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EXAMINATION OF THE NUTRITIONAL QUALITY OF FORBS FROM MOUNTAINOUS PASTURES IN THE SOUTHWESTERN BOHEMIA REGION

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Abstract

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The purpose of this study is to evaluate the nutrient quality of grazing herbaceous plants. Analysis was performed on 175 samples from *Taraxacum officinale, Alchemilla vulgaris, Achillea millefolium, Plantago lanceolata, P. major, Rumex obtusifolius* and *Ranunculus acris* which were collected in the Šumava Mts area at an altitude of 650–790 m a.s.l.. Two cattle fitted with permanent rumen cannulae were used in the rumen degradability studies. The lowest content of crude protein (CP) was recorded in *Ranunculus acris* at 106.5 g/kg DM, and the highest in *Rumex obtusifolius* at 203.8 g/kg DM. The lowest contents of neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were found in *Taraxacum officinale* (236; 200.6 and 30.6 g/kg DM). Meanwhile *Rumex obtusifolius* had the highest ADL content at 115.7 g/kg DM. Digestibility of organic matter (OM) was highest in *Taraxacum officinale* (77%) and lowest in *Rumex obtusifolius* (58.4 %). Nitrogen free extract (NFE) and nonfibrous carbohydrate (NFC) content was highest in *Alchemilla vulgaris* (597.9 and 483.9 g/kg DM) and the lowest was in *Rumex obtusifolius* (505.7 and 338.2 g/kg DM). The highest content of metabolizable energy (ME) and net energy for lactation (NEL) was found in *Taraxacum officinale* (10.1 and 6 MJ/kg DM) and the lowest content in *Rumex obtusifolius* (7.3 and 4.1 MJ/kg DM). The highest NDF degradability throughout incubation in the rumen was recorded in *Taraxacum officinale*. The lowest NDF degradability was found in *Rumex obtusifolius* (198.1 to 581.8 g/kg) and *Ranunculus acris* (278.6 to 566 g/kg). The highest differences in degradation between these species were observed in *Achillea millefolium, Plantago major* and *Rumex obtusifolius*.

Key words: grazing herbage, chemical composition, degradability

Abbreviations: ADF – acid detergent fiber, ADL – acid detergent lignin, CF – crude fiber, CP – crude protein, DM – dry matter, EE – ether extract, NDF – neutral detergent fiber, NFE – nitrogen free extract, NFC – nonfiber carbohydrates, OM – organic matter, OMD – organic matter digestibility, ME – metabolizable energy, NEL – net energy for lactation

Introduction

The nutritive value of forage for ruminants depends on the ratio between cell content and cell walls. The ability of the rumen microorganisms to degrade the plant cell walls and to ferment available carbohydrates is also very important (Waldo, 1986). These demands are essentially determined by the chemical composition of the feed (Van Soest, 1994). The neutral detergent fiber fractions (ADF and NDF) are the other chemical components used to predict the intake of forage (Čerešňáková et al., 2005). Due to the variability of NDF in rumen degradation and its influence on animal performance, the knowledge of NDF digestibility in forage is critical for effective ruminant feeding (Oba, Allen, 1999).

The ratio of stem to leaf increases as herbage grows. The stem initially contains high concentrations of soluble carbohydrates and its digestibility may be above that of leaves. However, as the stem ages, its soluble carbohydrate content decreases more rapidly and its lignin content increases more rapidly than those of leaves, so that the decline in digestibility of the feed on offer to the animals is greater than the decline in digestibility of the leaf fraction alone (Pearson, Ison, 1987; Fiala et al., 2008; Voženílková et al., 2010). The optimal structure of pasture consist of 50–70% grass, 15–25% clover, while others herbs make up the remainder (Dietl, Lehman, 2004).

The quality and quantity of feed determines animal intake. Consumption of pasture grass by ruminants is affected by sward height, leafiness, density and distribution (Frelich et al., 2006). Pasture volume intake can be influenced in two ways. Firstly, the ratio of intake is higher when the herbage is high, leafy and dense, and secondly, animals will select food which they can eat more quickly. This means that differences in sward structure lead to selective grazing (Pearson, Ison, 1987).

There are appreciable differences in the acceptance or deprecation of various plant species in mountainous pasture land vegetation (Boltižiar, 2010; Fiala, 2010). Mountainous grassland biotopes represent a specific feature with great biodiversity values (Halada et al., 2009) and therefore some plant species have a more positive influence on animal health and digestion. The most abundant preferential species include *Taraxacum officinale, Plantago lanceolata, Alchemilla vulgaris* and *Achillea millefolium* (Čermák et al., 2006, 2009). *Taraxacum officinale* is one of the most valuable grassland constituents, and is considered beneficial primarily for its high content of proteins and minerals (Gruber et al., 2006; Halabuk, Halada, 2006), while clover crops and some herbs such as *Plantago major* and *Alchemilla vulgaris* are rich in magnesium and other macro-minerals (Gralak et al., 2006).

Material and methods

The purpose of this study is to evaluate the nutrient quality of grazing herbaceous plants.

Three different experimental pastures were chosen in the mountainous region of the Šumava Mts at altitudes of 650 to 790 m a.s.l. All farms had dairy cows in pasture. Herbage sampling was conducted during 2006 and 2007 from the most prevalent herbage on the pasture land. This sampling was performed at 1–2 monthly intervals, dependent on grazing cycles. A total of 175 samples of the following seven herb species were collected: *Taraxacum officinale, Alchemilla vulgaris, Achillea millefolium, Plantago lanceolata, P. major, Rumex obtusifolius* and *Ranunculus acris.*

After drying at 50 °C for 48 hours, herb samples were milled through a 1 mm sieve for chemical analysis. All samples were analyzed for ash, ether extract (EE), crude protein (CP), crude fiber (CF), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL). Aliquots of the dried samples were then burned at 550 °C.

NDF, ADF and ADL were determined according to Van Soest et al. (1991) using an ANKOM 220 Fiber Analyzer (ANKOM Technology Corporation, NY, USA).

Dry matter content and ether extract were determined by the default laboratory procedure of Weende analysis. The Kjeldahl method was used to determine nitrogen (AOAC, 1990) and CP was calculated by N x 6.25.

The content of nitrogen free extract (NFE) was calculated as follows: DM – (CP + EE + CF + ash), and the nonfiber carbohydrate (NFC) was calculated by: 1000 – ash – CP – EE – NDF (Hall, 2003).

Organic matter digestibility (OMD) was calculated by the formula:

$$OMD\ (\%) = 0.98 \times (100\text{-}NDF) + NDF\times ((1.8008-0.966\log (ADL\times100/ADF)) - 12.9.$$

NDF and dry matter (DM) degradability were evaluated using the “in sacco” method. Each 1.5 g sample was weighed and placed in nylon bags with a pore size of 42 μm and internal dimensions of 50x120 mm. One Holstein steer and cow fitted with permanent rumen cannulae were used in the rumen degradability studies.

These animals were fed individually twice daily with 12 kg of meadow hay and 2 kg of ground barley per animal/day, and they had free access to drinking water and mineral block. Bags were inserted into the rumen after feeding and removed after 6, 12, 24, 48 and 72 hours. A total of 6 bags (3 bags per animal) were used for each incubation interval. The bags were immediately rinsed in cold water by hand for 30 min after removal from the rumen, dried for 48 hours at 50 °C and analyzed for NDF by the STATISTICA 6.0 programme.

Results and discussion

The aim of this experiment is to determine the chemical composition of herb samples and their NDF degradability. The chemical composition is presented in Tables 1–3.

Ash content was recorded in the range from 83.6 g/kg DM in *Ranunculus acris* to 133.5 g/kg DM in *Taraxacum officinale,* and EE varied from 13.6 g/kg DM in *Rumex obtusifolius* to 29.2 g/kg DM in *Taraxacum officinale*. Meanwhile, Hummel et al. (2006) reported an average ash content of 128 g/kg DM and an EE content of 31 g/kg DM in their herb sample.

T a b l e 1. Content of dry matter, ash, ether extract, and crude protein of observed species.

Species	*n*	DM	ash	EE	CP
Taraxacum officinale	30	$138.6^{abcd} \pm 25.0$	$133.5^{abcd} \pm 15.1$	$29.2^{acde} \pm 6.3$	$187.3^{acde} \pm 43.0$
Achillea millefolium	28	$219.8^{ae} \pm 62.0$	$115.3^{aeh} \pm 16.0$	$18.6^{ab} \pm 4.1$	$140.2^{af} \pm 31.7$
Alchemilla vulgaris	24	$225.3^{cgh} \pm 33.7$	$90.1^{ag} \pm 10.7$	$28.1^{bfgh} \pm 5.3$	$145.0^{ehi} \pm 21.8$
Plantago lanceolata	21	$174.0^{efg} \pm 35.8$	$105.5^{bef} \pm 18.7$	$15.0^{af} \pm 2.4$	$132.3^{cg} \pm 34.9$
Plantago major	29	$194.1^{bf} \pm 33.1$	$120.4^{fgi} \pm 11.5$	$15.2^{cg} \pm 3.7$	$140.9^{bd} \pm 24.8$
Rumex obtusifolius	28	$193.4^{d} \pm 69.8$	$93.9^{dhi} \pm 22.1$	$13.6^{be} \pm 3.8$	$203.8^{bfgi} \pm 49.8$
Ranunculus acris	18	$198.3^{ah} \pm 28.7$	$83.6^{cef} \pm 11.2$	$21.7^{dh} \pm 4.3$	$106.5^{abh} \pm 18.2$

Note: ^{a,b,c,d,e,f,g,h,i} – means in columns with the same superscripts differed ($P < 0.05$).
DM = g/kg; ash, EE, and CP = g/kg of DM
Values in mean ± SD (standard deviation)

T a b l e 2. Content of organic matter, organic matter digestibility, crude fiber, and neutral detergent fiber of observed species.

Species	*n*	OM	OMD	CF	NDF
Taraxacum officinale	30	$866.5^{abc} \pm 15.1$	$77.0^{abc} \pm 4.1$	$127.5^{abc} \pm 19.5$	$236.0^{abcd} \pm 31.0$
Achillea millefolium	28	$884.7^{de} \pm 16.0$	$69.8^{ah} \pm 6.5$	$200.3^{ade} \pm 57.3$	$327.2^{ae} \pm 74.9$
Alchemilla vulgaris	24	$909.9^{adh} \pm 10.7$	$76.8^{dfg} \pm 3.1$	$138.9^{eg} \pm 15.4$	$252.9^{efgh} \pm 27.1$
Plantago lanceolata	21	$894.5^{af} \pm 18.7$	$70.5^{cd} \pm 3.8$	$156.0^{df} \pm 37.4$	310.8 ± 61.5
Plantago major	29	$879.6^{ghi} \pm 11.5$	$70.9^{be} \pm 4.1$	168.4 ± 45.7	$334.7^{bf} \pm 92.3$
Rumex obtusifolius	28	$906.0^{cefi} \pm 22.1$	$58.4^{bgh} \pm 7.8$	$182.9^{c} \pm 65.3$	$350.5^{dh} \pm 102.3$
Ranunculus acris	18	$916.4^{bg} \pm 11.2$	$67.2^{aef} \pm 4.6$	$277.0^{bfg} \pm 42.5$	$423.7^{cg} \pm 60.0$

Note: ^{a,b,c,d,e,f,g,h,i} – means in columns with the same superscripts differed ($P < 0.05$).
OM, CF, and NDF = g/kg of DM; OMD = %
Values in mean ± SD (standard deviation)

T a b l e 3. Content of acid detergent fiber, acid detergent lignin, nitrogen free extract, and nonfiber carbohydrates of observed species

Species	*n*	ADF	ADL	NFE	NFC
Taraxacum officinale	30	$200.6^{abc} \pm 22.9$	$30.6^{ac} \pm 10.5$	$522.5^{a} \pm 43.6$	$413.9^{bc} \pm 54.1$
Achillea millefolium	28	$268.1^{ade} \pm 57.4$	$53.3^{bc} \pm 21.9$	$525.6^{bc} \pm 43.8$	$398.7^{a} \pm 59.2$
Alchemilla vulgaris	24	$204.8^{eghi} \pm 17.3$	$30.7^{bfg} \pm 8.0$	$597.9^{acf} \pm 20.6$	$483.9^{aegh} \pm 36.6$
Plantago lanceolata	21	$238.3^{df} \pm 46.1$	$47.2^{d} \pm 9.4$	$591.1^{d} \pm 60.0$	$436.3^{de} \pm 77.7$
Plantago major	29	$248.6^{g} \pm 68.4$	$44.3^{ef} \pm 11.9$	$555.1^{e} \pm 44.2$	$388.8^{fg} \pm 87.7$
Rumex obtusifolius	28	$302.2^{cfi} \pm 98.7$	$115.7^{abde} \pm 40.7$	$505.7^{f} \pm 70.7$	$338.2^{ch} \pm 102.5$
Ranunculus acris	18	$341.5^{bh} \pm 44.8$	$62.3^{ag} \pm 14.0$	$511.2^{abde} \pm 41.9$	$364.5^{abdf} \pm 56.9$

Note: ^{a,b,c,d,e,f,g,h,i} – means in columns with the same superscripts differed ($P < 0.05$).
ADF, ADL, NFE, and NDF = g/kg of DM content
Values in mean ± SD (standard deviation)

The CP content was lowest in *Ranunculus acris* at 106.5 g/kg DM and highest in *Rumex obtusifolius* with 203.8 g/kg DM, while the quite high value of 294 g/kg DM was detected by Bohner (2001). We also found high CP content values in *Taraxacum officinale* (134–295 g/kg DM), consistent with those of Isselstein and Daniel (1996), who recorded 303 g/kg DM in the vegetative growth stage but only 113g/kg in the flowering stage.

The CF content herein varied from 127.5 g/kg DM in *T. officinale* to 277 g/kg DM in *Ranunculus acris*. Higher values for *Taraxacum officinale* (210; 221.5 and 173.2 g/kg DM) were reported by Bohner (2001) and Zeman (1995).

The lowest content of NDF, ADF and ADL was also recorded in *T. officinale* (236; 200.6 and 30.6 g/kg DM), while Zeman (1995) found the higher value of 60.1 g/kg DM ADL in this herb. The highest content of NDF and ADF was found in *Ranunculus acris* (423.7

T a b l e 4. Degradability of neutral detergent fiber of observed species using the *in sacco* method.

Species	*n*	Incubation intervals (h)				
		6	12	24	48	72
Taraxacum officinale	15	$453.1^{abcde} \pm 97.5$	$789.3^{abcde} \pm 80.7$	$857.0^{abcdef} \pm 30.9$	$870.9^{abcde} \pm 25.3$	$882.1^{abcde} \pm 22.3$
Achillea millefolium	15	$272.8^{c} \pm 102.9$	$484.9^{b} \pm 147.6$	$559.8^{a} \pm 165.1$	$605.3^{b} \pm 159.3$	$641.2^{b} \pm 145.2$
Alchemilla vulgaris	15	$259.4^{a} \pm 71.6$	$419.0^{a} \pm 83.4$	$683.4^{b} \pm 72.1$	$776.4^{f} \pm 68.7$	$803.2^{f} \pm 61.0$
Plantago lanceolata	15	$280.1^{b} \pm 115.5$	583.0 ± 146.1	$665.3^{c} \pm 123.4$	$700.9^{a} \pm 119.4$	$724.6^{a} \pm 108.0$
Plantago major	15	341.0 ± 184.0	$539.0^{c} \pm 228.9$	$591.0^{d} \pm 208.2$	$621.2^{c} \pm 198.4$	$656.6^{c} \pm 173.7$
Rumex obtusifolius	15	$198.1^{d} \pm 92.7$	$414.4^{d} \pm 201.0$	$517.0^{e} \pm 228.0$	$555.2^{d} \pm 234.7$	$581.8^{d} \pm 237.0$
Ranunculus acris	14	$278.6^{e} \pm 99.8$	$426.7^{e} \pm 123.9$	$497.8^{f} \pm 114.7$	$540.1^{ef} \pm 108.7$	$566.0^{ef} \pm 104.9$

Note: ^{a,b,c,d,e,f,} – means in columns with the same superscripts differed ($P < 0.05$).
Degradability of neutral detergent fiber = g/kg of NDF content
Values in mean ± SD (standard deviation)

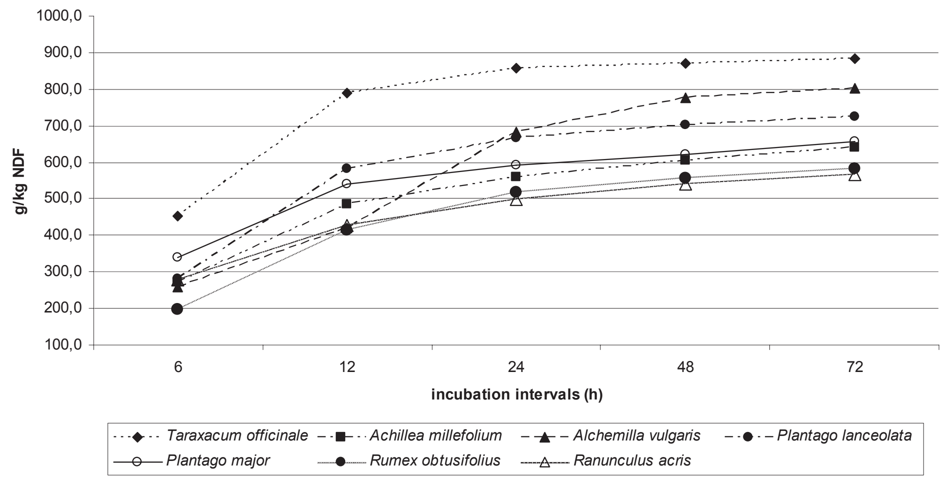

Fig. 1. NDF degradability during the incubation (average values in g/kg NDF).

and 341.5 g/kg DM) and the highest ADL content in *Rumex obtusifolius* (115.7 g/kg DM). Organic matter digestibility had the highest value of 77% in *Taraxacum officinale* and the lowest at 58.4% in *Rumex obtusifolius*. Meanwhile, NFE and NFC content was highest in *Alchemilla vulgaris* (597.9 and 483.9 g/kg DM) and lowest in *Rumex obtusifolius* (505.7 and 338.2 g/kg DM).

The highest content of ME and NEL was recorded in *Taraxacum officinale* (10.1 and 6 MJ/kg DM), and the lowest in *Rumex obtusifolius* (7.3 and 4.1 MJ/kg DM).

NDF degradability is highlighted in Table 4 and Figure 1. The highest NDF degradability throughout incubation in the rumen was noted in *Taraxacum officinale* and this varied from 453.1 g/kg NDF after 6 hours of incubation to 882.1 g/kg NDF after 72 hours. The lowest NDF degradability after the first twenty-four hours of incubation was in *Rumex obtusifolius*

T a b l e 5. Coefficients of linear correlation between chemical components and NDF degradability according to the incubation times.

	6h	12h	24h	48h	72h
CF	-0.58*	-0.73*	-0.86*	-0.80*	-0.87*
NDF	-0.60*	-0.75*	-0.89*	-0.84*	-0.91*
ADF	-0.64*	-0.77*	-0.90*	-0.87*	-0.92*
ADL	-0.50*	-0.52*	-0.62*	-0.61*	-0.66*
CP	0.12	0.22*	0.21*	0.18	0.17
NFE	0.26*	0.32*	0.46*	0.45*	0.51*
NFC	0.38*	0.46*	0.62*	0.60*	0.66*
OM	-0.53*	-0.59*	-0.49*	-0.41*	-0.46*
OMD	0.52*	0.56*	0.68*	0.66*	0.72*

* $P < 0.05$
DNDF = degradability of neutral detergent fiber

(198.1 g/kg NDF in 6 h. and 414.4 g/kg NDF in 12 h. of incubation), and between 24 and 72 hours incubation the lowest value was recorded in *Ranunculus acris* (from 497.8 to 566 g/kg NDF). The highest differences in degradation within the species were in *Achillea millefolium, Plantago major* and *Rumex obtusifolius*, where the NDF degradability before flowering was up to 480 g/kg DM higher than that found in the latest stages of growth. The highest increase in NDF degradability occurred between 12 and 24 hours incubation, and this concurred with the results of Čerešňáková et al. (2006) and Michałovski et al. (2002).

The correlation coefficients between NDF degradability and chemical composition are presented in Table 5. Apart from CP with $P < 0.05$, no other relationships were statistically significant, and the closest significant relationships were recorded between NDF degradability and ADF content.

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