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Nutritional attributes of understory plants known as components of deer diets

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Abstract

Nutritive quality of vegetation is important when evaluating the habitat to sustain wildlife. Crude protein, fiber content and in vitro digestibility were evaluated for 17 shrubs, 7 trees, 2 ferns, 3 forbs, and 4 grasses species of Galician (NW Spain) woodlands understory. Nutritional attributes showed forbs, *Frangula alnus* Miller, *Hedera helix* L. and *Lonicera periclymenum* L. as plants with the highest forage value. Crude protein levels of *Rubus* sp., *Robinia pseudacacia* L., *Castanea sativa* Miller, and grasses could meet deer nitrogen requirements but their low IVOMD and high fiber percentages make them mid-low feed value forages. Understory layer of oakwoods provides higher quality forage than conifer or eucalyptus stands. Crude protein and digestibility of plants peaked in spring-summer and the highest fiber content occurred in winter. Seasonal fluctuations in forage quality makes seasonal management and seasonal plans neccesary.

Resumen

La calidad nutritiva de la vegetación es importante para evaluar la capacidad de un hábitat como sustento alimenticio. Se estimaron los contenidos en proteína bruta, fibra y la digestibilidad de plantas de sotobosque en diferentes formaciones forestales gallegas (España). Las especies que presentaron mejores características nutricionales fueron *Frangula alnus* Miller, *Hedera helix* L y *Lonicera periclymenum* L. Otras como *Rubus* sp., *Robinia pseudacacia* L, *Castanea sativa* Miller y algunas gramíneas, podrían cubrir las necesidades de nitrógeno de los cérvidos pero presentan una baja digestibilidad y un alto porcentaje de fibra. El sotobosque de los robledales ofrece un mayor valor alimenticio que el de las formaciones de coníferas y eucalipto. Los valores máximos de contenido en proteína bruta y digestibilidad para la vegetación ocurren en primavera y verano, mientras que la mayor proporción de fibra ocurre en invierno. Las variaciones estacionales de los parámetros nutritivos hacen necesario coordinar los ciclos de oferta, demanda, y calidad de la vegetación con las necesidades nutricionales de los cérvidos.

Key Words: ADF, lignin, crude protein, in vitro digestibility, Spain

The carrying capacity of a habitat to sustain wildlife is frequently expressed as a balance between food supply and animal demand (Robbins 1973, Wallmo et al.1977, Bobek 1977, Mautz 1978, Hobbs et al. 1982). The knowledge of the nutritive quality of the vegetation is esssential to evaluate the resources available for herbivores. This feed value depends on plant species, portion of the plant consumed, genetic and environmental factors, seasonality, maturity, etc. (Van Soest 1982, Bailey 1984). It has been reported that poor forage quality may limit cervid populations more than forage quantity (Starkey et al. 1982). Pulses of food production are followed by prolonged periods in which there is no high quality food. Parameters such as crude protein, in vitro digestibility and fiber content reflect the nutritive quality or feed value. Digestibility and crude protein levels of forage are important components of quality in deer diets (Nagy et al. 1969, Drozdz and Oziecky 1973, Heady 1975, Bayoumi and Clarke 1976, Willms 1978, Crawford 1982) while fiber is usually detrimentally associated with digestibility (Van Soest 1982). Given that protein and energy are sometimes limiting in winter forages (Leslie et al. 1984), seasonal trends of nutritional parameters have been suggested as important factors in management of deer populations and diets (Happpe et al. 1990, González-Hernández and Silva-Pando 1996). This study examines the seasonal pattern of nutritional parameters in understory layers of oak, conifer, and eucalyptus stands with respect to deer nutrition. Our objectives included: (1) determine the nutritive value of the most common deer forage plants in the understory layer of representative woodlands in Galicia, (2) study the seasonal pattern of nutritional parameters in different types of plant communities, and (3) establish the basis for future management implications.

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Study Area

Our study was conducted in 3 oak, 1 conifer, and 1 eucalyptus forests located in Galicia (northwest Spain) and included common vegetation communities of this region. Climate is Atlantic with mild, wet winters at the coast, and colder inland. Maximum temperatures increase and minimum decrease from northwest to southeast. Mean annual temperatures of the study sites varied from 9.71 to 14.2˚C and annual precipitation from 1,419 to 1,800 mm (Table 1).

Table 1. Characteristics of the plots studied. Temperature and precipitation are expressed as mean annual temperature and annual precipitation respectively.

Type of Vegetation	Code	Altitude	Temp.	Ppt.
Oak woodlands		(m)	(˚C)	(mm)
Vaccinio myrtilli-Quercetum roboris	O-VaQr	800	10.78	1419
Blechno spicanti-Quercetum roboris	O-BlQr	680	9.71	1799
Rusco aculeati-Quercetum roboris	O-RuQr	60	14.23	1800
Conifer stand				
Ulici europaei-Ericetum cinereae	C	150	13.64	1800
Eucalyptus forest				
Ulici europaei-Ericetum cinereae	E	360	11.43	1600

Elevation of the study sites ranges from 60 to 800 m. Soils in Galicia are mainly acidic having developed from granite, slate, or schists. Because of its hilly topography the evolutionary rank of these soils varies widely.

Material and Methods

Three 10m × 10m plots, homogeneous and representative of the area, were established in each stand. Species known as components of deer diets and abundant in the understory layer were selected for analysis (Table 2). Samples were collected quarterly during 2 years. Apical portions of each species were clipped randomly within the 3 plots and combined into a single sample for analysis. Plants did not receive heavy clipping since the same plants were not sampled more than once. Tree samples came from young trees potentially available considering deer food habits (i.e. height, twig diameter). Apical portions of plants were no longer than 15 cm and less than 1 cm in twig diameter. After drying at 80˚C overnight, dried samples were ground through a Wiley mill with 2mm mesh screen. Acid detergent fiber, permanganate lignin, cellulose, and silica contents were determined with sequential detergent analysis (Göering and Van Soest 1970) employing a Fibertec system DOSI-FIBER 4000599 (Selecta). In vitro digestibility of organic matter (IVOMD) was measured by the Tilley and Terry (1963) method as modified by Alexander (1969). Nitrogen content was determined by the micro-Kjeldahl method, the results being multiplied by 6.25 and expressed as crude protein (CP). All samples were analyzed in duplicate. Analysis of Variance was used to determine whether nutrient availability of each species varied among the different locations in each season. Correlation analysis between nutritional parameters were carried out using the SAS statistic package.

Results

In vitro Digestibility

Species with the highest in vitro digestibility (IVOMD) value were *Anemone nemorosa* and *Asphodelus albus* (Table 3). Digestibility of *Hedera helix*, *Frangula alnus* and *Lonicera periclymenum*, ranged from 50 to 64%. Grasses and grasslike (*Agrostis capillaris, Brachypodium sylvaticum* and *Carex remota*), trees (*Ilex aquifolium, Castanea sativa,* and *Robinia pseudacacia*) and shrubs other than heathers averaged from 40 to 50%. Heathers (*Erica, Calluna,* and *Daboecia* genera) belonged to the group with the lowest digestibility ranging between 16–25%.

On a seasonal basis, maximum IVOMD occured during the growing season. The fluctuation of IVOMD throughout the year was less pronounced for heathers and trees, and more apparent in forbs and grasses (Fig. 1). Digestibility of shrubs increased from winter to spring. Digestibility of heathers peaked in spring during the first year, but it was found a maximum during the fall in the second year. In vitro digestibility of forbs was highest in spring, and declined during summer when its vegetative period is completed. Annual grasses were also more digestible in spring and summer, IVOMD content decreasing through summer to winter.

The average values of IVOMD were quite different for the same species in different communities. In vitro digestibility of *Erica cinerea, Calluna vulgaris,* and *Ulex minor* were found significantly different in the eucalyptus and conifer stand (Table 3). *Calluna vulgaris* had highest IVOMD during the fall in the conifer stand (C), but it peaked in spring in the eucalyptus forest (E). The IVOMD percentages for these species were higher in the conifer stand than in eucalyptus. *Erica arborea* displayed maximum IVOMD percentages during spring in the *Vaccinio myrtilli-Quercetum roboris* and *Ulici europaei-Ericetum cinereae* (C), whereas in the other plant communities the highest value was in late summer. Nevertheless those seasonal differences between different type of plant communities were not significant ($P > 0.05$).

In vitro digestibility of *Hedera helix* in O-RuQr community was higher than in O-VaQr ($P < 0.05$). *Vaccinium myrtillus* at O-VaQr was more digestible than in O-BlQr ($P < 0.05$).

The greater proportion of forbs, grasses, ferns, and shrubs in oak stands make oakwoods had higher IVOMD, yet with more noticeable seasonal fluctuations than conifer and eucalyptus communities, which were mainly comprised of heathers (see presence of species in communities in Table 2).

Table 2. Presence of species analized in the locations studied.

Life form	Species	Vegetation type	Common name
Trees			
	Castanea sativa Miller	(O-RuQr)	sweet chestnut
	Eucalyptus globulus Labill.	(E)	eucalyptus
	Fagus sylvatica L.	(O-VaQr)	beech
	Ilex aquifolium L.	(O-VaQr, O-BlQr)	holy
	Laurus nobilis L.	(O-VaQr)	laurel
	Pyrus cordata Desv.	(O-VaQr , O-BlQr)	pear
	Robinia pseudacacia L.	(O-RuQr)	acacia
Shrubs			
	Calluna vulgaris (L.) Hull	(C, E)	heather
	Daboecia cantabrica (Hudson) C. Koch	(O-BlQr, E)	heather
	Erica arborea L.	(O-VaQr, O-BlQr, E)	heather
	Erica australis L.	(E)	heather
	Erica ciliaris L.	(E)	Dorset-heather
	Erica cinerea L.	(C, E)	bell-heather
	Erica umbellata L.	(C, E)	heather
	Frangula alnus Miller	(O-VaQr, O-RuQr)	black dogwood
	Halimium alyssoides(Lam.) C. Koch	(C, E)	cistus
	Hedera helix L.	(O-VaQr, O-BlQr, O-RuQr)	ivy
	Lonicera periclymenum L.	(O-VaQr, O-BlQr, O-RuQr)	honeysuckle
	Rubus sp.	(O-VaQr, O-BlQr, O-RuQr , C, E)	blackberry
	Ruscus aculeatus L.	(O-RuQr)	butcher's broom
	Teucrium scorodonia L.	(O-VaQr, O-BlQr, O-RuQr)	wood sage
	Ulex europaeus L.	(C, E)	gorse
	Ulex minor Roth	(O-RuQr, C, E)	gorse (dwarf furze)
	Vaccinium myrtillus L.	(O-VaQr, O-BlQr)	huckleberry
Ferns			
	Blechnum spicant (L.) Roth	(O-VaQr, O-BlQr, O-RuQr , E)	deer fern
	Pteridium aquilinum (L.) Kuhn	(O-BlQr, O-RuQr , C, E)	bracken fern
Forbs			
	Anemone nemorosa L.	(O-BlQr)	anemone
	Asphodelus albus Miller	(O-VaQr, O-BlQr, E)	lily
	Potentilla erecta (L.) Raüschel	(E)	common tormentil
Grasses			
	Agrostis capillaris L.	(O-BlQr, C, E)	bent-grass
	Agrostis curtisii Kerguélen	(O-BlQr, C)	bent-grass
	Brachypodium sylvaticum (Hudson) Beauv.	(O-VaQr, O-BlQr)	slender false-brome
	Carex remota L.	(O-RuQr)	sedge

Crude protein

The IVOMD was found positively correlated with protein content (r = 0.53, p $\leq$ 0.01). However, blackberry (*Rubus* sp.) and grasses had low digestibility values (between 31 and 45%), but met deer crude protein requirements (around 10%) established by A.R.C. (1968).

Crude protein content of *Rubus* sp., *Robinia pseudacacia*, *Castanea sativa*, and F*rangula alnus*, as well as forbs and grasses, met those nitrogen requirements for deer (10–21%). *Hedera helix a*nd *Lonicera periclymenum* had medium-high levels. Crude protein content of other trees and heathers was the lowest, hardly reaching 8% (Table 3).

Crude protein percentage increased during the growing season. Levels of crude protein were highest in spring-summer and declined during fall and winter (Fig. 1). We found some exceptions like *Lonicera periclymenum* and *Hedera helix* which crude protein content peaked in fall–winter. Heathers showed little seasonal changes, their protein levels remaining more uniform through the year. Appreciable seasonal fluctuations for *Lonicera periclymenum*, *Rubus* sp. and other shrubs, as well as in trees, were obtained.

The average values of crude protein were sometimes different for the same species in different oak communities. Crude protein content of *Hedera helix*, *Ilex aquifolium* and *Vaccinium myrtillus* were significantly different between locations (Table 3). Crude protein levels in *Hedera helix* and *Vaccinium myrtillus* were found significantly higher in O-RuQr than those for the same species in O-VaQr.

Conifer and eucalyptus stands, mostly constituted by heathers, displayed lowest protein levels and a more uniform quarterly protein content. Oakwoods, primary composed by forbs, grasses and other broadleaves species, had the highest crude protein levels, and fluctuation of crude protein content was more apparent through the year (see presence of species in communities in Table 2).

Acid Detergent Fiber, lignin, and silica

Fiber content was negatively correlated with crude protein (r = -0.31, p $\leq$ 0.01) and IVOMD (r = -0.64, p$\leq$ 0.01). We did not find a significant correlation between lignin and digestibility but a very weak correlation between IVOMD and silica. Plants with the highest crude protein and IVOMD content had the lowest fiber values. Acid detergent fiber

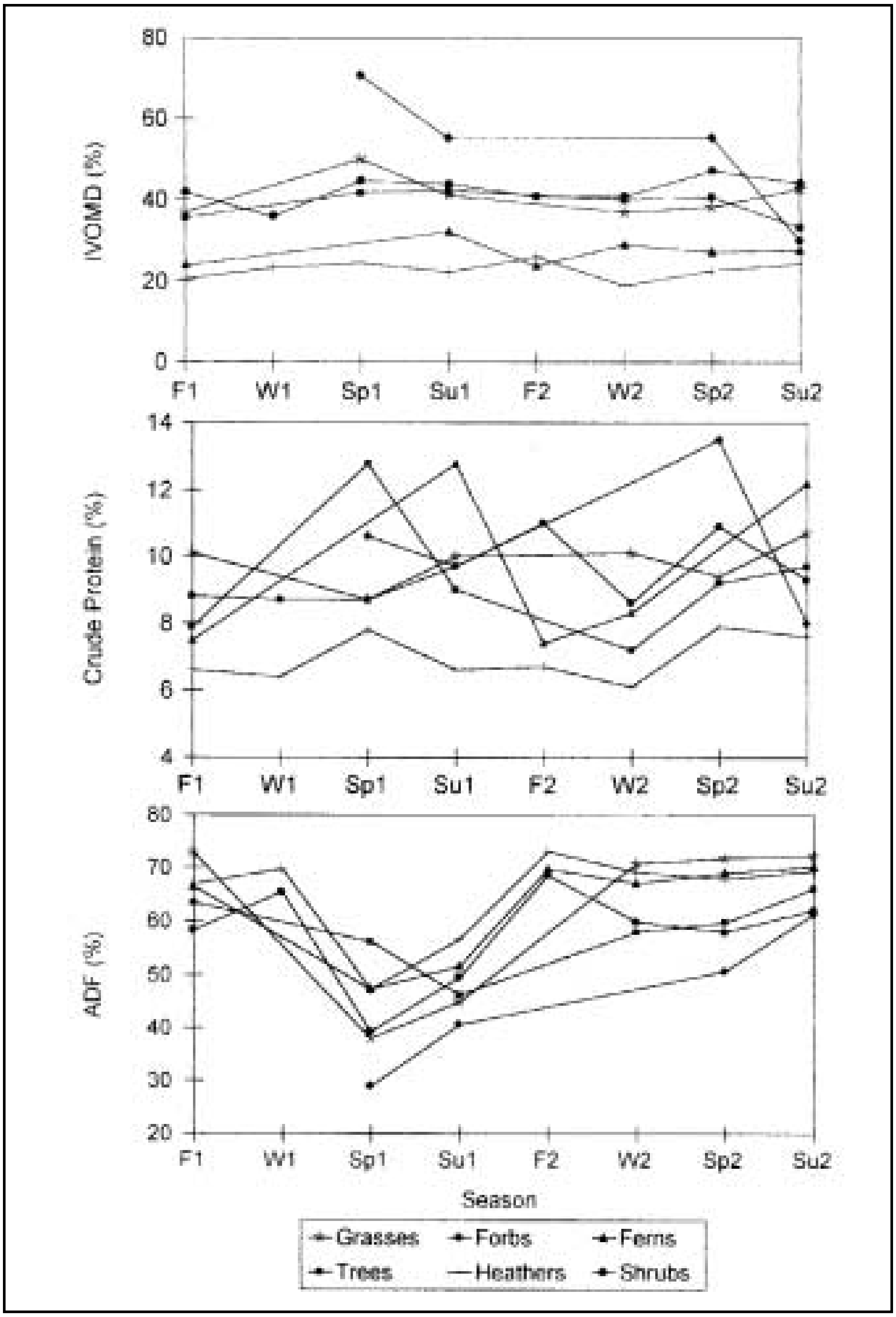

Fig. 1. Seasonal variation of digestibility (IVOMD), crude protein and fiber (ADF) for the different groups of plants in the study area. Heathers are showed separately from other shrubs since they constituted a group itself with lower nutritional attributes. See table 3 for specific values.

(ADF) of heathers, ferns, and some grasses (*Agrostis curtissii*, *Carex remota*) ranged from 60 to 70%. Forbs had the lowest fiber content (Table 3). Average fiber content of trees and shrubs could be considered in the medium-high range, some shrubs like *Lonicera periclymenum*, *Hedera helix* and *Frangula alnus* with fiber content below 50%. Lignin content was medium-high, with some values over 20%, but most species ranged from 14 to 18%.

Fiber content was lowest in the growing season and increased from spring through summer to fall-winter (Fig. 1). Seasonal trend of lignin and silica was more irregular and had many exceptions to this pattern. Average fiber content increased during second year of the study compared with the first.

Fiber content of *Teucrium scorodonia* in O-RuQr was significantly higher than in O-VaQr. *Ulex minor* showed significantly lower fiber proportions in the conifer stand than in eucalyptus. The average values of silica were not significantly different for a given species between locations, nor did the lignin content differ significantly among types of vegetation.

Understory plants from conifer and eucalyptus communities displayed the highest percentages of fiber. The quarterly fiber content did not remain more uniform for these communities. Fluctuations of fiber content were apparent in heathers as much as in the other groups of plants.

Discussion

Diet selection by deer is complex and reflects animal preferences, nutritional quality and availability. We found that forbs (except for *Potentilla erecta*) and some shrubs such as *Lonicera periclymenum*, *Frangula alnus* and *Hedera helix* had greater than 50% IVOMD, which, according to several authors is the minimum that allows deer to meet their nutritional requirements (Weiner 1977, Eisfeld 1985, Maizeret et al. 1991). We also found most of the plants consistently low in IVOMD to meet deer requirements since their values hardly reached 45%. Our results indicate that crude protein content of blackberry (*Rubus* sp.), *Carex remota*, *Agrostis capillaris*, *Robinia pseudacacia*, *Castanea sativa*, and *Frangula alnus* would meet those requirements. However, IVOMD of these species was low except for *Frangula alnus* (56%).

Crude protein and IVOMD content of *Frangula alnus*, *Hedera helix*, and *Lonicera periclymenum* met the minimum levels required for deer nutrition. *Hedera helix* and *Rubus* sp. have been reported as primary forages in some forest ecosystems mainly during fall-winter (Jackson 1980, Maizeret and Tran Manh Sung 1984, Maillard and Picard 1987). We found crude protein of *Lonicera periclymenum* and *Hedera*

Table 3. Nutritional attributes of understory species of Galician woodlands. Mean and standard deviation of ADF, Lignin, Silica, IVOMD and crude protein (CP) percentages.

Life form	Species	ADF	Lignin	Silica	IVOMD	CP
	Castanea sativa	48.4 ± 10.6	17.4 ± 2.2	2.3 ± 1.9	42.1 ± 6.1	10.2 ± 1.5
	Eucalyptus globulus	44.7 ± 2.9	21.3 ± 0.8	0.5 ± 0.4	48.7 ± 5.8	8.1 ± 0.6
	Fagus sylvatica	69.1 ± 7.4	16.0 ± 6.4	8.7 ± 5.4	22.7 ± 1.1	7.8 ± 1.8
Trees	*Ilex aquifolium*[a]	55.8 ± 7.1	20.3 ± 2.7	1.2 ± 0.7	47.9 ± 4.6	8.3 ± 1.1*
	Laurus nobilis	60.9 ± 4.6	14.7 ± 2.3	3.7 ± 2.0	34.6 ± 4.6	7.2 ± 1.5
	Pyrus cordata	59.8 ± 11.2	15.6 ± 4.0	4.8 ± 3.4	33.4 ± 5.3	7.7 ± 1.6
	Robinia pseudacacia	63.5 ± 2.1	24.4 ± 4.5	6.5 ± 0.5	45.0 ± 2.6	20.6± 1.0
Shrubs	*Calluna vulgaris*[a]	65.9 ± 9.8	13.4 ± 2.5	6.8 ± 3.2	26.1 ± 6.2**	6.1 ± 0.8
	Daboecia cantabrica	63.0 ± 13.1	13.2 ± 5.0	8.2 ± 4.6	24.1 ± 6.2	8.5 ± 1.8
	Erica arborea	60.3 ± 6.9	15.7 ± 2.6	1.4 ± 1.3	23.8 ± 5.1	7.8 ± 1.2
	Erica australis	73.4 ± 2.6	15.4 ± 1.6	3.1 ± 0.9	16.2 ± 3.7	6.5 ± 0.7
	Erica ciliaris	67.8 ± 7.1	16.9 ± 3.6	3.1 ± 2.0	18.0 ± 3.3	6.6 ± 0.6
	Erica cinerea[a]	61.0 ± 6.9	14.9 ± 1.7	2.2 ± 1.2	22.9 ± 4.6*	6.4 ± 1.0
	Erica umbellata	69.1 ± 6.1	14.6 ± 1.5	3.3 ± 1.9	19.3 ± 1.7	6.7 ± 0.8
	Frangula alnus	49.6 ± 8.2	18.2 ± 2.6	1.5 ± 1.3	56.2 ± 3.9	11.7 ± 2.8
	Halimium alyssoides	69.4 ± 8.8	18.2 ± 3.9	6.8 ± 3.2	22.1 ± 4.3	8.4 ± 1.2
	Hedera helix[a]	44.0 ± 7.4	16.6 ± 3.2	1.0 ± 0.6	63.4 ± 3.8**	9.3 ± 1.2**
	Lonicera periclymenum	49.2 ± 6.6	17.9 ± 1.0	2.0 ± 1.6	51.8 ± 10.8	9.7 ± 3.6
	Rubus sp.	54.9 ± 10.9	15.5 ± 3.3	6.2 ± 4.1	31.3 ± 5.7	10.4 ± 2.4
	Ruscus aculeatus	57.1 ± 5.5	14.6 ± 1.8	1.2 ± 0.6	37.3 ± 3.1	9.9 ± 1.8
	Teucrium scorodonia[a]	59.8 ± 7.8**	16.8 ± 3.6	7.6 ± 4.9	41.5 ± 9.9	8.9 ± 2.3
	Ulex europaeus	68.4 ± 8.2	13.9 ± 4.2	1.2 ± 1.1	40.4 ± 3.6	8.7 ± 1.9
	Ulex minor[a]	68.4 ± 5.1*	14.3 ± 3.3	0.7 ± 0.3	38.7 ± 6.7**	9.3 ± 1.4
	Vaccinium myrtillus[a]	59.5 ± 10.5	17.3 ± 3.6	2.6 ± 3.1	34.0 ± 5.9**	7.4 ± 0.8*
Ferns	*Blechnum spicant*	67.0	20.4	14.9	29.0	8.2
	Pteridium aquilinum	62.5 ± 9.2	16.9 ± 4.4	7.4 ± 4.7	28.4 ± 4.5	13.0 ± 6.2
Forbs	*Anemone nemorosa*	47.4	21.0	4.3	69.1	20.8
	Asphodelus albus	37.1 ± 10.3	12.4 ± 6.5	0.5 ± 0.3	78.2 ± 2.2	17.4 ± 3.7
	Potentilla erecta	48.9 ± 13.3	15.8 ± 5.6	3.0 ± 2.4	40.4 ± 7.5	9.8 ± 2.3
Grasses	*Agrostis capillaris*	38.2	7.1	4.9	32.0	10.5
	Agrostis curtisi	75.4 ± 2.2	17.1 ± 2.0	8.6 ± 2.2	33.1 ± 9.5	9.3 ± 0.9
	Brachypodium sylvaticum	59.5 ± 16.7	14.2 ± 6.2	5.6 ± 4.0	41.5 ± 7.8	9.6 ± 2.8
	Carex remota	68.1 ± 2.5	17.1 ± 3.9	10.3 ± 3.3	44.6 ± 9.6	11.0 ± 2.7

[a]Location effect significant ($P \leq 0.01$)**, ($P < 0.05$)*

helix peaked in fall–winter. Crude protein content is known to be loosely related to digestibility, and fiber fraction inversaly related with both (Cederlund and Nyström 1981, Varhegyi et al. 1987). Although some plants were close to the 10% of crude protein content, the low or the high percentages of IVOMD and ADF respectively, would not make them high quality nutritional forages (i.e. *Teucrium scorodonia*, *Ulex minor*, *Ruscus aculeatus*, and *Rubus* sp.). However, Palacios et al (1980) have reported *Ulex minor* as plant included in the diet of red deer, and *Rubus* sp. has been considered a very palatable plant for roe deer (Jackson 1980, Hosey 1981).

Grasses met the nitrogen requirements but had low IVOMD and high fiber percentages. They have been found not very palatable for roe deer (Maillard and Picard 1987, Costa 1992, Putman 1996), but very important as a constituent of red deer diet (Palacios et al. 1980, Putman 1996). We found protein levels in *Agrostis curtisii* peaked in fall–winter. This could be interpreted as a result of an increase in crude protein content during the fall regrowth (DÌaz and Guerreiro 1988). It has been reported that some grasses are important in red deer diets during winter, and shrubs are substitutes when those grasses get less palatable, either because of weather conditions or stage of maturity (Putman 1996).

Some forbs such as *Asphodelus albus* and *Anemone nemorosa* had low ADF percentages but high digestibility and high levels of crude protein. Costa (1992) have reported them as components of roe deer diet in Galicia during summer. Nevertheless, they seem to be not very palatable for roe deer since other species with lower digestibility and crude protein content, such as *Rubus* sp., *Halimium alyssoides*, and *Vaccinium myrtillus*, appeared in higher proportions in its diet in the same study. These results should be interpreted taking into account the presence of secondary metabolites. The availability of protein is influenced by astringent tannins which reduce protein digestibility (Robbins et al. 1987, Brayant et al. 1992). It is known that *Anemone nemorosa* appears as a constituent of deer diet. Nevertheless, the presence of protoanemonine it makes it not very palatable for livestock (Grime et al. 1988).

We found trees as a medium-low quality forage. *Ilex aquifolium*, has been reported a component of roe deer diets in England, but not preferential

(Jackson 1980). Our results found *Fagus sylvatica* a forage of poor quality, being reported as a species with low palatability for roe deer (Maillard and Picard 1987).

Nutritional attributes of heathers showed them low in forage quality, and their high tannin content could make them not very palatable (Robbins et al. 1987). However, a less pronounced seasonal variation in their crude protein content made them particularly important for animal maintenance in winter, when availability of herbaceous forage is reduced. Cervids have fat reserves to deal with winter but not an amino acid reserve in the same proportions (Flook 1970). The feeding strategy of deer would be to use herbaceous and evergreen plants in a complementary way to maintain equilibrium in the diet quality. Costa (1992) reported 81% of the biomass consumed by roe deer in winter as evergreen plants and only 15% as forbs, the rest being grass and lichens.

An increase of fiber content, and a slight decrease of IVOMD and crude protein in heathers during the second year of the study could be attributed to a progressive senescence of perennial vegetation (Moss et al. 1972, González-Hernández 1994). The herbaceous plants did not show such changes between years (Fig. 1), although the tendency was also to increase the fiber content the second year. Stage of maturity of plant material would be able to explain some exceptions found in the seasonal trend of nutritional parameters, as well as this annual variation in herbaceous species. It is known that weather conditions contribute to phenology of species and plant nutritional value (Van Soest 1982). Thus, one source of variability of the data could be the methodology used, which made it impossible to sample all study sites at the same date, or to find exactly the same stage of maturity when weather conditions differ between years.

It is not easy to interprete the differences found in nutritional attributes for the same species in different plant communities. We obtained higher nutritional quality for species collected in coastal communities or at lower elevations (O-RuQr, C), and lower nutritional attributes for the same species located more inland, with a mediterranean climate influence, or at higher altitudes (O-VaQr, O-BlQr). However, there were too many exceptions to base those differences on site factors such as altitude, and often those differences between communities were not significant. Genetic, stage of maturity, abiotic parameters, and phenology of vegetation have been reported as factors influencing nutritional quality (Van Soest 1982). Such a great variety of ecological conditions can result in wide nutritional data ranges between forest types, which makes it difficult to interprete nutritional differences in vegetation communities.

Understory of conifer and eucalyptus communities consists mainly of heathers, and displayed the poorest nutritional attributes. Heathers are known to be good competitors at community level with advantage over other plants. Thus, unlike most understory found in oakwood communities which consists of mosaics of other shrubs and broadleaves species, heathers become dominant in those communities. As a result, oakwoods displayed better nutritional attributes. In addition, phenology of plants makes the seasonal fluctuations of forage quality more uniform in evergreen communities. The fluctuation of understory production throughout the year has been reported to be more apparent in oakwoods than in conifer or eucalyptus stands, because of the seasonal growth pattern of the herbaceus species (González-Hernández et al. 1998). Thus, herbaceous plants which occured only in spring and summer and mainly in oakwoods, contribute to seasonal fluctuations in forage quality as well as to increase the quality of forage supply.

Conclusions and Recomendations

Understory plants of Galician woodlands constitute a mid quality forage supply to meet deer requirements. In vitro digestibility (IVOMD) of plants seems to be a factor more limited than crude protein content. Some plants would meet deer protein requirements, but their low IVOMD and high fiber percentages make them mid-low feed value forages.

Forbs, such as *Anemone nemorosa* and *Asphodelus albus* showed good nutritional attributes and can be important constituents of roe deer diets. However, other secondary compounds should be checked since their proportions in those diets are not as high as other plants with poorer nutritional attributes. Nutritive quality parameters do not entirely explain the selection of food by herbivores.

Low crude protein and IVOMD, as well as the high fiber content of heathers (*Erica arborea, E. cinerea, E. ciliaris, E. australis, C. vulgaris, D. cantabrica*) makes them the group with lowest nutritional quality. Nevertheless, the uniform trend of their crude protein content through the year could help deer to meet their nitrogen demands in winter.

Herbaceous species and shrubs meet deer requirements better than heathers. *Frangula alnus, Lonicera periclymenum* and *Hedera helix* were the shrubs with higher nutritional attributes. Evergreen shrubs (gorse, blackberry, etc.) can be an important forage supply when other palatable plants are not available due to their phenology or when the nitrogen content in the herbaceus plants decreases at maturity.

Different phenology of the species makes it necessary for deer to use different types of plant communities to meet their nutritional requirements. Variation in available nutrients among different vegetation communities will be a function of species composition. Vegetation does not always supply the nutrients required, nor is the feed the same quality throughout the year. Thus, the application of specialized seasonal grazing plans coordinated with the cycles of forage demand, supply, and quality are required to meet deer nutritional needs.

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