FORAGING BEHAVIOR BY MOOSE IN FOREST STANDS SUBJECTED TO SEVERE BROWSING

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ABSTRACT: I analyzed winter foraging behavior by moose in Swedish forest plantations severely damaged by browsing. Little selectivity in food plant selection was found; plant species tended to be used in proportion to availability. The results are discussed with reference to optimal foraging theory. I suggest that the apparent lack of preferential feeding patterns in this material might be related to depletion of highly preferred species due to accumulated effects of heavy browsing.

ALCES VOL. 30 (1994) pp.37-40

The relation between herbivore foraging behavior and food plant availability may affect the stability of plant-animal systems and therefore has to be considered in wildlife and range management. Selectivity in foraging behavior, i.e. disproportional use of food plants in relation to availability, is of particular importance. In Fennoscandia, moose (*Alces alces*) tend to rank their food plants by preference. During winter, aspen (*Populus tremula*), rowan (*Sorbus aucuparia*) and willows (*Salix* spp.) are considered to be highly preferred, whereas Scots pine (*Pinus sylvestris*), juniper (*Juniperus communis*) and birches (*Betula pendula* and *B. pubescens*) are of moderate preference (for review, see e.g. Bergström and Hjeljord 1987). Few studies have addressed food plant preference in relation to the relative abundance of co-occurring species. Here I report on winter food plant use by moose in heavily browsed forest plantations in Sweden.

MATERIAL AND METHODS

For this analysis I use data from regional moose damage surveys conducted by the County District Forestry Boards; one survey from the Västerbotten County in northern Sweden (Pettersson 1990) and one survey covering seven counties in different parts of Sweden (Skogsstyrelsen 1983).

Investigations of moose damage were made in 25-50 km^2 areas, primarily chosen on basis of expectancy of severe damage due to intense browsing. All young forest stands containing Scots pine were marked on a map. The lower size-limit for stands was set at 0.5 ha. To be selected stands had to consist of at least 30% Scots pine and have a mean height of 0.5-5 m. In each area, 25 stands were randomly selected for field-survey. A total of 375 and 511 stands from 15 and 21 areas, respectively, were investigated in the two studies.

For each stand, abundance of different browse species (aspen, rowan, willows, birches, Scots pine and juniper) was expressed as cover, i.e. the percentage of ground covered by the foliage within the browsing height (0.5-3 m) when projected to the ground in ten systematically spaced 100 m^2 circle sample-plots. Use by moose was determined on basis of the estimated proportion of the current and one-year-old growth affected by browsing. Recent browsing was not distinguished from older browsing. The categories used here were: 0=unbrowsed, 1=<1/3, 2=1/3-2/3, and 3=>2/3 of the biomass removed, respectively. Use by moose was calculated per species and area by summing the proportion of cover in different browsing intensity categories (1-3) times 0.167, 0.500 and 0.833, respectively. Cover was multiplied by use in order to estimate the amount of foliage removed by moose.

For each species, relative inclusion in the diet was regressed on relative abundance

(N=15 and 21, respectively, for each study). Food plant selectivity was assessed by testing whether the regression slopes significantly deviated from 1 for $P<0.05$ (t-test).

RESULTS

Cover of Scots pine and birches was high compared with aspen, rowan, willows and juniper in both studies (Fig. 1). In the Västerbotten study (Fig. 1 a), the cover of pine and birch was 5.2 and 2.2%, respectively, making up 62 vs. 26% of the available food (Fig 2 a). The corresponding figures for the other study were 17.1 and 3.1% (Fig. 1 b) and 82 and 15% (Fig. 2 b), respectively.

Use by moose was highest on aspen, rowan and willows (both studies; Fig. 1). In the Västerbotten study, moose used birches and Scots pine more intensively than juniper, whereas pine was least utilized in the other study.

Consumption by moose on different tree species tended to be proportional to availability (Fig. 2). Thus, Scots pine dominated both in the environment and in the diet, followed by birches. By contrast, juniper, aspen, rowan and willows occurred rarely both in environment and in diet. I found evidence of food plant selectivity only for aspen in the Västerbotten study, where it was included to a larger extent in the diet than expected by availability (Fig. 3).

DISCUSSION

Moose used aspen, rowan and willow trees much more intensively than pine, birch and juniper. These results confirm the view that the former species are highly preferred by moose on their Fennoscandian winter range. In the present material, aspen, rowan and willows constituted only a minor fraction of the amount of food available to moose. Therefore, when availability was taken into account, another pattern of use emerged. Although Scots pine and birches were browsed less intensively than aspen, rowan and willows, they were totally dominating in the diet.

Since relative inclusion in the diet closely followed availability for almost all species, little selectivity in moose foraging behavior was suggested. According to optimal diet choice (e.g. Stephens and Krebs 1986), foragers should concentrate on the most profitable items in terms of nutrient or energy content until availability drops below some lower treshold, and then turn over to less profitable

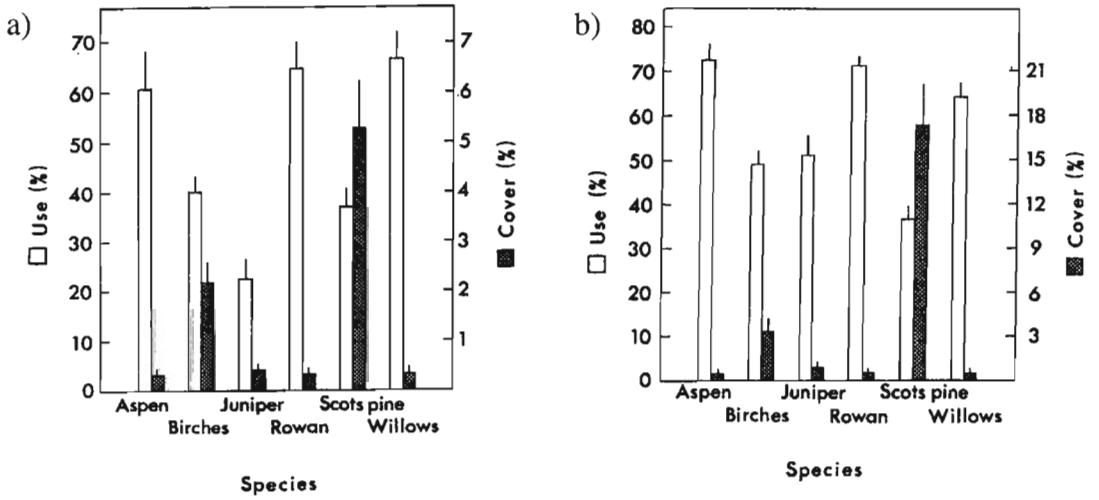

Fig. 1. Use by moose and cover of different food plant species in forest plantations in Västerbotten County in northern Sweden (a), and seven counties in different parts of Sweden (b). Means and 1 SE based on 15 and 21 areas, respectively, each comprised of 25 stands.

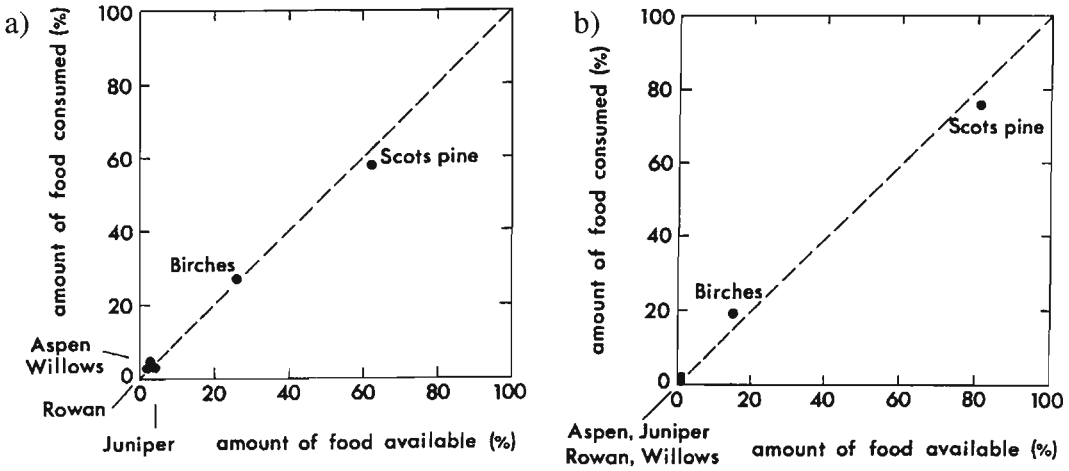

Fig. 2. Inclusion of food plant species in moose winter diets in relation to relative abundance in forest plantations in Västerbotten County, northern Sweden (a), and seven counties in different parts of Sweden (b).

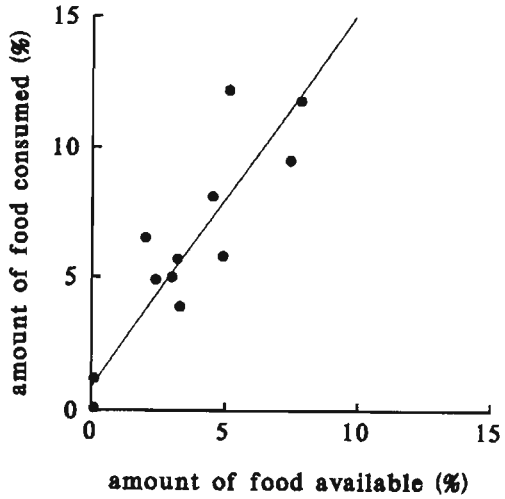

Fig. 3. Relative inclusion of aspen in moose winter diets in relation to relative abundance in forest plantations in Västerbotten county, Sweden. $y=0.88+1.43x$, $r^2=0.82$, $P<0.001$.

items. For moose, this could mean that pine, birches and juniper become progressively more important in the diet as an indirect cause of depletion of aspen, rowan and willows. Thus, one explanation for the pattern of little selectivity in food plant selection in the present material might be that availability of highly ranked species was so low that moose could not afford to specialize.

Selection of stands was partly based on expectancy of moose damage. They do not therefore constitute a random sample of Swedish forest plantations (Strauss 1988). Moose diet composition in the investigated stands may have been biased towards pine and birch because of a reduction in the availibility of aspen, rowan and willows due to the accumulated effects of heavy browsing. These species are browsed year-round, in contrast to Scots pine which is used primarily during winter. The deciduous species may therefore be particularly susceptible to repeated browsing. Preliminary analysis of moose browsing patterns in areas where the abundance of aspen, rowan and willows is higher do indicate preferential feeding on these species (Wallin *et al. unpublished material*).

ACKNOWLEDGEMENTS

I thank K. Danell and an anonymous reviewer for valuable comments on the manuscript. The study was supported by grants from the Swedish Council for Forestry and Agricultural Research and the Swedish National Environment Protection Board.

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