SUNNY AND SHADED GROWTH SITES - INFLUENCE ON MOOSE FORAGE QUALITY

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ABSTRACT: Feeding behaviour of moose (*Alces alces*) was observed in southeast Norway. Neither quantity of important forage species nor soil quality explains moose choice of feeding sites within forest types. Rather variation in forage quality caused by site variation in solar radiation is proposed as a possible explanation for moose choice of feeding sites. Comparing forage quality, moose growth rate and moose feeding behaviour during one cloudy and one sunny summer partly supported this hypothesis.

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Belovsky (1981) has developed models of moose diet optimization on summer ranges. These models emphasize the role of energy and nutrients of forage plants. The role of secondary compounds as a defence against vertebrate herbivory has also received much attention during recent decades. Bryant *et al.* (1983) discuss variation in plant chemical defence in relation to the carbon/nutrient balance of plants. Energy input through solar radiation has a strong influence on plant content of carbon-rich secondary compounds. Tannins and other phenolics increase in plants growing in the open compared to plants growing in shaded forest (Bryant et al. 1983, Hanley *et al.* 1986, Hjeljord et al. 1990), and there appears to be a corresponding deterioration in palatability to herbivores (Bryant 1986, Hanley *et al.* 1986).

During 1986-87 a study was conducted of moose feeding ecology during summer on semi-continental ranges in southern Norway (Hjeljord *et al.* 1990). Twenty-three radio-collard moose, mainly cows with calves, were observed at close distance. This paper examines the role of quality and quantity of forage plants in moose choice of feeding sites, with special emphasize on the influence of solar radiation on forage quality and moose feeding behaviour.

MOOSE MOVEMENTS

The observed moose showed a significant difference in selection of forest types over the summer. During May and June moose searched for the first growth of the year on the sun-exposed clearcuts and plantations. During this period the forage digestibility is high and the content of plant secondary compounds is low. Towards mid and late summer there was a gradual increase in the use of mature timber stands. In September and October, 70-80 % of the feding observations were in older forest, and bilberry (*Vaccinium myrtillus*) and willow (*Salix* sp.) dominated the diet (Hjeljord *et al.* 1990). Moose in the study area stay within the same summer range (approx. 300 ha) throughout their life span. They therefore become quite famliar with their habitat and should be capable of returning to good feeding sites, if these are predictable from year to year. Within similar forest types there was, however, no difference in degree of previous browsing on trees on feeding sites compared to trees on random plots. This would rule out an effect of soil quality; if nutritious forage are found on particular soil types, we would expect these sites to be visited repeatedly (e.g. Pastor *et al.* 1988). The occurrence of hedged trees is caused by the moose, when at a feeding site, browsing more heavily on previously browsed trees than on those not browsed

before (Hjeljord *et al.* 1990).

Within forest types, the observed moose did not choose feeding sites according to the density of important browse species (Hjeljord *et al.* 1990). The density of birch (*Pendula pubescens*) and willow, the most important browse species on plantations and in older forest, respectively, was the same on feeding sites and on random plots.

In conclusion, therefore, these findings indicate that either high quality forage is distributed randomly and unpredictably within forest types, or important elements of moose search strategy have not been identified.

SOLAR RADIATION AND FORAGE QUALITY

Analysis of birch leaves collected at feeding sites showed high contents of water, protein and fiber and a low content of tannin, compared to plants collected on random plots within similar forest types (Table 1). A similar difference in chemical content is found when plants growing on clearcuts are compared to plants growing under shaded conditions in mature forest (Table 1). Moose also used older forest more as the summer progressed.

The hypothesis is therefore that variation in forage quality caused by varying light/shade conditions may be one factor determining moose feeding strategy during summer. Light exposure changes from year to year and even within a year, as trees grow at different rates. This could explain the random movement of moose in relation to browse density and previously used sites found in this study.

CLOUDY AND SUNNY SUMMERS

If shaded habitats offer moose better forage than do open habitats, then forage quality should also improve during cloudy summers with reduced solar radiation. Thus during a cloudy summer moose should show higher growth rates than during a sunny summer. Sæther (1985) compared annual variation in autumn body weights of calves and yearling moose in Norway. He reported that moose were heavier after cool, dry summers in northern Norway, where the climate is generally humid; however, in a southern area with a continental climate moose were heavier after wet summers. Variation in precipitation is probably not the main factor influencing the chemical content of plants. Most studies show that high soil moisture either has no effect on or decreases digestibility of forage plants (see Deinum 1984 for a review).

Variation in solar radiation caused by variation in cloudiness is rather likely to be the driving factor. Laine and Henttonen (1986) and Bø and Hjeljord (1991) have shown that leaf tannin content is reduced in cloudy sum-

Table 1. Dry matter (DM) and chemical composition of birch leaves from moose feeding sites and from random sites within forest plantations and from random sites within mature forest. Six composite samles of leaves were collected from each site type during July - August 1987.

	Plantations				Mature forest	
	Feeding sites		Random sites		Random sites	
	X	SE	X	SE	X	SE
Dry matter, %	35.2B[a]	1.2	40.3A	3.1	32.8B	1.4
Tannin, % DM	8.5B	0.9	12.2A	1.5	7.8B	1.2
Protein, % DM	12.3A	2.1	10.9A	2.2	13.1A	1.9
Crude fiber, % DM	13.8B	1.5	11.5A	0.8	14.8B	1.8

[a]Means with different letters within rows are different ($P<0.05$) according to t-test.

mers. During cloudy summers there is also an increase in the protein: dry matter ratio. This is caused by a reduction in dry matter production with reduced light intensity, while nitrogen uptake from the soil remain stable (Deinum 1984, Bø and Hjeljord 1991). These differences in chemical content of forage plants during sunny and cloudy summers are analogous to those in plants from open and shaded growth sites.

Bø and Hjeljord (1991) hypothesized that both preference of moose for shaded habitats and the need to diversify diet should be lessened during a cloudy summer with delayed plant phenology and decreased production of secondary compounds. A comparision of moose feeding behaviour during a sunny and a cloudy summer showed a tendency in this direction, but differences were not statistically significant.

CONCLUSION

Variation in solar radiation exerts a powerful influence on plant growth and chemical composition. This should also be expected to influence nutritive quality of forage plants and ruminant feeding strategy. The studies published so far indicate an improvement of forage quality with reduced solar radiation within continental moose ranges.

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