USES AND LIMITATIONS OF FECAL ANALYSES IN *RANGIFER* STUDIES

by

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Abstract: Analysis of caribou fecal samples from 4 distinct caribou wintering areas revealed expected relative percentage use of lichens among the areas. Additional uses of fecal analyses include identification of most major plant groups in the diet, detection of trends in condition of *Rangifer* winter range, and substantiation of estimated winter diets of free-ranging *Rangifer* using captive *Rangifer* hand-fed the estimated diets. An index to relative winter diet quality can be developed using both fecal analyses and forage nutrient analyses. Nutrient analyses of fecal samples can provide indices to seasonal diet quality and nutrient flow. Fecal analyses inadequately estimate *Rangifer* diets by overestimating proportions of mosses and, at times, evergreen shrubs. Mushrooms and many green 'forbs' (excluding *Equisetum* spp.) are underestimated or not detected. These over- and underestimates require the investigator to adjust the proportions of other plant groups present, particularly lichens. Correction factors can become arbitrary unless additional information is obtained. Additional information can include data on actual diet composition or data from feeding trials. Development of correction factors through feeding trials is useful only on a case-by-case basis where estimates of individual diets require substantiation, and mushrooms and green forbs are not large proportions of suspected diets.

Résumé: L'analyse d'échantillons de crottins de caribou provenant de quatre aires d'hivernage distinctes a permis de déceler le pourcentage relatif prévu d'utilisation du lichen dans ces aires. Les analyses fécales peuvent aussi servir, entre autres, pour identifier les principaux groupes de plantes dans la diète, détecter des tendances dans l'état du territoire hivernal des *Rangifer*, et aussi pour confirmer les estimés de la diète hivernale des *Rangifer* en liberté, utilisant des *Rangifer* en captivité qu'on a nourri de ces diètes estimées. Un indice de la qualité relative de la diète hivernale peut être développé à l'aide d'analyses fécales et d'analyses nutritives des fourrages.

L'analyse nutritive de crottins peut fournir des indices sur la qualité de la diète saisonnière et sur le cheminement des élements nutritifs. Les analyses fécales évaluent inadéquatement la diète des Rangifer en surestimant la proportion de mousses et, parfois, de conifères arbustifs. Les champignons et plusieurs herbacées latifoliées (excluant Equisetum spp.) sont sous-estimés ou non détectés. Ces sur- et sous-estimations demandent au chercheur d'ajuster les proportions des autres groupes de plantes présents, les lichens en particulier. Les facteurs de correction peuvent comprendre des données sur la composition actuelle de la diète ou des données provenant d'essais d'alimentation. La formulation de facteurs de correction basés sur des essais d'alimentation n'est utile que dans des cas spécifiques où on recherche la confirmation de diètes individuelles et où les champignons et les herbacées latifoliées ne forment pas une grande proportion des diètes soupçonnées.

INTRODUCTION

In this paper, 'fecal analyses' or 'fecal analysis' refer to the percent composition of discerned plant fragments in caribou/reindeer (Rangifer tarandus) fecal samples. The terms do not refer to chemical or nutrient analyses of fecal samples, although these uses are also briefly discussed.

Most of this paper is devoted to describing applications of fecal analyses, partially through a review of the literature and partially through new insights, including analytical discussion. We emphasize the useful applications of fecal analyses in Rangifer studies, because these applications have not previously been clarified. Discussions are included on limitations of fecal analyses and the difficulty of deriving correction factors to estimate actual diets. To demonstrate 1 useful application of fecal analysis and to document methodology, we also present new data on caribou fecal analyses from 4 winter ranges in Alaska.

Several authors have reported caribou/reindeer fecal analyses simply as approximations of diet composition (Fischer and Duncan 1976, Fischer et al. 1977, Parker 1978, Thompson et al. 1978, Helle 1980, Davis et al. 1982, Sulkava et al. 1983. Dearden et al. (1975) attempted to develop correction factors for fecal analyses to approximate the percent composition of several forages in 2 diets fed to 2 captive reindeer. Boertje (1981, 1984): (1) compared the estimated diet of a tame reindeer (based on bite counts) and subsequent fecal analyses, and (2) estimated seasonal diets of the Denali caribou herd based on fecal analyses, field observations, and forage digestibilities. Boertje (1981) also documented the seasonal variation in nitrogen (N), phosphorous (P), and fiber content of fecal samples from the Denali herd to help calculate N and P output. Duquette (1984) attempted to correct fecal analyses to estimate spring diets of the Porcupine caribou herd by using captive reindeer and caribou fed 1 diet.

STUDY AREA

Caribou fecal samples were colelcted from 4 study areas: the soutwest Kantishna Hills and Stampede Hills in the Denali herd's range (Boertje 1981, 1984), and the southwest Arctic (including the Selawik Hills and Kollioksak Lake) and arctic coastal plain (near Teshekpuk Lake) in the Western Arctic herd's range (Davis and Valkenburg 1978). The study areas were separated by about 50 and 400 km for the Denali and Western Arctic herds, respectively. Although each area is considered a distinct wintering area in any 1 year, individual caribou within a herd often exchange wintering areas between years (Troyer 1979, Valkenburg et al. 1983).

METHODS

Fecal samples were analyzed (Sparks and Malechek 1968, Ward 1970) at the Composition Analysis Laboratory, Colorado State University, based on 100 fields per sample (100x). Each sample contained 25 fecal pellets, 1 from each of 25 different pellet-groups. Samples (N=21) were collected from the Kantishna Hills on 20-21 November 1978; from the Stampede Hills on 5 and 7 January and 7, 10, and 12 March 1979; from the southwest Arctic on 24-26 March (Selawik Hills) and 21 April (Kollioksak Lake) 1981; and from the arctic coastal plain in 1981 on 24-25 April (Price River), 26 April and 2 May (Judy Creek), and 2 May (Lonely). Samples were collected on top of the snow and, therefore, were between about 1 day and 1 month old. Snow depth was approximated during collection of fecal samples.

Fecal analyses revealed individual plant species. However, we grouped most plant species into major categories to simplify presentation. We classified Equisetum spp. as forbs.

We made ocular estimates of relative lichen abundance in study areas during ground activities and overflights. Lichen abundance was classified as abundant (30-80% cover in much of the area and very distinct from overflights), less abundant (5-30% cover in much of the area and less distinct from overflights), and scarce (<5% cover over vast expanses of the area and not visible from overflights). We feel this relative scale is easily duplicable if observers are familiar with caribou/reindeer range. Nevertheless, we recognize the weakness of this technique and present it here primarily to demonstrate 1 potential use of fecal analyses.

RESULTS

The proportion of lichens in fecal samples from the 4 study areas reflected the relative abundance of lichens (Table 1), even though sample sizes from the 4 areas were small (n=3-7). Lichens were abundant on the southwest Kantishna Hills, less abundant on the Stampede Hills and southwest Arctic, and scarce on the arctic coastal plain. Where lichens were less abundant than on the Kantishna Hills, caribou apparently replaced lichens in the diet with mosses (Stampede Hills); graminoids (southwest Arctic); or evergreen shrubs (primarily Vaccinium vitis-idaea), graminoids,

and Salix (arctic coastal plain) (Table 1). Mosses were presumably consumed incidentally (Skoog 1968).

Snow depth on the ground during collection of fecal samples varied from 0 to 40 cm in all 4 areas; the variation was due to wind action. We do not feel snow depth hindered consumption of lichens.

DISCUSSION

Uses of Fecal Analyses

Our hypothesis was that fecal analyses can reveal the relative availability of lichens on caribou winter ranges, assuming excessive snow depth does not hinder lichen consumption. We assumed that caribou consume lichens in direct proportion to lichen abundance, up to about 75% of their diet (Skoog 1968), based on the high palatability of lichens among caribou (Bergerud 1977). Fecal analyses revealed the expected trend in lichen use among study areas (Table 1). Further comparisons of caribou diets in the 4 study areas are beyond the scope of this paper. This concludes discussion of the above hypothesis. These data were presented to demonstrate 1 potential use of fecal analyses; the following discussion considers several additional uses and several limitations of fecal analyses.

In other studies, fecal analyses have accurately revealed which winter plant species (not proportions) caribou substitute for lichens in areas where lichens are not abundant (Boertje 1984, Duquette 1984). If snow conditions are similar among years, it follows that fecal analyses can be used: 1) to detect trends in winter range condition over several years, and 2) to compare range condition among areas, particularly in respect to the abundance and use of lichens. High, presumably incidental intake of mosses in winter may be found to coincide with a low or moderate abundance of lichens, but only in some cases. For instance, data from the Stampede Hills (Table 1), where lichens are moderately abundant, indicate a high incidental intake of mosses. In contrast, fecal samples from the arctic plain (Table 1), where lichens are scarce, indicate a relatively low intake of mosses.

We suggest fecal analyses can also be used to substantiate estimates of winter caribou/reindeer diets through feeding trials with captive Rangifer. Duquette (1984) and Boertje (1984) present preliminary comparative data on feeding trials and subsequent fecal analyses of reindeer. Requisite conditions for feeding trials are discussed later. Combined with forage nutrient analyses (Bergerud 1977, Luick 1977, Boertje 1981), caribou fecal analyses can provide an index to relative winter diet quality. For instance, relatively high proportions of mosses and evergreen shrubs in winter caribou feces could be a key indicator of poor range condition (Karaev 1968, Skoog 1968, Steen 1968). It may also be possible to assess relative winter caribou body condition (if diet quantity is not limiting) by combining data from fecal analyses and forage nutrient analyses

Table 1. Average percent (± s.d.) composition of discerned plant fragments in winter caribou fecal samples collected from the Denali and Western Arctic herds, 1978-79 and 1981.

	Denali samples		Western Arctic samples	
	Kantishna Hills	Stampede Hills	southwest Arctic	arctic plain
Plant group	(N=3)	(N=7)	(N=5)	(N=6)
Forbs	3 ± 0.6	1 ± 1.2	4 ± 6.0	4 ± 4.0
Graminoids	4 ± 2.6	3 ± 1.6	13 ± 4.0	18 ± 5.7
Salix	--	1 ± 1.9	3 ± 2.0	10 ± 8.2
Evergreen shrubs	7 ± 2.2	10 ± 3.1	8 ± 3.3	32 ± 4.7
Lichens[1]	80 ± 4.8	62 ± 10.4	69 ± 7.9	28 ± 11.3
Mosses	6 ± 1.3	22 ± 7.4	3 ± 3.1	8 ± 4.4
Mushrooms	< 1	1 ± 2.1	--	--

[1]Lichens were abundant in the Kantishna Hills, less abundant in the Stampede Hills and southwest Arctic, and scarce on the arctic plain.

with caribou nutrient requirements (Boertje 1981).

These latter 2 uses are most valuable when assessing the influence of changing conditions on a single herd. For instance, an investigator can assess the influence of changing range condition, range use patterns, and/or snow conditions on a caribou herd's winter diet or nutritional status. Caution must be applied, however, when evaluating the adequacy of approximate diets between caribou/reindeer herds, particularly in respect to herds experiencing winter seasons of different duration and to herds adapted to different seasonal diets and environmental conditions (Boertje 1981). A variety of environmental conditions, particularly a crusted snow cover, might cause declines in food intake, thereby exerting greater influences on winter caribou nutritional status than proportions of dietary plant species (as estimated by fecal analyses). However, factors acting to decrease food intake may also influence species selection, thereby giving fecal analyses broader applications for indicating relative nutritional status; however, this concept has not been tested. Chemical and nutrient analyses of fecal samples can also be valuable tools in range or nutrition studies. Boertje (1981) used nutrient analyses of forages and feces and estimates of forage intake and digestibility to model nutrient ingesta, output, and use in caribou. Nutrient analysis of fecal samples can also be used for relative assessments of seasonal diet quality, if samples are collected regularly throughout the season of use.

Limitations of Fecal Analyses and Derivation of Correction Factors

The primary use of *Rangifer* fecal analysis in the last decade has been to report fecal analyses as approximations of diet composition, without modifications (Fischer and Duncan 1976, Fischer *et al.* 1977, Parker 1978, Thompson *et al.* 1978, Helle 1980, Davis *et al.* 1982, Sulkava *et al.* 1983). Yet, fecal analyses have been widely criticized as a means of estimating diet composition and have inadequately estimated diet composition of reindeer and caribou (Boertje 1981, 1984; Duquette 1984), deer (*Odocoileus* spp.) (Gill *et al.* 1983), sheep (Slater and Jones 1971), cattle (Vavra *et al.* 1978), and elk (*Cervus canadensis nelsoni*)

(Pulliam and Nelson 1979). The major criticism has been that fecal analyses severely underestimate proportions of forbs and highly digestible forages, resulting in overestimates of remaining forages. These overestimates are artifacts resulting from the real underestimates of highly digestible forages.

To identify artifacts of *Rangifer* fecal analyses, investigators must be aware that fecal analyses consistently overestimate mosses and many evergreen shrubs and underestimate mushrooms and many green forbs. Lichen proportions from fecal analyses exemplify these artifacts, as fecal analyses can either over- or underestimate dietary lichen proportions depending on proportions of mosses, evergreen shrubs, mushrooms, and forbs. Boertje (1981, 1984), for example, found that fecal analyses

inadequately estimated the autumn diet composition of a tame reindeer. The proportions of green forbs were severely underestimated and mushrooms were not detected, resulting in overestimates of lichen and Salix proportions in the diet. In contrast, Duquette (1984) stated that fecal analyses underestimated lichen proportions and overestimated proportions of Vaccinium vitis- idaea. That is, lichen proportions from Duquette's fecal analyses needed to be increased (to duplicate the diet) simply to compensate for the overestimation of Vaccinium vitis-idaea proportions in the diet.

Characteristics that cause fecal analyses to overestimate dietary moss include the high degree of fragmentation, low digestibility, and ease of identification of mosses (Dearden et al. 1975). Some or all of these characteristics, particularly low digestibilities (Boertje 1981), also likely cause the overestimation of evergreen shrubs, including Vaccinium vitis-idaea. Opposite characteristics cause underestimation or non-detection of mushrooms and green 'forbs' (excluding Equisetum spp.) (Boertje 1981, Samuel and Howard 1983). Failure to detect forbs or mushrooms through fecal analyses is, therefore, not evidence of their absence in the diet.

It follows that fecal analyses most accurately detect relative winter diets, because mushrooms and green forbs are usually minor proportions of winter Rangifer diets (Bergerud 1977; Boertje 1981, 1984). Comparison between seasonal caribou diets and corresponding fecal analyses (Boertje 1981, 1984) reveal more of the seasonal artifacts of fecal analysis. Seasonal artifacts of fecal analyses are the proportions of lichens, graminoids, berries, and deciduous shrubs. Changes in these proportions are needed to compensate for the underestimates of mushrooms and green forbs and overestimates of mosses and, at times, evergreen shrubs.

Due to this interaction of mosses, evergreen shrubs, mushrooms, and forbs in fecal analyses, derivation of actual diets of wild Rangifer using fecal analyses is somewhat arbitrary unless additional information is obtained. Additional information for developing correction factors can include actual diet composition (Boertje 1981, 1984), rumen content analyses, or feeding trials with captive animals to develop correction factors. Seasonal artifacts of fecal analyses demand that correction factors be developed only on a case-by-case basis where individual diets have been estimated, yet require substantiation. Dearden et al. (1975) failed to reveal that correction factors were limited to deriving diets on a case-by-case basis. Several feeding trials may be required before fecal analyses are statistically similar between the captive and free-ranging animals. Also, development of correction factors is restricted primarily to early, mid-, and late winter diets because correction factors cannot be developed for plant groups that may not appear in the fecal analyses, e.g., mushrooms and many green forbs which are largely spring, summer, and autumn food items.

To conduct useful feeding trials for the purpose of developing correction factors, captive animals must be fed the

identical diet composition consumed by their free-ranging counterparts, and plant species must be in identical phenological condition. Duquette (1984) fed Bromus sp. and Hylocomium splendens in feeding trials, yet these species were not mentioned as food items of the Porcupine caribou herd. In addition, other conditions important to feeding trials are that captive animals be adapted to the diets, that rumen microbe populations are similar between the captive and free-ranging animals, and that food intake rates are comparable (Van Soest 1982). If all these conditions are met and if fecal analyses are statistically similar between the captive and free-ranging animals, then the estimated diet fed the tame animals can be expected to closely approximate the diet composition of the free-ranging animals.

CONCLUSION

The use of fecal analyses simply as estimates of Rangifer diets is inappropriate due to the overestimation of proportions of mosses and, at times, evergreen shrubs and underestimation or non-detection of proportions of mushrooms and many green forbs. Insights into these limitations and the uses of fecal analyses should allow readers: 1) to better understand the qualifications of data presented (but not explained) in previous Rangifer studies, and most significantly, 2) to design studies of Rangifer habitat and nutrition using fecal analyses in ways not previously described.

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REFERENCES

Bergerud, A.T., 1977. Diets for caribou. Pages 243-294 in M. Recheigl, Jr., ed. CRC handbook series in nutrition and food. Section G: Diets, culture, media, and food supplements. Vol. 1. CRC Press, Cleveland, Ohio.

Boertje, R.D., 1981. Nutritional ecology of the Denali caribou herd. M.S. thesis. Univ. Alaska, Fairbanks. 294 pp. (Available from Masters Abstracts, University Microfilms International, 300 N. Zeeb Road, Ann Arbor, MI 48106, U.S.A.).

--------, 1984. Seasonal diets of the Denali Caribou Herd, Alaska. Arctic 37(2):161-165.

Davis, J.L., and P. Valkenburg, 1978. Western Arctic caribou studies. Alaska Dept. Fish and Game, Fed. Aid Wildl. Rest. Final Rep. Proj. W-17-8 and W-17-9. Juneau. 95 pp.

--------, --------, and R.D. Boertje, 1982. Home range use, social structure, and habitat selection of the Western Arctic caribou herd. Final Research Report prepared for National Park Service, Alaska Dept. Fish and Game, Fairbanks. 87 pp.

Dearden, B.L., R.E. Pegau, and R.M. Hansen, 1975. Precision of microhistological estimates of ruminant food habits. J. Wildl. Manage. 39(2):402-407.

Duquette, L.S., 1984. Patterns of activity and their implications to the energy budget of migrating caribou. M.S. thesis, Univ. Alaska, Fairbanks. 95 pp. (Available from Alaska Cooperative Wildlife Research Unit, Univ. of Alaska.).

Fischer, C.A., and E.A. Duncan, 1976. Ecological studies of caribou and muskoxen in the Arctic Archipelago and northern Keewatin. Rep. to Polar Gas Environ. Prog. Renewable Resources Consult. Serv. Edmonton. 194 pp.

--------, D.C. Thompson, R.L. Wooley, and P.S. Thompson, 1977. Ecological studies of caribou on the Boothia Peninsula and in the District of Keewatin, N.W.T. 1976 - with observations on the reaction of caribou and muskoxen to aircraft disturbance, 1974-76. Rep. to Polar Gas Environ. Prog. Renewable Resources Consult. Serv. Edmonton. 239 pp.

Gill, R.B., L.H. Carpenter, R.M. Bartmann, D.L. Baker, and G.G. Schoonveld, 1983. Fecal analysis to estimate deer diets. J. Wildl. Manage. 47(4):902-915.

Helle, T., 1980. Sex segregation during calving and summer period in wild forest reindeer (Rangifer tarandus fennicus Lonn.) in eastern Finland with special reference to habitat requirements and dietary preferences. Pages 508-518 in E. Reimers, E. Gaare, and S. Skjenneberg, eds. Proc. 2nd Int. Reindeer/Caribou Symp., R ros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim.

Karaev, G.I., 1968. Reindeer fodder resources. Pages 129-175 in P.S. Zhigunov, ed. Reindeer husbandry. Transl. from Russian by the Israel Prog. for Sci. Transl., Jerusalem. USDI. Washington, D.C. Luick, J.R., 1977. Diets for freely grazing reindeer. Pages 267-278 in M. Recheigl, Jr., ed. CRC handbook series in nutrition and food. Section G: Diets, culture, media, and food supplements. Vol. 1. CRC press, Cleveland, Ohio.

Parker, G.R., 1978. The diets of muskoxen and Peary caribou on some islands in the Canadian High Arctic. Can. Wildl. Serv. Occ. Pap. No. 35. 18 pp.

Pulliam, D.E., Jr., and J.R. Nelson, 1979. Determination of digestibility coefficients for quantification of fecal analysis with elk. Pages 240-247 in M.S. Boyce, and L.D. Hayden-Wing, eds. North American elk: ecology, behavior, and management. Univ. Wyoming, Laramie. 294 pp.

Samuel, M.J., and G.S. Howard, 1983. Disappearing forbs in microhistological analysis of diets. J. Range Manage. 36(1):132-133.

Skoog, R.O., 1968. Ecology of the caribou (Rangifer tarandus granti) in Alaska. Ph.D. Thesis. Univ. Calif., Berkeley. 720 pp.

Slater, J., and R.J. Jones, 1971. Estimation of the diets selected by grazing animals from microscope analysis of the feces--a warning. J. Aust. Inst. Agric. Sci. 37(3):238-239.

Sparks, D.R., and J.C. Malechek, 1968. Estimating percentage dry weight in diets using a microscope technique. J. Range Manage. 21(4):264-265.

Steen, E., 1968. Some aspects of the nutrition of semi-domestic reindeer. Pages 117-128 in M.A. Crawford, ed. Comparative nutrition of wild animals. Acad. press, New York.

Sulkava, S., E. Erkinaro, K. Hiekura, E. Lindgren, and E. Pulliainen, 1983. Food of the wild forest reindeer, Rangifer tarandus fennicus, in Finland in winter and summer 1981. Acta Zool. Fennica 175:17-19.

Thompson, D.C., G.H. Klassen, and C.A. Fischer, 1978. Ecological studies of caribou in the southern District of Keewatin, 1977. Rep. to Polar Gas Environ. Prog. Renewable Resources Consult. Serv. Edmonton. 194 pp.

Troyer, W.A., 1979. Population and movement studies of the McKinley caribou herd. Prog. Rep., Nat. Park Serv. Anchorage. 18 pp.

Valkenburg, P., J.L. Davis, and R.D. Boertje, 1983. Social organization and seasonal range fidelity of Alaska's Western Arctic caribou-- preliminary findings. Acta. Zool. Fennica 175:125-126.

Van Soest, P.J., 1982. Nutritional ecology of the ruminant. O and B Books, Corvallis, Oregon. 373 pp.

Vavra, M., R.W. Rice, and R.M. Hansen, 1978. A comparison of esophageal fistula and fecal material to determine steer diets. J. Range Manage. 31:11-13.

Ward, A.L., 1970. Stomach content and fecal analysis: methods of forage identification. Pages 146-158 in Range and wildlife habitat evaluation: a research symposium. USDA Misc. Publ. No. 1147. 220 pp.

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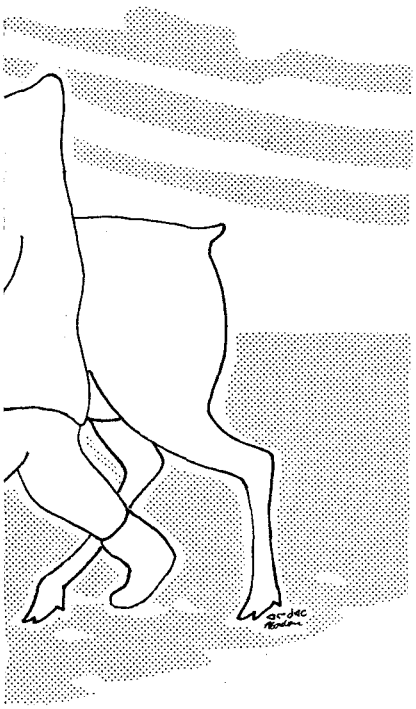

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