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# MORPHOMETRIC SURVEYS ON *ELEOCHARIS PALUSTRIS* (L.) ROEM. ET SCHULT. (CYPERACEAE). THE CONTRIBUTION OF HERBARIUM INVESTIGATIONS TO THE DELIMITATION OF ITS SUBSPECIES AND THEIR DISTRIBUTION IN ITALY

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Abstract - According to the most recent floristic and taxonomic works, *Eleocharis palustris* (L.) Roem. et Schult. is present in Europe with two subspecies: *E. palustris* subsp. *palustris* and *E. palustris* subsp. *waltersii* Bureš et Danihelka. Up to now in Italy only the first taxon has been reported in literature, and no specific study was recently carried out to assess the presence of both subspecies on the Italian territory. Accordingly, we conducted a comprehensive analysis of Italian herbarium specimens of *E. palustris* in order to verify presence and distribution of its subspecies in Italy. Towards these aims, we collected a wide set of morphological (glume length and number per cm; spikelet length, culm width, achene length and width, stylopode length and width) and anatomical characters (stomata length) and evaluated their contribution to the differentiation of the two subspecies adopting a classification tree analyses. The analyses lead us to report for the first time in Italy *E. palustris* subsp. *waltersii*. This taxon was found to be present in 9 northern and central Italian regions. Our contribution allowed to confirm the presence of *E. palustris* subsp. *palustris* in almost all the Italian regions.

Keywords: Cyperaceae; distribution; herbarium collections; systematics; univariate classification tree analysis

## Introduction

The species *Eleocharis palustris* (L.) Roem. et Schult., belonging to *Eleocharis* R. BR. subser. *Eleocharis* (see Strandhede, 1966; Bureš et al., 2004), is distributed in Europe with two subspecies: *E. palustris* subsp. *palustris* and *E. palustris* subsp. *waltersii* Bureš et Danihelka (≡ *E. palustris* subsp. *vulgaris* Walters nom. illeg., see Bureš & Danihelka, 2008).

Already Walters (1980) highlighted a certain degree of difficulty in distinguishing between the two subspecies in many European countries, although he assumed that the subsp. *palustris* was relatively rare in the British Isles, while on the other hand the subsp. *waltersii* (mostly recorded sub *E. palustris* subsp. *vulgaris*) was not common in southern Europe. The presence of the latter in the Mediterranean area was subsequently confirmed by several Flora's authors such as Jiménez Mejías & Luceño (2007) and Tison et al. (2014). In the recent works on the Italian flora (Pignatti, 2017; Bartolucci et al., 2018) only the subsp. *palustris* has been reported, however no specific study on the *E. palustris* s.l. complex was recently carried out for the Italian territory. Therefore, there is no evidence if only the first or both subspecies are present.

A very important character for the distinction of these two taxa is represented by their chromosome number. *E. palustris* subsp. *palustris* is diploid, with a strong presence of hypoploids, mixoploids and disploids, thus resulting in a broad variety of chromosome numbers, ranging from 2n=10 to 2n=18. On the contrary, *E. palustris* subsp. *waltersii* is considered a tetraploid, and it also shows wide variability in the chromosome numbers, varying from 2n=35 to 2n=41 (see Bureš et al., 2004; Jiménez Mejías & Luceño, 2007).

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This character is very useful when dealing with living material, but not in case of herbarium specimens, especially old samples which often exhibit very low viability of seeds (see Godefroid et al., 2011). Nevertheless, some morphological and anatomical characters such as the stomata length, the spikelet glume number and length and the size of the achenes (see Strandhede, 1966; Walters, 1980; Jiménez Mejías & Luceño, 2007) can be used on herbarium specimens to distinguish the two *taxa*.
Indeed, herbarium data represent an important resource for taxonomic and phytogeographic studies and the revision of herbarium materials leads often to deep changes in the taxonomic attribution of the specimens and, consequently, in the knowledge of the species distribution (Lastrucci et al., 2014 and references therein). Accordingly, within this work, we focused on the analysis of herbarium specimens belonging to *E. palustris* s.l. considering the main morphological and anatomical characters, with the aim of understanding whether only one or both subspecies are really present in the Italian territory and what is their distribution.

## Materials and Methods

### Plant material considered

All the specimens of the *Eleocharis palustris* group preserved in almost all the main Italian herbaria, i.e. the Herbaria of AO, FI, MSNM, MNAV, PAL, PI, RO-HR, RO-HG, RO-HA, ROV, SIENA, TO-HP, TO-HG (Herbarium codes according to Thiers, 2018) and the Herbarium of the Floristic Laboratory of the Department of Biology of Florence University (here named EST) have been checked. Only the specimens with mature achenes have been considered for the analyses. For each specimen, we measured the following characters under a binocular: culm width (mm, abbr. cul_wid); spikelet length (cm, abbr. spi_len); achene length and width (mm, abbr. ach_len and ach_wid); stylopodium length and width (mm, abbr. sty_len and sty_wid); fertile glume length (mm, abbr. glu_len) measured in the middle part of the spikelet; glume number per cm of spikelet (abbr. glu_num).
In addition, we took a culm fragment of the middle part of the culm under the spikelet (see Strandhede, 1966) from each specimen for microscope analyses. The fragments were subsequently immersed in a solution of glycerol and water (1:80 dilution), heated up to gentle boiling and thus left to cool for 15 minutes. Successively, once epidermis had been removed using lancets and tweezers, epidermis fragments were stained with toluidine (0.05% in water) and mounted on a slide. The samples were thus observed and measured (µm) under an optical microscope at a magnification of 40 x. All the overall mentioned length and width values per specimen have been expressed as the mean of five independent measures of the same character on the same specimen.
According to all the character cited above, specimens were assigned to one or the other subspecies using the key in Strandhede (1966), Walters (1980), Stace (2010), Jiménez Mejías & Luceño (2007), Tison et al. (2014).
After the identification, all the collection sites of the specimens (if readable) were geo-referred and their geographic coordinates were plotted in a cartographic layer using the open source software QGIS 2.18, to obtain the distribution maps of the recorded taxa.

### Statistical analyses

We selected 113 determined specimens (99 *E. palustris* subsp. *palustris* and 14 *E. palustris* subsp. *waltersii*) for which we could measure all the traits taken into account. We used a non-parametric Kruskal-Wallis ANOVA test to detect differences in the main morphological characters between the two subspecies. Moreover, the relationship among the identity of the taxa and the main morphological characters was studied using univariate classification tree (CT) analysis. Classification trees represent a flexible statistical procedure used when a qualitative response variable is to be predicted by a decision tree (Legendre & Legendre, 2012). The resulting predictive tree allows to repeatedly split the response data into more homogeneous groups, with indication of the variance explained by the explanatory variables at each split (Legendre & Legendre, 2012). The analyses produce a list of possible candidate splits and also allow the identification of surrogate splits (De'ath & Fabricius, 2000). As it is a non-parametric procedure, it is not necessary to test normality or other assumptions regarding the statistical distribution of data in advance. Results are graphically presented in the form of a classification tree diagram, which includes the explanatory variables that resulted to be predictive of the correct classification of the dependent variable. Accordingly, we used CT to verify the contribution of the different morphological traits studied in this work (see the abbreviation reported above) to the taxonomic attribution of the 113 selected specimens, whose identification was given a priori according to our assessment.

## Results

Starting from about 650 samples observed and excluding those re-identified as different species from *E. palustris* – mainly as *E. mamillata* (H.Lindb.) H.Lindb. subsp. *austriaca* (Hayek) Strandh. or *E. uniglumis* (Link) Schult. – and the immature

**Table 1.** Results of non-parametric Kruskal-Wallis ANOVA test for differences in the main morphological character between *E. palustris* subsp. *palustris* and *E. palustris* subsp. *waltersii.* Means (n = 99 and 14 respectively) ± standard errors are shown. Significance codes: P value < 0.001 "***"; P value < 0.05 "*"; P value < 0.1 "°".

| Charachter | PAL | WAL | Kruskal-Wallis χ2 | P_value | |
|---|---|---|---|---|---|
| glu_len (mm) | 3.15 ± 0.04 | 3.87 ± 0.09 | 29.283 | <0.001 | *** |
| glu_num (n/cm) | 46.29 ± 0.83 | 36.27 ± 2.1 | 13.068 | <0.001 | *** |
| ach_wid (mm) | 0.99 ± 0.01 | 1.09 ± 0.04 | 3.715 | 0.054 | ° |
| ach_len (mm) | 1.35 ± 0.01 | 1.54 ± 0.04 | 19.055 | <0.001 | *** |
| sto_len (μm) | 45.23 ± 0.36 | 55.18 ± 1.53 | 29.925 | <0.001 | *** |
| spi_len (cm) | 1.39 ± 0.04 | 1.69 ± 0.12 | 5.654 | 0.017 | * |
| cul_wid (mm) | 1.44 ± 0.05 | 1.57 ± 0.15 | 0.418 | 0.518 | |
| sty_len (mm) | 0.48 ± 0.01 | 0.55 ± 0.04 | 3.794 | 0.051 | ° |
| sty_wid (mm) | 0.53 ± 0.01 | 0.56 ± 0.03 | 0.526 | 0.468 | |

*E. palustris* s.l. specimens, a total of 132 mature specimens have been measured and identified at the subspecies rank (see Appendix). We found that 119 belong to *E. palustris* subsp. *palustris* and 14 to *E. palustris* subsp. *waltersii.*

The Kruskal-Wallis test (Table 1) detected highly significant differences (P value < 0.001) for the measure of glume length (glu_len), number of glumes per centimeter (glu_len), achene length (ach_len) and stomata length (sto_len). We detected significant difference (P value < 0.05) also concerning spike length (spi_len). In case of achene width (ach_wid) and stylopodium length (sty_len), we detected only partially significant differences (P value < 0.10), while culm width (cul_wid) and stylopodium width (sty_wid) showed no difference at all. Generally, *E. palustris* subsp. *waltersii* is characterized by longer glumes, by a lower number per centimeter even if the spike is generally shorter, longer achenes and longer stomata, compared to *E. palustris* subsp. *palustris.* Moreover, the latter species displayed slightly narrower achenes and slightly shorter stylopodia.

According to the CT model (Table 2), stomata length (sto_len) resulted the more important variable allowing the classification of the specimens (variable importance = 46%), followed by glume length (glu_len, variable importance = 25%), achene width (ach_wid, variable importance = 11%) and culm width (variable importance = 9%). The importance of the other variables was negligible (ach_len, glu_len and sty_wid variable importance was 3%).

The first node primary split is based on the length of stomata (Fig. 1 and Fig. 2); specimens with stomata shorter than 51.25 μm are mostly classifiable as *E. palustris* subsp. *palustris* (E-PAL). Other candidate characters may be the glume and achene length. As a surrogate split allowing a splitting consistent to the one offered by length of stomata, the CT model indicates glu_len (< 3.85 mm) and ach_wid (< 1.25 mm), see Table 2.

**Table 2**. Main results of the Classification tree model. cul_wid = culm width (mm); spi_len = spikelet length (cm); ach_len = achene length (mm); ach_wid = achene width (mm); sty_len = stylopodium length; sty_wid = stylopodium width (mm); glu_len = fertile glume length (mm); glu_num = number of glumes per cm of spikelet.

| **Node number 1** | | | | |
|---|---|---|---|---|
| **Primary splits:** | **Split** | **Direction** | **Improve** | |
| sto_len | < 51.25 | to the left | 15.027 | |
| glu_len | < 3.65 | to the left | 12.848 | |
| ach_len | < 1.55 | to the left | 8.362 | |
| glu_num | < 34.20 | to the right | 6.401 | |
| ach_wid | < 1.25 | to the left | 4.731 | |
| **Surrogate splits:** | **Split** | **Direction** | **Agreement** | **Adj** |
| glu_len | < 3.85 | to the left | 0.957 | 0.455 |
| ach_wid | < 1.25 | to the left | 0.942 | 0.273 |
| **Node number 2** | | | | |
| **Primary splits:** | **Split** | **Direction** | **Improve** | |
| ach_len | < 1.55 | to the left | 3.307 | |
| glu_len | < 3.55 | to the left | 2.353 | |
| sto_len | < 47.75 | to the left | 0.866 | |
| spi_len | < 2.35 | to the left | 0.686 | |
| **Node number 5** | | | | |
| **Primary splits:** | **Split** | **Direction** | **Improve** | |
| glu_len | < 3.50 | to the left | 2.400 | |
| sto_len | < 46.50 | to the left | 2.400 | |
| glu_num | < 31.50 | to the right | 1.067 | |
| cul_wid | < 1.85 | to the right | 1.067 | |
| sty_wid | < 0.55 | to the left | 1.067 | |
| **Surrogate splits:** | **Split** | **Direction** | **Agreement** | **Adj** |
| sto_len | < 46.50 | to the left | 1.000 | 1.000 |
| cul_wid | < 1.85 | to the right | 0.800 | 0.500 |
| sty_wid | < 0.55 | to the left | 0.800 | 0.500 |
| glu_num | < 41.11 | to the right | 0.800 | 0.500 |

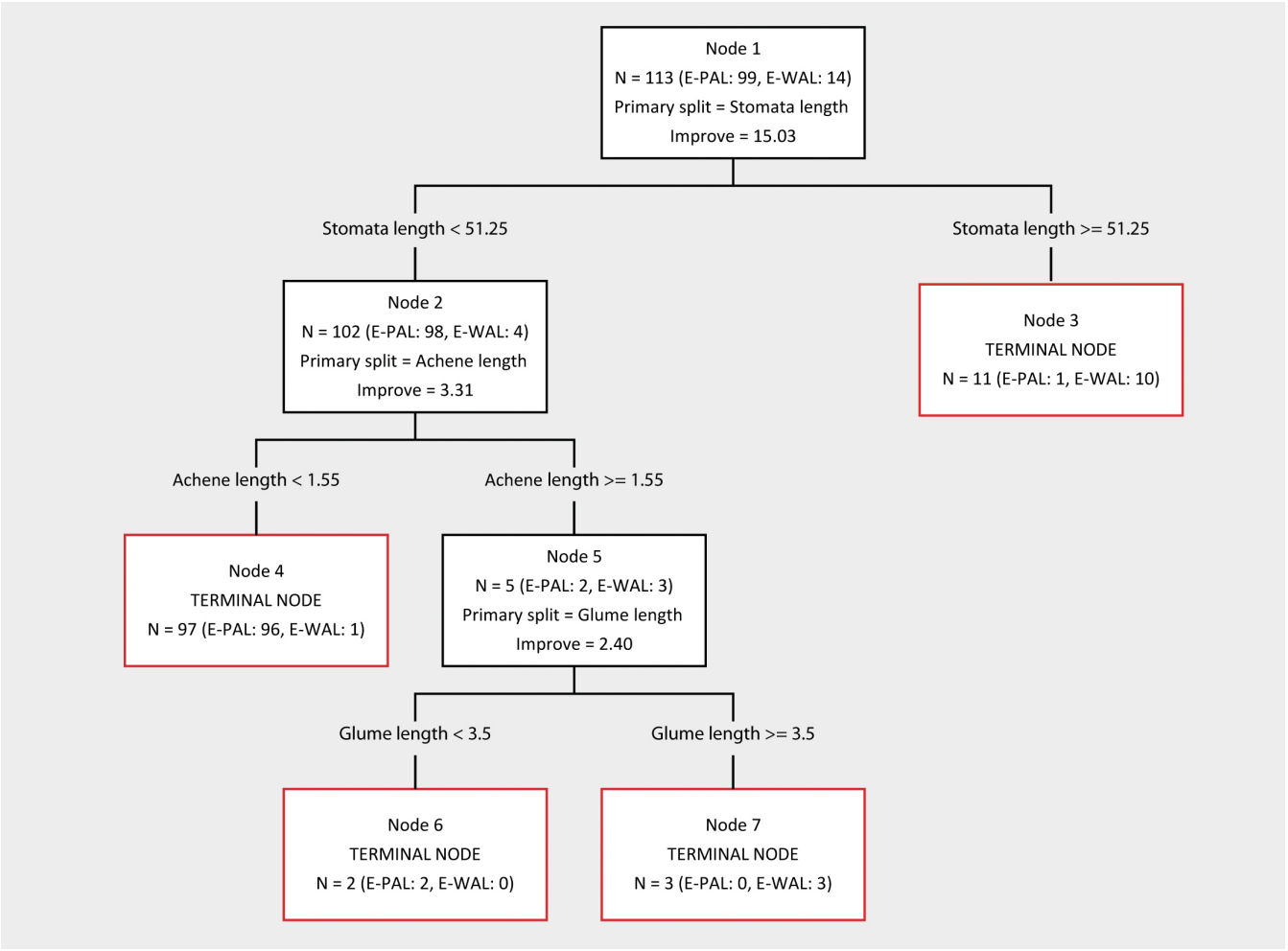


**Figure 1.** Classification tree model showing the contribution of morphological traits allowing the distinction between *Eleocharis palustris* subsp. *palustris* (E-PAL) and *E. palustris* subsp. *waltersii* (E-WAL).
N: number of total cases in each node (numbers in parenthesis refer to cases of specimen identified as E-PAL and E-WAL, respectively).
Improve: improvement in explained variation according to the primary split selected.

On the left side of the tree, a further splitting is represented by achene length (Fig. 1). Most of specimens with achene length < 1.55 mm were classified as E-PAL, while the others still show mixed classification. No surrogate split is available in this case (node 2, Fig. 1). The left side of the tree is finally terminated by the measure of glume length (node 5, Fig. 1), allowing to separate E-PAL from E-WAL (*E. palustris* subsp. *waltersii*), fully replaceable by sto_len < 46.5 µm. Sto_len is indeed the first surrogate split, followed by glu_num, cul_wid and sty_wid.
In case of stomata longer than 51.25 µm the right branch of node 1 lead mostly to E-WAL specimens, but still with one E-PAL (node 3, Fig. 1).

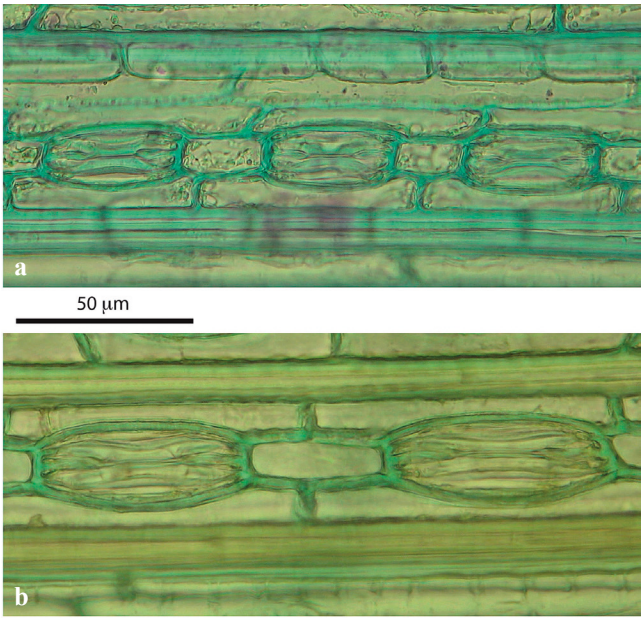


**Figure 2.** Section of *Eleocharis* epidermis showing stomata length. (a) *Eleocharis palustris* subsp. *palustris*, (b) *E. palustris* subsp. *waltersii*.

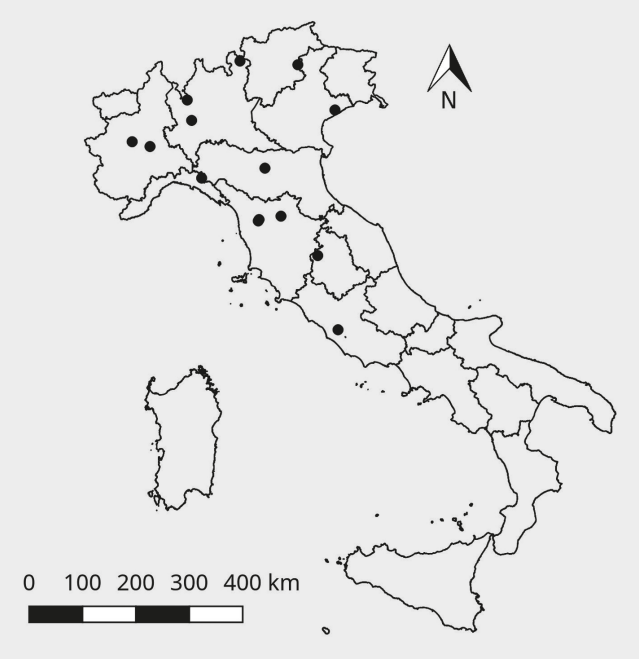


**Figure 3.** Distribution map of the *E. palustris* subsp. *waltersii* analysed specimens.

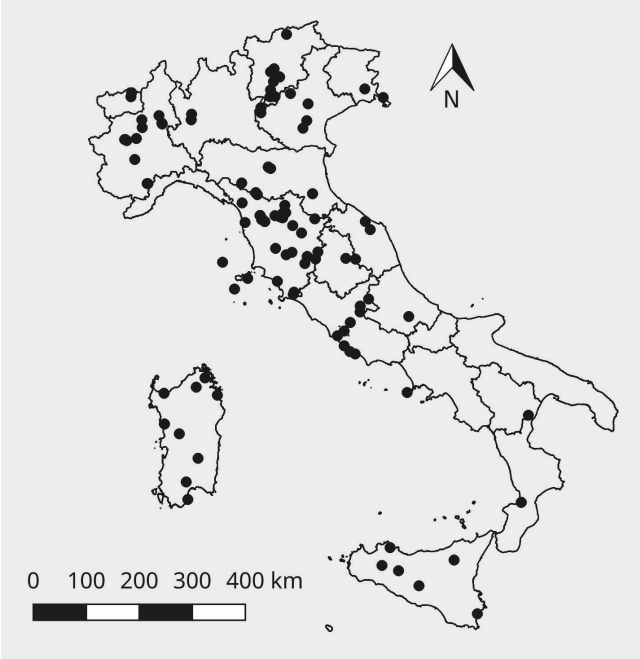


**Figure 4.** Distribution map of the *E. palustris* subsp. *palustris* analysed specimens.

Our investigations allowed to create the Italian distribution maps of *E. palustris* subsp. *waltersii* (Fig. 3) and of *E. palustris* subsp. *palustris* (Fig. 4).

## Discussion

Our data lead us to point out the presence of *E. palustris* subsp. *waltersii* in Italy. Based on the herbarium specimens analyzed, the presence of this *taxon* is ascertained for Liguria, Piedmont, Lombardy, Trentino-Alto Adige, Veneto, Emilia-Romagna, Tuscany, Umbria and Latium (Fig. 3). However, for some localities the specimens are very old or geographically rather vague [e.g. Romae], therefore the current presence of the subsp. *waltersii* should be confirmed with field surveys (see Appendix).

The number of specimens belonging to this subspecies is much lower than the samples belonging to *E. palustris* subsp. *palustris*; our data show clearly that the latter *taxon* is the most widespread in Italy. According to Bartolucci et al. (2018), *E. palustris* subsp. *palustris* grows in all the Italian regions. Our data lead us to confirm the presence of this subspecies in all the regions with the exception of Molise and Puglia (Fig. 4). For Puglia, only immature specimens were found in the surveyed herbaria, making possible to confirm only the presence of *E. palustris* s.l.

Strandhede (1966) put in evidence a certain geographic and ecological isolation between *E.* subsp. *palustris* and *E.* subsp. *waltersii*. Nevertheless, an overlapping in the habitat requirement and distribution sites was already put in evidence by Walters (1949) and it is confirmed also analyzing the regional distribution, at least at regional scale, of the two entities in the Flora Iberica (Jiménez Mejías & Luceño, 2007). From an ecological point of view, both entities are reported for subnitrophilous shallow ponds and ditches, marshes, wet meadows and lagoons, tolerating water level variations, different pH values and substratum types (Waters, 1949; Jiménez Mejías & Luceño, 2007). Moreover, the differences in the ecological needs of the two entities are not so clear, also because the two subspecies are sometimes treated as *E. palustris* aggregate (e.g. Chytrý et al., 2018). Very few differences are reported by Julve (2019), who states that *E. palustris* subsp. *palustris* seems to be slightly more tolerant with respect to soil salinity, less demanding in soil humidity but more demanding in atmospheric humidity, and less related to sandy soils compared to *E. palustris* subsp. *waltersii*. From a chorological point of view, according to Bureš et al. (2004, and references therein), *E. palustris* subsp. *palustris* is subcosmopolitan, while *E. palustris* subsp. *waltersii* shows a mainly sub-Atlantic distribution. However, according to Jiménez Mejías & Luceño (2011), the distribution of *E. palustris* subsp. *waltersii* seems to be wider, becoming somewhat central-western European. The presence of spontaneous hybrids between the two entities, with chromosome number 2n=27 and sometimes fruit setting

reduced, is sometime reported (Strandhede, 1966; Stace, 2010; Tison et al., 2014). In addition, Strandhede (1966) underlined that back-crossing of the hybrid has been observed only towards subsp. *waltersii.*

## Conclusions

Our study put in evidence that the distribution pattern of the two *taxa* in Italy shows a lack of geographic and ecological separation. In few cases, even for the same collection (e.g. wetlands near Modena), we found specimens belonging to both the *taxa*.
According to some authors (e.g. Arrigoni, 2017 and references therein) the subspecies taxonomic concept is strongly related to two or more interfertile systematic units spatially separated. In this work, we adopted the subspecies rank for the two entities according to the commonly accepted nomenclature. Nevertheless, adopting the taxonomic concept of Arrigoni (1988, 2006, 2017) and considering that the two entities have different chromosome numbers, *E. palustris* subsp. *waltersii* might be treated at the species rank; in this case, according to Bureš et al. (2008) the correct name *Eleocharis vulgaris* Á. Löve et D. Löve should be used.

## Aknowledgements

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## Appendix – *Specimina visa*

***Eleocharis palustris*** subsp. ***waltersii***

***Emilia Romagna***: Nei pantani intorno a Modena, 05/1875, *G. Gibelli* (TO-HG).

***Lazio****:* Romae, s.d.*, Fiorini* (FI).

***Liguria***: Rezzoaglio, Lago di Agoraie, 09/09/1937, *A. Chiarugi* (FI).

***Lombardia***: In paludibus prope Comum, s.d., *G. Comolli* (FI); Bormio. Piazza (1200) luoghi acquosi, 06/1893, *Longa* (FI); Milano, zona 18, via Forze Armate, prato militare tra via della Rovere e via Massarino m 120, 02/06/1991, *G. Galasso* (MSNM).

***Piemonte***: S. Mauro lungo il Po, 18/07/1915, *E. Ferrari* et *F. Santi* (TO-HG); Tonco (AT), loc. stazione, nei prati lungo il rio detto del Cavallo Morto, 10/06/1996, *F. Picco* (TO-HP).

***Toscana***: Propre Florentiam, ghiacciaia di Trespiano, 09/06/1887, *S. Sommier* (FI); Toscana, padule di Bientina alle Pinete (Cerreto Guidi), 20/07/1892, *S. Sommier* (FI); Padule di Fucecchio, l. d. Porto di Guido, 26/05/1920, *R. Pampanin*i (FI).

***Trentino Alto Adige***: Val di Fassa, Passo san Pellegrino Laghetto delle Pozze 1914 m sponda umida, 11/09/2001, *F. Prosser* (ROV).

***Umbria***: Trasimeno lacus, 09/06/1870, *H. Groves* (FI).

***Veneto***: Sacca (del Piave), 21/02/1912, *M. Minio* (FI).

***Eleocharis palustris*** subsp. ***palustris***

***Abruzzo***: In lacu prope Campo di Giove in Aprutio, 08/1875, *H. Groves* (FI).

***Basilicata***: Italia, provincia di Matera, Nova Siri, prato acquitrinoso, con *Carex distans*, 11/05/1957, *L. Tamanini* (ROV).

***Calabria***: In humentibus prope flumen Angitola in Calabria, 06/05/1877, *A. Biondi* (FI); In paludosis prope flumen Angitola in Calabria, 07/05/1877, *G. Arcangeli* (FI).

***Campania***: Ischia, 06/1900, *F. Cavara et P. Pirotta* (FI).

***Emilia-Romagna***: Nei pantani intorno a Modena, 05/1875, *G. Gibelli* (TO-HG) *sp. pl.*; Castrocaro haud procul a Forlì in loci inundatis, 31/03/1877, *S. Sommier* (FI) *sp. pl.*; Nei prati umidi e con acqua stagnante in alto sopra Fiumalbo, 07/1880 (TO-HG); Prati dell'Archirola presso Modena, 12/06/1884, *A. Fiori,* (FI); In una buca d'acqua al Carletto presso Modena, 01/08/1894, *A. Fiori* (FI); S. Andrea Pelago, lago Cavo, 05/08/1920, *A. Lunardi* (FI); Lagaccioni sopra il cacciatore nel laghetto, 25/09/1920, *A. Lunardi* (FI); Lago Verde di M. Ventasso, 08/08/1932, *T. Provasi* (FI).

***Friuli Venezia Giulia***: Fossati orientali del forte di Palmanova, 20/05/1949, *G. Fornaciari* (MFU); Carso triestino: stagno di Colludrozza m 260, 01/05/1980, *E. Polli* (MFU).

***Lazio***: Lago dei Tartari, 06/1829, *P. Sanguinetti* (RO-HR); Presso Nettuno, 25/05/1857, *E. Rolli* (RO-HR); Paludi Pontine, 06/1874*, N. Cherici*, (RO-HR); Da Orvinio a Scandriglia, 05/08/1894, *A. Pappi* (RO-HR); Tenuta La Fossa, nella macchia, 10/06/1898, *A. Pappi* (RO-HR); Torre S. Lorenzo, 11/06/1898, *A. Papp*i (RO-HR); Lungo il fiume Astura, 14/06/1898, *A. Pappi*, (RO-HR); Lungo il fiume Turano nel piano di Rieti, 23/08/1900, *A. Pappi* (RO-HR); Roma, stagno tra via Appia antica e la stazione di Torricola, 29/05/1952, *A. Cacciato* (RO-HR); Piani di Rascino e verso Petrella Salto (RI), 24/06/1982, *B. Anzalone* (RO-HA); Tenuta di Castel Porziano (Roma), 06/1986, *B. Anzalone* (RO-HA).

***Lombardia***: Stagno a Baggio, (Milano), 06/1955, *A. Piazzoli* (MSNM); Stagno a Baggio (Milano), 20/05/1958, *A. Piazzoli* (MSNM); Castellazzo, 06/06/1981, *E. Banfi* (MSNM).

***Marche***: Nell'acquitrino sul laghetto di Fiorenza [sic] al Brugnetto di Senigallia, 19/04/1950, *A. Bettini* (FI); Jesi, 08/1937, *A. Bettini* (FI).

***Piemonte***: Ponte Maurizio, lungo la fiumana di Caramagna, 08/1839, *G. Berti* (FI); In fossis aquaticis prope le Mollere, 18/06/1864, *G.B. Romano* (TO-HP); Oldenico paludi e risaie, Primavera 1869, *A. Malinverni* (TO-HP); Risaie a Oldenico (Vercelli), Estate 1869, *A. Malinverni* (FI); Settimo nei siti umidi, 15/09/1869, *M. Defilippi* (TO-HP); Torino, lago di Alpignano [Lago di Sclopis] Brione laghi di Caselette, 06/06/1880, *F. Ungern-Sternberg* (TO-HP); Torino, praglia di Pianezza (bei einem Teiche),17/06/1880, *F. Ungern-Sternberg* (TO-HP); Fossi alla Praglia di Pianezza Caselette, 1903, *F. Vallino* (TO-HP); Ivrea: sotto Candia paludi, 26/06/1913, *P. Bolzon* (FI); Pedemontibus herbosis castro Fortezza, s.d., *G. B. Romano* (TO-HG).

***Sardegna***: Pula, 05/1862 s.c. (FI); Presso il lago Platamani, Portotorres, 11/05/1899, *U. Martelli* (FI); Bosa lungo i fossi verso il Semaforo m 1, 29/03/1912, *A. Fiori* (FI); Bosa nei fossi verso il semaforo m 1, 29/03/12, *A. Fiori* (FI); Tra Uta e Decimomannu (Sardegna), 27/06/1921, *G. Gola* (TO-HG); Calangianus pascoli umidi a isoetofile in loc. Graminatogliu m 500, terre brune su granito, 31/05/1968, *P.V. Arrigoni et C. Ricceri* (FI); San Teodoro, lungo la SS Orientale Sarda in un prato umido vicino al mare, 13/06/1972, *C. Steinberg et C. Ricceri* (FI); Arzachena, zone palustri al lago di Cannigione substr. granitico, 27/06/1983, *P.V. Arrigoni et A. Mazzanti* (FI); Abbasanta, prati umidi lungo la SS. Carlo Felice, presso il bivio di Norbello, substrato basaltico, 06/06/1989, *P. V. Arrigoni, R. Baldini et C. Ricceri* (FI); Nurri, luoghi umidi nei pressi del paese substrato calcareo, 09/06/1989, *P.V. Arrigoni, R. Baldini et C. Ricceri* (FI).

***Sicilia***: In paludosis- Palermo, s.d., *Todaro* (FI); In uliginosis (Avola), s.d., *G. Bianca* (FI); Nebrodi: biviere di Cesarò 1250-1450 m a.s.l., 10/06/1990, *F.M. Raimondo, S.L. Jury, R.M. Gebauer, A. Charpin, S. Brullo, H. Hofmann, M. Mastracci, D. Lakusic, E. Perez Caro, P. Minissale, G. Certa, A. Gambino, F. Gendusa et L. Gianguzzi* (PAL); Pres du torrent Giulfo, commune de Chiusa Sclafani province de Palerme, exposition sud, 440m, dans le terrains incultes humides, 26/05/1993, *G. Certa* (PAL); Palermo, Monti Sicani, Gorgo di Silvio, 02/06/2018, *L. Lastrucci, R. Bolpagni et L. Gianguzzi* (FI); Palermo, Monte Carcaci presso Prizzi, area umida sotto la strada, 02/06/2018, *L. Lastrucci, R. Bolpagni et L. Gianguzzi* (FI).

***Toscana***: Boscolungo, luoghi umdi nella regione del faggio, 03/08/1837, *F. Parlatore* (FI); In humentibus Apennini estrusci, 07/1841, *P. Savi* (TO-HG); Firenze in laghetto nella via che va a Pratolino, 12/06/1842, *F. Parlatore* (FI); Pianure Pisane, 24/06/1856, *A. Andreucci* (SIENA); Florentia alle Cascine, 07/1865, *E. Levier* (FI); Toscana, marais di Fucecchio aquis lente fluentibus, 24/06/1871, *S. Sommier* (FI); In palude vulgo "Padule di Fucecchio", 09/05/1878, *G. Arcangeli* (FI); Fra Capalbio e lago Acquato, Maremma Orbetellana, loci hieme inundatis, 28/05/1892, *S. Sommier* (FI), *sp. pl.*; Prope Florentiam padule fra Brozzi e Sesto, 09/05/1897, *S. Sommier* (FI); Prope Florentiam pantano fra Brozzi e Sesto, 09/05/1897, *S. Sommier* (FI); Insula Elba (olim Ilva vel Aetalia) Porto Longone presso la spiaggia di Mola, 12/05/1898, *S. Sommier* (FI); Pantano presso Sesto, 29/06/1905, *S. Sommier* (FI); Insula Pianosa, Fornace Vecchia in una buca da dove vi è levata la terra per i mattoni, 20/05/1909, *S. Sommier* (FI); Padule di Fucecchio l. d. Porto di Guido, 26/05/1920, *R. Pampanini* (FI); Fucecchio, macchia alle Vedute (Cerbaie), 26/05/1920, *R. Pampanini* (FI); Lago di Sibolla, 27/05/1920, *R. Pampanini* (FI); Parco delle Cascine (Firenze) greto dell'Arno presso il Ponte Sospeso, 28/06/1928, *R. Corradi* (FI); Cascine di Firenze lungo l'Arno, 29/06/1932, *R. Corradi* (FI); Greto d'Arno, 24/05/1934, *U. Losacco* (FI); Nel lago di Chiusi e nei canali adiacenti, 29/06/1951, *R.E.G. Pichi -Sermolli et R. Corradi* (FI); Altopascio, prati e fossi lungo l'autostrada presso Sibolla, 27/05/1958, *C. Ricceri et A. Contardo* (FI); Alpi Apuane, Fociomboli in acquitrino su scisti paleozoici m 1100, 05/08/1967, *E. Ferrarini* (FI); Padule di Fucecchio: porto di Salanova, 16/05/1975, *P.E. Tomei* (PI); Siena, Lago di Montepulciano. Zone lacustri della riva occidentale del lago, in località Colmata del Lago II, 27/08/1980, *P.V. Arrigoni et C. Ricceri* (EST); Siena, Lago di Montepulciano. Zone perilacustri della riva sud occidentale, nella parte Nord di Colmata del Lago II, 15/10/1980, *P.V. Arrigoni, C. Ricceri et M. Rizzotto* (EST); Siena, Lago di Montepulciano. Zone perilacustri della riva sud occidentale, nella parte Nord di Colmata del Lago II, 15/10/1980, *P.V. Arrigoni, C. Ricceri et M. Rizzotto* (EST); Grosseto tenuta "la Trappola" campi e pascoli salsi, 25/06/1982, P. *V. Arrigoni, A. Mazzanti et C. Ricceri* (FI); Livorno Isola di Capraia. Lo Stagnone, 23/06/1991, *B. Foggi et P. Luzzi* (EST); Valdarno riserva Valle dell'Inferno-Bandella veg. palustre dell'ansa di Bandella, 06/1998, *M. Raffaelli et D. Viciani* (FI); Monticiano, Siena, a Fiume Merse presso il pod. Funina 154 s.l.m., 05/08/1999, *M. Landi* (SIENA); Mugello (S. Piero a Sieve) Bosco ai Frati, 09/2005, *L. Lastrucci et R. Becattini* (FI); Presso il laghetto vicino Suvignano (com. Montenori d'Arbia), 25/05/2006, *M. Landi et C. Centi* (SIENA); Prov. di Arezzo, Appennino aretino, pozze e pantani sotto il passo della Gualanciole, 26/05/2007, *L. Lastrucci, V. Gonnelli, A. Zoccola et A. Bottacci* (FI); Siena, Radicondoli, podere Colleaperto, Cornocchia, Riserva Naturale Statale Cornocchia 355 s.l.m., 19/06/2008, *M. Landi* (SIENA); SIR/SIC/EPS "Crete dell'Orcia e del Formone", 28/06/2013, *G. Bonari et G. Mottola* (SIENA); Pog. Caiano, s.d., *s.coll*. (FI).

***Trentino Alto Adige***: Vipiteno, Verso il ponte ferroviario di Rio Vizze, acquitrini e lame (nelle buche delle granate) alluvioni miste q. 950, 19/07/1950, *S. Zenari,* (FI); Luoghi paludosi, umidi, 165 m laghetti Marco, 16/07/1985, *F. Festi* (ROV); Italia, provincia di Trento, Valle di Cei, in loc Cimani di Pomarolo alla pozza d'acqua al margine 1276 m, 26/07/1999, *F. Prosser* (ROV); Italia, provincia di Trento, Valle dell'Adige, zona umida tra Interporto Doganale e ferrovia 195 m prato umido a *Carex* e *Juncus*, 24/07/2000, *F. Prosser* (ROV); Italia, provincia di Trento, Val di Non, 1,5 km a NNW di Vervò, pozza tra la cava di Pietra e fontana Nuova 935 m, 13/08/2000, *F. Prosser* (ROV); Italia, provincia di Trento, comune di Trambileno, M. Pasubio: a Est della sella tra M. Buso e M. Bisorte in una pozza, 1761 m, pozza ad acqua profonda, 14/10/2005, *F. Prosser* (ROV); Italia, provincia di Trento, Comune di Campodenno, Val di Non ca. 200 m a NW della fermata ferroviaria di Crescino lungo il percorso di visita del biotopo Rocchetta, in una bassura umida del prato falciato 260 m, 25/09/2009, *A. Bertolli et F. Prosser* (ROV); Italia, provincia di Trento, comune di Valda-Val di Cembra, Riserva Naturale Locale Palù del Moro, sopra Valda, Altitudine 1230 m, 30/06/2014, *A. Bertolli* (ROV); Italia, provincia di Trento, comune di Cembra-Praticello a S di loc. Vegiose. Prato paludoso su silice, Altitudine 1230, 09/08/2016, *F. Prosser* (ROV).

***Umbria***: Laghetto della Spella e M. Subasio, 26/07/1886, *A. Terracciano* (RO-HG); Padule di Colfiorito (Foligno), 22/07/1951, *A. Messeri* (FI); Perugia, Castiglion del lago, Lago Trasimeno: tra Ferretto e Petrignano in zona acquitrinosa del bosco 280 m, 13/06/1999, *A. Mazzeschi* (SIENA).

***Valle d'Aosta***: Valtournenche, Lago di Cortina 2079 m, 22/09/2002, *M. Bovio* (AO); Lac de Lod (Chamois) 2018 m, 19/08/2011, *L. Lastrucci, C. Coli et L.V. Colella* (FI).

***Veneto***: Fossi attorno a Padova, 20/06/1894, *A. Fiori* (FI); Colli Euganei presso il Monte Sieva [Ceva], 05/1896, *A. Fiori,* (FI); Prai de Godego (Treviso), ca 95 m depressioni fangose, 22/05/1991, *G. Busnardo* (ROV); Italia, provincia di Verona, Monte Baldo: il Lavaccio sopra Belluno Veronese alla pozza, 670 m terreno fangoso umido (calcare), 07/06/2003, *F. Prosser* (ROV); Italia, provincia di Verona, Comune di S. Zeno di Montagna, M. Baldo: stradina (segnavia CAI) da Lumini di là per Malga Zilone 757 m pozza d'alpeggio fangosa, 05/07/2006, *A. Bertolli et F. Prosser* (ROV) *sp. pl*; Altopiano di Asiago, conca centrale, Caberlaba, 1000 m pozza d'alpeggio, 19/07/2009, *S. Scortegagna* (MNAV).