Bull. Environ. Contam. Toxicol. (1986) 37:213–218

Environmental Contamination and Toxicology

Metal Content in the Fur of Domestic and Experimental Animals

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Bird feathers and animal hairs accumulate various metals, and they have been used often as analytical materials for biological monitoring of essential and pollutant metals (Berg et al. 1966;Doi and Fukuyama 1983). The usefulness of those materials, however, is relatively limited probably owing to our insufficient knowledge on inter- and intra-species characteristics of metal accumulation in animals. The present report deals with the characteristics of metal accumulation in the fur of domestic and experimental animals.

MATERIALS AND METHODS

Materials were collected from domestic cats in Tokyo, Norway and the Philippines, stray dogs in Asahikawa City and 9 species of experimental animals, i.e. beagles, rabbits, goats, miniature pig, crab-eating monkey, guinea pigs, golden hamsters, rats and 4 strains of inbred mice (AKR/J, ddN, C3H/HeN and C58/J) in the Experimental Animal Center of Asahikawa Medical College. Fur was collected with an electric clipper from the back of large animals and from the whole body surface of small animals such as mice, golden hamsters and rats. Metal content in pork, porcine liver on the market and feeds for experimental animals was also determined.

Animal hair was washed once with 0.5% solution of Haemo-Sol(Haemo-Sol Inc.), rinsed thoroughly with tap water and distilled water, and then rinsed once with acetone. Analytical procedures were followed according to the method described in our previous report (Doi and Fukuyama 1983). Mercury was determined only as total mercury.

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RESULTS AND DISCUSSION

Metal content in the fur is shown in Figures 1 - 5.

Copper content in the fur of some stray dogs was extraordinarily higher than that of beagles (Fig 1 D and E). Various factors may be considered as the causes of high copper content in dog fur. Stray dogs may eat feed containing much more copper than pellet feed for beagles. Further, dogs are liable to exhibit copper toxicity because they have deficient copper metabolism owing to the molecular structure of their albumin which lacks the first binding site for Cu(II), i.e. histidine at the 3rd position from the N-terminal (Appleton and Sarkar 1971;Giroux and Schoun 1981).

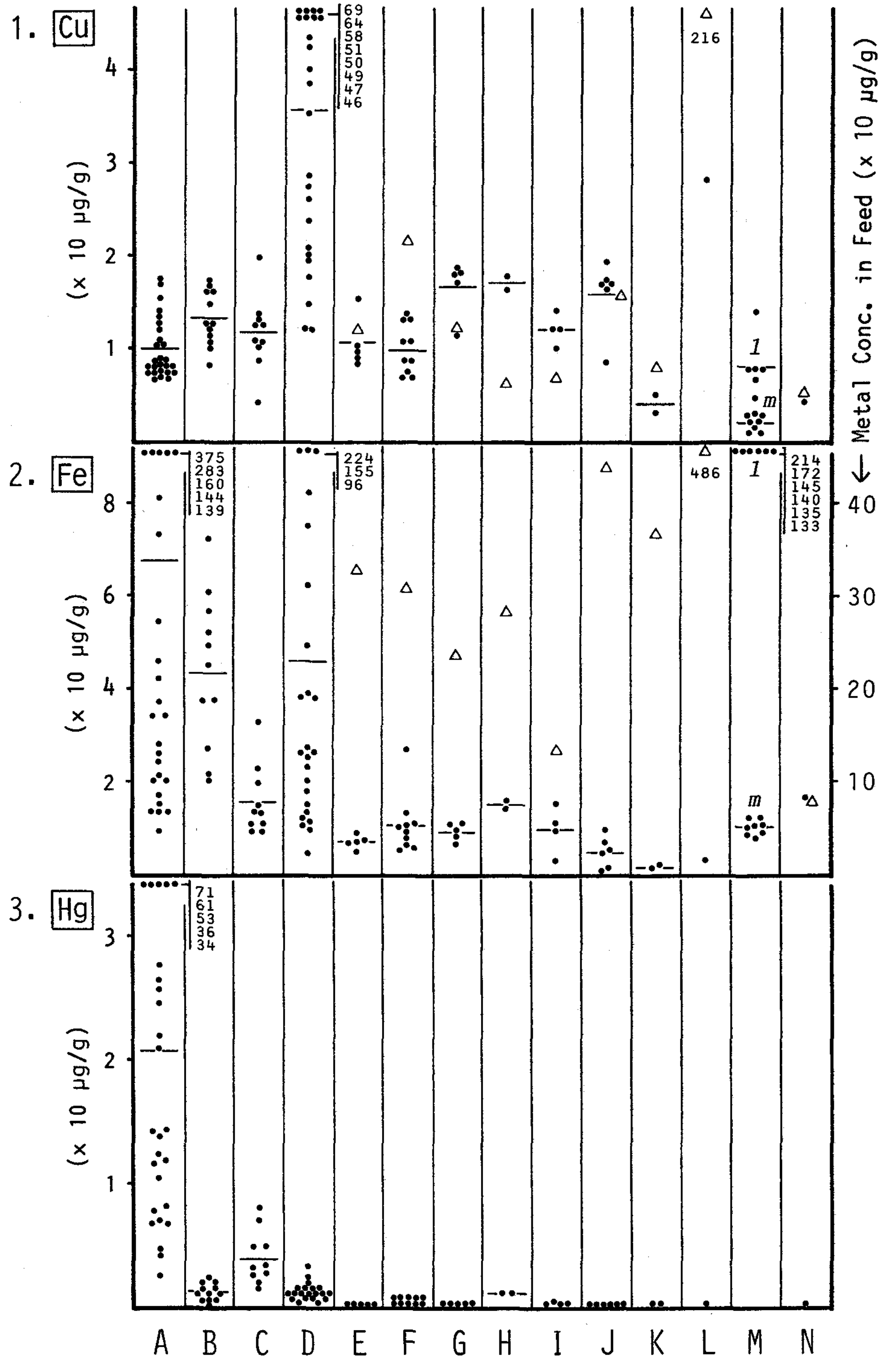
Copper concentration in the hair of a miniature pig was higher than that of other animals except for the stray dogs. The possibility of contamination cannot be neglected as the cause, since pig ration contains an extremely high concentration of copper. Usually copper is supplemented as $CuSO_4$ up to 250 ppm in pig rations to accelerate weight gain of pigs (Braude 1967). Iron as $FeSO_4$ and zinc as $ZnCO_3$ are also supplemented in pig rations for the sake of acceleration of weight gain.

Copper concentration in pork on the market was in the range 0.7 ppm to 2.9 ppm, and that of porcine liver was from 4.6 to 13.9 ppm. These values in pork and porcine liver are comparable to those of other species of animals (Underwood 1977).

No great difference was observed in the copper content of the fur of cats, beagles, guinea pigs and mice. Mean copper concentration in the fur of golden hamsters, rats and rabbits was significantly higher than those of cats, beagles, guinea pigs and mice at $p<0.05$, and about 4-fold higher than those of goats and a crab-eating monkey.

Iron content in the fur of cats in Tokyo and the Philippines and in the stray dogs was much higher than those of experimental animals. Iron content in the fur of Norwegian cats was significantly lower than those of Tokyo and Philippine cats. It was not elucidated in this study whether or not this was owing to external contamination. No significant difference was found between iron content in the fur of experimental animals. There was no great difference in iron content in the feeds of 7 experimental animals, with the exception of those for rabbits and pigs which contained 3 times the concentration of iron than that for mice.

Mercury was found at extremely high concentrations in



1. Cu
2. Fe
3. Hg
(x 10 μg/g)
(x 10 μg/g)
(x 10 μg/g)
← Metal Conc. in Feed (x 10 μg/g)
69 64 58 51 50 49 47 46
216
375 283 160 144 139
224 155 96
486
214 172 145 140 135 133
71 61 53 36 34
A B C D E F G H I J K L M N

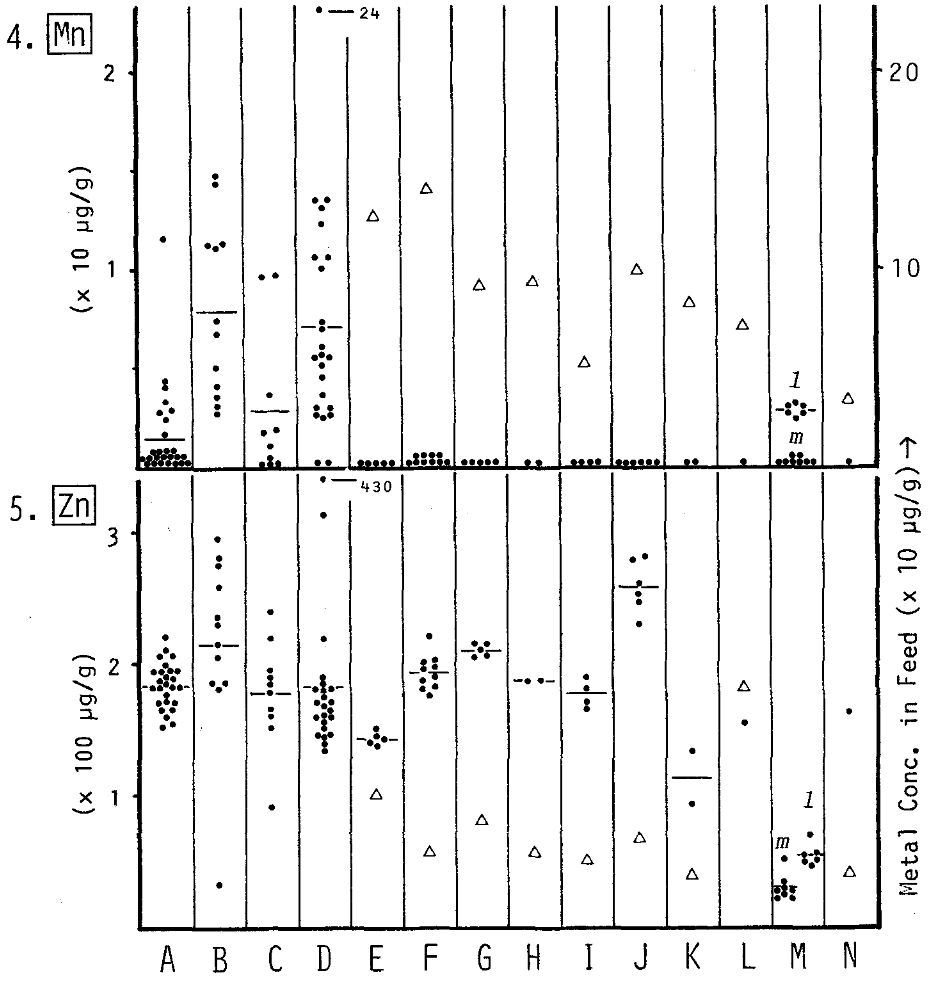


Figure 1 - 5. Metal content in the fur of domestic and experimental animals.

A: cat (Japan), B: cat (Philippine), C: cat (Norway), D: stray dog, E: beagle, F: guinea pig, G: golden hamster, H: rat, I: mouse, J: rabbit, K: goat, L: miniature pig, M: porcine meat (*m*) and liver (*l*), N: crab-eating monkey, △: metal content in feed.

the fur of cats in Tokyo compared to that of cats from the Philippines and Norway and those of the other animals. Fur of Norwegian cats contained about 2 times the concentration of mercury than that of Philippine cats. No significant difference was found in mercury content of the fur of all other species. Mercury was under the detectable limit of analysis in all feeds for experimental animals. High mercury content in the fur of cats in Tokyo is considered to be due to their large consumption of fish and fish products. A long-estab-

Table 1. Correlation coefficients (r) for metal concentrations in the fur of cats, dogs and guinea pigs.

	Cu	Fe	Hg	Mn	Cu	Fe	Hg	Mn
	[Japanese cats]				[Philippine cats]			
Fe	0.149				0.310			
Hg	-0.032	0.063			-0.456	-0.150		
Mn	-0.013	-0.014	0.024		0.157	0.169	0.373	
Zn	0.344	0.406*	0.249	0.042	0.721*	0.487	-0.135	0.284
	[Norwegian cats]				[Stray dogs]			
Fe	0.102				-0.021			
Hg	-0.008	0.696*			0.113	0.260		
Mn	0.439	-0.215	-0.507		0.122	0.500*	0.089	
Zn	0.852*	0.464	0.225	0.313	0.075	-0.047	-0.046	0.011
	[Guinea pigs]							
Fe	0.653*							
Hg	0.188	0.133						
Zn	0.539	0.386	0.268					

* $p < 0.05$

lished custom to feed cats with scraps of cooked fish is probably the largest cause of high mercury content in the fur of cats in not only Tokyo but also all over Japan. Recently city cats are being fed with canned tuna in multistoried apartment buildings in large cities in Japan.

Manganese in the fur was below the detectable limit of analysis except in cats and stray dogs. Mean manganese content was higher in the fur of stray dogs than in Tokyo and Norwegian cats. No great difference was found in manganese content in the feed for experimental animals. Manganese level was higher in the pork than in the porcine liver.

Zinc content in the fur showed no significant difference among cats, stray dogs, guinea pigs, golden hamsters, rats, mice, a miniature pig and a crab-eating monkey. Rabbits showed the highest mean zinc concentration among 10 species, and goats the lowest. Zinc content in the fur of beagles was lower than that of stray dogs, though the difference was not significant. Zinc concentration in the feed was highest in pig ration owing to zinc supplementation. Porcine liver contained a little higher concentration of zinc than pork.

Correlation coefficients for metals in the fur are shown in Table 1. It is interesting that the pattern of correlation are different between species.

Interspecies difference of metal content in the fur may be due to various factors such as external contamination, species differences in metal metabolism, difference of metal concentration in the feed and overlapping of these factors. Effects of age, sex and physiological condition on the organ distribution and metabolism of metals have been reported by various investigators (Nordberg et al. 1979). Further investigations will be necessary to elucidate the cause of species differences in the distribution of metals.

Acknowledgements. We are grateful to members of the Japan Small Animal Veterinary Association for the collection of fur samples, and also to Mr. J. A. Sunley for correcting the manuscript.

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Received December 12, 1985; accepted December 16, 1985.