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Kierownik: prof. dr Józef Motyka

Jan RYDZAK

Influence of Small Towns on the Lichen Vegetation

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Часть VII. Обсуждение и выводы

The problem of poverty of lichen vegetation in large or industrial towns was raised by W. Nylander in 1866. Since then several large European cities have been studied and, after Sernander (1926), there were described zones of gradual impoverishment of lichen flora from the outskirts to the centre of the town. The zones are: 1. Zone of normally developed flora at the outskirts of the town. 2. „Struggle zone" which is a more or less extensive area with scattered houses and which surrounds the crowded central quarters. In this zone scanty specimens of a few lichen species were found; their thalli were contracted, underdeveloped, as if fighting for life in unfavourable environmental conditions. 3. lichen-free zone, „lichen desert", which comprises the centre of the town and its industrial quarters; no lichens could be found there.

The results of these investigations strengthened the belief, expressed in the form of supposition by F. Arnold in 1892, that lichens are organisms very sensitive to the action of substances formed during coal combustion in towns. Sulphur dioxide (SO_2) was believed to be especially harmful to lichens, causing their death even in trace concentrations (W. Nylander 1866, S. Arnold 1891/98, B. Kajanus 1911, F. Tobler 1925, P. K. Hagsjå 1930, O. A. Höeg 1934, V. Varna 1934, V. Vareschi 1936, F. Mattick 1937, L. Felföldy 1942,

O. Almborn 1943, M. Bouly de Lesdain 1948, A. Sauberer 1951, J. Zurzycki 1951, and others). From specialized publications this belief passed to manuals and became a universally accepted axiom (G. Lindau 1923, T. Sulma 1949, W. Sławiński 1949, H. des Abbayés 1951, P. Żukowski 1951, A. Szennikow 1952, W. Szafer 1949, 1952, and others).

The above hypothesis is based on the following two facts which, as it has been demonstrated lately, are valid to a certain extent only. 1) Sulphur dioxide is a gas toxic to plants;; 2) lichen vegetation becomes poorer and poorer towards the centre of towns.

These two facts having been accepted as premises and linked with each other as the cause and the effect, a very attractive conclusion presented itself: lichen flora in large cities cannot thrive because of the toxic action of sulphur dioxide and other products of coal combustion. The attraction of this reasoning was so great that even the soundest minds among the scientists interested in the problem were carried away by it. In consequence, the hypothesis began to assume the features of a theory. In each of the studied towns lichen deserts were looked for, and effects of the toxic action of gases were seen. Facts were modified to serve the theory. Some investigators found a normally developed lichen flora at the outskirts of large towns, others saw the effects of the action of toxic gases on lichens in woods situated as far as 20 km from the town. Observations and conclusions formed a vicious circle: gases — desert — gases. No wonder the „theory" became an inhibitory factor in the advance of the studies on the ecology of town lichens.

As a matter of fact, we still do not know to what extent gases formed during coal combustion are toxic to lichens, what is the lethal concentration and time of exposure for the individual species. Schröder (1883), Wieler (1897), Wislicenus (1914) and others (quoted after P. Sorauer 1921) showed experimentally (in special gas chambers) the toxic influence of strong SO_2 concentrations (more than 1 per cent) on some trees. Most sensitive was spruce, then came, in the order of decreasing sensitivity, pine, beech, hornbeam, lime, horse-chestnut. Concentrations as low as 10^{-6} were still slightly harmful, though not lethal. In the conditions created by large towns, SO_2 and other products of coal combustion (soot, tar and other gases) must exercise their toxic action in a very small degree, since various trees and other plants can be successfully grown there. Even parasitic and saprophytic fungi, e.g. *Merulius lacrimans*, *Psaliota campestris*, thrive in towns. In a similar way, algae, e.g. *Pleurococcus vulgaris* and *Cystococcus humicola*, find good living conditions in towns, occurring in masses on tree trunks.

There seems to be little sense in applying the results of investigations on higher plants to lichens, and especially imputing them an exceptional sensitivity to SO_2 concentrations which are several times lower than those used in the above-mentioned experiments. It is known from H a h n's studies that Manchester, which is a great industrial centre with strongly polluted air, SO_2 concentration in the air is 4.3 mg/m^3, i.e. the volume ratio is 1 : 700,000 (0.000147 per cent). According to P f a f f, similar values of SO_2 concentration in Saarbrücken are 1.5 mg/m^3 or 1 : 1.960.000 (0.000051 per cent) (K r a t z e r 1937). At the outskirts of those cities the quantity of SO_2 in a cubic metre of air is by 50 per cent lower. According to other authors these values are lower still: 0.0000116 per cent for Leeds, and from 0.00001 to 0.0000126 per cent for London (B a r k m a n 1958, p. 115).

It is only experimental investigations which will answer the question whether such low concentrations of SO_2 are able to kill lichens. From what we know now this appears to be unlikely, and the investigations of the followers of the „gas theory" on the distributions of lichens in the zones of large towns seem to support this view to some extent. Though some of the studied towns are larger and others smaller, in all of them at least three zones were found and in all of them the peripheral quarters had a normal lichen vegetation. If the lichen vegetation of Manchester and Saarbrücken were studied, the followers of the „gas theory" would place the lichen desert in the centre of those towns, the struggle zone round it, and the zone of normal lichen flora at the outskirts. They would explain the presence of these zones by the toxic action of SO_2 on lichens. There is no reason to think that it could be otherwise. Thus, at the outskirts of Manchester, where SO_2 concentration in air is more than 2.0 mg/m^3, there could grow a normal lichen vegetation (Normalzone), and in the centre of Saarbrücken, where the concentration is only about 1.5 mg SO_2/m^3, there would be a lichen-free zone (Flechtenwüste).

Thus it is evident that the basic premise of the theory advocating the toxic action of such low concentrations of gases on lichens is not proved, and that attempts at extending it are a mistake which brings the reasoning *ad absurdum*.

Other proofs will be given below.

Then a follower of the „gas theory", the present writer began in 1948 studies on the distribution of lichens in Lublin, a Polish town of medium position as far as its size and industry are concerned. Examination of a number of habitats revealed some facts which were clearly at variance with the hypothesis on the decisive influence of toxic gases on the distribution of lichens in towns. There were two ways leading to the explanation of these facts: 1) the direct one which consisted in placing in various points of the town instruments recording various meteorological and microclimatic factors of the individual habitats for the period of at least one year; 2) the indirect one consisting in a) detailed investigation of the greatest possible number of lichen stations with regard to the species present, degree of development and vitality, exposure, surface cover, distribution of species in each station etc.; b) comparing data obtained from all habitats; c) evaluation of the conditions found in each habitat from the standpoint of physics, meteorology and climatology, and, if possible, comparison with neighbouring and analogous spots devoid of lichens; d) confrontation of the data thus obtained with the information given by the literature on morphology, anatomy, biology and physiology of lichens and on meteorology and climatology of towns.

For obvious reasons it was impossible to use the first method, the direct or experimental one. The second, the indirect, floristic-comparative method was therefore adopted, the investigations being extended over a great number of stations.

In this way a considerable number of facts could be collected, which allowed to develop a new conception. The facts have been presented in detail in the publication entitled „Rozmieszczenie i ekologia porostów miasta Lublina" (Dislokation und Ökologie von Flechten der Stadt Lublin) (Rydzak 1953, p. 242—331). Here is a brief summary of some of them.

1. In the centre of densely crowded quarters of the town and in industrial areas there are numerous stations of epilithic lichens growing on plaster (Tünchflechten, Mörtelflechten). Some habitats cover the area of many square metres. Other authors also found species growing on plaster in the centre of large towns (Steiner-Schultze-Horn 1955, Klement 1956, 1958, and others). This means that some lichen species are able to live in the so-called „lichen-free zones" without apparent damage from the gases. Thus the proposition on the toxic influence of SO_2 and smoke on lichens, in general, is not true in the case of the observed species.

2. On the same wall on which lichens occur, there are usually much larger areas completely devoid of lichens. In the nearest vicinity of lichen habitats there are walls equally exposed to the action of gases and smoke, but completely lacking lichen vegetation. The „gas theory" is quite unable to explain these facts. An explanation may be found in the action of factors changing microclimatic conditions. It is often obvious that the individual habitats differ in their insolation, temperature, shading, moisture of the substratum etc. Sometimes, observation does not reveal subtle microclimatic variations, but they must be present if there are differences in the distribution of lichens. Self-recording precision instruments would show differences after a year's observation. On the oher hand, it seems highly improbable that the distribution of

lichens varies because of subtle differences in the concentration of toxic gases.

Thus understood, the hypothesis on the action of microclimatic factors stimulates further research, whereas the „gas" hypothesis hinders the progress of ecological investigations.

3. Some authors are of the opinion (according to H. des Abbayes 1951) that in towns lichens can grow on calcareous substratum. In Lublin lichens were repeatedly found to grow, in suitable conditions, on sandstone, granite and brick, i.e. on substratum which can hardly neutralize the action of H_2SO_3 or H_2SO_4 (Rydzak 1953, e.g. p. 244, pos. 11, 12; Barkman 1958).

4. Lichens were often found growing abundantly on the crowns of walls or near the ground, both on plaster and on brick, whereas there were no or very scanty specimens on vertical parts of the walls (ibidem, pos. 52, p. 275, pos. 237).

5. Habitats were described where lichens were growing in masses on the summit of the wall and on its slanting supports, whereas large areas of the vertical part were completely bare (ibidem, e.g. pages 252—254, pos. 69, fig. 3).

6. Even near the gasworks and railway station, where the air is strongly polluted with smoke and coal gas, plaster lichens grow freely on concrete fencing posts, though only at the base and on the top. All posts are devoid of lichens on their vertical surfaces (ibidem, pp. 273—274, pos. 226).

According to the „gas theory", lichens would be completely absent from habitats mentioned in paragraphs 4, 5 and 6 or should grow only on vertical walls, not on the crowns of walls, near their bases, or on slanting surfaces where smoke and SO_2, being heavier than air, should exert the strongest toxic action. This does not mean that the descending gases favour the growth of lichens; they grow freely in such places because of the greatest moisture supply, thanks to increased condensation of vapour and formation of dew, which can be ascertained on the basis of the simplest principles of meteorology, without using special instruments. For the same reason it is quite superfluous to introduce the concepts of lichens resistant to toxic influences — „toxitolerant" (Barkman 1952 according to Klement 1956, and Barkman 1958) in order to defend the „gas theory".

7. On the premises of the gasworks, on the plaster covering the wall of an old abandoned furnace, there grow freely plaster lichens in good light conditions (S and W exposure) even on vertical surfaces. The wall is moderately moist because of contact with the ground. Near-by, on a willow-tree and on a wooden fencing rail, grow even foliaceous species. The neighbouring locust tree, however, is free from lichens.

The presence of foliaceous lichen species on trees in this area speaks against the „gas theory" and makes us suppose that the thalli are able to resist draught thanks to penetration of humid air from the adjacent meadows, especially at night. This supposition is partly confirmed by the data from the meteorological station „B" situated near-by (ibidem, p. 274, pos. 227—235, tables VI and VII, fig. 10).

No less convincing is the evidence of hundreds of observations confirming the occurrence of a considerable number of epidendric lichens in the town of Lublin. Detailed comparative analysis of the distribution of lichens in some habitats also furnishes numerous arguments against the gas hypothesis (ibidem, p. p. 242—277).

8. The extent to which the surface of tree trunks is covered with lichens, estimated according to the five-grade scale, decreases very clearly from the outskirts to the centre of most crowded areas. A sudden impoverishment of lichen vegetation can be often observed. The distance between habitats with a normal cover of grade 3 to 5 and habitats in which only a few, if any, thalli can be found is often less than a hundred metres. There are even cases when of two trees of the same species one is covered with lichens and the other is quite bare, the distance between them being only a few metres (ibidem, p. 269, pos. 185 and 186). It also happens that nearer the centre lichen vegetation is better developed (p. 255, pos. 71 and 72). On trees growing along the road no lichens were found, only a few small thalli of *Xanthoria parietina* were present on two horse-chestnuts near the crossing. In habitat No. 72, situated 80 m nearer the centre, lichens were comparatively numerous on trees of a garden (cover grade 3); even *Parmelia sulcata* was found there. In the same garden trunks of better lighted ash trees are covered with lichens up to 25 per cent (grade 3), whereas shaded trunks are bare.

The possible slight differences in the concentration of toxic gases between not very distant habitats cannot produce opposite effects. Differences in the development of lichen vegetation described above could be only produced by local differences of microclimatic factors.

9. In densely built-over quarters lichens can be sometimes found only at the base of the trunks, i.e. where the heavy gases should be present in highest concentration and where air humidity is greatest and desiccation smallest. Then again thalli are hidden in the bark fissures, in axils of branches, in rain-tracks and in other places hidden from excessive insolation and desiccation by wind. These microclimatic niches are equally, if not more exposed to the action of gases and smoke.

10. In Lublin, a small area devoid of epidendric lichens is found in a densely crowded but not industrial quarter situated on an elevation of the terrain. In this quarter smoke from elevated house chimneys can

exercise only a weak action, being directed by the wind towards the outskirts or meadows which extend at the base of the elevation to S and E.

11. Damp meadows situated along the river Bystrzyca occupy the centre of the town. From W, N, and E they are surrounded by residential quarters, from S and SE by industrial quarters, railway station and again by residential quarters. Smoke and gases emitted from chimneys, if heated and therefore lighter than air, should be blown to peripheric quarters or beyond and show their strongest action there. Or, if cooled and heavier than air, they should accumulate in the lowest parts of the town, i.e. in the meadows, and there produce the strongest toxic effect. In reality, both the peripheric areas and the meadows have a normal lichen flora, and two avenues running across the meadows have a rich lichen vegetation on poplars and ash trees reaching cover grade 4 and 5, i.e. 25 to 60 per cent of trunk surface up to 3 m high.

12. A number of examples illustrate the fact that in a given spot of the town, in circumstances in which uniform action of gases and smoke can be expected, and in apparently analogous climatic conditions, the lichen flora is not the same on different tree species growing close to each other. Most frequently lichens cover ashes, aspens, poplars and willows; if they are scanty on these trees, they are completely absent from others, e.g. from locust trees. Evidently it is not gases which produce these anomalies, but some subtle differences in physical properties of the bark, such as thickness, hardness, smoothness, pattern of fissures, anatomic structure, water absorption, desiccation rate, heating and radiating capacity, vapour condensation, formation of dew, and possibly pH differences (for crustaceous species). Even different parts of the same tree present different microclimatic conditions.

The above-mentioned facts and arguments are a sufficient proof of the conviction that the distribution, occurrence and impoverishment of lichen vegetation in the town of Lublin are not dependent on the toxic influence of products of coal combustion but on other factors which shape the local town climate and the specific microclimate of the given habitat.

13. A great number of investigations conducted by various authors show how different the climate of towns can be from the climate of their surroundings. It should be clearly realized that every town is a more or less extensive area of geographic space deformed by man. In definite geographic and climatic conditions man has destroyed nature and instead has accumulated an enormous quantity of stone blocks placing them along paved streets running in various directions. Town is an artificial desert with a very large surface of roofs, walls, built-over

quarters etc. drained by the sewerage, and quickly evaporating water from atmospheric precipitations.

Moreover, these exposed surfaces are artificially heated by combustion of coal in houses and factories as well as by intense solar radiation. To this the street traffic should be added, which produces irregular air currents. These are the main factors which form the specific local town climate. In all larger towns they are more or less identical, therefore the local climate of all towns situated in the given macroclimatic zone must be the same in their broad features.

Plots of uncovered soil, small water reservoirs, gardens, squares, isolated trees and parks occupy only a small percentage of the stony area and can little influence the general character of the local town climate. Still, they have great influence on the formation of the microclimate of adjacent habitats.

It has been observed that in artificial woods lichen vegetation is different and much poorer than in natural, virgin forests, and that even a way freshly cut through the wood causes a change in lichen flora on the wayside trees. No wonder therefore that lichen flora of towns is altered and poor in comparison with that of the surroundings. In this connection, attempts at introducing one more factor in the form of coal combustion gases, and ascribing to them the main responsibility for the poverty of lichen flora in towns should be regarded as a misunderstanding.

The specific town climate outlined above is produced by numerous factors, of which the most important ones were measured by many investigators.

a) Temperature. Smoke and dust hanging in the air over cities decrease heat radiation. The town heats in the morning and cools in the evening more slowly than its surroundings. The stony substratum of the town is heated by the solar radiaton more strongly than the environment covered with vegetation, and the air reaches a higher temperature. When there is little wind, temperature differences between day and night are smaller in the centre than at the outskirts (Geiger, Knochenhauer, Albrecht and others, according to Kratzer 1937). Coal combustion in houses and factories also increases the temperature of air in towns. Faton found that the general temperature increase in London was 1.4°C. For Berlin the mean yearly difference is 1°C, for Moscow 0.7°C. Individual measurements show much greater differences. On 23rd July, 1929, at 9 p.m. Pepler found in Karlsruhe the difference of 7°C between the countryside and the town, and Grunow in Berlin 10°C, where even 300 m above the city the air was by 1°C warmer than in the surroundings. During the frosty night of 12th May, 1927, Schmidt found in Vienna the temperature + 5°C inside the city, and —3°C in a place 10 km from it. Pepler and Schmidt drew isotherms for Karlsruhe and Vienna, which show a distinct gradual rise of temperature from the outskirts to the centre of crowded areas. Figures 5, 6 and 7 serve to illustrate this (Rydzak 1953, p. 313, according to P. Kratzer 1937). Numerous measurements carried out by Tollner, Geiger and others revealed considerable variations of temperature reaching sometimes as much as 6°C in spots distant a few metres from each other. P. Kratzer says (p. 65): „It is possible to speak not only of a special climate of the town, but also of the particular climates of streets, avenues, squares and narrow lanes". Studies conducted by O. Lange (1953) and W. Lüdi — H. Zoller (1953) show that even in one spot there can exist considerable microclimatic differences between points distant less than a metre from each other. This agrees very well with what can be inferred from the distributions of lichens.

b) Relative humidity. Absolute and relative humidity of town air is determined by small amount of moisture in the substratum and by increased temperature of air. Kremser, Büdel, and Wolff found in Munich that differences between the relative humidities of the town and of its environment are greatest in summer and reach their maximum about 9 p.m. At that hour the air in the town can be by 12 or even 15 per cent drier than in the surrounding country. During hot weather differences of relative humidity between two not very distant points of the town reached 30 per cent in the evening (Kratzer 1937). Kremser presents the following table giving percentage differences between relative humidities of towns and their surrroundings:

	7 h	14 ha	21 ha
Berlin	4	4	8
Wrocław	5	5	9
Munich	4	4	9

The relative data for Lublin were shown in Tables VI and VII (Rydzak 1953) and also in Table 2 included to the present paper.

The drawing of the course of isohyets in Munich on lst July, 1932, given by Büdel and Wolff shows a gradual decrease of relative humidity from the outskirts (75 per cent) to the centre of the city (45 per cent) (Kratzer 1937). Kremser is right in observing that the great quantity of smoke and dust particles absorb vapour on their surface and contribute to the desiccation of air.

Increased temperature and lowered humidity of air in towns restrict the possibility of vapour condensation and impede the formation of dew, which can form in some places only, where there is a favourable configuration of exposure, environment, heat conduction, radiation and air movement. In such spots, where favourable conditions for the formation of dew occur more frequently, lichens can settle.

c) Wind. The above-mentioned factors shape the climate of towns together with the wind, which not only influences the mean value of temperature and humidity of air, but strongly modifies the microclimate of each habitat by hastening evaporation and in consequence desiccation of substratum and thalli, and by hindering the formation of dew. Besides normal winds, in the microclimate of towns a local wind can be observed — „Stadtwind" or „Flurwind" („field wind") according to F e l s, which was studied by S c h m a u s in Dortmund, E c k a r d in Essen, L a u s c h e r in Vienna, and by others (K r a t z e r 1937). This wind arises because of temperature differences between the town and its surroundings and brings fresh, more humid air from adjacent fields. Increased temperature over the densely built-over centres produces ascending currents of warmer air. In its place comes the air from the surroundings, becomes gradually warmer, decreases its relative humidity, heightens the dew point and ascends slowly. Owing to this, quarters situated at the outskirts of the town have a more humid atmosphere than the crowded centre, and lichens find there better climatic conditions.

Depending on the configuration of the town, on the direction and course of principal streets, extent of crowded areas, distribution of factories etc., the gradual decrease of air humidity from the outskirts to the centre of the town is more or less regular. These changes of relative humidity are more or less correlated with the zones of distribution of lichens in towns, described by a number of authors. This hypothesis is shown schematically in fig. 9, p. 319 (R y d z a k 1953).

d) Radiation. The climate of the town is also influenced by the decrease of the intensity of solar radiation caused by dust particles and smoke hanging in the air over the city. B ü t n e r reports that on a clear day in June the decrease of general radiation in Berlin and of red radiation in particular, was 20 per cent in comparison with Potsdam. In a similar way, L e t t a u's measurement of the brightness of sky in Königsberg in 1931 revealed a 30 per cent decrease in comparison with the surroundings (K a t z e r 1937, R y d z a k 1953, pp. 309 and 310). This factor co-operates with the above-mentioned one in establishing an increased temperature of air in towns and must have a certain influence on the process of assimilation in lichens.

e) Other factors. Besides the above-mentioned factors determining the mean local climate of a town within the climate of a certain geographic area, there are factors which shape the particular microclimate of a habitat and very strongly influence the life and distribution of lichens in towns. Here are some of them: direction of exposure to solar radiation, heating by this radiation, shading and its duration, artificial lighting, street traffic, heat conductivity of the substratum, its heat radiation properties, colour, smoothness or roughness, hardness, water absorption and chemical properties, influence of man, etc.

These factors contribute to desiccation of the substratum, hinder condensation of vapour and formation of dew, or decrease the intensity of vital processes in lichens and render impossible the germination of spores and the development of young thalli. The most evident effect of the co-operation of all these factors is a decrease of relative humidity and an increase of humidity deficit in the air of towns. This is well illustrated by the microclimate of numerous habitats, the dominating feature of which is drought.

Some data found in the literature on the occurrence of lichen species in natural conditions as well as investigations on their biology, physiology and ecology (e.g. F. Tobler 1925, H. des Abbayes 1951, J. Barkman 1958) furnish proof of sensitivity of lichens (its degree depending on the species) to climatic factors. Unfortunately, sufficiently exact data on the ecology of the individual species are still scanty.

14. A brief survey of some biological and physiological properties of lichens will allow us to appreciate better the great dependence of the occurrence and distribution of these organisms on climatic conditions of the town habitats.

First of all, it must be remembered that a lichen consists of two components: an autotrophic alga and a fungus living on the former's expense. In favourable conditions gonidia must assimilate both for their own need and for the fungus which usually has a much larger volume. In addition, gonidia must produce enough organic compounds and reserve material to assure the growth of the thallus, production of spores and respiration during unafovurable periods, when assimilation is considerably decreased or even completely suspended for a certain time. The intensity of assimilation depends chiefly on the intensity of light, temperature, and hydrature of the thallus. In some places light is too weak because of shading, whereby absorption of light by the more or less transparent cortex of the thallus should be also taken into account; in others insolation is too strong and causes heating of the lichen, sometimes up to — 80°C. Lichens soaked with water are especially sensitive to heating (at 50°C they die in one minute). In dry state they are more heat-resistant, but then their assimilation is too weak (L a n g e 1953).

Lichens are usually hygrophytes-aerohygrophytes and substratohygrophytes (H. d e s A b b a y e s 1951, and others). They are unable to adapt themselves to drought and dry up easily, which leads to a considerable decrease of vital processes. Numerous experiments have shown, it is true, that lichens are very drought-resistant (Q u i s p e l, T o b l e r, and others) and even in a herbarium can live several months, but in such circumstances they do not assimilate, only use up reserve materials. O. L a n g e (1953) reports on his own and other investigators' experiments which prove that numerous species remain alive after more than ten weeks' desiccation. Even *Dermatocarpon aquaticum*, a hydrophyte which in natural conditions grows only under constant spray of water, has shown a very high resistance to heat and drought (54 weeks). On the strength of these findings O. L a n g e arrives at a paradoxical conclusion that in nature lichens are never exposed to such long periods of desiccation, and in consequence are not damaged by drought, which therefore has no influence on their distribution: „Keine der untersuchten Flechtenarten kann an irgendeinem natürlichen Standort (unseres Klimagebietes) von so langem Trockenperioden getroffen werden, dass eine unmittelbare Trockenbeschädigung eintreten und dadurch die Verbreitung eingeschränkt werden könnte" (p. 94). But *Dermatocarpon aquaticum* never grows in dry places because in dry state its metabolism is disturbed, e. g. when assimilation is suspended and weak respiration continues at the expense of reserve materials. Drought has therefore an essential influence on the distribution of species; it simply makes impossible their existence in many habitats.

In natural conditions every lichen species can grow only where it can develop all its living activities, where its life-balance is positive. In all places where the configuration of the previously mentioned climatic factors would result in the given species in the preponderance of dissimilation processes over assimilation, the species is unable to live. I n n a t u r a l c o n d i t i o n s e v e r y s p e c i e s l i v e s o n l y w h e r e, t h a n k s t o i t s m o r p h o l o g i c a l a n d a n a t o m i c a l s t r u c t u r e a n d p h y s i o l o g i c a l p r o p e r t i e s, t h e r a t i o o f t h e p r o d u c t s o f m e t a b o l i s m $CO_2 : O_2$ i s m o r e t h a n 1. There are numerous spots in towns where the conditions of local climate and microclimate would produce a negative balance of CO_2 and O_2. No wonder therefore that lichens are absent from such places, and that numerous species, especially aerohygrophilous fruticose species, do not enter the town at all.

A number of other data can be found in literature, but quoting them would unduly increase the size of the present paper (T o b l e r 1925, H. d e s A b b a y e s 1951, L a n g e 1953, R y d z a k 1953, B e s c h e l 1958, B a r k m a n 1958).

In connection with the research work presented above, the present writer developed in 1950 and prepared for publication a hypothesis on the influence of drought on the distribution of lichens in large towns. The hypothesis was discussed at a meeting of the Lublin Section of the Polish Botanic Society in 1951 and during the 25th Congress of the same Society in Warsaw in 1952. Because of the publisher's delay the paper was printed in 1953. This allowed the writer to strengthen his conclusions by adding a table containing data furnished by a newly established meteorogical station in the centre of the town, and by comparing them with those obtained from two other stations situated in the town near the meadows and outside the town respectively (R y d z a k 1953, table VI and VII).

The author's hypothesis is as follows:

Sulphur dioxide and other gases and smoke polluting the air are not a decisive factor as far as occurrence and distribution of lichens in towns are concerned. The commonly accepted view on the eliminating influence of SO_2 on lichens is not based on experimental investigations, nor does it agree with more exact studies on the distribution of lichens in towns. It must be therefore regarded as an instance of collective scientific illusion.

The occurrence, distribution, weak growth or elimination of some lichen species in towns are governed by a complex of factors of which the most decisive is a group of interdependent climatic factors; these determine the humidity of the air and substratum in the town as a whole and in the individual habitats. In towns lichens occur where there is sufficient humidity in the air and substratum for the given species, where dew is formed most frequently, and where there is enough light. The quantity of food-stuffs available in dust is everywhere more or less sufficient. In towns only these lichen species can survive which thanks to their morphological, physiological and biological structure are able to keep up for a number of years a positive balance of their metabolism in the given microclimatic conditions. The same factors determine also the occurrence of lichens in nature.

The previously mentioned zones of distribution of lichens in towns correspond to the arrangement of isolines of climatic factors and are the result not of the struggle with toxic gases but of the struggle with drought-struggle for water.

The lichen species give excellent information on the humidity of the environment.

15. This hypothesis aroused vivid interest in the west-European literature, and the latest investigations on lichen flora in towns confirm the essential influence of climatic factors on the life and distribution of lichens in towns.

a) M. Steiner and D. Schultze-Horn carried out detailed studies on epidendric lichen vegetation in Bonn and determined their zones of distribution. These zones were then compared with the results of Emonds's studies on the climate of Bonn, and evident conformity could be observed. In view of this, the authors say: „Wir sind also nicht ganz sicher, ob nicht bisher dem Faktor Luftverunreinigung bei der Erklärung der Epiphytenfeindlichkeit eine zu grosse, um nicht zu sagen ausschliessliche Bedeutung beigemessen wurde. Das Bonner Beispiel scheint zu zeigen, dass die rein klimatischen Faktoren zumindest eine sehr grosse Beachtung verdienen... Es wird darauf hingewiesen, dass für die Epiphyten- und spezielle Flechtenfeindlichkeit der Städte rein klimatische Ursachen neben oder sogar vor der Luftverunreinigung ausschlaggebend sein dürften".

In connection with my paper of 1953 the same authors write this: „Auf Grund von Untersuchungen in einem, im einzelnen sehr verschiedenartigen Gebiete werden hier also sehr entschieden dieselben Schlussfolgerungen ausgesprochen, die uns nach unseren Studien in Bonner Stadtgebiet nahezuliegen schienen". (Steiner and Schultze-Horn 1955, pp. 14 and 15, table 1).

Although the above statements cannot be regarded as a proof of the authors' acceptance of climatic conditions as the only influence on the distribution of lichens in Bonn, nevertheless the discovery of conformity between the isolines of climatic conditions and lichen zones is a confirmation of the present writer's hypothesis based on data from Lublin and other towns (Rydzak 1953, pp. 310—319, fig. 4, 5, 6, 7, 8, 9, 10; Steiner-Schultze-Horn 1955, table 1).

b) O. Klement seems to be more convinced of the truth of the „drought hypothesis". He writes: „Dagegen sprechen alle Beobachtungen dafür, dass nur die Luftfeuchtigkeit und alle von dieser beeinflussten mikroklimatischen Komplexe den „Faktor in Minimum" darstellt und alleine oder doch fast alleine darüber entscheidet, ob noch ein Flechtenleben in der Steinwüste der Städte möglich ist. Denn über den Wüstencharakter des Stadtklimas kann nicht der geringste Zweifel bestehen... Deswegen sind Stadtflechten in erster Linie auf eine ausreichende Taubildung angewiesen. Wo eine solche ganz ausfällt und überdies die Luftfeuchtigkeit zu gering ist, hört aber schliesslich jedes Flechtenleben auf". These statements are in perfect agreement with the present writer's conclusions (Klement 1958, pp. 4 and 5, 1956, Rydzak 1953, pp. 316, 317, 331).

O. K l e m e n t's reasoning is just though he himself did not make appropriate „exact measurements". His reasoning is based on fairly numerous data in the literature on climatological investigations. In this connection this opinion of his seems unjust: „Ganz klar hat dies aber bereits Rydzak (l. c.) formuliert, doch muten seine Begründungen zunächst etwas spekulativ an, weil sie sich nur auf reine Beobachtungen und nicht auf exacte Messungen stützen". (K l e m e n t 1958, p. 1). None of the lichenologists concerned with the problem of lichen flora in towns has so far carried out „exact measurements" in order to corroborate either the gas or the drought hypothesis. All speculations were based on more or less exact studies on the distribution of lichen flora in towns, attention being paid to some data on toxic or harmful qualities of polluted air and on the general characteristics of the town climate. In his paper of 1953, the present writer included not only detailed investigations on the occurrence of lichen species in Lublin and a general evaluation of conditions in the given site and habitat, but also numerous data found in the literature on the biology and physiology of lichens and on the climate of Lublin and of other towns (pp. 236—331, in Polish). The character of that paper (and of the present one) did not allow a more extensive presentation of facts and arguments. They can be found in a greater number in publications of monographic character, e.g. by F. T o b l e r 1925, H. d e s A b b a y e s 1951, J. B a r k m a n 1958, A. K o s k i n e n 1955, and others.

The analysis of a number of facts and their comparison with each other lead to a certain idea, generalization or synthesis in the form of working hypothesis, explaining hypothesis, and theory. Every hypothesis and theory is a generalization which includes both known and possible, supposed facts. In this meaning every hypothesis and theory must have a speculative character. Of two theories the best is which embraces and explains best a greatest number of known facts, and which will confirm a greater number of future investigations. Still in the same meaning, the stronger theory has a more creative character.

May the discussion which is going on in literature, together with still existing doubts, incite the future investigators to perform appropriate measurements („exacte Messungen") of factors influencing the distribution of lichen species in towns and in natural conditions. This performance will be very difficult and, above all, very costly. The present results of meteorological investigations in towns, though valuable for comparative purposes, are quite insufficient to characterize the microclimates or to explain the cause of the presence or absence of individual lichen species from the given site. They are usually mean monthly values from two or three daily readings taken in a broader area of the town or of its surroundings. Of course, readings taken in various sites can be very different. On the strength of valuable measurements taken on one tree only, W. Lüdi and H. Zoller write: „So entstehen am Baum, in der Krone und am Stamm, recht ausgeprägte und verschiedenartige Kleinklimate, die ihre stärksten Gegensätze wohl am Südfusse und am Nordfusse des Stammes finden". (W. Lüdi und H. Zoller 1953, p. 128). It would be therefore necessary to study microclimatic and other factors by placing in various towns and in various natural control sites a great number of self-recording instruments which would operate there for one year at least. Even then an attempt on the part of specialists to combine these exact but independent data into a synthetic whole of the „cause-effect" type will have a somewhat speculative character, though the area of probability may be larger. So far it has been impossible to carry out such investigations. Therefore lichenologists use the less perfect, indirect method, which consists in studying and comparing the distribution of lichen species in various habitats. In spite of the imperfection of this floristic method, Steiner and Schultze-Horn remark justly: „Es zeigt sich, dass die Aufnahme der Flechtenvegetation zu ähnlichen Schlussfolgerungen führt wie die genaue klimatologische Analyse" (ibidem, p. 15).

The organisms of the individual lichen species are subtle instruments reacting to various environmental factors characterizing the climate and the site, and registering during their life the fluctuations of these factors. Free growth of lichens in a certain habitat proves that the mean values of these factors approached the optimum of the requirements of the plants during a sufficiently long period of time. When the fluctuations of some of the factors surpass the minimum or maximum for a certain time, the species cannot grow in the habitat.

Unfortunately, we have no comparison scale, the key to decipher the records of these instruments (Rydzak 1956, Part II, p. 56).

c) Beschel investigated the lichen vegetation of five Austrian towns; two of them are larger: Salzburg (102,000 inhabitants) and Innsbruck (about 100,000 inhabitants), and three small: Bregenz 21,100 inhabitants), Wornbirn (21,800 inhabitants) and Landeck (about 5,500 inhabitants). The author describes climatic conditions and ascribes to them a considerable influence on the occurrence and distribution of lichens in the studied towns. Nevertheless, he has not yet freed himself from the influence of the gas hypothesis; having quoted some fragments of my paper (from a summary published in German) he writes: „Ich bin der Ansicht, dass klimatische Faktoren das Aufkommen und Wachstum der Flechten in höherem Masse bestimmen als chemische Faktoren der Luft und des Substrates... Sicherlich wurde die Erklärung der „Flechtenwüste" durch Luftverunreinigungen und besonders durch den SO_2-Gehalt der Luft von vielen zu gutglaubig und unkritisch übernommen. Die Abnahme der Grossflechten in den letzten hundert Jahren hauptsächlich auf den Sulfatgehalt der Niederschläge zurückzuführen, wie es M r o s e 1941 getan hat, halte ich für voreilig. Die Schwankungen des Grossklimas müssen hier zumindest auch berücksichtigt werden" (B e s c h e l 1958, p. 149). To the last sentence the remark can be added that the impoverishment of lichen flora may be the result of changes in the local climate produced by devastation of natural forests.

In comparison with the above enunciations, Beschel's remark quoted below must be a misunderstanding and illustrates his tendency to respect both hypotheses: „Rydzak betont vor allem den Einfluss des Stadtklimas. Er geht allerdings in seiner Zusammenfassung (1953 : 354) über die Feststellung „über Vorkommen, Dislokation, schwache Entwicklung und Elimination von Flechtenarten in den Städten entscheidet nicht ein einziger Faktor, ...sondern ein Komplex von vielen Faktoren..." hinaus, indem er im selben Satz gleich ins andere Extrem verfällt und den Einfluss nur auf die Faktoren beschränken will, „welche das Verhältnis von Luft und Untergrundfeuchtigkeit in der ganzen Stadt und an den einzelnen Standorten gestalten". „In the Polish text of his publication of 1953 the present writer considers numerous factors influencing the occurrence and distribution of lichens in towns and proves that of all these the most important factors are those determining the humidity of air, substratum and lichen thalli. In nature lichens are also distributed according to the configuration of climatic factors. This does not mean that toxic gases should be regarded as favourable or at least indifferent to the growth of lichens; enough evidence has been collected by the present writer that it is not gases which are responsible for the poverty of lichen vegetation in the studied owns, but a factor much more essential for the life of every species and which occurs there in minimum quantity-water.

It is not excluded that in conditions of high air humidity and excessive concentration SO_2 may have an eliminating influence on lichens. The same can be said about all other substances emitted into air by industrial centres. Even excess of moisture would be for most species an eliminating factor. But so far only a dry climate has been found in towns, and the SO_2 concentration is measured in the millionth parts of gram in one cubic metre of air. It goes without saying that in small localities and health resorts the concentration of this gas must be many times lower. That is why investigations conducted in small towns completely deny the possibility of the decisive influence of toxic gases on the occurrence and distribution of lichen vegetation (R y d z a k 1956—58).

d) S k y e investigated the distribution of foliaceous and fruticulous epidendric lichens around a large factory (shale-oil works) at Kvarntorp near Kumla in Sweden. He found that lichens near the works showed a weaker growth than in a control area situated about 10 km from the locality. Two stations situated more or less close to the works had the degree of surface covering of 1/4 and 1/2 only, whereas in two other stations situated in the distant control area lichens occupied 3/4 of the trunk surface. The author is of the opinion that these differences of surface covering are produced not by changes of climatic factors, especially of humidity, but by toxic properties of gases from the works. The answer to this has been given in the preceding paragraph. It can be added that in the climate of Poland (and of Sweden as well) there can be easily found trees with lichen covering less than 1/4 or trees completely bare. Ecology of lichens is still unable to appreciate the subtle variations of microclimate which undoubtedly produce such differences.

To the argument that in the town of Lublin, in some places which are particularly exposed to desiccation, lichens can be found only at the base of the trunk and on the top of the wall, i.e. where there is most moisture and where SO_2, being heavier than air, should act most intensely, S k y e answers as follows: „R y d z a k has, however, obviously failed to observe two facts, viz. that the poisonous smoke gases often have a higher temperature than surrounding layers of air, and that the specific weight is of no consequence as the gas is mixed with air to such a great extent". (S k y e 1958. p. 174).

The effects of the relevant physical laws were taken into account in the present writer's paper of 1953 (see fig. 9, p. 319). But it is the same laws which, when applied wrongly, deny the conclusions reached by Skye on the strength of his studies carried out in the surroundings of the Kvarntorp works. If SO_2, lighter than air because of heating, did not descend in the town and near the factory, there would be no use investigating and discussing its eliminating influence on lichens in towns and near industrial centres. But it does descend and its presence in the town can be proved. And if we suppose (before exact investigations have confirmed it) that the gas is uniformely distributed in the air surrounding the studied tree or wall by air currents, it will be even more difficult to explain why, according to S k y e, the flora of epidendric lichens has been impoverished near the Kvarntorp shale-oil works, but not in an area distant 10 km from it. Why is it then that, in spite of its uniform concentration, the gas has no harmful effect on lichens growing at the base of the trunk or of the wall, but attacks those situated 1 or 2 m higher? This is namely where no lichens can be found on the vertical surfaces of numerous stations because of the toxic action of gases, as the „poisoning theory" has it.

The conclusion is that the hypothesis of the toxic influence of gases, instead of making it easier, renders much more difficult the understanding of questions connected with the ecology of lichens.

e) In his paper of 1958, Barkman has gathered the results of his own studies in Holland as well as data found in the extensive literature on the subject. On this basis he discusses ecological factors which determine the growth of lichens in various habitats. The majority of collected facts speak strongly in favour of the hypothesis on the decisive influence of climatic factors on the occurrence of lichens in towns and in natural conditions.

The same author has also collected arguments pro and contra the draught and poisoning hypotheses; he divides them into positive and negative arguments with regard to either hypothesis (Barkman 1958, pp. 123—127). Here is a brief summary of positive and negative arguments in favour of the toxic gas hypothesis and against the drought hypothesis.

I. Negative arguments supporting the toxic gas hypothesis:

Argument 1. a) „Lichens are not only more aerohygrophilous than mosses, but probably also more toxiphobous, owing to their structure and physiology".

b) „In Caracas (Vareschi 1953) lichens are absent, where aerohygrophytic phanerogams like Fillandsia thrive on the trees".

Counterargument 1. a) Distinguishing between „toxiphobous" and „toxitolerant" lichens is not sufficiently motivated. Of this opinion is also Beschel: „Die Ansicht Barkmans, dass die Flechtenpioniere in den Städten toxitolerant seien, ist ohne Experimente nicht zu widerlegen". (Beschel 1958, p. 149).

b) Firstly, this argument contradicts the author's opinion on p. 125, line 12: „The comparatively rich lichen growth in this town and the small size of its epiphyte deserts is another argument in favour of the toxic gas theory". Secondly, lichen thallus and *Tillandsia* can be compared neither from morphological and anatomical, nor from physiological point of view.

A. 2 „In the centre of Vienna even crustaceous lichens are absent, but algae are present, though considered more acrohygrophilous".

C. — a. 2. It is little problable that no crustaceous lichens could be found on old walls in Vienna. Algae grow in more shady places and their water balance and metabolism are independent of the presence of a fungus, as it is in the case of lichens. Apparently toxic gases spare algae.

A. 3. „The zones of bad climate in Bonn are not only characterised by drought, but also by high dust concentrations. In addition, air circulation is much weaker, so that dust and soot are likely to be more readily deposited on the epiphytes".

C. — a. 3. Lichens are never covered with a deposit of dust and soot of longer standing; every rain leaves them quite clean. Lichens need small amounts of dust, from which they derive mineral salts.

Dust and soot could not be deposited on lichens which never were present at certain stations. Where lichens are present in towns, dust and soot evidently have no harmful effect.

A. 4. „It should be borne in mind that epiphytic vegetation around Bonn is also rather poor, a fact mentioned by Steiner and Schultze-Horn themselves".

C. — a. 4. Barkman gives the following argument in favour of the drought hypothesis: „On the other hand, the epiphytic vegetation of Bonn as a whole is poor, in spite of the fact that the town is small and has little industry". If the lichen vegetation in Bonn is poor not because of toxic gases, it is still less probable that this reason would produce impoverishment of lichens around the town. There is little wonder that the town of Bonn is poor in lichens, if the same can be said about its surroundings.

A. 5. Calcareous and other alkaline substrata neutralize acids formed from gases and allow lichens to grow there.

C. — a. 5. Gases act on lichens and on their substratum simultaneously. Therefore, even neutralization of the substratum could not protect lichens against the toxic influence of gases.

II. Positive arguments supporting the poisonous gas hypothesis.

A. 1. „Tobler found that in cities several lichens can only be cultivated in filtered air".

C. — a. 1. This still needs exact experimental investigations, as it is possible to find in towns and in their surroundings lichen species growing in non-filtered air. The same author gives, by way of a negative argument in favour of the drought theory, the fact that „Maas Gesteramus (1952) collected fine specimens of Physcia dubia in the centre of Dutch towns and once on a factory wall near a railway-yard".

A. 2. Mrose supposes that the absence of the *Usnea* species from mountain forests is caused by a high concentration of SO_2 in air.

C. — a. 2. Already Beschel, in a sentence quoted before, draws attention to the unsatisfactory experimental foundations of this view. It happens very often that certain plants do not occur in various parts of the country or of the world, but this is not explained by an excess of toxic gases.

A. 3. „Trees in the centre of large cities, for example Paris and London, but also in Stockholm (Sernander 1926) are often covered with soot, which would suffocate the epiphytes, if not prevent their establishment at all".

C. — a. 3. Vide I. A. 3 and C. — a. 3.

In small towns and other places where trees are not covered with soot, some species of lichens can be found, others not.

C. — a. 4. The author's arguments contained in paragraphs 13 and and 14 speak much more strongly in favour of the drought hypothesis.

A. 5. In paragraphs 15, 16 and 17 the author quotes a number of arguments: impoverishment of lichen vegetation is also observed near factories situated outside towns; drought can be felt in towns but gases have a wider range of action; a map of the Netherlands shows whole areas of the country as lichen deserts; the woods are poor in spite of a great rainfal; there are some historical data from which it can be concluded that in older times lichens were more plentiful in those parts.

C. — a. 5. These proofs and problems transgress the limits of the discussed hypotheses and are part of ecology of lichens growing in the so-called natural conditions. It is evident that gases extremely diluted over large areas cannot be the cause of the impoverishment of lichens in a country or of changes of their distribution mentioned in historical records. The reason for these changes must be looked for in the spreading activity of man. Unsatisfactory protection of natural resources, devastation of natural forests and cultivation of artificial woods, regulation of rivers, melioration, tillage, etc. modify the original local climatic conditions. Because of these changes, disappear not only lichens but also numerous species of phanerogamic plants, and there is no need to explain this by the toxic action of gases and smoke produced by coal combustion in towns and industrial centres.

The author says finally: „In conclusion one may say that drought of town climate has an undeniable effect upon epiphytic vegetation, but the influence of toxic gases is not to be discounted either" (B a r k m a n 1958, p. 126).

The results of investigations carried out in a number of small health resorts, which will be discussed below, indicate that the influence of toxic gases on the distribution of lichens in towns need not be taken into consideration (R y d z a k 1956—58).

16. The influence of small towns on the lichen vegetation.

Propagation of new ideas always meets with difficulties and resistance, and requires time, discussion and new proofs.

Studies on the lichen vegetation in Lublin seemed therefore unsatisfactory to strengthen the „drought hypothesis", which explains the poverty of lichens in towns better than the „poison hypothesis". Lublin, which has more than 100,000 inhabitants and a medium-size industry, does not differ in this respect from other European towns studied so far. That is why the present writer undertook in 1953 studies on lichen vegetation in small towns and localities situated in various climatic regions of Poland. The starting point were the following facts disregarded by the followers of the poisonous gas hypothesis: 1. The toxic influence of coal combustion gases on lichens decreases in proportion to the growing distance from the centre of the town and from industrial centres. At the outskirts of large cities there begins the normal lichen vegetation. The concentration of gases is there probably so low that it does not influence the growth any more. 2. It has been really found that at the outskirts of the large, industrial towns of Manchester and Saarbrücken the amount of SO_2 in air is about 50 per cent of that in the central quarters. There are therefore sufficient reasons to suppose that the concentration of toxic gases in the centre of small and non-industrial places cannot be higher than at the outskirts of large towns. If it is possible to find normal lichen vegetation in the suburban areas of large towns, this vegetation should be also normally developed in the centre of small towns. Epidendric lichen vegetation in small towns should not be different from that of the surrounding country as far as species composition, degree of covering, growth and vitality are concerned, and should even contain species which willingly grow on wayside trees. The contrary would be a sufficient direct proof that factors other than toxic components of the air determine the occurrence and distribution of lichens in towns.

By means of this working hypothesis the writer carried out investigations of the lichen flora of 25 small towns and places. The size of these localities is given in Table 1 (according to official data and Rocznik polityczny i gospodarczy 1958).

The second object of the research was to establish whether the macroclimate of a certain climatic region influences the composition of species growing in small towns in Poland. In this connection a number of small towns situated in various climatic regions of Poland (according to E. Romer, see Map) were investigated. Out of these 14 are health resorts, for the most part in the mountaineous or sub-mountainous regions; they are: Kudowa, Duszniki, Polanica, Lądek, Wisła, Ustroń, Muszyna, Iwonicz, Rymanów, Zakopane, and Busko; Międzyzdroje, Ustka and Łeba are situated at the seaside.

The methods of investigation were the same as those applied to the studies on the lichen vegetation of Lublin, and consisted in: 1. Minute search for lichen stations in the centre of the locality; 2. Collecting data on the qualitative and quantitative occurrence of lichen species in these stations. 3. Collecting data from some stations situated at the outskirts of the place and comparing them with those obtained in the centre of the town. 4. Describing the stations in order to determine indirectly the ecological conditions of each habitat.

The results of these investigations were published in six parts, according to the division into climatic regions (Rydzak 1956, 1957, 1958).

Table 1. The size of towns and localities

No	Town	Area in ha	Number of houses	Number of rooms	Number of inhabitants	Number of factories
1.	Kudowa Zdrój	1947	491	—	1950	3
2.	Duszniki Zdrój	1968	301	2227	4800	5
3.	Polanica Zdrój	1060	—	3426	3861	6
4.	Kłodzko	1837	1098	12391	23000	23
5.	Lądek Zdrój	2050	637	3474	5700	3
6.	Stronie Śląskie	s. 500	104	—	s. 2000	1
7.	Wisła Uzdrowisko	1102	1332	2836	4890	20
8.	Ustroń Uzdrow.	4635	1100	5500	7495	7
9.	Muszyna Zdrój	1147	629	1320	3250	5
10.	Iwonicz Zdrój	545	225	1873	1425	—
11.	Rymanów Zdrój	27	12	—	151	2
12.	Lesko	300	350	1676	2200	6
13.	Zakopane Uzdrow.	3399	3066	13340	24563	26
14.	Kluczbork	1208	862	8687	13050	19
15.	Wołczyn	757	262	—	4100	2
16.	Opole	3800	4110	42856	55903	34
17.	Cieszyn	1273	1656	13941	24146	31
18.	Lublin	4407	6395	62203	150000	260
19.	Puławy	39200	—	5081	12979	11
20.	Zamość	2862	2630	12352	30000	27
21.	Busko Zdrój	1121	848	2654	7236	3
22.	Siedlce	2798	2661	15599	30900	21
23.	Białowieża	470	691	—	2600	1
24.	Międzyzdroje	3100	—	5400	3457	1
25.	Ustka	950	—	3693	5409	12
26.	Łeba	4210	—	1571	2862	1

The purpose of the present paper is to sum up these results and to present the general conclusions.

Meterological data for the studied localities are given in Table 2; they are based on recordings taken by the local stations *. Unfortunately, the lack of data made it impossible to tabulate meteorological

* With regard to temperature, rainfall and relative humidity, the data have been computed and tabulated by doc. dr. W. Zinkiewicz, dr. E. Michna of the Maria Curie-Skłodowska University; the data on humidity deficit have been furnished by dr Z. Wierzbicki and are part of a paper which is being prepared for publication. The author's vivid thanks are due to both of them.

Table 2. The meteorological data for 1953

No	Town	H m		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Yearly means
				Monthly means												
1	Kudowa Zdrój	385	t	—2,4	— 1,9	1,8	8,8	11,3	16,5	17,7	14,2	12,0	9,4	2,3	—0,4	7,4° C
			p	74,1	41,2	37,6	25,0	53,9	121,6	182,2	35,5	31,7	16,8	2,5	21,8	643,9 mm
			rh	91	87	75	61	75	76	78	81	82	81	83	86	80 %
			s	0,5	0,8	2,6	5,3	4,6	5,5	5,5	4,2	3,6	2,9	1,4	0,9	3,2 mb
2	Duszniki Zdrój	532	t	—3,1	—2,5	1,4	7,1	10,1	14,9	17,0	14,0	11,5	8,7	2,3	—0,2	6,8
			p	44,6	55,3	38,7	25,0	67,1	89,1	119,5	31,4	50,8	26,4	10,8	25,5	584,2
			rh	87	84	73	63	74	79	77	77	78	80	83	84	78
			s	0,7	0,8	2,4	4,4	4,5	4,3	5,2	4,7	3,8	2,8	1,3	1,0	3,0
3	Polanica Zdrój	400	t	—2,3	—1,4	2,3	21,0	11,2	16,4	18,5	15,0	12,8	9,6	2,9	0,6	8,8
			p	56,6	25,6	28,3	8,1	46,8	69,5	12 0	43,2	67,1	20,4	5,1	15,7	583,4
			rh	91	85	72	66	77	76	73	78	78	80	82	85	79
			s	0,5	1,1	2,8	4,5	4,2	5,1	6,6	4,9	4,3	3,0	1,6	1,1	3,3
4	Kłodzko	318	t	—2,4	—1,3	2,6	8,9	11,7	17,0	18,6	15,6	13,4	10,2	3,3	1,1	8,2
			p	37,9	20,9	19,5	25,9	50,5	46,9	131,5	24,0	34,1	15,5	2,0	9,9	418,6
			rh	86	81	72	60	72	73	72	73	72	76	77	79	74
			s	0,8	1,2	2,9	5,5	5,0	6,2	7,2	6,0	5,5	3,6	1,9	1,5	3,9
5	Lądek Zdrój	460	t	—2,9	—1,9	1,6	7,8	10,8	16,1	18,0	14,4	12,6	9,6	3,0	0,8	7,4
			p	60,1	41,9	52,1	55,8	83,1	52,8	134,0	40,7	38,6	24,0	19,7	19,3	622,2
			rh	88	82	72	64	75	75	71	75	74	76	79	80	76
			s	0,6	1,1	2,8	4,6	4.5	5,1	6,8	5,3	4,8	3,5	1,7	1,4	3,5
6	Iwonicz Zdrój	304	t	—3,3	—2,9	1,3	8,1	11,3	16,2	18,6	15,6	13,2	—	1,2	—0,7	7,1
			p	87,8	48,4	26,0	34,1	92,0	200,1	126,4	202,7	65,4	—	95,5	23,5	1001,9
			rh	88	86	73	66	76	82	76	80	81	—	80	81	79
			s	0,6	0,8	6,5	4,2	4,2	4,0	6,2	4,3	3,5	—	1,4	1,5	3,4
7	Zakopane	844	t	—4,5	—4,3	—1,6	5,4	8,8	13,9	15,8	12,9	11,3	7,2	0,8	—2,0	5,3
			p	89,4	39,5	64,3	109,8	109,3	123,0	190,1	144,1	106,0	38,5	39,7	31,4	1085,1
			rh	88	81	74	71	76	80	77	79	78	85	84	87	80
			s	0,6	1,0	2,2	3,3	3,5	3,8	5,0	4,0	3,8	2,2	1,3	0,9	2,6
8	Opole	177	t	—1,8	—1,0	3,6	9,7	13,2	19,0	20,4	17,4	14,0	10,9	4,1	0,7	9,2
			p	80,9	21,6	18,5	39,1	54,7	32,7	63,3	37,3	27,5	16,1	27,3	14,8	433,8
			rh	92	81	69	60	74	70	69	72	74	80	80	87	75,5
			s	0,5	1,3	3 3	5,7	5,4	7,8	8,7	7,0	5,4	3,4	1,7	0,9	4,3
9	Cieszyn	300	t	—2,1	—0,9	2,9	9,5	12,1	17,5	19,6	16,1	13,8	11,2	3,9	0,7	8,7
			p	86,8	34,6	39,7	60,8	123,6	116,8	156,5	76,3	59,1	19,2	31,4	21,7	826,5
			rh	88	80	72	62	77	79	75	80	81	79	78	85	78,0
			s	0,7	1,3	3,0	5,3	4,3	5,0	6,8	4,8	3,9	3,4	1,8	1,2	3,5

10	Lublin — st. „B" P.I.H.M.	172	t	—2,8	—3,2	2,0	8,4	13,2	18,3	20,0	16,6	13,3	8,8	2,2	—1,0	7,9
			p	45,3	53,1	13,7	9,2	40.5	57,0	52,3	114,8	22,1	10,5	55,2	12,1	485,8
			rh	89	86	76	68	71	75	74	77	77	81	81	87	78,5
			s	0,5	0,7	2,0	4,2	5,5	6,3	7,5	5,5	4,5	2,7	1,4	0,8	3,5
11	Lublin — st. „U" Univ. M.C.S.	199	t	—2,8	—3,1	2,3	8,6	13,8	18,6	20,7	17,5	13,7	9,1	1,9	—1,3	8,3
			p	47,5	54,0	11,7	9,8	39,3	58,5	56,4	111,5	24,4	11,8	54,8	15,2	494,9
			rh	92	87	76	65	66	72	76	75,	75	80	86	88	78,0
			s	0,4	0,7	2,1	4,5	6,5	7,0	6,4	5,7	4,6	2,8	1,0	0,7	3,5
12	Zamość	218	t	—3,2	—3,5	1,7	8,1	13,0	18,1	19,9	16,8	13,3	8,3	1,3	—1,8	7,7
			p	27,7	49,8	79,0	10,0	31,0	72,3	71,2	109,7	23,5	20,5	50,6	11,3	557,5
			rh	90	87	76	71	70	79	74	78	78	82	81	87	79
			s	0,5	0,6	2,1	3,8	5,6	5,3	7,4	5,4	4,2	2,6	1,3	0,8	3,3
13	Puławy	142	t	—2,4	—2,7	2,4	8,8	13,8	18,3	20,3	17,2	13,7	9,3	2,4	—1,1	8,3
			p	50,3	36,9	7,9	17,7	23,7	85,7	50,0	50,7	41,7	9,5	46,8	10,6	521,5
			rh	90	85.	73	64	65	75	71	71	73	76	78	86	76
			s	0,5	0,8	2,4	4,7	6,7	6,3	8,2	7,0	5,1	3,5	1,6	0,8	4,0
14	Busko Zdrój	225	t	—2,4	—2,2	2,6	9,2	13,0	18,3	20,3	17,3	13,9	9,8	2,4	—0,8	8,4
			p	64,4	35,0	10,9	24,1	53,4	48,9	64,8	59,1	38,0	10,6	45,2	15,2	469,6
			rh	86	82	74	68	73	75	70	72	75	82	85	90	77
			s	0,7	1,1	2,5	4,2	5,4	6,2	8,4	6,8	4,8	2,8	1,2	0,7	3,7
15	Siedlce	147	t	—2,9	—3,4	1,8	7,9	13,0	17,7	19,6	16,3	12,6	8,5	1,8	—1,8	7,7
			p	31,6	32,0	5,1	9,8	32,4	62,7	47,4	6,0	32,0	7,7	32,1	11,4	470,2
			rh	92	87	77	68	67	77	73	76	77	80	80	89	78
			s	0,4	0,6	2,0	4,1	6,3	5,7	7,3	5,8	4,3	2,9	1,4	0,6	3,4
16	Białowieża	164	t	—3,2	—4,4	1,2	7,1	12,3	17,6	19,1	16,0	12,1	7,9	0,4	—2,9	6,8
			p	33,9	49,2	8,2	9,0	35,7	70,3	101,2	39,9	30,8	4,6	26,0	17,1	465,9
			rh	91	87	77	74	71	78	76	80	82	83	83	90	81
			s	0,4	0,7	1,9	3,2	5,4	5,5	6,6	4,7	3,3	2,3	1,2	0,5	2,9
17	Międzyzdroje	10	t	0,5	—0,2	4,3	8,4	12,5	17,2	18,2	17,2	13,8	11,4	5,2	1,5	9,2
			p	54,2	34,8	15,3	13,3	50,3	91,7	56,5	42,8	44,4	15,6	21,8	19,1	459,8
			rh	91	88	77	69	77	78	75	79	80	84	85	91	81
			s	0,6	0,8	2,5	4,1	4,2	5,1	5,8	4,9	3,8	2,4	1,3	0,7	3,0
18	Ustka	6	t	—0,3	—1,0	2,9	7,2	10,8	15,4	17,8	16,3	13,4	10,5	4,4	1,0	8,2
			p	59,0	40,1	21.5	29,5	38,1	60,9	113,7	73,0	62,6	16,6	19,0	2,0	536,0
			rh	89	87	82	71	77	79	78	80	79	81	82	86	81
			s	0,6	0,8	1,7	3,8	3,8	4,2	5,1	4,3	3,8	2,7	1,5	1,0	2,8
19	Łeba	2	t	—0,6	—1,1	2,8	7,3	10,6	15,1	17,5	15,9	13,4	10,4	4,4	0,7	8,6
			p	43,9	35,3	17,7	18,9	41,9	86,2	125,6	76,8	78,5	23,0	17,6	12,9	572,3
			rh	87	87	81	72	77	81	79	82	80	80	80	87	81
			s	0,8	0,8	1,6	3,6	3.6	3,7	4,7	3,8	3,4	2,8	1,7	0,8	2,6

H — Height abowe sealevel in m t — temperature in °C p — precipitation in mm rh — relative humidity in % s — humidity deficit in mb records of the same years for all the localities. The table also contains data from two stations operating in the town of Lublin. The location of these stations was marked on the plan with the sign of triangle and with the letters U and B (R y d z a k 1953, fig. 10).

Table 2 permits only a cursory survey of the climatic conditions of the studied localities. Of course, the microclimatic conditions of the individual lichen habitats may be quite different and can be determined approximately only, on the strength of the description of habitats and species occurring there. The yearly means on relative humidity and on humidity deficit given in Table 2 confirm, in general, those computed in Table 4, column 2, although they are calculated for one year only.

Table 3 presents the number of stations and the species found. Considered are both stations located in the centre (c) and at the outskirts near the outmost houses (p). To preserve the comparability of the data, the species which occurred in habitats distant more than 100 m from the outmost houses of the settlement have been excluded from the table. However, no strict delineation of the town boundary is possible because in health resorts houses are much scattered, they are often quite distant from the centre or situated among woods in atypical climatic conditions. For these reasons the number of stations studied at the outskirts of the towns is different for each locality. Usually there were chosen only a few habitats which seemed to be most characteristic. The number of species growing at the peripheries of the towns, and especially the frequency of their occurrence may be therefore much greater than what can be gathered from Table 3. In fact, there was no necessity to extend the investigations over the peripheries. On the other hand, it was possible to study exactly the interior of the town. In the centre all trees growing in the streets and public places were examined. For obvious reasons trees growing in private gardens and on closed state-owned grounds were not studied. Because of limited space descriptions of numerous stations devoid of lichen vegetation or resembling in that respect the neighbouring stations were left out. Nevertheless, these habitats were taken into consideration when the general view on the state of lichen vegetation and on the ecological conditions of the locality was formed. The collection of data from the centre of the town cannot be regarded as complete either. More exact (and more laborious) research might have revealed more stations and lichen species. Yet the presented data are quite sufficient to observe distinct differences between the state of lichen flora inside the towns and at their autskirts.

Of the total number 102 found species, 95 grow at the outskirts, and 73 inside the towns. 29 species do not enter the towns although they grow on their margins. From the total number of stations of the given species are excluded the data found at the outskirts of Białowieża, and mainly in the palace park where the abundance of species and stations is out of proportion with the peripheries of other towns.

In Table 3 there are given numbers of crustaceous, foliaceous, and fruticose species found in the centres (c) and at the outskirts of the towns (p), as well as total numbers. The numbers of stations of the species found in the centres and at the outskirts of all towns have been also summed up. These sums are fairly representative of the state of lichen flora in the centres of the individual towns, but they also show some variations because of: 1. The influence of the microclimate. 2. Quantitative and qualitative differences in arboreal vegetation. 3. Close or scattered structure of the town. 4. The possible imperfections of the author's research. For these reasons the attempt at an approximate evaluation of the state of lichen vegetation in the individual towns has been based not only on the quantity of species and stations found, but also on the degree of cover and on the vitality of the species. This is presented in Table 4 in which the names of the localities are arranged beginning with the best developed lichen vegetation, and ending with the poorest one. The following criteria were used: 1. Decreasing number of species occurring in the centre. 2. Evaluation based on the analysis of cover degree and vitality of species in the studied habitats according to the data collected in the writer's six papers (Rydzak 1956—1958). Column II was obtained earlier than Column I and Table 2 and is in better harmony with the actual state although the evaluation is not quite free from being subjective.

Table 3 shows which species occur most often in the centres and at the outskirts of the studied towns. Thus, it is evident that the centres of even the smallest localities are most rarely penetrated by fruticose species, of which only 5 were found in all the localities, occurring mostly as single specimens in 20 stations (of which 10 at Białowieża).

Table 3 also shows some differences in the composition of species growing inside the small towns, which may point to the influence of the macroclimate on the possibility of the penetration of more sensitive species into the town. This influence, however, is usually slight. For instance, at Kluczbork the park is directly connected with the wood, but lichen vegetation in the latter is much richer at the distance of some dozens of steps than in the park on the same species of trees. The species *Parmeliopsis ambigua* and *P. pallescens*, which can be found in the wood at a short distance, do not enter the park at all, although all conditions seem to be identical in both adjacent areas. At Zakopane, Puławy, Międzyzdroje and Łeba, on the other hand, they can be found at the outskirts of these localities. At Kluczbork *Lecanora*

Table 3. Number

No	Lichen species	Kłodzko		Kotlina Kłodzka									Beskidy Zachodnie							
				Kudowa		Duszniki		Polanica		Lądek		Stronie Śląskie	Wisła	Ustroń		Muszyna		Iwonicz	Rymanów	Lesko
I	*Crustaceous* species	c	p	c	p	c	p	c	p	c	p	c	c	c	p	c	p	c	c	c
1	*Bacidia rosella*																			
2	*Buellia myriocarpa*			1													1		1	
3	*Caloplaca cerina*																			
4	*Caloplaca citrina*					1				1	1									
5	*Caloplaca decipiens*	1																		
6	*Caloplaca murorum*	1																		
7	*Caloplaca pyracea*																	1		
8	*Caloplaca tegularis*																			1
9	*Caloplaca vitellinula*											1								
10	*Candelariella vitellina*		1													1				
11	*C. v. xanthostigma*		4	2	1	3	1	4	1	2	3		1	2	1			2	1	
12	*Coniocybe furfuracea*																			
13	*Diploschistes scruposus*		1																	
14	*Graphis scripta*														1					
15	*Lecanora badia*		1																	
16	*Lecanora campestris*																			1
17	*Lecanora carpinea*			1		1	1							1			1			
18	*Lecanora dispersa*	1								1							1			
19	*Lecanora galactina*																			
20	*Lecanora Hagenii*																			
21	*Lecanora intumescens*					1					1		1					1	1	
22	*Lecanora pallida*																			
23	*Lecanora saxicola*		3							1				1						1
24	*Lecanora subfusca*					3	1								1		1			
25	*Lecanora symmictera*																			
26	*Lecanora varia*										1									
27	*Lecidea enteroleuca*																			
28	*Lecidea euphorea*		1			1				1								1	1	
29	*Lecidea goniophila*	1								1							1			
30	*Lecidea olivacea*				1	1					1							1		
31	*Lecidea ostreata*		1	2							1									
32	*Lepraria aeruginosa*		1				1				1			1						

of lichen stations

Tatry		Dolny Śląsk							Lubelszczyzna – Kieleckie – Podlasie								Region nadbałtycki						Number of stations		
Zakopane		Kluczbork		Wołczyn		Opole		Cieszyn	Puławy		Zamość	Busko		Siedlce	Białowieża		Międzyzdroje		Ustka		Łaba		in c	at p	Sum without Białowieża
c	p	c	p	c	p	c	p	c	c	p	c	c m	p z	c	c	p	c	p	c	p	c	p			p
																1								1	
	1									2													2	4	6
									1														1		1
		4	1						1	2													8	4	12
3		16	6			1		1	3	2	8			3						2			37	10	47
		5	6			2		2	3	6	7	1		3			1			1			26	16	42
1																		1					2	1	3
		6	5			1		1		2													9	7	16
1																							2		2
4		2	2						1	5	2			1	1	1		1					12	9	20
		2	9		2				2	1			8		5	4	5		2		3	2	36	37	69
									1	2						1							1	3	3
																								1	1
										1						1								3	2
																								1	1
4		3	6							2	3	1	1	2			1			1			15	10	25
10	1		2						4	3	2		3		3	20		4			1		23	35	38
4		16	11			3	2	4	4	3	7		1	2			1			1			43	19	62
		1	2							1	1			1									3	3	6
							1		1														1	1	2
5			1						1				3		1	13		1					11	19	17
3			1												1	7	1	1					5	9	7
1		6	8			2			1	3			1	2		2							15	17	30
			8					1	4	4			7		3	24	3	10		1	2	1	16	58	54
										3												1		4	4
																3								4	1
1																							1		1
2													2		1	3		2					8	8	13
		1	1																				3	2	5
6	1								2	1	2		3		2	23		6		1			14	37	28
			6						1	4						1							3	13	15
1		2	4		4			3		2			2			18	4		2	1			13	34	29

Contimation of

No	Lichen species	Kotlina Kłodzka											Beskidy Zachodnie							
		Kłodzko		Kudowa		Duszniki		Polanica		Lądek		Stronie Śląskie	Wisła	Ustroń		Muszyna		Iwonicz	Rymanów	Lesko
		c	p	c	p	c	p	c	p	c	p	c	c	c	p	c	p	c	c	c
33	*Opegrapha atra*																			
34	*Opegrapha herpetica*														1					
35	*Opegrapha varia*																			
36	*Pertusaria amara*										1							3		
37	*Pertusaria coccodes*												1							
38	*Pertusaria communis*																			
39	*Pertusaria discoidea*			1							2		1					1	1	
40	*Pertusaria globulifera*			1			1				6									
41	*Pertusaria maculata*																			
42	*Phlyctis argena*				1	1	1											3		4
	Number of species	4	8	6	3	8	6	1	1	6	10	2	4	4	4	1	5	8	5	4
	Number of stations	4	13	8	3	12	6	4	1	7	18	2	4	5	4	1	5	13	6	7
II	*Foliaceous species*																			
43	*Candelaria concolor*																			
44	*Cetraria chlorophylla*										1									
45	*Cetraria glauca*																			
46	*Cetraria pinastri*														1					
47	*Lobaria pulmonaria*																			
48	*Parmelia acetabulum*		1			1		2			2		1							
49	*Parmelia aspidota*																			
50	*Parmelia caperata*										6		1		1		1	3		
51	*Parmelia conspersa*		2								1				1					
52	*Parmelia dubia*		1	2	1	1		1			1							1	1	
53	*Parmelia exasperatula*			2	1	2	3	2			5		2	1		2		1	2	
54	*Parmelia fuliginosa*																2			
55	*Parmelia furfuracea*																			
56	*Parmelia glomellifera*			1																
57	*Parmelia physodes*		2	5		1	4	2	2		10				1		4			
58	*Parmelia quercina*																			
59	*Parmelia saxatilis*			1											1					
60	*Parmelia scortea*										3									
61	*Parmelia subaurifera*										1							2		

table 3

Tatry		Dolny Śląsk							Lubelszczyzna — Kielec-kie — Podlasie								Region nadbałtycki						Number of stations		
Zakopane		Kluczbork		Wołczyn		Opole		Cieszyn	Puławy		Zamość	Busko		Siedlce	Białowieża		Między-zdroje		Ustka		Łeba		in c	at p	Sum with-out Biało-wieża p
c	p	c	p	c	p	c	p	c	c	p	c	c m	p z	c	c	p	c	p	c	p	c	p			
																1								1	
																3								4	1
														1		3							1	3	1
									1	1			2		2	19		1					6	24	11
																12							1	12	1
																		2						2	2
1									1	2			2			10							6	16	11
															1	18	1	2					3	28	13
																2								2	
			3						1	4			1		3	21		1					12	32	23
15	3	12	18		2	5	2	6	18	22	8	2	13	8	11	24	8	11	2	7	3	3			
47	3	64	85		6	9	3	12	33	56	32	2	36	15	23	211	17	31	4	8	6	4			
																	1	1					1	1	2
																3								4	1
1	2															3		1					1	6	4
																1								2	1
																2								2	
										1						4	1	1			1	1	6	10	12
			1							1														2	2
			3							10			2			2						1	4	26	28
																2								6	4
1									1	2			2			1	1						9	8	16
10			4		3			3	1	5			3		1	16	1			2	4		34	42	60
2										2			3		3	38	2	2		4		1	7	52	21
5			6						1	5				1	2	21		4		3	2	6	11	45	35
					4											1							1	5	5
12	5	1.	19						2	9			5	1	1	46	2	6	1	6	2	6	30	125	109
	1																							1	1
																1							1	2	2
			1										1			1		1						7	6
2													1			10							4	12	6

Continnation of

No	Lichen species	Kotlina Kłodzka												Beskidy Zachodnie					
		Kłodzko		Kudowa		Duszniki		Polanica		Lądek		Stronie Śląskie	Wisła	Ustroń		Muszyna		Iwonicz	Rymanów	Lesko
		c	p	c	p	c	p	c	p	c	p	c	c	c	p	c	p	c	c	c
62	*Parmelia sulcata*		2	1	1	2	3	4		1	12						1	2	2	1
63	*Parmelia tubulosa*																			
64	*Parmeliopsis ambigua*																			
65	*Parmeliopsis pallescens*																			
66	*Physcia aipolia*					1					1	1				1		1	2	
67	*Physcia ascendens*		1	1	1	5	2	1	1		3	1	1	4		2		2	1	
68	*Physcia caesia*		3									1		1						
69	*Physcia caesiella*																			
70	*Physcia dubia*																			
71	*Physcia farrea*		1																	
72	*Physcia grisea*	1	4	6	1	7	5	3	2	1	5	3		8		3		2		1
73	*Physcia intermedia*																			
74	*Physcia lithotea*																			
75	*Physcia nigricans*																			
76	*Physcia orbicularis*				1	1					2			3						
77	*Physcia pulverulenta*			1	1						4	1	1	1					2	
78	*Physcia sciastra*																			
79	*Physcia sciastrella*																			
80	*Physcia stellaris*			2		1			1		1			1		1		2	1	
81	*Physcia tenella*				1		2												1	
82	*Physcia virella*		1	6				1				1		1				3		
83	*Xanthoria candelaria*																			
84	*Xanthoria parietina*			3	1	4	5	1	1		5	3	1	2	1	1		4	2	4
85	*Xanthoria polycarpa*			3														1		
86	*Xanthoria lobulata*										1									
87	*Xanthoria substellaris*			4			1				2		1	3				2	2	4
	Number of species	1	10	14	9	12	8	9	5	2	19	7	7	10	6	6	4	13	10	4
	Number of stations	1	18	38	9	27	25	17	7	2	66	11	8	25	6	10	8	26	16	10
III	*Fruticose species*																			
88	*Alectoria jubata*																			
89	*Anaptychia ciliaris*																			
90	*Cladonia fimbriata*		1															1		

table 3

Tatry		Dolny Śląsk							Lubelszczyzna — Kieleckie — Podlasie								Region nadbałtycki						Number of stations		
Zakopane		Kluczbork		Wołczyn		Opole		Cieszyn	Puławy		Zamość	Busko		Siedlce	Białowieża		Międzyzdroje		Ustka		Łeba		in c	at p	Sum without Białowieża
c	p	c	p	c	p	c	p	c	c	p	c	c m	p z	c	c	p	c	p	c	p	c	p			p
15	4	1	12		3			1	2	10			7	3	8	67	3	9	1	7	4	5	51	143	127
																1								1	
	3																	2				2		7	7
	1									4						2		1				1		9	7
6													2		1	12		1		1			13	17	18
4		1	3		4	1	2		3	6			5		8	21		2	1	1	1		37	52	68
1			6						1	7						2							4	18	20
										2														2	2
1			1																				1	1	2
							3		3					1		2		1		1			4	8	10
28			11	4	7	2	4	3	21	10	11	5	15	15	9	16	3	1		4	6		142	85	211
1																							1		1
						2			1	3	1												4	3	7
										4						1		1	1	1			2	6	7
6		1	2						2		2		4	1	4	6	1	1			1		22	16	32
4							3		4	5′			8	1	7	21	1	4		1	1		25	47	51
1																							1		1
						2																	2		2
9									4	3			8	3	3	7							27	20	40
4			2							4			1		3	14	1	5		3			9	32	27
		3	9	3	7				3	5			1		1	4	1	1	1		1		25	29	50
									1	2			1			1							1	4	4
20	1		11		3	2	4	4	20	13	9	3	16	7	16	31	5	10		5	10		121	107	197
2			2	2	7	1	4		3	2				1	2								15	15	30
																								1	1
3									6	4		2	6	4			1	1			1		33	14	47
22	7	5	16	3	8	6	6	4	18	24	4	3	19	11	15	32	15	20	5	13	12	8			
138	17	7	93	9	38	10	20	11	79	118	23	10	91	38	69	360	25	55	5	39	34	23			
										2														2	2
										1			3		2	35							2	39	6
1													1			2							2	4	4

Continnation of

No	Lichen species	Kotlina Kłodzka											Beskidy Zachodnie							
		Kłodzko		Kudowa		Duszniki		Polanica		Lądek		Stronie Śląskie	Wisła	Ustroń		Muszyna		Iwonicz	Rymanów	Lesko
		c	p	c	p	c	p	c	p	c	p	c	c	c	p	c	p	c	c	c
91	*Cladonia rangiformis*		1																	
92	*Evernia prunastri*		1													1	1			
93	*Ramalina farinacea*																			
94	*Ramalina fastigiata*																		1	
95	*Ramalina fraxinea*																			
96	*Ramalina obtusata*																			
97	*Ramalina pollinaria*			1																
98	*Ramalina populina*					1														
99	*Usnea comosa*																			
100	*Usnea dasypoga*																			
101	*Usnea compacta*																			
102	*Usnea hirta*																			
	Number of species		3	1		1										1	1	1	1	
	Number of stations		3	1		1										1	1	1	1	
	Sum of species	5	21	21	12	21	14	10	6	8	29	9	11	14	10	8	10	22	16	8
	Sum of stations	5	34	47	12	40	32	21	8	9	84	13	12	30	10	12	14	40	23	17

saxicola is very common, and *Xantheria parietina* rare. The reverse can be said about Busko Zdrój.

The fruticose species are comparatively common at Puławy, Białowieża, Busko Zdrój, Łeba, and Międzyzdroje.

Much more pronounced are differences in the frequency of occurrence, degree of cover, and vitality of the species. In this respect the richest are Białowieża, Zakopane, Puławy and Międzyzdroje. The following localities deserve special attention: 1. Białowieża, a village, where in the palace park the lichen vegetation is the richest of all the studied localities, but at the distance of a dozen steps from the park, on the roadside trees, it is strikingly poor. At Białowieża houses are heated with wood, and coal is used exceptionally. 2. At Busko, a small town situated on an elevation, lichen flora is poor, but in the spa itself, which has a less elevated situation and is connected with the town by a street 1 km. long, some species grow in masses. In the street the

table 3

Tatry		Dolny Śląsk							Lubelszczyzna — Kielec-kie — Podlasie								Region nadbałtycki						Number of stations		
Zakopane		Kluczbork		Wołczyn		Opole		Cieszyn	Puławy		Zamość	Busko		Siedlce	Białowieża		Między-zdroje		Ustka		Łaba		in	at	Sum without Białowieża p
c	p	c	p	c	p	c	p	c	c	p	c	c m	p z	c	c	p	c	p	c	p	c	p	c	p	
																								1	1
			5				2		2	8			7	1	3	83		4		4		8	7	123	47
										1						39								40	1
																							1		1
													1		3	22		3				2	3	28	9
																1								1	
										5					1	7		2	1			2	3	16	12
																6		2				3	1	11	6
																7								7	
	1																							1	1
																2						1		3	1
										3					1	28						5	1	36	9
1	1		1				1		1	6			4	1	5	11		4	1	1		6			
1	1		5				2		2	19			12	1	10	232		11	1	4		21			
38	11	17	35	3	10	11	9	10	37	52		5	36	20	31	67	23	35	8	21	15	17			
186	21	71	183	9	44	19	25	23	114	195		12	139	54	102	803	42	97	10	51	40	48			

In the centres of the towns — 73 species. At the outskirts of the towns — 95 species

flora of epidendric lichens becomes richer in proportion as the spa is approached. 3. At Zakopane, at the feet of the Tatra mountains, an abundant lichen vegetation begins less than a hundred metres from the town. Inside the town foliaceous lichens occur quite often, but not a species of the *Usnea* or *Alectoria* genus can be found. This sudden impoverishment is striking when compared with the overwhelming abundance of the lichen vegetation in the near mountains. This is a very convincing proof that in the pure highland air of Zakopane the growth of lichens is restrained by microclimatic factors, and not by toxic gases. The state of the lichen flora shows clearly that microclimatic factors in the centre of Zakopane predominate over the mountain macroclimate of the surroundings. Nevertheless, the influence of the macroclimate can still be felt in the town since the lichen vegetation

Table 4. The state of lichen vegetation in small towns

No	Number of species	I	II
1.	38	Zakopane Uzdrowisko	Białowieża
2.	37	Puławy	Zakopane Uzdrowisko
3.	31	Biłowieża	Puławy
4.	23	Międzyzdroje	Międzyzdroje
5.	22	Iwonicz Zdrój	Iwonicz Zdrój
6.	21	Kudowa Zdrój	Rymanów Zdrój
7.	21	Duszniki Zdrój	Łeba
8.	20	Siedlce	Ustka
9.	17	Kluczbork	Busko Zdrój
10.	16	Rymanów Zdrój	Polanica Zdrój
11.	15	Łeba	Wisła Uzdrowisko
12.	14	Ustroń Zdrój	Kudowa Zdrój
13.	12	Zamość	Duszniki Zdrój
14.	11	Wisła Uzdrowisko	Ustroń Zdrój
15.	11	Opole	Muszyna Zdrój
16.	10	Polanica Zdrój	Lądek Zdrój
17.	10	Lesko	Stronie Śląskie
18.	10	Cieczyn	Lesko
19.	9	Stronie Śląskie	Siedlce
20.	8	Ustka	Wołczyn
21.	8	Muszyna Zdrój	Zamość
22.	8	Lądek Zdrój	Kluczbork
23.	5	Kłodzko	Opole
24.	5	Busko miasto	Kłodzko
25.	3	Wołczyn	Cieszyn

In column I small towns are put according to the number of species found in the centre of the town.

In column II small towns are put according to the degree of cover and vitality of the species.

at Zakopane is comparatively richer than in other health resorts, such as Duszniki, Kudowa, Ustroń, Muszyna, or Lądek, although Zakopane is a larger and more closely built-over town.

The investigations carried out by Beschel in Austria also show that in small towns (Bregenz, Dornbirn, Landeck) lichen vegetation does not disappear completely (there are no lichen-free areas), but is only impoverished. Even in Innsbruck and Salzburg, towns with about

100,000 inhabitants each, foliaceous species grow near small areas in densely built-over centres, where only plaster species are common (Beschel 1958).

The results of the present writer's investigations on the lichen flora of Lublin and 25 small Polish towns, supplemented by the data obtained by other authors, and critically discussed in the previous part of this paper suggest the following conclusions.

CONCLUSIONS

1. In all the small towns which have been studied by the author, situated in different climatic regions of Poland, there are no lichen-free areas. Not only crustaceous epilithic species („plaster lichens") grow there on man-built stony surfaces, but also foliaceous species can be found on trees. Species with fruticose thalli, on the other hand, occur very rarely.

2. In all the studied small towns lichen vegetation is very distinctly poorer than that of the surrounding countryside, both with regard to the number of species and to the frequency of occurrence, vitality, and degree of surface cover to the habitats.

3. Lichen vegetation in small towns is not only quantitatively poorer in comparison with the neighbouring woods, but is also altered as far as the species composition is concerned. Some species (see Table 3) do not penetrate from the wood into the town; there appear species characteristic for wayside trees, which do not grow in the wood. Some authors regard these species as nitrophilous or ammonophilous others as coprophilous or coniophilous. However, observations made in mountain health resorts and in seaside towns do not support these views, and further exact studies seem to be necessary. Most data point to the photophilous character of these species.

4. Impoverishment of lichen vegetation in small towns, and especially in health resorts, fully confirms the conclusions reached on the strength of the investigations carried out in Lublin, viz. that climatic factors are responsible for this impoverishment (Rydzak 1955, 1956/58).

5. Concentration of SO_2 and other impurities in the air of small towns, and especially in mountain and seaside health resorts, is so low, and consequently so insignificant in its toxic influence upon lichens in comparison with the studied large or industrial towns, that it cannot control the occurrence and distribution of lichen species, or produce the impoverishment of lichen vegetation in these towns. At Białowieża, which is a village situated on a clearing amidst the largest lowland forest in Europe, or in mountain and seaside health resorts, air pollu-

tion cannot be taken seriously or regarded as decisive with regard to the impoverishment of lichen flora.

6. Climatic differences have some influence on the composition of species, and especially on the frequency of their occurrence in towns situated in various parts of the country, but this influence does not modify very clearly the character of lichen vegetation of the studied towns. Generally speaking, it is similar in all these localities because the individual lichen species growing within the boundaries of a certain climate choose for themselves the optimum microclimatic conditions in their habitats. The results of measurements concerning the macroclimate or even the local climate of a certain place sometimes fail to explain the distribution or the lack of certain species in some habitats. The scanty investigations carried out so far show that the microclimatic conditions of a given habitat can differ considerably from the mean 24-hours readings, and the more so from the mean monthly or yearly values recorded by meteorological stations. In similar habitats and in apparently similar microclimatic conditions, similar types of lichen vegetation are found. When lichen species form similar floral communities in different towns, they probably find there similar habitats with the same microclimatic characteristics.

7. If it were possible, after extensive studies on microclimatic factors operating in lichen habitats, to work out a key for comparing the habitats, the individual lichen species could be excellent indices of the microclimate of the habitats, and collections of species could characterize the local climate better than the most sensitive meteorological instruments.

8. Both in nature and in towns, the individual lichen species grow where, besides suitable light conditions and substratum, they find at least the minimum necessary amount of water. Lichen species grow where during the long period of their life they are able to keep up a positive balance of metabolism.

9. Impoverishment of lichen vegetation in small towns is an unquestionable proof that the analogical poverty of lichen flora in the studied large towns is not produced by toxic components of the air. Apparently the same factors operate both in small and large cities, only their intensity is different.

10. The specific conditions in large towns, and to a smaller extent in small towns, mainly heating, excessive insolation of the stony substratum, and directing of the rainfall into the sewerage, produce an increase of temperature, formation of convective air currents and a decrease of air humidity. Insolation and convective currents must exercise a strong modifying influence on the microclimate of numerous stations in the towns by raising the temperature of air and by their

desiccating action. This leads to a prolonged negative metabolic balance in the growing species, or to a complete inhibition of the growth of young lichen thalli.

The more humid air, which slowly penetrates into the town from its surroundings, thanks to the action of convective currents and wind, mitigates to a certain extent these desert conditions and allows some species to vegetate at the outskirts of the town and in the „struggle zone".

11. The greatest impoverishment of lichen vegetation in the centre of the town is observed in Cieszyn, Kłodzko, Opole and Kluczbork. These towns are more closely built-over. Smaller towns, such as Wołczyn, Zamość and Siedlce, show an impoverishment of lichen vegetation, chiefly because of the scarceness of trees in their centres. All health resorts and small places, on the other hand, have an epidendric lichen flora which is much richer, especially with regard to the cover degree, than that of all larger European towns which have been studied so far. The lichen-free zone is absent, and only some fruticose species are missing. As it could be expected, the problem of drought is not so serious as in large towns, and the struggle for water is not too hard in most habitats; this is evidenced by a more abundant growth of foliaceous species in these small localities. Nevertheless, there can be still found numerous stations where the configuration of microclimatic factors resembles that of large towns. The same causes and the laws of nature operate in both cases, only their intensity differs.

12. If there existed an industrial centre emitting high concentrations of SO_2 and other toxic products into the air (no such centre has been studied so far) then, of course, the toxic and drought factors would co-operate in eliminating lichens from this place.

13. In large and small towns studied so far, the condition of lichen flora depends not on toxic gases, but on climatic factors. The occurrence and distribution of some lichen species in towns, the impoverishment of lichen vegetation, and even the existence of areas and stations devoid of lichens are the result not of their struggle against toxic gases or of their tolerance to poison, but of their struggle against air drought in towns, of their struggle for water.

In towns lichens grow where, on a certain substratum, they find sufficient humidity in the air and in the substratum, where dew is formed, and where is enough light.

The same factors decide on the occurrence of lichens in natural conditions.

The present state of investigations and the discussion presented above give the assurance that the future town, which will derive energy from nuclear reactions and whose atmospere will be free from SO_2 and other poisons, will not be able to attract numerous lichen species from their woody recesses; neither will *Usnea longissima*, just as it happens now, display the beautiful garlands of its thallus on the trees of this non-toxic city.

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STRESZCZENIE

Autor zestawia wyniki swych badań przeprowadzonych w 25 małych miastach i osiedlach położonych w różnych regionach klimatycznych Polski (mapa i tabela 3). Wyniki szczegółowe były opublikowane w sześciu częściach według regionów klimatycznych (R y d z a k 1956—1958). Wśród zbadanych miast jest 11 małych, klimatycznych uzdrowisk górskich i podgórskich oraz 3 kąpieliska nad Bałtykiem. W badanych osiedlach nie może być mowy o trującym działaniu SO_2 i innych substancji, wydzielanych podczas spalania węgla kamiennego, na porosty. A jednak flora porostów wykazuje analogiczne zubożenie jak w miastach dużych — tylko w mniejszym stopniu. Wyniki tych badań potwierdzają w zupełności hipotezę autora o decydującym wpływie czynników klimatycznych na występowanie i rozmieszczenie porostów w miastach, opublikowaną w r. 1953. Wobec żywego zainteresowania tymi badaniami różnych autorów w literaturze zachodnio-europejskiej i ich nowych badań, podkreślających rolę czynników klimatycznych, autor w dyskusji przytacza szereg argumentów przemawiających za słusznością swej hipotezy a przeciw hipotezie trującego wpływu gazów na porosty.

Na podstawie swych badań oraz danych z literatury autor przedstawia następujące wnioski:

1. We wszystkich zbadanych miastach, małych, położonych w różnych regionach klimatycznych w Polsce, nie ma obszarów bezporostowych. Rosną w nich nie tylko gatunki skorupiaste naskalne — „natynkowe" — na sztucznych budowlach, ale też gatunki listkowate na drzewach. Natomiast bardzo rzadko można znaleźć gatunki o plechach krzaczastych.

2. We wszystkich zbadanych małych miastach flora porostów jest bardzo wyraźnie uboższa w porównaniu do flory okolic tak pod względem ilości gatunków, jak zwłaszcza pod względem częstości występowania, żywotności i stopnia pokrycia powierzchni stanowisk.

3. Flora porostów w małych miastach jest nie tylko uboższa pod względem ilościowym w porównaniu z sąsiednim lasem, ale też jest zmieniona pod względem składu gatunkowego. Pewne gatunki (co wykazuje tabela 3) z lasu do osiedla nie wnikają, a pojawiają się gatunki charakterystyczne dla drzew przydrożnych, które znów w lesie nie rosną. Niektórzy autorzy uważają te gatunki za nitrofilne, amonofilne, inni za koprofilne lub koniofilne. Na podstawie obserwacji w górskich miejscowościach klimatycznych jak również w miastach nadmorskich nasuwają się w tej sprawie wątpliwości. Zagadnienia te wymagają jeszcze dalszych dokładnych badań. Najwięcej danych wskazuje na to, że są to gatunki światłolubne.

4. Stwierdzenie zubożenia flory porostów w małych miastach — a zwłaszcza w uzdrowiskach klimatycznych — w zupełności potwierdza wnioski wyprowadzone na podstawie badań w Lublinie, że przyczyną tego zubożenia są tylko czynniki klimatyczne (Rydzak 1953, 1956/58).

5. Stężenie SO_2 i innych zanieczyszczeń powietrza w tych miastach, a zwłaszcza w uzdrowiskach górskich i nadmorskich, w porównaniu do zbadanych dotychczas miast dużych i uprzemysłowionych, jest bez wątpienia tak małe i wpływ ich trujących własności na porosty jest oczywiście tak nieznaczny, że nie może być czynnikiem decydującym o występowaniu i rozmieszczeniu gatunków porostów i nie może być przyczyną zubożenia flory porostów w tych miastach, A w Białowieży, — wsi położonej na polanie wśród największej na niżu puszczy leśnej w Europie — gdzie w domach zasadniczo nie pali się węglem, jak również w kąpieliskach nadmorskich i w podgórskich uzdrowiskach nie można zupełnie brać poważnie pod uwagę zanieczyszczeń powietrza i przypisywać im wpływ decydujący na zubożenie flory porostów.

6. Różnice klimatyczne w różnych okolicach kraju wprawdzie odbijają się na składzie gatunków, a zwłaszcza na obfitości ich występowania w różnych miastach, ale wpływ ten nie zmienia zbyt wyraźnie charakteru flory porostów badanych miast. Na ogół flory te są podobne. Poszczególne gatunki porostów bowiem, żyjące w granicach danego klimatu, wyszukują dla siebie optymalnych warunków mikroklimatycznych na danych stanowiskach. Wyniki pomiarów w zakresie makroklimatu a nawet klimatu lokalnego pewnej okolicy nie zawsze pozwalają zrozumieć rozmieszczenie, a zwłaszcza brak pewnych gatunków na niektórych stanowiskach. Albowiem, jak wykazują nieliczne dotychczas badania, warunki mikroklimatyczne na danym stanowisku mogą się różnić bardzo znacznie od średnich wartości dobowych, miesięcznych, a tym bardziej rocznych, podawanych przez stacje meteorologiczne. Na podobnych stanowiskach i widocznie w podobnych warunkach mikroklimatycznych rośnie podobna flora porostów. Prawdopodobnie w różnych miastach gatunki porostów znajdują często podobne stanowiska o jednakowych warunkach mikroklimatycznych, jeżeli tworzą tam podobne zespoły florystyczne.

7. Gdyby po wielu badaniach mikroklimatycznych warunków działających na tych stanowiskach, gdzie rosną porosty, udało się stworzyć klucz porównawczy, to poszczególne gatunki porostów mogłyby być doskonałymi wskaźnikami mikroklimatu stanowisk a zespoły gatunków wskaźnikami klimatu lokalnego, zastępującymi najczulsze aparaty meteorologiczne.

8. Poszczególne gatunki porostów tak w warunkach naturalnych, jak i w miastach rosną tam, gdzie w odpowiednim oświetleniu i na

odpowiednim podłożu znajdują przynajmniej minimalnie odpowiednią ilość wody. Gatunki porostów rosną tam, gdzie w ciągu długiego okresu swego życia mogą utrzymać dodatni bilans przemiany materii.

9. Zubożenie flory porostów w małych miastach dowodzi niezbicie, że analogiczne ubóstwo tej flory w zbadanych miastach dużych nie jest spowodowane trującymi składnikami powietrza w tych miastach. Działają widocznie jednakowe przyczyny w miastach małych i dużych a tylko stopień działania jest różny.

10. Specyficzne warunki w miastach dużych i na mniejszą skalę w małych osiedlach — głównie ogrzewanie miast, nadmierna insolacja słoneczna kamiennego podłoża, odprowadzanie wód opadowych do ścieków i kanałów — powodują podwyższenie temperatury w miastach, powstawanie prądów konwekcyjnych i zmniejszenie wilgotności powietrza. Insolacja i prądy konwekcyjne muszą bardzo silnie modyfikować mikroklimat wielu stanowisk w mieście, podnosząc znacznie temperaturę i działając głównie osuszająco. Musi to prowadzić do ujemnego bilansu przemiany materii przez długi okres czasu u rosnących gatunków lub w ogóle uniemożliwi rozwój młodych plech porostów.

Na skutek prądów konwekcyjnych i wiatrów napływające powoli bardziej wilgotne powietrze z okolic miasta w pewnym stopniu łagodzi te pustynne warunki i umożliwia niektórym gatunkom egzystencję na skraju miasta i w „strefie walki".

11. Największe zubożenie flory porostów w centrum wykazują miasta: Cieszyn, Kłodzko, Opole, Kluczbork. Są to miasta bardziej zwarcie zabudowane. Miasta mniejsze, jak Wołczyn, Zamość, Siedlce, wykazują uboższą florę porostów głównie ze względu na stan zadrzewienia w centrum. Natomiast wszystkie uzdrowiska i małe osiedla mają florę porostów nadrzewnych znacznie bogatszą, zwłaszcza pod względem stopnia pokrycia niż wszystkie zbadane dotąd większe miasta w Europie. Strefa bezporostowa nie występuje — brak tylko gatunków krzaczastych. Jak można było przypuszczać, zagadnienie suszy nie występuje tu tak ostro jak w miastach dużych, walka o wodę nie jest zbyt trudna na większej ilości stanowisk. Świadczy o tym bardziej bujny rozwój flory porostów listkowatych. Pozostaje jednak jeszcze wiele stanowisk, na których działanie czynników mikroklimatycznych jest podobne jak w miastach dużych. Wywołują je te same przyczyny, te same prawa przyrody — tylko natężenie ich jest mniejsze.

12. Gdyby istniał gdzieś jakiś ośrodek przemysłowy, wydzielający SO_2 i inne trujące produkty do powietrza w znacznym stężeniu (takiego ośrodka dotąd nie zbadano), wówczas naturalnie czynniki trucizny i suszy współdziałałyby z sobą w eliminowaniu porostów z tej okolicy.

13. W dotychczas zbadanych miastach dużych i małych stan flory porostów zależy nie od trujących gazów, lecz od czynników klimatycz-

nych. Występowanie i rozmieszczenie niektórych gatunków porostów w miastach, zubożenie flory porostów, nawet istnienie obszarów i stanowisk bezporostowych, jest wynikiem nie walki porostów ze szkodliwymi gazami, ani tolerancji na truciznę — lecz skutkiem ich walki z suszą powietrza w mieście — walki o wodę.

W miastach porosty rosną wszędzie tam, gdzie na danym podłożu jest dla gatunku dostateczna wilgotność powietrza i podłoża, gdzie tworzy się rosa i gdzie jest odpowiednie oświetlenie.

Te same też czynniki decydują o występowaniu porostów w warunkach naturalnych.

Na podstawie dotychczasowych badań i powyższej dyskusji można być pewnym, że do miasta przyszłości, które energię czerpać będzie tylko z reakcji jądrowych, w którego powietrzu nie będzie SO_2, ani innych trucizn, wiele gatunków porostów nie przeprowadzi się ze swych ostoi leśnych, a *Usnea longissima* — tak jak i dziś — nie rozwiesi pięknych festonów swej plechy na drzewach tego nie trującego gazami miasta.

РЕЗЮМЕ

Автор сопоставляет результаты своих исследований, произведенных в 25 малых городах и населённых пунктах, расположенных в различных климатических областях Польши. (Карта и таблица III). Подробные результаты были опубликованы в шести частях в соответствии с климатическими областями (Рыдзак 1956 — 1958.) Среди исследованных городов имеется 11 малых климатических горских и подгорных курортов, а также 3 купальных курорта у берегов Балтийского моря. По отношению к исследованным населённым пунктам не может быть и речи об отравляющем действии SO_2 и других веществ, выделяемых во время сгорания каменного угля, на лишайники. Однако флора лишайников проявляет обнищание, аналогичное по отношению к большим городам, — но только в меньшей степени. Итоги этих исследований подтверждают полностью гипотезу автора о решающем влиянии климатических факторов на появление и размножение лишайников в городах, опубликованную в 1953 г. В виду проявления большого интереса к этим исследованиям со стороны различных авторов в западноевропейской литературе и ввиду их новых иследований, подчеркивающих роль климатических факторов, автор в дискуссии перечисляет ряд аргументов говорящих в пользу его гипотезы об отравляющем влиянии газов на лишайники.

На основании своих исследований, а также данных, зачерпнутых из соответствующей литературы, автор приводит следующие выводы:

Выводы

1. Во всех исследованных малых городах, расположенных в различных климатических областях Польши, нет безлишайниковых пространств. Растут на них не только лишайники скорлуповидные, наскальные, „штукатурные" на искусственных строениях, но также лиственные на деревьях, между тем как очень редко можно найти виды с кустистыми слоевищами.

2. Во всех исследованных малых городах лишайниковая флора выразительно более скудна в сравнении с флорой окрестностей в отношении качества видов, особенно же в отношении частоты появления, живучести и степени покрова поверхности местообитаний.

3. Лишайниковая флора в малых городах не только более скудна в количественном отношении в сравнении с соседним лесом, но также разнится в отношении видового состава. Некоторые виды (что показывает таблица III) из лесу в населённые пункты не проникают, но появляются виды, характерные для придорожных деревьев, которые в лесу не растут. Некоторые авторы считали эти виды нитрофильными, аммонофильными, другие же копрофильными и кониофильными. На основании наблюдений в горных климатических местностях, равно как в приморских городах возникают по этому вопросу сомнения. Эти проблемы требуют еще дальнейших подробных исследований. Наиболее данных указывает на то, что эти виды светолюбивы.

4. Констатирование обнищания лишайниковой флоры в малых городах — особенно же в климатических курортах — полностью подтверждает выводы, сделанные на основании исследований в Люблине, что причиной этого обнищания являются только климатические факторы (Рыдзак 1953, 1056/58).

5. Концентрация SO_2 и других загрязнений воздуха в этих городах, особенно же в горских и приморских курортах, в сравнении с исследованными доныне большими и промышленными городами, несомненно столь невелика, влияние же их отравляющих свойств на лишайники столь незначительно, что оно не может быть фактором, решающим о появлении и размещении видов лишайников и не может быть причиной обнищания флоры лишайников в этих городах. А в Беловеже — деревне, расположенной на поляне среди наибольшей лесной пущи на низменной равнине в Европе, — где вообще в жилых помещениях не топят углем, равно как в приморских и подгорных курортах нельзя серьезно относиться к загрязнениям воз-

духа и приписывать им решающее влияние на обнищание лишайниковой флоры.

6. Хотя климатическая разница в различных местностях страны отражается на составе видов, особенно же на обилии их появления в разных городах, однако это влияние не вызывает слишком выразительного изменения характера лишайниковой флоры исследуемых городов. В общем эти флоры очень сходны, ибо отдельные виды лишайников, живущие в границах данного климата, ищут для себя оптимальных микроклиматических условий на данных местообитаниях. Результаты измерений в пределах макроклимата и даже локального климата известной местности не всегда позволяют понять размещение, особенно же отсутствие известных видов в некоторых местообитаниях, потому что, как показывают немногочисленные доныне исследования, микроклиматические условия в данном местообитании, могут довольно значительно отличаться от средних показаний суточных, месячных, а тем более годовых бюллетеной передаваемых метеорологическими станциями. В подобных местообитаниях и повидимому в подобных микроклиматических условиях растёт подобная флора лишайников. Вероятно в различных городах виды лишайников находят часто подобные местообитания с одинаковыми микроклиматическими условиями, коль скоро образуют там подобные флористические ассоциации.

7. Если бы после многих исследований микроклиматических условий, действующих в тех местообитаниях, где растут лишайники, удалось создать сравнительный ключ, то отдельные виды лишайников могли бы быть превосходными показателями микроклимата местообитаний, а ассоциации видов показателями местного климата, заменяющими самые чувствительные метеорологические аппараты.

8. Отдельные виды лишайников как в естественных условиях, так и городах растут там, где при соответствующем освещении и на соответствующем субстрате находят по крайней мере минимально соответствующее количество воды. Виды лишайников растут там, где в течение продолжительного периода своей жизни могут сохранить положительный баланс обмена веществ.

9. Обнищание флоры лишайников в малых городах неопровержимо доказывает, что аналогичное убожество этой флоры в исследованных больших городах не было вызвано отравляющими составными частями воздуха в этих городах. Повидимому действуют одинаковые причины в больших и малых городах, но только степень действия различна.

10. Специфические условия в больших городах и в меньшем масштабе в малых—главным образом отопление городов, чрезмерная

инсоляция каменного субстрата, отвод атмосферных осадков в сточные канавы и каналы — вызывают повышение температуры в городах, возникновение конвекционных течений и уменьшение влажности воздуха. Инсоляция и конвекционные течения очень сильно модифицируют микроклимат многих местообитаний в городе, значительно повышая температуру и действуя главным образом осушительно. Это неуклонно ведет к отрицательному балансу обмена веществ в течение продолжительного периода времени у растущих видов или же вообще делает невозможным развитие молодых слоевищ лишайников.

Вследствие конвекциональных течений и ветров вторгающийся медленно более сырой воздух из окрестностей города до некоторой степени смягчает эти пустынные условия и делает возможным для некоторых видов существование на окраине города и в полосе борьбы".

11. Наибольшее обнищание лишайников флоры в центре обнаруживают города: Цешин, Клодзко, Ополе, Ключборк. Эти города более плотно застроены. Меньшие города, как Волчин, Замостье, Седлец выказывают более убогую флору лишайников главным образом вследствие озеленения в центре, между тем как все курорты и малые поселки обладают значительно более богатой флорой древесных лишайников—особенно в отношении степени покрова, чем все исследованные доныне большие города Европы. Безлишайниковая зона отсутствует—нецостает только кустистых видов Как можно было полагать, проблема засушливости не проявляется здесь так резко, как в больших городах, борьба за воду не чересчур трудна в большей части местообитаний. Об этом свидетельствует более буйное развитие флоры лиственных лишайников. Однако существуют еще многочисленные местообитания, в которых действие микроклиматических факторов приблизительно такое же, как и в больших городах. Вызваны они теми же причинами, теми же законами природы—только их напряжение менее велико.

12. Если бы где — нибудь существовал какой — нибудь промышленный центр, выделяющий SO_2 и другие отравляющие продукты в воздух в значительной концентрации (такого центра доныне не исследовано), тогда очевидно факторы яда и засухи действовали бы совместно в устранении лишайников из этой местности.

13. В исследованных доныне больших и малых городах ситуация флоры лишайников зависит не от отравляющих газов, но от климатических факторов. Появление и размещение некоторых видов лишайников в городах, обнищание флоры лишайников, существование даже свободных от лишайников пространств и местообитаний—не являются последствием борьбы лишайников с вредоносными га-

зами или же терпимости по отношению к отраве, — но результатом их борьбы с сухостью воздуха в городе—борьбы за воду.

В городах лишайники растут везде там, где на данном субстрате имеется для вида достаточная влажность воздуха и субстрата, где появляется роса и где имеется соответствующее освещение.

Те же факторы также решают о появлении лишайников в естественных условиях.

На основании проведенных до сих пор исследований и вышеизложенной дискуссии можно быть уверенным, что в город будущего, который будет черпать энергию только из ядерных реакций, в воздухе которого не будет ни SO_2 ни других ядов, многие виды лишайников не перекочуют из своих лесных пристанищ, а *Usnea longissima* — также как и сегодня — не развесит прелестных фестонов своего слоевища по деревьям этого свободного от газов города.

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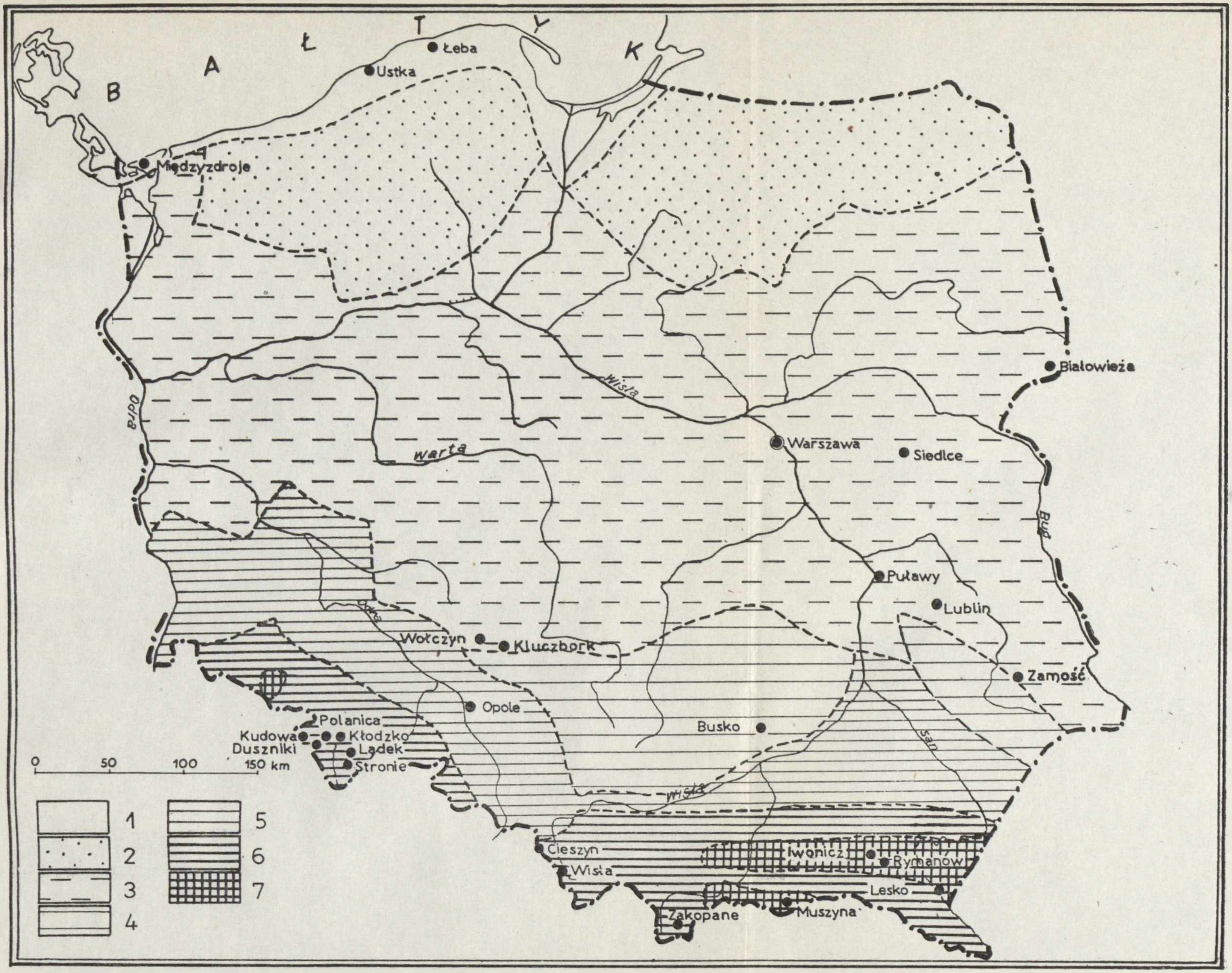

E. Romer's map of climatic regions in Poland (simplified by the present writer). The regions are: 1. Baltic region, 2. lake region, 3. region of great lowlands, 4. region of central elevations, 5. region of pre-mountainous lowlands and basins, 6. mountainous region, 7. region of intermountainous retreats.

The map is based on he map of climatic isogradients published in E. Romer's paper entitled „Regiony klimatyczne Polski" („Poland's Climatic Regions") (Prace Wrocławskiego Towarzystwa Naukowego, Wrocław 1949, seria B). According to E. Romer, the term „climatic gradient" denotes the sum of variations of climatic elements in the given area.

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2. J. Łobarzewski: Rozdział chromatograficzny frakcji humusu nie strącalnych w obecności Ca.
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6. Cz. Kowalczyk: Widłonogi (*Copepoda*) jezior Libiszowskich.
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7. K. Strawiński: *Hempitera-Heteroptera* runa leśnego z okolic Wandzina.
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