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HEAVY METAL DISTRIBUTION IN WEDDELL SEALS (*LEPTONYCHOTES WEDDELLII*) FROM THE ANTARCTIC DURING JARE-32

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Abstract: Concentrations of heavy metals in five Weddell seals (*Leptonychotes weddellii*) captured in the Antarctic for 1990–91 winter during JARE-32 were determined. Fe and Cu concentrations in the liver of Weddell seals were remarkably higher than those of other marine mammals, while Cd levels in the livers were rather lower. Markedly high Fe concentrations in the liver of Weddell seals might be related to the excellent diving ability of this species. Relatively lower Cd concentration in the liver of these seals suggests less feeding on squids which contain high Cd levels compared to fish.

1. Introduction

The Weddell seal (*Leptonychotes weddellii*) is the most southerly ranging pinniped and shows strong affinities to the coastal shelf waters throughout the year. This species is well known for its excellent diving ability (KOOYMAN, 1981; BONNER, 1989; KING, 1983).

This seal is a relatively large, long-lived animal and occupies a high trophic level in the food web of the Antarctic. Anthropogenic effect of metal pollution on this animal is considered to be negligible, when compared with other seals from the northern hemisphere. Thus, the Weddell seal is useful as an 'indicator species' for understanding the bioaccumulation process of heavy metals under natural condition.

Although the concentrations levels of heavy metals in some Antarctic seals have been reported (DENTON *et al.*, 1980; MCCLURG, 1984), characteristics of heavy metal accumulation in Antarctic seals are not extensively discussed.

We have already reported tissue distribution of heavy metals in three Weddell seals captured in the Antarctic near Syowa Station in 1981 (YAMAMOTO *et al.*, 1987). This paper further reports the analysis of heavy metals in some tissues of five Weddell seals captured in the Antarctic for 1990–91 winter during JARE-32. The present result of heavy metal accumulation of Weddell seals was compared with those of other marine mammals from different waters.

2. Materials and Methods

Four adult Weddell seals and one newborn calf were collected near Syowa Station (39°E) and Breid Bay (24°E).

These specimens were transported from Syowa Station to the National Science Museum of Tokyo by the icebreaker SHIRASE, and were dissected at the museum in order to examine their biometries, sexual conditions, stomach contents and so on.

Samples of this study were stored in polyethylene bags at −18°C until analysis. For the analysis of the heavy metals, 3–10 g of each cut tissue was digested with a mixture of nitric, perchloric, and sulfuric acids in Kjeldahl flasks. The resultant solutions were then diluted to 50 m*l* with distilled water, and the concentrations of Fe, Mn, and Zn were directly measured by atomic absorption spectrophotometry (AAS). Cu and Cd were determined by AAS after diethyldithio-carbamate-methyl isobutyl ketone extraction.

3. Results and Discussion

Heavy metal concentrations in the liver, kidney, and muscle of five Weddell seals captured in the Antarctic for 1990–91 winter during JARE-32 and those of three seals captured there in 1981 are shown in the Table 1.

Fe, Mn, Zn and Cu concentrations were the highest in the liver, but Cd concentration was the highest in the kidney. Cd concentrations in liver, kidney and muscle of NF were lower than any other adult seals and those of NM were below the detection limit. In case of the striped dolphin, very low Cd concentrations of fetuses and increase of Cd concentrations with age in various tissues were reported (HONDA and TATSUKAWA, 1983). Similar to the striped dolphin, these newborn calves of Weddell seal probably have not been so exposed to Cd in food because they were very young. Fe concentration in the liver of AF2 seal and Mn concentration in the liver of AM1 seal were extraordinarily higher compared with other seals. Except for these values, heavy metal concentrations in Weddell seals captured for 1990–91 were generally of the same order of magnitude with concentrations in seals collected in 1981. But Cd concentrations in tissues of Weddell seals captured for 1990–91 were higher than those captured in 1981. Because of accumulation of Cd with age, this elevation of Cd concentrations in seals captured for 1990–91 might be caused by the increase with age. Though ages of seals captured for 1990–91 are unknown, body weight and length were not different between seals captured for 1990–91 and 1981.

In order to know the characteristics of heavy metal accumulation in the Weddell seal, combined data of both years were compared with those of other marine mammals from different waters.

Although Zn and Mn concentrations in the liver, kidney, and muscle of Weddell seals are comparable to those of other marine mammals, Fe concentrations in the liver of Weddell seals are remarkably higher than other marine mammals from different waters (Figs. 1–3). The Weddell seal is known to be the most competent diver among all species of pinnipeds. The Weddell seal has a large volume of blood and the haemoglobin concentrations and oxygen-holding capacity of the seal are considered to

Table 1. Heavy metal concentrations in μg g^{-1} (wet wt) in liver, kidney and muscle of Weddell seals captured in 1990/91 and 1981.

Specimens		Sex	Weight (kg)	Length (cm)	Fe			Mn			Zn			Cu			Cd		
					Liv.	Kid.	Mus.	Liv.	Kid.	Mus.	Liv.	Kid.	Mus.	Liv.	Kid.	Mus.	Liv.	Kid.	Mus.
1990/91	AM	♂	225	243	856	166	248	9.08	1.20	0.19	73.8	85.6	36.4	42.5	7.35	0.52	3.28	18.6	0.01
	AF1	♀	256	247	518	157	249	2.85	0.80	0.08	43.1	24.6	35.3	31.1	5.66	0.58	1.94	30.5	0.04
	AF2	♀	264	241	4119	220	251	2.75	1.37	0.15	50.1	28.0	30.9	22.3	4.33	0.83	5.08	27.9	0.10
	AF3	♀	288	276	752	196	246	1.89	1.14	0.11	33.9	26.6	29.3	16.1	5.09	0.68	3.02	20.5	0.04
	NF	♀	15	92	1789	132	148	2.06	0.54	0.13	150.0	18.3	23.2	22.3	2.64	0.76	0.002	0.012	0.004
1981*	AM	♂	383	235	389	618	237	1.86	1.12	0.13	47.0	27.4	33.7	25.8	11.00	1.02	1.31	9.93	0.30
	AF	♀	317	212	940	159	267	1.80	0.90	0.14	41.7	30.7	39.6	15.0	5.12	0.85	0.96	2.89	0.01
	NM	♂	26	116	403	359	146	1.10	0.37	0.18	55.1	12.6	34.2	19.0	2.50	1.59	<0.005	<0.005	—

AM: adult male, AF: adult female, NM: newborn male, NF: newborn female.
Liv.: liver, Kid.: kidney, Mus.: muscle.
* The data were cited from YAMAMOTO *et al.* (1987).

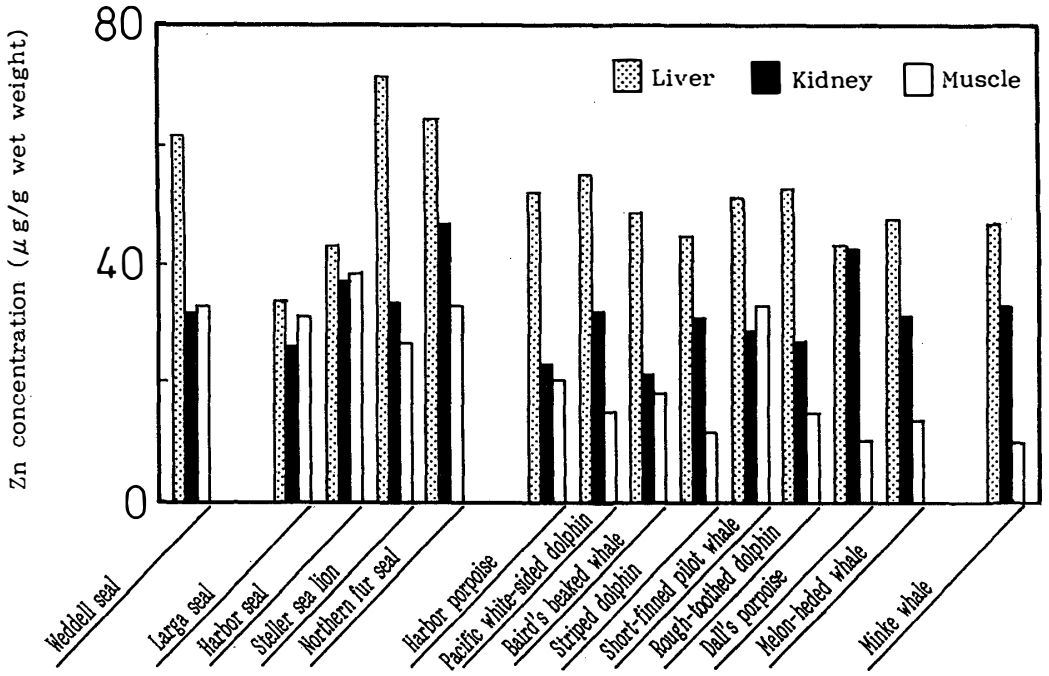

Fig. 1. Comparison of Zn concentrations in the liver, kidney, and muscle of various marine mammals.

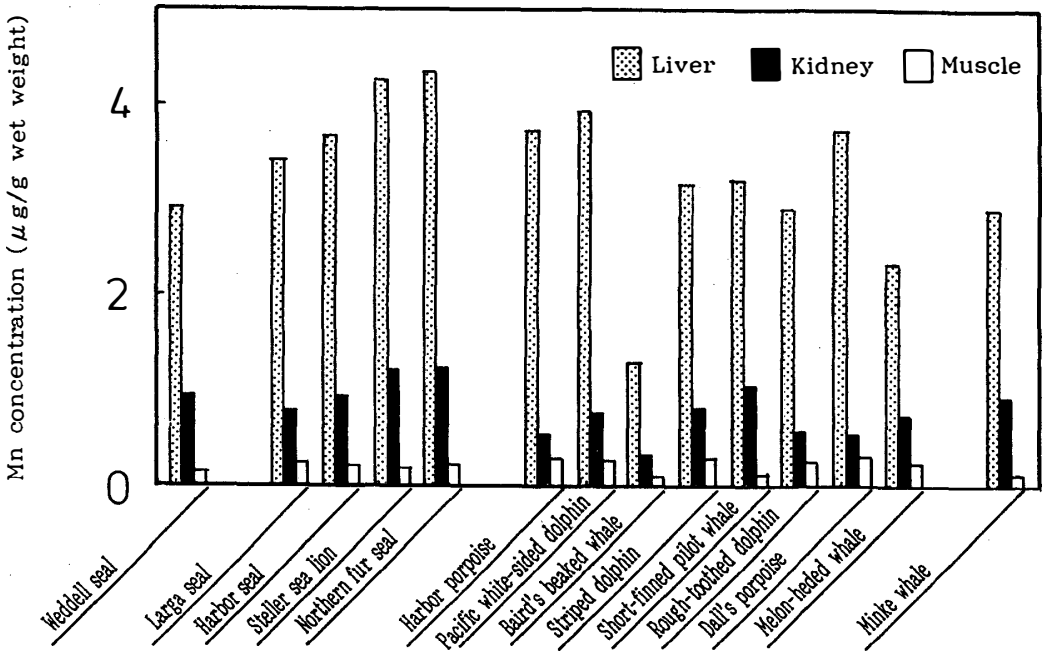

Fig. 2. Comparison of Mn concentrations in the liver, kidney, and muscle of various marine mammals.

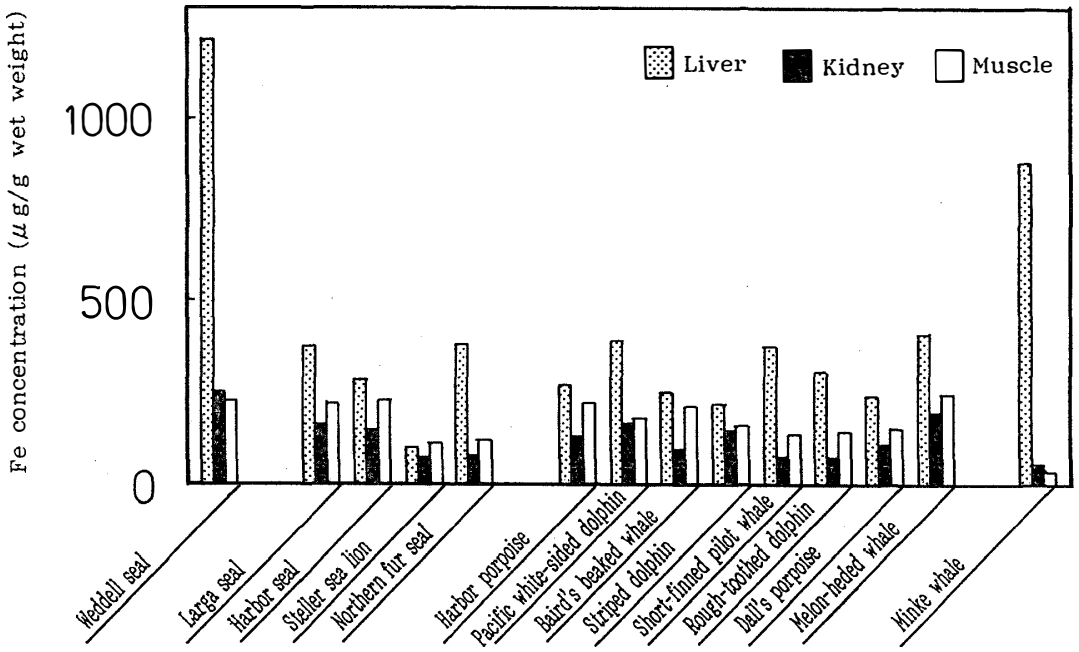

Fig. 3. Comparison of Fe concentrations in the liver, kidney, and muscle of various marine mammals.

be the highest among mammals (KOOYMAN, 1981; KING, 1983). Markedly high Fe concentrations in liver of the Weddell seal might be related to the excellent diving ability of this species.

Cu concentrations in the liver of Weddell seals are also high when compared with other pinnipeds and cetaceans from different waters, except for the Steller sea lion (*Eumetopias jubatus*) (Fig. 4).

Cd accumulations in marine mammals are considered to be related to their feeding habits. Cd concentrations in the liver, kidney and muscle of the Weddell seal show lower levels compared with other pinnipeds except the northern fur seal (*Callorhinus ursinus*) captured off Sanriku, Japan (Fig. 5). Higher concentrations of Cd in the liver of the Ross seal (*Ommatophoca rossi*) captured in the Antarctic (33–422 μg/g dry weight) have also been reported (MCCLURG, 1984). Both of the Ross seal and the northern fur seal are believed to feed primarily on squid and to a lesser extent on fish and krill (LAWS, 1977; WADA, 1969). Squids have higher concentrations of Cu, Cd and Zn. Lower concentrations of Cd in the Weddell seal and other pinnipeds might be due to their food composition predominated by fish and invertebrates excluding squids (LAWS, 1977; PLÖTZ *et al.*, 1991; HAMANAKA *et al.*, 1982; NAKAOKA *et al.*, 1986).

High concentration of Fe in the livers of the southern minke whale (*Balaenoptera acutorostrata*; HONDA *et al.*, 1986, 1987), the crabeater seal (*Lobodon carcinophagus*) and the leopard seal (*Hydrurga leptonyx*) (1200–15200 μg/g dry weight, 2000–8100 μg/g dry weight, respectively; DENTON *et al.*, 1980) captured in the Antarctic waters were also reported. However, the Ross seal from the Antarctic showed lower concen-

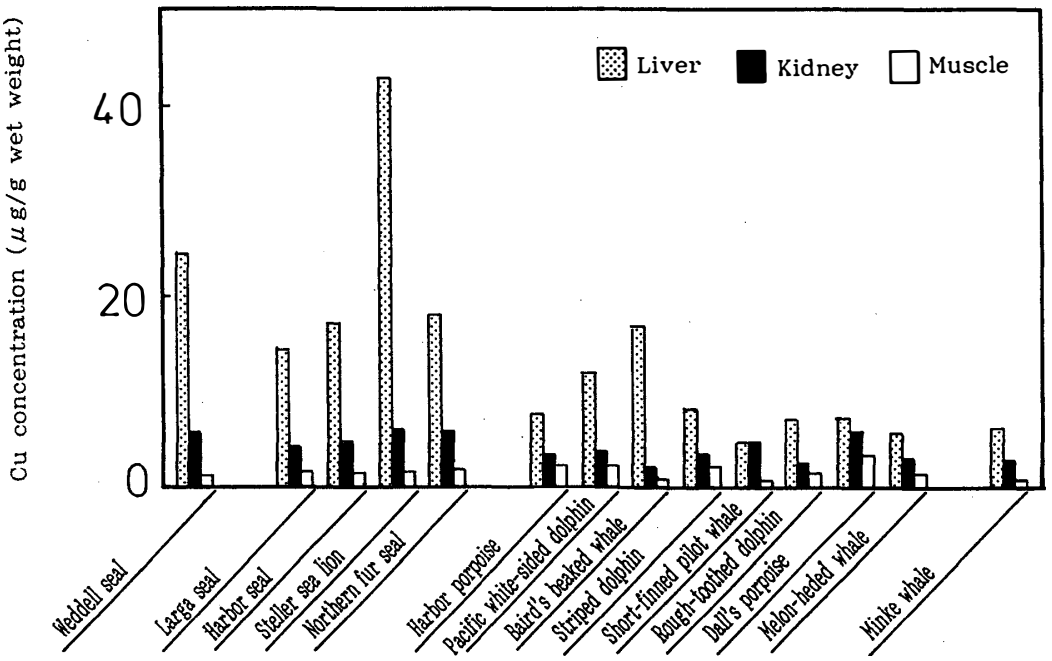

Fig. 4. Comparison of Cu concentrations in the liver, kidney, and muscle of various marine mammals.

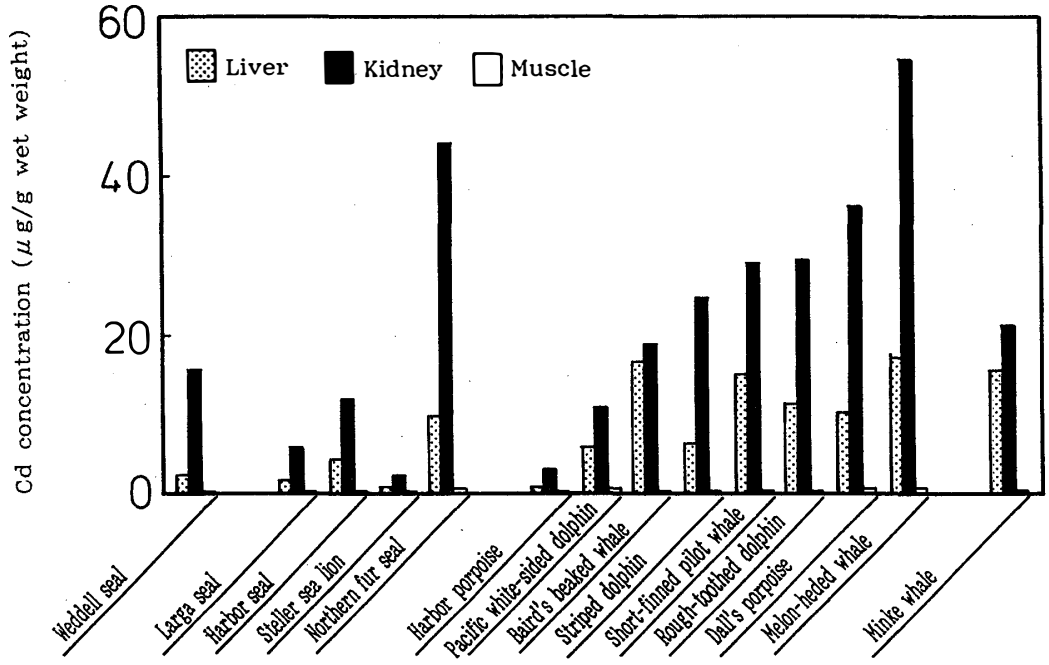

Fig. 5. Comparison of Cd concentrations in the liver, kidney, and muscle of various marine mammals.

trations of Fe in the liver (231–961 μg/g dry weight) (MCCLURG, 1984). Considering the exceptionally high Cd levels in the liver, the heavy metal status in the Ross seal might be different from other Antarctic seals. Those high concentrations of Fe in the liver of Antarctic seals and whales except the Ross seal might be a case of adaptation to the cold Antarctic circumstances.

For the leopard seal and the Ross seal similar high concentrations of Cu in the liver as the Weddell seal were also reported (84–105 μg/g dry weight, 16–255 μg/g dry weight, respectively; DENTON *et al.*, 1980; MCCLURG, 1984).

Essential element accumulations like Fe and Cu in marine mammals are controlled by species-specific metabolism. So, the high concentrations of Fe and Cu in these Antarctic seals could not be explained only by their feeding habits. Cu plays an important role in Fe metabolism. The role of the Cu protein ceruloplasmin in mobilizing Fe from storage tissue like liver to sites of haemoglobin synthesis has been identified. Therefore, excessive Fe deposits in the liver are a prominent feature of Cu-deficiency. The dugong (*Dugong dugon*) from northern Queensland, Australia has also high hepatic Fe and Cu concentrations. Although high Cu accumulations in the liver of the dugong, conspicuous Fe deposits as haemosiderin in the liver and other symptoms of Cu-deficiency were observed (DENTON *et al.*, 1980). The Cu requirements of the Weddell seal and other Antarctic seals might be high as those of the dugong, and high Fe accumulations in their liver might be caused by Cu-deficiency.

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