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The winter browse supply for moose in different forest site-types in the Biebrza Valley, Poland

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The winter biomass of browse for moose was estimated in the fresh pine forest, the moist coniferous forest and the alder wood in the Biebrza Valley (NE Poland). Fifteen species of trees and shrubs were available to moose in the forest site-types examined. Ten of them were identified to be important: six in each forest association. On the basis of their biomass, *Betula pubescens*, *B. pendula* and *Frangula alnus* were the most important food plants in coniferous forests and *Sorbus aucuparia* in the alder wood. The highest supply of browse was found in the timber stand of the moist coniferous forest (27.42 kg dry wt/ha) and the alder wood (25.97 kg dry wt/ha). The lowest supply of 5.43 kg dry wt/ha was available in the fresh pine forest. Browse was least abundant in the pole-sized stands of both fresh pine (0.78 kg dry wt/ha) and the moist coniferous forest 0.87 kg dry wt/ha).

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Introduction

The Biebrza Valley is the main concentration area of the moose *Alces alces* (Linnaeus, 1758) in Poland. It supports moose population of 500–600 animals on 170 000 ha in 1989–1991 (Gębczyńska and Raczyński 1993). Spatial distribution, population structure and social organization and habitat preference of moose have been described by Gębczyńska and Raczyński (1983, 1984, 1989). However, the winter food resources for moose in winter have not been estimated in forests of the Biebrza Valley until now. Pine forests with rich undergrowth on mineral soils and bog alder forest were the main moose winter habitats (Gębczyńska and Raczyński 1983, Fedyk *et al.* 1984). Therefore, we used those biotops in our study.

The purpose of the present investigation was: (1) to establish a list of the most important plant species which could compose a potential winter food resource in various forest site-types in the Biebrza Valley and (2) to estimate of the browse supply for moose in those environments.

Study area and methods

The studies were carried out in the central part of the southern basin of the Biebrza Valley (NE Poland, 53°21'N, 22°38'E). The southern basin covers the area of 40000 ha with the forest area of

6800 ha (Bosiak 1991). The moose winter density was estimated at 3.1–5.0 animals per 1000 ha (Gębczyńska and Raczyński 1983). The study areas included: (1) the fresh pine forest (*Vaccinio myrtilli-Pinetum typicum*), (2) the moist coniferous forest (*Vaccinio myrtilli-Pinetum molinietosum*) and (3) the alder wood (*Carici elongatae-Alnetum typicum*) (Czerwiński 1978).

Dzięciołowski (1969) defined browse as shoots on trees and shrubs from the previous growing season within the zone from the ground (or snow) surface to the height of 2 m. We observed moose contacts on trees from 0.5 to 3.5 m high, so we took six tree height classes in our study: class I: 0.5–0.99 m, class II: 1.0–1.49 m, class III: 1.5–1.99 m, class IV: 2.0–2.49 m, class V: 2.5–2.99 m, class VI: 3.0–3.49 m.

The studies were carried out in 1989, 1990 and 1992, after the end of the vegetation period (September–October). The plot method with clipping shoots was used (Dzięciołowski 1969, Bobek and Dzięciołowski 1972, modified). Four hundred unfenced plots (2 × 5 m each) were distributed systematically along the transects in three forest site-types.

The amount of browse were estimated for 10 species because others were too rare to be included. The number of trees was recorded for each plot in six tree height classes. The browse was clipped from 1130 trees growing on the plots and weighed to 0.1 g. Clipped samples were dried during 48 hours at 65°C and reweighed with the same accuracy (Dzięciołowski 1969). Coefficients W (i.e. dry matter/fresh matter of sample) were used to calculate average dry matter of browse per stem and plot.

Differences in browse supply among types of forest were tested using Kruskal-Wallis one-way analysis by ranks because data were not normally distributed ($p > 0.05$ in χ^2-test). Kruskal-Wallis analysis was also used to test the differences in biomass production among browse species and tree height classes.

Results

Ten species of trees and shrubs constituted the basis of winter browse supply in the studied forests of the Biebrza Valley (Table 1). The others, like *Pinus sylvestris*, *Juniperus communis*, *Corylus avellana*, *Viburnum opulus* were too rare

Table 1. Winter browse production (kg dry wt/ha ± SD) of browse species examined in forest site-types, the Biebrza Valley, Poland. p – significance level in Kruskal-Wallis test, ns – not significant ($p \geq 0.05$).

Browse species	Fresh pine forest		Moist coniferous forest		Alder wood
	Pole-sized stand	Timber stand	Pole-sized stand	Timber stand	Timber stand
Betula pendula	0.40 ± 2.14	0.71 ± 3.13	0.01 ± 0.14	2.17 ± 4.37	–
Betula pubescens	0.10 ± 0.58	2.73 ± 7.10	0.27 ± 1.06	10.43 ± 9.56	1.82 ± 1.77
Alnus glutinosa	–	–	–	–	0.98 ± 3.26
Quercus spp.	0.21 ± 0.84	0.58 ± 3.13	0.28 ± 0.70	1.30 ± 3.39	–
Populus tremula	–	0.09 ± 0.62	0.01 ± 0.08	0.13 ± 0.48	–
Salix spp.	–	0.01 ± 0.14	0.05 ± 0.28	2.52 ± 7.34	–
Ribes spp.	–	–	–	–	3.58 ± 4.77
Sorbus aucuparia	–	–	–	–	8.78 ± 10.86
Padus avium	–	–	–	–	4.15 ± 11.94
Frangula alnus	0.08 ± 0.39	1.31 ± 3.24	0.25 ± 0.67	10.87 ± 13.45	6.66 ± 7.60
$p <$	ns	0.0001	0.0001	0.0001	0.0001

or their heights were lower than 0.5 m. On the other hand, we did not observe moose feeding on *Picea excelsa* in the forests of the Biebrza Valley.

Biomass production of some browse species differed in relation to forest site--type: $p < 0.05$ in Kruskal-Wallis test for *Betula pendula* and *Frangula alnus* in pole-sized stands and *B. pendula*, *B. pubescens*, *Quercus* spp. and *F. alnus* in timber stands (Table 1).

Browse species produced more biomass of twigs ($p < 0.05$, Kruskal-Wallis test) in the timber stands than in the pole-sized stands, both in the fresh pine forest (*B. pubescens* and *F. alnus*) and in the moist coniferous forest (*B. pendula*, *B. pubescens*, *Salix* spp., *F. alnus*) (Table 1).

Table 2. Winter browse supply in the tree stands of different forest site-types (kg dry wt/ha ± SD), the Biebrza Valley, Poland. p – significance level in Kruskal--Wallis test, ns – not significant ($p \geq 0.05$).

Forest site-type	Pole-sized stand	Timber stand	$p <$
Fresh pine forest	0.78 ± 2.37	5.43 ± 10.18	0.001
Moist coniferous forest	0.87 ± 1.72	27.42 ± 20.47	0.0001
Alder wood	–	25.97 ± 22.11	–
$p <$	ns	0.0001	

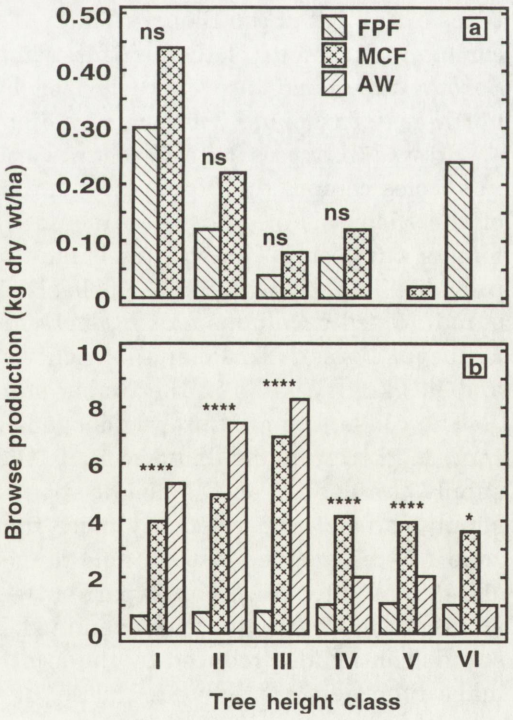

Fig. 1. The winter browse supply in six tree height classes in the pole-sized stand (a) and the timber stand (b) of different forest site--types; the Biebrza Valley, Poland. FPF – fresh pine forest, MCF – moist coniferous forest, AW – alder wood. Significance levels in Kruskal--Wallis test are given above the bars, ns – not significant difference ($p \geq 0.05$), **** – $p < 0.0001$, * – $p < 0.05$.

The browse supply varied between stands (Table 2). The pole-sized stands provided less biomass of browse than the timber stands in the fresh pine (H = 12.40, $p < 0.001$) and in the moist coniferous forest (H = 92.12, $p < 0.0001$). Pole-sized stands examined produced similar browse supply (H = 2.84, ns). On the other hand, the timber stand of the fresh pine forest had about one fifth of browse supply available to moose in the other timber stands. The timber stand of the alder wood had similar browse supply to the moist coniferous forest (H = 0.29, ns) (Table 2).

Browse production differed in relation to tree height classes ($p < 0.001$, Kruskal--Wallis test for each forest site-type). In the timber stands only we found significant differences ($p < 0.05$, Kruskal-Wallis test) in the amount of browse available in tree height classes among forest types (Fig. 1). The highest classes (IV, V and VI), the most suitable to moose, produced more biomass of twigs than lower ones only in the timber stand of the fresh pine forest (Fig. 1b).

Discussion

Moose diet composition is characterized by a high variability which depends on the habitat and geographical distribution of the species (Peterson 1955, Joyal 1976, Dunin and Januško 1979, Cederlund *et al.* 1980, and others). The results obtained suggest that species diversity of the browse is rather low in the forest types examined in the Biebrza Valley. Ten species are important because they are common. Only four of them (*Betula pubescens, B. pendula, Frangula alnus* and *Sorbus aucuparia*) are characterized by a high production. In other forests of north-eastern Poland winter moose diet consists of 16 tree species (Morow 1976).

Browse resources are different in various forest site-types because of differences in species composition, frequency, site productivity and earlier browsing. Forests of the Biebrza Valley have rather low browse supply in comparison with other forests studied in Poland. Fresh pine forest (*Peucedano-pinetum*) in SE Poland provides 3 kg dry wt/ha in the pole-sized stand and 26 kg dry wt/ha in the timber stand. Mixed deciduous forest (*Querceto-Betuletum serratuletosum*) in Białowieża Primeval Forest, NE Poland, is richer: 551 kg dry wt/ha in the pole-sized stand and 149 kg dry wt/ha in the timber stand (Bobek *et al.* 1975).

The consumption of browse depends on the height or age of food plant (Bobek *et al.* 1972, Dunin and Januško 1979, Oldemeyer 1983). Therefore, the real browse supply can depend on the height structure of food plants. Areas with low browse supply can be used relatively more frequently if twigs are available within the zone 1.5–3.5 m, the most suitable to moose. However, the top tree height classes (1.5–3.5 m) offer the greatest part of twig production (51–75 %) only in the timber stand of the forest site-types examined. The small browse supply of the pole-sized stands can be also reduced by the location on the lower trees (0.5–1.49 m) which make them less attractive to moose.

Browse resources of older forest stands are also poorer in comparison with younger stands (up to 3.2 t dry wt/ha in thicket of the fresh pine forest – Borkowska and Konopko 1994). However, older stands occupy about 77 % of the total forest area of the Biebrza Valley (Bosiak 1991). On the other hand, pine and bog alder forests together with willow-birch shrubs compose the major winter feeding grounds for moose and other deer species in the southern Biebrza basin (Fedyk *et al.* 1984).

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