MOOSE DEFECATION RATES IN RELATION TO HABITAT QUALITY

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ABSTRACT: Defecation rates (DR) of moose *Alces alces* in relation to sex and age, and to habitat and season were investigated by collecting pellet groups in four study areas during the winters 1984-87. Differences among age and sex classes in DR did not occur. However, the DR of adult cows and calves were higher than reported for free-ranging moose in other areas. Variation in DR within and between study areas were related to change in diet composition. A positive correlation between DR and dry weight of feces (DWF) exists for both cows and calves. A decrease from early (Dec. - Feb.) to late (March - April) winter in DR and DWF of both cows and calves is likely to reflect decreasing quality and availability of browse. The recorded variation in DR may bias comparisons of habitat or area-use.

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The count of pellet-groups has been used to both estimate density and habitat utilization of different deer species (e.g. roe deer *Capreolus capreolus*, Dzieciolowski 1976; white-tailed deer, *Odocoileus virginianus*, Eberhardt and Van Ehen 1956; elk *Cervus canadensis*, Neff *et al.* 1965; moose, Oldemeyer and Franzmann 1981). This method assumes that the DR is constant, irrespective of age, sex habitat and output of feces (Bennett *et al.* 1940, Neff 1968, Timmermann 1974). In this paper we will test this assumption for Norwegian moose by analyzing the relationship between average DWF and daily DR for different ages in four populations living in different habitat types. We will also briefly discuss the reliability of the pellet-group technique for management purposes.

STUDY AREA AND METHODS

DR and DWF was studied in four populations of free-ranging Norwegian moose. One study area was located in southern, two in central (alpine and interior) and one in northern Norway, at 59.9°, 60.7°, 61.3° and 69° northern latitude, respectively. In the southern area gross production and diversity of browse species are high while snow depth is low. This is also within the area of highest moose density in Norway (Solbraa *et al.* 1987). The interior area also supports high moose densities and snow depth is comparable to the southern area, but pine and birch are the dominant browse species, both of medium to low preference to moose.

In the alpine area snow accumulation over winter is high and birch with low yearly twig production is the only browse species available to moose (Sæther and Andersen 1990). In the northern area, browse diversity is comparable to the southern area, but yearly twig production is low and snowdepth is high (Sæther and Andersen 1990). The interior, alpine and northern study areas are within heavy winter concentration of moose and a large proportion of the available biomass is removed each winter (Sæther *et al.* 1987, Sæther and Andersen 1990). Within the southern area moose are more dispersed and browsing less severe (Solbraa *et al.* 1987). The best winter-ranges appear to be in the southern area and the poorest in the alpine area. Due to heavy browsing pressure, range conditions also appear poor in the interior and northern area.

The tracks of radio-collared cow moose and their calves were followed to collect all pellet groups expelled during a 24-hr period. Pellet groups were dried at 70° C for 24 hours and weighed to get daily dry matter output of feces.

During 1984 to 1987 pellet groups were collected from a number of different individuals: 6 cows and 10 calves in the southern area, 4 cows and 8 calves in the interior area and 5 cows, 2 yearling bulls, 2 adult bulls and 4 calves in the alpine area, and 10 cows and 9 calves in the northern area. When cows were followed by calves, the pellets were easily separated by size. In the case of twin calves, the total number of pellet groups was halved to get values for single animals. In the northern area darkness prevented feces collection during January and February. Data from the interior and alpine areas, were pooled due to limited material.

RESULTS

Defecation Rate in Relation to Range

Throughout the winter DR both for cows and calves was highest in the southern area (Table 1). For both cows and calves DR were significantly higher in the southern than in the interior/alpine areas during early and late winter ($P < 0.05$). Differences were not significant between the southern and northern areas for cows ($P > 0.05$) or calves ($P > 0.1$). There was no significant difference in DR's between the interior/alpine and the northern areas. The average dry matter weight per pellet group (DWG) did not differ between areas, except on the ranges of poor/medium quality of the interior/alpine areas, were DWG during early winter was significantly higher than within other areas and periods ($P < 0.05$). It is of interest that a cow radio-collared on the alpine ranges, which later moved ca. 50 km to lowland ranges with abundant browse of high quality, had a low DWG (X = 136 g, range 109 - 179 g) and a high DR (X = 17.8, range 15 - 19), the collections were done during 5 days in early winter.

Defecation Rate in Relation to Season

For all areas pooled a seasonal decrease from early (December - February) to late winter (March - April) was found in DR both for calves and cows ($F = 26.6$, $P < 0.001$ and $F = 10.2$, $P < 0.001$, respectively). These differences were associated with a decrease in DWF, ($F = 16.1$ and $F = 36.9$, $P < 0.001$ for calves and cows, respectively). In the southern area a significant two-way interaction age *season revealed that the decrease in DWF was most pronounced for cows ($F = 6.0$, $P < 0.05$).

Defecation Rate in Relation to Dry Weight of Feces

As DWG was generally stable it follows that the southern area with the highest DR also had the highest DWF. The DWF in the southern area during early and late winter was 4.1 kg and 3.5 kg respectively for cows and 2.4 kg and 2.1 kg, respectively for calves. DWF in the interior/alpine area during early winter was as high as in the southern area; 4.1 kg, but decreased sharply to 2.8 kg in late winter. DWF of calves in the interior and alpine areas was low compared to the southern area; 1.6 kg and 1.4 kg for early and late winter respectively. The values for the northern area during late winter was 2.9 kg for cows and 1.6 kg for calves.

Pooling the data from all areas there was a significant positive correlation between DR and DWF (Fig. 2, $R^2 = 0.30$ and $R^2 = 0.52$ for cows and calves, respectively). Within areas there was a significant positive correlation only for the interior area. For a single cow and her calf followed for 6 days in the southern area there was a significant correlation between DR and DWF ($R^2 = 0.61$ and $R^2 = 0.53$, $P < 0.01$ for cow and calf respectively). During five successive days of collection, wet weight of feces was very stable with a SD of only 1.6 % and 1.8 % of the means for the cow and her calf respectively. DR showed a much higher variation with a SD of 13.0 % and 6.5 % of means for cow and her calf, respectively. Generally, the largest variation in DR and also in DWF was found in the alpine area.

Table 1. Number of pellet groups /day and average weight/group of Norwegian moose during the winters 1984-87. Complete fecal collections were made for free-ranging animals in one southern, one interior, one alpine and one northern area.

Month	Animal	Pellet	Southern				Interior/Alpine				Northern			
	category	groups	N*	X	SD	Range	N	X	SD	Range	N	X	SD	Range
Dec.	cow	number/day	14	22.9	3.8	17-31	11	16.9	5.1	8-27				
Feb.		weight/ group(g)	14	188	54	125-319	11	255	63	156-378				
March	cow	number/day	5	22	5.3	15-29	9	15.6	4.5	7-20	15	16.1	2.9	11-21
April		weight/ group(g)	5	162	26	126-192	9	188	53	131-319	15	185	49	127-290
Dec.	calf	number/day	11	26.9	2.4	23-30	5	20.8	4.9	17-29				
Feb.		weight/ group(g)	11	90	15	63-109	5	82	28	65-122				
March	calf	number/day	5	22.6	2.3	20-25	6	16.1	3.1	13-21	10	17.3	3.9	13-24
April		weight/ group(g)	5	95	18	75-118	6	90	17.1	62-105	10	97	23	72-129
Dec.	yearling	number/day					2	15.5		15-16				
Feb.	bull	weight/ group(g)					2	145		133-156				
March	bull	number/day					2	17		12-22				
April	(small)	weight/ group(g)					2	157		130-183				

*Number of animal-days, twin groups of calves counted as one animal. The number of twin groups during early and late winter in the southern area was 8 and 0 respectively, in the interior/alpine area was 2 and 3 respectively and in the northern area 2, yearling bull was also in twin group.

Defecation Rate in Relation to Age and Sex

DR of lone cows, cows followed by calves, calves and yearling bulls did not differ (Table 1, $P > 0.05$) except for the southern area where calves had a significantly higher DR than cows ($F = 5.4$, $P < 0.05$). For all areas the mean daily DR was 18.6 (SD 5.0) for cows, 20.4 (SD 5.3) for calves and 16.3 (SD 4.2) for 2 yearling bulls. DR varied from 7 to 31 pellet-groups/day for cows and from 13 to 30 for calves.

DISCUSSION

Great differences were reported in winter defecation rates of moose, ranging from 9.6 (DesMeules 1968) to 32.2 (Le Resche and Davis 1971). With the exception of the southern area, our estimates concerning DR agree well with the values obtained in Alaska from penned moose (Franzmann and Arneson 1976; Oldenmeyer and Franzmann 1981). Rogers (1987) found that DR was higher for free-ranging than for penned white-tailed deer in all seasons. To our knowledge the only data on DR from free-ranging moose were reported by DesMeules (1968) and Joyal and Ricard (1986). Both papers reported low DR compared to our data.

Joyle and Ricard (1986) reported a discontinuity (gap) in the frequency distribution of pellet groups/day. This was not found in our study (Fig. 1).

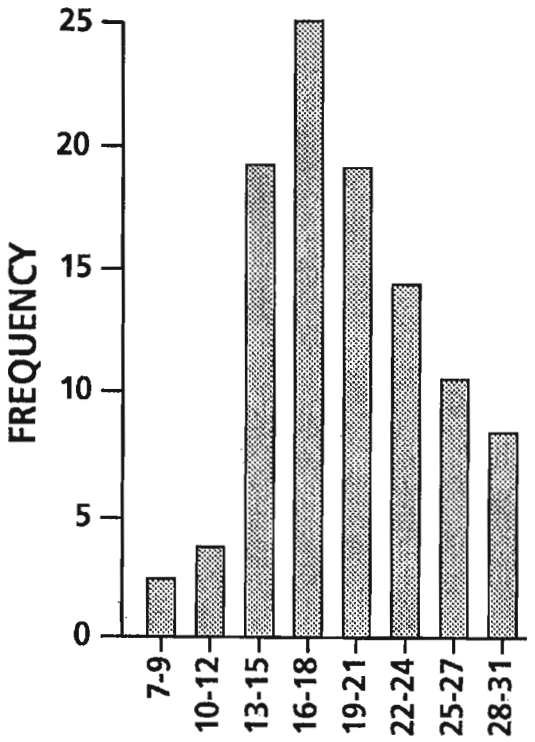

Fig. 1. Frequency distribution of pellet-groups expelled per day by free-ranging moose in four different winter populations.

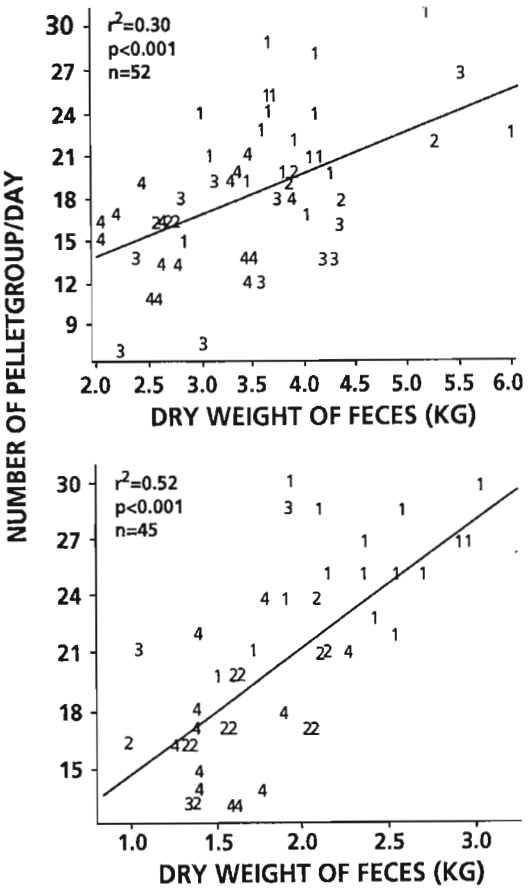

Fig. 2. Relationship between number of pellet-groups and dry weight of feces of moose cows a) and calves b) during winter. 1-Southern area, 2-Interior area, 3-Alpine area, 4-Northern area.

Daily feces output depends on quality and quantity of forage consumed. Reduced intake is common for ruminants on low quality diets (Hale *et al.* 1962, Halls 1970), and in general, the rate of disappearance of digesta from the reticulo-rumen, and thereby fecal output, are highly correlated with forage quality and rate of digestion (Hungate 1966, Thornton and Minson 1972, Church 1975). Thus, we hypothesize that the differences between habitats and study areas in DWF and DR reported in this study are related to differences in composition and quality of diet. This agrees with earlier results from Gibson (1964), Smith (1964) and Rogers (1987). We will assume that decreasing DR and DWF with the advance of winter reflect a general deterioration of browse, forcing the moose to utilize browse of lower quality, which in turn decrease forage consumption and rumen passage and thereby feces output.

Despite a low DR in the interior and alpine areas, a high DWG during early winter brings the DWF up on the same level as in the southern area. Apparently high availability of low quality forage at the start of winter, influences moose forage strategy and rumen kinetics.

Calves generally had a higher DR than cows, although this difference was significant only in the southernmost area. Higher DR for fawns than yearlings and adults has also been found in mule deer (*Odocoileus hemionus*) (Smith 1964).

When fecal pellet-count data are used to compare animal densities and use of different

habitats, the number of pellet groups is often converted to animal-days of use. When this is done, the relationship between DR and diet as well as rumen turn-over time should be considered. Because the first particles of ingested browse appear in the feces not earlier than 10-20 hours after ingestion and will remain for several days (Hjeljord *et al.* 1982), change in diet will not immediately change DR. Therefore, if animals wander continously between habitats, DR will adjust to average browse level and fairly accurately reflect time spent in different habitats. If, on the other hand, comparisons are made between habitats or areas where DR is influenced by difference in browse availability, conversion to animal-days may be misleading. We also recommend that pellet-groups of calves be treated separately from pellet-groups of adults due to the higher DR.

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