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Chara virgata (Charophyceae, Characeae) – new species record for the south of the Far East (the Kurils), unusual stem cortex deformation

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Summary. *Chara virgata* Kütz. was found in a sphagnum bog on Urup Island of the Kurils. This is a first species record of charophytes for the Sakhalin Region and new species record for the south of the Far East. The plants have notable deformation of stem cortex at old parts rarely noted for *Chara* L. and unknown for this species.

Chara virgata (Charophyceae, Characeae) – новый вид для юга Дальнего Востока (Курильские острова), необычная деформация стеблевой коры

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Ключевые слова: остров Уруп, Сахалинская область, сфагновое болото, флористическая находка, Characeae.

Аннотация. *Chara virgata* Kütz. найдена в двух внутренних водоёмах обширного сфагнового болота на юге острова Уруп. Это первая находка вида для Сахалинской области и юга Дальнего Востока. Некоторые изученные растения характеризовались примечательной деформацией стеблевой коры на старых частях, которая редко отмечается для представителей рода *Chara* L. и была неизвестна для этого вида.

Introduction

Charophytes (Charophyceae, Characeae) are a group of macroscopic algae, occurring in all biomes world-wide. Regional surveys focused at charophytes are still missing for many areas across the globe. The south of the Far East is one of these regions, where few species and few localities are known (cf. Medvedeva, Nikulina, 2014). Recent survey of the Kurils resulted in new species record of *Chara virgata* Kütz. for this large region is reported here.

Material and methods

The second author carried out botanical investigations on the Kuril Islands (Urup, Simushir and Broutona) in 2023 (17 July – 5 August), as part of a long-term complex expedition "Eastern Bastion – Kuril Ridge". Samples of *Chara* L. were

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collected by the second author on July 22–23, 2023, during survey of a vast sphagnum bog system in the southern extremity of Urup Island. Subsequently, scans and a series of photographs were made for samples of charophytes, using a binocular stereoscopic microscope. The vouchers are stored in the algological herbarium of the BIN RAS (LE). Nomenclature follows latest reference (Charophytes of Europe, 2024).

Description of study site and field survey

Urup Island belongs to the southern group of the Great Kuril Islands; it is the fourth largest island of the archipelago. It stretches from northeast to southwest for 116 km with a width of up to 20 km, the area is about 1428 km². The island's relief is mid-mountain (mountain heights range from 800 to 1426 m), with gently sloping sea terraces cut through a network of river valleys.

On the southern extremity of the island, at the foot of the southern macroslope of Mount Marina, a vast sphagnum bog system (ca. 26 km²) is located on a gently sloping plateau (Fig. 1A, B). The system consists of several mire massifs, one of which, meso-oligotrophic, located in the westernmost part of the bog system, was firstly examined by the second author and N. S. Liksakova within the expedition "Eastern Bastion – Kuril Ridge" in 2019 (Glazkova, Liksakova, 2021; Liksakova et al., 2021). Despite very limited time for the survey of the bog in 2019 (actually one day – September 4), preliminary floristic and geobotanical studies showed that this vast ridge-lake bog is of extreme botanical interest. Many rare and protected species of vascular plants, as well as a number of new species were discovered there both for Urup, the Southern Kuriles and for the whole archipelago, including one very rare aquatic species *Myriophyllum ussuriense* (Regel) Maxim.), a novelty for the Sakhalin Region (Glazkova, Liksakova, 2021). The unique character of the southern bog on Urup Island was for the first time highlighted also on geobotanical and geomorphological basis (Liksakova et al., 2021).

The studied area represents a complex wetland system, including bogs, numerous lakes of different size and watercourses (Fig. 1C–E). The surveyed bog areas are located at an altitude of 221–321 m above sea level, on a slope composed of waterproof volcanic rocks. The surface of the bog follows the contours of the underlying surface – at the edge of the massif there are hillocks with a lithogenic base (S. F. Khokhlov, personal communication), and closer to the center of the ridge they repeat the ledges of the slope, and lakes are located under them (Liksakova et al., 2021). Closer to the center of the massifs, the slope forms low (0.5–1.5 m) terraces, where mineral soil comes to the surface. The depth of peat varies in different parts of the massifs from 0.3 to 1.5 m.

In 2021 a survey of aquatic vascular plants on this bog was conducted (Volkova et al., 2022), which resulted in new interesting findings of both terrestrial and aquatic species. High number of rare southern species (in the northern margin of their distribution range) found on the bog could be explained by its position, facilitating income of diaspores from the south, and large size, buffering negative climatic influence of the Pacific Ocean (Volkova et al., 2022). In 2023, Elena Glazkova continued the survey of the vast bog system on Urup Island. Northern, northwestern and partly central parts of the bog were explored with a special attention to aquatic plants. As a result, not only new localities of rare vascular plants were found, but also new species record of *Chara* was revealed.

Results

Morphology. The plants were unincrusted with calcite, up to 15(20) cm in length, consisting of numerous stems originated from basal entangled part with abundant rhizoids (Fig. 1F–H, 2B). Lowest stem nodes were moderately enlarged. Stem cortex was triplostichous nearly isostichous with easily recognizable solitary spherical spine cells (Fig. 2D). The irregularity of stem and rarely branchlet cortex was notable at seven shoots of the specimens LE A0005762 (Fig. 2E, F). The stem cortex was splitting and peeling off the central internodal cell. It was consisted of irregularly bended tubes evidently longer than the central internodal cell. The stipulode whorl was diplostephanous with poorly developed low row and elongated cells in upper row (Fig. 2D). The branchlets were consisted of 5–7 completely corticated segments with clearly visible line of cortex tube cell ends joining at the center of segment and 2–3-celled end ecorticate part (Fig. 2C, D). The plants were richly fertile. Conjoined gametangia were formed at 2-3 lowest basal nodes. The adaxial bract cells exceeded oogonia length at least two times (Fig. 2C, D).

Specimens. Russia, Sakhalin Region, the Kurils, Urup Island, southern part: 1. "a vast sphagnum ridge-lake bog at the foot of the southern macroslope of Mount Marina, the outskirts of a bog massif, 272 m a. s. l., in a lake on a sedge-sphagnum bog, on a muddy-sandy bottom near the shore, at a depth of up to 0.5 m, very abundant. 45°39'33.9"N, 149°33'32.4"E

(GPS dot 89). 22 VII 2023. Elena Glazkova" (LE A0005763) (Fig. 1G). 2. "a vast sphagnum ridge-lake bog at the foot of the southern macroslope of Mount Marina, 262 m a. s. l., in a lake on a cascade terrace of a stream, at a depth of up to 0.5 m, between stones, on a stony-sandy bottom, abundant. 45°39'35.4"N, 149°33'47.5"E (GPS dot 118). 23 VII 2023. Elena Glazkova" (LE A0005761, LE A0005762) (Fig. 1H).

Habitat. On Urup, *C. virgata* was discovered in two shallow waterbodies located at a distance of 300 m from each other, in the northwestern part of a vast sphagnum ridge-lake bog. In one locality (site 89) it formed rather dense community in a lake (Fig. 1E, F), with few aquatic vascular plants (*Utricularia minor* L., *Potamogeton fryeri* A. Benn., and *Sparganium* sp.). In the second locality (site 118), *C. virgata* formed almost monospecific association in a small waterbody on the cascade terrace; only sparse plants of *U. minor* occurred among *Chara* patches.

Fig. 1. Localities and specimens of *Chara virgata* from Urup Island (A–H): A, B – locations; C–E – aquatic habitats within sphagnum bog; E – waterbody harboring community of *C. virgata*; F – plants; G, H – specimens.

Discussion

The morphology of the studied plants is in good agreement with species descriptions from Europe, North and East Asia, and North America (Imahori, 1954; Imahori, Kasaki, 1962; Mann, 2021; Charophytes of Europe, 2024; Romanov, unpubl. data). The plants have notable deformation of stem cortex at old parts rarely noted for *Chara* and unknown for this species before. Few old branchlets have the same deformation of their cortex. This splitting and peeling off stem cortex consisted of tubes evidently longer than central internodal cell is not an infrequent trait of *C. hispida* L., although it is typical for this species (Armleuchteralgen von Deutschland, 2016). In addition, the first author saw the same pattern at plants of *C. papillosa* Kütz. from travertine stream and inundated travertine quarry in the Leningrad Region and *C. aspera* Willd. from inundated sand pit in Hungary. The cause and frequency of occurrence of this kind of deformation is still unknown, but maybe it is caused by intracellular parasite targeting cells of cortex tubes and resulting in their disproportional elongation and irregular bending and peeling off from the surface of central cell of internode.

A new species record of *C. virgata* is a notable addition to the limited knowledge of charophytes from the south of the Far East. Only *Nitella* sp. was reported from the Khabarovsk Region (Medvedeva, Nikulina, 2014; Medvedeva, 2019) and the Kurils (Okada, 1934) from single locality each. Probably they belonged to sterile plants of *Nitella flexilis* (L.) C. Agardh or *N. opaca* (Bruz.) C. Agardh, undistinguishable without traits of gametangia arrangement. The presence of *Chara* sp. and charophytes was reported for lakes Khvalisekskoe and Sladkoe on Sakhalin (Borutzky, Bogoslovsky, 1964; Labay et al., 2014). In contrast to other regions of the south of the Far East, at least 5 species, incl. 2 species of *Chara* (*C. braunii* C. C. Gmel., *C. vulgaris* L.), 2 species of *Nitella* C. Agardh (*N. gracilis* (Smith) C. Agardh, *N. mucronata* (A. Braun) Miq.) and one species of *Lamprothamnium* J. Groves (*L. papulosum* (Wallr.) J. Groves), are known from the Primorye Territory, but from few localities only (Medvedeva, Nikulina, 2014; Nikulina, 2016).

Chara virgata is rarely reported from the Far East and neighboring Russian regions. In the Far East, it is known from the Kamchatka Territory only (Romanov et al., 2015a). Few localities from the Republic of Sakha (Yakutia) and Baikal Siberia (Romanov et al., 2015a, b; Chemeris, Filippova, 2017) are situated far from the Far East. Some localities in Eastern Asia are close to new site on Urup Island. They are the northernmost records on Hokkaido, Japan (Imahori, 1954; Imahori, Kasaki, 1977). This distribution pattern fits the suggestion by Imahori (1962) about possible dispersal routs of charophytes by aquatic birds based on similarity of charophyte floras of of Southeast and East Asia reflecting migration ways of aquatic birds. They are widely known as the main vector of charophyte dispersion (Charalambidou, Santamaría, 2005; Lovas-Kiss at al., 2018). Therefore, this species should be expected in the Primorye and Khabarovsk Territories.

This species seems to be infrequent in inland and coastal areas of Northeast and East Asia (Flora algarum …, 1994; Romanov et al., 2014a, 2015b; Chemeris, Filippova, 2017), although it is the species of charophytes having northernmost locality in mainland Eurasia (Romanov et al., 2022). The recent record of *C. virgata* from Mongolia (Romanov et al., 2014b) actually belongs to *C. leptosperma* A. Braun. The close records from North America are known from Alaska (Langangen, 2002) and British Columbia (Allen, 1951), where it seems to be not a common species too, in contrast to Newfoundland and Labrador (Mann, 2021). *C. virgata* has a world-wide distribution with most records concentrated in Europe (Charophytes of Europe, 2024). This species is also known from Africa, Asia, Australia, North and South America (Corillion, Guerlesquin, 1973; Flora algarum …, 1994; Casanova, 2005; Scribailo, Alix, 2010; Bueno et al., 2011; Gupta, 2012).

C. virgata is mainly freshwater species associated with slightly acid to slightly alkaline, soft to calcareous, calcium-poor to calcium-rich waters with low to increased conductivity, variable substrates, different depths, but mainly shallows (Mann, 2021; Charophytes of Europe, 2024). It avoids turbid and eutrophic waterbodies, because it has low tolerance to eutrophication (Charophytes of Europe, 2024). It is able to grow at lower pH values than many other species of *Chara* of temperate regions (Moore, 1986), which explains its success in a waterbody inside sphagnum bog on Urup Island. *C. virgata* can form monospecific associations described as *Charetum virgatae* Doll 1989 corr. Täuscher (Felzines, Lambert, 2012). On Urup Island *C. virgata* was very abundant in surveyed localities, forming similar associations in one of them and predominating in the second one, where it occurred with few species of aquatic vascular plants.

Fig. 2. *Chara virgata* from waterbody in a sphagnum bog on Urup Island, Kurils, light microscopy (A–F): A – upper parts of plants showing straight to slightly arcuate branchlets with gametangia; B – basal parts of plants with numerous rhizoids (double arrowhead), slightly enlarged old stem nodes, branchlet and stem cortex piling off the central internodal cells (arrowhead); C – whorl of fertile branchlets with short ecorticate parts (arrowhead), conjoined gametangia (double arrowhead), elongated adaxial bract cells; D – base of branchlet whorl with elongated upper stipulodes (arrowheads) and nearly isosichous stem cortex with short solitary spine cells (double arrowhead); E, F – branchlet cortex (double arrowhead) and stem cortex (arrowheads) piling off the central internodal cells. Scale: A – 4 mm; B, C – 1 mm; D–F – 0.5 mm.

This species seems to be sensitive to pollution and changes in the hydrological regime of waterbodies. Though the localities of *C. virgata* on an uninhabited remote Urup Island are rather difficult to reach, however a threat to the species population may be posed by further industrial gold mining in future in the southern part of Urup Island. Due to the extensive area of the ridge-lake system and time constraints, some parts of the vast bog still remain unexplored, and further floristic inventories, including a special survey of aquatic plants are required. Very probably, *C. virgata* can be found in other waterbodies within the vast bog system in the southern extremity of Urup Island. The wetland system in the south of Urup is a unique natural complex, which harbors many rare and protected plant species, as well as rare plant communities recently discovered. It deserves further detailed comprehensive study and protection.

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