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GROWTH OF LICHENS ON LIMESTONE OUTCROPS IN NORTHERN ESTONIA

Das Wachstum von Flechten auf Kalkaufschlüssen in Nordestland

by

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Key words: Growth rate of lichens, life span of lichens, limestone outcrops.

Schlagwörter: Wachstumsgeschwindigkeit von Flechten, Lebensdauer von Flechten, Kalkaufschlüssen.

Summary: Growth and life span of 10 lichen species on primarily exposed limestone outcrops of different exposure ages in two areas of Northern Estonia are analysed. The investigated areas are similar in natural conditions (geological structure, relief, climate, soils, etc.) but differ in the degree of air pollution. The limestone outcrops are of the same exposure age (from 5 to 34 years) but differ in texture and hardness. It is established that (1) the rate of colonization by lichens of primarily exposed limestone outcrops depends on substrates texture and hardness: harder limestones of crystalline texture are colonized by lichens later than those less hard of schistic texture; (2) the growth rate of lichens slows down but their life span increases under the impact of air pollution.

Zusammenfassung: Das Wachstum und die Lebensdauer von 10 Flechtenarten werden auf verschieden alten primären Kalkaufschlüssen in zwei Gebieten Nordestlands analysiert. Die untersuchten Gebiete haben ähnliche Naturbedingungen (der geologischen Struktur, Relief, Klima, Boden und so weiter), aber sie unterscheiden sich voneinander durch die Luftverunreinigung. Die Kalkaufschlüsse haben dasselbe Alter (von 5 bis zu 34 Jahren), aber sie unterscheiden sich voneinander durch die Struktur und die Härte. Es wird festgestellt: (1) Die Geschwindigkeit der Besiedlung von Flechten der primären Kalkaufschlüssen hängt von der Härte und von der

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Struktur des Substrats ab: die härtesten Kalksteine mit der Kristallstruktur werden mit Flechten später besiedelt, als weniger harte Kalksteine mit der Schieferstruktur. (2) Die Wachstumsgeschwindigkeit von Flechten wird wegen der Luftverunreinigung verlangsamt, aber die Lebensdauer von Flechten wird größer.

Introduction

Little is known about the influence of air pollution on the growth and life span of lichens. There are only a few publications on the negative influence of air pollution on lichen increment (GILBERT, 1971; SEAWARD, 1976). The present paper describes the growth and life span of 10 lichen species on primarily exposed limestone outcrops of different exposure ages in Maardu and Vasalemma quarries (Northern Estonia).

Maardu is a small town located 15 km northeast of Tallinn. Vasalemma is a village located 40 km southwest of Tallinn. The invetigated areas are similar in natural conditions (gelogical structure, relief, climate, soils, etc.) but differ in the degree of air pollution. The limestone outcrops are of the same exposure age (from 5 to 34 years) but differ in texture and hardness. In Vasalemma there is no local air pollution and investigated limestones are hard, with coarse-graned crystalline texture (RÕÕMUSOKS, 1983). In Maardu atmospheric air has been polluted by chemical industry emissions for a long period (KALLASTE, ROOTS, SAAR & SAARE, 1992) and investigated limestones are less hard, with clay schistic texture (RÕÕMUSOKS, 1983).

Materials and Methods

In order to establish the time of appearance of the first lichens on the rock surfaces and the life span of the chosen lichen species, limestone substrates of different exposure ages (from 5 to 34 years) were examined in 1986, 1991, 1995 in five quarries at Maardu and four quarries at Vasalemma.

The following ten lichen species were measured: *Caloplaca decipiens* (ARNOLD) BLOMB. & FORSSELL, *Lecanora muralis* (SCHREB.) RABENH., *Lecidella stigmatea* (ACH.) HERTEL & LEUCKERT, *Phaeophyscia orbicularis* (NECK.) MOBERG, *Physcia adscendens* (FR.) H. OLIVIER, *P. caesia* (HOFFM.) FÜRNR., *Placynthium nigrum* (HUDS.) GRAY, *Protoblastenia rupestris* (SCOP.) J. STEINER, *Verrucaria nigrescens* PERS., *Xanthoria parietina* (L.) TH. FR. In 1991 measurements were made in three Maardu and three Vasalemma quarries. In 1995 repeated measurements were made in the same quarries. The year of the formation of each quarry was known. Thus, the exposure time of the investigated limestone outcrops could be exactly dated. In 1991 it was 15, 25, 30 years in Maardu and 13, 16, 30 years in Vasalemma. In 1995 the exposure age of limestone substrates was 14, 29, 34 years in Maardu and 17, 20, 34 years in Vasalemma. In each quarry the diameters of all thalli (including very small) of the chosen lichen species

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growing on horizontal surfaces of limestone were measured by calliper with 0,05 mm accuracy.

Results and discussion

In Maardu quarries the following 6 lichen species were measured: *Caloplaca decipiens, Lecanora muralis, Phaeophyscia orbicularis, Physica caesia, Verrucaria nigrescens, Xanthoria parietina.* The results of measurements are presented in Tables 1 and 2.

Table 1: Average diameters of lichen thalli in Maardu quarries

Species	Average diameters of lichen thalli [mm] Age of substrates [years]					
	14	15	25	29	30	34
Caloplaca decipiens	-	-	12.30	14.37	17.55	-
Lecanora muralis	-	-	17.00	23.14	24.80	28.38
Phaeophyscia orbicularis	13.66	13.78	21.71	25.03	27.64	29.08
Physica caesia	10.03	13.21	41.18	43.63	44.64	45.32
Verrucaria nigrescens	11.38	-	-	21.76	-	23.63
Xanthoria parietina	18.41	-	50.04	50.90	50.21	-

At Maardu foliose species *P. orbicularis, P. caesia, X. parietina* and crustose *V. nigrescens* started to colonize limestones within 5-7 years from the exposure of substrates and grew very slowly in the course of 3-5 years. During the subsequent 4 years P. orbicularis, *X. parietina* and *V. nigrescens* demonstrated a period of rapid growth. The values of average annual increment of these lichens in that period were determined to be 3.42 mm/year for *P. orbicularis,* 4.60 mm/year for *X. parietina* and 2.85 mm/year for *V. nigrescens.* Afterwards, the average annual increment of the studied lichens decreased (Table 2).

As distinct from other lichen species *P. caesia* had no period of rapid growth, but showed an almost linear growth during 15 years. The average annual increment of this lichen in that period was determined to be 2.51 - 2.80 mm/year.

Squamulose species *C. decipiens* and *L. muralis* appeared on the Maardu limestones 10 years after the exposure of substrates and grew slowly in the course of 5 years. During the following 10 years these lichens had a period of rapid growth. The values of average annual increment of these lichens in that period were determined to be 1.23 mm/year for *C. decipiens* and 1.70 mm/year

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for *L. muralis*. Further, the growth of these lichen species slowed down (Table 2).

The life span of studied lichens at Maardu was estimated to be 20 years for *C. decipiens*, 25 years for *X. parietina* and about 30 years for *L. muralis*, *P.*

Table 2: Average annual increment of lichens in Maardu quarries

Species	Average annual increment of lichens [mm/year] Substrate age [years]			
	10-14	14 (15)-25	25-29	30-34
Caloplaca decipiens	-	1.23	0.52	-
Lecanora muralis	-	1.70	1.54	0.90
Phaeophyscia orbicularis	3.42	0.79	0.83	0.36
Physica caesia	2.51	2.80	0.61	0.17
Verrucaria nig rescens	2.85	substrate age from 14 to 29 years 0.69		0.37
Xanthoria parietina	4.60	2.88	0.22	-

orbicularis and *P. caesia*. The life span of *V. nigrescens* was not established due to lack of sufficiently old limestone outcrops in Maardu.

In Vasalemma quarries the following 9 lichen species were measured: *Lecanora muralis, Lecidella stigmatea, Phaeophyscia orbicularis, Physcia adscendens, P. caesia, Placynthium nigrum, Protoblastenia rupestris, Verrucaria nigrescens, Xanthoria parietina*. The results of these measurements are presented in Table 3 and 4.

At Vasalemma foliose species *P. orbicularis, P. adscendens, P. caesia, X. parietina* started to colonize limestone within 8 years from the exposure of substrates and grew slowly in the course of 5 years. During the subsequent 3-4 years these lichens had a period of rapid growth when the values of average annual increment were 4.61 -4.67 mm/year for *P. orbicularis*, 4.92 mm/year for *P. adscendens*, 5.42 mm/year for *P. caesia* and 5.89 mm/year for *X. parietina*. Afterwards, the average annual increment of the studied lichens decreased (Table 4).

Squamulose lichen *L. muralis* appeared on the Vasalemma limestones 13 years after the exposure of substrates and grew slowly in the course of 3-4 years. During the following 3-4 years *L. muralis* had the period of rapid growth. In that time its average annual increment reached 4.51 mm/year.

Crustose lichen species *L. stigmatea* and *P. rupestris* began to colonize the

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Vasalemma limestones within 8 years from the exposure of substrates and grew very slowly for 2 years. After that these lichens had a period of rapid growth in the course of 7 years. The values of average annual increment of these lichens in that period were determined to be 1.68-1.76 mm/year for *L. stigmatea* and 1.21 mm/year for *P. rupestris*. During the subsequent years the average annual increment of the studied lichens decreased (Table 4).

Table 3: Average diameters of lichen thalli in Vasalemma quarries

Species	Average diameters of lichen thalli [mm] Age of substrates [years]					
	13	16	17	20	30	34
Lecanora muralis	-	-	-	18.04	-	-
Lecidella stigmatea	8.63	13.90	15.33	20.95	-	-
Phaeophyscia orbicularis	-	13.84	18.69	23.45	-	-
Physcia adscendens	-	14.75	-	18.60	-	-
Physcia caesia	-	-	21.67	33.09	-	-
Placynthium nigrum	-	-	-	-	19.37	37.69
Protoblastenia rupestris	8.91	11.98	13.76	16.81	19.08	21.30
Verrucaria nigrescens	-	-	15.89	19.29	30.54	35.35
Xanthoria parietina	-	-	23.57	34.89	-	-

Table 4: Average annual increment of lichens in Vasalemma quarries

Species	Average annual increment of lichens, mm/year				
	10-13	13-16(17)	16 (17)-20	20-30	30-34
Lecanora muralis	-	-	4.51	-	-
Lecidella stigmatea	2.88	1.68	1.76	-	-
Phaeophyscia orbicularis	-	4.61-4.67	2.40	-	-
Physcia adscendens	-	4.92	0.96	-	-
Physcia caesia	-	5.42	3.81	-	-
Placynthium nigrum	-	-	-	substrate age from 25 to 30 3.87	4.58
Protoblastenia rupestris	2.97	1.21	1.21	0.23	0.56
Verrucaria nigrescens	-	3.97	1.13	1.13	1.20
Xanthoria parietina	-	5.89	3.77	-	-

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Crustose *V. nigrescens* started to colonize the Vasalemma limestones within 11 years from the exposure of substrates and grew very slowly for 2 years. During the following 4 years *V. nigrescens* had a period of rapid growth when its average annual increment reached 3.97 mm/year. Further, the growth of this lichen slowed down and its average annual increment was 1.13-1.20 mm/year in the course of subsequent 13-17 years.

Crustose *P. nigrum* appeared on the Vasalemma limestones 20-22 years after the exposure of substrates and during the first 3-5 years grew very slowly. Then its growth increased. The average annual increment of this lichen was 3.87 mm/year in the course of 5 years. During the subsequent 4 years its average annual increment reached 4.58 mm/year.The life span of studied lichens at Vasalemma was estimated to be 17 years for *X. parietina* and about 20 years for *L. muralis, P. orbicularis, P. adscendens* and *P. caesia.* The life span of crustose lichen species was not established due to lack of sufficiently old limestone outcrops in Vasalemma.

The above data show that the growth of studied lichen species on limestone outcrops in Vasalemma quarries differs from the growth of the same lichens on limestone outcrops in Maardu quarries.

Firstly, the Vasalemma limestones were colonized by lichens later, than the Maardu limestones. It is connected with the different characteristics of the investigated limestone substrates.

Secondly, the studied lichens grow faster (they have greater average annual increment and, as a consequence, greater size of thalli) in Vasalemma, than in Maardu. But in Maardu the life span of the studied lichens is longer that the life span of the same lichens in Vasalemma. These facts are related to the difference in the degree of air pollution of the investigated areas.

Thus, the study of lichen growth on limestone outcrops in Northern Estonia showed that (1) the rate of colonization by lichens of primarily exposed limestones outcrops depends on substrates texture and hardness: harder limestones of crystalline texture are colonized by lichens later than those less hard of schistic texture; (2) the growth rate of lichens slows down but their life span increases under the impact of air pollution.

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