

***Nitella tenuissima*, a rare Charophyte in Central and Southern Europe**

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Abstract – The past and recent distributions of *N. tenuissima* in Central and Southern Europe are investigated, as little is known from monographs and literature concerning charophytes. Our data show that while over the last 150 years the species has disappeared from previously recorded localities, most probably due to eutrophication and urbanization, in the last two decades several new sites have been found. This paper presents new information on the distribution and ecology of *N. tenuissima* in particular from Central and Southern Europe.

***Nitella tenuissima* / Charophytes / eutrophication / distribution / Europe / algae / freshwater**

Résumé – *Nitella tenuissima*, une charophyte rare en Europe centrale et méridionale. La littérature scientifique fait état de peu d'information sur la répartition et l'écologie de *Nitella tenuissima* en Europe centrale et méridionale. Cette espèce est considérée dans plusieurs pays comme « rare » ou « en voie de disparition ». À partir des spécimens d'herbier et des données de la littérature, le présent travail rend compte de la répartition, ancienne et actuelle, de *Nitella tenuissima* en particulier en Europe centrale et méridionale.

***Nitella tenuissima* / Charophytes / eutrophication / distribution / Europe / algues d'eau douce**

INTRODUCTION

Nitella tenuissima (Desvaux) Kützing 1843 (Dwarf stonewort) is one of the most threatened charophyte species in Europe (Balevicius & Ladyga, 1992; Gärdenfors, 2005; Palamar-Mordvinceva & Tsarenko, 2004; Schmidt *et al.*, 1996; UK Species Checklist for Characeae, 2003). According to the IUCN threatened criteria, *N. tenuissima* has been placed on a “red” list of endangered algae in Poland

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in the category “critically endangered” (Siemińska, 1992), however in Southeastern Europe this species is more common (Blaženčić & Blaženčić, 2002). Various authors have attempted to summarize the species’ distribution in Europe (Krause, 1997; UK Biodiversity Group, 1999; Urbaniak, 2007), but the data from the eastern and central part of the continent are scarce or absent (Corillion, 1957). Additionally, data from Southeastern Europe are hardly known and rarely cited.

The main aim of this work is to present a review of the all known data of *N. tenuissima* in Central and Southern Europe, including its past and present distribution. Additionally, the data about ecology of *N. tenuissima* from European sites are presented.

METHODS

The study is based upon two types of data: herbarium collections gathered mostly between 1820-2005, and literature data. We have examined the following herbarium collections in Poland: Poznań (I. Dąbwska collection, placed in Department of Hydrobiology, Adam Mickiewicz University), Wrocław (WRSŁ); in Serbia: Belgrade (BEOU) and the author’s own collections. We have also studied specimens from Copenhagen (C).

RESULTS

Species Description

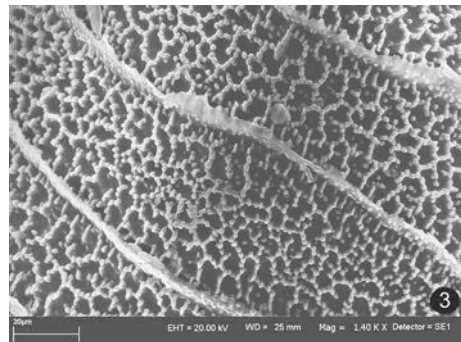
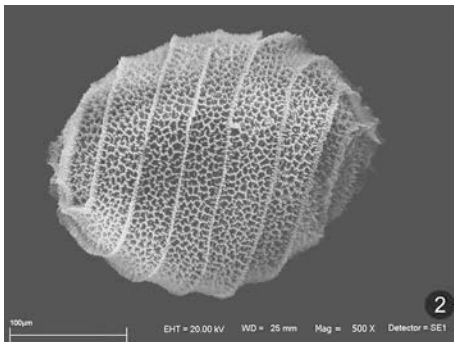
Plants erect, small or medium sized, up to 20 cm with long internodes and small compact whorls (Fig. 1), often with a gray – green or fresh green colour and moderately to heavily encrusted. Axes slender, less than 0.3 mm in diameter. Internodes 2-5 times as long as branches. Plant monoecious, oospores (Figs 2, 3) golden-reddish brown. Plants are annuals and hibernate by means of oospores (Moore, 1986). Additional morphometric data of *N. tenuissima* from Balkans and Poland are given in Tab. 1.

Ecology

In general, *N. tenuissima* grows in lime – rich and alkaline – rich water, pH (6.2 – 8.5) (Bruinsma & Berkelmans, 2002; Dąbwska, 1964; Krause, 1997). Other details on chemical parameters are given in Tab. 2. In Britain, this species occurs in calcareous fenland habitats, such as peat pits, lakes and ditches to depths of 1 m. It seems to favour a fairly firm, peaty substratum without much competition from filamentous algae or vascular plants (Groves & Bullock Webster, 1920; Moore, 1986; UK Biodiversity Group, 2003). In Germany and Poland, the species prefers sheltered sites and has been recorded from calcareous peat pits on calcareous, sandy and muddy bottom (Dąbwska, 1964; Krause, 1997), but maximum depths in Germany and France range from 5 to 12 m (Krause, 1997; Corillion, 1957). In Balkans, the species occurs in association *Chareto* - *Nitellopsidetum obtusae* in Skadar Lake (Blaženčić *et al.*, 1998).



Fig. 1. Habit showing compacted whorls of *Nitella tenuissima*. Scale = 1 cm.



Figs 2-3. **2.** Oospore of *Nitella tenuissima* from Poland (Brzeźno) (Scale = 50 μm). **3.** Details of the oospore wall showing the regular reticulate ornamentation (Scale = 20 μm).

Distribution in Central and Southern Europe: New Ecological Data

Nitella tenuissima has been found in some localities in Europe. A map of the distribution, especially in western Europe can be found in Corillion (1957) (Fig. 4), but detailed information on distribution in the eastern part of Europe is lacking (sites listed below and presented in Fig. 5 and Fig. 6).

Balkan localities

Albania

- Lake Skadar – northern Albania: *N. tenuissima* has been found in shallow water, (coll. ?) in 1990 (Kashta, 1994; Rakaj & Kashta, 1999; Dhora & Sokoli, 2000).

Table 1. Morphometric data of *N. tenuissima* from balkan and polish localities.

| <i>Specimen studied</i> | <i>Lake Skadarsko near Plavnica (Montenegro)</i> | <i>Marshes near Ulcinj (Montenegro)</i> | <i>Hutovo blato (Bosnia & Hercegovina)</i> | <i>Pond near lake Modre (Poland)</i> | <i>Brzežno peat bog (Poland)</i> |
|------------------------------------|--------------------------------------------------|-----------------------------------------|------------------------------------------------|--------------------------------------|----------------------------------|
| Height (cm) | 5.5 - 6.5 | 4.5 | 4.2 | 5-10 | 9-10.5 |
| Incrustation | + | - | - | - | - |
| Axis diameter (µm) | 130 | 125 | 120 | 150-183 | 130-155 |
| Length of internodes | 2-4 × branchlet length | 2-3 × branchlet length | 2-3 × branchlet length | 2-3 × branchlet length | 2-3 × branchlet length |
| Branchlet number in a whorl | 2-3 furcate 6 | 2-3 furcate 6 | 2-3 furcate 6 | 2-3 furcate 6 | 2-3 furcate 6 |
| - length (cm) | 0.25 | 0.28 | 0.3 | 3 | 2.4 |
| - length of primary ray | 1/3 × branchlet length | 1/3 × branchlet length | 1/3 × branchlet length | 1/3 × branchlet length | 1/3 × branchlet length |
| - diameter (µm) | 75 | 87.5 | 100 | | 112 |
| - dactyls | 4 (3-celled) | 4 (2-celled) | 4 (2-celled) | | 4 (2-celled) |
| Oogonium | on the 2nd - 3rd branchlets | on the 2nd - 3rd branchlets | not present | not present | not present |
| - length (including coronula) (µm) | 340-350 | 270-290 | | | |
| - width (µm) | 255-275 | 235 | | | |
| - convolutions | 9 | 8-9 | | | |
| - coronula: | | | | | |
| - width at base (µm) | 55 | 46 | | | |
| - height (µm) | 30 | 32.5 | | | |
| Oospore | bright brown | bright brown | not present | light brown | brown |
| - length (µm) | 212 | 177-187 | | | 218-224 |
| - width (µm) | 187 | 152-170 | | | 170-180 |
| - striae | 7 | 7 | | | 7 |
| - ridges | not prominent | not prominent | | | not prominent |
| - fossa (µm) | 33 | 25-27.5 | | | 35 |
| Antheridium | | | not seen | | |

Bosnia & Hercegovina

- Hutovo blato (Hercegovina) in the canal between Karaotok and Krupa river, coll. by J. & Ž. Blaženčić in 1989 (no. 1303 BEOU). The species has been found in depths of 2 (3) m in clear water, together with *Nitella syncarpa* (Thuill.) Chevall., *N. capillaris* (Krock.) J. Grov. et Bull.-Web., *Myriophyllum spicatum* L., *M. verticillatum* L., *Potamogeton lucens* L. and *Najas marina* L.

Montenegro

- Lake Skadar (locality Plavnica) coll. by J. & Ž. Blaženčić in 1980 (no. 87 BEOU), coll. by W. Krause (Blaženčić *et al.*, 1998). The plants were found on muddy and sandy bottoms in depths ranging from 0.2 – 1.0 m in water at pH 7-8. *N. tenuissima* was found together with *Potamogeton pusillus* L., *P. crispus* L., *P. lucens*, *Chara globularis* Thuill. and *Nitella opaca* (Bruz.) Agardh.

Table 2. Comparison of physico-chemical parameters of the water quality from *N. tenuissima* sites (* Data from recently found localities in Balkans and Poland).

| | <i>Auderset – Joye, 1993</i> | <i>Caffrey & Monahan, 1994</i> | <i>This work*</i> |
|-----------------------------------------------------------|------------------------------|------------------------------------|-------------------|
| pH | 7.9-8.0 | 7.8-8.0 | 7.0-8.0 |
| Conductivity $\mu\text{S cm}^{-1}$ | 418-462 | 384-564 | 404-565 |
| Total Hardness $\text{mg l}^{-1} \text{CaCO}_3$ | 207-226 | 168-307 | 267 |
| Alkalinity mEq l^{-1} | | 3.2-5.7 | |
| Water color 5-30 Pt/l | | 5-30 | 19 |
| Turbidity $\text{mg l}^{-1} \text{SiO}_2$ | | 2.0-26 | 1 |
| Ca mg l^{-1} | 65.6-76.2 | 41-103 | 25-72 |
| K mg l^{-1} | | | 3.5-8.0 |
| Mg mg l^{-1} | 9.3-8.8 | | 1.4-5.6 |
| Cl mg l^{-1} | 10.1-10.2 | | 7 |
| N _{total} (Kiejdahl) $\text{mg l}^{-1} \text{N}$ | | 0.206-1.673 | |
| N-NH ₄ $\text{mg l}^{-1} \text{N}$ | 0.019-0.027 | | 0.33 |
| N-NO ₃ $\text{mg l}^{-1} \text{N}$ | 1.1-1.4 | | < 0.03 |
| N-NO ₂ $\text{mg l}^{-1} \text{N}$ | 0.01-0.04 | | < 0.02 |
| Dissolved Oxygen $\text{mg l}^{-1} \text{O}_2$ | 6.2-14.2 | | |
| P _{tot} $\text{mg l}^{-1} \text{P}$ | 0.004-0.124 | 0.007-0.182 | 0.03 |

Lake Skadar is located on the Monenegro – Albanian border (40°10' N, 19° 15' E). The lake is located in the karst region of the Dinaric Alps. It is the largest of the Balkan lakes with a surface area fluctuating between 370 to 600 km² seasonally. It is a subtropical lake where the temperature has dropped to 0°C only twice in the past 30 years. Mean depth of the Skadar Lake is 5.0 m, transparency 2-3 m in summer and about 5 m in winter (Secchi disc). The waters of Lake Skadar are characterized by high dissolved-oxygen content and a relatively low dissolved salts content, waters are rich in bicarbonate and other anions are in low concentrations. The nutrient content of the waters is low (Beeton & Karaman, 1981).

- Marshes near the Adriatic sea coast, near Ulcinj; coll. by V. Stevanović in 2003 (no. 1099 BEOU). *Nitella tenuissima* was found together with *N. syncarpa*, *Chara aspera* Deth. ex Wildenow, *Chara intermedia* A. Braun, *Myriophyllum spicatum*, *Utricularia vulgaris* L. in shallow water, 0.5 m depth, on sandy and muddy substrate (Blaženčić & Blaženčić, 2002, 2003).

Greece

- Peleponissos, part of Lake Trichonis, near Ntougri and Pantanassa and near Kainourgion (Koumpli-Sovantzi, 1997).
- Peleponissos between Mili and Argos, coll. by U. Raabe in 1995 (Raabe & Koumpli-Sovantzi, 2000, 2002).

Bulgaria

- The species has been found in the vicinity of Danube River near Sviščov (Vodeničarov, 1963; Vodeničarov *et al.*, 1971).

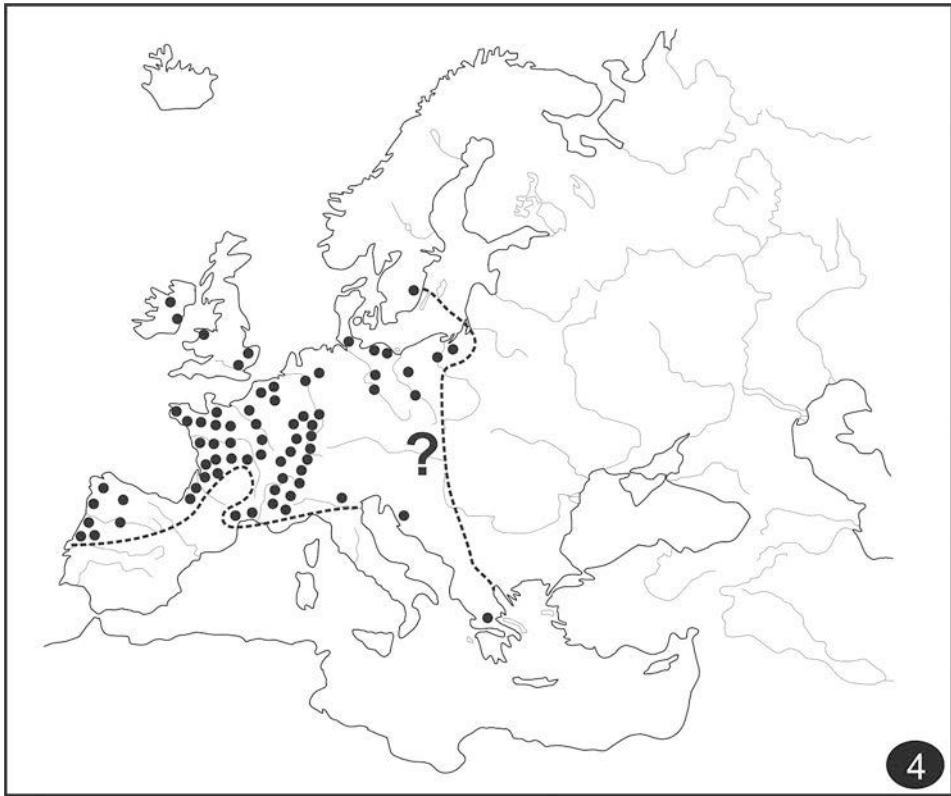


Fig. 4. Localities of *Nitella tenuissima* in Europe (Corillion, 1957).

Romania

- The species has been found in only one locality in the vicinity of the Danube River near Salicea, coll. E. Nyárády in 1938 (Ionescu-Teculescu, 1970; Stefureac & Teculescu, 1963).

In Serbia, Macedonia, Slovenia and Croatia *Nitella tenuissima* has thus far not been found.

Central Europe Localities

Czech Republic

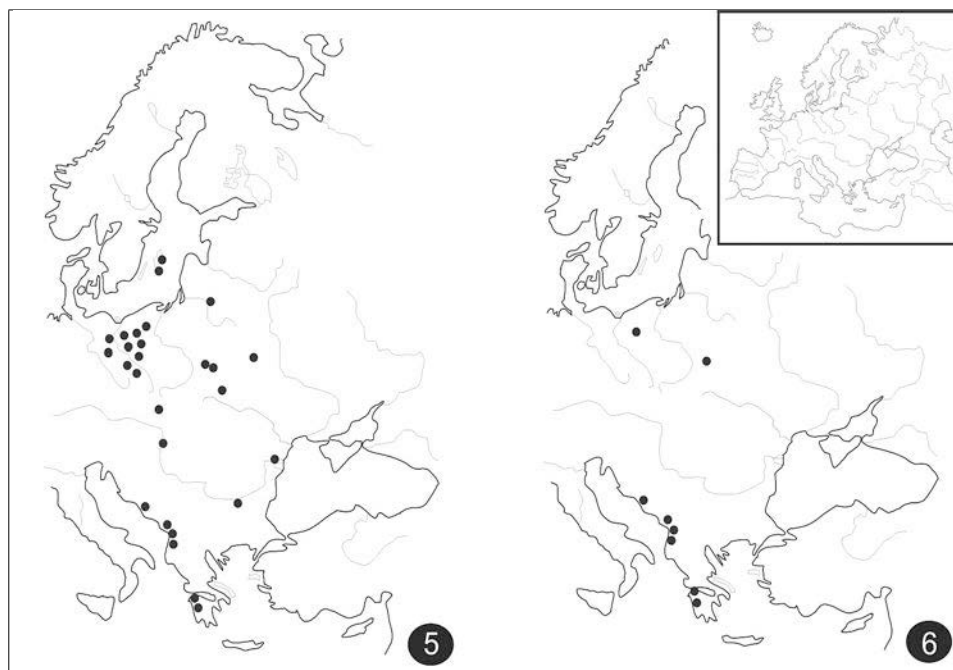
- Fish pond “Kupcov” near Blatna – southern part of the country, coll. by I. Dąmbaska in 1958.

Lithuania

- Lake Pohulanka – eastern part of Lithuania, near the capital city – Wilno, coll. by Dąbkowska in 1936.

Germany (eastern part of the country)

- Berlin – in a pit near Lankewitz and Weissensee, coll. by Bauer in 1831. The species is now extinct there (Kusber *et al.*, 2004, 2005).
- Grosse Plagenssee bei Brodowin – coll. in 1863 and in 1868 by Jahn. During the field investigations in the northern part of the Brandenburg Region,



Figs 5-6. **5.** All known localities of *Nitella tenuissima* in Central and Southern Europe (1820-2005). **6.** All known localities of *Nitella tenuissima* in Central and Southern Europe (1980-2005). Inside the detail maps – the area studied.

carried out by Mauerebreger (2004), *N. tenuissima* was found. Only doubtful information on the findings in Wuckersee/Schorfheide in 1995 is given.

Poland

- Kobierzyce near Wrocław, coll. at the beginning of the 19th century by Wimmer (Milde). The species was found in small pits in the park. Specimens were small (5-6 cm), well developed and richly fertile, but *N. tenuissima* was not found again while collecting between 1999-2004. This area is intensively used for food production and has become eutrophic in the last decades, which could be responsible for the disappearance of the species in the area (own observations, J. U.).
- Bulmersee near Lubsko, coll. by Helwig in the 19th century. The species was probably found in shallow peat bogs, but no more data about this site are available.
- Sarbinowo near Kostrzyn, coll. 1853 by Rothe. No more data about this site are available
- Jungfernheide bei Driessen (Drezdenko) (Migula, 1897).
- Lake Jarosławieckie near Poznań (Wielkopolski National Park), the specimens were found in SE part of the lake, coll. Dąmbska in 1949. *N. tenuissima* grew in water at pH 8.7 (Dąmbska, 1952). Presently, this locality is clearly eutrophied and the plants have probably died off during the last years (own observation, M. G.).
- Meadow near Żur village, district Osie (Migula, 1897).

- Lake Boszkowo, Przemęt district: southern part of the lake, coll. Cz. Kaczmarek in 1961 (Dąbska, 1963). Presently, this lake is clearly eutrophied and its condition has deteriorated due to tourism.
- Ditch on the peat bog “Krowie Bagno” near Lubowież in Eastern Poland, coll. by I. Dąbska in 1960. This site is in the same area and has similar characteristics as the locality in Brzeźno (peat bog). It is expected that *N. tenuissima* might be found in several new localities in this area.
- Brzeźno, ditch on the peat bog “Brzeźno” near Chełm in Eastern Poland, coll. in 2005 by J. Urbaniak. *N. tenuissima* was found on calcareous bottom in a depth 0.3-0.7 m together with *Typha angustifolia* L., *Phragmites communis* L. and charophytes *Nitella syncarpa*, *Chara intermedia* and *C. globularis*. The specimens were well developed, with sparse oospores.
- Small artificial pond near Lake Modre, 2 km far to E from Tuczno coll. by M. Gąbka in 2005. The plants were found on mineral – organic bottom in depth range 0.05-0.1 m. *N. tenuissima* was found together with *Myriophyllum verticillatum*, *Nuphar lutea* (L.) Sibth. et Sm. Other water plants such as mosses (*Warnstorfia fluitans* (Hedw.) Loeske, *Calliergonella cuspidata* (Hedw.) Loeske) and charophytes (*Chara globularis*, *C. intermedia*) have been found in the same localization.

Hungary

- *N. tenuispina* was found in Pest (presently part of Budapest) by Filarszky in the 19th century. It can be expected, that *N. tenuissima* has disappeared from this site.

Ukraine

- Gollerbach & Palamar – Mordvinceva (1991) reported about 7 localities for *N. tenuissima* in Ukraine, mostly near the Carpatians and on the Right bank Forest steppe, but no distribution map and details on them were given. The authors concluded that the species is rare in Ukraine. General data are given by Palamar-Mordvintseva & Tsarenko (2004) and it is unknown how many of these localities still exist. The species can be found in a peat pits, small ditches and in pools.

Other European Localities

Sweden

N. tenuissima has only been found in Sweden in two sites, both on the island of Gotland.

- Roma myr, leg. by L. Wahlstedt in 1871 (Norstedt & Wahlstedt, 1871, 1872). The last record was from 1937. One of these sites was a calcium-rich mire area which was drained long time ago, and the species has probably disappeared (I. Blindow pers. comm.).
- Bäste Träsk, on the second site, a calcium – oligotrophic lake, the species was found previously in very shallow water. Surveys were carried out during 1995 and 1999 in order to find *N. tenuissima* at this site, but without success. It is assumed that the species disappeared from Sweden – in the Red List which was published recently it is classified as “Regionally extinct” (Gärdenfors, 2005; I. Blindow pers. comm.).

In Slovakia, Norway, Finland and Denmark, *Nitella tenuissima* has thus far not been found.

DISCUSSION

Migula (1897) stated: “*N. tenuissima* can be found frequently in old peat bogs, clay pits or in shallow meadow ditches which dry up completely in the summer. In the peat bogs the plants often form dense mats carpets (...).”

The new localities of *Nitella tenuissima* in Poland are a ditch on the peat bog “Brzeźno” and a small artificial pond near lake Modre, which confirm this observation. During the summer the localities partly become dry with the plants *N. tenuissima* lying on the bottom. Similarly, the other findings from the Balkans and Poland, and from the whole of Europe come mostly from shallow or from very shallow water. Therefore, it is expected that the drying periods play an important role in the biology of *N. tenuissima*, though experimental studies are needed to understand the requirements of the species.

Nitella tenuissima seems to be more common in the Balkan states (Blaženčić & Blaženčić, 2002, 2003). Almost all recent findings (former Yugoslavia, Greece) have been made close to each other, and all have been made in the karstic region in waters rich in calcium, which seems to be the reason for which *N. tenuissima* is more common in southern Europe.

The observed physico-chemical parameters of the water quality from the recently found localities in Balkans and Poland correspond well to those previously observed by Auderset-Joye (1993) and Caffrey & Monhan (1994) (Tab. 2). However, the content of N-NH₄ in the water was higher and the content of N-NO₂ was below the detection limit than observed by Auderset-Joye (1993).

N. tenuissima showed some morphological variations between Balkan and Polish localities (Tab. 1). Most of these are common among charophytes, and are most probably due to environmental variations. In general, specimens collected in Poland were longer and the axis diameter was up to 183 μm. The examined oospores varied in length, 218-224 μm, and in width, 170-180 μm (Poland). The oospores collected in Montenegro were smaller (Tab. 1), however all examined oospores had 7 striae. Specimens collected in Poland (Brzeźno) show the regular reticulate ornamentation on the surface (Figs 2, 3). This strongly supports the use of both ultrastructural oospore characters and vegetative characters for taxonomic discrimination within this genus. However, reticulate oospore wall ornamentation was reported earlier by John & Moore (1987) and Ray *et al.* (2001) in other species of the genus. Two of them: *Nitella mucronata* (A. Braun) Miquel and *N. capillaris* (Krockner) J. Groves can be distinguished from *N. tenuissima* by a more robust appearance and, additionally, *N. capillaris* is a dioecious species. *N. allenii* Imahori, *N. bastinii* T. F. Allen, *N. divaricata* J. Groves *et* Stephens, *N. duthieae* J. Groves *et* Stephens, *N. leptostachys* A. Braun and *N. stuartii* A. Braun, according to John & Moore (1987) have a reticulate oospore, but are not found in Europe.

Similar as in the case of the other *Chara* species, eutrophication, low transparency, mass growth of filamentous algae and site degradation are the most probable reasons for the decline of charophytes in general, and *Nitella tenuissima* in particular (Blindow & Langangen, 1995). Additionally, urbanization seems to be the reason of the disappearance of *N. tenuissima* from eastern Poland. Examples of degradation are localities from Berlin and the Brandenburg region or from Pest (Budapest). The vicinity of Berlin and Brandenburg region are highly urbanized which, together with strong eutrophication, is considered the main cause of the decline of *N. tenuissima*. The number of charophyte species presently recorded from the Berlin area is five or six, while 23 species have been

recorded in previous years (Langangen & Sviridenko, 1995; Kusber *et al.*, 2004). The other reason for the disappearance of *N. tenuissima*, might be the destruction of the localities, or by natural filling in of the pits and ditches also encouraged by human activities. This seems to be especially important, because *N. tenuissima* has been mainly found in small temporary water reservoirs, e. g. peats, ditches, drainage channels or in the shallow water of lakes, and this type of wetlands can be easily destroyed. Additionally, especially in shallow water reservoirs, the species composition can change naturally in just a few years, affecting not only *N. tenuissima* but charophytes in general.

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