Acute Oral Toxicity and Tissue Residues of Thallium Sulfate in Golden Eagles, *Aquila Chrysaetos*

by JERRY R. BEAN and RICK H. HUDSON
U.S. Fish and Wildlife Service
Wildlife Research Center
Building 16, Denver Federal Center
Denver, Colorado 80225

Thallium sulfate (Tl_2SO_4) has been used as a poison to control predators and rodents and as a household insecticide (MERCK INDEX 1968; FARM CHEMICALS HANDBOOK 1973). Its use in the environment poses both primary and secondary poisoning hazards to raptors and other predatory wildlife (CRABTREE 1962; ROBINSON 1948). However, we know of no data on its toxicity to raptors or on body residues in exposed birds. We have dosed three golden eagles (Aquila chrysaetos) with thallium sulfate and measured residues of the chemical in tissues of two of them. Our information, though meager, is being reported because it gives toxicity and residue levels that may assist in assessing the hazards of thallium sulfate and indicates residue levels that can be expected in birds poisoned by a single exposure.

ACUTE TOXICITY

This study made use of three immature eagles whose physical condition prevented complete rehabilitation, making them unsuitable for release to the wild or for zoo specimens. After being fasted for 3 days, the eagles were given a single dose of thallium sulfate in a gelatin capsule inserted through glass tubing to the level of the proventriculus. Bird 1 (2.8 kg) was given 60 mg/kg; birds 2 (3.2 kg) and 3 (4.6 kg), 120 mg/kg. About 2 hours after treatment the birds were offered fresh food.

Bird 1 survived, and birds 2 and 3 died, suggesting that the acute oral LD_{50} lies between 60 and 120 mg/kg. Clinical signs of intoxication appeared the day after treatment and included, in approximate order of appearance, loss of muscular coordination, imbalance, reluctance to move, hyporeactivity, loss of appetite, belligerence, fear-threat displays, falling, debilitation, loss of righting reflex, drooping of the eyelid, distress calls, slow and labored breathing, and immobility. In birds 2 and 3, these signs increased in severity until death at 6-1/2 and 4-1/2 days after treatment; in bird 1, remission occurred by 4 days.

Bulletin of Environmental Contamination & Toxicology,
Vol. 15, No. 1 © 1976 by Springer-Verlag New York Inc.

Birds 2 and 3 lost an average of 620 g of body weight before death; bird 1, which was observed for 21 days before being released to a holding pen, had gained 100 g by the end of the observation period.

RESIDUE ANALYSES

Tissues of birds 2 and 3, and the feces from bird 3, were analyzed for thallium (Tl_2) by the atomic-absorption spectrophotometric method of CURRY et al. (1969). This is a relatively rapid and simple method that, as used, easily detected as little as 1 part per million (ppm). The equivalent amount of thallium sulfate was calculated by multiplying the concentration of thallium (ppm) found in each tissue by 1.235 (the ratio between the molecular weights of Tl_2SO_4 and Tl_2). The residue results, except for the fecal values, are presented in Table I. The total amount of Tl_2SO_4 recovered from the feces of bird 3 during the time between treatment and death (4-1/2 days) was 12.5 mg. Most of this residue in the feces (65%) appeared within 24 hours after treatment.

DISCUSSION

In an attempt to measure the absorption of thallium, we calculated the recovery of thallium sulfate from bird 3 (unfortunately, the organs from bird 2 were not weighed). From the work of STURKIE (1965), we conservatively assumed that blood constituted 5% of the body weight, so subtracted this weight and the organ weights from the terminal body weight. The recovery of thallium from the organs and blood was calculated using individual organ weights and the calculated blood weight. The breast muscle concentration was used to calculate the remaining body burden, since the total skeletal weight was not available. (However, if all bone were as high in residues as the sternum, excluding it will cause this recovery estimate to be conservative.) Using these assumptions, we calculated a total of 435 mg thallium sulfate recovered from the body. With the 12.5 mg recovered from the feces, this constitutes a total recovery of 448 mg of the 556 mg administered. This 80% recovery of thallium sulfate indicates considerable absorption and a slow rate of excretion during the 4-1/2 days before death in this individual.

TABLE I

Thallium residues (wet weight) in two golden eagles that died from a single oral dose of 120 mg/kg thallium sulfate.

	Thallium (ppm)		Equivalent thallium sulfate	
Tissue	Bird 2	Bird 3	Bird 2	Bird 3
Brain	22	26	27	33
Liver	26	47	32	58
Kidney	39	104	48	128
Heart	32	51	40	63
Lung	NA*	22	NA	27
G.I. Tract	36	43	44	53
Blood	30	21	37	26
Breast Muscle	172	96	212	118
Sternum	122	170	151	210
Feathers	3	NA	4	NA

*NA = Not analyzed.

CROMARTIE et al. (In Press) analyzed the kidneys from nine bald eagles (Halliaetus luecocephalus) suspected of having been poisoned by thallium sulfate. Thallium residues in eight of these, collected during May 1971 in Wyoming, ranged from 14 to 59 ppm. The other one, from Utah, contained 63 ppm. W. L. Reichel (Patuxent Wildlife Research Center, personal communication) analyzed the kidneys from five golden eagles collected in Wyoming during May 1971 finding from 21 to 152 ppm thallium, while a liver from one other had 67 ppm. From the data we present, these levels could be indicative of thallium poisoning.

ACKNOWLEDGEMENTS

We appreciate the valuable assistance of coworker William H. Robison, who performed the chemical analyses.

REFERENCES

CRABTREE, D. G.: Vertebrate Pest Control Conf. Proc. 1, 327 (1962).

CROMARTIE, E., W. L. REICHEL, L. N. LOCKE, A. A. BELISLE, T. E. KAISER, T. G. LAMONT, B. M. MULHERN, R. M. PROUTY, and D. M. SWINEFORD: Pestic. Monit. J. (In Press).

CURRY, A. S., J. F. READ, and A. R. KNOTT: Analyst 94, 744 (1969).

FARM CHEMICALS HANDBOOK: G. L. Berg, Ed. Willoughby, Ohio: Meister Publishing Co. (1973).

MERCK INDEX: 8th ed. P. G. Stecher, Ed. Rahway, N.J.: Merck and Co., Inc. (1968).

ROBINSON, W. B.: J. Wildl. Manage. 12, 279 (1948).

STURKIE, P. D.: Avian physiology. 2 ed. Ithaca, New York: Comstock Publishing Associates 1965.