Influence of abiotic and biotic factors on the diversity of soil-growing lichens along the BIOTA Southern Africa transect

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Introduction

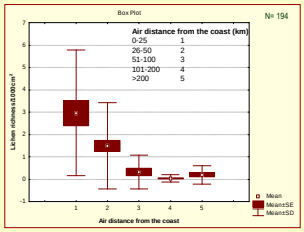
This work was carried out by the BIOTA South subproject S04 in cooperation with subprojects S02 and S06. The main aim of subproject S04 is to explore lichen diversity changes due to different abiotic and biotic factors. Lichens are an important component of biological soil crusts, and are widely distributed throughout arid to semi-arid regions of the World. They are usually found in later successional stages of microbiotic crusts since they have longer recovery times in comparison to other organisms, and require a certain soil stability for the growth. Investigations were carried out along the BIOTA South transect. The aim of this work is to investigate whether lichens can be regarded as good indicators of climatic changes and of soil type and stability, and to see how changes in vegetation cover and diversity of higher plants, can influence soil-growing lichens.

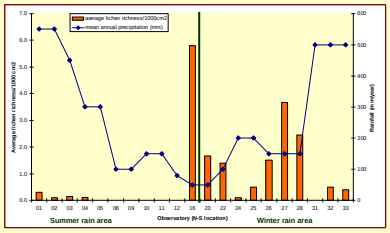
Material and methods

Taxa richness was selected as a measure of lichen diversity. This is referred to a 20 cm x 50 cm large sampling area (1000 cm²) placed north of the centre point of at least 10 hectares per BIOTA Observatory, selected according the randomized BIOTA ranking procedure. Analyses are based on data from 22 BIOTA Observatories. Data on soil and phanerogamic vegetation were taken from the identical sites as the lichenological data. Soil parameters used for statistic analysis were measured at soil surface (0-1 cm).

Climate

Key questions: 1) Is the species richness of lichens influenced by the vicinity to the coast and by rainfall?
2) Are there any differences in species richness between summer and winter rain areas?



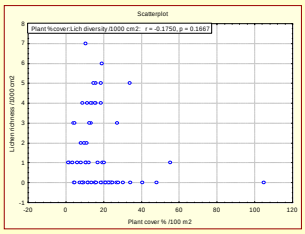


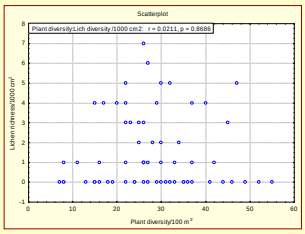
	Rain system	Air distance from the coast (km)	Mean annual precipitation (mm)
Lichen richness/1000cm²	0.15	-0.52	-0.32

The average richness of soil-growing lichens per 1000 cm² is clearly higher close to the coast (<50 km distance) due to the strongest frequency of fog and dew at these sites. Mean annual precipitation is inversely correlated with average lichen richness, and more taxa are found in average at the observatories of the winter rainfall areas compared to those with summer rainfall.

Higher plant vegetation

Key questions: 1) Does the cover of higher plants influence lichen species richness?
2) Is the species richness of higher plants correlated with richness in lichens?





Lichen richness is higher where the total plant cover is below 60%. However, the correlation is only poorly statistically supported. No correlation is found between lichen and plant diversity (N=158).

Soil and climate

Key questions: 1) Which of the examined factors have a stronger influence on lichen diversity?
2) Are climate changes more important than changes in soil features?

Multiple Regression Results

Dependent variable: *Lichen richness/1000 cm²*

Multiple R = .65396132 F = 23.28866

R²= .42766541 df = 6,187

No. of cases: 194 adjusted R²= .40930173 p = 0.000000

Standard error of estimate: 1.379203539

Intercept: 166.98665677 Std.Error: 32.90272 t(187) = 5.0752 p = .0000

pH	beta=.125
EC µS/cm	beta=.143
Silt,%	beta=-.04
Clay,%	beta=.078
Rain system	beta=-.45
Air distance from the coast	beta=-.82

After a regression analysis of data from the entire transect, climate as well as soil features mostly influence lichen richness whereas climate appears to have the strongest influence along the transect.

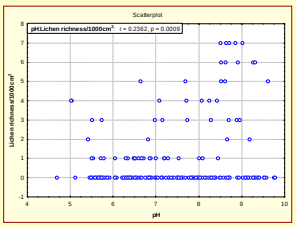
Correlations
Marked correlations are significant at p <.05000 N=95 (Casewise deletion of missing data)

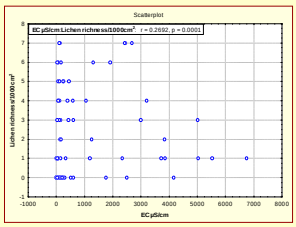
	pH	EC µS/cm	Silt,%	Silt + clay %	Inf. 0.5	Air distance from the coast
Lichen diversity/1000cm²	0.29	0.17	0.30	0.36	-0.27	-0.15

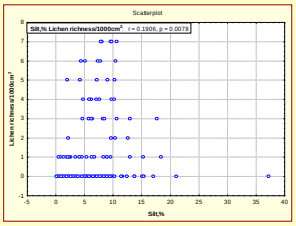
Considering only the observatories of the winter rain area, the richness of soil-growing lichens is stronger correlated with soil parameters, especially the content of silt (%), clay (%) and soil pH.

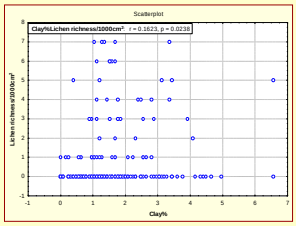
Soil

Key questions: 1) Is lichen richness influenced by soil chemistry and texture?
2) Which soil parameters are most important for lichen richness?









The considered soil parameters (pH, EC, silt % and clay %) are all significantly correlated to lichen diversity along the transect. The strongest correlation are found for soil salinity (EC) and pH. Lichen diversity is higher on alkaline soils, having a pH > 8, and on saline soils (N=194).

Discussion and conclusions

The richness of soil-growing lichens is clearly positively influenced by climate, especially by the vicinity to the coast, where the influence of fog and dew is stronger, and favoured by a winter rain system. Rainfall is in most cases directly correlated to air distance from the coast, and therefore inversely to lichen richness. The higher richness of lichens by lower cover degrees of higher plants is most probably indirectly related to climate and soil type, since higher plants usually avoid alkaline and saline soils, and have greater cover far from the coast where rainfall increases. The greater richness of lichens on soils with higher pH is probably due to higher contents of calcium-, magnesium and/or sodium carbonates, and to a lower competition with higher plants. The preference for saline soils can also be explained by a lower total cover of higher plants on saline soils, but it could also be that saline soils, being these mostly fine-textured, have higher stability at superficial layers than sandy soils. Moreover, certain lichen species are known to benefit from salts in aerosols. It has been demonstrated that given lichen species show a more rapid rehydration of the thallus when this is covered by a salt crust, thus having a more efficient photosynthetic rate (Follmann 1967; Huiskes & Moerdijk-Poortvliet 2000). Lichens are also more diverse as the finer particles of soil increase (percentage of silt and of clay), favouring these soils lichen growth thanks to their greater stability. The influence of soil properties is stronger in observatories having similar climatic conditions (e.g. winter rainfall areas).

Perspectives for the III BIOTA Phase

The role of lichen soil crusts in actively modifying soil superficial properties, and in the protection against soil erosion is going to be explored. Parameters such as water runoff/infiltration, pH, availability of essential elements will be analyzed at observatory level, comparing crusted and non-crusted conditions. It is also intended to investigate which effects potential changes in soil properties, caused by lichens, might have on the diversity, germination and survival of vascular plants at these sites. We also believe that there could be a dependence of certain lichen species on given higher plant species or vegetation types, due for instance to greater shadow and micro-environmental air humidity occurring under shrubs, and intend to explore potential interactions of lichens and plants.

Man-made disturbance is surely also an important factor influencing the diversity of soil-growing lichens at local level. Since the influence of climate and soil type results so important at transect level, it will be preferable to investigate the effect of land use on lichen crusts at sites which have similar climatic and soil conditions, but different land use systems.

References

Follmann 1967, Berichte der Deutschen Botanischen Gesellschaft 80, 206–208.
Huiskes & Moerdijk-Poortvliet 2000, Bibl. Lichenol. 75, 209–218.

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Projektträger im DLR
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