NOTE *Public Health*

Contents of Various Elements in the Organs of Seabirds Killed by an Oil Spill around Tsushima Island, Japan

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ABSTRACT. Twenty nine oil-soaked birds were collected from around the Coast of Tsushima Island. The contents of eight elements in the livers and kidneys of the birds were investigated. Statistically higher concentrations of vanadium and thallium in the liver and of titanium in the kidney were found in the birds that were found dead compared with those that died after rescued. A significant correlation ($r=0.695$, $P<0.01$) was observed only for the molybdenum content between the kidneys and livers from the birds found dead. Although the controls of the eight elements of birds investigated in the present study remain unexplained, some of lower concentration in rescued birds can be blamed on a decrease in food intake of birds. The relation between oil contamination and concentration of elements need to be further explored.

KEY WORDS: black-throated loons, heavy metal, oiled seabirds, Pacific loon, wild bird.

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Tsushima Island is located between Japan and the Korean Peninsula in the Japan Sea. It is an important area for the Japanese biota including avian species. In particular, this area is important as a staging post for various migratory wild birds, including seabirds. The presence of oil-affected wildlife has been reported recently in various areas of Japan [11]. According to the report of an investigation conducted by the Japanese Coast Guard, the number of cases of oil contamination in the sea around Japan is approximately 400 per year [11]. Furthermore, Oka [11] suggested that there is an exceptionally high incidence of damage to seabirds resulting from offshore oil contamination, especially in the winter season. Around Tsushima Island, many seabirds have also been killed as a result of an oil spill of unknown origin [13]. Most deaths took place in February and March [13], when seasonal winds carried the fossil oil to the coastal area of Tsushima Island.

It is thought that studies of oiled birds are important, because information about oiled birds will support provision of aid and care to them. Thus, interesting studies have described body conditions and provision of aid and care to these birds [2]. Furthermore, various substances, such as polycyclic aromatic hydrocarbons [12], have been used as indicators of oil contamination in wild birds. However, there are few reports describing the degree of contamination by elements, although it is well known that oil contains various elements [1, 9]. It is thought that various characteristics differ in birds found dead after oil contamination and birds that have been rescued. Thus, the concentrations of various elements in birds found dead and in rescued birds were compared in the present study, and the relationships among the element concentrations were investigated to understand the influence of oil on birds.

A total of 29 wild birds collected from Tsushima Island were used in the present study. The birds comprised 19 Pacific loons (*Gavia pacifica*; female, n=7; male, n=8; unknown, n=4), 2 black-throated loons (*Gavia arctica;* male, n=2), seven Gaviidae (female, n=2; male, n=4; unknown; n=1) individuals unidentifiable to the species level owing to oil contamination and one unknown species (male, n=1). Of these birds, 16 were killed by an oil spill around Tsushima Island in February 2006. A typical picture of birds contaminated by oil is shown in Fig. 1. Yellow oil was adhered to the feathers of the birds. There were few birds with oil covering the entire body, and almost all birds were contaminated by the partially adhered oil [13]. The birds beached on the shore

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were transported immediately to Tsushima Wildlife Conservation Center, an extra-departmental body of the Ministry of the Environment in Japan. At approximately the same time as the above accident, 13 oiled sea birds were rescued and taken to Tsushima Wildlife Conservation Center, but they died subsequently. As shown in Fig. 2, the birds were collected from various areas of Tsushima Island. Kidney and liver samples were isolated from the birds immediately and transported to our laboratory on ice. Each approximately 200 mg wet weight (wt.) sample was dried, weighed and digested. The standard addition methods were employed for the analysis, which was performed using inductively coupled plasma atomic emission spectrometry (ICP-AES, FTP08, Kleve Germany). The target elements for analysis were cadmium (Cd), copper (Cu), chromium (Cr), molybdenum (Mo), lithium (Li), titanium (Ti), thallium (Tl) and vanadium (V). The statistical analyses used in the present study were performed with the computer software packages Lotus 2001 (Lotus Development Cambridge, U.S.A.), Excel 2010 (Microsoft Corporation, Redmond, Washington, U.S.A.) and JMP (SAS Institute, Tokyo Japan). The concentrations of the elements are presented as mean values with the standard error of the mean (SEM). Significant differences in mean values were detected using the Student's *t*-test. The statistical significance of the correlation (Pearson's product-moment correlation coefficient) was tested using Excel add-in software (Esumi, Tokyo Japan).

Fig. 1. Picture of typical birds contaminated by oil. Tsushima Wildlife Conservation Center provided this picture [13].

The contents of the eight elements in the kidneys and livers obtained from the birds found dead and the rescued birds are shown in Tables 1 and 2, respectively. The mean concentrations of the eight elements in the liver showed higher tendencies in the birds found dead that in those that died after rescue, with the difference statistically significant for V and Tl, while in the kidney, only the concentration of Ti was significantly higher in the birds found dead. The lower concentration in rescued birds can be blamed in part on the decrease in food intake of the birds. A significant correlation ($r=0.695$, $P<0.01$) was observed only for the Mo content between the liver and the kidney from the birds found dead. The concentrations of the elements in the present sample (found dead or died after rescue) were comparable to those reported in normal birds [5–8, 10, 14]. Reportedly, crude oil generally contains V, Ni and Fe in the range of several to tens of ppm [1], and it is well known that the several elements such as Cd, Cu and mercury, in birds that live on the open ocean

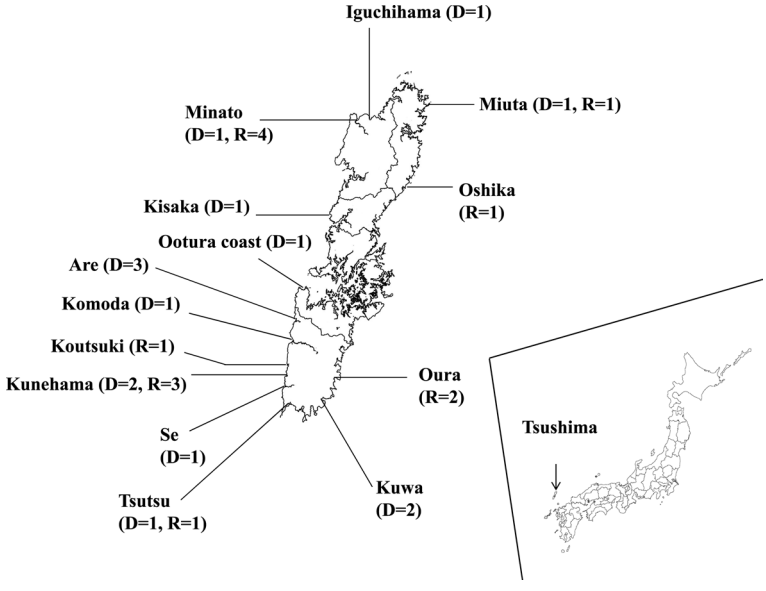

Fig. 2. The sampling areas used in the present study. D, number of birds found dead; R; number of rescued birds; the sampling area of one bird was unknown.

Table 1. The element contents (μg/g dry wt.) in the kidneys of birds found dead and in rescued birds. ND: not detectable

Kidney	n	Cd	Cr	Cu	Li	Mo	Ti	Tl	V
Birds found dead									
Pacific loon	8	25.19 ± 2.65	5.24 ± 0.49	24.06 ± 2.98	5.44 ± 0.57	7.43 ± 0.73	3.75 ± 0.35	11.30 ± 1.20	4.62 ± 0.56
Black-throated loon	1	8.30	2.65	28.87	2.77	6.23	2.73	ND	2.28
Gaviidae	6	18.56 ± 3.32	2.84 ± 0.63	27.23 ± 4.57	3.21 ± 0.79	7.75 ± 1.10	2.46 ± 0.50	7.57 ± 1.56	2.97 ± 0.81
Total	15	21.41 ± 2.25	4.11 ± 0.48	25.65 ± 2.36	4.37 ± 0.52	7.48 ± 0.57	3.16 ± 0.31*	9.06 ± 1.43	3.80 ± 0.48
Rescued birds									
Pacific loon	8	25.25 ± 2.78	2.89 ± 0.55	27.15 ± 5.17	2.97 ± 0.70	7.07 ± 0.63	1.85 ± 0.46	8.00 ± 1.46	2.61 ± 0.54
Black-throated loon	1	25.53	2.86	21.46	2.74	9.93	2.17	4.56	3.48
Unknown	1	31.99	4.30	42.55	4.56	7.11	3.78	5.62	4.15
Total	10	25.95 ± 2.29	3.03 ± 0.46	28.12 ± 4.42	3.10 ± 0.58	7.36 ± 0.58	2.08 ± 0.41	7.41 ± 1.22	2.85 ± 0.46

*P<0.05.

Table 2. The element contents (μg/g dry wt.) in the liver of birds found dead and rescued birds

Liver	n	Cd	Cr	Cu	Li	Mo	Ti	Tl	V
Birds found dead									
Pacific loon	8	7.81 ± 0.88	6.16 ± 0.64	50.64 ± 12.60	7.09 ± 1.44	8.81 ± 0.93	3.66 ± 0.58	21.62 ± 4.12	6.74 ± 1.22
Black- throated loon	1	5.75	8.15	64.44	13.57	12.00	6.23	29.53	11.26
Gaviidae	7	6.34 ± 1.42	4.81 ± 0.59	61.01 ± 14.75	5.60 ± 1.06	10.68 ± 2.70	2.48 ± 0.37	18.94 ± 4.18	6.04 ± 1.26
Total	16	7.04 ± 0.76	5.69 ± 0.46	56.04 ± 8.78	6.84 ± 0.96	9.83 ± 1.25	3.30 ± 0.40	20.94 ± 2.73*	6.72 ± 0.85*
Rescued birds									
Pacific loon	10	5.49 ± 0.84	4.70 ± 0.41	47.36 ± 8.66	4.76 ± 0.93	7.42 ± 0.91	2.64 ± 0.44	13.48 ± 1.93	4.68 ± 0.88
Black- throated loon	1	3.10	3.70	21.96	3.44	4.35	2.04	6.72	2.47
Unknown	1	5.34	2.24	46.91	0.72	4.14	0.35	5.05	1.60
Total	12	5.28 ± 0.72	4.41 ± 0.40	45.20 ± 7.45	4.32 ± 0.84	6.89 ± 0.83	2.40 ± 0.41	12.22 ± 1.81	4.24 ± 0.79

*P<0.05.

are higher than in birds that live in littoral regions [3, 4]. Thus, the concentration of elements in the oiled loons in the present study may largely reflect their habitat environment or their feeding habitat, because the loon is a carnivorous bird. The results suggesting that the deaths of the oil-soaked bird may not be due to absorption of oil would be helpful not only for clarifying the mode of death but also for treatment of the oil-soaked birds.

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