FORENSIC MINERAL ANALYSIS IN MOOSE MANAGEMENT

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Abstract: Control of illegal harvesting of moose is costly and difficult even when the probable individuals can be identified. Generally, the evidence collected is circumstantial in nature and provides little objective proof in a court of law. We have examined mineral element analysis of mammal hair as an objective link between kill site remains and carcasses found in the possession of suspects.

Hair samples of only 100 mg are needed for analysis by atomic absorption spectroscopy for 8 elements: Ca, Cu, Fe, K, Mg, Na, Pb, and Zn. Pearson r coefficient of correlations were calculated comparing hair samples and critical values of r determined to describe the probability of such correlations. These elemental patterns in the hair "fingerprint" the samples and allow for good statistical comparison. Four cases involving illegally taken moose from the state of Alaska will be discussed to demonstrate the utilization of the results as objective evidence. Mineral element analyses may have even greater potential than just comparative analysis, for such determinations can also pinpoint geographical site and month of harvest.

Over the past 5 years we have demonstrated that hair acts as a recording filament of nutritional changes in intake of mineral elements in Alaskan moose. The series of studies completed have demonstrated the great breadth of application of hair mineral analysis. It was 1st noted that hair analysis was able to indicate seasonal changes in elemental intake in the moose that relate to browse quality (Literature Cited 1.) Variations in mineral content of hair in relation to geographical sites have delineated subpopulations of moose within the state of Alaska (2.). One of the subpopulations on the Kenai Peninsula was likewise noted to manifest a Cu deficiency with faulty hoof keratinization initially defined by hair analysis (3.).

The relationship of mineral nutrition to moose management techniques has been discussed at these meetings (4.). Land-use planning was a major

area dealt with, but may not be the only area of impact. Other areas of management concerned demonstrate attempts to limit uncontrolled population influences (5.,6.). Karnes et al. (7.) reported that in nonhunting losses of moose, vehicular accidents and poaching were by far the top 2 causes related to man. Methods that would allow for closer control or limit these 2 areas would be a worthy management tool.

Direct application of hair analysis to moose management may be noted in several areas, 1 being forensic analysis. Control of illegal harvesting of moose would be greatly enhanced if more objective proof could be provided in a court of law.

Human forensic science has utilized hair mineral comparison and demonstrated the range of content among different persons to be considerable thus allowing individualization. Jervis in 1956 initially showed that the pattern of 3 elements, As, Cu, and Na, could clearly distinguish individuals (8.). Large scale surveys have since delineated the strength of hair mineral comparisons in determining individuality (9.). Factors thought to influence hair comparison were noted: geographical location, occupational exposure, age, family groups, identical twins, and mothers with newborn infants, and none appeared to be a major factor clouding individuality (10.). Subsequently, hair mineral analysis comparisons have been successfully used in courts of law in the United States and Canada (11.). Application of the mineral analysis of hair to forensic comparisons in wildlife management was examined based on the human studies.

A series of cases that utilize hair mineral element assays to determine if samples found at a poaching site and in the possession of a hunter had come from the same animal provided an opportunity to test hair analysis as a tool in wildlife forensic work.

METHODS AND MATERIALS

Properly identified hair samples were sent to the laboratory in Cleveland, Ohio by registered mail. The samples were then entered into a log and prepared for analysis of 8 mineral elements.

The cleansing and digestion of the moose hair have been described elsewhere (12.). The procedure involves washing the hair twice with an organic solvent, diethyl ether, to remove surface particulate matter without leaching minerals from the hair structure. The hair is dried for 24 hours at 55°C and weighed. One-hundred mg of hair was then digested in 10.0 ml of 24 percent methanolic tetramethyl ammonium hydroxide for 2 hours at 55°C (13.). The clear amber digestants were then diluted and analyzed for 8 mineral elements (Ca, Cu, Fe, Pb, Mg, K, Na, and Zn) by flame atomic absorption spectroscopy. Recoveries from this digestion technique were determined by means of standard additions and found to be greater than 90 percent for every element. The determinations were conducted on a semiautomated Perkin-Elmer Model 503 spectrometer adapted for automated dilutions with a Hamilton precision dispenser. Standard methods for flame atomic absorption analysis were used throughout this study (14.).

A statistical comparison of the results from the 2 samples provided per case was made calculating Pearson r coefficients of correlation. The significance of the coefficients for the 8 elements was determined by computing the critical values of r (15.).

RESULTS

Case 1

The mineral element analyses of the 2 hair samples are noted below. Sample 1 came from the kill site of the illegally harvested moose and Sample 2 from pieces of moose found in the possession of the alleged poacher. The request received by the laboratory from the state was: are the 2 samples from the same animal?

Mineral Analysis of Hair (PPM)

	Ca	Cu	Fe	Pb	Mg	K	Na	Zn
Sample 1	132	25	24	14	30	438	206	133
Sample 2	144	18	8	11	23	410	202	115

The Pearson r coefficient of correlation on these results was: $r = +0.923$; $P < 0.01$.

The strong positive correlation indicated that the 2 samples came from the same animal. The outcome of the case was an admission of guilt on the part of the alleged poacher.

Case 2

The mineral element analyses of the 2 hair samples are noted below. Sample 1 came from pieces of moose found in the possession of an alleged poacher and Sample 2 from other pieces of moose in the possession of the same individual. The alleged poacher stated they came from the same animal; the state contended they were from 2 animals.

Mineral Analysis of Hair (PPM)

	Ca	Cu	Fe	Pb	Mg	K	Na	Zn
Sample 1	72	25	42	16	17	308	230	157
Sample 2	118	18	16	11	14	368	162	112

The Pearson r coefficient of correlation on these results was: r = +0.364. This coefficient did not show significant correlation.

The results suggested that the 2 samples came from different animals. The outcome was also an admission of guilt on the part of the alleged poacher.

Case 3

The mineral element analyses of the 2 hair samples are noted below. Sample 1 came from the drag path of the illegally harvested moose and Sample 2 from pieces of moose found in the possession of the alleged poacher at his home. The request from the state was to match by chemical analyses the 2 samples and determine seasonal differences.

Mineral Analysis of Hair (PPM)

	Ca	Cu	Fe	Pb	Mg	K	Na	Zn
Sample 1	98	5	6	8	20	88	560	40
Sample 2	33	5	7	10	12	62	560	21

The Pearson r coefficient of correlation on these results was: r = +0.909; $P < 0.05$.

The strong positive correlation indicated that the 2 samples came from the same animal. The outcome of this case is still pending.

The question of seasonal difference was determined since the alleged poacher stated the hair from his home came from an animal killed 3 months earlier. The results compared with the data base in hand did not agree with the month the alleged poacher indicated.

Case 4

The mineral element analyses of the 2 hair samples are noted below. Sample 1 came from the kill site of the illegally harvested moose and Sample 2 from the box of the alleged poacher's pick-up truck. The request received by the laboratory was to determine if Samples 1 and 2 were from the same animal.

Mineral Analysis of Hair (PPM)

	Ca	Cu	Fe	Pb	Mg	K	Na	Zn
Sample 1	83	22	35	0.1	24	54	530	38
Sample 2	85	36	46	0.1	26	126	581	25

The Pearson r coefficient of correlation on these results was: $r = +0.902$; $P < 0.05$.

The strong positive correlation indicated that the 2 samples came from the same animal. The outcome of this case has been delayed.

A general comparison of randomly selected hair samples from the over 3,000 hair samples analyzed to date was made for 50 pair of samples and the Pearson r coefficient of correlation of $r = +0.550$. This coefficient of correlation is not significant, but indicates the species similarity.

DISCUSSION

The availability of hair from mammals makes its use in forensic analysis very opportune. With the establishment of a data base, a significant body of information covering seasonal variations in addition to numbers, strong evidence can be generated from hair mineral analysis. The strength of this type of information comes in addition in the use of this type data in human forensic analysis (9.,10.). The widespread use of comparative hair analysis in rape and murder cases establishes the precident in a court of law (9.).

Several important strengths and weaknesses are to be noted in the use of such information. The strength of the analysis lies in comparing 2

samples as coming from the same animal. Very positive correlations can be noted. Although not discussed in the results, a number of samples received showed no strong correlation and were determined as not coming from the same animals. The ability to contract samples, however, is not as strong a point. Since samples are from moose, a certain amount of similarity will always be noted. The general survey of random analysis of known different samples was $r = +0.550$. This positive but not significant coefficient of correlation does not lend itself to strong conclusions as to the origin of the hair samples.

Several factors must also be considered in the variability of results from hair analysis. An attempt was made to analyze only the nonpigmented section of the hair shaft adjacent to the follicle since variations in pigmentation have been reported to influence mineral element levels (16.). Slight variations in mineral element values are also noted with differences in the body site of sampling. Such body site variations may be the major source of difference in hair sample comparisons. Other influences, such as age and sex, have also been considered but our results have not shown these to significantly vary the hair mineral element results (1.).

The utilization of hair mineral element analysis to demonstrate other features of the animal's history can also be contemplated. One cannot overemphasize that a good data base allows for many additional conclusions to be drawn. Season variations have been determined via hair mineral analysis and related to primarily dietary changes (1.,16.). Establishing the season of a kill may be a vital comparative point in a court of law. Geographical differences have also been noted which relate to different subpopulation restrictions (2.). All this information can directly relate to the strength of such evidence in a court of law.

Hair mineral element analysis may provide, therefore, another moose management tool to allow the control of another variable of the population growth. However, the strength of the tool will come with use and publicity of this technique.

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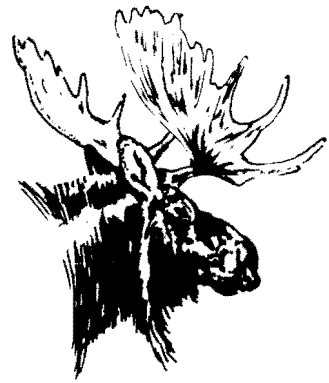

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