REBROWSING ON BIRCH (*BETULA PENDULA* AND *B. PUBESCENS*) STEMS BY MOOSE

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Abstract: Within the Sunnäs moose (*Alces alces*) enclosure (6.2 km^2) in central Sweden 134 stems of *Betula pendula* and 111 of *B. pubescens* were permanently tagged. Winter browsing by moose was recorded every spring in four consecutive years. The observed distribution of the number of trees in classes with different "browsing history" differed significantly from what could be expected. The difference was most striking in the two groups "unbrowsed all years" and "browsed all years". In these groups observed frequencies were considerably larger than expected. There was also a quantitative relationship: the more a plant was browsed as a total during the first three years the more it was browsed in the fourth year. The results are discussed in relation to food selection and dynamics of the moose-browse system.

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Few publications dealing with the browse-moose relationships have considered the dynamic aspects of the forage component (Axelsson and Ågren 1981, Blackwell 1981, Oldemeyer 1981, Blackwell 1982). The variation in the abundance of available browse depends greatly on the browsing on individual plants and their responses to repeated biomass removal. The ultimate response is probably influenced not only by the magnitude of the single browsing impact but also by the interval of rebrowsing. The pattern of rebrowsing between years is a result of

inherent and initial characters of individual plants and also of their history of browsing during the preceding years (Penner 1978, Machida 1979, Danell, Huss-Danell and Bergström (in prep.)). These authors have shown that a plant that was browsed in one winter had a higher probability than an unbrowsed plant to be browsed in the following winter. Bryant (1981) concluded that adventitious shoots produced after browsing on adult deciduous trees were extremely unpalatable. This difference between studies has not yet been thoroughly explained.

The present study aimed at analysing the rebrowsing pattern during consecutive years on birch (*Betula pendula* Roth and *B. pubescens* Ehrh.).

Betula pendula and *B. pubescens* are species that are moderately preferred by moose (Ahlén 1975, Cederlund et al. 1980). They are common in many habitats in Sweden and they are both important forage species during different seasons.

STUDY AREA AND METHODS

The study was carried out within the Sunnäs moose enclosure (61°06'N, 17°05'E) which has been described further by Bergström (1981). The enclosure is 615 ha. Bogs cover about 15% of the area. The rest of the land comprises the managed forests that are commonplace in central Sweden with Scots pine (*Pinus silvestris*) and Norway spruce (*Picea abies*) as the dominating tree species.

About 0.4 m of snow usually covers the ground from mid-November to mid-April.

As part of a study of production and consumption of browse, 134 *B. pendula* and 111 *B. pubescens* were permanently tagged. The sampling design is described by Bergström (1981) and is briefly related here.

Sampling points were laid out systematically in randomly selected stands from three forest age classes (0-17, 18-40 and 40 + years) and in mires. Trees were selected according to the "corrected point distance" method (Batcheler 1973). All trees with at least one current annual shoot within the height of 0.5-2.5 m were considered for sampling. With the described sampling procedure the selected trees had a clumped distribution with systematically spread triplets where the mean distance between individual trees amounted to a few meters. In late April and early May, i.e., between snow melt and leaf flush, during 1980-83 the following data were recorded for the tagged birches: a) total tree height, b) number of bites from the last winter within 0.5-2.5 m above ground and c) the stem diameter at breast height on trees taller than 5.0 m.

The trees were observed to fall into groups with different browsing history. Some trees had remained unbrowsed during the four consecutive winters and at the other extreme some had been browsed in all the winters concerned. Altogether 16 combinations with unbrowsed/browsed were possible. The observed number of trees in each group was compared with expected numbers. The latter were calculated by a proportional allocation of browsed and unbrowsed trees in one winter on the two groups, unbrowsed and browsed, the preceding winter starting with the observed number in 1979/80.

The observed and expected frequencies were tested against each other by chi-square analyses. A correlation analysis was used to study a possible relation between browsing intensity in one winter and the accumulated browsing pressure during three preceding winters.

The moose densities within the pen during the four winters 1979/80 - 1982/83 were 1.3, 2.3, 3.4 and 4.5 moose/km^2 respectively.

RESULTS

The mean height of *B. pendula* (n=128) at the beginning of the study was 1.6 m (SE=±0.06) and for *B. pubescens* (n=107) 1.2 m (±0.06).

Of the tagged 134 *B. pendula*, 37 stems were browsed in the first winter (1979/80). The number increased to 95 (1980/81) but a slight decrease was recorded in 1982/83. This reduction in number was probably due to a mild winter when dwarf-shrubs were available. This continuous change made it difficult to compare the variables studied between years and it seemed more relevant to compare the observed results with expected values. Table 1 shows the observed and expected number of *B. pendula* belonging to different browsing histories. It was expected that four trees should have been browsed in all four years. However, the observed value was 14 trees. Higher observed than expected frequencies were recorded for the combinations 0001 and 0010 (Table 1). For all trees with other browsing histories, except the group with trees browsed in all years, the observed values were slightly lower than expected. The most striking discrepancy between observed and expected values was in the group of trees browsed in all four years. In this class almost three times as many trees were browsed as could be expected from a random browsing behaviour. A chi-square test showed a highly significant difference between the observed and expected distribution.

The results of the study also confirmed that *Betula pubescens* is not as preferred as *B. pendula* (Table 3). The percentage of browsed *B. pendula* stems during the different years was 3-4 times that of *B. pubescens*. However, the rebrowsing pattern was about the same (Table 2) as the one shown for *B. pendula*. The frequencies observed were considerably higher at the extremes, i.e. more stems than expected were

Table 1. The observed and expected numbers of *Betula pendula* stems browsed during different combinations of winters (0=unbrowsed; 1=browsed).

Browsing history				Number of trees				(Observed-expected)² / expected
79/80	80/81	81/82	82/83	Observed		Expected		
0	0	0	0	14		4		25.0
0	0	0	1	13		9		1.2
0	0	1	0	14		11		0.8
0	0	1	1	14		22		2.9
0	1	0	0	5		5		0.0
0	1	0	1	6		10		1.6
0	1	1	0	8		12		1.3
0	1	1	1	23	23	24	26	0.3
1	0	0	0	0		2		
1	0	0	1	3	4	3	7	1.3
1	0	1	0	1		4		
1	0	1	1	4	5	8	10	2.5
1	1	0	0	1		2		
1	1	0	1	1	3	4	9	4.0
1	1	1	0	2		5		
1	1	1	1	25		9		28.4
				134		134		χ^2=69.3
								(P<0.001)

Table 2. The observed and expected numbers of *Betula pubescens* stems browsed during different combinations of winters (0=unbrowsed; 1=browsed).

Winter of browsing				Number of browsed trees		(Observed-expected)² / expected
79/80	80/81	81/82	82/83	Observed	expected	
0	0	0	0	67	58	1.4
0	0	0	1	15	16	0.1
0	0	1	0	8	13	1.9
0	0	1	1	5	4	0.2
0	1	0	0	5	8	1.1
0	1	0	1	2	2	0.0
0	1	1	0	1	2	
0	1	1	1	0	0	4.5
1	0	0	0	1	5	
1	0	0	1	0	1	
1	0	1	0	2	1	
1	0	1	1	0	0	
1	1	0	0	0	1	12.5
1	1	0	1	0	0	
1	1	1	0	4	0	
1	1	1	1	1	0	
				111	111	χ^2=21.70
						(P=<0.01)

Table 3. Observed and expected numbers of trees (*Betula pendula* and *B. pubescens*) browsed a certain number of years.

Number of years	*B. pendula* Number of trees		$\frac{(Obs-exp)^2}{exp}$	*B. pubescens* Number of trees		$\frac{(Obs-exp)^2}{exp}$
	Observed	expected		Observed	expected	
0	14	4	25.0	67	58	1.4
1	32	29	0.5	29	42	4.0
2	33	51	7.1	10	11	
3	30	41	2.9	4 (15)	0 (11)	1.4
4	25	9	28.4	1	0	
Σ	134	134	χ^2=63.9 (P<0.001)	111	111	χ^2=6.8 (P<0.01)

Table 4. Winter browsing intensity (expressed as % of trees in different browse use classes) in 1982/83 on *B. pendula* stems exposed to varying browsing pressures during three earlier winters.

Accumulated number of bites 1979/80-1981/82	% of trees (1982/83)					
	0	1-10	11-20	21-50	51-100	100+
0	50	27	12	12	0	0
1-10	47	40	10	3	0	0
11-20	33	47	13	0	7	0
21-50	33	33	25	8	0	0
51-100	17	22	35	17	4	4
100+	0	25	6	56	13	0

totally unbrowsed or browsed every winter. Because of the lower number of browsed trees many frequencies were low, which necessitated lumping of groups to get frequencies larger than one.

Table 3 shows the number of trees which were browsed 0, 1, 2, 3 and 4 years respectively. The observed distribution for each of the two birch species was tested against the expected one. The highest relative deviations between observed and expected values were found in the tail classes. The differences for *B. pubescens* were not quite so pronounced but a significant difference was still found.

The results presented have shown the difference between unbrowsed and browsed plants. Table 4 shows that not only browsing as such but also the magnitude of browsing will influence future use. Only *B. pendula* are analysed in this way as too few individuals of *B. pubescens* were browsed to permit a meaningful analysis. The more intensively a plant was browsed during the winters 1979/80, 1980/81 and 1981/82, the more bites the moose took from that plant during 1982/83 ($r=0.49$, $N=134$, $P<0.001$).

DISCUSSION

The rebrowsing pattern by moose showed a clear trend towards more browsing than expected on already browsed stems of *B. pendula* and *B. pubescens*. The pattern was most pronounced for *B. pendula*. This difference could perhaps be explained by the number of browsed trees of the two species. Browsing on previously browsed woody plants (*Salix* spp.) has also been reported by Penner (1978) and Machida (1979). Penner concluded that "browsing influenced some 'palatability' factor of the following season's growth which in turn stimulated a selective

response by moose". The same author also argued that the preference for shrubs browsed earlier resulted in reduced browsing time and feeding movements for the moose. This seems reasonable also for the two birch species as Danell (1983) showed that birches browsed by moose produced fewer but larger current annual shoots and thereby increased "food density". However, it cannot be excluded that chemical changes are involved in the selection process, although published results are too scarce or contradictory to be used as explanations.

Danell and Bergström (in prep.) showed by means of simulated browsing that the morphological responses of birches were dependent also upon the amount of browse removed. Their conclusions and the results in Table 4 showed that rebrowsing is not a matter of "either - or" but merely a dynamic phenomenon dependent on browsing levels.

Paper birch is reported to be fairly tolerant to browsing (Oldemeyer 1981). The same is true for *B. pendula* and *B. pubescens* in Sweden. Few individuals are found to have been killed by moose browsing, even in areas with extreme moose densities. None of the trees in the present study were killed by moose. About 65% of *B. pendula* and 14% of *B. pubescens* were browsed more than once during the period of four years (Table 3). Further, the number of bites per tree was low. Considering the tolerance and the possible beneficial responses of the birch to moderate browsing (Oldemeyer 1981), it seems that the moose densities within the enclosure have not overused the two birch species.

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