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PRIMARY PRODUCTION OF THE HERB LAYER AND PLANT FALL IN A DRY PINE FOREST (*CLADONIO-PINETUM* KOBENDZA 1930) IN THE KAMPINOS NATIONAL PARK

(Ekol. Pol. 18: 393:409). Herb layer production, moss and lichen biomass, and the plant fall from trees and shrubs was studied in *Cladonio-Pinetum* Kobendza 1930 association in the Kampinos National Park near Warsaw in 1967.

These investigations fom part of an extensive research programme on the biological production of terrestrial ecosystems, carried out in a large number of forest associations in northern Poland by the Institute of Ecology, under the International Biological Programme.

INTRODUCTION AND DESCRIPTION OF THE STUDY AREA

Within a complex research programme on biological production carried out in a large number of forest associations by the Institute of Ecology, Polish Academy of Science, under the International Biological Programme, I endeavoured to estimate the production of herb layer and plant fall in a dry pine forest. These studies include not only chosen elements of primary production but also secondary production of small rodents feeding on this primary production.

Dry pine forest (*Cladonio-Pinetum* Kobendza 1930)

Tab. I

Successive number of the record	1	2	3	4	5	6	7	8
Cover of the tree layer (%)	20	15	25	45	35	25	50	25
" " " shrubs " "	5	5	10	5	20	20	20	5
" " " herb " "	30	40	35	25	25	50	50	20
" " " moos " "	30	50	25	50	70	70	45	40
" " " lichens " "	60	40	10	10	15	15	.	+
Number of the species	12	15	15	15	21	16	18	10
" " " vascular plants species	7	8	9	8	15	11	14	10
Trees:								
Pinus silvestris L. a_1	2.1	2.1	2.3	3.4	3.4	2.3	4.4	2.1
" " a_2		+	1.2	1.1	2.2	2.2	1.2	
" " *b*		+	+		+	+	1.1	
" " *c*	+	1.1		+			+	+
Quercus robur L. a_2								2.1
" " *b*	1.1	1.1		1.1	2.1	2.1	1.1	1.1
" " *c*	1.1	1.1	2.1	2.1	1.1	1.1	2.1	
Populus tremula L. *b*					+			
" " *c*					+		1.1	
Betula verrucosa Ehrh. *b*			2.1					
Species characteristic and differential of the association								
Festuca ovina L.	3.2	2.2	1.2	1.2	2.2	2.2	1.2	1.2
Cladonia sylvatica (L.) Rabenh.	2.2	2.2	1.2	1.2	1.2	1.2		
C. rangiferina (L.) Web.	3.2	3.3	1.2	1.2	1.2	1.2		

Luzula multiflora (Retz.) Lej.		1.2	1.2		1.2	+	+	+
Dicranum scoparium Hedw.	2.2	+	1.2	2.2				
Carex ericetorum Poll.	1.2	1.2	+			+	+	
Cladonia cornuta (L.) Schaer.	1.2	+	+	1.2				
C. deformis (L.) Hoffm.			+.2	+.2				
Agrostis canina L. var. *arida*	1.2							
Rumex acetosella L.								1.2
Species characteristic of the alliance, order and class *Vaccinio-Piceetea*								
Melampyrum pratense L.			2.1	+	2.1	3.1	1.1	
Dicranum undulatum Ehrh.		1.2			2.2	1.1	2.2	
Vaccinium myrtillus L.				2.3	+		2.3	1.2
V. vitis idaea L.							3.2	
Accompanying species								
Juniperus communis L.		1.1	2.1	1.1	2.1	2.1	2.1	1.1
Calluna vulgaris (L.) Salisb.	1.2	2.3	3.3	1.3	2.3	2.3	2.3	1.2
Entodon Schreberi (Wild.) Mnkm.	1.2	3.3		3.3	4.4	4.4	3.3	
Convallaria maialis L.				1.3		3.3	1.3	1.2
Hylocomium splendens (Hedw.) Br. eur.					1.1	2.3	1.1	
Cladonia furcata (Huds.) Schrad.			+.2	+.2	+.2		+.2	
Peucedanum oreoselinum (L.) Moench					1.1		1.1	
Polygonatum odoratum (Mill.) Druce					+	1.1		
Agrostis vulgaris With.						2.2	2.2	
Hieracium pilosella L.	1.3							
Ceratodon purpureus Brid.		+						
Cytisus nigricans L.		+						
Genista tinctoria L.					+			
Solidago virga-aurea L.					+			
Calamagrostis epigeios					+			
Hypericum perforatum L.								1.2

I carried out my investigations within a large area of pine forests in the eastern part of the Kampinos Forest (Nowy Dwór Mazowiecki administrative district, Warsaw voivodship). The study area is situated at the foot of a very large parabolic dune called Wywrotnia Góra, on the side of its gentle windward slope. The terrain is not uniformly flat – there are little hillocs and hollows – and the whole area is gently sloping westward. Under the circumstances, both habitat conditions and vegetation are differentiated to some extent within the range of six hectares; the size of area under study is determined by the investigations on rodents.

The soil in the study area consists of loose dune sands, somewhat fine-grained, without raw humus horizon and with low humus content. It contains a very small amount of food components and is acid. It is very dry in summer, since it is formed from deep sands. It would seem that water is the chief limiting factor in this habitat, especially for herb layer vascular plants with shallow roots.

The study area has a thin cover of pine forest; the average height of the pine trees is about 12 m. The oak trees, *Quercus robur*, occur occasionally, their number being larger in the northern part; there are several birches in one of the depressions. Tree-crown cover is neither dense nor uniform (25–60%), and there are places completely devoid of trees. The undergrowth is scanty, and consists chiefly of juniper bushes and young oak trees which, although very scantily represented in the tree layer, sprout again and grow back afresh better than pine.

Herb layer cover is poor and varies greatly, from 20 to 50%, with an average of 25%; it is only in certain depressions that there are occasional compact patches of heather. Apart from the pine-tree crowns, the moss and lichen layer is the best developed layer of vegetation in this forest; taken together its cover varies from 30 to 80%, with an average of 50%. There are, however, some places closely covered by a dense moss carpet and patches of almost bare earth. Mosses play a far more important role than lichens in this layer, particularly in lower and more shaded places. Lichens form considerable patches in places, and occur almost everywhere in small amounts.

The species composition and structure of the vegetation in the study area are illustrated by the table of phytosociological records (Tab. I). The analysis of the table shows that the forest associations covering the study area should be considered as belonging mainly to the *Cladonio-Pinetum* Kobendza 1930 association (Kobendza 1930; Traczyk H., Traczyk T. 1964[1]). The relatively extensive patches of *Vaccinio myrtilli-Pinetum* association (see Tab. I – record no. 7) occurring in depressions form a complex of several variants of pine forest; this increases the mosaic character of the habitat examined.

[1] Phytosociological description of the reservations in the National Park of Kampinos (msc.) in the Direction of the National Park of Kampinos.

The mosaic character is manifested in the configuration of the area, in the different density of the tree stand and – the most important point in these studies – in the highly mosaic character of distribution of species in the lower layers of vegetation – both the herb layer and the moss and lichen layer.

STUDY METHODS

I carried out my investigations on the primary production of a dry pine forest by the method proposed by Traczyk (Traczyk T. 1967a, 1967b); some slight deviations from this method were necessitated chiefly by the poverty of the plant cover in the habitat under study.

Analysis of increase in mass of the above-ground parts of herb layer plants and density of individuals was made solely in relation to vascular plants. The standing crop biomass of mosses and lichens was evaluated only on the days on which I carried out the examinations.

In these investigations, the biomass produced by individual species was used as the initial value for calculation of the herb layer biomass produced during one year. The annual production of individual herb layer species, i.e. the biomass produced by them in 1967, was determined by multiplying the average growth of individuals of each species by its average density in the study area.

I defined density twice: on July 25th and 26th, and on September 5th and 6th 1967. On each of these dates I took samples by throwing at random a hoop covering an area of 0.1 m²; within the hoop I found the number of individual plants, above ground shoots or clumps of particular species of vascular plants, depending on their life forms. I listed the data collected on these two dates, jointly, since they differed very little from each other. I calculated the density of particular species of vascular plants on the basis of 200 samples.

For the purpose of estimating organic production, I used only samples which occured with relatively large frequency in the study area. In order to select these species I calculated their frequencies (in percentages) from 200 samples collected for definition of density of species. My estimate of the primary production of the herb layer is based on species with the frequency higher than 1%.

The average increase in the mass of individuals for the various species of vascular plants was calculated on the basis of samples taken in amounts approximately proportional to their density in the study area. With the majority of species I carried out sampling in July at the same time as the hoop samples for density, and for four species *Vaccinium vitis idaea*, *Melampyrum pratense*, *Calluna vulgaris* and pine seedlings in September, also on hoop sampling days. I dried the samples (at 85°C for 48 hours) and weighed them with accuracy to 0.001 g.

I carried out additional investigations in relation to *Festuca ovina*, the only plant fructifying abundantly in the herb layer of the study area in 1967. In order to define its density I selected four places differing markedly in the herb layer and in each of them, I threw at random 40 squares measuring 1 m^2 in area. Within these 160 squares I counted all clumps of the species in question and all the fruiting stalks, obtaining in this way their average density per 1 m^2 of the forest floor. I also took samples of the panicles with mature caryopses in order to determine the fruit biomass. As it was difficult to separate the husk from the grain, I estimated the fruit production of this species with grains unhusked.

I determined moss biomass in the following way. When laying out hoops to determine the density of vascular plants I collected all the mosses and lichens found within these hoops and, at the same time, defined their degree of cover. I dried and weighed both mosses and lichens, without segregating them into species. I calculated the mean value of moss and lichen biomass per 1 m^2 on the basis of 200 samples taken on two different dates.

On the whole, I used the method given by Traczyk (1967b) for estimating the extent of plant fall. I laid out 25 metal hoops 0.1 m^2 in area at random in different places, and left them permanently on ground cleared of litter and plants. I took samples at intervals of 1–2 months, with a longer gap during the winter period (from December to April). On account of the differences in intervals between the various samples, I converted the plant fall values obtained, into mean daily values for the periods between samplings.

RESULTS

Floristic composition

The floristic composition (Tab. I) of the herb layer in the area of the pine forest under study is very poor. Although I found as many as 24 species over the whole 6-hectare area with a mosaic structure, 11 of this number were species occurring only sporadically. Individual records (corresponding to the area of 100 m^2) gave only 7–15 species each in the herb layer, and only 7–8 in places representing typical dry pine forest. It was only the sum total of species from several records made in different parts of the study area (that is, from several hundred square metres), which exceeded the number of species found in 200 random samples measuring 0.1 m^2 in area (17 species).

The floristic list of the association is lengthened by the mosses and lichens commonly occuring there. The list of these plants in the phytosociological table does not, however, pretend to be exhaustive, neither can it be compared with the results of sampling for frequency of vascular plants

Frequency, density and biomass production of herb layer (Dry pine forest (*Cladonio-Pinetum*) in Old Kampinos Forest)

Tab. II

Plant species	Fre-quency	Average density D		No.	Individual average increase	Net production – P in g/10 m²			
		per 10 m²	%			v + f	common	%	% cum.
Calluna vulgaris	21	354	48	200	0.2270	80.4715	80.4715	45.5	45.5
Convallaria maialis	14	52	7	60	0.8404	44.1210	44,1210	24,9	70.4
Festuca ovina (veg.)	14	35	5	70	0.2687	9.4045	15.8503	9.0	79.4
" " (fruct.)	6	20	3	40	0.3228	6.4558			
Vaccinium vitis idaea	12	122	16	100	0.0906	11.0532	11.0532	6.2	85.6
V. myrtillus	6	76	10	100	0.1241	9.3722	9.3722	5.3	90.9
Melampyrum vulgatum	17	44	6	50	0.2107	9.3782	9.3782	5.3	96.2
Carex ericetorum	4	13	2	30	0.2486	3.2325	3.2325	1.8	98.0
Quercus robur (seedl.)	4	4	1	10	0.3511	1.5800	1.5800	0.9	98,9
Pinus silvestris (seedl.)	6	8	1	20	0.0524	0.4450	0.4450	0.3	99.2
Genista tinctoria	1	4	1	10	0.1375	0.5500	0.5500	0.3	99.5
Calamagrostis epigeios	2	2	1	5	0.1960	0.4900	0.4900	0.3	99.8
Luzula multiflora	2	2	1	5	0.1175	0.2350	0.2350	0.1	99.9
Polygonatum odoratum	2	2	1	5	0.1300	0.2600	0.2600	0.1	100.0

since both mosses and lichens have been treated jointly in these samples (only their mass, and not frequency of species, was evaluated)..

Frequency of species

The frequency values obtained for herb layer species (ratio of full samples to total number of samples expressed in percentages) have been set out in Table II. It can be easily seen that these values are very low. In the case of one species only freqency is expressed by a figure slightly higher than 20%, and while the following four occur with the frequency higher than 10%, the remaining species are only sporadic and seven of them, have been entirely omitted from the table, as a their frequency is lower than 1%.

These results, together with data from phytosociological records are evidence of the poverty of the association as to number of species and their uneven distribution over the study area.

Density of species

The mean density of individuals of the various species differs greatly over the study area (Tab. II) and varies from 0.5 to 35 per. 1 m^2. Only two species occur with density exceeding 10 individuals per 1 m^2. The absolute dominant, *Calluna vulgaris*, occurs in a superior average number of 35 individuals per 1 m^2, which forms almost half (48%) of the average density of individuals of vascular plants in the study area. There are also 6 species with the density greater than $1/m^2$, but the density of the remainder is negligible. The mean density of individuals of all species is 74.3/1 m^2 of the study area.

Annual increase in mass of individual plants

Figures illustrating the mean annual increase in mass of individual plants of the 13 most common species in the study area (Tab. II) never in any case reach as much as 1 g of dry mass. Maximum individual increase of the upper parts of plants found in *Convallaria maialis* was only 0.84 g, while the annual increase in over half the species is less than 0.1 g per individual plant.

Fructification

The majority of species in the herb layer of the pine wood examined either did not fruit at all or only very weakly. Only *Festuca ovina*, which occurs in relatively great density, fruited abundantly. Production of its fruit was therefore determined per unit of area and the following results obtained:

1. Density of fruiting stalks per 1 m² of the forest floor = 2.0087;
2. Ratio of fruiting stalks to clumps = 1(2.0087/2.1250);
3. Dry mass of caryopses from an average panicle at the time of fruiting = = 0.0205 g;
4. Production of unhusked caryopses = 0.0412 g/m², that is 0.4 kg per 1 ha;
5. Ratio of fruit biomass to total biomass of the species in the study area was 2.25% (on an average).

These figures served not only to render the values obtained from sampling for density and biomass more exact; they also have their own intrinsic value as an estimate of the supply of the only food available to certain groups of small mammals in this poor habitat.

A further three species from among the remaining fruited in the herb layer of the pine forest: 48% of the individual plants fruited in a population of Melampyrum pratense, 29% of the aerial shoots of *Luzula multiflora*, and 26% of *Carex ericetorum*. The mean biomass of individual plants of the species in Table II, however, was calculated jointly on the basis of the mass of both fruiting and non-fruiting individual plants.

Calluna vulgaris, although flowering very abundantly, did not fruit at all, and other species such as *Convallaria maialis Vaccinium vitis idaea, V. myrtillus, Genista tinctoria* and *Polygonatum multiflorum* (L.) All., did not flower at all during the summer-months of 1967.

Annual production of individual species

Annual production of species occurring in this layer of the pine forest (Tab. II) varies within wide limits. Maximum production of the dominating species (*Calluna vulgaris*) is 8 g of dry mass per 1 m² of the study area. Production of the subdominant (*Convallaria maialis*) is about 4.5 g/m². Nine species, however, do not even produce 1 g from 1 m², the production of five of them falling even below 0.1 g/m².

Annual increase in mass of species and their density and frequency

The fact that a particular species gives maximum production does not necessarily mean that its density is also maximum in the study area. Although the absolute dominant in respect of organic mass production (*Calluna vulgaris*) is simultaneously the most numerous species (density = 35.4 individual plants per 1 m²), and most frequently encountered (frequency – 21%) yet the production subdominant (*Convallaria maialis*) is much less numerous than *Vaccinium vitis idaea*, which in respect of biomass production comes only fourth in this order. *V. vitis idaea* and pine seedlings, although occuring with the same frequency, differ greatly both in respect of density per 1 m^2, and production value per unit of area. *Melampyrum pratense*, a species with fairly considerable density and high frequency, produces very little biomass on account of the negligible mass of the individual plant. *Convallaria maialis*, which is not much more numerous in the study area, yields 50 times greater organic production. *V. vitis idaea* and *M. pratense* give identical production per 1 m^2, with different density and frequency as the result of different individual mass.

Annual production of the herb layer

Joint production of vascular plants of the herb layer in the pine forest was assessed as 17.6943 g/m^2, which is equal to 177 kg per 1 ha. This production is distributed in the study area between 13 species characterized by frequency higher than 1% and density of at least 1 individual plant per 10 m^2.

Weight structure of herb layer increase

It is obvious from comparison of net production of species foming the herb layer of a dry pine forest (Tab. II) that 70% of the total production is formed by two dominating species only (*Calluna vulgaris* and *Convallaria maialis*). A further 5 species form the next 27%, and the last 6 – only 2% of joint production. A certain completely negligible percentage (0.5), is probably formed by species occurring sporadically and not included in the table (the figure in brackets is of course only approximate, since it was calculated from a very small number of individual plants).

Biomass of vascular plants of the herb layer

The biomass of vascular plants in the herb layer of our dry pine forest, i.e. the sum total of their annual increase (17.7 g/m^2) and old biomass that remained from previous years (5.03 g/m^2) is 22.7 g/m^2, i.e. 227 kg per ha.

Ratio of the old biomass to the current year's biomass

The ratio of the biomass produced in previous years to that produced during the current year by herb layer plants in the pine forest is 28.5%; in relation to the whole of the herb layer biomass this is 22%. This is an unexpectedly small value for a coniferous forest (Traczyk T. 1968). It was found that under these extremely dry conditions very little organic matter is accumulated from year to year in the upper parts of herb layer plants. In many plants these parts dry up during the summer and next spring's growth starts from the underground organs once again. It is primarily *Vaccinium* *vitis idaea* which grows in this way, and which in 1967 was represented in the herb layer mainly by very small current year plants; it was also true for *V. myrtillus*. The organic mass above ground left from previous years consists chiefly of *Calluna vulgaris*, with a very small admixture of *V. myrtillus* and small oak seedlings. Very small pine seedlings vere relatively numerous (0.85 indiv./1 m^2) during the study year. These were, however, almost no seedlings from the previous year or from any of the immediately preceding years. It would seem probable that almost 100% of the pine seedlings, at any rate during the last few years, died for lack of water and no biomass was retained from one year to another.

Mosses and lichens

The moss and lichen layer in the forest association examined plays a relatively important role, this applying particularly to mosses. But my estimate, which forms part of the complex of studies on herb layer production, made in a large number of forest associations, does not – unfortunately – include the yearly production of this layer.

The joint cover of mosses of all species estimated in 5 phytosociological records made on July 26th 1967, was on an average, 50%. Cover value estimated on the same day on the basis of 100 samples measuring 0.1 m^2 scattered at random over the study area was 50.5%, and that estimated on September 9th 1967 – 52%, the average of 200 samples being 51.2%.

Although the distribution of mosses over the study area was not quite uniform, frequency of mosses was very high. Out of 200 samples mosses were present in 178 (there were 18 samples without moss in July, and 4 in September). Frequency was thus 89% (respectively 82% for July, and 94% for September), but cover differed greatly in these full samples (from 0–100%).

Total biomass of all mosses was on an average 158 g/m^2 for the study area, i.e. 1580 kg/ha, that is almost 1.6 t/ha. This is a very high value, 7 times greater than the biomass value found in the herb layer. The biomass of individual species was not examined.

No investigation was made of annual increase in mosses. If we accept, after Traczyk's provisional studies (Traczyk T. 1967b), that annual increase in mosses is about 1/3 of total biomass, then the value sought for will be 52.66 g/m^2, that is 527 kg/ha. This is a value almost three times greater than the value of the annual production of the herb layer. In this extremely dry pine forest association, however, the ratio of annual increase in mosses to the currently existing biomass in the study area may turn out to be quite different from that in a wet meadow where Traczyk carried out his preliminary sampling for this purpose.

Although lichens occupy less space in the pine-forest, they form an

Plant fall from tree and shrub layers since spring 1967 till spring

Kind of fall		May		June, July		August	
		g/m²	%	g/m²	%	g/m²	%
Deciduous trees leaves	g/m² %	0.228 0.48	4.93	0.000 0.00	0.00	0.040 0.10	0.85
Coniferous trees leaves	g/m² %	19.300 40.51	7.74	21.205 32.25	8.51	19.002 44.97	7.62
Fruits	g/m² %	10.338 21.70	16.40	20.138 30.62	31.96	4.904 11.61	7.78
Plant debris	g/m² %	17.780 37.32	11.94	24.419 37.13	16.53	18.300 43.32	12.29
Total fall	g/m² %	47.646 100	10.23	65.762 100	13.90	42.246 100	9.04

important element there, which strikes the eye and distinguishes the lower layers of its vegetation from other forest associations.

The joint cover of all ground lichen species estimated on the basis of 5 phytosociological records was on an average 10%, and frequency estimated on the basis of 200 sampling throws – was 40%.

Lichen biomass in the study area assessed on the basis of 200 sampling throws was 11.4815 g/m², i.e. 115 kg/ha. This is a considerable value, although far lower than the value of moss biomass; it is, nevertheless, equal to almost half the total biomass of vascular plants in the herb layer. No investigation was made of the annual increase in lichens.

The total biomass of mosses and lichens is 169.5 g/m², i.e. 1695 kg/ha and is 7.5 times greater than the biomass of vascular plants in the herb layer of this pine forest.

Plant fall

The amount of plant fall per 1 m² of study area (Tab. III and Fig. 1) shows distinct seasonal variation both as a whole and in its component fractions. The mean daily fall per 1 m² (Tab. IV), very small during winter and in early spring, increases greatly in spring and remains on a more or less unchanging average level through summer; then it increases sharply at the begining of autumn and reaches its maximum value in October, from which it at once falls to the winter minimum.

The fall of pine needles, which forming over half (53.5%) of the whole fall mass follows a certain pattern, which is, quite understandingly, very

1968 (Dry pine forest (*Cladonio-Pinetum*) in Old Kampinos Forest)

Tab. III

September		October		November		Winter and early spring		Whole year	
g/m²	%	g/m²	%	g/m²	%	g/m²	%	g/m²	%
0.726 0.84	15.41	1.532 1.54	32.53	1.720 3.63	36.52	0.464 0.60	9.85	4.710 1.02	100
62.896 72.92	25.23	72.323 72.80	29.01	25.920 54.70	10.40	28.664 37.07	11.50	249.310 53.53	100
5.643 6.54	8.96	7.677 7.73	12.18	6.340 13.38	10.06	7.964 10.29	12.64	63.004 13.52	100
16.987 16.69	11.40	17.818 17.93	11.97	13.404 28.29	9.00	40.240 52.04	27.01	148.948 31.96	100
86.252 100	18.08	99.350 100	21.32	47.384 100	10.17	77.332 100	16.59	465.962 100	100

similar to that for total falls. Although needles fall from trees throughout the year, there is a distinct maximum fall in autumn; more than half of the total yearly fall of needles takes place in September and October (54.23%); there is also a minimum occurring in the winter and early spring months, even more clearly evident than the minimum of the whole fall.

Leaf fall from the small number of oak trees and oaks saplings foms the smallest, almost negligible, fraction of fall in a dry pine forest – only 1%. Maximum leaf fall is a whole month later than maximum needle fall (over 60% of leaves fall in October and November); this, however, exerts hardly any influence on the dynamics of plant fall as a whole. Leaves are the only fraction of plant fall in the study area which are not collected throughout the year. The interval in leaf fall from oaks is, however, short and late, lasting only through June, July and possibly the beginning of August.

The summer maximum of flower and fruit fall, occurring in June and July, compensates for a certain reduction in needle fall during this time so that the latter is not evident in the course of the total fall. The percentage of flower and fruit fall in the whole of plant fall in a pine forest is not high, being only 13%.

Fall of dead parts (branches, twigs, bits of bark etc.) remains on the same level throughout the year, decreasing slightly only during the winter months. This fall is very important in a dry pine forest, since it forms 1/3 (32%) of the total plant fall.

The total yearly mass of plant fall per 1 m² on the bottom of a dry pine forest is 465.962 g, that is, 4660 kg per 1 ha.

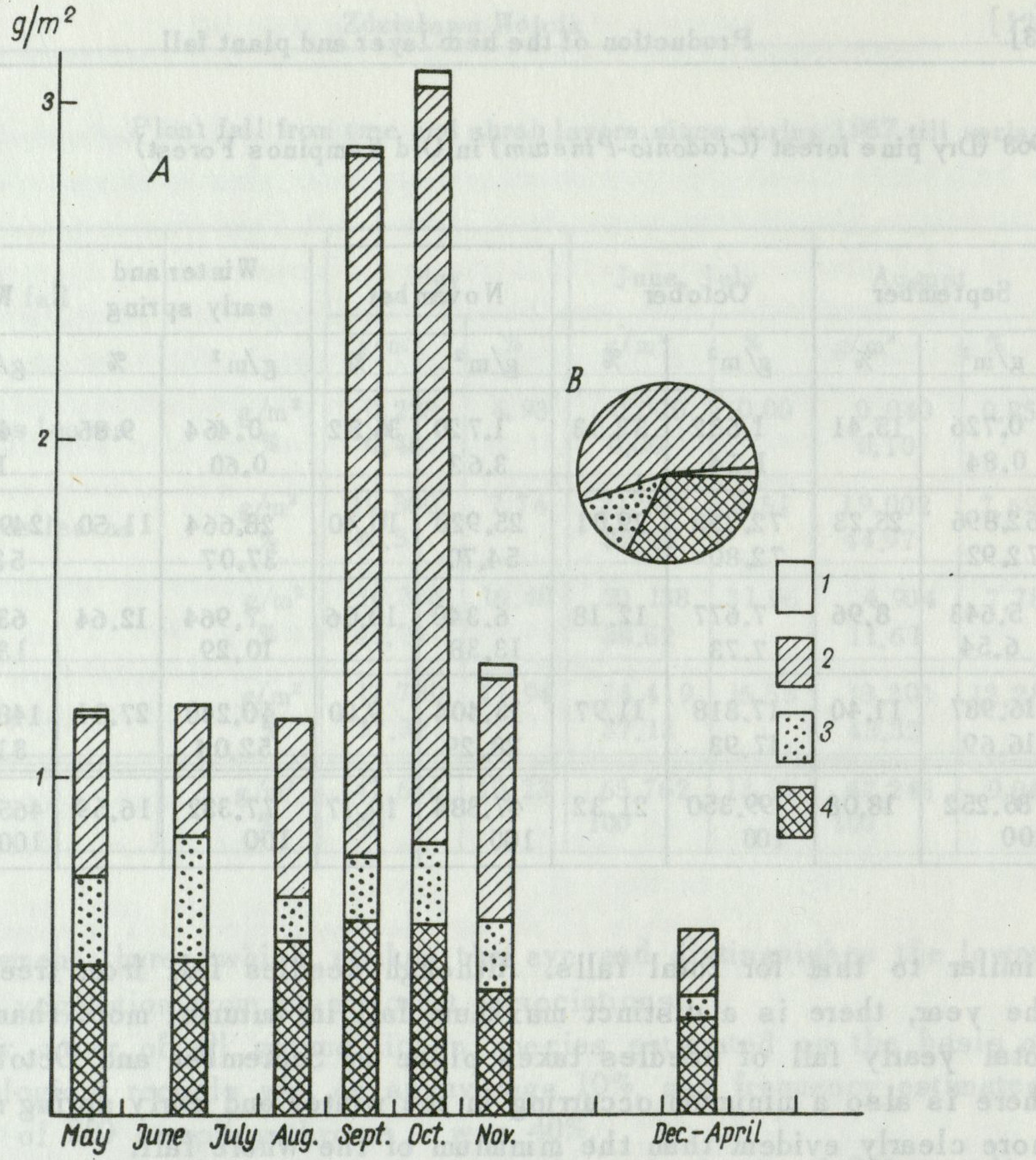

Fig. 1. Plant fall from tree and shrub layers since spring 1967 till spring 1968

A — average fall for day, *B* — total fall in whole year (g/m^2); *1* — deciduous trees leaves, *2* — coniferous trees leaves, *3* — fruits, *4* — plant debris

Plant fall from tree and shrub layers since spring 1967 till spring 1968. Average fall for day in g/m^2 (Dry pine forest (*Cladonio-Pinetum*) in Old Kampinos Forest)

Tab. IV

Kind of fall	May	June July	August	September	October	November	December till April	Whole year
Deciduous trees leaves	0.0057	0.0000	0.0011	0.0242	0.0479	0.0478	0.0033	0.0128
Coniferous trees leaves	0.4825	0.3927	0.5278	2.0965	2.2600	0.7200	0.2048	0.6794
Fruits	0.2584	0.3729	0.1362	0.1881	0.2399	0.1980	0.0572	0.1713
Plants debris	0.4445	0.4522	0.5083	0.5662	0.5568	0.3723	0.2892	0.4059
Total fall	1.1911	1.2178	1.1734	2.8750	3.1046	1.3381	0.5563	1.2694

SUMMING UP THE RESULTS

The following remarks sum up the results of studies carried out in the dry pine forest (*Cladonio-Pinetum* Kobendza 1930):

I. The herb layer of vascular plants has the following structural characteristics:

1. Poverty of floristic composition (from 7–15 species in a single phytosociological record; 17 species in 200 random samples, each measuring 0.1 m^2);

2. Low frequency of the majority of species (frequency is over 10% in the case of 4 species only);

3. Low mean density of individual plants of all species (74 indiv. /1 m^2).

II. Herb layer production is low:

1. Combined production of all species is 17.7 g of dry mass per 1 m^2;

2. Distinct domination structure is found in production – 2 species only produce 70% of biomass, and 5 species – 90%;

3. Biomass from previous years, smaller than it usually is for pine forest associations, forms 22% of total standing crop biomass and 28.5% of current production.

III. The moss and lichen layer plays a dominating role on the floor of the forest examined – mosses predominate, and attain a high degree of cover, forming a large amount of biomass (1695 kg/1 ha).

IV. Over 50% of the plant fall from trees and shrubs is formed by pine needles, and that is why the total plant fall is greatly influenced by seasonal fluctuations in the fall of pine needles. Similarly, fall of dead parts of trees and shrubs is of great importance, as they form almost 1/3 of the whole fall.

REFERENCES

1. Kobendza, R. 1930 – Stosunki fitosocjologiczne Puszczy Kampinoskiej (Les rapports phytosociologiques dans l'ancienne grande Forêt de Kampinos) – Planta Polonica 2, Warszawa (Polish, French summary).
2. Traczyk, T. 1967a – Propozycja nowego sposobu oceny produkcji runa (A proposed new way of estimating the production of the forest herb layer) – Ekol. Pol. B, 13: 241–247 (Polish, English summary).
3. Traczyk, T. 1967b – Studies on herb layer production estimate and the size of plant fall – Ekol. Pol. A, 15: 837–867.
4. Traczyk, T. 1968 – Zasobność siedlisk a produkcja runa leśnego (Resources of habitats and production of forest ground vegetation) – Ekol. Pol. B, 14: 321–324 (Polish, English summary).

PRODUKCJA PIERWOTNA WARSTWY ZIÓŁ I OPAD ROŚLINNY BORU SUCHEGO (*CLADONIO-PINETUM* KOBENDZA 1930) W PUSZCZY KAMPINOSKIEJ

Streszczenie

W borze suchym (*Cladonio-Pinetum* Kobendza 1930) na piaskach wydmowych Puszczy Kampinoskiej zbadałam w 1967 r. produkcję warstwy ziół, stan biomasy mchów i opad roślinny z drzew i krzewów metodami zaproponowanymi przez Traczyka T. (1967a, 1967b). Przedstawiana praca jest fragmentem kompleksowych badań prowadzonych przez Zakład Ekologii PAN w ramach Międzynarodowego Programu Biologicznego w kilkunastu zespołach leśnych. Obejmują one nie tylko wybrane elementy produkcji pierwotnej, ale i produkcję wtórną drobnych gryzoni korzystających z tej produkcji pierwotnej.

Przeprowadzone oceny doprowadziły do uzyskania następujących wyników.

Skład florystyczny badanego środowiska leśnego jest bardzo ubogi (tab. I). W poszczególnych zdjęciach (100 m^2) znajdowałam w runie 7 do 15 gatunków roślin naczyniowych, 200 prób rzutowych wychwytywało ich 17. Łącznie znalazłam na całej sześciohektarowej powierzchni 24 gatunki.

Frekwencja tych gatunków (tab. II) jest na ogół niska. Oceniona na podstawie 200 rzutów losowych frekwencja jednego gatunku (*Calluna vulgaris*) wynosi 20%, 7 gatunków – od 6 do 20%, 5 – od 1 do 5% i 6 – poniżej 1%.

Zagęszczenie osobników (tab. II) poszczególnych gatunków jest na ogół niskie z wyraźnym dominowaniem najliczniejszego. Średnie zagęszczenie pędów nadziemnych jednego gatunku (*Calluna vulgaris*) wynosi 35 na 1 m^2, tj. prawie 48% całości. Jeszcze 7 gatunków występuje w zagęszczeniu średnim (1–12/m^2), a zagęszczenie reszty jest znikome. Zagęszczenie osobników wszystkich gatunków wynosi średnio 74,3/1 m^2.

Przyrost roczny osobników (tab. II) jest bardzo mały i u żadnego z gatunków nie dochodzi do 1 g suchej masy. Maksymalny przyrost osobniczy wykazuje *Convallaria maialis* (0,85 g).

Jedynym gatunkiem, który owocował stosunkowo licznie w runie badanego doboru w 1967 r., była *Festuca ovina*. Zagęszczenie jej źdźbeł owocujących na badanej powierzchni oceniłam na 2 na 1 m^2; produkcję ziarniaków oplewionych na 0,4 kg na ha; wskaźnik owocowania na 0,26% na ha.

Produkcja roczna poszczególnych gatunków jako funkcja przyrostu osobników i zagęszczenia osobników na badanej powierzchni nie idzie w parze z samym tylko zagęszczeniem. Maksymalna produkcja gatunku (*Calluna vulgaris*) wynosi 8 g na 1 m^2; produkcja 9 gatunków jest mniejsza niż 0,01 g suchej masy.

Globalną produkcję warstwy roślin zielnych jako sumę przyrostów rocznych poszczególnych gatunków występujących na badanej powierzchni z częstością nie mniejszą niż 1% oceniłam na 17,7 g/m^2, tj. 177 kg na 1 ha.

Stan biomasy roślin naczyniowych w runie badanego boru suchego, tj. suma ich przyrostu rocznego (177,7 g/m^2) i biomasy starej z lat ubiegłych (5,03 g/m^2) wynosi 22,7 g/m^2, tj. 227 kg na 1 ha.

W strukturze wagowej przyrostu runa zaznacza się wyraźnie dominowanie dwu gatunków, które łącznie tworzą 70% przyrostu rocznego (*Calluna vulgaris* i *Convallaria maialis*); następne 27% przyrostu daje 5 dalszych gatunków. Udział pozostałych gatunków w produkcji runa jest znikomy.

Stosunek biomasy z lat ubiegłych do tegorocznej produkcji określiłam na 28,5%, a jej udział w całości biomasy runa – na 22%. Jest to mało jak na zbiorowisko

borowe. Prawdopodobnie większość siewek i wiele pędów wyrastających z podziemnych organów ginie w ciągu lata.

Biomasa mchów w badanym borze suchym wynosi średnio 158 g/m², tj. 1580 kg na ha, przy średnim pokryciu nieco ponad 50%. Jest to wartość 7 razy większa od wartości biomasy roślin naczyniowych runa tego zespołu leśnego. Jeśliby przyjąć za Traczykiem T. (1967b), że przyrost roczny mchów równa się 1/3 ich aktualnej biomasy, to wynosiłby on 527 kg na ha. Jest to prawie 3 razy tyle co przyrost roczny roślin naczyniowych w tym środowisku.

Biomasa porostów na badanej powierzchni wynosi średnio 115 kg na ha, tj. równo 2/3 biomasy roślin naczyniowych runa. Łączna biomasa mchów i porostów w badanym borze suchym wynosi 1695 kg na ha, tj. 7,5 razy tyle co biomasa roślin zielnych.

Opad roślinny z drzew i krzewów w badanym borze suchym wyniósł w ciągu okresu rocznego (od kwietnia 1967 do kwietnia 1968) 4660 kg na ha. Jego maksimum w przebiegu rocznym przypada na wrzesień i październik, a minimum na miesiące zimowe i wczesnowiosenne.

Opad szpilek sosnowych stanowi ponad 50% całego opadu roślinnego i narzuca mu swoją dynamikę roczną.

Opad liści z nielicznych drzew oraz podrostu i krzewów ma wartość znikomą (1%). Maksimum przypada na październik i listopad, przerwa w opadaniu liści — na miesiące letnie.

Opad kwiatostanów i owocostanów wynosi 13% całości opadu, a jego maksimum przypada w czerwcu i lipcu.

Opad części martwych (gałęzi, gałązek, kory itp.) stanowiący 32% całości, ma w ciągu roku wartość mniej więcej wyrównaną ze słabo zaznaczonym minimum w miesiącach zimowych i wczesnowiosennych.

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