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HEAVY METALS IN GREY SEALS (Halichoerus grypus) FROM THE EAST COAST OF SCOTLAND

by

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SUMMARY

Mercury, cadmium, lead and arsenic have been determined in the brain, blubber, liver and kidney of grey seals (Halichoerus grypus) caught of the east coast of Scotland between 1975 and 1978.

Results are discussed in relation to age and weight and an assessment made of the suitability of grey seals as indicators of environmental quality.

SUMMAIRE

On a pu etablir la presence du mercure, du cadmium, du plomb et de l'arsenic dans le cerveau, le lard, la foie et les reius des phoques gris (Halichoerus grypus) pris sur la cote est de l'Ecosse entre 1975 et 1978.

On discute les resultats par rapport a l'age, au poids et on fait une estunation de la valeur des phoques gris comme indicateurs de la qualite de l'environment.

INTRODUCTION

Studies of heavy metals in the tissues of grey seals from British waters (Heppleston and French, 1973; Holden, 1975 and Caines, 1979) have provided data for specimens from East Anglia, Farne Islands, East and West Scotland, Outer Hebrides and Orkney/Shetland areas. Relatively few data were available for specimens from the east coast of Scotland, an area known to contain large numbers of grey seals (Rae, 1965). In view of ICES interest in contaminant levels in marine mammals, we report here some measurements of mercury, cadmium, lead and arsenic in tissue samples from grey seals which were collected in this area during the period 1975-1978.

MATERIALS AND METHODS

Samples of brain, blubber, liver and kidney were obtained from 60 specimens. All samples were deep frozen at -20°C during storage prior to analysis. Length and weight were measured at the time of sampling and the eyes and jawbones were sent to the Sea Mammals Research Unit, Cambridge, England, for age determination.

Mercury concentrations were determined by the method of Topping et al., (1975) and arsenic by the method of Shepherd and Topping (1977). Cadmium and lead concentrations were measured by atomic absorption following wet digestion with nitric acid. These analytical methods have been successfully compared with the methods used by other ICES laboratories in recent ICES intercomparison exercises.

RESULTS AND DISCUSSION

The results of the analyses of materials collected in 1975, 1976, 1977 and 1978 are given in Tables 1-4 respectively.

Concentrations of lead in all tissues were generally found to be below the level of detection (<0.5 $\mu g\ g^{-1}$). Several brain samples from seals which had been shot in the head were found to contain high concentrations of lead (>100 $\mu g\ g^{-1}$). Since these values presumably reflect contamination from the lead shot they are not presented. The highest concentrations of cadmium (0.1-15.1 $\mu g\ g^{-1}$) were found in the kidney, intermediate concentrations (0.05-8.49 $\mu g\ g^{-1}$) in the liver and the lowest concentrations (<0.05-1.13 $\mu g\ g^{-1}$) in the brain. Mercury residues were highest in the liver (0.23-126 $\mu g\ g^{-1}$), intermediate in the kidney (0.88-6.73 $\mu g\ g^{-1}$) and lowest in the brain (0.15-1.16 $\mu g\ g^{-1}$). By comparison with many fish species (Shepherd and Topping, 1977) arsenic residues in the tissues were low ie blubber (0.34-1.10 $\mu g\ g^{-1}$), kidney (0.07-0.46 $\mu g\ g^{-1}$), liver (0.10-0.43 $\mu g\ g^{-1}$) and brain (0.04-0.11 $\mu g\ g^{-1}$). No differences were observed between the respective metal concentrations in males and females.

The means and standard deviations for mercury and cadmium for three age groups (0-3, 4-6 and 7-9 years) for 1975-1978 are presented in Table 5. On the basis of the data in Table 5 there is little evidence that residue levels in any tissue increase with the age of the seal. There is also no evidence to suggest that metal residues for each age group have changed during the four year sampling period. There is some evidence however that the mercury concentration in liver increases with the weight of the seal (Figure 1) and there is an indication that the arsenic concentration in blubber decreases as the weight increases (Figure 2).

The concentrations of mercury and cadmium in both liver and kidney fall into the range of values reported for British seals (Table 6). It should be noted however (Table 7) that our maximum values for seals whose ages range from 1-9 years are much higher than the maximum values reported by Heppleston and French (1973) and Caines (1979) for seals of the same age group. For example Caines (1979) reported maximum concentrations of 0.3 $\mu g\ g^{-1}$ and 3.3 $\mu g\ g^{-1}$ for cadmium in liver and kidney respectively for seals whose age were ≤ 9 years and by comparison our values are 8.5 $\mu g\ g^{-1}$ and 15.1 $\mu g\ g^{-1}$ respectively. Unlike the above authors we were unable to show that mercury concentrations in liver increased with age during the first 9 years of the life of the seal. Similarly unlike Caines (1979) we were unable to show that cadmium concentrations in kidney increase with age during this period of the life of the seal. Our data, however, do provide evidence that there is a positive relationship between cadmium concentrations in liver and kidney.

According to Holden (1975) seals would appear to be unsuitable as species for monitoring levels of metal pollution in the sea. Although Caines (1979) felt that his data also supported this view, he suggested that comparison of metal pollution in different areas might be possible provided that animals of the same age were analysed. The data presented in Table 5

indicate that there have been no significant changes in mercury and cadmium concentrations in the liver and kidney of juvenile seals of the same age group over the 4 year sampling period. The absence of significant changes in metal concentration could be construed as providing evidence of uniform water quality in the sampling areas. It is more likely, however, that the metal residues in seals encountered in this study merely reflect the accumulation of metal from feeding on a variety of food organisms which do not themselves differ significantly in metal content with time and space. Since scientists involved in trend monitoring of heavy metals in relation to fish species have encountered great difficulties in showing variations in time and space for the North Sea area we question the use of seals in this context and we would support the view stated by Holden (1975) that seals which are to some extent migratory, are unsuitable as a monitoring species for metal contamination.

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TABLE 1

Cadmium and Mercury concentrations ($\mu g\ g^{-1}$ wet wt) in the tissues of Grey Seal sampled during 1975.

Age (yr)	Weight (Kg)	Sex	Cadmium /$\mu g\ g^{-1}$ wet wt Brain	Liver	Kidney	Mercury /$\mu g\ g^{-1}$ wet wt Brain	Liver	Kidney
1	36	M	-	-	0.10	-	1.00	1.10
1	37	F	-	0.11	0.47	0.21	6.50	1.74
1	33	M	-	0.09	0.28	0.50	-	2.02
2	63	M	0.54	1.48	2.65	0.23	9.80	1.19
2	68	M	-	2.21	4.21	0.21	25.0	3.30
2	43	F	-	0.11	0.52	0.37	9.60	1.56
2	61	M	-	0.23	0.66	0.42	17.10	2.55
3	83	M	-	0.42	1.55	0.22	13.6	2.10
3	89	M	-	0.71	2.64	0.20	8.90	1.64
3	80	M	-	0.13	0.73	0.29	8.90	2.28
4	75	M	-	8.49	15.1	0.20	31.7	3.38
4	96	M	-	1.86	4.65	0.15	7.20	2.30
4	91	M	-	3.30	7.34	-	26.8	1.37
5	68	F	1.13	0.23	1.15	0.73	11.7	3.15
5	131	M	-	0.97	3.54	0.18	21.2	2.02
5	+	M	-	0.30	1.06	-	54.0	2-02
5	85	F	-	1.18	4.38	0.25	4.10	2.76
6	100	M	-	2.75	9.26	0.24	14.4	*
8	125	M	-	0.32	1.47	*	24.4	3.70
9	127	M	-	0.61	2.18	0.67	41.5	2.86
9	238	M	-	0.53	1.64	0.29	44.4	2.33

\+ No weight data

* No sample available

\- Below Detection Limit

TABLE 2

Cadmium and Mercury Concentration (ug g^{-1} wet wt) in the tissues of Grey Seal sample during 1976.

Age (yrs)	Weight (kg)	Sex	Cadmium (ug g^{-1} wet wt) Brain	Liver	Kidney	Mercury (ug g^{-1} wet wt) Brain	Liver	Kidney
1	45	F	-	0.19	0.39	0.17	4.70	0.90
1	45	M	-	-	0.17	0.47	4.90	1.76
1	49	M	-	-	0.28	0.17	3.14	0.84
1	57	M	-	0.07	0.20	0.28	5.56	2.53
2	84	M	-	0.72	1.84	0.15	8.90	2.07
2	88	M	-	0.79	2.67	0.65	16.70	3.05
2	79	M	-	1.53	2.85	0.39	60.6	4.13
2	59	F	-	0.07	0.37	0.29	11.4	2.38
3	64	F	-	0.08	0.76	-	26.5	2.90
3	92	M	-	0.20	0.70	0.21	11.9	1.83
3	74	F	-	0.76	3.82	0.21	89.3	4.56
4	70	F	-	0.87	2.06	-	29.1	2.05
4	73	M	-	0.17	1.36	0.16	31.6	1.77
5	95	M	-	0.67	1.67	-	8.20	3.25
5	125	M	-	0.50	2.76	0.11	2.64	1.48
5	121	M	-	0.34	1.52	0.28	77.3	3.32
6	91	F	-	2.95	8.08	0.18	41.2	2.71
6	118	M	-	0.35	1.68	0.20	31.6	3.08
7	121	M	-	0.17	0.87	0.33	28.7	2.55
8	155	M	-	1.26	2.50	0.33	11.7	3.18
8	157	M	-	0.48	1.46	*	48.1	5.64
9	138	M	-	0.25	0.83	*	37.4	3.56
21	305	M	-	-	1.25	0.20	57.1	3.69

* No sample available
- Below detection limit

TABLE 3

Cadmium Mercury and Arsenic concentrations ($\mu g\ g^{-1}$ wet wt) in the tissue of Grey Seal sampled during 1977

			Cadmium $\mu g\ g^{-1}$ wet wt			Mercury $\mu g\ g^{-1}$ wet wt			Arsenic $\mu g\ g^{-1}$ wet wt			
Age	Weight	Sex	Brain	Liver	Kidney	Brain	Liver	Kidney	Blubber	Brain	Liver	Kidney
1	+	M	-	0.05	0.28	0.60	11.5	4.09	1.23	0.04	0.22	0.23
2	46	F	-	-	0.44	1.21	13.2	1.72	0.88	0.08	0.31	0.26
3	68	F	-	1.64	4.77	0.48	37.9	3.41	1.10	0.05	0.33	0.25
3	75	M	-	0.59	2.11	0.67	18.6	6.00	0.91	0.07	0.25	0.37
4	76	M	-	0.19	0.59	0.63	32.4	2.99	0.86	0.09	0.41	0.36
4	74	F	0.05	0.51	1.78	0.24	48.6	3.38	1.07	0.08	0.29	0.16
4	98	F	-	0.12	0.39	0.36	20.8	3.51	0.42	0.07	0.16	0.23
4	98	M	-	0.71	1.29	0.39	22.2	3.16	0.75	0.03	0.10	0.08
5	91	M	-	0.74	1.81	*	19.1	3.69	0.83	-	0.52	0.37
5	77	F	-	0.80	2.10	0.14	28.9	1.20	0.75	0.04	0.16	0.21
5	86	F	-	0.07	0.19	0.15	2.14	1.79	0.53	-	0.11	0.14
6	120	M	0.70	0.15	0.58	0.20	16.2	1.35	0.46	0.07	0.82	0.45
6	95	F	-	0.05	2.12	0.39	0.26	0.88	0.77	0.11	0.17	0.30
7	125	F	-	0.15	0.40	1.16	123.9	6.73	0.30	0.06	0.12	0.07
9	190	M	-	0.23	0.52	*	0.23	4.73	0.34	-	0.15	0.10
9	132	F	-	0.32	0.77	*	23.1	1.71	0.30	0.06	0.12	0.07

\+ No weight data
* No sample available
\- Below detection limit

TABLE 4

Cadmium and Mercury concentrations ($\mu g\ g^{-1}$ wet wt) in the tissue of Grey Seal sampled during 1978

Age (yrs)	Weight (kg)	Sex	Cadmium			Mercury		
			Brain	Liver	Kidney	Brain	Liver	Kidney
3	100	M	-	0.31	1.39	0.31	9.55	4.06
3	82	M	-	0.65	1.18	0.20	91.1	2.27
4	109	M	-	0.24	0.50	0.32	36.1	3.28
4	91	M	-	0.85	1.37	0.26	35.3	1.42
4	+	F	-	0.28	1.85	0.59	74.7	2.22
5	+	M	-	0.64	*	*	25.1	*
5	103	F	-	0.26	2.00	0.14	12.3	1.41
6	109	M	-	0.76	1.43	0.62	51.5	4.42
7	+	M	0.05	0.91	2.52	0.45	27.0	4.31
7	109	M	-	1.23	2.42	0.40	27.4	2.46
9	109	F	-	0.53	1.95	0.28	37.0	2.33
9	+	F	-	*	4.24	0.27	125.9	*
14	+	F	-	1.20	3.09	0.17	91.7	3.70

\+ No weight data
* No sample available
\- Below detection limit

TABLE 5

Mercury and Cadmium concentrations ($\mu g \cdot g^{-1}$ wet weight) in the tissue of Grey Seals in relation to age group and year of sampling

Age Group (Years)	MERCURY Brain n*	$\bar{x}$+	σ**	Liver n	$\bar{x}$	σ	Kidney n	$\bar{x}$	σ	Liver n	$\bar{x}$	σ	Kidney n	$\bar{x}$	σ
1975															
0 - 3	9	0.29	0.11	9	11.45	6.25	10	1.95	0.66	9	0.61	0.75	10	1.38	1.36
4 - 6	6	0.29	0.48	8	21.61	15.89	7	2.43	0.71	8	2.39	2.70	8	5.81	4.68
7 - 9	2	0.48	0.19	3	36.77	8.82	3	2.96	0.56	3	0.49	0.12	3	1.76	0.30
1976															
0 - 3	10	0.30	0.16	11	22.44	27.45	11	2.45	1.18	9	0.49	0.50	11	1.28	1.30
4 - 6	5	0.19	0.06	7	31.80	24.20	7	2.38	0.66	9	0.84	0.96	7	2.73	2.40
7 - 9	2	0.33	0.00	4	31.48	13.33	4	3.73	1.16	3	0.54	0.43	3	1.42	0.69
1977															
0 - 3	4	0.74	0.32	4	20.30	12.12	4	3.81	1.77	3	0.76	0.66	4	1.80	1.89
4 - 6	8	0.31	0.16	9	22.12	13.41	9	2.44	1.12	9	0.38	0.31	9	1.21	0.77
7 - 9	1	1.16	0.00	3	49.08	53.73	3	4.39	2.06	3	0.23	0.07	3	0.56	0.15
1978															
0 - 3	2	0.26	0.06	2	50.33	40.8	2	3.17	0.90	2	0.48	0.17	2	1.29	0.11
4 - 6	5	0.40	0.20	5	39.16	21.72	5	2.55	1.30	3	0.45	0.28	3	1.24	0.56
7 - 9	4	0.35	0.09	4	54.33	47.9	3	3.03	1.11	2	0.89	0.16	3	3.06	0.84

* No of samples
\+ Mean value
** Standard Deviation

TABLE 6

Mercury and cadmium concentration ($\mu g\ g^{-1}$ wet weight) in Grey Seals in British waters

Species	Area	MERCURY Brain	Liver	Kidney	CADMIUM Brain	Liver	Kidney	Source
Grey Seal *Halichoerus grypus*	Farne Island E Coast of England		5.8 - 478.7	1.5 - 12.2	-	0.1 - 2.8	0.68 - 16.88	1
Grey Seal	British Coast	0.6 - 16.8	6 - 175	2.3 - 6.8	-	1.1 - 2.3	-	2
Grey Seal	Farne Island	*0.7 ± 0.2	*8.42 ± 68.9	-	< 1	< 1	*5.3 ± 4.0	3
Grey Seal	Outer Hebrides	*0.7 ± 0.2	*113 ± 68.0	-	< 1	< 1	*11.6 ± 7.5	3
Grey Seal	Shetland	*0.3 ± 0.1	4.9 ± 3.6	-	< 1	< 1	2.2 ± 2.0	3
Grey Seal	East Coast of Scotland	0.15 - 1.16	0.23 - 125.9	0.88 - 6.73	< 0.05	0.05 - 8.49	0.04 - 8.08	4

Key to sources

1 Caines 1978
2 Holden 1975
3 Heppleston and French 1973
4 This study

* Mean ± standard deviation

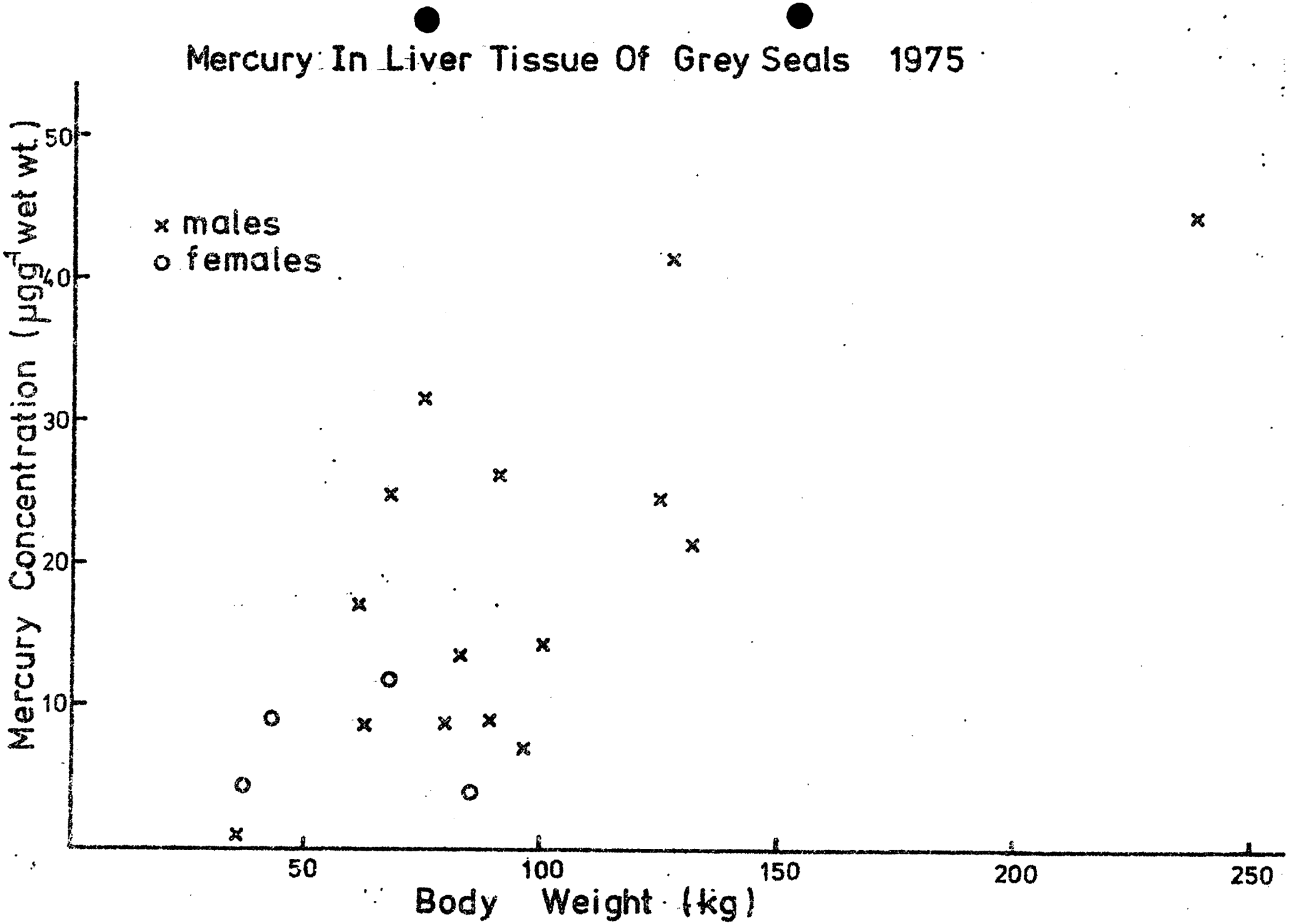
- No results available

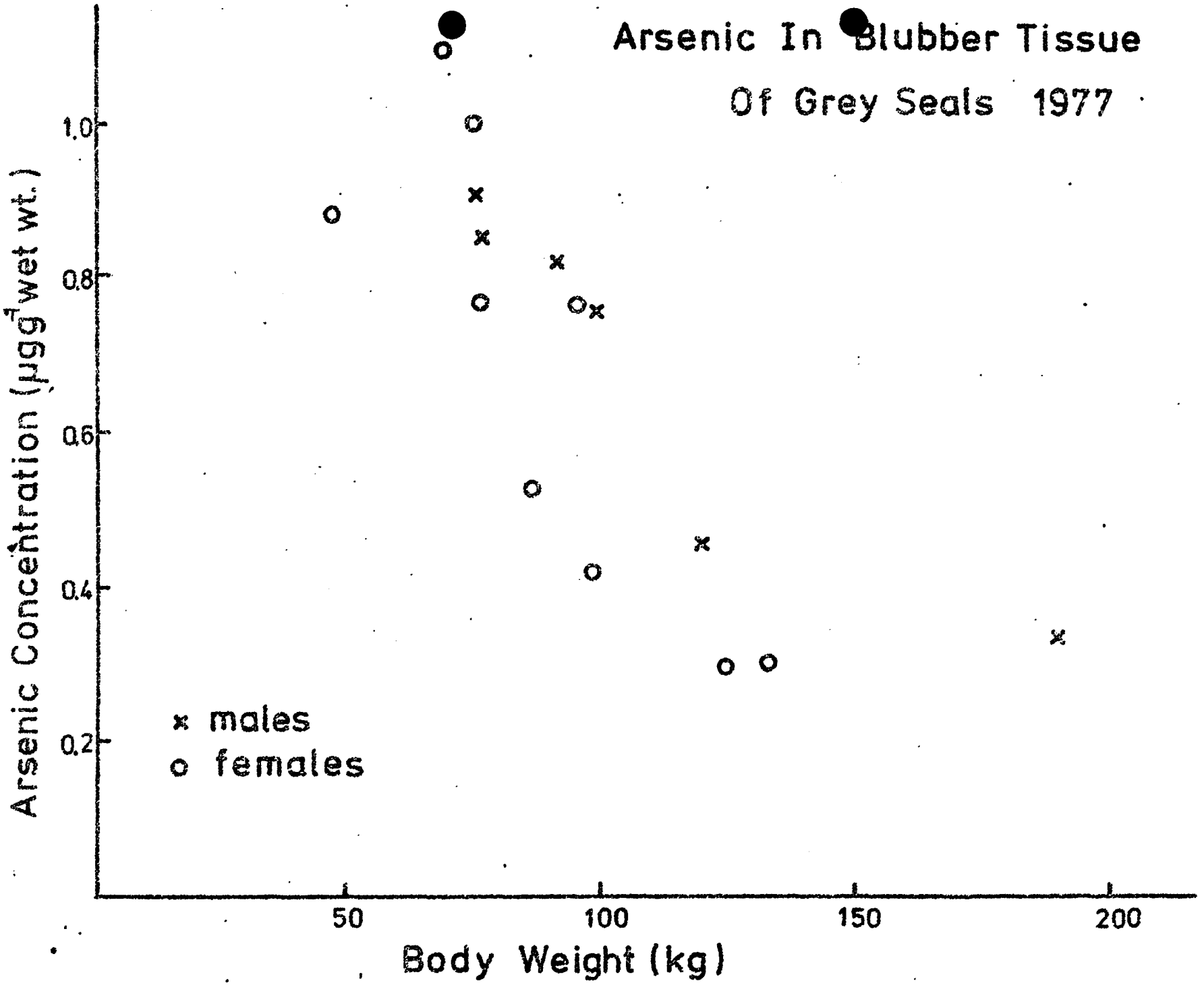
TABLE 7

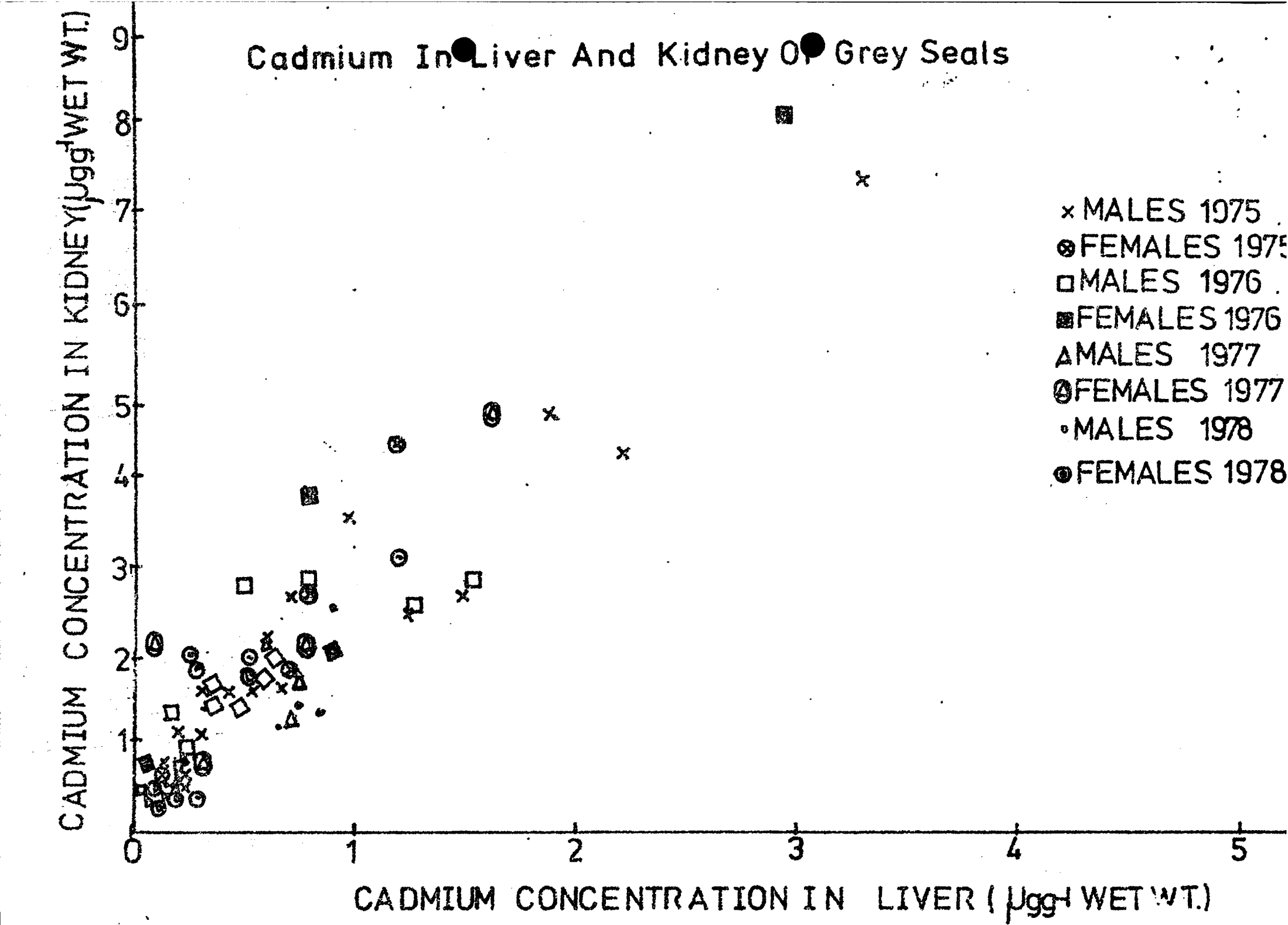
Maximum concentrations of cadmium and mercury ($\mu g\ g^{-1}$ wet weight) in liver and kidney of juvenile* grey seals

Reference	Cadmium		Mercury
	Liver	Kidney	Liver
Heppleston and French (1973)	-	-	74+
Caines (1979)	0.3+	3.3+	70+
This study	8.5	15.1	126

* 1 - 9 years
+ interpolated from figures presented in Caines (1979) and Heppleston and French (1973)


Mercury In Liver Tissue Of Grey Seals 1975
× males
o females
Mercury Concentration (μgg⁻¹ wet wt.)
10
20
30
40
50
50
100
150
200
250
Body Weight (kg)


Arsenic In Blubber Tissue
Of Grey Seals 1977
Arsenic Concentration (μgg⁻¹ wet wt.)
1.0
0.8
0.6
0.4
0.2
× males
o females
50
100
150
200
Body Weight (kg)


Cadmium In Liver And Kidney Of Grey Seals
CADMIUM CONCENTRATION IN KIDNEY(µgg⁻¹WET WT.)
CADMIUM CONCENTRATION IN LIVER (µgg⁻¹ WET WT.)
0
1
2
3
4
5
6
7
8
9
× MALES 1975
⊗ FEMALES 1975
□ MALES 1976
■ FEMALES 1976
△ MALES 1977
Ⓐ FEMALES 1977
· MALES 1978
◉ FEMALES 1978