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DISPERSAL OF FRAGMENTS OF TWO PENDULOUS LICHEN SPECIES

Verbreitung von Fragmenten zweier Bartflechtenarten

by
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Key words: Epiphytic lichens, dispersal, thallus fragmentation, boreal forests, forestry.
Schlagwörter: Epiphytische Flechten, Verbreitung, Thallusfragmentierung, boreale Wälder, Forstwirtschaft.

Summary: Dispersal processes are suspected to be one of the most important factors limiting abundance and species composition of epiphytic lichen species. This study focuses on the number and size of dispersed lichen fragments on a clear-cut in relation to the distance from a lichen-rich forest. Fragments of the pendulous lichens *Alectoria sarmentosa* and *Bryoria* spp. were collected for two months in traps made of plastic pots. The traps were located on a clear-cut at 0 - 300 m distance from the edge of an old-growth *Picea abies* forest in northern Sweden.

Of 2214 fragments (≥ 0.5 mm) counted, only 9 could be identified as *Alectoria sarmentosa* fragments. Most fragments (94%) were deposited within 100 m from the edge. The size distribution of fragments was significantly different between forest and clear-cut, and between edge and clear-cut, but not between forest and edge. Results suggest that dispersal by thallus fragments is much less efficient in *A. sarmentosa* than in *Bryoria* spp. and that fragments of *Bryoria* species disperse efficiently up to 100 m. Conditions changing throughout the edge zone of the forest seem to have only minor influence on quality but significant influence on quantity of dispersed fragments.

Zusammenfassung: Es wird angenommen, daß der Verbreitungsprozeß einer der wichtigsten Faktoren ist, der die Menge und Artzusammensetzung von epiphy-

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tischen Bartflechten begrenzt. Diese Studie untersucht das Verhältnis zwischen der Anzahl und Größe von verbreiteten Flechtenfragmenten und dem Abstand vom Rand eines flechtenreichen Waldes auf einen Kahlschlag hinaus.

Fragmente der Bartflechten *Alectoria sarmentosa* und verschiedene *Bryoria*-Arten wurden zwei Monate lang in Flechtenfallen gesammelt, die aus Plastikeimern bestanden. Die Fallen wurden auf einem Kahlschlag mit einem Abstand von 0 - 300 m von der Kante eines *Picea abies*-Urwaldreservates in Nordschweden aufgestellt. Im Labor wurden die Arten der Fragmente bestimmt, gezählt und deren Länge gemessen.

Von 2214 gezählten Fragmenten (≥ 0.5 mm) konnten nur 9 als *Alectoria sarmentosa*-Fragmente identifiziert werden. Die meisten Fragmente (94%) lagerten sich innerhalb von 100 m von der Waldkante weg ab. Die Verteilung in unterschiedliche Größenklassen war signifikant verschieden zwischen Wald und Kahlschlag, Kante und Kahlschlag, nicht aber zwischen Wald und Kante.

Die Resultate lassen vermuten, daß die Verbreitung durch Thallusfragmente bei *A. sarmentosa* weniger effizient ist als bei *Bryoria* spp., und daß Fragmente von *Bryoria*-Arten sich effizient bis zu 100 m verbreiten. Bedingungen, die sich innerhalb der Randzone verändern, scheinen nur einen geringen Einfluß auf die Qualität, aber einen signifikanten Einfluß auf die Anzahl von verbreiteten Fragmenten zu haben.

Introduction

The abundance of epiphytic macrolichens in boreal forests has decreased markedly during this century. Besides air pollution, to which lichens are very sensitive, mainly forestry is thought to be responsible: forest cutting decreases the amount of suitable substrate, changes the quality of available substrate and changes the microclimatic conditions that regulate lichen growth. Another factor may be the changes in landscape structure caused by clear-cutting: the area of old-growth forest that functions as a propagule source is reduced with increasing isolation between forest patches as a result. This causes an increasing distance that lichen propagules have to disperse in order to re-colonise second-growth forests. However, even mature second-growth forests (> 100 years) have considerable lower lichen biomass and a different species composition than near-by old-growth forests (Esseen et al. 1996). An explanation to those differences may be: increased distance between dispersal source and suitable substrate offers different opportunities to lichen species with different dispersal strategies.

While other studies mostly had focused on the changed amount and quality of habitat (e.g. Kuusinen 1994 a, b; Gauslaa et al. 1992; Lesica et al. 1991), or on changes in microclimate (e.g. Goward 1994; Canters et al. 1991; Lechowitz 1981) only few authors considered dispersal ability as a restricting factor to lichen colonisation. Bailey (1976) gives an overview about more general studies concerning lichen propagule liberation and dispersal. Armstrong (1981) showed that small fragments of *Parmelia conspersa* were most successful at colonising 'safe sites' on rock surfaces compared to other types of propagules. For alectorioid, pendulous species dispersal through thallus fragments may be

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most important for local dispersal (STEVENSON 1988, 1990) due to the fragile growth form. This study addresses the following questions: i) does the deposition of thallus fragments differ quantitatively between *Alectoria sarmentosa* and *Bryoria* species, ii) is there a relationship between the distance from dispersal source (old-growth forest) and the size and number of thallus fragments?

Material & methods

Plastic rose-flower pots (7.0 l, opening ∅ 210 mm = 0.0346 m^2) with paper coffee filters at the bottoms were used as lichen traps to collect fragments of pendulous lichens at different distances from the dispersal source. The pots were fixed to wooden poles with the opening at 1 m height above ground. The lichen traps were placed along three parallel transects (300 m long and 50 m apart) 90 degrees to the forest edge in the main wind direction at 7 distances (0, 10, 25, 50, 100, 200, 300 m) from the edge of a mature spruce forest. In addition, one trap per transect was placed 50 m inside the forest.

The study was performed on a clear-cut sized 1460 m x 1500 m (219 ha) at the south-east edge of the forest reserve Alpliden (64° 40′ N and 17° 40′ E, 283 ha) in northern Sweden. The old-growth *Picea abies* (Norway spruce) forest had an abundant growth of pendulous lichens, dominated by *Alectoria sarmentosa* (ESSEEN et al. 1996). Beside this the pendent species *Bryoria fuscescens* and *B. capillaris* were common.

The sampling started on September 9th, 1995 and the filters were collected after 63 days. All fragments attached to the sides of the pot were washed to the bottom with distilled water before removal of the filters. After transportation to the laboratory the filters were deep-frozen until processing. During four weeks all fragments of *Alectoria sarmentosa* and *Bryoria* spp. ≥ 0.5 mm in length were identified and measured under a dissecting microscope (6 - 50 x).

Results

In total 2214 fragments were counted. This represents an average of between 11 (clear-cut and 211 (forest) fragments per m^2 and day (Table 1)). Most fragments (99.6%) were *Bryoria* spp. fragments. In spite of the fact that the old-growth forest was dominated by *Alectoria sarmentosa* only 9 fragments were found of this species. The control traps in the forest alone accounted for 62.0% of all fragments found.

The decrease in frequencies of lichen fragments with increasing distance follows the inverse power law (Fig. 1). The inverse power model explained 68% (R^2) of the relation frequencies / distances. Only a small fraction of all fragments had dispersed beyond 100 m, 91.6% and 95.6% were encountered within 100 m for size classes 0.5 - 0.8 mm and 1.8 - 3.3 mm, respectively (Fig. 2).

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The size distribution of thallus fragments was significantly different (Table 2) between forest and clear-cut and between edge and clear-cut ($p < 0.01$ in both cases; Chi2 test). No significant difference between forest and edge was found ($p > 0.05$; Chi2 test). However, there was a large difference in the total number of fragments: 69.6% fewer fragments on the edge compared to forest, and 81.8% fewer fragments on the clear-cut compared to the edge.

Discussion

The finding that almost all trapped fragments constituted *Bryoria* spp. is particularly interesting as the epiphyte vegetation was dominated by *Alectoria sarmentosa*. The biomass of *A. sarmentosa* on spruce branches in the lower canopy was three times higher than the biomass of *Bryoria* spp. (ESSEEN et al. 1996).

Results indicate that *A. sarmentosa* produce much fewer but larger fragments than *Bryoria* species which is consistent with the findings of RENHORN & ESSEEN (1995) and STEVENSON (1988). This suggests that the effective dispersal distance of *A. sarmentosa* may be small. Field observations support this conclusion: when *A. sarmentosa* occur in young forests, mostly single, medium sized thalli are found scattered in the canopy of young trees. These thalli rarely occur on trees positioned further than 20 m from the edge of an old growth forest (pers. obs.). Thus, dispersal by thallus fragments appears to be much less efficient in *A. sarmentosa* than in *Bryoria* spp.

However, the size distribution of fragments may be important for the short-distance dispersal of alectorioid lichens. Most dispersed fragments were less than 5 mm in size. *Bryoria* fragments with sizes between 0.5 and 5.0 mm disperse effectively up to 100 m. 100 m may be therefore defined as an Effective Dispersal Distance for *Bryoria* species in boreal forests (94% or more of all available fragments dispersed). In contrast, on Vancouver Island, Canada, STEVENSON (1988) found dispersal distances for *Bryoria* fragments up to 450 m. This may be due to taller lichen source trees (Douglas fir, *Pseudotsuga menziesii*).

In general, the fragmentation process is influenced by factors like humidity and wind speed (ARMSTRONG 1994, VON SCHRENK 1898). Wind speed and humidity were not measured in this experiment, but other studies showed higher wind speeds (CHEN et al. 1993) and lower humidity (MURCIA 1995) in forest edges compared to forest interior. However, those factors seem not to change the size distribution of the fragments but the overall number. Another factor influencing the number of fragments is the available lichen biomass in the source forest (STEVENSON 1988).

However, the average lichen biomass in the source forest might not influence the dispersal distance of a single fragment, but the overall probability of an adjacent young forest to be colonised by those lichens. It can be assumed

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that with increasing lichen biomass in the forest, the total number of fragments on the clear-cut will increase, but the proportion of fragments settled at a specific distance might be the same. This will cause a higher probability for fragment deposition at distances greater than 100 m. This, in combination with other dispersal strategies (e.g. soredia), might explain why *Bryoria* spp. colonises even larger young stands within 20 to 30 years.

In consistence with ESSEEN et al. (1996) the results thus suggest that dispersal limitations in alectorioid lichens may be a major cause for their sensitivity to forest cutting. Further on the results imply higher lichen colonisation in young forests bordering old-growth, lichen-rich forest compared to young forests bordering lichen-poor, second-growth forests. Lichen colonisation by thallus fragments in second-growth forest might not so much depend on specific microclimatic or substrate conditions but more on the size and form of the young stand itself and its position in relation to lichen-rich forest in the landscape mosaic.

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Tab. 1: Total number and average number of *Alectoria sarmentosa* and *Bryoria* spp. fragments ≥ 0.5 mm for 3 transects during 63 days of deposition. * indicates lost lichen traps.

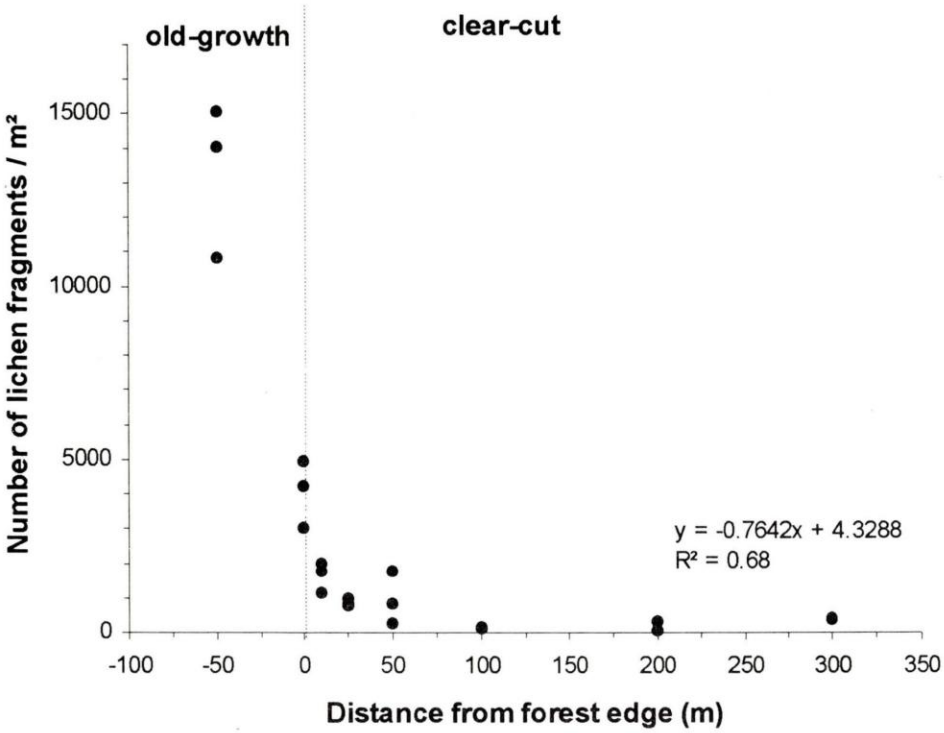
	forest	edge	clear-cut					
Distance (m)	**-50**	**0**	**10**	**25**	**50**	**100**	**200**	**300**
Transect								
A	522	105	39	27	9	6	2	14
B	486	171	62	29	62	*	2	*
C	375	145	69	35	28	4	10	12
Average per trap	461.0	140.3	56.7	30.3	33.0	5.0	4.7	13.0
Average per m²	13309.8	4051.7	1636.1	875.8	952.8	144.4	134.7	375.3
Average ± SD per m² & day	211.3 ± 35.1	64.3 ± 15.2	26.0 ± 7.2	13.9 ± 1.9	15.1 ± 12.3	2.3 ± 0.6	2.1 ± 2.1	6.0 ± 0.6

Tab. 2: Average number of *Bryoria* thallus fragments for 5 size classes in the forest (n=3), on the edge (n=3) and on the clear-cut (n=16).

Fragment size (mm)	Class	forest	edge	clear-cut
0.5 - 3.4	0	327.0	113.0	23.3
3.5 - 6.7	1	55.0	14.7	1.3
6.8 - 10.0	2	27.0	3.3	0.6
10.1 - 15.0	3	19.0	4.7	0.2
15.1 -	4	33.0	4.7	0.4
total		461.0	140.3	25.6

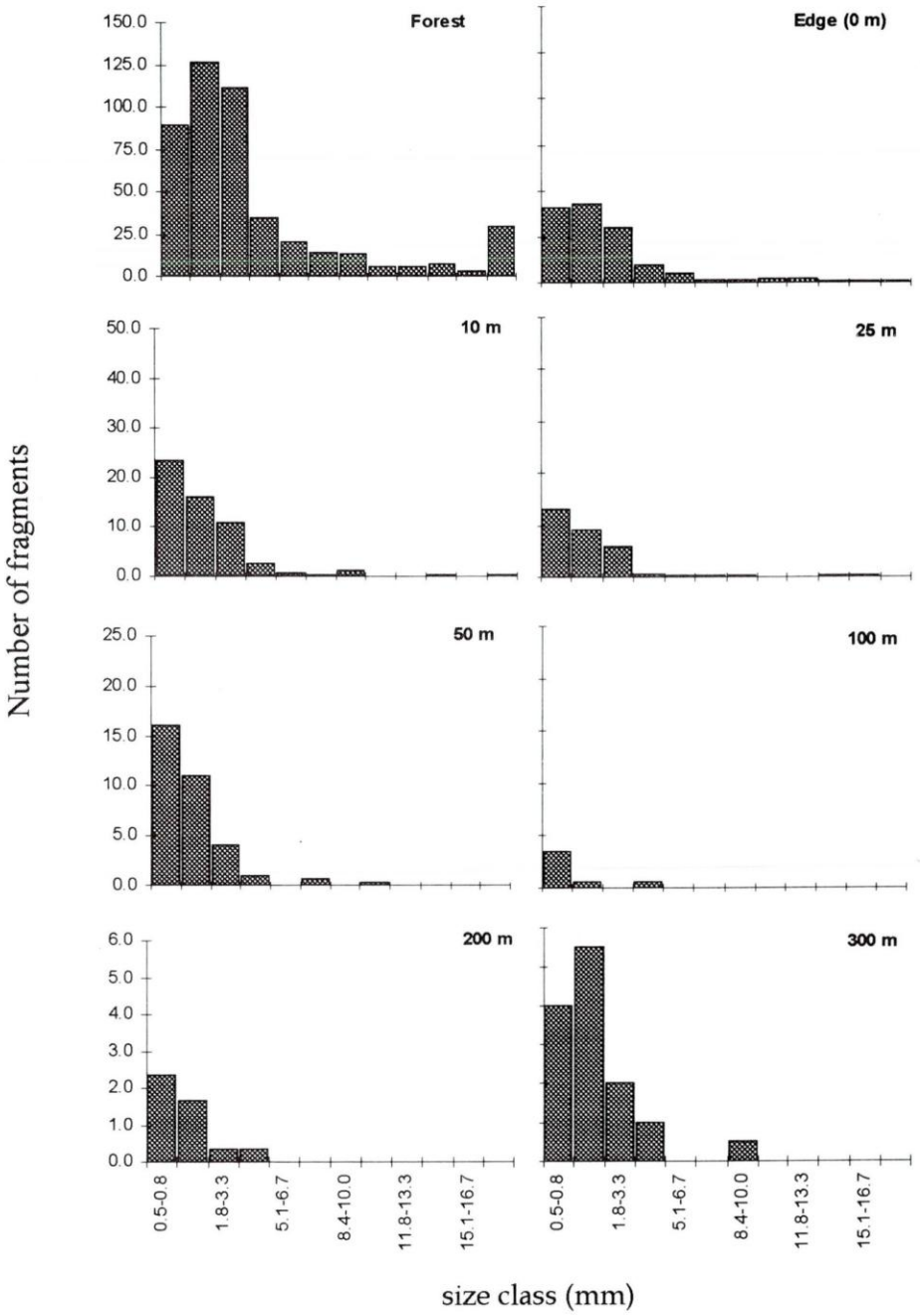
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Fig. 1: Deposition of *Bryoria* spp. thallus fragments in the old-growth forest, the edge and the clear-cut during 63 days.



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Fig. 2: Size distribution of *Alectoria sarmentosa* and *Bryoria* spp. thallus fragments for 8 distances from the edge of an old-growth forest.



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