Microbial adaptations to environmental change: a moving target for global change ecology

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Yuste et al 2007

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CO_2

Acclimation of microbial respiration to experimental warming

Mass specific substrate respiration
($\mu\text{g C g microbial biomass}^{-1} \text{ d}^{-1}$)

Are short-term responses to environmental change good predictors of long-term responses?

How could microbial communities adapt to environmental change?

- Individual: Physiological changes
- Populations: Genetic evolution
- Communities: Shifts in community structure

Individual Adaptation: Physiological

Populations: Evolution

Sleight, S.C., Lenski, R.E., 2007.
Evolutionary adaptation to
freeze-thaw-growth cycles in
Escherichia coli. *Physiological
and Biochemical Zoology* 80,
370-385.

Community-level thermal adaptation

Rcenas-Moreno, G., M. G"Mez-Brand"N, et al. (2009). "Adaptation of soil microbial communities to temperature: comparison of fungi and bacteria in a laboratory experiment."

Community changes under stress: **plants**

Ambient conditions

Disturbance or stress
(e.g. severe drought)

Community changes:
Biomass decreases
Tolerant species survive

Ecosystem changes:
Water balance
Spatial uniformity
Nutrient dynamics

Future drought

Disturbance or stress
(e.g. severe drought)

Little change in composition

“Resilient plant community”

Community changes under stress: **microbes**

Ambient conditions

Altered rainfall timing
→ Drying-rewetting stress

Community changes

Biomass decrease?

Tolerant species?

Ecosystem changes

Nutrient transformations

Future drying-rewetting

“Resilient community”

**Drying-rewetting
stress in the lab**

**Less change in
composition?**

Rainfall Manipulation Plot Study (RaMPS)

- Mimics predicted changes in rainfall
- Change *timing* of rainfall but not amount
 - Increased time between rainfall events
 - Larger events.

KONZA Biolo

Does long-term exposure to an intensified precipitation regime alter the resistance or resilience of soil microbial communities to additional rewetting stress?

Lab experimental design

work by Sarah Evans

Average respiration rate after each moisture pulse

Microbial biomass carbon

Community composition: Fungal: bacterial ratios

Bacterial species composition

Non-metric multiple dimension scaling (NMS) ordination of bacterial communities

Results summary

Normal climate

Altered rainfall timing
→ Drying-rewetting stress

Community did change:
Biomass higher
More fungi
Change in bacterial species

Future drying-rewetting

Drying-rewetting
stress in the lab

Resilience developed
Delayed showed less
change in respiration and
fungal:bacteria ratio

Community is more resilient

Conclusions

1. Altered rainfall timing affects microbial community structure and function.
2. However, legacies may be short-lived

Testing assumptions

Do microbial communities 'acclimate' to environmental change?

By what mechanisms?

Over what time scale?

What are the consequences for ecosystem function?

Thank you!

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SYMP 13-7: Microbial adaptations to environmental change: a moving target for global change ecology

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Background/Question/Methods As the abiotic conditions that structure biological communities and elicit physiological responses continue to change at an unprecedented rate, we need to understand how biological responses to global change will affect ecosystem functioning. A number of studies have detected shifts in the structure of microbial communities in response to experimental warming, elevated CO₂ altered precipitation, and increased N deposition. However, since the links between microbial phylogeny and function are poorly understood, it can be challenging to predict how these changes in community structure will affect the rates of specific processes. It is often assumed that the high diversity of microbial communities makes them functionally redundant, and thus changes in community composition should have no direct effects. This paradigm has resulted in model structures that famously represent microbes as 'black boxes'. Recently, significant progress has been made in linking microbial community structure to function, and efforts have been made to incorporate microbial physiology into biogeochemical models.

Results/Conclusions Most efforts to predict the rates of microbially driven processes under future climates have extrapolated contemporary relationships between abiotic drivers and process rates, derived from either short-term lab studies under artificial conditions, or from large-scale patterns across resource or climate gradients. This approach assumes that the nature of these relationships will not change through time. However, recent studies have shown that microbial communities can acclimate to changing environments over time. For example, we recently found that the temperature sensitivity of soil respiration decreased in response to experimental warming in forest mineral soils. This mechanism may contribute to the ephemeral stimulation of respiration following experimental warming that has been observed at many sites, and has important implications for soil C responses to climate change. Other research suggests the ability of microbes to adapt to environmental change can be constrained by nutrient availability. In aquatic systems, the ability of bacteria to acclimate to temperature regimes, possibly through modifications in cell wall structure, can be limited by P. Similarly, in soils, N availability can modify the balance of r vs K selected microbes, thus altering the ability of microbial communities to utilize short-lived pulses in C availability due to rhizodeposition or precipitation events. Ongoing research will elucidate the specific nature of biological adaptation and acclimation that will enable us to better constrain ecosystem response to global change and manage for preferential outcomes.