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Department of Wildlife Management, Warsaw Agricultural University, Warszawa

Head: Prof. Dr. Jan Dominik

Władysław AULAK

# STUDIES ON HERB LAYER PRODUCTION IN THE *CIRCAEO-ALNETUM* OBERD. 1953 ASSOCIATION*

(Ekol. Pol. 18: 411–427). Studies were made using the DG method (Traczyk T. 1967), of net herb layer production in the *Circaeo-Alnetum* Oberd. 1953 association in the Białowieża National Park in 1967. It was found that 100 samples per 0.1 $m^2$ is too small a number to permit of calculating the population density of different species in the herb layer with only a small degree of error. The calculated net production of dry biomass in the herb layer was 1,074.572 ± 140.016 kg/ha, with standard error of 6.6%. This production is formed by a small number of herb layer species, while the remaining species occurring in this layer form only a small percentage of the total production.

The International Biological Programme lays particular emphasis on investigation of the productivity of ecosystems and analysis of energy flow between different trophic levels within the given ecosystem.

Studies on primary production occupy an important place in this work. In addition to very interesting analysis of primary production of different biotopes, which often form an end in themselves, studies of the producer levels in

*This study was carried out in the Mammals Research Institute, Polish Academy of Sciences, at Białowieża under the International Biological Programme.

different ecosystems provides a basis for analysis of secondary production, and particularly of first order consumers making direct use of plant production, and of reducers of plant mass.

Estimation of primary production is not any easy matter, particularly in such complex ecosystems as forests. Up to the present the best developed studies are those on the production of the herb layer, and thus of the corresponding layer in forests.

The present study is concerned with investigation of primary production of the herb layer in *Circaeo-Alnetum* Oberd. 1953 association growing in a wet habitat by the side of a stream. This association forms a very small part of forest associations in Poland, apart from nature reserve areas, and is gradually becoming extinct (Szafer 1959).

## STUDY AREA

The investigations were confined to a patch of the *Circaeo-Alnetum* Oberd. 1953 association (= *Fraxino-Alnetum* Matuszkiewicz 1952) in the Białowieża National Park, in sector 398, and were carried out in 1967. The *Circaeo-Alnetum* association occupies a small area only in this national park and stretches in narrow belts along the banks of the forest rivers and streams, and varies in width from the edge of these waters. A detailed description of this association is given by Matuszkiewicz (1962). A fairly typical patch, 0.20 ha in area, was chosen as the study site. The distance from the edge of the stream at which samplings were carried out was never greater than 30 m to avoid entering upon the *Tilio-Carpinetum stachyetosum* Traczyk 1962 association which, depending on the local configuration of the ground, varied in closeness of approach to the stream.

The patch examined was characterized by fairly uniform and compact cover of the tree layer, which varies greatly in geight, and as a result, despite its fairly considerable density, admits light on to the floor of the forest in many places. The density of the tree cover was about 85%. The percentages formed by the various trees in this cover (taken as 100%) were as follows:

| | |
|---|---|
| *Fraxinus excelsior* L. | – 50% |
| *Alnus glutinosa* (L.) gaertn. | – 25% |
| *Picea excelsa* (Lam.) Lk | – 20% |
| *Tilia cordata* Mill. <br> *Ulmus campestris* L. | – 5% |

About 50% of the area is covered by young trees and undergrowth, in which *Tilia cordata* and *Fraxinus excelsior* predominate, *Alnus glutinosa*, *Ulmus* *campestris*, *Corylus avellana* L. and *Acer platanoides* L. are fairly numerous, while *Sorbus aucuparia* L. and *Picea excelsa* (Lam.) Lk. occur in small numbers only. Among the lower shrubs the following are found in small numbers in this area: *Ribes nigrum* L., *Ribes Schlechtendalii* Loc. and *Viburnum opulus* L. The herb layer is described later in this study.

The soil on which the association grows is very fertile, silt and mud, with neutral reaction (Matuszkiewicz 1952). The patch examined is periodically flooded by flowing water which has no tendency to stagnation. The stream on the banks of which the patch was situated only loses its free-flow of water in very dry periods and summers.

## METHODS

The method for assessing herb layer production proposed by Traczyk T. (1967a) and applied by the Laboratory of Plant Ecology of the Institute of Ecology, Polish Academy of Sciences, was used in the present investigations. 100 sampling areas 0.1 m² in extent were chosen at random. In addition for the large perennials and rare species 15 samples 25 m² in area were laid out. In order to grasp any differences in the patch examined small samples (0.1 m²) were taken every 5 m along transecting lines. The transecting lines were arranged every 5 m. In this way 80 samples were taken. An additional 20 samples were taken on two transecting lines running through the middle of the study patch. In this way 10 m² was covered by small samples, which constituted 0.5% of the patch examined; large samples covered 375 m², which forms 18.75% of the patch.

The number of individual plants of the various species were calculated in the samples. Botanical nomenclature was accepted after Szafer, Kulczyński, Pawłowski (1953). Samples were taken for weighing, in numbers proportionate to the density of the species in the study area, during the growth culmination period of the given species. The current year's growth on the plants collected was dried and weighed with accuracy to 10 mg, to determine dry mass. When arranging the small sample sites the moss cover and herb layer cover was determined in percentages. The latter value is very variable, in comparison with that of mosses, over the course of the year and therefore the cover value for the herb layer on the forest floor is only a temporary value, valid for the period in which it was estimated.

The density of large perennials assessed by small samples was taken into consideration only in the part analysing study methods and frequency of species, but the density of these plants according to calculations obtained from large samples as taken into account when determining the actual herb layer production value.

## DISCUSSION OF RESULTS

### ANALYSIS OF METHODS

The only parameters according to which calculation is made of net primary production in the method used are as follows: density ($D$) and average individual growth ($G$) determined for the population of each species occurring in the herb layer. The sum total of the products of these values gives the net primary production of the patch examined:

$$P = \sum_{i=1}^{n} G_i \cdot D_i \qquad n - \text{number of species occurring in the herb layer}$$

Values $P$ is burdened with the errors of each of these parameters for $n$ species of the herb layer, hence it is essential to make the most accurate definition possible of values $D$ and $G$, the possibility od increasing the accuracy of parameters $G$ being greater here than for parameters $D$. The average individual growth is calculated from the quotient of the sum total of growths of the individuals taken for weighing, divided by their number. Hence we reach the simple conclusion that increasing the numbers of weighed individuals and their random collection in the area give a value $G$ closer to the real one.

When taking individual plants for laboratory samples great care was taken to separate the current year's growth from the parts of the plants which grew in preceding years. In the study patch any possible mistakes arising from incorrect separation of previous years' growth are very slight, due to the fact that only a few species possessed biomass originating from previous years, and in addition these were species not growing very densely and exhibiting little individual growth. This error thus affects definition of value $P$ for the given association only to a minimal degree.

The random sampling of individual plants for weighing tests from different places in the patch was of great importance, on account of some differences in the amount of light falling in different places in the study area. It has been found that increase in the amount of light reaching the forest floor exerts a very great influence on value $G$ (Tab. I). An attempt was made at eliminating this error by taking individual plants at random from different places in the patch along transecting lines. It can therefore be assumed that values $G$ for populations of different species were calculated in a way guaranteeing that error is reduced to a minimum.

Dependence of individual growth on compactness of tree stand

Tab. I

| Species | Compactness | | | |
|---|---|---|---|---|
| | 80% | | 20% | |
| | *N* | *G* | *N* | *G* |
| *Urtica dioica* | 200 | 1.069 g | 100 | 3.245 g |
| *Cirsium oleraceum* | 50 | 2.386 g | 30 | 8.180 g |

*N* — number of individuals according to which individual growth was determined, *G* — individual growth.

Greater errors could arise when calculating the density of different species of the herb layer. 100 small samples measuring 0.1 $m^2$ were arranged in the study patch (jointly forming 0.5% of the area). In addition, 15 samples 25 $m^2$ in area were laid out (jointly 18.75% of the area) for the large perennials. The total number of small samples covers only a small part of the study area and on this account, in order to ensure accurate and even cover of the area by these samples, they were arranged at random on transecting lines.

Species, the density of which was calculated on the basis of large samples, also occurred in the small samples. Their density in large samples was taken into account when calculating the production of the association, whereas in ensuing discussion their density was examined on the basis of small samples. On an average there were about 6 species of plants, extreme values being 2 and 12, in one sample measuring 0.1 $m^2$ in size. The average number of individual plants (taking all species jointly) in a 0.1 $m^2$ sample was 61, the extreme values being 7 and 190.

A total of 37 species of plants was found in small samples, out of a total number of 41 plants found jointly in small and large samples. The number 41 differs very little from the actual number of species in the patch examined. In addition to samples it was found, during examination of the patch, that a small number of species occur singly (*Solanum dulcamara* L., *Ajuga reptans* L., *Carex remota* L., *Equisetum silvaticum* L.).

The frequency of species in small samples varied greatly. 78.4% of the species exhibited frequency up to 20%, while frequency of over 60% was found in 10.8% of the species (Fig. 1). As an example calculation was also made of the coefficient of density variability for 6 species, on the basis of 100 small samples (Tab. II). This table reveals the dependence of the coefficient of density variability on frequency, irrespective of the density of the herb layer species analysed. A diagram was made (Fig. 2) to illustrate this relation and the equation of straight line regression calculated for the above relation.

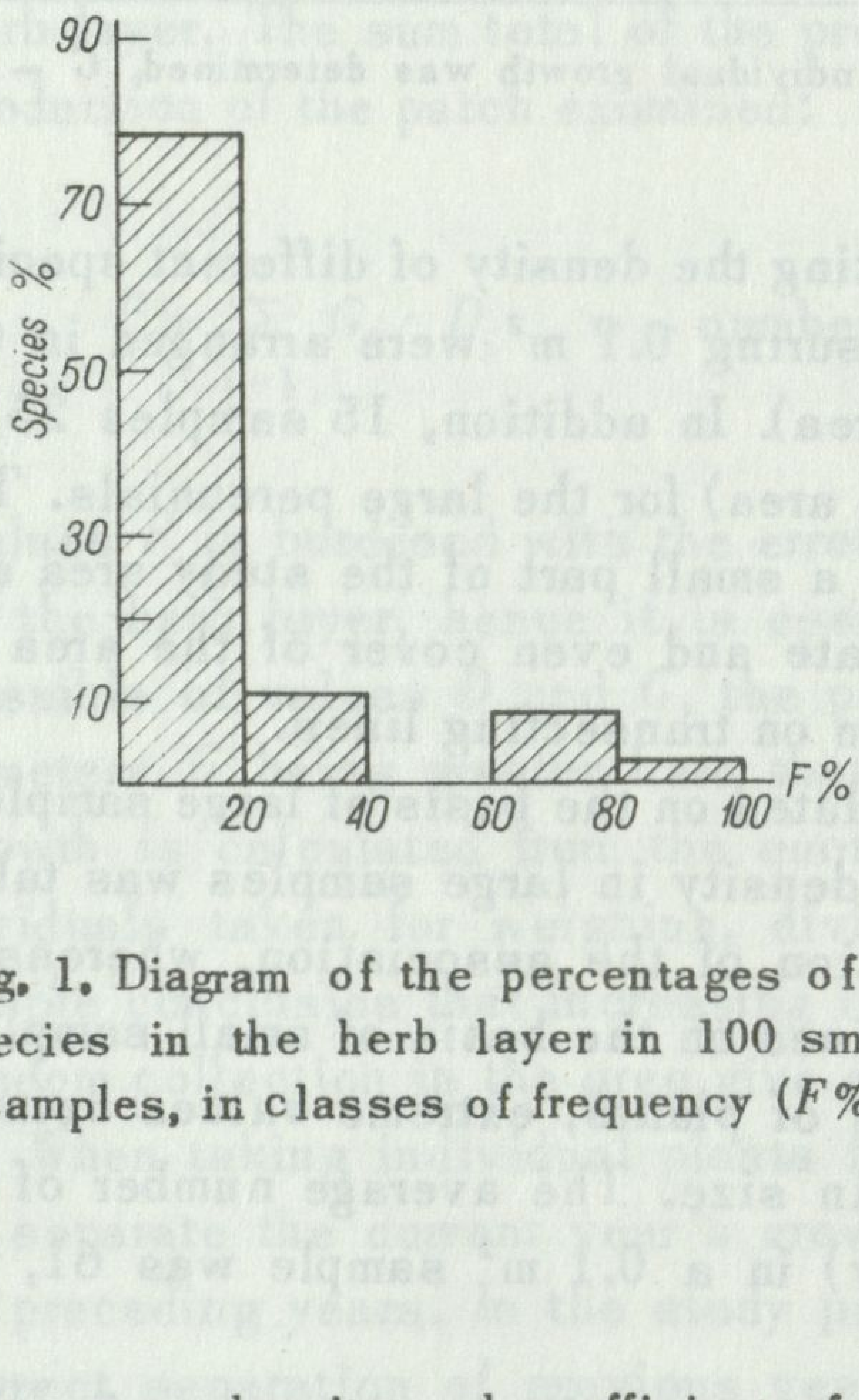


Fig. 1. Diagram of the percentages of 37 species in the herb layer in 100 small samples, in classes of frequency ($F\%$)

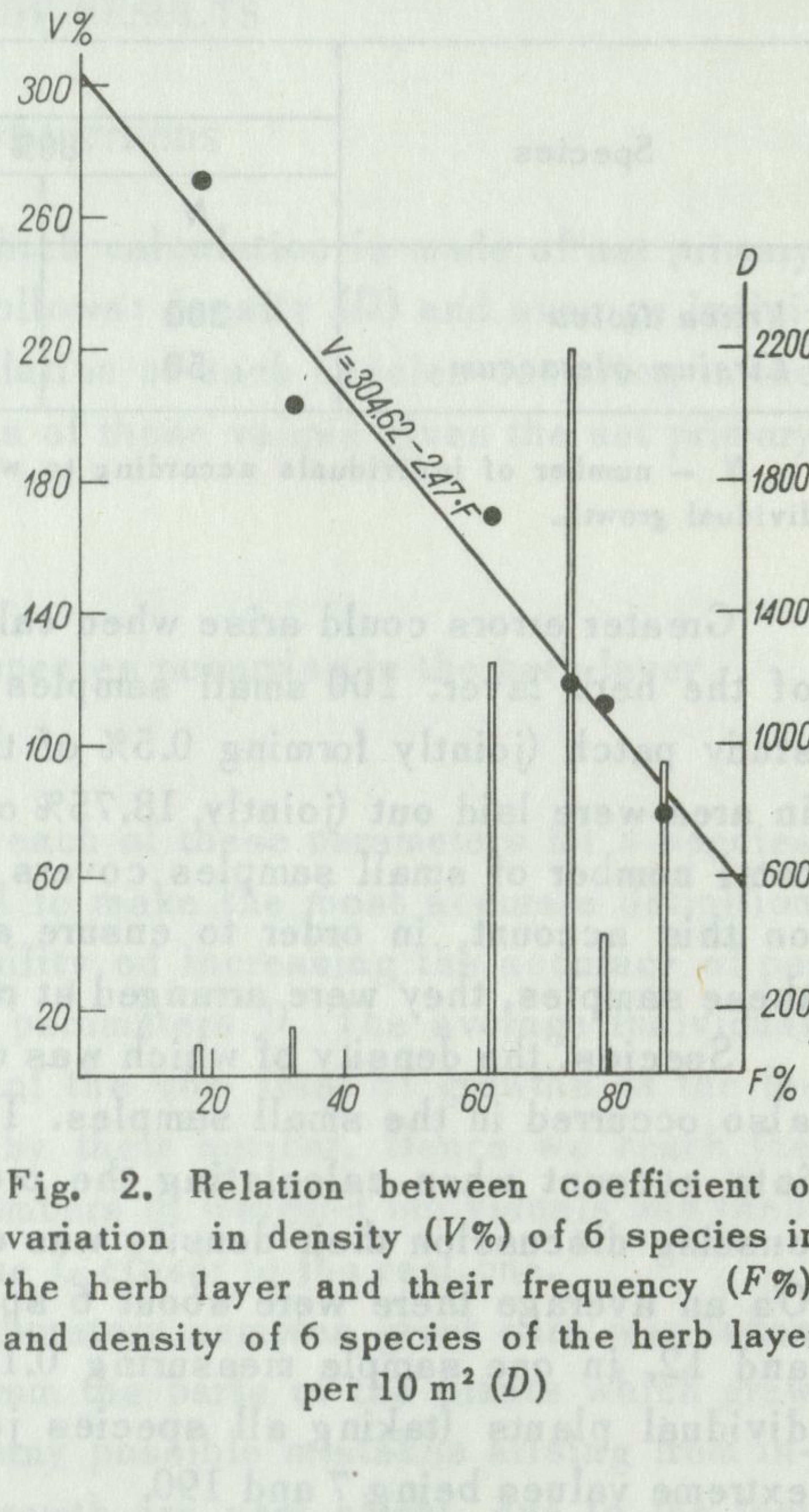


Fig. 2. Relation between coefficient of variation in density ($V\%$) of 6 species in the herb layer and their frequency ($F\%$), and density of 6 species of the herb layer per 10 $m^2$ ($D$)

Frequency, density and coefficient of density variation for 6 species of the herb layer

Tab. II

| Species | Frequency (%) | Density per 1 ha | Coefficient of variation (%) |
|---|---|---|---|
| *Impatiens noli tangere* | 88 | 952,000 | 79.37 |
| *Urtica dioica* | 79 | 424,000 | 111.52 |
| *Chrysosplenium alternifolium* | 74 | 2,205,000 | 118.92 |
| *Oxalis acetosella* | 62 | 1,261,000 | 168.85 |
| *Aegopodium podagraria* | 32 | 150,000 | 202.00 |
| *Galeobdolon luteum* | 18 | 99,000 | 275.00 |

This atraight line includes only 6 species, and therefore forms only a guide to the whole of the material. The direction coefficient of straight regression is fairly characteristic, its high value forming evidence that the variability coefficient reduces its value fairly abruptly with an increase in frequency. The second finding revealed by this diagram is the fact that even with high frequency the coefficient of density variability is fairly high and exceeds the value of 50%. This is evidence that the 100 samples measuring 0.1 m² is too small a number for accurate calculation of the density of different species of the herb layer, particularly of those which are distributed unevenly and in the given case exhibit low frequency. This is confirmed by the diagram of the percentage of standard error of density of the above species in the herb layer (Fig. 3). This error, for *Impatiens noli tangere* L. only, with 70 samples, possesses a value below 10%. The remaining 5 species, even 100 samples, reveal a standard error value of over 10%, and here the lesser the frequency characterizing the species, the lower the reliability of 100 samples for calculation of its true density. When these data are compared with the diagram of frequency of species (Fig. 1) it will be found that for the majority of species 100 samples is too small a number for calculation of real density. Since, however, species with low frequency form only a negligible percentage of total herb layer production in the patch examined of the *Circaeo-Alnetum* association, the possible error in determining their density only affects calculation of total herb layer production to a slight degree.

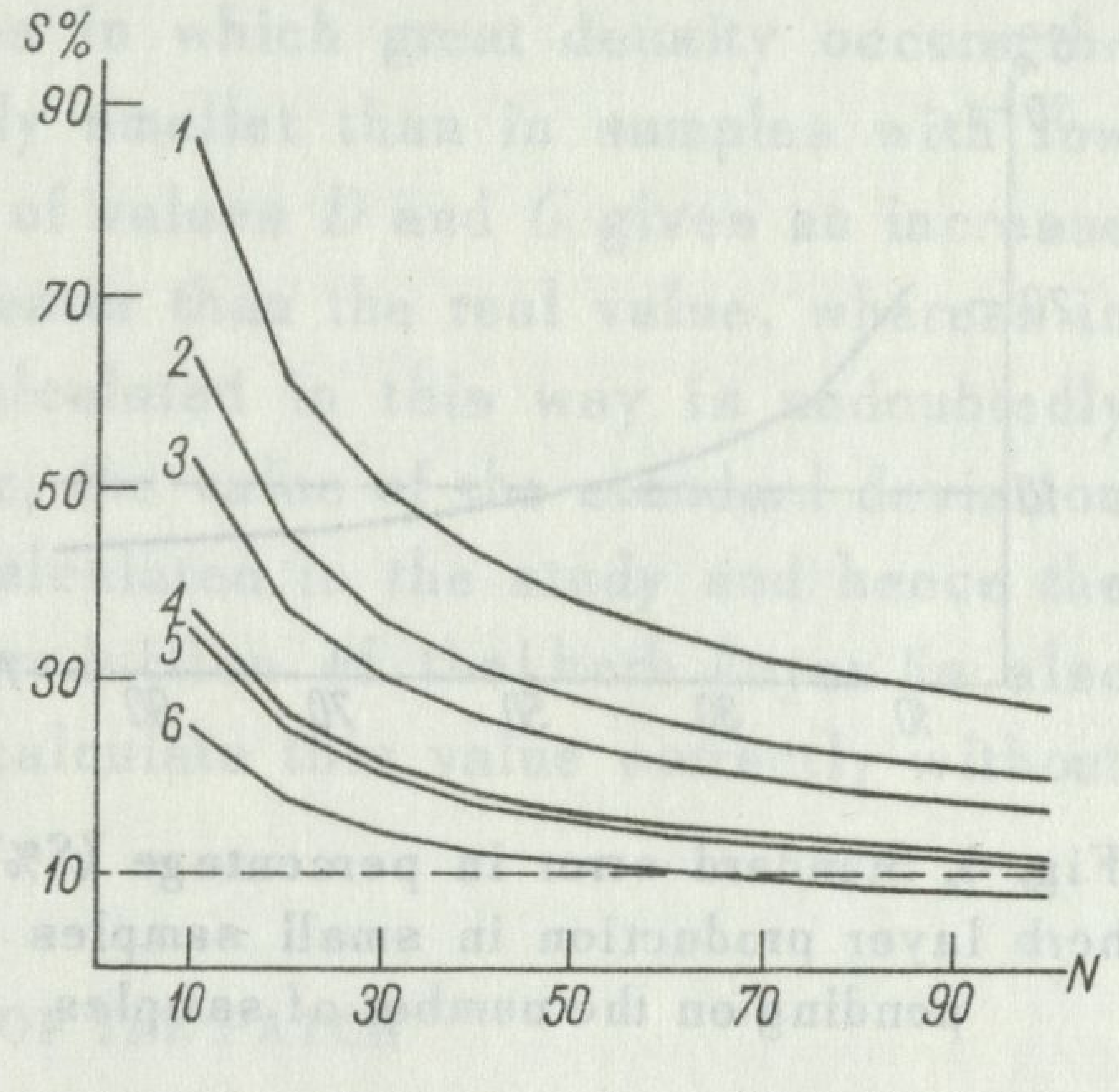


Fig. 3. Standard error in percentage (S%) of the density of 6 species of the herb layer in small samples, depending on the number of samples (N)

1 — *Galeobdolon luteum*, 2 — *Aegopodium podagraria*, 3 — *Oxalis acetosella*, 4 — *Chrysosplenium alternifolium*, 5 — *Utrica dioica*, 6 — *Impatiens noli tangere*

When investigating the primary production of the herb layer by the method used, the correct determination of the density of different species interests us only as far as it affects correct calculation of production. As errors in determining the density of different species may possess different deviations (plus and minus) it may be accepted that part of the errors cancel each other out. In order to find out whether a certain lack of accuracy in defining the density of different species in the herb layer greatly affects calculation of herb layer production, calculation was made of the percentage of standard error of average increase in herb layer biomass in small samples depending on the number of samples (Fig. 4). It can be seen from this diagram that even with 50 samples this error falls below the value of 10%.

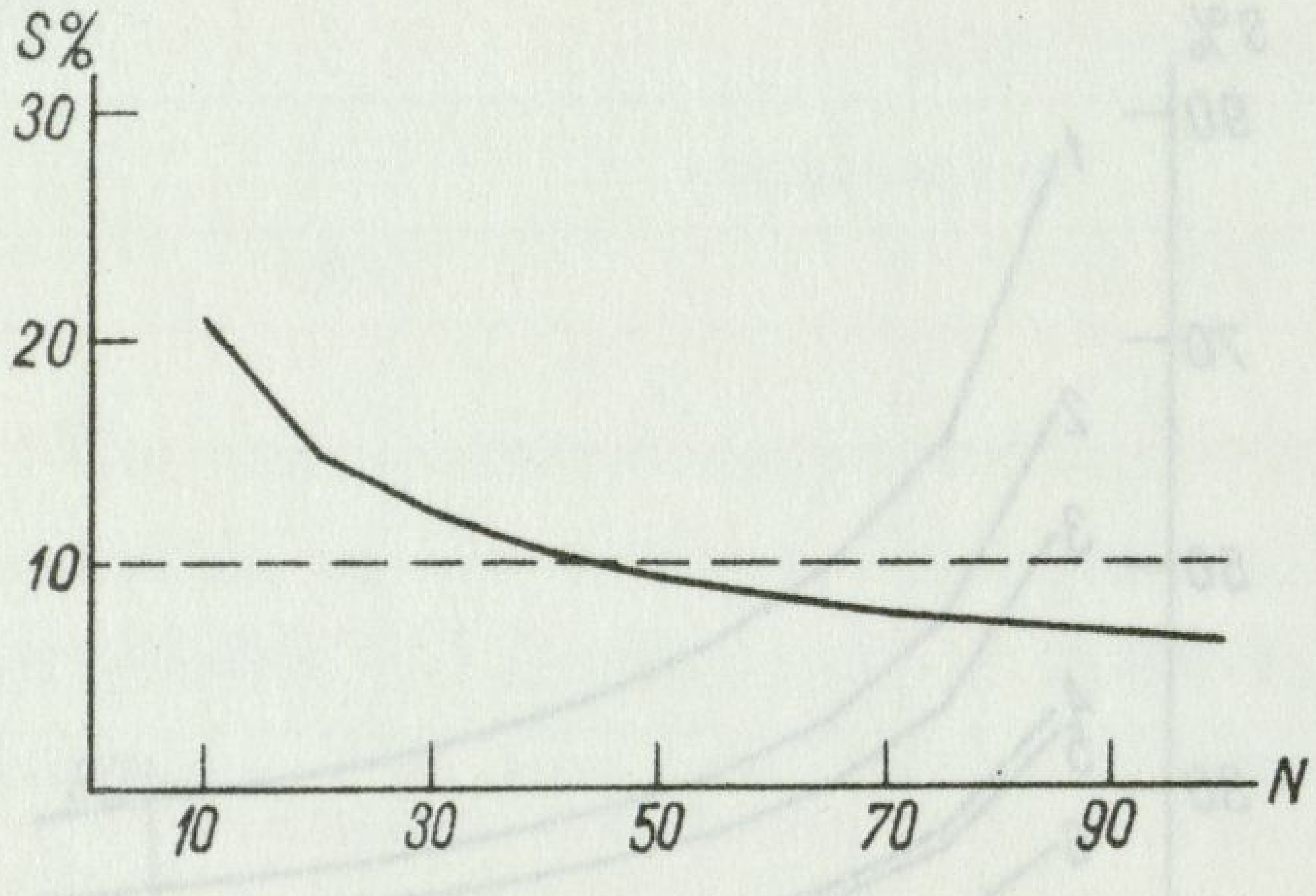


Fig. 4. Standard error in percentage (S%) of herb layer production in small samples depending on the number of samples

It follows from this that production, despite the different dispersion of individuals of different species, is more evenly distributed in space than the distribution of individuals of different species in the herb layer. It may therefore be considered that the reduced number of individual plants of a given species in a given place is compensated for by the increased number of individuals of other species.

A diagram was made of the percentage of dry mass of the annual growth of the herb layer in 100 small samples (Fig. 5). This exhibits an evenly rising oblique line which shows that there are few samples with great increases. The majority of the samples come within the class from 4.5 to 8.5 g/0.1 m². Mean production of dry biomass of the herb layer on the basis of 100 small samples was 107.622 g/m². The coefficient of herb layer production variation was 66.49% for 100 samples. It must be emphasised here in connection with so high a variation coefficient, that its value, although correctly calculated, is probably slightly over-estimated on account of the method used for calculating production in each sample.

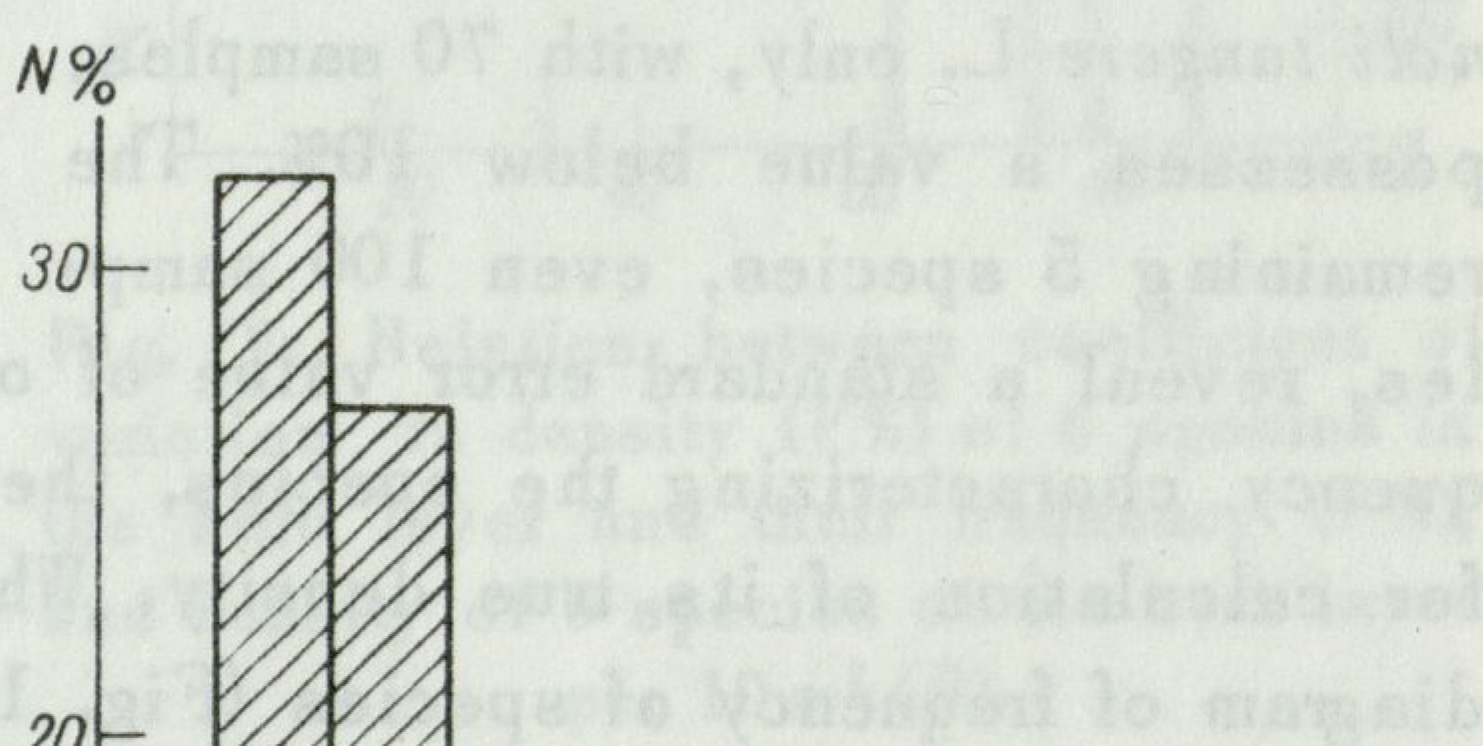


Fig. 5. Diagram of the percentages found of 100 small samples (N%) in classes of annual increase in dry mass (B) in g/0.1 m²

Calculated production in each sample is burdened with errors which cannot be eliminated without setting up permanent sampling areas. Herb layer production in a sample was calculated assuming that each individual of a given species occurring in a sample produces as much biomass as the mean value from samples taken for weighing growth. Where there are considerable differences in the number of individuals of all species jointly in the samples, in those samples in which great density occurs the production of each individual is probably smallet than in samples with low density. Hence the simple multiplication of values *D* and *G* gives an increase probably in samples of great density, greater than the real value, whereas in samples of low density the increase calculated in this way is undoubtedly underestimated. With the same mean value, the value of the standard deviation is thus certainly far smaller than that calculated in the study and hence the variability coefficient of dry biomass production of the herb layer is also lower. It is unfortunately impossible to calculate this value correctly without permanent study areas.

## DIFFERENTIATION OF THE PATCH

In order to check whether the homogeneity of the patch shown by small samples is correct, calculation was made of the coefficients of floristic similarity between small samples after Jaccard's formula. Four groups of samples were distinguished on Czekanowski's diagram. A shortened form of this diagram is given in Figure 6. In this diagram the values shown on the diagonal give

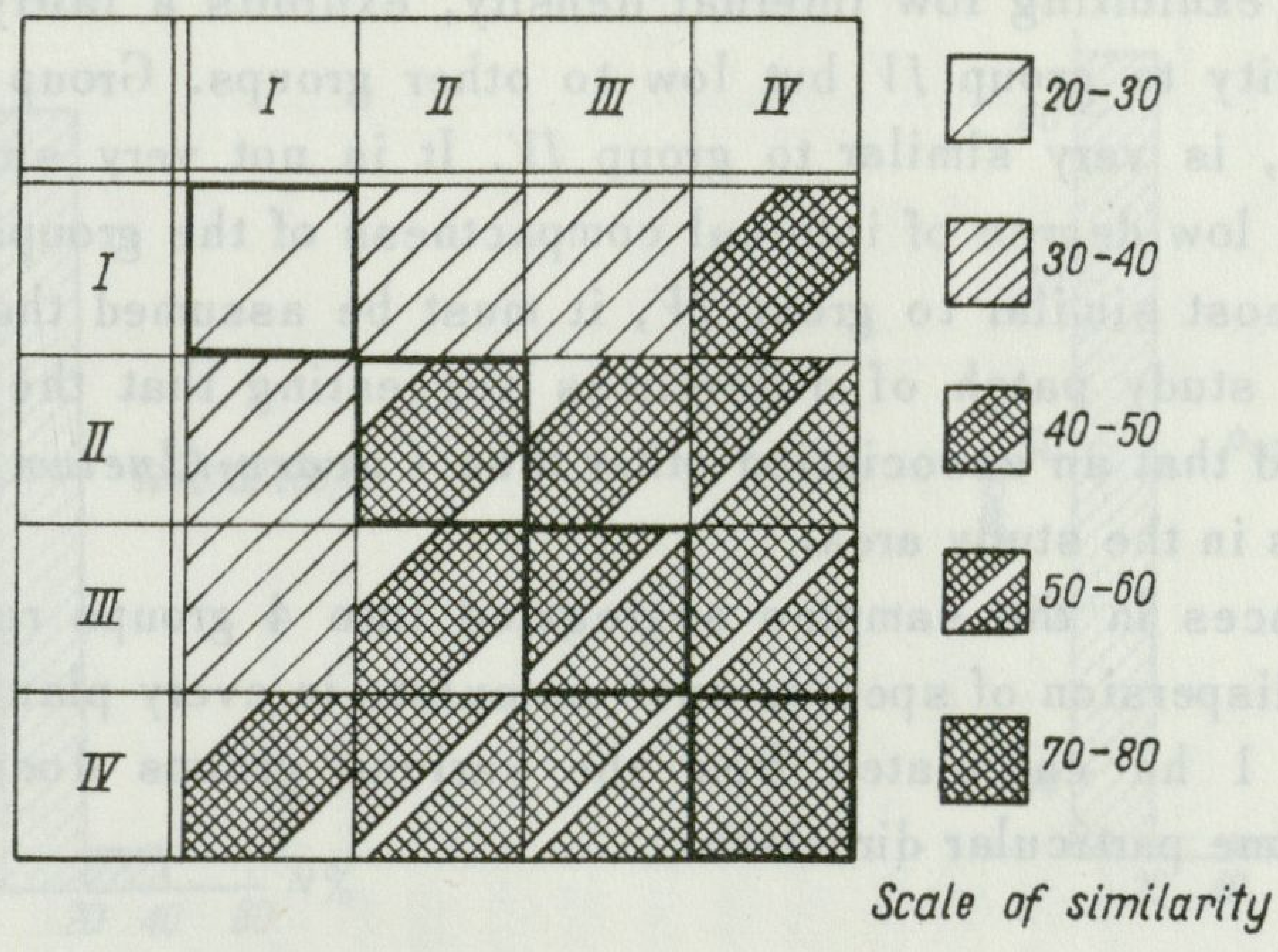


Fig. 6. Differentiation of 100 small samples in a patch of *Circaeo-Alnetum*

the mean similarity coefficient between samples in the given group. The remaining values give the mean value of the similarity coefficient between samples in the given group and samples in the other groups. The groups were arranged on the diagram in order of increasing value of the mean similarity coefficient of the given group. Some data on the groups distinguished are given in Table III.

Description of the groups of samples distinguished in Czekanowski's diagram

Tab. III

| Group | *I* | *II* | *III* | *IV* |
|---|---|---|---|---|
| Number of samples in a group | 23 | 20 | 28 | 29 |
| Number of herb layer species in a group | 30 | 28 | 27 | 22 |
| Mean number of species in a sample | 4.56 | 6.10 | 6.18 | 6.28 |
| Mean number of individuals in a sample | 33.70 | 55.25 | 79.18 | 72.69 |
| Herb layer production in kg/ha | 930.390 | 1234.260 | 911.360 | 1215.120 |

Group *I* exhibits the minimum internal compactness. It includes samples with a small number of species and with low numbers of individual plants in a sample. This group exhibits the maximum number of listed species, but with the small number of species per sample this value indicates that they are distributed over the area in differing combinations. The most compact group is group *IV*, which is characterized by a small number of the listed species, but a large number of species per sample and considerable density of individuals. This is the group including the samples most typical of the study patch. Group *II*, while exhibiting low internal density, exhibits a fairly high coefficient of similarity to group *IV* but low to other groups. Group *III*, with low internal density, is very similar to group *IV*. It is not very similar to other groups. With the low degree of internal compactness of the groups distinguished, which are most similar to group *IV*, it must be assumed that there is an absence in the study patch of differences suggesting that the patch is not homogeneous and that an association other than *Circaeo-Alnetum* was included in investigations in the study area.

The differences in the samples segregated into 4 groups result from the natural spatial dispersion of species such as exists in every plant association. Production per 1 ha calculated from the various groups does not exhibit changes in any one particular direction.

## PRODUCTION OF THE PATCH

Net herb layer production was defined in the study patch by the DG method on the basis of small (0.1 m²) and large (25 m²) samples. When investigating the density of large perennials and rare species determined from large samples their density obtained from small samples was omitted in order to avoid doubling results.

When investigating production sampling revealed that 41 species occur in the herb layer. This value is not much lower than the actual number of species occurring in the patch examined. The density of different species, their frequency in small samples and production are given in Table IV. Species for which frequency is not given, come from large samples. The combined number of individuals of all species was 6157580/ha, which gives an average of about 616 individuals per 1 m² of the patch.

Numerical dominants in the study patch are: *Chrysosplenium alternifolium* L., *Oxalis acetosella* L., *Impatiens noli tangere* and *Urtica dioica* L. The first two species, which are absolute numerical dominants, are not simultaneously dominants in total herb layer production. On account of the differing individual increase in biomass numerical and productive domination do not coincide. Absolute dominants in production are: *Urtica dioica, Impatiens noli tangere* and *Chaerophyllum hirsutum* L., which jointly give 69.10% of herb layer production. Together with such species as: *Cirsium oleraceum* (L.) Scop., *Stellaria nemorum* L., *Circaea lutetiana* L., *Chrysosplenium alternifolium, Aegopodium podagraria* L., *Geum urbanum* L. and *Crepis palludosa* (L.) Mnch. they yield about 90% of the total herb layer production. This constitutes 24.4% of the species in the herb layer, and thus the remaining 10% of production is produced by about 75% of the species.

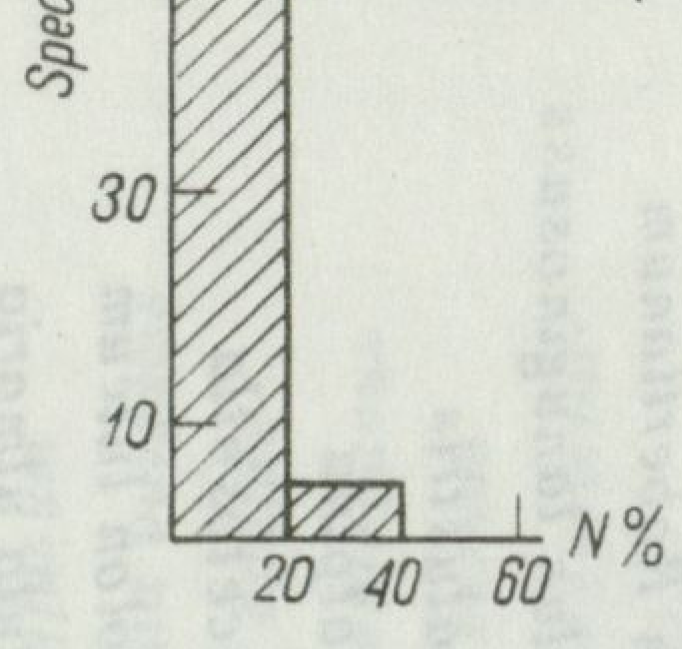


Fig. 7. Diagram of numerousnes of species (%) in classes of percentages of total abundance of the herb layer ($N$%)

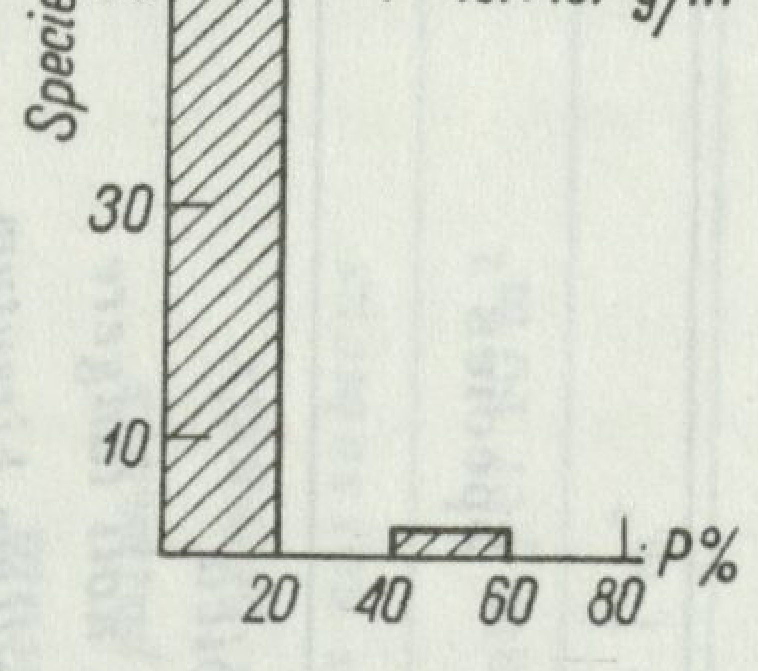


Fig. 8. Diagram of numerousness of species (%) in classes of percentages of total production ($P$%)

Frequency ($F$) of herb layer in 100 small samples, density per 10 m² ($D$) and dry biomass production ($P$) per 10 m² in the *Circaeo-Alnetum* association

Tab. IV

| No. | Species | $F$ % | $D$ | | $N$* | Individual growth | $P$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | $n$ | % | | | g/10 m² | % | Cumulated % |
| 1 | *Urtica dioica* | 79 | 424 | 6.89 | 200 | 1069 | 453.256 | 42.18 | 42.18 |
| 2 | *Impatiens noli tangere* | 88 | 952 | 15.46 | 300 | 174 | 165.774 | 15.43 | 57.61 |
| 3 | *Chaerophyllum hirsutum* | 74 | 115 | 1.87 | 100 | 1074 | 123.510 | 11.49 | 69.10 |
| 4 | *Cirsium oleraceum* | 3 | 18 | 0.29 | 50 | 2386 | 42.948 | 4.00 | 73.10 |
| 5 | *Stellaria nemorum* | 36 | 141 | 2.29 | 100 | 282 | 39.734 | 3.70 | 76.80 |
| 6 | *Circaea lutetiana* | 23 | 75 | 1.22 | 50 | 489 | 36.682 | 3.41 | 80.21 |
| 7 | *Chrysosplenium alternif.* | 74 | 2205 | 35.81 | 400 | 15 | 32.654 | 3.04 | 83.25 |
| 8 | *Aegopodium podagraria* | 32 | 150 | 2.44 | 50 | 205 | 30.750 | 2.86 | 86.11 |
| 9 | *Geum urbanum* | 10 | 26 | 0.42 | 40 | 741 | 19.266 | 1.79 | 87.90 |
| 10 | *Crepis palludosa* | 12 | 43 | 0.70 | 50 | 347 | 14.921 | 1.39 | 89.29 |
| 11 | *Geranium Robertianum* | 26 | 49 | 0.80 | 50 | 277 | 13.580 | 1.26 | 90.55 |
| 12 | *Ranunculus lanuginosuss* | 7 | 22 | 0.36 | 40 | 605 | 13.310 | 1.24 | 91.79 |
| 13 | *Caltha palustris* | 3 | 59 | 0.96 | 50 | 216 | 12.714 | 1.18 | 92.97 |
| 14 | *Circaea alpina* | 13 | 135 | 2.19 | 50 | 89 | 11.981 | 1.11 | 94.08 |
| 15 | *Oxalis acetosella* | 62 | 1261 | 20.48 | 300 | 8 | 9.573 | 0.89 | 94.97 |
| 16 | *Galeobdolon luteum* | 18 | 99 | 1.61 | 80 | 93 | 9.207 | 0.86 | 95.83 |
| 17 | *Filipendula ulmaria* | 5 | 48 | 0.78 | 40 | 186 | 8.928 | 0.83 | 96.66 |
| 18 | *Asarum europaeum* | 10 | 62 | 1.01 | 40 | 96 | 5.936 | 0.55 | 97.21 |
| 19 | *Ribes nigrum* | 4 | 8 | 0.13 | 30 | 480 | 3.840 | 0.36 | 97.57 |
| 20 | *Galium aparine* | 6 | 9 | 0.15 | 30 | 375 | 3.375 | 0.31 | 97.88 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 21 | *Paris quadrifolia* | 13 | 24 | 0.39 | 30 | 110 | 2.647 | 0.25 | 98.13 |
| 22 | *Dryopteris spinulosum* | – | 8.16 | 0.13 | 50 | 290 | 2.366 | 0.22 | 98.35 |
| 23 | *Asperula odorata* | 2 | 23 | 0.37 | 30 | 96 | 2.216 | 0.21 | 98.56 |
| 24 | *Millium effusum* | 4 | 38 | 0.62 | 30 | 54 | 2.036 | 0.19 | 98.75 |
| 25 | *Lysimachia vulgaris* | 1 | 2 | 0.03 | 30 | 1011 | 2.022 | 0.19 | 98.94 |
| 26 | *Viburnum opulus* | 4 | 5 | 0.08 | 30 | 325 | 1.625 | 0.15 | 99.09 |
| 27 | *Lycopus europaeus* | 3 | 4 | 0.06 | 30 | 394 | 1.576 | 0.15 | 99.24 |
| 28 | *Lathyrus vernus* | 5 | 7 | 0.11 | 30 | 148 | 1.038 | 0.10 | 99.34 |
| 29 | *Fraxinus excelsior* | 1 | 3 | 0.05 | 30 | 345 | 1.035 | 0.10 | 99.44 |
| 30 | *Poa trivialis* | 3 | 37 | 0.60 | 30 | 26 | 0.962 | 0.09 | 99.53 |
| 31 | *Polygonatum multiflorum* | 1 | 2 | 0.03 | 30 | 460 | 0.920 | 0.09 | 99.62 |
| 32 | *Athyrium filix femina* | – | 1.72 | 0.03 | 50 | 462 | 0.796 | 0.07 | 99.69 |
| 33 | *Ficaria verna* | 4 | 50 | 0.81 | 30 | 15 | 0.757 | 0.07 | 99.76 |
| 34 | *Ranunculus repens* | 1 | 4 | 0.06 | 30 | 166 | 0.662 | 0.06 | 99.82 |
| 35 | *Cardamine amara* | 5 | 23 | 0.37 | 30 | 25 | 0.567 | 0.05 | 99.87 |
| 36 | *Majanthemum bifolium* | 5 | 13 | 0.21 | 30 | 42 | 0.546 | 0.05 | 99.92 |
| 37 | *Anemone nemorosa* | 2 | 11 | 0.18 | 30 | 44 | 0.481 | 0.04 | 99.96 |
| 38 | *Actaea spicata* | – | 0.12 | 0.01 | 30 | 1470 | 0.168 | 0.02 | 99.98 |
| 39 | *Myosotius palustris* | – | 0.12 | | 30 | 783 | 0.090 | 0.02 | 100.00 |
| 40 | *Mercurialis perennis* | – | 0.18 | | 30 | 364 | 0.066 | | |
| 41 | *Ranunculus cassubicus* | – | 0.28 | | 30 | 205 | 0.057 | | |
| | Totalled data per 10 m² | | 6157.58 | 100.00 | | | 1074.572 | 100.00 | |
| | Values per 1 m² | | 616 individuals/m² | | | | 107.457 g/m² | | |

*N** – number of individuals of each species according to which the individual increase in biomass was calculated.

A diagram was made showing the percentage of species in the total numbers of the herb layer (Fig. 7). It can be seen from this diagram that in over 95% of the species numbers come within the limits of the class from 0–20%.

The percentage of biomass increase in total production of the herb layer given in the diagram (Fig. 8) shows that about 98% of the species exhibit production within the limits of the class 0–20%.

The individual annual increase in herb layer species is shown in diagram form in Figure 9. Only a few species have annual increase of over 1 gram. Over 70% of the species exhibit annual individual increase within limits up to 0.4 g, with extreme values for all species of 8–2386 mg.

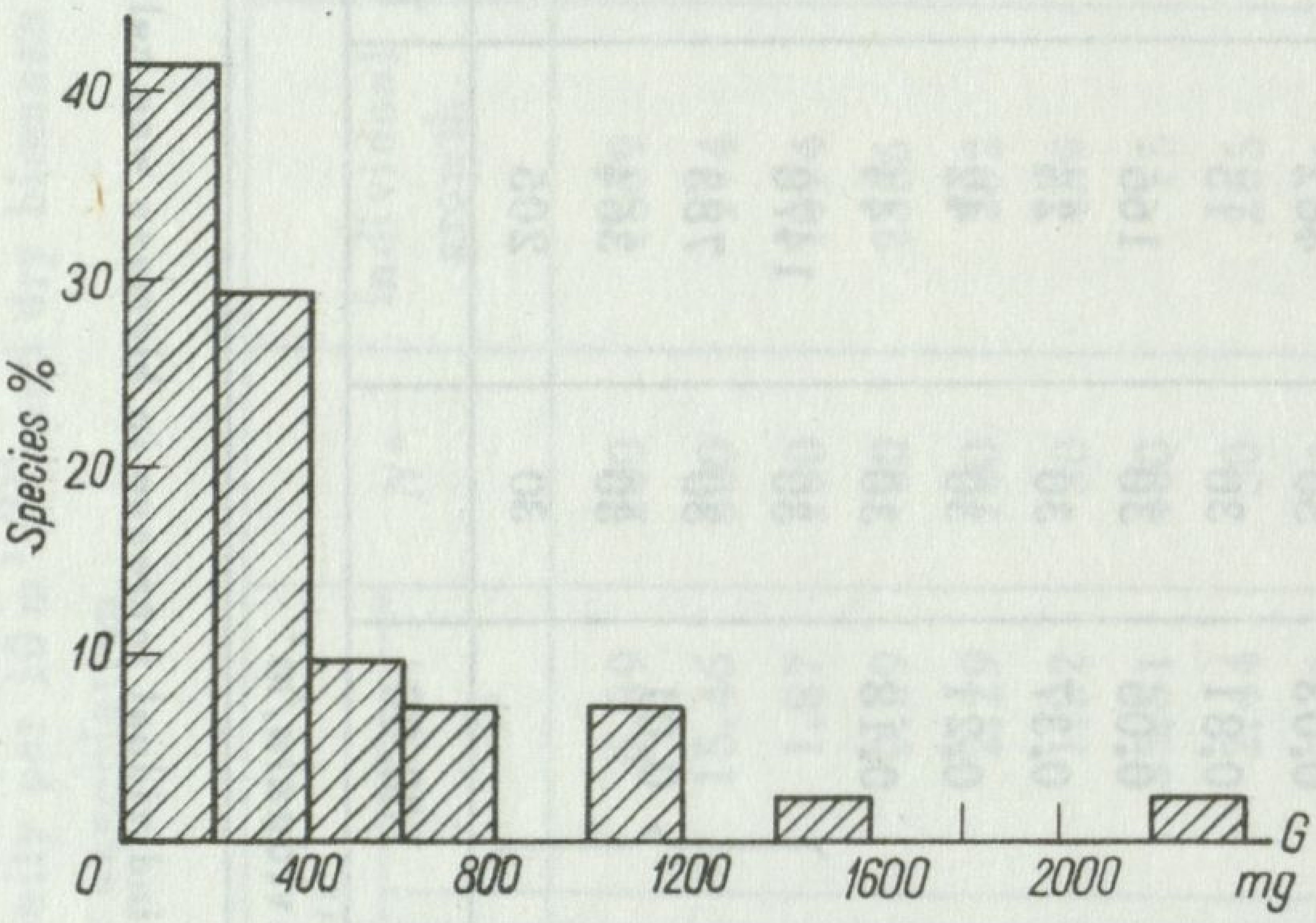


Fig. 9. Diagram of percentages of species in classes in individual growth ($G$) in mg

The average annual individual increase of dominants is as follows: *Urtica dioica* 1.069 g, *Impatiens noli tangere* 0.174 g, *Chaerophyllum hirsutum* 1.074 g. The sum total of annual increases in the population of all species of the herb layer on the basis of samples was 1074.572 kg/ha, which gives about 107.457 g/m².

Annual production of the herb layer in the patch of the *Circaeo-Alnetum* association examined was, with $P_a = 95\%$

$$1,074.572 \pm 140.016 \text{ kg/ha}.$$

The confidence interval was calculated according to the percentage of standard error of net herb layer production from small samples. As in the foregoing discussion this error was considered as probably overestimated, it should be assumed that the confidence interval is in reality far narrower.

Calculated production per 1 m² was thus 107.457 ± 14.002 g.

This production is obtained when the average herb layer cover is 72.1% (in May). Production of mosses, the average cover of which was 11.5%, was not analysed.

## CONCLUSIONS

1. The DG method necessitates setting up fairly densely distributed random sampling areas in order to be able to grasp the true density relations in the population of herb layer species occurring there.

2. Sampling for the purpose of weighing annual increases must be distributed evenly over the whole area, since it is necessary to grasp the mean individual increase. This is particularly important when the density of the tree stand varies, which causes differences in value $G$.

3. 100 samples proved, generally speaking, to be too small a number for proper calculation of herb layer production in the study patch. Although percentage of the standard error ($S\%$) of calculated production drops below 10% when the number of samples is increased to about 45, yet in order to attain the level of 5% most frequently accepted in biological investigations the number of samples should in the given case be about 180 ($S\% = \frac{V}{\sqrt{n}}$, for $S\% = 5\%$, $n = 175.6$ that is, about 180). With this number of samples the confidence interval for calculated production would be far narrower.

4. It is impossible to calculate the density of large perennials by means of small samples ($0.1\ m^2$). For these large plants it would be necessary to lay out larger samples, in which rare species occurring sporadically in the patch would be frequently encountered.

5. The majority of the herb layer species exhibited a low degree of frequency, which is evidence that they are unevenly distributed over the area. For such species 100 samples is a number insufficient to calculate real density with a small degree of error.

6. The study patch of the association *Circaeo-Alnetum*, which was 0.2 ha in extent, proved to be fairly homogeneous.

7. When large and small samples were taken jointly the total number was 41 herb layer species, which figure differs very little from the real value. Only a few species occurring sporadically in the study patch were missed by the samples.

8. The calculated production value per $1\ m^2$ is

$$107.457 \pm 14.002\ g$$

which in comparison with other forest associations is a fairly large value (Kaźmierczakowa 1967, Rajchel 1965, Traczyk T. 1967b, Traczyk H. and Traczyk T. 1967).

9. Production in the *Circaeo-Alnetum* association is formed in principle by a small number of dominating species. The remaining majority of herb layer species forms a negligible percentage of total production.

10. The average number of individual plants in the herb layer per 1 $m^2$ is 616, about 56% of this number being formed by two very small species (*Chrysosplenium alternifolium* and *Oxalis acetosella*), whereas the three absolute dominants in total herb layer production jointly form 24% of the numbers.

11. In the *Circaeo-Alnetum* association biomass from previous years occurs only sporadically on biennials and perennials. This is probably due to the fact that during winter a specific "fibrous ice" occurs in this biotope (Sokołowski 1962), which pulls the herb layer from the ground. During spring few of the individual biennials and perennials were capable of forming new roots and the majority of them died.

12. The DG method is not very laborious and is based on direct measurements of two parameters (*D* and *G*), hence it would seem that the possibility of making errors is far smaller then when using other methods (e.g. rate of disappearance of the dead parts of plants and changes in state of biomass).

13. It would appear that with this method the calculated herb layer production is to some, most certainly very slight, degree underestimated. This may be due to the fact that certain individuals in the population of different species of the herb layer may not survive to the time at which density is calculated. That part of the population which dies during the first period of development of the population of different species is not included in the investigations. As individuals which die while still young have relatively little growth, the underestimation of the calculated value is undoubtedly also slight. It would, however, be desirable to carry out investigations on the development dynamics of the populations of different species, particularly of dominants, on permanent study areas, in order to define the error which burdens the herb layer production calculated by means of the DG method.

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## BADANIE PRODUKCJI RUNA W ZESPOLE *CIRCAEO-ALNETUM* OBERD.

### Streszczenie

W roku 1967 w zespole *Circaeo-Alnetum* Oberd. 1953, na powierzchni 0,2 ha w Białowieskim Parku Narodowym zbadano produkcję netto runa według metody DG (Traczyk T. 1967a). W tym celu założono na transektach losowo 100 prób małych (0,1 m²) oraz 15 prób dużych (25 m²).

Stwierdzono, że ilość prób małych, według których obliczono zagęszczenie większości gatunków (oprócz wielkich bylin i gatunków rzadkich) jest dla przeważającej ilości występujących gatunków za mała dla obliczenia rzeczywistego zagęszczenia z małym błędem. Przy tym im gatunek wykazuje mniejszą frekwencję tym błąd w określeniu zagęszczenia jest większy. Dla obliczenia rocznej produkcji runa ilość prób małych wykazała błąd standardowy około 6,6%.

Badany płat o pow. 0,2 ha nie wykazuje zmienności, która wskazywałaby na istnienie w nim innych zespołów czy też podzespołów.

Obliczona produkcja runa według prób małych i dużych wynosi: 1074,572 ± ± 140,016 kg/ha.

Przeciętna ilość osobników wszystkich gatunków łącznie na 1 m² wyniosła 616.

Stwierdzono, że tylko niewielka ilość gatunków tworzy produkcję biomasy runa. Przeważająca większość gatunków ma znikomy udział w produkcji ogólnej. Dominanty w ogólnej produkcji runa nie są jednocześnie dominantami ilościowymi w badanym płacie.

AUTHOR'S ADDRESS:
Dr. Władysław Aulak
Katedra Gospodarstwa Łowieckiego SGGW
Warszawa, Rakowiecka 8
Poland.