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## *Carex delongii* (Cyperaceae), a new sedge from Russia

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**Summary.** While performing vegetation surveys in the southern part of the Lena delta, a new species of *Carex* from section *Phacocystis* has been found. Morphologically, *Carex delongii* sp. nov. is most close to *C. cespitosa* and *C. minuta* but differs from the former in smaller inflorescences, shorter pistillate spikes, narrow and soft leaves, oblong-ovoid (vs. ovoid) utricles; from the latter, it is distinguished by having smaller spikes and larger utricles. This relationship is also confirmed by molecular data. A detailed description of *Carex delongii*, its comparison with related species, illustrations, characteristics of habitat and phylogenetic position are reported.

## *Carex delongii* (Cyperaceae) – новый вид из России

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**Ключевые слова:** дельта р. Лены, новый вид, осока, Республика Саха, Якутия, ETS, *matK*.

**Аннотация.** В работе описывается новый вид из секции *Phacocystis*, выявленный при изучении растительности южной части дельты реки Лены. Морфологически *Carex delongii* sp. nov. наиболее близок к *C. cespitosa* и *C. minuta*, но отличается от первого меньшими размерами соцветий, более короткими женскими колосками, узкими и мягкими листьями, продолговато-яйцевидными (а не яйцевидными) мешочками, а от второго – более короткими колосками и большими мешочками; выявленное родство подтвердилось молекулярным анализом. Приводится подробное описание, диагноз, иллюстрации, характеристика места произрастания, а также филогенетическое положение нового вида.

## Introduction

*Carex* L. (about 2000 species) is the largest genus in the family Cyperaceae (Govaerts et al., 2020). *Carex* section *Phacocystis* Dumort. is one of the most diverse and taxonomically complex groups of sedges (Egorova, 1999; Benítez-Benítez et al., 2021). There are about 116 to 147 species and subspecies of this section in the world (Benítez-Benítez et al., 2021), 24 of them found in Asian Russia (Shekhovtsova, 2012).

During the vegetation surveys of 2017 to 2019 in the southern part of the Lena River delta we found a few unusual specimens of *Carex* from section *Phacocystis* on three neighboring islands: Arga-Bilir-Aryta, Kurungnakh, and Samoylov. Here we describe these specimens as a new species.

## Materials and methods

Morphological description of the new species is based on live (from nature) and herbarium specimens. We examined in detail the morphology of our specimens and closely related species of the section *Phacocystis* from the LE, MW, NS, NSK, and TK herbaria and reviewed the relevant literature (Hultén, 1968; Malyshev, 1990; Egorova, 1999; Standley et al., 2002). We also performed sequencing of the new species with its close relatives, *C. cespitosa* L. from Yakutia and *C. minuta* Franch. from the Khabarovsk Territory, as well as with the species of the section *Phacocystis* from GenBank.

DNA extraction was performed from 100 mg of leaf tissue taken from the herbarium samples as described in Shekhovtsov et al. (2012). We amplified and sequenced the *matK* and ETS loci using universal primers taken from Starr et al. (2003) and Shekhovtsov et al. (2012). The obtained sequences were submitted to GenBank under accession numbers MZ197172–MZ197177. We compared the obtained sequences with those of several species of the section *Phacocystis* from the northern Palearctic. Phylogenetic trees were constructed using the Maximum Likelihood and Minimum Evolution algorithms. Maximum Likelihood analysis was performed using RAxML v.8 with the GTR+I+G model (Stamatakis, 2014). Minimum Evolution trees were built with the Kimura-2-parameter model, and Maximum Parsimony, with the Subtree-pruning-regrafting search method, using Mega X (Kumar et al., 2018). In all cases, 1000 bootstrap replicates were performed.

***Carex delongii*** Shekhovts. et Lashchinskiy, **sp. nov.** (Fig. 1).

**Type:** “Russian Federation, Sakha Republic (Yakutia), Bulunsky district, Kurungnakh Island, a floodplain along the Olenekskaya channel, 20 m from river bank, N72.35511°, E126.32572°, pioneer plant community. 26 VII 2018. N. N. Lashchinskiy” (NSK: NSK0000905; iso – NSK: NSK0000906).

**Paratypes:** “Russian Federation, Sakha Republic (Yakutia), Bulunsky district: Arga-Bilir-Aryta Island, floodplain along the Bolshaya Tumatskaya channel, 50 m from river bank, N72.39954°, E126.37525°, pioneer plant community. 15 VIII 2017. N. N. Lashchinskiy” (NSK0000917); “Kurungnakh Island, floodplain along the Olenekskaya channel, 20 m from river bank, N72.35511°, E126.32572°, pioneer plant community. 26 VII 2018. N. N. Lashchinskiy” (NSK0000918); “Samoylov Island, floodplain along the Olenekskaya channel on a distance 80 m from river bank, N72.37000°, E126.51685°, pioneer plant community. 21 VII 2019. N. N. Lashchinskiy” (NSK0000919); “Delta of the Lena River, mainland shore of the Olenekskaya channel, near Chai-Tumus town, low sand terrace, 7 VII 1956, T. Polozova, B. Yurtsev” (LE01082047).

**Diagnosis.** The new species belongs to the section *Phacocystis*, subsection *Caespitosae* Fries ex Kük. *C. delongii* differs from *C. cespitosa* by having smaller inflorescences, shorter pistillate spikes, narrow and soft leaves, oblong-ovoid utricles vs. ovoid in *C. cespitosa*. The new species differs from *C. minuta* by having smaller spikes: staminate spike is 0.8–1.5 cm long vs. to 1.5–4 in *C. minuta*; pistillate spikes 0.6–0.8 cm long vs. 0.7–1.5(3). Utricles of *C. delongii* are larger (2.5–3 mm) than those of *C. minuta*. A detailed comparison of the species is shown in Table.

**Description.** Perennial, 25–30 cm tall, forms loose tufts. Stems about 0.7–0.8 mm in diameter, smooth, striated; base of the stem wrapped in purplish-brown sheath. Leaves 1.2–2 mm wide, bright green, somewhat shorter than the stems. Inflorescence 3.3–5.5(6) cm long, with 3–4 spikes. Upper spike staminate, (0.8)1.2–1.5 cm long and 2 mm wide. Bottom 2–3 spikes pistillate, 0.6–0.8 cm long and 2 mm wide, on a peduncle 0.4–0.5 cm long. Bracts 3.5–4 cm long, leaf-like, without sheath, longer than the bottom spike but shorter than the whole inflorescence. Pistillate glumes 1.5 mm long. Utricles 2.5–3 mm long and 0.9–1 mm in diameter, with papillae, brownish at the top. Fruits 1.2 mm long.

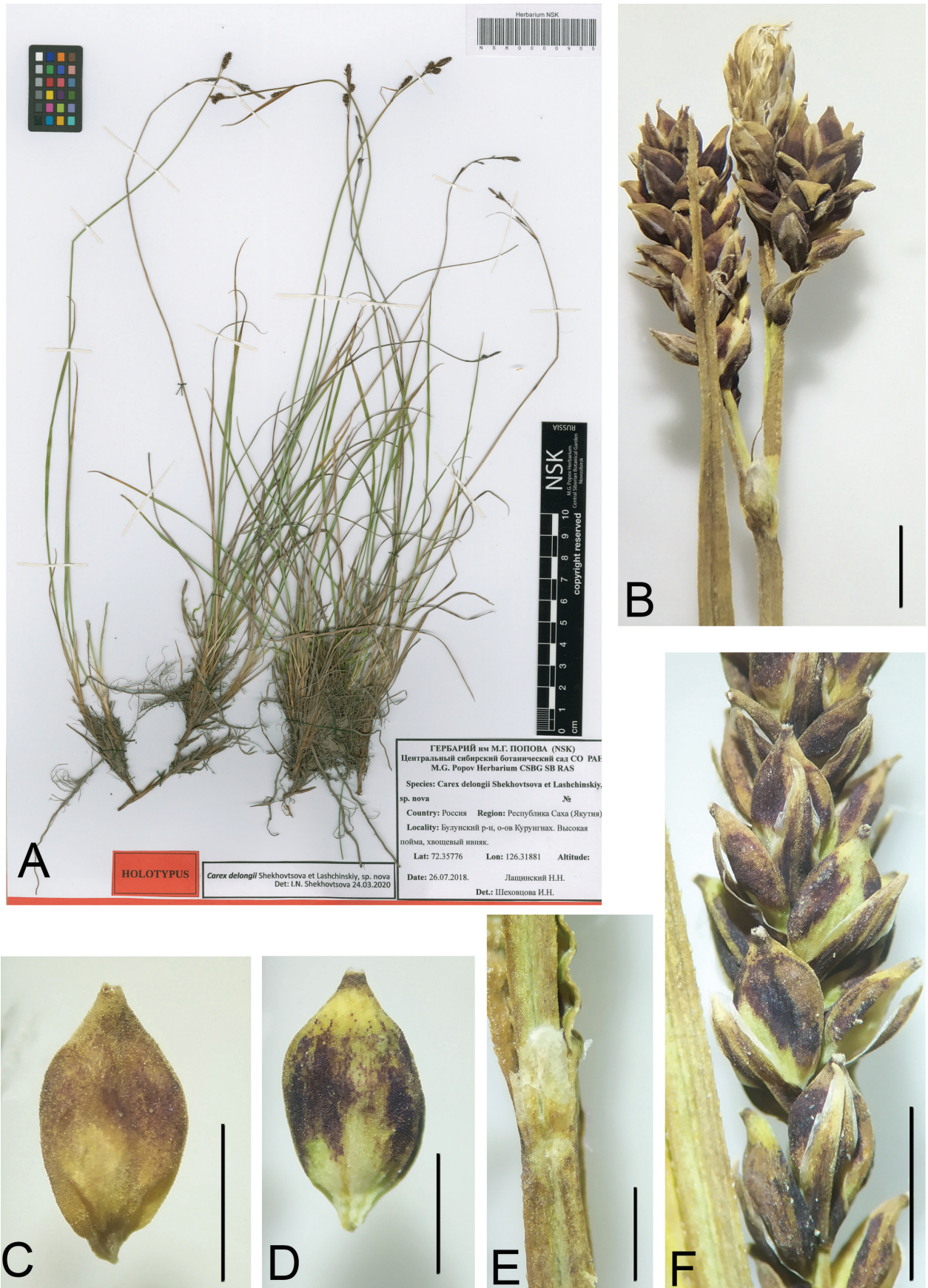


Fig. 1. Morphology of *Carex delongii* sp. nov. (from the holotype): A – holotype of *Carex delongii* sp. nov. (NSK0000905); B and F – pistillate spikes; C and D – utricles; E – leaf sheath. Scale bar – 2 mm.

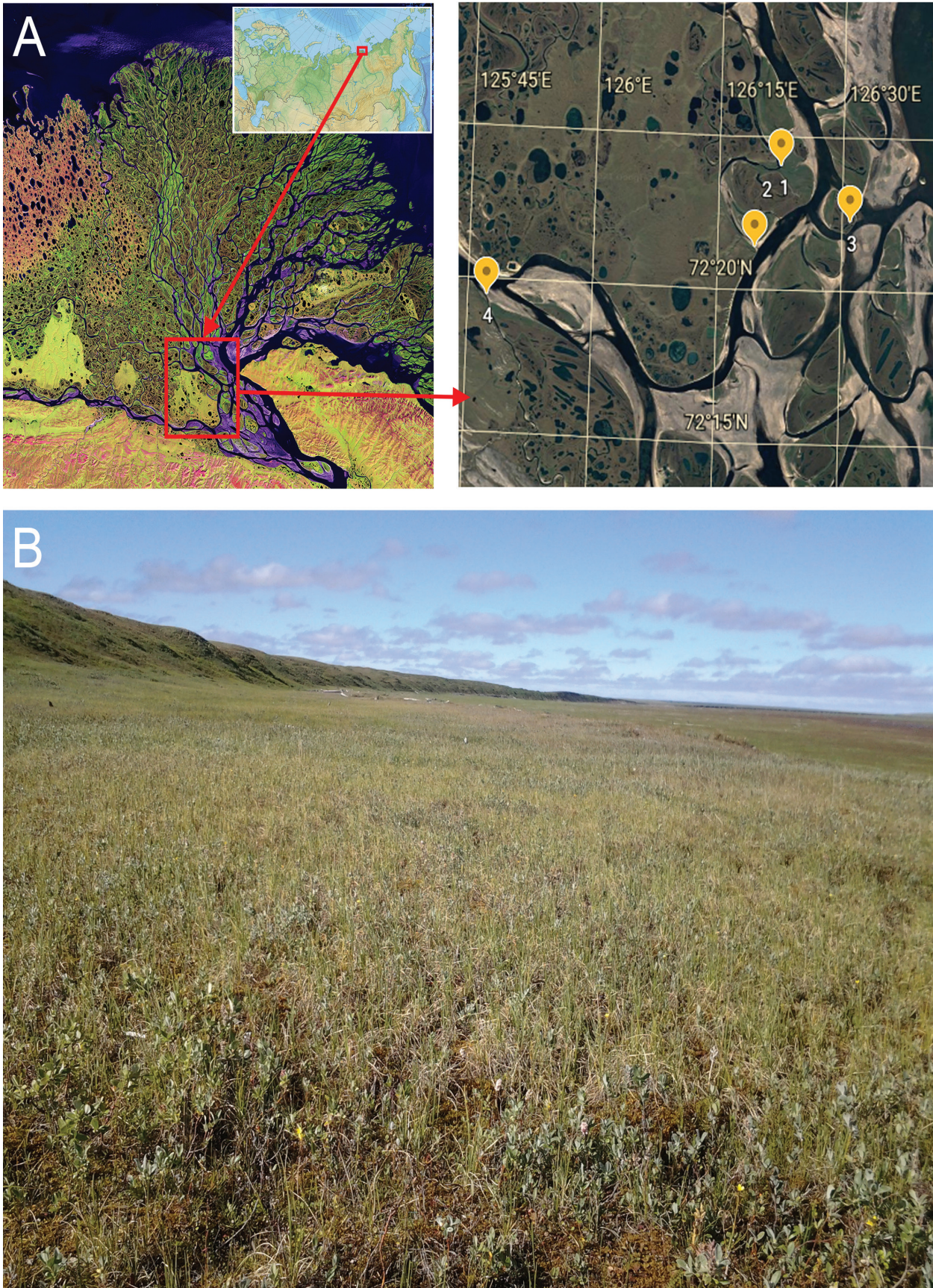


Fig. 2. Habitat and distribution *Carex delongii* sp. nov.: A – locations in the Lena River delta (NASA, 2000); B – classical habitat.

Table

Diagnostic characters of *Carex delongii* sp. nov., *C. cespitosa* L., and *C. minuta* Franch.

Character	<i>C. delongii</i> sp. nov.	<i>C. cespitosa</i> L.	<i>C. minuta</i> Franch.
<b>Stems</b>	25–30 cm	up to 70 cm	up to 100 cm
<b>Leaves</b>	1.2–1.5(2) mm wide, bright green, soft, shorter than stems	2–3 mm wide, green or greyish green, shorter than stems or of similar length	1–1.5 mm wide, greyish green, folded, shorter than stems or of similar length
<b>Inflorescences</b>	3.3–5.5(6) cm long, consist of 3–4 spikes; staminate spikes (0.8)1.2–1.5 cm long; bottom 2–3 spikes pistillate 0.6–0.8 cm long, the lowermost spike on a distance to others	3–5 cm long, consist of 2–4 adjacent spikes	staminate spike 1.5–4 cm long; bottom 2–3 spikes pistillate 0.7–1.5(3) cm long
<b>Male glumes</b>	light-colored	brown or reddish-brown	red or reddish-brown
<b>Female glumes</b>	brown, pointed, usually shorter than utricles	dark brown or brown, usually shorter and narrower than utricles	almost black or reddish purple, with a narrow light-colored fringe, significantly shorter and narrower than utricles
<b>Utricles</b>	with papillae, brownish, oblong ovoid, 2.5–3 mm	ovoid or elliptic, light grey or greenish, 2–3.5 mm	with papillae, oblong ovoid, 1.8–2.2 mm, greyish green, without veins, small

**Distribution.** Distributed on the Arctic islands in the Lena River delta. (Fig. 2A).

All listed locations were restricted to annually flooded floodplain surface at two to three meters above the lowest river level (in mid-August) (Fig. 2B). The surface layer consisted of fine sand mixed with silt. The specimens grew at 20–80 m from the shoreline in pioneer plant communities. Vegetation covered 40 to 70 % of the soil surface. Two main layers could be distinguished in community vertical structure: the shrub layer up to 60–80 cm high with projective coverage of 5 to 50 % of the soil surface, and the herbaceous layer 20 to 40 cm high with 40 to 70 % coverage. The shrub layer consists mainly of two widespread tundra *Salix* species: *S. glauca* L. and *S. reptans* Rupr., with a small admixture of riparian *Salix* species (*S. alaxensis* (Andersson) Coville and *S. boganidensis* Trautv.) and *Duschekia fruticosa* (Rupr.) Pouzar, which is on its northern limit (Nikolin et al., 2019). The dominant taxon in herbaceous layer is *Equisetum arvense* L. subsp. *alpestre* (Wahlenb.) Schönswetter et Elven, a common Arctic pioneer plant colonizing fresh alluvium along streams (Kholod, 2007). The number of vascular plant species varied from 14 to 26 per community with an average of 23. Three main groups could be distinguished among the constant species:

(1) Riparian species indicating alluvial substrate and periodical flooding (*Tanacetum bipinnatum*

(L.) Sch. Bip., *Cerastium regelii* Ostenf., *Stellaria humifusa* Rottb.).

(2) Swamp species indicating water-saturated soil conditions (*Pedicularis albolabiata* (Hultén) Kozhev., *Cardamine pratensis* L., *Parnassia palustris* L., *Caltha radicans* T. F. Forst.).

(3) Tundra species indicating zonal climate conditions (*Calamagrostis holmii* Lange, *Bistorta vivipara* (L.) Delarbe, *Poa arctica* R. Br.).

We should note the constant occurrence of *Arctagrostis arundinacea* (Trin.) Beal, a grass more typical in southern tundra, which occurred there near its northern limit.

Moss cover on the soil surface was thin and fragmented with total coverage below 30 % and consisted of *Bryum* sp., *Marchantia* sp., and young specimens of *Aulacomnium palustre* (Hedw.) Schwägr. and *Tomentypnum nitens* (Hedw.) Loeske.

Thickness of the active layer measured in mid-August was significantly deeper in the studied habitats (90–110 cm) compared to tundra communities on the first terrace (30–40 cm). Based on the community structure and its floristic composition, the habitat of the new species could be described as a periodically flooded low floodplain in the tundra zone covered by fine alluvial sediments and occupied by pioneer vegetation on the initial stage of swamp formation. Deep active layer and the presence of species with more southern distribution (*Duschekia fruticosa*,

*Arctagrostis arundinacea*) allowed us to assume that more findings of this species could be possible on floodplain habitats upstream of the studied area.

**Etymology.** The species was named after the American seafarer and Arctic explorer George Washington DeLong, who died in 1881 in the Lena River delta, very close to “locus classicus”. DeLong’s expedition was a tragic one, only twelve of its 32 members returned alive (De Long, 2018).

**Comment.** Neither *C. cespitosa* (Egorova, 1966, map 33, 1999; Malyshev, 1990, map 183) nor *C. minuta* (Malyshev, 1990, map 188; Egorova, 1999) were reported for the northern part of Yakutia, including the Lena River delta. However, *C. minuta*

was listed in the “Conspectus florae of the Arctic Yakutia: Plantae vascular” (Egorova, 2016: 115) for the Tit-Ary Island. We did not examine this herbarium specimen, but its location and ecology suggest that it probably belongs to *C. delongii*.

### Molecular analysis

The loci used for species barcoding and identification of sedges are known to have insufficient diversity and many sister species have identical DNA barcodes (Starr et al., 2009). The plastid *matK* gene fragment of *C. delongii* was found to be identical for a whole group of species in the section *Phacocystis*.

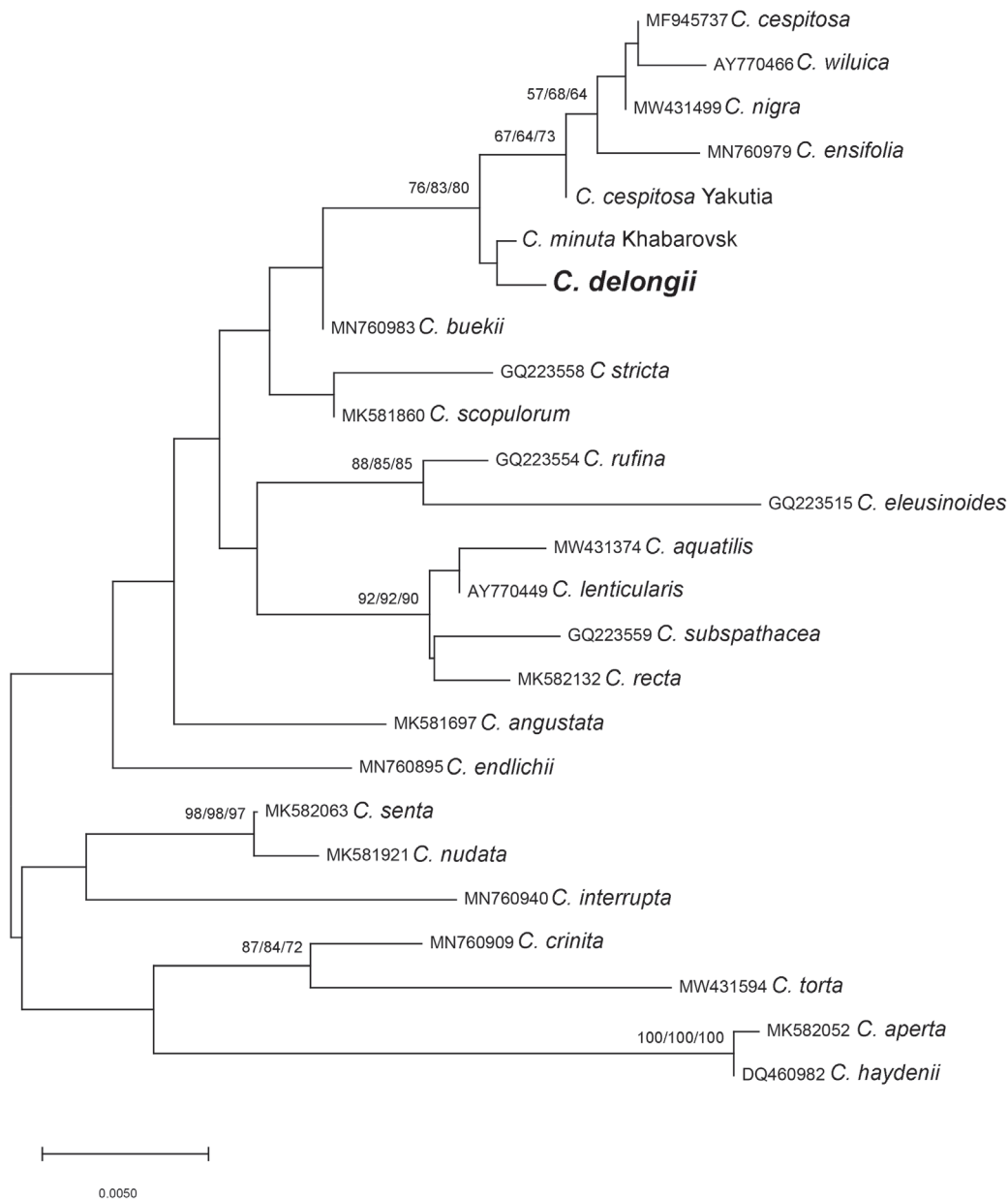


Fig. 3. Phylogenetic tree of the ETS sequences built using the ME algorithm. Number near branches indicate ME/MP/ML bootstrap support.

However, ETS demonstrated certain diversity. In addition to our sequences of *C. cespitosa* (MZ197172) and *C. minuta* (MZ197173) obtained in this study, we also compared *C. delongii* to a set of species of the section *Phacocystis* from the northern Palearctic (Fig. 3; since too many accessions were available, only one sequence per species is shown on the tree). One can see that *C. delongii* falls within a group comprising *C. nigra* (L.) Reichard, *C. juncella* (Fr.) Th. Fr. (*C. wiluica* Meinsh.), *C. cespitosa*, *C. ensifolia* Turcz. ex V. I. Krecz., and *C. minuta*. Within this group, *C. delongii* groups with a specimen of *C. minuta* from the Khabarovsk Territory (Russian Far East; MZ197173) also sequenced by us. The ETS sequence of this specimen differs from *C. delongii* by one nucleotide substitution and two degenerate positions (ETS is the part of the ribosomal cluster, which can consist of

slightly divergent copies resulting in degenerate positions in the sequence). Genetic diversity within the section *Phacocystis* is low and many species have identical ETS sequences, so the fact that the ETS of *C. delongii* differs from those of closely related species is an evidence corroborating the hypothesis that it is a separate species.

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