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Mineral Content of Canada Goose Eggs and Implications for Environmental Surveillance Along the Columbia River

Abstract

Historically the main stem Columbia River has been relatively free from direct releases of man-induced mineral elements from industrial facilities. Eggs taken from deserted Canada goose nests from islands in the Hanford Reach of the Columbia River were chemically analyzed for an array of essential mineral nutrients as well as potentially toxic elements. These data provide new information concerning the mineral concentrations of soft parts of Canada goose eggs. Eggs are especially useful for environmental surveillance purposes because killing of birds is not required and eggs are available year after year. Mineral analyses are especially important at this time if changes in mineral concentrations in future years are to be detected following the addition of new industrial facilities along the Columbia that could introduce metals to terrestrial and aquatic ecosystems as airborne or liquid effluent releases.

Introduction

Canada Geese, *Branta canadensis moffiti*, have maintained a small breeding population along the undammed Columbia River in southeastern Washington since the late 1940's (DeWaard 1981, Hanson and Eberhardt 1971) during an era when historical island nesting sites have steadily diminished with the construction of large hydroelectric dams on the Columbia and Snake Rivers (Gibson and Buss 1977, Ball *et al.* 1981). The Hanford Site, a 1400 km^2 area of mostly undeveloped sagebrush land, was established by the federal government in 1943 to provide an isolated location for the production and processing of plutonium. As a part of the Hanford site biological resource and wildlife surveillance programs, an annual census of goose nests on 20 riverine islands has been performed since 1953 (Rickard *et al.* 1982).

For 20 years plutonium production reactors located on the shore of the Columbia River used its water as a coolant. Heated water was returned to the river along with burdens of radioactive phosphorus, radioactive zinc and other radionuclides. Zinc-65 and ^{32}P was easily measured in the tissues of migrating ducks and geese that used the Hanford Reach of the Columbia River in autumn and winter (Hanson and Case 1963). Following the closure of eight of the production reactors in the 1970's, goose eggs from the Hanford Reach had low concentrations of radiocesium and radiostrontium derived from global fallout (Rickard and Sweany 1977). Zinc-65 and ^{32}P had disappeared due to river flushing and radioactive decay (Cushing *et al.* 1981).

The purpose of this article is to present data concerning stable (non-radioactive)

mineral element concentrations of goose eggs collected as available from deserted goose nests on islands in the Hanford Reach of the Columbia River on 15 April 1980, one month before the eruption of Mount St. Helens which deposited massive amounts of mineral rich tephra in a wide zone across eastern Washington and muddied the usually clear Columbia River in the Hanford Reach for more than a week.

Methods

Eggs were taken from deserted goose nests on islands numbers 11, 12, 15, 17, and 19 in the Columbia River near Richland, Washington (Figure 1). The egg shells were removed and the inner contents freeze-dried preparatory to elemental analyses. The freeze-dried material was digested in a mixture of nitric and perchloric acid. Lead, copper, and chromium were determined by graphite furnace atomic absorption spectroscopy; selenium by hydride generation, sulfur by Leco induction furnace; and aluminum, calcium, iron, magnesium, manganese, nickel, phosphate, potassium, barium, strontium, sodium, and zinc by inductive coupled argon plasma spectroscopy. Results are expressed as parts per million dry weight.

Results and Discussion

Phosphorus, sulfur, and sodium were the most abundant elements in goose eggs followed by calcium, potassium, and magnesium. Calcium concentrations were higher in eggs from certain clutches taken from islands 17 and 19 with values ranging from 4400-6600 ppm as compared to values ranging from 2200 to 4000 for upstream islands. This can probably be attributed to differences in embryo development stage because the elevated levels were associated with the most advanced embryo stages.

Eggs collected from island 17 had about the same levels of trace elements Cu, Zn, Mn, and Se as compared to eggs taken from islands 11, 12, 15, and 19 (Table 1). Eggs from two of three clutches from island 17 had enhanced levels of Al, Ni, and Cr but Pb levels were only marginally elevated (Table 1). One egg from a single clutch from island 19 also had enhanced levels of these same elements. Island 17 is located within one kilometer of a uranium fuel fabrication facility located on the western bank of the Columbia River (Figure 1) and island 19 is located several km downstream. Leaching ponds located near the western shore of the Columbia River have received liquid effluents and slurry generated during 40 years of fabrication of uranium fuel. These ponds may be the source of enhanced levels of Al, Ni, and Cr in Canada Goose eggs as these materials are abundantly used in fuel fabrication. It is also possible that these values are well within the normal range of mineral concentrations for goose eggs, but no published information for comparison purposes was found.

Goose nesting along the Hanford Reach begins in early March (Hanson and Eberhardt 1971). Nesting geese provide a natural population that can be used as an indicator of biologically available metal contamination in their foraging environment. In order for female geese to obtain body burdens of metals for transfer to eggs, a metal source needs to be present before and possibly throughout the spring egg-laying season. This source could be either green plants or soil particles externally attached to plants. It seems likely that nesting geese would not travel great distances in search of food if green forage plants were available near their nest islands. Green forage plants are available all along the shore of the Columbia River and also on the shorelines of the islands.

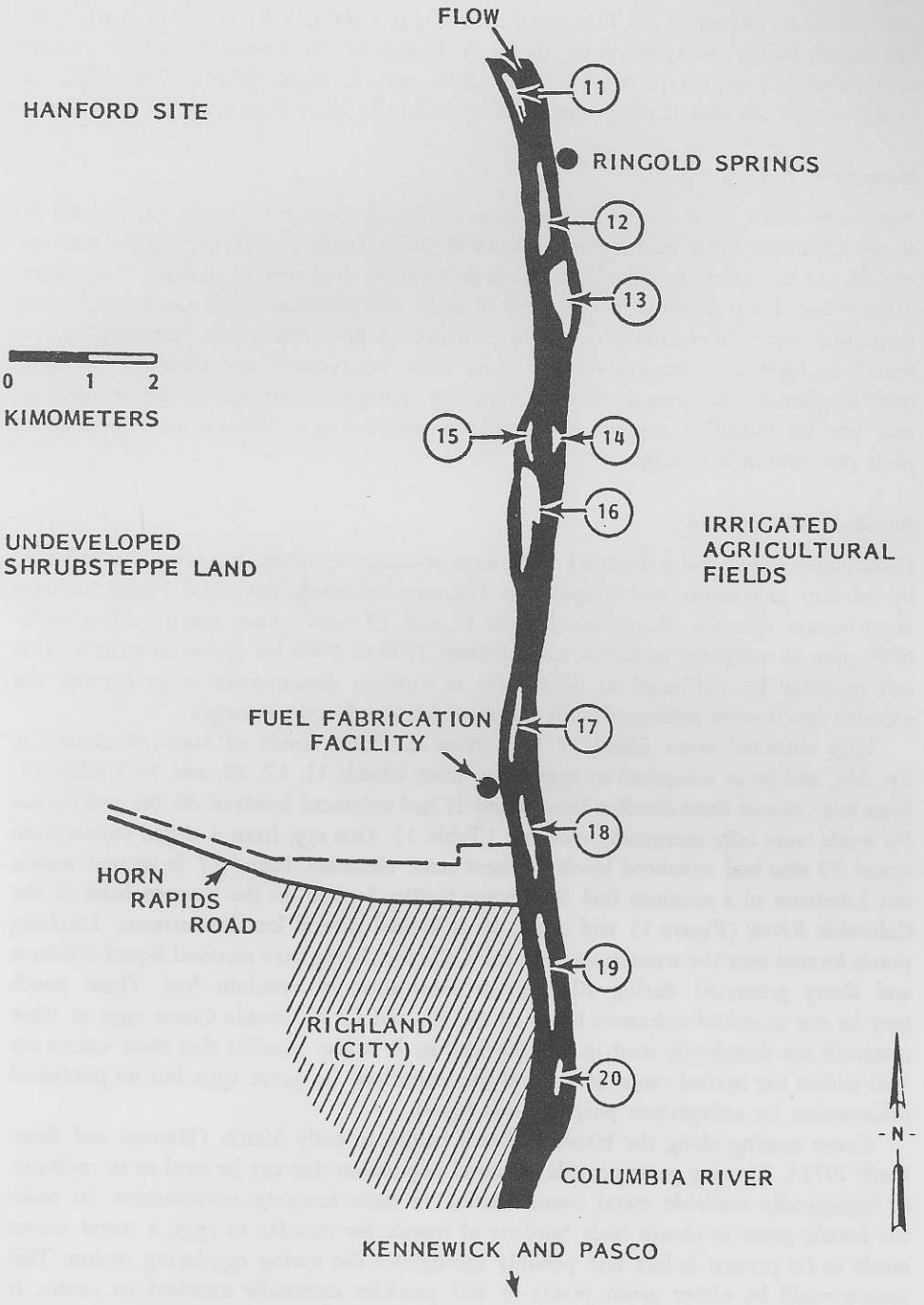

Figure 1. Map showing the Columbia River and goose nesting islands with identification numbers and the location of the fuel fabrication facility on the U.S. Department of Energy's Hanford Site.

TABLE 1. Range of mineral elements (ppm dry wt.) in Canada goose eggs collected from deserted nests on five island numbers 11, 12, 15, 17, and 19 on the Hanford Reach of the Columbia River arranged from upstream to downstream. Values under the lines are from the same clutch.

	11	12	15	17		19
	5 Eggs	3 Eggs	2 Eggs	2 Eggs	1 Egg	1 Egg	1 Egg
Se	0.45-0.60	0.25-0.80	0.35-0.35	0.45-0.60	0.60	0.75	0.50
Mn	1.8-2.0	1.0-1.2	1.0-1.0	3.8-4.7	2.2	2.5	1.9
Cu	3.6-5.0	3.6-3.8	3.8-4.1	4.2-4.3	4.5	3.2	4.3
Zn	47-49	47-57	46-50	55-56	52	51	49
Pb	0.80-0.90	0.68-0.90	0.93-1.0	1.5-1.7	0.93	1.2	1.5
Cr	0.50-0.20	<0.05-0.10	<0.05-0.25	1.5-3.2	3.95	0.65	3.7
Ni	<1.3	<1.3	<1.3	16-25	14	<1.3	7.9
Al	<8-15	<8-10	<8	43-118	58	<8	294
Fe	99-115	85-107	92-103	156-156	140	116	106
Sr	1.7-2.5	3.9-4.4	2.6-2.8	4.8-5.1	3.4	3.1	4.9
Ba	3.9-7.8	5.8-6.6	5.6-6.6	4.8-7.1	8.0	6.2	9.1
Ca	2200-3300	2900-4100	3400-4000	4400-4800	4800	2300	6600
Mg	390-480	400-470	360-380	440-490	520	500	450
PO_4	21000-23000	23000-24000	22000-23000	24000-25000	24000	21000	23000
S	5500-6800	4600-6100	5000-5400	4600-4600	7800	5300	5400
K	2900-3400	3600-4100	3100-3600	3500-3500	3800	3500	3500
Na	3800-4300	4000-4300	3600-3700	4400-4500	4200	4000	4100

Leakage from the retention ponds has reached the shoreline of the Columbia River but there are no measurements of mineral concentrations in shoreline vegetation as most of the environmental surveillance associated with the Hanford Site has been concerned with radionuclides rather than stable elements.

Historically the Hanford Reach of the Columbia River and its shoreline environment has been relatively free from industrially induced metals in comparison to streams in northern Idaho, for example, where mining and/or smelting has been practiced for a century or more. Fish scraps and feces collected from heron nests on the Hanford Reach showed relatively low amounts of Cd, Pb, and Hg as compared to heron debris collected at Lake Chatcolet in northern Idaho (Fitzner *et al.* 1982).

Most studies of waterfowl and mineral elements have been concerned with measurement of specific toxic elements in body tissues and determining the amount of material required to cause mortality (Alder 1944, Bellrose 1959, Chupp and Dalke 1964, Longcore *et al.* 1974, Stendell 1980).

Goose eggs taken from the Umatilla National Wildlife Refuge located downriver from the Hanford Reach had high levels of heptachlor (Blus *et al.* 1979). Heptachlor is used as an insecticide treatment for winter wheat prior to planting in the fall. These data show the potential for parent birds to transfer the organic chemical compounds to eggs and to embryos.

Our preliminary study relied on taking egg samples as available because we did not wish to impose additional mortality on a goose population that had declined from 300 nesting pairs in the early 1950's to about 150 nesting pairs in the 1980's (Ball *et al.* 1981).

Collecting eggs from abandoned goose nests is a practical way to monitor an important wildlife species for metals like mercury that can be passed from the parent birds to eggs (Stendell, 1977). Eggs are especially useful for surveillance purposes be-

cause birds of high esthetic and recreational value need not be killed to obtain samples suitable for chemical analyses, and eggs can be obtained year after year.

It is likely that in future years the Columbia Basin will receive inputs of trace elements from coal combustion plants producing electricity for a growing population and that various agricultural chemicals will be employed to sustain crop production. The only way to determine whether or not these environmental pollutants affect wildlife populations is to conduct environmental surveillance programs that include wildlife sampling and appropriate chemical measurements.

Acknowledgements

Support for this study was provided by the U.S. Department of Energy under Contract DE-AC06-76RL0 1830.

Literature Cited

Alder, F. E. W. 1944. Chemical analyses of organs from lead poisoned Canada geese. J. Wildl. Manage. 8:83-85.

Ball, I. J., E. L. Bowhay, and C. F. Yocom. 1981. Ecology and management of the western Canada goose in Washington. Wash. Dept. of Game, Biol. Bull. No. 17.

Bellrose, F. C. 1959. Lead poisoning as a mortality factor in waterfowl populations. Ill. Nat. History Surv. Bull. 27:235-288.

Blus, C. J., C. Henny, D. J. Lenhart, and E. Cromartie. 1979. Effects of heptachlor-treated cereal grains in Canada geese in the Columbia Basin. *In:* R. L. Jarvis and J. C. Bartonek (eds.), Management and Biology of Pacific Flyway Geese, pp. 115-116, Oregon State Univ. Book Stores, Inc., Corvallis, OR.

Chupp, N. R., and P. D. Dalke. 1964. Waterfowl mortality in the Coeur d'Alene River Valley, Idaho. J. Wildl. Manage. 28:692-702.

Cushing, C. E., D. G. Watson, A. J. Scott, and J. M. Gurtisen. 1981. Decrease of radionuclides in Columbia River biota following the closure of Hanford reactors. Health Physics 41:59-67.

DeWaard, B. K. 1981. Reproduction and ecology of Canada geese on the Hanford Reservation: 1953-1980. Wash. State Univ., Pullman. Thesis.

Fitzner, R. E., W. H. Rickard, and W. T. Hinds. 1982. Excrement from heron colonies for environmental assessment of toxic elements. Environ. Monit. and Assess. 1:383-386.

Gibson, L. W., and I. O. Buss. 1977. Reactions of Canada geese to reservoir impoundment on the Snake River in Washington. Northw. Sci. 47:301-318.

Hanson, W. C., and L. L. Eberhardt. 1971. A Columbia River goose population 1950-1970. Wildl. Monogr. 28.

———, and A. C. Case. 1963. A method of measuring waterfowl dispersion utilizing phosphorus-32 and zinc-65. *In:* V. Schultz and A. W. Klement (eds.). Radioecology, Proceedings of the First National Symposium in Radioecology held at Colorado State University, Fort Collins, CO. Sept. 10-15, 1961. Reinhold Publishing Corp., N.Y. Pp. 451-454.

Longcore, J. R., L. N. Locke, G. E. Bagley, and R. Andrews. 1974. Significance of lead residues in mallard tissues. U.S. Fish and Wildl. Service Special Report Wildl. 182.

Rickard, W. H., W. C. Hanson, and R. E. Fitzner. 1982. The non-fisheries biological resources of the Hanford Reach of the Columbia River. Northw. Sci. 56:62-76.

———, and H. A. Sweany. 1977. Radionuclides in Canada goose eggs *In:* R. E. Wildung and H. Drucker (eds.). Biology Implications of Metals in the Environment. CONF-750929. TIC Oak Ridge, TN. 623-627.

Stendell, R. C. 1980. Lead residues in Sora Rails from Maryland. J. Wildl. Manage. 44:525-526.

———, E. Cromartie, S. N. Wiemeyer, and J. R. Longcore. 1977. Organochlorine and mercury residues in canvasback duck eggs, 1972-73. J. Wildl. Manage. 41:453-457.