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ESTIMATION OF THE QUALITY OF THE NUTRITION OF ROE DEER BASED ON CHEMICAL COMPOSITION OF THE RUMEN CONTENT

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Analysis of the rumen content was carried out on a total of 43 samples taken from deer (Capreolus capreolus L.) shot on the hunting grounds of "Barajevska Reka" (Serbia). All animals were males and were hunted in the early morning. The experiment was set as a randomized trial with four treatments (spring, summer, autumn and winter) and an uneven distribution of animals per treatment.

Organoleptic examination of the stomach content revealed that cereals were the most abundant feed ingested (present in 25% of summer samples and 62.5% autumn samples). Results of chemical analysis confirmed a significant seasonal influence on total nitrogen and protein content, fats, cellulose, ash, phosphorus, pH and ammonia nitrogen within the content of the rumen. Contrary to this, calcium within the dry matter and total mineral content varied regardless of the season. A significantly high protein (360.84 g/kg DM) and low cellulose content (170.30 g/kg) was present during the spring season. A high negative correlation (r=-0.7398) between protein and cellulose content was present throughout the year. The quantity of extracted non nitrogenous supstances was lowest during the winter period (152.10 g/kg). The highest pH value (6.33) was recorded during the winter season and in during the rest of the year it showed limited oscillations (5.52 – 5.62). The quantity of ammonia nitrogen was 1% of total nitrogen throughout the year.

Considering the results of this study, and compared to the published literature data, it can be concluded that the high feeding selectivity of deer and the good quality of offered feedstuffs on the hunting grounds in Serbia are responsible for the high protein content in the rumen throughout all seasons.

Key words: Capreolus capreolus L., chemical composition, rumen content, season

INTRODUCTION

Being a herbivore the ruminant deer (*Capreolus capreolus* L.) eats a large variety of feeds, the choice of which depends on the characteristics of the hunting grounds and the season of the year (Holisova *et al*., 1989). Their main natural food is pasture and shrubs, supplemented with acorns, chestnuts, mushrooms, berries etc. and available cultures (alfalfa, cereals, corn, soybean, beans, potatoes, etc...). In the nutrition of deer dicotiledonous plants are the dominant ones (Mussa *et al*., 2003). Deer mainly do not eat the whole plant as they nibble the most nutritious parts with a high protein and low cellulose content. Deer eagerly graze leguminous plants, specially alfalfa, as well as tender cereal plants. On hunting grounds where oak trees are not common deer feed on cereals and corn. During the summer deer mainly feed on green feedstuffs. Holisova *et al*. (1984) have also determined that 10% of the summer meal in deer consist of small tree and shrub branches and tree bark. The authors have described that the summer meal of two year old and older deer consists of mainly beans and fruits. Opposite to this during the winter time their nutrition is mainly based on grazing shrubs, small branches and buds. Moreover, deer peel the cork of trees and fruit trees and thus inflict a substantial damage to orchards (Malik and Karnet, 2008). The damage caused to agricultural plantations is mainly less than 1% and thus is of minor importance (Obrtel and Holisova, 1983). The total damage to the cultures, forests and orchards can be substantial if there is a lack of natural feedstuffs or the number of game exceeds the capacity of the hunting grounds.

The determination of the composition of nutrition of deer is complex and all procedures carried out so far have some shortcomings. Among such methods are: esophageal drain, determination of rumen content and analysis of feces (Holehek *et al*., 1982). Analysis of the feces is easy and convenient, while in order to study the content of the rumen we have to catch and/or kill the animal (Watanabe and Takatsuki, 1993). This can be a significant problem in hunting grounds which are poor in game, in protected areas and parks, and selective shooting can make obsolete the random sample. Between the composition of the feces and the rumen content there is a high correlation (Mayumi *et al*., 2007), but not always this is the case, as in cases of high tannin or phenol content (Mould and Robbins, 1985). Padmal and Takatsuki (1993) describe that the feces contains components of meals of a few previous days and therefore is a representative sample of nutrition. Feeds which are highly digestible pass the digestive system quickly thus alter the overall picture (Hanley *et al*., 1985). Not only, but the feces contains the remains of the digested rumen microflora and endogenous substances (Kamler and Homolka, 2005). Watanabe and Takatsuki (1993) have determined that throughout all seasons the rumen nitrogen content is higher compared to feces. Opposite to this finding are the results published by Kamler and Homolka (2005). Due to all the above described discrepancies it is still better to rely on the chemical determination of the rumen content.

In this experiment the chemical composition of the rumen content of deer hunted on the hunted grounds of "Barajevska reka" was determined. The following parameters of chemical composition and nutritional value were

determined: protein content, cellulose, fats, non nitrogenous extracted substances (NFE), mineral content, and pH value. Some of the obtained values were compared to the values acquired from other European sites and/or other ruminant game species.

MATERIAL AND METHODS

Management of the hunting grounds in Serbia is in accordance to the Regulations for Hunting (Official Bulletin, 1993) on a total surface of 8 828 438.29 ha. The percentage of hunted deer is from 2.02 to 3.55%, based upon the population dynamics data for the period 1997-2006 (Popović *et al*., 2007).

Studies on the quality of nutrition of deer were carried out on the hunting grounds of "Barajevska Reka" (44º34'N, 20º25'E) which include woods, grounds and waters on the territory of the municipality of Barajevo (Belgrade, Serbia). The total area of the grounds is 213.08 km^2. Based upon ecological parameters which are relevant to the survival, development and reproduction of deer this hunting ground is ranked as second class (Tomasević *et al*., 1997). The area is situated at an altitude of 160 and 330 m. Out of the total surface 15.95% are woods, and agricultural soil covers 63.27%. The remaining area consists of pasture and orchards. The altitude, as well as the fraction of woods defines the hunting grounds as typical and representative for the region of Serbia.

The experiment was performed as a random plan, with four treatments i.e. seasons. In order to minimize the variations for each season one month was chosen as the representative (spring = May; summer = July; autumn = November; winter = January) The distribution between treatments was uneven and the total number of sampled animals (n) was 43. Rumen content samples were taken immediately, or at the latest one hour after shooting. Hunting was in the early morning and all killed animals were males. The rumen content was homogenized and a 500 cm^3 sample was frozen until subsequent analysis. Chemical analysis of the collected samples was done at the Laboratory for Animal Nutrition at the Faculty of Agricultural Science, Belgrade University, Serbia.

Firstly were identified the fragments of ingested cereals and fruits. After being identified the cereal and fruit rumen content was dried and their dry mass expressed as relative to the total dry mass. Due to the high volatility of ammonia, the sum of the total and ammonia nitrogen, as well as the pH value, were determined in the moist samples. In the dry matter were determined the following parameters: crude protein, crude fats, cellulose, total mineral content, calcium, phosphorus (AOAC, 2002). BEM was determined by calculation.

Statistical analysis was done with the Statsoft (2003) software. Analysis of variance defined the effect of the season on the chemical composition of the rumen content. Where the results were positive Tukey test was done to determine the significance of the differences between the treatments and chemical parameters. The coefficient of correlation described the strength of the interrelationship between the parameters.

RESULTS

Based upon sensory analysis it was found that in the summer season rumen content consisted mainly of wheat grains and plum kernels. The autumnal rumen content differed as it was based on corn grains, acorn and apples (Table 1). Samples taken during the spring and winter season contained mainly a macerated green mass. Autumn samples contained about 62.5% corn grains and 12.5% acorn, which is typical for these herbivores as they accumulate the adipose tissue as a good energy source for the winter (Tixier *et al*., 1997).

Table 1. Sensory examination of the rumen content

Season	Basic composition	Other components	% of the samples for the season	% in sample dry matter (DM)
Spring	Macerated plant material	–	100.00	100.00
Summer	Macerated plant material	–	58.33	90.10
		Cereal grain	25.00	5.30
		Plum seeds	16.67	4.60
Autumn	Macerated plant material	–	15.00	61.61
		Corn grain	62.50	11.44
		Acorn	12.50	16.27
		Apples	10.00	10.68
Winter	Macerated plant material		100.00	100.00

The quantity of dry matter varied throughout the season, and was highest during the autumn and lowest in the winter time (Table 2). The spring season, rich in green matter originating from natural sources or cultured fields, is the major source of proteins during the year. As a result deer shot during the spring have within the rumen content a significantly higher protein concentration ($p<0.01$). Contrary to this during the winter season the highest cellulose content was recorded ($p<0.01$). Between these two parameters a high negative correlation was confirmed ($r=- 0.7398$). A significantly low part of BEM was registered in the winter season.

The amount of total mineral content and phosphorus is significantly low during the winter period (Table 3). The relative content of calcium within the ashes and total dry matter was half the concentration compared to phosphorus. The variations of this parameter were not affected by the tested seasonal factor. Phosphorous concentration was lowest during the autumn season.

The rumen content pH value in deer was lower compared to domestic ruminants. (Grubic and Adamovic, 2003). The highest values were recorded during the spring (Table 4). Between the concentration of raw protein and the pH a

weak negative correlation (r= -0.193) was calculated. Compared to total nitrogen, the concentration of ammonia nitrogen was about 1%, and the correlation between these two parameters was weak (r= 0.1227). The highest values for this parameter were recorded during the spring season, as the feed contained the highest protein content and the lowest cellulose content. At the same time the feed was at its highest digestibility.

TABLE 2. Dry matter content and chemical composition of organic matter in the rumen content

Treatment	Dry matter, g/kg	Organic matter g/kg DM			
		Crude protein	Crude lipids	Crude cellulose	Non nitrogenous substances
Spring	133.96^{ab}	360.84 ^{a}	116.18 ^{a}	170.30 ^{c}	226.58 ^{a}
Summer	142.57^{ab}	287.62 ^{b}	95.85 ^{b}	237.53 ^{bc}	254.69 ^{a}
Autumn	158.73 ^{a}	247.27 ^{b}	97.10 ^{b}	280.82 ^{ab}	251.41 ^{a}
Winter	125.86 ^{b}	269.40 ^{b}	96.62 ^{b}	322.95^{a}	152.10 ^{b}
Value for P	0.02*	0.00**	0.04*	0.00**	0.00**

TABLE 3. Ash, calcium and phosphorus concentration in the rumen content

Treatment	Ash, g/kg DM	Calcium, g/kg ash	Phosphorous, g/kg ash	Calcium, g/kg DM	Phosphorous, g/kg DM
Spring	126.11 ^{b}	86.72	161.59 ^{a}	10.87	20.37^{ab}
Summer	123.43 ^{b}	80.46	154.73 ^{a}	10.03	18.87 ^{ab}
Autumn	123.40 ^{b}	79.28	131.69 ^{b}	9.52	16.30 ^{b}
Winter	158.92	78.04	145.39 ^{ab}	12.24	23.01 ^{a}
Value for P	0.01*	0.77^{ns}	0.00**	0.36 ^{ns}	0.01*

Table 4.Physiological parameters of the rumen content

Treatment	pH	Total N, g/kg DM	NH_3N, g/kg DM	NH_3N, g/kg N
Spring	5.52 ^{b}	60.47 ^{a}	0.70 ^{a}	11.62 ^{a}
Summer	5.62 ^{b}	48.04 ^{b}	0.42 ^{b}	8.96 ^{ab}
Autumn	5.55 ^{b}	42.23 ^{b}	0.32 ^{b}	7.68 ^{b}
Winter	6.33^{a}	45.49 ^{b}	0.46 ^{b}	10.49 ^{ab}
Value for P	0.00**	0.00**	0.00**	0.03*

DISCUSSION

The highest dry matter content was recorded in the autumn samples. This can be explained by the significant content of grains and acorns, as well by mature plants in the feed. Deer prefer feeds with at least 40% moisture content (Ševković *et al*., 1991). During the spring and summer deer eat feeds with at least 80% water content (Đorđevic *et al*., 2005). A well defined feed water content is of great importance for the normal activity of the rumen microflora, as well as for optimal physiological processes in the rumen. Compared to cows (50% rumen moisture content) (Grubić and Adamović, 2003) a decisively higher moisture content is needed by deer for a more efficient digestion (Rowell-Schafer *et al*., 2001).

The significantly highest total nitrogen (60.74%) and raw protein content (360.84 g/kg DM) was during the spring season, which coincides with the plentitude of available natural fresh greens. A similar trend was reported by Lathman *et al*., (1999) and Kramler and Homolka (2005). However, the concentration of raw protein in the rumen content is not only an indicator of the feed quality, as part of the nitrogen originates from the saliva urea and from the rumen microflora (Kramler and Homolka, 2005). The lowest concentration of raw protein (247.27 g/kg DM) was during the autumn season. This can be explained by the highest presence of corn grain and fruits of the forest as typical concentrated feeds (Table 2). The feed protein content during the autumn (247.27 g/kg DM) and winter (269.40 mg/kg DM) period is higher than the recommended value (14% crude protein) for the concentrated feed used for the feeding of deer during the winter time (Pavlicevic *et al*., 1999). The feeding selectivity of roe deer comes of no surprise, as they are known for their poor fiber digestion when compared to other wild ruminants (Prins and Geelen, 1971; Cederlund and Nystrom, 1981; Lathman *et al*., 1999). It is known that fat tissue energy depots accumulated during the period of vegetation and high energy feed consumption during the winter months are indispensable to deer and other animals that remain active throughout the winter season (Popovic and Djordjevic, 2009). Proteins can be an energy source in physiological processes (Mc Donald *et al*., 1988). However, during the winter conditions in Serbia's hunting grounds a protein and energy deficit is recorded and thus additional feeding is recommended (Djordjevic *et al*., 2006).

In this study the total nitrogen value was 40 – 60 g/kg DM. Ševkovic *et al*. (1991) reported that the rumen protein content in roe deer is 31% (equivalent to 49.6 g/kg nitrogen) and in stags it reaches only 20% (equivalent to 32.0 g/kg DM nitrogen). Other studies have published lower results for total nitrogen: 13 – 34 g/kg DM for red and black-tailed deer (Leslie *et al*., 1984), 19.5 – 34 g/kg DM for sika deer (Watanabe and Takatsuki, 1993), 9.6 – 29 g/kg black-tailed and mule deer (Hogman *et al*. 1996), 12 – 30 g/kg DM and 14 – 28.5 g/kg DM for red deer (Lathman *et al*. 1999; Kamler and Homolka, 2005, respectively). The differences recorded between different species of wild ruminants can be attributed to the high selectivity of feedstuff in roe deer (Lathman *et al*., 1999). The twice as high total nitrogen content in the deer rumen in Serbia (42.23 – 60.47 g/kg DM), compared

to the values reported by Kamler and Homolka (2005) for the same game species (14.9 – 31.3 g/kg DM) is the result of a higher nutritive potential on the hunting grounds in Serbia (Đorđević *et al*., 2005). The studied grounds enclose large agricultural areas (>60%) and are at an altitude of 160 – 330 m. Traditionally, in Serbia are grown alfalfa and red clover which are, besides corn, major agricultural crops (Đorđević and Dinić, 2007). These cultures, as well as soy bean and beans are throughout the period of vegetation the favorite food source for deer (Popović, 2006). Opposite to this Kramler and Homolka (2005) reported in their studies, carried out at an altitude of 700 – 1490 m, the dominant feed were plants of the *Rubus spp* (80 – 90%) and during the winter deer fed on fruits of the forest and pine leaves. A lower protein content in the deer's feedstuff was reported by Lathman et al. (1999), also. This being the result of poor quality feed that was on disposition to the animals in their study, as they were feeding on *Chamerion, Rumex, Ranunculus, Galium, Plantago* and *Taraxacum* which made 60 – 80% of the rumen content and in some samples the value was as high as 99%. Other studies report a wide variety of feeds which are accessible to deer in different hunting grounds. Petersen and Standgaard (1994) have analyzed the deer's rumen content in Danmark in the districts of Borris and Kalo.In the Borris district deer ate 99 different plant species. The greatest part of which was Saturea Montana L (45%), medicinal herbs (16%), grasses (19%) trees (11%) and some barley grains. In the Kalo district deer ate about 55 different plant species such as: *Anemone nemorosa* L (21%) medicinal herbs (25%), grasses (2%) trees (34%) and agricultural crops (18%).

Calcium present in the ashes and dry matter of the rumen's content varied to a small extent (Table 3) and was not under a significant influence of the tested parameters. Phosphorus was present in larger concentrations compared to calcium, which is probably the consequence of more abundant cereals in the feed. A certain amount of phosphorus originates from the saliva (Grubić and Adamović 2003). Fickle *et al*. (1998) report that deer have larger salivary glands and a more abundant production of saliva compared to other ruminants, thus explaining such large quantities of phosphorus in the rumen content. for the majority of domestic animals the optimal relationship between calcium and phosphorous is from 1:1 to 2:1. Ruminants can tolerate an even wider range of these two mineral elements (Mc Donald *et al*., 1988).

The concentration of cellulose varied from 170.3 g/kg DM during the spring to 322.95 g/kg DM in the winter season. This can be explained by the poor choice of feeds during the winter period with scarce vegetation. The differences between the recorded values were statistically significant. Contrary, Watanabe and Takatsuki (1993) reported a more discrete variation in NDF in the rumen content of sika deer (62.54% in the winter, 54.12% and 57.45% during the summer and autumn, respectively). The values obtained in these two experiments cannot be compared, but it is obvious that a similar trend across the seasons is present. Opposite to the cellulose content, the nonnitrogenous substances were at their lowest during the winter season. It can be concluded that structural fibers and proteins are the major energy source during the winter season.

The pH of the rumen content was highest (pH = 6.33) during the winter. Harvas *et al*. (2005) have studied a number of biochemical parameters of *in vitro* digestibility of different feeds by inoculated rumen content of sheep and deer. The authors determined varying pH values for different substrates from 6.71 to 7.6 for sheep rumen content inoculums and from 6.73 to 7.17 for deer inoculums. The significantly lower pH of deer rumen content can be explained by a good digestibility of the selected feeds taken and by the significant presence of cereals in the meals during the summer and autumn season. Besides it is a consequence of a set of specific factors in the digestion in deer, compared to other ruminants. It is of relevance that deer satisfy only 50% of their energy needs with short chain fatty acids. In order to cover up for the overall energy needs additional mechanisms for the prevention of energy loss due to microbial fermentation are set in motion. These mechanisms include direct passage of nutrients through the ventricular sulcus and minimized fermentation of nutrients which is achieved by an improved flow of digested material through the digestive tract (Rowell- Schafer *et al*., 2001).

The total rumen nitrogen content consists of protein and non protein compounds. The lowest values (Table 4) are described for the autumn season and the highest are for the spring, which is the direct result of the feed composition at different seasons during the year. The percentage of total and ammonia nitrogen varied significantly during the year. The highest percentage of nitrogen ammonia was during the spring and the lowest during the autumn season. The same trend was observed for total nitrogen. We did not find any literature data for comparison with our findings. However, Hervas *et al*. (2005) during their studies of *in vitro* digestibility of different feedstuff by sheep and deer rumen inoculums have measured variations of ammonia nitrogen (mg/L) from 163 to 281 for sheep and from 93 to 309 for deer, respectively.

CONCLUSION

Results of chemical analysis of deer rumen content show a significant influence of the season on total nitrogen, total protein, fats, crude cellulose, ash, phosphorous, pH and ammonia nitrogen in the rumen content ($p<0.05$). Contrary, there was no significant effect of the season on calcium content in the dry matter and total mineral concentration in the rumen content. The significantly high protein content and low cellulose concentration was recorded in the spring samples.

The higher values obtained for total nitrogen and crude protein in the deer rumen content compared to studies completed on other wild ruminants (red deer, sika deer and mule deer), as well as deer in Scotland and the Czech Republic can be explained the feed high selectivity of deer, a variety of feedstuffs, as well as feeding on cultured fields which is a common finding in the hunting grounds in Serbia.

Based upon the results obtained in this study it can be concluded that the high selectivity of deer is the key factor for its widespread presence in Europe on different grounds with a different nutritional base.

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PROCENA KVALITETA ISHRANE SRNE NA OSNOVU HEMIJSKE ANALIZE BURAŽNOG SADRŽAJA

POPOVIĆ Z, ĐORĐEVIĆ N, ĐORĐEVIĆ M, GRUBIĆ G i STOJANOVIĆ B

SADRŽAJ

Ispitivanje hemijskog sastava buražnog sadržaja srne (*Capreolus capreolus L*.) obavljeno je u lovištu "Barajevska Reka" (Srbija) na uzorcima koji su uzeti od 43 odstreljena grla u periodu od maja 2006. do januara 2007. godine. Sva odstreljena grla su bila muškog pola a odstrel je vršen u jutarnjim satima. Eksperiment je postavljen po modelu slučajnog plana, sa četiri tretmana (godišnja doba: proleće, leto, jesen i zima) i nejednakom distribucijom životinja po tretmanima.

Organoleptički pregled uzoraka buražnog sadržaja ukazuje na značajnu ulogu cerealija u ishrani srna (prisutne u 25% uzoraka iz letnjeg i 62,5% iz jesenjeg perioda), kao i hrastovog žira (prisutan u 12,5% uzoraka iz jesenjeg perioda). Rezultati hemijske analize potvrđuju signifikantan uticaj godišnjeg doba na količinu ukupnog azota i sirovih proteina, masti, sirove celuloze, pepela, fosfora, pH vrednosti i amonijačnog azota u buražnom sadržaju. Nasuprot tome, sadržaj kalcijuma u suvoj materiji i ukupnim mineralnim materijama buražnog sadržaja je slobodno varirao. Signifikantno najveći sadržaj proteina (360,84 g/kg SM) i najmanji sadržaj celuloze (170,30 g/kg SM) imali su uzorci iz prolećnog perioda. Utvrđena je visoka negativna korelacija između sadržaja proteina i celuloze u toku godine ($r = - 0,7398$). Količina bezazotnih ekstraktivnih materija je bila najmanja u uzorcima iz zimskog perioda ishrane (152,10 g/kg SM). Za isto godišnje doba detektovana je najveća pH vrednost u uzorcima (6,33), dok je u ostalom periodu godine pH bila značajno niža i relativno ujednačena (5,52-5,62). Količina amonijačnog azota je iznosila oko 1% od ukupnog azota tokom cele godine.

S obzirom na rezultate iz ovog eksperimenta kao i na brojne literaturne podatke, može se zaključiti da je visoka selektivnost srne pri ishrani, kao i kvalitetnija krmna baza u lovištima Srbije, objašnjenje za visok nivo proteina u buražnom sadržaju srne tokom cele godine.