

## Cyperaceae Juss. and Juncaceae A. Rich ex Kunt. Phytoliths of Western Siberia

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The article presents results of studies of silica phytoliths in seven species of Cyperaceae and two species of Juncaceae from Western Siberia. The participation of different morphotypes in the total phytolith assemblage was calculated as percentages. The analysis of the specificity of different forms of silicification was carried out.

**Keywords:** *Carex*; Cyperaceae; Juncaceae; *Juncus*; *Luzula*; phytoliths; monocotyledons

Many living organisms are known to accumulate minerals in their tissues. Terrestrial plants are able to actively accumulate hydrogenated silica in cell walls, intracellular and intercellular spaces (Blackman, 1971, Kiseleva, 2006, Kumar et al., 2018). As a result, the specific microscopic bodies (phytoliths) are formed. Phytoliths find wide use in paleoecology, paleobotany, soil science, including in Russia (Piperno, 2006; Matiushkina et al., 2017; Semenyak et al., 2018).

Phytolith analysis, as the paleobotanical method, is mainly based on the use of phytoliths of monocotyledons (Blinnikov, 2005, Fredlund, Tieszen, 1994, Strömberg et al., 2018). Of these, grass (Poaceae) silica cells are the most studied (Neumann et al., 2017; Novello, Barboni, 2015). Expansion of paleoecological opportunities requires the research of silicaforms of Cyperaceae and Juncaceae, which species often dominate ground layer in many plant communities worldwide. Despite earlier studies (Mehra, Sharma, 1965; Bobrov et al., 2016), Cyperaceae phytoliths remain understudied, while Juncaceae remain virtually unstudied.

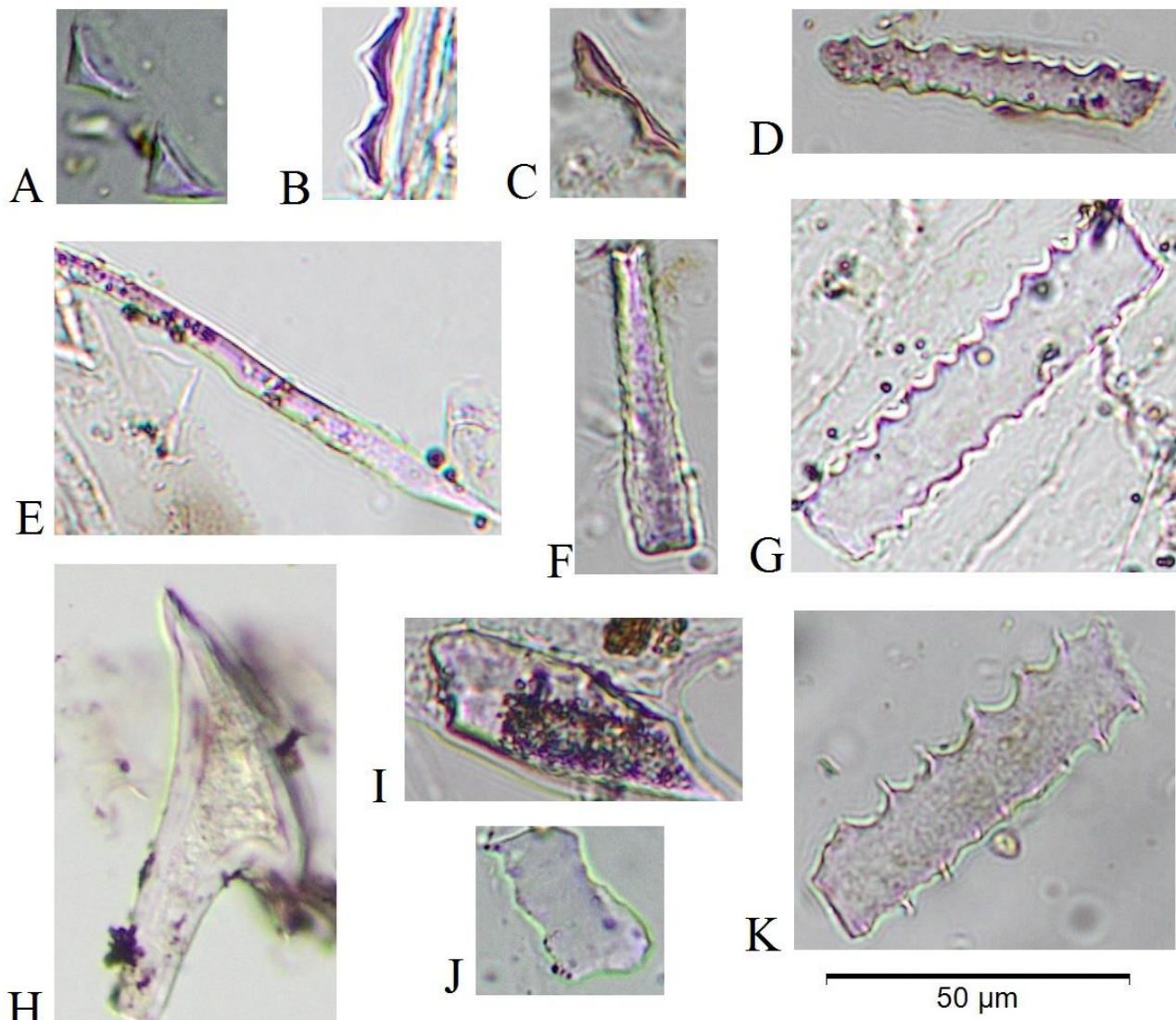
### Materials and methods

We investigated phytolith production in seven species of Cyperaceae and two species of Juncaceae. Plant material was carefully identified and thoroughly washed and dried to preclude contamination from other plants. Phytoliths were then isolated by the dry ashing at 400 °C in a muffle furnace. The final stage included the counts of the obtained samples under Olympus BX-51 optical microscope at x400-x1000 magnifications.

### Results

**Cyperaceae phytoliths.** *Carex dichroa* (Freyen) V.I. Krecz. forms conical phytoliths (60%), lanceolate (16%), irregular plates (7%), roundish long cells (2%), multisided long cells (5%), and toothed long cells (10%) (Fig. 1. C). *C. duriuscula* C.A. May produces conical phytoliths (72%) (Fig. 1. A), irregular plates (9%) (Fig. 1. J), and multisided long cells (19%). *C. macroura* Meinsh. has conical phytoliths (62%), irregular plates (9%), multisided long cells (7%) (Fig. 1. F), roundish long cells (4%), toothed long cells (4%), and lanceolate forms (14%). *C. muricata* L. produces conical phytoliths (96%) and toothed long cells (4%). *Carex perfusca* V. Krecz. produces conical phytoliths (40%) (Fig. 1. C), lanceolate forms (2%), irregular plates (5%), roundish long cells (15%), and multisided long cells (38%). *C. rostrata* Stokes has conical phytoliths (58%) (Fig. 1. B), irregular plates (15%), roundish long cells (13%) (Fig. 1. E), multisided long cells (15%), toothed long cells (10%) (Fig. 1. G). *C. supina* Willd. ex Wahlenb. forms conical phytoliths (59%), multisided long cells (12%), lanceolate cells (18%) (Fig. 1. I), and irregular plates (11%).

**Juncaceae phytoliths.** *Juncus compressus* Jacq. produces lanceolate forms (65%) (Fig. 1. H), multisided long cells (9%), roundish long cells (6%), irregular plates (20%). *Luzula sibirica* V.I. Krecz. forms multisided long cells (60%), irregular plates (32%) and toothed long cells (8%) (Fig. 1. K).



**Figure 1.** Phytolith forms. Cyperaceae: conical cells – A) *Carex duriuscula*; B) *C. rostrata*; C) *C. perfusca*; toothed long cells – D) *C. dichroa*; G) *C. rostrata*; roundish long cells – E) *C. rostrata*; multisided long cells – F) *C. macroura*; lanceolate cells – I) *C. supina*; irregular plates – J) *C. duriuscula*. Juncaceae: lanceolate cells – H) *Juncus compressus*; toothed long cells – K) *Luzula sibirica*.

## Discussion

The main forms of phytoliths for representatives of Cyperaceae and Juncaceae are lanceolate, long cells (mostly multisided), irregular plates, and for representatives of Cyperaceae they are also well-known conical.

Conical phytoliths are formed in the papillate structures of the sedge epidermis (Mehra et al., 1965), they have the polygonal base in *Carex* L. in the top view and are diagnostic to the family (Bobrov et al., 2016). This morphotype is dominant in *Carex* species of Western Siberia, but its percentage ratio varies relative to other morphotypes depending on the species. If there is an active silicification of trichomes and other plant parts in *Carex*, the participation of conical phytoliths in the phytolith assemblage of the species is shown below.

Besides the Cyperaceae family, conical phytoliths may also be found in some dicot families (e.g., Euphorbiaceae, Boraginaceae, Scrophulariaceae), in which they have more elongated shape, larger sizes, and complex ornamentation (Wallis, 2003); and they can be distinguished from the *Carex* morphotypes.

Long cells are not considered, as a rule, in phytolith analysis as diagnostic forms, because they are formed in various plant species of many families: Poaceae, Asteraceae, Fabaceae, Mimosaceae, etc. (Thorn, 2004; Wallis, 2003). The exception is toothed long cells, which are considered the classical phytoliths of grass epidermis. However, recent research showed that these forms are also formed in conifers, specifically Pinaceae (An, 2016). The significant participation of phytoliths of this form in *Carex* of Western Siberia also indicates the need for additional studies of the specificity of this morphotype.

Lanceolate cells are the result of silicification of trichomes (Gol'eva, 2001, Speranskaya et al., 2018) and they are noted for both the Juncaceae family and the Cyperaceae of Western Siberia. This is the dominant morphotype in *Juncus compressus*, because the silicification of other cells in this species is weakly expressed. Besides the Juncaceae and Cyperaceae, lanceolate are found in significant numbers in the mesophytic species of Poaceae of Western Siberia (Speranskaya et al., 2018), but in dicots, trichomes are found in only few individual species (Solomonova et al., 2016). Thus, the silicification of these anatomical structures is more characteristic for monocots.

Irregular plates are found in plants of different taxonomic groups: Polypodiophyta (Kondo et al., 1994), Euphorbiaceae, Moraceae, and Scrophulariaceae (Wallis, 2003). They apparently result from the silicification of cell walls and they are weakly preserved in soils (Silantyeva et al., 2018). At present, the accumulated data do not allow the separation of plates from Cyperaceae and Juncaceae from other similar forms of other taxa of Western Siberia.

We conclude that the researched morphotypes of phytoliths from Cyperaceae and Juncaceae of Western Siberia have different degrees of systematic and anatomical specificity.

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## References

- Blackman, E. (1971). Opaline silica bodies in the range grasses of southern Alberta. *Canadian Journal of Botany*, 49, 769-781. DOI: 10.1139/b2012-070.
- Blinnikov, M. (2005). Phytoliths in plants and soils of the interior Pacific Northwest, USA. *Review of Palaeobotany and Palynology*, 135, 71-98. DOI: 10.1016/j.revpalbo.2005.02.006.
- Bobrov, A.A., Semenov, A.N., Alexeev, Yu.E. (2016). Phytoliths of species some genera of the family Cyperaceae. *Environmental dynamics and global climate change*, 7(1), 27-33 (in Russian).
- Gol'eva, A.A. (2001). *Phytoliths and their information role in natural and archaeological objects*. Moscow-Syktvykar: Elista (in Russian).
- Fredlund, G. Tieszen, L.T. (1994). Modern phytolith assemblages from the North American Great Plains. *Journal of Biogeography*, 21(3), 321-335. DOI: 10.2307/2845533.
- Kiseleva, N.K. (2006). Phytolith analysis in paleoecological research. In: Savinetsky A.B. (ed) *The Dynamics of Modern Ecosystems in the Holocene Proceedings of the Russian Scientific Conference (Yekaterinburg, 2-3 February 2006)*. Moscow: KMK Scientific Press Ltd. (in Russian).
- Kondo, R., Childs, C., Atkinson, I. (1994). *Opal Phytoliths of New Zealand*. Lincoln: Manaaki Whenua Press.
- Kumar, S., Soukup, M., Elbaum, R. (2017). Silicification in grasses: variation between different cell types. *Frontiers in Plant Science* 8(438). DOI: 10.3389/fpls.2017.00438.
- Matiushkina, L.A., Golyeva, A.A., Stenina, A.S. Kharitonova, G.V. (2017). Forms of biogenic silica in meadow soils of the Middle Amur Lowland. *Regionalnyye problemy (Regional problems)*, 20(1), 34-38 (in Russian).
- Mehra, P.N., Sharma, O.P. (1965). Epidermal silica cells in the Cyperaceae. *Botanical Gazette*, 126(1), 53-58.
- Neumann, K., Fahmy, A.G., Müller-Scheeßel, N., Schmidt, M. (2017). Taxonomic, ecological and palaeoecological significance of leaf phytoliths in West African grasses. *Quaternary International*, 434(B), 15-32. DOI: 10.1016/j.quaint.2015.11.039.
- Novello A., Barboni, D. (2015). Grass inflorescence phytoliths of useful species and wild cereals from sub-Saharan Africa. *Journal of Archaeological Science*, 59, 10-22. DOI: 10.1016/j.jas.2015.03.031.
- Semenyak, N.S., Golyeva, A.A., Syrovatko, A.S., Troshina, A.A. (2018). The comparative characteristics phytolith, pollen and charcoal methods (by materials archaeological sites in the middle river Oka I millennium AD). *Problems of Botany of South Siberia and Mongolia: Proceedings of 17th International Scientific-Practical Conference (Barnaul, Altai Republic 24-26 May 2018)*. Barnaul: Publishing Altai St. University, 304-308 (in Russian).
- Silantyeva, M., Solomonova M., Speranskaja N., Blinnikov M.S. (2018). Phytoliths of temperate forest-steppe: A case study from the Altay, Russia. *Review of Palaeobotany and Palynology*. 250, 1-15.
- Solomonova, M.Yu., Grebennikova, A.Yu., Kornievskaya, T.V., Mitus, A.A. (2016). First results of the recent basis design for paleoecological phytolith researches of North Kulunda. *Privolzhsky nauchny vestnik* 11(63), 11-16 (in Russian).
- Speranskaya, N.Yu., Solomonova, M.Yu., Silantyeva, M.M., Genrih, Yu.V., Blinnikov, M.S. (2018). Cereal phytoliths of Northern Altai. *Ukrainian Journal of Ecology* 8(1), 762-771 (In Russian).
- Strömberg, C.A.E., Dunn, R.E., Crifò, C., Harris, E.B. (2018). Phytoliths in Paleoecology: Analytical Considerations, Current Use and Future Directions. Chapter 12. In: Croft D.A., Su D.F., Simpson S.W. (eds.). *Methods in Paleoecology: Reconstructing Cenozoic Terrestrial Environments and Ecological Communities, Vertebrate Paleobiology and Paleoanthropology*. Springer International Publishing, 235-287. DOI: 10.1007/978-3-319-94265-0\_12.
- Thorn, V.C. (2004). An annotated bibliography of phytolith analysis and atlas of selected New Zealand subantarctic and subalpine phytoliths. *Antarctic Data Series*, 29, 61-67.
- Wallis, L. (2003). An overview of leaf phytolith production patterns in selected northwest Australian flora. *Review of Palaeobotany and Palynology*, 125, 201-248.

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