MONOGRAPHIAE BOTANICAE

Vol. 73, 1991

WIESŁAW FAŁTYNOWICZ, IRENEUSZ IZYDOREK,
ELŻBIETA BUDZBON

THE LICHEN FLORA AS BIOINDICATOR OF AIR POLLUTION OF GDAŃSK, SOPOT AND GDYNIA

Porosty Gdańska, Sopotu i Gdyni jako wskaźniki
zanieczyszczenia powietrza atmosferycznego

Redaktor: R. Olaczek

Warszawa

Wydano z pomocą finansową
Polskiej Akademii Nauk

KOMITET REDAKCYJNY

R. Olaczek (Łódź), E. Sidorkiewicz (Warszawa)

RADA REDAKCYJNA

W. Matuszkiewicz (Warszawa), Z. Podbielkowski (Warszawa), E. Sidorkiewicz (Warszawa), R. Olaczek (Łódź), H. Piotrowska (Gdańsk), K. Rostański (Katowice), W. Żukowski (Poznań)

Adres redakcji: A. Ujazdowskie 4, 00-478 Warszawa

© Copyright by Państwowe Wydawnictwo Naukowe, Warszawa 1991

ISBN 83-01-09547-4
ISSN 0077-0655

PAŃSTWOWE WYDAWNICTWO NAUKOWE — WARSZAWA 1991

Wydanie I. Ark. wyd. 4,5. Ark. druk. 3,25. Papier offsetowy kl. III. 80g 70×100 cm. Oddano do składania w czerwcu 1990 r. Do druku podpisano w marcu 1991 r. Druk ukończono w kwietniu 1991 r.
Zam. 253/90.

WROCŁAWSKA Drukarnia Naukowa

CONTENTS

Introduction	5
1. Geographical and ecological characteristics of the study area	6
2. Lichens and air pollution	9
3. Comments on methodology	10
4. The occurrence of lichens as affected by air pollution	11
4.1. Introductory comments	11
4.2. The distribution of indicator species and other lichens	12
4.3. Lichen zones in the Gdańsk conurbation	17
4.3.1. Gdańsk	18
4.3.2. Sopot	20
4.3.3. Gdynia	21
4.4. Changes in the lichen flora of Gdańsk, Sopot and Gdynia	22
4.5. Predicted of changes in the air pollution zones in the Gdańsk conurbation	25
5. List of species	26
6. Summary of results and conclusions	44
7. Streszczenie	47
8. References	50

ABSTRACT

Wiesław Fałtynowicz, Ireneusz Izydorek, Elżbieta Budzbon. *The lichen flora as bioindicator of air pollution of Gdańsk, Sopot and Gdynia*. Monogr. Bot. vol. 73, 1991.

Four zones of lichen occurrence have been distinguished in Gdańsk, Sopot and Gdynia (N Poland). They are: 1) a total lichen desert zone, 2) a relative lichen desert zone, 3) a stunted growth zone, 4) a normal growth zone. Four groups of indicator species have been distinguished — they enable one to identify and characterize the lichen growth zones and the boundaries between them. Changes in the boundaries of the lichen growth zones have been predicted on the basis of the results of this study. 269 lichen species have been recorded from the study area, of which 183 have been discovered or refound during the present survey.

Key words: lichens, bioindication, air pollution, cities

INTRODUCTION*

The ongoing pollution of the air by smoke and gases emitted by industrial and domestic sources has meant that methods of qualitatively and quantitatively estimating pollution and its effects on living organisms are urgently being sought. Measurements of pollution made with a variety of complicated and costly apparatus will not tell us anything definite until we discover the action and reaction of living organisms to it (Fabiszewski et al. 1983). That is why bioindicator methods are gaining ground and are already in widespread use. The principal advantages of these methods are:

- the ability to determine the quantitative composition of pollutants in a given period of time, and hopefully the qualitative composition by means of bioassay;
- a rapid estimate of the effect of toxic substances on organisms (this is connected with the speedy reaction of bioindicators);
- the visual effects of the reaction to pollutants;
- readily available research material;
- low cost (even the most time-consuming biological tests are far less expensive than tests done with a battery of measuring instruments).

Various species of plants, animals, fungi and microorganisms are utilized as bioindicators. However, lichens are the most sensitive bioindicators and have been used for over 100 years, and extensively employed over the past 30 years (Hawksworth 1971, Hawksworth and Rose 1976). In the resolution carried at the 1st European Congress on "The Effect of Air Pollution on Plants and Animals" (Wageningen — Holland, 1968), we read that "... cryptogamic epiphytes should be strongly recommended for general use as biological pollution indicators..." (Hawksworth 1971).

The object of our study, which covered the conurbation of Gdańsk, Sopot and Gdynia, was to locate the areas where lichens do or do not occur, and to assess the numbers and luxuriance of the lichen flora at the localities inspected. The information obtained enabled us to estimate the extent, and in some cases also the nature, of the air pollution in this conurbation. It also allowed us to identify indicator species and to delimit zones of lichen occurrence, each of

* This paper was compiled at the request of the Town and Country Planning Office, Gdańsk. Manuscript received 15.06.1987.

which displayed a different concentration of phytotoxic — in actual fact biotoxic — substances.

The data obtained on the present-day lichen flora of Gdańsk, Sopot and Gdynia were compared with the information given in Reyger (1764-1766), Ohlert (1863, 1870), Krawiec (1933, 1938), Mattick (1934, 1937) and Piotrowska and Stasiak (1975). Thus we were able to estimate the extent of and trends in the changes in the area's lichen flora over the past 100 years.

We would like to thank Professor H. Piotrowska, Professor M. R. D. Seaward and Docent Dr. J. Kiszka for helpful comments on the manuscript.

1. GEOGRAPHICAL AND ECOLOGICAL CHARACTERISTICS OF THE STUDY AREA

The urban environment has been characterized in numerous publications (eg. Brodo 1972, Wójcicka 1973, Andrzejewski 1975, Zimny 1976, Różycka 1978, Sowa and Olaczek 1978, Seaward 1982, Sukopp et al. 1982, Sukopp 1983, Sukopp and Werner 1983). This section will describe briefly only those geomorphological, climatic, biological and urban factors which significantly affect the occurrence and distribution of lichens in the study area.

The Gdańsk conurbation is situated within a number of geomorphological units (Fig. 1) (Szukalski 1974). The differences in height (from 0 to 100 m a.s.l.), the very varied relief, the different geological substrata, the layout of the geomorphological units with respect to one another, and the Baltic shoreline — are all factors naturally limiting the expansion of urban areas here. Until recently, the continuous built-up areas extended only as far as the edge of the Gdańsk Upland; now, more and more new estates are being constructed on the Upland itself.

From the standpoint of the present paper, the slope of the terrain is significant: towards the Kashubian Ice-marginal Valley in the north, towards the Gulf of Gdańsk in the central part, and towards the plain of the Vistula delta in the south. This causes cold air to flow into the natural depressions in the terrain, that is, onto the most densely built-up areas, creating cold-air pockets in many places.

The most important climatic factors as far as lichen growth is concerned are temperature, air humidity and wind. Temperature relationships in the conurbation are modified by the proximity of the Baltic Sea, so that temperatures are rather higher in autumn and winter, but lower in spring and summer than in inland areas. The nearness of the sea also raises the air humidity: it is 90% in December (many years' average), and 78% in June (Kwiecień 1982). The relatively high temperatures in winter and the low ones in summer, combined with a high air humidity, mean the lichens are

Fig. 1. Division of study area into physiographical units (after Szukalski 1974)

Ryc. 1. Podział badanego terenu na jednostki fizjograficzne (wg Szukalskiego 1974)

physiologically active practically the whole year round, and thus react strongly to the presence of pollutants in the air.

The prevailing winds are from the west and north-west: for instance, 36% of the winds experienced in Gdynia during the year are from these directions (Kwiecień 1979). In the built-up areas at the foot of the Gdańsk Upland the wind direction is very changeable (Szukalski 1974). Sea breezes, i.e. local winds blowing inland off the sea during the day and in the other direction during the night, appear to be important to lichen growth.

A large area of Gdańsk, Sopot and Gdynia is covered by woodland communities and other tall vegetation such as trees in parks, cemeteries and by roadsides. These are principally deciduous forests with a large proportion of beech (*Fagus sylvatica*), which cover the edge and top of the Gdańsk Upland from Gdańsk to Wejherowo (Piotrowska and Mąkosa 1985), and also remaining stands of deciduous trees on cliffs and promontories, e.g. on the Redłowo promontory in south Gdynia, and north-east Sopot, fragments of the badly-damaged coastal pine forests in north Gdańsk and the relatively well-preserved pine woods in east Gdańsk (localities 405-415 — see Fig. 2). These

woodland areas exert a very great positive influence on lichen growth in the Gdańsk conurbation. There are other large stands of tall vegetation in parks and cemeteries situated mostly within the built-up areas. Roadside trees are quite numerous – in 1973, there were over 27 thousand of them in Gdańsk (Piotrowska and Stasiak 1975) – not to mention trees growing in gardens, near houses and in squares.

Fig. 2. Position of localities. 1 – forests, 2 – city boundaries, 3 – streets and roads
Ryc. 2. Rozmieszczenie stanowisk. 1 – lasy, 2 – granice miast, 3 – ulice i szosy

The spatial layout of this conurbation is atypical. Its characteristic features include the following:

- the most densely built-up areas extend along the shores of the Gulf of Gdańsk;
- concentrations of built-up areas and industrial centres are widely spaced; between them there are much less densely settled areas;

— there are strongly urbanized enclaves on the Upland and on its edges, separated from the built-up coastal terrace by non-urban areas, and even woodland;

— some areas have come within the administrative boundaries of the cities relatively recently and still retain their rural character.

Now the hitherto existing separation of the built-up areas is disappearing as new housing estates are being constructed, and this process is reflected in the occurrence of lichens (see sect. 4).

The axis of the continuous built-up area in the Gdańsk conurbation comprises the very busy rail and road routes connecting the southern boundaries of Gdańsk with the northern boundaries of Gdynia and running roughly parallel to the coastline. It is one of the significant elements of urbanization along which there is a zone of intensified emission of smoke and fumes and hence considerable air pollution. Other important lines of communication are the main roads leading out of Gdańsk and Gdynia.

Over large areas of these cities, the permitted concentrations of atmospheric pollutants, especially smoke, sulphur oxides and fluorids, and xylene, are exceeded (Zatorska 1984). The chief emitters of these pollutants are industrial plants, the ports, shipyards, power stations, boiler houses, domestic coal-fired heaters, road vehicles and diesel locomotives. However, information on the amounts and types of pollutants in this conurbation is fragmentary. According to the Institute for Environmental Development (IKŚ) (1984), the average annual fluorids concentration in Gdańsk in 1978 ranged from $105 \mu\text{g m}^{-3}$ to $118.2 \mu\text{g m}^{-3}$. Over a large area of the Gdańsk conurbation, the solid particle (smoke) fallout is within legally acceptable limits (i.e. $259 \text{ t km}^{-2} \text{ year}^{-1}$), but in the vicinity of some industrial concerns it is several times higher, e.g. around the premises of the Gdańsk Phosphates Company it may be as high as $3100 \text{ t km}^{-2} \text{ year}^{-1}$ (information from 1982). Permitted concentrations of SO_2 are also exceeded; in the centre of Gdańsk the average daily concentration of this gas may reach $754 \mu\text{g m}^{-3}$ and instantaneous concentrations may exceed $2500 \mu\text{g m}^{-3}$.

2. LICHENS AND AIR POLLUTION

Epiphytic and terricolous lichens are the most sensitive to air pollution. Saxicolous species, which in urban situations grow mostly on anthropogenic substrates like cement rendering, bricks, concrete and roof-tiles, display a much greater resistance which is due chiefly to the buffering properties of the calcium-carbonate-containing substratum (e.g. Brightman 1959, Laundon 1967, Gilbert 1973, Seaward 1977, 1980), and not to their biological properties.

The most important phytotoxic compound causing the death and disappearance of lichens is sulphur dioxide (Hawksworth and Rose 1970, 1976, Richardson and Puckett 1973, Kiszka 1975, 1977, Deruelle 1978,

Fabiszewski et al. 1983). The toxic effect of SO_2 is evident when the thalli are physiologically active; the more water the organism contains, the higher is the toxicity of SO_2 (Rao and LeBlanc 1966). This is the situation especially in autumn and winter when the air humidity is high but the temperature is low. During these seasons SO_2 emission is much greater from municipal sources (boiler houses, domestic heaters), and the toxicity of SO_2 is potentiated by frequent fog and thermal inversions. In summer there are often periods when metabolic processes are considerably slowed down or almost halted owing to the desiccation of the thalli (Barkman 1969). Lichens are then less sensitive to SO_2 ; but when the air humidity is continuously high (as in this area — see section 1), thalli are affected practically the whole year round. The concentration of SO_2 lethal to epiphytic lichens is, in a damp climate, $150 \mu\text{g m}^{-3}$ in the winter months (Hawksworth and Rose 1970), and in relatively dry air, in inland cities it is $200 \mu\text{g m}^{-3}$ (Kiszka 1977).

During lichen-indicator studies, one often distinguishes zones of lichen occurrence: lichen desert, a zone of stunted growth (the “struggle zone”) and a zone of normal growth (Hawksworth 1971). Lichen growth zones in towns and cities usually exhibit a concentric layout (see Vaarana 1934, Laundon 1967, Kozik 1970, LeBlanc and De Sloover 1970, Doll 1976, Toborowicz 1976, Kiszka 1977, Kuziel and Halicz 1979, Śpiewakowski and Izydorek 1981, Farkas et al. 1985).

3. COMMENTS ON METHODOLOGY

This study of the lichens in Gdańsk, Sopot and Gdynia was undertaken in 1983-84 in areas lying within the administrative boundaries of these cities. It is mostly based on material collected from built-up areas.

During the field work, as many accessible places as possible where lichens might occur were searched, and localities where these were found were given a number, which was marked on a map of the cities. The habitat occupied by the lichens at a given locality was precisely defined: the tree species in the case of epiphytes, the nature of the secondary substratum for epilithic lichens, and of the substratum for terricolous lichens. The position of localities with respect to the urban elements (buildings, streets etc.) typical of a place was given. Following this, the lichen species occurring in a locality were listed. The viability and degree of degeneration of the thalli of every lichen found was assessed. The percentage cover of each epiphytic species on a tree trunk up to 2 m from the ground was estimated. 415 localities were examined (Fig. 2) and 489 lists compiled. A complete list of localities and herbarium material are available for inspection at the Department of Plant Ecology and Nature Protection of the University of Gdańsk.

The laboratory work included drawing maps showing the distribution of selected species. The localities of these taxa were helpful in drawing the boundaries between bioindicator zones: lichen desert, struggle zone and normal growth zone.

The species were named in accordance with the guidelines of Wirth (1980), Santesson (1984) and Nowak (1986).

In the list of localities and in Table 1 the following abbreviations are used:

C — crustose lichens, F — foliose lichens,
Fr — fruticose lichens, S — squamulose lichens.

4. THE OCCURRENCE OF LICHENS AS AFFECTED BY AIR POLLUTION

4.1. INTRODUCTORY COMMENTS

Four bioindicator zones, denoting areas of differing degrees of air pollution were distinguished in Gdańsk, Sopot and Gdynia:

1. total lichen desert zone;
2. relative lichen desert zone;
3. a stunted growth zone;
4. normal growth zone.

The total lichen desert is the area in which no epiphytic lichens were found, though very small numbers of thalli of saxicolous species were present. This zone is delimited by spots where deformed thalli of the most pollution-resistant epiphytes were found (see section 4.2., Table 1) and/or by localities with luxuriant saxicolous lichens.

The relative lichen desert is indicated by the presence of small numbers (cover up to 5%) of the three most pollution-resistant epiphytic species, with much weakened viability and deformed thalli (see sect. 4.2., Table 1).

The stunted growth zone is where there are localities with a larger number of lichens, as regards both the numbers of species and the cover. Besides crustose and squamulose lichens there are also some foliose lichens here (see Table 1), but the state of their thalli shows signs of failing viability.

The normal growth zone comprises areas in which the numbers of species are well up on those in the struggle zone, and crustose, squamulose and foliose lichens grow in greater abundance. In this zone there are also epiphytic and terricolous species with fruticose thalli.

The boundaries of only the first three of these zones could be drawn accurately. This was not possible with the boundary between the struggle and normal growth zones because of the difficulties arising out of the considerable anthropogenic distortion of the woodland communities lying within the administrative boundaries of the conurbation. The tree stands concur with the habitat and have been little changed by man only in a few places (see Fałtynowicz et al. 1980a, b, c, 1985). It was primarily here that species typical of the normal growth zone were found, e.g. *Bryoria fuscescens*, *Pertusaria hemisphaerica*, *Pyrenula nitida* and *Usnea subfloridana*. Lichen growth in tree plantations is limited, mainly as a result of changes to the

Tablę 1 — Tabela 1

Indicator species for the, Gdańsk-Sopot-Gdynia area
Gatunki wskaźnikowe dla obszaru Gdańska, Sopotu i Gdyni

Group Grupa	Name of species Nazwa gatunku	MF	Indicator role Rola wskaźnikowa	Comments Uwagi
I	<i>Lecanora conizaea</i>	C	indicative of the relative lichen desert	degenerating thalli; <i>Lecanora</i> often sterile; cover up to 5%*
	<i>L. conizaeoides</i>	C	wyróżniają względną	plechy degenerujące;
	<i>Lepraria incana</i>	C	pustynię porostową	<i>Lecanora</i> często płonna; pokrywanie do 5%*
II	<i>Buellia punctata</i>	C	delimit boundary between lichen desert and struggle zone	deformed thalli, esp. in <i>Ph. adscendens</i> ; cover up to 10%*
	<i>Hypocenomyce scalaris</i>	S	wyróżniają granicę między pustynią porostową a strefą osłabionej roślinności	plechy zniekształcone, zwł. u <i>Ph. adscendens</i> ;
	<i>Physcia adscendens</i>	S		pokrywanie do 10%*
III	<i>Hypogymnia physodes</i>	F	indicative of struggle zone	thalli small, deformed, often with necroses; seldom; cover up to 5%*
	<i>Parmelia sulcata</i>	F	wyróżniają strefę osłabionej roślinności	plechy małe, zdeformowane, często z nekrozami; nieliczne; pokrywanie do 5%*
	<i>Xanthoria parietina</i>	F		
IV	<i>Evernia prunastri</i>	Fr	delimit boundary between struggle and normal growth zones	thalli small, deformed; seldom; cover up to 1%*
	<i>Pseudevernia furfuracea</i>	Fr	wyróżniają granicę między strefami walki i normalnej roślinności	plechy niewielkie, zniekształcone; nieliczne pokrywanie do 1%*
	<i>Ramalina farinacea</i>	Fr		

* Percentage cover refers only to species of this group.

Wartości pokrywania odnoszą się tylko do gatunków tej grupy.

MF — morphological form.

forma morfologiczna.

habitat (Czyżewska 1976) and not because of the toxic action of pollutants. In the context of the present paper, these areas can be included in the normal growth zone.

4.2. THE DISTRIBUTION OF INDICATOR SPECIES AND OTHER LICHENS

Among the epiphytic lichens, the species most tolerant of air pollution, namely, *Lecanora conizaeoides* (Fig. 3), *L. conizaea* and *Lepraria incana*, have the greatest number of localities. They usually occur together and are

practically the only corticolous species which are still to be found in the relative lichen desert. Their thalli are but few (cover up to 5%), poorly developed and frequently dying, and the *Lecanora* species produce few and often degenerate fruiting bodies.

Fig. 3. Distribution of *Lecanora conizaeoides* (1) and *Buellia punctata* (2) and they both (3)
 Ryc. 3. Rozmieszczenie *Lecanora conizaeoides* (1) i *Buellia punctata* (2) i obu tych porostów (3)

The resistant species which delimit the lichen desert and the stunted growth zone include *Physcia adscendens*, *Buellia punctata* (Fig. 3) and *Hypocenomyce scalaris*. The last-mentioned, which grows naturally on the acid bark of coniferous trees in well-insolated spots, is widely regarded as sensitive to air pollution. In Cracov, for example, it occurs on the outskirts of the city (Kiszka 1977) in the outer struggle zone. The occurrence of *Hypocenomyce scalaris* in the Gdańsk conurbation at the struggle zone-lichen desert boundary is confirmation of the fact that this species exhibits enhanced resistance to air

pollution in coastal towns (see Gilbert 1973). Thalli of *Physcia adscendens*, growing in localities near the edge of the lichen desert, are always badly deformed (for. *subbreviata* — see Olech and Dudek 1981); in this study, morphological damage in this species was one of the features which enabled the lichen desert boundary to be located. A similar indicator was *Buellia punctata*, whose first localities mark the boundary between the struggle zone and the lichen desert.

Phaeophyscia orbicularis appears to be relatively tolerant to pollution, epilithic specimens being found even within the relative lichen desert. In the inner stunted growth zone, this lichen is epiphytic and grows on the bases of tree trunks. In this study, the exclusively epiphytic *Lecanora expallens* and *Xanthoria candelaria* have a very similar distribution, although the latter, in areas where the pollutant concentration is higher, grows mainly in bark fissures where it is less exposed to the direct action of the toxicants.

Besides the species already mentioned, the foliose lichens *Hypogymnia physodes* and *Parmelia sulcata* (Fig. 4) and *Xanthoria parietina* are also characteristic of the struggle zone in the Gdańsk conurbation. Of all the foliose lichens, these three species penetrate farthest into urbanized areas, although in extreme localities — close to the lichen desert — only single, small, discoloured thalli carrying signs of damage and senescence are found. These lichens demonstrate reduced viability throughout the struggle zone, as do other foliose lichens, e.g. *Parmelia acetabulum*, *P. exasperatula*, *P. glabrata* and *Physconia distorta*.

Crustose lichens are quite numerous in the stunted zone, especially *Lecidella elaeochroma*, *Lecanora expallens*, *L. hagenii*, *L. carpineae*, *L. argentata*, *L. pulicaris*, *Candelariella xanthostigma* and *Phlyctis argentea*. Apart from the first three, these lichens are not usually developed normally: their thalli are often discoloured and covered with algae, and their fruiting bodies (if formed) are damaged and devoid of spores.

The epiphytic species marking the boundary between the stunted and normal growth zones, are fruticose lichens such as *Evernia prunastri*, *Pseudevernia furfuracea*, *Ramalina farinacea*, some foliose species like *Cetraria chlorophylla*, *Platismatia glauca* and *Parmeliopsis ambigua*. Another clear indication of the dwindling effects of pollution and the transition to the normal growth zone was the occurrence of struggle zone species (see above) in large numbers and with undamaged thalli.

The most pollution-resistant fruticose species found in the Gdańsk conurbation turned out to be *Evernia prunastri*, single, small and deformed specimens of which were found even in the outer struggle zone. Likewise, *Pseudevernia furfuracea* and *Ramalina farinacea*, although at a smaller number of localities. Figure 5 shows the distribution of these fruticose lichens.

About 20 lichen species are particularly sensitive to air pollution were found in the study area. The locality topography of some of them is shown in Figure 6. Their distribution is very characteristic. Most of their localities are concentrated in east Gdańsk (loc. 405-415) and in the municipal forests in north-west Gdańsk.

Fig. 4. Distribution of *Hypogymnia physodes* and *Parmelia sulcata*: 1 — *Hypogymnia physodes* and *Parmelia sulcata*, 2 — *Hypogymnia physodes* only, 3 — *Parmelia sulcata* only

Ryc. 4. Rozmieszczenie *Hypogymnia physodes* i *Parmelia sulcata*: 1 — *Hypogymnia physodes* i *Parmelia sulcata*, 2 — tylko *Hypogymnia physodes*, 3 — tylko *Parmelia sulcata*

One indicator of normal growth is the presence of numerous terricolous species from the genera *Cladina*, *Cladonia*, *Peltigera*, *Placynthiella*, *Trapeliopsis*, *Cetraria*, *Coelocaulon* and *Baeomyces*. In the study area abundant localities of these lichens were found in only a few places — principally in the easternmost parts of Gdansk (loc. 405-415), which lie almost in their entirety in the normal growth zone. Moreover, up to 20 species from the above genera were found on the coastal dunes in north-east Gdansk.

Very typical habitats for lichens in towns are artificial saxicolous substrata, like cement rendering, bricks, roof-tiles and concrete, which contain much calcium carbonate. The fact that epilithic lichens penetrate furthest into urban territory is due mainly to the properties of the substratum and not of the species (Seaward 1977, 1979) (see sect. 2). The commonest saxicolous lichens in the study area were *Lecanora dispersa* and *Candelariella aurella*. Their localities were helpful in establishing the boundary between the total and

Fig. 5. Distribution of fruticose lichens: 1 — various species, 2 — *Evernia prunastri* only
 Ryc. 5. Rozmieszczenie porostów o plechach krzaczkowatych: 1 — różne gatunki, 2 — tylko *Evernia prunastri*

relative lichen deserts. In extreme localities, saxicolous lichens occur in small numbers and often exhibit signs of diminished viability, but in the relative lichen desert they are locally quite abundant. Besides the above two species, *Caloplaca citrina*, *C. decipiens*, *C. saxicola*, *Lecanora albescens*, *Phaeophyscia nigricans* and *Ph. orbicularis* were often frequent.

The fieldwork and analysis of results allowed us to identify four groups of indicator species, with the aid of which one can distinguish and characterize lichen growth zones and also assess the extent of air pollution in the Gdańsk conurbation (Table 1). These indicator species are all good bioindicators of air pollution, as they fulfil three basic conditions: they are easily identifiable in the field; they react to pollutants in a way that makes assessment feasible; they are common or at least frequent.

Fig. 6. Distribution of selected species particularly sensitive to air pollution:

Ryc. 6. Rozmieszczenie wybranych gatunków szczególnie wrażliwych na zanieczyszczenie powietrza:
 1 – *Anaptychia ciliaris*, 2 – *Bryoria fuscescens*, 3 – *Cetraria islandica*, 4 – *Chaenotheca chrysocephala*, 5 – *Coniocybe furfuracea*, 6 – *Graphis scripta*, 7 – *Pertusaria hemisphaerica*,
 8 – *Pyrenula nitida*, 9 – *Usnea hirta*, 10 – *U. subfloridana*

The significance of the species in Groups I-III (Table 1) is incontestable, but the Group IV lichens are not such good bioindicators. They occur within the struggle zone and in fact indicate its transition into the normal growth zone, however, this transition zone may very considerably in width.

4.3. LICHEN ZONES IN THE GDAŃSK CONURBATION

The following aspects of the lichen growth zones are common to the whole study area (see Fig. 7):

- apart from the normal growth zone, the other zones exhibit a strip layout which is a result of most of the built-up areas lying in a narrow belt along the Gulf of Gdańsk;

- the lichen desert zone (both total and relative) straddles the main Gdańsk-Sopot-Gdynia communication axis, and widens in the city centres and around port and industrial complexes;

- on the landward side, the struggle zone is a narrow strip along the edge of the Gdańsk Upland;
- there is a clear correlation between the normal growth zone and the woodland areas;
- there are enclaves of normal lichen growth in areas of deciduous woodland and pine forest close to the sea shore.

Fig. 7. Zones of lichen occurrence in Gdańsk, Sopot and Gdynia: 1 – total lichen desert, 2 – relative lichen desert, 3 – stunted growth zone, 4 – normal growth zone

Ryc. 7. Strefy występowania porostów w Gdańsku, Sopocie i Gdyni: 1 – bezwzględna pustynia porostowa, 2 – względna pustynia porostowa, 3 – strefa osłabionej wegetacji, 4 – strefa normalnej wegetacji

4.3.1. GDAŃSK

The total lichen desert zone in Gdańsk is very extensive (Fig. 7). It lies east and south-east of the chief pollutant emitters, that is, the port, shipyard and associated industrial plants, and of the main communication routes. The

layout of this zone is due to the prevailing westerly and north-westerly winds. Lichen growth is also hampered by the densely built old districts of Gdańsk.

The relative lichen desert also covers a fairly large area: in the residential districts in the northern and western parts of the city and the sparsely populated areas in the vicinity of large industrial complexes.

The stuted growth zone mainly stretches away to the south and south-west and covers almost all of the remaining built-up areas. It is rapidly moving south-westwards onto the moraine upland as this becomes overbuilt with new housing estates.

Lichens were growing normally only in a very few parts of the city, mainly in the municipal forests on the Gdańsk Upland and at localities 405-415. Small enclaves of this zone were also found along the west bank of the Vistula (localities 319-322) and along the sea shore in north-east Gdańsk. Numerous species of epiphytic and terricolous lichens were found at these localities, mainly of the genera *Parmelia*, *Lecanora*, *Cladina*, *Cladonia*, *Cetraria*, *Placynthiella*, *Lecidella* and *Coelocaulon*.

The changes in the lichen flora of Gdańsk on moving towards built-up areas is shown in Figure 8 (the line of the transects is shown in Fig. 9).

Fig. 8. Number of lichen species at selected spots in Gdańsk (transects): 1, 2, 3... — localities in transect; lichens: a — fruticose, b — foliose, c — squamulose, d — crustose; I, II... — transect numbers

Ryc. 8. Liczba gatunków porostów w wybranych miejscach w Gdańsku (transekty): 1, 2, 3... — stanowiska w transekcje; porosty: a — krzaczkowate, b — listkowate, c — łusczkowate, d — skorupiaste; I, II... — numery transektów

Transect I (Fig. 8) was taken from the normal growth zone across a large residential district to an enclave of normal growth on the sea shore. Transects II and III pass from the boundary with the normal growth zone to the communication artery which is the beginning of the total lichen desert zone. Transect IV cuts one of the main roads leading out of Gdańsk. Transect V starts near the port and large industrial areas and leads to one of the better-preserved fragments of pine forests with normal lichen growth.

Fig. 9. Position of transects: I, II... — transect numbers; 1, 2, 3... — numbers of localities on a transect

Ryc. 9. Rozmieszczenie transektów: I, II... — numery transektów; 1, 2, 3... — numery stanowisk w transekcje

4.3.2. Sopot

The total lichen desert occupies the central part of the densely built-up district on the coastal terrace (Fig. 7). In comparison with the rest of the town, this area is covered by a mass of low buildings among which there is very little vegetation. The relative lichen desert lies along the eastern side of the main communication axis. The main sources of air pollution here are domestic

heaters fuelled by high-sulphur coal, small boiler houses, and the fumes from motor vehicles and diesel locomotives (Sopot has practically no industry). The position of the lichen desert in Sopot also demonstrates that masses of cool polluted air flow from the higher-lying areas (on the edge of the Gdańsk Upland) down to the coastal terrace.

The struggle zone covers the remaining built-up parts of the town, and in places has entered the municipal forests.

The boundary of the normal growth zone runs through the woodland, bypassing the housing estates constructed on the Upland. Very interesting is the survival of a small area of normally growing lichens near the seashore in north-east Sopot. A small fragment of drained woodland with *Alnus glutinosa* at the base of the cliff still exists. 29 epiphytic lichen species with undamaged thalli were found there.

The decline of lichens on passing from the woods to the town centre is depicted in Figure 10 (transects VI and VII — see Fig. 9).

4.3.3. GDYNIA

The total lichen desert covers the oldest and most highly industrialized part of the city (Fig. 7).

The relative lichen desert stretches along the main communication artery, becoming much wider in the south of the city in the Redłowo depression (see Figs. 1 and 7). This is a pocket into which cold, strongly polluted, air flows from the north and west (see Szukalski 1974). Air exchange is thereby hindered because this area is sheltered by the surrounding upland, i.e. by the edge of the Gdańsk Upland and by the Redłowo promontory. The effect of this air pocket on the lichen flora is shown in Figure 10 (transect VIII — see Fig. 9).

The remaining built-up areas of Gdynia belong to the stunted growth zone, and this includes fragments of the municipal forests immediately adjacent to built-up areas. A special case where the natural environment has been interfered with is the Witomino estate, which lies on the Gdańsk Upland and is separated from the rest of the city by forests (localities 33-39). The extension of this estate means that its centre will probably become a lichen desert in the not too distant future. Transect IX, drawn across the estate, is evidence for this (Figs. 9 and 10). At the same time, the adverse effects of this urban enclave on the surrounding woodland are quite plain. Witomino is an example of the changes which are taking place and will take place in all the estates constructed on the Gdańsk Upland.

The normal growth zone lies beyond the urban areas and covers the forests in west and north Gdynia. On the seaward side, there is normal lichen growth only along a narrow strip of land along the edge of the cliff on the Redłowo promontory (Fig. 7). The morphological differentiation of the lichens on the Redłowo promontory and its changes towards the city centre is shown by transect X, taken from the „Redłowo promontory” nature reserve to the port in Gdynia (Figs. 9 and 10).

Fig. 10. Number of lichen species in selected spots in Sopot (VI and VII) and Gdynia (VIII-X) (transects). For explanations — see Fig. 8

Ryc. 10. Liczba gatunków porostów w wybranych miejscach w Sopocie (VI i VII) i Gdyni (VIII-X) (transekty). Objaśnienia — por. ryc. 8

4.4. CHANGES IN THE LICHEN FLORA OF GDAŃSK, Sopot AND GDYNIA DURING THE PAST 100 YEARS

There is no comprehensive study of the lichen flora of any of the cities studied which could serve as comparative material. There are only a few old works, in which from one to almost a hundred lichen species are mentioned (Reyger 1764-1766, Klinckmann 1863, Ohlert 1863, 1870, Krawiec 1933, 1938, Mattick 1934, 1937, Weichler 1935, Erichsen 1936).

The earliest information is from Reyger (1764-1766) who mentions 21 species from the Gdańsk area, including *Buellia epipolia*, *Lecidea nylanderii*, *L. quereana* and *Rinodina laevigata*, which are very rare on the Polish lowland. None of these species has ever been found again by lichenologists collecting lichens in Gdańsk.

Ohlert (1863, 1870) gives 48 taxa, mainly from Gdańsk and Sopot. About sixty years later, Mattick (1937) was already to refind some of them, and we could find only 15. There are no longer any localities for such lichens as *Catinaria grossa*, *Cladonia ramulosa*, *C. decorticata*, *Cyphelium inquinans*, *C. tigilare*, *Lobaria pulmonaria*, *L. scrobiculata*, *Nephroma resupinatum*, *Pachypiale fagicola*, *Pannaria pezizoides* and *Peltigera venosa*.

Mattick (1934, 1937) describes 95 lichen taxa from Gdańsk and Sopot. Most of them are taxa very tolerant to environmental changes and so some of their localities have survived to the present day. The localities of 20 species, i.a. *Bryoria implexa*, *Calicium adpersum*, *Cladina stellaris*, *Coniocybe pallida*, *Icmadophila ericetorum* and *Lobaria pulmonaria*, are now only of historical interest.

Krawiec (1933, 1938) provides some very important information as regards the present article. He mentions 92 lichen species from the Redłowo promontory and adjacent areas in Gdynia, including some sensitive to air pollution, namely *Calicium salicinum*, *C. quercinum*, *Collema limosum*, *C. tenax*, *Graphis scripta*, *Leptogium lichenoides*, *Pertusaria leioplaca*, *Pyrenula nitida*,

Fig. 11. Distribution of some extinct species:

Ryc. 11. Rozmieszczenie wybranych gatunków wymarłych:

- 1 – *Calicium adpersum*, *Nephroma resupinatum*, 2 – *Calicium quercinum*, *C. salicinum*, *Parmelia exasperata*, *P. quercina*, *P. subargentifera*, 3 – *Icmadophila ericetorum*, 4 – *Lobaria pulmonaria*, 5 – *L. scrobiculata*, 6 – *Pannaria pezizoides*, 7 – *Parmelia caperata*, 8 – *Peltigera venosa*, 9 – *Cladina stellaris*

Fig. 12. Area covered by total lichen desert zone in Gdańsk in 1973 (from Piotrowska and Stasiak) and in 1984. 1 — area of lichen desert in 1973, 2 — area taken over by lichen desert up to 1984, 3 — city boundaries, 4 — forests, 5 — more important roads

Ryc. 12. Obszar bezwzględnej pustyni porostowej w Gdańsku w 1973 (wg danych Piotrowskiej i Stasiak) i w 1984 roku. 1 — powierzchnia pustyni porostowej w 1973 r., 2 — obszar, o który powiększyła się pustynia porostowa do 1984 r., 3 — granice miasta, 4 — lasy, 5 — ważniejsze ulice

Parmelia caperata, *P. quercina*, *Usnea hirta* and *U. subfloridana*. Despite intensive searching, neither these species, nor many others could be found again. At present there are only 35 lichen species in the woods on the Redłowo promontory. They include *Bryoria fuscescens*, *Ramalina farinacea*, *Pertusaria amara*, *Coniocybe furfuracea* and *Cladonia* spp., so it was possible to classify a narrow strip along the coast as normal growth zone. But this lichen enclave will not survive for much longer. A sign of the worsening air pollution here is the disappearance of the last localities of *Bryoria fuscescens*. In 1977, this lichen was still abundant, but during the present study only a few scattered thalli could be found.

The former localities of some of the extinct lichen species are shown on Figure 11.

The most complete comparative material available is the unpublished work by Piotrowska and Stasiak (1975). During a study of the state of roadside trees in Gdańsk, Fałtynowicz, in cooperation with the above authors collected information on the occurrence or lack epiphytic lichens on over 27 thousand trees. From this, it was possible to delimit the boundaries of the absolute lichen desert in Gdańsk in 1973. A comparison of the 1973 data with the material collected for the present paper provides a picture of the changes in area of the lichen desert during the last 11 years (Fig. 12). The absolute lichen desert boundary has not shifted much to the west in this time, but has moved a long way east and south-east of the Gdańsk city centre. This is the result of the construction of a large port and oil refinery, a considerable increase in the transshipment of sulphur and in road and rail traffic on the exit routes to Warsaw and Bydgoszcz (see Piskozub and Wyszomirski 1982).

4.5. PREDICTED OF CHANGES IN THE AIR POLLUTION ZONES IN THE GDAŃSK CONURBATION

From an analysis of the current state of the lichen flora, historical data on lichens in Gdańsk, Sopot and Gdynia, projected extensions to the Gdańsk conurbation and construction work in adjacent areas (cf. Kołodziejski 1982, 1984), and the literature on bioindicator studies, it is possible to predict the directions in which the lichen growth zone boundaries will move in this conurbation (Fig. 13).

The absolute and relative lichen desert zones and struggle zone are tending to expand, while the normal growth zone is diminishing in size.

In the next few years the total lichen desert will probably expand to include the larger part of the present relative lichen desert. In Sopot the boundary of the absolute lichen desert is moving south and is expected to engulf not only the relative desert but also part of the struggle zone on the south-eastern edge of the town. In Gdańsk, Sopot and Gdynia the total lichen desert will extend away on either side of the main traffic artery.

The relative lichen desert will encroach onto territory which at present lies within the stunted growth zone. However, it does not seem likely that this zone will expand in the next 15 years or so (especially in Sopot and Gdynia) because the edge of the Gdańsk Upland and the close-canopy woodland are a natural and still effective barrier weakening the effects of polluted air. In Gdańsk, this zone is visibly shifting south and south-east, and is taking over the new estates sited on the Gdańsk Upland.

The struggle zone is penetrating deeper into the woodland, especially in Sopot. In the next few years, the last surviving enclaves of normal growth along the sea shore will no doubt join it too.

The boundary with the normal growth zone is receding further into the forests, particularly in Sopot and Gdynia. The woodland in north-west Gdańsk are not so much under threat, although here too disturbing signs of

Fig. 13. Predicted changes in lichen growth zone boundaries in Gdańsk, Sopot and Gdynia. 1 — boundary between lichen desert and struggle zone, 2 — boundary between struggle zone and normal growth zone, 3 — direction and rate (a — slow, b — fast) of zone boundary movement
 Ryc. 13. Prognoza zmian granic stref wegetacji porostów w Gdańsku, Sopotcie i Gdyni. 1 — granica między pustynią porostową a strefą osłabionej wegetacji, 2 — granica między strefami osłabionej i normalnej wegetacji, 3 — kierunek i tempo (a — wolne, b — szybkie) przesuwania się granic stref

dying among some of the more sensitive lichen species have been seen. One can assume that in 15-20 years' time, the normal growth zone will exist only north-west and east of the city (loc. 405-415).

5. LIST OF SPECIES

Over more than two centuries, 268 lichen species have been recorded from the study area, of which 183 have been discovered or refound during the present survey.

The following information is given about each species: name — habitat — morphological form — number of localities — list of localities — information whether and where the species was recorded by other authors.

Four principal morphological forms have been distinguished: crustose (C), foliose (F), fruticose (Fr) and squamulose (S) lichens. The morphological form is given only for species which we found during our field work.

The following abbreviations are used when bibliographical sources are quoted:

Rey.	— Reyger 1764-1766,	Kr. 38	— Krawiec 1938,
Kl.	— Klinsmann 1863,	Wei.	— Weichler 1935,
Ohl. 63	— Ohlert 1863,	Er.	— Erichsen 1936,
Ohl. 70	— Ohlert 1870,	Mat.	— Mattick 1937.
Kr. 33	— Krawiec 1933,		

Since Mattick's article of 1937 contains all the information he gave in his 1934 paper, only the later work is quoted in the list of species.

Acarospora

fuscata (Nyl.) Arn. — On siliceous rocks. C. 2 loc.: 298, 415. Gdańsk (Rey., Mat.) and Gdynia (Kr. 38).

veronensis Massal. — On siliceous rocks. C. 1 loc.: 415. Gdynia (Kr. 33, 38).

Anaptychia

ciliaris (L.) Koerb. — On bark of deciduous trees. F. 3 loc.: 8, 84, 190. Gdynia (Kr. 33), Sopot and Gdańsk (Mat.).

Arthonia

didyma Koerb. — On bark of sycamore. C. 1 loc.: 390.

elegans (Ach.) Almqu. — Sopot (Ohl. 70, as *A. ochracea* Duf.).

patellulata Nyl. — Gdańsk (Ohl. 70).

punctiformis Ach. — Sopot (Ohl. 70).

radiata Ach. emend. Th. Fr. — On bark of young sycamores, rowan trees and maples. C. 2 loc.: 178, 415. Gdynia (Kr. 33) and Sopot (Mat.).

tumidula (Ach.) Ach. — Gdańsk (Ohl. 70, as *A. cinnabarina* Wallr.).

Arthopyrenia

grisea (Schleich. ex Schaer.) Koerb. — Sopot (Ohl. 70, as *Verrucaria epidermis* Ach. for. *grisea* Schaer.).

punctiformis Massal. — Gdańsk (Ohl. 70, as *Verrucaria epidermis* Ach. for. *punctiformis* Ach.).

Arthrorhaphis

citrinella (Ach.) Poelt [*Bacidia citrinella* (Ach.) Branth et Rostr.] — Gdańsk (Ohl. 70, as *Lecidea flavo-virescens* Borr.).

Aspicilia

calcarea (L.) Mudd — On concrete and bricks. C. 5 loc.: 113, 212, 222, 253, 254.

cinerea (L.) Koerb. — On siliceous rock. C. 1 loc.: 415. Gdańsk (Mat.) and Gdynia (Kr. 38).

contorta (Hoffm.) Krempelh. — On concrete. C. 1 loc.: 415.

Bacidia

auerswaldii (Hepp ex Stiz.) Migula — Sopot (Ohl. 70, as *Lecidea effusa* Auersw.).

bagliettoana (Massal. et DNot. in Massal.) Jatta [*B. muscorum* (Sw.) Mudd] – On mosses. C. 1 loc.: 222. Gdańsk (Ohl. 70, as *Lecidea muscorum* Sw.) and Gdynia (Kr. 33).

hegetschweileri (Hepp) Vain. v. *vermifera* (Nyl.) Vain. [*B. vermifera* (Nyl.) Th. Fr.] – Gdańsk (Ohl. 70, as *Lecidea vermifera* Nyl.).

incompta (Borr. ex Hook. et Sowerb.) Anzi – Gdańsk, Gdynia (Ohl. 70, as *Lecidea atro-sanquinea* Schaer. v. *incompta* Borr.).

metamorphaea (Nyl.) Oliv. – Gdańsk (Ohl. 70, as *Lecidea metamorphaea* Nyl.).

rosella (Pers.) DNot. – On bark of beech. C. 1 loc.: 390.

subincompta (Nyl.) Arn. – On bark of maple. C. 1 loc.: 140.

tetramera (DNot.) Coppins [*B. sphaeroides* (Dicks.) A. Zahlbr.] – Gdańsk (Ohl. 70, as *Lecidea sphaeroides* Dicks.).

Baeomyces

rufus (Huds.) Rebert. – On soil and siliceous stones. C. 7 loc.: 32, 83, 97, 99, 167, 390, 415. Gdynia (Kr. 33, as *B. byssoides* (L.) Gärtner) and Gdańsk (Mat.).

Bryoria

fuscescens (Gyeln.) Brodo et Hawksw. – On bark of deciduous trees (mainly of *Betula*). Fr. 8 loc.: 99, 167, 191, 405, 408-410. Gdańsk (Mat., as *Alectoria jubata* for. *sorediata*).

implexa (Hoffm.) Brodo et Hawksw. – Gdańsk (Mat., as *Alectoria implexa* Hoffm.).

Buellia

disciformis (Fr.) Mudd – Gdynia (Kr. 33, as *B. parasema* (Ach.) DNot.).

epipolia (Ach.) Mong. – Gdańsk (Rey.).

griseovirens (Turn. et Borr. ex Sm.) Almb. – On bark of beech and hornbeam. C. 2 loc.: 64, 80.

punctata (Hoffm.) Massal. – On bark of deciduous trees. C. 139 loc.: 7-9, 13, 14, 16, 17, 33, 39, 41, 44, 46, 48, 52-57, 60, 61, 83-85, 89, 122-124, 131, 133, 134, 140, 141, 149, 154, 155, 161, 162, 165, 169, 174, 175, 180, 182-184, 187-190, 192, 193, 195-197, 202, 203, 205, 207, 210, 211, 215-219, 221, 223-226, 228, 230, 233, 234, 238, 241-252, 258-260, 262-266, 269, 270, 273-280, 282, 284, 288, 289, 296-298, 301, 303-309, 313, 314, 324-327, 330, 339, 340, 342, 343, 348, 356, 370, 372, 383, 384, 415. Gdynia (Kr. 33, 38, as *B. myriocarpa* (DC.) Mudd).

schaereri DNot. – Gdańsk (Rey.).

Calicium

adpersum Pers. – Sopot (Mat.).

quercinum (Retz.) Pers. – Gdynia (Kr. 33).

salicinum Pers. – Gdynia (Kr. 33).

viride Pers. – On bark of *Quercus*. C. 4 loc.: 80, 98, 167, 415. Gdańsk (Rey., Mat.).

Caloplaca

cerina (Ehrh. ex Hedw.) Th. Fr. — Gdynia (Kr. 33).

citrina (Hoffm.) Th. Fr. — On concrete. C. 23 loc.: 35, 67, 70, 88 (c.ap.), 102, 103, 107, 113 (c.ap.), 118, 120, 145, 163, 210, 212, 215, 222, 253, 254, 286, 366, 378, 388, 415. Gdynia (Kr. 33, 38).

decipiens (Arn.) Blomb. et Forss. — On concrete and bricks. S. 22 loc.: 62, 67, 88, 102, 107, 109, 113, 115, 118, 179, 210, 212, 222, 253, 257, 261, 302, 310, 346, 368, 385, 415. Gdynia (Kr. 33, 38) and Gdańsk (Mat.).

flavorubescens (Huds.) Laundon — Gdańsk (Ohl. 70, as *Lecanora aurantiaca* Lightf.) and Gdynia (Kr. 33, as *C. aurantiaca* (Lightf.) Th. Fr.).

holocarpa (Hoffm.) Wade [*C. pyracea* (Ach.) Th. Fr., *C. lithophila* H. Magn.] — On bark of deciduous trees and on concrete. C. 14 loc.: 62, 67, 88, 102, 113, 118, 212, 254, 258, 260, 310, 378, 413, 415. Gdynia (Kr. 38).

saxicola (Hoffm.) Nordin — On concrete. S. 25 loc.: 62, 88, 103, 109, 116, 163, 210, 212, 220, 222, 253, 254, 256, 257, 260, 261, 286, 302, 310, 321, 360, 408-410, 415. Gdańsk (Ohl. 70, as *Lecanora murorum* Hoffm. v. *tegularis* Ach.) and Gdynia (Kr. 38, as *C. murorum* (Hoffm.) Th. Fr.).

teicholyta (Ach.) Stnr. — On bricks. S. 1 loc.: 253.

Candelaria

concolor (Dicks.) Stein — On bark of deciduous trees. S. 19 loc.: 52, 65, 75, 80, 83, 89, 223, 243, 244, 259, 264, 267, 274, 289, 290, 296, 326, 329, 356. Sopot (Mat.) and Gdańsk (Ohl. 70, as *Lecanora candelaria* Ach.; Mat.).

Candelariella

aurella (Hoffm.) A. Zahlbr. — On concrete, somewhat on non-calciferous stones. C. 40 loc.: 35, 62, 67, 70, 73, 88, 102, 107, 109, 115, 116, 118, 120, 122, 130, 159, 179, 210, 212, 220, 222, 251, 254, 256, 260, 261, 286, 302, 310, 321, 331, 346, 368, 382, 385, 388, 391, 408, 409, 415.

vitellina (Hoffm.) Müll. Arg. — On bark of deciduous trees, decaying wood and concrete. C. 12 loc.: 17, 53, 54, 118, 155, 243, 297, 310, 387, 405, 409, 415. Gdańsk (Mat.) and Gdynia (Kr. 38).

xanthostigma (Ach.) Lett. — On bark of deciduous trees. C. 50 loc.: 3, 7, 8, 44, 57, 78, 122-124, 128, 131, 133, 134, 140, 155, 175, 181, 195-197, 204-207, 219, 224, 226, 233, 249, 251, 254, 258, 264, 265, 268, 272, 277, 279, 284, 288, 296, 297, 300, 303, 313, 325, 326, 330, 343, 415. Gdynia (Kr. 33, as *C. vitellina* v. *xanthostigma*).

Catillaria

griffithii (Sm.) Malme — On bark of oak. C. 1 loc.: 98. Sopot (Ohl. 70, as *Lecidea tricolor* With.) and Gdańsk (Rey.).

Catinaria

grossa (Pers. ex Nyl.) Vain. — Sopot (Ohl. 70, as *Lecidea grossa* Pers.).

Cetraria

chlorophylla (Willd.) Vain. — On bark of deciduous trees, mainly on *Betula*.

F. 19 loc.: 41, 48, 91, 99, 126, 190, 195, 210, 323, 324, 405-411, 414, 415. Gdańsk (Mat.).

ericetorum Opiz. — On soil in pine-forest. Fr. 1 loc.: 415.

islandica (L.) Ach. — On soil in pine-forests and psammophilous swards. Fr. 13 loc.: 321, 360, 405-415. Gdańsk (Rey; Wei.; Mat.).

pinastri (Scop.) Ach. — On bark of birches. F. 7 loc.: 318, 359, 364, 408, 409, 411, 415. Gdynia (Kr. 33) and Gdańsk (Mat.).

sepincola (Ehrh.) Ach. — On bark of birches. F. 8 loc.: 406, 407, 409-412, 414, 415. Gdańsk (Mat.).

Chaenotheca

chrysocephala (Turn. ex Ach.) Th. Fr. — On bark of deciduous trees. C. 3 loc.: 140, 217, 415. Gdynia (Kr. 33).

ferruginea (Turn. ex Sm.) Migula — On bark of pines and deciduous trees. C. 9 loc.: 64, 125, 140, 167, 409-411, 413, 415. Gdańsk (Ohl. 70, as *Calicium melanophaeum* Ach.; Mat.) and Gdynia (Kr. 33, as *Ch. melanophaea* (Ach.) Zw.).

trichialis (Ach.) Th. Fr. — Gdańsk (Mat.).

Chrysothrix

candelaris (L.) Laundon — Sopot (Mat., as *Lepraria candelaris* (L.) Fr.).

Cladina

arbuscula (Wallr.) Hale et W. Culb. — On soil in pine-forests. Fr. 11 loc.: 405-415. Gdańsk (Mat., as *Cladonia sylvatica* (L.) Hoffm.).

ciliata (Stirt.) Trass v. *tenuis* (Flk.) Ahti et Lai — On soil in pine-forests. Fr. 7 loc.: 405, 408-412, 414. Gdańsk (Mat., as *Cladonia tenuis* (Flk.) Harm.).

mitis (Sandst.) Hustich — In pine-forests and on open grounds, mainly on acidic soil. Fr. 14 loc.: 321, 360, 365, 405-415. Gdańsk (Mat., as *Cladonia mitis* Sandst.).

portentosa (Duf.) Follm. — On soil in pine-forests. Fr. 11 loc.: 405-415. Gdańsk (Ohl. 70, as *Cladonia sylvatica* Hoffm. v. *portentosa* Del.; Mat.) and Gdynia (Kr. 33).

rangiferina (L.) Nyl. — In pine-forests on acidic soil. Fr. 10 loc.: 405-411, 413-415. Gdańsk (Wei.; Mat., as *Cladonia rangiferina* (L.) Web.) for. *tenuior* Del. — Gdańsk (Mat.).

stellaris (Opiz.) Brodo — Gdańsk [Rey.; Mat., as *Cladonia alpestris* (L.) Rabenh.].

Cladonia

bacillaris Nyl. — On acidic soil rich in humus, on decaying wood and on bark of trees. Fr. 17 loc.: 32, 99, 112, 359, 360, 365, 405-415. Gdańsk (Mat.).

bellidiflora (Ach.) Schaer. — Gdańsk (Rey.).

botrytes (Hag.) Willd. — On decaying wood, mainly on pine stumps. Fr. 5 loc.: 405-407, 409, 410.

- caespiticia* (Pers.) Flk. — Gdańsk (Ohl. 70; Mat.).
- cariosa* (Ach.) Spreng. — On open sunexposed sandy not too acid soil. Fr. 1 loc.: 415.
- cenotea* (Ach.) Schaer. — On decaying wood and on bases of pine trunks. Fr. 6 loc.: 407, 408, 410, 411, 413, 414. Gdynia (Kr. 33).
- cervicornis* (Ach.) Flot. — On acidic sandy soil in psammophilous swards. Fr. ssp. *cervicornis* — Gdańsk (Ohl. 70).
ssp. *verticillata* (Hoffm.) Ahti — 5 loc.: 32, 360, 407, 409, 415. Gdańsk (Mat., as *C. verticillata* Hoffm.).
v. *evoluta* (Th. Fr.) Vain. for. *subverticillata* Nyl. — Gdańsk (Mat.).
for. *sobolifera* (Del.) A. Zahlbr. — Gdańsk (Ohl. 70, as *C. sobolifera* Del.).
- chlorophaea* (Flk. ex Sommerf.) Spreng. — On soil, decaying wood and on tree bases. Fr. 31 loc.: 18, 30, 32, 40, 65, 80, 97, 99, 125, 167, 216, 217, 321, 358-360, 364, 365, 371, 390, 405-415. Gdańsk (Mat.).
- coniocraea* (Flk.) Vain. — On soil rich in humus, on decaying wood and on bark of trees. Fr. 30 loc.: 7, 18, 32, 64, 65, 122, 125, 126, 132, 140, 145, 167, 196, 217, 236, 238, 240, 316-318, 324, 359, 360, 364, 365, 390, 406, 410, 411, 415. Gdynia (Kr. 33), Sopot and Gdańsk (Mat.).
for. *ceratodes* (Flk.) Vain. — Gdynia (Kr. 33) and Gdańsk (Mat.).
- cornuta* (L.) Hoffm. — On sandy soil in pine-forests and psammophilous swards. Fr. 13 loc.: 321, 360, 405-415. Gdańsk (Mat.) and Gdynia (Kr. 33).
- crispata* (Ach.) Flot. — Gdańsk (Mat.).
- decorticata* (Flk.) Spreng. — Gdańsk (Ohl. 70).
- deformis* (L.) Hoffm. — On acidic soil in pine-forests and psammophilous swards. Fr. 8 loc.: 65, 406-411, 414.
- digitata* (L.) Hoffm. — On soil rich in humus, on decaying wood and on bases of pine trunks. Fr. 11 loc.: 18, 32, 99, 125, 167, 405, 407-409, 411, 414. Sopot and Gdańsk (Mat.).
- fimbriata* (L.) Fr. — On soil, decaying wood and on bark of trees. Fr. 15 loc.: 32, 80, 132, 167, 321, 360, 405-411, 413, 415. Gdynia (Kr. 33), Sopot and Gdańsk (Mat.).
for. *prolifera* Retz. — Gdynia (Kr. 33).
- floerkeana* (Fr.) Flk. — On sandy soil in psammophilous swards. Fr. 13 loc.: 321, 360, 405-415. Gdańsk (Mat.).
- foliacea* (Huds.) Willd. — On sunexposed places, mainly in psammophilous swards. Fr. 13 loc.: 321, 360, 405-415. Gdańsk (Mat.).
- furcata* (Huds.) Schrad. — In forests and on open ground on acidic soil. Fr. 14 loc.: 32, 167, 321, 360, 365, 371, 405-409, 411, 414, 415. Gdańsk (Rey.; Mat.) and Gdynia (Kr. 33).
v. *furcata* for. *furcatosubulata* (Hoffm.) Vain. — Gdańsk (Mat.).
v. *palamaea* (Ach.) Nyl. for. *implexa* Flk. — Gdańsk (Mat.).
v. *pinnata* Vain. for. *foliosa* Del. — Gdynia (Kr. 33).
for. *truncata* Flk. — Gdynia (Kr. 33).

- for. *syratica* Ohl. — Gdańsk (Ohl. 70).
- glauca* Flk. — On soil, decaying wood and on bark of trees, especially on treebases. Fr. 15 loc.: 32, 99, 125, 167, 321, 360, 405-410, 413-415.
- gracilis* (L.) Willd. — On soil in pine-forests and psammophilous swards. Fr. 11 loc.: 321, 360, 406-412, 414, 415. Gdańsk (Mat.).
- macilenta* Hoffm. — On soil rich in humus and on decaying wood. Fr. 9 loc.: 405-410, 412, 413, 415. Gdańsk (Mat.).
- ochrochlora* Flk. — On soil, decaying wood and on bark of trees. Fr. 6 loc.: 32, 80, 359, 364, 390, 415. Gdańsk (Mat.).
- phyllophora* Ehrh. ex Hoffm. — On acidic soil in psammophilous swards and pine-forests. Fr. 11 loc.: 321, 360, 365, 405-411, 415. Gdańsk (Mat., as *C. degenerans* (Flk.) Spreng.).
- pleurota* (Flk.) Schaer. — On sandy soil in psammophilous swards. Fr. 5 loc.: 405-407, 409, 410. Gdańsk (Rey.; Mat.).
- pyxidata* (L.) Hoffm. — On sandy soil in psammophilous swards and pine-forests. Fr. 5 loc.: 32, 167, 222, 407, 409.
- for. *lophyra* Ach. — Gdańsk (Ohl. 70).
- ramulosa* (With.) Laundon — On sandy soil on sand-dunes. Fr. 1 loc.: 415. Gdańsk (Rey.; Ohl. 70; Mat., as *C. pityrea* (Flk.) Fr.).
- rangiformis* Hoffm. — On soil in psammophilous swards. Fr. 4 loc.: 407, 410, 414, 415. Gdańsk (Mat.).
- v. *pungens* (Ach.) Vain. — Gdańsk (Mat.).
- scabriuscula* (Del.) Leight. — On sandy soil in psammophilous swards. Fr. 13 loc.: 32, 365, 371, 405-411, 413-415. Gdańsk (Rey.; Mat.) and Gdynia (Kr. 33).
- for. *surrecta* Flk. — Gdańsk (Mat.).
- squamosa* (Scop.) Hoffm. — On soil rich in humus in pine-forests. Fr. 4 loc.: 407, 409, 414, 415.
- subulata* (L.) Web. in Wigg. — On sandy soil in psammophilous swards. Fr. 16 loc.: 32, 112, 321, 360, 365, 405-415. Gdańsk (Mat.) and Gdynia (Kr. 33, as *C. cornutoradiata* (Coem.) Vain.).
- uncialis* (L.) Wigg. — On acidic soil in pine-forests and psammophilous swards. Fr. 11 loc.: 405-415. Gdańsk (Rey.).

Coelocaulon

- aculeatum* (Schreb.) Link. — On sandy soil in pine-forests and psammophilous swards. Fr. 12 loc.: 260, 405-415. Gdańsk (Rey.; Kl.; Ohl. 70; Mat., as *Cornicularia aculeata* (Schreb.) Ach.).

Collema

- limosum* (Ach.) Ach. — Gdynia (Kr. 33, as *C. glaucescens* Hoffm.).
- tenax* (Sw.) Ach. emend. Degel. — On calciferous soil. F. 1 loc.: 212. Gdynia (Kr. 33, as *C. pulposum* Nyl.).

Coniocybe

furfuracea (L.) Ach. — On bark of deciduous trees, also on soil. C. 4 loc.: 64, 100, 167, 408. Gdynia (Kr. 33).

gracilentata Ach. — Gdynia (Kr. 33).

pallida (Pers.) Fr. — Sopot (Ohl. 70; Mat.).

Cyphelium

inquinans (Sm. in Sow. et Sm.) Trevis. — Gdańsk (Ohl. 70, as *Trachylia tympanella* Ach.).

tigillare (Ach.) Ach. — Gdańsk (Ohl. 70, as *Trachylia tigillaris* Pers.).

Dimerella

diluta (Pers.) Trevis. — On bark of elm. C. 1 loc.: 155.

Eopyrenula

leucoplaca (Wallr.) Harris. — Sopot (Ohl. 70, as *Verrucaria farrea* Ach.).

Evernia

prunastri (L.) Ach. — On bark of deciduous trees. Fr. 46 loc.: 30, 64, 89, 98, 132, 133, 140, 155, 169, 182, 184, 188-190, 192, 195, 205, 216, 223, 225, 226, 243, 247, 248, 259, 262, 267, 271, 278, 297, 300, 319, 323, 324, 390, 405-415. Gdańsk and Sopot (Rey.; Mat.).

v. *arenaria* Fr. — Gdańsk (Mat., as for. *arenophila* Ohl.).

Graphis

scripta (L.) Ach. — On bark of ash and oak. C. 1 loc.: 415. Gdynia (Kr. 33), Sopot (Mat.) and Gdańsk (Ohl. 70; Mat.).

v. *serpentina* (Schaer.) G. F. Mey — Sopot (Ohl. 70; Mat.), Gdynia and Gdańsk (Ohl. 70).

Gyalecta

truncigena (Ach.) Hepp — Gdańsk (Ohl. 70, as *Lecidea truncigena* Ach.).

Huilia

cinereoatra (Ach.) Hertel in Hawksw., P. James et Coppins — Gdynia (Kr. 38, as *Lecidea cinereoatra* Ach.).

crustulata (Ach.) Hertel — On siliceous stone. C. 1 loc.: 32. Gdynia (Kr. 33, as *Lecidea crustulata* (Ach.) Spreng.).

soredizodes (Lamy) Hertel — On siliceous stone. C. 1 loc.: 125. Gdynia (Kr. 38, as *Lecidea soredizodes* (Lamy) Sandst.).

tuberculosa (Sm.) P. James [*Lecidea tumida* Massal.] — On siliceous boulder. C. 1 loc.: 390.

Hypocenomyce

scalaris (Ach.) Choisy — On bark of deciduous trees and pines. S. 117 loc.: 4, 6, 14, 17, 18, 21, 22, 27, 31, 33, 39, 42-44, 47, 49-51, 55, 58, 64, 71-73, 77, 79, 80, 87, 89, 91, 95, 97-99, 110, 112, 125, 126, 132, 133, 135, 142, 145, 152-156, 160, 167, 169, 171-174, 176, 178, 180-182, 184-186, 188, 189,

191, 193, 196-202, 204-206, 221, 225, 227, 232, 235, 241, 243, 255, 266, 271, 295, 299, 316, 317, 320-324, 332, 334, 341, 345, 349, 351, 357, 359, 361, 364, 405-415. Gdynia (Kr. 33, as *Lecidea ostreata* Hoffm.) and Gdańsk (Mat., as *Lecidea ostreata* (Hoffm.) Schaer.).

Hypogymnia

physodes (L.) Nyl. — On bark of trees, on decaying wood, sometimes on soil.

F. 168 loc.: 2, 3, 5-8, 10, 11, 14, 15, 17, 21, 25, 30, 33, 34, 36-42, 44, 48, 49, 52, 55, 58, 60, 62-64, 66, 69, 71, 73, 75, 78-80, 83-87, 89-93, 97-99, 104, 105, 122, 124-126, 128, 129, 132, 133, 140, 141, 155, 160, 162, 165, 167, 168, 174, 175, 178, 182-186, 188-190, 192, 195, 202-207, 210, 213, 214, 221, 223, 225, 227, 230, 232, 235-238, 242, 243, 246-248, 262, 267, 268, 271, 283, 284, 289, 290, 295, 298, 300, 304, 305, 316-324, 326, 327, 329, 339, 352, 358, 359, 364, 367, 370-372, 379, 387, 389, 390, 405-415. Gdynia (Kr. 33, as *Parmelia physodes* (L.) Ach.), Sopot and Gdańsk (Mat.).

v. *subcrustacea* (Flot. ex Koerb.) Rassad. — 3 stan.: 126, 221, 379.

tubulosa (Schaer.) Hav. — On bark of deciduous trees. F. 4 loc.: 321, 406, 410, 415. Gdańsk (Mat.) and Gdynia (Kr. 33, as *Parmelia tubulosa* (Schaer.) Bitt.).

for. *farinosa* Hillm. — On bark of aspen. 1 loc.: 415.

Icmadophila

ericetorum (L.) A. Zahlbr. — Gdańsk (Mat.).

Lecania

cyrtella (Ach.) Th. Fr. — On bark of oak. C. 1 loc.: 30.

erysibe (Ach.) Mudd — On concrete. C. 3 loc.: 80, 388, 415.

Lecanora

albescens (Hoffm.) Flk. — On concrete and bricks, exceptional on bark of lime.

C. 21 loc.: 62, 70, 88, 102, 103, 113, 120, 179, 191, 212, 222, 253, 254, 256, 257, 261, 296, 302, 310, 385, 415.

for. *lignicola* (Zw.) A. Zahlbr. — On bark of lime. 1 loc.: 296.

allophana (Ach.) Nyl. — On bark of *Ulmus*. C. 1 loc.: 155.

argentata (Ach.) Malme [*L. subfuscata* H. Magn.] — On bark of deciduous trees. C. 65 loc.: 2, 7, 8, 12, 16, 30, 39, 41, 44, 46, 53, 56, 57, 60, 63, 70, 78, 80, 83, 84, 87, 89, 97, 98, 123, 124, 128, 131-133, 140, 141, 155, 161, 178, 182, 193, 195, 204, 216, 217, 225, 226, 232, 233, 241, 243, 246, 248, 284, 289, 297, 298, 300, 305, 308, 312, 324, 329, 330, 340, 390, 415. Gdynia (Kr. 33, as *L. subfusca* Ach. v. *argentata* Ach.).

atra (Huds.) Ach. — Gdańsk (Ohl. 70; Mat.).

campestris (Schaer.) Hue — Gdynia (Kr. 38).

carpineae (L.) Vain. — On bark of deciduous trees. C. 56 loc.: 3, 14, 17, 33, 34, 39, 41, 44, 45, 48, 63, 64, 72, 75, 80, 83, 98, 140, 155, 161, 174, 178, 190, 205, 207, 214, 216-218, 225, 226, 233, 241, 243, 246-249, 252, 254, 262,

- 267, 268, 308, 321, 327, 330, 339, 406, 409-415. Gdynia (Kr. 33), Sopot and Gdańsk (Mat.).
- cenisia* Ach. — Gdynia (Kr. 33, as *L. atrynea* (Ach.) Nyl.).
- chlarotera* Nyl. — On bark of deciduous trees. C. 15 loc.: 7, 124, 127, 128, 155, 161, 175, 177, 196, 207, 214, 258, 300, 321, 415.
- conizaea* (Ach.) Nyl. — On bark of trees and on decaying wood. C. 218 loc.: 1-7, 12, 14, 15, 17-23, 25, 29-37, 39, 41-43, 45, 46, 48-50, 52, 53, 56, 58, 59, 62, 64, 66, 68-73, 76-87, 90-97, 99, 101, 104, 105, 108, 110-112, 114, 121, 122, 125-127, 132, 133, 138, 140-142, 144, 145, 147-151, 153-160, 162-164, 166, 168-176, 178-182, 184, 185, 189, 196-202, 206, 209, 210, 213-217, 221, 227, 229, 232, 235-237, 239-241, 272, 279, 281, 285, 291, 292, 294, 295, 297, 299, 315-320, 323, 327-329, 332-339, 341, 343, 344, 349-354, 361, 367, 372, 373, 376-379, 381, 383, 384, 387, 392-398, 405-415. Gdańsk (Rey.) and Gdynia (Kr. 33).
- conizaeoides* Nyl. in Cromb. — On bark of trees, sometimes on decaying wood. C. 221 loc.: 1, 3-6, 14, 15, 17-22, 24-26, 30, 31, 33-37, 39, 42-44, 46-49, 51, 52, 64, 69, 71, 73, 77-81, 84, 86, 87, 89-99, 101, 103-106, 108, 112, 114, 119, 121, 122, 125, 126, 130, 132, 135, 136, 140-142, 144-159, 162-164, 166, 168-174, 176, 178-182, 184-186, 189, 190, 192, 194, 196-202, 206, 208-210, 213-215, 221, 227, 229, 231, 232, 235-241, 243, 246, 248, 254, 270, 271, 279, 281, 285, 291-295, 299, 309, 313, 315-318, 320-324, 327-330, 332-339, 341, 344, 349-354, 356, 357, 359, 361, 364, 367, 371-373, 375-381, 383, 384, 394-402, 404, 406, 410, 411, 413, 415.
- crenulata* (Dicks.) Hook. — On concrete. C. 5 loc.: 88, 179, 212, 222, 415.
- dispersa* (Pers.) Sommerf. — On concrete and bricks. C. 46 loc.: 53, 58, 62, 67, 70, 73, 88, 102, 103, 107, 109, 113, 115, 116, 118, 120, 122, 159, 163, 179, 191, 210, 212, 220, 222, 251, 253, 254, 256, 257, 260, 261, 286, 292, 302, 306, 310, 321, 331, 346, 366, 368, 385, 388, 409, 415. Gdańsk (Ohl. 70) and Gdynia (Kr. 33).
- for. *pruinosa* (Anzi ex Arn.) A. Zahlbr. — 1 loc.: 261.
- expallens* Ach. — On bark of deciduous trees, exceptional on pine. C. 75 loc.: 6, 7, 16, 30, 39-41, 44-46, 48, 64, 80, 83, 97, 98, 123, 124, 132, 133, 139-142, 146, 155, 162, 172, 181, 182, 187-190, 192, 205, 207, 211, 213, 214, 216, 217, 219, 224-226, 230, 233, 238, 241-244, 247, 248, 252, 254, 258, 267, 268, 271, 274, 279, 285, 288, 295, 308, 323-325, 330, 348, 355, 415.
- glabrata* (Ach.) Malme — On bark of hornbeam. C. 1 loc.: 99.
- hagenii* (Ach.) Ach. — On bark of deciduous trees, exceptional on decaying wood. C. 36 loc.: 7, 8, 10, 13, 45, 63, 131, 155, 204, 216, 223, 226, 233, 241, 243, 245, 249, 252, 254, 258, 260, 268, 269, 274, 277, 282, 283, 296, 299, 303, 309, 313, 314, 324, 344, 415. Gdańsk (Rey.), Sopot (Ohl. 70) and Gdynia (Kr. 33, 38).
- intumescens* (Rebent.) Rabenh. — On bark of beech and maple. C. 1 loc.: 178.
- muralis* (Schreb.) Rabenh. — On concrete and bricks. S. 11 loc.: 113, 220, 253, 254, 286, 310, 321, 378, 409, 410, 415. Gdańsk (Mat.).

- pallida* (Schreb.) Rabenh. — Gdynia (Kr. 33), Sopot and Gdańsk (Mat.).
- polytropa* (Ehrh.) Rabenh. — On stones and boulders. C. 3 loc.: 113, 220, 222. Gdańsk (Mat.).
- populicola* (DC. in Lam. et DC.) Duby — On bark of poplar. C. 1 loc.: 415.
- pulicaris* (Pers.) Ach. — On bark of deciduous trees. C. 32 loc.: 2, 6, 30, 33, 36, 39, 48, 58, 62, 83, 85, 97, 140, 141, 191, 192, 214, 216, 217, 219, 221, 223-226, 232, 233, 248, 254, 327, 370, 415. Sopot (Mat.) and Gdynia (Kr. 33, as *L. chlarona* Nyl.).
- saligna* (Schrad.) A. Zahlbr. — On bark of deciduous trees. C.
v. *saligna* — 2 loc.: 217, 415.
v. *sarcopis* (Ach.) Hillm. — 14 loc.: 2, 3, 122, 124, 133, 140, 155, 161, 165, 207, 216, 262, 274, 298.
- subrugosa* Nyl. — On bark of deciduous trees. C. 10 loc.: 15, 97, 124, 133, 155, 161, 203, 207, 233, 254.
- symmicta* (Ach.) Ach. — On bark of deciduous trees. C. 5 loc.: 97, 213, 214, 248, 415. Gdynia (Kr. 33) and Gdańsk (Ohl. 70, as *L. varia* Ach. v. *symmicta* Ach.).
- umbrina* (Ehrh.) Massal. — On bark of deciduous trees, rare on decaying wood. C. 30 loc.: 14, 17, 39, 48, 50, 52, 55, 63, 80, 84, 102, 140, 155, 196, 216, 218, 224, 226, 246, 255, 256, 267, 290, 296, 313, 329, 330, 356, 383, 415.
- varia* (Ehrh.) Ach. — On bark of trees and on decaying wood. C. 24 loc.: 7, 39, 42, 53, 62, 83, 87, 97, 99, 104, 161, 175, 191, 232, 248, 299, 358, 359, 362-364, 371, 387, 415. Sopot and Gdańsk (Mat.).

Lecidea

- albohyalina* (Nyl.) Th. Fr. — Gdańsk (Ohl. 70, as *L. globulosa* Flk. v. *albohyalina* Nyl.).
- erythrophaea* Flk. ex Sommerf. — Gdańsk (Ohl. 70, as *L. tenebricosa* Ach. v. *erythrophaea* Flk.).
- fuscoatra* (L.) Ach. — On boulder. C. 1 loc.: 390. Gdańsk (Mat.).
- nylanderi* (Anzi) Th. Fr. — Gdańsk (Rey.).
- quernea* (Dicks.) Ach. [*Protoblastenia quernea* (Dicks.) Clauz.] — Gdańsk (Rey.).
- turgidula* Fr. — Gdańsk (Ohl. 70).
- vernalis* (L.) Ach. — Gdańsk (Ohl. 70).

Lecidella

- achristotera* (Nyl.) Hertel et Leuckert — On bark of beech and elder. C. 2 loc.: 83, 415.
- elaeochroma* (Ach.) Choisy — On bark of deciduous trees. C. 51 loc.: 7, 16, 44, 45, 57, 60, 83, 97, 98, 123, 128, 133, 140, 141, 155, 177, 178, 192, 196, 207, 216, 219, 221, 223, 224, 226, 233, 241, 243-245, 252, 254, 263, 305, 312, 321, 327, 329, 330, 405-415. Gdynia (Kr. 33, as *Lecidea olivacea* (Hoffm.) Massal.), Sopot and Gdańsk (Mat., as *Lecidea parasema* Ach.).
- for. *flavicans* (Ach.) Th. Fr. — Gdynia (Ohl. 70, as *Lecidea parasema* v. *flavens* Nyl.).

- v. *hyaline* (Mast.) A. Zahlbr. — Gdańsk (Ohl. 70, as *Lecidea parasema* v. *colorata* Ohl.).
- euphorea* (Flk.) Hertel — On bark of deciduous trees. C. 6 loc.: 7, 8, 17, 39, 44, 415. Gdynia (Kr. 33, as *Lecidea euphorea* (Flk.) Nyl.).
- stigmatea* (Ach.) Hertel et Leuckert — On concrete. C. 12 loc.: 67, 102, 113, 145, 159, 251, 253, 254, 256, 378, 415.

Lepraria

- incana* (L.) Ach. — On bark of trees, sometimes on soil. C. 204 loc.: 1-3, 5-7, 13, 14, 16, 18, 21, 22, 30, 32, 39-41, 43-47, 49, 52, 53, 55, 56, 58, 59, 64, 67, 69, 70, 72, 73, 78, 80, 83, 84, 92, 93, 97-99, 106, 108, 110, 112, 114, 122, 123, 125-127, 130-134, 137-141, 145-147, 151, 154-157, 159-162, 164, 166-168, 171-176, 178, 180-186, 188-190, 192, 193, 195-201, 203-207, 211, 213, 214, 216, 217, 221, 223, 225-230, 232, 235-241, 248, 252, 254-256, 258-260, 262, 264, 266-268, 270, 271, 273, 277-280, 284, 285, 287, 288, 291, 294, 295, 304, 305, 309, 311, 313, 314, 317, 318, 320, 323-327, 329, 330, 333, 336, 342, 344, 345, 347, 348, 355, 356, 358, 359, 364, 376, 378, 380, 384, 390, 403, 405-415.
- membranacea* (Dicks.) Vain. — On bark of trees and on concrete. C. 21 loc.: 7, 16, 83, 132, 138-140, 142-144, 180-183, 190, 216, 217, 252, 253, 327, 377.

Leptogium

- lichenoides* (L.) A. Zahlbr. — On mosses on the embankment by the Vistula river. S. 1 loc.: 415. Gdynia (Kr. 33).

Lobaria

- pulmonaria* (L.) Hoffm. — Sopot, Gdańsk (Mat.).
- scrobiculata* (Scop.) DC. — Gdańsk (Ohl. 70, as *Stictina scrobiculata* Scop.).

Micarea

- denigrata* (Fr.) Hedl. [*Catillaria denigrata* (Fr.) Hedl.] — On bark of deciduous trees, on pines and on decaying wood. C. 6 loc.: 7, 39, 53, 292, 387, 415.
- peliocharpa* (Anzi) Coppins et R. Sant. [*Bacidia trisepta* (Naeg.) A. Zahlbr.] — On bark of sycamore. C. 1 loc.: 246.
- sylicola* (Flot.) Vězda et Wirth [*Lecidea sylicola* Flot.] — On boulder in the beech forest. C. 1 loc.: 390.

Nephroma

- resupinatum* (L.) Ach. — Sopot (Ohl. 70, as *Nephromium tomentosum* Hoffm.).

Ochrolechia

- arborea* (Kreyer) Almb. — On bark of hornbeam. C. 1 loc.: 390.

Opegrapha

- atra* Pers. — On bark of deciduous trees. C. 2 loc.: 140, 312. Gdańsk (Ohl. 70) and Gdynia (Kr. 33).
- for. *denigrata* (Ach.) Leight. — Gdańsk (Ohl. 70).
- for. *rimosa* (DC.) J. Nowak — Gdańsk (Ohl. 70, as v. *hapalea* Ach.).

- for. *abbreviata* Flk. — Gdańsk (Ohl. 70).
herbarum Mont. — Gdańsk (Ohl. 70, as *O. atro-rimalis* Nyl.).
niveoatra (Borr.) Laundon [*O. subsiderella* (Nyl.) Arn.] — On bark of maple and oak. C. 2 loc.: 97, 98.
rufescens Pers. — On bark of sycamore and ash. C. 2 loc.: 390, 415. Gdańsk (Ohl. 70) and Gdynia (Kr. 33, as *O. herpetica* Ach.).
varia Pers. — On bark of beeches. C. 2 loc.: 177, 390. Gdynia (Kr. 33).
 for. *astericus* Ohl. — Sopot (Ohl. 70).
 for. *phaea* (Ach.) Oliv. — Gdańsk (Ohl. 70).
viridis Pers. — On bark of beech. C. 1 loc.: 177. Sopot (Mat.) and Gdańsk (Ohl. 70; Mat.).

Pachyphiale

- fagicola* (Hepp ex Arn.) Zw. — Sopot (Ohl. 70, as *Lecidea congruella* Nyl.).

Pannaria

- pezizoides* (Web.) Trevis. — Gdynia (Kr. 33) and Gdańsk (Ohl. 70, as *Lecanora brunnea* Sw.).

Parmelia

- acetabulum* (Neck.) Duby — On bark of deciduous trees. F. 15 loc.: 134, 162, 175, 216, 221, 226, 228, 242, 244, 246, 248, 267, 290, 298, 300 (c.ap.).
caperata (L.) Ach. — Gdynia (Kr. 33) and Gdańsk (Kl.; Sulma — lg. 1956, could not be found again).
conspersa (Ehrh.) Ach. — Gdańsk (Mat.).
elegantula (A. Zahlbr.) Szat. — On bark of deciduous trees. F. 7 loc.: 3, 89, 133, 140, 190, 205, 207.
exasperata DNot. — Gdynia (Kr. 33, as *P. aspidota* Röhl.).
exasperatula Nyl. — On bark of deciduous trees. F. 46 loc.: 8, 16, 17, 39, 41, 44, 46, 48, 52, 55, 75, 78, 83, 89, 93, 124, 133, 149, 155, 182-184, 190, 191, 195, 203, 205-207, 226, 230, 233, 238, 246, 248, 254, 258, 267, 271, 290, 298, 300, 323, 324, 330, 415.
glabratula (Lamy) Nyl. — On bark of deciduous trees. F.
 v. *glabratula* — 31 loc.: 7, 9, 16, 18, 21, 30, 44, 64, 80, 84, 114, 122, 124, 128, 132, 140, 172, 175, 195, 205, 207, 214, 217, 225, 232, 247, 248, 254, 258, 319, 415. Sopot and Gdańsk (Mat.).
 v. *fuliginosa* (Fr. ex Duby) Grumm. — Gdynia (Kr. 38).
loxodes Nyl. — Gdańsk (Mat., as *P. glomellifera* Nyl.).
mougeotii Schaer. ex Dietr. — Gdynia (Kr. 38).
quercina (Willd.) Vain. — Gdynia (Kr. 33).
saxatilis (L.) Ach. — Gdańsk (Mat.).
subargentifera Nyl. — Gdynia (Kr. 33, as *P. verruculifera* Nyl.).
subaurifera Nyl. — On bark of deciduous trees. F. 6 loc.: 30, 98, 323, 358, 364, 390. Gdynia (Kr. 33).
sulcata Th. Tayl. — On bark of deciduous trees. F. 146 loc.: 2, 3, 5, 7-9, 11, 14, 16, 17, 30, 32-34, 41, 42, 44-46, 48, 52-55, 57, 58, 60, 61, 63, 64,

75, 78, 80, 83-87, 89, 90, 93, 97, 98, 121-124, 127-129, 131-134, 137, 140, 142, 149, 155, 160-162, 165, 175, 180, 182, 184, 185, 187-190, 192, 193, 195, 202-207, 210, 213, 214, 216-218, 221, 224-226, 230, 233, 237, 238, 241-244, 246-248, 258, 259, 262, 266, 267, 271, 274, 283, 284, 289, 290, 297, 298, 300, 304, 305, 307, 308, 319, 321, 323, 325, 326, 330, 334, 339, 340, 369, 370, 372, 389, 390, 405-415. Sopot and Gdańsk (Mat.).

tiliacea (Hoffm.) Ach. — On bark of lime and maple. F. 1 loc.: 254.

Parmeliopsis

aleurites (Ach.) Lett. — On bark of pines. F. 2 loc.: 409, 412. Sopot and Gdańsk (Mat.).

ambigua (Wulf.) Nyl. — On bark of deciduous trees. F. 13 loc.: 41, 64, 80, 98, 99, 125, 132, 214, 317, 327, 359, 390, 415. Gdynia (Kr. 33), Sopot and Gdańsk (Mat.).

Peltigera

canina (L.) Willd. — On soil in swards. F. 3 loc.: 32, 407, 415. Sopot and Gdańsk (Mat.).

degenii Gyeln. — Gdynia (Kr. 33).

didactyla (With.) Laundon — On soil in swards. F. 3 loc.: 32, 225, 415. Gdynia (Kr. 33, as *P. spuria* (Ach.) DC.) and Gdańsk (Rey.; Mat.).

horizontalis (Huds.) Baumg. — Gdynia (Kr. 33).

lactucifolia (With.) Laundon — Gdańsk (Mat., as *P. polydactyla* (Neck.) Hoffm. v. *crassoides* Gyeln.).

polydactyla (Neck.) Hoffm. — On soil in swards. F. 3 loc.: 30, 32, 415. Gdynia (Kr. 33), Sopot (Mat.) and Gdańsk (Ohl. 70; Mat.).

v. *leptophyllina* (Wallr.) Arn. — Gdańsk (Ohl. 70, as v. *submembranacea* Nyl.).

praetextata (Flk.) Zopf — On soil rich in humus in forests. F. 3 loc.: 30, 32, 205. Gdynia (Kr. 33).

rufescens (Weis) Humb. — On soil in swards. F. 4 loc.: 30, 32, 222, 415. Gdynia (Kr. 33).

venosa (L.) Hoffm. — Gdańsk (Ohl. 63).

Pertusaria

albescens (Huds.) Choisy et Wern. in Wern. — On bark of deciduous trees. C. v. *albescens* — 4 loc.: 80, 99, 205, 415. Gdynia (Kr. 33, as *P. orbiculata* (Schreb.) A. Zahlbr.).

v. *corallina* (A. Zahlbr.) Laundon — 1 loc.: 205.

amara (Ach.) Nyl. — On bark of deciduous trees. C. 15 loc.: 7, 30, 64, 80, 97, 98, 125, 132, 133, 140, 190, 192, 205, 389, 390. Sopot and Gdańsk (Mat.).

brachyspora Erichs. — Sopot (Er.). (?)

coccodes (Ach.) Nyl. — On bark of deciduous trees. C.

v. *coccodes* — 3 loc.: 39, 41, 89.

v. *phymatodes* (Ach.) Almb. — 1 loc.: 7.

- flavida* (DC.) Laundon — On bark of beech. C. 1 loc.: 390.
- hemisphaerica* (Flk.) Erichs. — On bark of beech and oak. C. 2 loc.: 80, 390. In 1965, this lichen was still abundant on localities 405 and 415, but during the present study *P. hemisphaerica* could not be found again.
- leioplaca* (Ach.) DC. — On bark of hornbeam. C. 1 loc.: 389. Gdynia (Kr. 33), Sopot and Gdańsk (Mat.).
- v. tetraspora* Th. Fr. — Gdynia (Kr. 33).
- pertusa* (L.) Tuck. — On bark of deciduous trees. C. 5 loc.: 7, 8, 39, 64, 80. Sopot (Mat.).

Phaeographis

- dendritica* (Ach.) Müll. Arg. — Gdańsk (Kl., as *Graphis dendritica* Ach.).

Phaeophyscia

- ciliata* (Hoffm.) Moberg — Gdańsk (Ohl. 70, as *Physcia obscura* Ehrh. v. *ulothryx* Ach.).
- nigricans* (Flk.) Moberg — On concrete. S. 13 loc.: 67, 102, 113, 118, 210, 253, 261, 302, 310, 321, 368, 378, 415.
- orbicularis* (Neck.) Moberg — On bark of deciduous trees and on concrete. F. 89 loc.: 8-10, 17, 28, 44, 52, 62, 74-78, 80, 88-90, 97, 102, 109, 113, 115, 117, 118, 123, 127, 131, 133, 142, 145, 151, 161, 162, 175, 180, 187, 190, 195, 202, 205, 207, 210, 212, 216, 218-220, 222-224, 226, 233, 241, 245, 249, 253 (c.ap.), 256-258, 261, 263, 267, 270, 277, 280, 282-284, 286, 288, 296, 299, 300, 302, 306, 310, 321, 324-326, 330, 342, 347, 360, 405, 408-411, 413, 415. Gdynia (Kr. 33, as *Physcia virella* Flag.).

Phlyctis

- argena* (Ach.) Flot. — On bark of deciduous trees. C. 82 loc.: 7, 8, 16, 21, 30, 39, 41, 44, 46, 47, 49, 52, 53, 62, 64, 70, 83, 97-99, 114, 123, 124, 128, 131-134, 140, 142, 143, 149, 155, 160, 162, 172, 174, 175, 177, 180, 182-185, 188, 190, 192, 193, 195, 203, 205-207, 216, 217, 221, 225, 226, 238, 243, 244, 247, 254, 258, 271, 278, 279, 288, 289, 295, 297, 300, 304, 324-326, 329, 330, 348, 390, 415. Gdynia (Kr. 33), Sopot and Gdańsk (Mat.).
- for. *erythroa* (Erichs.) Almb. — 1 loc.: 142.

Physcia

- adscendens* (Fr.) Oliv. — On bark of deciduous trees and on concrete. S. 180 loc.: 2, 3, 5, 7-11, 13-17, 30, 33, 34, 39, 41, 44-46, 48, 52-58, 60-62, 63 (c.ap.), 64, 66, 74-76, 78, 80, 83-86, 89, 90, 93, 95, 121, 123, 124, 127, 128, 130, 131, 133, 134, 136, 140-142, 149, 151, 155, 156, 159, 161, 162, 165, 174, 175, 178, 180, 182-187, 189-191, 193, 196, 197, 202-207, 210, 211, 216, 218, 219, 224, 226, 228, 233, 238, 241-247, 249-252, 254, 258, 259, 262-269, 271, 272, 274-278, 280, 282-284, 286, 288-290, 296-301, 303-309, 313, 314, 323-326, 330, 339, 340, 342, 343, 347, 348, 356, 360, 369, 370, 372, 374, 383, 384, 386, 406, 407, 409-411, 414, 415. Sopot and Gdańsk (Mat.).
- caesia* (Hoffm.) Hampe — On concrete. S. 11 loc.: 113, 118, 210, 253, 310, 360, 406, 409-411, 415 (c.ap.). Gdańsk (Mat.).

dubia (Hoffm.) Lett. — On bark of willow. S. 1 loc.: 415. Gdańsk (Mat.).
stellaris (L.) Nyl. — On bark of deciduous trees. F. 10 loc.: 90, 233, 243, 245, 264, 267, 289, 298, 415. Gdynia (Kr. 33)..

tenella DC. emend. Bitt. — On bark of deciduous trees and on concrete. S. 57 loc.: 44, 80, 122, 131, 140, 155, 175, 190 (c.ap.), 191, 205, 207, 216, 217, 219, 221, 224-226, 228, 230, 233, 241-243, 245-248, 251, 252, 258, 262, 264, 267, 268, 270, 271, 274, 278, 280, 288, 300, 305, 308, 310, 321, 323, 330, 372, 384, 406-408, 410, 411, 413, 415.

tribacia (Ach.) Nyl. — On bark of deciduous trees and on concrete. F. 4 loc.: 122, 155, 241, 253.

Physconia

distorta (With.) Laundon — On bark of deciduous trees. F. 14 loc.: 7, 8, 15, 16, 52, 56, 63, 78, 133, 190, 205, 207, 216, 340. Gdynia (Kr. 33, as *Physcia pulverulenta* (Schreb.) Hampe), Sopot (Mat.) and Gdańsk (Ohl. 70).
for. *argyphaea* (Ach.) Nyl. — Gdańsk (Ohl. 70).

enteroxantha (Nyl.) Poelt — On bark of deciduous trees. F. 37 loc.: 7, 8, 16, 83, 89, 122, 123, 127, 131, 133, 134, 162, 175, 180, 183, 184, 190, 205, 207, 216, 224, 226, 228, 243, 258, 263, 266, 267, 274, 277, 278, 282, 284, 290, 300, 383, 415.

grisea (Lam.) Poelt — On bark of deciduous trees and on concrete. F. 34 loc.: 52, 57, 131, 133, 155, 162, 175, 180, 205, 211, 223, 226, 228, 243-245, 247, 251, 252, 258, 271, 274, 284, 289, 296, 300, 304, 305, 307, 325, 330, 347, 377, 415.

perisidiosa (Erichs.) Moberg [*Physcia farrea* (Ach.) Vain.] — On concrete. S. 1 loc.: 415.

Placynthiella

oligotropha (Vain.) Coppins et P. James [*Lecidea oligotropha* Laundon] — On soil rich in humus and on bark of birch. C. 15 loc.: 65, 80, 318, 360, 405-415. Gdańsk (Mat., as *Lecidea uliginosa* Vain.).

uliginosa (Schrad.) Coppins et P. James [*Lecidea humosa* (Ehrh. ex Hoffm.) Nyl., *L. uliginosa* (Schrad.) Ach.] — On soil, decaying wood and on bark of beech. C. 15 loc.: 18, 40, 97, 240, 405-415.

Placynthium

nigrum (Huds.) S. F. Gray — On concrete embankment by the Vistula river. C. 1 loc.: 415 (det. Z. Tobolewski).

Platismatia

glauca (L.) W. Culb. et C. Culb. — On bark of deciduous trees, exceptionally on boulder. F. 18 loc.: 80, 91, 99, 132, 167, 232, 300, 317, 324, 359, 406-409, 411, 412, 414, 415. Gdańsk (Mat.).

Porina

aenea (Wallr.) A. Zahlbr. — On bark of deciduous trees. C. 3 loc.: 140, 141,

415. Gdynia (Kr. 33, as *P. carpinea* (Pers. ex Ach.) A. Zahlbr.) and Gdańsk (Ohl. 70, as *Verrucaria carpinea* Pers.).

for. *subathallina* Ohl. — Gdańsk (Ohl. 70).

chlorotica (Ach.) Müll. Arg. — Gdynia (Kr. 38).

Pseudevernia

furfuracea (L.) Zopf — On bark of deciduous trees and pines. F. 23 loc.: 52, 62, 87, 129, 167, 191, 192, 232, 246, 267, 271, 324, 405-415. Sopot and Gdańsk (Mat., as *Parmelia furfuracea* (L.) Ach.).

Pyrenula

nitida (Weig.) Ach. — On bark of beech and hornbeam. C. 2 loc.: 30, 389.

Gdynia (Kr. 33) and Sopot (Mat.).

Ramalina

baltica Lett. — Gdynia (Kr. 33).

farinacea (L.) Ach. — On bark of deciduous trees. Fr. 24 loc.: 7, 8, 16, 52, 64, 89, 98, 132, 175, 189, 190, 211, 216, 225, 226, 228, 247, 271, 297, 324, 405, 409, 410, 415. Sopot and Gdańsk (Mat.).

fastigiata (Liljebl.) Ach. — On bark of deciduous trees. Fr. 14 loc.: 7, 8, 178, 182, 189, 195, 205, 225, 246, 267, 297, 300, 413, 415.

fraxinea (L.) Ach. — On bark of deciduous trees. Fr. 9 loc.: 189, 224, 246, 297, 300, 330, 407, 413, 415. Gdańsk (Mat.).

pollinaria (Westr.) Ach. — On bark of maple. Fr. 1 loc.: 178.

Rhizocarpon

distinctum Th. Fr. — Gdynia (Kr. 38, as *Rh. ambiguum* A. Zahlbr.).

geographicum (L.) DC. — Gdynia (Kr. 38).

obscuratum (Ach.) Massal. — Gdańsk (Mat.).

Rinodina

conradii Koerb. — Gdańsk (Rey.; Ohl. 70, as *Lecanora conradii* Koerb.).

exiqua (Ach.) S. F. Gray — On bark of alder. C. 1 loc.: 140.

gennarii Balg. — On concrete. C. 4 loc.: 253, 254, 310, 415. Gdynia (Kr. 38, as

R. demissa (Flk.) Arn.).

laevigata (Ach.) Malme — Gdańsk (Rey., as *Lecanora sophodes* v. *laevigata*).

pyrina (Ach.) Arn. — On bark of deciduous trees, especially on maples.

C. 6 loc.: 7, 8, 11, 39, 140, 243.

Sarcogyne

regularis Koerb. [*S. pruinosa* (Sm.) Koerb.] — On concrete. C. 2 loc.: 113, 415.

Staurothele

catalepta Malme — On concrete embankment by the Vistula river. C. 1 loc.: 415.

Scoliciosporum

chlorococcum (Stenham.) Vězda [*Bacidia chlorococca* (Graeve) Lett.] — On bark of deciduous trees and pines. C. 20 loc.: 1, 30, 33, 64, 80, 125, 141, 214, 217, 230, 232, 260, 319, 406, 408-412, 415.

umbrinum (Ach.) Arn. [*Bacidia umbrina* (Ach.) Bausch.] — On boulder. C. 1 loc.: 390.

Strangospora

moriformis (Ach.) Stein [*Biatorella moriformis* (Ach.) Th. Fr.] — Gdańsk (Ohl. 70, as *Lecidea improvisa* Nyl. for. *trabicola* Koerb.).

pinicola (Massal.) Koerb. [*Biatorella pinicola* (Massal.) Anzi] — On bark of deciduous trees and on decaying wood. C. 7 loc.: 7, 39, 84, 155, 242, 387, 415.

Thelidium

velutinum (Bernh.) Koerb. — Sopot (Ohl. 70, as *Verrucaria velutina* Bernh.).

Trapelia

coarctata (Turn. ex Sm. et Sow.) Choisy in Wern. — On concrete and on non-caliceriferous stones. C. 3 loc.: 32, 321, 390.

involuta (Tayl.) Hertel [*T. ornata* (Sommerf.) Hertel] — On boulder. C. 1 loc.: 390.

Trapeliopsis

flexuosa (Fr.) Coppins et P. James [*Lecidea flexuosa* (Fr.) Nyl.] — On bark of alder and birch. C. 2 loc.: 232, 317. Gdańsk (Rey.).

granulosa (Hoffm.) Lumbsch in Hertel [*Lecidea granulosa* (Ehrh.) Ach.] — On soil, decaying wood and on bark of deciduous trees. C. 19 loc.: 40, 99, 217, 240, 267, 321, 359, 364, 405-415.

Usnea

hirta (L.) Web. in Wigg. — On bark of deciduous trees and pines. Fr. 14 loc.: 267, 323, 324, 405-415. Gdynia (Kr. 33) and Gdańsk (Ohl. 70, as *U. barbata* Fr. for. *hirta* L.; Mat.).

ssp. *villosa* Mot. — Gdynia (Kr. 33).

for. *sorediella* Oliv. — Gdańsk (Mat.).

subfloridana Stirt. — On bark of deciduous trees. Fr. 5 loc.: 390, 408-410, 415. Gdynia (Kr. 33, as *U. comosa* (Ach.) Röhl.).

v. *scabriuscula* Mot. — Gdynia (Kr. 33).

for. *sordidula* Mot. — Gdynia (Kr. 33).

ssp. *similis* Röhl. — Gdynia (Kr. 33).

Verrucaria

confluens Massal. — On concrete. C. 1 loc.: 222.

nigrescens Pers. — On concrete. C. 3 loc.: 113, 253, 310.

rupestris Schrad. — Gdynia (Kr. 33, 38).

Vezdaea

aestivalis (Ohl.) Tsch.-Woess et Poelt — Gdańsk (Ohl. 70, as *Lecidea aestivalis* Ohl.; Tschermak-Woess and Poelt 1976).

Xanthoria

calcicola Oxner — On concrete. F. 1 loc.: 415. Gdynia (Kr. 33, as *X. parietina* (L.) Th. Fr. v. *aureola* (Ach.) Th. Fr.).

candelaria (L.) Arn. — On bark of deciduous trees. S. 70 loc.: 3, 8, 9, 14, 33, 39, 44, 53, 56, 61, 80, 84, 86, 87, 89, 122, 123, 131, 156, 159, 160, 174, 180, 182, 189-191, 193, 204, 221, 223, 226, 232, 241-245, 246 (c.ap.), 247, 248, 250, 252, 255, 260, 262, 266-269, 271, 274, 277, 278, 282-284, 289, 290, 296, 298, 300, 306, 308, 309, 313, 314, 324, 339, 370. Gdańsk (Ohl. 70; Mat.).

elegans (Link.) Th. Fr. — Gdynia (Kr. 33, 38).

parietina (L.) Th. Fr. — On bark of deciduous trees and on concrete. F. 106 loc.: 7, 8, 14-17, 30, 44, 48, 52, 54, 55, 57, 60, 63, 65, 66, 72, 74, 75, 80, 86, 89, 90, 113, 118, 122, 123, 131, 133, 154, 155, 161, 162, 180, 183, 185, 187, 189-191, 195, 207, 210, 216, 218, 219, 223-226, 229, 232, 233, 241-243, 245, 249, 251, 252, 257, 258, 263, 265, 267-270, 272, 274, 280, 283, 284, 288, 296, 298-301, 303, 304, 306, 307, 310, 313, 324, 325, 330, 340, 342, 347, 360, 374, 383, 384, 406-413, 415. Gdynia (Kr. 33, 38), Sopot and Gdańsk (Mat.).

polycarpa (Ehrh.) Rieber — On bark of deciduous trees. S. 49 loc.: 9, 10, 14, 33, 34, 41, 48, 55, 61, 63, 75, 83, 85-87, 89, 189, 210, 216, 218, 219, 226, 233, 242, 244-246, 248, 249, 255, 258, 260, 262, 264, 267, 271, 278, 283, 296, 298, 304-306, 308, 313, 321, 324, 339, 415. Gdynia (Kr. 33).

6. SUMMARY OF RESULTS AND CONCLUSION

The current lichen flora of Gdańsk, Sopot and Gdynia comprises 183 species. An analysis of their distribution, and information on their state of health and the abundance of particular taxa provided the basis for distinguishing 4 zones of lichen occurrence — which is equivalent to defining areas variously affected by air pollution. They are:

1. Total lichen desert zone: this is the area where there are no epiphytic lichens and where calciphilous saxicolous species are rare and then only present in small numbers.

2. Relative lichen desert zone — characterized by the occurrence in small numbers (cover up to 5%) of the three epiphytic crustose species most resistant to air pollution, namely *Lecanora conizaea*, *L. conizaeoides* and *Lepraria incana*.

3. A stunted growth zone in which, besides, crustose and squamulose lichens, there are also foliose lichens, albeit usually deformed and atypical.

4. A normal growth zone in which are present lichens having thalli of all types of morphological organization.

Four groups of indicator species (Table 1) have been distinguished — they enable one to identify and characterize the lichen growth zones in the Gdańsk conurbation and the boundaries between them, and thus the degree of air pollution:

1. *Lecanora conizaea*, *L. conizaeoides* and *Lepraria incana* are the only epiphytic lichens growing within the relative lichen desert. At the same time their extreme localities delimit the boundary between the relative and total lichen deserts.

2. *Buellia punctata*, *Hypocenomyce scalaris* and *Physcia adscendens* — the extreme localities of these species determine the boundary between the relative lichen desert and the struggle zone.

3. The presence of *Hypogymnia physodes*, *Parmelia sulcata* and *Xanthoria parietina* in the simultaneous absence of fruticose lichens is typical of the struggle zone.

4. The extreme localities of *Evernia prunastri*, *Pseudevernia furfuracea* and *Ramalina farinacea* delimit the boundary between the struggle and normal growth zones.

The value of these indicator species is probably not limited only to the study area. The authors' own numerous observations and the literature data show that a simple, quick and cheap monitoring system can be based on the above groups of lichen species.

In recent decades, the lichen flora in Gdańsk, Sopot and Gdynia has been much impoverished. This study failed to reveal 85 species given by Reyger (1764-1766), Klinsmann (1863), Ohlert (1863, 1870), Krawiec (1933, 1938), Mattick (1934, 1937) and Erichsen (1936). Most of the lichen species which have been lost are very sensitive to air pollution, e.g. *Bryoria implexa*, *Lobaria pulmonaria*, *Nephroma resupinatum*, *Parmelia caperata*, *P. quercina*, *Peltigera venosa* and species of *Calicium*, *Coniocybe* and *Opegrapha*. The state of the lichen flora of the study area is rapidly deteriorating — an indication of this is the considerable expansion of the total lichen desert in Gdańsk from 1973 to 1984 (Fig. 12).

Unlike most other cities in which lichen-indicator studies have been undertaken, Gdańsk, Sopot and Gdynia display a unique belt-type layout of lichen growth zones. In their general outline, these zones lie parallel to the shore of Gulf of Gdańsk (Fig. 7). The total lichen desert stretches away on either side of the main traffic route extending from one end of the study area to the other and broadens distinctly in city centres and in port and industrial districts. The relative lichen desert zone is the area which will degenerate to total desert within a few years; this zone covers a large area in all three cities. With the exception of south and south-east Gdańsk the struggle zone is usually present as narrow strips along the edge of the Gdańsk Upland and along the sea shore. The normal growth zone is found in the close-canopy municipal woodland and in forest enclaves by the sea.

Changes in the boundaries of the lichen growth zones have been predicted on the basis of the results of this study (Fig. 13). The total and relative desert

zones and the struggle zone are tending to expand but areas of normal lichen growth are diminishing. The lichen desert and struggle zones will mostly extend away from either side of the main communication routes, i.e. the road and rail route connecting Gdańsk, Sopot and Gdynia, and the exit routes, and also in the direction of the prevailing winds, i.e. to the east and south-east. The normal growth zone will recede into the forests and its seashore enclaves will disappear.

The reaction of living organisms to air pollution presented in this paper is a clear warning. Around one million people in the Gdańsk conurbation live in the same conditions as these lichens, and almost half of them live and work in the total and relative lichen desert zones.

*Dr Wiesław Fałtynowicz
Department of Plant Ecology and Nature Protection,
University of Gdańsk,
Czołgistów 46, 81-378 Gdynia, Poland*

*Dr Ireneusz Izydorek
Department of Plant Ecology,
High Pedagogical School,
Arciszewskiego 22, 76-200 Słupsk, Poland*

*Mgr Elżbieta Budzbon
Institute of Environment Protection,
Techniczna 14, 81-528 Gdynia, Poland*

Translated by Peter Seen

7. STRESZCZENIE

Badania lichenoindykacyjne prowadzono w Gdańsku, Sopocie i Gdyni (Trójmiasto), na obszarze określonym granicami administracyjnymi w.w. miast. Teren ten, rozciągnięty wzdłuż brzegu Zatoki Gdańskiej, obejmuje kilka jednostek geomorfologicznych (ryc. 1). Głównymi czynnikami, decydującymi o rozmieszczeniu porostów w badanych miastach, są: — układ szlaków komunikacyjnych, — bardzo bogata rzeźba terenu, — stopień zanieczyszczenia powietrza, — rodzaj i zagęszczenie zabudowy, — bliskość Zatoki Gdańskiej i jej wpływ na czynniki klimatyczne, — czynniki klimatyczne (wiatry, opady, temperatura i wilgotność powietrza), — obecność dużych powierzchni lasów komunalnych.

W Trójmieście największymi emitorami zanieczyszczeń do atmosfery są zakłady przemysłowe, porty, stocznie, elektrociepłownie, kotłownie, paleniska domowe (bardzo liczne) i silniki spalinowe (samochody, lokomotywy spalinowe itp.).

Badania prowadzono w latach 1983-1984. Dokonano spisów porostów na 415 stanowiskach (ryc. 2).

Współczesna flora porostów badanego terenu liczy 183 gatunki. W trakcie badań nie odnaleziono 85 gatunków, podanych z obszaru Trójmiasta przez innych autorów (Reyger 1764-1766, Klinsmann 1863, Ohlert 1863, 1870, Krawiec 1933, 1938, Mattick 1934, 1937, Erichsen 1936).

Flora porostów badanych miast uległa w ciągu ostatnich kilkudziesięciu lat znacznemu zubożeniu. Większość z 85 taksonów, których współcześnie nie odszukano, to porosty bardzo wrażliwe na zanieczyszczenia powietrza, np. *Bryoria implexa*, *Nephroma resupinatum*, *Parmelia caperata*, *P. quercina*, *Peltigera venosa* oraz gatunki z rodzajów *Calicium*, *Coniocybe*, *Lobaria* i *Opegrapha* (ryc. 11). Tempo ubożenia lichenoflory w Gdańsku, Sopocie i w Gdyni jest szybkie, na co wskazuje m.in. znaczne zwiększenie się obszaru bezwzględnej pustyni porostowej w Gdańsku od 1973 do 1984 roku (Ryc. 12).

Analiza rozmieszczenia współcześnie występujących w badanych miastach gatunków porostów, dane dotyczące zdrowotności ich plech, oraz obfitości występowania stanowiły podstawę do wyróżnienia 4 stref lichenoindykacyjnych. Jest to równoznaczne z określeniem obszarów o różnym stopniu skażenia powietrza atmosferycznego, przede wszystkim przez dwutlenek siarki.

Wyróżniono następujące strefy (ryc. 7):

1. Bezwzględnej pustyni porostowej – obejmuje obszar, na którym nie występują gatunki epifityczne, a kalcyfilne gatunki epilityczne spotyka się bardzo rzadko i nielicznie.

2. Względnej pustyni porostowej – charakteryzuje się występowaniem w niewielkich ilościach (pokrywanie do 5%) trzech najbardziej odpornych gatunków epifitycznych o plechach skorupiastych i proszkowanych: *Lecanora conizaea*, *L. conizaeoides* i *Lepraria incana*.

3. Osłabionej vegetacji („walki”) – występują tutaj, obok porostów o plechach skorupiastych i łusczkowatych, gatunki o plechach listkowatych, ale z reguły zdeformowanych i przebarwionych.

4. Normalnej vegetacji – występują tutaj porosty o plechach reprezentujących wszystkie typy organizacji morfologicznej i nie wykazujące objawów obniżonej żywotności.

Wydzielono cztery grupy gatunków wskaźnikowych (tab. 1), za pomocą których można zidentyfikować i scharakteryzować strefy vegetacji porostów w badanych miastach oraz granice między poszczególnymi strefami, a także określić stopień zanieczyszczenia powietrza atmosferycznego:

1. *Lecanora conizaea*, *L. conizaeoides* (ryc. 3) i *Lepraria incana* są jedynymi porostami epifitycznymi, które rosną w obrębie względnej pustyni porostowej. Ich krańcowe stanowiska stanowią jednocześnie granicę między strefami względnej i bezwzględnej pustyni porostowej.

2. *Buellia punctata* (ryc. 3), *Hypocenomyce scalaris* i *Physcia adscendens* – krańcowe stanowiska tych gatunków wyznaczają granicę między względną pustynią porostową a strefą osłabionej vegetacji.

3. *Hypogymnia physodes* (ryc. 4), *Parmelia sulcata* (ryc. 4) i *Xanthoria parietina*, przy jednoczesnym braku porostów krzaczkowatych, wyróżniają strefę osłabionej vegetacji.

4. *Evernia prunastri*, *Pseudevernia furfuracea* i *Ramalina farinacea* – ich krańcowe stanowiska wyznaczają granice między strefami osłabionej i normalnej vegetacji.

Wartość wyróżniający omówionych wyżej grup gatunków wskaźnikowych nie jest prawdopodobnie ograniczony tylko do terenu badanych miast. Liczne obserwacje własne autorów, a także dane literaturowe, wskazują, że opierając się na wymienionych wyżej grupach gatunków (por. także tab. 1) można stworzyć prosty, tani i szybki system monitoringu. Należy jednak przeprowadzić jeszcze ukierunkowane badania w innych miastach w różnych regionach kraju.

W stosunku do innych miast, w których prowadzono badania lichenoindeksacyjne, Trójmiasto wyróżnia specyficzny pasmowy układ stref występowania porostów. W ogólnym zarysie strefy te układają się równolegle do brzegu Zatoki Gdańskiej (ryc. 7). Strefa bezwzględnej pustyni porostowej rozciąga się na terenach położonych wzdłuż głównej osi komunikacyjnej przecinającej badany obszar i wyraźnie rozszerza się w centralnych częściach miast oraz przy

dzielnicach portowo-przemysłowych. Strefa względnej pustyni porostowej stanowi obszar, który w najbliższych latach przekształci się w pustynię bezwzględną i zajmuje znaczną powierzchnię w każdym z badanych miast. Strefa osłabionej roślinności występuje z reguły (z wyjątkiem południowej i południowo-wschodniej części Gdańska) w postaci wąskich pasów położonych na krawędzi Wysoczyzny Gdańskiej oraz wzdłuż brzegu Zatoki Gdańskiej. Strefa normalnej roślinności jest związana ze zwartymi kompleksami leśnymi lub z enklawami lasu nad brzegiem morza.

Na podstawie uzyskanych wyników opracowano prognozę zmian granic wyróżnionych stref roślinności porostów na terenie badanych miast (ryc. 13). Zarysowuje się wyraźna tendencja do powiększania obszarów zajętych przez bezwzględną i względną pustynię porostową oraz strefę osłabionej roślinności. Jednocześnie zmniejsza się powierzchnia terenów o normalnej roślinności porostów. Rozszerzanie się pustyni i strefy osłabionej roślinności następować będzie przede wszystkim prostopadle do głównych szlaków komunikacyjnych, tj. do szlaku drogowo-kolejowego Gdańsk-Sopot-Gdynia oraz ulic wylotowych, a także zgodnie z najczęstszymi kierunkami wiatrów, tj. w kierunku wschodnim i południowo-wschodnim. Strefa normalnej roślinności ulegnie przesunięciu w głąb kompleksów leśnych, a jej enklawy na obrzeżach Zatoki Gdańskiej zanikną.

Przedstawiona w niniejszej pracy reakcja żywych organizmów na zanieczyszczenia powietrza jest wymownym ostrzeżeniem. W takich warunkach jak porosty, żyje w aglomeracji gdańskiej około jednego miliona ludzi, z których prawie połowa mieszka i pracuje w strefach bezwzględnej i względnej pustyni porostowej.

8. REFERENCES

- Andrzejewski R., 1975. Problemy ekologiczne kształtowania środowiska w mieście. Wiad. Ecol. 21: 175-186.
- Barkman J.J., 1969. Phytosociology and ecology of cryptogamic epiphytes. Van Gorcum et Comp. N. V., Assen.
- Brightman F.H., 1959. Some factors influencing lichen growth in towns. Lichenologist 1: 104-108.
- Brodo I.M., 1972. Lichens and cities. In: International Symposium on Identification and Measurement of Environmental Pollutants, ed. B. Westley. National Research Council, Ottawa, p. 325-328.
- Czyżewska K., 1976. Zanikanie porostów epifitycznych pod wpływem antropogenicznej degeneracji lasów liściastych Puszczy Pilickiej. Phytocoenosis 5: 363-375.
- Deruelle S., 1978. Les lichens et la pollution atmosphérique. Bull. Ecol. 9, 2: 87-128.
- Doll R., 1976. Die Verbreitung der epixylen Flechten in der Kreisstadt Parchim (Mecklenburg). Z. Hyg. Berlin 22: 840-843.
- Erichsen C.F.E., 1936. *Pertusariaceae*. In: Rabenhorst's Kryptogamen-Flora von Deutschland, Österreich und der Schweiz. 9, 5, 1: 321-728. Akademie Verlag, Leipzig.
- Fabiszewski J., Brej T., Bielecki K., 1983. Fitoindykacja wpływu huty miedzi na środowisko biologiczne. Pr. Wrocł. Tow. Nauk, E 207: 5-109.
- Fałtynowicz W., Herbichowa M., Herbich J., Markowski R., Szmeja J., 1980a. Współczesny stan flory i zbiorowisk roślinnych projektowanego rezerwatu "Łasy w Dolinie Bystrzcy". Unpubl., Gdańsk University.
- Fałtynowicz W., Herbichowa M., Herbich J., Markowski R., Szmeja J., 1980b. Współczesny stan flory i zbiorowisk roślinnych projektowanego rezerwatu "Źródlika w Dolinie Ewy". Unpubl., Gdańsk University.
- Fałtynowicz W., Herbichowa M., Herbich J., Markowski R., Szmeja J., 1980c. Współczesny stan flory i zbiorowisk roślinnych projektowanego rezerwatu "Kacze Łęgi". Unpubl., Gdańsk University.
- Fałtynowicz W., Picińska-Fałtynowicz J., Szmeja J., 1985. Roślinność projektowanego Nadmorskiego Ogrodu Botanicznego w Trójmieście. Zesz. Nauk. Wyd. BGiO UG, Biol. 6: 117-131.
- Farkas E., Lőkös L., Verseghy K., 1985. Lichens as indicators of air pollution in the Budapest agglomeration. Acta Bot. Hungarica 31, 1-4: 45-68.
- Gilbert O.L., 1973. Lichens and air pollution. In: The lichens. Eds. V. Ahmadjian and M.E. Hale, Academic Press, New York-London, p. 443-472.
- Hawksworth D.L., 1971. Lichens as litmus for air pollution: a historical review. Intern. J. Environmental Studies 1: 281-296.
- Hawksworth D.L., Rose F., 1970. Qualitative scale for estimating sulphur dioxide air pollution in England and Wales using epiphytic lichens. Nature 227: 145-148.
- Hawksworth D.L., Rose F., 1976. Lichens as pollution monitors. Edward Arnold Ltd., London, 60 pp.

- Instytut Kształtowania Środowiska, 1984. Raport o stanie środowiska miasta Gdańska. Unpubl., Gdynia.
- Kiszka J., 1975. Wpływ emisji miejskich i przemysłowych na florę porostów. *Aura* 10: 7-8.
- Kiszka J., 1977. Wpływ emisji miejskich i przemysłowych na florę porostów (*Lichenes*) Krakowa i Puszczy Niepołomickiej. *Pr. Monogr. WSP w Krakowie* 19: 5-132.
- Klinsmann E.F., 1863. Beiträge zu einer Cryptogamen-Flora Danzigs, erweitert durch Mitteilungen aus West- und Ostpreussen mit einem einleitenden Bericht der ganzen botanischen Literatur der Provinz Preussen. *Schrift. Kgl. Phys.-ökon. Ges. Königsberg* 3: 36-62.
- Kołodziejski J., 1982. Podstawowe kierunki rozwoju układu funkcjonalno-przestrzennego dolnej Wisły. In: *Dolina Dolnej Wisły*. Ed. B. Augustowski. Ossolineum, Wrocław-Warszawa-Kraków-Gdańsk-Łódź, p. 421-449.
- Kołodziejski J., 1984. Stan i prognoza zagospodarowania przestrzennego. In: *Pobrzeże Pomorskie*. Ed. B. Augustowski. Ossolineum, Wrocław-Warszawa-Kraków-Gdańsk-Łódź, p. 611-641.
- Kozik R., 1970. Porosty miasta Tarnowa i okolicy. *Fragm. Flor. Geobot.* 16: 361-381.
- Krawiec F., 1933. Materiały do flory porostów Pomorza. *Acta Soc. Bot. Pol.* 10: 25-47.
- Krawiec F., 1938. Flora epilityczna głazów narzutowych zachodniej Polski. *Pr. Komis. Mat.-Przyr. PTPN*, B 9: 1-254.
- Kuziel S., Halicz B., 1979. Występowanie porostów epifitycznych na obszarze Łodzi. *Łódzkie Tow. Nauk., Spraw. z Czynności i Posiedzeń Naukowych* 33: 1-7.
- Kwiecień K., 1979. Warunki klimatyczne. In: *Pojezierze Kaszubskie*. Ed. B. Augustowski. Ossolineum, Gdańsk, p. 95-120.
- Kwiecień K., 1982. Główne cechy klimatu. In: *Dolina Dolnej Wisły*. Ed. B. Augustowski, Ossolineum, Wrocław-Warszawa-Kraków-Gdańsk-Łódź, p. 81-101.
- Laundon J.E., 1967. A study of the lichen flora of London. *Lichenologist* 3: 277-327.
- LeBlanc F., De Sloover J., 1970. Relation between industrialization and the distribution and growth of epiphytic lichens and mosses in Montreal. *Can. J. Bot.* 48, 7: 1485-1496.
- Mattick F., 1934. Die Flechten des Gebietes der Freien Stadt Danzig. *Ber. Westpr. Bot.-Zool. Ver.* 56: 46-57.
- Mattick F., 1937. Flechtenvegetation und Flechtenflora des Gebietes der Freien Stadt Danzig. *Ber. Westpr. Bot.-Zool. Ver.* 59: 1-54.
- Nowak J., 1986. Wykaz porostów Polski. Unpubl., Institute of Botany, Cracow.
- Ohlert A., 1863. Verzeichniss Preussischer Flechten. *Schrift. Kgl. Phys.-ökon. Ges. Königsberg* 4: 6-34.
- Ohlert A., 1870. Zusammenstellung der Lichenen der Provinz Preussen. *Schrift. Kgl. Phys.-ökon. Ges. Königsberg* 11: 1-31.
- Olech M., Dudek K., 1981. Epiphytic lichens of Skawina (southern Poland). *Zesz. Nauk. UJ, Pr. Bot.* 8: 173-189.
- Piotrowska H., Mąkosa K., 1985. Warunki fizjograficzne i roślinność leśna nadleśnictwa Gdańsk. *Sylvan* 129: 61-69.
- Piotrowska H., Stasiak J., 1975. Ocena stanu zdrowotności drzew ulicznych miasta Gdańska oraz określenie gatunków najbardziej przydatnych do nasadzeń ulicznych. Unpubl., Gdańsk University.
- Piskozub A., Wyszomirski O., 1982. Komunikacja. In: *Dolina Dolnej Wisły*. Ed. B. Augustowski, Ossolineum, Wrocław-Warszawa-Kraków-Gdańsk-Łódź, p. 377-399.
- Rao D.N., LeBlanc F., 1966. Effects of sulphur dioxide on the lichen alga, with special reference to chlorophyll. *Bryologist* 69: 69-75.
- Reyger G., 1764-1766. Tentamen Florae Gedanensis methodo sexuali accomodate. *Dantisci*: I - 293 pp; II - 224 pp. Gedani.
- Richardson D.H.S., Puckett K.J., 1973. Sulphur dioxide and photosynthesis in lichens. In: *Air pollution and lichens*. Eds. B.W. Ferry. M.S. Baddeley and D.L. Hawksworth. The Athlone Press, London, p. 283-298.

- Różycka W., 1978. Opracowania fizjograficzne jako źródło informacji o środowisku abiotycznym na obszarach zurbanizowanych. Wiad. Ekol. 24: 41-50.
- Santesson R., 1984. The lichens of Sweden and Norway. Grafiska Tryckeriet, Stockholm and Uppsala.
- Seaward M.R.D., 1977. A nature touch to stonework. Gardeners Chronicle 182: 35-37.
- Seaward M.R.D., 1979. Lower plants and the urban landscape. Urban Ecology 4: 217-225.
- Seaward M.R.D., 1980. The use of lichens as bioindicators of ameliorating environments. In: Bioindikation auf der Ebene der Individuen. Eds. R. Schubert and J. Schub. Martin-Luther-Universität, Halle-Wittenberg, pp. 17-23.
- Seaward M.R.D., 1982. Lichen ecology of changing urban environments. In: Urban ecology. The Second European Ecological Symposium, Berlin, 8-12 September 1980. Eds. R. Bornkamm, J.A. Lee and M.R.D. Seaward. Blackwell Sci. Pubs., Oxford, pp. 181-189.
- Sowa R., Olaczek R., 1978. Stan badań szaty roślinnej miast Polski. Wiad. Ekol. 24: 25-42.
- Sukopp H., 1983. Ökologische Charakteristik von Grossstädten. In: Grundriss der Stadtplanung. Akademie für Raumforschung und Landesplanung, Hannover, pp. 51-82.
- Sukopp H., Elvers H., Mattes H., 1982. Studies in urban ecology of Berlin (West). In: Zwierzęta w świecie zurbanizowanym. Ossolineum, Wrocław, p. 115-130.
- Sukopp H., Werner P., 1983. Urban environments and vegetation. In: Man's impact on vegetation. Eds. W. Holzner, M.J.A. Werger and I. Ikusima. Dr W. Junk Publ., Hague-Boston-London, pp. 247-260.
- Szukalski J., 1974. Środowisko geograficzne Trójmiasta (Gdańsk, Sopot, Gdynia). Wyd. Uniwersytetu Gdańskiego, Gdańsk.
- Śpiewakowski M.R., Izydorek I., 1981. Porosty Słupska na tle warunków ekologicznych miasta. Wyd. WSP, Słupsk.
- Toborowicz K., 1976. Porosty miasta Kielc i najbliższej okolicy. Fragm. Flor. Geobot. 22: 575-603.
- Tschermak-Woess E., Poelt J., 1976. *Vezdaea*, a peculiar lichen genus, and its phycobiont. In: Lichenology: progress and problems. Eds. D.H. Brown, D.L. Hawksworth and R.H. Bailey, Academic Press, London-New York, pp. 89-105.
- Vaarana V.V., 1934. Helsingin kaupungin puiden ja pensaiden jäkäläkasvisto. Ann. Bot. Soc. Zool.-Bot. Fenn. "Vanamo" 5: 1-32.
- Weichler H. v., 1935. Beiträge zur Kenntnis der Vegetationsverhältnisse der Dünen bei Danzig. Die Dünentaler. Schrift. Naturf. Ges. Danzig 20: 49-63.
- Wirth V., 1980. Flechtenflora. E. Ulmer Verl., Stuttgart.
- Wójcicka I., 1973. Miasto a przekształcenia środowiska przyrodniczego. Biul. Inst. Urbanistyki i Architektury 32: 25-43.
- Zatorska J., 1984. Ochrona i kształtowanie środowiska. In: Pobreże Pomorskie. Ed. B. Augustowski. Ossolineum, Wrocław-Warszawa-Kraków-Gdańsk-Łódź, pp. 361-383.
- Zimny K., 1976. Miasto jako układ ekologiczny. Wiad. Ekol. 22: 345-353.