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Food of the Red Deer in an Annual Cycle

[With 3 Figs. & 6 Tables]

Three methods for studying the food taken by the red deer, *Cervus elaphus* Linnaeus, 1758, have been used, namely: (1) direct observation of feeding by wild deer, (2) tracking in snow after feeding deer, and (3) observation of feeding by tamed deer. During the period of more than two years there was collected the material of ca 44 thousands of observational units, which provided some characteristics of the food of red deer in annual cycle. The winter food of red deer in studied environments consists of bark and twigs of trees and shrubs (53%) and dwarf-shrubs (43%), which comprise in total 96%. Red deer food during spring consists of: trees and shrubs (54%), herbs (19%), dwarf-shrubs (9%), and grasses, sedges, and rushes (7%). In the summer food of red deer there again prevail twigs of trees and shrubs (38%), the proportion of herbs reaches its annual maximum (36%), while that of graminids approaches 19%. In the autumnal food there prevail grasses, sedges and rushes (about 37%), which at this season reach their maximum proportion in deer diet. The next group of food plants present trees and shrubs (almost 22%), followed by herbs and dwarf-shrubs (15% each).

I. INTRODUCTION

Ever increasing conflict between silvicultural goals of forest production and those of game management in forests rises many violent discussions in professional circles of numerous European countries. In the course of these discussions there are expressed extremistic opinions demanding the total extinction of big game on valuable forest lands or the full subordination of forest economy to the park raising of game animals. It is our opinion that the pursuit after the coordination between these two kinds of forest use on the way of the adjustment of population level to the actual carrying capacity of definite forest communities should present the goal for forest and game management practice. The attainment of this goal requires, however, a thorough research in the autecology and synecology of several species of big herbivorous animals (red deer, moose, roe deer), which uncontrolled increase in numbers in contemporary, intensively managed forests of Europe, creates major economic problems.

The research presented below aims at the quantitative and qualitative characteristics of the food of red deer (*Cervus elaphus* Linnaeus, 1758) inhabiting intensively managed and utilized forests within the

moderate zone — in lowland Poland. This is a fragment of broad studies on the ecology of red deer carried out by the Forest Research Institute in Warsaw with a financial support of the U. S. Department of Agriculture in a form of grant No FG-PO-169.

II. TIME AND PLACE OF STUDY

Direct observation of red deer feeding was undertaken in September of 1964. It is continued for more than two years and until the November of 1966 there were taken in total ca 13 hours of observation, during which 10,665 contacts had been recorded.

Observations of red deer feeding taken with the aid of tracking in snow have been carried out during two winter seasons: 1964/65 and 1965/66, during which 4,108 bites were recorded.

Observations of the feeding by the tamed hind of red deer were undertaken in April 1966 and during 8 months (until November, 1966 inclusive) rather abundant research material, including 29,342 contacts, was collected.

Table 1.

Distribution of observational units collected with each of three techniques used during subsequent months.

Months	T e c h n i q u e s			Total
	Tracking in snow	Observation of wild red deer	Observation of tamed red deer	
January	1,274	699	—	1,973
February	1,587	12	—	1,599
March	1,154	—	—	1,154
April	—	204	1,162	1,366
May	—	2,192	9,892	12,084
June	—	2,424	2,480	4,904
July	—	950	5,235	6,185
August	—	845	1,184	2,029
September	—	573	964	1,537
October	—	1,742	4,390	6,132
November	49	532	4,035	4,607
December	53	492	—	547
Total	4,108	10,665	29,342	44,115

As a result the composition of red deer food during winter months was based on the observation of deer feeding with the aid of tracking on snow and on direct observations of red deer feeding, while the composition of food during remaining seasons — on the observation of feeding by the tamed hind and also on direct observation of wild deer.

In table 1 the distribution of observations collected with each of three used techniques during subsequent months is given.

Study areas were three state forest-districts situated in various parts of Poland, namely: Józefów (Lublin province), Pszczyna (Katowice province), and Smolniki

(Olsztyn province). Description of environment in the mentioned forest objects is inserted in the paper by Dzieciółowski (1967b).

On the area of mentioned forest-districts there have been carried out direct observations of red deer feeding and tracking in snow. Observations of feeding by the tamed hind were taken in a spacious pen with circa 15 hectares in area, in the compartment 230 of the forest-district Smolniki. The enclosure includes a part of timber stand, thicket, young plantation, and a patch of meadow on riverside. Within the enclosure there occur two forest site types: mixed deciduous forest and fresh, mixed coniferous forest. From the phytosociological viewpoint the association was classified as *Stellario-Carpinetum* Oberd., 1957, *subass. calamagrostietosum*. The stand has two storeys. The upper storey (canopy) consists of: Scots pine (82—92) 87 years old, in patches Norway spruce, sporadic oak and basswood; the lower storey: hornbeam (42—62) 52 years old. These species are singly mixed, with moderate density. Crown density — 0.7, site index class —1st. In shrub stratum there occur locally hornbeam and hazel, the ground vegetation is dominated by: whortleberry, *Calamagrostis arundinacea*, *Oxalis acetosella*, *Hepatica triloba*, *Anemone sp.*, *Luzula sp.*, *Pteridium aquilinum*.

III. STUDY METHODS

1. Winter tracking of red deer was carried out with the use of author's own method. Observers were undertaking the fresh track of single individual or a herd of red deer and followed it stopping at deer feeding grounds for the sake of a detailed examination of them. They were provided with instruction and observational cards. The instruction provided for: recording of plant species on which obvious marks of red deer feeding were found, description of plant portion taken, and the estimate of the per cent of consumed parts of plant individual. From recorded food plants, excluding the most common ones, samples were taken, on the base of which botanist identified the species. Printed observational cards, besides of the note about the place and time of observation, contained the plan of route with feeding grounds marked on them. These plans were plotted on the network of the spatial division of state forests with numbers of compartments. The method was described in detail by Dzieciółowski (1967a, b). One year after the initiation of our study there was out of print the paper by Ahlén (1965), who used analogous techniques of tracking in snow in his studies on the ecology of red deer in Scandinavia. After Ahlén (1965) the idea of conversion of observational data into weight units, called bites, was accepted.

2. Direct observations of feeding as a method of the collection of information concerning the composition of animal food, were carried out by: Wilkins (1957), Lovaas (1958), Martin (1960), White (1961). These authors based themselves on Dixon's method, called commonly deer-minute techniques. Hunter (1962) used the method of direct observations to sheep grazing on hills of Scotland. Nocturnal observations of deer feeding carried out by Montgomery (1963), Progulske & Duerre (1964), Ahlén (1965) present certain modification of the method. In the present work Dixon's method has been used with the total time of deer feeding on each plant species and number of contacts with plant being recorded. The time of feeding was recorded with the accuracy of 5 seconds. The situation of poorly visible feeding grounds was sketched for the sake of their later location. The number of contacts not always could be precisely counted and in many cases observers gave only the duration of feeding. In order

to obtain the data comparable with materials collected with the aid of the two remaining methods the total duration of feeding was divided by 5 second units what gave an observational units equivalent to one bite from tracking techniques and to one contact from observations of tamed deer. On the base of several thousands of contacts obtained with the latter method the average duration of one contact was calculated. It amounted to 6.5 second.

3. Observations of tamed red deer were carried out with the aid of a method described by Mc Mahan (1964). One year old tame hind of the red deer was used for observations. She was settled down permanently in the pen described above. The hind was accompanied during feeding by two observers. One of them stood closely enough to the animal to observe the number of contacts and take, at the same time, samples of plants requiring the identification by botanist, while the other recorded results.

Obtained results were subjected to statistical calculations with the use of the analysis of variance for per cent data transformed into angle values according to C. I. Bliss formula (Elandt, 1964) in order to find the significance of resulting differences, as well as with the aid of Student's t-test.

The nomenclature of specific names of food plants follows: — for vascular plants — Szafer, Kulczyński & Pawłowski (1953), for mosses — Szafran (1961), for lichens — Motyka (1960), for fungi — Moser (1955) and Orłowski (1966). Samples of food plants are stored in the Section of Game Management, Forest Research Institute, Warsaw and could be, at wish, made available for reference.

IV. RESULTS

All results are compiled in table 2, which illustrates the quantity of food (in bites or contacts) taken by red deer in three studied forest areas during subsequent months. These data are grouped according to growth habit (biomorph class) of food plants.

In the first group, including trees and shrubs, deer feeding on representatives of 27 species and genera of trees and 18 species and genera of shrubs was noted. (Not in all cases observers identified the species of food plant on the base of bare shoots only and then the genus is gives). Among trees the greatest importance, as red deer food, have: *Pinus silvestris* L., *Quercus sessilis* Ehrh., *Salix caprea* L., *Carpinus betulus* L., *Sorbus aucuparia* L., then *Populus tremula* L., *Acer platanoides* L., *Picea excelsa* Lk., *Quercus robur* L., *Betula verrucosa* Ehrh., *Padus serotina* Ehrh., and *Prunus padus* L. Among shrubs the majority of food for the red deer provided: *Rubus idaeus* L. and *Corylus avellana* L., followed by *Frangula alnus* Mill., *Rubus caesius* L., *Juniperus communis* L., and *Berberis vulgaris* L.

The second group includes four dwarf-shrubs with following sequence of decreasing importance in food: *Vaccinium myrtillus* L., *Calluna vulgaris* (L.) Salisb., *Vaccinium vitis-idaea* L., and *V. uliginosum* L. The proportion of the latter, however, was negligible.

Table 2.
The composition of red deer food in annual cycle.

№	Species	Number of contacts or bites per season				Total
		Winter (XII, I, II)	Spring (III, IV, V)	Summer (VI, VII, VIII)	Autumn (IX, X, XI)	
1	2	3	4	5	6	7
TREES AND SHRUBS						
1.	<i>Pinus silvestris</i> L.					
	bark	1,954	916	—	33	
	twigs	43	52	55	36	
	together	1,997	968	55	69	3,089
2.	<i>Quercus sessilis</i> Ehrh.	—	2,670	249	30	2,949
3.	<i>Salix caprea</i> L. (twigs and leaves)	5	728	1,420	117	2,270
4.	<i>Carpinus betulus</i> L.	—	1,288	156	138	1,582
5.	<i>Sorbus aucuparia</i> L.	—	589	459	12	1,060
6.	<i>Quercus</i> sp.	—	—	945	1	946
7.	<i>Populus tremula</i> L.					
	bark	5	1	—	—	
	leaves and twigs	2	299	162	22	
	together	7	300	162	22	491
8.	<i>Acer platanoides</i> L.	—	2	4	410	416
9.	<i>Picea excelsa</i> Lk.					
	bark	281	76	—	—	
	twigs	15	—	—	—	
	together	296	76	—	—	372
10.	<i>Quercus robur</i> L. (twigs and leaves)	2	1	192	48	243
11.	<i>Betula</i> sp. (twigs and leaves)	—	48	81	49	178
12.	<i>Betula verrucosa</i> Ehrh. (twigs and leaves)	7	35	95	21	158
13.	<i>Padus serotina</i> Ehrh.	—	—	—	120	120
14.	<i>Prunus padus</i> L.	—	49	—	58	107
15.	<i>Betula pubescens</i> Ehrh.	—	—	12	79	91
16.	<i>Tilia cordata</i> Mill. (twigs)	1	61	27	—	89
17.	<i>Alnus</i> sp. (leaves)	—	—	54	—	54
18.	<i>Pinus strobus</i> L. (bark)	40	—	—	—	40
19.	<i>Pirus communis</i> L.	—	—	30	2	32
20.	<i>Prunus</i> sp.	—	—	26	—	26
21.	<i>Salix</i> sp.	—	20	—	—	20
22.	<i>Abies alba</i> Mill. (bark)	15	—	—	—	15
23.	<i>Fraxinus excelsior</i> L.	—	—	—	9	9
24.	<i>Fagus silvatica</i> L. (leaves and shoots)	1	6	—	1	8
25.	<i>Pinus Banksiana</i> Lam b.					
	bark	3	—	—	—	
	twigs	2	—	—	—	
	together	5	—	—	—	5
26.	<i>Malus silvestris</i> L.	—	5	—	—	5
27.	<i>Larix europaea</i> D.C. (twigs)	—	—	—	3	3
28.	<i>Rubus idaeus</i> L. (leaves and shoots)	19	411	536	48	1,014
29.	<i>Corylus avellana</i> L.					
	leaves and shoots	—	299	197	375	
	flower buds	—	—	—	140	
	together	—	299	197	515	1,011
30.	<i>Frangula alnus</i> Mill.					
	bark	2	1	—	—	
	shoots	54	25	300	4	
	together	56	26	300	4	386
31.	<i>Rubus caesius</i> L.	—	—	69	179	248

1	2	3	4	5	6	7
32.	<i>Juniperus communis</i> L.	143	13	—	71	227
33.	<i>Berberis vulgaris</i> L.					
	leaves and shoots	—	—	84	58	
	fruits	—	—	—	10	
	together	—	—	84	68	152
34.	<i>Rubus saxatilis</i> L.	—	9	3	81	93
35.	<i>Rubus</i> sp. (leaves and shoots)	3	3	87	—	93
36.	<i>Evonymus verrucosa</i> Scop. (leaves and shoots)	4	37	—	2	43
37.	<i>Salix cinerea</i> L. (shoots)	16	1	15	—	32
38.	<i>Crataegus monogyna</i> Jacq.	—	—	9	—	9
39.	<i>Viburnum opulus</i> L.	—	6	—	—	6
40.	<i>Daphne mezereum</i> L.	—	—	5	—	5
41.	<i>Rosa canina</i> L.	—	3	—	1	4
42.	<i>Cornus sanguinea</i> L.	—	1	—	—	1
43.	<i>Sambucus racemosa</i> L.	—	1	—	—	1
44.	<i>Rubus suberectus</i> Anders.	—	—	—	1	1
45.	Unidentified shoots	—	14	—	—	14
46.	Unidentified seedlings	—	6	—	—	6
Total		2,617	7,676	5,272	2,159	17,724

DWARF-SHRUBS

1.	<i>Vaccinium myrtillus</i> L.	876	894	595	354	2,719
2.	<i>Calluna vulgaris</i> (L.) Salisb.	411	74	5	2,111	2,601
3.	<i>Vaccinium vitis-idaea</i> L.	27	9	24	278	338
4.	<i>Vaccinium uliginosum</i> L.	4	3	—	—	7
Total		1,318	980	624	2,743	5,665

GRASSES, SEDGES, RUSHES

1.	<i>Calamagrostis arundinacea</i> L. (Roth.)	3	25	2	2,342	2,372
2.	<i>Carex digitata</i> L.	—	3	60	1,381	1,444
3.	<i>Poa trivialis</i> L.	—	661	—	—	661
4.	<i>Secale cereale</i> L.	1	208	—	312	521
5.	<i>Molinia coerulea</i> (L.) Moench.	3	2	192	282	479
6.	<i>Phleum pratense</i> L.	—	—	390	—	390
7.	<i>Carex</i> sp.	1	329	6	1	337
8.	<i>Dactylis glomerata</i> L.	—	216	—	—	216
9.	<i>Alopecurus geniculatus</i> L.	—	—	—	216	216
10.	<i>Festuca ovina</i> L.	12	—	—	138	150
11.	<i>Calamagrostis epigeios</i> (L.) Roth.	3	—	114	25	142
12.	<i>Deschampsia caespitosa</i> (L.) P.B.	9	88	35	1	133
13.	<i>Carex brizoides</i> L.	10	—	—	120	130
14.	<i>Deschampsia flexuosa</i> (L.) Trin.	29	—	—	82	111
15.	<i>Juncus effusus</i> L.	3	2	56	30	91
16.	<i>Arrhenatherum elatius</i> (L.) P.B.	—	—	84	—	84
17.	<i>Avena sativa</i> L.	—	2	60	—	62
18.	<i>Agrostis vulgaris</i> With.	—	—	12	50	62
19.	<i>Festuca rubra</i> L.	19	12	24	—	55
20.	<i>Festuca gigantea</i> (L.) Vill.	—	41	—	—	41
21.	<i>Dactylis</i> sp.	—	40	—	—	40
22.	<i>Anthoxanthum odoratum</i> L.	—	12	21	—	33
23.	<i>Poa pratensis</i> L.	—	32	—	—	32
24.	<i>Festuca pratensis</i> Huds.	2	—	24	—	26
25.	<i>Lolium perenne</i> L.	—	—	24	—	24
26.	<i>Carex panicea</i> L.	—	21	—	—	21
27.	<i>Juncus</i> sp.	12	—	—	2	14
28.	<i>Luzula pilosa</i> (L.) Willd.	—	2	—	11	13

1	2	3	4	5	6	7
29.	<i>Calamagrostis</i> sp.	—	10	—	—	10
30.	<i>Agrostis canina</i> L.	2	—	—	—	2
31.	<i>Agrostis stolonifera</i> L.	—	2	—	—	2
32.	<i>Poa pratensis</i> var. <i>angustifolia</i> L.	1	—	—	—	1
33.	<i>Sieglingia decumbens</i> (L.) Lam.	—	—	—	1	1
34.	Unidentified grasses	16	94	923	198	1,231
35.	Roots of grasses	—	—	—	5	5
36.	Hay on meadow	1	—	—	—	1
Total		127	1,802	2,297	4,927	9,153

FERNS

1.	<i>Dryopteris spinulosa</i> (Müll.) O. Kuntze	34	65	—	—	99
2.	<i>Dryopteris filix-mas</i> (L.) Schott.	—	1	42	24	67
3.	<i>Phegopteris dryopteris</i>	—	—	—	21	21
4.	<i>Athyrium filix-femina</i> (L.) Roth.	—	1	—	—	1
5.	Unidentified ferns	—	17	14	7	38
Total		34	84	56	52	226

MOSESSES AND LICHENS

1.	<i>Parmelia</i> sp.	1	—	8	216	225
2.	<i>Cladonia rangiferina</i> (L.) Web.	9	—	—	3	12
3.	<i>Entodon Schreberi</i> (Wild.) Mnk. m.	1	—	—	—	1
4.	<i>Dicranum scoparium</i> (L.) Hedw.	—	—	1	—	1
Total		11	—	9	219	239

FUNGI

1.	<i>Armillariella mellea</i> Karst.	—	—	—	185	185
2.	<i>Russula alutacea</i> Fr.	—	—	27	49	76
3.	<i>Lactarius volemus</i> Fr.	—	—	—	74	74
4.	<i>Paxillus involutus</i> Fr.	—	—	—	25	25
5.	<i>Marasmius alliaceus</i>	—	—	—	14	14
6.	<i>Amanita muscaria</i> Fr.	—	—	—	8	8
7.	<i>Boletus bovinus</i> Fr.	—	—	6	—	6
8.	<i>Lycoperdon perlatum</i>	—	—	—	4	4
9.	<i>Macrolepiota procera</i>	—	—	—	4	4
10.	<i>Leccinum scabrum</i> Fr.	—	—	1	2	3
11.	<i>Tricholoma portentosum</i>	—	—	—	3	3
12.	<i>Lactarius vellereus</i> Fr.	—	—	—	2	2
13.	<i>Boletus cyanescens</i> (Bull.) Fr.	—	—	—	1	1
14.	Unidentified fungi	—	—	8	11	19
Total		—	—	42	382	424

LYCOPODS AND HORSETAILS

1.	<i>Lycopodium clavatum</i> L.	—	—	—	12	12
2.	<i>Equisetum silvaticum</i> L.	—	2	—	—	2
3.	<i>Equisetum</i> sp.	1	—	—	—	1
Total		1	2	—	12	15

HERBS

1.	<i>Oxalis acetosella</i> L.	—	702	1,283	493	2,478
2.	<i>Hepatica nobilis</i> Garsault	—	148	620	142	910
3.	<i>Convallaria maialis</i> L.	—	620	131	3	754

1	2	3	4	5	6	7
4.	<i>Ajuga reptans</i> L.	—	193	424	35	652
5.	<i>Stellaria holostea</i> L.	—	525	1	83	609
6.	<i>Majanthemum bifolium</i> (L.) F. W. Schm.	—	334	206	2	542
7.	<i>Fragaria vesca</i> L.	—	173	273	69	515
8.	<i>Veronica officinalis</i> L.	—	—	17	439	456
9.	<i>Viola silvestris</i> Rchb.	—	66	164	50	280
10.	<i>Melampyrum pratense</i> L.	—	—	208	—	208
11.	<i>Galeobdolon luteum</i> Huds.	—	83	14	111	208
12.	<i>Plantago lanceolata</i> L.	—	—	180	—	180
13.	<i>Lupinus polyphyllus</i> Ldl.	—	—	—	180	180
14.	<i>Hieracium Lanchenalii</i> Gmel.	—	117	49	8	174
15.	<i>Ranunculus acer</i> L.	—	156	—	—	156
16.	<i>Trifolium repens</i> L.	—	—	123	—	123
17.	<i>Leontodon autumnalis</i> L.	—	—	120	—	120
18.	<i>Anemone nemorosa</i> L.	—	111	—	—	111
19.	<i>Asperula odorata</i> L.	—	46	11	51	108
20.	<i>Lychnis flos-cuculi</i> L.	—	108	—	—	108
21.	<i>Ranunculus</i> sp.	—	101	—	—	101
22.	<i>Hieracium pilosella</i> L.	—	54	41	5	100
23.	<i>Mycelis muralis</i> (L.) Dum.	—	37	59	1	97
24.	<i>Filipendula ulmaria</i> (L.) Maxim.	—	—	95	—	95
25.	<i>Trifolium pratense</i> L.	—	—	83	—	83
26.	<i>Trifolium</i> sp.	—	—	27	53	80
27.	<i>Angelica silvestris</i> L.	—	21	56	—	77
28.	<i>Peucedanum palustre</i> (L.) Moench.	—	68	—	—	68
29.	<i>Chrysanthemum leucanthemum</i> L.	—	68	—	—	68
30.	<i>Lathyrus silvester</i> L.	—	—	67	—	67
31.	<i>Sonchus oleraceus</i> L.	—	8	57	1	66
32.	<i>Aegopodium podagraria</i> L.	—	13	46	—	64
33.	<i>Galium palustre</i> L.	—	60	—	—	60
34.	<i>Potentilla Tormentilla</i> Neck.	—	26	29	1	56
35.	<i>Galium</i> sp.	—	30	18	—	48
36.	<i>Polygonatum multiflorum</i> (L.) All.	—	46	—	—	46
37.	<i>Hypericum</i> sp.	—	—	39	—	39
38.	<i>Glechoma hederacea</i> L.	—	38	—	—	38
39.	<i>Polygonatum officinale</i> All.	—	—	36	—	36
40.	<i>Polygonatum odoratum</i> (Mill.) Druce	—	—	33	—	33
41.	<i>Betonica officinalis</i> L.	—	—	28	—	28
42.	<i>Polygonum</i> sp.	—	—	24	3	27
43.	<i>Trientalis europaea</i> L.	—	—	10	12	22
44.	<i>Lamium</i> sp.	—	20	—	—	20
45.	<i>Moehringia trinervia</i> (L.) Clairv.	—	2	—	17	19
46.	<i>Lathyrus</i> sp.	—	—	18	—	18
47.	<i>Galium silvaticum</i> L.	—	—	17	—	17
48.	<i>Rumex acetosella</i> L.	—	—	14	3	17
49.	<i>Polygonatum</i> sp.	—	—	15	—	15
50.	<i>Lysimachia thyrsoflora</i> L.	—	—	15	—	15
51.	<i>Lotus uliginosus</i> Schk.	—	—	15	—	15
52.	<i>Rumex</i> sp.	—	14	—	—	14
53.	<i>Plantago maior</i> L.	—	—	14	—	14
54.	<i>Urtica dioica</i> L.	—	—	10	2	12
55.	<i>Achillea millefolium</i> L.	—	3	8	—	11
56.	<i>Scorzonera humilis</i> L.	—	11	—	—	11
57.	<i>Galium mollugo</i> L.	—	4	5	—	9
58.	<i>Veronica</i> sp.	—	9	—	—	9
59.	<i>Meum mutelina</i> (L.) Gaettn.	—	9	—	—	9
60.	<i>Anagalis</i> sp.	—	—	7	—	7
61.	<i>Sarothamnus scoparius</i> (L.) Wimm.	—	—	—	6	6
62.	<i>Trifolium alpestre</i> L.	—	6	—	—	6
63.	<i>Lathyrus vernus</i> (L.) Bernh.	—	6	—	—	6

1	2	3	4	5	6	7
64.	<i>Lysimachia vulgaris</i> L.	—	—	6	—	6
65.	<i>Potentilla erecta</i> (L.) Humpe.	5	—	—	—	5
66.	<i>Anthyriscus silvestris</i> (L.) Hoffm.	—	—	5	—	5
67.	<i>Chrysosplenium alternifolium</i> L.	—	4	—	—	4
68.	<i>Achillea</i> sp.	—	4	—	—	4
69.	<i>Asarum europaeum</i> L.	—	1	—	3	4
70.	<i>Hypericum perforatum</i> L.	—	—	4	—	4
71.	<i>Carduus</i> sp.	—	—	3	—	3
72.	<i>Scirpus silvaticus</i> L.	—	2	—	—	2
73.	<i>Stellaria graminea</i> L.	—	2	—	—	2
74.	<i>Vicia</i> sp.	—	—	2	—	2
75.	<i>Campanula trachelium</i> L.	—	—	2	—	2
76.	<i>Chamaenerion angustifolium</i> (L.) Scop.	—	—	2	—	2
77.	<i>Campanula persicifolia</i> L.	—	—	2	—	2
78.	<i>Veronica chamaedrys</i> L.	—	—	2	—	2
79.	<i>Cirsium lanceolatum</i> (L.) Scop.	1	—	—	—	1
80.	<i>Polygonum bistorta</i> L.	1	—	—	—	1
81.	<i>Caltha palustris</i> L.	—	1	—	—	1
82.	<i>Carduus nutans</i> L.	—	—	1	—	1
83.	<i>Clinopodium vulgare</i> L.	—	—	—	1	1
84.	<i>Stachys silvatica</i> L.	—	—	—	1	1
85.	<i>Potentilla alba</i> L.	—	—	—	1	1
86.	<i>Coronilla varia</i> L.	—	—	—	1	1
87.	<i>Thymus</i> sp.	—	—	—	1	1
88.	Unidentified herbs	—	5	37	4	46
Total		7	4,060	4,776	1,782	10,625
OTHER						
1.	<i>Typha</i> sp.	2	—	—	—	2
REMAINING						
1.	<i>Pinus silvestris</i> L. (bark from stump)	—	—	15	—	15
2.	<i>Pinus silvestris</i> L. (dry twigs)	—	—	11	—	11
3.	<i>Pinus silvestris</i> L. (dry leaves)	—	—	8	—	8
4.	<i>Pinus silvestris</i> L. (root phloem)	—	—	6	—	6
5.	<i>Pinus silvestris</i> L. (rotten wood)	—	—	2	—	2
Total		—	—	42	—	42
Grand total		4,117	14,604	13,118	12,276	44,115

The third group — grasses, sedges, and rushes — included 33 species and genera of red deer food plants. The following two were taken most frequently: *Calamagrostis arundinacea* L. (Roth.) and *Carex digitata* L., besides of them: *Poa trivialis* L., *Secale cereale* L., *Molinia coerulea* (L.) Moench., *Phleum pratense* L., unidentified sedges, *Dactylis glomerata* L., *Alopecurus geniculatus* L., *Festuca ovina* L., *Calamagrostis epigeios* (L.) Roth., *Deschampsia caespitosa* (L.) P. S., *Carex brizoides* L., and *Deschampsia flexuosa* (L.) Trin.

Among ferns four species were recorded. Only *Dryopteris spinulosa* (Müll.) O. Kuntze was relatively most often eaten.

From the subsequent group of mosses and lichens, including also four species, only lichens from *Parmelia* group had some importance as the red deer food.

Among thirteen species of mushrooms the honey fungus (*Armillariella mellea* Karst.) was eaten most frequently.

Lycopods and horsetails only on few occasions were found in the diet of red deer.

Table 3.

General analysis of variance for the empiric material presented in table 2.

Variation	Sums of squares	Degrees of freedom	Variance	F _{emp.}	F _{0.01}
Plant groups	6471.4966	4	1617.87	9.01 ⁺⁺	3.83
Seasons	158.6261	3	52.88	< 1	4.31
Plant groups × seasons	6024.2236	12	502.02	2.80 ⁺⁺	2.66
Error	7183.9337	40	179.60		
Total	19838.2800	59			

Table 4.

Analysis of variance for the composition of red deer food according to seasons.

Source of variation		Sum of squares	Degrees of freedom	Variance	F _{emp.}	F _{0.05}
Plant groups	Winter	5661.7934	4	1415.50	5.86 ⁺⁺	3.48
	Spring	3041.8177		760.45	3.31	
	Summer	2903.1473		725.79	7.35 ⁺⁺	
	Autumn	888.9618		222.40	1.99	
Error	Winter	2417.4935	10	241.75		
	Spring	2299.2953		229.93		
	Summer	986.9111		98.69		
	Autumn	1120.2338		112.02		
Total	Winter	8079.2869	14			
	Spring	5701.1130				
	Summer	3890.0584				
	Autumn	2009.1956				

The group of dicotyledonous plants (herbs) includes not less than 87 species and genera. *Oxalis acetosella* L. was most frequently eaten and was followed by: *Hepatica nobilis* Garsault, *Convallaria maialis* L., *Ajuga reptans* L., *Stellaria holostea* L., *Majanthemum bifolium* (L.) F. W. Schm., *Fragaria vesca* L., *Veronica officinalis* L., *Viola silvestris*

Rchb., *Melampyrum pratense* L., *Galeobdolon luteum* Huds., *Plantago lanceolata* L., *Lupinus polyphyllus* Ldl., *Hieracium Lanchenalii* Gmel., *Ranunculus acer* L., *Trifolium repens* L., *Leontodon autumnalis* L., *Anemone nemorosa* L., *Asperula odorata* L., *Lychnis flos-cuculi* L., unidentified crowfoot, and *Hieracium pilosella* L.

For empiric data presented in table 2 there have been calculated per cent proportions of individual groups of food plants in relation to the total of observations in the definite season of year and these per cents were transformed into Bliss angles. For these values the analysis of variance was carried out in order to find, if differences in the composition of red deer food during individual seasons of year are significant.

Table 5.

Analysis of variance for the composition of red deer food according to five groups of food plants.

Plant groups	Variation	Degrees of freedom	Sums of squares	Variance	F _{emp.}
Trees and shrubs	seasons	3	765.85	255.28	0.74*)
	error	8	2772.16	346.52	
	total	11	3538.01		
Dwarf-shrubs	seasons	3	1779.63	593.21	2.24
	error	8	2120.76	265.10	
	total	11	3900.39		
Grasses, sedges, and rushes	seasons	3	1481.65	493.88	5.82+
	error	8	678.82	84.85	
	total	11	2160.47		
Dicotyledonous plants	seasons	3	1992.26	664.09	3.54
	error	8	1498.87	187.36	
	total	11	3491.13		
Remaining	seasons	3	163.46	54.49	3.85
	error	8	113.30	14.16	
	total	11	276.76		

*) $F_{0.05} = 4.07$

The general analysis of variance (Table 3) revealed the high significance of difference at the confidence level 0.01 for plant groups, as well as for the cooperation: plant groups \times seasons.

In this connection the analysis of variance in a pattern splitted into four seasons of a year (Table 4) has been carried out. It revealed highly significant differences among plant groups during two seasons: winter and summer.

There have been carried out, moreover, five analyses of variance for plant groups (Table 5). These analyses revealed a significant differentiation for one of groups, namely for grasses, sedges, and rushes.

Afterwards means within each season have been classified into homogenous groups in order to compare them with the aid of Student's *t*-test at the confidence level of 0.05. Table 6 contains these data. In this table besides of Bliss angles there are given per cent values for proportions of individual groups of plant species, which were obtained after the retransformation of angle values into per cents unbiased with the unequal number of observations within individual seasons (see Table 1). In the last column of table 6 there are given lowest significant differences for the comparison of interrelationship among plant groups ($t \cdot S_r$).

Table 6.

Comparison of means of the proportion of individual groups of food plants during four seasons of a year.

Bliss angles (1) and per cents (2) for different groups of plants are summarised.

Groups of plants		Season					$t \cdot S_r$
		Winter	Spring	Summer	Autumn	All year	
Trees and shrubs	1	46.90	47.32	38.18	27.72	40.03	34.97
	2	53.30	54.05	38.20	21.65	41.40	
Dwarf-shrubs	1	40.81	17.60	7.19	22.83	22.11	30.66
	2	42.71	9.15	1.57	15.05	14.20	
Grasses, sedges, rushes	1	7.94	15.23	26.04	37.32	21.63	17.50
	2	1.91	6.90	19.30	36.75	13.60	
Dicotyledonous plants	1	1.15	26.04	36.58	22.91	21.67	25.77
	2	0.04	19.30	35.50	15.15	13.64	
Remaining	1	4.84	4.92	5.85	13.68	7.32	7.08
	2	0.71	0.74	1.05	5.60	1.62	
$t \cdot S_r$		28.3	27.6	18.0	19.2	22.13	

The relationship between the proportion of individual groups of food plants in the diet of red deer and the season is illustrated by figure 1. In this figure values of Bliss angles have been plotted on the axis of ordinates, while subsequent seasons of year — on the axis of abscissae. The height of vertical lines presents the value of the lowest significant difference ($t \cdot S_r$) for the comparison of interrelationship within individual seasons.

The most important group of browse plants are trees and shrubs, the proportion of which in the total food of deer on an annual

basis exceeds 41%. Trees and shrubs provide the browse mainly in a form of bark and twigs during winter and young, tender foliage and shoots during spring and early summer. The contribution of this group to the annual diet of red deer reveals the peak during winter and spring periods (53—54%), followed by a decline during summer (ca 38%) down to the minimum occurring in autumn (almost 22%).

Next three groups of food plants show rather uniform proportion on annual basis (13—14%), while considerable differences in their seasonal pattern.

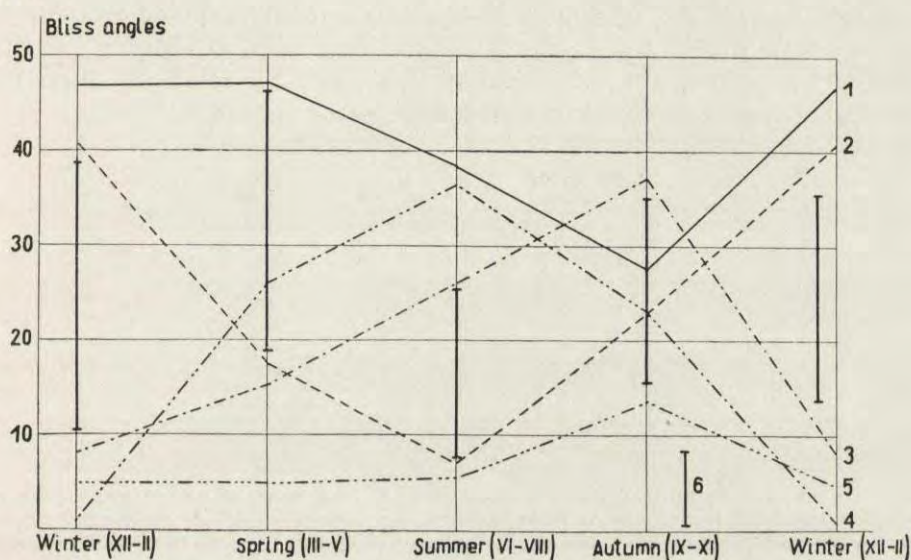


Fig. 1. Relationship between the proportion of food plant groups and season. 1 — trees and shrubs; 2 — dwarf-shrubs; 3 — grasses, sedges, rushes; 4 — herbs; 5 — remaining; 6 — average interval for the comparison of coefficient ($t \cdot S_r$).

The general proportion of dwarf-shrubs in red deer diet amounts to more than 14% on annual basis. The maximal consumption of plants from this group occurs in autumn and winter seasons (22 up to almost 43% of the total food). During spring there occurs a rapid drop to 9%, while minimum occurs in summer with the level of nearly 2% of dwarf-shrub proportion in red deer diet.

The subsequent group of food plants — grasses, sedges, and rushes — contributes on annual basis in almost 14% to the diet of red deer. It reveals a distinctly seasonal pattern of occurrence. Its minimum occurs in winter (almost 2% of the winter food) and since then the proportion of these plants consistently rises to 7% in spring, 19% in summer, and reaches the maximum in autumn, when grasses, sedges, and rushes provide nearly 37% of red deer diet.

The total proportion of dicotyledonous plants (herbs) in the annual diet of red deer amounts also to circa 14%. This group reveals quite distinct seasonal distribution, resulting obviously from the phenology of their development and growth. From a sporadic occurrence in deer diet during winter their proportion increases to more than 19% during spring, reaches its maximum in summer, when herbs comprise more than 35% of the food taken by observed deer, and drops down to 15% during autumn.

The contribution of remaining groups of food plants in red deer diet amounts to circa 2% on annual basis. During winter, spring and autumn it fluctuates within the level of 1% and it is only in autumn, when it reaches more than 5%, what can be explained by relatively high proportion of mushrooms in the autumnal diet of red deer.

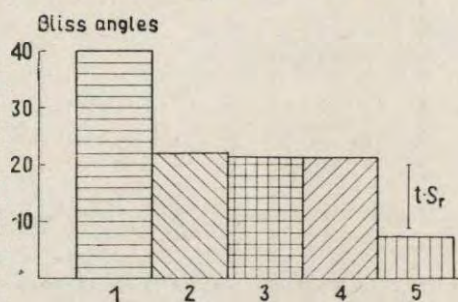


Fig. 2. Comparison of unbiassed means of the proportion of plant groups in the annual food of red deer.
1 — trees and shrubs; 2 — dwarf-shrubs; 3 — grasses, sedges, rushes; 4 — herbs;
5 — remaining.

An analysis of the course of curves on figure 1 proves a close relationship between the diet of red deer and a season of year during winter and spring, while loose relation between these two variables during summer and autumn.

The figure 2 is an illustration of data from the table 6. Here also for the comparison of proportions between plant groups values of Bliss angles have been used. The average interval (the smallest significant difference) for the comparison of mean proportions ($t \cdot S_r$) amounts here to 11.03. Using this interval one can find that in the annual diet of red deer there decidedly dominate the group of trees and shrubs, which significantly surpasses in numbers three following groups: dwarf-shrubs, graminids, and herbs. These mentioned three groups of food plants reveal negligible differences in their proportions in the annual diet with each other, while significant domination, in turn, over the fifth group, which consisted of all other categories of deer food.

Winter food of red deer characterizes itself with a decided prevalence of browse coming from trees and shrubs (their bark and twigs), which comprise more than 53% of the seasonal total. This is considerably less, when compared with the value obtained with the use of tracking techniques only, where this group presented 85% of the winter food (Dzięciołowski, 1967b). Dwarf-shrubs presented the second group in respect to numbers. They contributed in 43% to the winter food. This is, in turn, four times more, when compared with results of the mentioned paper (Dzięciołowski, 1967b) where this pro-

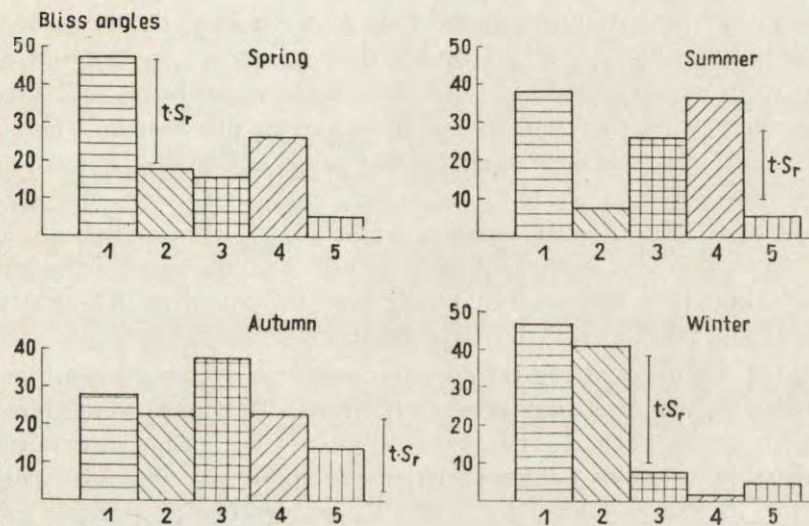


Fig. 3. Comparison of unbiased means of the proportion of plant groups within individual seasons. Denotations as on figure 2.

portion amounted to ca 10% of the winter diet. Interesting enough, that the total of both these groups of food plants in both cases amounted to 95—96% and for remaining groups only 4—5% of the total number of observations is left. These differences result from the fact of the use of two research methods at present (tracking in snow plus direct observations of wild deer), from somewhat different time (in the cited paper on winter tracking the whole period of snow cover prevalence was included — from November until March, while in the present material only three winter months, i. e. December, January and February), as well as from the use of per cents unbiased by the unequal number of observations in the present material (the number of observational units for winter season amounts to ca 4 thousands of observations, while for

spring — to 15 thousands, for summer — 13 thousands, and for autumn — 12 thousands). The remaining 4% consisted of grasses, sedges, and rushes, ferns, mosses, lichens, lycopods, and horsetails (Fig. 3). From this figure it results that in the winter food of red deer there dominate two groups of food plants (trees and shrubs, and dwarf-shrubs), which in a highly significant way prevail in numbers over all other groups of food plants.

The most important group of food plants in the spring food are again trees and shrubs, which proportion is increased to 54%. This is connected with the development of young, tender foliage, which at this season of year presents a preferred food of deer. The advancing development of herbaceous vegetation causes that it appears in the diet of red deer in rather high per cent (19%). The third place is taken by dwarf-shrubs comprising some 9% of red deer diet at this season. The contribution of graminids is expressed by the value of 7% of the total spring food. In negligible amounts there occur, moreover, ferns and sporadic lycopods and horsetails. It results from figure 3 that significant differences occur between the group of trees and shrubs, which are dominant in the spring diet, and all remaining groups, except of dicotyledonous plants, which take an intermediate position.

Summer food of red deer is characteristic by the drop in per cent proportion of browse from trees and shrubs. They represent, however, still the most numerous group of food plants with the contribution of more than 38% to the total quantity of food. Herbs are only slightly lower and as a group they increased their per cent proportion in deer diet since the spring period from 18 to 36%. The proportion of grasses, sedges, and rushes from 7% at spring increased to more, than 19% in summer. These three groups of plants (trees and shrubs, herbs, and graminids) comprise in summer about 93% of red deer food. The remaining 7% consists of dwarf-shrubs (ca 2%), ferns and mushrooms. Three groups of food plants, namely: trees and shrubs, grasses and grass-like plants, and herbs do not reveal any significant differences in their mutual proportions, but they significantly prevail in numbers over two remaining groups.

Autumnal food differs significantly from the food taken in other seasons of year. The fundamental difference is the fact that the most important group represent here grasses, sedges, and rushes, which comprise almost 37% of the food taken by red deer during this season of year. The second position is occupied by trees and shrubs, which proportion reaches almost 22% of the total food. Dwarf-shrubs and herbs reveal an equal proportion (ca 15% each) in the autumnal food of red deer.

These four groups form jointly 89% of the autumnal diet. Among remaining groups of food plants the high proportion of mushrooms attracts the attention. The consumption of mushrooms reaches during autumn its annual peak. There are taken, besides, mosses and lichens, sporadic ferns, lycopods and horsetails. In the autumnal diet the proportion of individual groups of food plants has the most uniform character and even the difference between values for the two extremal groups, namely graminids and the group of »remaining« food plants, has insignificant character.

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POKARM JELENIA SZLACHETNEGO W CYKLU ROCZNYM

W oparciu o ponad dwuletnie badania terenowe prowadzone na trzech reprezentatywnych dla lasów Polski niżowej terenach doświadczalnych, przy zastosowaniu trzech metod badawczych uzyskano obfity materiał obserwacji (tabela 1) pozwalający na stosunkowo pełną charakterystykę składu pokarmu jeleni, *Cervus elaphus* Linnaeus, 1758 w cyklu rocznym.

W wyniku badań stwierdzono żerowanie jeleni na: 27 gatunkach i rodzajach drzew, 17 gatunkach krzewów, 4 gatunkach krzewinek, 33 gatunkach i rodzajach traw, turzyc i sitów, 4 gatunkach paproci, 4 gatunkach mchów i porostów, 13 gatunkach grzybów, 3 gatunkach widłaków i skrzypów, 87 gatunkach i rodzajach roślin dwuliściennych, ogółem na 192 gatunkach roślin (tabela 2).

Oprócz zestawienia listy roślin żerowych uzyskany materiał pozwolił na charakterystykę stosunków ilościowych pomiędzy wyodrębnionymi grupami roślin w poszczególnych porach roku (tabela 6).

Stwierdzono, że na zimowy pokarm jeleni (ryc. 3) w badanych środowiskach składają się kora i pędy drzew i krzewów (53% całości pokarmu zimowego) oraz krzewinki (43%), które stanowią łącznie 96% pokarmu. Skład pokarmu zimowego jest stosunkowo mało urozmaicony, co wynika z niedostępności wielu składników runa i roślin uprawnych.

Na pokarm jeleni wiosną (ryc. 3) składają się: drzewa i krzewy (54%), rośliny dwuliścienne (19%), krzewinki (9%) oraz trawy, turzycy i sity (7%). Wzrasta znacznie rozmaitość pokarmu dzięki rozwojowi roślinności runa leśnego i młodych pędów drzew i krzewów.

W pokarmie letnim jeleni (ryc. 3) przeważają nadal pędy drzew i krzewów (38%), udział roślin dwuliściennych osiąga swoje maksimum roczne (36%) a udział traw i roślin trawopodobnych sięga 19%. W sumie te trzy grupy roślin stanowią około 93% pokarmu jeleni latem.

Skład pokarmu jeleni jesienią (ryc. 3) wykazuje największe różnice w stosunku do pokarmu w pozostałych porach roku. W pokarmie jesiennym przeważają trawy, turzycy i sity (około 37% ogólnej ilości), które wówczas osiągają swoje maksimum udziału w pokarmie jeleni. Następną grupą roślin żerowych są drzewa i krzewy (22%), dalej krzewinki (15%) i rośliny dwuliścienne (również 15%). Te cztery grupy stanowią łącznie 89% jesiennego pokarmu. Stosunkowo wyrównany udział czterech zasadniczych grup roślin żerowych w jesiennym pokarmie jeleni sprawia, że skład pokarmu w tej porze roku jest najbardziej urozmaicony (ryc. 1).

Przedstawiona charakterystyka naturalnego pokarmu jeleni w cyklu rocznym (ryc. 2) może dostarczyć podstaw do klasyfikacji zbiorowisk leśnych pod kątem ich użyteczności dla hodowli jeleni i innych dużych przeżuwaczy. Problem ten jest przedmiotem dalszych, intensywnych badań.