.257	ND
12655	Jan-98	Cambridgeshire	J	M	ND	0.016	ND	ND
12657	Jan-98	Northumberland	J	M	ND	ND	ND	ND
12661	Feb-98	Derbyshire	J	F	ND	ND	ND	ND
12663	Feb-98	Grampian	J	M	ND	ND	ND	ND
12666	Feb-98	Oxfordshire	J	M	0.026	ND	ND	ND
12667	May-97	Oxfordshire	J	F	ND	ND	ND	ND
12671	Feb-98	Norfolk	J	F	0.014	0.038	ND	ND
12673	Feb-98	Essex	J	M	ND	ND	0.037	ND
12680	Feb-98	Essex	J	F	ND	0.015	0.073	ND
12684	Mar-98	Lothian	J	F	ND	0.091	0.024	ND
12685	Feb-98	Cheshire	A	M	ND	ND	ND	ND
12688	Mar-98	Wiltshire	J	M	ND	ND	0.149	ND
12691	Mar-98	Isle of Wight	J	F	ND	ND	ND	ND
12694	Mar-98	Wiltshire	J	M	ND	ND	ND	ND
12696	Mar-98	Yorkshire	J	M	ND	ND	ND	ND
12698	Mar-98	Lincolnshire	A	M	ND	0.027	ND	ND
12714	Apr-98	Dorset	J	F	0.085	0.222	ND	ND
12739	Mar-98	Lothian	J	M	ND	0.026	ND	ND
12746	Jul-98	South Yorkshire	J	F	ND	0.197	0.159	ND
12751	Nov-97	Highland	J	M	ND	ND	ND	ND
12752	Oct-97	Highland	J	F	0.022	ND	ND	ND
12771	Aug-98	Lincolnshire	J	F	ND	0.127	ND	ND

Specimen No.	Date	County	Age	Sex	brod	difen	brom	floc
12778	Jul-98	Dorset	A	M	ND	ND	ND	ND
12789	Aug-98	Lincolnshire	J	M	ND	0.004	ND	ND
12790	Aug-98	Dorset	A	M	ND	ND	ND	ND
12796	Sep-98	Surrey	J	M	ND	ND	ND	ND
12797	Sep-98	Lincolnshire	A	F	0.018	0.079	ND	ND
12800	Sep-98	Wiltshire	J	F	ND	0.018	0.162	ND
12804	Sep-98	Borders	J	M	ND	ND	ND	ND
12805	Sep-98	Cumbria	-	F	0.044	ND	ND	ND
12811	Oct-98	Wiltshire	J	M	0.034	0.048	ND	ND
12812	Oct-98	D & G	J	F	ND	ND	ND	ND
12813	Oct-98	Lothian	J	F	ND	ND	ND	ND
12818	Oct-98	Oxfordshire	J	M	0.079	ND	ND	ND
12820	Oct-98	Clywd	J	F	0.022	0.030	ND	ND
12821	Apr-98	Strathclyde	J	M	ND	ND	ND	0.040
12824	Oct-98	Cheshire	J	M	ND	ND	ND	ND
12829	Oct-98	Essex	J	M	0.023	0.076	ND	ND
12830	Nov-98	North Yorkshire	J	F	ND	0.014	0.032	ND
12835	Nov-98	Essex	J	F	ND	ND	ND	ND
12844	Nov-98	Strathclyde	J	M	ND	ND	ND	ND
12845	Nov-98	Lincolnshire	A	F	ND	0.031	ND	ND
12852	Dec-98	D & G	J	F	0.089	0.040	ND	ND

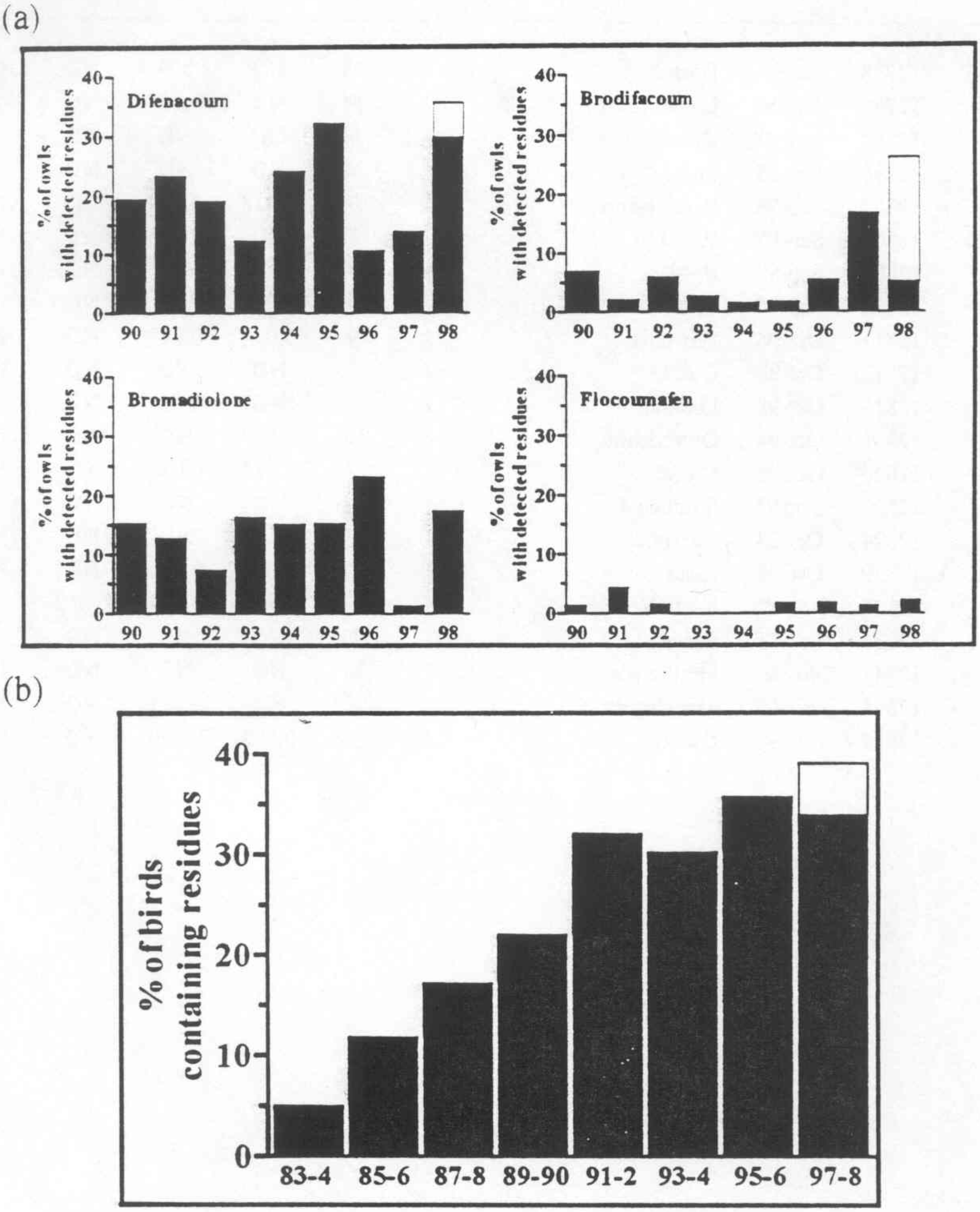

Figure 1. Percentage of barn owls analysed between 1983 and 1998 that contained (a) detectable residues of difenacoum, bromadiolone, brodifacoum and flocoumafen, (b) detectable residues of one or more of these compounds. The numbers of owls analysed each year varied between 46 and 94. Data for 1998 are represented as the estimated proportion of birds that would have been detected as contaminated when analysed by the old HPLC system (filled part of the bar) and the actual proportion of birds that were detected as containing residues when analysed by the new LC-MS system (whole bar).