

New records and observations to the Characean flora of Sicily (Italy)

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ABSTRACT

New records to the Characean flora of Sicily are presented. Five species (*Chara baltica*, *C. conimbrigensis*, *C. oedophylla*, *Nitella gracilis*, *Tolypella salina*) are new to Sicily, including two that are new also to Italy (*Chara conimbrigensis*, *C. oedophylla*). Two species are confirmed for Sicily (*Chara aspera*, *Nitella opaca*), three (*Chara braunii*, *C. canescens*, *Nitella capillaris*) are rare taxa. The Characean flora of Sicily, updated with these records, currently includes 25 species, distributed in four genera: *Chara* (13 species), *Nitella* (8 species), *Tolypella* (3 species), and *Lamprothamnium* (1 species).

KEYWORDS

Characeae; *Chara*; *Nitella*; *Tolypella*; Sicily

Introduction

Knowledge about Characean flora in Sicily is very scarce. Most of the available data are basically limited to more than one hundred years old reports (Braun and Nordstedt 1882;

Tornabene 1887; Ross 1905 [reprinted in German by Holtz 1906a, 1096b]; Formiggini 1908; Damino 2004). A similar situation can be said also for the Italian Characean flora (Bazzichelli and Abdelahad 2009), but with some regional exceptions and recent contributions (Piccoli and Pellizzari 2009; Azzella and Abdelahad 2011; Azzella 2014; Lefebvre et al. 2014; Ruocco and Ansaloni 2015a, 2015b; Abdelahad and Piccoli 2017; Becker 2018, 2019).

As a first step towards a better knowledge of this group of freshwater macrophytes, very important for their contribution to the biodiversity and their ecological role, we present here the main results of some recent field investigations.

Materials and methods

During the last year, Angelo Troia and Teresa Napolitano continued their survey of the Characean flora in the island of Sicily. We had the opportunity to include here some results deriving from the visit in Sicily made by Klaus van de Weyer in March 2018, and also from the excursions made by the other authors during the 22nd GEC meeting (Troia 2018). Roman Romanov identified some specimens and revised some identifications.

The specimens were usually collected by hand (by hook, in the case of Lago Preola). Some were preserved in water for morphological observations, some dried as herbarium specimens and stored in PAL, NS or other herbaria (acronyms according to Thiers 2019), some preserved in 70 % ethanol.

Occasionally, some water parameters (electro conductivity, Total Dissolved Solids [TDS], Sodium Chloride [NaCl]) were measured with the waterproof portable microprocessor-based meter Hanna HI9835. Percent Sodium Chloride on this meter refers to percentage of seawater salinity: 100% is equal to seawater.

Morphological features of the specimens were studied using stereomicroscopes Leica (MZ12 and MZ9.5). Photomicrographs of diagnostic traits were made with a digital camera. The photos were taken with a Carl Zeiss Stereo Discovery V12 stereomicroscope equipped with an AxioCam MRs-5 digital camera.

Specimens were identified according to Mouronval et al. (2015) but with the help of an extensive literature review (see References). Since a shared, modern and comprehensive taxonomy of Characeae in Europe is still to come, and especially two of the taxa here presented (*C. conimbrigensis* A.G. Cunha and *C. oedophylla* Feldmann) are not unanimously recognized, we add here detailed descriptions and images of the Sicilian plants of those taxa, useful for other studies and analyses by other colleagues and researchers, hoping to reach – as soon as possible – a more stable, shared and possibly phylogenetic taxonomy.

Results

Chara aspera Dethard. ex Willd. in Mag. Neuesten Entdeck. Gesamten Naturk. Ges. Naturf. Freunde Berlin 3: 296-298. 1809 (Fig. 1A, B)

(confirmed for Sicily)

Specimen – Lago Preola (Trapani province), 37°37'12.30"N, 12°38'32.43"E, ca. 2 m a.s.l., ca. 2 Km from the seacoast, 19 September 2018, *Roman Romanov* (NS).

Notes – The species is present with rare plants, especially compared to the abundant co-occurring *C. baltica*. It was previously known in Sicily from two localities near Trapani and Palermo (according to Formiggini 1908, who reported it as *C. aspera* f. *brevispina* ε *pseudofragilis*). The specimens collected can be referred to var. *subinermis* Kütz.

Chara baltica (C.J. Hartmann) Bruzelius, Observ. Charae: 11. 1824 (Fig. 1C-H)

(new for Sicily)

Specimens – Lago Preola, 37°37'12.30"N, 12°38'32.43"E, ca. 2 m a.s.l., ca. 2 Km from the seacoast, 24 May 2018, *Angelo Troia* (PAL); *ibidem*, 19 September 2018, participants of GEC 22nd meeting (NS).

Notes - Collected in different seasons in the lake Preola (Nature Reserve near Mazara del Vallo, Trapani province), where it probably colonises most of the lake bottom, reaching a depth of ca. 2 m. The lake is permanent, with slightly brackish (conductivity ca. 4 mS/cm) and alkaline (pH ca. 9) water (Troia et al. 2018). The species is known from the Baltic area, where it was originally described, Netherlands, Great Britain, Greenland, Mediterranean area and NW Africa (Krause 1997; Langangen and Bennike 1997; Muller et al. 2017). It is not reported for Italy by Bazzichelli and Abdelahad (2009), but Becker (2018, 2019) found it in Sardinia.

Krause (1997) illustrated two morphotypes of *C. baltica*, from Baltic Sea and Southern France (l.c.: Fig. 22, A, B), the latter is recently informally called “Mediterranean baltica” or “French baltica” (Blindow and Erichsen 2010). According to Krause (l.c.), the two morphotypes differ by the length of the ecorticate part of the branchlets which was shown to be short for the Mediterranean form but longer and swollen for the Baltic form. However this difference seems to be not significant. Mediterranean plants of *C. baltica* frequently have a more prominent length of posterior bract cell, and the branchlets with long ecorticate segment looking similar to the Baltic morphotype usually present at their lower whorls (Cirujano et al. 2008; Mouronval et al. 2015; Zeneli and Kashta 2016; MA, checked by R. Romanov). In addition the Mediterranean morphotype seems to occur in Baltic Sea (Migula 1897, 1909; Blümel 2004; LE, W, checked by R. Romanov). We found different combination of relative length of anterior and posterior bract cells and length of ecorticate segment in the same

population in Lago Preola. Analysis of genetic polymorphism, ecophysiological traits and results of cross-fertilisation experiments showed no clear difference between Mediterranean and Baltic populations of *C. baltica* (Boegle et al. 2010; Blindow and Erichsen 2010), obviously further complicating this taxonomic issue.

Chara braunii C.C. Gmelin, Fl. Bad. 4 (Suppl.): 646. 1826 (Fig. 2A)

(new for Palermo province, new population of a rare species in Italy)

Specimen – Gorgo di Rebuttone (near Piana degli Albanesi, Palermo province), 38° 1'41.85"N, 13°19'34.17"E, ca. 700 m a.s.l., 8 May 2018, *Angelo Troia & Teresa Napolitano* (PAL).

Notes - Collected in the small temporary mountain pond of Rebuttone, where it grows (few scattered plants) together with *Nitella opaca* (see below), *Chara globularis* Thuill., *Ranunculus trichophyllus* Chaix in Vill., and other vascular plants.

Chara canescens Loisel., Not. Fl. France: 139. 1810 (Fig. 2B, C)

(new population of a rare species in Italy)

Specimen – Margi Milo (Petrosino, Trapani province), 37°43'23.49"N, 12°28'26.21"E, temporary pond with brackish waters, ca. 1 m a.s.l., ca. 150 m from the seacoast, 24 May 2018, *Angelo Troia* (PAL).

Notes - We found this new parthenogenetic population (abundant - but only female - plants) in a coastal pond, where it grows together with *Chara* cf. *aspera* and *Tolypella* sp. Single measurement made on 17 April 2018 shows conductivity = 9.22 mS/cm, TDS = 4.61 gm, NaCl = 17.3%.

Chara conimbrigensis A.G. Cunha in Bull. Soc. Portug. Sci. Nat. 12: 48. 1935 (Fig. 3 D, E, Fig. 4A-H)

(new for Sicily and Italy)

Specimens – Nebrodi Mts (Messina province), frequent but localised in small shallow waterbodies downstream of the Maulazzo dam, 37°56'30.37"N, 14°40'16.74"E, about 1400 m a.s.l., 27 June 2018, *Angelo Troia & Teresa Napolitano*. Nebrodi Mts (Messina province), seepage of groundwater near the road to the Maulazzo dam, Lago Maulazzo and small waterbodies downstream of the Maulazzo dam, about 1400 m a.s.l., 20 September 2018, *Roman Romanov* (NS).

Description of the Sicilian plants - Plants from a few cm to 15-20 cm high, weakly to moderately incrustated in shallow water or unincrustated in deeper water, condensed and short in ground water seepage or uncondensed and long in deeper waters, growing as a one shoot or more commonly as several shoots arising from the common base with rhizoids, sparsely branched or unbranched. Stem rather thin, 390-740 µm in diameter. Nodal multicellular bulbils up to 1.15 mm in diameter are formed at lowest nodes in all localities. Stem cortex complete, diplostichous, mostly isostichous, commonly slightly tylacanthous (this trait is often barely recognisable in pressed specimens mainly), absent or peeling off in lowermost internodes. Secondary tubes commonly contact as a slightly overriding each other. Spine cells solitary papillate, papilliform or elongated, shorter than stem diameter, up to 4/5 of its diameter or even slightly longer than last one, emerging at acute angle or almost adpressed, adpressed if short, up to 240-740 µm in length. Stipulodes in double rows, obtuse to narrow rounded, short or rarely irregularly elongated, upper ones sometimes more elongated than lower ones. Upper stipulodes 170-280 µm length, lower ones 170-260 µm or rudimentary at lowermost nodes. Branchlets 8-9 in a whorl, arcuate and nearly hiding the upper internodes and apex in groundwater seepage and nearly straight or slightly arcuate and spreading in

deeper habitats, 8.7-11 mm in length. In any cases the internodes are shorter or much shorter than branchlets at least in apical parts. Branchlets entirely ecorticate, consisting of one or mainly two, rarely three ecorticate unabbreviated segments and undifferentiated part formed by 3 or 4 cells. End cell short but not mucronate, conical or conical-cylindrical, with acute apex. Bracts clearly unilateral, posterior bract cells papilliform or extremely rarely slightly elongated, anterior bract cells long, usually slightly longer than the adjacent branchlet segment and from several to many times longer than the oogonium (in these cases they can have clearly uneven length), sometimes short, several times shorter than the adjacent branchlet segment, from conical, i.e. much shorter than oogonium (extremely rare), to slightly longer than oogonium. Bracteoles usually several times shorter than anterior bract cells sometimes their difference not so drastic. Gametangia conjoined on 1, 2, only in one case on 3 lowest branchlet nodes. Antheridia (and - extremely rarely – oogonia) can be solitary. This is not frequent but it is characteristic for the plants from groundwater seepage. Bractlet is shorter than oogonium. Oogonia can be (very rarely) vertically geminate with antheridium below, 568-740 x 444-460 μm , rarely forming a neck below coronula. Coronula slightly spreading. Antheridia 360-420 μm in diameter.

Notes - This species was described from Portugal (Gonçalves da Cunha 1935) and later reported from Spain (Sánchez Castillo 1984), Croatia and Macedonia (Blaženčić et al. 2006). Wood and Imahori (1965) treated it as *C. vulgaris* var. *gymnophylla* f. *conimbrigensis*. Krause (1997) merged *C. conimbrigensis* and *C. rohlena* in *C. gymnophylla* A. Braun. A recent record of *Chara rohlena* Vilh. in Serbia (Blaženčić and Stevanović 2018) seems to belong to *C. conimbrigensis* because the plants were described as having irregular stem cortex varied from tylacanthous to isostichous rarely even aulocanthous.

Chara conimbrigensis was described as having tylacanthous stem cortex (Gonçalves da Cunha 1935), this feature being later confirmed after the study of its type (Wood and Imahori

1964, 1965). *Chara conimbrigensis* is different from the similar *C. gymnophylla* mainly for its tylacanthous stem cortex and for the occasional presence of sejoined gametangia, which seem to be typical mainly of the plants growing in very shallow water or nearly as terrestrial ones, as it was known for the type specimen (Wood and Imahori, 1964, 1965; LISU, checked by R. Romanov). Compared to the other gymnophyllous diplostephanous European species of *Chara*, *C. conimbrigensis* differs by its complete diplostichous tylacanthous to isostichous stem cortex from the imperfectly to almost completely corticated monoecious *C. dissoluta* A. Braun ex Leonh. (*C. conimbrigensis* distinct from it also by the long anterior bracts), from the imperfectly corticated dioecious *C. imperfecta* A. Braun in Durieu, as well as from the nearly ecorticate monoecious *C. ochridana* Kostić, aulacanthous or isostichous diplostichous monoecious *C. rohlenae*, and isostichous triplostichous monoecious *C. kokeilii* A. Braun; the uncondensed habit of the last one seems to be somewhat resembling “deep water” form of *C. conimbrigensis* due to long bract cells.

Chara oedophylla Feldm.-Maz. in Bull. Soc. Hist. Nat. Afrique N. 36: 168. 1946 (Fig. 2F-I)
(new for Sicily and Italy)

Specimen – Contrada “Critazzo” near Mazara del Vallo (Trapani province), 37°41'10.63"N, 12°36'59.77"E, temporary pond, ca. 60 m a.s.l., 17 Apr. 2018, *Angelo Troia* (NS).

Description of the Sicilian plants - Plant moderately encrusted up to 7 cm in height, forming multicellular nodal bulbils in lowest parts. Stem is 360-570 µm in diameter. Stem cortex diplostichous clearly aulacanthous. Spine cells solitary, elongated, bluntly pointed if elongated and obtuse if short, emerging at acute angle from the stem, 2-2.5-times (or more) shorter than stem diameter. Stipulodes diplostephanous, short, obtuse or bluntly pointed. Branchlets recurvate, arcuate or straight and spreading, 6-7 in a whorl, up to 1 cm, consisting of 4 corticated segments and a short ecorticate two-three-celled part (comparable in length to

the last corticated segment or slightly longer), rarely 3 segments and in this case ecorticate part is three-celled and from one to more than two times the length of the last corticated segment. Ecorticate part can be slightly longer than anterior bract cells. End cell small conical mucronate. Bract cells clearly unilateral, posterior bract cells rudimentary. Anterior bract cells inflated, 1.5-2-3.5–times longer than oogonium. Anterior bract cell 1.5-2-times longer or nearly the same length on nodes with solitary antheridium. Anterior bract cells shorter, nearly the same or slightly longer than adjacent branchlet segment. Gametangia mainly sejoned, rarely conjoned, may be sejoned and conjoned even within the same branchlet. Oogonia frequently vertically geminate and in these cases anterior bract cells and bracteoles are twice in number in comparison with solitary oogonia or conjoned gametangia gradually decreasing in length from branchlet node to a bractlet. Bractlet is short. In case of solitary antheridium only anterior bract cells are present. The oogonium at the end node of a branchlet tends to nearly replace an ecorticate segment position shifting it outside the whorl. Oogonia up to 800 µm in length, coronula not spreading. Antheridia 490-590 (unripe), 742-830 µm in diameter.

Notes – The population here reported consists of few scattered plants in a temporary pond surrounded by vineyards (in the *locus classicus* of *Isoetes todaroana* Troia & Raimondo near Mazara del Vallo) (Troia and Raimondo 2010): single measurement made on 17 April 2018 shows conductivity = 3.38 mS/cm, TDS = 1.69 gm, NaCl = 6.3%. The taxon is currently known in few sites in W-Mediterranean (Morocco, Tunisia, Spain, France). Sometimes accepted as a variety of *C. vulgaris* L. (Wood and Imahori 1965; Mounroval et al. 2015). We agree with Soulie-Märsche and Muller (2016) and Muller et al. (2017), treating it at the species rank.

Nitella capillaris (Krock.) J. Groves et Bull.-Webst., Brit. Charoph. (Groves) 1: 96. 1920 (Fig. 4A, B)

(species not recently reported for Sicily and Italy)

Specimens – Anguillara temporary pond, near Calatafimi (Trapani province), 37°51'29.41"N, 12°55'14.72"E, 13 April 2013, *Angelo Troia & Teresa Napolitano* (PAL); *ibidem*, 17 April 2018, *Angelo Troia* (NS).

Notes – Few scattered plants were found in the temporary wetlands of Anguillara, a unique biodiversity hotspot (Troia and Lansdown 2016), unfortunately not yet protected. The only previous reports of the species in Sicily (Formiggini 1908, under “*Nitella capitata* (N. ab. Es.) Ag.”) are based on two XIX century herbarium specimens, collected in the “gurgo di San Ciro” near Palermo (a wetland nowadays destroyed), and in a undefined locality in Catania.

Nitella gracilis (J.E. Smith) C. Agardh, Syst. Alg.: 125. 1824 (Fig. 4C, D)

(new for Sicily)

Specimen – Nebrodi Mts (Messina province), Lago Maulazzo, 37°56'30.37"N, 14°40'16.74"E, about 1400 m a.s.l., 20 September 2018, *Roman Romanov* (NS).

Nitella opaca (C. Agardh ex Bruzelius) C. Agardh, Syst. Alg.: 124. 1824 (Fig. 4E)

(confirmed for Sicily)

Specimens – Gorgo di Rebuttone (near Piana degli Albanesi, Palermo province), 38°1'41.85"N, 13°19'34.17"E, ca. 700 m a.s.l., 8 May 2018, *Angelo Troia & Teresa Napolitano* (PAL). Nebrodi Mts (Messina province), Lago Maulazzo, 37°56'30.37"N, 14°40'16.74"E, about 1400 m a.s.l., 20 September 2018, *Roman Romanov* (NS).

Notes - Collected also in the small mountain pond of Coda di Riccio (in the Nature Reserve of Ficuzza, Palermo province), in all reported sites it is scattered but frequent. The species, not reported for Sicily in Bazzichelli and Abdelahad (2009), was already reported for

the Rebuttone pond by Naselli-Flores and Barone (2012) and for Nebrodi Mts by Damino (2004).

Tolypella salina Corill. in Rev. Algol. n.s. 5(3): 198. 1960 (Fig. 4F)

(new for Sicily)

Specimen – Margi Milo (Petrosino, Trapani province), 37°43'27.12"N, 12°28'26.71"E, temporary pond with brackish waters, ca. 1 m a.s.l., ca. 150 m from the seacoast, 17 March 2018, Klaus van de Weyer (Herbarium by Klaus van de Weyer).

Notes - Collected in a single pond, where it is localized but frequent, it probably occurs also in other sites along the western coast of the island. The main diagnostic characters were small size of the plants consisting of few whorls and having very long protonema, the chestnut colour of the oospore and the structure of the oospore membrane which is smooth. *Tolypella salina* is not reported for Italy by Bazzichelli and Abdelahad (2009), but Becker (2018, 2019) reports it for Sardinia.

Discussion

Here we present data about ten species. Five (*Chara baltica*, *C. conimbrigensis*, *C. oedophylla*, *Nitella gracilis*, *Tolypella salina*) are species not previously reported for Sicily, two of them being also new to Italy (*Chara conimbrigensis*, *C. oedophylla*). Two are species confirmed for Sicily (*Chara aspera*, *Nitella opaca*), the other three are rare taxa in Italy (*Chara braunii*, *C. canescens*, *Nitella capillaris*). I

The Characean flora of Sicily, updated with these records, currently includes 25 species (Table 1), distributed in the genera *Chara* (13 species), *Nitella* (8 species), *Tolypella* (3

species), and *Lamprothamnium* (1 species). Seven species are known from old publications only and need to be confirmed. It is unclear if previous records of *C. hispida* and *C. gymnophylla* as well as some forms and varieties (Braun and Nordstedt 1882; Ross 1905; Formiggini 1908) are in agreement with recent species concepts. Therefore search and checking of their vouchers are desirable. Twenty-five is evidently not the real and definitive number of the species occurring in Sicily, because further field and taxonomic investigations are needed: but this number is comparable with that (26) of the species currently known from Sardinia (Becker 2019).

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Captions for figures

Figure 1. *Chara aspera* f. *subinermis* (A-B) and *C. baltica* (C-H) from Lago Preola. A – base of the whorl of branchlets and stem, B – rhizoidal bulbils, C – whorl of branchlets with short or moderately long ecorticate segments and verticillate bracts, D – whorl of branchlets with long undifferentiated ecorticate segments and short posterior bract cells, E – conjoined gametangia, F – stipulodes, G – stem cortex, H – nodal bulbil. All photos by R. Romanov but E by A. Troia.

Figure 2. *Chara braunii* (A) from Gorgo di Rebuttone, *C. canescens* (B, C) from Margi Milo, *C. conimbrigensis* (D, E) from seepage of ground water and from Lago Maulazzo, *C. oedophylla* (F-I) from Contrada “Critazzo”. A – apical part, B – base of whorl of branchlets, C – stipulodes and stem cortex, D – apical part of plant from ground water seepage, E – apical part of plant from the lake, F – general habit, G – apical part, H, I – sejoined and conjoined gametangia incl. vertically geminate oogonia. Photos A-C, F by A. Troia, D, E, H, I by R. Romanov.

Figure 3. *Chara conimbrigensis* from seepage of ground water and from Lago Maulazzo. A – apical part with conjoined gametangia, B – sejoined gametangia, C – conjoined gametangia with vertically geminate oogonia, D – end cells of branchlets, E – stem cortex, F – stipulodes and stem cortex, G – base of the whorl of branchlets and stem cortex, H – nodal bulbil. Photos by R. Romanov.

Figure 4. *Nitella capillaris* (A, B) from Anguillara temporary pond, *N. gracilis* (C, D), *N. opaca* (E) from Lago Maulazzo and *Tolypella salina* (F) from Margi Milo. A, E – apical parts of female plants, B – apical parts of male plants, C – apical part, D – dactyls, F –general habit. All photos by R. Romanov but F by K. van de Weyer.

Table 1. List of Characeae species known from Sicily.

No	Species	Last report
1	<i>Chara aspera</i> Willd.	Present report
2	<i>C. baltica</i> (Hartman) Bruzelius	Present report
3	<i>C. braunii</i> C.C. Gmelin	Present report
4	<i>C. canescens</i> Loisel.	Present report
5	<i>C. conimbrigensis</i> A.G. Cunha	Present report
6	<i>C. contraria</i> A. Braun ex Kütz.	Troia and Barone 2017
7	<i>C. galioides</i> DC.	Formiggini 1908
8	<i>C. globularis</i> Thuill.	Present report
9	<i>C. gymnophylla</i> A. Braun	Damino 2004
10	<i>C. hispida</i> L.	Formiggini 1908
11	<i>C. oedophylla</i> Feldmann	Present report
12	<i>C. tomentosa</i> L.	Formiggini 1908
13	<i>C. vulgaris</i> L. (incl. <i>C. crassicaulis</i> Schleicher)	Troia and Barone 2017
14	<i>Lamprothamnium papulosum</i> (Wallr.) J. Groves	Damino 2004
15	<i>Nitella capillaris</i> (Krock.) J. Groves et Bull.-Webst.	Present report
16	<i>N. flexilis</i> (L.) C. Agardh	Formiggini 1908
17	<i>N. gracilis</i> (J.E. Smith) C. Agardh	Present report
18	<i>N. hyalina</i> (DC.) C. Agardh	Formiggini 1908
19	<i>N. mucronata</i> (A. Braun) Miq.	Damino 2004
20	<i>N. opaca</i> (C. Agardh ex Bruzelius) C. Agardh	Present report
21	<i>N. tenuissima</i> (Desv.) Kütz.	Formiggini 1908
22	<i>N. translucens</i> (Pers.) C. Agardh	Formiggini 1908
23	<i>Tolypella glomerata</i> (Desv.) Leonh.	Formiggini 1908 (van de Weyer 2018, unpubl.) (Troia 2018, unpubl.)
24	<i>T. hispanica</i> Nordstedt	Damino 2004 (van de Weyer 2018, unpubl.) (Troia 2018, unpubl.)
25	<i>T. salina</i> Corill.	Present report