Research Area 1 | Landscape Functioning
Working Group | Silicon Biogeochemistry

It is not plants alone – Protozoic silica and its role in terrestrial silicon cycling

Daniel Puppe

Introduction

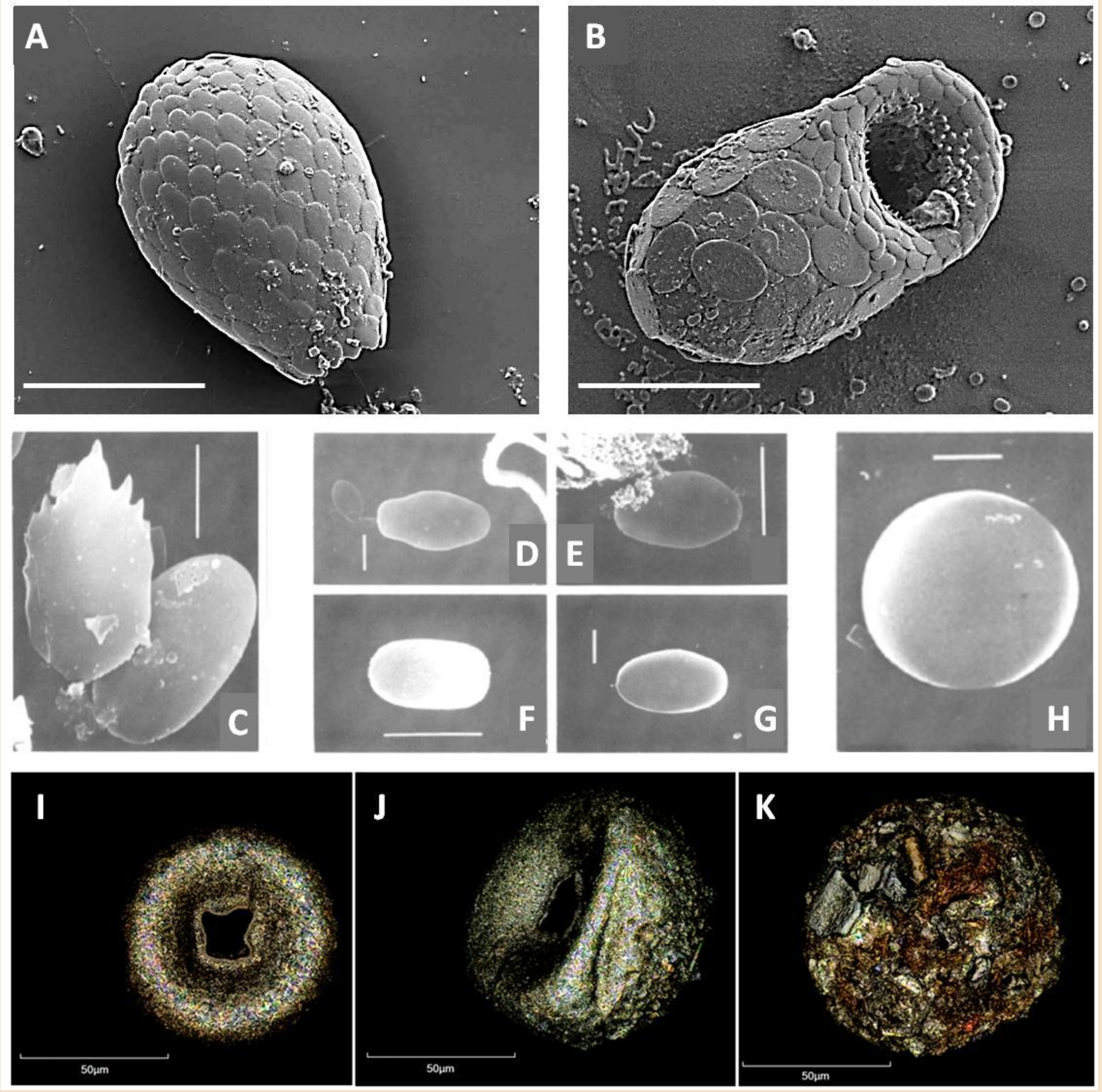
- The role of biogenic silicon (BSi) in linking global Si and carbon cycles has been emphasized since decades now
- Moreover, the importance of Si cycling for agricultural plant-soil systems is in the focus of many studies
- BSi is considered as one of the main drivers of plant-available Si in soils
- However, the vast majority of researchers actually mean phytogenic Si (BSi formed in plants) when talking or writing about BSi
- Protozoic BSi (BSi synthesized by testate amoebae) represents a neglected BSi pool in soils

Goals

- (i) Summary of knowledge on protozoic Si pools to underline the hypothesis that testate amoebae might play a key role in Si cycling in terrestrial ecosystems
- (ii) Encouragement of further field and laboratory research to verify this assumption and gain a deeper understanding of Si cycling by testate amoebae in terrestrial ecosystems

Testate amoebae

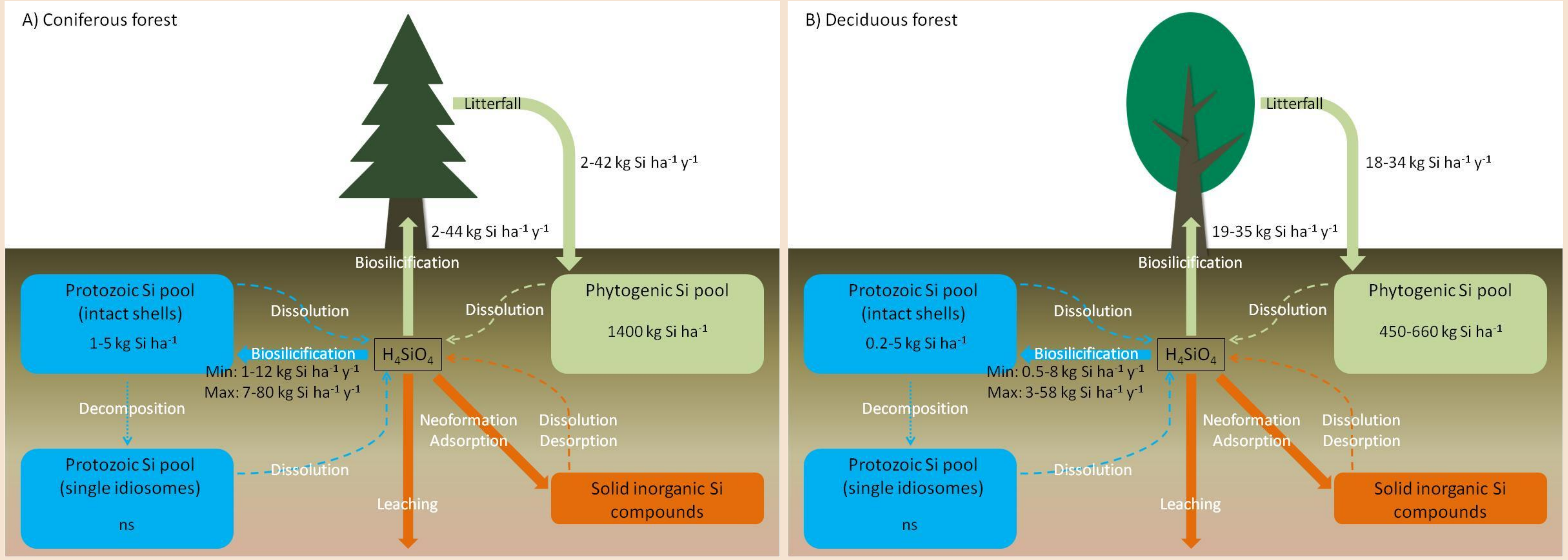
- Polyphyletic group of unicellular eukaryotes (protists)
- Shell (or test) with a size range of about 5-300 µm
- Shells are made by secretion (autogenous shells), agglutination of foreign material (xenogenous shells), or a combination of secretion and agglutination
- Many testate amoeba taxa are characterized by siliceous shells made up of self-synthesized silica platelets, the so-called idiosomes



Intact siliceous testate amoeba shells (A: *Euglypha rotunda* type, B: *Puytoracia bonneti*), single idiosomes (C-H), and xenosomic testate amoeba shells (*Trigonopyxis arcula*, I-K) (Puppe 2020).

What do we know about protozoic Si?

1. Annual Si fixation in testate amoeba shells can exceed annual Si uptake of trees



Pools and annual biosilicification of testate amoebae and trees in coniferous (left) and deciduous forests (right). Si pools of intact testate amoeba shells are relatively small. No information on total (intact shells plus single idiosomes) protozoic Si pools available. Biosilicification rates of testate amoebae and trees are in the same order of magnitude (Puppe 2020).

Interested? Get more information right here:

Qin, Y., Puppe, D., Payne, R., Li, L., Li, J., Zhang, Z., Xie, S. (2020). Land-use change effects on protozoic silicon pools in the Dajiuhu National Wetland Park, China. ***Geoderma*** 368, 114305.

Puppe, D. (2020). Review on protozoic silica and its role in silicon cycling. ***Geoderma*** 365, 114224.

Puppe, D., Höhn, A., Kaczorek, D., Wanner, M., Wehrhan, M., Sommer, M. (2017). How big is the influence of biogenic silicon pools on short-term changes in water-soluble silicon in soils? Implications from a study of a 10-year-old soil-plant system. ***Biogeosciences*** 14, 5239-5252.

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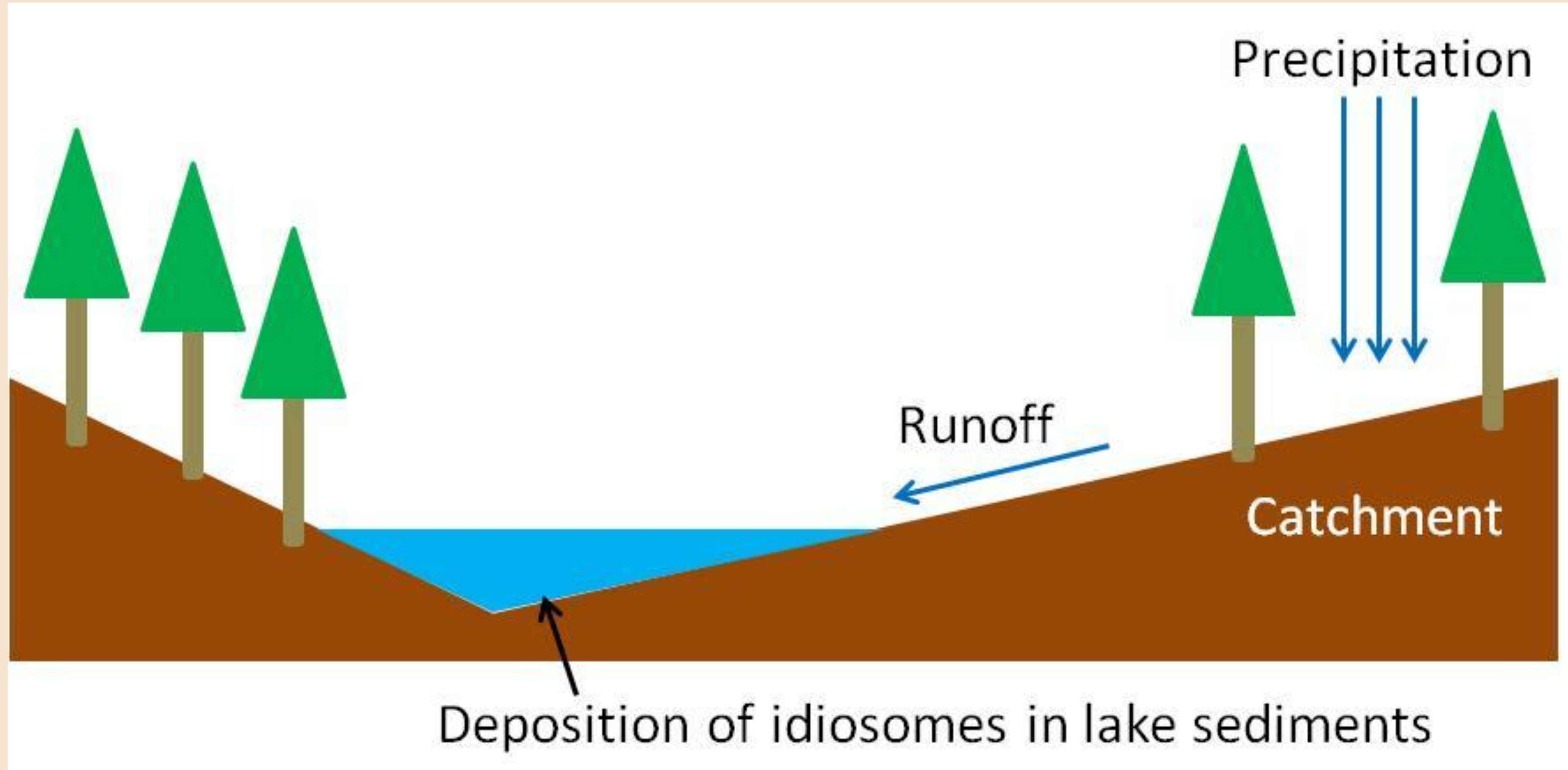
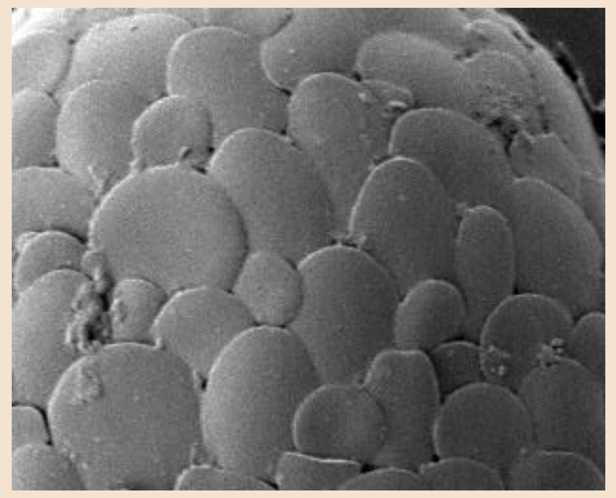
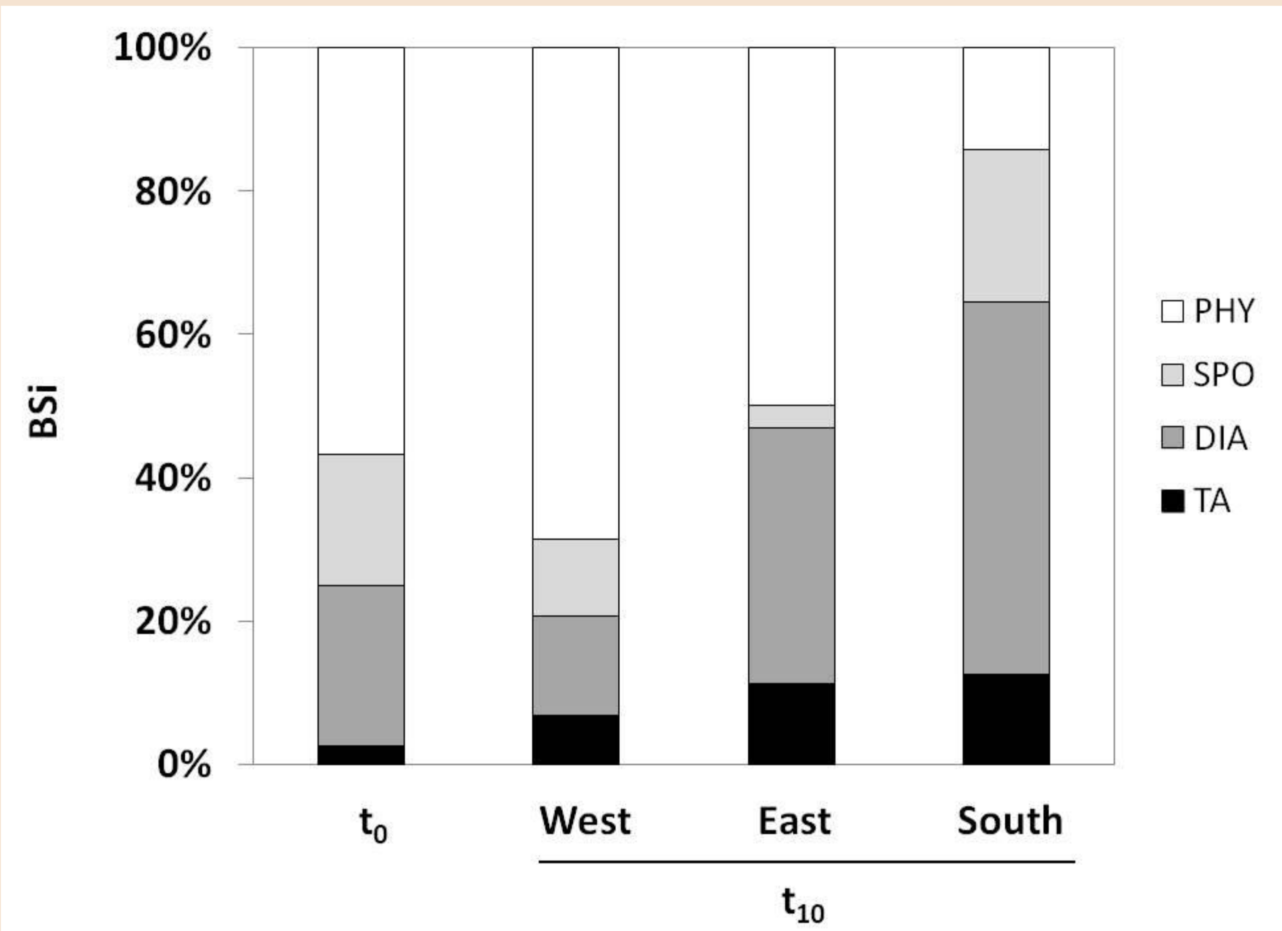
2. Idiosomes are well preserved in soils



Studies showed that idiosomes in catchment soils are transported with runoff and deposited in lake sediments (Douglas and Smol 1987: Siliceous protozoan plates in lake sediments, Hydrobiologia 154, 13-23. Pienitz et al. 1995: Diatom, chrysophyte and protozoan distributions along a latitudinal transect in Fennoscandia. Ecography 18, 429-439). Thus, it can be assumed that idiosomes are quite abundant in soils. This assumption is underlined by the fact that various xenosomic testate amoeba taxa (e.g., *Heleopera*, *Schoenbornia*) use idiosomes collected from the environment for shell construction.

Close-up of a *Heleopera* shell composed of collected idiosomes.

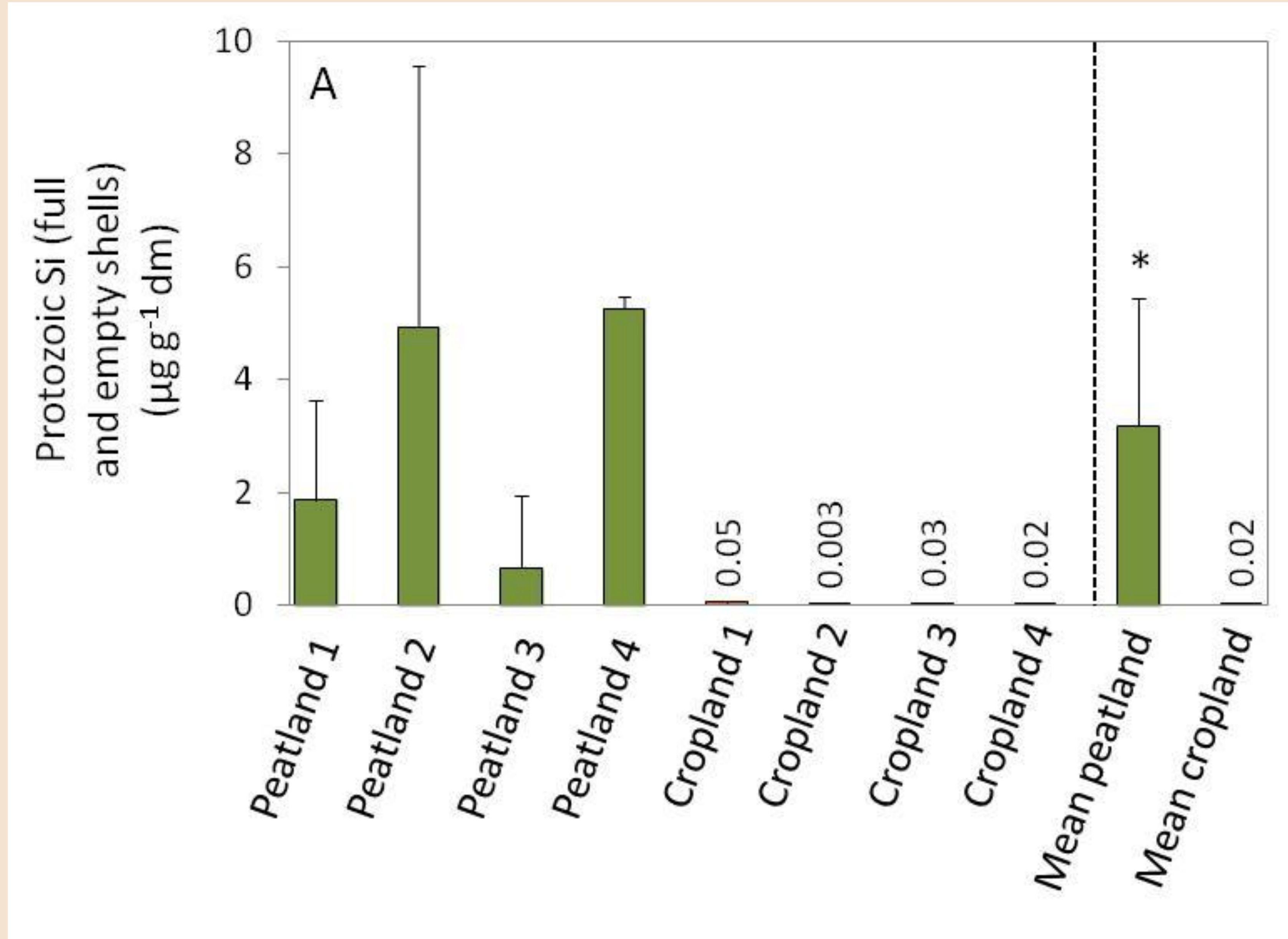




BSi pools in soils of a 10-year-old artificial catchment (Puppe et al. 2017).
PHY = phytoliths
SPO = sponge spicules
DIA = diatom frustules
TA = intact testate amoeba shells

The proportion of single idiosomes to total BSi remains unknown so far.

3. Land-use change affects protozoic Si pools



Testate amoebae and corresponding protozoic Si pools are very sensitive to land-use change. The conversion of peatland into cropland, for example, leads to a significant loss of protozoic Si (Qin et al. 2020). This depletion of protozoic Si pools caused by human activities represents an example for anthropogenic desilication at the microorganismic level.

Conclusions

The role of testate amoebae in Si cycling might represent another example for the essentiality of protists for ecological processes. What we need now is research to answer the following questions: (i) How big are total (intact shells plus single idiosomes) protozoic Si pools in soils? (ii) How long does it take for idiosomes to dissolve? The answers to these questions will lead us to a deeper understanding of Si cycling by testate amoebae in particular and the role of these microbes in soil ecology in general.

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