INSTITUTE OF TERRESTRIAL ECOLOGY
(NATURAL ENVIRONMENT RESEARCH COUNCIL)

NCC/NERC CONTRACT HF3/03/190
ITE PROJECT 181
Annual Report to Nature Conservancy Council

BIRDS OF PREY AND POLLUTION

Part I Monitoring
II Mersey bird mortality
III PCB residues in PCB-dosed puffins

I NEWTON, M P HARRIS, K R BULL, D OSBORN,
A A BELL, M B HAAS & W J EVERY

Monks Wood Experimental Station
Abbots Ripton
Huntingdon
Cambs. PE17 2LS

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1 MONITORING

1.1 Organochlorines and metals in livers

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. During 1980, the livers from 119 birds were analysed, including those from 37 kestrels, 49 sparrowhawks, 9 herons, 8 great-crested grebes, 5 kingfishers and 11 others, although not all were analysed for all residues. The results from these birds are given in Table 1, and for easy comparison in Figures 1-5. Some results from 1980 birds that were given in the previous report are incorporated in the figures, so as to give the complete picture for this year, and some results obtained in 1980 for birds received in earlier years are given in the Table.

As in previous years, there was often considerable variation in pollutant levels between individuals of each species. Nonetheless, the variation in residues between the five main species was significant for DDE, HEOD and Hg, but not for PCBs and Cd (Table 2). Mercury varied more between species than did other pollutants, with the highest levels in herons (Table 1, Figure 4), while HEOD levels seemed higher in the terrestrial predators than in the aquatic ones (Figure 2). With so much variation between individuals, the differences in mean values in particular species between 1980 and 1979 were not statistically significant.

1.2 Pollutants in gannet eggs

In 1980, gannet eggs were obtained from 3 colonies, at Grassholm (south-west Wales), Scare Rocks (Solway), and Hermaness (Shetland) (Table 3). These eggs were analysed for residues of DDE, HEOD, PCBs, mercury and cadmium, which are shown in Figures 6-10, together with results obtained from Ailsa Craig, Bass Rock and St Kilda in 1979. Our attempts to get eggs from these last three colonies in 1980 failed for one reason or another.

Assuming that results from the two years are comparable, significant variation between colonies was found for DDE, HEOD, PCBs and Hg (Table 4). Inspection of the data showed that DDE concentrations were generally higher in the Irish Sea colonies than elsewhere, especially at Ailsa Craig. HEOD levels were also high at Ailsa Craig and at Bass Rock. In general, the variations between colonies were more marked in the pesticide residues than in PCBs, and to a large extent fitted with known regional patterns of pesticide usage. Thus, DDE use in recent years is known to have been heavy in south-west Scotland (near Scare Rocks and Ailsa Craig), as is dieldrin use in Ayrshire (near Ailsa Craig) and East Lothian (near Bass Rock); in addition, dieldrin enters the Clyde Estuary from industrial sources in Glasgow. Dieldrin is the main source of the residue HEOD.

The highest mercury levels were also found in eggs from the north end of the Irish Sea, on Scare Rocks and Ailsa Craig. Cadmium showed a more curious pattern: the limit of detection was 0.2 ppm dry weight, and amounts greater than this were found only at the three colonies examined in 1979: at Ailsa Craig (8 out of 10 eggs), St Kilda (9 out of 10 eggs), and Bass Rock (8 out of 14 eggs). The distribution of mercury among eggs from the different colonies was more or less as expected, because the main source was probably industrial effluent. On the other hand, most of the cadmium was probably natural in origin, and was already known to be present at relatively high levels in some other seabirds on St Kilda (Osborn 1980). It is unlikely that its presence at detectable levels in 1979 eggs, and not in 1980 ones, was due to analytical differences between years.

1.3 Pollutants in guillemot eggs

As about 10 years have elapsed since the previous survey of pollutants in guillemot eggs (Parslow & Jefferies 1975), the situation was re-examined in 1980, when eggs were obtained from five colonies, at Skomer (south-west Wales), Scare Rocks, St Kilda, Fair Isle and Isle of May (Table 5). Only three of these colonies (Skomer, Scare Rocks and St Kilda) had been sampled at the previous survey in 1969-72.

DDE concentrations were mostly less than 2 ppm in wet weight (Figure 11); HEOD levels were mostly less than 0.5 ppm, and none was detected in any of the 10 eggs from St Kilda (Figure 12); PCB concentrations were mainly in the range 1-10 ppm (Figure 13). Significant variation in residue levels between colonies was found only for mercury (Table 6). This seemed higher in the Irish Sea colonies than elsewhere, and, in the sample available, Scare Rocks showed no overlap with the rest (Figure 14). No cadmium was found in any eggs.

In the 3 colonies that had been sampled on both occasions some significant reductions in residues were apparent (Table 7, Figures 11-14). These included DDE and PCBs on Scare Rocks, PCBs on St Kilda, HEOD on Scare Rocks, and mercury in all three colonies. Moreover, the concentrations of most of these pollutants were lower in the other colonies sampled in 1980 than they were in the next nearest colonies sampled in the previous survey. On the other hand, DDE residues had increased significantly in eggs from St Kilda. It is hoped to repeat the exercise for a few more years to gain some idea of the annual variation. Declines in HEOD would be expected from known reductions in the agricultural uses of aldrin and dieldrin; declines in PCBs would be expected from restrictions in industrial use, and declines in mercury from its reduction in industrial effluent. The increase of DDE in eggs from St Kilda may be due to this compound having become more widely dispersed from its sources than at the time of the previous survey. In both surveys, cadmium was below the detectable level in most eggs, but this metal is thought to be mainly natural in origin. It thus served as a useful control on the comparability of the data.

The higher pollutant levels in eggs from Irish Sea colonies both in gannet and in guillemot is presumably due to the enclosed and shallow nature of this sea, and to the fact that much industrial waste and effluent enters it.

1.4 Analysis of kestrel tissues

The main pollutant monitoring scheme at Monks Wood has been based on birds found dead, and sent in by members of the public. From most specimens over the years, only the liver has been analysed and, because such birds were often in a starved condition, the concentrations of pollutants in the liver may have been higher than in healthy birds. It was therefore important to find for healthy birds what relationship the concentration of pollutants in the liver bore to concentrations in other tissues, and how the levels in healthy birds compared with those in birds found dead. As a start, 10 kestrels were trapped at Monks Wood and killed for analysis, 6 in autumn and 4 in spring. Concentrations of organochlorines and metals were then determined separately in the brain, breast muscle, liver, kidney and (where present) body fat from each bird, and correlation coefficients between the concentrations in different tissues were calculated (Table 8). For each pollutant this investigation gave 10 possible cross-correlations.

Organochlorines are fat-soluble, and different tissues in the body contain different amounts of fat. It would be expected, therefore, that concentrations of organochlorines would vary between different tissues in each bird; however, the concentrations of DDE in different tissues were correlated, with coefficients ranging between 0.5 and 0.9 (Table 8). In most cases, the relationships were significant at least at the 5% level, and only one relationship, between body fat and brain, was not statistically significant, although close to 0.5 in value.

In contrast, heavy metals which are generally associated with specific proteins, showed very poor correlations between tissues, with most coefficients less than 0.5. Significant relationships were found for cadmium between kidney and liver ($r = 0.64$; $P < 0.05$), for copper between body fat and brain ($r = -0.85$; $P < 0.02$) and between kidney and muscle ($r = 0.71$; $P < 0.05$), and for zinc between kidney and liver ($r = 0.77$; $P < 0.01$). For mercury, no significant relationships between the concentrations in different tissues were found. It is difficult to know what to make of these results, especially on small samples, and it seems best to wait for further data before attempting any interpretation. Nonetheless, it seems clear that, for mercury, which has received most attention in the past, none of the tissues analysed gave values which could be extrapolated to other tissues, or (by inference) to the body as a whole.

As some of the kestrels were killed in autumn, and others in the following spring, it was possible to compare organochlorine and metal levels at the two seasons (Table 9). Although all birds were caught at Monks Wood, we had no idea how long they had been in the area before capture; almost certainly, the birds caught in spring had not overwintered locally. DDE was the only compound which changed appreciably between seasons, with median concentrations in all tissues higher in spring than in autumn. This increase was especially marked in the case of body fat. With a few exceptions, none of the metals differed appreciably in concentration between tissues of birds caught at the two seasons.

It was also of interest to compare the results from the livers of these kestrels with similar results obtained from kestrels found dead, and sent in by other people (Figures 1, 4 and 5). For DDE, mercury and cadmium, concentrations were generally lower in killed birds than in birds found dead. The same was true for PCBs and HEOD, which were not even detected in any of the killed birds. This implied that birds found dead were not typical of the population at large, in agreement with some previous suggestions (Cooke *et al.* 1979).

1.5 Sparrowhawk survey

The sparrowhawk suffered a marked population decline in the late 1950s, following the widespread introduction of cyclodiene pesticides (aldrin, dieldrin, etc.) in agriculture. Since 1964, in each of several areas, known territories have been checked periodically for details of occupation and breeding success. The aim was to find whether sparrowhawks were recovering in numbers, following successive restrictions in cyclodiene use. Two areas, Cumbria and York, were searched during 1980 and the findings are summarised in Table 10.

In Cumbria, 18 traditional territories were visited and 3 were found to be unsuitable because of total or partial tree-felling. On the 15 remaining, nests with eggs were found in two (c/4; c/5), and single birds were seen in 2 others. One recent old nest was adjacent to the c/4, and very old nests were found in five other territories. On 9 territories, no signs of any kind were found. The poor occupancy may have been due partly to the effects of the hard winter of 1978/79.

In the York area, again, partial or total destruction of some sites, together with changes in ownership or in shooting rights, and consequent difficulty in obtaining permissions, meant that not all the former territories could be checked. Of the 19 potential sites searched, only one showed current evidence of sparrowhawks. Here a nest with 2-3 large young was located; there were fragments of broken eggshells beneath the nest, indicating that at least one egg had been destroyed. This territory was the only one which contained old nests.

Although the York area was formerly one of the least occupied of our study-areas, it was surprising that so little evidence of re-occupation had become apparent since the last survey in 1970, although the 1978/79 winter might have had some effect here too. The whole area is not only intensively cultivated, but it is also heavily keepered, and evidence of shooting-activity was found in almost every territory. Perhaps significantly, the old nests and the current nest were all found in a single wood no longer keepered, but used only as a rough shoot, so the intense regime of game-preservation may be operating against the species' recolonisation of this area.

1.6 Acknowledgments

We are grateful to all the many people who sent us carcasses and eggs for analysis.

1.7 References

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TABLE 1

Residues of organochlorine insecticides (ppm wet weight) and heavy metals (ppm dry weight) in the livers of birds of prey, results reported April 1980-March 1981.

Specimen number	Collection date	pp'-DDE	Dieldrin	PCBs	Hg	Cd
Kestrel						
6714	78	13.5	ND	5.3	1.68	0.78
6045	Jul 79	1.3	ND	2.1	1.76	0.49
5927	Sep 79	-	-	-	0.57	0.31
5928	Sep 79	1.8	ND	3.4	0.62	2.39
5929	Oct 79	1.3	ND	3.9	1.13	ND
5930	Oct 79	2.7	ND	5.9	1.49	1.20
5938	Oct 79	1.2	0.2	2.9	0.31	1.05
5962	Oct 79	2.4	ND	2.5	1.05	2.45
6033	Oct 79	5.8	0.4	4.7	1.30	1.76
6061	Oct 79	1.4	ND	8.4	1.15	0.51
6038	Nov 79	-	-	-	0.55	2.08
6092	Jan 80	1.5	ND	11.8	1.53	1.17
6114	Jan 80	2.0	ND	3.9	2.93	1.65
6093	Feb 80	3.3	ND	4.2	2.00	0.68
6104	Feb 80	2.3	ND	6.0	2.28	3.35
6122	Mar 80	3.1	0.1	4.1	0.90	0.12
6159	Mar 80	10.1	0.3	12.1	1.12	0.66
6160	Mar 80	3.1	0.2	3.7	0.66	0.34
6162	Mar 80	2.0	0.1	23.5	0.66	5.62
6172	Mar 80	29.2	3.6	25.1	0.96	1.04
6169	Apr 80	12.0	0.3	10.8	2.91	3.22
6182	Apr 80	1.0	ND	3.6	0.72	8.89
6197	Apr 80	0.9	ND	1.8	0.62	1.47
6294	Apr 80	7.6	ND	19.2	1.85	2.51
6368	Jun 80	1.7	ND	5.9	1.52	4.33
6381	Jul 80	1.5	0.3	1.1	1.47	0.13
6383	Jul 80	5.7	0.4	24.7	1.24	0.15
6384	Jul 80	2.0	ND	4.0	1.76	0.60
6387	Jul 80	1.4	ND	4.9	2.18	1.42
6401	Aug 80	4.0	ND	7.4	1.84	2.35
6404	Aug 80	2.0	ND	7.1	2.15	1.56
6412	Aug 80	5.1	0.4	24.9	2.96	6.58
6688	?	3.4	2.2	10.4	1.54	2.83
6716	Oct 80	1.5	ND	4.4	10.7	1.41
6719	Oct 80	4.1	0.8	2.0	0.67	0.81
6740	Nov 80	2.1	0.5	4.5	2.50	1.18
6742	Nov 80	0.7	ND	3.9	2.32	0.33

Table 1 (contd)

Specimen number	Collection date	*pp'*-DDE	Dieldrin	PCBs	Hg	Cd
Sparrowhawk						
6100	? 76	-	-	-	0.81	0.45
5968	Apr 78?	-	-	-	4.38	0.84
6071	Apr 78	-	-	-	7.70	0.89
5997	Jul 78	-	-	-	4.38	0.84
5998	Aug 78	1.0	ND	5.7	2.00	ND
5999	Aug 78	0.6	ND	3.1	0.70	0.11
6398	Aug 78	-	-	-	0.98	0.17
6113	Apr 79	29.6	0.8	46.8	0.98	0.81
6448	Jul 79	7.9	ND	10.4	3.69	2.90
6118	Sep 79	7.3	ND	3.8	9.24	2.55
5972	Oct 79	1.9	ND	2.2	1.01	0.48
6293	Dec 79	4.1	ND	8.5	1.32	1.21
6380	Jan 80	5.2	ND	2.2	2.75	0.37
6449	Jan 80	3.3	ND	20.5	1.47	0.84
6091	Feb 80	2.0	0.1	2.4	3.62	0.53
6108	Mar 80	1.4	ND	4.0	1.00	0.78
6110	Mar 80	10.6	0.3	23.6	1.58	0.97
6111	Mar 80	1.7	ND	2.3	2.40	1.61
6112	Mar 80	9.1	0.5	26.0	5.62	1.59
6117	Mar 80	19.8	0.8	36.0	5.52	1.29
6158	Mar 80	3.3	0.1	6.6	1.56	0.36
6168	Apr 80	2.3	ND	3.4	4.18	0.68
6170	Apr 80	2.2	ND	0.8	2.54	2.04
6199	Apr 80	3.9	ND	4.4	3.52	1.14
6201	Apr 80	18.6	ND	31.8	11.0	2.13
6295	Jun 80	4.2	ND	5.3	2.34	0.54
6378	Jun 80	5.7	0.2	3.9	11.0	1.44
6379	Jun 80	6.2	ND	10.7	6.00	2.23
6382	Jul 80	2.8	ND	2.1	1.24	0.51
6386	Jul 80	12.3	2.5	35.6	4.32	2.11
6402	Aug 80	1.6	ND	6.7	1.49	1.17
6403	Aug 80	1.5	ND	6.6	5.79	2.20
6406	Aug 80	1.7	ND	6.2	1.43	0.72
6407	Aug 80	7.7	ND	24.9	4.76	2.52
6408	Aug 80	2.4	ND	4.2	1.30	ND
6450	Sep 80	4.3	ND	14.2	4.98	0.42
6621	Sep 80	2.0	ND	5.5	3.03	0.77
6622	Sep 80	0.6	ND	2.9	1.30	1.76
6624	Sep 80	1.3	ND	6.1	3.27	1.73
6684	Sep 80	-	-	-	3.46	0.83
6687	?	2.3	ND	2.6	2.50	0.33
6715	Oct 80	1.2	ND	0.7	1.30	0.43
6717	Oct 80	2.8	ND	0.1	1.19	0.46
6718	Nov 80	5.8	ND	3.3	3.19	0.77
6732	Nov 80	1.1	ND	0.1	1.24	0.30
6733	Nov 80	6.0	ND	0.3	4.73	0.96
6736	Nov 80	-	-	-	2.02	ND
6737	Nov 80	14.1	ND	5.1	2.47	1.01
6739	Nov 80	1.2	ND	1.6	0.80	0.06
Merlin						
6743	Nov 80	5.4	ND	6.7	2.60	0.24

TABLE 1 (contd)

Specimen number	Collection date	*pp'*-DDE	Dieldrin	PCBs	Hg	Cd
Peregrine						
6101	Dec 79	19.5	0.3	18.8	1.32	0.38
6102	Feb 80	11.5	0.2	10.1	1.12	0.67
6119	Feb 80	7.7	0.1	21.4	0.32	0.23
6312	May 80	6.2	ND	8.3	1.97	0.29
6319	May 80	5.7	ND	25.2	1.96	1.12
6686	Sep 80	6.8	3.0	42.1	11.4	ND
Long-eared owl						
6070	Feb 80	2.6	ND	2.9	1.03	0.36
6171	Apr 80	22.4	1.0	40.2	8.38	1.75
6194	Apr 80	3.2	ND	3.1	0.62	1.08
6196	Apr 80	20.5	1.8	33.7	3.54	3.45
Heron						
5926	Sep 79	-	-	-	7.61	0.07
6073	Sep 79	-	-	-	6.14	0.42
6116	Feb 80	11.6	0.1	33.7	65.1	0.57
6109	Mar 80	0.8	ND	2.9	9.35	1.88
6115	Mar 80	0.5	ND	3.7	15.7	1.98
6311	Jun 80	0.7	ND	2.4	3.38	0.76
6385	Jul 80	1.3	ND	7.6	3.91	1.28
6395	Aug 80	1.1	ND	5.4	10.4	1.95
6400	Aug 80	10.3	2.0	39.0	49.6	2.09
Great crested grebe						
6107	Aug 79	-	-	-	18.9	0.33
6163	Feb 80	2.9	ND	3.7	2.40	0.33
6164	Feb 80	0.3	ND	3.1	4.71	0.54
6165	Feb 80	0.5	ND	3.7	2.07	0.47
6166	Feb 80	0.6	ND	1.9	4.44	0.91
6167	Feb 80	0.2	ND	2.2	2.58	0.45
6388	Jul 80	16.2	2.2	162	26.4	0.90
6399	Jul 80	1.4	ND	2.4	26.0	2.17
Kingfisher						
6120	Mar 80	2.2	ND	1.5	5.01	0.60
6121	Mar 80	6.0	0.2	1.1	2.90	0.63
6410	Jul 80	2.6	ND	3.6	6.03	0.58
6633	Sep 80	12.8	ND	11.5	0.66	5.58
6741	Nov 80	4.1	ND	5.7	0.66	0.26

TABLE 2

Analyses of variance on residues in livers of five species

	Source	d.f.	Sum of squares	Mean square	F-ratio	Significance of variation between species
DDE	within species	4	2.0355	0.5089	2.6214	$P < 0.05$
	between species	82	15.9178	0.1941		
HEOD	within species	4	18.2722	4.5681	2.9202	$P < 0.025$
	between species	82	128.2710	1.5643		
PCBs	within species	4	0.5618	0.1404	0.3690	NS
	between species	82	31.2058	0.3806		
Hg	within species	4	5.4031	1.3508	11.7857	$P < 0.001$
	between species	75	8.5958	0.1146		
Cd	within species	4	1.1800	0.2950	1.1722	NS
	between species	75	18.8748	0.2517		

Note: Zero values for DDE and HEOD taken as 0.001 ppm, for PCBs, Hg and Cd as 0.01 ppm. Analyses on $\log_{10}$ values.

TABLE 3

Residues of organochlorine insecticides (ppm wet weight) and heavy metals (ppm dry weight) in the eggs of gannets.

Specimen number	*pp'*-DDE	Dieldrin	PCBs	Hg	Cd
Grassholm					
6183	0.59	ND	2.35	0.94	ND
6184	0.69	ND	3.49	1.27	ND
6185	0.68	ND	1.81	1.82	ND
6186	0.50	ND	2.74	1.32	ND
6187	0.77	0.05	1.76	1.55	ND
6188	0.31	ND	0.77	0.98	ND
6189	0.92	ND	2.81	2.32	ND
6190	0.36	ND	0.69	1.11	ND
6191	1.12	ND	2.98	2.34	ND
6192	0.40	ND	1.16	1.51	ND
Scare Rocks					
6225	0.66	ND	2.00	3.52	ND
6226	0.54	ND	1.02	4.19	ND
6227	1.39	ND	4.77	4.17	ND
6228	0.59	ND	1.14	4.33	ND
6229	0.66	ND	1.47	5.01	ND
6230	0.98	ND	3.03	4.26	ND
6231	0.68	ND	1.57	4.52	ND
6232	1.26	0.10	5.26	3.92	ND
6233	0.68	ND	4.00	4.49	ND
6234	0.94	ND	2.93	2.37	ND
Hermaness					
6348	1.11	ND	3.31	2.48	ND
6349	0.40	ND	0.63	1.10	ND
6350	0.16	ND	0.49	1.32	ND
6351	0.18	ND	0.52	1.61	ND
6352	0.47	ND	1.16	1.43	ND
6353	0.36	ND	1.75	0.41	ND
6354	0.46	ND	1.86	0.33	ND
6355	0.89	ND	3.63	1.04	ND

TABLE 4

Analyses of variance on residues in gannet eggs.

	Source	d.f.	Sum of squares	Mean square	F-ratio	Significance of variation between species
DDE	within colonies	5	3.3611	0.6722	13.6731	$P < 0.001$
	between colonies	56	2.7531	0.0492		
HEOD	within colonies	5	36.6045	7.3209	14.1948	$P < 0.001$
	between colonies	56	28.8817	0.5157		
PCBs	within colonies	5	4.3543	0.8709	3.9059	$P < 0.005$
	between colonies	56	12.4857	0.2230		
Hg	within colonies	5	2.2546	0.4509	11.9125	$P < 0.001$
	between colonies	56	2.1198	0.0379		

Note: Zero values for DDE and HEOD taken as 0.001 ppm, for PCBs and Hg as 0.01 ppm. Analyses on $\log_{10}$ values.

TABLE 5

Residues of organochlorine insecticides (ppm wet weight) and heavy metals (ppm dry weight) in the eggs of guillemots.

Specimen number	*pp'*-DDE	Dieldrin	PCBs	Hg	Cd
Skomer					
6296	1.38	ND	5.13	0.20	ND
6297	0.85	ND	2.09	1.30	ND
6298	0.21	ND	5.98	1.13	ND
6299	1.17	ND	4.04	1.45	ND
6300	1.42	0.59	5.30	1.19	ND
6301	1.08	ND	3.44	1.12	ND
6302	-	-	-	1.31	ND
6303	1.10	0.09	4.72	1.55	ND
6304	0.87	ND	ND	1.11	ND
6305	2.54	0.37	9.76	1.20	ND
Scare Rocks					
6244	1.66	ND	9.56	3.99	ND
6245	0.88	ND	4.64	3.07	ND
6246	1.18	ND	3.43	2.84	ND
6247	1.13	0.09	5.65	1.99	ND
6248	1.37	ND	5.64	3.06	ND
6249	1.08	ND	2.93	2.53	ND
6250	1.35	0.06	5.96	2.27	ND
6251	1.14	ND	4.09	3.11	ND
6252	1.09	ND	4.57	2.96	ND
6253	1.70	ND	14.52	4.33	ND
St Kilda					
6654	1.65	ND	2.53	0.63	ND
6655	3.35	ND	4.63	0.86	ND
6656	0.48	ND	0.97	0.84	ND
6657	0.51	ND	1.55	0.77	ND
6658	1.47	ND	2.96	0.60	ND
6659	1.42	ND	0.16	0.65	ND
6660	1.38	ND	1.12	0.84	ND
6661	0.55	ND	1.92	0.68	ND
6662	0.73	ND	3.08	1.58	ND
6663	0.59	ND	1.20	0.51	ND
Fair Isle					
6273	1.87	0.04	5.21	0.53	ND
6274	0.63	ND	0.75	0.66	ND
6275	1.50	ND	6.03	0.72	ND
6276	2.52	0.05	7.44	1.92	ND
6277	0.77	ND	3.28	0.45	ND
6278	0.80	ND	1.33	0.42	ND
6279	1.19	ND	1.71	0.42	ND
6280	1.61	0.04	3.42	0.32	ND
6281	0.78	ND	1.40	0.45	ND

Table 5 (contd).

Specimen number	*pp'*-DDE	Dieldrin	PCBs	Hg	Cd
Isle of May					
6213	0.72	ND	1.41	0.37	ND
6214	1.00	0.05	1.71	0.43	ND
6215	0.69	ND	1.56	0.27	ND
6216	0.93	ND	3.92	0.22	ND
6217	0.91	ND	3.29	0.22	ND
6218	0.70	0.07	3.14	0.45	ND
6219	0.62	ND	1.62	0.78	ND
6220	0.76	ND	2.77	0.23	ND
6221	0.71	ND	2.99	0.76	ND
6222	0.83	ND	1.76	0.59	ND

TABLE 6

Analyses of variance on residues in guillemot eggs.

	Source	d.f.	Sum of squares	Mean square	F-ratio	Significance of variation between species
DDE	within colonies	4	0.2400	0.0600	1.3873	NS
	between colonies	43	1.8594	0.0432		
HEOD	within colonies	4	3.3307	0.8328	1.2718	NS
	between colonies	43	28.1533	0.6547		
PCBs	within colonies	4	1.6267	0.4067	1.8137	NS
	between colonies	43	9.6417	0.2242		
Hg	within colonies	4	4.4554	1.1139	29.3318	$P < 0.001$
	between colonies	44	1.6709	0.0380		

Note: Zero values for DDE and HEOD taken as 0.001 ppm, for PCBs and Hg as 0.01 ppm. Analyses on $\log_{10}$ values.

TABLE 7

Significance of differences in residues in guillemot eggs in 1969-72 and in 1980.

	Skomer	Scare Rocks	St Kilda
DDE	t_{16} = 2.0703 NS	t_{23} = 2.3547 $P < 0.05$	t_{12} = 2.2529 $P < 0.05$
HEOD	t_{16} = -1.6105 NS	t_{13} = -5.6393 $P < 0.001$	t_{26} = 1.6857 NS
PCBs	t_{9} = -1.8016 NS	t_{25} = 3.2773 $P < 0.01$	t_{23} = -2.5271 NS
Hg	t_{12} = -7.0472 $P < 0.001$	t_{17} = 6.4037 $P < 0.001$	t_{22} = 3.7851 $P < 0.01$

Note: Degrees of freedom were calculated using the formula given in Bailey (1959) for the comparison of means of two samples where the variances were unequal.

TABLE 8

Coefficients of linear correlation between concentrations of pollutants in different tissues of ten kestrels.
**, P < 0.05; **, P < 0.01; ***, P < 0.001; ns - not significant.*

	Cd				Cu				Zn				Hg				DDE			
	Muscle	Liver	Kidney	Fat	Muscle	Liver	Kidney	Fat	Muscle	Liver	Kidney	Fat	Muscle	Liver	Kidney	Fat	Muscle	Liver	Kidney	Fat
Brain	-0.02 ns	0.13 ns	0.34 ns	0.03 ns	0.03 ns	0.54 ns	0.39 ns	-0.85 *	-0.32 ns	0.36 ns	0.46 ns	0.43 ns	-0.10 ns	-0.06 ns	-0.13 ns	-0.19 ns	0.67 *	0.69 *	0.65 *	0.46 ns
Muscle		0.16 ns	0.18 ns	-0.30 ns		0.29 ns	0.71 *	-0.08 ns		-0.41 ns	-0.06 ns	-0.16 ns		-0.07 ns	-0,04 ns	-0.58 ns		0.67 *	0.73 *	0.85 *
Liver			0.64 *	-0.04 ns			0.33 ns	-0.35 ns			0.77 **	-0.24 ns			-0.14 ns	-0.16 ns			0.64 *	0.76 **
Kidney				-0.54 ns				-0.54 ns				-0.36 ns				-0.32 ns				0.78 **

TABLE 9

Median concentrations of pollutants in different tissues of ten kestrels: 6 in autumn and 4 in spring.

	Cd		Cu		Zn		Hg		DDE	
	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring
Brain	0.09	0.02	1.53	2.25	8.12	8.38	0.12	0.10	0.66	1.10
Muscle	0.02	0.03	4.12	4.36	10.20	10.00	0.11	0.11	0.99	1.87
Liver	0.06	0.17	2.67	3.35	15.15	16.90	0.22	0.20	1.02	1.54
Kidney	0.85	1.07	1.71	2.45	12.45	13.50	0.26	0.21	0.74	1.88
Fat	0.05	0.03	0.37	-	2.27	4.68	0.20	0.09	6.52	28.40

TABLE 10

Occupancy of sparrowhawk territories, 1980

	North Cumbria	York
Total territories checked	15	19
Number with successful nests	2	1
Number with failed nests	0	0
No new nest, but other signs	2	0
No sign	11	18
Number territories with old nests	6	1
Proportion of territories with old nests	0.40	0.05

Fig. 1. DDE concentrations in livers of various predatory birds in 1980. Geometric mean values (——) are shown. ND - nil determined. Killed birds - O.

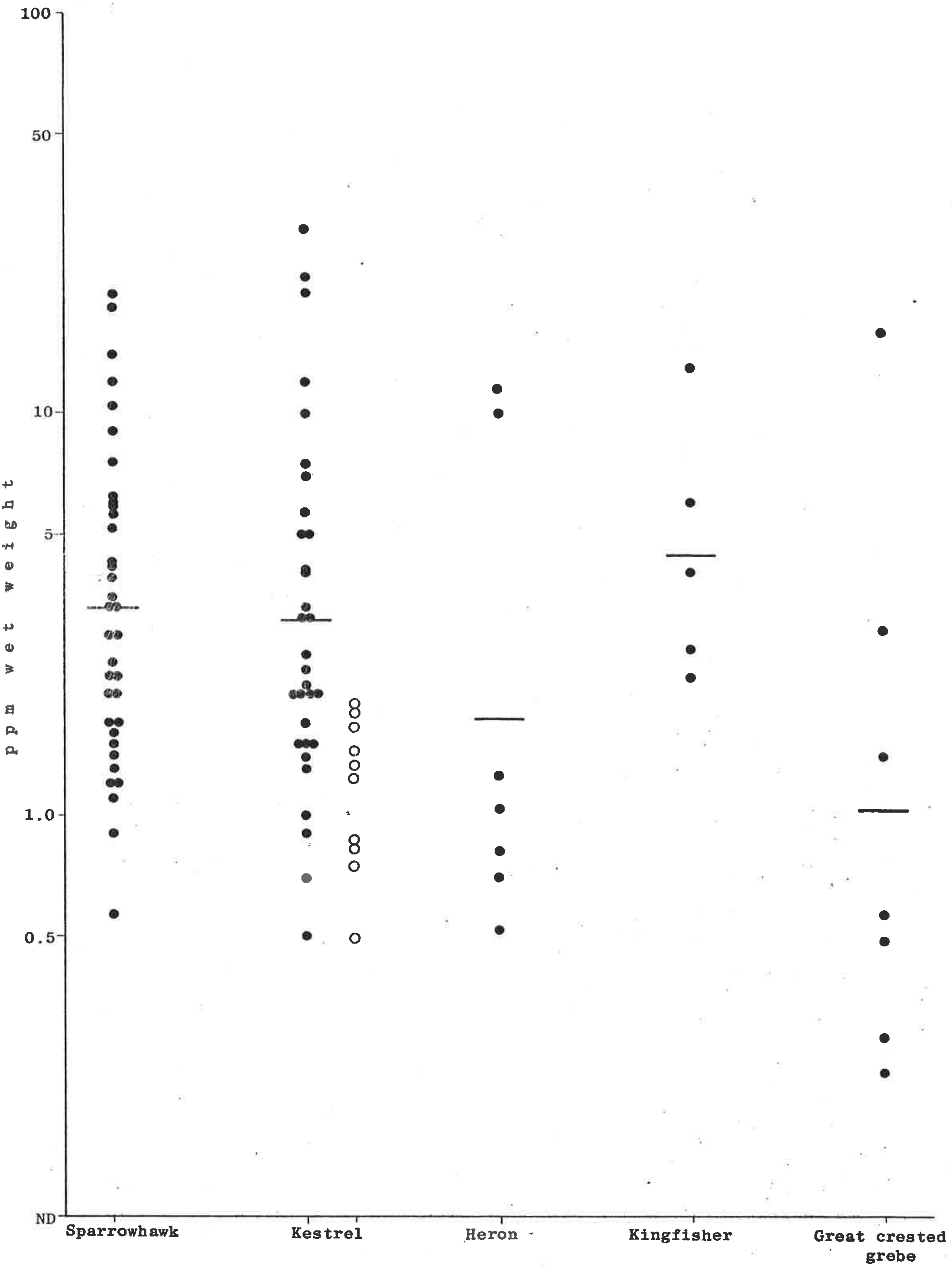


Fig. 2. HEOD concentrations in livers of various predatory birds in 1980. The two categories at the base of the graph refer to trace levels (Tr) and nil levels (ND).

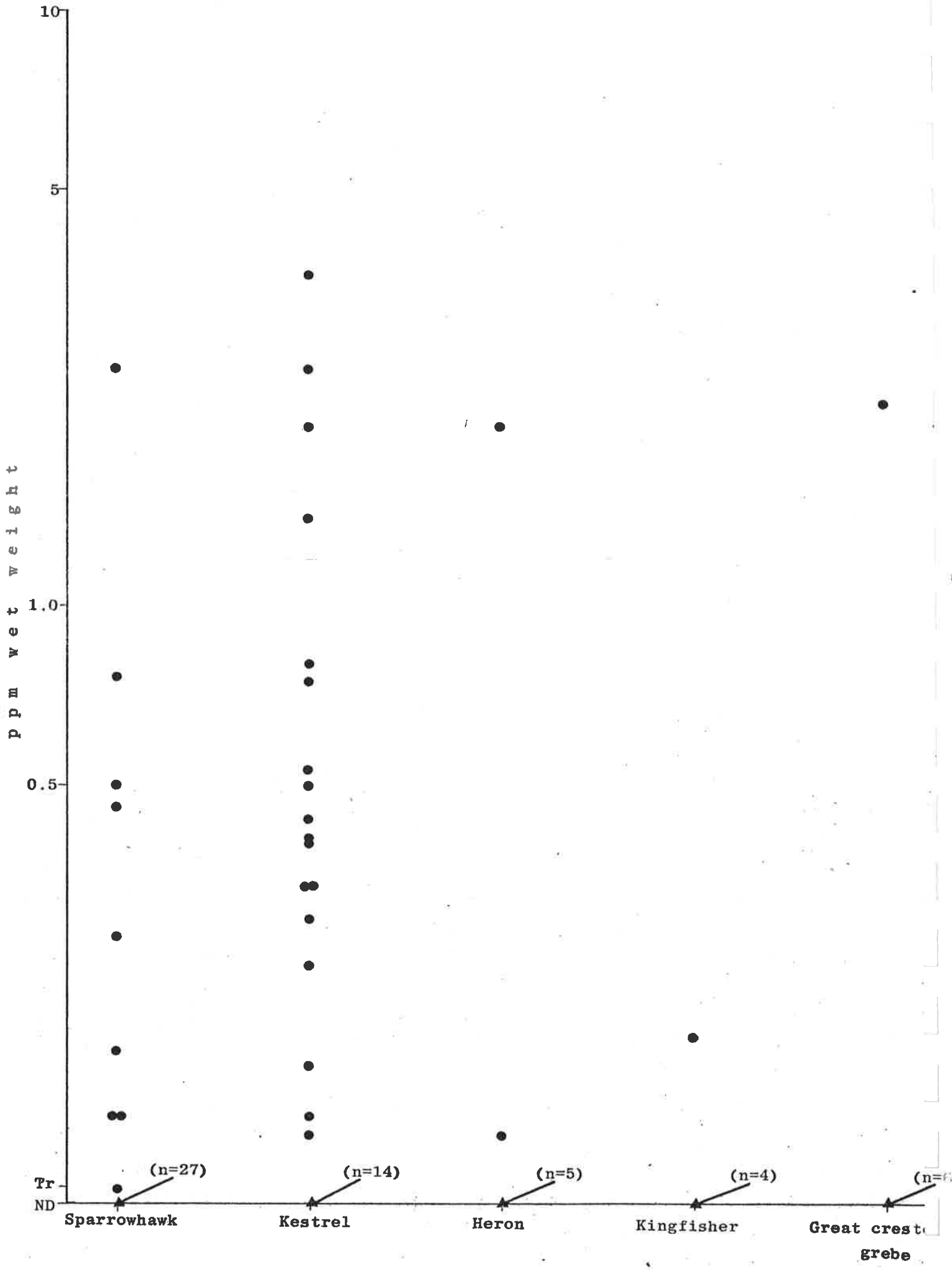


Fig. 3. PCB concentrations in livers of various predatory birds in 1980. Geometric mean values (⟶) are shown. ND - nil determined.

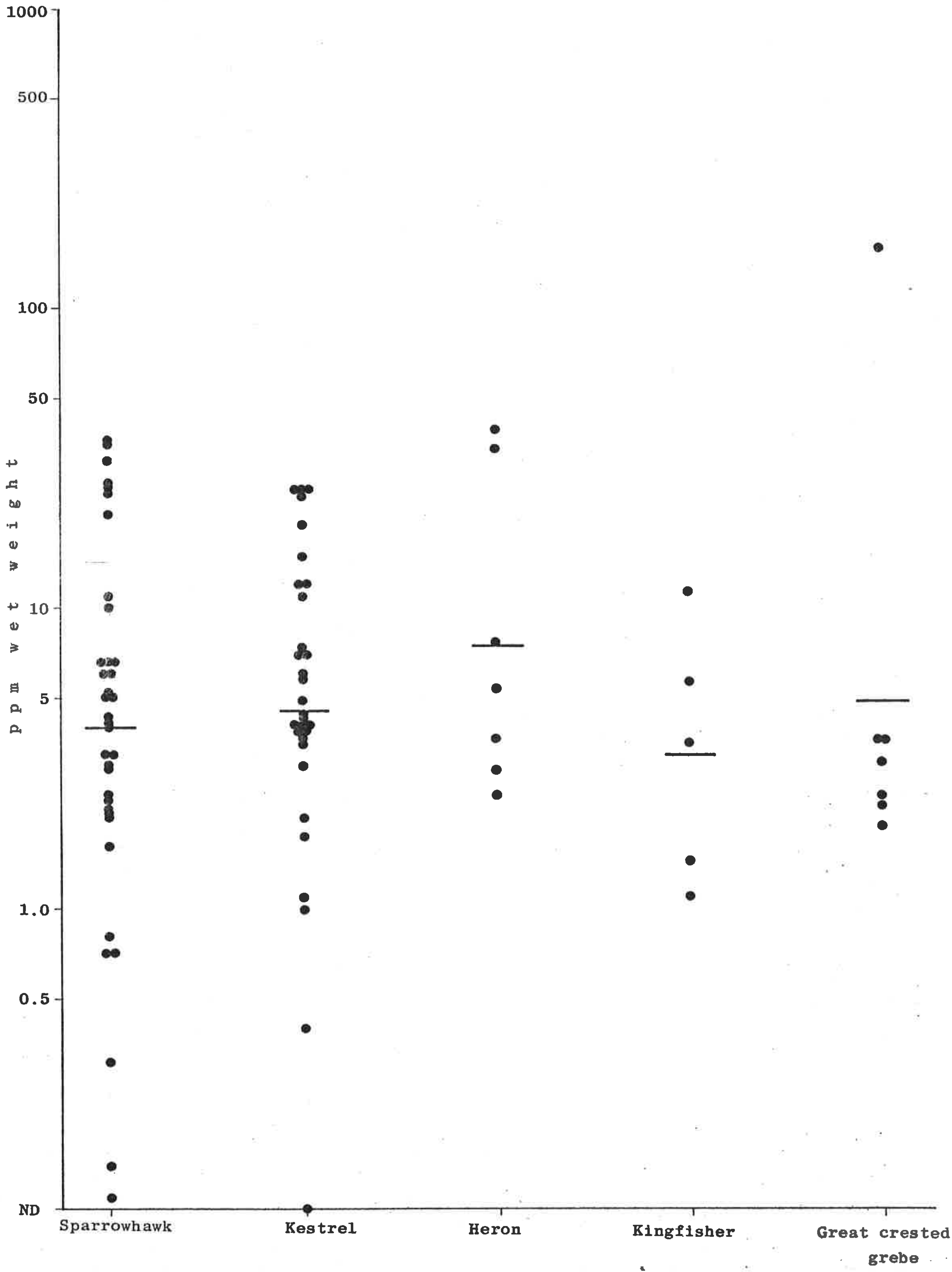


Fig. 4. Mercury concentrations in livers of various predatory birds in 1980. Geometric mean values (——) are shown. Killed birds - O.

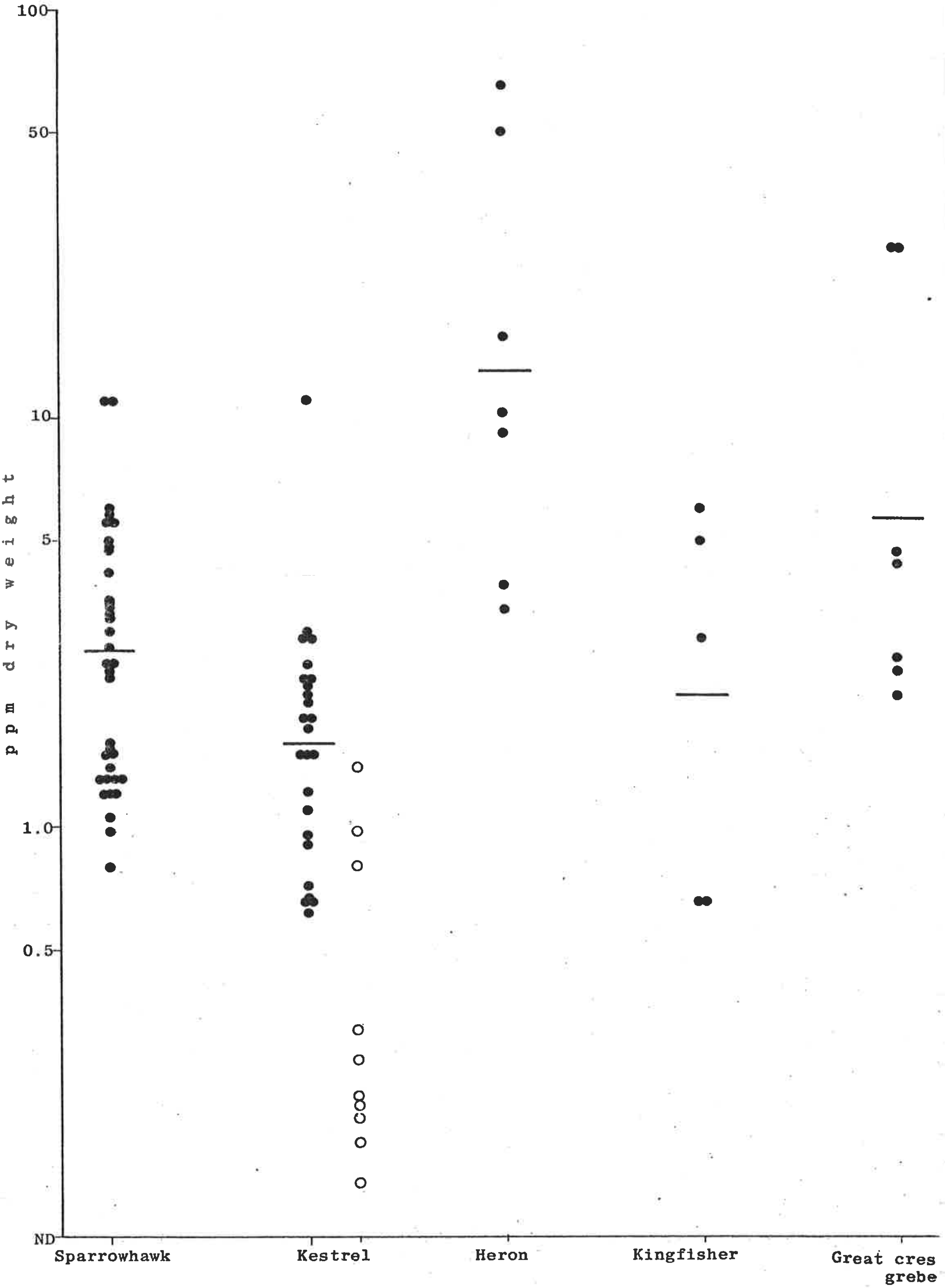


Fig. 5. Cadmium concentrations in livers of various predatory birds in 1980. Geometric mean values (——) are shown. ND - nil determined. Killed birds - O.

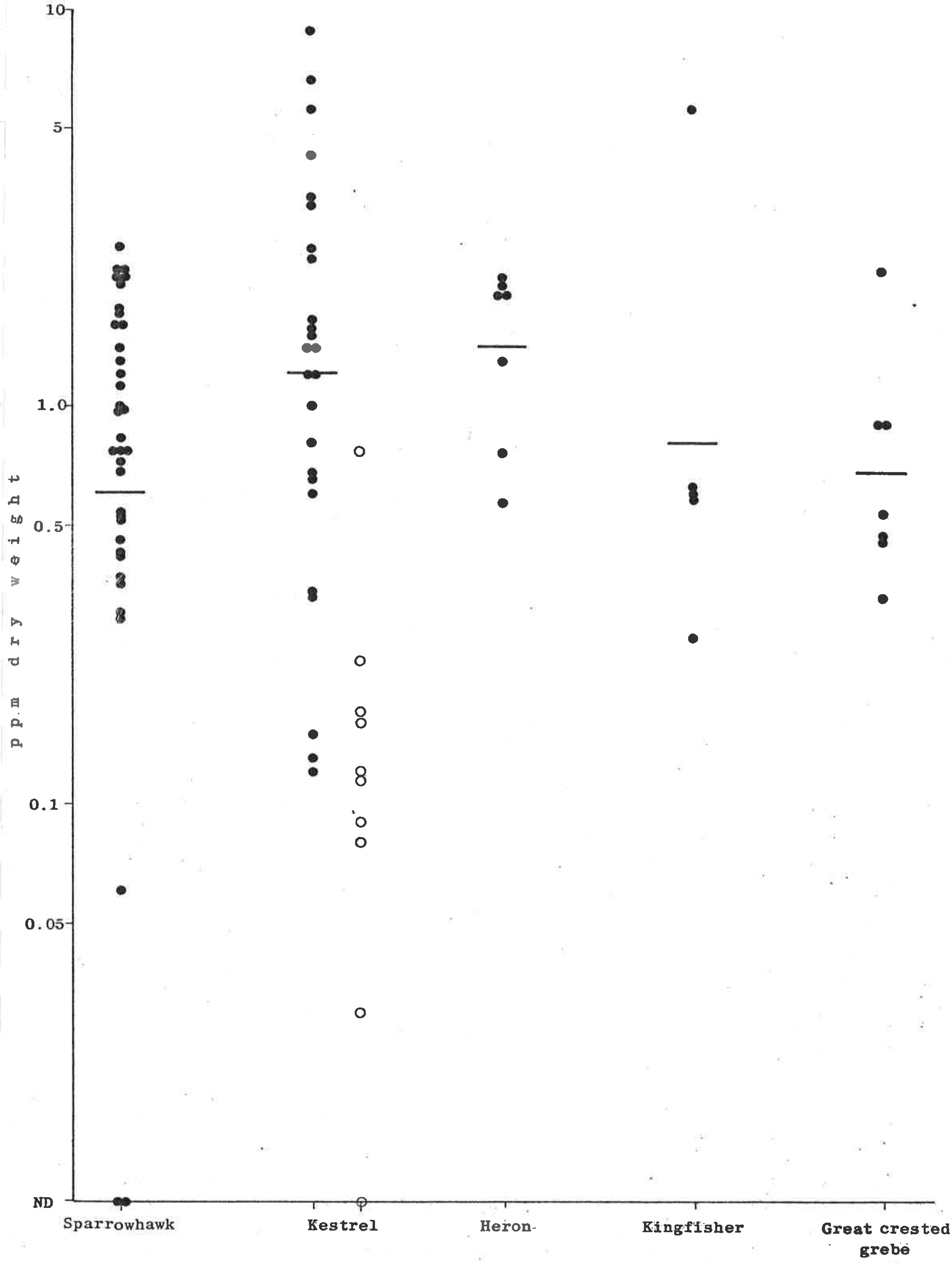


Fig. 6. DDE concentrations in eggs of gannets in 1980 (●) (1979 ○).

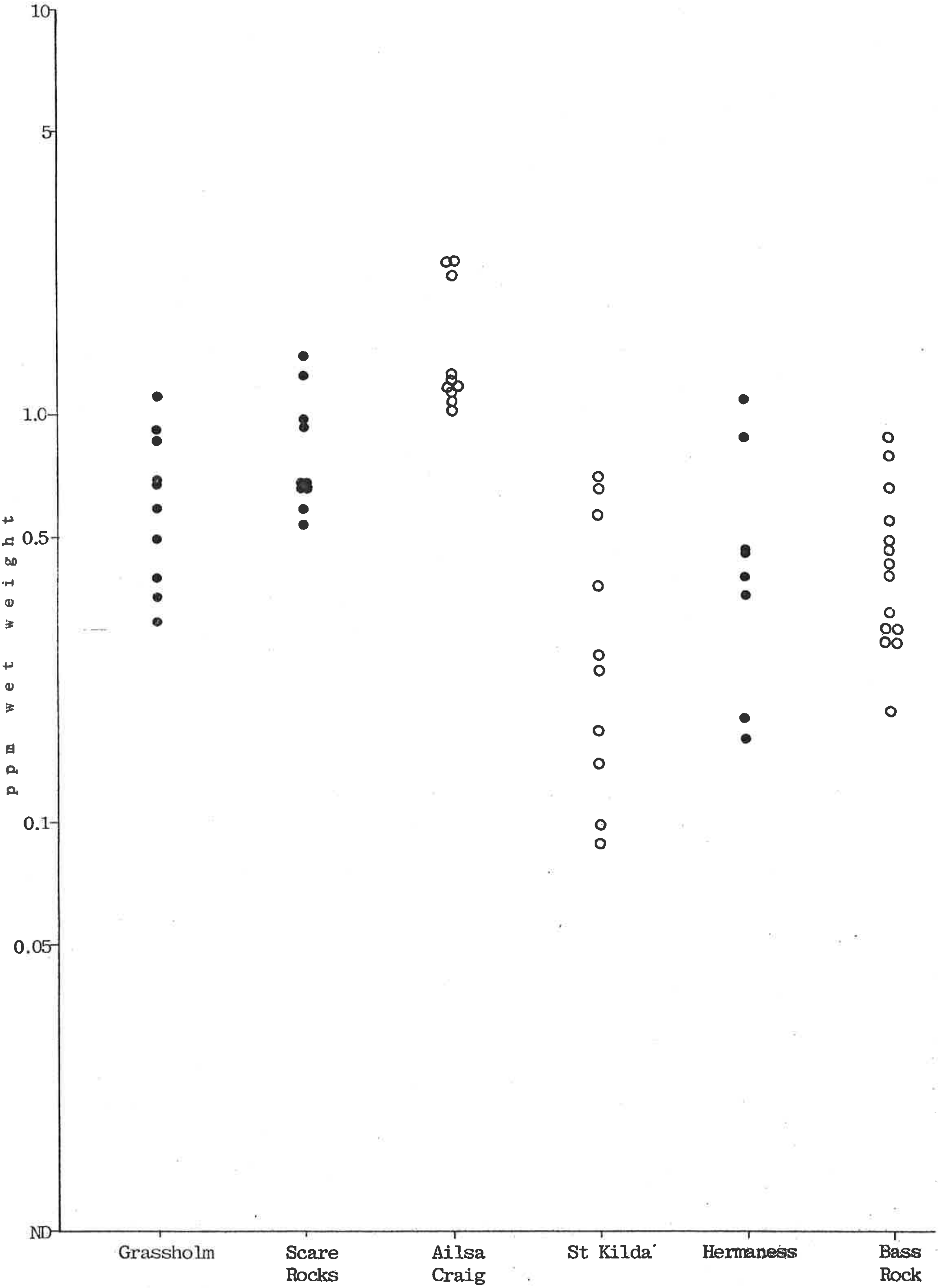


Fig. 7. HEOD concentrations in eggs of gannets in 1980 (●) (1979 ○). The two categories at the base of the graph refer to trace levels (Tr) and nil levels (ND).

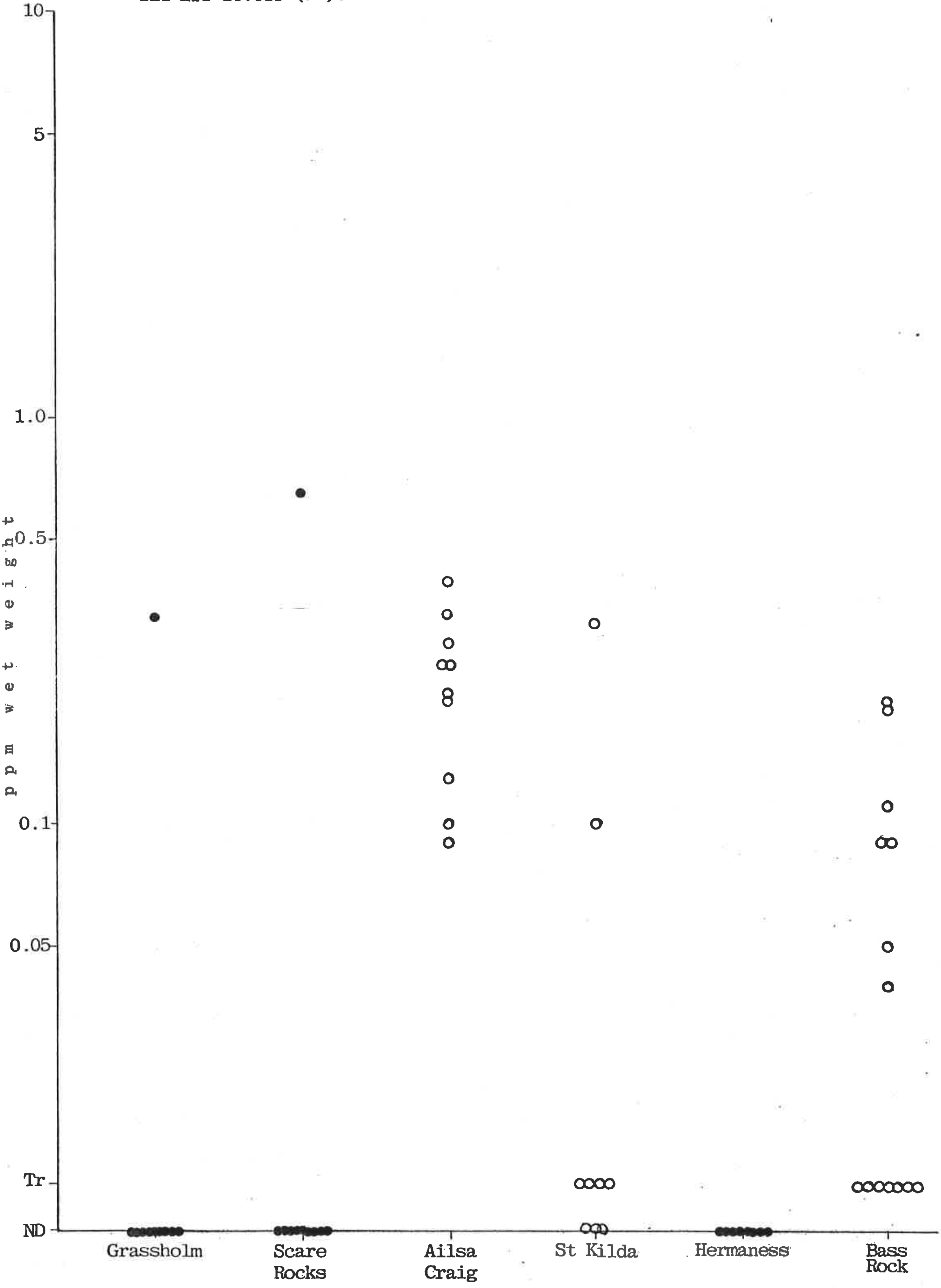


Fig. 8. PCB concentrations in eggs of gannets in 1980 (●) (1979 O).
ND - nil determined.

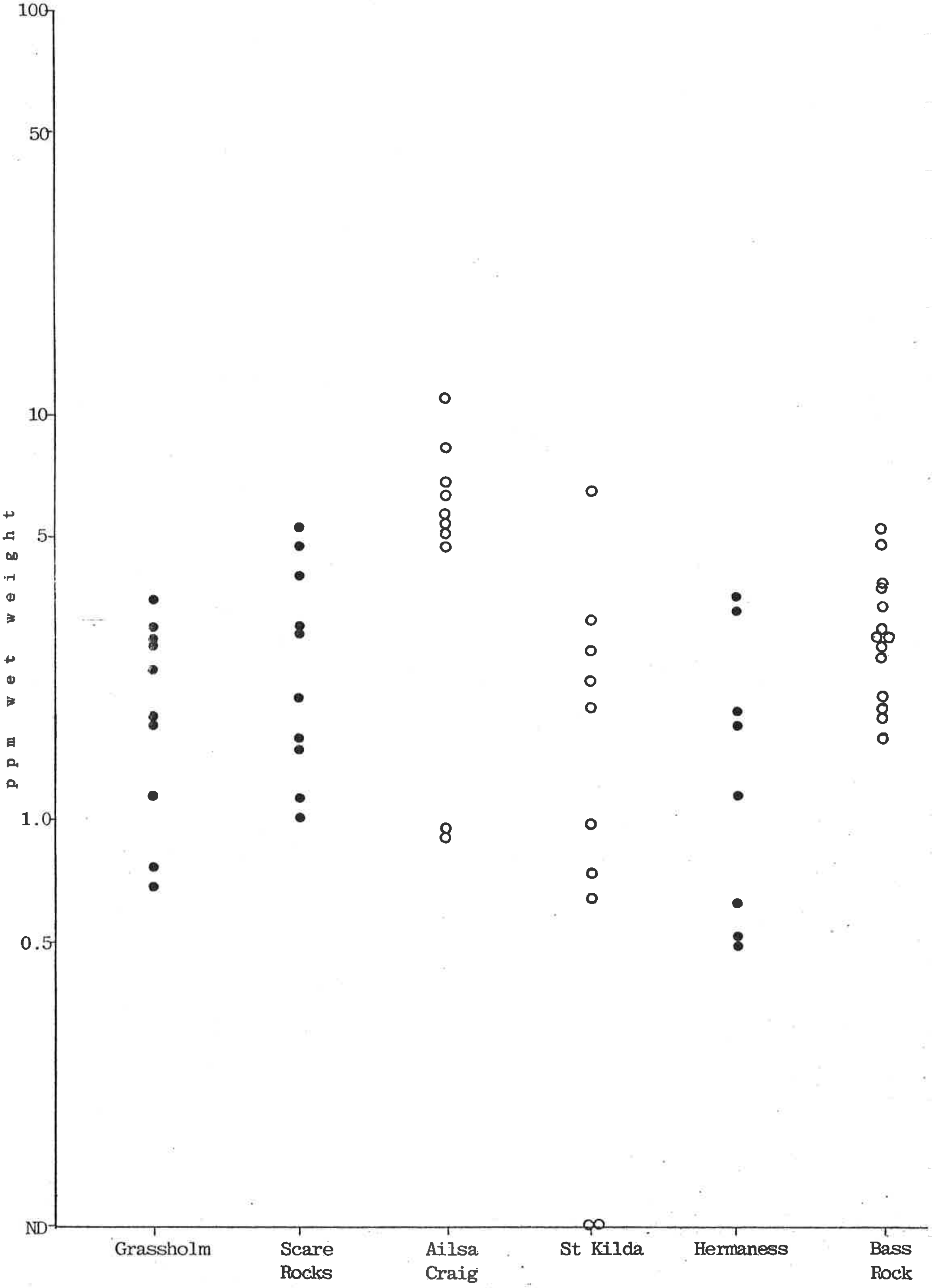


Fig. 9. Mercury concentrations in eggs of gannets in 1980 (●) (1979 ○).

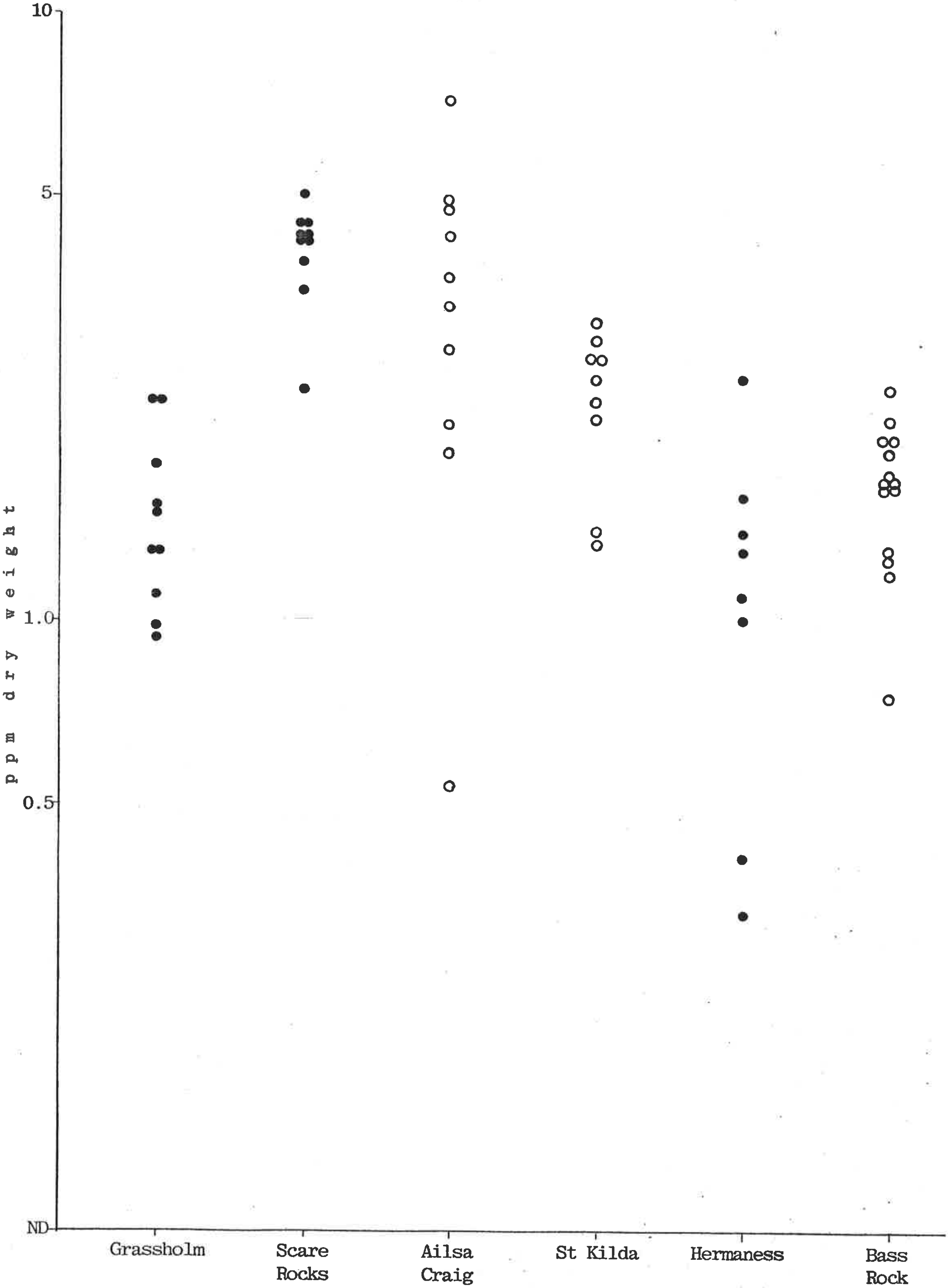


Fig. 10. Cadmium concentrations in eggs of gannets in 1979 (O). The two categories at the base of the graph refer to trace levels (Tr) and nil levels (ND).

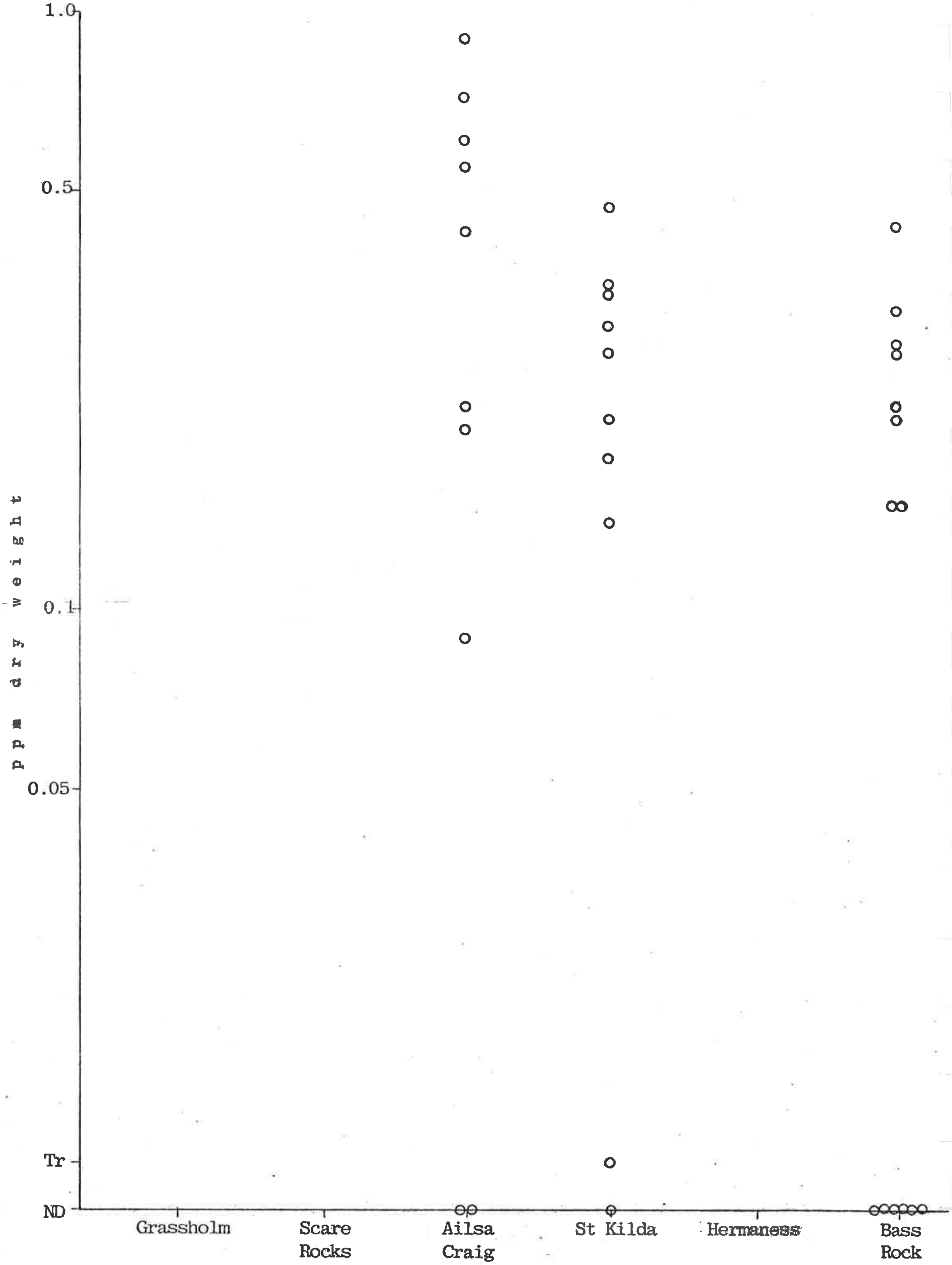


Fig. 11. DDE concentrations in eggs of guillemots in 1980 (●) and in 1969-72 (○).

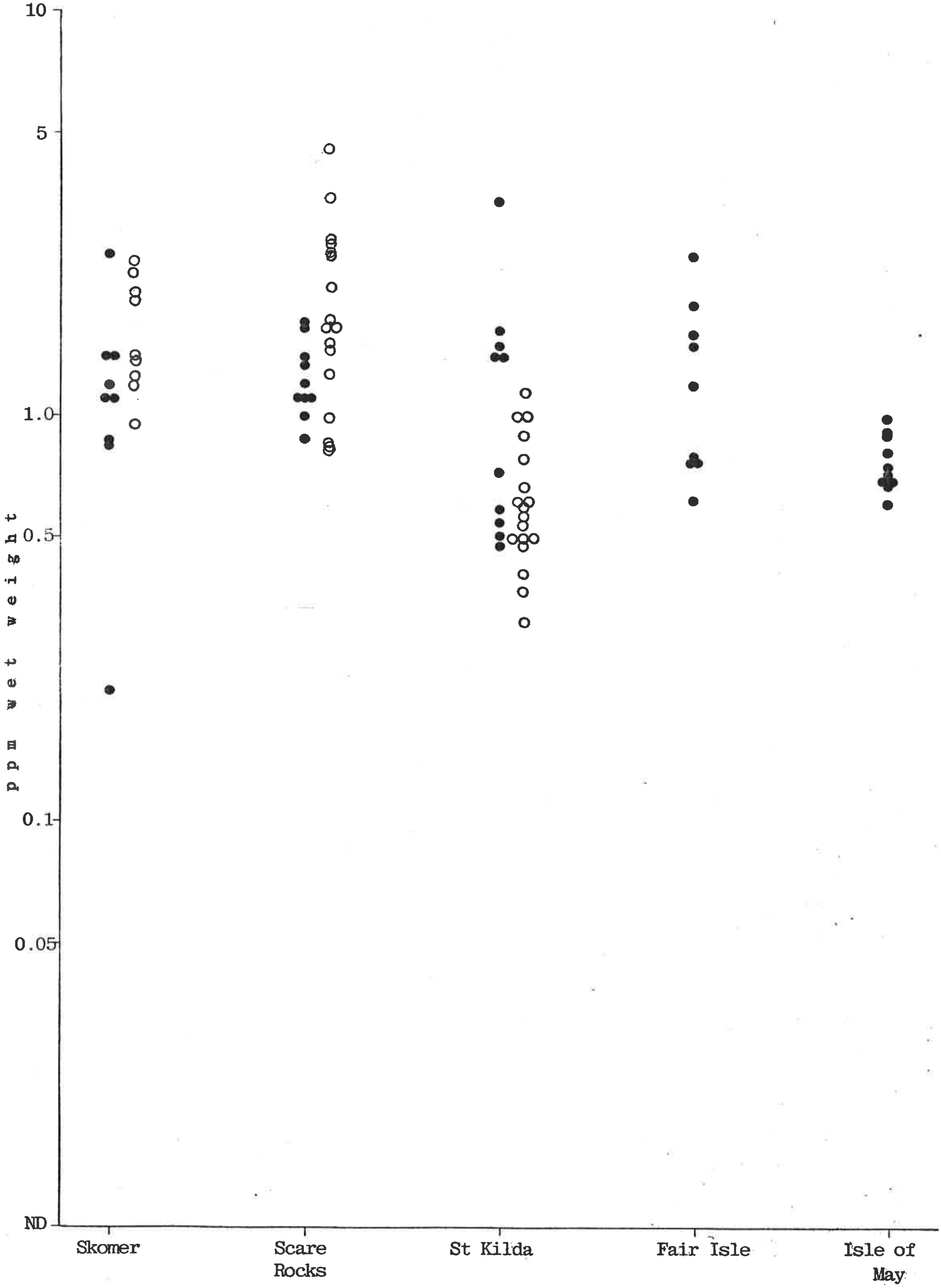


Fig. 12. HEOD concentrations in eggs of guillemots in 1980 (●) and in 1969-72 (○). ND - nil determined.

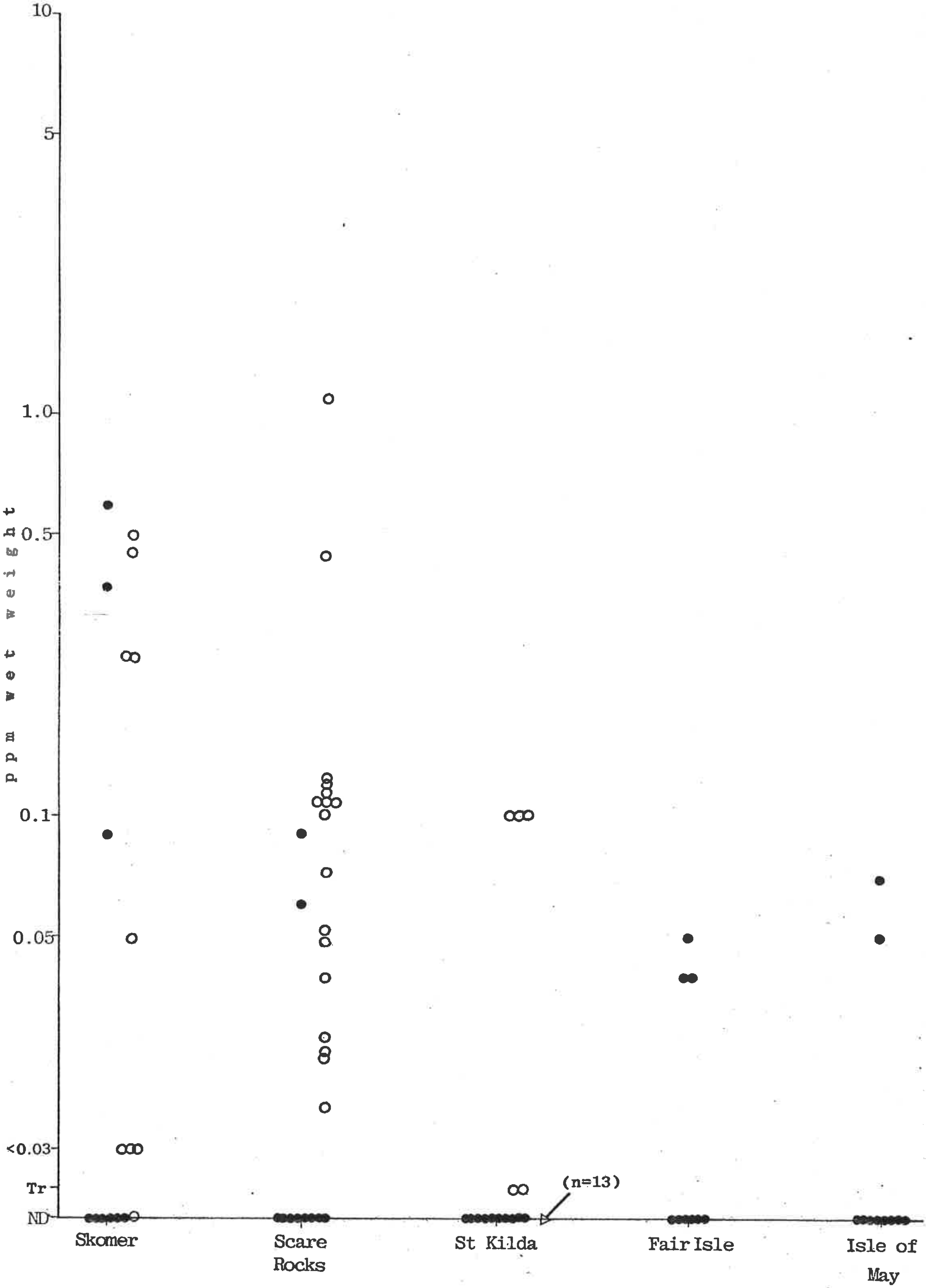


Fig. 13. PCB concentrations in eggs of guillemots in 1980 (●) and in 1969-72 (○).

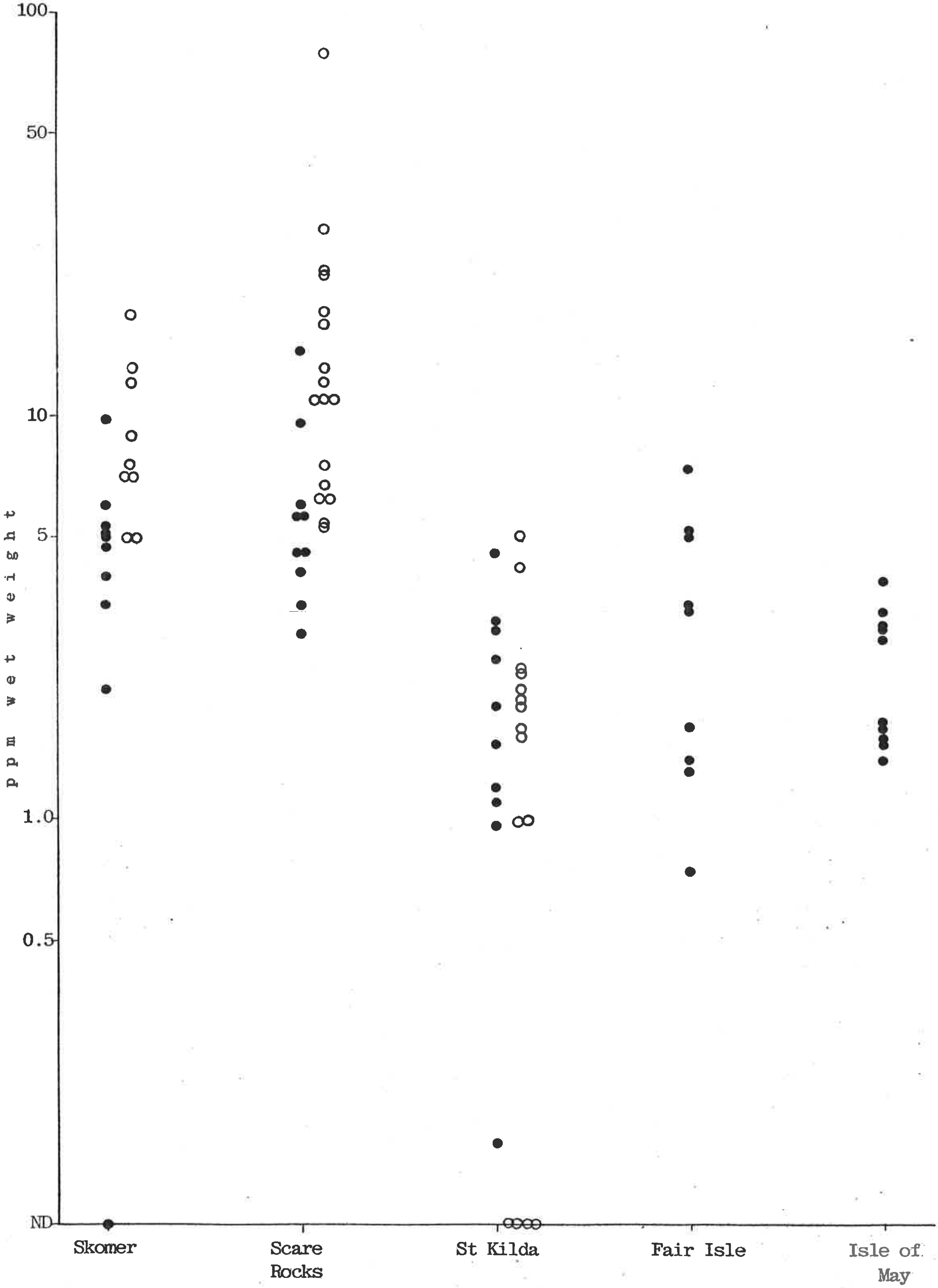
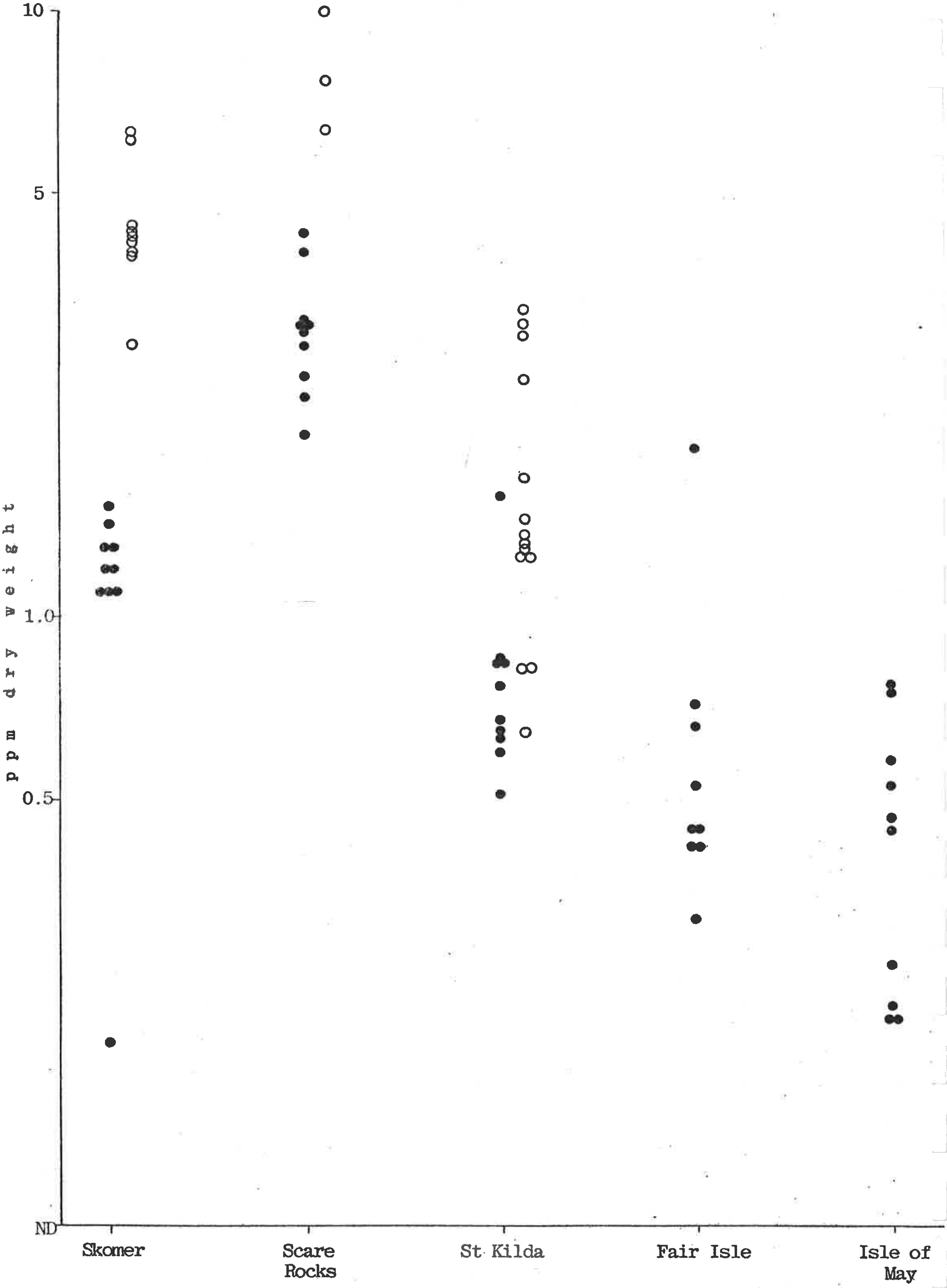


Fig. 14. Mercury concentrations in eggs of guillemots in 1980 (●) and in 1969-72 (○).



INSTITUTE OF TERRESTRIAL ECOLOGY
(NATURAL ENVIRONMENT RESEARCH COUNCIL)

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ITE PROJECT 181
Annual Report to Nature Conservancy Council

BIRDS OF PREY AND POLLUTION

Part II Mersey bird mortality

D OSBORN, K R BULL & W J EVERY

Monks Wood Experimental Station
Abbots Ripton
Huntingdon
Cambs. PE17 2LS

June 1981

2 MERSEY BIRD MORTALITY

2.1 Introduction

2.1.1 Mortalities before 1979

MAFF were sent bodies of birds found on the Mersey during 2-3 years prior to 1979; most of these bodies had been found in late summer and autumn. No details from their analyses have been made available to us, but we understand that no agricultural material was thought responsible for their deaths (lead was not analysed for).

2.1.2 Mortalities during 1979

Mortalities during 1979 were mainly dunlin *(Calidris alpina)* and various species of wildfowl. Table 11 is reproduced from the last report. A few mammal deaths have since come to light. These are reported in the North West Water Authority report (Head, D'Arcy & Osbaldeston 1980). Negative reports of tests for various pathogens (including botulism) were received from veterinarians, and lead was the only toxic chemical identified in their tissues. It was concluded in the last report that lead was the primary cause of the 1979 incident.

2.1.3 Mortalities during 1980

A substantial research programme was organised to investigate the 1979 incident more thoroughly. Before this programme could reach a conclusion, further deaths occurred in the late summer and autumn of 1980. The incident differed from 1979 in the important respect that gulls, mostly black-headed gull *(Larus ridibundus)*, were the main casualties. Table 12 (RSPB data) summarises the dead bird counts. In general, waders and wildfowl were little affected and total numbers on the Mersey were as in previous years or higher (Table 13, NCC data). It may be significant that only 63 dunlin were counted on one occasion early in the 1980 season. It is possible that the dunlin killed in 1979 were a discrete sub-population of the Mersey birds, which usually arrived early and were thus absent in 1980, having died in 1979. Alternatively, the dunlin were simply late arriving on the Mersey, although normal numbers were present on other estuaries at this time. RSPB have suggested that the voluntary restriction on shooting may have led more birds to use the estuary in 1980 than in previous years.

2.1.4 Investigations by other bodies

NWWA are continuing to investigate the relationships between lead in the Manchester Ship Canal (from effluent) and its subsequent passage into the Mersey. Their results are not yet to hand, but we understand they are making good progress. NWWA are also studying levels of lead in animals and plants which are possible food sources for waders and wildfowl. They hope ITE will be able to provide data from bird studies to set criteria for an acceptable concentration of lead in industrial effluent in the Mersey area.

MAFF has analysed a number of 1980 birds, mostly gulls, for lead by a dithiozone technique (Table 14a). The levels in the gulls are slightly elevated in comparison with data held in the Monks Wood record books

(Table 14b). MAFF has also found botulism in one of the gulls. One other bird was also identified as having botulism.

Industrial analysts have also measured lead in birds killed in 1980 (Table 15). As in 1979, some contained considerable amounts of organic lead.

2.1.5 Investigations by ITE

Since last year's report, ITE has (i) examined birds from estuaries and places other than the Mersey for comparative purposes, (ii) examined more birds from the Mersey, and (iii) done some experimental work on the toxicity of triethyl lead to birds. These investigations have reached a point where it may be possible to put a threshold value of organic lead compounds in birds, beyond which death is likely.

ITE has also kept relevant health authorities informed of the amounts of lead in the Mersey, and, following discussions with DHSS, has written to WAGBI outlining a course of action to prevent any risk to humans, until the hazards can be evaluated by the health authorities.

2.2 Methods

2.2.1 Collection of birds

Efforts of ITE staff have been needed to supplement the flow of wildfowl provided by WAGBI (Mr E. Wilkinson and other members of the Frodsham club). Collection of waders was difficult and only a few corpses were obtained from the Mersey. Once again (courtesy Mr R. Cockbain) an attempt was made to collect waders late in the season from New Brighton, but weather conditions were unfavourable. Local difficulties prevented WAGBI members assisting in the collection of waders. Thus, the sample of Mersey waders for 1980 is very small.

2.2.2 Analytical methods

Total lead analyses were made using atomic absorption spectrophotometry (AAS) following acid digestion of tissue samples with concentrated 'AnalaR' nitric acid. Either flame AAS (detection limit 2.5 μg/g for a 1 g sample) or furnace AAS (detection limit approximately 0.05 μg/g for a 1 g sample) were used, depending on the quantity of lead present. For both techniques, corrections were made for acid strength, acid blanks and non-atomic absorption.

Alkyl lead analyses were done by the anodic stripping voltammetric (ASV) method of AOC Ltd (Hodges & Noden 1979). The method has been adapted by AOC for analysis of fresh tissues, and modified by us for our analytical requirements. The initial extraction of di- and tri-alkyl lead from homogenized tissue into toluene is followed by re-extraction into dilute acid. The acid solution is subsequently analysed by ASV, using a glassy carbon electrode. Our detection limit for a 1 g tissue sample was approximately 0.02 μg/g. The method does not distinguish between dimethyl, diethyl, trimethyl and triethyl lead, but all four compounds have similar analytical sensitivities.

2.2.3 Experimental details

The aim was to determine the effects of organic lead compounds on birds. Triethyl lead was used, although we now understand that Associated Octel have known for some time that trimethyl lead, with a somewhat different toxicity, is the predominant organic form present in the birds. Whilst it is unfortunate that the earlier impression gained from the company, and, indirectly from NWWA staff, was not corrected, we think that the differences between trimethyl and triethyl are probably too small to make much difference to the general findings of the experiment with triethyl lead.

We were disappointed to learn that Octel had relevant data to which we were not given immediate access. This omission stresses the importance of obtaining an independent data set when investigating pollution incidents of this kind.

About 20 starlings *(Sturnus vulgaris)* were collected from Cambridgeshire towards the end of their moulting period. After acclimatisation to captivity in outside aviaries, they were transferred to individual cages indoors where it was possible to record general activity and feeding patterns and to weigh food eaten daily.

Because individual weights varied, it was decided to dose animals with triethyl lead so as to achieve dose rates of approximately 28, 2.8 and 0 (as control) mg kg^{-1} (body weight) day^{-1}. Thus, 6 birds were dosed with 2 mg day^{-1} triethyl lead, 6 with 200 µg day^{-1} and 6 others served as controls. Dosing was by a single oral dose in a gelatin capsule, the triethyl lead first being dissolved in a minimum quantity of an ethyl alcohol to minimise the risk of breakdown of the organo-lead compound in water during the relatively long period required for the chemical to dissolve in water. The dose was then made up to volume with saline. Control birds received a capsule containing only alcohol and saline in the same proportions as did dosed birds. It was calculated that, after 10 days, birds in the low dose group (assuming 10% absorption of each dose, and storage mainly in liver and kidney) should contain 10-20 mg kg^{-1} in the liver and the experiment was therefore ended at this point.

Birds were frozen after being killed with chloroform. Later they were dissected and tissues removed for analysis and some post-mortem observations were made. Pectoral muscles were removed and the muscle and the remaining carcass were dried at 105°C for at least 3 days before extracting lipids in warm dichloromethane, in order to determine indices of body condition.

2.3 Results

2.3.1 Field studies

a. Levels of lead in wild birds

Birds from the Mersey, Severn and Medway estuaries were examined along with a few from other sites. Mersey birds generally contained more lead than similar species from elsewhere (Tables 16-19). Wildfowl collected early in the season seemed to have higher levels than those collected at other times.

b. Post-mortem findings

Post-mortem results from wild birds were similar to those from 1979. Birds from the Mersey which were later found to have high lead levels sometimes had a characteristic 'Mersey' odour and often a discoloured liver which contained much green-brown material. In these birds, the intestine was sometimes discoloured and the gall bladder enlarged.

2.3.2 Laboratory studies

a. Mortalities

All high dose birds died within 6 days of the start of dosing. There were no deaths in the low dose or control groups.

b. Behaviour

No unusual behaviour was seen in control birds.

In the high dose group, a number of behavioural characteristics were noted. Most commonly, feathers were fluffed and the head was retracted. Movements were a little unco-ordinated, and the wings sometimes drooped at the side. There was some inability to stand upright. Respiration was slower and more laboured than in the control birds.

The low dose birds occasionally showed some of these effects, especially fluffed feathers.

c. General activity and feeding

Perch hopping in the cage and activity in the feeding box were recorded, as was daily food consumption (Figure 19), but the records need fuller analysis and are not presented here.

General perch hopping seemed higher in the low dose than in the control birds, but the difference could be due to individual variation and should not be given much weight at present.

The total amount of food eaten was similar in the control and low dose groups, the mean food intake over the whole course of the experiment being 244 g/bird in the low dose group and 241 g in the controls. However, low dose birds ate erratically, whereas control birds - except for 2 birds on one day - showed the consistent eating pattern typical of starlings kept in cages. Some further investigations may be needed to correct the data for body size, as this correction might reduce the considerable variation in food consumption found between individuals.

d. Post-mortem findings

Odour: one high dose and one low dose bird had the odour characteristic of birds containing elevated lead levels from the Mersey.

Gastro-intestinal tract: one high dose bird had a dark intestine, and one high and one low dose bird showed green staining of the gut near the gall bladder ducts.

Gall-bladder: gall bladders in all dosed birds were noticeably enlarged. They were scored by eye as 0 for normal to 4 for very enlarged. All controls had 0 scores, the low dose group all scored 2, whilst the high dose group scored three 3s and three 4s.

Liver: the liver in the dosed birds was darker and less cohesive in structure than that in the controls. The underside of the liver in one high dose bird was noticeably green, in another the left lobe was unusually small, and in 3 others there were lesions.

Heart: in 2 high dose birds, pale areas were seen on the heart; the significance of this colour change is unknown.

Kidneys: nothing obviously abnormal.

Bone: the marrow of all dosed birds was darker than that of controls, suggesting that red blood cell production was in progress. This effect was scored as 0 for controls to 4 for the darkest red marrows. All controls scored 0, while low dose birds all scored 1. There were 2 each which scored 2, 3 and 4 in the high dose group.

e. Body condition

Several measures of body condition were taken: pectoral muscle lean (fat-free) dry weight - as an index of protein reserves; total body lipid - as an index of energy reserves; intramuscular lipid; and total body lead dry weight. In the raw data (Table 20), all the high dose birds were significantly different in these respects from the control birds, but only intramuscular lipid was reduced in the low dose group, compared to control birds. However, if correction is made for body size (these birds varied in size by 10%) then the total body lipids of low dose birds were also reduced significantly below those of the control birds.

f. Residue levels

Controls: Very small peaks on the analytical traces were noted in the same position as the triethyl lead peaks, but these were considered to be 'carry over' of inorganic lead as a new operator became accustomed to the technique.

Low dose: Values in these birds were close to those found in several of the live birds that had been collected on the Mersey. Also, ratios in liver and kidney concentration at about 1:2 were about the same as in live birds from the Mersey (Table 21).

High dose: Lead levels were not much above the values for birds found dead on the Mersey in 1979 and 1980. Also, the ratio of liver:kidney concentration was >0.5, as found in some dead Mersey birds (Table 21).

The ratio of liver:kidney lead concentrations in the gulls found dead on the Mersey in 1980 generally was >0.5. Thus despite the lower levels of lead in the gulls, the possibility that lead also killed these birds cannot be ruled out because of possible differences in sensitivity.

g. Summary of results

Daily dosing of starlings with 200 μg and 2 mg of triethyl lead for 10 days resulted in the death of all those dosed with 2 mg and sublethal effects on those which received 200 μg. Sublethal effects included reduction in fat reserves, activation of bone marrow, gall bladder enlargement, and marked irregularity in feeding pattern.

h. Significance

The effects of fat reserves and feeding patterns are particularly significant for wild birds. Effects on feeding pattern may be the primary factor as they could lead to reduced fat levels. If normal feeding patterns were disrupted, the birds could well have greatly reduced chances of survival, possibly because fat reserves fall below an adequate level.

It is difficult to assess the significance of enlarged gall bladder and activated bone marrow. However, it seems reasonable to suppose that the loss and replacement of red blood cells that may be occurring is an additional strain on the bird.

In the wild, it is probable that lower levels of lead than those found in the experimental dead birds could cause death, as wild birds would cease to ingest lead once they stopped eating. In the experiment, birds were still dosed even when they had stopped eating, and thus continued to accumulate lead. Consequently, the figures from the experiment could well be an overestimate of the levels which kill birds in the wild.

2.4 Conclusions

2.4.1 Field studies

Substantial numbers of wildfowl and waders contain about 1 mg kg^{-1}, or more, lead in their tissues, much of which is trialkyl lead. The highest levels are found in the autumn.

Levels of lead in the Mersey are often higher than those found elsewhere.

2.4.2 Laboratory experiments

Dosing studies suggested that birds containing about 1 mg kg^{-1} trialkyl lead are likely to be suffering from adverse effects which in the wild would tend to reduce survival. The studies also suggested that birds containing 15-80 mg kg^{-1} trialkyl lead in the liver - or less (see 2.3.2.g) - could be reasonably supposed to have died from lead poisoning. This suggestion assumes, of course, that similar concentrations are needed to kill waders and ducks as starlings. Higher or lower values might be found for different species.

2.4.3 General conclusion

As low levels of some trialkyl lead compounds seem to affect birds adversely, it seems reasonable to attempt to reduce the levels of lead present in the Mersey estuary.

2.5 Acknowledgments

We are grateful to the staff of ITE Chemistry and Instrumentation, Monks Wood, for analytical help, and the following who have helped with bird collection: Mr E. Wilkinson, Dr J. Harradine (WAGBI) and Mr R. Cockbain.

2.6 References

HEAD, P.C., d'ARCY, B.J. & OSBALDESTON, P.J. 1980. *The Mersey estuary bird mortality autumn-winter 1979 - preliminary report.* North West Water. Directorate of Scientific Services. Scientific Report Ref. no.DSS-EST-80-1.

HODGES, D.J. & NODEN, F.G. 1979. The determination of alkyl lead species in natural waters by polarographic techniques. *Proc. int. Conf. Management and Control of Heavy Metals in the Environment, London, 1979,* 408-411.

TABLE 11

Mersey incident casualty total at 18 January 1980

The following table related to casualties mainly on the north side of the estuary. Prepared by RSPB from figures supplied largely by R. Cockbain *et al.*

	Dead	Live		
Wildfowl				
Teal	39	13		
Mallard	24	6		
Pintail	22	15		
Shelduck	12	3		
Mute swan	2			
			99	37
Waders				
Dunlin	910	213		
Redshank	86	74		
Curlew	41	28		
Grey plover	5			
Knot	5			
Little stint	5			
Green sandpiper	4			
Lapwing	2			
Ruff	1	1		
Golden plover	1			
			1060	316
Gulls				
Black-headed gull	320	8		
Herring gull	23	3		
Common gull	14	1		
Lesser black-backed gull	4			
Great black-backed gull	1			
Unidentified gull	14			
			376	12
Others				
Moorhen		1		
Carrion crow	1			
Heron	1			
Starling	5			
Unidentified birds	28			
			35	1
TOTAL			1570	366

TABLE 12

Mersey Incident Casualties during late summer early autumn 1980

Species involved	North shore	South shore
Black-headed gull	333 (+6 sick)	4
Herring gull	82 (+2 sick)	3
Lesser black-backed gull	48 (+2 sick)	-
Common gull	22	-
Gull sp.	-	197
Mallard	7 (+2 sick)	20 (+1 sick)
Curlew	7	1
Dunlin	-	2
Redshank	2	3
Lapwing	3 (+1 sick)	-
Bar-tailed godwit	1	-
Pintail	1	-
Bird sp.	8 (+5 sick)	c100
	514 (+18 sick)	c330 (+1 sick)

Data supplied by RSPB from R. Cockbain *et al.*

1981 Common sandpiper (1 sick)

TABLE 13

Winter numbers of selected duck and wader species on the Mersey estuary: mean for 1971/1977 (Buxton 1978) compared with counts for 1980/81 (G Thomason et al.*)*

		Sep	Oct	Nov	Dec	Jan	Feb	Mar
Mallard	1971/7	920	740	910	1350	1150	890	500
	1980/1	1250	1700	2400	1750	2400	1300	660
Teal	1971/7	2400	4200	6900	7100	7900	6100	3400
	1980/1	2500	7200	11000	18000	20000	26000*	13000
Pintail	1971/7	1200	3300	6200	8500	7700	5300	1250
	1980/1	1950	13000	18500*	8000	3900	12500	4000
Shelduck	1971/7	180	360	700	1300	2300	2500	2600
	1980/1	1000	1300	8100	11000	9400	12000*	3900
Dunlin	1971/7	3900	11500	25000	23000	26000	25000	11500
	1980/1	63	10000	21000	40000	24000	31000	18500
Redshank	1971/7	670	860	1400	960	1100	870	900
	1980/1	250	510	670	380	210	1050	600
Curlew	1971/7	900	520	400	570	480	560	720
	1980/1	1250	430	490	91	440	300	880

*Highest counts ever for Mersey.

TABLE 14a

Lead content of MAFF analysed birds

Identification	Total Pb ($mg\ kg^{-1}$ wet wt) Liver	Kidney
Mallard	16	16
Mallard	20	20
Black Backed Gull	1	1
Black Headed Gull	3	3
Black Headed Gull	2	5
Black Headed Gull	3	3
Black Headed Gull	1	2
Black Headed Gull	6	8
Duck (Mallard)	10	15
Lapwing	3	2

TABLE 14b

Late 1960s and early 1970s lead levels (mg kg^{-1} wet weight) in gull livers. Data from Monks Wood record books.

GBB	LBB	HG	C	BH
< 0.05		< 0.05	< 0.05	< 0.05
< 0.05	< 0.05			
0.94*	2.99	4.41**	-	< 0.2
				< 0.2
		0.8		< 0.2
		< 0.2		< 0.2
		0.2		
		< 2		
		< 2		
		< 2		
		< 2		

*, Cheshire; **, Irish Sea area.

All values shown < 2 are probably much less than 2 since the lead study was running down and low levels of detection were thought unnecessary at this time.

GBB = Great black-backed gull *(Larus marinus)*
LBB = Lesser black-backed gull *(L. fuscus)*
HG = Herring gull *(L. argentatus)*
C = Common gull *(L. canus)*
BH = Black-headed gull *(L. ridibundus)*

TABLE 15

Birds analysed by AOC for total lead and trialkyl lead. All birds from 1980 mortalities (August/September)

Identification	Total Pb ($mg\ kg^{-1}$ wet wt) Liver	Kidney
Gull 1	3.5	4.35
Gull 2	3.3	6.0
Tern	1.39	4.02
Duck 1	22.4	28.6
Duck 2	36.1	50.2
Duck 3	11.6	17.3
Curlew	8.6	11.5
Dunlin 1	28.4	34.8
Dunlin 2	5.83	9.56

% of organic lead ranged between <10% in Gull 1 to 78% in Dunlin 1

TABLE 16

Birds shot 7.9.80 by Frodsham Wildfowlers

Species	Pb (mg kg^{-1} wet wt) Muscle	Liver	Kidney
Teal	0.31	0.89	2.40
Teal	1.12	< 0.31	< 0.6
Teal	1.50	2.01	9.78
Teal	0.47	2.99	5.05
Teal	< 0.27	0.33	1.38
Teal	1.18	3.97	45.8*
Shoveler	1.27	3.01	7.32
Shoveler	3.33	6.46	11.4
Mallard	4.57	8.50	16.6
Mallard	0.34	1.01	2.07

*Possibly contaminated with lead shot. There is no evidence that shooting raises Pb levels except when this is fairly obvious. Compare levels in Table 8 where ducks were also shot.

TABLE 17

Collected by ITE 25.9.80

Species	Details		Pb (mg kg^{-1} wet wt) Muscle	Liver	Kidney
Teal	1979 Feb 1980.	Found sick. Green liver	3.99	13.25	14.8
Ruff	Aug 1980.	Power cables. Very fat	1.41	7.08	12.6
Little grebe (juvenile?)	Aug 1980.	Power cables. Healthy	0.92	<0.3	<0.56
Greenshank	Aug 1980.	Power cables. Fat	1.23	3.74	5.42
Common sandpiper	25/9/80.	Found sick. Fat. Dark liver	1.08	4.71	6.06
Black-headed gull	25/9/80.	Found sick	0.49	2.00	4.57
Teal	25/9/80.	Netted at Hale. Healthy	<0.21	0.84	3.89
Teal	25/9/80.	Netted at Hale. Healthy	<0.19	1.05	3.40
Teal	25/9/80.	Netted at Hale. Healthy	<0.21	<0.25	<0.53
Teal	25/9/80.	Netted at Hale. Healthy	<0.21	0.93	<0.53

TABLE 18

Lead in waders and ducks from other estuaries

Species	Place and date collected		Lead (total) in tissues mg kg^{-1} wet weight basis: Brain	Muscle	Liver	Kidney	Bone
Dunlin	Severn March 1980	Netted	0.227	0.040	0.155	0.152	3.18
			0.099	0.022	0.170	0.578	4.02
			0.066	0.016	0.096	0.277	3.84
			0.667	0.025	0.063	0.212	2.86
			0.081	0.028	0.107	0.323	1.76
			0.066	0.014	0.649	0.027	1.40
			0.064	0.013	0.014	0.043	8.44
			0.038	0.128	0.074	0.114	5.00
			0.065	0.015	0.024	0.034	1.59
			0.049	0.015	0.013	0.024	2.29
			0.14 ± 0.06	0.038 ± 0.01	0.14 ± 0.06	0.18 ± 0.05	3.44 ± 0.67
Mallard	Medway Jan/Feb 1980	Shot	-	0.219	0.286	0.272	11.09
			0.033	0.015	0.006	0.024	0.14
			511.71*	0.121	0.102	0.447	1.08
			0.053	0.014	0.139	0.187	3.28
			-	0.011	0.084	0.286	1.56
Teal	Medway Jan/Feb 1980	Shot	0.038	0.047	0.018	0.078	0.340
			0.022	0.008	0.032	0.059	0.188
			0.065	0.008	0.011	0.010	0.143
			0.010	0.007	0.600	0.330	0.658
			0.027	0.024	0.020	0.047	0.364

*Sample probably contained lead shot.

TABLE 19

Lead in wildfowl tissues (mg. kg^{-1} wet weight)
WAGBI Mersey and elsewhere sample

	Sex		Liver	Muscle
Mallard				
1	M	Mersey No 4 Pool 19/10	0.6	0.2
2	M	"	1.1	0.8
3	F	"	<0.2	0.2
4	F	Mersey Weaver 23/10	8.7	3.8
5	M	Bridgemere Wildlife Park 25/11	<0.2	<0.2
6	M	"	0.3	0.3
7	M	"	0.3	<0.2
8	F	"	0.2	<0.3
9	F	"	<0.2	<0.2
10	F	"	<0.3	3.4*
11	M	Huxley, Nr Tarporley 7/10	<0.2	<0.3
12	F	"	<0.3	<0.2
13	M	Bickerton Hall, Nr. Cholomondley 22/9	0.3	<0.2
14	F	"	<0.2	<0.2
15	F	Duddon, Tarporley, 26/10	<0.3	<0.2
16	F	"	1.7	<0.3
28	M	Goyt Valley, Derbyshire 21/10	0.6	<0.3
29	F	"	<0.3	10.4*
Teal				
17	M	Farindon 26/10	<0.2/0.3	<0.2/0.3
18	M	"	<0.3	<0.3
19	F	"	<0.3	<0.2
20	F	Bickerton Hall, Cholomondley 27/9	<0.3	<0.2
21	M	Mersey No 4 Pool 19/10	0.8	4.6*
22	M	"	1.1	11,000*
23	M	Mersey Weaver 23/10	2.0	1.1
24	M	"	<0.2/0.3	<0.2/0.3
25	F	"	<0.3	<0.4
Shoveler				
26	F	Mersey No 4 Pool 19/10	3.9	2.9

*Probably Pb-shot contamination (muscle and liver figures inconsistent).
Further analysis needed.

TABLE ~~20~~ 3

Measures of body condition in starlings. (Means ± S.E.), n = 6; Range shown for body lipid values)

	Lean dry body weight (g)	Pectoral muscle (g)	Body lipid (g)	Intramuscular fat (g)
Triethyl experiment				
Controls	21.51 ± 0.68	1.89 ± 0.08	2.92 ± 0.51 [2 – 5]	0.10 ± 0.02 [0.04 – .13]
Low dose	21.53 ± 1.00	1.85 ± 0.14	1.73** ± 0.23 [0.7 – 2.4]	0.05 ± 0.01 [0.02 – 0.08]
High dose	17.69* ± 0.26	1.25* ± 0.05	0.39* ± 0.02 [0.3 – 0.5]	0.005* ± 0.002 [0 – 0.01]
Trimethyl experiment				
Controls	20.5 ± 0.8 (21.3 ± 0.3)	1.98 ± 0.07 (2.03 ± 0.07)	4.5 (5) [2 – 7.5]	? 0.16 [0.05 – 0.22]
Low dose	19.7 ± 0.4	1.75* ± 0.09	4.3 [2 – 11.5]	0.13 [0.06 – 0.3]
High dose	17.9* ± 0.7	1.26* ± 0.12	2.3 [0.5 – 11]	0.02* [0 – 0.13]

* Means so marked are significantly different (P < 0.05) from controls; Student's t-test.
** significantly different if corrected for body size

In the trimethyl experiment one of the controls was "mishappen". The figures in parentheses are the means without this bird included.

TABLE 21

Tri~~ethyl~~ lead levels (mg kg^{-1} wet weight) ~~of lead~~ in tissues of 6 dosed starlings.

Details	Mean	S.E.	Range
~~Low dose starlings~~			
Muscle	1.47	0.36	0.44-2.93
Liver	1.07	0.2	0.59-1.92
Kidney	1.85	0.17	1.39-2.51
Bone	0.19	0.02	0.10-0.29
Brain	0.54	0.04	0.43-0.66
~~High dose starlings~~			
Muscle	20.0	2.78	9.50-30.0
Liver	40.2	9.35	14.6-92.3
Kidney	19.9	3.22	9.90-28.7
Bone	6.0	1.59	1.35-9.62
Brain	7.3	1.27	3.80-12.3

Levels in control birds were less than 0.1 in all cases. However some 'carry over' of inorganic lead during analyses may have occurred in the control samples and the true values are very probably much less than 0.1.

Figure 15a. Daily food consumption of control starlings

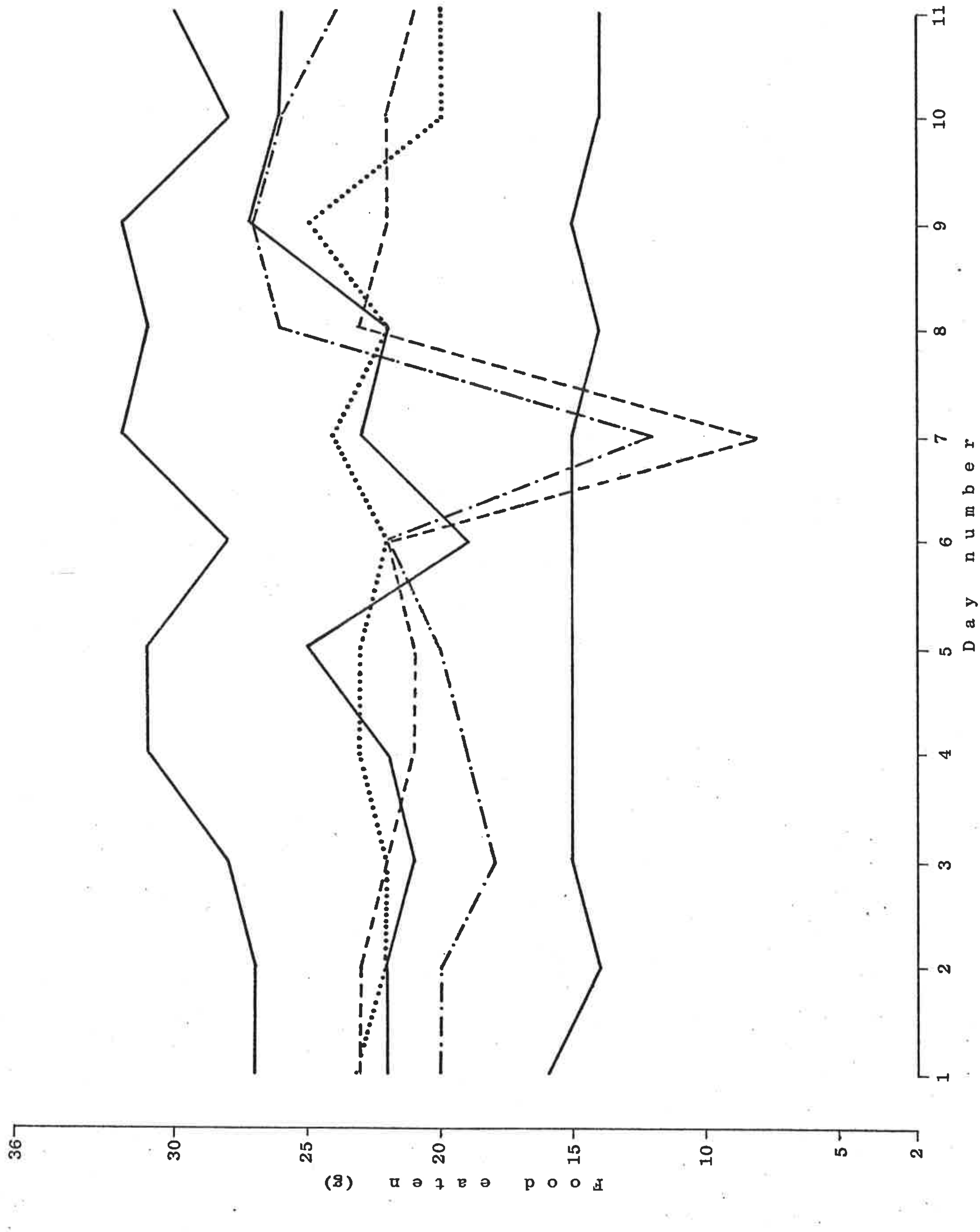
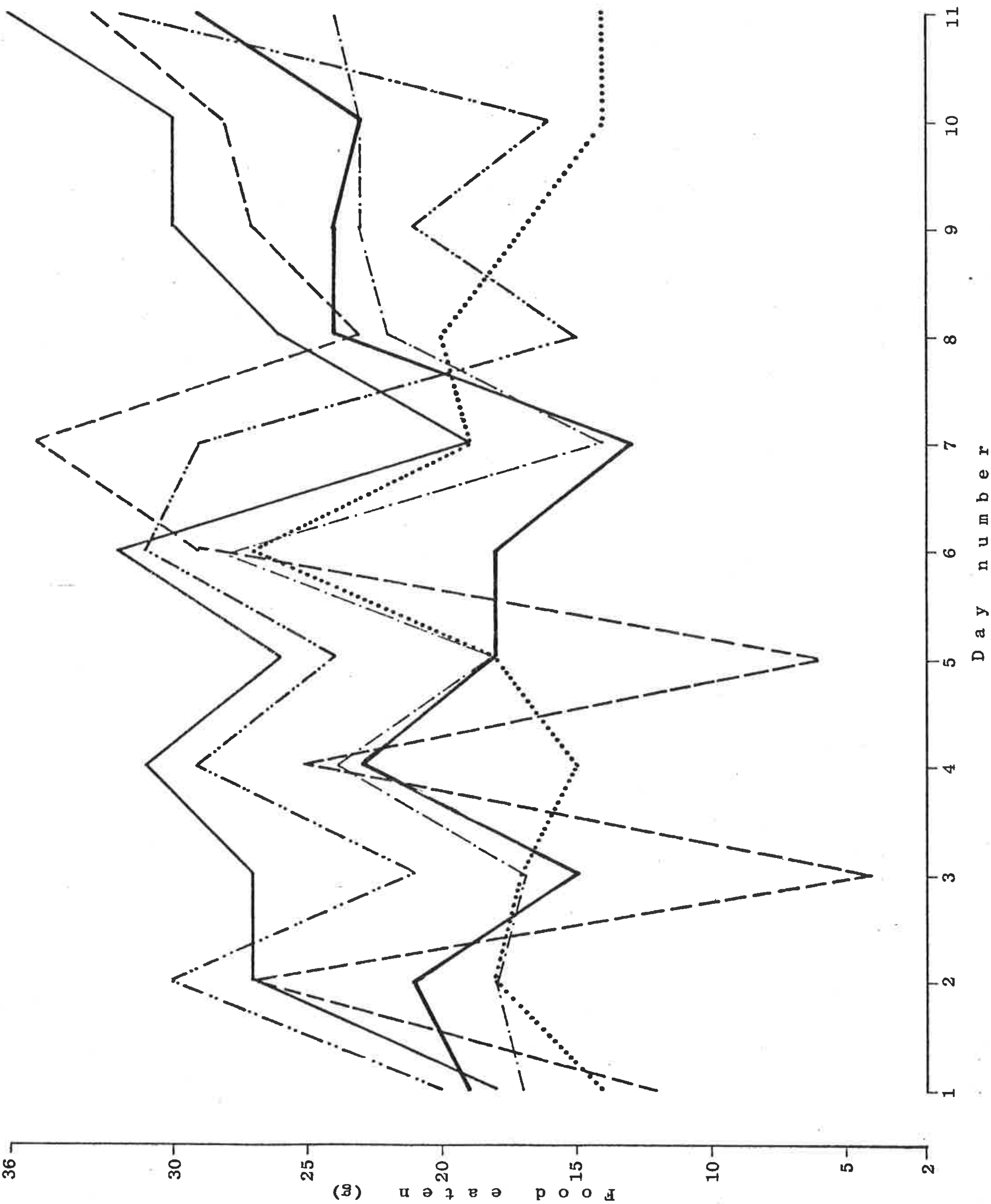


Figure 15b. Daily food consumption of low dose starlings



INSTITUTE OF TERRESTRIAL ECOLOGY
(NATURAL ENVIRONMENT RESEARCH COUNCIL)

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BIRDS OF PREY AND POLLUTION

Part III PCB residues in PCB-dosed puffins

M P HARRIS & D OSBORN

Monks Wood Experimental Station
Abbots Ripton
Huntingdon
Cambs. PE17 2LS

June 1981

3 PCB RESIDUES IN PCB-DOSED PUFFINS

3.1 PCB residues

Table 22 from a paper in press contains the data on puffins analysed recently for PCB levels following dosing. Levels are still elevated in dosed birds and monitoring of excretion and for effects on survival and breeding continues.

TABLE 22

Levels (mg kg^{-1} wet weight) of PCB in tissues of puffins killed at various times after implantation of PCB (dosed) or sucrose (control).

	Months after implantation	Fat	Liver	Kidney	Muscle	Brain
Dosed	1	301	43.1	ND	6.9	ND
	1	299	24.5	2.6	3.9	ND
	1.5	251	9.9	ND	7.3	ND
	3.5	280	ND	ND	ND	ND
	3.5	347	48.4	ND	21.1	50.9
	3.5	612	16.4	9.9	20.4	4.0
	3.5	610	21.5	12.5	20.1	ND
	3.5	516	24.0	11.3	25.2	ND
	3.5	451	23.1	11.6	17.8	13.0
	9	654	6.3	4.7	2.3	<1.0
	9	371	2.1	<1.0	2.6	<1.0
	9	429	14.0	<1.0	6.3	1.2
	12	284	10.0	4.5	8.1	ND
	12	105	3.5	2.6	4.0	ND
	12	294	17.3	2.8	10.2	4.5
	12	141	9.8	2.7	3.4	1.0
	12	457	10.5	8.2	14.8	6.0
	16	341	ND	ND	ND	ND
	16	200	ND	ND	ND	ND
	16	128	<1.0	ND	ND	ND
	16	211	30.3	14.1	12.4	8.2
	16	214	ND	ND	ND	ND
	16	118	1.2	1.0	7.7	2.7
	34	-	7.7	1.6	3.2	7.6
	34	93.5	2.4	ND	ND	ND
	34	124	3.2	ND	2.0	ND
	34	82.2	ND	ND	ND	ND
	34	97.1	2.6	ND	ND	ND
	34	97.1	1.0	ND	ND	ND
Control	3	ND	ND	ND	ND	ND
	24	25.7	ND	ND	ND	ND
	24	69.9	1.3	1.9	1.0	1.4
	24	34.5	ND	ND	ND	ND
	26	49.4	ND	ND	ND	ND
	28	38.5	ND	ND	ND	ND
	34	57.0	ND	ND	ND	ND
	34	73.6	ND	ND	ND	ND
	34	28.7	ND	ND	ND	ND
	34	28.1	ND	ND	ND	ND

Note: ND, none detected; -, no fat present at sampling site.