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Browse Supply and Its Utilization by Deer in Carpathian Beechwoods, Fagetum carpaticum [1]

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The supply of browse and its utilization by deer were estimated in a *Fagetum carpaticum* biotope in two mountain forest administration districts: Piwniczna and Stuposiany. Parallel tests were made of three methods for estimating browse supply from the aspect of their suitability for use under mountain conditions. A very abundant supply of browse was found in the Piwniczna forest administration district (from 26.0 g of dry mass per m² in the old tree stand to 106.8 g of dry mass in the young tree plantation). The biomass of browse was clearly less abundant at Stuposiany — reaching a maximum of 24.9 g dry mass per m² in plantations. Trees most intensively bitten (up to 85% of accessible browse of these species) were sycamore and willow. The greater part of feeding by deer (up to 80% of bites) was concentrated on four forest-forming species: beech, fir, sycamore and spruce. The great abundance and nutrient value of the winter food supply in the *Fagetum carpaticum* biotope created the conditions essential for the red deer to make use of nutrient mixing strategy.

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I. INTRODUCTION

Little is as yet known about the food supply for deer in mountain biotopes, chiefly on account of the difficulties presented by the special character of the area. Apart from the paper by Jamrozy (1980), there is still a lack of detailed comparative data from the Carpathian region which could provide a basis for estimating the capacity of different mountain forest types of biotope for feeding the most important game species living there — the red deer *(Cervus elaphus)*.

It is of particularly great importance to obtain information as to the biomass of food available during the winter season, when these animals have a far smaller amount of food of lower nutrient value at their disposal (Bobek *et al.*, 1974, Perzanowski *et al.*, 1982). Browse, which in winter has far lower nutrient value than herb layer plants (Bobek

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et al., 1974; Mydlarz, 1976), is often almost the only food accessible to game, particularly in mountains where the snow cover is usually thicker and lies longer than in lowland forests (Tomanek, 1963).

The Carpathian bechwood *(Fagetum carpaticum)* is the dominant biotopic type of forest over the region from the Bieszczady Mountains to the Tatra Mountains (Myczkowski & Grabski, 1962). The forest-building species there are beech and fir, which at the same time are among species most readily bitten by deer, which consequently creates many problems when determining habitat feeding capacity. It is therefore this particular biotope for which it appears important to determine both the supply of browse and the degree of its utilization.

Mountain conditions often make it difficult to apply standard research techniques used for lowland forests, *inter alia*, on account of the different character of forest management carried out there. The formation of the region results in the diversity of the spatial distribution of vegetation being far greater than in lowland areas, making it essential to take a relatively great number of samples. Consequently it is a serious problem to find quick methods for accurately estimating browse supply in a mountain area.

As a result, in addition to obtaining data for calculating the feeding capacity of Carpathian beech stands in winter, this study is also aimed at evaluating the suitability of different methods applied to estimate browse supply.

II. STUDY AREA, MATERIAL, METHODS

The studies were carried out in two forest administration districts: Stuposiany (eastern Bieszczady Mountains) and Piwniczna (Sądecki Beskid Mountains) where the dominating biotopic type of forest is Carpathian beechwood *(Fagetum carpaticum)*.

This association develops in the lower mountain forests, that is, in the zone from 600 to 1200 m above sea level. These are usually mixed tree stands in which the following dominate: beech *(Fagus silvatica)*, fir *(Abies alba)* and spruce *(Picea excelsa)*, in different proportions depending on local biotope conditions (Myczkowski & Grabski, 1962).

In the Stuposiany forest administration district, at the end of winter and beginning of spring 1983, 100 study areas were set up measuring 10×2 m, chosen at random along previously selected tracts, 10 of which were situated in plantations and thickets, and 80 in older age classes of tree stands varying in degree of density. Browse supply was estimated by the twig count method (Schafer, 1963). Bites were simultaneously recorded in all the study areas.

In the Piwniczna forest administration district work was also carried out in the pre-spring and early spring period in 1981 and 1982, marking out a total of 210 plots each also measuring 20 m^2. The plots were distributed in 8 1-hectare squares chosen in three different age classes of the tree stands: plantation, thicket and timber stand. In the old tree stand sub-units were distinguished according

to their degree of density — sparse, intermediate and dense, and two areas with similar exposure of hillside slope were set up in each. Basal tree area (Blair, 1971) was measured in each. Trees with diameter of breast height of less than 7 cm were not included. Basal tree area in m^2/ha was here respectively 16.76; 16.98; 21.14; 23.92; 27.88 and 32.61. The plots were distributed systematically along the linear tracts within the selected areas. The tracts ran along both diagonals of the square and through its centre according to the slope of the mountain-side. A total of 170 plots were marked out in the old tree stand, and 20 each in the plantation and young tree stand. Browse supply and the feeding of deer were estimated in each plot.

Parallel use was made of three methods to estimate browse supply. The twig count method was used for all deciduous species, but for conifers only for trees not more than 30 cm in height. The technique described by Bobek and Bergstrom (1978) was used as the second method for conifers not exceeding 3.5 m in height, employing the correlation between the diameter of the tree multiplied by its height and the browse biomass for this given tree. In order to estimate browse supply in the zone accessible to red deer (up to 2.5 m) the part of browse biomass above this height was subtracted from the calculated total browse supply present on the given tree. To avoid measuring the diameter of a tree at the height of 2.5 m each time, the regression equation was calculated between height of trees from 2.5 to 3.5 m inclusively, and their diameter at a height of 2.5 m.

These equations took the following forms:

for spruce: $Y_1 = -2.90 + 1.31x$ $(r = 0.92)$

for fir: $Y_2 = -3.51 + 1.60x$ $(r = 0.82)$

where: Y — diameter of a tree at the height of 2.5 m
x — height in the range from 2.5—3.5 m.

The third method used for large coniferous trees (over 3.5 m in height) consisted in counting branches to a height of 2.5 m. Browse supply was estimated by multiplying the number of branches by the mean amount of current growth per branch and then by the mean weight of such a single twig. Data for this calculation were obtained from 30 branches cut at random for each species. The cut material was dried under standard conditions (Górecki, 1965).

III. RESULTS

3.1. Supply and Species Composition of Browse

The study area in the Piwniczna forest administration district had a far greater browse supply which in the timber stand was even about eight times greater than in the Stuposiany forest administration district. Plantations differed relatively to the least degree, but even in this case the difference was about 4 times greater in favour of Piwniczna. In both the study areas decidedly the richest age classes were the plantations and thickets with very similar browse supply (Table 1). In the timber stand browse supply was in inverse proportion to basal tree area. This relation was described by the linear regression equation:

Table 1

Species composition of winter browse in three age classes of treestand in the *Fagetum carpaticum* association in the Stuposiany and Piwniczna forest administration districts (g dry mass per m² ±SE).

Species	Plantation	Thicket	Timber stand
	Stuposiany		
Picea excelsa	9.93±3.84	14.56±5.13	0.68±0.06
Abies alba	7.78±2.31	0.36±0.16	0.87±0.09
Fagus silvatica	2.39±0.04	0.21±0.02	1.21±0.02
Alnus incana	2.19±0.39	7.60±2.12	0.11±0.04
Rubus idaeus	1.44±0.01	0.57±0.21	0.78±0.01
Corylus avellana	0.96±0.35	1.00±0.66	0.02±0.02
Salix sp.	0.19±0.08	0.14±0.05	—
Acer pseudoplatanus	0.03±0.01	—	0.05±0.01
Lonicera xylosteum	—	—	0.05±0.02
Total	24.91	24.44	3.68
	Piwniczna		
Fagus silvatica	40.67±7.91	1.25±0.41	6.21±0.32
Picea excelsa	26.20±8.71	55.39±14.09	5.40±0.47
Rubus idaeus	13.68±1.17	9.55±1.41	8.33±0.32
Abies alba	12.37±3.38	36.71±18.38	3.55±0.40
Salix sp.	2.35±0.56	0.13±0.06	0.04±0.00
Sambucus sp.	1.11±0.48	1.12±0.25	0.73±0.04
Acer pseudoplatanus	1.10±0.52	0.88±0.60	0.22±0.02
Corylus avellana	—	1.72±0.87	1.51±0.15
Total	97.48	106.75	25.99

$$Y = 63.9 - 1.63x \quad (r = -0.79)$$

where: Y — browse supply (g of dry mass per m²)
x — basal tree area (m² per ha)

This correlation is statistically significant with $p \leqslant 0.05$. The species composition of the tree stand is very similar in both areas. Beech, fir, spruce and raspberry provide jointly more than 90% of browse, but differences were found in occurrence of alder, and also of honeysuckle and elder, these species forming an admixture there (Table 1).

3.2. Feeding by Deer

Estimates of feeding by deer were made on the basis of three parameters: (1) preference index P, which is the ratio of the proportion of a given species in the total number of bites to its proportion in

browse supply, (2) utilization index *U*, which gives the percentage of bitten browse for the different species and (3) Z — the percentage of a given species in the total number of bites.

Two species, willow and sycamore, were particularly clearly preferred in both the areas compared. Basic differences occurred, however, in the degree of preference shown by red deer for different species in different age classes of the forest. Such species were bitten to a minimum degree in one class, but were among preferred species in another class, as can be seen from the example of raspberry bushes, fir and beech trees at Stuposiany and beech and hazel at Piwniczna (Table 2).

Considerable differences were also found in the degree of utilization (% of biten browse) of different species both between the two study areas and between different age classes of the treestand. The greatest degree of utilizzation was found for sycamore, which in the case of Stuposiany was even as much as 85%. Raspberry was also utilized to a great degree in this forest district, i.e. over 60% and willow from about 27 to over 60%, depending on the age class of the treestand. At Piwniczna equally intensive feeding was found in the plantation only, where almost 80% of willow browse was bitten and in the thicket, where about 36% of sycamore browse was bitten. The group of species least utilized were: alder, elder and honeysuckle (Table 2).

Taking not only the preferences of deer but also the proportion of browse of different species in the total browse supply into consideration, an estimate was made of which species provide the decisive part of actually consumed browse. This estimate was based on the proportion of different species in the total number of bites. In this case also considerable differences occurred between age classes. At Stuposiany about 30% of the bites in the timber stand were concentrated on fir, beech and sycamore, but in the thicket and plantation, on fir, spruce and willow. At Piwniczna almost 80% of bites were found in the timber stand on beech and raspberry, and in the thicket on beech, sycamore and fir, but in the plantation about 95% of bites were recorded on willow, beech and raspberry (Table 2). When the percentages of the different age classes were taken into account in the total forest area, spruce was of relatively slight importance in both forest districts, since despite its high proportion in browse supply (about 50% at Stuposiany and over 30% at Piwniczna) bites of this species formed on an average about 6% of all bitten browse. It was only in the young age classes of tree stands at Stuposiany that this species were among those intensively bitten. Alder is decidedly of the least importance as a potential source of food for deer, since it has exceptionally low indices for both preference and utilization.

Table 2

Comparison of feeding by deer on different species of trees and bushes in three age classes of treestand in the *Fagetum carpaticum* association in the Stuposiany and Piwniczna forest administration districts.

U — percentage of bitten shoots; P — preference index (ratio of the proportion of the given species in the total number of bites to its proportion in browse supply); Z — percentage of given species in total number of bites.

Species	Plantation			Thicket			Timber stand		
	U	P	Z	U	P	Z	U	P	Z
				Stuposiany					
Abies alba	17.9	1.8	55.3	19.8	12.6	18.6	27.7	1.6	37.9
Fagus silvatica	6.4	0.5	5.2	9.1	4.9	4.2	12.0	0.8	25.4
Picea excelsa	10.7	0.6	25.5	3.5	0.7	41.3	6.3	0.3	5.9
Alnus incana	—	—	—	0.3	0.1	2.8	—	—	—
Salix sp.	61.5	8.4	6.4	27.7	41.5	24.9	—	—	—
Corylus avellana	—	—	—	—	—	—	5.8	3.2	1.7
Sambucus sp.	—	—	—	—	—	—	50.0	20.0	0.6
Acer pseudoplatanus	85.0	23.3	2.8	—	—	—	84.2	12.4	16.9
Rubus idaeus	62.5	0.8	4.8	63.1	8.2	8.2	65.4	0.5	8.9
Lonicera xylosteum	—	—	—	—	—	—	16.7	2.0	2.7
				Piwniczna					
Sambucus sp.	—	—	—	—	—	—	13.1	0.3	1.0
Fagus silvatica	2.2	0.8	34.8	18.5	24.7	28.9	8.3	1.9	55.0
Acer pseudoplatanus	8.5	2.0	2.3	36.2	30.8	25.3	20.0	4.4	3.0
Corylus avellana	—	—	—	3.1	1.7	2.7	1.6	0.2	1.0
Salix sp.	78.9	22.1	54.7	27.7	30.0	3.6	33.8	8.0	1.1
Abies alba	0.6	0.1	0.3	0.5	0.7	23.6	2.2	0.7	7.5
Picea excelsa	—	—	—	0.1	0.2	10.7	0.5	0.6	8.5
Rubus idaeus	10.1	0.6	8.0	24.2	0.6	5.2	17.2	0.6	23.0

IV. DISCUSSION

4.1. Methods of Estimating Browse Supply

In respect of deciduous species the twig count method (Shafer, 1963) is the method most highly recommended as quickk and simultaneously giving results burdened with relatively low error. Hitherto there are no known satisfactory correlations for these species between browse supply and some of the trunk or tree crown parameters.

In relation to coniferous species, on the other hand, the correlation proposed by Bobek and Bergstrom (1978) between browse supply and tree height-diameter index proves very effective, particularly in thickets and older plantations, where the classic harvest plot technique (Whittaker, 1966; Young *et al.*, 1967; Bobek & Dzięciołowski, 1972) is exceptionally time-consuming.

Use of the high correlation between basal tree area (Blair, 1971) and browse supply proved to be very useful for quick estimates of browse below the tree-top canopy in timber stands. This method is particularly suitable in mountain regions where, on account of the selection system of forest management, plantations and thickets form a very low percentage of the treestand. Moreover it is the only one which makes it possible to foresee the dynamics of variations in browse supply depending on the timber harvest plans. It may thus be used for envisaging variations in the food supply of a hunting area and determining the desired density of deer there.

4.2. Browse Supply and its Utilization

In comparison with the biotopic types of forest in Poland so far studied, the Carpathian beechwood is one of the richest in browse supply. In particular that part of it included in the Piwnicznza forest administration district is nearly equal in abundance of winter browse supply to the biotope of mixed coniferous forest hitherto considered the richest (Bobek *et al.*, 1975). In relation to other mountain biotopes, such as *Piceetum tatricum* and *Abieti-Piceetum montanum,* the Carpathian beechwood at Piwniczna proved to be richer in this respect and even its poorer form at Stuposiany was only slightly less abundant in winter browse than the above biotopes (Tables 1, 2, 3).

This means that this association provides very good trophic conditions for deer, as even when there is deep snow cutting off the animals' access to the herb layer, there continues to be an abudance of food in the form of browse. Differences between the two forest administration districts are due chiefly to species composition — at Stuposiany there are far fewer conifer plantations, and also as can be seen from field

data from this forest administration district, the average weight of a single twig is slightly lower. It is difficult to make a precise comparison of results with the data obtained by Jamrozy (1980) since this author does not give basal tree area as a measure of the density of the tree stand. In addition he estimates browse supply not only in the Carpathian beechwood itself, but also in forest ecosystems where this association dominates. The average browse supply calculated by this author for Stuposiany, taking into account the proportion of the different age classes of treestand, differs to the extent of about 30% from the analogical value in the present paper.

Table 3

Comparison of browse supply in three age classes of treestand in different biotopic types of the Carpathian forests in winter (g dry mass per m²). The values given do not include spruce shoots.

Forest association	Locality	Plantation	Thicket	Timber stand
Fagetum carpaticum	Piwniczna	71.28	51.36	20.61
	Stuposiany	14.98	9.88	3.00
Piceetum tatricum [1]	Tatra National Park	31.24	4.97	3.26
Abieti-Piceetum montanum [1]	Limanowa	—	—	13.26

[1] After Lignar, 1981.

An undesirable phenomenon for forest management in this biotope is the fact that the species most important economically, i.e. in this case beech, fir and sycamore, usually belong simultaneously to the group of species highly preferred by red deer. If also spruce is included — a species far less readily bitten but constituting a very considerable proportion in the treestand, it appears that feeding may concentrate even to as much as 80% on these four species (Table 2). In addition in the case of seedlings or young trees it is primarily the top shoots which are bitten, which not infrequently causes serious damages to the treestand (Podyma, unpubl. data). Under these circumstances it is difficult to calculate the potential food supply acceptable from the aspect of forest conservation, since it must be of necessity based on a subjectively established level of admissible damage in the treestand. The only two species which, as it were, provide some relief for the forest-building species, are willow and especially raspberry, about two-thirds of its supply being utilized, and if this species as at Piwniczna, forms an important part of browse supply, then as much as 20% of all bites may be concentrated on it (Tab. 1, 2). It is clear from the foregoing that the system

so far used for estimating the food supply for deer, based on mechanical assuming of browse supply according to the biotopic type of forest, does not give a true picture of the actual situation. The decisive factors for estimating browse supply are the species composition of the treestand and the latter's age. This is directly connected with the food preferences of deer which, as Kossak has shown (1976, 1981), are of a complex character. Dependence of preferences in relation to one species, depending on the co-occurrence of others, can be clearly seen in the case of, for instance, fir. At Stuposiany it is the most intensively bitten species, but at Piwniczna is among the group of less readily bitten species. The occurrence of food blocks described by Kossak (1976) is, however, more complicated as the result of their variability at different seasons of the year, whereas the data presented in this paper were obtained during the winter period only. Nevertheless there is a distinct regularity that admixture species are very frequently among those greatly preferred, although their proportion in the whole of the food consumed is negligible. As searching for such single plants involves relatively high expenditure of time and energy, their role is limited to supplying the animals with certain essential components of their diet or to stimulating the process itself of consumption and digestion of food.

The way in which an animal chooses the composition of its diet has not as yet been completely clarified i.e. how it distinguishes preferred plants. In the first place there are suggestions that an animal searching for food in its habitat does not move about at random but moves within preferred microhabitats (Nudds, 1980). The choice of a given food item may take place on the basis of sight, smell or taste stimuli and thus the decision to consume or reject the given portion may not be taken even until after it has been bitten off (White *et al.*, 1975). In addition a connection has been found between the animal's food strategy and the quality, amount and diversity of the food available. When these parameters are reduced then food preferences are also less distinct — the animals consume food more for its energy content than for its quality and bite size and daily eating time determine the level of consumption (Trudell & White, 1981). In extreme situations this may lead to feeding on practically any food available — even food with low nutrient value but guaranteeing the largest possible portion of energy in a unit of time. This may take place, for instance, by eating foods which have an exceptionally rapid rate of passage through the alimentary tract. In species with a smaller rumen, the anatomy of which does not greatly slow down the passage rate of food e.g. the mule deer *(Odocoileus hemionus)*, consumption of food with high lignine content gives a high total metabolizable energy intake, even though achieved at the expense

of digestion output and thus is energy maximizizng strategy (Hobbs *et al.*, 1983).

Maintenance of the nutrient mixing type strategy (Nudds, 1980) depends on the accessibility and nutrient value of different plant species in the habitat. The possibility of implementing a given food strategy is of course limited by the animal's morphological and anatomical parameters. Larger ruminants can feed on food with lower digestible energy concentration than it is possible with species of small body dimensions (Janis, 1976; Kay *et al.*, 1980). The relatively high proportion of admixture species in the diet of deer in both the forest administration districts shows that these animals tend to employ the nutrient mixing more than the energy maximizing strategy. This is possible owing to the relatively high resource level in the *Fagetum carpaticum* association, which results in food energy not forming a limiting factor for deer under normal winter conditions.

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ZASOBNOŚĆ BAZY ŻEROWEJ I JEJ WYKORZYSTANIE PRZEZ JELENIOWATE W SIEDLISKU BUCZYNY KARPACKIEJ *(FAGETUM CARPATICUM)*

Streszczenie

W dwóch nadleśnictwach górskich: Piwniczna (Beskid Sądecki) i Stuposiany (Bieszczady) przeprowadzono oceny zasobności żeru pędowego i jego wykorzystania przez jeleniowate w siedlisku buczyny karpackiej *(Fagetum carpaticum)*. Testowano równolegle kilka metod: (1) opartą na liczeniu pędów (Shafer, 1963) oraz w stosunku do gatunków iglastych, metodę opartą na ocenie średniej ilości pędów na gałęzi, (2) technikę wykorzystującą korelację indeksu wysokości i średnicy drzewa z biomasą pędów (Bobek & Bergstrom, 1978) i (3) w starodrzewiu metodę opartą na pomiarze basal tree area (Blair, 1971).

W porównaniu do innych siedlisk górskich (Tabela 3) powierzchnia w Piw-

nicznej posiadała bardzo wysoką zasobność żeru pędowego (od 25.99 g suchej masy na m^2 w starodrzewiu do 106.75 g suchej masy na m^2 w młodniku). Biomasa pędów w Stuposianach była wyraźnie niższa i wahała się od 3.68 g suchej masy na m^2 w starodrzewiu do 24.91 g suchej masy na m^2 w młodniku. W obu nadleśnictwach buk, jodła, świerk i malina dają łącznie ponad 90% żeru pędowego (Tabela 1). Wykorzystanie poszczególnych gatunków zależała od stopnia preferowania ich przez jeleniowate oraz ich udział w puli żeru pędowego. Najsilniej wykorzystywanymi były: jawor i wierzba, oraz w Nadleśnictwie Stuposiany malina. Główne gatunki lasotwórcze — buk i jodła były silniej zgryzane w Nadleśnictwie Stuposiany. Biorąc pod uwagę także świerk i jawor, okazuje się, że na tych gatunkach może skupiać się nawet do 80% zgryzania (Tabela 2).

Ocenia się, że jeleniowate w siedlisku buczyny karpackiej stosują strategię pokarmową typu nutrient-mixing (Nudds, 1980) co jest możliwe dzięki wyjątkowo bogatej bazie pokarmowej tego siedliska.