Journal of Elementology ISSN 1644-2296

Grzegorczyk S., Alberski J., Olszewska M., Grabowski K., Bałuch-Małecka A. 2017. *Content of calcium and phosphorus and the Ca:P ratio is selected species of leguminous and herbaceous plants*. J. Elem., 22(2): 663-669. DOI: 10.5601/jelem.2016.21.4.1214

**ORIGINAL PAPER**

# CONTENT OF CALCIUM AND PHOSPHORUS AND THE CA:P RATIO IN SELECTED SPECIES OF LEGUMINOUS AND HERBACEOUS PLANTS*

**Stefan Grzegorczyk, Jacek Alberski, Marzenna Olszewska, Kazimierz Grabowski, Anna Bałuch-Małecka**

**Chair of Grassland and Green Space Management**
**University of Warmia and Mazury in Olsztyn**

**Abstract**

Green fodder plays a key role in nutrition of ruminants, and its quality is determined by the species composition of meadow and pasture swards. Legumes and herbs are generally more abundant in nutrients, especially minerals, than grasses. Calcium (Ca) and phosphorus (P) are particularly important for animal health. The dietary levels of Ca and P should be balanced to increase their availability and utilization. The aim of this study was to determine the content of calcium and phosphorus and the Ca:P ratio in selected legume and herb species from extensively used grasslands in the Olsztyn Lakeland. The study covered the following species of leguminous plants: *Trifolium pratense*, *Trifolium repens*, *Lotus corniculatus*, *Lathyrus pratensis*, *Lotus uliginosus* and *Vicia cracc,* and herbaceous plants: *Taraxacum officinale*, *Achillea millefolium*, *Plantago lanceolata*, *Alchemilla vulgaris*, *Heracleum sibiricum* and *Cirsium oleraceum*. The investigated legumes and herbs differed significantly in their Ca and P content and the Ca: P ratio. All the species were abundant in Ca, and two taxa: *Cirsium oleraceum* and *Heracleum sibiricum*, were characterized by particularly high levels of calcium. The highest levels of phosphorus were noted in *Heracleum sibiricum*, whereas the lowest content of P was determined in *Alchemilla vulgaris*, *Cirsium oleraceum* and *Trifolium pratense*. *Cirsium oleraceum* was abundant in Ca and deficient in P, hence it was distinguished by the widest Ca:P ratio. Legumes and herbs are valuable components of meadow sward and a rich source of minerals, in particular Ca, in animal diets.

**Keywords**: grasslands, legumes, herbs, calcium, phosphorus, Ca:P.

prof. dr hab. Stefan Grzegorczyk, Chair of Grassland and Green Space Management, University of Warmia and Mazury in Olsztyn, pl. Łódzki 1, 10-727 Olsztyn, Poland, e-mail: stefang@uwm.edu.pl

* Supported by the University of Warmia and Mazury in Olsztyn (Project No. 20.610.011-300).

## INTRODUCTION

Green fodder plays a key role in nutrition of ruminants, and its quality depends on the species composition of meadow and pasture swards. Legumes and herbs are particularly valuable components of grassland flora (Kienzle et al. 2008, Grzegorczyk et al. 2013, Lüscher et al. 2014). They are generally more abundant in nutrients, particularly mineral compounds and total protein, than grasses.

The quality of animal products (meat, milk) is largely determined by the nutritional value of feed. Research has demonstrated that a cow's diets enriched with herbs increases milk yield and improves the chemical composition, physicochemical parameters, processing suitability and nutritional value of milk (Kraszewski et al. 2004, Budny et al. 2012). The ratio of dietary components in animal diets sometimes plays a more important role than the content of individual elements (Trąba, Wolański 2003, Albu et al. 2012). The above is particularly true about calcium and phosphorus, which are vital for animal health (Soetan et al. 2010, Maziarka, Pasternak 2013, Kumar, Soni 2014, Wyłupek et al. 2014). An inadequate Ca:P ratio can lower the availability, absorption and utilization of those elements (Albu et al. 2012).

The research hypothesis put forth in the study was that common species of leguminous and herbaceous plants can exert different effects on the nutritional value of feed. Therefore, the objective of this study was to determine the content of calcium and phosphorus and the Ca:P ratio in selected legume and herb species from extensively used grasslands in the Olsztyn Lakeland.

## MATERIALS AND METHODS

The presence of selected legume and herb species in extensively used grasslands in the Olsztyn Lakeland was determined at first harvest (from June to the first half of July) in 1998-2000. Plant samples for mineral composition analysis were collected from communities with the minimum 5% coverage of selected species of leguminous plants: *Trifolium pratense* L. (T.p.), *Trifolium repens* L.(T.r.), *Lotus corniculatus* L. (L.c.), *Lathyrus pratensis* L. (L.p.), *Lotus uliginosus* Schkuhr. (L.u.), *Vicia cracca* L. (V.c.) and herbaceous plants: *Taraxacum officinale* F. H. Wigg. (T.o.), *Achillea millefolium* L. (A.m.), *Plantago lanceolata* L. (P.l.), *Alchemilla vulgaris* L. (A.v.), *Heracleum sibiricum* L. (H.s.) and *Cirsium oleraceum* (L.) Scop. (C.o.). In total, 444 plant samples were analyzed (Table 1).

The Ca content of plants was determined by flame photometry, and the concentrations of P were estimated by the colorimetric method with vanadium and molybdenum. The results were processed by analysis of variance (ANOVA) in the Statistica 12 program.

Table 1

Variations in Ca and P levels and the Ca:P ratio in the dry matter of selected plant species, expressed by the coefficient of variation (%)

| Species | Number of samples | Ca content | P content | Ca:P ratio |
|---|---|---|---|---|
| *Taraxacum officinale* F.H.Wigg. | 33 | 28.4 | 20.7 | 25.0 |
| *Achillea millefolium* L. | 52 | 21.0 | 29.0 | 48.1 |
| *Plantago lanceolata* L. | 32 | 20.7 | 17.4 | 22.8 |
| *Alchemilla vulgaris* L. | 48 | 36.4 | 28.3 | 63.4 |
| *Heracleum sibiricum* L. | 29 | 17.1 | 19.5 | 31.5 |
| *Cirsium oleraceum* (L.) Scop. | 49 | 14.0 | 22.6 | 21.5 |
| *Lathyrus pratensis* L. | 42 | 18.9 | 27.2 | 31.0 |
| *Vicia cracca* L. | 34 | 17.9 | 29.3 | 25.4 |
| *Lotus uliginosus* Schkuhr. | 52 | 18.4 | 19.1 | 31.8 |
| *Lotus corniculatus* L. | 22 | 18.6 | 31.6 | 28.2 |
| *Trifolium repens* L. | 26 | 19.6 | 30.6 | 46.9 |
| *Trifolium pratense* L. | 25 | 21.7 | 26.5 | 30.0 |

## RESULTS AND DISCUSSION

Calcium concentrations differed significantly in the analyzed plant species. The highest levels of Ca were noted in *Cirsium oleraceum* at 41.5 g $kg^{-1}$ on average, followed by *Heracleum sibiricum* at 33.6 g $kg^{-1}$ (Figure 1). The Ca content of the remaining species ranged from 15.2 g $kg^{-1}$ (*Achillea millefolium*) to 20.6 g $kg^{-1}$ (*Trifolium pratense*), and the difference between extreme values was statistically significant. The differences in Ca levels within a species generally did not exceed 20%. The smallest difference (coefficient of variation 14.0%) was noted in samples of *Cirsium oleraceum*. The greatest differences were noted in *Alchemilla vulgaris* and *Taraxacum officinale*, where the coefficients of variation were determined at 36.4% and 28.4%, respectively (Table 1).

All of the evaluated plant species were characterized by a high average Ca content, which ranged from 15.2 to 41.5 g $kg^{-1}$. In three species (*Cirsium oleraceum*, *Heracleum sibiricum* and *Trifolium pratense*), the average Ca concentrations exceeded 20 g $kg^{-1}$, which is considered to be a toxic level (NCR 1980). However, in view of the fact that grasses accumulate significantly less Ca than leguminous plants (Juknevičius, Sabienė 2007, Soetan et al. 2010, Lüscher et al. 2014), legumes can be regarded as a highly valuable component of grassland flora and a rich source of Ca in animal nutrition (Kulik 2009, Pirhofer-Walzl et al. 2011, Gaweł, Nędzi 2014). Herbs play a

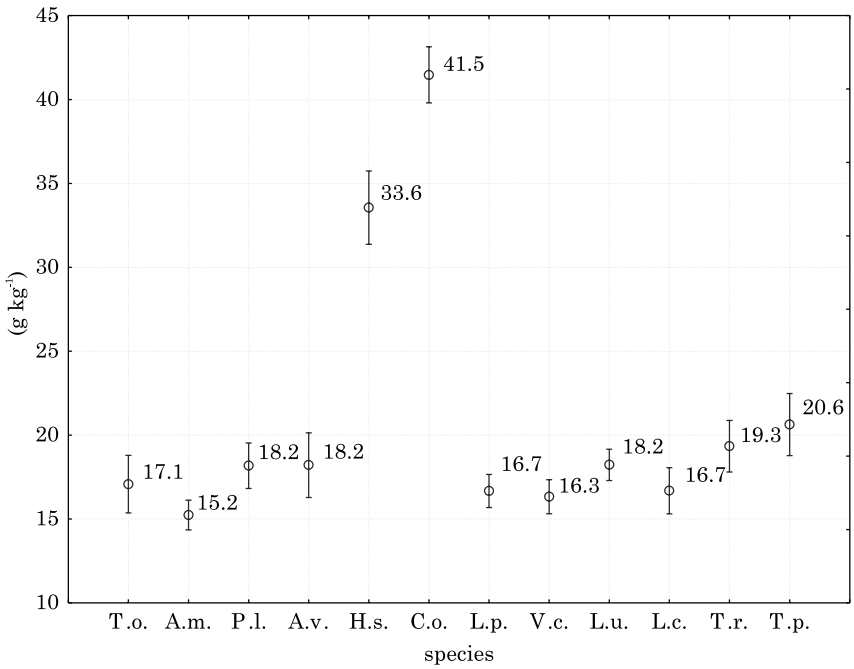


Fig. 1. Calcium content of the dry matter of plants (means and 95.00% confidence intervals)

similar role in animal feed. Kienzle et al. (2008) demonstrated that hay with more than 10% content of herbs and legumes was characterized by higher concentrations of Ca. Herbs also improve the availability and utilization of other nutrients, which positively influences the quality of animal products (Budny et al. 2012).

The average content of P in the analyzed plants ranged from 2.8 g $kg^{-1}$ (*Alchemilla vulgaris*, *Cirsium oleraceum* and *Trifolium pratense*) to 4.9 g $kg^{-1}$ (*Heracleum sibiricum*). The highest concentrations of P were determined in *Heracleum sibiricum* and *Taraxacum officinale*. Species with the lowest P levels differed significantly from the remaining taxa, and similarly low concentrations of P were found only in *Lotus corniculatus*, *Alchemilla vulgaris*, *Cirsium oleraceum* and *Trifolium pratense* (Figure 2). The content of P differed significantly within species. The lowest coefficients of variation were noted in *Plantago lanceolata* (17.4%), *Lotus uliginosus* (19.1%), *Heracleum sibiricum* (19.5%) and *Taraxacum officinale* (20.7%). The greatest intraspecific variations in P levels were observed in *Lotus corniculatus* (31.6%) and *Trifolium repens* (30.6%) – Table 1.

The average concentrations of P in the examined plant species did not exceed the toxic level of 10 g $kg^{-1}$ (NCR 1980). Legumes and herbs are generally more abundant in P than grasses (Gaweł, Nędzi 2014), but some authors did not report differences in the P content of grasses and legumes (Juknevičius, Sabienė 2007). In a study by Pirhofer-Walzl et al. (2011), herbs were

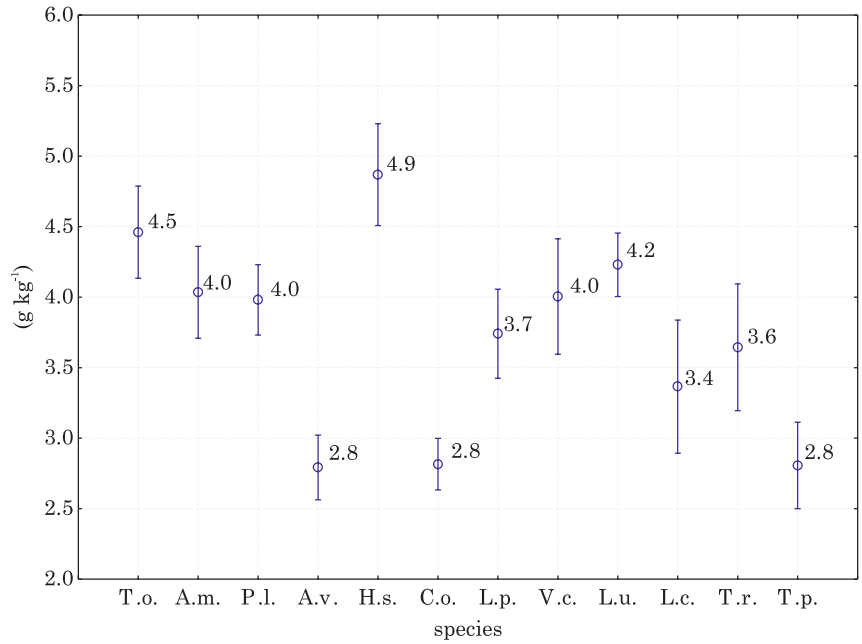


Fig. 2. Phosphorus content of the dry matter of plants (means and 95.00% confidence intervals)

characterized by higher P levels than grasses and legumes, and an addition of herbs increased the mineral content of animal feeds. Phosphorus concentrations in plants vary across developmental stages and are determined by the leaf to stem weight ratio. Leaves are generally more abundant in P than stems, and the P content of feed decreases with plant aging (Marković et al. 2008, Mahala et al. 2012).

The widest Ca:P ratio of 15.3 was noted in *Cirsium oleraceum* (Figure 3) on account of its high Ca content and low P content. In the remaining plant species, the Ca:P ratio was even several-fold lower, and it ranged from 3.9 (*Taraxacum officinale*) to 7.8 (*Trifolium pratense*). The narrowest Ca:P ratio was found in *Taraxacum officinale*, *Achillea millefolium*, *Vicia cracca*, *Lotus uliginosus*, *Plantago lanceolata* and *Lathyrus pratensis*. The coefficients of variation for Ca:P values were determined in a broad range of 21.5% (*Cirsium oleraceum*) to 63.4% (*Alchemilla vulgaris*) – Table 1.

Calcium and phosphorus play a very important role in the growth and development of animals. Those macroelements should be analyzed in combination because the dietary levels of Ca and P should be balanced to increase their availability and utilization (Albu et al. 2012). The Ca:P ratio of animal feeds should range from 1:1 to 2:1 (Miller et al. 1995). The National Research Council (NCR 1980) recommends a Ca:P ratio of 1.5-2:1. According to some authors, the optimal Ca:P ratio is 2:1 (Trąba, Wolański 2003, Kumar and Soni 2014). Diets with a Ca:P ratio higher than 2 can have a detrimental effect on animal health (Ayan et al. 2010). In the present study, the aver-

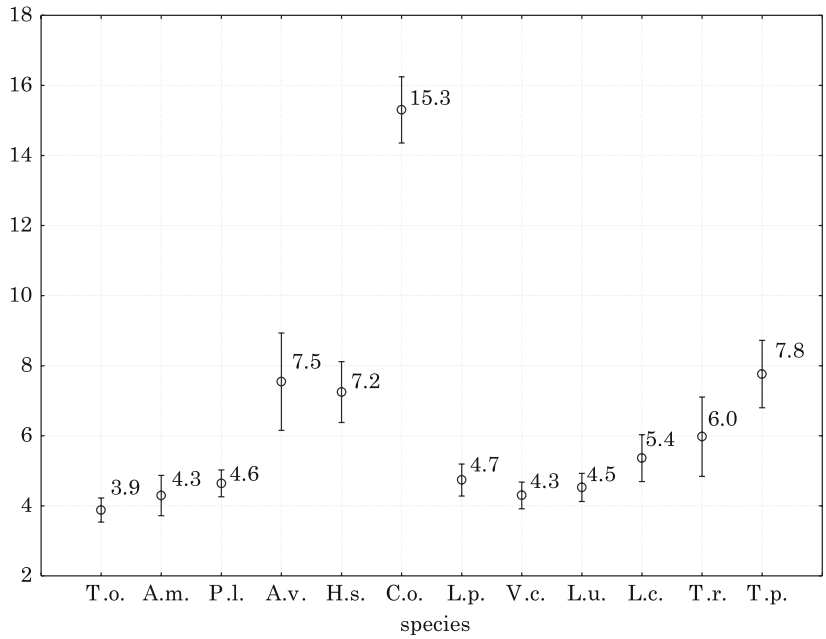


Fig. 3. Ca:P ratio in the dry matter of plants (means and 95.00% confidence intervals)

age Ca:P ratio exceeded 2 in every analyzed species of legumes and herbs. A wide C:P ratio is often noted in leguminous plants (Trąba, Wolański 2003, Żuk-Gołaszewska et al. 2010, Sosnowski et al. 2014).

## CONCLUSIONS

1. The analyzed species of legumes and herbs are abundant in Ca. The highest Ca levels were noted in *Cirsium oleraceum* and *Heracleum sibiricum*.

2. The highest concentrations of P were observed *Heracleum sibiricum*, whereas the lowest content of P was found in *Alchemilla vulgaris*, *Cirsium oleraceum* and *Trifolium pratense*.

3. *Cirsium oleraceum* was characterized by the highest Ca:P ratio on account of its high Ca content and low P content.

4. Legumes and herbs are valuable components of grassland flora and a rich source of minerals, particularly Ca, in animal diets.

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