Nutritive value of leaf fodder from the main woody species in Iceland

Hejcman M.[1], Hejcmanová P.[1], Pavlů V.[1], and Thorhallsdottir A.G.[2]
[1]*Czech University of Life Sciences, Kamýcká 129, CZ-165 21 Prague, Czech Republic*
[2]*Agricultural University of Iceland, Hvanneyri, IS-311 Borgarnes, Iceland*
Corresponding author: hejcmanova@ftz.czu.cz

Abstract

In the past, leaf fodder from woody species played an important role as animal feed in Iceland. However, very limited information exists on the nutritive value of the main woody species used as fodder. The aim of our study was therefore to determine forage quality of leaves of *Betula nana, B. pubescens, Salix lanata, S. phylicifolia* and *Sorbus aucuparia* and to compare it with forage quality of a common native grass, *Deschampsia cespitosa,* and with an introduced grass, *Alopecurus pratensis,* used by contemporary Icelandic farmers for forage production. In late June 2013, we collected samples of all species at four localities in Iceland and determined concentrations of nitrogen, phosphorus, neutral and acid-detergent fibre and lignin and compared them with the optimum range required for sheep nutrition. Nutritive value of leaves of woody species was relatively high and browsing of their leaves and collection of their leaf fodder for winter feeding could satisfy sheep/cattle nutritional requirements for N and P. However, the high content of indigestible lignin, present in all the woody species, functions as a barrier to nutrient digestibility. Grasses were characterized by lower P. The forage quality of leaves of woody species increased in the order *B. nana* < *B. pubescens* < *S. phylicifolia* < *S. aucuparia* < *S. lanata.*

Keywords: livestock feeding, forage quality, North Atlantic Isles

Introduction

In northern regions, human subsistence in the past was almost exclusively based on animal products. The colonization of the North Atlantic islands, including Iceland, by Norse settlers (AD 800 – 1000) was thus connected with the spread of livestock; namely cattle, sheep, horses and goats (Amorosi *et al.*, 1997). Livestock browsing was, together with wood collection and charcoal production (Church *et al.*, 2007), one of the reasons for forest degradation, because livestock diets were, in addition to grassland forage, based on leaves, generative organs, bark and the annual twigs of woody species (Gauthier *et al.*, 2010). In Iceland, Norse colonization followed by year-round livestock grazing and browsing has been considered one of the main reasons for the decline of *Betula pubescens* forests at the beginning of the 20th century (Ólafsdóttir and Guðmundsson 2002). Although woody species played, and in some Nordic regions still play, an important role in livestock feeding, information on the nutritive value of leaves (i.e. nitrogen, phosphorus and fibre fractions) of common woody species has been missing (see though Sigvaldason (1967) for earlier estimates). The aim of this study was to determine forage quality of leaves of common woody species (*Betula nana, B. pubescens, Salix lanata, S. phylicifolia* and *Sorbus aucuparia*) in Iceland and to compare it the with forage quality of two grasses, both common in old hayfields in Iceland: the native *Deschampsia cespitosa* and the high-yielding grass *Alopecurus pratensis,* introduced from Europe (Helgadóttir *et al.*, 2013; Kristinsson, 2013).

Material and methods

We collected leaf biomass of five common broad-leaved woody species (*Betula nana, B. pubescens, Salix lanata, S. phylicifolia* and *Sorbus aucuparia*) and two grass species (*Deschampsia cespitosa* and *Alopecurus pratensis*) at four localities in Iceland in late June 2013. A total 28 biomass samples were oven-dried at 60 °C for 48 hours, ground to powder and analysed for the concentration of nitrogen (N), phosphorus (P) and the content of neutral- (NDF)

and acid-detergent fibre (ADF) and acid-detergent lignin. The N concentration in the plant samples was determined using an automated analyser TruSpec (LECO Corporation, USA) and P concentration using ICP–OES (Varian VistaPro, Mulgrave, Vic., Australia) after mineralization using *aqua regia* of burnt samples in in a microwave oven at a temperature of 550 °C. Contents of NDF, ADF and ADL were determined by standard methods of AOAC (1984). All analyses were performed in an accredited national laboratory, Ekolab Žamberk (http:// www.ekolab.zamberk.cz). Data were tested by one-way ANOVA followed by post-hoc comparison using the post-hoc HSD Tukey's tests to identify differences in concentrations of N, P, NDF, ADF and lignin contents among species.

Results and discussion

All values of concentrations of N, P, NDF, ADF and lignin are given in Table 1.

Table 1. Concentration (means ± standard error of mean) of N, P, neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin in leaf biomass of studied species. Calculated by one-way ANOVA followed by Tukey post-hoc comparison test, significant differences ($P<0.01$) among species are indicated by different letters. Chemical properties of fodder from Icelandic grasslands (with dominant *Alopecurus pratensis*, *Poa pratensis*, *Phleum pratense* and *Agrostis capillaris*) follow Ragnarsson and Lindberg (2010) and Thorvaldsson *et al.* (1998) and optimum range for sheep and cattle follows Whitehead (1995).

Species	N (g kg^{-1})	P (g kg^{-1})	NDF (g kg^{-1})	ADF (g kg^{-1})	Lignin (g kg^{-1})
Betula nana	24.1±1.0^{a}	2.6±0.2^{a}	328±23^{ab}	305±15^{abc}	154±7^{d}
Betula pubescens	28.7±1.4^{a}	3.1±0.2^{ab}	315±16^{ab}	294±16^{abc}	123±10^{cd}
Salix lanata	27.5±0.9^{a}	3.8±0.4^{b}	376±25^{c}	345±22^{bd}	96±6^{bc}
Salix phylicifolia	27.7±2.2^{a}	3.9±0.3^{b}	272±28^{a}	243±15^{a}	119±19^{cd}
Sorbus aucuparia	26.5±1.3^{a}	3.0±0.3^{ab}	285±17^{ab}	269±12^{ab}	95±3^{bc}
Alopecurus pratensis	23.2±1.5^{a}	2.5±0.2^{a}	631±22^{d}	388±13^{d}	65±7^{ab}
Deschampsia caespitosa	25.1±0.8^{a}	2.0±0.2^{a}	614±12^{d}	324±6^{bcd}	38±2^{a}
Grassland forage optimum range for sheep/cattle	19-32 19.2 - 25.6	1.9-2.4 2.3 - 3.7	500-550 330-450	270-310 190-300	30-50 max. 80

Concentrations of N were similar and concentrations of P, NDF, ADF and lignin were significantly different among species (Table 1). Nitrogen and phosphorus concentrations were also within the optimum range for nutrition of cattle in all analysed species, with the exception of the too-low P concentration in *D. cespitosa* and a slightly higher P concentration in *S. phylicifolia*. Optimum NDF content for sheep and cattle nutrition was recorded only in *S. lanata*, whereas optimum content of ADF was recorded in *B. pubescens*, *S. phylicifolia* and *S. aucuparia*. Content of lignin was substantially higher in woody species than in grasses. Relatively high lignin content in all woody species in comparison with grasses could be the most problematic for livestock metabolism, because digestibility of the biomass generally decreases with an increase in lignin content (Cherney *et al.*, 1993). On the other hand, woody species offer considerable amounts of indispensable nutrients, particularly N and P. The nutritive value of leaves of the main woody species in Iceland was relatively high in comparison with the dominant broad-leaved woody species in Central Europe (Hejcmanová *et al.*, 2013) and could satisfy livestock requirements. The forage quality of leaves of woody species increased in the order *B. nana* < *B. pubescens* < *S. phylicifolia* < *S. aucuparia* < *S. lanata*. Both *Betula* species are browsed by Icelandic sheep, but *B. pubescens* substantially more and mainly in the spring and early summer (Thorhallsdottir and Thorsteinsson, 1990) This pattern is in agreement with higher forage quality of *B. pubescens* than of *B. nana* and this probably explains why *B. pubescens* was harvested in the past for leaf fodder by Icelandic farmers while *B. nana* was rarely used (Gunnlaugsson, 1969). Very high P concentration was recorded in the leaves of both *Salix* species, probably due to lower temperatures and slower plant growth (Reich and

Oleksyn, 2004). We recorded that leaves of both *Salix* species were browsed by sheep in high quantity, much more than *B. nana* or *B. pubescens*, and that free-ranging sheep seem to be able to prevent regeneration of *Salix* shrubs in some Icelandic regions. Browsing of *Salix* species probably helps the animals to avoid P and Ca deficiency, especially high-milk-yielding ewes. *Salix* species are generally considered to be the best forage woody species in Nordic regions (Forbes *et al.*, 2010; Myking *et al.*, 2013).

Conclusions

The nutritive value of leaves of the main woody species in Iceland was relatively high and can satisfy livestock requirements for N and P. The most problematic for livestock metabolism would be the relatively high lignin content in all woody species, in comparison with grasses.

Acknowledgements

We gratefully acknowledge the valuable advice of Aslaug Helgadottir. The study was funded by grant from Czech University of Life Sciences Prague, CIGA 20114205.

References

Amorosi T., Buckland P., Dugmore A., Ingimundarson J.H. and McGovern T.H. (1997) Raiding the landscape: human impact in the Scandinavian North Atlantic. *Human Ecology* 25, 491–517.

Cherney D.J.R., Cherney J.H. and Lucey R.F. (1993) *In vitro* digestion kinetics and quality of perennial grasses as influenced by forage maturity. *Journal of Dairy Science* 76, 790–797.

Church M.J., Dugmore A.J., Mairs K.A., Millard A.R., Cook G.T., Sveinbjarnardóttir G., Ascough P.A. and Roucoux K.H. (2007) Charcoal production during the norse and early medieval periods in Eyjafallahreppur, southern Iceland. *Radiocarbon* 49, 659–672.

Gauthier E., Bichet V., Massa C., Petit C., Vanniere B. and Richard H. (2010) Pollen and non-pollen palynomorph evidence of medieval farming activities in southwestern Greenland. *Vegetation History and Archeobotany* 19, 427–438.

Gunnlaugsson T. (1969) Notes on leaf fodder and leaf fodder collection (*Um laufhey og laufheyskap*) Ársrit Ræktunarfélags Norðurlands 66:76-84 (*in Icelandic*)

Helgadóttir A., Eythórsdóttir E., Jóhannesson T. (2013) Agriculture in Iceland – A grassland based production. *Grassland Science in Europe* 18, 30–43.

Kristinsson H. (2013) *Flowering plants and ferns of Iceland*. Mál og menning, Reykjavík.

Myking T., Solgerg E.J., Austrheim G., Speed J.D.M., Bohler F., Astrup R. and Eriksen R. (2013) Browsing of sallow (*Salix caprea* L.) and rowan (*Sorbus aucuparia* L.) in the context of life history strategies: a literature review. *European Journal of Forest Research* 132, 399–409.

Ólafsdóttir R. and Guðmundsson H. (2002) Holocene land degradation and climatic change in northeast Iceland. *The Holocene* 12, 159–167.

Ragnarsson S. and Lindberg J.E. (2010) Nutritional value of mixed grass haylage in Icelandic horses. *Livestock Science* 131, 83–87.

Reich P.B. and Oleksyn J. (2004) Global patterns of plant leaf N and P in relation to temperature and latitude. *PNAS* 101, 11001–11006.

Sigvaldason J. (1967) What is leaf fodder? (*Hvað er laufhey?*) Ársrit Ræktunarfélags Norðurlands 64:79-82

Thorhallsdottir A.G. and Thorsteinsson I (1993) Behaviour and plant selection. Icel Agr Sci (*Búvísindi*) 7,59-77

Whitehead D.C. (1995) *Grassland Nitrogen*. Wallingford, CAB International, 397 pp.