Effect of harvest date on the chemical composition and nutritive value of *Cerastium holosteoides*

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Abstract

Cerastium holosteoides is a short-lived plant often found in small proportions on dry and mesotropic semi-natural, species-rich grassland communities. To obtain more information about its nutritive value, two experiments on *Arrhenatheretum elatioris* grassland were carried out to examine the effect of harvest date on *in vitro* organic matter digestibility (IVOMD), neutral-detergent fibre (NDF), acid-detergent fibre (ADF), acid-detergent lignin (ADL), estimated net energy for lactation (NEL) and crude protein (CP) concentrations of *C. holosteoides*, and selection of this plant by dairy cows grazing on semi-natural grassland. *C. holosteoides* starts flowering in spring and continuously develops new flowers on new branches throughout the summer. Harvests were made in relation to particular growth stages of *Dactylis glomerata* present in the sward: (A) tillering; (B) stem elongation; (C) ear emergence; (D) flowering; and (E) ripening.

Chemical composition and nutritive value were evaluated in 1998 and 1999. With advancing maturity, IVOMD of *C. holosteoides* decreased from 0·771 at growth stage A to 0·485 at growth stage E. At the same time, CP concentration decreased from 153 to 69 g kg^{-1} dry matter (DM) and estimated NEL concentration from 6·00 to 4·07 MJ kg^{-1} DM. With advancing maturity, there was a significant increase in NDF, ADF and ADL concentrations. In the summer harvest season, *C. holosteoides* contained significantly higher NDF, ADF and ADL concentrations, lower NEL concentration and had a lower IVOMD value than in the spring. Differences between years were also found for IVOMD and for NDF, ADF, ADL and NEL concentrations.

In a grazing experiment in the year 1999, at growth stage B, Simmental cows grazed an *A. elatioris* sward in which the main species was *D. glomerata* (0·092), and the proportion of *C. holosteoides* was 0·034. *C. holosteoides* was, on average, grazed by cows to the same relative extent as other species in the sward.

Keywords: *Cerastium holosteoides*, nutritive value, chemical composition, harvest date, grazing

Introduction

A short-lived plant, *Cerastium holosteoides* FRIES, also described as *Cerastium fontanum* Baumg. ssp. *holosteoides* (Fr.) Salman, Ommering & de Voogd (Stace, 1997) or *Cerastium fontanum* Baumg. ssp. *triviale* (Link) Jalas (Hegi, 1979), is most frequent on dry and mesotropic meadows, pastures and also in fields (Hegi, 1979). Ellmauer and Mucina (1993) classified this plant as a characteristic species or a constant companion species of many species-rich grassland communities. Usually, the percentage of *C. holosteoides* in the botanical composition of the sward does not exceed more than a few per cent.

Cerastium holosteoides has been studied in relation to the factors influencing botanical compositions of swards (e.g. Hanley *et al.*, 1996) and seedbanks (e.g. Graham and Hutchings, 1988; Tsuyuzaki and Kanda, 1996; Falińska, 1998). However, there is a lack of data about its nutritive value. Hegi (1979) described *C. holosteoides* as a less valuable forage plant. On the other hand, there are other reports from which it is possible to conclude that this plant has a relatively high nutritive value. Bhadresa (1987), for example, reported that rabbits preferred *C. holosteoides* to the same extent or more than *Festuca rubra* L., *Plantago lanceolata* L. and *Trifolium repens* L.

Semi-natural grassland is important for its conservation value with particular emphasis on its biodiversity in many countries of Europe (Kramberger and Gselman, 2000). In such grasslands, grasses, clovers and herbs provide plant diversity. From the nutritive point of view, Buchgraber *et al.* (1994) argued that these species-rich grasslands should be composed of 0·5–0·6 grasses and 0·2–0·3 clovers with the remainder as herbs.

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grasses and clovers. There is some knowledge about some of the herb species, for example *P. lanceolata* and *Taraxacum officinale* Wigers, but current knowledge about most of the herb species is still insufficient. *C. holosteoides* is one such herb species. Consequently, the objective of our experiments was to obtain more information about its nutritive value for ruminants.

Materials and methods

The experiments were carried out at Pernica (46° 34′ 20″ N, 15° 44′ 50″ E, 280 m above sea level) near Maribor, Slovenia. The soil was brown earth, with a mean pH of 6·5. The average annual rainfall in the area is 1000–1100 mm (the lowest in January with 47 mm, and the highest in the summer months with 100–130 mm per month). The yearly mean air temperature is 10 °C, the mean monthly minimum is in January with −1·3 °C, and the average monthly maximum is in July (≈ 20 °C). The mean number of days with the average above 0·0 °C is 272.

The grassland used in the experiments was an *Arrhenatheretum elatioris* Br.-Bl. 1919 (syn. *Pastinaco-Arrhenatheretum* Passarge 1964) semi-natural mesotropic grassland, *Pastinaca sativa* subcommunity (MG1) (Rodwell, 1992). In the years before the experimental work, the grassland had been used for extensive traditional hay-making with cuts in late May and early August. There was also a third cut in late autumn every year, which was sometimes replaced by grazing with cattle. In 1997 and during the experimental work (1998 and 1999), the main species in the sward was *Dactylis glomerata* L. with 0·09–0·10 relative contribution to the herbage mass. *D. glomerata* was also one of the early flowering components of the sward. The contribution of *C. holosteoides* was 0·03–0·04. This small proportion of *C. holosteoides* is typical of *A. elatioris* grassland.

Experiment 1: The evaluation of chemical composition and nutritive value of *C. holosteoides* at different growth stages

In March 1998, the grassland area of 0·5 ha was divided into 20 plots. Five treatments (harvesting the *C. holosteoides* at the different growth stages of cocksfoot, *D. glomerata*) were in a complete randomized block design with four replicates.

Owing to the fact that *C. holosteoides* starts to flower in spring and develops flowers on the new branches throughout the whole summer, harvests were made in relation to particular growth stages of cocksfoot, which was present in the sward during the whole experiment. *C. holosteoides* was harvested when cocksfoot was at the

same time, *C. holosteoides* had developed flowers on the main stem and on branches at the first node above the cutting height (A), flowers on the branches at the first and second nodes (B), flowers on the branches at the second and third nodes (C), flowers on the branches at the third and fourth nodes (D), and flowers on the branches also at the third and fourth nodes above the cutting height (E). The harvest dates of *C. holosteoides* were 18 April, 2, 10 and 22 May and 9 June 1998 and 15 and 29 April, 7 and 17 May and 6 June 1999 for ‘first cut’. The whole plots were cut on 13 June 1998 and 9 June 1999. Dates of ‘second’ harvests of *C. holosteoides* were 5, 13, 21 and 30 July and 7 August 1998 and 2, 11 and 20 July and 9 August 1999.

Cerastium holosteoides was harvested to a stubble height of 5 cm. Samples from each plot were taken for analysis. Dry matter (DM) content was determined by drying at 70 °C for 24 h in a forced-draught oven. On subsamples, organic matter (OM) content was determined after ashing at 500 °C. *In vitro* organic matter digestibility (IVOMD) was determined using the two-stage technique of Tilley and Terry (1963) and crude protein (CP) concentration by the Kjeldahl method. Acid-detergent fibre (ADF), neutral-detergent fibre (NDF) and acid-detergent lignin (ADL) concentrations were determined according to the method of Goering and Van Soest (1970). Net energy for lactation (NEL) was calculated using the equation:

$$\text{NEL (MJ)} = 0{\cdot}6 \times (1 + 0{\cdot}004 \times [q - 57] \times \text{metabolizable energy (ME) (MJ)}$$

described by DLG (1997).

The data were subjected to an analysis of variance. An *F*-ratio with $P < 0{\cdot}05$ was regarded as statistically significant. Comparison of treatments was made using Student’s *t*-test.

Experiment 2: The effect of growth stage at grazing on selection of *C. holosteoides* by dairy cows

On 22 and 23 April 1999, 20 Simmental dairy cows (average live weight 610 kg) grazed an *A. elatioris* sward for 1·5 days at the beginning of growth stage B in four paddocks (five dairy cows in each). The total grazed area was 0·17 ha. Apart from grazing, cows were also fed whole-crop maize silage (on average 15 kg d^{-1}). The average daily yield of dairy cows was 15·2 L milk d^{-1}.

Pre- and post-grazing samples for the determination of herbage mass and for the determination of proportion of *C. holosteoides* in botanical composition were taken by cutting to 5 cm height in 0·5 × 0·5 m squares in the proportions of *C. holosteoides* in the herbage mass before and after grazing.

Annual application of fertilizers to experimental plots in both experiments was 180 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1} and 200 kg K_2O ha^{-1}.

Results

Table 1 shows mean IVOMD values and CP, NDF, ADF, ADL and NEL concentrations of *C. holosteoides* at different growth stages, in different years and from different cuts in Experiment 1. The NDF and ADF concentrations increased from 466 and 262 g kg^{-1} DM, respectively, at growth stage A to 609 and 384 g kg^{-1} DM, respectively, at growth stage E. Also, the ADL concentration increased from 40 (growth stage A) to 77 g kg^{-1} DM (growth stage E). The IVOMD decreased from 0·771 at growth stage A to 0·485 at growth stage E. Consequently, the NEL concentration also decreased from 6·00 (growth stage A) to 4·07 MJ kg^{-1} DM at growth stage E. The CP concentration decreased from 153 (growth stage A) to 69 g kg^{-1} DM (growth stage E).

As well as growth stages, years also significantly affected the concentrations of NDF, ADF and ADL in *C. holosteoides*. These values in the second year of the experiment were lower than those in the first year, whereas IVOMD and NEL concentration were significantly higher in the second year. The CP concentration did not differ significantly between years.

The CP concentration of harvests in both 'cuts' was not significantly different. Although the average IVOMD value and NEL concentration in the second 'cut' in comparison with the first 'cut' decreased significantly, the NDF, ADF and ADL concentrations increased.

No significant interaction between growth stages and years was observed in the variables studied ($P < 0·05$). However, in all variables, there was significant interaction between growth stages and 'cuts' (Table 1). The interaction between years and 'cuts' was significant only for CP ($P < 0·001$) and ADL ($P = 0·001$; Table 1) concentrations. The interaction between growth stages and years and cuts was significant for CP ($P = 0·001$), ADL ($P < 0·001$) and NDF ($P = 0·012$; Table 1) concentrations.

Table 2 shows the results obtained in Experiment 2. It can be seen that the total herbage mass (1554 kg DM ha^{-1}) present at growth stage B was

Table 1 *In vitro* organic matter digestibility (IVOMD) and crude protein (CP), neutral-detergent fibre (NDF), acid-detergent fibre (ADF), acid-detergent lignin (ADL) and net energy for lactation (NEL) concentrations for *Cerastium holosteoides* at different growth stages in first and second 'cuts' in both years of Experiment 1.

	IVOMD	CP (g kg^{-1} DM)	NDF (g kg^{-1} DM)	ADF (g kg^{-1} DM)	ADL (g kg^{-1} DM)	NEL (MJ kg^{-1} DM)
Growth stages (G)						
A	0·771^{a}	153^{a}	466^{a}	262^{a}	40^{a}	6·00^{a}
B	0·680^{b}	119^{b}	490^{b}	295^{b}	46^{a}	5·49^{b}
C	0·630^{c}	108^{c}	532^{c}	326^{c}	55^{b}	5·12^{c}
D	0·558^{d}	85^{d}	568^{d}	359^{d}	64^{c}	4·87^{d}
E	0·485^{e}	69^{e}	609^{e}	384^{e}	77^{d}	4·07^{e}
s.e.m.	0·015	3·1	7·8	6·5	2·3	0·11
Years (Y)						
1	0·597^{a}	108^{a}	553^{a}	341^{a}	59^{a}	4·95^{a}
2	0·654^{b}	105^{a}	513^{b}	310^{b}	54^{b}	5·19^{b}
s.e.m.	0·0097	2·1	4·9	4·1	1·5	0·07
'Cuts' (C)						
1	0·669^{a}	107^{a}	512^{a}	317^{a}	52^{a}	6·36^{a}
2	0·580^{b}	106^{a}	554^{b}	333^{b}	61^{b}	4·48^{b}
s.e.m.	0·0097	2·1	4·9	4·9	1·5	0·07
Significance						
G × Y	NS	NS	NS	NS	NS	NS
G × C	0·009	<0·001	<0·001	0·006	<0·001	0·042
Y × C	NS	<0·001	NS	NS	0·001	NS
G × Y × C	NS	0·001	0·012	NS	<0·001	NS

Means within contrast values with different superscripts differ significantly ($P < 0·05$).

Table 2 Pre- and post-grazing herbage mass and contribution of *Cerastium holosteoides* in herbage mass for grazing at growth stage B.

	Herbage mass (kg DM ha^{-1})		*Cerastium holosteoides* (proportion)	
	Mean	s.e.m.	Mean	s.e.m.
Before grazing	1554	144	0·034	0·003
After grazing	51	3·3	0·033	0·003

substantially removed by dairy cows, because the herbage mass remaining was only 51 kg DM ha^{-1}. The proportions of *C. holosteoides* before grazing (0·034) and after grazing (0·033) did not differ markedly (s.e.m. = 0·003).

Discussion

The results from Experiment 2 showed that *C. holosteoides* at growth stage B, when cocksfoot was at the stage of stem elongation, was selected by dairy cows to the same relative extent as, on average, the total of other species of the experimental semi-natural grassland. It was not avoided by dairy cows in this experiment, as was reported by Salt *et al.* (1992) for the botanically very similar species, *Cerastium fontanum*, in a pasture grazed by sheep. In their grazing experiment, they suggested that the hairy leaves of *C. fontanum* could be the reason for the lower proportion of this plant in the diet compared with the grazed layer of the sward. *C. holosteoides* in our experiments was only slightly hairy. This is in agreement with one of the botanical classifications, where this species is one of the subspecies of *C. fontanum* that should be the least hairy (Garcke, 1972). However, this was also a greater opportunity for selection by sheep in the continuously grazed swards of Salt *et al.* (1992).

There are no data currently available in the literature on antinutritive factors in *C. holosteoides*, except for hairiness; there are also no data on adverse effects on ruminant livestock that could be attributed to the consumption of *C. holosteoides*.

The nutritive value of young plants of *C. holosteoides*, established on the basis of the chemical analyses in Experiment 1, is comparable to that of some other forage species. IVOMD at growth stages A (0·771) and B (0·680), however, is lower than that of the most commonly sown grasses at the same growth stages, e.g. perennial ryegrass (*Lolium perenne* L.) and timothy (*Phleum pratense* L.). Organic matter digestibility of these

applies for crude protein and NEL concentrations. However, in comparison with some other herb species, *C. holosteoides* is of a similar quality. For example, digestibility of dry matter of dandelion (*T. officinale*) is 0·68 and that of ribwort (*P. lanceolata*) is 0·72 when measured at the non-flowering stage by Wilman and Riley (1993). Also, Isselstein (1995) established values similar to the findings from our experiment for some other herb species. For yarrow (*Achillea milefolium* L.), he measured crude protein concentration within the range of 84 and 198 g kg^{-1} DM, NEL concentration between 4·56 and 6·56 MJ kg^{-1} DM, and ADF concentration between 190 and 378 g kg^{-1} DM. For ribwort, he measured values ranging between 71 and 222 g CP kg^{-1} DM, NEL concentration between 4·36 and 6·16 MJ kg^{-1} DM, and ADF concentration ranging between 154 and 263 g kg^{-1} DM.

In more mature plants (growth stage D), the nutritive value of *C. holosteoides* decreased sharply, much more than in *D. glomerata*, for example, in which the organic matter digestibility at growth stage D is approximately 0·70 (DLG, 1997), whereas in *C. holosteoides*, IVOMD in this experiment in the same period fell well below 0·60 (Table 1).

The comparison of the nutritive value of *C. holosteoides* with the nutritive value of other sward species described by other authors is difficult to make, because of different experimental conditions. In addition, the growth stages are not directly comparable, as *C. holosteoides* is grazed by ruminant livestock mainly when it is already in its flowering stage, which does not hold true for most other sward species. As is observed in this study, the nutritive value of *C. holosteoides* is higher at the time when animals usually graze the sward because of high nutritive value of the grasses (tillering and stem elongation stages of growth), even if *C. holosteoides* is already at the first stage of flowering, and its nutritive value is decreasing rapidly at the stages of advancing maturity.

In comparison with the first 'cut' carried out in the spring months, the lower nutritive value of the second 'cut' (Table 1), carried out in the warmer summer months, accords well with the results obtained by authors investigating other forage plants (Marten *et al.*, 1988; Wilson *et al.*, 1991). They reported that the quality of the forage decreases as a result of higher summer temperatures, which increase lignification, respiratory losses of non-structural carbohydrates and decrease forage digestibility.

Differences between the years also significantly affected forage quality, although the average daily temperatures during experimental periods from April to August were only slightly different. In the year 1998, years was sufficient because, in the same period, the precipitation in 1998 was 526 mm and 743 mm in 1999 (whereas the long-term average is 531 mm).

In conclusion, it has been shown that the nutritive value of *C. holosteoides* depends on growth stage, harvest season and year. Generally, in spite of *C. holosteoides* already being at the flowering stage, its nutritive value is still high in the periods when tillering and stem elongation of the main components of the sward are occurring, and cattle do not reject this plant as a forage. With advancing maturity, the nutritive value of *C. holosteoides* decreases rapidly.

References

Bhadresa R. (1987) Rabbit grazing. Studies in a grassland community using faecal analysis and exclosures. *Field Studies*, **6**, 657–684.

Buchgraber K., Deutsch A. and Gindl G. (1994) *Zeitgemässe Grünland – Bewirtschaftung*. Graz: Leopold Stocker Verlag.

Dlg (1997) *Futterwerttabellen – Wiederkäuer*. Universität Hohenheim – Dokumentationsstelle. Frankfurt: DLG Verlag.

Ellmauer T. and Mucina L. (1993) Molinio-Arrhenatheretea. In: Mucina, L., Grabherr, G. and Ellmauer, T. (eds) *Die Pflanzengesellschaften Österreichs*. Teil I. Jena: Gustav Fischer Verlag.

Falińska K. (1998) Long-term changes in size and composition of seed bank during succession: from meadow to forest. *Acta Societatis Botanicorum Poloniae*, **67**, 301–311.

Garcke A. (1972) *Illustrierte Flora*. Berlin: Paul Parey.

Goering H.K. and Van Soest P.J. (1970) Forage fiber analyses (apparatus, reagents, procedures and some applications). *Agriculture Handbook No. 379*. Washington, DC: Agricultural Research Service, United States Department of Agriculture.

Graham D.J. and Hutchings M.J. (1988) A field investigation of germination from the seed bank of a chalk grassland ley on former arable land. *Journal of Applied Ecology*, **25**, 253–263.

Hanley M.E., Fenner M. and Edwards P.J. (1996) The effect of mollusc grazing on seedling recruitment in artificially created grassland gaps. *Oecologia*, **106**, 240–246.

Hegi G. (1979) *Illustrierte Flora von Mitteleuropa. Pteridophyta, Spermatophyta. Band III. Angiospermae, Dicotyledones 1*, Teil 2. Berlin: Paul Parey.

Isselstein J. (1995) Zur Variabilität von Futterwereigenschaften verbreiteter Grünlandkräuter. *Verband Deutscher Landwirtschaftlicher Untersuchungs- und Forschungsanstalten-Schriftenreihe*, **40**, 405–408.

Kramberger B. and Gselman A. (2000) Changes in productivity and botanical composition of semi-natural grassland as a consequence of cutting frequency. *Rostlinná Výroba*, **46**, 325–330.

Marten G.C., Buxton D.R. and Barnes R.F. (1988) Feeding value (forage quality). In: Hanson, A.A., Barnes, D.K. and Hill, R.R. (eds) *Alfalfa and Alfalfa Improvement*, Agronomy Monograph no. 29, pp. 463–491. Madison, WI: American Society of Agronomy.

Rodwell J.S. (1992) *British Plant Communities: Grasslands and Montane Communities*. Cambridge: Cambridge University Press.

Salt C.A., Mayes R.W. and Elston D.W. (1992) Effect of season, grazing intensity and diet composition on the radiocaesium intake by sheep on re-seeded hill pasture. *Journal of Applied Ecology*, **29**, 378–387.

Stace C.A. (1997) *New Flora of the British Isles*. Cambridge: Cambridge University Press.

Tilley J.M.A. and Terry R.A. (1963) A two-stage technique for the *in-vitro* digestion of forage crops. *Journal of British Grassland Society*, **18**, 104–111.

Tsuyuzaki S. and Kanda F. (1996) Revegetation patterns and seed bank structure on abandoned pastures in northern Japan. *American Journal of Botany*, **83**, 1422–1428.

Wilman D. and Riley J.A. (1993) Potential nutritive value of a wide range of grassland species. *Journal of Agricultural Science, Cambridge*, **120**, 43–49.

Wilson J.R., Deinum B. and Engels F.M. (1991) Temperature effects on anatomy and digestibility of leaf and stem of tropical and temperate forage species. *Netherlands Journal of Agricultural Science*, **39**, 31–48.