

Changes in lichen and bryophyte communities on Scots pines along an alkaline dust pollution gradient

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Introduction

- ❑ The total emission of many air pollutants (e.g. SO_2 , CO , C_6H_6) has reduced in Europe for now (Guerreiro et al. 2015), while particulate matter (PM) is still acute as it poses a remarkable threat to human health (WHO 2013) and local environment (Farmer 1993; Paal et al. 2013).
- ❑ Coarse PM (larger dust particles, hereafter dust pollution) is released to environment from rock quarrying, combustion processes, kiln grinding or directly from surfaces of gravel roads by intensive traffic, and thereafter deposits generally in the vicinity of power plants, cement industries, limestone quarries or unpaved roads (Fig. 1).
- ❑ Epiphytic lichens and bryophytes are widely used as indicators for monitoring the air quality (e.g. Gilbert 1968; Nimis et al. 2002), and the present study was driven by the goal to broaden the selection of ecological indicators for estimating the alkaline dust pollution.
- ❑ We aimed to study the response of lichen and bryophyte diversity and cover in relation to alkaline dust pollution emitted from limestone quarries in Estonia.



Fig. 1. One of the particulate matter source – limestone quarry (Rammu quarry, northern Estonia).

Material & Methods



Fig. 2. The locality of study area in Estonia, Northern Europe. Sample plots (marked with red circles) are located close to the limestone quarries (Vasalemma, Harku, Vao, Maardu; marked with black).

- ❑ The study area was situated in Estonia, in the surroundings of four major limestone quarries (Fig. 2).
- ❑ The study was carried out in 32 sample plots, located at different distances (up to ca. 3 km) from the nearest limestone quarry.
- ❑ In every plot the occurrence and cover (at the height of 120 cm) of all lichen and bryophyte species were recorded from 0.5 to 2 m above ground on five random pine trees (altogether on 160 trees); the line cover method was used for measuring the cover of species.
- ❑ The bark pH was measured in laboratory using a flathead pH meter Consort C532.

Results & Conclusions

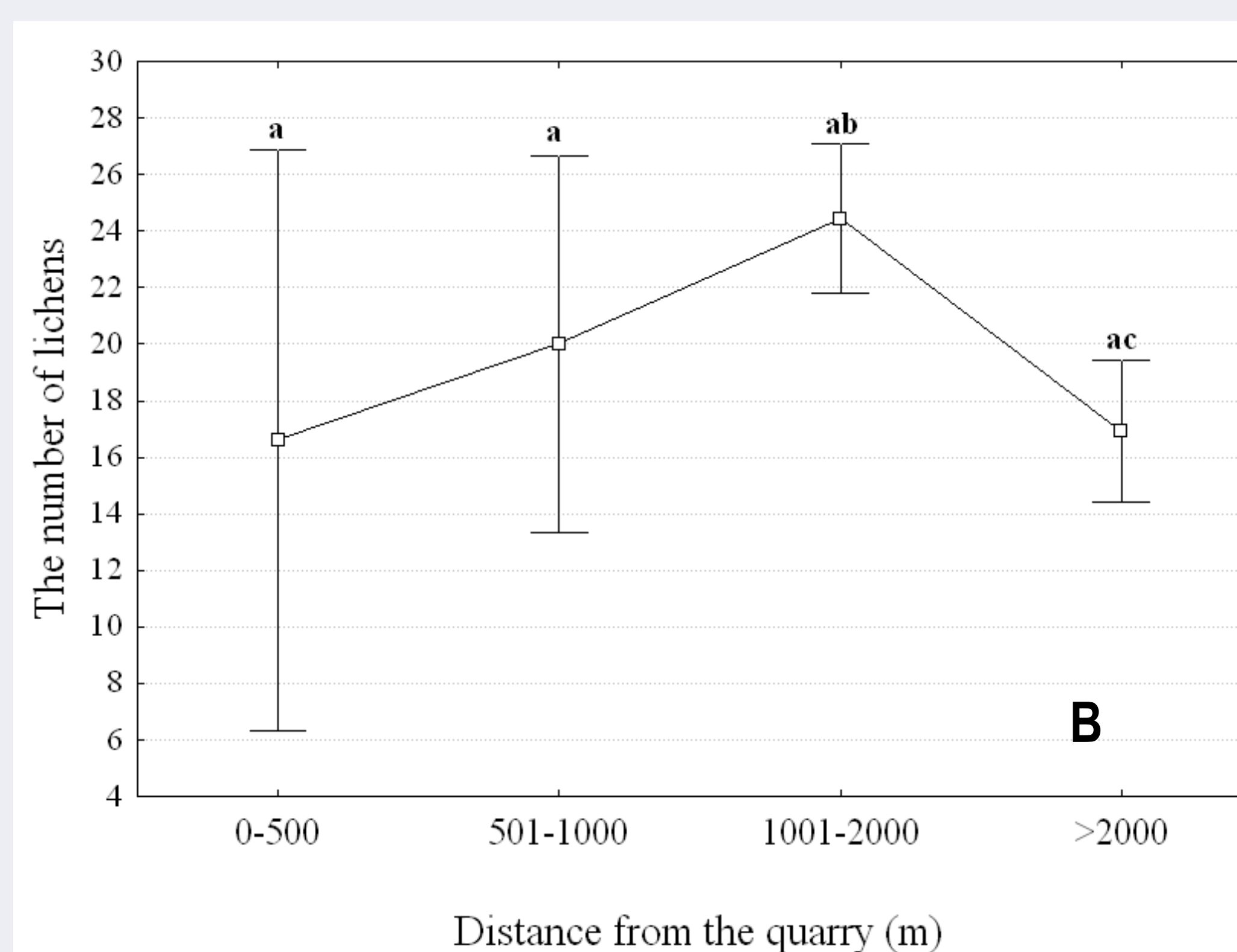
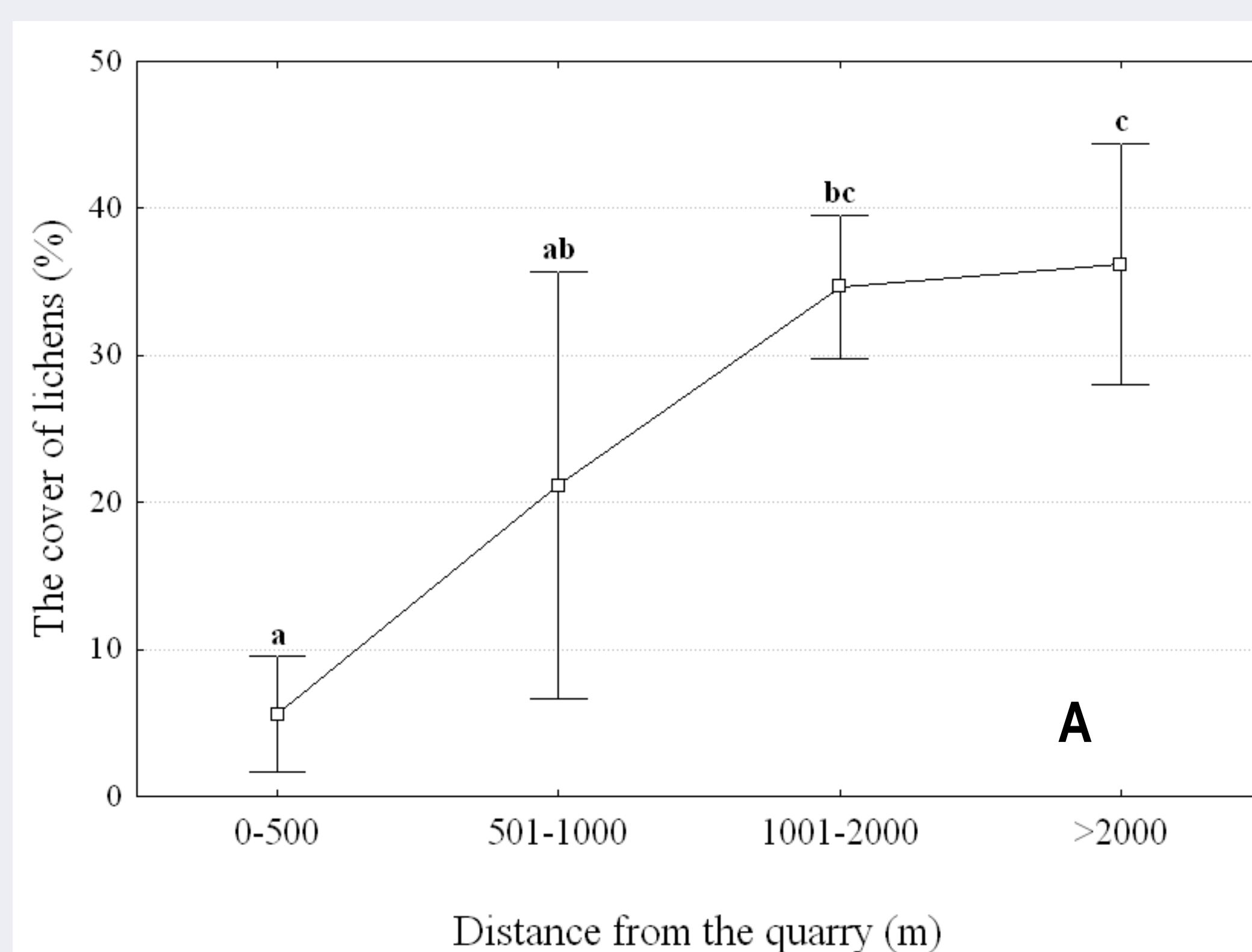


Fig. 3. The mean percentage of lichen cover (± 0.95 confidence interval, at the height of 120 cm, A) and the mean number of lichen species (± 0.95 confidence interval, B) on Scots pines per sample plot at different distances from the quarry; the significant differences between the groups are marked with letters a-c according to Tukey's HSD test.

- ❑ The bark pH decreased gradually with increasing distance from quarries ($F(3,28)=19.5$; $p<0.000001$).
- ❑ The cover (A) and species richness (B) of epiphytic lichens essentially responded to the effect of alkaline dust pollution (Fig. 3).
- ❑ We recorded the drastic changes in natural epiphytic communities, resulting in diversified artificial communities near the pollution source; the distance over 2000 m from the quarries was sufficient to re-establish the normal acidity of the bark and natural communities of both cryptogams.
- ❑ The cover of lichens and number of bryophytes could be more promising indicators of environmental conditions in dust-impacted areas than individual species occurrence.
- ❑ We suggest additional bioindicator species of dust pollution on pines (e.g. lichens *Lecidella elaeochroma*, *Alyxoria varia* and e.g. bryophytes *Orthotrichum pallens*, *Schistidium apocarpum*).
- ❑ Dust pollution revealed a 'parapositive' impact on cryptogamic communities; we registered on pines several locally rare bryophytes and lichen species (Fig. 4). This means that quarrying might temporarily contribute to distribution of locally rare species.



Fig. 4. The red-listed in Estonia as VU *Caloplaca ulcerosa* was recorded on Scots pines in high abundance in close vicinity to Vasalemma quarry. This species grows commonly on the bark of broad-leaved trees.

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