

Food eaten by the free-living European bison in Białowieża Forest

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Rumen contents of the European bison ($n = 67$) living free in herds within Białowieża Forest have been estimated. In winters of continuous snow cover, when bison have access to hay offered in feeding racks, their basic food consisted of grasses, sedges and herbs (90.4% per cent of the rumen capacity), with trees and shrubs as supplementary food (9.5% of the rumen capacity). In spring the proportions of these two groups of plants are 88.2 and 11.2%, in summer 86.3 and 13.0%, in autumn 93.2 and 6.7%, respectively. Mosses, horsetails, ferns and fungi combined account for 0.1 to 0.7% of the rumen capacity, depending on the season.

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Introduction

The European bison, *Bison bonasus* (Linnaeus, 1758) has little known food preferences. Only in a few places in the world do European bison live outside enclosures and have a free choice of food. Białowieża Forest is such a place, although additional food is made available to animals during winter. The reasons for this winter supply of hay have never been clearly identified, but it is known to have started as early as in the 19th century. One unquestionable reason was, that a large number of the European bison, red deer and moose were kept for hunting purposes, so their nutritional needs had to be secured by man (Wróblewski 1927). This tradition of hay supplies has been kept up to the present day. During snowless winters this fodder is not used (Z. Krasieński, personal inf.), a fact which suggests that it is not an indispensable condition for the winter survival.

Studies of the bisons' diet have been carried out so far by taking account of foraging traces (Koroćkina 1969a, b; Borowski and Kossak 1972) or by direct observation of their feeding behaviour in the field (Caboń-Raczyńska *et al.* 1987). Food preferences were also determined by means of cafeteria tests (Gębczyńska and Krasieńska 1972). Prior to these studies information on the food of this mammal was collected from foresters and farmers (*cf.* Wróblewski 1927, Borowski *et al.* 1967). Up to now, however, the bison's diet was not assessed by analysing of the rumen contents, a method which gives direct, quantitative and qualitative estimation of the food intake, despite some limitations (Bergerud and Russell 1964, Gaare *et al.* 1978).

The aim of this study was to find, which species of plants were eaten and in what amounts, by the free-living European bison within Białowieża Forest. A comparison was then made between this data and results obtained in the same area from two other methods: (1) diet assessed by the traces of foraging (Koroćkina 1969a, b, 1972; Borowski and Kossak 1972) and (2) the study of feeding behaviour (Caboń-Raczyńska *et al.* 1987). It allowed not only to improve the knowledge about trophic relationships in the European bison but also to compare the validity of the basic methods used in assessing the diet of wild species of ruminants.

Material and methods

One-litre samples of rumen contents, fixed with 4% formalin, were collected in the field, after an incision of the rumen wall and proper, thorough mixing of its contents. The samples were taken from animals intentionally culled or killed in accidents. No samples were taken from animals found dead from natural causes. Data was obtained in this way from 44 individuals in winter, 10 in spring, 4 in summer and 9 in autumn. The analysis began by rinsing the samples under running water, on a sieve with a 2 mm mesh. The filtrate contained small particles of food and mineral components, mainly sand. The filtrate, after passing through filter paper and after drying, was weighed, however any identification of species or genera from these contents was not possible. Attempts to estimate the specific composition of this fraction indicated, that about 90% of the fraction were herbs and grasses, and the remaining 10% were leaves and ground twigs. To adjust the data on the food intake, the mass of the tree food was increased by 1/10 of the unidentified fraction, and the mass of the grasses, sedges and herbs by 9/10 of the undetermined fraction. It should be mentioned that although in the European bison 19.5% of the rumen contents could not be identified, in other species, for example the caribou (Berjerud and Russell 1964), roe deer and red deer (Gębczyńska 1980) as much as 77%, 58%, and 45% respectively, were left undetermined. This comparatively small indeterminate amount in the European bison makes this method of diet assessment more accurate than in the caribou, roe and red deer.

Part of the rumen contents left on the sieve were identified under a dissection microscope. It allowed identification accurate to the level of species or genus. The grasses were much more difficult to identify, though they could be easily distinguished as a systematic group. Therefore they were treated together and identified only as the family *Gramineae*.

Study area

Białowieża Forest is a densely forested area of mixed woods covering a total of 1100 km². The flora of this territory consists of 953 species of flowering plants, 37 species of pteridophytes, 254 species of bryophytes, 54 species of liverworts, about 200 species of lichens and over 2000 species of fungi (Faliński 1986). A detailed description of the biotopes is given by Borowski and Kossak (1972) and by Krasieńska *et al.* 1987. Generally it can be said that the European bison prefer to live in the *Pino-Carpinetium* mixed forests and mixed coniferous woods which cover 47 and 26 per cent of the Forest area, respectively.

The way of gathering in herds, moving around, and the circadian rhythms all influence the utilization of food resources; all these parameters referring to the European bison living in Białowieża Forest have been well-acknowledged (Krasieński 1978, Krasieńska *et al.* 1987, Caboń-Raczyńska *et al.* 1987).

Results and discussion

The analysis of the rumen contents in the European bison living in Białowieża Forest shows that they eat over 90 species of plants, however this number does not take into account individual species of grasses which were not identified. A longer list of plants in the diet was

made on the basis of the foraging trace analysis and, after Borowski and Kossak (1972), it included 137 species, while after Koroćkina (1969a, b, 1972) - as many as 376 species.

Such large differences in the number of species recorded, i.e. eaten by the bison, may perhaps be explained by the level of accuracy in registering the foraging traces (data after Koroćkina 1969a, b, 1972 versus Borowski and Kossak 1972). On the other hand, in identifying the specific composition of the rumen content, single plants eaten may escape observation and, besides, some of them are not identifiable. If, however, we compare the list of species ($n = 137$) set by Borowski and Kossak (1972), and part of the list accepted by Koroćkina (1969a, 1972) as a basic composition ($n = 130$, where 45 were the species of trees and shrubs, plus 85 species of grasses and herbs), with our list ($n = 93$ species completed with 18 species of grasses after Koroćkina 1972) then all these lists range between 111 and 137 species of plants included in the diet of the bison in Białowieża Forest. Thus, it can be accepted that both methods, to some extent give a similar basic list of the plant species included in the diet.

The morphology of the alimentary tract in the European bison allows us to include it among animals feeding on grass and fibrous fodder (Hofmann 1978), taken in large amounts and with little selectivity. Nevertheless, the bison prefer certain types of food, as well as specific species within these types. This is strongly supported by the fact, that in experimental conditions trees are conspicuously preferred (Gębczyńska and Krasieńska 1972). Other evidence of tree food preference is provided by our data on food in winter, where, in spite of grazing in the vicinity of the feeding racks stacked with an overabundance of hay, the bison still ate the twigs and bark from 13 species of trees and 4 species of shrubs. In this period, preferred species were: *Picea excelsa*, *Belula pubescens*, *Carpinus betulus*, *Quercus robur* (Table 1). From spring to autumn the bison chose *Picea excelsa*, *Pinus silvestris*, *Quercus robur*, *Betula pubescens*, *Carpinus betulus*, *Populus tremula* (Table 1). In this period similar preferences among tree species were recorded by the foraging trace method (Koroćkina 1969a, Borowski and Kossak 1972). Also the cafeteria test showed that *Quercus robur*, *Fraxinus excelsior*, *Acer platanoides*, *Salix caprea*, *Ulmus campestris*, *Malus silvestris* were willingly eaten by the European bison (Gębczyńska and Krasieńska 1972).

As regards grasses, sedges and herbaceous plants, assessment of the diet composition clearly depends on the method used. Only several species like: *Aegopodium podagraria*, *Urtica dioica*, *Ranunculus lanuginosus*, give estimates consistent with the method of the rumen content analysis and the method of foraging trace observations (our data versus Borowski and Kossak 1972). The assessment of the rumen contents shows that 50 species of plants occur over 10% and 22 species of plants over 20% within the diet components (Table 1). Koroćkina (1972) calculated that 85 species of grasses, sedges and herbs were included in the basic diet, with 18 species belonging to the family of *Gramineae*, 15 to *Compositae*, 20 to *Leguminosae* and the remaining species belonging to other families.

The quantitative proportion of individual food types in the rumen contents is surprisingly stable, though from spring to autumn the bison acquire their food in a natural way, while in winter they mainly utilize the hay from the feeding racks (Table 2). Despite this, grasses and sedges contribute from 65.5% (in spring) to 72.4% (in winter) of the rumen contents. Most herbaceous plants were found in autumn (6.7%) and least in winter (0.9%). Surprisingly the presence of trees in the diet was uniform throughout winter, spring and summer (from 7.4 to

Table 1. Frequency of occurrence (in percentage) of trees, bushes, and herbaceous plants in stomach contents of the European bison from the Białowieża free-living herd.

Species	Spring - Autumn (n = 23)	Winter (n = 44)
1	2	3
Trees		
<i>Picea excelsa</i> (Lam.) Lk.	82.6	54.5
<i>Carpinus betulus</i> L.	69.5	43.2
<i>Pinis silvestris</i> L.	56.5	18.2
<i>Quere us robur</i> L.	65.2	43.2
<i>Betula pubescens</i> Ehrh.	73.9	54.5
<i>Populus trémula</i> L.	43.5	18.0
<i>Tilia cordata</i> Mill.	34.8	15.9
<i>Alnus glutinosa</i> (L.) Gaertn.	21.1	11.3
<i>Fraxinus excelsior</i> L.	20.0	0.0
<i>Ulmus</i> sp.	14.3	0.0
<i>Salix</i> sp.	0.0	4.6
<i>Acer pseudoplatanus</i> L.	11.1	0.0
<i>Acer platanoides</i> L.	30.8	4.5
Bushes		
<i>Corylus avellana</i> L.	39.1	9.1
<i>Vaccinium myrtillus</i> L.	30.0	2.3
<i>Calluna vulgaris</i> (L.) Salisb.	10.5	13.2
<i>Evonymus verrucosa</i> Scop.	0.0	9.0
<i>Vaccinium vitis-idaea</i> L.	15.4	15.9
<i>Vaccinium uliginosum</i> L.	61.5	16.8
<i>Frangula alnus</i> Mill.	22.2	6.0
<i>Viburnum opulus</i> L.	0.0	2.2
<i>Sorbus aucuparia</i> L.	15.4	0.0
<i>Ledum palustre</i> L.	15.4	0.0
Herbaceous plants		
<i>Oxalis aceto sella</i> L.	43.5	20.4
<i>Stellaria holostea</i> L.	36.8	6.8
<i>Ajuga reptans</i> L.	40.0	11.5
<i>Urtica dioica</i> L.	26.1	6.8
<i>Geum urbanum</i> L.	26.1	4.5
<i>Aegopodium podagraria</i> L.	28.6	2.3
<i>Galeobdolon luteum</i> Huds.	26.3	13.6
<i>Stachys silvático</i> L.	15.8	11.3
<i>Cardamine amara</i> L.	15.8	0.0
<i>Geranium Robertianum</i> L.	15.8	0.0
<i>Anemone nemorosa</i> L.	20.0	2.3
<i>Solanum tuberosum</i> L.	31.5	11.4
<i>Rumex</i> sp.	21.0	18.1
<i>Hepatica nobilis</i> Gersault	14.3	6.8
<i>Mercurialis perennis</i> L.	13.0	0.0
<i>Mycelis muralis</i> (L.)	10.0	0.0
<i>Paris quadrifolia</i> L.	10.0	0.0
<i>Asarum europaeum</i> L.	10.0	0.0
<i>Ranunculus lanuginosus</i> L.	10.0	0.0
<i>Cirsium oleraceum</i> (L.) Scop.	21.0	6.8
<i>Asperula odorata</i> L.	21.1	0.0

Table 2 continued

1	2	3
<i>Stellaria nemoriim</i> L.	10.0	0.0
<i>Stellaria media</i> (L.) Vill.	21.7	2.3
<i>Ficaria verna</i> Huds.	10.0	0.0
<i>Veronica chamaedrys</i> L.	10.5	0.0
<i>Vicia</i> sp.	0.0	4.6
<i>Plantago</i> sp.	44.4	6.8
<i>Lathyrus pratensis</i> L.	15.4	9.1
<i>Ranunculus repens</i> L.	15.4	15.9
<i>Artemisia vulgaris</i> L.	0.0	6.8
<i>Filipéndula ulmaria</i> (L.) Maxim.	38.4	15.9
<i>Actaea spicata</i> L.	11.1	4.5
<i>Sonchus arvensis</i> L.	0.0	2.3
<i>Geum rivale</i> L.	15.4	4.6
<i>Lathraea squamaria</i> L.	11.1	0.0
<i>Chenopodium</i> sp.	11.1	0.0
<i>Leontodon autumnalis</i> L.	11.1	2.3
<i>Potentilla anserina</i> L.	11.1	0.0
<i>Circaea lutetiana</i> L.	11.1	0.0
<i>Valeriana officinalis</i> L.	11.1	0.0
<i>Primula officinalis</i> (L.) Hill.	0.0	2.3
<i>Chrysosplenium allernifolium</i> L.	0.0	2.3
<i>Capsella bursa-pastoris</i> (L.) Med.	22.2	0.0
<i>Dentaria bulbifera</i> L.	22.2	0.0
<i>Genista tinctoria</i> L.	11.1	0.0
<i>Piróla</i> sp.	25.0	0.0
<i>Epilobium alsinifolium</i> Vill.	11.1	0.0
<i>Galium</i> sp.	11.1	0.0
<i>Lotus corniculatus</i> L.	11.1	0.0
<i>Majanthemum bifolium</i> (L.) F. W.Schmidt	25.0	0.0
<i>Fragaria vesca</i> L.	25.0	0.0
<i>Brassica</i> sp.	11.1	0.0
<i>Compositae</i>	11.1	0.0
<i>Leguminosae</i>	11.1	11.3
<i>Beta vulgaris</i> L.	25.0	31.8

Table 2. Frequency of biomass of the different food groups in the stomach of the European bison.

Food group	Spring (April - May) n = 10	Summer (June - Aug.) n = 4	Autumn (Sept. - Oct.) n = 9	Winter (Nov. - March) n = 44
Trees	8.8	9.8	4.3	7.4
Bushes	0.1	1.4	0.6	0.2
Grasses and sedges	65.5	68.6	69.9	72.4
Herbaceous plants	1.5	1.7	6.7	0.9
Mosses	0.2	0.5	0.0	0.0
Pteridophytes	0.4	0.2	0.0	0.1
Fungi	0.0	0.0	0.1	0.0
Unidentified parts	23.5	17.8	18.0	19.0

Table 3. Estimations of occurrence (%) of trees and bushes (A); grasses, sedges and herbs (B) in the bison diet, according to the different methods.

A	B	Season	Method	Authority
33	67	Spring - autumn	Feeding traces in the forest	Borowski and Kossak 1972 ¹
39	61	Winter and summer	Cafeteria test in the enclosure	Gębczyńska and Krasińska 1972
4.8 ¹	95.2	Spring - autumn	Direct observations in the forest	Caboń-Raczyńska <i>et al.</i> 1987
9.5 ²	90.4	Winter	Stomach contents analysis	This study
11.2	88.2	Spring	As above	As above
13.0	86.3	Summer	As above	As above
6.7	93.2	Autumn	As above	As above

¹in April bison may bark up to 20.7% of the feeding time and in June and July they may browse up to 11.8% of the feeding time.

²To adjust data on food intake calculated by stomach contents analysis the mass of tree food was increased by 10% of the unidentified fraction, and the mass of grasses, sedges and herbs was increased by 90% respectively (for details see in the text).

9.8%) and only in autumn was it lower (4.3%). Mosses, ferns, horsetails and fungi were always found in amounts below one per cent of the total rumen contents (Table 2). The adjustments used to incorporate the unidentifiable food in the rumen contents, correspondingly increased the proportion of trees and shrubs as well as grasses, sedges and herbs (compare Table 3).

The presence of tree food in the diet of other ruminants in Białowieża Forest ranges considerably: in roe deer it comprises 12% in summer and 23% in winter (Gębczyńska 1980). According to Kossak (1983) the roe deer covers its requirements of tree food from spring to autumn in variable amounts (from less than 10% to 60%); in the snowless period of winter about 15% and nearly 100% during permanent snow cover. On the other hand, in the red deer this proportion comprises 60% in autumn and winter (Gębczyńska 1980). The European bison have additional hay provided in winter and this fact influences its diet composition during this season, the extent to which is not quite known.

During snowless winters the bison in Białowieża Forest did not utilize the food provided on racks (Z. Krasiński, personal inf.). However, so far it has not been possible to obtain samples of the rumen from such individuals. Only if this was possible could it be determined whether the proportion of the tree food taken by the European bison depends upon the season or not. There was a striking difference in the proportion of trees, shrubs, grasses and herbs in the bison's diet from spring to autumn, when the various methods used, were compared (Table 3). The results of food obtained using the method of foraging traces, tends to overestimate the percentage of tree food in the diet of the European bison. A similar fact was found in studies on roe deer and red deer (Gębczyńska 1980). On the other hand direct observations of the bison's feeding behaviour in the forest showed that most of their time is spent grazing as much as 95.2% of time, while barking and browsing constitutes only 4.8% (Caboń-Raczyńska *et al.* 1987). As the contents of the rumen indicates that the food taken from trees and shrubs contributes about 10% of the diet, it is likely that this food is digested quite slow or, even more likely, that the actual bites taken are of a substantial size. Accepting such an assumption allows us to say that direct observations of the bison feeding habits underestimates the amount

of tree food in their diet. If we accept, according to the rumen contents, the quantitative estimates of the percentages of food groups as the nearest to the actual figure; it can be stated that the European bison feeds principally on grasses, sedges and herbs (about 90% of the diet) and supplements it with the tree food (about 10% of the diet). These figures remain in similar proportions also during the winter period, when additional feeding of the European bison in Białowieża Forest is applied.

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