

Successional development of the phototrophic community in biological soil crusts on coastal and inland dunes

Sandra Kammann¹, Ulf Schiefelbein², Christian Dolnik³, Tatiana Mikhailyuk⁴, Eduard Demchenko⁴, Ulf Karsten¹, Karin Glaser¹

¹ Institute for Biological Sciences, Applied Ecology and Phycology, Rostock University, Albert-Einstein-Straße 3, 18059 Rostock, Germany

² Botanical Garden, University of Rostock, Schwaansche Straße 2, 18055 Rostock, Germany

³ Institute for Natural Resource Conservation, Landscape Ecology, Kiel University, Ohlshausenstr. 40, 24098 Kiel, Germany

⁴ M. G. Kholodny Institute of Botany, National Academy of Science of Ukraine, Tereshchenkivska St. 2, Kyiv UA-01601, Ukraine

Table S1: Overview of all defined functional biotic and abiotic groups used to determine the dune surface coverage. Abbreviations of these groups, a short description, a color code, and visual examples of each functional group are given.








Category	Short	Description	Code	
Vascular plants	VP	Tracheophyta		
Bare sediment/sand	Ba	No vegetation or biocrust visible, loose sand layer		
Litter	Li	Litter layer i.e. needles, leaves, branches		
Biocrust				
Green algae	GA	Early successional stage, slightly brittle, <3 mm thick, greenish-shimmering		
Green algae-dominated /mosses	GA/M	Stable green crust, occasionally mosses		
Moss-dominated	MD	biocrust dominated by mosses, partly many algae species (mostly green algae), several cm thick/high		
Moss-dominated /lichens	MD/L	MD-type, occasionally lichens (mostly chlorolichens), many algae species (mostly green algae), several cm thick/high		

Figure S1: Sampling plot (1 m²) divided into 16 equal subplots (0.0625 m²) with 25 cm x 25 cm (0.0625 m²) grid of 25 intersections. A metal pin was dropped next to each intersection, and the ground covering functional group, including bare sediment, was recorded.



Table S2: Chlorophyll *a* content (mg m⁻²) for biocrusts or sediment (*) along both dune chronosequences.

Study site	Dune area	Sampling plot	Chl <i>a</i> (mg m ⁻²)
Schaabe (Rügen)	Coastal dune	FD	0*
		ID	161.34 ± 56.51
		GD	150.92 ± 26.49
		MD	287.63 ± 49.07
Verden (Aller)	Inland dune	DC	5.86*
		DS	112.07 ± 20.0
		DF	210.80 ± 109.01

Figure S2: Venn diagrams showing the total species number of (A) algae, (B) mosses, and (C) lichens at the two sampling sites. The number of species that were found at both sites are represented as an overlap between the two circles.

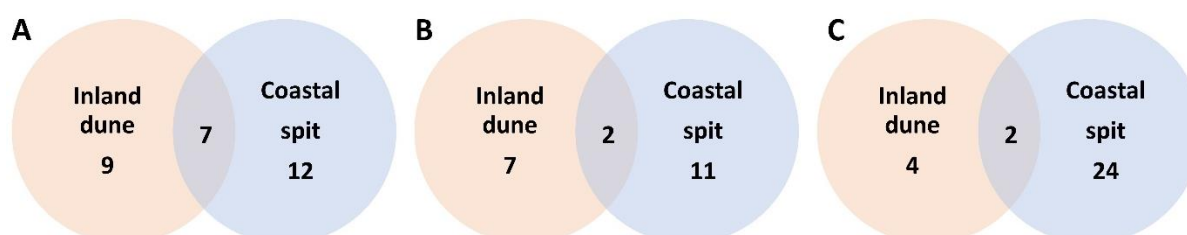


Table S3: Lichen species in biocrusts. Listed by the order of lichen-forming fungi (Mycobiont). Columns differentiating between lichens occurrence and characterizing the preliminary settled pH range; Abbreviations: e=extreme, v=very, q=quite, m=moderate.

Phylum, class, order (Mycobiont)	Species	Occur on	pH range
Ascomycota			
Lecanoromycetes			
Baeomycetales	<i>Placynthiella uliginosa</i>	Sand	e.acidoph.-q.acidoph.
Lecanorales	<i>Bacidina etayana</i>	Litter	
	<i>Cladonia arbuscula</i>	Sand	e.acidoph.-m.acidoph.-(subneutroph)
	<i>Cladonia chlorophaea</i>	Sand	(e.acidoph.-)v.acidoph.-m.acidoph.
	<i>Cladonia conista</i>	Sand	acidoph.
	<i>Cladonia fimbriata</i>	Sand	q.acidoph.-m.acidoph.-(subneutroph)
	<i>Cladonia foliacea</i>	Sand	(q.acidoph.-)m.acidoph.
	<i>Cladonia furcata</i>	Sand	q.acidoph.-subneutroph
	<i>Cladonia gracilis</i>	Sand	e.acidoph.-m.acidoph.
	<i>Cladonia humilis</i>	Sand	q.acidoph.-subneutroph
	<i>Cladonia phyllophora</i>	Sand	q.acidoph.-m.acidoph.
	<i>Cladonia portentosa</i>	Sand	e.acidoph.-m.acidoph.-(subneutroph)
	<i>Cladonia ramulosa</i>	Sand	v.acidoph.-q.acidoph.
	<i>Cladonia rei</i>	Sand	m.acidoph.-subneutroph
	<i>Cladonia scabriuscula</i>	Sand	m.acidoph.-subneutroph
	<i>Cladonia uncialis</i> ssp. <i>biuncialis</i>	Sand	e.acidoph.-m.acidoph.-(subneutroph)
	<i>Evernia prunastri</i>	Sand	v.acidoph.-m.acidoph.
	<i>Hypogymnia physodes</i>	Sand	v.acidoph.-m.acidoph.
	<i>Lecania cyrtella</i>	Litter	subneutroph
	<i>Myriolecis hagenii</i>	Litter	subneutroph.-basiph.
	<i>Myriolecis persimilis</i>	Litter	subneutroph.-neutroph.
	<i>Micarea misella</i>	Litter	v.acidoph.-q.acidoph.
	<i>Parmelia sulcata</i>	Sand	(q.acidoph.-)m.acidoph.
Peltigerales	<i>Peltigera extenuata</i>	Sand	q.acidoph.-subneutroph.
Teloschistales	<i>Athallia cerinella</i>	Litter	subneutroph.
	<i>Physcia tenella</i>	Litter	subneutroph.-m.basiph.
	<i>Xanthoria parietina</i>	Litter	subneutroph.m.basiph.

Figure S3: Table showing Pearson correlation coefficients to reveal correlations between nutrient contents, which might affect or be affected by the richness of the phototrophic biocrust community. Plot of moss richness in biocrusts over the total phosphorus content in the biocrusts from both sites. The line indicates the best linear fit ($p = 0.115$ (ANOVA)).

	Richness All	Richness Algae	Richness Mosses	Richness Lichens
Ct (g/kg)	0.196	0.021	0.432	0.118
Nt (g/kg)	0.154	0.016	0.408	0.059
Pt (g/kg)	0.441	0.102	0.649	0.396

