Proc. Fifth Bienn. Symp. North.
Wild Sheep and Goat Council 1986

ANIMAL CONDITION-A COMPARISON OF FECAL NITROGEN AND DIAMINOPIMELIC ACID

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ABSTRACT:
Fecal nitrogen (N) was initially used to determine condition in domestic animals and more recently has been used for bighorn sheep, deer, elk and moose. Mould & Robbins (1981) indicated that ingested phenolics significantly increased fecal N excretion and Nelson et al (1972) suggested that diaminopimelic acid (DAPA) may be used instead of fecal N as an indicator of digestible energy levels. This paper suggests a strong correlation between fecal N and DAPA annual curves but does not indicate a strong relationship between DAPA and digestible energy. Fecal N curves among studies were significantly related even though the diet varied from 92% grass to 64% browse.

Fecal nitrogen (N) techniques have been utilized to determine changes in animal condition in several species (Hebert et al 1984). The fecal N index is related to changes in nitrogen intake and weight change in sheep (Hebert et al 1984), to changes in digestibility and weight change in elk (Janz 1983, Gates 1980, Leslie & Starkey 1982) and to changes in nitrogen intake and dry matter digestibility in moose (Renecker and Hudson 1985). Recently, Mould and Robbins (1981) suggested that plant species with high phenolic levels significantly increased fecal nitrogen excretion when fed as a single species diet or in simple mixed diets where species with supposedly high phenolic levels composed as much as 33 percent of the diet. Thus, it has recently been suggested that diaminopimelic acid (DAPA), an indigestible and unabsorbed by product of rumen fermentation, could be used as an indicator of digestible energy level in diets of ruminant animals(Nelson et al 1982). Initial trials were conducted on domestic sheep. This study reports on annual fecal nitrogen curves for wild bighorn sheep utilizing a wide range of diets.

Although, most ungulate species utilize a wide range of forage species on a seasonal basis, thus reducing the influence of phenolics, it appears useful to compare the shape of fecal N and DAPA curves and their relationship with other nutritional indicators.

METHODS:

The collections of data from the three bighorn sheep research studies (Hebert 1973 and Hebert et al 1984) has been described in previous publications. In this paper, correlation coefficients were established between fecal N, DAPA and a range of nutritional indices such as plant nitrogen, plant energy, digestible protein and energy and seasonal weight change.

Similarly, correlation coefficients were developed for annual fecal N curves over a wide range of dietary composition. Tests of significance at the 0.05 level identified the important relationships. Comparison of data resulted from the analysis of the same samples for both fecal N and DAPA.

RESULTS:
The annual curves of fecal N and DAPA exhibit a similar decline throughout the period April through December (Fig. 1). The curves differ at two points. The fecal N curve declines gradually during the sampling period, with a slight increase during September - November as a result of fall greenup. The DAPA curve declines sharply during this period. The DAPA curve shows a sharp increase in May, paralleling somewhat, the change in plant gross energy (Hebert 1973).

As a result of this similarity to the plant gross energy curve, the DAPA curve was compared to the digestible energy curve in Kcal/day and in Kcal/gm dry matter intake, (Hebert 1973) as shown in Figure 2. Although gross and digestible energy are significantly related ($r=.621$, $P<0.10$), the DAPA and digestible energy curves appear to differ during the early growth stages in May and June. Although digestible energy (Kcal/day) increases from April through June, digestible energy (Kcal/gm) declines in May as root and photosynthetic carbohydrates exchange and as the rumen adjust to high quality spring growth. It is during this period that forage quality and forage intake often do not show consistent changes, depending on the magnitude of effect of low quality winter diets.

Both fecal N and DAPA are significantly related to changes in seasonal plant protein (Table 1). Thus, the curves for DAPA and fecal N are significantly related ($r=.943$). Neither fecal N or DAPA are related to plant or digestible energy.

As a result of the similarity between the fecal N and DAPA curves both are significantly related to seasonal weight change and digestible protein (Table 2).

Since Mould and Robbins (1981) suggested that phenolic activity may reduce the digestion of nitrogen and influence the annual fecal N curve, fecal N curves were compared through a range of studies and food habits (Table 2). In the three studies examined, fecal N curves were significantly related to each other. All herds were non-migratory in nature and subsisted on forage from the winter range year around. The fecal N curves of the Junction and O.K. studies were not significantly related until adjustments were made for latitude (Phenology) and fall greenup. The Junction study, being 500 km further north, was adjusted by one month, to accommodate the earlier phenological growth of the southern PH.D and O.K. studies. Similarly, the wet fall months (1982 and 1983) of the Junction were compared to an earlier year(1978) of the O.K. study to standardize fall greenup.

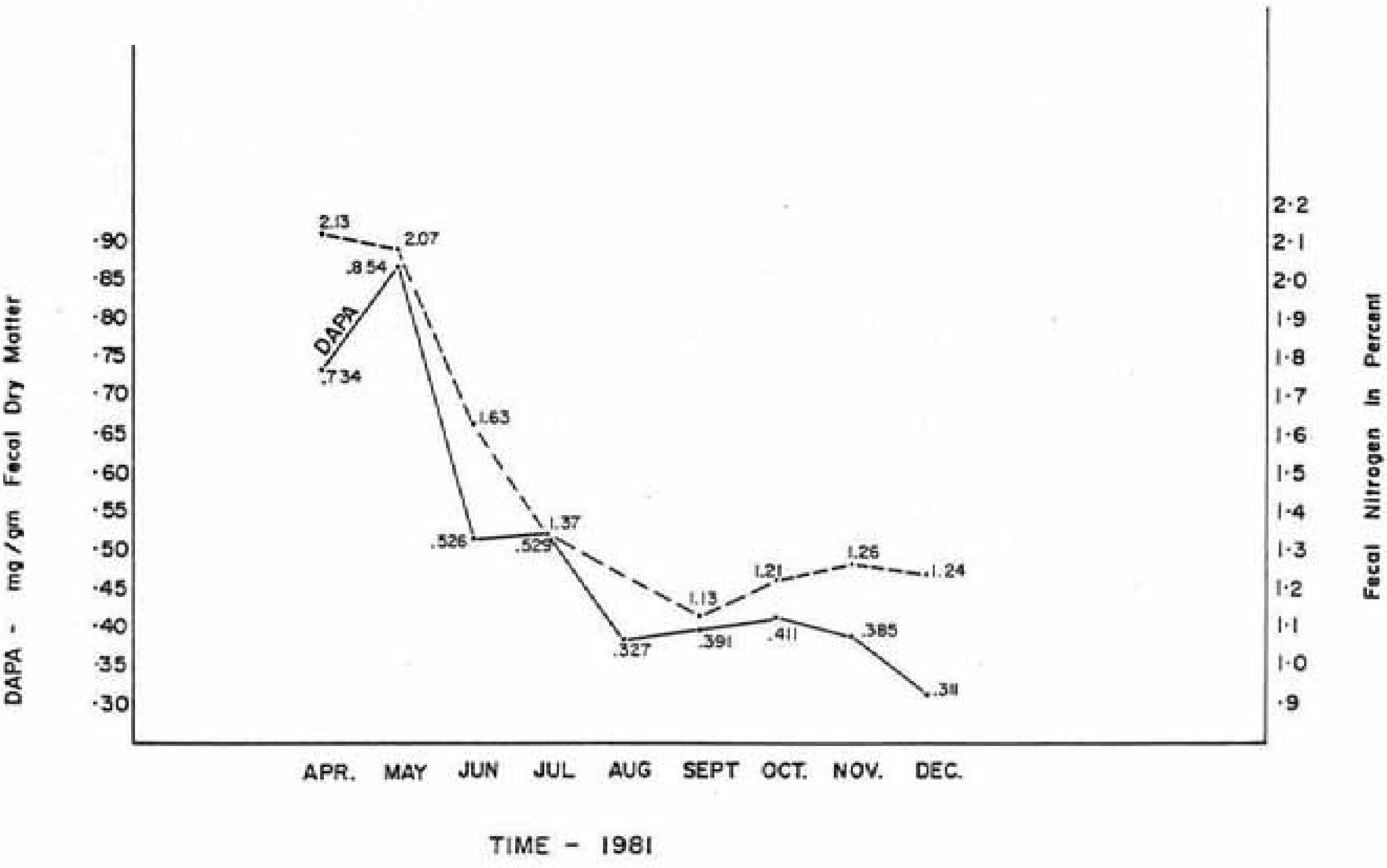

Fig. 1 : A comparison of the Annual Curves for Fecal Nitrogen and DAPA during 1981.

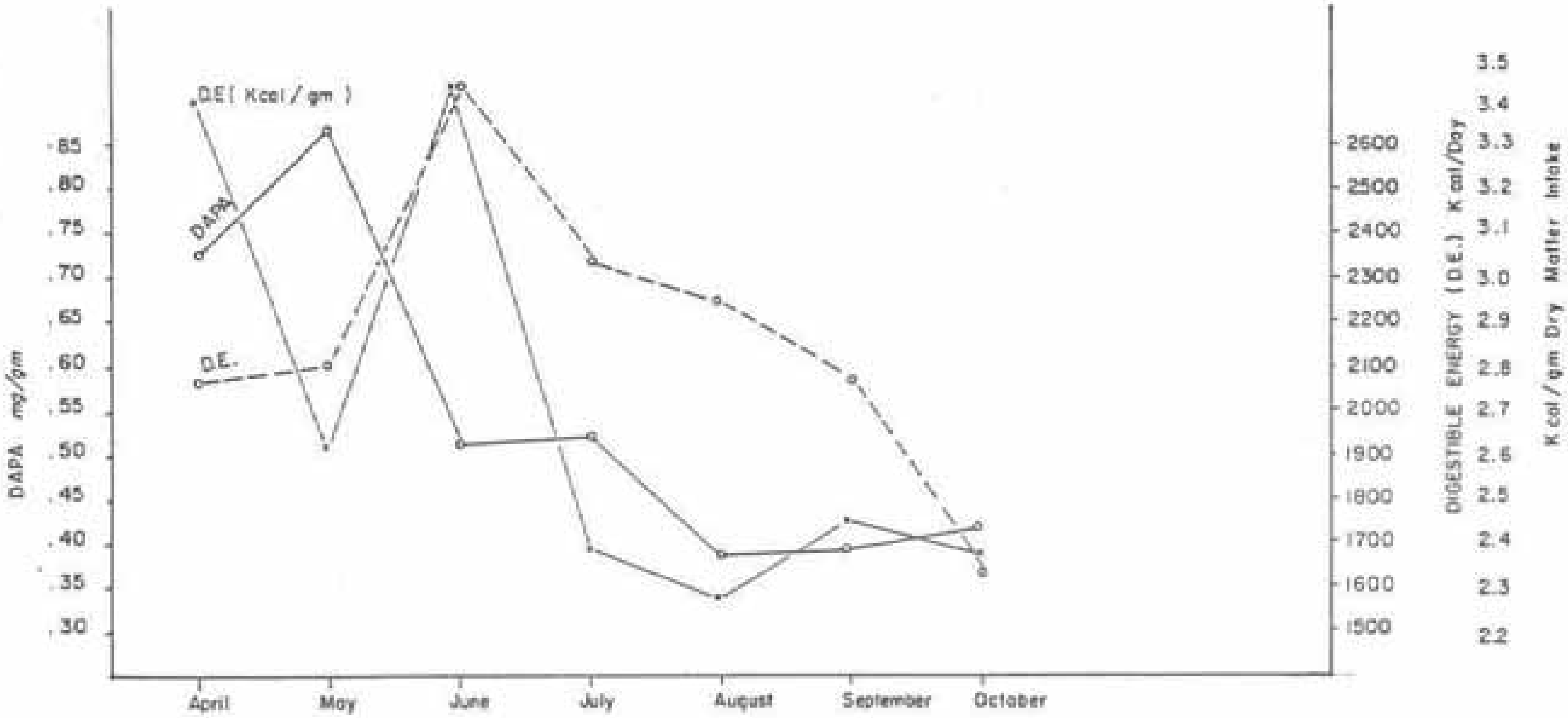

Figure 2. A comparison of the Annual Curves for DAPA and Digestible Energy.

The data suggests that even though diet composition differed dramatically from 92 percent grass to 64 percent browse (largely pasture sage), fecal N curves were similar and reflected diet quality and animal condition. Phenolics present in the higher browse plants (dicots) (Levin 1976) did not appear to alter nitrogen digestion.

DISCUSSION:
Fecal N has been shown to be a consistent indicator of diet quality and animal condition over an extremely wide range of forage composition. Similarly, DAPA has been shown to be significantly related to fecal N, plant and digestible protein and is also a valid indicator. Although Nelson et al 1982, suggests that DAPA is related to digestible energy (Kcal/gm) in domestic sheep, it did not appear to be related to the digestible energy components of wild sheep forage. The gross and digestible energy component of wild forage follows a marked set of changes from greenup, to root reserve - leaf carbohydrate exchange to winter dormancy. Hebert (1973) has shown that digestible energy can change from 3.40 Kcal/gm in spring growth winter range forage to 3.5 Kcal/gm in alpine forage to 1.8 Kcal/gm in low quality winter range forage. Energy changes in tame pasture undergo considerable less change (2.20 Kcal/gm to 2.75 Kcal/gm) due to the constancy of growing conditions. Thus, it appears that the degree of change, including carbohydrate exchange is relatable to changes in DAPA rather than the energy component itself. Nelson etal (1982)indicated a significant increase in non-DAPA bacteria simply by increasing the feed intake from maintenance to ad libitum. In this case there is no change in species composition or diet quality. When wild ungulates change from maintenance diets of winter range forage to ad libitum or growth diets, there is a change in species composition, forage quality and associated forage intake. These changes produce different digestible energy curves as shown in Figure 2.

Similarly, it appears that phenolics are less an inhibitor of N digestion than was originally suspected. Mould and Robbins (1981) fed single species or simple mixed diets supposedly high in phenolics. Since their elk were probably on a staple diet of grass or alfalfa prior to the digestion trails, it is possible that the drastic change in species and quality alone (maple =3.8% protein) could have produced the slight deviation in fecal N-dietary N relationship. Inclusion of his mixed rations in the relationship would probably have changed the r2 value very little. Most food habit studies indicate that ungulates select a wide range of forage species. In association, it is likely that ungulates have evolved to select forage species low in phenolics if digestion can be improved as a result. Recent work on mule deer (Langin pers comm.) suggests that mule deer in the central interior of B.C., which require mature Douglas fir as winter range, select mature fir branches in their diet (80% Douglas fir) which are four times lower in phenolics than younger aged fir.

Levin (1976) suggests that the higher plants contain complex mixtures of phenolics. The phenolic compounds appear to have evolved to serve as resistance to attack, especially from microbes or herbivores. In general, herbivores have learned to avoid them, or can degrade, recycle or respire them.

Recent work on browsing ungulates (Gates 1980, Janz 1983, Renecker and Hudson 1985) suggests that fecal N is related to a variety of nutritional indicators (weight change, digestibility, etc.) with no apparent negative effects from phenolics. In general, there appears to be no selective advantage for herbivores to use plants with phenolics which affect them negatively.

TABLE 1. Correlation coefficients established with fecal nitrogen and DAPA to examine nutritional condition.

Parameter	Study	Parameter	Study	N	Correlation coefficient	Sig .05
Fecal N	OK[1]	Plant N	OK	7	.920	Y
DAPA	OK	Plant N	OK	7	.81	Y
Fecal N	PhD[2]	Plant N	PhD	7	.994	Y
Fecal N	OK	Plant N	PhD	7	.952	Y
DAPA	OK	Plant N	PhD	7	.832	Y
Fecal N	OK	DAPA	OK	9	.943	Y
Plant N	PhD	Plant En.	PhD	7	.634	N
Fecal N	PhD	Plant En.	PhD	7	.625	N
Fecal N	OK	Plant En.	PhD	7	.447	N
DAPA	OK	Plant En.	PhD	7	.520	
Dig.Prot.	PhD	Dig.En.	PhD	7	.486	N
Fecal N	PhD	Dig.En.	PhD	7	.310	N
Fecal N	OK	Dig.En.	PhD	7	.149	N
DAPA	OK	Dig.En.	PhD	7	.069	N
DAPA	OK	Dig.En.[3]	PhD	7	.464	N
Fecal N	OK	Wt.Change	OK	7	.986	Y
DAPA	OK	Wt.Change	OK	7	.923	Y
Fecal N	PhD	Dig.Prot.	PhD	7	.949	Y
Fecal N	OK	Dig.Prot.	PhD	7	.923	Y
DAPA	OK	Dig.Prot.	PhD	7	.813	Y

[1] Okanagan Game Farm Study (Hebert et al 1984)
[2] PhD study (Hebert 1973)
[3] Digestible Energy in Kcal/gm Dry Matter Intake

TABLE 2. A comparison of differences in fecal N with differences in food habits.

FECAL N COMPARISON

	n	Correlation Coefficient	Sig .05
PhD vs OK(81)	7	.920	Y
OK(81) vs Jct[1](82)	8	.552	-
OK(81) vs Jct(83)	6	.672	-
OK(81) vs Jct(82) (Adj. for Phenology)	8	.603	-
OK(81) vs Jct(83) (Adj. for Phenology)	5	.900	Y
OK(78) vs Jct(82) (Adj. for Phenology & Fall Greenup)	9	.724	Y

FOOD HABITS COMPARISON

	Grass	Forbs	Browse
PhD	91.8	6.0	3.2
OK[2] (May-Aug)	56.1	31.3	12.6
OK(82) (Jun-Mar)	86.8	9.75	3.25
Jct(82)	44.1	6.2	64.0

[1] Junction Sheep Range
[2] Pit & Wikeem, 1978

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QUESTIONS AND ANSWERS

Marco-Festa Bianchet: Did you look at ash values in the fecal samples and did the ash as a component affect the nitrogen values?

Daryll Hebert: I haven't looked specifically at ash values in these cases, although Dale Seip has in Stone sheep. Certainly in the work that we've done, the ash values are not being affected by salt licks or any large ingestion of any nonorganic materials. With the data we have and the correlations as we've established to date, there's no problem from that end as far as I'm concerned. But again, its another component that people could examine further because it may play a role in some cases.