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IMPACT OF PEDOCOMPACTION ON SOIL ATTRIBUTES AND PASTURE ABOVEGROUND PHYTOMASS

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Abstract

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This experiment was carried out in the deforested mountain pasture land – 845 m a.s.l. The impact of pedocompaction on soil attributes and pasture land aboveground phytomass was studied in south and north oriented locations for year-round unstabled Charolais cattle pasture breeding. Results showed the number of microscopic fungi to range from 4.31 to 14.10^3 $CFU.g^{-1}$ in the upper horizon of soil type, at depths from 0 to 100 mm and within the mean values for N, P, K, Mg and humus. Forty plant species with the dominant *Festuca rubra* (17%) and *Agrostis capillaris* (15%) were isolated in an *Agrosti–Festucetum rubrae* association. From a qualitative viewpoint, the aboveground phytomass had the mid-range values for organic matter digestibility of from 55.30 to 68%. Fourteen *Penicillium* and 33 species of the most frequently isolated fungi were found at a depth of 0.60 m. These infected the aboveground phytomass by animal pounce (excrements) in damp soil and sod destruction. This was expressed by the increased concentration of ergosterol from 62 up to 323 $mg.kg^{-1}$. Penetration resistance of both locations for middle loading by cattle was relatively equal – up to 3.01 MPa. It reached 50 mm and 4.48 MPa in the upper layer of highly loaded areas (site 1) with increased animal presence and it gradually descended in depth. The upper layer of site 2 was under heavy loading and it had a penetration resistance of 3.73 MPa. There were similar values also at a depth of 0.32 m which demonstrates a damper soil profile of the north exposition. Humid periods during 2004 and 2005 were associated with both a higher pedocompaction and also a higher content of ergosterol and quality of aboveground phytomass compared with the 2003 period of low rainfall. The content of crude protein depended upon the proportion of *Trifolium repens* in the grassland.

Key words: soil, pedocompaction, penetration resistance, mountain pasture, aboveground phytomass, microscopic fungi, ergosterol

Introduction

Pedocompaction is the reduction of soil capacity due to reduced porosity which is the space required for water and air in the soil (Bedrna, 2002). Year-round breeding in mountain pastureland without housing and with a high live weight of 750 kg or over requires light shallow soils with a great proportion of sand. It is not inclined to suffer water logging and it is not influenced by back or subsurface water (Opitz von Boberfeld, 1997, 2001). Basic physical and mechanical land attributes are considered to be the criteria of oppressed soil. Wet surface depressing increases the percentage of soil penetration (Betteridge et al., 1999). Crushed and depressed wet soil surfaces increase the volume weight and penetration resistance accompanying increased depression intensity (Bajla, 1999). Animal pressure forms a rammed zone to a depth of 0.07–0.11 m (Mulholland, Fullen, 1991) and excessive pedocompaction interferes with the constitutional volume soil condition. One possibility for fortification recognition is by conic penetrometer measurement of penetration resistance. This penetration method is based on the principle of resistance measurement of the specific entity pushing in the soil (Bajla, 1998).

Soil texture influences both sod load and the aboveground phytomass (Achilles et al., 2002). Traditional management of semi-natural grassland sustainment is based on low soil loading by the livestock (Isselstein et al., 2005). Pasturelands are not equally loaded during the year for year-round cattle pasture breeding. Disturbance commences in the soften sod after long lasting rain periods, during the beginning and end of the vegetation period (Opitz von Boberfeld, 1997). Stress evoked by disturbance causes total destruction of the original plant community and violation of the grass agro–ecosystem stability. Synantrophic vegetation increases in new conditions influenced by mud sod loading with empty space formation (Novák, 2008).

Trampled sod enables contact between overhead plant organisms and soil whole soil has been considered to be the shelter for almost all main taxonomic groups of fungi by Thorn (1997). These develop in the aboveground phytomass of grassland in autumn when fungi and blight growth are supported by heavy vegetation and air humidity (Giesler et al., 1996). Fungi mycelium attack bodies of dead, over–seasoned and lodged plants in humid environments and cause mycotoxin occurrence (Wheeler, 1968; Opitz von Boberfeld, 1997, 2000). Their negative influence is expressed for example in health problems, a reduction in food intake, diarrhoea and a reduction in animal production efficiency (Kalač, Míka, 1997; Devegowda, 2002). Ergosterol is the prevailing steroid fungus component, an important membrane component and it also serves as a chemical indicator for the quantitative determination of actual mycelia condition caused mainly by the following species: *Penicillium, Aspergillus, Fusarium, Alternaria* and *Mucor* (Shapiro, Gealt, 1982; Yokokawa, 1987; Weete, 1989). Ergosterol can be used to determine the presence of fungi in examined samples.

Material and methods

The experimental parcels of land are situated in the mountain area at the "Diel" location, which is situated in the Slovenské Rudohorie, 3 km above Ďubákovo village, 845 m a.s.l. (48°33` N, 19°46` E), with a southern exposition and 15° inclination. This location was previously used for pastureland 50 years ago, when private lands was under cooperative administration and before these areas became overgrown with ground woods. Forest formed with

Betula pendula dominance until the areas were restored to their original proprietors in 1993. They were then used as forest-pasture lands for non-stabled Charolais grazing. Previously, these were pastured in deforested areas during the vegetation period and fed by hay and haylage from their own grasslands during winter. Livestock loading ranged from 0.30–0.60 $LU.ha^{-1}$ during the year with forest–pasturelands gradually being purified from ground wood vegetation to fulfil agro-environmental conditions. In 1993, the groundwood vegetation with *Betula pendula* dominance was eliminated from the experimental area by filing, with tree trunks removed and branches burnt.

The parent rocks are hybrid granodiorites with a transition to migmatites and the soil profile is loam throughout its depth. The dominant profile fraction is sand with 66.99% humic horizon content and 63.80% cambic horizon. The texture is the result of original granitic rock weathering which together with slope inclination caused soil failure which is with deleterious structure in the lower parts of the profile and a high level of skeleton. The long–term average annual air temperature is 5.1 °C and 10.5 °C in the vegetation period IV.– X., during April to October (1961–2005)while the long–term average total precipitation is 926.72 mm and 629.81 mm in the vegetation period with an average number of 80 days snow cover.

The following 2 locations were observed from 2003 to 2005: Location No 1 with a southern exposition – SE, and location No. 2 with a northern exposition – NE. These were in deforested pastureland in middle range loading of 1 $LU.ha^{-1}$ and high loading of 3 $LU.\ ha^{-1}$. These locations 3x5 m (15 m^2) were arranged in a Latin square with three repetitions. Soil fungus isolation from soil samples was achieved by the dilution method at the Department of Microbiology, Slovak University of Agriculture (SUA) in Nitra (Labuda, 2007). The Penetrometer P–BDH 3A (Fig. 1) was used to measure soil depression. The measured values of penetration resistance represent an empirical scale of soil strength. Individual measurements were represented by prick-points 1x1 m apart at a depth of 0.45 m. Measurements were then graphically evaluated by the program editor (Bajla, 1998). The floristic composition of pastureland vegetation was given by the reduced projective dominance method in percentages according to Klapp (1965) with a net size of 1 m^2 (size of squares 0.01 m^2).

The pasturelands had been used by Charolais beef cattle, and surface phytomass samples were taken at the end of October and at the beginning of November before snowing and three repetitions were subjected to 60 °C drying. These were then sent in 200 g homogenized form for laboratory chemical analysis to JLU Giessen in Germany. The ergosterol concentration was determined after extraction by High Performance Liquid Chromatography at UV detector according to Schwadorf, Müller (1989). The ash level in $g.kg^{-1}$ of solids, NEL and ME in $MJ.kg^{-1}$ of solids and also the digestibility of organic matter (DOM) in % was evaluated by Steigass, Menke (1986) by the Hohenheim Gas Test, which is an in vitro fermentation method with rumen liquor. This takes the gaseous formation, the crude protein and crude fat content into consideration. The results were statistically evaluated with Statistica software by dispersion analysis and by contrast testing of the analyzed indicators (correlation matrix) by Tukey HSD test (Table 6).

Fig. 1. Measurement of soil depression by penetrometer P–BDH 3A.

Results and discussion

As the level of nutrients in the soil demonstrates, N level values rose from 2 257 to 4 611 mg.kg^{-1}, P from 10 to 48 mg.kg^{-1}, K from 150 to 355 mg.kg^{-1}, Mg from 73 to 180 mg.kg^{-1}, humus from 5.58 to 10.55% and the pH from 4.08 to 4.42 (Table 1). This occurred in middle and high loading at site 1 in the southern exposition and in site 2 with a northern exposition at depths from 0 to 100 mm. The values of individual elements and humus at 100 mm were found to be the highest.These consisted of nitrogen and potassium in site 1, phosphorus, magnesium and pH in site 2 and humus in site 1. Tables 1 and 2 show that the top soil (0–100 mm Aoq) humus content was 7.38 to 11.03% and 55.73% sand content with a fraction > 0.25 mm and 11.26%, with a fraction of 0.25 to 0.05. The deep levels of humus and sand with a fraction > 0.25 mm decreased, and only the 0.25 to 0.05 fraction increased.

The growth and development of *Agrosti-Festucetum rubrae* pasture land vegetation was directly influenced by livestock. The elastic sod was able to resist mechanical pressure of Charolais draught cattle in conditions of middle loading. The soil structure worsened, and pore and air depression negatively influenced plant growth to 0.30 m in areas of dense fencing equipment and permanent loading of fodder and narrow paths. Heavy loading damaged leaves, footstalk, buds and roots by contusion and disruption. The soil profile was loamy–sandy in complete depth with a dominant fraction of sand. The authors share the opinions of Mörchen (1996) and Opitz von Boberfeld, Banzhaf (2006) that cambisols are more favorable for livestock. These contain a higher content of sand and therefore higher resistance to compaction, they are less susceptible to waterlogging and they resist turf disturbance for medium load animals. Observed growths were equally resistant to the mechanical loading of animals. Extremely compacted areas had uncovered soil without vegetation. Grassland sod contained a higher water quantity than it could bear which diminished load capacity. It had also given way under depression with gaps and undulations forming in the sod. It therefore changed into a paludal area with soil and sod destruction. The grassland loading and year-round utilization was lower than the 0.60 LU.ha^{-1} recommended by Jilg (1998).

According to Bedrna (2002), disturbances of the soil should not occur. We agree with Fiala et al. (1999), that in a loamy–sandy soil profile with a texture due to weathering of the original

T a b l e 1. Stocking rate, site and depth impact on soil attributes.

Stocking rate	Site/Depth	N	P	K	Mg	C_{ox}	Humus	pH/ KCl
	mm	mg.kg^{-1}				%	%	
Middle	1/0 – 100	4490	14	188	110	6.56	11.03	4.13
High	1/0 – 100	4611	44	355	170	6.12	10.55	4.33
Middle	1/101 – 200	3986	12	185	113	5.44	9.38	4.16
High	1/101 – 200	4559	42	318	150	5.43	9.36	4.40
Middle	2/0 – 100	2939	14	195	110	4.28	7.38	4.13
High	2/0 – 100	4409	48	255	180	6.90	8.48	4.42
Middle	2/101 – 200	2257	14	150	73	3.24	5.58	4.08
hHgh	2/101 – 200	3048	10	288	93	3.92	6.76	4.19

granitic rock with a high rate of drying and a water permeable mould layer, as seen here in Table 2, that resistance values depend on the size of soil particles and the distribution of soil moisture. The values here, however, were not high on the northern exposition which contained a greater degree of moisture in the soil profile. Grasslands of the *Agrosti-Festucetum rubrae* association with elastic and firm sod are relatively resistant to pedocompaction.

The ergosterol level in the overhead grassland phytomass is connected with the existence of pathogenic fungi in the soil, as in Bedrna (2002) and Javoreková et al. (2008). An appropriate fungi environment was created in conditions of long lasting cold and wet weather before the snow-falls of 2004 and 2005. This increased fungi phenomenon in the soil was expressed by the increased level of ergosterol in the aboveground phytomass. Wolf (2002) mentioned similar results in the aboveground phytomass of the *Festuco-Cynosuretum* association occurring from 335 to 460 m above sea level, although Wöhler (2003) asserted that altitude is unrelated to increased ergosterol concentration. Herein, a lower number of foxed parts of plants were discovered during the dry autumn of 2003, and the ergosterol concentration was significantly lower than in 2004 and 2005.

Penetrometry determined the soil loading when heavy animals were standing at 1.30 $kp.cm^{-2}$ and while walking this value was 4.25 $kp.cm^{-2}$ with a depression depth of 100–150 mm. These values concurred with those of authors in similar conditions (Mulholland, Fullen, 1991; Woike, Zimmermann, 1992). Penetration measurement showed that penetration resistance in both locations for middle loading was relatively equal. Values in the first location were lower reaching a maximum value of 2.44 Mpa at a depth of 130 mm, while the second site maximum was 3.01 MPa at 80 mm (Figs 2, 3). Penetration resistance in the upper level of soil in heavily loaded areas (site 1) reached 50 mm and 4.48 MPa. These values, however, decreased with decreasing depth of soil. The maximum penetration resistance of heavy loading at the northern exposition (site 2) was 3.73 MPa and similar values were also reached at a depth of 0.32 m which indicates a moister soil profile. Bedrna's 2002 measured values reported weak pedocompaction in the middle loaded areas with loamy–sandy soil, and strong pedocompaction in the heavily loaded ones.

Table 3 lists the values of microorganism numbers in the soil profile and Table 4 shows the occurrence of isolated species of microscopic fungi at three cambisol soil depths. Microscopic

T a b l e 2. Grain composition of soil and soil humidity in volumetric %.

Horizon	Depth in m	Percentage of particular fractions (amount in mm) (site 1, 2)						Humidity in %	
		> 0.25 5. fr.	0.25–0.05 4. fr.	0.05–0.01 3. fr.	0.01–0.001 2. fr.	< 0.001 1. fr.	< 0.01 1. + 2. fr.	1 SE	2 NE
Aoq	0 – 0.05	55.73	11.26	19.80	11.06	2.15	13.21	26	28
Bv_1	0.06 – 0.45	51.27	12.87	19.72	10.85	3.89	14.93	21	23
Bv_2	0.46 – 0.75	48.85	14.96	19.61	10.60	5.98	16.58	17	19

Notes: Aoq – humic ochric silicate horizon, Bv_1, Bv_2 – cambic horizons (inprofile weathering horizons), fr. – fractions: < 0.001 mm – powder dust, 0.001–0.01 mm – middle size dust, 0.01–0.05 mm – coarse dust, 0.05–0.25 mm – tender sand, > 0.25 mm – middle size sand, site 1 – southern exposition (SE), site 2 – northern exposition (NE).

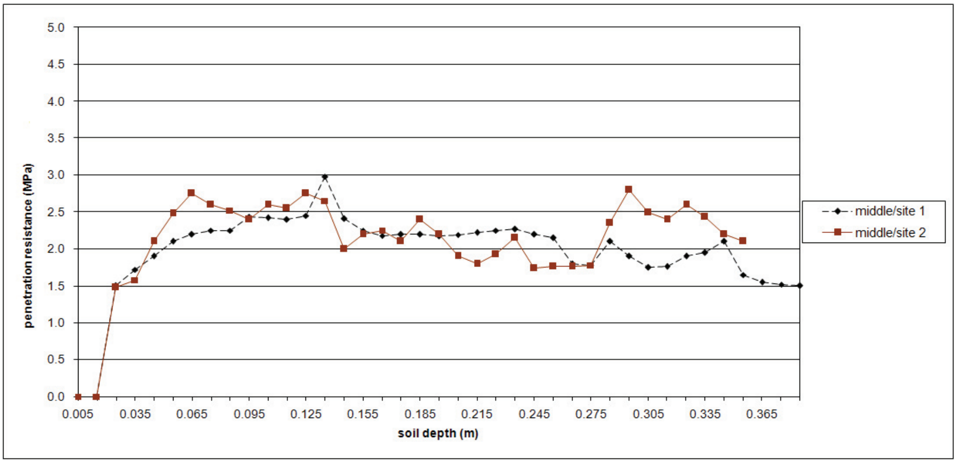

Fig. 2. Penetration resistance in dependence on the soil depth at sites 1 and 2 with a middle stocking rate.

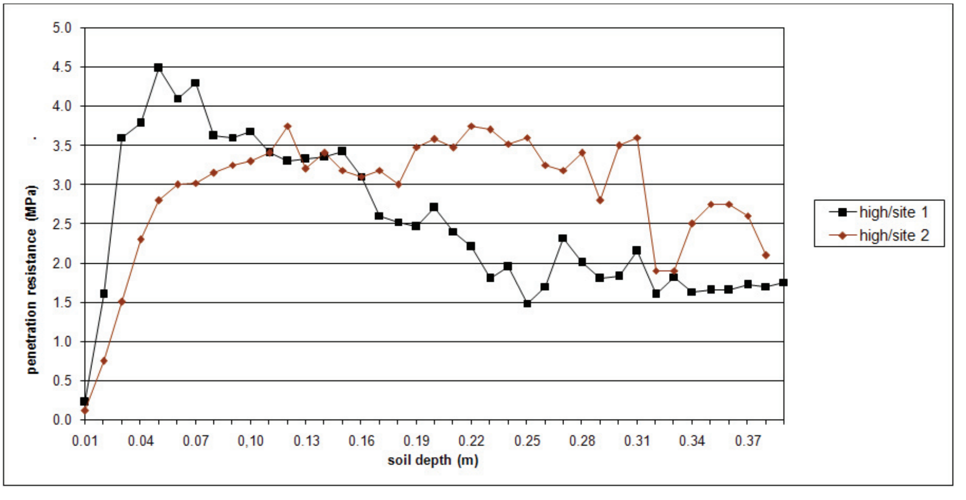

Fig. 3. Penetration resistance in dependence on soil depth at sites 1 and 2 with a high stocking rate.

fungi formed the most numerous group at 4.31 to 14.10^3 CFU.g^{-1}, while the following species were located at depths of up to 0.75 m: *Penicillium* (14 species), *Trichoderma* (4 species), and also *Mucor* and *Fusarium*. Additional fungal species included *Cladosporium* (3 species), *Mortierella* (2 species) and species representatives of *Absidia, Acremonium, Gelatinospora, Rhizopus, Talaromyces*, *Umbellopsis* and *Zygorrhynchus*. It is assumed that the location of fungi in the soil in unfavourable conditions endangered the aboveground phytomass. This especially

T a b l e 3. Abundance of microorganisms in the soil profile of cambisol.

Soil type	Depth [m]	TNM	SB	AM	MF	Ach
		10^3 CFU.g^{-1}				
Cambisol – KMm^e	0.00 – 0.05	3971.00	456.00	0.36	14.00	0.10
	0.06 – 0.45	5005.00	237.00	0.19	4.31	0.14

Notes: TNM – total number of microorganisms, SB – sporiferous bacteria, AM – actinomycetes, MF – microscopic fungi, Ach – *Azotobacter chroococcum.*

T a b l e 4. Diversity of microscopic fungi isolated from soil – Diel (Labuda, 2007).

Species	Abundance in depth (m)		
	0.00–0.05	0.06–0.45	0.46–0.75
Absidia spp. T i e g h.	+		
Acremonium spp. L i n k: F r.			+
Acrostalagmus luteoalbus (L i n k: F r.) W. G a m s et al.		+	
Cladosporium cladosporioides (F r e s) G.A. de V r i e s	+		+
Cladosporium oxysporum B e r k & M.A C u r t .	+		
Cladosporium sphaeosporum P e n z.		+	
Fusarium spp. L i n k: F r.	+		
Gelatinospora spp. D o w d i n g emend. C a i l e u x	+		
Mortierella minutissima T i e g h.	+		
Mortierella spp. C o e m.		+	+
Mucor spp. P. M i c h e l i: S t. - A m a n s	+		
Penicillium aurantiogriseum D i e r c k x			+
Penicillium bilaiae C h a l a b.			+
Penicillium brevicompactum D i e r c k x	+	+	+
Penicillium canescens S c o p p		+	
Penicillium citrinum T h o m		+	
Penicillium crustosum T h o m		+	+
Penicillium daleae K.M. Z a l e s s k y	+		+
Penicillium expansum L i n k	+		+
Penicillium griseofulvum D i e r c k x			+
Penicillium janczewskii K.M. Z a l e s s k y	+	+	+
Penicillium janthinellum B i o u r g e	+	+	
Penicillium purpurogenum S t o l l	+		
Penicillium restrictum J.C. G i l l m a n & E.V. A b b o t t	+	+	
Penicillium spp. L i n k: F r.	+		
Rhizopus stolonifer (E h r e n b.: F r.) V u i l l. var. *stolonifer*		+	
Talaromyces spp. C.R. B e n j a m i n		+	
Trichoderma harzianum R i f a i	+		+
Trichoderma longipilis B i s s e t t		+	
Trichoderma pseudokoningii R i f a i	+		
Trichoderma tomentosum B i s s e t t	+	+	+
Umbellopsis vinacea (Dixon-Steward) A r x	+	+	+
Zygorrhynchus moelleri V u i l l.	+	+	+

applies to *Penicillium* which comprised the most numerous species there. The *Aspergillus* species, however, was not represented in this soil. The total number of microscopic fungi were not influenced by middle or high loading. The *Trichoderma longipilis* species, initially introduced into Slovakia by Šimonovičová (2002), was detected at depths from 0.15 to 0.20 m.

Javoreková et al. (2008) claim that fungi play an unchanging role in soil decomposition processes. Filamentous microscopic fungi support structural aggregate formation but when pathogenic, they can negatively influence plant growth (Krnáčová et al., 2008). *Fusarium* species of isolated microscopic fungi situated in soil at "Diel" (Javoreková et al., 2008) can be potentially phytopathogenic according to Bedrna (2002). They can be transported from the soil to overhead plant organs where there is overhead pedocompaction in marshy soils with a moist environment.

Forty plant species of the grassland vegetation of *Agrosti-Festucetum rubrae* association were found at sites 1 and 2. Middle loaded areas contained *Festuca rubra* (17%), *Agrostis capillaris* (15%), *Festuca pratensis* (7%), *Dactylis glomerata* (5%), *Phleum pratense* (5%), *Anthoxanthum odoratum* (5%), *Poa pratensis* (4%) and *Cynosurus cristatus* (3%). The following highest percentage representations were also registered for; *Trifolium repens* (9%), *Trifolium pratense* (2%), *Lotus corniculatus* (2%), *Taraxacum officinale* (9%), *Rhinanthus minor* (5%), *Leontodon autumnalis* (4%), *Stellaria graminea* (2%), *Plantago lanceolata* (1%), *Pimpinella saxifraga* (1%), *Acetosa pratensis* (1%) and *Acetosella vulgaris* (1%). Low percentages of other plant species were also represented.

Dactylis glomerata (9%) and ruderal species *Rumex obtusifolius* (7%) existed in areas heavily loaded by animals and excrement occurrence to the prejudice of the highly ranked grass species of *Festuca pratensis* (4%). The occurrence of *Anthoxanthum odoratum* (2%), *Leontodon autumnalis* (2%), *Stellaria graminea* and *Rhinanthus minor* was reduced compared to that in middle loaded areas, while *Plantago major* (1%) species was increased. Optimally reduced sod,which existed in a maximum of 4% of empty space, was preserved by permanent foraging. The utilization of mountain pasture for year-round pasture breeding of cattle without stabling is a priority. Plants with deep roots such as *Taraxacum officinale*, and with shallow roots like *Plantago major* were resistant to loading. This group also included *Poa pratensis* which supported sod fortress and elasticity with its long underground growths. Its role was irreplaceable in the process of slope stabilization and erosion resistance during periods of slope endangerment by storm rainfall. The final effect of soil strengthening was expressed by the retardation of aboveground phytomass growth and development, which agreed with similar results published by Bedrna (2002). *Poa annua*, *Trifolium repens*, *Tripleurospermum perforatum*, *Matricaria discoidea* and *Plantago major* existed in degraded areas settled initially by pioneer plants, while ruderal species such as *Rumex obtusifolius* occurred in the heavily loaded and hyper-fertilized areas, and its 7% share in the aboveground phytomass caused decreased nutritional intake and digestibility as reported by Novák (2004) and Cauwer et al. (2006).

The following average values in middle loading areas were attained; ash level to 93.80 g.kg^{-1}, crude protein to 150.78 g.kg^{-1}, NEL to 4.58 and ME to 7.98 MJ.kg^{-1} of solids and the digestibility of organic matter (DOM) ranged from 55.83 to 60.28%. In heavy loading areas, ash increased to 108.25 g.kg^{-1}, crude protein to 268.75 g.kg^{-1}, NEL to 5.20 and ME to 8.90 MJ.kg^{-1} of solids and DOM ranged from 55.30 to 68% while the ergosterol concentration varied from 62 to 323 mg.kg^{-1} (Table 5). A higher rate of leguminose was registered in heavily loaded areas of grassland vegetation. This consisted mainly of white clover (*Trifolium repens*), conferring increased crude protein concentration compared to the middle loaded areas. Here, determined values exceeded Skládanka's 2004 values for sown vegetation at 553 m above sea level without animal influence. These included increased levels of; crude protein

T a b l e 5. Laboratory analysis of aboveground phytomass and its grassland vegetation (JLU Giessen).

Year	Site	Stocking rate	Ash g.kg^{-1}	Crude protein g.kg^{-1}	NEL MJ. kg^{-1}	ME MJ.kg^{-1}	DOM %	Ergosterol mg.kg^{-1}
2003	1	middle	76.20	85.00	4.33	7.35	57,10	90.00
		high	87.00	156.25	5.10	8.75	64,25	74.75
	2	middle	74.50	86.25	4.18	7.40	55.83	79.50
		high	79.00	112.25	4.65	8.03	59.68	68.00
2004	1	middle	89.00	150.75	4.33	7.63	57.10	176.00
		high	96.00	182.00	4.63	8.08	61.03	254.50
	2	middle	89.25	136.75	4.45	7.80	59.15	154.75
		high	92.75	173.50	4.70	8.10	61.43	250.50
2005	1	middle	93.75	148.00	4.58	7.98	60.28	159.98
		high	92.25	157.00	4.93	8.53	63.65	195.23
	2	middle	87.50	126.75	4.55	7.95	59.73	135.85
		high	108.25	268.75	5.20	8.90	66.25	199.93

Notes: DOM – digestibility of organic matter, NEL – net energy of lactation, ME – metabolised energy.

T a b l e 6. Summary of analyzed parameter contrast testing.

Factor	Contrast	Analysed indicators					
		Ash (g.kg^{-1})		Crude protein (g.kg^{-1})		NEL (MJ.kg^{-1})	
		Pr. > Diff	Significant	Pr. > Diff	Significant	Pr. > Diff	Significant
Year	2005 ~ 2003	< 0.0001	Yes	< 0.0001	Yes	0.007	Yes
	2005 ~ 2004	0.217	No	0.987	No	0.009	Yes
	2004 ~ 2003	< 0.0001	Yes	< 0.0001	Yes	0.997	No
Stocking rate	middle-high	0.000	Yes	0.000	Yes	0.000	Yes
Factor	Contrast	Analysed indicators					
		ME (MJ.kg^{-1})		DOM (%)		Ergosterol (mg.kg^{-1})	
		Pr. > Diff	Significant	Pr. > Diff	Significant	Pr. > Diff	Significant
Year	2005 ~ 2003	0.004	Yes	< 0.0001	Yes	< 0.0001	Yes
	2005 ~ 2004	0.006	Yes	0.003	Yes	0.068	No
	2004 ~ 2003	0.989	No	0.506	No	< 0.0001	Yes
Stocking rate	middle-high	0.000	Yes	0.000	Yes	0.000	Yes

Notes: DOM – Digestibility of organic matter, NEL – net energy of lactation, ME – metabolised energy.

from 95.10 to 151.80 g.kg^{-1}, NEL from 3.38 to 4.74 MJ.kg^{-1}, DOM from 52.40 to 60.60% and ergosterol concentration from 71 to 111 mg.kg^{-1}.

A statistically significant dependence ($\alpha \leq 0{,}0001$) was determined in the covariance analysis of ash, crude protein, NEL and ME level in kg of solids, DOM in % and ergosterol in 2003–2004 and 2003–2005. This was also the case in heavy and middle loading in 2003–2005 and 2004–2005. However, no significant difference occurred among other factors such as variant, location and repetition (Table 6).

Conclusion

Higher stocking occasioned greater compaction dependent on soil moisture and exposition. Penetrometer measurements revealed that higher values of pedocompaction were at high load and high soil moisture on the northern exposition. During year-round cattle breeding on the deforested mountain pasture land at 845 m a.s.l., high loading caused strong pedocompaction of hoofed game in damp and rainy weather prior to snow-fall in the following manner:

- (1) sod of pastureland destruction,
- (2) an abundance of microscopic fungi in the soil, and the development of plant infection with rising concentration of ergosterol in the surface phytomass,
- (3) a rising share of synanthropic species,
- (4) increasing penetration resistance on the southern exposition slope gradually descending in depth. It attained lower values on the upper stratum of the northern exposition and its lack of descent indicates a damper soil profile.

Finally, pedocompaction in middle stocking areas with increased soil moisture prior to winter did not negatively influence either soil properties with a loamy–sandy soil profile and given texture or the properties of the aboveground phytomass.

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References

Achilles, W. (ed.), 2002: Ganzjährige Freilandhaltung von Fleischrindern. KTBL, Darmstadt, 103 pp.
Bajla, J., 1998: Penetrometer measurements of soil properties (in Slovak). SPU, Nitra, 112 pp.
Bajla, J., 1999: The measurement of soil compaction by means of interpenetration method (in Slovak). Poľnohospodárstvo, 3: 215–230.
Bedrna, Z., 2002: Environmental soil science (in Slovak). Veda, Bratislava, 352 pp.

Betteridge, K., Mackay, A.D., Shepherd, T.G., Barker, D.J., Budding, P.J., Devantier, B.P., Costall, D.A., 1999: Effect of cattle and sheep treading on surface configuration of a sedimentary hill soil. Aust. J. Soil Res., 37, 4: 743–760.

Cauwer, B., Reheul, D., Nijs, I., Milbau, A., 2006: Dry matter yield and herbage quality of field margin vegetation as a function of vegetation development and management regime. NJAS – Wageningen Journal of Life Sciences, 54, 1: 37–60.

Devegowda, G., 2002: Mycotoxins – world-wide threat (in Czech). Feeding Times, 7: 2–3.

Fiala, K. (ed.), 1999: Obligatory methods of soil analyses. Partial monitoring system – soil (in Slovak). VÚPOP, Bratislava, 142 pp.

Giesler, L.J., Yuen, G.Y., Horst, G.L., 1996: The microklimate in tall fescue turf as affected by canopy density and its influence on brown patch disease. Plant Disease, 80: 389–394.

Isselstein, J., Jeangros, B., Pavlů, V., 2005: Agronomic aspects of biodiversity targeted management of temperate grasslands in Europe – A rewiev. Agronomy Research, 3, 2: 139–151.

Javoreková, S., Králiková, A., Labuda, R., Labudová, S., Maková, J., 2008: Biology of soil in agroecosystems (in Slovak). SPU, Nitra, 249 pp.

Jilg, T., 1998: Futterqualität und Zuwachsleistung auf einer ganzjährig beweideten Rindweide im westlichen Albvorland. Ber. 42. Jahrestagung. AG Grünland u. Futterbau, Giessen, p. 90–93.

Kalač, P., Míka, V., 1997: Natural harmful substances in plant forages (in Czech). ÚZPI, Praha, 317 pp.

Klapp, E., 1965: Grünlandvegetation und Standort. Verlag Paul Parey, Berlin und Hamburg, 384 pp.

Labuda, R., 2007: Mycobioty of chosen Slovak soils with the emphasis on thermoresistant and keratin species: pilot study (in Slovak). Život v pôde 8, Brno, p. 77–91.

Krnáčová, Z., Hreško, J., Ďugová, O., 2008: Basis of pedology for ecologists and environmentalists (in Slovak). UKF, Nitra, 190 pp.

Mörchen, F., 1996: Winterassenhaltung von Mutterkühen auf Flussauestandorten. Freihaltung von Rindern im Winter. Verband Förderung extensiver Grünlandwirtschaft, Berlin, p. 16–20.

Mulholland B., Fullen F.A., 1991: Cattle trampling and soil compaction on loamy sands. Soil Use Manag., 7, 4: 189–193.

Novák, J., 2004: Evaluation of grassland quality. Ekológia (Bratislava), 23, 2: 127–143.

Novák, J., 2008: Pastures, meadows and lawns (in Slovak). Patria I. s.r.o., Prievidza, 708 pp.

Opitz von Boberfeld, W., 1997: Winteraussenhaltung von Mutterkühen in Abhängigkeit von Standort unter pflanzenbaulichem Aspekt. Ber. Ldw., 75: 604–618.

Opitz von Boberfeld, W., 2000: Selen- und Schwefel-Konzentrationen verschiedener Grünlandaufwüchse in Abhängigkeit von Pflanzenbestand und Düngung. Trierer Bodenkundl. Schriften, 1: 134–142.

Opitz von Boberfeld, W., 2001: Grassland management aspects for year-round outdoor stock keeping of suckler cows. Grassl. Sci. in Poland, 4: 137–147.

Opitz von Boberfeld, W., Banzhaf, K. 2006: The effects of sward management on mineral content of winter grazed herbage. J. Agron. Crop Sci. 192: 1–9.

Schwadorf, K., Müller, H. M., 1989: Determination of ergosterol in cereals, feed components and mixed feed by liquid chromatography. J. Assoc. Off. Anal. Chem. 72: 457–462.

Shapiro, B.E., Gealt, M.A., 1982: Ergosterol and lanosterol from *Aspergillus nidulans*. J. General Microbiology, 128: 1053–1056.

Skládanka, J., 2004: Productive and qualitative characteristic of grasslands for extended autumn and winter pasture (in Czech). Dissertation Thesis. MZLU, Brno, 125 pp.

Steigass, H., Menke, K.H., 1986: Schätzung des energetischen Futterwertes aus der in vitro mit Pansensaft bestimmten Gasbildung und der chemischen Analyse. 1. Mitteilung: Untersuchungen zur Methode. Übers. Tierernährung, 14: 251–270.

Šimonovičová, A., 2002: Soil microscopic fungi which are new for Slovakia (variety *Eurotiales*, family *Trichocomaceae*) (in Slovak). In Ďugová, O. (ed.), Život v pôde 3. Bratislava, p. 22–23.

Thorn, G., 1997: The fungi in soil. In Van Elsas, J.D., Trevors, J.T. Wellington, E.M.H. (eds), Modern soil microbiology. Marcel Dekker, New York, p. 63–127.

Weete, J.D., 1989: Structure and function of sterols in fungi. Advances in Lipid Research, 23: 115–170.

Wheeler, J.L., 1968: Major problems in winter grazing. Herb. Abstr., 38: 11–18.

Woike, M., Zimmermann, P., 1992. Biotope Pflegen mit Schafen. AID 1197, Bonn, 30 pp.

Wöhler, K., 2003: Zur Qualität und Masse von Winterweidefutter in Abhängigkeit von Standort, Pflanzengesellschaft und Bewirtschaftung. Dissertation. JLU, Giessen, 134 pp.
Wolf, D., 2002: Zum Effekt von Pflanzenbestand, Vornutzung und Nutzungstermin auf Qualität und Masse von Winterweidefutter. Dissertation. JLU, Giessen, 127 pp.
Yokokawa, H., 1987: Sterol compositions of the fruit – bodies of higher fungi. Trans. Mycol. Soc. Japan, 28: 313–318.