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# Investigations on the Growth Rate of Lichens

## Badania nad szybkością wzrostu porostów

## Исследования над скоростью роста лишайников

Attempts have been made by many lichenologists to assess the growth rate of lichens, but planned investigations are scarce. In their recent works on lichens Beschel (1958) and Frey (1959) have given a historical survey, references and the results of up-to-date observations. As lichens live a great many years and their growth is extremely slow, attempts were made to assess the growth of thalli by various methods: 1) casual observations based on the knowledge of the age of a substratum, e. g. roofs of buildings, tomb-stones, rocky substratum modified by man's activity or occasionally by nature; 2) spatial measurements of lichens found on branches of trees; on the basis of the age of the trees examined calculations were made to assess the spatial increment; 3) planned examinations were conducted — some plots were chosen on which once a year or once over a period of several years measurements of the diameter of thalii were taken in order to assess the yearly increment in mm. Long-term and exact investigations were carried out by Frey in Switzerland. He made measurements of the diameter of selected thalli at certain intervals of time or calculated the growth of lichens by means of photographs. This latter method also enabled the examination of several features and succession on chosen plants (Frey 1959).

### METHODS OF MY OWN EXAMINATIONS.

In 1953 in the reserve of the Białowieża National Park, a part of the Białowieża forest, quadrats were established on 10 trees to assess the growth of crustaceous lichens. In the following years examinations

were extended to a larger number of trees, including epiphytic foliose and crustaceous species and epilithic foliose species. At present investigations are in progress in Lublin and Puławy.

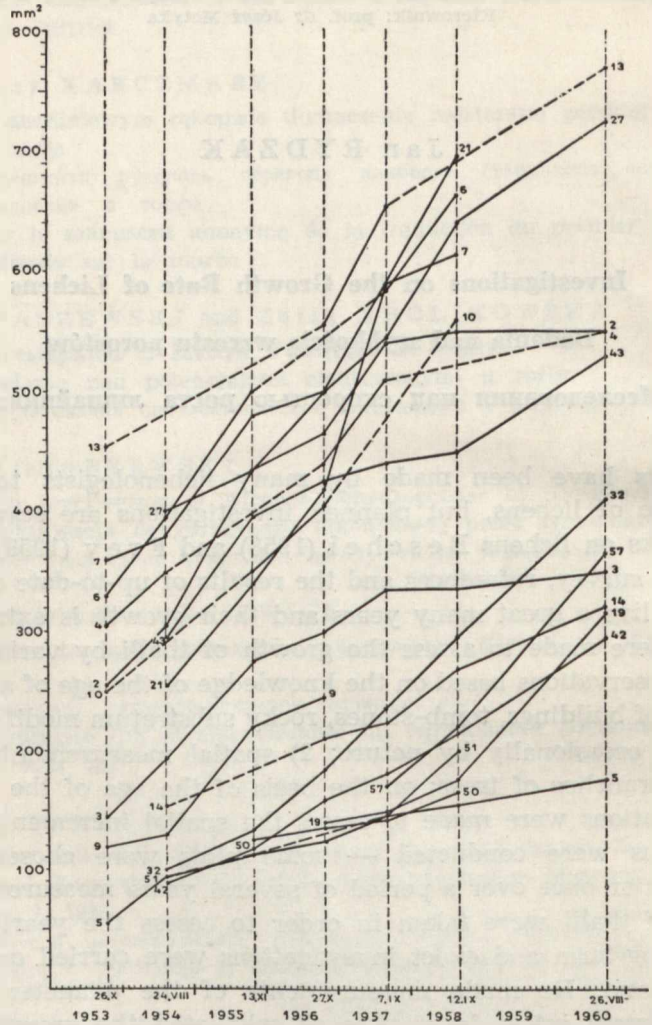


Fig. 1. The growth rate of epiphytic lichens in the Białowieża National Park. Numbers according to Tables 1 and 2.

In the Białowieża National Park quadrats were set up on limes and yoke-elms. The trees and quadrats on which measurements of the thalli Nos. 1—11, 56, 57 were taken are in Section No. 399. Thalli Nos. 12—14, 20—54 are in Section 398 (area VII) subassociation *Querceto-Carpinetum typicum*, T ü x e n 1937. Those with Nos. 15—19 are in

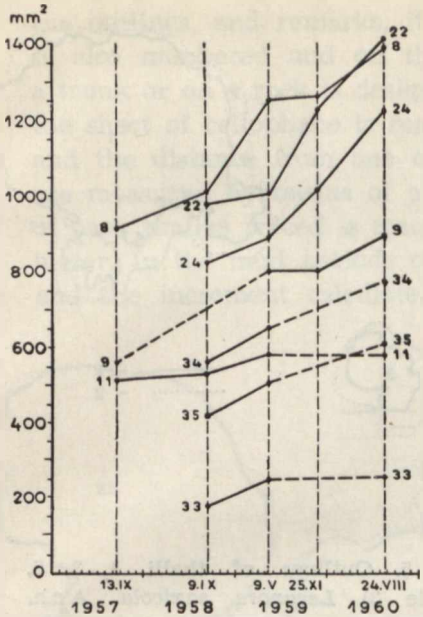


Fig. 2. The growth rate of epilithic lichens in the Białowieża National Park. Numbers according to Table 3.

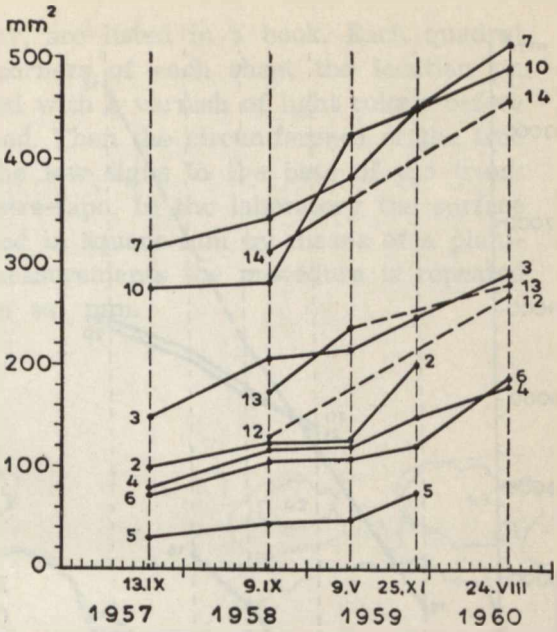


Fig. 3. The growth rate of epilithic lichens in the Białowieża National Park. Numbers according to Table 3.

Section 340 (area VIII) subassociation *Querceto-Carpinetum caricetosum pilosae* (Braun-Blanquet 1932) Moor 1938. Ecological observations and the state of lichen flora in the subassociation were reported earlier (Rydzak 1961).

Meteorological data (Figs. 12—15) were obtained from field meteorological stations set up by Prof. W. Matuszkiewicz. They are situated in the vicinity of the trees examined. I wish to thank Prof. W. Matuszkiewicz and Mgr S. Sokołowski by whose courtesy I could make use of some meteorological data (Figs. 12—15) so far unpublished.

As soon as I obtained some positive results I gave an account of my method (Rydzak 1956). The method in question is as follows; a sheet of cellophane of approximate size 15 x 20 cm² is pinned up with steel needles to the surface of a tree trunk. Its size depends on the distribution of suitable thalli. Outlines of all the thalli are traced out on the cellophane with a pen. For tracing minute outlines of the thalli a magnifying glass was used (5 x). Recently I have been using excellent material called „Kodatrees" (of German make, NRD) which is highly valued for three reasons: it does not shrink, it has one dull side and tracing with a pencil is possible. Each outline of a thallus is designated by a number, and the name of a species together with the numbers of

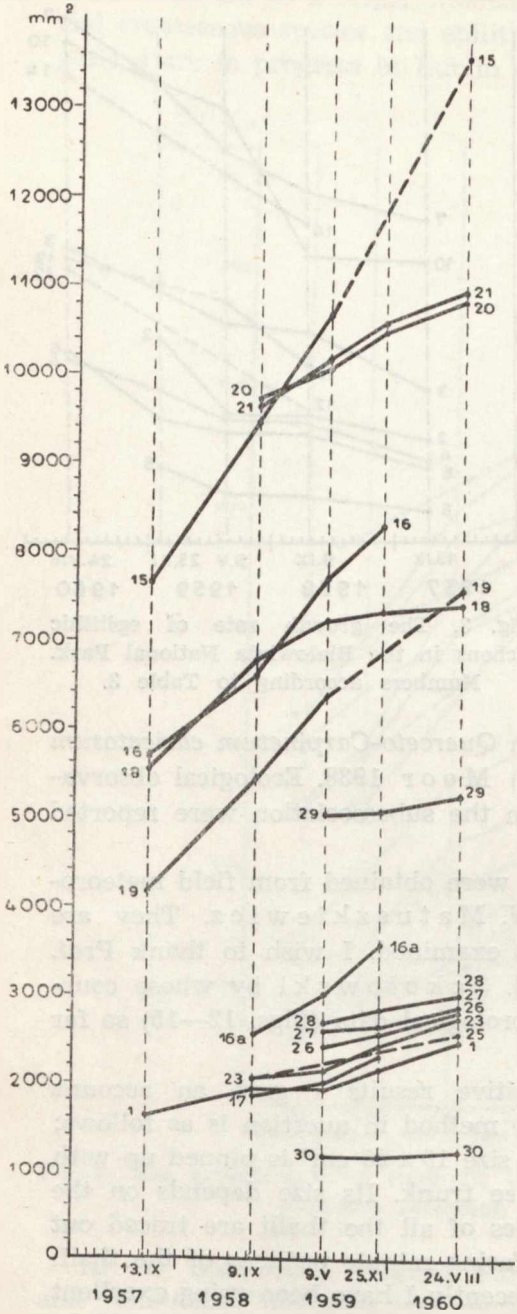


Fig. 4. The growth rate of epilithic lichens in the Białowieża National Park. Numbers according to Table 3.

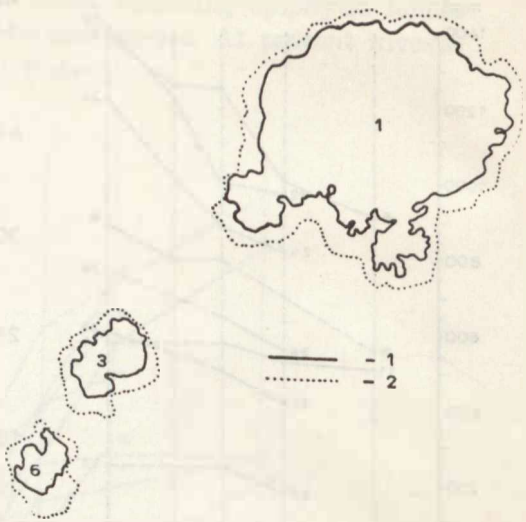


Fig. 5. Outlines of thalli 1, 3, 6, (Table 3) *Lecanora saxicola* Ach. (*Placodium saxicolum* Kbr.) from the years 1957 (1) and 1960 (2).

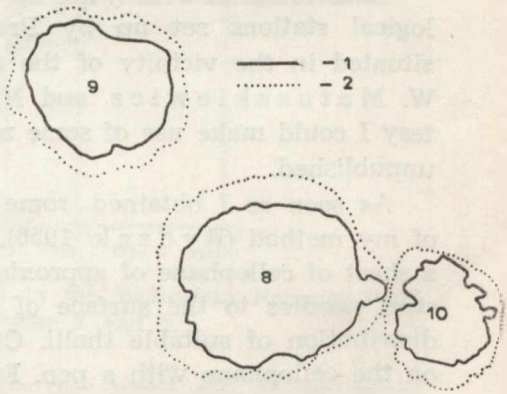


Fig. 6. Outlines of thalli 8, 9 — *Aspicilia cinerea* Th. Fr., 10 — *Lecanora saxicola* (Table 3) from the years 1957 (1) and 1960 (2).

the outlines, and remarks, if any, are listed in a book. Each quadrat is also numbered and on the corners of each sheet the location on a trunk or on a rock is designated with a varnish of light colour before the sheet of cellophane is removed. Then the circumference of the tree and the distance from one of the low signs to the base of the trunk are measured by means of a metre-tape. In the laboratory the surface of each thallus traced is measured in square mm by means of a planimeter. In the next periods of measurements the procedure is repeated and the increment calculated in sq. mm.

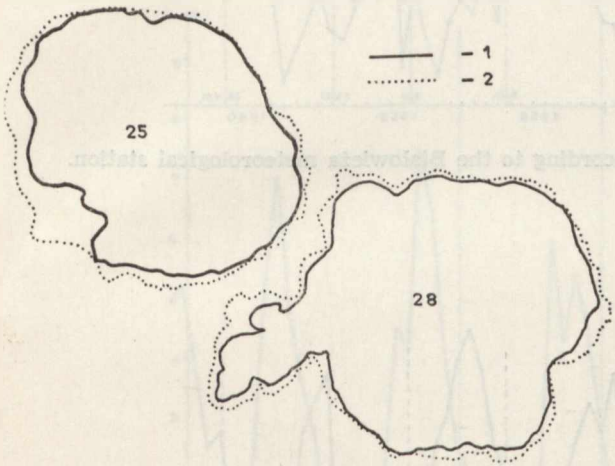


Fig. 7. Outlines of thalli 25 — *Lepraria latebrarum* Ach. from November 26, 1959 (1) and 1960 (2). Outlines of thalli 28 — *Lepraria latebrarum* from May 10, 1959 (1) and 1960 (2) — Table 3.

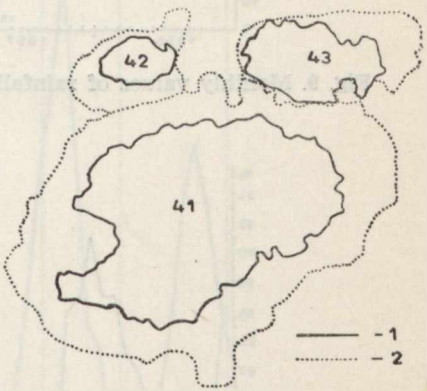


Fig. 8. Outlines of thalli 41, 42 — *Graphis scripta* (L.) Ach., 43 — *Pertusaria coccodes* (Ach.) Nyl. from 1954 (1) and 1960 (2).

This method ensures the recording of all changes in the shape of the thallus of crustaceous and foliose species. However, its application to fruticose species is very difficult as each thallus should be covered with sheets of cellophane on all sides; this may damage the thalli or at least jeopardize their growth.

After my method had been published I received from Mr. Mason E. Hale Jr. (U.S.A.) a published account of the preliminary results of his investigations by tracing the outlines of thalli (Hale 1954, 1959). Hale calculates the average length of the thallus and gives its increment in mm. From the average length of the radius Hale calculates approximately the size of the surface of the thallus.

An exact calculation of the surface increment of lichens by my

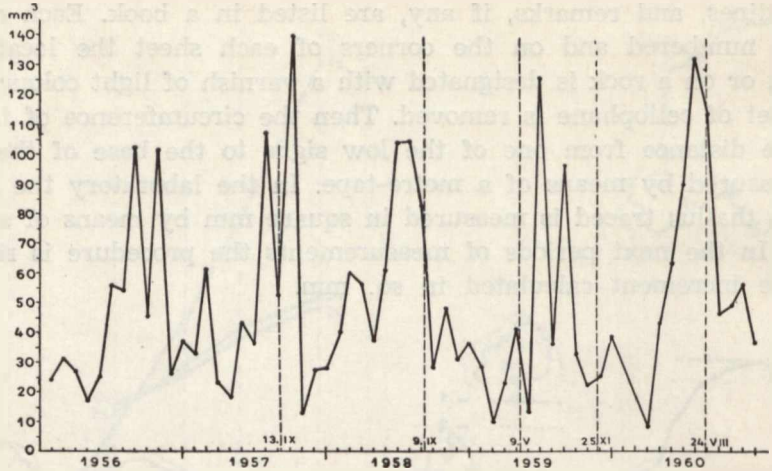


Fig. 9. Monthly values of rainfall according to the Białowieża meteorological station.

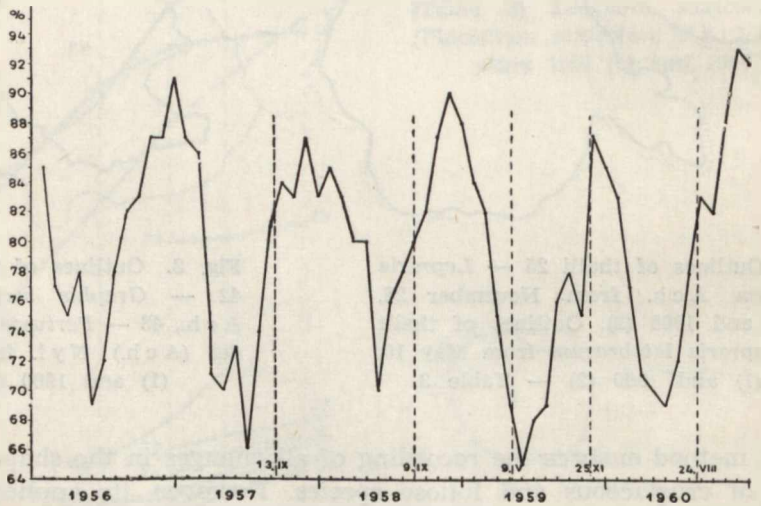


Fig. 10. Mean monthly values of relative humidity according to the Białowieża meteorological station.

method ensures not only a comparison of the growth rates of individual thalli and species, but makes it also possible to fathom the slow rate of developmental dynamics of these „starvelings" of the plant world. This method undoubtedly enables us to assess the amount of organic mass produced at a given time per unit of the surface increment of the thallus, and the simultaneous intake of mineral salts.

## RESULTS OF INVESTIGATIONS.

Part of the results of the investigations carried out by this method from 1953 to 1960 is given in Tables 1—3. The growth rate of some thalli is shown in diagrams (Figs. 1—4). The outlines of the thalli, traced (1 : 1) at the beginning and the end of each period, show the extent of the increment (Figs. 5—8). The tables and figures also present the results of investigations into the growth rate of epilithic lichens, which have been carried out since 1957 in the park set on Polana Białowieska, at a distance of about 900 m from the boundary of the reserve.

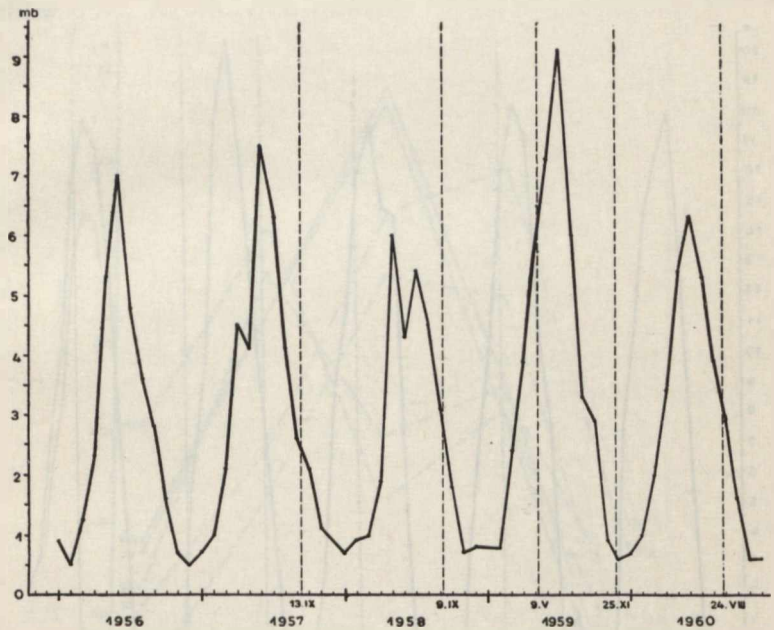


Fig. 11. Mean monthly saturation deficit of air according to the Białowieża meteorological station.

The distribution and the state of the epiphytic lichen flora in this park are presented in a previous paper (R y d z a k 1957). Investigations were made into epilithic lichens which grow on granite blocks on both sides of the road which leads to a former palace (EW direction). The upper parts of the blocks (0.8 m in width and about 0.5 to 1 m in length) are placed at a level of 0.4 to 1 m above the ground and have good irradiation. Only a few of them were slightly shaded by young trees and bushes which have grown up around the palace, which was burnt during the war. The upper parts of the slanting surfaces of those blocks are abundantly covered by lichens, among which prevail *Lecanora*

*saxicola, Aspicilia cinerea, Physcia caesia, Parmelia conspersa* and *Parmelia prolixa*. The biggest specimens of *Parmelia prolixa* were more than 20 cm in diameter. The surface coverage of the upper parts of the blocks ranged from 30 to 80 per cent. The side surfaces of those blocks were covered neither from the S nor from the N by lichens. From the N some side surfaces were covered by *Lepraria latebrarum*. This may serve as evidence to what extent lichens are influenced even by slight differences in ecological conditions. Accordingly lichens could be an index of ecological conditions, if lichenologists succeeded in elaborating suitable coefficients of correlation.

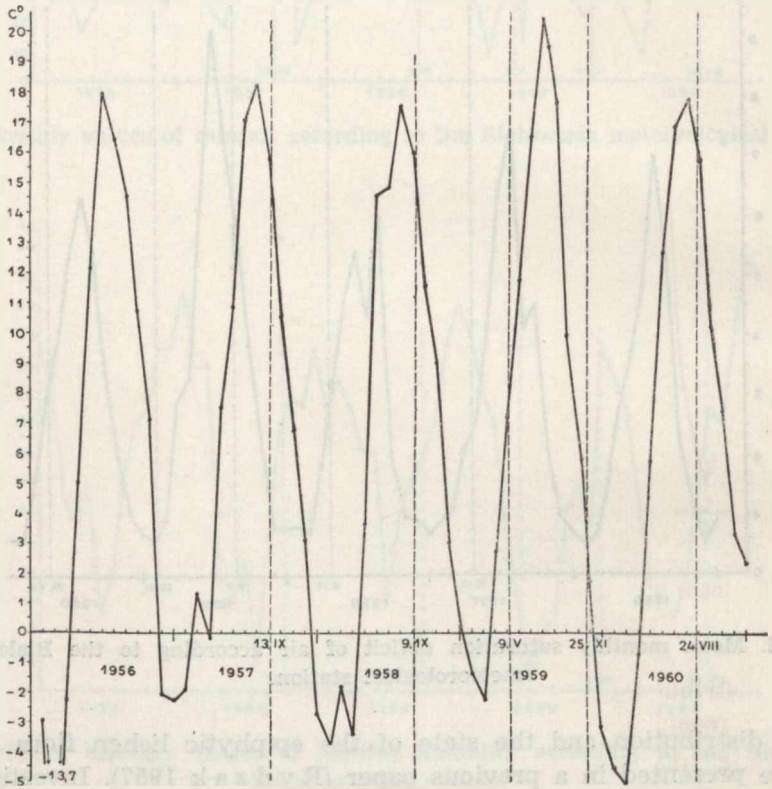


Fig. 12 Mean monthly values of temperature according to the Białowieża meteorological station.

At a distance of about 150 m from the stands there is a meteorological station. Some data obtained from this station for the years 1956—1960, are listed in Figs. 9—12. Unfortunately there are no data concerning the degree and time of insolation, which is of vital importance for lichen vegetation.

Table 4 presents the stands of epiphytic species in the Białowieża National Park. The values showing the distance from the bottom of the quadrat to the base of the tree are not exact because of the varied thickness of leaf litter; they are only given for the reader's information.

Tables 1—3 give the values concerning the surface of the thalli in square mm — the actual increase in surface over a given period of time and that calculated as a percentage, the general increment over a period of time calculated by the month, the general increment in percentage and average increase in percentage per year. In the diagrams and figures the numbers of the thalli are the same as those given in the tables.

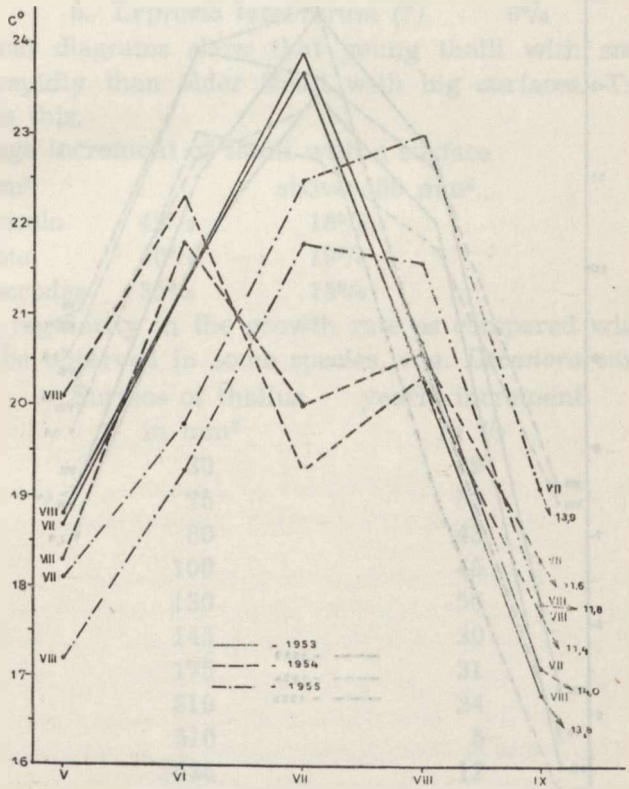


Fig. 13. Maximum temperature — mean monthly values for areas VII and VIII in the Białowieża National Park

It was impossible to continue the investigations on the growth rate of lichens in winter because of bad weather in the third decade of March. Some measurements were taken in 1959 on May 9th but they were too late to serve as a basis for an assessment of the growth rate of lichens in winter time, i. e. from December till March. The data

show that the largest growth is in summer, while in the winter the growth of lichens is inhibited. However, a comparison of the average monthly values shows that some species grow slightly even in winter, e.g. *Lecanora saxicola*, *Parmelia conspersa*, *Parmelia prolixa* (Nos. 10, 13, 16, 16a, 19). Further studies on this very interesting problem should be undertaken in various climatic regions using a larger number of examples.

The growth rate of lichens, as shown in the tables and diagrams, is different in various species and in various periods. The average increase value in all specimens over the whole period, expressed as a percentage, was the basis of the calculation and is set out below.

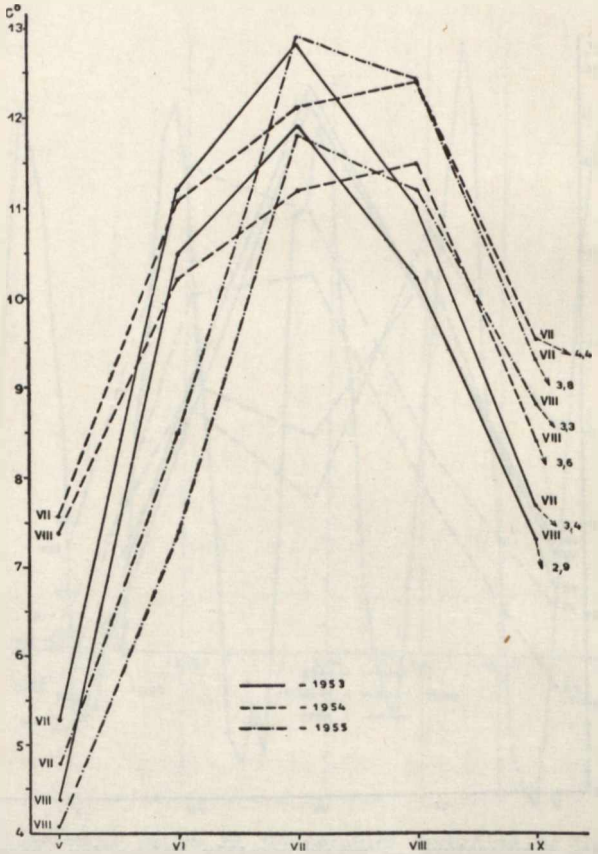


Fig. 14. Minimum temperature — mean monthly values for areas VII and VIII in the Białowieża National Park

a. epiphytic species.

| | | |
|---|---|---|
| 1. | *Parmelia subaurifera* | 37% |
| 2. | *Lecidea euphorea* | 25% |
| 3. | *Parmelia caperata* | 23% |

4. *Pertusaria coccodes* 22%
5. *Graphis scripta* 21%
6. *Pertusaria leioplaca* 18%
7. *Lecanora subfusca* 11%
8. *Lecanora carpinea* 9%

b. epilithic species.

1. *Lecanora saxicola* 36%
2. *Parmelia conspersa* 27%
3. *Physcia caesia* 22%
4. *Parmelia prolixa* 17%
5. *Aspicilia cinerea* 17%
6. *Lepraria latebrarum (?)* 9%

Tables and diagrams show that young thalli with small surfaces grow more rapidly than older thalli with big surfaces. The following list illustrates this.

The average increment of thalli with a surface

| | below 150 mm² | above 450 mm² |
|---|---|---|
| *Lecanora saxicola* | 49% | 18% |
| *Graphis scripta* | 40% | 19% |
| *Pertusaria coccodes* | 35% | 15% |

A certain regularity in the growth rate as compared with the initial values is to be observed in some species, e. g. *Lecanora saxicola:*

| Surface of thallus in mm² | yearly increment in % |
|---|---|
| 30 | 69 |
| 75 | 50 |
| 80 | 43 |
| 100 | 46 |
| 130 | 56 |
| 145 | 30 |
| 175 | 31 |
| 310 | 24 |
| 510 | 5 |
| 1635 | 12 |

It was noted, however, that thalli with numerous apothecia or soralia, being in the prime of their development, have a considerably slower growth, and in some periods show no increase in surface irrespective of the size of the thallus. Thalli of crustaceous species touching thalli of the same or another species did not grow at all and regardless of the size of the thallus reached the stage of maturity or began to wither.

In two cases (Nos. 16 and 17) the thalli of *Parmelia conspersa* were

observed to grow on very large specimens of *Parmelia prolixa;* the medial parts of the thalli of *P. prolixa* then fell off together with *Parmelia conspersa.* The remaining marginal parts of the thalli of *Parmelia prolixa* continued to grow, showing vitality and considerable spatial increment over a one-year period.

The diagrams presenting the changes in the temperature, relative humidity and rainfall over a five-year period give a general picture of the climatic conditions of the area bordering on that in which investigations were carried out (Figs. 9—12). Although the average values of

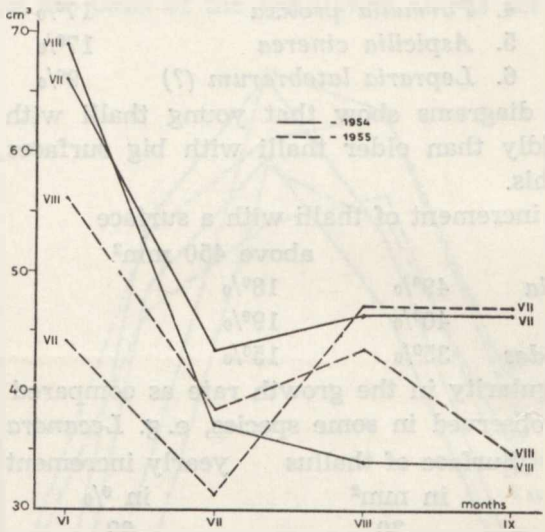


Fig. 15. Monthly values of evaporated water from Pische's evaporimeter in areas VII and VIII in the Białowieża National Park.

the meteorological measurements deviate to a considerable degree from those concerned with the intensity of the actual factors when active, a comparison of the growth rate of the surfaces of the majority of lichens examined shows correlation with the meteorological data. In a summer characterized by a higher temperature and lower relative humidity, the growth rate of lichens is usually lower than in a summer characterized by lower temperatures and higher relative humidity.

Figs. 13—15 partly present the climatic conditions in communities VII and VIII of the Białowieża National Park.

The above method of assessing the growth rate of lichens also makes possible a qualitative examination of the volume increase in lichens per surface unit. As an illustration parts of the thalli of *Parmelia conspersa* (No. 16a) and *Parmelia prolixa* (No. 18) were taken and the mean value per surface unit of the thallus of both species was examined. Table 5. shows the results.

## CONCLUSIONS

This method of examining the growth rate of foliose and fruticose lichens enables:

1. A very exact assessment of the growth rate of lichens, by calculating the spatial increment in $mm^2$ per time unit.

2. An estimation of the developmental dynamics of individual thalli by calculating the increment of organic and inorganic mass expressed in gramms per surface and time unit.

3. General conclusions in the field of the biology and ecology of lichens, which grow in different climatic and ecological conditions.

The material and results presented in this paper are of a preliminary character and although with their help many assumptions could be made, yet they are still not sufficient for statistical purposes. They do not lead to any general conclusions because of the lack of comparable data in up-to-date reports.

It is urged that other lichenologists, who are working on lichens growing in different climatic conditions, should take interest in this problem.

It would then be possible to find coefficients for many species; through these coefficients from a given surface of the thallus the approximate age of the lichens could be estimated.

## REFERENCES

1. Beschel R.: Flechtenvereine der Städte. Stadtflechten und ihr Wachstum. Ber. d. Naturwis. — Med. Vereins in Insbruck. Bd. 52, 1958.
2. Frey E.: Die Flechtenflora und — vegetation des Nationalparks im Unterengadin. II Teil: Die Entwicklung der Flechtenvegetation auf photogrammetrisch kontrolierten Dauerflächen. Ergeb. der Wiss. Untersuch. des schweiz. Nationalpark., N. F. 6 (41), 1959.
3. Hale M. E.: First report on lichen growth rate and succession at Aton Forest, Connecticut. Bryologist, Vol. 57, No 3, 1954.
4. Hale M. E. Studies on lichen growth rate and succession. Bull. of the Torrey Botanical Club, Vol 86, No. 2, 1959.
5. Rydzak J.: A method of studying growth in lichens. Metoda badania wzrostu porostów. Ann. Univ. Mariae Curie-Skłodowska, Sectio C, Vol. X (1955) 4, Lublin 1957.
6. Rydzak J.: Wpływ małych miast na florę porostów. Cz. IV. Lubelszczyzna-Kieleckie-Podlasie. Puławy-Zamość-Busko-Siedlce-Białowieża. Ann. Univ. Mariae Curie-Skłodowska, Sectio X, Vol. X, (1955) 14, Lublin 1957.
7. Rydzak J.: Tree Lichens in the Forest Communities of the Białowieża National Park. Ann. Univ. Mariae Curie-Skłodowska, Sectio C, Vol. XV (1960), 14, Lublin 1961.

## STRESZCZENIE

Zastosowana metoda badania wzrostu porostów o plechach listkowatych i skorupiastych umożliwia:

1) bardzo dokładne określanie szybkości wzrostu porostów przez wyrażenie przyrostu powierzchni w $mm^2$ na jednostkę czasu;

2) ujęcie dynamiki rozwojowej poszczególnych plech przy pomocy wyrażenia przyrostu masy organicznej i nieorganicznej w gramach na jednostkę czasu;

3) wnioski ogólne w zakresie biologii i ekologii porostów, rosnących w różnych warunkach klimatycznych i ekologicznych.

Przedstawione w niniejszej rozprawie materiały i wyniki badań są wstępne i, chociaż nasuwają już przypuszczenia, są niewystarczające do opracowania statystycznego oraz nie upoważniają jeszcze do wyciągania wniosków ogólnych zwłaszcza, że jest brak porównywalnych danych w dotychczasowej literaturze.

Potrzebne są dalsze badania i zainteresowanie się tym zagadnieniem innych lichenologów, pracujących nad porostami, rosnącymi w różnych warunkach klimatycznych.

Przypuszczam, że wówczas w ten sposób można by eksperymentalnie znaleźć dla wielu gatunków współczynniki, przy pomocy których, z danej powierzchni plechy porostu, można by obliczyć przybliżony wiek badanego porostu.


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## РЕЗЮМЕ

Примененный автором метод исследования роста корковых и листоватых лишайников дает возможность:

1. очень точно определить скорость роста лишайников путем определения прироста поверхности в $мм^2$ в единицу времени;

2. определить динамику развития отдельных талломов путем обозначения прироста органической и неорганической массы в граммах на единицу поверхности и в единицу времени;

3. сделать общие выводы по биологии и экологии лишайников, произрастающих в разных климатических и экологических условиях.

Изложенные в настоящей работе материалы и результаты исследований следует считать предварительными и, хотя они выдвигают уже некоторые предположения, еще недостаточными для статистической обработки а также они не позволяют еще делать общих выводов, тем более, что пока не существует в соответственной литературе сравнительных данных. Необходимы дальнейшие исследования и воз-

буждение интереса к этой проблеме других лихенологов, занимающихся лишайниками, растущими в различных климатических условиях.

Автор предполагает, что тогда была бы возможность найти экспериментально для многих видов коэффициенты, при помощи которых и на основании данной поверхности таллома лишайника можно бы определить приближенно возраст исследуемого лишайника.

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Table 1. The growth of tree lichens

| No of thallus | Date of measurement / Period of growth (months) / Species | 26.X 1953 | 24.VIII 1954 | Increment | | 13.XI. 1955 | Increment | | 27.X. 1956 | Increment | | 7.IX. 1957 | Increment | | 10.IX. 1958 | Increment | | 24.VIII. 1960 | General increment | | Increment general | Increment average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Size of the thalli of the lichens and the increment expressed in square millimetres and as a percentage | | | | | | | | | | | | | | | | | | | | |
| | | mm² | 10 mm² | mm² | % | 15 mm² | mm² | % | 11 mm² | mm² | % | 11 mm² | mm² | % | 12 mm² | mm² | % | 23 mm² | mm² | Number of months | % | per year % |
| 1. | *Pertusaria coccodes* | 475 | 555 | 80 | 17 | 765 | 210 | 38 | 780 | 15 | 2 | — | — | — | 925 | — | — | 970 | 495 | 82 | 104 | 15 |
| 2. | *Pertusaria coccodes* | 255 | 305 | 50 | 20 | 435 | 130 | 43 | 465 | 30 | 7 | 540 | 75 | 16 | 550 | 10 | 2 | 550 | 295 | 82 | 115 | 17 |
| 3. | *Pertusaria coccodes* | 145 | 195 | 50 | 35 | 275 | 80 | 41 | 300 | 25 | 8 | 335 | 35 | 10 | 335 | — | — | 350 | 205 | 82 | 141 | 21 |
| 4. | *Pertusaria coccodes* | 305 | 350 | 45 | 15 | — | — | — | 440 | — | — | 510 | 70 | 14 | — | — | — | 550 | 245 | 82 | 80 | 12 |
| 5. | *Pertusaria coccodes* | 55 | 95 | 40 | 73 | — | — | — | — | — | — | 145 | — | — | 155 | 10 | 7 | 175 | 120 | 82 | 218 | 32 |
| 6. | *Pertusaria coccodes* | 330 | 395 | 65 | 19 | 500 | 105 | 26 | — | — | — | 585 | — | — | 665 | 80 | 13 | — | 335 | 59 | 102 | 21 |
| 7. | *Pertusaria coccodes* | 360 | 380 | 20 | 6 | 480 | 100 | 26 | 500 | 20 | 4 | 585 | 85 | 17 | 615 | 30 | 5 | — | 255 | 59 | 71 | 14 |
| 8. | *Pertusaria coccodes* | 205 | 250 | 45 | 22 | — | — | — | — | — | — | 305 | — | — | — | — | — | — | 100 | 46 | 49 | 13 |
| 9. | *Pertusaria coccodes* | 120 | 130 | 10 | 7 | 220 | 90 | 69 | 245 | 25 | 11 | — | — | — | — | — | — | — | 125 | 36 | 104 | 35 |
| 10. | *Pertusaria coccodes* | 250 | — | — | — | 350 | — | — | 405 | 55 | 16 | — | — | — | 560 | — | — | — | 310 | 59 | 124 | 25 |
| 11. | *Parmelia subaurifera* | — | — | — | — | 450 | — | — | — | — | — | — | — | — | 885 | — | — | 1250 | 800 | 57 | 178 | 37 |
| 12. | *Lecanora carpinea* | 650 | — | — | — | 685 | — | — | 730 | — | — | — | — | — | — | — | — | 955 | 305 | 82 | 47 | 7 |
| 13. | *Lecanora carpinea* | 455 | — | — | — | — | — | — | 555 | — | — | 655 | 100 | 18 | — | — | — | 770 | 315 | 82 | 70 | 10 |
| 14. | *Pertusaria leioplaca* | — | 155 | — | — | — | — | — | 210 | — | — | 225 | — | — | 270 | 45 | 20 | 320 | 165 | 72 | 107 | 18 |
| 15. | *Graphis scripta* | — | — | — | — | — | — | — | 1875 | — | — | 1955 | 80 | 4 | 2100 | 145 | 8 | 2685 | 810 | 46 | 43 | 11 |
| 16. | *Pertusaria coccodes* | — | — | — | — | — | — | — | 125 | — | — | 140 | 15 | 12 | 140 | 0 | 0 | 205 | 80 | 46 | 64 | 17 |
| 17 | *Graphis scripta* | — | — | — | — | — | — | — | 255 | — | — | 275 | 20 | 8 | 290 | 15 | 5 | 395 | 140 | 46 | 55 | 14 |
| 18. | *Graphis scripta* | — | — | — | — | — | — | — | 455 | — | — | 480 | 25 | 5 | — | — | — | 525 | 70 | 46 | 15 | 4 |
| 19. | *Graphis scripta* | — | — | — | — | — | — | — | 140 | — | — | 145 | 5 | 4 | 175 | 30 | 21 | 315 | 175 | 46 | 125 | 33 |
| 20. | *Graphis scripta* | — | 1620 | — | — | 1865 | 245 | 15 | 1955 | 90 | 5 | — | — | — | — | — | — | 3110 | 1490 | 72 | 92 | 15 |
| 21. | *Graphis scripta* | — | 255 | — | — | 340 | 85 | 33 | 420 | 80 | 24 | 565 | 145 | 35 | 695 | 130 | 23 | 1065 | 810 | 72 | 318 | 53 |
| 22. | *Graphis scripta* | — | 450 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 1115 | 655 | 72 | 146 | 24 |
| 23. | *Graphis scripta* | — | 335 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 655 | 320 | 72 | 96 | 16 |
| 24. | *Graphis scripta* | — | 170 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 280 | 110 | 72 | 65 | 11 |
| 25. | *Pertusaria coccodes* | — | 310 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 705 | 395 | 72 | 127 | 21 |
| 26. | *Graphis scripta* | — | 475 | — | — | 505 | 30 | 7 | 595 | 90 | 18 | 650 | 55 | 9 | 775 | 125 | 19 | 970 | 495 | 72 | 104 | 17 |
| 27. | *Graphis scripta* | — | 400 | — | — | 435 | 35 | 9 | 500 | 65 | 15 | 545 | 45 | 9 | 640 | 95 | 17 | 725 | 325 | 72 | 81 | 14 |
| 28. | *Graphis scripta* | — | 675 | — | — | 800 | 125 | 19 | — | — | — | 1175 | — | — | 1415 | 240 | 20 | 1925 | 1250 | 72 | 185 | 31 |
| 29. | *Graphis scripta* | — | 185 | — | — | 240 | 55 | 30 | — | — | — | — | — | — | — | — | — | 415 | 230 | 72 | 124 | 21 |
| 30. | *Graphis scripta* | — | 175 | — | — | 210 | 35 | 20 | — | — | — | — | — | — | — | — | — | 345 | 170 | 72 | 97 | 16 |
| 31. | *Graphis scripta* | — | 385 | — | — | 510 | 125 | 32 | 580 | 70 | 14 | 690 | 110 | 19 | 780 | 90 | 13 | 980 | 595 | 72 | 155 | 26 |
| 32. | *Pertusaria coccodes* | — | 100 | — | — | 130 | 30 | 30 | 185 | 55 | 42 | 235 | 50 | 37 | 295 | 60 | 26 | 410 | 310 | 72 | 310 | 52 |

Table 2. The growth of tree lichens (sequel)

| No of thallus | Date of measurement / Period of growth (months) / Species | 24.VIII. 1954 | 13.IX. 1955 | Increment | | 27.X. 1956 | Increment | | 7.IX. 1957 | Increment | | 10.IX. 1958 | Increment | | 24.VIII. 1960 | General increment | | Increment general | Increment average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mm² | 15 mm² | mm² | % | 11 mm² | mm² | % | 11 mm² | mm² | % | 12 mm² | mm² | % | 23 mm² | mm² | Number of months | % | per year % |
| 33. | *Graphis scripta* | 1655 | 2030 | 365 | 22 | 2300 | 270 | 13 | 2585 | 285 | 12 | 2840 | 255 | 9 | 3825 | 2160 | 72 | 129 | 21 |
| 34. | *Graphis scripta* | 80 | 160 | 80 | 100 | 165 | 5 | 3 | 205 | 40 | 24 | 225 | 20 | 10 | 315 | 235 | 72 | 294 | 49 |
| 35. | *Graphis scripta* | 245 | 350 | 105 | 43 | — | — | — | 415 | — | — | 625 | 210 | 51 | — | 380 | 49 | 155 | 38 |
| 36. | *Graphis scripta* | 660 | 915 | 255 | 38 | — | — | — | 1250 | — | — | 1315 | 65 | 5 | — | 655 | 49 | 99 | 24 |
| 37. | *Graphis scripta* | 215 | 315 | 100 | 47 | 365 | 50 | 16 | 370 | 5 | 1 | 465 | 95 | 26 | — | 250 | 49 | 116 | 28 |
| 38. | *Graphis scripta* | 340 | 440 | 100 | 29 | 500 | 60 | 14 | 535 | 35 | 7 | 605 | 70 | 13 | 790 | 450 | 72 | 132 | 22 |
| 39. | *Graphis scripta* | 195 | 245 | 50 | 25 | 265 | 20 | 8 | 335 | 70 | 26 | 365 | 30 | 9 | — | 170 | 49 | 87 | 21 |
| 40. | *Graphis scripta* | 315 | 450 | 135 | 43 | — | — | — | 500 | — | — | 590 | 90 | 18 | 690 | 375 | 72 | 116 | 19 |
| 41. | *Graphis scripta* | 1455 | 1905 | 450 | 31 | — | — | — | 2350 | — | — | 2640 | 290 | 12 | 3010 | 1555 | 72 | 107 | 18 |
| 42. | *Graphis scripta* | 90 | 120 | 30 | 33 | 160 | 40 | 33 | 180 | 20 | 12 | 215 | 35 | 19 | 295 | 205 | 72 | 228 | 38 |
| 43. | *Pertusaria coccodes* | 295 | 395 | 100 | 34 | 425 | 30 | 8 | 440 | 15 | 4 | 450 | 10 | 2 | 530 | 235 | 72 | 80 | 13 |
| 44. | *Pertusaria coccodes* | 260 | 580 | 320 | 123 | — | — | — | 650 | — | — | 680 | 30 | 5 | — | 420 | 49 | 162 | 40 |
| 45. | *Pertusaria coccodes* | 435 | — | — | — | 445 | — | — | 525 | 80 | 18 | — | — | — | — | 90 | 37 | 21 | 7 |
| 46. | *Pertusaria coccodes* | 220 | 255 | 35 | 16 | — | — | — | 260 | — | — | 275 | 15 | 6 | — | 55 | 49 | 25 | 6 |
| 47. | *Pertusaria coccodes* | 280 | 295 | 15 | 5 | 345 | 50 | 17 | 350 | 5 | 1 | 365 | 15 | 4 | — | 85 | 49 | 30 | 7 |
| 48. | *Graphis scripta* | 155 | 165 | 10 | 6 | 250 | 85 | 51 | 300 | 50 | 20 | 380 | 80 | 27 | — | 255 | 49 | 165 | 40 |
| 49. | *Graphis scripta* | 265 | 340 | 75 | 28 | 425 | 85 | 25 | — | — | — | — | — | — | — | 160 | 37 | 60 | 19 |
| 50. | *Lecanora subfusca allophana* | 115 | 125 | 10 | 9 | 135 | 10 | 8 | 140 | 5 | 4 | 165 | 25 | 18 | — | 50 | 49 | 43 | 11 |
| 51. | *Lecidea euphorea* | 95 | 115 | 20 | 21 | 125 | 10 | 9 | 145 | 20 | 16 | 200 | 55 | 38 | — | 105 | 49 | 111 | 25 |
| 52. | *Graphis scripta* | 525 | 690 | 165 | 31 | 720 | 30 | 4 | 810 | 90 | 11 | 825 | 15 | 2 | 1060 | 535 | 72 | 102 | 17 |
| 53. | *Pertusaria coccodes* | 70 | 80 | 10 | 14 | 105 | 25 | 31 | 120 | 15 | 14 | 155 | 35 | 29 | 165 | 95 | 72 | 136 | 23 |
| 54. | *Pertusaria coccodes* | — | — | — | — | 300 | — | — | 345 | 45 | 15 | 410 | 65 | 19 | 505 | 205 | 46 | 68 | 18 |
| 55. | *Pertusaria coccodes* | — | — | — | — | 200 | — | — | 210 | 10 | 5 | 250 | 40 | 19 | 335 | 135 | 46 | 68 | 18 |
| 56. | *Parmelia caperata* | — | — | — | — | — | — | — | 900 | — | — | 1100 | 200 | 22 | 1310 | 410 | 35 | 46 | 16 |
| 57. | *Parmelia caperata* | — | — | — | — | — | — | — | 170 | — | — | 245 | 75 | 44 | 365 | 195 | 35 | 115 | 39 |

Size of the thalli of the lichens and the increment expressed in square millimetres and as a percentage

Table 3. The growth of epilithic lichens

| No of thallus | Date of measurement / Period of growth (months) / Species | 13.IX. 1957 | 9.IX. 1958 | Increment | | 9.V. 1959 | Increment | | 25.XI. 1959 | Increment | | 24.VIII. 1960 | Increment | | General icrement | | Increment general | Increment average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mm² | 12 mm² | mm² | % | 8 mm² | 6½ mm² | % | 14 mm² | mm² | % | 9 mm² | mm² | % | mm² | Number of months | % | per year % |
| 1. | *Lecanora saxicola* | 1635 | 1930 | 295 | 18 | 1975 | 45 | 2 | 2125 | 150 | 8 | 2225 | 100 | 5 | 595 | 35 | 36 | 12 |
| 2. | *Lecanora saxicola* | 100 | 125 | 25 | 25 | 125 | 0 | 0 | 200 | 75 | 60 | — | — | — | 100 | 26 | 100 | 46 |
| 3. | *Lecanora saxicola* | 145 | 205 | 60 | 41 | 215 | 10 | 2 | 245 | 30 | 14 | 270 | 25 | 12 | 125 | 35 | 86 | 30 |
| 4. | *Lecanora saxicola* | 80 | 120 | 40 | 50 | 120 | 0 | 0 | 150 | 30 | 25 | 180 | 30 | 20 | 100 | 35 | 125 | 43 |
| 5. | *Lecanora saxicola* | 30 | 45 | 15 | 50 | 50 | 5 | 11 | 75 | 25 | 50 | — | — | — | 45 | 26 | 150 | 69 |
| 6. | *Lecanora saxicola* | 75 | 105 | 30 | 40 | 110 | 5 | 5 | 120 | 10 | 9 | 185 | 65 | 54 | 110 | 35 | 147 | 50 |
| 7. | *Aspicilia cinerea* | 315 | 345 | 30 | 10 | 385 | 40 | 12 | 450 | 65 | 17 | 490 | 40 | 9 | 175 | 35 | 55 | 19 |
| 8. | *Aspicilia cinerea* | 910 | 1010 | 100 | 11 | 1250 | 240 | 24 | 1260 | 10 | 1 | 1390 | 130 | 10 | 480 | 35 | 53 | 18 |
| 9. | *Aspicilia cinerea* | 560 | — | — | — | 800 | — | — | 800 | 0 | 0 | 905 | 105 | 13 | 345 | 35 | 62 | 21 |
| 10. | *Lecanora saxicola* | 275 | 280 | 5 | 2 | 425 | 145 | 52 | 450 | 25 | 6 | 510 | 60 | 13 | 235 | 35 | 86 | 29 |
| 11. | *Lecanora saxicola* | 510 | 530 | 20 | 4 | 575 | 45 | 9 | — | — | — | 580 | — | — | 70 | 35 | 14 | 5 |
| 12. | *Lecanora saxicola* | — | 130 | — | — | — | — | — | — | — | — | 270 | — | — | 140 | 23 | 108 | 56 |
| 13. | *Lecanora saxicola* | — | 175 | — | — | 235 | 60 | 34 | — | — | — | 280 | — | — | 105 | 23 | 60 | 31 |
| 14. | *Lecanora saxicola* | — | 310 | — | — | 360 | 50 | 16 | — | — | — | 455 | — | — | 145 | 23 | 47 | 24 |
| 15. | *Parmelia conspersa* | 7675 | 9475 | 1800 | 23 | 10690 | 1215 | 13 | — | — | — | 13585 | — | — | 5910 | 35 | 77 | 26 |
| 16. | *Parmelia prolixa* | 5680 | 6600 | 920 | 16 | 7715 | 1115 | 17 | 8325 | 610 | 8 | — | — | — | 2685 | 26 | 47 | 21 |
| 16a. | *Parmelia conspersa* | — | 2545 | — | — | 3020 | 475 | 19 | 3600 | 580 | 19 | — | — | — | 1055 | 14 | 41 | 35 |
| 17. | *Parmelia prolixa* | — | 1850 | — | — | 1990 | 140 | 8 | 2340 | 350 | 18 | — | — | — | 490 | 14 | 26 | 22 |
| 18. | *Parmelia prolixa* | 5525 | 6780 | 1255 | 23 | 7260 | 480 | 7 | 7310 | 50 | 1 | 7430 | 120 | 2 | 1905 | 35 | 34 | 12 |
| 19. | *Parmelia conspersa* | 4185 | 5450 | 1265 | 30 | 6395 | 945 | 17 | — | — | — | 7605 | — | — | 3420 | 35 | 82 | 28 |
| 20. | *Aspicilia cinerea* | — | 9700 | — | — | 10070 | 370 | 4 | 10510 | 440 | 4 | 10865 | 335 | 3 | 1165 | 23 | 12 | 6 |
| 21. | *Aspicilia cinerea* | — | 9670 | — | — | 10150 | 480 | 5 | 10585 | 435 | 4 | 10955 | 370 | 3 | 1285 | 23 | 13 | 7 |
| 22. | *Aspicilia cinerea* | — | 980 | — | — | 1010 | 30 | 3 | 1225 | 215 | 21 | 1405 | 180 | 15 | 425 | 23 | 43 | 22 |
| 23. | *Aspicilia cinerea* | — | 2045 | — | — | 2145 | 100 | 5 | 2430 | 285 | 13 | 2780 | 350 | 14 | 735 | 23 | 36 | 19 |
| 24. | *Aspicilia cinerea* | — | 825 | — | — | 875 | 50 | 6 | 1015 | 140 | 16 | 1215 | 200 | 20 | 390 | 23 | 47 | 24 |
| 25. | *Lepraria latebrarum?* | — | — | — | — | 2060 | — | — | — | — | — | 2550 | — | — | 490 | 15½ | 24 | 19 |
| 26. | *Lepraria latebrarum?* | — | — | — | — | 2420 | — | — | 2515 | 95 | 4 | 2800 | 285 | 11 | 380 | 15½ | 16 | 12 |
| 27. | *Lepraria latebrarum?* | — | — | — | — | 2600 | — | — | 2655 | 55 | 2 | 2850 | 195 | 7 | 250 | 15½ | 10 | 8 |
| 28. | *Lepraria latebrarum?* | — | — | — | — | 2670 | — | — | 2725 | 55 | 2 | 3005 | 280 | 10 | 335 | 15½ | 13 | 10 |
| 29. | *Lepraria latebrarum?* | — | — | — | — | 5065 | — | — | 5105 | 40 | 1 | 5280 | 175 | 3 | 215 | 15½ | 4 | 3 |
| 30. | *Lepraria latebrarum?* | — | — | — | — | 1195 | — | — | 1205 | 10 | 1 | 1265 | 60 | 5 | 70 | 15½ | 6 | 5 |
| 31. | *Lepraria latebrarum?* | — | — | — | — | — | — | — | 1630 | — | — | 1740 | 110 | 7 | 110 | 9 | 7 | 9 |
| 32. | *Parmelia prolixa* | — | — | — | — | — | — | — | 12555 | — | — | 13790 | 1235 | 10 | 1235 | 9 | 10 | 13 |
| 33. | *Physcia caesia* | — | 185 | — | — | 255 | 70 | 38 | — | — | — | 260 | 5 | 2 | 75 | 23 | 41 | 21 |
| 34. | *Physcia caesia* | — | 560 | — | — | 650 | 90 | 16 | — | — | — | 775 | 125 | 19 | 215 | 23 | 38 | 20 |
| 35. | *Physcia caesia* | — | 420 | — | — | 505 | 85 | 20 | — | — | — | 610 | 105 | 20 | 190 | 23 | 45 | 23 |

Table 4. Stands of epiphytic lichens examined in the Białowieża National Park

| No of section | No of surface | Nos. of lichens | No of tree | Species of tree | Exposition | Circumference of trunk in the middle of the quadrat, in cm / Distance from the low margin of the quadrat to the base of the trunk, in cm | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 |
| 399 | 1 | 1 — 11 | 1 | *Tilia cordata* | W | 33/130 | — | 35/128 | 35/130 | 38/130 | 39/129 | — | 41/— |
| 399 | 2 | 56,57 | 2 | *Corpinus betulus* | NW | — | — | — | — | 110/120 | 110/120 | — | 110/120 |
| 398 | 3 | 12 — 14 | 3 | *Corpinus betulus* | S | 25/144 | 25/144 | 26/143 | 26/143 | — | 29/140 | — | 29/141 |
| 398 | 4 | 20 — 25 | 4 | *Tilia cordata* | N | — | 27,3/125 | 29,2/125 | 29,3/125 | 33/126 | 33/125 | — | 35/125 |
| 398 | 5 | 26 — 30 | 4 | *Tilia cordata* | NW | — | 28/100 | 29,8/101 | 30,3/101 | 34/102 | 35,5/102 | — | 38,6/105 |
| 398 | 6 | 31,32 | 4 | *Tilia cordata* | SO | — | 28/116 | 29,3/116 | 30/116 | 34/120 | 35,3/121 | — | 38/118 |
| 398 | 7 | 33 — 40 | 5 | *Tilia cordata* | S | — | 38,5/128 | 40/128 | 40,5/128 | 44/134 | 46/134 | — | 49/133 |
| 398 | 8 | 41 — 43 | 5 | *Tilia cordata* | N | — | 39/125 | 40,5/125 | 41/125 | 45/128 | 46/128 | — | 50/127 |
| 398 | 9 | 44 — 47 | 6 | *Tilia cordata* | NW | — | 42/140 | 43/141 | 43,5/141 | 46,5/146 | 47,5/146 | — | — |
| 398 | 10 | 48 — 51 | 7 | *Tilia cordata* | S | — | 62/145 | 64,5/145 | 66,5/145 | 72,5/149 | 73,5/150 | — | — |
| 398 | 11 | 52 — 55 | 8 | *Carpinus betulus* | S | — | 15/119 | 15/119 | 15/119 | 15,8/122 | 16/122 | — | 16/122 |
| 340 | 12 | 15 — 19 | 9 | *Tilia cordata* | W | — | — | — | 54/126 | 58/130 | 58,5/128 | — | 60,5/128 |

Table 5

| No | Species | Measurements and weight | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Surface in $cm^2$ | Weight of preserved thallus in gr | Weight of dry mass in gr | Percentage | Weight of evaporated water | Percentage | Weight of organic mass in gr | Percentage of dry mass | Weight of ash in gr | Percentage of dry mass |
| 16 a | *Parmelia conspersa* | 10,95<br>1 $cm^2$ | 0,3404<br>0,0319 | 0,3058<br>0,0279 | 89,84 | 0,0346<br>0,0032 | 10,16 | 0,2548<br>0,0232 | 83,32 | 0,0510<br>0,0024 | 16,68 |
| 18 | *Parmelia prolixa* | 20,25<br>1 $cm^2$ | 1,0670<br>0,0527 | 0,9508<br>0,0469 | 89,11 | 0,1162<br>0,0057 | 10,89 | 0,7807<br>0,0385 | 82,11 | 0,1701<br>0,0084 | 17,89 |