© Verlag Alexander Just: Dorfbeuern - Salzburg - Brüssel; download unter www.biologiezentrum.at

Sauteria 9, 1998 IAL 3 - Proceedings 71-78

THE LICHEN SYNUSIA OF A BIRCH FOREST (SOUTHERN URALS) WITH RESPECT TO INDICATION OF RADIOACTIVE CONTAMINATION AND DIAGNOSING OF ECOSYSTEM HEALTH

Die Flechten Synusien eines Birkenwaldes (südlicher Ural) als Indikator für radioaktive Kontamination zur Bewertung des Gesundheitszustandes von Ökosystemen

by

Lev G. Biazrov

Key words: Bioindication, radioactive contamination, ecosystem health, lichens.

Schlagwörter: Bioindikation, radioaktive Kontamination, Gesundheit des Ökosystems, Flechten.

Summary: In 30 years after nuclear accident at South Urals (Kyshtym) were studied a state of lichen vegetation in forest communities of the contaminated territory and a reaction of lichens to prolong effect of radioactive contamination. Only such index as concentration of radionuclides in thalli of epiphytic lichens reflects more or less degree of radioactive contamination of territory.

Zusammenfassung: 30 Jahre nach dem Reaktorunfall südlich des Urals (Kischtim) studierte man den Flechtenvegetationszustand in Waldbeständen des kontaminierten Gebietes und die Resonanz der Flechten unter dauerndem Einfluß einer radioaktiven Kontamination. Nur die Konzentration von Radionukliden in Flechtenlagern spiegelt mehr oder weniger die Belastung der radioaktiven Verschmutzung wider.

© Verlag Alexander Just: Dorfbeuern - Salzburg - Brüssel; download unter www.biologiezentrum.at

Introduction

Over the last several years enjoy rather wide popularity the conception of "ecosystem health" (SHRADER-FERCHETTE 1994). In my opinion, "the health of ecosystem" is the degree to which the revealed integral indications of the ecosystem under study correspond to the properties which are expected in certain place, and whose picture is formed either on the basis of the personal experience of the expert or by the results obtained by other researches under similar conditions. Diagnosing can be made by comparing a wide range of signs of the specific ecosystem and ecosystem imaginary for the given conditions. The use of ecological indicators can be undoubtedly very helpful in making a correct diagnosis. The presence of rather much quantity of man-made radionuclides in an ecosystem is serious symptom of the illness of the ecosystem.

A purpose present paper is an estimation of a suitableness of the lichens for diagnosing of ecosystem health in cases of radioactive contamination of an area and what characteristics of lichens are necessary to study for trustworthy diagnosis.

Area, objects, methods

In 1957 close to a military plant in the Chelyabinsk Region (the Urals) took place an explosion of a depot for wastes of the nuclear industry; the pollutant being mainly Sr-90. As a result the so-called Eastern-Urals radioactive trace was formed of about 10 km wide and above 100 km long. Areas of the same type were chosen in a birch forest at a comparatively short distance from the place of explosion between lakes Kasli and Bolshoj Kuyash:

- **plot A** of a high degree of contamination, which is situated in the centre of the radioactive trace and is close to the site of explosion. The level of contamination by Sr-90 was estimated shortly before my study to be 8×10^{10} Bq / km^2 or more than 310×10^{10} Bq / km^2 in 1957;
- **plot B** of the medium degree of contamination, which is situated several kilometres to the East-North-East from site A, on the edge of the trace. The level of contamination at this site is 2×10^{10} Bq / km^2 or above 80×10^{10} Bq / km^2 in 1957;
- **plot C** is situated outside the main radioactive trace though it could be subjected to particles of radionuclides due to wind migration.

Sites A, B, and C relate to grassy birch forest which is formed by *Betula verrucosa* of sprout and seed origin with prevailing 50 to 60 years trees.

More than 30 tree trunks of different diameters were inspected on each area under study for recording of epiphytic lichens. Two level of lichen settlements were established on the inspected trunk: the base, or butt, of a tree,

© Verlag Alexander Just: Dorfbeuern - Salzburg - Brüssel; download unter www.biologiezentrum.at

from the ground surface to the height of 0.3 m (1), and the trunk level, at the height of a man's breast or 1.3 m (2). On each of these levels of lichen settlement, four plots were inspected each of 20 x 20 cm wide and oriented respectively to the North, East, South, and West. Species identify of the found thalli, their life form, and covering (in %) by representatives of each species were recorded on these plots.

On the inspected sites the lichens belong to the following groups of life forms: (Cr) monotonous crustose, (Sq) squamose crustose, (Sl) rhizoid lobate foliaceous, (Cl) non-rhizoid inflated-lobate foliaceous, (Sc) with awl-shaped and cup-shaped or blunt clubs podetia squamose-fruticose, (Fp) pendulous fruticose (GOLUBKOVA, BIAZROV 1989).

At the same time, thalli of *Hypogymnia physodes* (Cl) and *Parmelia sulcata* (Sl) were collected to measure of radionuclides activity in them. The lichens were taken from several trees of the inspected site. Separately thalli of diameter below 20 mm (the age of 8 to 10 years), 21 to 40 mm (the age from 8-10 to 16-20 years), and above 40 mm (the age above 16-20 years old) were taken on site A to reveal the dependence of accumulation of radionuclides by thalli from the age of the thalli.

Results and Discussion

Information about the composition of epiphytic lichens on trees in plots under study is presented in Table 1. Some indices in this table need explanations: "frequency, %" mean a part (in percentage) of the tree trunks on which lichens were found in the inspected level of a settlement, in relation to the total number of the inspected trunks in the plot under study; "life forms spectrum, %" means a part (in percentage) of species which belong to the one group of life forms, with respect to the total number of species in the inspected level of a settlement on trunks.

The results prove that the composition of lichen species on the sites subjected to a different degree of contamination by radionuclides have both much in common and certain differences. Three inspected plots of grassy birch forest have a common main body of epiphytic lichen flora. Fifteen of the 30 recorded species were found on all three plots under study. Percentage similarity of lichen species composition of plots under study is rather high - from 50 to 82.

Main direction of the radioactive trace from the place of the explosion is North-North-East. Occurrence of lichens on different inspected surfaces of tree trunks is far from same (Table 2). It is different on the studied levels of settlement also. The lichens are least abundant on the southern side of a trunk and are most frequent on the northern side, though they are found quite frequently on the eastern and western sides of trunks as well. Such distribution

© Verlag Alexander Just: Dorfbeuern - Salzburg - Brüssel; download unter www.biologiezentrum.at

of lichens are typical of forests in forest-steppe regions (BIAZROV 1974). The inspected plots do not actually differ in these indices. Therefore, the outburst of radionuclides in 1957 does not reveal any peculiarities of lichens distribution on different inspected sides of trunks 30 years after the accident.

The lichens of plots under study belong to six groups of life forms, while only Plot A has no representatives of squamose crustose (Sq) lichens, and the composition of life forms of Plots B and C coincide.

Various lichen species associate with other lichen species in tree trunks and form lichen synusium. Depending on the complexity of association they are divided into several types:

- **gregations** which means combinations of individuals of one species;
- **aggregations** which means combinations of individuals of different species of one life form;
- **congregations** which means combinations of individuals of species of different life forms which create one layer, i.g. they have no co-ordination;
- **mixgregations** which means combinations of individuals of different life forms which are included in different layers, i.g. they have co-ordination.

The quota of lichen synusium which belong to the cited types of association is almost the same on all three inspected areas irrespective of the degree of contamination by radionuclides (Table 3). The existing differences between the plots under study are within natural spatial variation of the index.

The values of the concentration of radionuclides in thalli of lichens on the Plot C outside the trace are close to the baseline values for the Urals (Table 4). However on the contaminated Plots A and B the values of radionuclides activity in thalli correspond to the level of contamination of an area. It is all the more notable that of the thalli chosen for measurements most probably had no thalli which would date to the time of the explosion of the depot of radioactive wastes. The thalli were predominantly 15 to 20 years old. They appeared after explosion. They developed in the conditions of the increased radiation background which resulted in accumulation of radionuclides of different quantities. Judging from the results of measurements of activity in the thalli of different diameters, there is a distinct and direct relationship between accumulation of isotopes and the period of effect of the radioactive background. The thalli of both species greater than 40 mm in diameter (the older ones) have a higher concentration of radionuclides than the thalli of smaller diameters.

Thus, the study of epiphytic lichens undertaken 30 years after the nuclear accident in the Urals on three plots of grassy birch forest has proved that, at the time of the study, only such index as concentration of radionuclides in thalli of epiphytic lichens reflects more or less degree of contamination of territory. Comparison of lichens of three plots by other indices (composition of lichen

© Verlag Alexander Just: Dorfbeuern - Salzburg - Brüssel; download unter www.biologiezentrum.at

species, of complex of lichen synusium, degree of their development, etc.) has not revealed marked differences between the inspected plots with respect to these indices. They do not go outside variation of indications of lichen vegetation on trees, and it is not possible to explain them by the effect of some external factors.

Acknowledgements

I am much obliged to the Organisers of IAL3-Symposium for financial support to my participation in Symposium.

References

BIAZROV, L.G. (1974): Lichen synusia in herb larch forest (Khangai mountain ridge, Mongolia). *Botanicheskij Zhurnal* (USSR) **59, 10**: 1425-1438 (In Russian).

GOLUBKOVA, N.S. & L.G. BIAZROV (1989): Life forms of lichens and lichen synusia. *Botanicheskij Zhurnal* (USSR) **74, 6**: 794-805 (In Russian).

SHRADER-FRECHETTE, K.S. (1994): Ecosystem health: a new paradigm for ecological assessment? *Trends in ecology and evolution* **9, 12**: 456-457.

Address:

Lev G. Biazrov
Inst. Ecology & Evolution, Russian Acad. Sci.,
Leninsky pr. 33
Moscow 117071
Russia
Fax: 7 095 954 55 34
E-Mail: sevin@glas.apc.org

© Verlag Alexander Just: Dorfbeuern - Salzburg - Brüssel; download unter www.biologiezentrum.at

Table 1: Mean covering (%) lichens on trees in birch forest plots situated in different parts of East-Urals radioactive trace with respect to level of radioactive contamination

Lichens	Life form	A - centre of trace		B - edge of trace		C - outside of trace	
		Base	Trunk	Base	Trunk	Base	Trunk
Brodoa intestiniformis	Cl	1	-	-	-	-	-
Bryoria simplicior	Fp	1	-	1	-	-	-
Cetraria sepincola	Sl	1	1	1	-	-	1
Cladonia bacillaris	Sc	-	-	1	-	-	-
C. botrytes	Sc	1	-	1	1	-	-
C. chlorophaea	Sc	1	-	-	-	-	-
C. coniocraea	Sc	2	-	3	1	3	-
C. fimbriata	Sc	1	-	1	-	1	-
C. gracilis	Sc	1	-	-	-	-	-
C. ochrochlora	Sc	1	-	1	-	-	-
Evernia mesomorpha	Fp	1	1	1	1	1	2
Flavopunctelia soredica	Sl	1	-	1	1	1	1
Hypocenomyce scalaris	Sq	-	-	1	-	1	-
Hypogymnia physodes	Cl	5	1	7	4	12	10
H. tubulosa	Cl	1	-	-	-	-	-
Lecanora pulicaris	Cr	-	-	1	-	-	-
L. varia	Cr	-	-	-	1	-	-
Lecidea meiocarpa	Cr	1	1	1	-	2	1
Lepraria incana	Cr	1	-	1	-	1	1
Melanelia olivacea	Sl	2	2	3	3	1	1
Ochrolechia arborea	Cr	1	-	1	1	1	-
Opegrapha atra	Cr	1	-	1	-	1	1
Parmelia sulcata	Sl	5	2	6	4	3	4
Parmeliopsis ambigua	Sl	1	-	1	-	1	-
P. hyperopta	Sl	1	-	-	-	-	-
Physcia aipolia	Sl	-	1	-	-	-	1
Scoliciosporum chlorococcum	Cr	1	1	-	-	-	-
Usnea glabrata	Fp	1	1	1	-	1	1
Usnea hirta	Fp	1	-	-	-	1	-
Vulpicida pinastri	Sl	1	1	1	1	1	1
Number of species	30	25	10	21	10	16	12
Frequency, %		100	24	100	23	100	32
Of life forms spectrum	Cr	20	20	24	20	25	25

© Verlag Alexander Just: Dorfbeuern - Salzburg - Brüssel; download unter www.biologiezentrum.at

%							
	Sq	-	-	5	-	6	-
	Sc	24	-	24	20	13	-
	Cl	12	10	5	10	6	8
	Sl	28	50	28	40	31	50
	Fp	16	20	14	10	19	17
Number of lichen synusia		21	10	28	10	24	13

Table 2: Frequency (%) of lichens on base of trunks (G), and on height of 1.3 m (H) a total (M), on northern (N), eastern (E), southern (S), and western (W) sides of trunks in birch forest on plots under study

Plot	A level of settlement	M	N	E	S	W
A	G	100	95	92	32	83
	H	24	23	1	-	5
B	G	100	94	90	30	81
	H	23	20	7	1	13
C	G	100	92	74	20	66
	H	32	30	12	-	20

Table 3: Quota of lichen synusia (%) with various type of lichen species association in synusia on base of trunks (G) and on height of 1.3 m (H) in birch forest on plots under study

Plot	A level of settlement	Number of lichen synusia	Type of Gregations	lichen Aggrega-tions	species Congre-gations	association Mixgrega-tions
A	G	21	19	10	19	52
	H	10	40	10	20	30
B	G	28	21	4	14	61
	H	10	40	10	20	30
C	G	24	25	4	17	54
	H	13	39	-	15	46

© Verlag Alexander Just: Dorfbeuern - Salzburg - Brüssel; download unter www.biologiezentrum.at

Table 4: Total activity (Bq g^{-1} dw) of radionuclides in the epiphytic lichen thalli of the different sizes clusters in the birch forest on plots under study

Plot	*Hypogymnia physodes*				*Parmelia sulcata*			
	Mean for thalli all sizes	D<20 mm	D=21-40 mm	D>20 mm	Mean for thalli all sizes	D<20 mm	D=21-40 mm	D>20 mm
A	56.2	62.5	30.2	72.5	46.4	39.8	35.7	67.0
B	11.8	n.m.	n.m.	n.m.	11.5	n.m.	n.m.	n.m.
C	1.2	n.m.	n.m.	n.m.	0.7	n.m.	n.m.	n.m.

ZOBODAT - www.zobodat.at

Zoologisch-Botanische Datenbank/Zoological-Botanical Database

Digitale Literatur/Digital Literature

Zeitschrift/Journal: Sauteria-Schriftenreihe f. systematische Botanik, Floristik u. Geobotanik

Jahr/Year: 1998

Band/Volume: 9

Autor(en)/Author(s): Biazrov Lev G.

Artikel/Article: Die Flechten Synusien eines Birkenwaldes (südlicher Ural) als Indikator für radioaktive Kontamination zur Bewertung des Gesudheitszustandes von Ökosystemen 71-78