MOOSE MILK AND HAIR ELEMENT LEVELS AND RELATIONSHIPS 1

Author: FRANZMANN, ALBERT W.

Source: Journal of Wildlife Diseases, 12(2) : 202-207

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-12.2.202

MOOSE MILK AND HAIR ELEMENT LEVELS AND RELATIONSHIPS[1]

ALBERT W. FRANZMANN, Kenai Moose Research Center, Alaska Department of Fish and Game, Soldotna, Alaska 99669, USA

ARTHUR FLYNN, Case Western Reserve University School of Medicine, Cleveland, Ohio, USA

PAUL D. ARNESON, Kenai Moose Research Center, Alaska Department of Fish and Game, Soldotna, Alaska 99669, USA

Abstract: Milk was collected from 21 Alaskan moose (*Alces alces gigas*) at the Kenai Moose Research Center (MRC), Soldotna, Alaska and analyzed by atomic absorption spectroscopy for Al, As, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, Pb, Se and Zn. Hair samples were collected from 100 moose at the MRC to correspond with the lactation period and serve as a metabolic indicator of mineral elements stored in tissue. Published analyses of bovine milk were compared to moose milk; Al, Fe, Se and Zn were higher in moose milk by factors of 1.6 to 290. Elements potentially influenced by nutrition and those determined genetically were also considered. Elements in moose milk and hair values were compared, since mineral element levels in hair potentially reflect the availability and intake of these elements. Calcium and Mg were the only values in hair lower than the values in milk (factors of 4.2 and 1.5 respectively). Moose, as well as domestic cattle, apparently are subjected to lactation stress by the genetically determined levels of Ca and Mg in milk.

INTRODUCTION

One aspect of studies at the Kenai Moose Research Center (MRC), Soldotna, Alaska was to monitor mineral metabolism in moose. Tissues from moose, as well as forage, soil and water from the study area have been analyzed.[10] This paper reports the results of analyses of selected macro- and micro-elements in milk and compares this data with the values found in hair corresponding to the period of maximum lactation.

Gross composition, fatty acid content and mineral levels in moose milk (Ca, Fe, K, Mg, Na and P) have been reported for only three moose.[8] Mineral analyses were expressed as percent of ash and are not comparable to this study. We attempted to define some major and trace element nutrients of moose milk and their relationship to stored nutrients in the body tissues by using mineral element levels in hair as the indicator.

Mineral elements in moose hair have been analyzed for the past three years and marked seasonal rhythms occur for most elements.[10,11] During this study period changes in dietary mineral element quality was reflected in the moose hair. This method of sampling facilitates monitoring levels of macro- and micro-elements in body tissues. Comparison of mineral levels in hair with values in milk was made to indicate influences of genetic or nutritional stress in moose milk composition.

In domestic cattle, macro-element composition of milk (Ca, Cl, K, Mg, Na, P, S and Si) is largely determined by genetic factors; nutrition and other environmental factors have little effect.[16] Certain

[1] This work was supported, in part, by Federal Aid in Wildlife Restoration Projects W-17-R.

micro-elements (Al, B, Co, I, Mn, Mo and Zn), however, can be altered by nutrition, whereas concentrations of other elements can be varied minimally by environmental conditions.[16] Moose milk and hair were sampled from 1971 through 1974 in an effort to determine the characteristic qualities of moose milk and the influences of genetics and environment in the content of mineral elements.

MATERIALS AND METHODS

Study Area

Moose were sampled at the MRC, a cooperative project between the Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service, Kenai National Moose Range. The MRC consists of four 2.6 km^2 enclosures located in the area of a 1947 fire, 35 km northeast of Soldotna, Alaska. The MRC study area has been mapped according to vegetative types, and classified as to soil profiles of representative types. Twenty-two fenceline traps are strategically located (13 within and 9 outside the enclosures) to facilitate the capture and handling of moose.[18] The moose population within the enclosures, as of January, 1975, totalled 47 moose and consists of 27 adult females, 8 calves and 12 adult males.

Collection and Analysis of Samples

Twenty-one lactating moose were trapped, immobilized[9] and "milked" to obtain a minimum 5 ml sample. Posterior pituitary extract (10 U.S.P. units) was administered intravenously to some moose to stimulate milk release and facilitate "milking." Milk samples were frozen at —20 C in vials until analyzed.

Hair samples were obtained by plucking hair from the shoulder hump and placed in plastic containers[11] Hair values for mineral elements reflect dietary intake of moose on a delayed basis.[10] We therefore, utilized the mean hair values for August and September obtained during 1972, 1973 and 1974 to reflect intake of elements during the peak of lactation. Hair was washed twice with diethyl ether to remove surface particulate matter without leaching minerals from the hair structure. Two hundred milligrams of hair were digested in 10 ml of 24% methanolic tetramethyl ammonium hydroxide for two hrs at 55 C.[12] Milk samples were obtained primarily in June and July during 1971, 1972 and 1973, and were digested at room temperature with 24% tetramethyl ammonium hydroxide, using a 1:4 dilution (v/v). Milk and hair samples were analyzed by the Department of Surgery, Cleveland Metropolitan General Hospital, Case Western Reserve University School of Medicine, Cleveland, Ohio on a semi-automated Perkin-Elmer Model 503 spectrometer adapted for automated dilution with a Hamilton Precision Dispenser. Samples were analyzed by flame (Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Na, Pb and Zn),[3] electrically heated graphite furnace (Al, Mo, Mn, and Ni),[4] a flame volatilization methed (As and Se),[19] and a flameless volatilization technique (Hg).[22] Twelve milk samples were not analyzed for Cd, Hg, Pb, and Se. The 1972 and 1973 were not monitored for Al, As, Co, Cr, Hg, Mo, Ni and Se, but these elements were determined in August and September 1974.

RESULTS AND DISCUSSION

Levels of macro- and micro-elements in moose milk and hair are given in Tables 1 and 2 and compared with values reported for domestic cattle milk. Mineral element requirements for moose have not been established; therefore, the role of genetic or nutritional influences on milk levels is unknown. Comparisons made must be evaluated considering potential differences between species. A statistical test for differences between moose and bovine milk was not possible due to unavailability of raw data on bovine milk.

Moose and Bovine Milk Comparisons

The levels of Ca, K, Mg and Na in moose and bovine milk were comparable (Table 1). The levels of these elements in bovine milk are primarily genetically determined,[16] and we assume they are genetically determined for moose since no

TABLE 1. Macro-element values (ppm) of moose milk and hair with reported values of bovine milk and hair.

	Milk (n=21)				Hair (n=100)			
Element	$\bar{X}$	S.D.	Bovine Milk (ppm)	Reference	$\bar{X}$	S.D.	Bovine Hair (ppm)	Reference
Ca	1562.0	232.4	1240.0	15	371.3	230.5	1000	1
K	1006.0	85.4	1270.0	10	1324.3	662.1	220	1
Mg	192.8	22.7	114.0	10	133.8	59.9	260	1
Na	394.3	34.8	430.0	10	758.0	283.4	520	1

TABLE 2. Micro-element values (ppm) of moose milk and hair with reported values of bovine milk and hair.

	Milk (ppm)					Hair				
Element	N	$\bar{X}$	S.D.	Bovine Milk	Reference	N	$\bar{X}$	S.D.	Bovine Hair (ppm)	Reference
Al	21	1.24	0.5	0.5	3	40	1.67	0.34	—	
As	21	<0.05		0.03	10	40	<0.1	—	—	
Cd	9	0.06		0.015	12	98	1.51	1.03	—	
Co	21	<0.01		0.001	11	40	1.19	0.52	—	
Cr	21	<0.01		0.015	10	40	0.31	0.10	—	
Cu	21	2.90	1.28	0.01	11	100	9.77	3.95	7.6	1
Fe	21	3.12	1.25	0.5	11	100	48.06	14.83	35	1
Hg	9	<0.05		—	11	40	0.25	0.07	—	
Mn	21	<0.01		<0.1	11	100	1.68	1.59	2.3	1
Mo	21	<0.01		<0.1	11	40	0.68	0.17	0.1	1
Ni	21	<0.05		<0.025	2	40	0.46	0.15	—	
Pb	9	0.39		0.4	10	100	9.61	6.99	—	
Se	9	0.11		0.005-0.067	8	40	2.44	0.70	—	
Zn	21	6.23	2.34	3.9	10	100	79.09	20.48	105	1

major differences were discernable. The levels of As, Cd, Co, Cr, Hg, Mn, Mo and Ni were 0.1 ppm or less in both moose and cattle (Table 2). The mean value for Pb in moose milk was 0.39 ppm and 0.40 ppm in bovine milk. The differences between species for most of these micro-elements is negligible.

Aluminum, Co, Mn, Mo and Zn are potentially influenced by nutrition;[16] levels of Al and Zn in moose milk were higher by factors of 2.5 and 1.6, respectively than levels in bovine milk, suggesting the moose sampled had higher available levels of these elements in their diet. Copper, Fe and Se are not influenced nutritionally in cattle and were higher in moose by factors of 1.6 or more (Cu-290.1, Fe-6.2, Se-1.6 to 22). This, in turn, suggests that the genetic determinant for these elements in moose milk is greater than for cattle. Unfortunately, we do not have definitive data indicating that any of the elements in moose are nutritionally or genetically influenced.

All the elements analyzed are essential except As, Cd, Hg and Pb.[25] These elements are considered toxic and their presence in milk may reflect, to an unknown degree, their distribution in an area. We noted no difference in As and Pb between bovine and moose milk samples. Cadmium levels in moose milk were higher than in bovine, but there was less than 1 ppm in samples from either species. A high level of Cd intake in cows produced no greater than 1 ppm levels in milk with less than 0.02% of the extra cadmium given appearing in milk.[20] No values for Hg in bovine milk were available for comparison.

Moose and Bovine Hair Comparisons

Numerous studies on animals and humans have demonstrated the effectiveness of hair to monitor intake of mineral elements. Only two of the 18 elements (Fe and K) analyzed in hair in this study are independent of dietary intake. Seven elements in bovine hair (Ca, Co, Mg, Mn, Mo, Na, and Zn),[1,21] one in deer (Cu),[26] and three toxic elements in man (As, Hg and Pb)[7,22,23] have significant positive correlations between dietary or environmental intake and hair values. There are no comparisons available for five elements (Al, Cd, Cr, Ni and Se) measured in moose hair.

Tables 1 and 2 compare bovine and moose hair values at approximately the same time of the year. Calcium and Mg levels in bovine hair are higher by factors of 2.7 and 1.4, respectively, than in moose hair; K and Na are lower, by factors of 6.0 and 0.46, respectively, than in moose hair. Comparable data on hair is available for only Cu, Fe, Mn, Mo and Zn in the moose hair. Copper, Fe and Mo were lower in the bovine hair (factors of 0.29, 0.37 and 6.8) whereas Mn and Zn were higher (factors of 1.4 and 13.) when seasonally compared with moose hair. The differences in the range of elemental values are greater for hair than for milk comparisons between the two ruminant species.

Moose Milk and Hair Comparisons

The mean values for elements in moose hair in August and September of 1972, 1973 and 1974 are listed in Tables 1 and 2. The seasonal changes the values in moose hair reflect the availability and intake of these elements on a 1 to 2 month delayed basis.[10,11] Hair sampled during these months reflects intake during the peak of lactation and milk sampling (June and July).

The levels of Ca and Mg were lower in hair than in milk. Calcium was lower by a factor of 4.2 and Mg by a factor of 1.5. Both elements are essential, and both are macro-elements. We were not concerned with hair values that were higher than milk values since those elements were potentially available at adequate levels, assuming levels in moose hair and moose tissue are consistent for each element Nevertheless, it is important to note that Ca and Mg levels are much lower in hair than milk and, therefore, may not be available at an adequate intake level during lactation. It may be necessary for moose to draw on body reserves, particularly bone, to maintain apparent genetically determined milk levels of Ca and

Mg. Ninety-nine percent of body Ca is found in bones and teeth and 70 percent of Mg in the animal body is in bone.[14]

The two common diseases in lactating dairy cattle related to Ca and Mg metabolism (milk fever-hypocalcemia and grass tetany-hypomagnesemia)[14] have not been observed in moose. However, apparently moose, as well as cattle, are potentially subjected to additional stress during lactation by genetically determined milk levels of Ca and Mg.

Acknowledgements

The authors wish to express their appreciation to R. A. Rausch, R. E. LeResche, and D. C. Johnson who assisted in collecting several milk samples and to K. B. Schneider and D. M. McKnight who read this manuscript and provided assistance throughout the study.

LITERATURE CITED

1. ANKE, M. 1965. Der Mengen- und Spurenelementgehalt des Rinderhaares als Indikator der Calcium-, Magnesium-, Phosphor-, Kalium-, Natrium-, Eisen-, Zink-, Mangan-, Kupfer-, Molybdän-, und Kobaltversorgung, II. Archiv Für Tierernährung 15: 469-485.
2 ————. 1966. Der Mengen- und Spurenelementgehalt des Rinderhaares als Indikator der Calcium-, Magnesium-, Phosphor-, Kalium-, Natrium-, Eisen-, Zink-, Mangan-, Kupfer-, Molybdän-, und Kobaltversorgung, III. Archiv Für Tierernährung 16: 57-75.
3. ANONYMOUS. 1973. Analytical methods for atomic absorption spectrophotometry. Perkin-Elmer Corp., Norwalk, Conn.
4. ————. 1973. Analytical methods for atomic absorption spectroscopy using the HGA graphite furnace. Perkin-Elmer Corp., Norwalk, Conn.
5. ARCHIBALD, J. G. 1949. Nickel in cows' milk. J. Dairy Sci. 32: 877-880.
6. ————. 1955. Aluminum in cow's milk. J. Dairy Sci. 38: 159-162.
7. CHATTOPADHYAY, A. and R. E. JERVIS. 1974. Hair as an indicator of Multi-element exposure of population groups. *Trace Substances in Environmental Health—VIII*. Ed. by D. D. Hemphill, Univ. Missouri Press, Columbia, Mo.
8. COOK, H. W., R. A. RAUSCH and B. E. BAKER. 1970. Moose (*Alces alces*) milk. Gross composition, fatty acid, and mineral composition. Can. J. Zool. 48: 213-215.
9. FRANZMANN, A. W. and P. D. ARNESON. Immobilization of Alaskan moose. J. Zoo An. Med. 5: 26-32.
10. ————, A. FLYNN, P. D. ARNESON and J. L. OLDEMEYER. 1974. Monitoring moose mineral metabolism via hair element analysis. Proc. 10th N.Am. Moose Workshop, Duluth, MN.
11. ————————. 1975. Levels of some mineral elements in Alaskan moose hair. J. Wildl. Manage. 39 (2): 374-378.
12. GROSS, S. B. and E. S. PARKINSON. 1974. Analyses of metals in human tissues using base (TMAH) digests and graphite furnace atomic absorption spectrophotometry. Interface 3: 10.
13. HADJIMARKOS, D. M. and C. W. BONHORST. 1961. Selenium content of eggs, milk and water in relation to dental caries in children. J. Pediat. 59: 256-259.
14. HAYS, V. W. and M. J. SWENSON. 1970. In *Dukes Physiology of Domestic Animals*. Edited by M. J. Swenson. Cornell Univ. Press, Ithaca and London.

15. KIRCHGESSNER, M. 1957. Der Mengen und Spurenelementgehalt von Rinderblut. Ztschr. Tierphysiol., Tierernahrung Futtermitlelk. 12: 156.

16. ————, H. FRIESEKE and G. KOCH. 1967. *Nutrition and the Composition of Milk*. J. B. Lippincott Co., Philadelphia and Toronto.

17. KUBOTA, J. A. LAZAR and F. L. LOSEE. 1968. Copper, zinc, cadmium, and lead in human blood from nineteen locations in the United States. Arch. Environ. Health 16: 788.

18. LE RESCHE, R. E. and G. M. LYNCH. 1973. A trap for free-ranging moose. J. Wildl. Manage. 37: 87.

19. MANNING, D. C. 1971. A high sensitivity arsenic-selenium sampling system for atomic absorption spectroscopy. Atomic Absorption Newsletter 10: 123-129.

20. MILLER, W. J. B. LAMPP, G. W. POWELL, C. A. SALOTTI and D. M. BLACKMAN. 1967. Influence of a high level of dietary cadmium on cadmium content in milk, excretion and cow performance. J. Dairy Sci. 50: 1404.

21. ————, G. W. POWELL, W. J. PITTS and H. F. PERKINS. 1965. Factors afffecting zinc content of bovine hair. J. Dairy Sci. 48: 1091-1095.

22. NORD, P. J., M. P. KADABA and J. R. J. SORENSON. 1973. Mercury in human hair. Arch. Environ. Health 27: 40-44.

23. OBRUSNIK, I. J. FISLASON, D. K. McMILLAN, J. D'AURIA and B. D. PATE. 1972. The variation of trace element concentrations in single human head hairs. J. Forensic Sci. 17: 426-438.

24. ROBINSON, C. H., I. HLYNKA, F. A. HERMAN and J. W. McARTHUR. 1947. Calcium content of fluid milk. Can. J. Public Health. 38: 236.

25. SCHWARTZ, K. 1974. New essential trace elements (Sn, V, F, Si): Progress report and outlook *Trace Element Metabolism in Animals—II*. Ed. by W. G. Hoekstra, J. W. Suttie, H. E. Ganthes and W. Mertz. University Park Press, Baltimore, Md.

26. TOLGYESI, G. and L. BENCZE. 1970. The microelement contents of plants consumed by wild mammals, particularly by big game, in dfferent Management Regions. In *Trace Element Metabolism in Animals* Ed. by C. F. Mills. E. & S. Livingstone, London.

Received for publication 21 March 1975