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DYNAMICS OF THE FLORISTIC COMPOSITION OF EPILITHIC LICHEN GROUPINGS IN MAARDU PHOSPHORITE QUARRIES, NORTHERN ESTONIA

Abstract. The dynamics of vegetation groupings on newly exposed limestone substrates of different exposure ages (5, 10, 15, 20, 25, 30 years) in the phosphorite quarries in Northern Estonia is analysed. Successional changes in the composition and structure of lichen groupings of different limestone horizons are investigated. It is shown that on younger substrates, lichen groupings on various limestone horizons differ sufficiently from each other both in the species composition and projective cover; however, together with an increase in the age of substrate exposure also the similarity of lichen groupings of different limestone horizons increases. With an increase in the age, lichens and mosses become dominant (lichens becoming prevalent in the majority of substrates) in the vegetation grouping on every substrate, while the role of algae decreases.

Key words: community dynamics, epilithic lichens, limestone.

Open mining of deposits brings forth great changes in the industrial landscape. In particular, rocks are exposed and come into contact with atmospheric and biotic agents for the first time. After mining such rocks are colonized gradually by vegetation. These new habitats are called primary substrates (Александрова, 1964). Investigation of the formation of vegetation communities on such substrates is of great ecological interest. So far there exist only a few special studies on the formation of epilithic lichen groupings on exposed rocky substrates (Degelius, 1955; Martin and Tevet, 1988; Мартин, 1969, 1975; Магомедова, 1979; Абрамян, 1984). The purpose of the present work was to study the formation of lichen groupings on newly exposed limestone substrates in the quarries of Maardu, a small town located in the northern part of Estonia 15—18 km northeast of Tallinn. All the subject quarries are of different age, formed as a result of mining in the Maardu phosphorite deposits (Аннука, 1988). Here, lichen groupings are looked upon as synusiae (Lippmaa, 1935; Трасс, 1970).

Material and Methods

The characterization of the geological structure and relief of the research area follows Müürisepp (Мюйрисепп, 1983).

The crystalline foundation on the territory of Maardu has sunk to the depth of 130—150 metres below sea level. On the foundation, Proterozoic and Paleozoic sea sediments lie.

The oldest complex of Ordovician sedimentary rocks in Estonia is formed by the Pakerort horizon, whose lower part consists of obolus sandstones and the upper part of argillites. Obolus sandstones form the industrial phosphorite deposits at Maardu. The Latorp horizon, which lies above the Pakerort horizon, consists of glauconitic sandstones.

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The upper part of the Glint consists of Ordovician limestones. The oldest of them are limestones from the Volkhov, Kunda, and Aseri horizons. The uppermost part of the Glint consists of limestones from the Lasnamäe horizon.

Geomorphologically, the territory of the research area is divided into a limestone plateau, which is covered with rather thin Quaternary sediments, and the fore-Glint lowland, covered with sediments of the Baltic Sea stage. In some places, the transition from the plateau to the plain is sharp, amounting to 20 m.

Field studies were carried out in 1989—1990. To study the succession of cryptogamic plants on the exposed limestones in the Maardu quarry complex, the method of sample plots was used. The plots were chosen by a random method. Observation points were selected on different limestone horizons in quarries of different ages. The first series of plots was located in quarries which were recultivated in 1961, the second — in 1966, the third — in 1971, the fourth — in 1976, the fifth — in 1981, and the sixth — in 1986, i.e., the studies were conducted on such lichen groupings which began to form 30, 25, 20, 15, 10, and 5 years ago.

In all the series observations were carried out on the following substrate types: (1) clay limestones with numerous glauconite grains of the Volkhov horizon; (2) clay limestones with glandular oolites of the Kunda horizon; (3) fine crystalline limestones with glauconitic grains of the Kunda horizon; (4) limestones with phosphate particles of the Kunda horizon; (5) clay limestones with numerous large glandular oolites of the Aseri horizon; (6) thick-schistose dolomite limestones of the Lasnamäe horizon (Rõõmusoks, 1983). The six types of substrates were not found in all quarries.

In order to protocol vegetation groupings, a sample quadrat of 20×20 cm, with a 2×2 cm grid, was used. The following data were entered on a special form: the year of the quarry's recultivation, location on the relief of the subject vegetation grouping, and habitat description (type of substrate, rock size, aspect and slope of the given surface, surrounding vegetation). The species composition of lichen groupings was shown; for each species, the projective cover and frequency were estimated. On each sample plot, the projective cover was estimated also for algae and mosses.

In order to compare the floristic composition of the sampled groupings, Sørensen's index of similarity (Greig-Smith, 1964) was used. To find the relation between the age of substrate exposure and projective cover of lichens, mosses, and algae, regression analysis was applied.

For studying the dynamics of lichen communities, 313 descriptions were made and analysed.

Results and Discussion

Of the 37 listed lichen species, 17 turned out to be common for all substrates, among them 12 crustaceous species (*Acarospora cervina* Massal., *Caloplaca citrina* (Hoffm.) Th. Fr., *C. decipiens* (Arnold) Blomb. & Forss., *C. holocarpa* (Hoffm.) Wade, *C. lactea* (Massal.) Zahlbr., *Candelariella aurella* (Hoffm.) Zahlbr., *Ionaspis rhodopis* (Sommerf.) Blomb. & Forss., *Lecanora crenulata* (Dicks.) Hooker, *Lecidella stigmatea* (Ach.) Hertel & Leuckert, *Micarea lutulata* (Nyl.) Coppins, *Verrucaria nigrescens* Pers., and *V. rupestris* (Schrader)) and 5 foliose ones (*Phaeophyscia nigricans* (Flörke) Moberg, *Ph. orbicularis* (Necker) Moberg, *Physcia adscendens* (Fr.) Oliv., *Ph. caesia* (Hoffm.) Fürnrohr., and *Ph. dubia* (Hoffm.) Lettau). In order to elucidate synonyms and to update the nomenclature of lichens, publications of Egan (1987), Coppins (1983), and Fröberg (1989) were used.

The biggest number of lichen species was found on glauconitic limestones of the Volkhov and Kunda horizons (33 and 30, respectively), the smallest number was registered on oolitic limestones of the Aseri and Kunda horizons (22).

Fig. 1 shows that the general floristic composition changes on all substrates depending on their age. On some substrates younger limestones have a wide variety of species which decreases as the age of the substrate increases. Other substrates, on the contrary, have fewer species at a younger age and more when the age increases.

Table 1 shows how the number of lichen species of various growth forms changes depending on the increase of substrate age. In the succession of lichen groupings the role of foliose lichens increases considerably until 1966 and then begins to fall on all substrates.

On all substrates of the same age the average number of species per sample plot is approximately equal and it decreases together with the increase in the age of substrate exposure (from 4—6 in 1981 to 5—7 in 1961).

Changes were observed in the cover degree of 15 lichen species (Figs. 2, 3, and 4). It was found that on younger substrates, lichen groupings on various limestone horizons differ substantially from each other both in the species composition and projective cover, but together with an increase in substrate age also the similarity of lichen groupings of different limestone horizons as to the species composition and projective cover increases.

Analysis of Sørensen's coefficients of floristic similarity of different substrates in quarries of the same age (Tables 2, 3, and 4) shows plainly that an increase in substrate age is accompanied by an increase in the floristic similarity of different limestone horizons.

Table 1

Changes in the number of lichen species of various growth forms depending on the age of exposed substrates

Substrate	Number of lichen species of various growth forms														
	1981			1976			1971			1966			1961		
	t. n.	cr.	fol.	t. n.	cr.	fol.	t. n.	cr.	fol.	t. n.	cr.	fol.	t. n.	cr.	fol.
Aseri (1)	10	10	—	—	—	—	—	—	—	6	3	3	15	10	5
Kunda oolitic (2)	16	14	2	—	—	—	—	—	—	14	10	4	10	5	5
Lasnamäe (3)	—	—	—	6	6	—	4	4	—	14	9	5	20	16	4
Volkhov (4)	25	19	6	—	—	—	—	—	—	20	11	9	17	12	5
Kunda glauconitic (5)	8	8	—	—	—	—	—	—	—	20	12	8	24	15	9
Kunda phosphatic (6)	6	6	—	—	—	—	—	—	—	22	14	8	21	14	7

t. n. — total number of lichen species, cr. — crustaceous lichens, fol. — foliose lichens.

Table 2

Sørensen's coefficients of floristic similarity (*K*) of different substrates in the quarry in 1981

Substrate	Aseri (1)	Kunda oolitic (2)	Volkhov (4)	Kunda glauconitic (5)
Kunda oolitic (2)	33			
Volkhov (4)	37	73		
Kunda glauconitic (5)	50	71	81	
Kunda phosphatic (6)	43	56	45	38

Table 3

Sørensen's coefficients of floristic similarity (*K*) of different substrates in the quarry in 1966

Substrate	Aseri (1)	Kunda oolitic (2)	Lasnamäe (3)	Volkhov (4)	Kunda glauconitic (5)
Kunda oolitic (2)	22				
Lasnamäe (3)	38	61			
Volkhov (4)	22	52	56		
Kunda glauconitic (5)	31	47	58	68	
Kunda phosphatic (6)	16	81	60	54	51

Table 4

Sørensen's coefficients of floristic similarity (*K*) of different substrates in the quarry in 1961

Substrate	Aseri (1)	Kunda oolitic (2)	Lasnamäe (3)	Volkhov (4)	Kunda glauconitic (5)
Kunda oolitic (2)	54				
Lasnamäe (3)	66	45			
Volkhov (4)	74	57	82		
Kunda glauconitic (5)	63	64	72	80	
Kunda phosphatic (6)	79	47	85	84	73

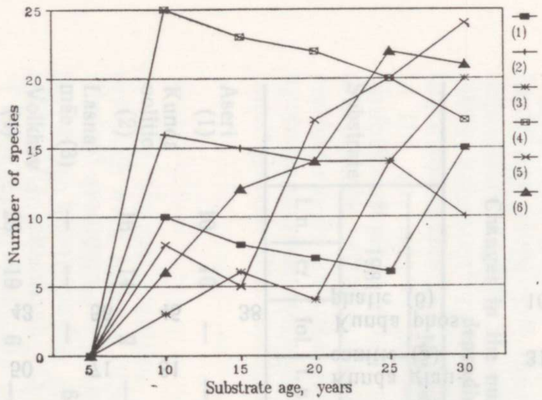

Fig. 1. Dependence of the number of lichen species on the age of the exposed substrate. (1) — Aseri horizon, oolitic limestone; (2) — Kunda horizon, oolitic limestone; (3) — Lasnamäe horizon, dolomitic limestone; (4) — Volkhov horizon, glauconitic limestone; (5) — Kunda horizon, glauconitic limestone; (6) — Kunda horizon, limestone with phosphate particles.

(Here and in all other figures and tables the explanations are the same.)

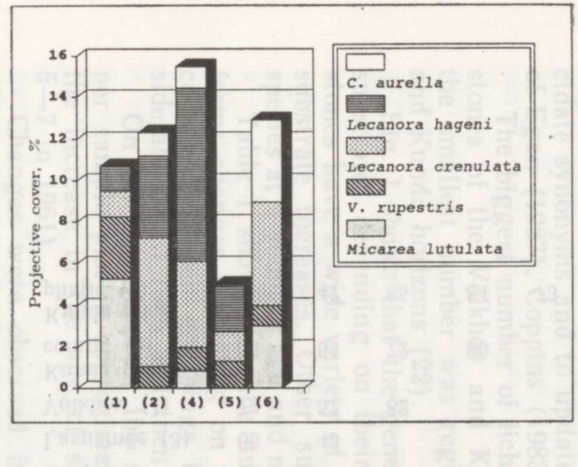

Fig. 2. Projective cover of some lichen species on different substrates in the quarry in 1981.

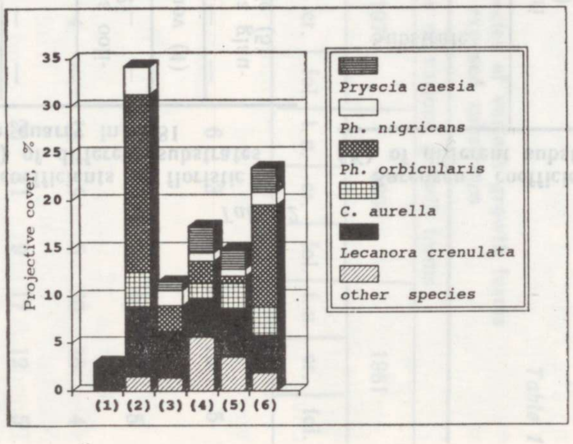

Fig. 3. Projective cover of some lichen species on different substrates in the quarry in 1966.

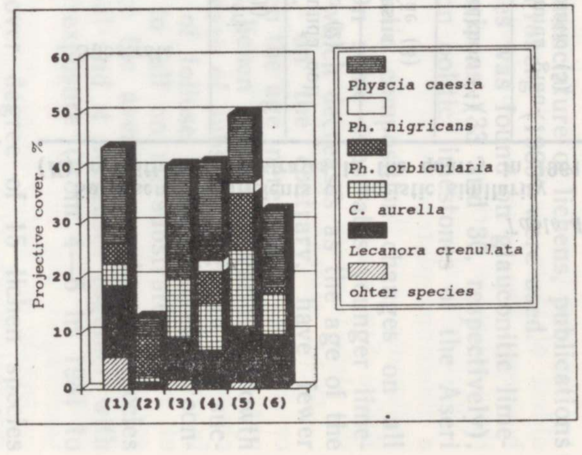

Fig. 4. Projective cover of some lichen species on different substrates in the quarry in 1961.

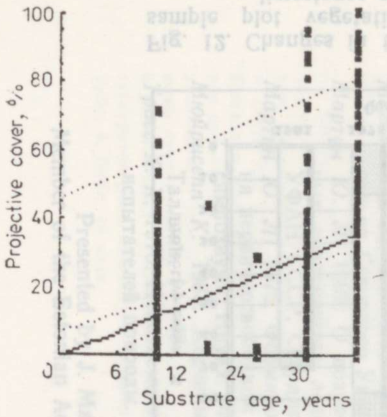

Fig. 5. Dependence of the average projective cover of lichens in sample plot on the age of exposed substrates (on all substrates together).

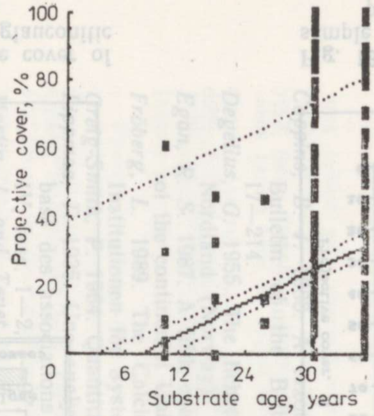

Fig. 6. Dependence of the average projective cover of mosses in sample plot on the age of exposed substrates (on all substrates together).

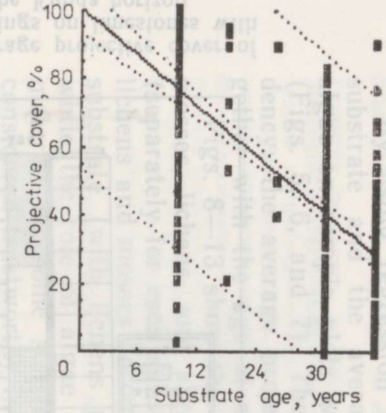

Fig. 7. Dependence of the average projective cover of algae in sample plot on the age of exposed substrates (on all substrates together).

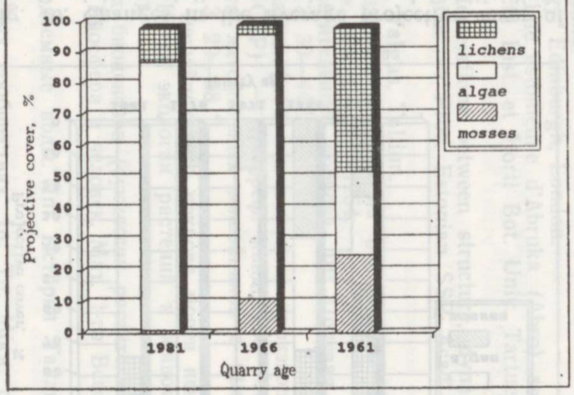

Fig. 8. Changes in the average projective cover of sample plot vegetation groupings on oolitic limestones of the Aseri horizon.

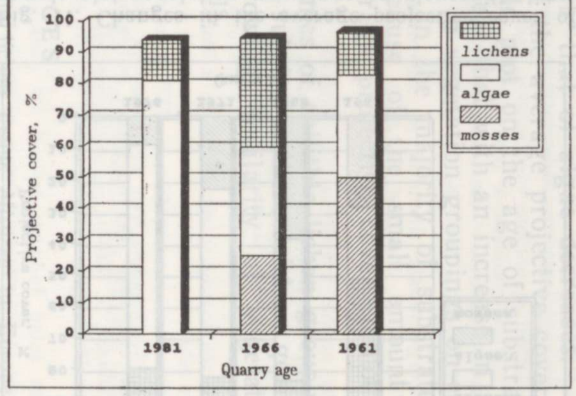

Fig. 9. Changes in the average projective cover of sample plot vegetation groupings on oolitic limestones of the Kunda horizon.

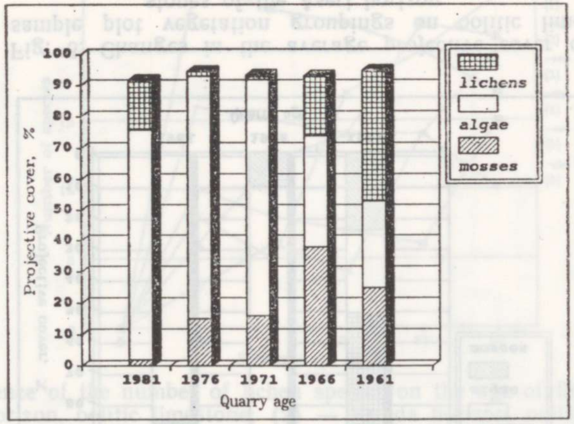

Fig. 10. Changes in the average projective cover of sample plot vegetation groupings on dolomitic limestones of the Lasnamäe horizon.

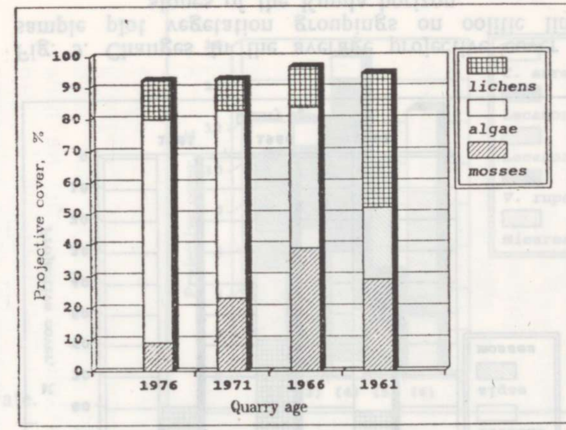

Fig. 11. Changes in the average projective cover of sample plot vegetation groupings on glauconitic limestones of the Volkhov horizon.

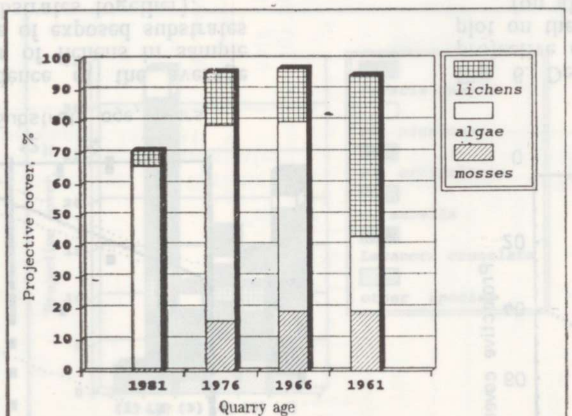

Fig. 12. Changes in the average projective cover of sample plot vegetation groupings on glauconitic limestones of the Kunda horizon.

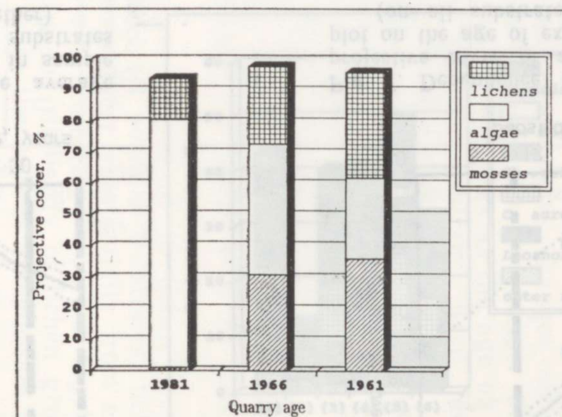

Fig. 13. Changes in the average projective cover of sample plot vegetation groupings on limestones with phosphate particles of the Kunda horizon.

By using regression analysis, the relationship between the age of substrate and the average projective cover of lichens, mosses, and algae on sample plots was determined for all the substrates together (Figs. 5, 6, and 7). The analysis indicated to a certain general tendency: the average projective cover of mosses and lichens grows together with the age of substrates, while that of algae decreases.

Figs. 8—13 show the dependence of the average projective cover of mosses, lichens, and algae of a sample plot on the age of substrates (separately for each substrate). It is clear that with an increase in age lichens and mosses become dominating in vegetation groupings on each substrate (with lichens predominating in the majority of substrates), while the role of algae decreases. Because of the small amount of material on some substrates, the average projective cover cannot be considered trustworthy in every case.

Therefore, the analysis of the dynamics of epilithic lichen groupings in Maardu quarries showed that on all substrates there exists a general age-dependent tendency toward a growing similarity of vegetation groupings of different limestone horizons.

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