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ARTICLE

Photoautotrophic organisms control microbial abundance, diversity, and physiology in different types of biological soil crusts

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光自养生物控制生物土壤结皮中的微生物丰度、多样性及生理特性

IF=9.520

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17.05 · PhD

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Conference Paper | Full-text available | Apr 2015 · EGU 2015 Vienna

Laura Briegel-Williams · Lingjuan Zheng · Stefanie Maier · [...] · Burkhard Büdel

The " Soil Crust INternational " (SCIN) Project aims to improve the appreciation and understanding of European Biological Soil Crusts (BSC) with the goal of developing biodiversity conservation and sustainable management strategies. Our objective is to study the uniqueness of European BSC on a local scale and investigate how these...

Contents

Introduction

Dryland regions

vascular vegetation quite sparse

biological soil crusts (biocrusts)

Central role

carbon and nitrogen cycles

cyanobacteria-

lichen-

moss-

dominated types

different successional stage

Issues: The photoautotrophic organisms affect the composition of the heterotrophic microbial community, thus also the physiological properties of different biocrust types.

Materials and methods

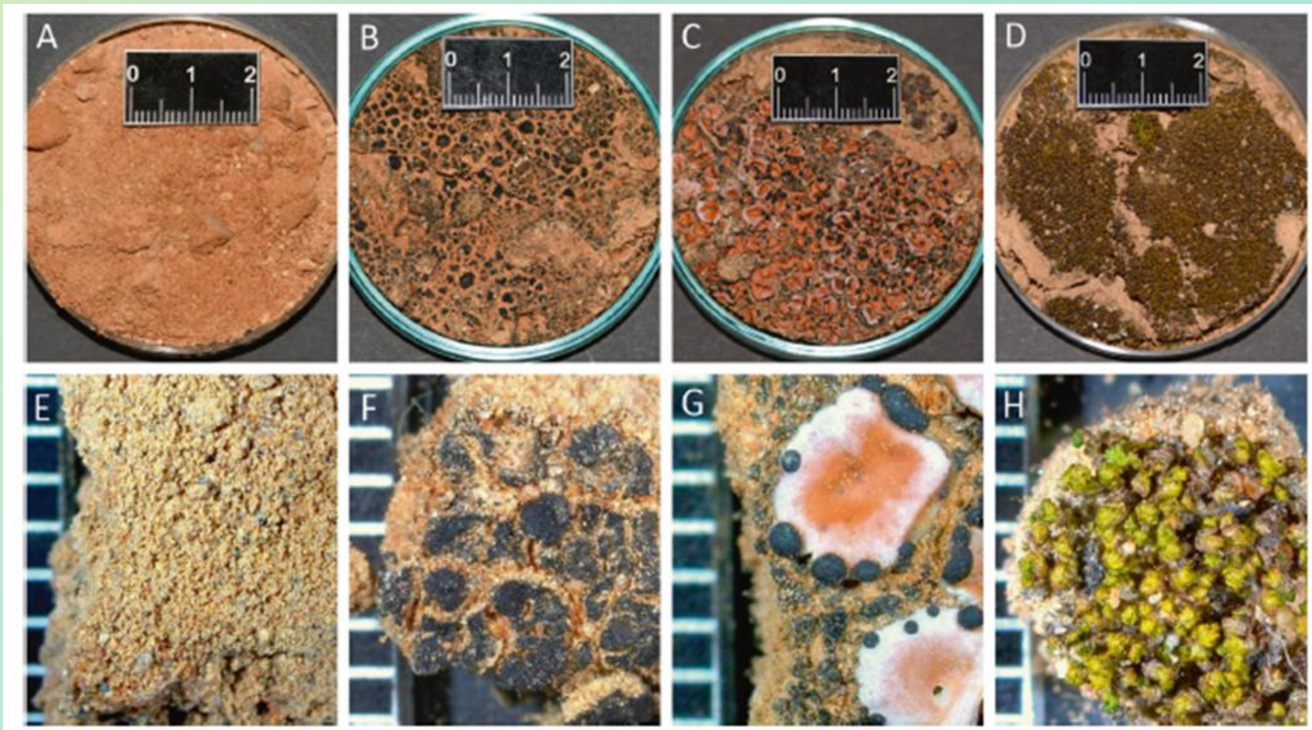
Sampling area

Northern Cape Province, South Africa

Karoo biome （卡鲁生态区）
known for its unique flora of succulent plants,
high plant diversity and biocrust cover

Materials and methods

Sampling and storage



bare soil cyanobacteria lichen moss

DNA extraction, 16S rRNA gene PCR amplification and sequencing: PowerSoil® DNA Isolation Kit

Materials and methods

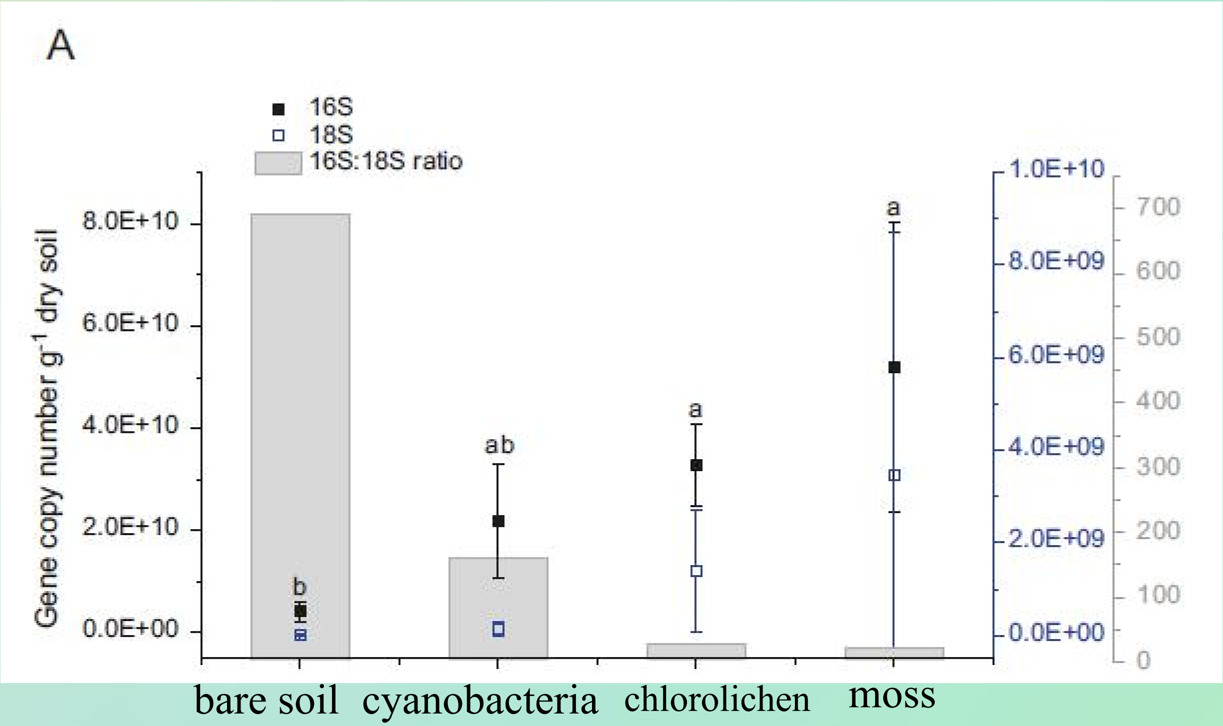
Biomass and soil parameters

CO2 gas exchange measurements

Dynamic chamber measurements： Nitrous acid (HONO) and nitric oxide (NO) emissions of biocrusts were measured with a laboratory dynamic chamber system, described in detail by Wu et al. and Weber et al.

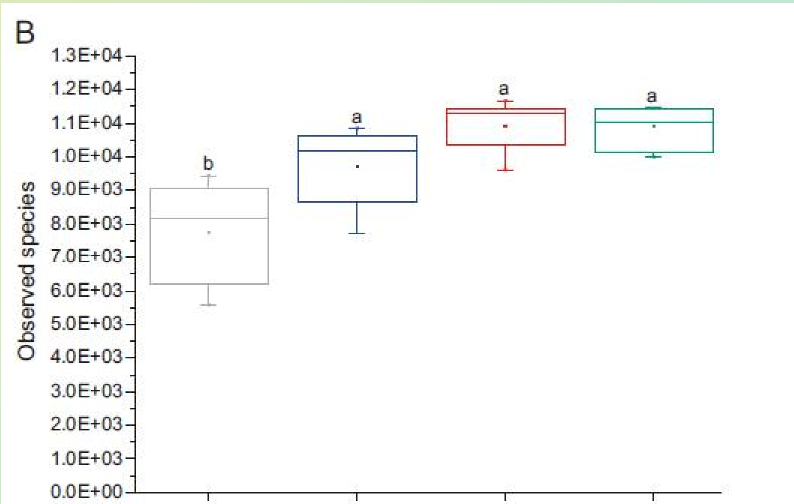
Results

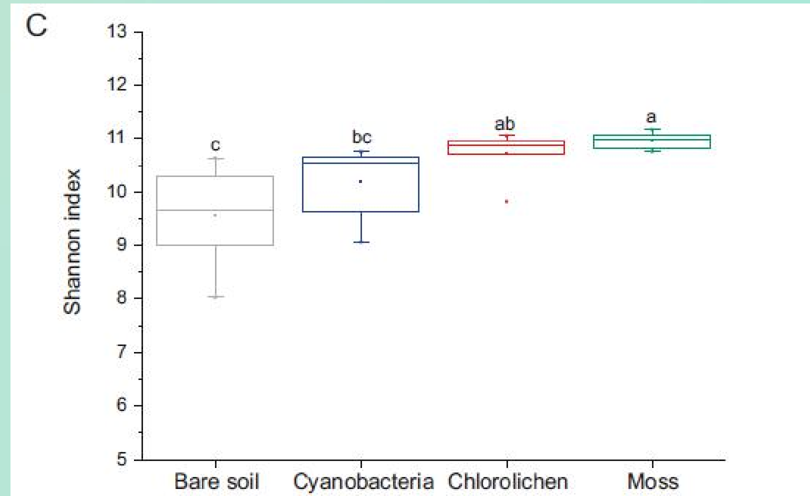
Abundance and diversity

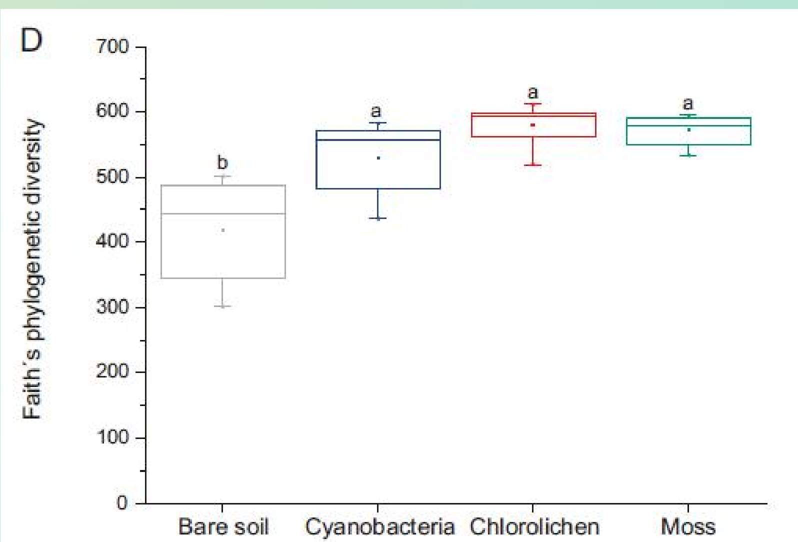


The bacterial and fungal gene copy numbers were highest in moss-dominated biocrusts, The abundance of bacteria and fungi in bare soil was significantly lower than in chlorolichen- and moss-dominated biocrusts. The ratio of bacterial and fungal gene copy numbers decreased with succession.

Results

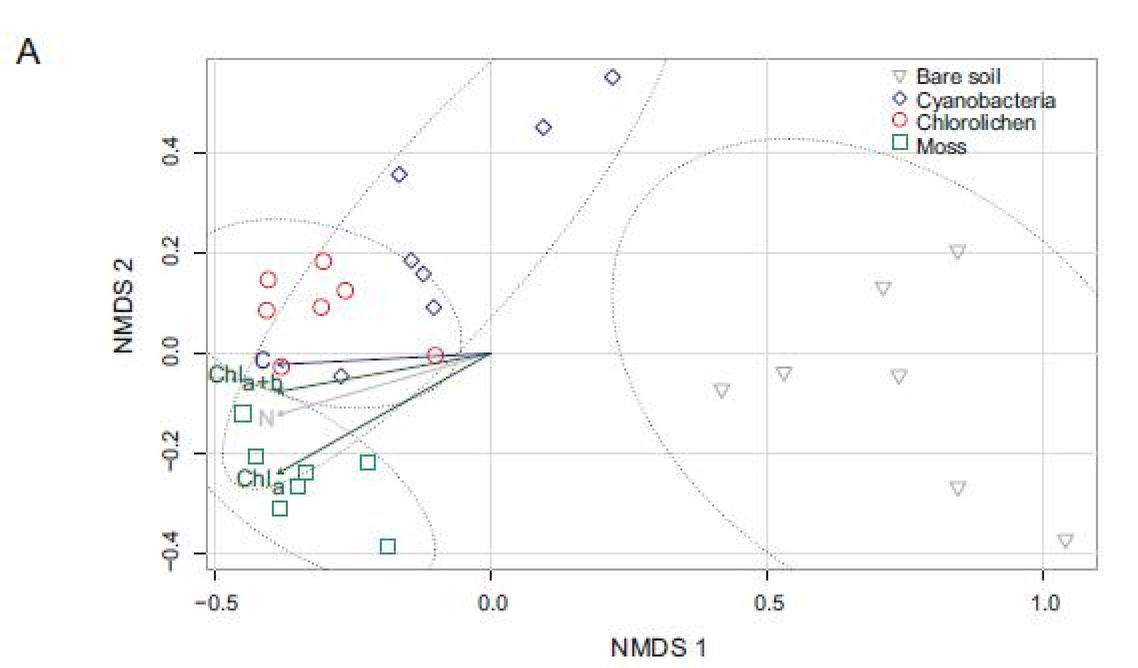






α-diversity values increased with the succession, regardless of sequencing depth and diversity measure used

Results



非度量多维尺度法是一种将多维空间的研究对象（样本或变量）简化到低维空间进行定位、分析和归类，同时又保留对象间原始关系的数据分析方法。特点是根据样品中包含的物种信息，以点的形式反映在多维空间上，而对不同样品间的差异程度，则是通过点与点间的距离体现的，最终获得样品的空间定位点图。

Results

Microbial composition

Phyla level

Bacteroidetes	18.5%	Proteobacteria	15.8%
Actinobacteria	15.2%	Cyanobacteria	9.5%
Acidobacteria	8.7%	Chloroflexi	7.3%
Verrucomicrobia	5.8%	Planctomycetes	5.6%

Class level

Alphaproteobacteria	11.9%	Saprospirae	9.2%
Cytophagia	7.6%	Actinobacteria	5.5%
Chloracidobacteria	5.5%	Oscillatoriophycideae	5.9%
Spartobacteria	5.3%		

Results

Microbial composition

OUTs level

Significant differences between surface cover types. Comparing bare soil bacterial communities with those of biocrusts, the number of OTUs that were differentially abundant increased with succession.

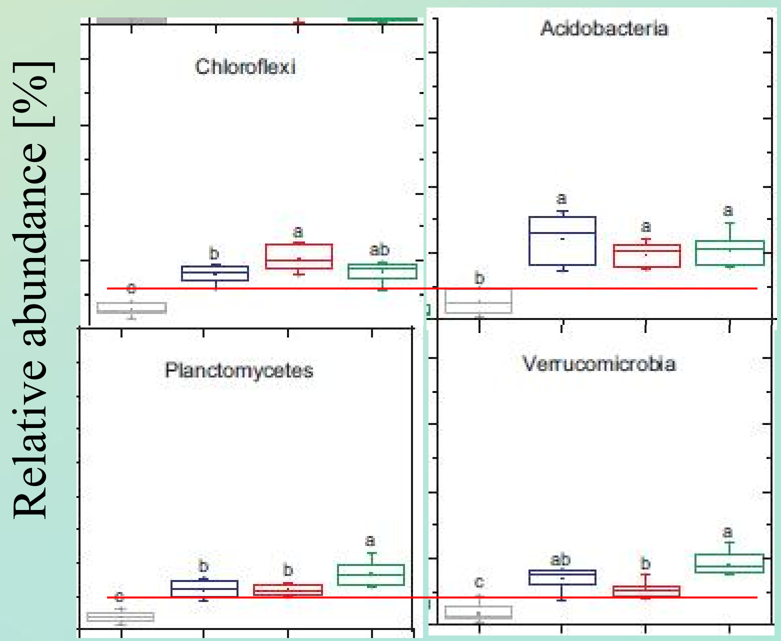
The relative abundance of OTUs in bare soil showed most similarities to cyanobacteria-dominated biocrusts, Microbial communities of chlorolichen- and moss-dominated biocrusts were less similar to bare soil.

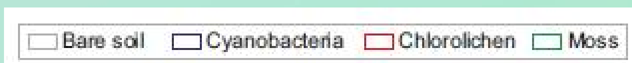
Results

Table 1 Comparison of the bacterial taxonomic composition at phylum level across the four categories: cyanobacteria-, chlorolichen-, moss-dominated biocrust associated soil and bare soil

		Bare	Moss	Cyanobacteria
Chlorolichen	U	$P < 0.00001$	$P < 0.00001$	$P < 0.00001$
	B	$P < 0.00001$	$P < 0.00005$	$P < 0.00001$
Cyanobacteria	U	$P < 0.00027$	$P < 0.00001$	
	B	$P < 0.0016$	$P < 0.00001$	
Moss	U	$P < 0.00001$		
	B	$P < 0.00001$		

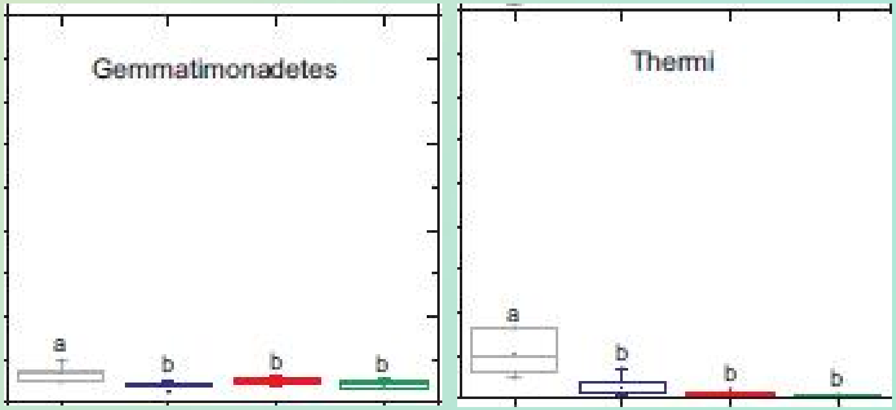
Comparing the samples of the four soil/biocrust types, significant taxonomic differences were observed between all of them





The relative abundance of Acidobacteria, Chloroflexi, Planctomycetes and Verrucomicrobia was significantly higher in biocrusts compared to bare soil

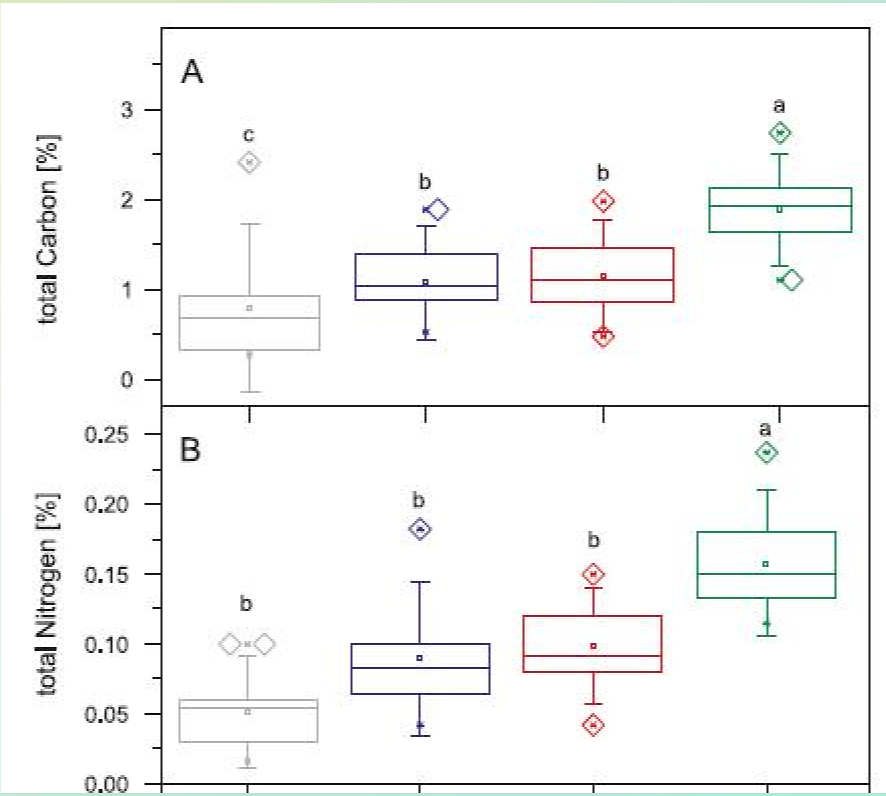
Results



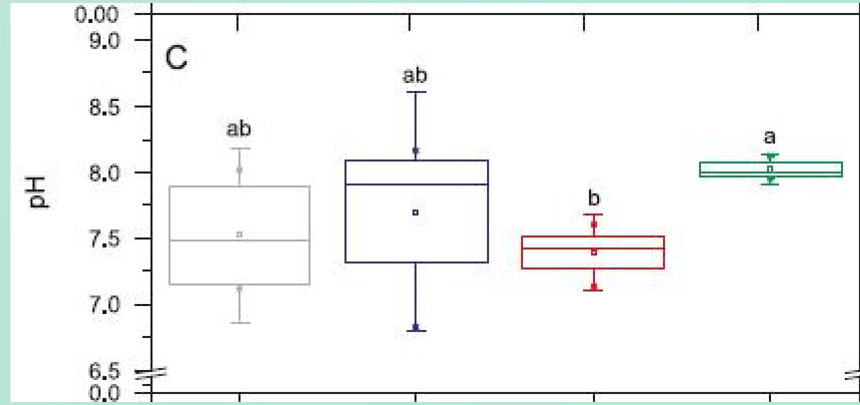
The relative abundance of Gemmatimonadetes and Thermi was significantly higher in the bare soil as compared to biocrusts.

Results

Soil parameters



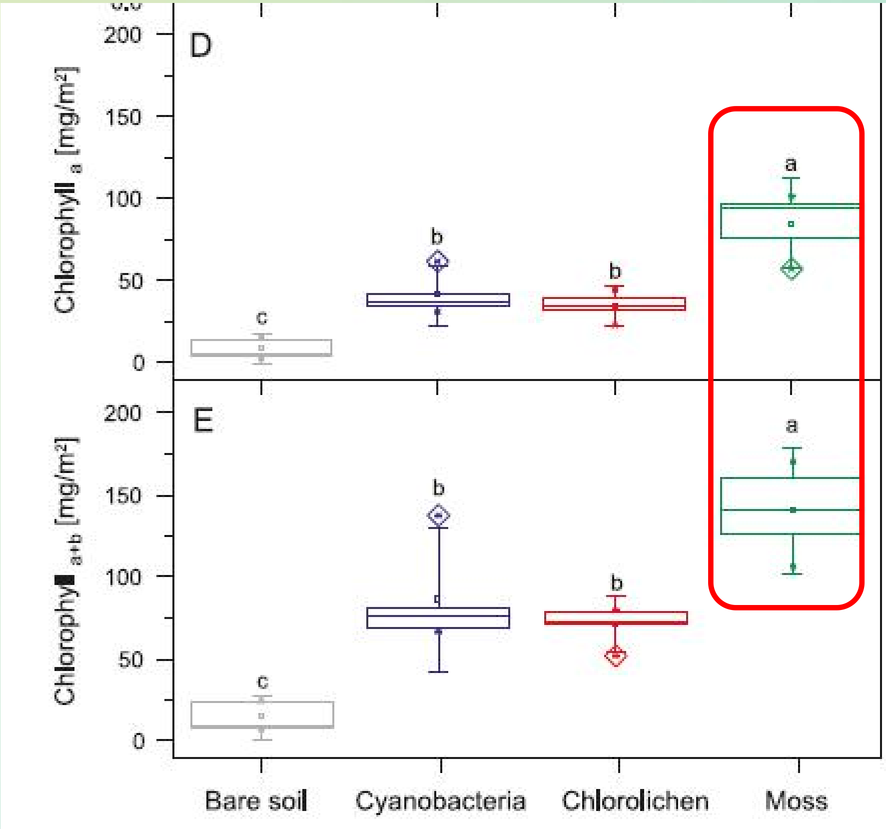
bare soil cyanobacteria chlorolichen moss



pH：7.4-8.0 neutral to weakly alkaline range moss-dominated reaching significantly higher values than chlorolichen-dominated biocrusts, whereas cyanobacteria-dominated biocrusts and bare soil did not differ significantly from them.

Both total carbon and nitrogen contents increased with biocrust succession.

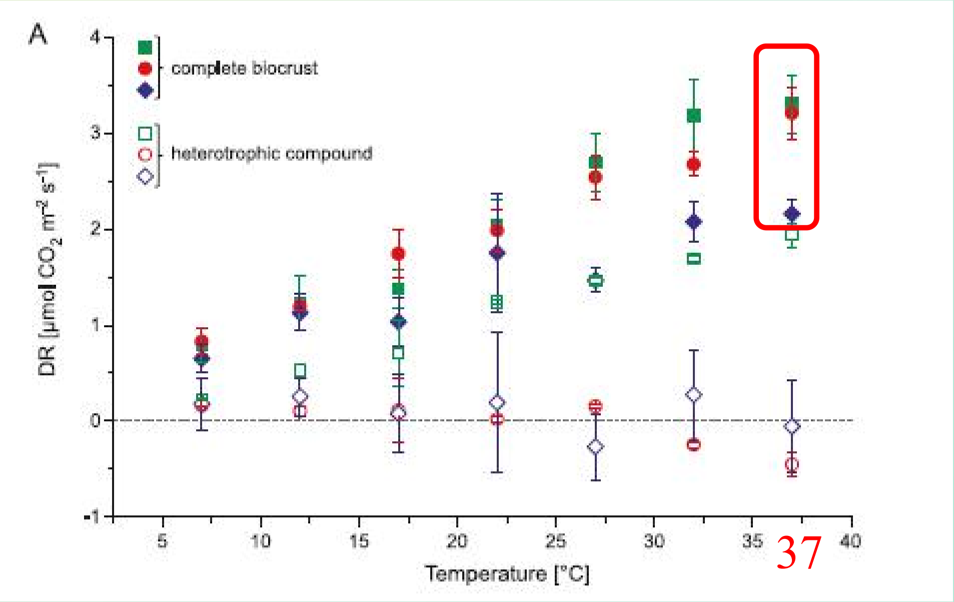
Results



Photosynthetically active biomass measured as chlorophylla (chla) and chla+b contents showed similar patterns of increasing contents with progressing biocrust succession.

Results

Soil respiration



Respiration (DR) of different biocrust types and their heterotrophic fraction at varying temperatures

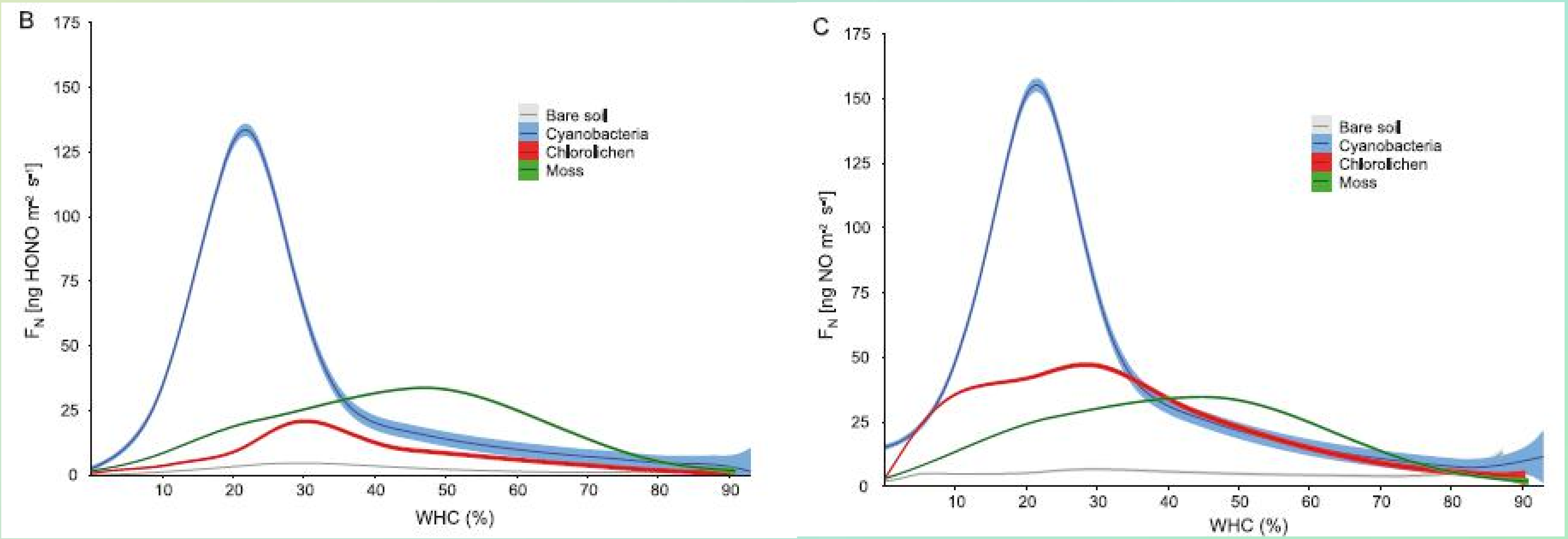
Moss-dominated 3.3µmol $CO2\ m^{-2}\ s^{-1}$

Chlorolichen-dominated 3.2 µmol

Cyanobacteria-dominated 2.2 µmol

Results

Reactive nitrogen emissions



Characteristic HONO and NO emission patterns were observed for all types of biocrusts, whereas for bare soil no significant amounts of reactive nitrogen emissions were measured

WHC： water-holding capacity

Discussion

Shift in diversity and relative abundance along the successional stages

- Alpha diversity values were highest in late successional biocrust stages, which is in line with the results of a study conducted at the Colorado Plateau.
- Bare soil was different from biocrust communities and successional stage determined the assembly of heterotrophic soil communities. Besides heterotrophic organisms, cyanobacteria were also present, with the highest relative abundance in bare soil.
- Similar mechanisms probably also occur in biocrusts, e.g., via substrate stabilization and nutrient input by early colonizers, thus driving microbial succession.

Discussion

Altered microbial composition reflected by shifts in nutrient composition

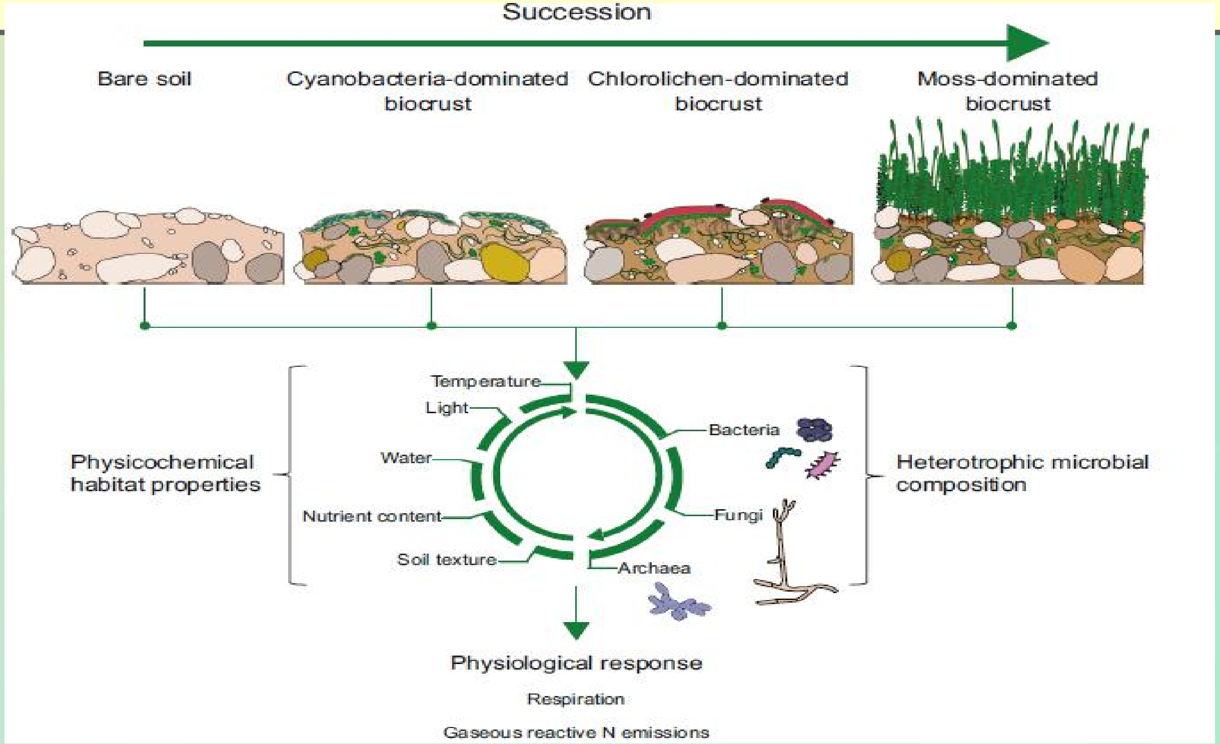
- Our study revealed increasing carbon and nitrogen contents from bare soil via initial to developed biocrusts (Fig. 6a, b) and statistically significant correlations between community composition and soil parameters
- In our study, OTUs classified as Chloroflexi occurred more frequently in biocrusts as compared to bare soil, Chloroflexi have been observed to occur in close contact with Cyanobacteria in microbial mats.

Discussion

Effects of altered microbial community composition on soil respiration and reactive nitrogen gas emissions

- Our results provide evidence that altered microbial communities may affect soil respiration, which is higher in moss-dominated as compared to earlier biocrust stages and bare soil.
- Recent studies showed that reactive nitrogen gases, such as HONO, NO and the greenhouse gas N2O (nitrous oxide) are emitted by biocrusts. Our results suggest an increased relative abundance of the family *Nitrospiraceae* in cyanobacteria-compared to moss-dominated biocrusts. the HONO and NO emission patterns changed with the successional stages of biocrusts, resulting in a sharp peak for cyanobacteria-dominated biocrusts.

Conclusion



We show here that they strongly affect the heterotrophic microbial composition and the physiological properties, probably via impacting the physicochemical habitat properties. The community composition combined with particular habitat conditions likely determines the physiological properties of different successional stages of biocrusts.

THANKS FOR LISTENING!