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Ceratophyllum tanaiticum Sapjeg. (Ceratophyllaceae) in the lakes of the islands in the mouth area of the Sula River (Ukraine)

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During the field research at the stream outlet of the Sula river (Poltava and Cherkassy region, Ukraine) on the islands of Zhovnyno and Romaniv Horb, the complexes of flooded biotopes with the rare relict plant *Ceratophyllum tanaiticum* Sapjeg. were revealed. At the time of investigations, this species was abundant in the lakes outside the floodplain and played a codominant role in groups of aquatic macrophytes. A characteristic feature of the described groups is a significant role of *Salvinia natans, Utricularia vulgaris* and hygrophytes in them, which is an indicator of the biotopes shallowness and sufficient water warming in them. Four classes of higher aquatic plants were detected in the communities with *C. tanaiticum* in the studied area, which significantly complemented the existing phytocenotic data on this species. At this research stage we considered it possible to assign the received geobotanical descriptions to a single association *C. tanaiticum*. Collecting additional phytocoenotic data will give a possibility to make a different decision in the future. *C. tanaiticum* is protected in the revealed locations on the territory of the national natural park «Nyzhniosulskyi». The main condition of its preservation is to maintain sufficient water level in the little lakes outside the floodplain of the islands.

Key words: *Ceratophyllum tanaiticum, rare species, ecology, preservation, water vegetation, lakes of islands, mouth of Sula, Ukraine*.

Ceratophyllum tanaiticum Sapjeg. (Ceratophyllaceae) в озерах островів гирла р. Сула (Україна)

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Під час експедиційних досліджень в гирлі Сули (Полтавська та Черкаська області, Україна) на островах Жовнино та Романів Горб виявлено комплекси обводнених біотопів зі зростанням рідкісної реліктової рослини *Ceratophyllum tanaiticum* Sapjeg. На час обстежень даний вид був масово поширений у позазаплавних озерцях і відігравав роль кондомінанта в угрупованнях водних макрофітів. Характерною ознакою описаних угруповань є значна участь *Salvinia natans, Utricularia vulgaris* та гігрофітів, що вказує на мілководність біотопів малозаростих евтрофних пересихаючих водойм із органогенними донними відкладами й добре прогрівання в них води. В угрупованнях із участю *C. tanaiticum* представлені діагностичні види чотирьох класів вищої водної рослинності, що значно доповнює наявну фітоценотичну картину за цим видом. *C. tanaiticum* у виявлених місцезнаходженнях охороняється на території національного природного парку «Нижньосульський». Головною умовою його збереження є підтримання достатнього рівня води у специфічних умовах – позазаплавних озерцях на островах.

Ключові слова: *Ceratophyllum tanaiticum*, *рідкісний вид, екологія, охорона, водна рослинність, озера островів, гирло Сули, Україна.*

Ceratophyllum tanaiticum Sapjeg. (Ceratophyllaceae) в озерах островов устья р. Сула (Украина)

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В ходе экспедиционных исследований в устье Сулы (Полтавская и Черкасская области, Украина) на островах Жовнино и Романов Горб обнаружены и изучены комплексы обводненных биотопов с произрастанием реликтового растения *Ceratophyllum tanaiticum* Sapjeg. Во время исследований вид был массово представлен во внепойменных озерах и играл роль кондоминанта в сообществах водных макрофитов. Характерной особенностью описанных нами сообществ является значительное участие *Salvinia natans, Utricularia vulgaris* и гигрофитов, что указывает на мелководность биотопов малозаросших пересыхающих эвтрофных водоемов с органогенными донными отложениями и хорошее прогревание в них воды. В сообществах с участием *C. tanaiticum* представлены диагностические виды четырех классов высшей водной растительности, что значительно дополняет имеющуюся фитоценотическую картину по этому виду. *C. tanaiticum* в исследованных

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местонахождениях охраняется на территории национального природного парка «Нижнесульский». Главным условием его сохранения является поддержание достаточного уровня воды в специфических условиях – внепойменных озерах на островах.

Ключевые слова: *Ceratophyllum tanaiticum*, *редкий вид, экология, охрана, водная растительность, озера островов, устье Сулы, Украина.*

Introduction

The scientific interest in *Ceratophyllum tanaiticum* Sapjeg. research is determined, first of all, by the lack of information on its distribution on the territory of Ukraine (the Left Bank and South, except Crimea) in Eastern and Central Europe, West Kazakhstan. Considering the rarity of this species, the aim of this study is to reveal some features of its biology, ecology, phytocenology in the specific species site conditions in order to conserve and protect it.

C. tanaiticum belongs to a separate section *Muricatum* (Les, 1989) within the genus. This species belongs to the species with Pontic-Caspian type of habitat and also is a relict endemic of the Black Sea area. (Dubyna et al., 1985; Les, 1986). According to the sozological status (I – indeterminate) this species is one of 28 in the flora of Ukraine defined as those which face certain threats to the existence within the areal (Walters, Gillett, 1998). Most researchers indicate the threats to the existence of the populations and point out the necessity to protect all species sites (Csiky et al., 2010; Davydenko, 2014).

The species is included to the European Red list (R), and the list of protected macrophytes of Ukraine (Dubyna et al., 1993). Besides, the plant communities where *C. tanaiticum* is dominant or codominant are included to Green book of Ukraine (2009).

C. tanaiticum is a free floating plant in the water column with a very thin and long stem up to 100 cm or more. The leaves are placed in dense, contiguous rings, 3–4 times dissected into filiform lobes, soft, light green, sometimes with a brownish tinge. The plan has no conducting system. There are also special areas with thinner and unpainted leaves which serve as roots. The flowers are diclinous, monoecious, corolla is formed by (6) 9–12 petals, the male flower has a single stamen, which is a systematic feature. The plant blooms under the water during May–June. It's reproduced by seeds. Pollination occurs under water. The size of the fruit is 3–5×2–2,5 mm. It is attached to a visible peduncle, oval shaped, flattened, brown in color, spiniferous, with the lower two thorns being longer than the others. The species is defined as eutherophyte, since overwintering buds were not revealed in its life cycle.

After a long-term freezing the fruit loses its viability which is a significant limitation factor in species distribution (Csiky et al., 2010).

Materials and methods

The new locations of *C. tanaiticum* Sapjeg. on the islands of Zhovnyno and Romaniv Horb at the stream outlet of the Sula river within Poltava and Cherkassy regions of Ukraine became the objects of the research. The field research was carried out over the period of June-July 2015. Geobotanical descriptions of the identified species habitats were performed in the natural phytocenoses boundaries. Small areas of about 5×5 m² size were selected for description. The cenotic distribution of the species was characterized on the basis of Braun-Blanquet school (Solomakha, 2008). The abundance scores in the table correspond to the projective covering: + – <1%, 1 – 1–5 %, 2 – 6–15 %, 3 – 16–25 %, 4 – 26–50 %, 5 – 51–100 %. The names of the species are given according to Mosyakin and Fedoronchuk report (1999).

Results and discussions

C. tanaiticum was discovered in the southern part of the national natural park «Nyzhniosulskyi» on the islands of Zhovnyno and Romaniv Horb (Horbivka area) which are situated in the mouth area of the river Sula. The aquatic complexes with numerous low and high ground islands which formed here (Getman, 2014) are the centers of biodiversity preservation. The species on the islands is adapted to the conditions of the little lakes outside the floodplain, which are formed due to flooding by seepage and flood waters at high water level period in the reservoir (May-June). When the water level of all intra-island areas changes, some of them fully dry up, while others remain with very reduced water level. Communities including *C. tanaiticum* were revealed in the bench zone of the arid lakes at the depths of 20–100 cm. The species was identified in the majority of the studied lakes on the western part of Zhovnyno island, but was not revealed in similar water bodies on the eastern part (Fig. 1).

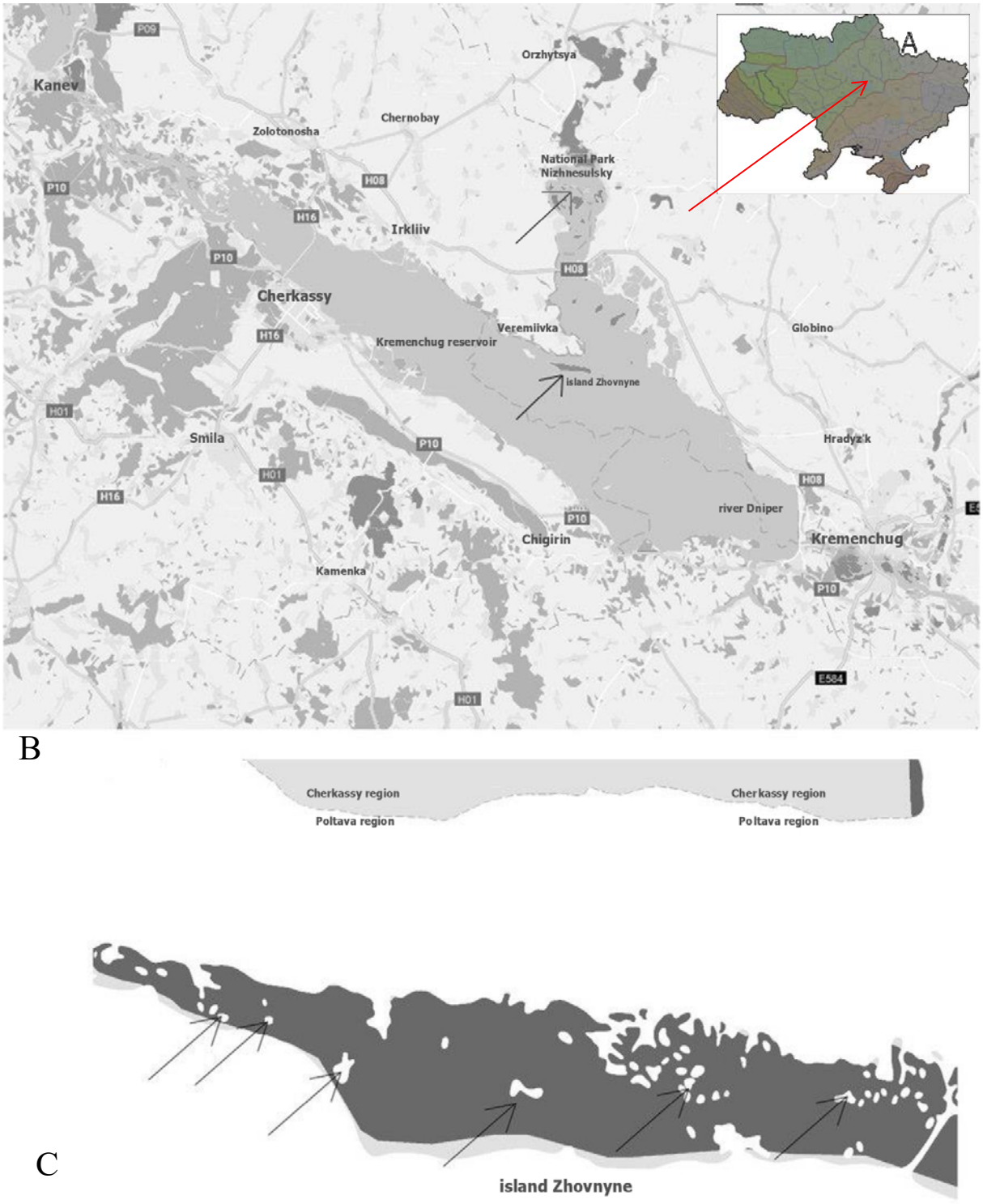

Fig. 1. Map A presents the location of the studied area on the territory of Ukraine. Map B shows the location of *Ceratophylleta tanaitici* on the islands of Zhovnyno and Romaniv Horb as indicated with the arrows, Map C demonstrates the lakes on Zhovnyno island, where *Ceratophyllum tanaiticum* was revealed

According to visual evaluation, the total area of the waters with mentioned species growing on Zhovnyno island reaches more than 2 hectares. The reasons for formation of highly dense population in the marked areas of the species localization at the time of our observations in the summer 2015 were hydrological and weather conditions during the winter 2014–2015, which ensured successful fruit hibernation. The average temperature of this synoptic winter according to the meteorological station in Kaniv natural reserve (from 23.11.2014 till 18.02.2015) was minus 1.8ºC, which was much warmer than previous years' indexes. Moreover, snowfalls usually preceded the periods of temperature decrease over the winter period 2014–2015. Perhaps the greater vitality of the populations is related to the phytocenotical environment. Since the coast of the island reservoirs is surrounded by forest vegetation, where deciduous trees are dominant, the fallen leaves accumulated on the bottom obviously contribute to the survival of the seeds during wintertime.

C. tanaiticum was revealed on the island of Romaniv Horb in a small (10×60 m) elongated and shallow lake (20–100 cm), which is similar to the hydroecosystems existing on Zhovnyno island (Smoliar et al., 2016). There are also other lakes nearby but they are much smaller. At the time of the study they were already dry. *C. tanaiticum* was also found on its bottoms under the layer of green filamentous algae. This fact indicates that the species is characteristic of the mentioned biotopes. It is known that when the reservoir dries up, the fruit is preserved in the dry bottom deposits.

Table 1.

Communities including *C. tanaiticum* in the lakes of the islands in the river Sula stream outlet

No of Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
depth (in cm)	20	50	80	90	100	50	80	30	10	50	50	50	30	70	20	50
general coverage (%)	60	60	70	60	50	70	60	30	50	30	40	50	90	50	60	30
area (m^2)	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
D.s.ass. Ceratophylletum tanaitici:																
Ceratophyllum tanaiticum	+	+	+	2	2	2	3	3	3	4	4	5	5	3	4	3
D.s. cl. Lemnetea:																
Salvinia natans	1	1	1	3	2	1	2	.	1	+	+	+	.	2	+	.
Lemna minor	.	+	+	.	+	1	2	.	.	.	.	.	.	+	+	.
Utricularia vulgaris	+	.	.	.	3	+	.	.	1	.	.	.	.	+	.	.
Lemna trisulca	.	+	.	.	.	.	.	.	1	.	.	.	.	1	+	
Lemna gibba	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Spirodela polyrrhiza	.	.	.	.	+	+	1	.	.	.	.	.	.	1	+	+
Hydrocharis morsus-ranae	.	.	.	.	.	.	+	.	1	.	.	.	.	1	+	.
Riccia fluitans	1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
D.s. cl. Potamogetonetea:																
Potamogeton lucens	.	5	5	.	.	+	2	.	+	.	.	.	.	2	.	.
Potamogeton berchtoldii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Potamogeton natans	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
D.s. cl. Phragmito-Magnocaricetea:																
Phragmites australis	1	.	.	.	2	5	.	2	4	.	4	4	.	2	.	.
Typha angustifolia	+	1	.	.	.	.	.	.	2	.	.	.	.	2	.	.
Oenanthe aquatica	.	.	.	4	.	.	.	.	.	1	.	.	+	+	.	.
Sparganium erectum	.	.	.	+	.	.	3	.	.	.	.	.	.	+	.	.
Lythrum salicaria	.	.	.	.	.	.	.	+	.	.	.	.	.	+	+	.
Lysimachia vulgaris	.	+	.	.	.	.	.	.	.	.	.	.	.	+	+	.
Polygonum amphibium	.	1	.	.	.	.	.	+	.	.	+	.	.	.	.	.
Carex riparia	.	.	.	+	.	.	.	1	.	.	.	.	.	.	.	.
Galium palustre	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.
Iris pseudacorus	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Sium latifolia	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
D.s. cl. Alnetea glutinosae:																
Carex acutiformis	4	.	.	.	.	.	.	2	.	.	.	.	.	2	1	.
Other species:																
Vallisneria spiralis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+

Description No. 1 was compiled by V.L.Shevchyk, I.V.Solomakha, 01.08.2015, drying lake in the interdunal depressions of the Zhovnyno island central part surrounded by shrubs (*Amorpha fruticosa* L.*).*
Description No. 2 was compiled by V.L.Shevchyk, I.V.Solomakha, 08.07.2015, internal, permanently flooded lake in the interdunal depressions of the Zhovnyno island western part surrounded by willow *(Salix alba* L.*)* forests.
Description No. 3 was compiled by V.L.Shevchyk, I.V.Solomakha, 08.07.2015, internal, permanently flooded lake in the interdunal depressions of the Zhovnyno island western part surrounded by pine *(Pinus sylvestris* L.*)* forests.
Description No. 4 was compiled by V.L.Shevchyk, I.V.Solomakha, 08.07.2015, internal, permanently flooded lake in the interdunal depressions of the Zhovnyno island western part.
Description No. 5 was compiled by V.L.Shevchyk, I.V.Solomakha, 31.07.2015, drying lake in the interdunal depressions of the Zhovnyno island central part.
Description No. 6 was compiled by V.L.Shevchyk, I.V.Solomakha, 01.08.2015, marginal strip of the permanently flooded lake in the interdunal depressions of the Zhovnyno island central part.
Description No. 7 was compiled by V.L.Shevchyk, I.V.Solomakha, 08.07.2015, the coastal strip of the channel in the Zhovnyno island western part.
Description No. 8 was compiled by V.L.Shevchyk, I.V.Solomakha, 31.07.2015, drying lake in the interdunal depressions of the Zhovnyno island central part.
Description No. 9 was compiled by V.L.Shevchyk, I.V.Solomakha, 09.07.2015, internal, permanently flooded lake on the Zhovnyno island.
Description No. 10 was compiled by V.L.Shevchyk, I.V.Solomakha, 08.07.2015, internal, drying lake in the interdunal depressions of the Zhovnyno island western part.
Description No. 11 was compiled by V.L.Shevchyk, I.V.Solomakha, 08.07.2015, internal, permanently flooded lake in the interdunal depressions of the Zhovnyno island western part.
Description No. 12 was compiled by V.L.Shevchyk, I.V.Solomakha, 31.07.2015, drying lake in the interdunal depressions of the Zhovnyno island western part.
Description No. 13 was compiled by V.L.Shevchyk, I.V.Solomakha, 08.07.2015, internal, drying lake in the interdunal depressions of the Zhovnyno island western part.
Description No. 14 was compiled by N.O.Smoliar, 27.07.2015, the mouth of the river Sula, Romaniv Horb island, little lake in the central part of the island, elongated in configuration, flooded, surrounded by communities of *Salix alba, Salix cinerea*.
Description No. 15 was compiled by N.O.Smoliar, 27.07.2015, the mouth of the river Sula, Romaniv Horb island, little lake in the central part of the island, oval in shape, drying.
Description No. 16 (nomenclative type: description No. 2 (table 34) was compiled by D.V.Dubyna, 19.09.1988, in the reservoir near the village Kardashynka Hola Prystan district, Kherson region (Dubyna, 2006).

The analysis of the descriptions enabled us to determine that the most frequent *C. tanaiticum* satellites are the macrophyte species of well-heated water bodies (*Potamogeton lucens* L.*, Salvinia natans* (L.) All*., Utricularia vulgaris* L., *Lemna minor* L.*, Spirodela polyrrhiza* (L.) Schleid., *Phragmites australis* (Cav) Trin ex Steud.).

Ecologically, the locations of *C. tanaiticum* represent the species biotopes – slightly plant-filled eutrophic drying up water bodies, with organogenic bottom deposits (Ecoflora…, 2004). The phytocoenosis which include *C. tanaiticum* are identified as conditionally clean (Baranovskyi, Aleksandrova, 2006), which is important for bioindication research and evaluation of the general ecological situation of the area.

According to Ukrainian phytosociologists, (Dubyna, 2006) cenology of *C. tanaiticum* is limited by association with *Ceratophylletum tanaitici* Dubyna 2006, union LEM-01C *Stratiotion* Den Hartog et Segal 1964, order LEM-01 *Lemnetalia minoris* O. de Bolos et Masclans 1955, class LEM *Lemnetea* O. de Bolos et Masclans 1955 (Mucina et al., 2016). This association is diagnosed by only one species of *C. tanaiticum* and combine communities of eutrophic closed, less often low flow freshwater and slightly brackish water bodies with a slightly alkaline reaction, silty bottom deposits and detritus admixture, where water is 40–70 (100) cm deep. In Ukraine these communities are abundant in lakes, river bays, inner floodland water bodies, shallow waters of artificial reservoirs, ponds, flooded peat quarries, abandoned drainage channels in the south-eastern part of the Forest-Steppe (Dubyna, 2006).

The analysis of the comparison of floristic composition of the communities that we carried out and presented in the tables with the description (table 1 – No. 16) performed by D.V.Dubyna on 19.09.1988 and taken as a nomenclature type (Dubyna, 2006) indicates a significant participation of *Lemna minor, Spirodela polyrrhiza, Hydrocharis morsus-ranae* L. in these communities. These species are typical hydrophytes and are viewed as diagnostic features of *Ceratophylletum tanaitici* association. Moreover, the typical feature of the communities described in our research is a significant presence of *Salvinia natans, Utricularia vulgaris* and hydrophytes. It indicates the biotopes shallowness and sufficient warming of water in them. The geobotanical descriptions performed in our study demonstrate the broader character of *C. tanaiticum* association (table 1), which is consistent with the data of other researchers (Davydenko, 2014). Four classes of higher aquatic plants were found present in the communities with *C. tanaiticum* participation in the studied area. These findings greatly complement the existing phytocenotic data on this species. However, at this stage of the research we considered it reasonable to assign the received geobotanical descriptions to a single association *Ceratophylletum tanaitici*. Collecting additional phytocoenotic data might give a possibility to make a different decision in the future.

In Forest-Steppe of Ukraine, the zone where our research areas are located, this species is also identified in Zmiiv district of the Kharkiv region. It is known due to Bradis herbarium collections (1955) from the lower reach of the Sula river (Drachky area in the outskirts of Horoshyno village, Semeniv district, Poltava region (*KW*) and the water bodies in the outskirts of the village Velyka Burimka, Chornobaivka district, Cherkassy region (Dubyna et al., 1985; Chorna, 2006). It is obvious that rare *C. tanaitici* community migrated from these locations to the territory of the national natural park «Nyzhniosulskyi» (Galchenko, 2012). Thus, the identified locations of the species in the basin of the lower Sula represent a single regional population with the above mentioned locality and are revealed on the North-Western border of the species distribution.

Conclusions

C. tanaiticum growing in the inland waters of the islands of Zhovnyno and Romaniv Horb (the Sula river mouth) and the existence of hydrophytes communities with its association determine the sozological priority of *C. tanaiticum* communities. This local cenopopulation of this rare species can serve as a model for studying the species ecology as well as a source of diasporas for the population reproduction in other reservoirs of the region. *C. tanaiticum* is protected in the revealed locations on the territory of the national natural park «Nyzhniosulskyi». The main condition of its preservation is to ensure sufficient water level in the little lakes outside the floodplain of the islands.

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