VERIFICATION OF FOOD SUPPLY FOR RED DEER UNDER CONDITIONS OF THE AIR-POLLUTED AREA OF MOUNTAIN FOREST ECOSYSTEMS IN THE ORE MOUNTAINS (FOREST DISTRICT KLÁŠTEREC NAD OHŘÍ)

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Abstract

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On the basis of typological classification, representative sample plots 1×1 m were established in forest stands, on meadows and pastures in hunting districts Jelení hora and Černý potok in the area of the Ore Mountains (Forest District Klášterec nad Ohří) in the growing season. The aim of the plots was to determine the existing average area production (kg.m⁻²) of biomass utilizable by game. The biomass was differentiated to herb, grass and woody components. Analyses proved that the total daily need of food, energy and mineral substances of red deer in both hunting grounds was fully covered by the natural food offer of herb, grass and woody biomass in the growing season even in case of increased requirements, e.g. in the period of growth, lactation or the development of antlers.

red deer, carrying capacity, food

Wildlife is the integral part of natural ecosystems finding the sufficient amount of natural food in these ecosystems. A number of authors dealt with the composition of natural food.

HEROLDOVÁ (1993) carried out analyses of the content of proventriculi of red deer in the Ore Mountains during the growing season. In the proventriculi, in total 53 components were identified. Grasses represented by 79.9% of the total amount were most abundant. Dicotyledonous plants were another important component. They represented 5.4%, seeds and fruits 1.1%, shoot and broadleaved trees occurred in 6.5% of the total amount of food. HOMOLKA (1990) carried out the microscopic analysis of 120 samples of faecal pellets in the course of one year in the Drahanská vrchovina Upland. The author found that the most important components of the red deer food consisted of trees and shrubs (39% of the total volume),

dicotyledonous plants represented 27% and grasses 20%. HOMOLKA (1995) carried out analyses of red deer and roe deer food in the region of the Moravian-Silesian Beskids. He found that blackberry (*Rubus idaeus*) was the most important component for both species of game. It represented 30–85% of the total volume of food. HOMOLKA (1994) mentions the percentage proportion of woody species in the food of red deer, namely in summer 35% and in winter 39% of the total volume of food in the southern part of the Drahanská vrchovina Upland.

HOMOLKA, HEROLDOVÁ (1992) carried out comparisons of the macroscopic analyses of stomachs and the microscopic analysis of the faecal pellet composition from 54 hunted animals of red deer, roe deer, sika deer and mouflons.

Samples of faecal pellets were taken from recta. The authors came to a conclusion that it was possible to achieve similar results using

both methods. By both methods, it is possible to determine easily all main components of food with the exception of fungi. Through the analysis of the content of rumens of red deer it was found that the proportion of grasses in food amounted to 62–80% of the total accepted food according to the environment (HOFMANN, 1978). The daily need of food is mentioned depending on the season, namely 20–30 kg green fodder with 3.5–5 kg DM content (BUBENÍK, 1954). LOCHMAN *et al.* (1964) mentions mean daily need of food of mature reed deer 3225 g. FEUEREISEL, ERNST (2009) determined mean daily need of food of one red deer animal in the amount of 11 kg grasses and herbs and 3 kg biomass of woody origin. TANENTZAP *et al.* (2009) dealt with the analysis of the content of 402 stomachs of red deer in New Zealand. They found out that the quantitative estimate of food palatability could be derived from the determination of damage to stands. JUDSON (2003) mentions the average daily consumption of energy 0.52–0.85 $MJ/W^{0.75}$ depending on the environment type. SEMIADI *et al.* (1994) mention the daily need of energy of red deer on average 0.57 $MJ/W^{0.75}$. The same daily consumption is mentioned also by FENNESSY *et al.* (1981). SIMPSON et al. (1978) mention the daily consumption of energy of red deer amounting to 0.50 $MJ/W^{0.75}$. Similar amounts of average daily need of energy 0.53 $MJ/W^{0.75}$ mention also BROCKWAY, MALOIY (1968). BUBENÍK (1984) mentioned the same average daily need of energy 0.53 $MJ/W^{0.75}$, namely 90–150 kcal.

MATERIAL AND METHODS

Two hunting districts were selected as model localities (Jelení hora and Černý potok) in the Ore Mountains, Forest District Klášterec nad Ohří. Both monitored areas are situated in the south-western part of the Ore Mts., i.e. in the north-western part of the Czech Republic. The altitude of the area ranges between 680 and 994 m (a.s.l.), mean annual temperature is 4.8 °C and total annual precipitation 800–850 mm.

The total area of the Jelení hora hunting district is 2 420 ha, viz. forest 2 137 ha, pasture land 280 ha and other areas 3 ha. About 20% of the total hunting ground areas are occupied by waterlogged sites, which represent the sufficient supply of water. Following forest vegetation zones (FVZ) are represented: 7 FVZ (52%), 8 FVZ (31%) and 6 FVZ (17%).

Stands of substitute species represented by blue spruce (*Picea pungens*) and Serbian spruce (*Picea omorica*), larch and birch predominate. Roughly 500 ha of the hunting ground area are created by peat soils where mountain pine (*Pinus mugo*), (*Pinus uncinata*) and birch (*Betula pubescens*) predominate.

Outside the Jelení hora massif where the proportion of beech (*Fagus sylvatica*) aged 90–130 years prevails, the 1st and the 3rd age class

predominate and, as against normal forest, the 5th to the 8th age class are missing.

In the Jelení hora hunting district, the standard number of red deer is 23 individuals, roe deer 10 individuals and wild boar 10 individuals.

The total area of the Černý potok hunting district is 1878 ha. It is created by two forest stands. Forest vegetation zones FVZ 6 (70%) and FVZ 7 (30%) predominate there. They consist particularly of stands of substitute species, namely blue spruce, Serbian spruce and Norway spruce. As against a normal forest, the proportion of the 5th to the 8th age class is minimal and the 1st to the 3rd age class predominates there.

In the Černý potok hunting district, the standard number of red deer is 15 individuals and roe deer 15 individuals.

On the basis of typological classification, representative sample plots 1×1 m were laid out in forest stands in both hunting districts in the growing season to determine the existing average area production (kg.m⁻²) of biomass utilizable by game. On meadows, pastures and other plots with the production of grasses and herbs, these plots were also laid out. The frequency of sample plots was selected depending on the total size of the assessed homogenous area of a grass, herb or woody stand. From these plots, representative samples of herbs, grass and shoots of woody species were taken in the growing season. The plant material was sampled using scissors just above the soil surface from a plot 1 m², namely with respect to its accessibility for game and in such an amount, which is used by game, however, at least two plots/stand. The wood matter was being removed to the height 2 m.

To obtain wood matter garden shears and a knife were used. Samples were weighed accurate to 0.01 kg (in fresh matter) using portable laboratory balance and differentiated to herb and woody components. Based on the samples, the average amount of biomass was calculated in kg.m⁻² available for game and the total average production of biomass available for game in the growing season in both hunting districts. For the purpose of calculations, mean daily consumption of food of one red deer was determined in the growing season amounting to 13 kg (74.3%) grass and herbs and 4.5 kg (25.7%) woody biomass. Duration of a period when natural food is available for game was selected according to the duration of an average snow cover in the region (120 days), namely 250 days. For the calculation of average daily consumption of energy a value of 120 kcal/$W^{0.75}$ was used. After conversion, it corresponds to 0.50 $MJ/W^{0.75}$. Converted to the average weight of red deer 100 kg the average daily need of energy of an average red deer animal in daily feeding ration is $100^{0.75} \times 0.50 = 15.81$ MJ. For the purpose of conversion the amount of energy contained in grasses and herbs was converted to average DM 25% and in woody food to average DM 50%.

Out of the total amount of biomass available for game the amount of food was expressed in percent necessary for the average stock of red deer determined by indirect methods of the calculation of pellet groups, namely 105 individuals in the Jelení hora hunting district and 77 individuals in the Černý potok hunting district (VALA, ERNST, 2011).

To determine basic nutrients in the sample, methods usual for these purposes were used. Dry matter (DM) was determined as a residue from the sample after water evaporation to a constant weight at 103 ± 2 °C in oven. Pulp (Fiber) was determined using the method of Hennenberg-Stohmann as a residue from a sample after a 30-minute hydrolysis in 1.25% solution of H_2SO_4 and in 1.25% solution of KOH after washing by an organic solvent and after deduction of ash under prescribed conditions (gravimetrically). Fat was determined under laboratory conditions gravimetrically on an extraction apparatus according to Twisselman. Nitrogen substances were determined according to Kjehldahl and multiplied by a factor 6.25. Ash materials were determined gravimetrically after the sample incineration at 550 °C in an electric muffle furnace. Gross energy was determined in a calorimeter by burning the food in an oxygen atmosphere (DOLEŽAL, 2004).

Based on these data, metabolized energy was calculated according to a regression equation for roughage. From this metabolic energy net energy was then calculated for feeding included in particular mixed formulas according to (VESELÝ, 2006).

The calculated value of net energy was compared with the average daily need of energy of red deer, which was determined by calculation on the basis of determining the metabolic size of body of the average red deer animal of a weight of 100 kg.

Dried plant material was homogenized on a laboratory mill. Determination of particular nutrients proceeded from mineralized matter. Mineralization was realized by a wet method (sulphuric acid + hydrogen peroxide). The content of phosphorus was determined by spectrophotometry, the content of calcium and magnesium by the method of atomic absorption spectrophotometry (AAS), that of potassium and sodium by the method of flame photometry (RICHTER et al., 1999).

RESULTS

Determination of biomass utilizable by game in the Jelení hora hunting district

On the basis of typological classification, in total 265 samples of grass, herb and woody biomass were taken in forest stands of an area of 2 417 ha in the Jelení hora hunting district in the growing season. In forest stands, average production of grass and herb biomass was 0.22 kg.m⁻² in the growing season. After conversion to the whole area of forest land 2 137 ha, the production of biomass amounted to 4 701 400 kg. In forest stands, the amount of woody biomass (leaves, buds and shoots) utilizable by game was also determined, viz. 0.23 kg.m⁻². After conversion to the whole area of forest land 2 137 ha, the amount of woody biomass amounted to 4 915 100 kg. At this locality, the woody component is created mainly by Norway spruce, blue spruce, Serbian spruce, larch, Scots pine, mountain pine, birch, beech and alder. On meadows, pastures and other areas, the average amount of biomass was 0.48 kg.m⁻². After conversion to 280 ha grass stands and other areas, average production of biomass utilizable by game amounted to 1 344 000 kg.

In total, forest and non-forest land provide 6 045 400 kg herb and grass biomass available for game and 4 915 100 kg woody biomass available for game. It is 10 960 500 kg plat biomass available for game.

Calculation of the quantitative consumption of grass, herb and woody food by red deer

The consumption of grass and herb food by red deer in the growing season

13 kg.day⁻¹ × 250 days = 3 250 kg × 105 individuals red deer = 341 250 kg

Total production of grass and herb biomass 6 045 400 kg (100%)

Total consumption of grass and herb food by red deer for 105 individuals = 341 250 kg (5.6%)

The surplus of grass and herb biomass 5 704 150 kg (94.4%)

The consumption of woody food by red deer in the growing season

4.5 kg.day⁻¹ × 250 days = 1 125 kg × 105 individuals red deer = 85 500 kg

Total production of woody biomass 4 915 100 kg (100%)

Total consumption of woody food by red deer for 105 individuals = 118 125 kg (2.4%)

The surplus of woody biomass 4 796 975 kg (97.6%)

Utilizable energy in biomass in the Jelení hora hunting district

Average daily need of energy of one red deer was calculated in the amount of 15.81 MJ (100%).

The uptake of 17.5 kg food per day corresponds to:
- 13 kg grass and herbs × 1.01 MJ = 13.13 MJ
- 4.5 kg woody biomass × 2.25 MJ = 10.12 MJ
- Total utilizable energy in the daily feed ratio = 23.25 MJ (147%)
- Surplus of energy in food = 7.3 MJ.

Our calculations demonstrate that energy needs of red deer in the Jelení hora hunting district in the growing season are covered by its daily quantitative consumption of herb, grass and woody biomass even in case of increased requirements, e.g. in the period of growth, lactation or the development of antlers. Increased needs are compensated by the

I: *Average values of nutrients in samples in the Jelení hora hunting district*

Nutrient	Woody biomass	Grass and herbs	Units
dry matter	91.1	91.5	g/100 g
fiber	39	35.6	%
ash material	2.8	8.6	g/100 g
N-matters	8.8	9.3	%
fat	5.4	2.1	g/100 g
NEF*	4.1	3.7	MJ/kg DM.
phosphorus	1.5	1.5	g/kg original matter
calcium	1 340	1 171	mg/kg original matter
natrium	33.7	41,2	mg/kg original matter

*Net energy of food

consumption of the higher amount of food in order the game to cover its energy needs. Measured values are given in table I.

Determination of utilizable biomass in the Černý potok hunting district

In the Černý potok hunting district in forest stands of an area of 1 878 ha, in total 248 samples of grass, herb and woody biomass were taken from representative plots of an area of 1×1 m and the production of biomass was determined in kg.m^{-2}. In forest stands, the average production of 0.32 kg. m^{-2} of grass and herb biomass was determined. After conversion to the whole area of forest land 1 878 ha, the production of biomass amounted to 5 718 400 kg.

In forest stands, the abundance of woody biomass (0.15 kg.m^{-2}, namely leaves, buds and shoots) utilizable by game was also determined. After conversion to the whole area of forest land 1878 ha, the amount of woody biomass reached 2 817 000 kg. The woody biomass is created there mainly by Norway spruce (*Picea abies*), blue spruce (*Picea pungens*), Serbian spruce (*Picea omorica*), European larch (*Larix decidua*), birch (*Betula* sp.) and alder (*Alnus* sp.). In total, forest areas provide 5 718 400 kg herb and grass biomass and 2 817 000 kg woody biomass available for game. It is 8 535 400 kg plat biomass available for game.

At sampling, the proportion of particular plant species was also determined. Hairy sedge (*Calamagrostis villosa*), blueberry (*Vaccinium myrtillus*), whisk wandering (*Avenella flexuosa*) and blackberry (*Rubus idaeus*) were most abundant.

The consumption of food by red deer in the Černý potok hunting district in the growing season

<u>Consumption of grass and herb food by red deer in the growing season</u>

13 kg.day^{-1} × 250 days = 3 250 kg × 77 individuals red deer = 250 250 kg

Total supply of grass and herb biomass 5 718 400 kg (100%)

Total consumption of grass and herb food by red deer for 77 individuals = 250 250 kg **(4.4%)**

Surplus of grass and herb biomass 5 468 150 kg (95.6%)

<u>Consumption of woody biomass by red deer in the growing season</u>

4.5 kg.day^{-1} × 250 days = 1 125 kg × 77 individuals red deer = 86 625 kg

Total consumption of woody biomass 2 817 000 kg (100%)

Total consumption of woody biomass by red deer for 77 individuals = 86 625 kg **(3.1%)**

Surplus of woody biomass = 2 730 375 kg (96.9%)

Utilizable energy in biomass in the Černý potok hunting district

Average daily need of energy of one red deer was calculated in the amount of 15.81 MJ (100%).

Uptake of 17.5 kg food per day corresponds to:
- 13 kg grass and herbs × 1.51 MJ = 19.63 MJ
- 4.5 kg woody material × 2.76 MJ = 12.42 MJ
- Total utilizable energy in daily feed ration = 31.78 MJ (201%)
- Surplus of energy in food = 15.97 MJ.

Calculations prove that the energy need of red deer in the Černý potok hunting district is fully covered by its daily quantitative consumption of herb, grass and woody biomass even in case of increased requirements, e.g. in the period of growth, lactation or the development of antlers. Measured values are given in table II.

DISCUSSION

The environment quality for red deer is particularly given by its carrying capacity, i.e. ability to provide sufficient amount of food of corresponding quality to wildlife. On the basis of results of the quantitative and qualitative survey of food supply, there is sufficient production of biomass utilizable by game in the growing season in mountain forest ecosystems damaged by air pollution. This production fully covers daily needs of food and particular nutrients of red deer.

II: *Average values of nutrients in the Černý potok hunting district in samples*

Nutrient	Woody material	Grass and herbs	Units
dry matter (DM)	92.42	92.48	g/100 g
fiber	15.42	22.65	%
ash material	3.6	6.1	g/100 g
N-matters	11.4	9.7	%
fat	6.8	3.4	g/100 g
NEF*	5.1	5.6	MJ/kg DM
phosphorus	2.43	1.69	g/kg original matter
calcium	314	405	mg/kg original matter
natrium	99	34	mg/kg original matter

Also FEUEREISEL (2005) and FEUEREISEL, ERNST (2009) came to similar conclusions at localities, which were not affected by air pollution. The quantitative amount of food available for game determined by our survey is based on the determination of the total amount of biomass regardless of the proportion of particular plant species, their attractiveness and palatability for game.

In the winter season, particularly at high snow cover, game is forced to accept food, which is available, e.g. annual shoots of broadleaved and coniferous trees, twigs, shoots, buds, bark etc. to satisfy its food requirements. From the aspect of foraging behaviour of red deer it is a quite natural (instinctive) phenomenon. The endeavour of users of both hunting districts is to close the maximum amount of red deer in wintering enclosures in the winter period by reason of prevention damage to forest stands. Red deer is intensively fed there within the winter season. Part of the red deer goes down to lower locations with the arrival of snow.

The quality of food supply available for game in the growing season was evaluated on the basis of determining particular nutrients and energy in mixed samples. The amount of the need of energy for the basal metabolism of red deer was calculated on the basis of the metabolic size of body. For the average red deer of a weight of 100 kg, the metabolic size of the body amounts to 31.62 units. On the basis of papers of BUBENÍK (1984), the average daily need of energy was determined in a number of 120 kcal per kg metabolic size of the body. At the average weight of red deer 100 kg, it corresponds to a value of energy 15.81 MJ.

The utilizable energy (MJ) determined under laboratory condition in mixed samples is contained in the daily feeding ration in surplus fully covering the energy needs of red deer in both hunting districts. The surplus of energy was determined in the Jelení hora hunting district in the amount of

147% and in the Černý potok hora hunting 201%. The determined values are considered to be realistic because the total need of energy depends upon the number of other factors (gravidity, lactation, antler development, moulting, period of growth). According to BUBENÍK (1984), basic energy needs increase 2–3 times in this period. Thus, the amount of utilizable energy determined by our research and included in the daily feeding ration fully covers also increased energy requirements of female game in the course of gravidity and subsequent lactation and also those of male game in the course of antler development.

The content of mineral substances in the daily feeding ration, particularly of phosphorus, ranges on average in the amount of 1.97 g and calcium 0.83 g per kg fresh matter. At the daily uptake of food 17. 5 kg, the content of phosphorus in the daily feeding ration is 33.49 g and calcium 14.52 g. LOCHMAN (1985) mentions the daily need of phosphorus in the amount of 18 g, WAGENKNECHT (1981) mentions daily need of phosphorus in the amount of 10 g per 100 kg. BUBENÍK (1984) mentions the need of phosphorus 4.5 g and the need of calcium 5 g per 100 kg body weight of red deer. The amount of calcium and phosphorus contained in the daily rations of food in both hunting districts fully covers basic physiological needs of red deer even at increased requirements.

Consumption of woody biomass by red deer in the growing season determined within our research in both hunting districts did not exceed a value of 10% of the total amount of available woody biomass.

It is consistent with recommendations of SLOUP (2008), who mentions the maximum admissible rate of browsing damage up to 10% in plantations and up to 5% peeling and browsing damage in forest stands. Owing to the irregular use of forest biotopes by red deer increased damage to forest stands can occur at some localities.

SUMMARY

On the basis of typological classification, representative sample plots 1×1 m were established in forest stands, on meadows and pastures in hunting districts Jelení hora and Černý potok in the area of the Ore Mountains (Forest District Klášterec nad Ohří) in the growing season. The aim of the plots was to

determine the existing average area production (kg.m^{-2}) of biomass utilizable by game. The biomass was differentiated to herb, grass and woody components.

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In the Černý potok hunting district in forest stands of an area of 1 878 ha, in total 248 samples of grass, herb and woody biomass were taken from representative plots of an area of 1×1 m and the production of biomass was determined in kg.m^{-2}. In forest stands, the average production of 0.32 kg.m^{-2} of grass and herb biomass was determined. After conversion to the whole area of forest land 1 878 ha, the production of biomass amounted to 5 718 400 kg. In forest stands, the abundance of woody biomass (0.15 kg.m^{-2}, namely leaves, buds and shoots) utilizable by game was also determined. After conversion to the whole area of forest land 1 878 ha, the amount of woody biomass reached 2 817 000 kg.

Analyses proved that the total daily need of food, energy and mineral substances of red deer in both hunting grounds was fully covered by the natural food offer of herb, grass and woody biomass in the growing season even in case of increased requirements, e.g. in the period of growth, lactation or the development of antlers.

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