Foraging Strategy of Mouflon during the Hunting Season as Related to Food Supply

M. HEROLDOVÁ[1], M. HOMOLKA[1], J. KAMLER[1], P. KOUBEK[1], P. FOREJTEK [2]

[1]Institute of Vertebrate Biology, AS CR, Brno, Czech Republic
[2]Institute for Wildlife Ecology, University of Veterinary and Pharmacological Sciences Brno, Czech Republic

Received August 25, 2006
Accepted April 26, 2007

Abstract

Heroldová M., M. Homolka, J. Kamler, P. Koubek, P. Forejtek: Foraging Strategy of Mouflon during the Hunting Season as Related to Food Supply. Acta Vet Brno 2007, 76: 195-202.

The aim of this study was to compare the diet composition based on rumen contents of mouflons from two localities differing in food supply. In northern Moravia (NM), secondary forests with dominance of conifers prevailed, whereas in southern Moravia (SM) forests with broad-leaved trees dominated. A total of 50 (NM, n = 23; SM, n = 27) quantitative and qualitative rumen analyses were carried out. In rumen specimens from both localities broad-leaved tree species predominated (NM 32.56% of volume; SM 38.92% v) during the autumn-winter season. Among the woody plants, ash was the most frequently consumed in both localities and in both diets approximately the same amount was found (17% v). In SM the mouflon consumed a high-energy diet of various seeds (34% v); acorns and horse chestnuts were the most abundant. Coniferous shoots were consumed in NM (14% v) twice as much as in SM (7% v). A higher number of food items (S = 70) and food diversity (H' = 3.49) was found in NM than in SM (S = 58; H'= 2.88). The quantitative similarity index (SI) of both diets (individual diet items) was low (SI = 39.12%). When calculated for the main diet groups the SI was higher (73.60%). The nutritional value (metabolisable energy) of the diet was correlated with diet quality (seeds, broad-leaved tree leaves). Mouflon is considered as a typical grazer but we found that during autumn and winter periods both Moravian subpopulations preferred browse and, where available, high-energy food for successful over-wintering. In SM the individuals had a non-significant tendency to be heavier and also their body fat content was higher ($p = 0.035$). The body condition of mouflons was thus related to the quality of the food supply in the biotope.

Autumn, winter, diet, nutritional value, body condition, digestive tract mass

Foraging strategy studies have considerable importance in ungulate ecology research. As for the mouflon, previous research had been mainly focused on the diet but information on the nutritional content of the diet can make the aspect of foraging strategy more meaningful. It may also help to elucidate the impact of mouflon on forest regeneration.

The introduction of mouflon was motivated by the aim to increase the variety of game species for hunters and to enhance the production of venison in a poor environment with grasses in the herb layer, and to decrease the impact of large herbivores on forest trees. Today, it is distributed all over Europe, both kept in game reserves and free-living in nature. The mouflon has found favourable conditions in the Czech Republic and over the last 30 years has dispersed into various types of environments. It has become an important game species in venison production and trophy collection (more than 6,000 heads of mouflon are shot annually and Czech hunting areas produce the best trophies of the world); hunting is encouraged also because of the damage the mouflon causes in forestry (Čermák and Mrkva 2003). For this reason, numerous data are presently available on its biology and feeding ecology.

On the basis of Hofmann's (1989) study, the mouflon is a grazer, capable of digesting coarse, fibrous forage. This is the main advantage of mouflon compared to our other wild ruminant species that consume grasses to a lower extent. The mouflon is therefore

Address for correspondence:
RNDr. Marta Heroldová PhD.
Institute of Vertebrate Biology AS CR
Květná 8, 603 65 Brno
Czech Republic

Phone: +420 543 422 539
E-mail: heroldova@brno.cz
http://www.vfu.cz/acta-vet/actavet.htm

considered to be a non-selective herbivore utilising low quality food neglected by other herbivores. A high proportion of grasses in the mouflon diet should also predict a low impact on forest regeneration. In several studies, the mouflon in the Czech Republic is characterized as a grass eater but grasses are not predominant in its diet in all seasons and environments. Outside the growing season, when grassy vegetation is mostly dried, of low quality and possibly even inaccessible due to the snow cover, the mouflon consumes predominantly woody plants. A winter diet with the majority of broad-leaved shoots is also found in other ruminant species regardless of their feeding types (Homolka 1996). The diet niches of the ungulates strongly overlap and the impact of the mouflon on forest regeneration is comparable to that of other ungulates (Homolka 1993; Heroldová 1997).

Despite the importance of the mouflon for game management, little attention has been paid to its basic ecological problems, such as its foraging strategy and interaction with the environment. Heroldová (1988, 1990) studied the diet of the mouflon in the Bouzov area where its trophic niches overlap with those of the sika deer (*Cervus nippon)*. Heroldová (1997) studied the overlap of trophic niches of three ungulates including mouflon in the Pálava Hills. Homolka (1991, 1993) studied the diet of mouflon in the Drahanská Highlands and focused on the overlap of its trophic niche with the European red and roe deer. The impact of mouflon is clearly related to the woody plant content in its diet (Homolka 1993).

Outside of the Czech Republic the diet of the mouflon was studied more intensively by Stubbe (1973), in Slovakia by Sabadoš and Manica (1977). Cransac et al. (1997) studied the mouflon diet in the mountains in the south of France. Garcia-Gonzalez and Cuartas (1989) compared the diets of various mountain ungulates including the mouflon. At the third international symposium on mouflon in Hungary in 2001, Anke et al. (2001) presented a study on the nutrients, macro-, trace- and ultra-trace elements in the food chain of mouflons and their mineral status. This work documented the great variety of the mouflon diet adapted to various environments in Europe.

The study of foraging ecology of herbivore species is one of the basic methods used for their management worldwide. Diet analysis of rumen samples is the most precise method of studying their foraging strategy. Our study on the autumn - winter diet aims to enrich our knowledge of the mouflon foraging behaviour in two Moravian populations and to evaluate the adaptability and influence of various diet supplies on its feeding strategy. This information may help to understand mouflon feeding strategies during the autumn - winter season.

Materials and Methods

Study area

In our study, the diet of the mouflon was analysed from rumen samples from two localities differing in food supply. A northern Moravian area (NM) was the northern part of the Drahanská Highlands in elevation from 300 - 600 m a.s.l. The landscape is hilly, covered with forests by more than a half of the area. Coniferous trees make 65% and the broad-leaved ones 35%. Among broad-leaved trees beech stands prevail (31%). The other broad-leaved trees are represented by much smaller percentage (about 4% all together). The dominant shrubs are *Sambucus nigra* and *S. racemosa* and in more open areas also *Prunus spinosa*. Abundant are the bramble and raspberry bushes and *Vaccinium myrtillus*. The herb stratum varies; under beech stands mostly *Luzula* spp., *Mercurialis perennis, Majanthenum bifolium, Asperula odorata, Stellaria holostea, Poa nemoralis* and *Calamagrostis arundinacea* are found. The climate is slightly warm and humid, with a mean annual temperature about 7 °C, precipitation about 700 mm.

The south Moravian area (SM) is vast, the distance among localities was up to 50 km (mean elevation about 350 m a.s.l.). This part of the country is mostly agricultural with low percentage of forests (less than 10%). Broad-leaved forest stands dominate (90%) with the prevalence of oak, hornbeam and ash. The dominant shrubs are *Cornus sanguinea, Euonymus europea, Acer campestre, Crataegus* sp., etc. The herb stratum is represented mostly with *Impatiens parviflora, Lamium maculatum, Urtica dioica, Glechoma hederacea, Stachys sylvatica* etc. The mouflon often moves to the fields or to grassy or shrubby stands of *Rosa canina, Crataegus* sp. or *Cornus sanguinea* as the dominant species. The climate of the area is warm and dry with a mean annual temperature around 9 °C and mean precipitation about 500 mm. In both areas the animals were offered additional food during the winter. In SM autumn 2003 was a seed year for many tree species.

Rumen analysis

A total of 50 (NM n = 23; SM n = 27) rumen analyses were done and compared in quantity and quality. The mouflon under study from NM were: 5 females (average weight 27 kg), 8 juveniles (15 kg), and 13 males (39 kg). In SM 6 females (average weight 28 kg), 2 juveniles (9 kg) and 19 males (46 kg) were studied. Non-eviscerated body mass was determined by game keepers and we were given the gralloch. The entire digestive tract and then separated rumen with contents were weighed. After opening the rumen the content was homogenized by mixing, and a sample of about 0.5 l in volume was taken into a polyethylene flask or plastic bag and kept in the freezer until further processing. For microscopic analysis the samples were thawed at room temperature. A sample of 25 ml was taken for detailed analysis. The rest of the sample was sequentially rinsed with water in a sieve (mesh size about 2 mm) and examined on a tray for those parts of plants that provided a clue to further identification of detailed items and elucidate the main characteristics of the diet. The results of this examination are expressed as the main items' coverage percent (relative volume) that can be used for a quick orientation of the diet of individual animals and is useful for veterinary personnel or game keepers. For exact analysis a sample of 25 ml was gradually transferred onto a Petri dish, diluted with water and examined under a stereoscopic microscope. From the diluted samples, particles greater than 2 mm or even smaller parts of undamaged plant organs (seeds, caryopses, floral parts etc.) were separated and the volume of each component obtained in this way was identified and then determined by calibration. Because of the difficulties in identification of individual grass species, all grasses were pooled as one item. From the data on the volume of food items contained in the rumen, larger than 2 mm or undamaged whole plant organs, we computed the relative volume of each item. From the values of percentage volume (% v) and percentage frequency of each food item (% f = 100 f/ Σf) (Holišová et al. 1984) we computed the importance index of each item (I = % f + % v) /2, Obrtel and Holišová 1974). Various diet items (plant taxa) were pooled into groups as grasses (grasses and grass-like species), broad-leaved species (shoots and leaves of broad-leaved tree species), needles (needles of coniferous tree species), seeds (seeds and fruit of herbs and trees), herbs (forbs), rubus (all *Rubus* sp.) and others (roots, fungi).

Trophic diversity was expressed by the index $H' = -\Sigma p_i \log_e p_i$, where $\Sigma p_i = 1$; p_i is the % quantitative representation of each food item in the total (100%) (Shannon and Weaver 1949).

The equitability index was calculated according to the formula $J' = H'/H_{max}$, where $H_{max} = \log_e$; S = number of identified food items (Sheldon 1969). Similarity index SI = Yi, where Yi is the lower value of % v found in an individual item occurring jointly in the compared samples (Anthony and Smith 1974).

Quality of the mouflon diet

During the autumn (November) and winter (December and January) season, quality of the diet was ascertained by chemical analysis of the rumen content in the southern Moravian population (n = 20) and compared. We assessed the content of crude protein, fat, fiber, nitrogen-free extract (NFE) and ash in the rumen content. On the basis of these data we calculated the content of dietary metabolisable energy (ME; Sommer et al. 1994). For ME we used the Axelsson's regression equation to assess the content of digestible organic matter and the regression equation according to McDonald et al. (1988) to calculate the content of digestible nitrogen compounds.

The botanical composition of the diet of mouflon (the presence of various diet groups such as grasses, broad-leaved trees and seeds) was related with the diet quality (metabolisable energy) .

Body condition

Body conditions from both localities were evaluated by non-eviscerated body mass and by weighing peritoneal and kidney fat of the mouflon. Body conditions of both Moravian populations were compared.

Digestive tract mass related to body mass and sex

Digestive tracts of 52 mouflons were examined and the mass of rumen (empty and with content) was measured and identified by sex of the animals.

All statistical evaluations were done by using the SPSS statistical program (*t*-test).

Results

Rumen analysis

In the autumn and winter season the diets in both localities under study were dominated by broad-leaved tree species (NM 32.56% of volume; SM 38.92%; Fig. 1). The most utilised woody plant during the autumn was *Fraxinus excelsior* and about the same amount was found eaten in both localities (mean 17%). Its highest consumption was found in mid November, when mouflon collect shed leaves. Other woody plants browsed to a large extent were oak and aspen in SM, beech and rowan in NM. Bramble was consumed more in NM (6.23%) than in SM (4.06%). In SM mouflon preferred high-energy diet of various seeds (34% v) with acorns and horse chestnuts being the most consumed items. This food was also readily taken from supplementary feeding places. Differences were found in the consumption of grasses, in NM it was one of the dominant items (30%) as compared to 14% of the diet in SM. However, the importance index was not in such a great contrast, as grasses were consumed frequently in both localities (Fig. 1) Coniferous shoots were present in the diet in NM (14%) twice as much as in SM (7%). The importance index expressed the consumption of herbs as being higher in NM, as it was consumed more frequently there. A higher number of food items (S = 70) and diet diversity (H' = 3.49) was found in NM than in SM (S = 58; H' = 2.88). Quantitative similarity index (SI) of both diets for individual diet items was low (SI = 39.12%) as the diets of each group of mouflon differed in the quantities of various species composition. When calculated for main diet groups, the SI was higher (73.60%). The highest SI was for broad-leaved trees, as in both localities these were predominant in the diet (32.56%).

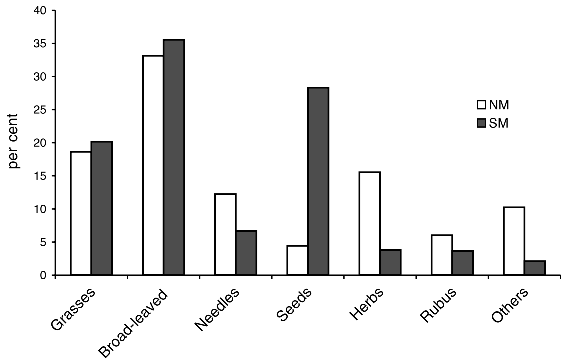

Fig. 1. Autumn and winter diet (Importance index I %) of mouflon in northern Moravia (NM) and southern Moravia (SM).

Diet composition changed during the autumn to winter season in SM (Table 1). In autumn a large amount of seeds was available as a food supply (oak mast, horse chestnuts, maize and corn in feeding places). This item comprised as much as 71% in the diet of the mouflon. Broad-leaved species were dominant in the diet in autumn but lower in winter (t = 4.75, $p = 0.001$). In contrast to autumn, grasses were dominant food items in winter (t = -3.68, $p = 0.005$). In spite of a low food supply of coniferous trees in the environment during the winter, a high percent of the diet consisted of pine needles and shoots (t = - 3.23, $p = 0.01$) in comparison with autumn.

Table1. The most important diet items (mean of volume) of the mouflon during the autumn and winter season and their comparison (t-test, ** significance level $p < 0.01$; NS - not significant)

	Diet items	Grasses	Broad-leaved	Seeds	Coniferous
Seasons	n	%v	%v	%v	%v
Autumn	10	17	49.4	27.20	3.33
Winter	10	46.50	13.2	17.10	15.90
Comparison	20	**	**	NS	**

Quality of the mouflon diet (metabolisable energy ME)

We compared the ME of the rumen contents (n = 20) with the presence of grasses, broad-leaved tree leaves and seeds in the diet. The highest proportion of grasses in the diet resulted in the lowest ME (negative correlation r = -0.50, $p = 0.02$). The dominance of broad-leaved tree leaves in the diet was significantly correlated with ME (r = 0.46, $p = 0.04$). The highest correlation of ME was found with the presence of seeds and fruits in the diet (r = 0.73, $p < 0.001$).

Body condition

In SM the individuals have a non-significant tendency to be heavier and also the amount of their fat was greater ($p = 0.035$) . In all individuals body fat and kidney fat were correlated (r = 0.61, $p < 0.05$). Body condition of mouflons was related to the quality of the food supply in the biotope.

Digestive tract mass related to body mass and sex

In males (n = 31), average age (4 years), non-eviscerated body mass (44 kg), rumen mass (empty 1.49 kg; with content 6.13 kg), and total mass of filled alimentary canal (8.37 kg) were measured. The same indicators were examined in females (n = 11) with the average values being as to age 3.7 years, body mass 27.85 kg, rumen empty mass 1.05, with content 3.5, and total mass of filled digestive tract being 5.52 kg. In juveniles (n = 10), the age was 0.85 years on average, with body mass being 16.85 kg. Mass of empty rumen of juveniles was 0.7 kg, rumen with content 2.15 kg, and 3.42 kg was the alimentary canal mass. The relationship between the total mass of the mouflon body and that of the rumen content was proportional. The animals' food intake was dependent on its body mass.

Discussion

The mouflon diet was studied in samples of their rumen contents. This is the most exact but also time-consuming method. Its disadvantage is the necessity to cooperate with game keepers to obtain the samples and the game harvest time is the only period during which evaluation can be done.

For successful over-wintering of large herbivores, not only the duration and height of the snow cover and the food supply in winter are important, but also the diet supply in the autumn period. Mautz (1987) showed the fat cycle in deer and the importance of a good food supply in summer and autumn for the accumulation of body reserves. Low-quality food in the growing season or a reduced availability of high-quality food could have the same influence on survival of herbivores as extreme winters do. Arnold et al. (2004) found that red deer, similar to many other northern ungulates, show large seasonal fluctuations of the metabolic rate, as indicated by the heart rate, with a 60% reduction at the winter nadir compared with the summer peak. A mechanism of energy conservation associated with peripheral cooling extensively lowers energy expenditure during winter. Therefore, studies of the foraging behaviour of large herbivores have to take into account both the accessibility and the quality of food during the growing season and the winter. Food quality is very important in winter as access to food is restricted. When evaluating the growing season the following is essential: the start of the vegetation period, its duration, and the nutritional value of the food in the second half of the growing season, when animals produce fat reserves (Arnold et al. 2004). In our study we concentrated on the transition from the autumn (fat reserve period) to the winter diet.

The diet of the mouflon under study only partly corresponded with its theoretical feeding strategy as a grazer (Hofmann 1989) that prefers grasses in its diet even in a biotope where other food supplies are available. Grasses were important in the diet of the mouflon even in the autumn-winter period in both studied localities but seeds and tree shoots were of high importance as well.

When seeds and fruit are available mouflon prefer to feed on them, as was the case in SM. In NM mouflon have to compensate with herbs, broad-leaved trees, and grasses. In this period the diet nourishment is very important for successful over-wintering. During the winter broad-leaved trees are the most important diet item for mouflon populations in all habitats under study (Heroldová 1988; Homolka 1991).

Seeds and fruit appeared in the mouflon diet in autumn as well as winter and made up as much as 27% of the autumn diet in SM. In other studied localities, not so many seeds and fruit were available and the diet depended on the food availability or supplementary feeding. For example, in the Pálava Game Reserve seeds and fruit made up 9% of the diet on average; similar results were mentioned by other authors (Stubbe 1973; Sabadoš and Manica 1977; Homolka 1991).

Our results on the dominance of woody plants in winter diet are identical to the mouflon diet in Pálava (Heroldová 1997) or in the Drahanská Highlands (Heroldová 1988; Homolka 1991). It is evident that this component is generally dominant in its diet during the autumn and winter (Stubbe 1973; Sabadoš and Manica 1977; Homolka 1991). Grassy vegetation during the winter is mostly inaccessible due to snow or is of a low quality. When there are limitations in the food supply, mouflon show a tendency to change into an intermediate feeding type.

Anděra and Hanzal (1995) mapped the occurrence of mouflon and other ungulates on squares (11.2 × 12 km) in the Czech Republic. According to these authors mouflon is widely dispersed (68% of square areas). On all the plots the mouflon occurs with other species and in as many as 45% of plots it shares the area with two other species. In winter the mouflon is constrained to eat shoots of woody plants as the dominant item. As this diet component also makes up the majority of food of other ungulate species, strong competition is manifested. As an example of this, 70 to 90% of spruce shoots were browsed in a large extent in the Drahanská Highlands plantations (Homolka 1991). In the Pálava Biosphere Reserve more than 75% of all shoots of woody plants were browsed during the winter (Heroldová 1997). The potential impact of mouflon on the forest habitat is comparable to that of the other ungulates. The introduction of mouflon is considered to be problematic in respect of feeding interactions with autochthonous species of large herbivores and also of the strong impact on forest regeneration this species has.

Mouflon can adapt very well to the conditions in which they live and utilise the food supply provided by the given environment (Lochman et al. 1979). They are capable of digesting coarse fibrous matter contained in grasses very well, since their digestive system is adapted to it (Lochman et al. 1979; Hofmann 1989).

In the Drahanská Highlands mouflon preferred the diet of grasses until the snow cover appeared, when they switched to a broad-leaved diet (Homolka 1991). In the Pálava Game Reserve, steppe-type biotope grasses soon dried up and mouflon started to consume some broad-leaved shoots from the abundant shrubs already in the summer (Heroldová 1997).

We used the peritoneal and kidney fat to evaluate the body condition. The amount of fat in various deposits throughout the body has been traditionally used as a general index of body condition for game species on the assumption that it is proportional to the total body-fat reserves in some predictive way. The maximum mean value of total body fat was found in the autumn (Finger et al. 1981).

The quality of the food supply markedly influenced the quality of the diet ingested. Also the metabolisable energy of the rumen samples reflected its quality being higher in autumn when seeds and fruit were consumed. The similarity of the diet and the available food supply was also stated by Anke et al. (2001) who compared the nutritional value of the rumen contents of the mouflon with the nutritional value of the food supply.

The results on the diet of the mouflon reflect the area's food supply and show the mouflon's capability of making a full use of the local food resources. The mouflon can be considered an opportunistic feeder whose optimal habitat is diverse (Cransac et al. 1997). It is adaptable and its diet reflects its environmental conditions.

Potravní strategie muflona v lovecké sezoně: vztah k potravní nabídce

Muflon byl introdukován do České republiky v polovině devatenáctého století a jeho populace se rychle rozšířila do různých prostředí. Potrava muflona (obsah bachoru) byla zkoumána na dvou lokalitách lišících se potravní nabídkou. Na severní Moravě (SM) žije muflon v prostředí sekundárních lesních porostů s dominancí jehličnanů. Na jižní Moravě (JM) jsou jeho životním prostředím převážně listnaté lesy. Potrava byla analyzována z 50 vzorků (23 - SM; 27 - JM) a porovnána byla její kvantita i kvalita. Během podzimu a zimy byly v potravě z obou území dominantní listnaté dřeviny (SM 32,56 % objemu; JM 38,92 %). Dominantní konzumovanou dřevinou byly na obou lokalitách listy a letorosty jasanu a jejich objem v potravě byl shodný (17 % v). Na jihu Moravy muflon konzumoval více semen a plodů (34 % v) zvláště plody jírovce a žaludy. Jehličnaté dřeviny byly konzumovány na severní Moravě dvakrát tolik než na jižní (SM 14 % v, JM 7 % v). Na lokalitě SM byla potrava pestřejší (H' = 3,49) a obsahovala více potravních složek (S = 70) než na JM (S = 58; H' = 2,88). Kvantitativní podobnost potravních složek z obou lokalit byla nízká (index SI = 39,12%). Při porovnání hlavních potravních skupin byla podobnost SI větší (73,60 %). Výživná hodnota (metabolizovatelná energie) potravy korelovala s kvalitou potravy (semena, listnaté dřeviny). Muflon je typický spásač, v průběhu podzimu a zimy na obou moravských lokalitách je jeho potrava okusovače a soustřeďuje se na kalorickou potravu, která mu umožňuje vytvořit zásoby tuku na úspěšné přezimování. Na JM měla hmotnost hodnocených jedinců z populace muflona tendenci být větší (NS) a měli více zásobního tuku (p = 0,04). Potrava i tělesná kondice muflona tak byla ovlivněna kvalitou potravní nabídky. Údaje o potravní strategii byly doplněny morfometrií trávicího traktu ve vztahu k tělesné hmotnosti a pohlaví muflona.

Acknowledgements

This study was supported by GA AS No. S6093003.

References

ANDĚRA M, HANZAL V 1995: Atlas rozšíření savců v České republice I. Sudokopytníci (Artiodactyla), zajíci (Lagomorpha). Národní museum Praha 64 p. (in Czech)

ANKE M, ARNOLD W, SCHÄFER U, MÜLLER R 2001: Nutrients, macro- trace- and ultratrace elements in the feed chain of mouflons and their mineral status. First part: Nutrients and macroelements. In: NÁHLIK A, ULOTH W. (Eds.) 2000: Proceedings of the third international symposium on mouflon. Sopron, Hungary, October 27 - 29, pp. 225-242

ANTHONY RG, SMITH NS 1974: Comparison of rumen and fecal analysis to describe deer diets. J Wildl Manage **38**: 535-540

ARNOLD W, RUF T, REIMOSER S, TATARUCH F, ONDERSCHEKA K, SCHOBER F 2004: Nocturnal hypometabolism as an overwintering strategy of red deer (*Cervus elaphus*). Am J Physiol-Regul Integr Comp Physiol **286**: 174-181

ČERMÁK P, MRKVA R 2003: Browsing damage to broadleaves in some national nature reserves (Czech Republic) in 2000 - 2001. Ekológia **22**: 394-403

CRANSAC N, VALET G, CUGNASSE JM, RECH J 1997: Seasonal diet of mouflon (*Ovis gmelini*): Comparison of population sub-units and sex-age classes. Rev Écol **52**: 21-36

FINGER SE, BRISBIN IL, SMITH MH 1981: Kidney fat as a predictor of body condition in white-tailed deer. J Wildl Manage **45**: 964- 968

GARCIA-GONZALEZ R, CURTAS P 1989: A comparison of the diets of wild goat (*Capra pyrenaica*), domestic goat (*Capra hircus*), mouflon (*Ovis musimon*) and domestic sheep (*Ovis aries*) in the Cazorla mountain range. Acta Biol Mont **9**: 123-132

HEROLDOVÁ M 1988: The diet of mouflon (*Ovis musimon*) outside the growing period 1983 - 1984. Folia Zool **37**: 309-318

HEROLDOVÁ M 1990: Trophic niches of the mouflon (*Ovis musimon*) and the sika deer (*Cervus nippon*) in the same biotope in winter. Folia Zool **39**: 105-110

HEROLDOVÁ M 1997: Trophic niches of three ungulate species in the Pálava Biosphere Reserve. Acta Sc Nat Brno **31**: 1-52

HOFMANN RR 1989: Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. Oecologia **78**: 443-457

HOLIŠOVÁ V, KOŽENÁ I, OBRTEL R 1984: The summer diet of field roe bucks (*Capreolus capreolus*) in Southern Moravia. Folia Zool **33**: 193-208
HOMOLKA M 1991: The diet of mouflon (*Ovis musimon*) in the mixed forest habitat of the Drahanská vrchovina Highlands. Folia Zool **40**: 193-201
HOMOLKA M 1993: The food niches of three ungulate species in a woodland complex. Folia Zool **42**: 193-203
HOMOLKA M 1996: Foraging strategy of large herbivores in forest habitats. Folia Zool **45**: 127-136
LOCHMAN J, KOTRLÝ A, HROMAS J 1979: Dutorohá zvěř (Muflon, Chamois, Goat). SZN, Praha, 380 p. (in Czech)
MAUTZ W 1987: Sledding on a bushy hillside: the fat cycle in deer. Wildl Soc Bull **6**: 88-90
McDONALD P, EDWARDS RA, GREENHALGH JFD 1988: Animal nutrition 4th. Longman Scientific and Technical, 543 p.
OBRTEL R, HOLIŠOVÁ V 1974: Trophic niches of *Apodemus flavicollis* and *Clethrionomys glareolus* in lowland forest. Acta Sc Nat Brno **8**: 1-37
SABADOŠ K, MANICA M 1977: Potrava muflonej zveri v mimovegetačnom období na Slovensku (Food of mouflon game outside the growing period in Slovakia) Folia Venat **7**: 81-94
SHANON CE, WEAVER W 1949: The mathematical theory of communication. University of Illinois Press, Urbana
SHELDON AL 1969: Equitability indices: dependence on the species count. Ecology **50**: 466-467
SOMMER A (Ed.) 1994: Potřeba živin a tabulky výživné hodnoty krmiv pro přežvýkavce (Nutrient need and tables of nutrient value of the feedstuff for ruminants). VÚVZ Pohořelice, 198 p. (in Czech)
STUBBE C 1973: Die Nahrungszusammensetzung des Muffelwildes in der Deutschen Demokratischen Republik. Jagdinf **3**: 48-50