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Mediterranean temporary wet systems in inland Central Italy: ecological and phytosociological features

D. Gigante, F. Maneli, R. Venanzoni
Department of Applied Biology, University of Perugia, Borgo XX giugno, 74, I-06121 Perugia, Italy.

Abstract
The results of a study about Mediterranean temporary wet habitats in central inland Italy are here presented. The surveyed phytocoenoses are developed in pools and waterlogged soils and each of them is characterized by different depth and duration of the flooded period. The plant communities have been analysed by applying Braun-Blanquet's approach and carrying out 95 phytosociological relevés. The use of multivariate analysis allowed the identification of eight main vegetation types, which have been referred to the classes *Isoëto-Juncetea, Littorelletea, Agrostietea stoloniferae* and *Phragmito-Magnocaricetea*. Four new associations are described: *Junco tenageiae-Solenopsietum laurentiae* ass. nova, *Hypochoerido glabrae-Cicendietum filiformis* ass. nova, *Callitricho brutiae-Ranunculetum ophioglossifolii* ass. nova, *Callitricho brutiae-Juncetum bulbosi* ass. nova, and four new subassociations: *Serapio-Isoëtetum histricis* Pedrotti 1982 *lotetosum angustissimi* subass. nova, *Solenopsio laurentiae-Juncetum pygmaei* V. Silva & Galán de Mera in V. Silva, Galán de Mera & Sérgio 2008 *isolepidetosum cernuae* subass. nova, *Alismo lanceolatae-Gratioletum officinalis* Biondi & Bagella 2005 *juncetosum conglomerati* subass. nova, *Callitricho brutiae-Ranunculetum ophioglossifolii* ass. nova *glycerietosum fluitantis* subass. nova. The floristic diversity of the identified plant communities has been analysed, considering species number, species density per m^2, Shannon's and Evenness Indexes. The stand's features have also been analysed, taking into account the minimum sampling area and the vegetation total cover values, and measuring in the fields pH values and O_2 content in the water. With regard to these parameters, the statistical significance of the differences among the detected vegetation types has been tested. The high floristic relevance of these systems is emphasized by the presence of some rare, localized and/or threatened species and Habitats from 92/43/EEC Directive's Annex I. The great coenotic diversity has been interpreted by applying the concept of microgeosigmetum.

Key words: ephemeral wetlands, microgeosigmetum, ponds, vegetation, phytosociology, waterlogged soils

Introduction

Mediterranean temporary ponds are very peculiar wet habitats which host fragile ecosystems. From the geobotanical point of view, they include rare plant species and communities whose survival is strictly dependent on the occurrence of precise ecological and hydrological conditions. Seasonal rainfall, soil pH and substratum permeability are among the most important environmental factors to drive the development of these phytocoenoses. Their importance has been emphasized by their inclusion in the Annex I to the 'Habitat' 92/43/EEC Directive, among the 'Standing water' habitats (code 31), with three different types: 3120 "Oligotrophic waters containing very few minerals generally on sandy soils of the West Mediterranean with Isoëtes spp."; 3130 "Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or *Isoëto-Nanojuncetea*"; 3170* "Mediterranean temporary ponds" (European Commission, 2007). All the three of them have been detected in peninsular Italy (Biondi *et al*., 2009, 2012).

Temporarily wet by definition, these systems show an amphibious character and need the alternation of wet and dry periods with a seasonal water availability (Deil, 2005); however, they can also develop in spatial (catenal) contact with permanently flooded communities. Their distributional range includes the Mediterranean Basin; they are present in Mediterranean and Submediterranean Italy, however, their actual distribution is restricted and very localized, due to the intrinsic peculiarity of their ecological needs as well as to environmental changes and human impact.

Recordings of this type of plant communities refer mostly to the Italian major and minor islands and to the coastal and subcoastal districts (Brullo & Di Martino, 1974; Brullo *et al*., 1977; 1994, 1996, 2001; Filipello & Sartori, 1981; Brullo & Minissale, 1998; Biondi *et al*., 2002; Biondi & Bagella, 2005; Ernandes *et al*., 2006; Bagella *et al*., 2007, 2009, 2013; Stanisci *et al*., 2007; Carta, 2008; Filibeck & Lattanzi, 2008; Cogoni *et al*., 2009; Ernandes & Marchiori, 2013). The inland territories are only seldom interested by their occurrence, although similar habitats have been reported also in inland Central Italy, in Umbria region (Pedrotti, 1982; Pedrotti *et al*., 1982; Biondi *et al*., 1988, 1990, 2010; Baldoni *et al*., 1995; Ballelli, 2003; Venanzoni *et al*., 2005; Gigante *et al*., 2007).

Aim of this paper is to provide an ecological and phytosociological interpretation of the temporary wet ecosistems occurring in inland areas of Central Italy, where the Mediterranean character, although still present from a bioclimatic point of view, gets in touch with flora and vegetation types affected by continental features.

Corresponding author: Daniela Gigante. *Department of Applied Biology, University of Perugia, Borgo XX giugno, 74, I-06121 Perugia, Italy; e-mail: daniela.gigante@unipg.it*

Study area

The study has been carried out in Piana di Ferretto (N: 43°9.957', S: 11°59.667'), a large flat area close to Castiglione del Lago (PG), on the west side of Lake Trasimeno in Central Italy. The pond systems, purely fed by rainwater, are scattered inside an area of about 2,500 Ha, covered by a mosaic landscape including crops, pig farms, Turkey oak forests and subatlantic heathlands close to their southern distributional border (Gigante *et al*., 2007). Because of the occurrence of several Habitats included in the Annex I to the 92/43/EEC Directive, the site has been selected as a S.C.I. belonging to Natura 2000 (IT5210020).

The whole area is located at an altitude between 260 and 320 m a.s.l. As concerns the climatic aspects, by applying the bioclimatic indexes as modified by Rivas-Martínez *et al*. (1999) to the data collected in Monte del Lago (PG) climatic station, the area can be referred to the Mesomediterranean belt of the Pluviseasonal Oceanic Mediterranean Bioclimate (Gigante & Venanzoni, 2007). The geologic outcrops are represented by fluvial-lacustrine sandy-clayey Plio-Pleistocenic sediments (known as 'Villafranchiano') which generate oligotrophic soils. As concerns the pedological types, leached decarbonated sandy-argillaceous soils are present in the study area (Giovagnotti *et al*., 2003). The water table is high for a part of the year; furthermore, in winter the most argillaceous soils support the flooded conditions by retaining the rainwater. This conditions give rise to a scattered pond system, which gets partially or totally dry during the period of summer drought.

The potential vegetation of the flat area where the ponds are developed has been referred to the *Asplenio onopteris-Quercetum cerridis* Ubaldi 1995 *Quercus virgiliana* variant (Gigante *et al*., 2008; Biondi *et al*., 2010). Its successional stages are represented by a shrubby mantle dominated by *Cytisus scoparius* with *Rubus canescens* and *Rosa gallica* (all. *Pruno-Rubion ulmifolii* O. Bolòs 1954); shrub vegetation dominated by *Erica scoparia* and *Cistus creticus* ssp. *eriocephalus* (*Cisto incani-Ericetum scopariae* Biondi, Orsomando, Baldoni & Catorci 1995); dry heathlands dominated by *Calluna vulgaris* and *Danthonia decumbens* (*Danthonio decumbentis-Callunetum vulgaris* Pedrotti 1982); mesophylous herbaceous fringes with *Oenanthe pimpinelloides* and *Linum bienne* (*Oenantho pimpinelloidis-Linetum biennis* De Foucault 1986); heliophylous herbaceous edges with *Genista germanica* and *Lathyrus niger* (ord. *Melampyro-Holcetalia mollis* Passarge 1979); thermophylous garrigues dominated by *Cistus salvifolius* and *Cistus creticus* ssp. *eriocephalus* with *Pulicaria odora* (*Cistetum eriocephali-salvifolii* Allegrezza, Biondi & Felici 2006); perennial grasslands dominated by *Agrostis capillaris* subsp. *capillaris* with *Anthoxanthum odoratum* and *Hypochoeris radicata* (all. *Bromion erecti* Koch 1926); ephemeral xerophytic communities with *Tuberaria guttata, Trifolium arvense* and *Lotus angustissimus* (all. *Tuberarion guttatae* Br.-Bl. in Br.-Bl., Molinier & Wagner 1940 nom. mut. propos. Rivas-Martínez, Diaz, Fernández-González, Izco, Loidi, Lousa & Penas 2002) (Pedrotti, 1982; Biondi *et al*., 1995; Gigante *et al*., 2007). The ponds can be found both in the clearings of the forest vegetation and in contact with the dry heathlands, creating a tiny, fine grain vegetational mosaic.

As concerns the environmental and hydroecological characteristics of the ponds, a basic role is played by the length of the flooded period together with the water depth, the pond size and its slope. On this ground, in order to represent any possible different ecological condition, we identified four types of pools: A) waterlogged soils, represented by water sheets thinner than 2 cm, which get totally dry at the start of May; B) flat ponds with gradually-sloping borders, 2 - 20 cm deep, which get totally dry in May; C) basin ponds with steep borders, 20 - 40 cm deep, whose bottom keeps wet till the start of June; D) large ponds deeper than 40 cm, with water persisting till the end of June. The different types can often be found in contact with each other, for instance the A-type can be present along the edge of the B- or D-type. The A- and B-types are completely colonized by dwarf-size, annual or perennial vegetation. The C-type may host perennial or annual communities, depending on the length of the water stagnation in the bottom sediment. The D-type is generally occupied by tall perennial vegetation. This ecological modeling fits with the interpretation of Deil (2005) who distinguishes waterlogged, amphibic, shallow and deep submerged aquatic conditions on the ground of the amplitude of water-level fluctuations in relation to soil surface.

Materials and methods

The field survey followed Braun-Blanquet's classical approach (Braun-Blanquet, 1979); the adopted methodology fits with the latest methodological remarks reported in Biondi (2011). We carried out 95 phytosociological relevés in the period 2004-2007. During the field activity, the selection of the sampling areas took care of the tiny ecological variations that characterize the amphibian systems, with special care for the water persistence, the slope and the time of the year. The slope of the sampling area is always flat, so slope and exposition have not been reported. Field measurements of pH and oxygen (mg/l) in the pond water have been carried out, by using a VWR SympHony Environmental Field Package.

For the vegetation data collection, a 9-values alpha-numerical scale was used, according to Westhoff & Van

Der Maarel (1978), including 2m, 2a and 2b as proposed in Barkman *et al*. (1964). All the relevés have been stored in the database VegItaly (Gigante *et al*., 2012; Landucci *et al*., 2012; Venanzoni *et al*., 2012) and the project number (VEGVEN#) has been reported in the tables. For the data processing, the relevés have been split into two groups: Group 1 (43 relevés) refers to the dwarf-size vegetation developed in early late spring withering ponds (mostly A- and B- pond type) and Group 2 (52 relevés) represents the medium to tall-size communities developed in early summer withering ponds (C- and D- type). The two groups have been processed separately because of their deeply different vegetation structure, size, ecology and phenology.

The total cover value, the number of species per relevé, the species density per m^2, the sampling plot area, the Shannon and Evenness Indexes have been calculated for each single relevé and represented with box-and-whisker charts for each identified cluster. Shannon and Evenness Indexes have been processed by using the Juice program (Tichý, 2002). The statistical significance of the differences between the 2 Groups of relevés has been tested with non-parametric statistics for two independent data sets, by using the Mann-Whitney U-Test. The statistical significance of the differences among the identified clusters has been also tested, by applying non-parametric statistics for multiple independent data sets, by using the Kruskal-Wallis Test.

For the multivariate analysis of the relevés, the cover values have been transformed according to Westhoff & Van Der Maarel (1978) and a matrix was created for each of the two data sets. The two "species x relevés" matrices have been processed using the Syn-Tax 5.02 package (Podani, 1995), by applying the complete link algorithm (Orloci, 1978) to the similarity ratio matrix (Westhoff & Van Der Maarel, 1978). According to the syntaxonomic analysis, on the ground of the available bibliographic references, the relevés have been referred to phytosociological units at the association level. When a suitable reference to already described associations was not possible, new syntaxa have been proposed. The description of new plant communities complies with the International Code of Phytosociological Nomenclature (Weber *et al*., 2000). The syntaxonomical and nomenclatural framework complies with Biondi & Blasi (2013). The names of the plant species follow the most recent taxonomic indications (Tutin *et al*., 1964-1980, 1993; Conti *et al*., 2005). The chorologic types, when used, refer to Pignatti (1982).

Results

By applying the cluster analysis to the two field data sets, we obtained two dendrograms displayed in Fig. 1 which refer, respectively, to the dwarf-size (Group 1) and to the medium/tall-size vegetation (Group 2). Both of them show 4 main groups for a total amount of 8 Clusters (C1 to C8) which can be referred to as many plant communities; as a whole, 8 phytocoenoses related to the analysed wet systems were recognized in the study area.

In Fig. 2, box-and-whisker charts representing the values of the six analysed indexes are reported, with reference to each of the eight detected Clusters: total cover value, number of species per relevé, species density per m^2, sampling plot area, Shannon and Evenness Indexes. For each of them, the statistical significance is reported, with reference to the differences between Group 1 and 2 (Mann-Whitney U-Test) and among the single Clusters (Kruskal-Wallis Test).

Finally, in Tab 1 the values (av±sd) of O_2 (mg/l) and pH measured in the water are reported for the 8 detected plant communities; also in this case, the statistical significance is indicated (Kruskal-Wallis Test).

On the ground of their floristic, ecological and structural features, after a large analysis of the available literature, the eight detected Clusters of relevés have been referred to four phytosociological classes: *Isoëto duriei-Juncetea bufonii* Br.-Bl. & Tüxen ex Westhoff, Dijk & Paschier 1946, *Littorelletea uniflorae* Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946, *Agrostietea stoloniferae* Oberdorfer 1983 and *Phragmito australis-Magnocaricetea elatae* Klika in Klika & Novák 1941. The first two include the annual/perennial amphibious communities representing the typical expression of, respectively, Mediterranean-Atlantic and N-European-Atlantic oligotrophic temporary wet systems. The third class refers to mesotrophic to eutrophic grasslands, periodically flooded for a more or less prolonged period; the fourth class represents the phytocoenoses developing in permanently wet conditions (Biondi & Blasi, 2013). In the next sections, a floristic, ecological and syntaxonomic characterization of the analyzed plant communities is reported, first the dwarf-size (Group 1) and then the medium to tall-size (Group 2) phytocoenoses.

Cluster 1 - *SERAPIO-ISOËTETUM HISTRICIS* Pedrotti 1982 (Tab. 2) *ISOËTETOSUM HISTRICIS* Pedrotti 1982, holotypus: Rel. 8, Tab. 4 in Pedrotti (1982) *LOLETOSUM ANGUSTISSIMI* subass. nova hoc loco, holotypus: Rel. 18, Tab. 2

Synecology: the dwarf amphibious ephemeral vegetation dominated by *Isoëtes histrix* is widespread in the waterlogged soils and very shallow ponds (A-type) in the study area. The dominant species, a geophytic amphibious fern, appears already in winter and can stand up to 3 months of flooding or even more, with exceptionally rainy springs. Very peculiar is the presence of a number of orchids, mainly from the genus *Serapias*, which share with *Isoëtes histrix* the

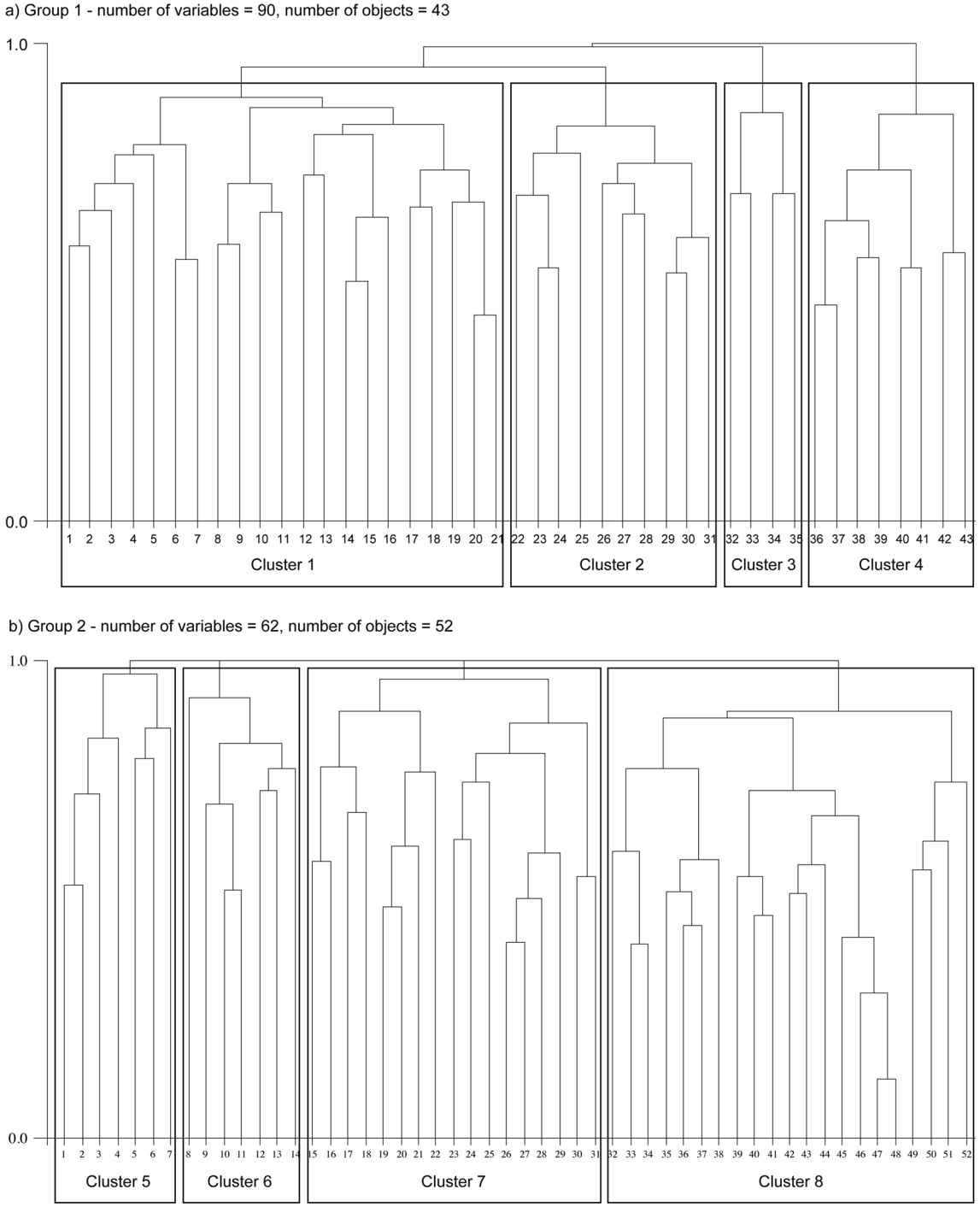

Fig. 1 - Dendrograms derived from the Hierarchical Clustering by Distance Optimization (Syn-Tax 5.02.Mac) applied to the surveyed plant communities: a) Group 1 (43 relevés) referring to the dwarf-size vegetation developed in early spring ponds; b) Group 2 (52 relevés) referring to the medium- to tall-size vegetation developed in early summer withering ponds (for both, sorting strategy: complete link, dissimilarity coefficient: similarity ratio).

geophytic life-form. Their presence, mostly restricted to this habitat, indicates a certain similarity with the meso-hygrophylous vegetation rich in *Serapias* sp. pl., observed in the cristalline Provence, developed in contact with *Isoëtes* communities and referred to the alliance *Serapion* Aubert & Loisel 1971 (Quezel, 1998). The other species, mostly annual and with a very short life span, appear a bit later and show their maximum development in April-May. The average species number is 15.9 and the average cover is around 46% (Fig. 2). The plot size is 1.3 m^2 on average.

This vegetation type is known for the study area only, where it has been observed for the first time by Pedrotti *et al.* (1979, 1980). The relevés in Tab. 1 indicate

Tab. 1 - Measured values (av±sd) of O_2 (mg/l) and pH in the water for the 8 detected plant communities; (Kruskal-Wallis Test: O_2 $p<0.05$, pH $p<0.001$). In brackets, the number of water samples per group.

	O_2	pH
Cluster 1 (n=3)	4,9±3,5	6,4±0,18
Cluster 2 (n=3)	6,7±1,3	5,4±0,20
Cluster 3 (n=2)	1,7±1,2	6,3±0,36
Cluster 4 (n=2)	7,5±0,1	5,6±0,01
Cluster 5 (n=8)	4,4±1,2	5,8±0,62
Cluster 6 (n=13)	4,9±2,0	5,8±0,47
Cluster 7 (n=19)	5,6±2,2	6,9±0,71
Cluster 8 (n=10)	4,0±1,4	5,8±0,70

that the observed community is a xerophylous expression of the typical association, differentiated by some annual xerophytes, as indicated later in the floristic characterization. This may be the result of a dryer condition due to a marginal position along the pond shores or to a general change in the climatic/edaphic conditions of the area. We propose to formalize this floristical and ecological aspect with a new subassociation called *lotetosum angustissimi*. As a consequence, according to the Art. 5 of the ICPN (Weber *et al*., 2000) the typus of the typicum subassociation, for which we propose the name *isoëtetosum histricis*, is represented by the holotypus of the association, indicated by Pedrotti (1982).

Syntaxonomy: the association *Serapio-Isoëtetum* has been described just for the study area (Pedrotti, 1982). Later, Brullo & Minissale (1998) considered Pedrotti's association as a synonymous of *Junco capitati-Isoëtetum histricis* Br.-Bl. 1935; however in the synoptic table (Tab. 3, Col. 23 in Brullo & Minissale, 1998) they omitted to consider the presence of *Serapias lingua* and *S. cordigera*, both characteristic species indicated by Pedrotti (1982). The ecologic value of *Serapias* species had already been pointed out by French Authors with the alliance *Serapion* Aubert & Loisel 1971, used in the identification of Natura 2000 habitats in France (Bensettiti *et al*., 2002) but later not accepted in the Prodrome des végétations de France (Bardat *et al*., 2004). Most likely the omitted species have been set aside by Brullo & Minissale (1998) as sporadic taxa during the processing of a very large data set; however, they are important elements of this association, clear expression of its ecology, with a differential value towards *Junco capitati-Isoëtetum histricis*. The species *Ranunculus paludosus* (= *R. flabellatus*) is also omitted in Brullo & Minissale (1998), while *Hypericum australe* is erroneously reported in place of *H. humifusum*. The latter species has a Southern Italian distribution, while the former, although considered as a Cosmopolite, is present only in Northern and Central Italy (Conti *et al*., 2005), playing probably a role as a bioclimatical differential taxon. Considering the diagnostic value of the mentioned species, we do not agree with the syntaxonomic arrangement proposed by

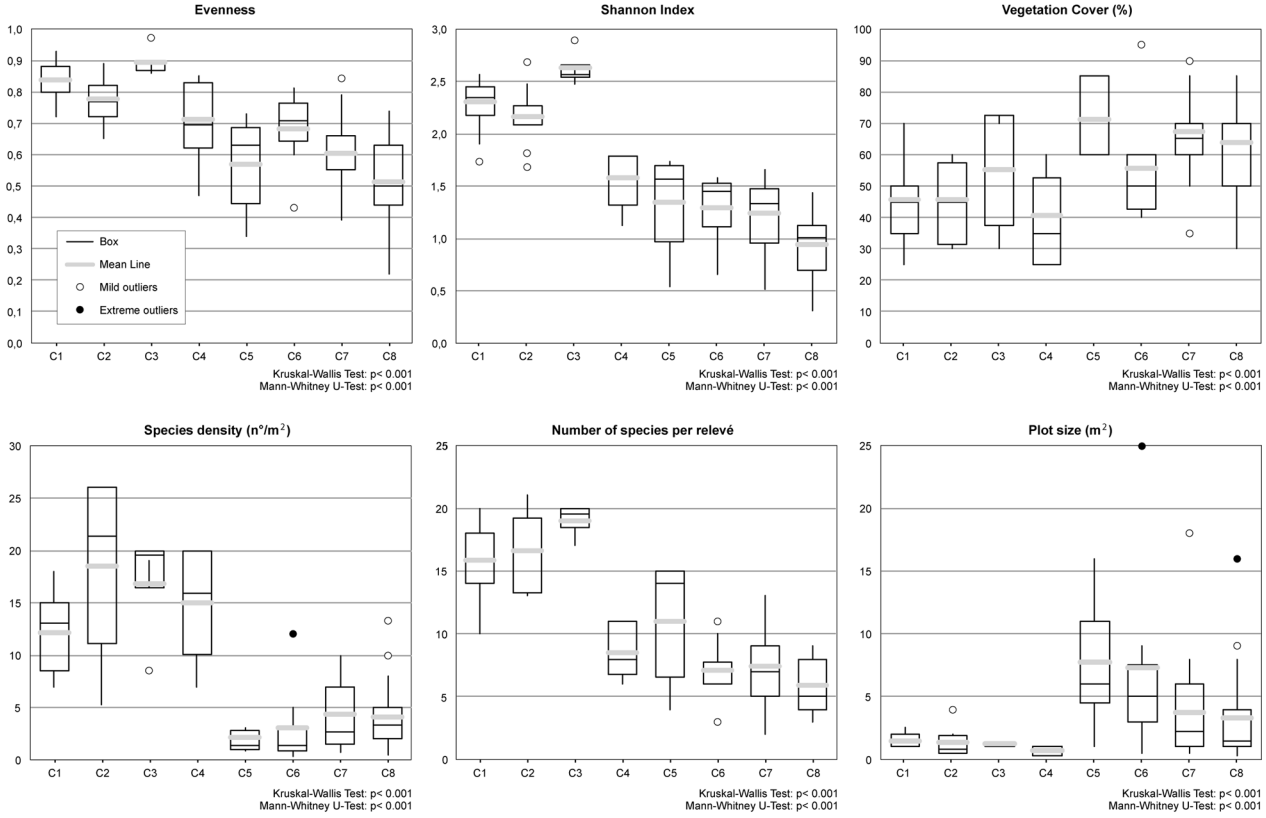

Fig. 2 - Graphic representation of the calculated Indexes for the 8 Clusters; p values with reference to the differences between Group 1 and 2 (Mann-Whitney U-Test) and among the single Clusters (Kruskal-Wallis Test) are reported.

Tab. 2 - *Serapio-Isoëtetum histricis* Pedrotti 1982 *lotetosum angustissimi* subass. nova

Number (dendrogram)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18*	19	20	21	
Original number (VEGVEN#)	2	11	12	15	9	3	10	4	7	5	6	8	39	27	29	28	16	17	18	25	26	
Number of species per relevé	11	15	17	15	18	10	16	14	17	22	14	15	20	14	13	14	16	16	18	20	19	
Cover (%)	40	30	35	30	50	70	70	50	40	60	50	50	40	30	25	40	35	45	60	60	50	
Area (m2)	1	2	2	1	1	1	1	1	2	2	2	1	2.5	1	1	1	1	1	1	2.5	2.5	Presences
Differential and characteristic species																						
Isoëtes histrix Bory	2b.2	2a.1	2b.2	2a.2	2a.1	3.3	2b.3	2b.2	2b.3	3.3	2a.3	2b.3	2b.2	2a.2	2b.2	2a.2	2a.2	2b.2	3.3	3.3	3.3	21
Ranunculus paludosus Poir.	2a.2	2a.1	1.1	1.1	1.1	2b.2	3.3	2a.2	1.3	+	.	.	1.1	+	2a.2	1.1	+	+	2a.2	+	+.1	19
Serapias lingua L.	+	.	1.3	+.2	+	2a.2	2a.1	+	+	+	+.2	.	.	r	.	+.2	1.1	+.2	1.1	+	.	16
Serapias cordigera L.	.	.	.	.	.	.	+.2	.	.	.	.	.	1.1	.	.	.	.	r	r	r	.	5
Differential species of the subass. *lotetosum angustissimi*																						
Filago gallica L.	+	+	+	r	2m	.	1.1	+	+	+	+	.	+	.	.	+	+	+	.	1.1	.	15
Lotus angustissimus L.	.	.	.	.	+	+	+	+	+	+	.	1.1	1.1	1.1	+	2a.2	+	+	.	1.1	1.1	15
Galium parisiense L.	.	.	.	.	.	.	.	+	.	+	+	.	+	.	.	.	+	1.1	+	+	+	9
Isoëtion, Isoëtetalia, Isoëto-Nanojuncetea																						
Juncus capitatus Weigel	2a.2	2a.1	2a.1	2b.3	2b.2	+	2m	.	.	.	.	1.3	1.1	2a.2	1.1	.	1.1	1.1	2b.2	2a.2	2a.2	16
Juncus bufonius L.	.	.	.	.	2a.1	.	.	.	.	.	.	.	2a.2	.	.	.	1.1	+	2a.2	1.1	1.1	7
Cicendia filiformis (L.) Delarbre	.	1.1	2m	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	r	1.1	6
Isolepis cernua (Vahl) Roem. et Schult.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	1.1	+	4
Anagallis arvensis L. subsp. parviflora (Hoffmanns. et Link) Arcang.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	1.1	4
Solenopsis laurentia (L.) C. Presl	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2m.1	2m.1	.	.	2
Montia fontana L. subsp. chondrosperma (Fenzl) Walters	.	r	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Helianthemetea guttati																						
Briza maxima L.	1.1	1.1	1.1	2a.1	+	1.1	1.1	3.3	2b.3	1.2	1.2	1.1	1.1	1.1	1.1	1.1	2b.2	1.1	2a.1	2b.1	2a.1	21
Aira elegantissima Schur subsp. elegantissima	.	+	.	.	2a.1	.	.	.	.	.	.	.	.	1.1	+	1.1	.	.	1.1	.	.	6
Linum strictum L. subsp. strictum	.	+	.	1.1	+	.	.	.	.	.	.	+	.	.	.	.	2a.1	.	.	.	1.1	6
Ornithopus compressus L.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	4
Euphorbia exigua L.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Hypericum humifusum L.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1
Other species																						
Leontodon hispidus L.	+	r	+	.	+	.	.	.	1.1	.	+	.	.	1.1	+	1.1	+	2a.2	+	2a.2	2a.2	14
Cerastium glomeratum Thuill.	+	.	+	+	.	.	.	2m	2a.1	1.1	+	.	+	+	r	+	.	r	.	.	r	13
Anthoxanthum odoratum L.	.	.	.	+	.	.	.	+	1.2	+	1.3	1.1	+	.	.	1.1	1.1	+.2	+	r	+	13
Hieracium piloselloides Vill.	.	.	1.1	1.1	+	+	1.1	+.2	.	+.2	.	.	.	+	+	+	.	.	.	.	.	10
Carex caryophyllea Latourr.	.	.	.	+	1.1	2b.3	1.1	.	.	1.1	1.1	.	r	.	.	.	1.1	.	.	.	.	8
Oenanthe pimpinelloides L.	.	.	.	.	.	.	.	.	+	r	1.1	+	+	+	+	2a.2	.	.	.	.	.	8
Myosotis laxa Lehm. subsp. cespitosa (Schultz) Hyl. ex Nordh.	.	.	+.2	.	.	.	.	.	1.1	r	.	.	.	.	.	.	1.1	r	.	+	1.1	7
Hypochaeris radicata L.	1.1	+	.	2a.1	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	5
Myosotis ramosissima Rochel ex Schult.	.	.	r	+	.	.	.	1.1	.	+	1.1	.	.	.	.	.	.	.	.	.	.	5
Juncus effusus L.	.	.	r	.	.	.	.	.	.	r	.	.	1.1	.	r	.	.	.	.	.	r	5
Anagallis minima (L.) E.H.L. Krause	.	.	+.2	.	.	.	.	.	.	.	.	1.1	.	.	+	.	.	.	2m.1	1.1	.	5
Briza minor L.	.	.	.	.	1.1	.	.	.	.	.	.	.	+	.	.	.	.	.	1.1	2a.2	2a.1	5
Vicia tetrasperma (L.) Schreb.	.	.	.	.	.	.	.	+	+	+	+	+	.	.	.	.	.	.	.	.	.	5
Cerastium brachypetalum Desp. ex Pers.	.	+	.	.	+	.	2a.1	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	4
Anagallis arvensis L.	+	.	.	.	.	1.1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
Sedum sexangulare L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+.2	.	.	.	3
Plantago lanceolata L.	.	r	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	3
Holcus mollis L. subsp. mollis	.	.	.	.	.	.	.	.	+	r	.	.	.	.	.	.	.	.	.	r	.	3
Melittis melissophyllum L.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	.	.	+	3
Medicago minima (L.) L.	.	.	+	.	.	.	.	.	.	1.2	.	.	.	.	.	.	.	.	.	.	.	2
Serapias parviflora Parl.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Genista tinctoria L.	.	.	.	.	.	.	r	.	.	r	.	.	.	.	.	.	.	.	.	.	.	2
Geranium dissectum L.	.	.	.	.	.	.	.	.	1.1	.	+	.	.	.	.	.	.	.	.	.	.	2
Sherardia arvensis L.	.	.	.	.	.	.	.	.	.	+	.	r	.	.	.	.	.	.	.	.	.	2
Carex flacca Schreb. subsp. flacca	.	.	.	.	.	.	.	.	.	.	.	2b.2	2a.2	.	.	.	.	.	.	.	.	2
Calluna vulgaris (L.) Hull	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	.	.	.	.	2
Agrostis capillaris L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	1.1	2
Sporadic species	0	0	1	0	1	1	1	0	2	2	1	2	1	1	0	0	0	0	2	0	0	

Brullo & Minissale (1998); for this reason we acknowledge the association *Serapio-Isoëtetum histricis* as a valid syntaxon. It is included in the alliance *Isoëtion* Br.-Bl. 1936.

Floristic characterization: *Serapias lingua* and *S. cordigera* are diagnostic species indicated by Pedrotti (1982). *Ranunculus paludosus* plays a differential role; it was also present in the majority of the original relevés in Pedrotti (1982), including the holotypus. The presence of thermo-xerophylous annuals is prominent; they are mostly transgressive species from *Tuberarietea guttatae* (Br.-Bl. in Br.-Bl., Roussine & Nègre 1952) Rivas Goday & Rivas-Martínez 1963 nom. mut. propos. Rivas-Martínez, Diaz, Fernández-González, Izco, Loidi, Lousa & Penas 2002. For the new subassociation here proposed, *Lotus angustissimus, Filago gallica* and *Galium parisiense* are differential species; they are not present in the original diagnosis of the association, apart from *Lotus angustissimus* which appears in one relevé only (Pedrotti, 1982).

Cluster 2 - *JUNCO TENAGEIAE-SOLENOPSIETUM LAURENTIAE* ass. nova hoc loco (Tab. 3), holotypus: Rel. 28, Tab. 3

Synecology: the annual phytocoenoses dominated by *Solenopsis laurentia*, a critically endangered (CR) species according to Conti *et al*. (1997), colonize the edges of the ponds with water depth between 2 and 20 cm (B-type). They form a sort of dense crown along the pond border, that gets larger as the water level gets lower. *S. laurentia* is also present (but never dominant) on the bottom of the ponds, where the argillaceous soil keeps drenched for a longer period and allows the development of *Juncus pygmaeus* dominated communities, described later. *S. laurentia* seems to find its optimum on the edges of the ponds and is almost totally absent on the waterlogged soils where *Isoëtes histrix* is dominant. *Junco-Solenopsietum* is an ephemeral, small-sized plant community, about 6-8 cm tall, with a fast development limited to a short period around the half/end of May. In this plant community, the recorded average species number is 16.6 and the average cover is around 45% (Fig. 2). The plot size is 2.3 m^2 on average. According to the measured pH values, this community prefers the most acidic waters in the surveyed wet system (Tab. 1).

Syntaxonomy: the analysed vegetation shows some similarity with the association *Laurentio michelii-Isolepidetum cernuae* Géhu, Kaabache & Gharzuoli 1994. In Mediterranean Italy, this association has been detected in Sardinia (Biondi & Bagella, 2005) and Elba Island (Carta, 2008). However, in its original description the important differential species *Bellis prostrata* is present, which does not occur in Italy. The North African *Bellis repens* auct. (reported in Géhu *et al*., 1994) has in fact been renamed *B. prostrata*, according to Ali (2010); this endemic is a good differential species for the N-African association. Also *Isoëtes velata*, present in the original description of *Laurentio-Isolepidetum* (Géhu *et al*., 1994), is completely missing in the observed community.

Brullo & Minissale (1998) described an association called *Kickxio cyrrhosae-Solenopsietum laurentiae*, based on relevés from Rivas Goday (1968, 1971) and Brullo *et al*. (1994), whose distribution area includes Sicily and Sardinia. The Authors indicate a synonymy with *Laurentio-Juncetum tingitani* Rivas Goday & Borja in Rivas Goday 1968 which should be an invalid name according to Art. 2b (Brullo & Minissale,

Tab. 3 - *Junco tenageiae-Solenopsietum laurentiae* ass. nova

Number (dendrogram)	22	23	24	25	26	27	28*	29	30	31	
Original number (VEGVEN#)	40	63	64	46	42	55	56	49	51	50	
Number of species per relevé	20	17	17	14	13	22	21	13	13	16	
Cover (%)	30	30	50	35	30	40	70	60	60	50	
Area (m2)	1	1.5	2	0.5	0.5	2	4	0.5	0.5	0.7	Presences
Differential and characteristic species											
Solenopsis laurentia (L.) C. Presl	+	3.3	3.3	2b.2	2a.3	3.3	4.4	3.3	4.4	3.3	10
Juncus tenageja Ehrh. ex L. fil.	+	1.1	1.2	1.1	1.1	.	2a.1	+	+	+	9
Serapias parviflora Parl.	+	+	+	.	+	+	+	.	.	.	6
Centaurium maritimum (L.) Fritsch	.	.	.	+	.	+	+	+	+	1.1	6
Linum strictum L. subsp. strictum	.	+	+	.	.	+	+	.	.	1.1	5
Euphorbia exigua L.	.	+	+	.	.	1.1	.	1.1	1.1	.	5
Cicendio-Solenopsion, Isoëtetalia, Isoëto-Nanojuncetea											
Isoëtes histrix Bory	2b.2	2a.1	2a.1	1.1	2a.2	2a.2	2a.2	2a.1	3.3	2a.1	10
Juncus bufonius L.	1.1	+	+	1.1	1.1	1.1	3.3	+	+	+	10
Cicendia filiformis (L.) Delarbre	+	1.1	.	+	.	1.1	1.1	r	+	+	8
Juncus capitatus Weigel	1.2	1.1	1.2	+	1.1	+.2	1.1	.	.	.	7
Juncus pygmaeus Rich. ex Thuill.	.	.	.	.	2b.3	2a.2	.	1.1	2a.3	1.1	5
Kickxia commutata (Bernh. ex Rchb.) Fritsch	1.1	.	+	+	.	.	.	.	.	.	3
Lotus angustissimus L.	.	.	+	.	.	1.1	+	.	.	.	3
Isolepis cernua (Vahl) Roem. et Schult.	.	.	.	2b.2	1.1	.	+.2	.	.	.	3
Radiola linoides Roth	.	.	.	.	.	+.2	2a.1	.	.	+.3	3
Anagallis arvensis L. subsp. parviflora	+	.	.	.	.	.	.	.	1.1	.	2
Serapias cordigera L.	.	.	.	+	.	.	.	.	.	1.1	2
Anagallis minima (L.) E.H.L. Krause	.	.	.	.	+	.	.	.	.	1.1	2
Ranunculus paludosus Poir.	.	1.1	.	.	.	.	.	.	.	.	1
Hypericum humifusum L.	.	.	.	+	.	.	.	.	.	.	1
Helianthemetea guttati											
Briza maxima L.	2m.1	1.1	2a.1	+	1.1	2a.1	1.1	2a.1	2a.1	1.1	10
Galium parisiense L.	+	.	.	.	.	+	+	.	.	.	3
Aira elegantissima Schur subsp. elegantissima	.	.	.	.	.	+	+	.	.	.	2
Other species											
Leontodon hispidus L.	1.1	1.1	1.1	2a.1	1.1	.	+	.	1.1	+	8
Agrostis capillaris L.	+.1	1.1	2a.1	.	.	.	.	+	.	+	5
Serapias lingua L.	+	+.2	+.2	.	.	.	+	.	.	.	4
Hypochaeris radicata L.	+	+	+	.	.	+	.	.	.	.	4
Linum bienne Mill.	1.1	+	.	.	+	+	.	.	.	.	4
Briza minor L.	.	.	1.2	.	2a.2	+.2	1.1	.	.	.	4
Leontodon cichoriaceus (Ten.) Sanguin.	.	.	.	.	.	+	+	.	+	.	3
Danthonia decumbens (L.) DC.	+.2	.	.	+	.	.	.	.	.	.	2
Carex caryophyllea Latourr.	.	.	1.1	.	.	.	.	+.2	.	.	2
Parentucellia viscosa (L.) Caruel	.	.	.	.	.	+	+	.	.	.	2
Carex flacca Schreb. subsp. flacca	.	.	.	.	.	.	.	.	1.1	1.1	2
Anagallis foemina Mill.	.	.	.	.	.	.	.	+	.	+	2
Sporadic species	3	1	0	0	0	2	1	1	0	0	

1998). Later, however, both Galán de Mera (in Pérez Latorre *et al*., 1999) and Rivas-Martínez *et al*. (2001) acknowledged the old association and reformulated its name as *Solenopsio laurentiae-Juncetum tingitani* Rivas Goday & Borja in Rivas Goday 1968 nom. mut. propos. according to Art. 45 of the ICPN (Weber *et al*., 2000). Later, the plant communities with *Solenopsis laurentia* have been analysed by Silva *et al*. (2008), who proposed a syntaxonomic revision based on unpublished and published relevés, the latter deriving from Braun-Blanquet (1936), Rivas-Goday (1971), Melendo & Cano (1997), Pérez Latorre *et al*. (1999). On the ground of this analysis, three associations with *Solenopsis laurentia* are recognized for the Iberian Peninsula, Portugal e N-Africa: the Thermomediterranean *Solenopsio laurentiae-Phymatoceretum bulbiculosi* Br.-Bl. 1936 ex V. Silva, Galán de Mera & Sérgio 2008, the already mentioned Thermomediterranean *Solenopsio laurentiae-Juncetum tingitani* and the Mesomediterranean *Solenopsio laurentiae-Juncetum pygmaei* V. Silva & Galán de Mera in V. Silva, Galán de Mera & Sérgio 2008 (treated later in this paper). Due to bioclimatic and structural reasons, all the above-mentioned associations are different from the here reported plant community, as explained in the following paragraph. For these reasons we propose a new association called *Junco tenageiae-Solenopsietum laurentiae*. As concerns the higher syntaxonomic arrangement, we refer the new association to the alliance *Cicendio-Solenopsion* Brullo & Minissale 1998, a Mediterranean syntaxon described with the aim to group separately some communities formerly referred to *Cicendion* (Rivas Goday in Rivas Goday & Borja 1961) Br.-Bl. 1967, giving rise to a sort of 'Cicendion Auct. Mediterran.' (Deil, 2005; Bagella *et al*., 2007).

Floristic characterization: besides *Solenopsis laurentia*, which is generally present with rather high cover values, the described community is characterized by several little annual species such as *Centaurium maritimum, Juncus tenageia, Radiola linoides*. The rare orchid species *Serapias parviflora*, normally absent in *Serapio-Isoëtetum histricis*, shows a preference for this vegetation type. *Euphorbia exigua* and *Linum strictum* subsp. *strictum*, transgressive from *Tuberarietea guttatae*, play a differential role. The study area represents the most inland location in central Italy where the rare *Solenopsis laurentia* is present (Gigante *et al*., 2005). The similar associations *Solenopsio laurentiae-Juncetum tingitani* and *Kickxio cyrrhosae-Solenopsietum* are differentiated by W-Stenomediterranean species such as *Hypericum australe* and *Polypogon subspathaceus*, or Atlantic-Mediterranean such as *Isolepis pseudosetacea*, completely absent from the Central-Italian relevés. The Stenomediterranean species *Lotus parviflorus* and *Juncus tingitanus* are here replaced, respectively, by the Eurimediterranean *Lotus angustissimus* and the Paleotemperate *Juncus tenageia*, which can both be considered as biogeographic vicarious.

Cluster 3 - *HYPOCHAERIDO GLABRAE-CICENDIETUM FILIFORMIS* ass. nova hoc loco (Tab. 4), holotypus: Rel. 35, Tab. 4

Synecology: the ephemeral community dominated by the tiny *Cicendia filiformis* grows on the edge of the waterlogged soils and the very shallow ponds (A-type) in topographic contact with *Serapio-Isoëtetum histricis*. Its phenology is slightly delayed, since the dominant species appear in May and their life span is much shorter, when compared to the coenosis of Group 1. The presence of Mediterranean elements such as *Tuberaria guttata* and *Ornithopus compressus* suggests that the upper soil layer gets dry rather early, allowing the colonization by many elements of the class *Tuberarietea*. This vegetation type represents the expression of particular edaphic features influenced by remarkable dry summers. At the same time, the lack of peculiar biogeographic differential species is an indication that the study area represents a transition between Mediterranean and Temperate climatic Regions. The average species number is 19 and the average cover is around 55% (Fig. 2). The plot size is 1.3 m^2 on average.

Syntaxonomy: the new association is referred to the mediterranean alliance *Cicendio-Solenopsion* Brullo & Minissale 1998. With reference to *Cicendietum filiformis* Allorge ex Moor 1937 (= ass. à *Cicendia filiformis* et *Stereodon arcuatus* Allorge 1922), the relevés of Cluster 3 show more thermophylous features. *Cicendietum filiformis*, lacking in xero-thermophylous taxa, is indeed an Atlantic-Mediterranean vegetation type (Allorge, 1922), even recorded in Denmark (Laweson, 2004), Germany (Täuben & Petersen, 2000), the Netherland (Weeda *et al*., 2003; Jansen *et al*., 2008) and also reported in Northern Umbria temperate territories by Pedrotti *et al*. (1982). On the other side, as concerns other Mediterranean *Cicendia filiformis*-dominated associations [such as *Isoëto-Cicendietum filiformis* Br.-Bl. 1967, *Hyperico australis-Cicendietum filiformis* Rivas Goday 1971, *Ophioglosso lusitanici-Cicendietum filiformis* Rivas Goday 1956, *Hyperico humifusi-Cicendietum filiformis* Rivas Goday (1964) 1970], they do not fit to the floristic composition of the observed phytocoenosis, the latter lacking in a number of thermomediterranean and endemic taxa.

Floristic characterization: the species *Ornithopus compressus, Tuberaria guttata, Hypochoeris glabra* play a differential role with reference to similar communities dominated by *Cicendia filiformis*. *Hypochaeris glabra*, reported for the study area only in the last decade (Ballelli, 2003), is a quite rare taxon in central Italy, strictly related to acidic substrata.

Tab. 4 - *Hypochaerido glabrae-Cicendietum filiformis* ass. nova

Number (dendrogram)	32	33	34	35*	
Original number (VEGVEN#)	13	14	222	223	
Number of species per relevé	17	20	19	20	
Cover (%)	40	30	70	80	Presences
Area (m2)	2	1	1	1	
Differential and characteristic species					
Cicendia filiformis (L.) Delarbre	2m.1	2m.1	2m.1	2b.1	4
Ornithopus compressus L.	1.1	1.1	1.1	1.1	4
Aira elegantissima Schur subsp. elegantissima	2m.1	1.1	2a.1	2m.1	4
Hypochaeris glabra L.	2a.2	.	1.1	+	3
Cicendio-Solenopsion, Isoëtetalia, Isoëto-Nanojuncetea					
Juncus capitatus Weigel	1.1	+	1.1	+	4
Lotus angustissimus L.	+	1.1	.	+	3
Anagallis minima (L.) E.H.L. Krause	.	.	2a.1	+	2
Ranunculus sardous Crantz	.	+	.	.	1
Serapias cordigera L.	.	r	.	.	1
Centaurium maritimum (L.) Fritsch	.	.	+	.	1
Isoëtes histrix Bory	.	.	+	.	1
Radiola linoides Roth	.	.	.	+	1
Helianthemetea guttati					
Tuberaria guttata (L.) Fourr.	1.1	2a.1	+	1.2	4
Vulpia myuros (L.) C.C. Gmel.	.	2m.1	+	2b.2	3
Trifolium striatum L.	2b.3	1.1	.	.	2
Filago gallica L.	+	+	.	.	2
Linum strictum L. subsp. strictum	+	+	.	.	2
Hippocrepis biflora Spreng.	.	.	+	1.1	2
Briza maxima L.			1.1		1
Other species					
Anthoxanthum odoratum L.	+	+	1.1	.	3
Hypochaeris radicata L.	.	1.1	2b.1	+	3
Cerastium glomeratum Thuill.	1.1	+.2	.	.	2
Leontodon hispidus L.	+	+	.	.	2
Sagina apetala Ard.	+	+	.	.	2
Myosotis ramosissima Rochel ex Schult.	.	+	.	1.1	2
Serapias lingua L.	.	.	2b.1	+	2
Cerastium sp.	.	.	1.1	2a.1	2
Parentucellia viscosa (L.) Caruel	.	.	+	+	2
Plantago lanceolata L.	.	.	+	+	2
Sporadic species	3	2	1	3	

Cluster 4 - *SOLENOPSIO LAURENTIAE-JUNCETUM PYGMAEI* V. Silva & Galán de Mera in V. Silva, Galán de Mera & Sérgio 2008 (Tab. 5) *JUNCETOSUM PYGMAEI*, holotypus: Rel. AA1 p. 269 in Silva *et al*. (2008) *ISOLEPIDETOSUM CERNUAE* subass. nova hoc loco, holotypus: Rel. 38, Tab. 5

Synecology: the dwarf phytocoenosis dominated by *Juncus pygmaeus* colonizes the bottom of the flat ponds (B-type) covered by shallow waters whose depth generally does not exceed 20 cm. The sediment is rich in clay and keeps wet for a longer period than the edges of the pond. The community starts to develop at the half of May and reaches its maximum at the start of June. At the end of June, the argillaceous substratum gets totally dry and does not allow the development of perennial hygrophylous communities. The average species number is 8.5 and the average cover is around 41% (Fig. 2). The plot size is 1 m^2 on average.

Syntaxonomy: in the already mentioned syntaxonomic revision proposed by Silva *et al*. (2008) an association is described which seems suitable to represent the Central-Italian *Juncus pygmaeus*-dominated communities: *Solenopsio laurentiae-Juncetum pygmaei* V. Silva & Galán de Mera in V. Silva, Galán de Mera & Sérgio 2008. The association arises from a suggestion of Rivas-Goday (1971), who observed a vegetation type dominated by *Solenopsia laurentia* and *Juncus pygmaus* but treated it as a fragment of *Laurentio-Juncetum* (= *Solenopsio-Juncetum tingitani*), without any further description of new syntaxa. There are several similarity, from a floristic, ecologic and bioclimatic point of view, with the here analysed vegetation. According to Silva *et al*. (2008) *Solenopsio-Juncetum pygmaei* is developed on clayey-slimy soils, in Mesomediterranean climatic context. The association is present in Spain (Extremadura) and Portugal. The Authors included it into the alliance *Isoëtion*; however, on the ground of its floristic and structural features, we believe that a more suitable placement is into the Mediterranean alliance *Cicendio-Solenopsion* Brullo & Minissale 1998.

Floristic characterization: from a floristic point of view it's a rather poor association, compared with the others included in the same class. *Juncus pygmaeus,* strongly dominant, creates a dense dwarf layer. The annual xerophytes from the *Tuberarietea guttatae* class are almost totally absent in relation with the wetter condition of the soil. According to Silva *et al*. (2008), *Solenopsio-Juncetum pygmaei* is dominated by S*olenopsis laurentia, Juncus pygmaeus, Juncus tenageia, Lythrum borysthenicum;* these Authors emphasize the constant presence of *Lythrum borysthenicum* as a peculiar trait of this community, although the species is only present in 2 relevés from 8 (Tab. 3 in Silva *et al*., 2008). This species is absent from the Central-Italian phytocoenosis, but apart from that there is a remarka-

Tab. 5 - *Solenopsio laurentiae-Juncetum pygmaei* V. Silva & Galán de Mera in V. Silva, Galán de Mera & Sérgio 2008 *isolepidetosum cernuae* subass. nova

Number (dendrogram)	36	37	38*	39	40	41	42	43	
Original number (VEGVEN#)	43	45	44	47	253	255	48	53	
Number of species per relevé	11	9	11	7	11	6	6	7	
Cover (%)	70	50	60	25	25	35	25	35	
Area (m2)	1	0.5	1.5	0.3	0.8	0.3	0.3	1	Presences
Differential and characteristic species									
Juncus pygmaeus Rich. ex Thuill.	4.4	3.3	3.3	2a.2	2b.2	3.3	2b.3	3.3	8
Solenopsis laurentia (L.) C. Presl	+	1.1	2a.2	1.1	1.1	1.1	2a.2	+	8
Juncus tenageja Ehrh. ex L. fil.	.	+	+	.	.	.	1.1	2a.1	4
Diff. subass. *isolepidetosum cernuae*									
Isolepis cernua (Vahl) Roem. et Schult.	+	1.1	1.1	2a.1	2b.2	2a.1	.	.	6
Cicendio-Solenopsion, Isoëtetalia, Isoëto-Nanojuncetea									
Isoëtes histrix Bory	+	+.1	1.1	1.1	1.1	.	.	.	5
Juncus bufonius L.	+	+	+	.	.	.	2a.1	1.1	5
Cicendia filiformis (L.) Delarbre	.	.	+	.	+	+	+	+	5
Alisma lanceolatum With.	+	.	+	1.1	.	.	.	.	3
Juncus capitatus Weigel	.	.	+	.	.	.	.	+.2	2
Centaurium maritimum (L.) Fritsch	+	.	.	.	.	.	.	.	1
Radiola linoides Roth	.	.	.	.	+	.	.	.	1
Lythrum junceum Banks et Sol.	.	.	.	.	.	.	.	1.3	1
Other species									
Leontodon hispidus L.	1.1	1.1	+	+	+	+	.	.	6
Juncus articulatus L.	1.3	1.2	.	.	.	.	.	.	2
Agrostis capillaris L.	.	+	.	+	.	.	.	.	2
Agrostis stolonifera L.	.	.	.	.	+	.	.	.	1
Sporadic species	2	0	1	0	3	1	1	0	

ble floristic and ecological resemblance between the observed vegetation and S*olenopsio-Juncetum pygmaei*.

Compared to the similar association *Cicendio-Juncetum pygmaei* Rivas-Goday 1956, our plant community lacks in many differential species such as *Antinoria agrostidea, Eryngium corniculatum, E. galioides, Pulicaria paludosa*, Stenomediterranean or endemic (Hiberian) species; analogous remarks can be given with reference to *Laurentio michelii-Isolepidetum cernuae* Géhu *et al*. 1994, where *Juncus pygmaus* is completely absent.

On the basis of the peculiar floristic composition, we point out a subgroup of relevés differentiated by *Isolepis cernua*, a species which is not present in the original description of *Solenopsio-Juncetum pygmaei;* we propose to use it to differentiate the new subassociation *isolepidetosum cernuae*.

Cluster 5 - *ALISMO LANCEOLATAE-GRATIOLETUM OFFICINALIS* Biondi & Bagella 2005 (Tab. 6) *ALISMETOSUM LANCEOLATAE*, holotypus: Rel. 3, Tab. 24 in Biondi & Bagella (2005) *JUNCETOSUM CONGLOMERATI* subass. nova hoc loco, holotypus: Rel. 4, Tab. 6

Synecology: *Gratiola officinalis* is a typical colonizer of areas where spring floods keep the soil wet for a rather long period, but where a locally dry climatic condition in summer dries up the ground, even in continental areas (Botta-Dukát *et al*., 2005). In the study area, a community with *Gratiola officinalis* was already noticed by Pedrotti (1982), who reported about its presence in 20-40 cm deep depressions. Indeed, we observed this community only in C- and D-type ponds. The average species number is 11 and the cover values range around 71% (Fig. 2). The plot size is 7.7 m^2 on average.

Syntaxonomy: *Gratiola officinalis* can be present as a companion in different vegetation types, from *Preslion cervinae* Br.-Bl. ex Moor 1937 to *Glycerio-Sparganion* Br.-Bl. & Sissingh in Boer 1942. Not many vegetation units have been described with reference to *Gratiola officinalis*-dominated vegetation. In continental Europe, the association *Lathyro palustris-Gratioletum* Balátová-Tuláčková 1966 (all. *Deschampsion cespitosae* Horvatić 1930) has been reported (Botta-Dukát *et al*., 2005). For the Hungarian territory the association *Ranunculo flammulae-Gratioletum* Borhidi & Juhász 1985 has been described and referred to *Eleocharition acicularis* Pietsch 1966 em. Dierss. 1975 (Borhidi & Juhász, 1985). For the Italian territory, the association *Alismo lanceolatae-Gratioletum officinalis* has been described at Caprera Island in La Maddalena Archipelago (Sardinia) and referred to *Nasturtio-Glycerietalia* order (Biondi & Bagella, 2005). It is a species-poor community (the reported average species number per relevé is 4); the characteristic specific complex includes *Baldellia ranunculoides* and *Alisma lanceolatum* (Biondi & Bagella, 2005). In spite of the lack of these two taxa, a certain ecological and floristic resemblance can be found with reference to *Alismo-Gratioletum;* this association seems indeed the most suitable to interpret the analysed community and there are no elements at the moment to describe a new association.

Floristic characterization: the reported relevés show a remarkable poverty in the left-hand part of Tab. 6, while relevés from 4 to 7 are differentiated by a number of contact species from mesic and ephemeral wet habitats. The presence, sometimes abundant, of *Juncus conglomeratus* together with *Oenanthe pimpinelloides* can play a differential role, probably indicating a trampled condition in the substratum. The first species is an Eurosibirian, not so common in Mediterranean Italy; it generally occurs in wet pastures and bogs, almost exclusively on acidic soils, rather tolerant to dry conditions (Richards & Clapham, 1941). The second is an Eurimediterranean frequently growing on acidic soils; it can stand from dry to damp habitats. We propose these two taxa as differential species for the new subassociation j*uncetosum conglomerati*, which represents a drier aspect of *Alismo-Gratioletum*, related to a lower clay content in the bottom sediment, causing a shorter water retention and an earlier desiccation.

Cluster 6 - *TRIFOLIO FRAGIFERI-RANUNCULETUM OPHIOGLOSSIPHOLII* Biondi, Casavecchia & Radetic 2002 (Tab. 7), holotypus: Rel. 2, Tab. 11 in Biondi *et al*. (2002)

Synecology: Tab. 7 includes relevés referred to *Ranunculus ophioglossifolius* and *Juncus effusus*-dominated stands. The average species number is 7.1 and

Tab. 6 - *Alismo lanceolatae-Gratioletum officinalis* Biondi & Bagella 2005 *juncetosum conglomerati* subass. nova

Number (dendrogram)	1	2	3	4*	5	6	7	
Original number (VEGVEN#)	19	241	20	61	59	65	249	
Number of species per relevé	4	5	8	14	15	16	15	
Cover (%)	60	60	60	90	85	85	60	
Area (m2)	4	1	6	16	6	16	5	Presences
Differential and characteristic species								
Gratiola officinalis L.	3.2	4.4	3.2	5.5	+.2	5.5	1.3	7
Oenanthe pimpinelloides L.	.	.	+	+	1.1	1.2	+	5
Juncus conglomeratus L.	.	.	.	1.2	4.4	1.1	3.3	4
Phragmito-Magnocaricetea								
Juncus effusus L.	.	+	2b.2	.	.	.	2a.2	3
Other species								
Agrostis stolonifera L.	1.1	+	2b.3	+	.	.	+	5
Juncus articulatus L.	r	.	2a.2	1.1	.	.	.	3
Isoëtes histrix Bory	+	.	+	.	.	+	.	3
Ranunculus ophioglossifolius Vill.	.	+	.	2b.3	.	.	1.1	3
Anthoxanthum odoratum L.	.	.	+	.	2a.2	+	.	3
Myosotis laxa Lehm. subsp. cespitosa	.	.	.	.	+	+	1.1	3
Ranunculus sardous Crantz	.	.	+	.	+	.	.	2
Galium palustre L.	.	.	.	2b.1	+	.	.	2
Juncus bufonius L.	.	.	.	+	.	+	.	2
Agrostis capillaris L.	.	.	.	.	2b.3	2a.1	.	2
Danthonia decumbens (L.) DC.	.	.	.	.	+.2	+	.	2
Carex flacca Schreb. subsp. flacca	.	.	.	.	.	1.1	1.1	2
Sporadic species	0	1	0	6	6	6	7	

the cover values range around 55% (Fig. 2). The plot size is 8.5 m^2 on average. This vegetation type colonizes deep ponds (D- and C-type), on clayey soils with almost no sandy component. The occurrence of *Eleocharis palustris* also testifies for a hygrophilous ecology, depending on a prolonged period of submersion. As concerns the abundant presence of *Juncus effusus*, this species has a wide ecological range, colonizing different environments, from edges of ponds and ditches to eutrophicated marshes, from road margins to bogs and wet meadows. Just because of its wide ecological amplitude, it has only seldom been referred to specific syntaxa (Venanzoni & Gigante, 2000).

Syntaxonomy: a certain similarities can be pointed out with the association *Trifolio fragiferi-Ranunculetum opioglossipholii*, described by Biondi *et al*. (2002) for temporary wetlands in Marche region. This syntaxon refers to a permanently wet phytocoenosis differentiated by *Trifolium fragiferum* and *Eleocharis palustris* as sub-dominant species. Although the Authors refer this association to the alliance *Oenanthion fistulosae* (De Foucault 1984) Julve 1989 (class *Molinio-Arrhenatheretea*), we believe it might find a better arrangement in the alliance *Ranunculo ophioglossifolii-Oenanthion fistulosae* De Foucault 2012 (class *Agrostietea stoloniferae* Oberdorfer 1983), which refers to Atlantic-Mediterranean vegetation developed on flooded habitats on mineralized soils (Biondi & Blasi, 2013). The presence of differential species from *Phragmito-Magnocaricetea* is remarkable, certainly due to the prolonged permanence of the water.

Floristic characterization: besides the dominant species, *Glyceria fluitans* and *Galium debile* are also frequent, indicating again a catenal connection to the permanently wet vegetation of the class *Phragmito-Magnocaricetea*. At the same time, the differential species *Trifolium fragiferum* has never been observed. The low average number of species per relevé indicates a poor floristic composition, probably linked to the prolonged permanence of the water.

Cluster 7 - *CALLITRICHO BRUTIAE-RANUNCULETUM OPHIOGLOSSIFOLII* ass. nova hoc loco (Tab. 8), holotypus: Rel. 25, Tab. 8, *RANUNCULETOSUM OPHIOGLOSSIPHOLII* subass. nova hoc loco, holotypus Rel. 25, Tab. 8, *GLYCERIETOSUM FLUITANTIS* subass. nova hoc loco, holotypus Rel. 17, Tab. 8

Synecology: the phytocoenosis dominated by *Ranunculus ophioglossipholius* with *Callitriche brutia* can be found on clay-rich substrata, where waters can be retained till the very start of june, in deep ponds (mainly C-type). The average species number is 7.5 and the average cover is around 64% (Fig. 2). The plot size is 6.2 m^2 on average. This type of vegetation is sometimes localized also in disturbed areas, along small unpaved roads rarely crossed by cars. The subassociation with *Glyceria fluitans*, sometimes co-dominant, develops in the center of deeper ponds affected by a longer submersion period (D-type) and occupies a transitional habitat between temporary and permanent flooding. The co-occurence of the two species is rather peculiar, considering that *G. fluitans* is known for neutral-basic waters (Dawson & Szoszkiewicz, 1999). Indeed, as concerns the pH values, this plant communities shows the highest values (6.9 on average, Tab 1) among the monitored vegetation types. With reference to *Trifolio-Ranunculetum* (Tab. 7), *Callitricho-Ranunculetum* shows higher cover values, species number and species density (Fig. 2), confirming that the former one represents probably a stage linked to the presence of deeper waters.

Tab. 7 - *Trifolio fragiferi-Ranunculetum ophioglossipholii* Biondi, Casavecchia & Radetic 2002

Number (dendrogram)	8	9	10	11	12	13	14	
Original number (VEGVEN#)	22	23	24	236	224	246	233	
Number of species per relevé	7	11	6	7	6	10	3	Presences
Cover (%)	95	60	60	50	45	40	40	
Area (m2)	5	25	4	6	0.5	2	9	
Differential and characteristic species								
Ranunculus ophioglossifolius Vill.	1.1	3.3	2b.2	2a.2	2b.3	3.3	1.1	7
Juncus effusus L.	1.1	2a.2	2b.3	2b.2	2b.3	2b.3	3.3	7
Eleocharis palustris (L.) Roem. et Schult.	5.5	+.2	2b.3	+.2	.	.	.	4
Agrostietea stoloniferae								
Agrostis stolonifera L.	1.2	2b.3	.	.	.	.	.	2
Rumex conglomeratus Murray	.	+.2	.	.	+	.	.	2
Anthoxanthum odoratum L.	.	+	.	.	.	.	2a.2	2
Poa trivialis L.	.	.	.	1.1	.	+	.	2
Phragmito-Magnocaricetea								
Galium debile Desv.	2a.2	1.1	.	1.1	+	1.1	.	5
Myosotis laxa Lehm. subsp. cespitosa	.	+	+	.	.	+.2	.	3
Glyceria fluitans (L.) R. Br.	.	1.2	3.3	3.3	.	.	.	3
Sporadic species	2	2	1	1	2	5	0	

Syntaxonomy: *Ranunculus ophioglossipholius* has often been considered as belonging to *Isoëto-Juncetea* class (Biondi & Bagella, 2005; Bagella *et al*., 2009). It has been indicated as a differential taxon for the association *Apio crassipedis-Isoëtetum tigulianae* Biondi & Bagella 2005 (Bagella *et al*. 2009). The association *Veronico beccabungae-Ranunculetum ophioglossifolii* has been described by Brullo *et al*. (2001) for the Aspromonte territory in S-Italy, and included in *Montio-Cardaminetea* Br.-Bl. & Tüxen ex Br.-Bl. 1948. It is indeed a vegetation type developed in running waters in the Supratemperate belt, so ecologically distant from the here reported plant community. However, remarkable similarities can be observed between the studied wet system and the microgeosigmetum described for Aspromonte, since both have in close topographic contact two vegetation types dominated, respectively, by *Ranunculus ophioglossipholius* and *Juncus bulbosus* (Brullo *et al*., 2001). The same Authors also described the association *Ranunculo ophioglossifolii-Callitrichetum stagnalis*, included in the alliance *Ranunculion aquatilis* Passarge 1964, which refers to a real aquatic community and develops in depressions

where water remains for a large part of the year (Brullo *et al*., 2001). In Corsica, several vegetation types dominated by *Ranunculus ophioglossipholius* have been described and referred to various sintaxonomic frames: from *Littorellion uniflorae* Koch 1926 to *Ranunculion aquatilis* Passarge 1964 and *Glycerio-Sparganion* Br.-Bl. & Sissingh in Boer 1942, however none of them has been formalized at the association level (Paradis *et al*., 2009).

As concerns *Callitriche brutia,* the association *Isoëto tigulianae-Callitrichetum brutiae* was described for Sardinia, differentiated by *Isoetes tiguliana* and *Apium crassipes* (Bagella *et al*., 2009), while Brullo & Minissale (1998) described *Ranunculo-Callitrichetum brutiae* with a Subatlantic, W-Mediterranean-Montane and Stenomediterranean biogeographic character given by the species *Crassula vaillantii, Ranunculus trilobus, Polypogon subspathaceum*. The last two vegetation types are included in the alliance *Preslion cervinae*, however there is no similarity with the surveyed vegetation.

On the ground both of the dominant species and the general floristic composition, together with its structure and ecology, we think that the new association should be ascribed to the alliance *Ranunculo ophioglossifolii-Oenanthion fistulosae*.

Floristic characterization: the analysed community is differentiated by the co-occurence of *Ranunculus ophioglossifolius, Callitriche brutia* and *Lythrum portula*. Both *Ranunculus ophioglossifolius* and *Callitriche brutia* are rather localized species in Italy: the first one is an Eurimediterranean therophite, present in all the Italian Peninsula but often considered as "Vulnerable" or even "Endangered", according to the IUCN cathegories; the latter is a Subatlantic hydrophite and is considered as "Vulnerable" in several C-Italian Regions including Umbria (Conti *et al*., 1997). *Lythrum portula* is a S-European-S-Siberian species and well represents the different biogeographic-bioclimatic context of the study area, when compared to the frankly Mediterranean conditions detected for the mentioned similar vegetation types in Sardinia, Calabria and Corsica.

Cluster 8 - *CALLITRICHO BRUTIAE-JUNCETUM BULBOSI* ass. nova hoc loco (Tab. 9), Holotypus: Ril. 42, Tab. 9

Synecology: the observed vegetation dominated by *Juncus bulbosus* colonizes the ponds with steep borders and water depth included between 20 and 40 cm, whose flat bottom keeps wet till the start of June (C-type). Sometimes the bottom of the ponds is characterized by a peculiar shape where each tuft of *Juncus bulbosus* creates small bulges separated from each other by shallow depressions. This becomes evident in summer, when the dry tufts appear raised over the bottom level. *Juncus bulbosus* is described as a short-lived perennial species, often persisting in sites where

Tab. 8 - *Callitricho brutiae-Ranunculetum ophioglossifolii* ass. nova *ranunculetosum ophioglossipholii* subass. nova *glycerietosum fluitantis* subass. nova

Number (dendrogram)	23	24	25*	26	27	28	29	30	31	15	16	17*	18	19	20	21	22	
Original number (VEGVEN#)	225	226	227	851	858	861	865	252	256	62	250	232	235	852	853	859	860	
Number of species per relevé	11	7	12	2	4	4	9	7	5	7	9	13	13	7	7	6	4	
Cover (%)	50	60	70	65	90	35	65	65	85	70	60	60	90	70	70	80	60	Presences
Area (m2)	1.5	2.2	8	1.5	1	2.2	6	0.5	0.5	1	6	18	8	2	0.7	2.2	2.2	
Differential and characteristic species																		
Ranunculus ophioglossifolius Vill.	3.3	4.4	4.4	2a.2	2b.2	1.1	2b.3	4.4	5.5	2b.2	2a.1	4.4	1.3	2b.2	2b.2	2a.2	.	16
Callitriche brutia Petagna	1.2	1.2	3.3	4.4	4.4	3.3	4.5	+.2	.	+	.	+.2	+.2	3.3	3.3	4.4	2b.2	15
Lythrum portula (L.) D.A. Webb	1.1	2b.3	+	.	1.1	1.1	2a.3	.	.	.	.	.	+.3	.	.	.	.	7
glycerietosum fluitantis																		
Glyceria fluitans (L.) R. Br.	.	.	.	.	.	.	.	.	.	4.4	4.4	2b.1	5.5	3.3	3.3	1.1	2a.2	8
Juncus effusus L.	3.3	.	.	.	.	.	.	.	1.2	.	.	1.1	+.2	1.1	.	2a.2	.	5
Agrostietea stoloniferae																		
Rumex conglomeratus Murray	1.1	+	+	.	1.1	.	.	.	.	.	.	+	+	1.1	1.1	1.1	.	9
Agrostis stolonifera L.	1.1	2a.1	.	.	.	.	.	1.2	+.2	.	+	.	.	.	.	.	.	5
Ranunculus repens L.	1.1	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	3
Mentha longifolia (L.) Huds.	+.2	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Phragmito-Magnocaricetea																		
Alisma plantago-aquatica L.	.	1.1	1.1	.	.	1.1	.	1.1	2a.2	.	+	+	2a.1	1.1	.	1.1	3.3	11
Galium debile Desv.	1.1	.	.	.	.	.	+	.	.	.	+	2a.1	1.1	.	+	.	.	6
Gratiola officinalis L.	.	.	.	.	.	.	.	1.1	.	2a.1	2b.3	.	.	.	1.1	.	.	4
Eleocharis palustris (L.) Roem. et Schult.	.	.	.	.	.	.	.	.	.	+.2	+	+.2	.	.	.	.	.	3
Other species																		
Juncus articulatus L.	.	1.1	2a.1	.	.	.	.	.	.	1.3	.	2a.1	+	.	.	.	.	5
Callitriche palustris L.	.	.	.	.	.	.	.	.	.	.	.	.	1.3	2b.2	+	.	2b.2	4
Oenanthe pimpinelloides L.	+	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	3
Poa trivialis L.	.	.	1.1	.	.	.	1.3	.	.	.	.	.	2a.1	.	.	.	.	3
Poa annua L.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Anthoxanthum odoratum L.	.	.	.	.	.	.	+	.	.	.	.	+.2	.	.	.	.	.	2
Holcus lanatus L.	.	.	.	.	.	.	.	.	.	.	.	+.2	+.2	.	.	.	.	2
Sporadic species	1	0	2	0	0	0	2	2	1	1	2	1	0	0	0	0	0	

ephemeral species have disappeared (Brouwer at al., 2001). *Callitriche brutia i*s a tipically amphibious species and stands the first part of the dry period creeping directly on the ground and sinking inside the wet soil with its fruits. At the end of June this community is almost totally dry. The average species number is 5.9 and the average cover is around 64% (Fig. 2). The plot size is 4.7 m^2 on average. In the surveyed study area, the measured pH values ranged aroung 5.8 (Tab. 1). According to Dawson & Szoszkiewicz (1999), in Great Britain the most frequent pH value for *Juncus bulbosus*-dominated communities is indicated at 6.3, however *Juncus bulbosus* is documented to grow at pH 3 and below (Sand-Jensen & Rasmussen, 1978; Pietsch, 1998; Fyson, 2000).

Syntaxonomy: the species *Juncus bulbosus* has been indicated as typical or at least frequent in a number of vegetation classes, such as *Oxycocco-Sphagnetea* Br.-Bl. & Tüxen ex Westhoff, Dijk & Paschier 1946, *Scheuchzerio-Caricetae nigrae* nom. mut. propos. ex Steiner 1992, *Utricularietea intermedio-minoris* Pietsch ex Krausch 1968 and *Littorelletea* Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946 (Dawson & Szoszkiewicz, 1999). Perennial amphibian communities dominated by *Juncus bulbosus* and the Eurasiatic *Ranunculus flammula*, developed on flat surfaces emerged in summer, have been described as *Ranunculo flammulae-Juncetum bulbosi* Oberdorfer 1957, recorded in several W and C-European countries, e.g. France (Ninot *et al*., 2000), Slovakia (Hrivnák *et al*., 2011), Czech Republic (Šumberová, 2011), Poland (Szankowski & Kłosowski, 2006) and referred either to the alliance *Eleocharition acicularis* Pietsch 1967 or *Littorellion uniflorae* Koch 1926. *Anagallido tenellae-Juncetum bulbosi* Br.-Bl. 1967, included in the alliance *Anagallido tenellae-Juncion bulbosi* Br.-Bl. 1967 (class *Scheuchzerio-Caricetea fuscae* Tüxen 1937), has been reported for Spain and Portugal (Rivas-Martínez *et al*., 2001, 2002; Pereira & Silva Neto, 2008). At the same time, according to Brullo and Minissale (1998), *J. bulbosus* is also a very frequent species in some *Isoëto-Juncetea* vegetation types reported by Pietsch (1973), while the association *Ranunculo nodiflori-Juncetum bulbosi*, described by Gamisans (1976) for Corsica, is included in the class *Isoëto-Juncetea* (*Nanocyperion flavescentis* W. Koch ex Libbert 1932). Also according to Brouwer at al. (2001), *J. bulbosus* is a typical species from *Nanocyperion*.

In Italy, Brullo *et al*. (2001) described the association *Agrostio aspromontanae-Juncetum bulbosi*, endemic for the Supratemperate belt (above 1000 m a.s.l.) in the Aspromonte territory, with *Agrostis canina* ssp. *aspromontana* and *Juncus bulbosus* fo. *prolyfer*. It has been referred to *Dactylorhizo-Juncion striati* Brullo & Grillo 1978 (*Molinio-Arrhenatheretea*), a montane alliance according to Biondi & Blasi (2013).

On the ground of its floristic, biogeographical and ecological features, we propose that the observed *J. bulbosus*-dominated community is referred to a new association called *Callitricho brutiae-Juncetum bulbosi*. *Callitriche brutia* and *Ranunculus ophioglossipholius*, a Subatlantic and an Eurimediterranean species respectively, are here indicated as differential taxa compared to the above mentioned C- and W-European vegetation types. As concerns the upper syntaxonomic arrangement, similar types of plant communities have often been referred to the alliance *Eleocharition acicularis* Pietsch 1967, which represents the vegetation developed in continental fluctuating waters, on silty or silty-clayey soils, able to withstand flooding and drying alternations (Biondi & Blasi, 2013). It is included in the class *Littorelletea*, which groups the aquatic and amphibian perennial phytocoenoses developed on the shores of nutrient-poor standing to slow-flooding waters, generally linked to continental waters and montane habitats, but also present in coastal and subcoastal sites (Izco *et al*., 2000). According to Brullo *et al*. (2001), the class *Littorelletea* has a holoarctic distribution, mainly in Atlantic and Boreo-Atlantic Europe, although it can also occur in the Mediterranean area, where it has a role as glacial relict whose persistence is allowed by peculiar climatic-edaphic conditions. Furthermore, the Annex I Habitat 3110 ("Oligotrophic waters containing very few minerals of sandy plains - *Littorelletalia uniflorae*) has been recently recorded in Tuscany (Biondi *et al*., 2009), thus its presence also in the close Umbria is definitely likely. On this ground, the alliance *Eleocharition acicularis* seems at the moment the most suitable for the syntaxonomic arrangement of the new association.

Floristic characterization: *Juncus bulbosus* L., a species with European distribution, is only known for few Administrative Regions in peninsular Italy: Emilia Romagna, Tuscany, Umbria, Latium and Calabria; its presence is uncertain in Sardinia (Conti *et al*., 2005). In Umbria it was observed only in two locations: Ferretto and Colfiorito, although in the latter the species is not confirmed after 1950 (Ballelli, 2003). It's a rare entity in central Italy indeed, also in relation with its peculiar ecological needs which can actually be satisfied only in few areas. Its morphology is rather variable and two subspecies have been described: *J. bulbosus* ssp. *bulbosus* and ssp. *kochii* (F.W. Schultz) Reichg. Some Authors accepted these subspecies (Oberdorfer, 1994; Prockow, 2008), while other (e.g. Kirschener, 2002) regarded the latter simply as a synonym of *J. bulbosus*, suggesting to interpret the different morphological types inside the wide variability of the species, since the two entities are not geographycally isolated and the natural populations show a wide range of morphological characters (Prockow, 2008). In this paper, we opted for this interpretation, in accordance with Conti *et al*.

Tab. 9 - *Callitricho brutiae-Juncetum bulbosi* ass. nova

Number (dendrogram)	32	33	34	35	36	37	38	39	40	41	42*	43	44	45	46	47	48	49	50	51	52	
Original number (VEGVEN#)	52	240	855	242	244	257	254	57	243	247	60	862	856	237	238	854	863	239	251	248	857	
Number of species per relevé	5	7	4	5	4	4	7	6	8	8	9	5	5	4	4	3	3	7	8	8	9	
Cover (%)	40	70	50	30	90	85	70	70	65	50	80	70	60	80	70	35	40	85	65	70	65	
Area (m2)	1	16	0.5	0.5	1	0.3	1	7.5	9	3	4	1.5	1.5	4	1.5	0.5	1	1.5	4	8	2.2	
Differential and characteristic species																						
Juncus bulbosus L.	3.3	4.4	3.3	3.3	5.5	5.5	4.4	4.4	4.4	3.3	5.5	3.3	2b.2	5.5	4.4	3.3	3.3	4.4	4.4	2a.3	2a.2	21
Ranunculus ophioglossifolius Vill.	.	.	.	.	.	.	.	1.2	2a.2	2a.2	2a.3	1.1	3.3	2a.3	+	+	1.1	1.1	1.2	2a.2	2b.2	14
Callitriche brutia Petagna	.	+	1.2	.	.	.	.	+.2	1.3	+.2	2b.3	3.3	2a.2	1.2	+	1.2	1.1	2a.3	.	.	1.2	14
Gratiola officinalis variant																						
Gratiola officinalis L.	.	+.2	.	+	.	.	.	.	.	+.2	.	.	.	.	.	.	.	3.3	1.1	4.4	3.3	7
Phragmito-Magnocaricetea																						
Juncus effusus L.	2b.2	2a.2	2a.2	+	.	1.2	.	2a.3	1.1	2a.1	+.2	.	.	.	+	.	.	+	+.2	2a.1	1.1	14
Alisma plantago-aquatica L.	.	1.1	1.1	.	.	.	1.1	.	1.1	1.1	+	.	.	+	.	.	.	1.1	+	.	.	9
Galium debile Desv.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	+	1.1	.	3
Glyceria fluitans (L.) R. Br.	.	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Juncus articulatus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	.	1
Other species																						
Leontodon hispidus L.	.	.	.	.	+	+.2	.	.	1.1	.	.	.	1.1	.	.	.	.	.	.	.	1.1	5
Agrostis stolonifera L.	.	.	.	.	.	+.2	+	.	.	.	.	.	.	.	.	.	.	+	1.2	1.2	.	5
Holcus lanatus L.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	4
Anthoxanthum odoratum L.	.	+	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
Myosotis laxa Lehm. subsp. cespitosa (Schultz) Hyl. ex Nordh.	.	.	.	.	.	.	.	.	+	+	+.2	.	.	.	.	.	.	.	.	.	.	3
Hypericum sp.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	2
Oenanthe pimpinelloides L.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	r	.	2
Hypochaeris radicata L.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	2a.1	2
Sporadic species	3	0	0	0	1	0	1	2	0	0	2	2	0	0	0	0	0	0	1	0	1	

Presences

(2005). Besides the dominant species, which creates a short and thick bed, *Ranunculus ophioglossifolius* and *Callitriche brutia* are typically present, sometimes with a high cover degree. A variant with *Gratiola officinalis* can be observed in wetter situations (Tab. 9, rell. 49-52), where the soil is richer in clay and the flooding persists for a longer period. Other frequent species are *Juncus effusus* and *Alisma plantago-aquatica*. The relevés 32 to 38 in Tab. 9 show a poor aspect of the association.

Discussion and conclusion

The surveyed vegetation of the Mediterranean temporary wet systems in central inland Italy shows a high level of floristic and coenotic diversity, offering peculiar habitats for rare and endangered taxa and syntaxa. Indeed, these habitats are particularly rich in flora and phytocoenoses, in spite of their reduced size (Oertli *et al*., 2002). Their coenotical peculiarities show a clear correspondence with a number of environmental features, above all the different hydrological regimes, mainly due to microtopography, water-depth dynamics and flooding period, in accordance with several studies carried out in other Mediterranean areas (Oertli *et al*., 2002; Grillas *et al*., 2004; Biondi & Bagella, 2005; Deil, 2005; Bagella *et al*., 2009; Alonso, 2010; Ernandes & Marchiori, 2013). The plant communities colonizing these habitats are strictly dependent on the temporary stagnation of the autumn/winter rain in the soil and need a special edaphic condition, for this reason they cannot be included in the climatophylous vegetation series. They should be considered as an example of hygro-edaphic vegetation at microtopographic level. Furthermore, the mono-stratified phytocoenoses which colonize the temporary ponds do not show any type of successional development, unless the site ecologic features considerably change, e.g. when flooding disappears or gets permanent, or because of changes in the soil nutrients. For instance, an increase in the soil nitrogen content and a decrease in phosphorus can affect the development of some ephemeral species and stimulate the settlement of nitrophilous perennial ones (Brouwer at al., 2001). In undisturbed conditions, oligotrophy prevents the growth of competitor species and reduces competition; it is also the reason for the plants general short size. Indeed, the dwarf size of many of the detected vegetation types in the temporarily wet environments, mainly expressed by geophytic and therophytic life-forms, has been interpreted as an adaptive trait due to the thin oligotrophic soils, the lack of nutrients, the alternance between summer dry and winter wet periods (Paradis *et al*., 2009).

Highly specialized and many times pioneer, the dynamics of these plant communities generally gives rise to a typically blocked succession and for this reason they can be considered as a microgeosigmetum (Rivas-Martínez *et al*., 1999, 2002), in accordance with Biondi & Bagella (2005). This vegetation system can be interpreted as a particular type of geopermaseries (Rivas-Martínez, 2005) and corresponds to the "zonation complexes" described by Deil (2005). It includes a complex of plant communities which share a topographic (catenal) contact with each other, likewise

the vegetation systems of lake shores, cliffs, bogs, snowdrifts, mobile dunes and springs. The particular features of the temporarily flooded habitats prevent permanent vegetation from developing; the dry period excludes plant species characteristic of permanent wetlands, and on the other side the flooded conditions are unsuitable for xero- and meso-phytic taxa (Grillas *et al*., 2004; Bagella *et al*., 2009). Thus, although not perennial, even the ephemeral vegetation represents a blocked stage in the vegetation series. A similar point of view is expressed by Deil (2005) who affirms that "the habitats are not submitted to progressive succession, when they are of primary nature and when the natural dynamic of the hydrological or geomorphological process continues": small-scale ecological gradients give rise to a mosaic. For this reason, these complexes of neighbouring plant communities should be surveyed within their microgeomorphologic and ecological borders, following the gradient of their driving ecological factor (Rivas-Martínez *et al*., 2002).

Mediterranean temporary ponds have been included in the 92/43/EEC Directive's Annex I (European Commission, 1992, 2013); in particular, the vegetation belonging to the classes *Isoëto-Juncetea* and *Littorelletea* can be referred to the habitats 3120, 3130 and 3170* (Biondi *et al*., 2009, 2012). Also habitat 3110, although not tipically Mediterranean, results strictly connected with the temporary wet systems. We wish to stress that these habitats deserve protection as they face the risk of extinction due to eutrophication, changes in land use and climate change. Their correct management should be grounded on their deep knowledge, which is essential for the understanding of the ecological processes underpinning these plant communities. Last but not least, it should be remembered that these vegetation types are a very important habitat for many animal species, especially amphibians (Gómez-Rodríguez *et al*., 2009; Gasparri *et al*., 2013).

Syntaxonomical scheme

ISOËTO DURIEI-JUNCETEA BUFONII Br.-Bl. & Tüxen ex Westhoff, Dijk & Paschier 1946
ISOËTETALIA DURIEI Br.-Bl. 1936
Isoëtion duriei Br.-Bl. 1936
Serapio-Isoëtetum histricis Pedrotti 1982
isoëtetosum histricis Pedrotti 1982
lotetosum angustissimi subass. nova hoc loco
Cicendio filiformis-Solenopsion laurentiae Brullo & Minissale 1998
Junco tenageiae-Solenopsietum laurentiae ass. nova hoc loco
Hypochaerido glabrae-Cicendietum filiformis ass. nova hoc loco
Solenopsio laurentiae-Juncetum pygmaei V. Silva & Galán de Mera in V. Silva, Galán de Mera & Sérgio 2008
juncetosum pygmaei V. Silva & Galán de Mera in V. Silva, Galán de Mera & Sérgio 2008
isolepidetosum cernuae subass. nova hoc loco

LITTORELLETEA UNIFLORAE Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946
LITTORELLETALIA UNIFLORAE Koch 1926
Eleocharition acicularis Pietsch 1967
Callitricho brutiae-Juncetum bulbosi ass. nova hoc loco

AGROSTIETEA STOLONIFERAE Oberdorfer 1983
DESCHAMPSIETALIA CESPITOSAE Horvatic 1958
Ranunculo ophioglossifolii-Oenanthion fistulosae De Foucault 2012
Trifolio fragiferi-Ranunculetum opioglossipholii Biondi, Casavecchia & Radetic 2002
Callitricho brutiae-Ranunculetum ophioglossifolii ass. nova hoc loco
glycerietosum fluitantis subass. nova hoc loco

PHRAGMITO AUSTRALIS-MAGNOCARICETEA ELATAE Klika in Klika & Novák 1941
NASTURTIO OFFICINALIS-GLYCERIETALIA FLUITANS Pignatti 1953
Glycerio fluitantis-Sparganion neglecti Br.-Bl. & Sissingh in Boer 1942
Glycerienion fluitantis (Géhu & Géhu-Franck 1987) J.A. Molina 1996
Alismo lanceolatae-Gratioletum officinalis Biondi & Bagella 2005
alismetosum lanceolatae Biondi & Bagella 2005
juncetosum conglomerati subass. nova hoc loco

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Appendix 1: Dates and localities of the relevés

Tab. 2: Rel. 1: 2004-05-07, Monelli; Rel. 2: 2004-05-12, Pod. Marella; Rel. 3: 2004-05-12, Pod. Marella,; Rel. 4: 2004-05-17, Monelli; Rel. 5: 2004-05-12, Pod. Marella; Rel. 6: 2004-05-07, Monelli; Rel. 7: 2004-05-12, Pod. Marella; Rel. 8: 2004-05-12, Monelli, vicino al laghetto; Rel. 9: 2004-05-12, Monelli, vicino al laghetto; Rel. 10: 2004-05-12, Monelli, vicino al laghetto; Rel. 11: 2004-05-12, Monelli, vicino al laghetto; Rel. 12: 2004-05-12, strada Ferretto-Petrignano; Rel. 13: 2004-06-08, vivaio Rose; Rel. 14: 2004-05-25, Pod. Marella; Rel. 15: 2004-05-25, Pod. Marella; Rel. 16: 2004-05-25, Pod. Marella; Rel. 17: 2004-05-17, Monelli; Rel. 18: 2004-05-17, Monelli; Rel. 19: 2004-05-22, Monelli; Rel. 20: 2004-05-25, Monelli; Rel. 21: 2004-05-25, Monelli.

Tab. 3: Rel. 22: 2004-06-16, SE of Ferretto; Rel. 23: 2004-06-16, Pod. Marella; Rel. 24: 2004-06-16, Pod. Marella; Rel. 25: 2004-06-16, SE of Ferretto; Rel. 26: 2004-06-16, SE of Ferretto; Rel. 27: 2004-06-16, Monelli; Rel. 28: 2004-06-16, Monelli; Rel. 29: 2004-06-16, SE of Ferretto; Rel. 30: 2004-06-16, SE of Ferretto; Rel. 31: 2004-06-16, SE of Ferretto.

Tab. 4: Rel. 32: 2004-05-12, vivaio Rose; Rel. 33: 2004-05-12, vivaio Rose; Rel. 34: 2005-05-16, W of Castiglione del Lago; Rel. 35: 2005-05-16, W of Castiglione del Lago.

Tab. 5: Rel. 36: 2004-06-16, SE of Ferretto; Rel. 37: 2004-06-16, SE of Ferretto; Rel. 38: 2004-06-16, SE of Ferretto; Rel. 39: 2004-06-16, SE of Ferretto; Rel. 40: 2005-05-23, SE of Ferretto; Rel. 41: 2005-05-23,

SE of Ferretto; Rel. 42: 2004-06-16, SE of Ferretto; Rel. 43: 2004-06-16, SE of Ferretto.
Tab. 6: Rel. 1: 2004-05-22, Monelli; Rel. 2: 2005-05-23, Monelli; Rel. 3: 2004-05-22, Monelli; Rel. 4: 2004-06-16, Pod. Marella; Rel. 5: 2004-06-16, Monelli; Rel. 6: 2004-06-22, Pod. Marella; Rel. 7: 2005-05-23, Pod. Marella.
Tab. 7: Rel. 8: 2004-05-22, Vivaio Rose; Rel. 9: 2004-05-22, Vivaio Rose; Rel. 10: 2004-05-22, Vivaio Rose; Rel. 11: 2005-05-23, Vivaio Rose; Rel. 12: 2005-05-20, turkey farms; Rel. 13: 2005-05-23, Pod. Marella; Rel. 14: 2005-05-23, Vivaio Rose.
Tab. 8: Rel. 23: 2005-05-20, turkey farms; Rel. 24: 2005-05-20, turkey farms; Rel. 25: 2005-05-20, turkey farms; Rel. 26: 2008-05-06, Le Sette Strade; Rel. 27: 2008-05-12, Le Sette strade; Rel. 28: 2008-05-12, Le Sette strade; Rel. 29: 2008-05-12, Le Sette strade; Rel. 30: 2005-05-23, SE of Ferretto; Rel. 31: 2005-05-23, SE of Ferretto; Rel. 15: 2004-06-16, Pod. Marella; Rel. 16: 2005-05-23, Pod. Marella; Rel. 17: 2005-05-23, Vivaio Rose; Rel. 18: 2005-05-23, Vivaio Rose; Rel. 19: 2008-05-06, Le Sette strade; Rel. 20: 2008-05-06, Le Sette strade; Rel. 21: 2008-05-12, Le Sette strade; Rel. 22: 2008-05-12, Le Sette strade.
Tab. 9: Rel. 32: 2005-05-23, Monelli; Rel. 33: 2005-05-23, Monelli; Rel. 34: 2005-05-23, SE of Ferretto; Rel. 35: 2005-05-23, SE of Ferretto; Rel. 36: 2004-06-16, SE of Ferretto; Rel. 37: 2005-05-23, Monelli; Rel. 38: 2008-05-06, Le Sette strade; Rel. 39: 2004-06-16, Monelli; Rel. 40: 2005-05-23, Pod. Marella; Rel. 41: 2005-05-23, Monelli; Rel. 42: 2004-06-16, Monelli; Rel. 43: 2005-05-23, Monelli; Rel. 44: 2008-05-06, Le Sette strade; Rel. 45: 2008-05-12, Le sette strade; Rel. 46: 2005-05-23, Monelli; Rel. 47: 2008-05-06, Le Sette strade; Rel. 48: 2008-05-12, Le Sette strade; Rel. 49: 2005-05-23, Monelli; Rel. 50: 2005-05-23, Pod. Marella; Rel. 51: 2005-05-23, Pod. Marella; Rel. 52: 2008-05-06, Le Sette strade.

Appendix 2: Sporadic species

Tab. 2 - Rel. 3: Trifolium subterraneum L. 1.2; 5: Trifolium strictum L. +; Rel. 6: Linum bienne Mill. +; Rel. 7: Lysimachia nummularia L. +; Rel. 9: Cardamine hirsuta L. 1.1; Senecio vulgaris L. r; Rel. 10: Medicago lupulina L. 1.2; Vicia hirsuta (L.) Gray +; Rel. 11: Hypochaeris glabra L. +; Rel. 12: Luzula multiflora (Ehrh.) Lej. r; Veronica persica Poir. 3; Rel. 13: Trifolium striatum L. +; Rel. 14: Orchis morio L. subsp. morio r; Rel. 19: Parentucellia latifolia (L.) Caruel +; Platanthera bifolia (L.) Rich. subsp. bifolia +.
Tab. 3 - Rel. 22: Anthoxanthum odoratum L. +; Vicia tetrasperma (L.) Schreb. +; Romulea columnae Sebast. et Mauri+; Rel. 23: Filago gallica L. +; Rel. 27: Vulpia myuros (L.) C.C. Gmel. 1.1; Brachypodium distachyon (L.) P. Beauv. +; Rel. 28: Vulpia ciliata Dumort. +; Rel. 29: Paspalum paspalodes (Michx.) Scribn. +.2.
Tab. 4 - Rel. 32: Hieracium piloselloides Vill. +.2; Parentucellia latifolia (L.) Caruel r; Vicia sativa L. r; Rel. 33: Cerastium brachypetalum Desp. ex Pers. 1.1; Vicia tetrasperma (L.) Schreb. +; Rel. 34: Linum bienne Mill. +; Rel. 35: Medicago lupulina L. +; Trifolium subterraneum L. +; Vicia disperma DC. +.
Tab. 5 - Rel. 36: Paspalum paspalodes (Michx.) Scribn. +.2; Anthoxanthum odoratum L. r; Rel. 38: Ranunculus ophioglossifolius Vill. +; Rel. 40: Hypochaeris glabra L. +; Briza maxima L. +; Euphorbia exigua L. +; Rel. 41: Alisma plantago-aquatica L. +; Rel. 42: Carex caryophyllea Latourr. 1.1.
Tab. 6 - Rel. 2: Juncus bulbosus L. 1.3; Rel. 4: Eleocharis palustris (L.) Roem. et Schult. 2b.3; Juncus pygmaeus Rich. ex Thuill. 1.2; Callitriche brutia Petagna +.2; Carex otrubae Podp. +.2; Rumex conglomeratus Murray +; Phalaris aquatica L. +; Rel. 5: Briza maxima L. 1.1; Cynosurus cristatus L. 1.1; Gaudinia fragilis (L.) P. Beauv. 1.1; Bromus hordeaceus L. +.2; Phleum pratense L. +; Trifolium echinatum M. Bieb. +; Rel. 6: Kickxia commutata (Bernh. ex Rchb.) Fritsch r; Holcus lanatus L. +; Leontodon hispidus L. +; Betonica officinalis L. subsp. officinalis +; Linum bienne Mill. +; Serapias cordigera L. +; Rel. 7: Veronica serpyllifolia L. 1.3; Galium debile Desv. 1.2; Alisma plantago-aquatica L. 1.1; Poa trivialis L. +; Calluna vulgaris (L.) Hull +; Festuca arundinacea Schreb. +; Rumex sanguineus L. r.
Tab. 7 - Rel. 8: Geranium dissectum L. 1.1; Ranunculus repens L. +; Rel. 9: Rumex acetosa L. 1.1; Oenanthe pimpinelloides L. +.2; Rel. 10: Gratiola officinalis L. +.2; Rel. 11: Juncus articulatus L. +.2; Rel. 12: Mentha longifolia (L.) Huds. 2b.2; Festuca arundinacea Schreb. 1.1; Rel. 13: Juncus bulbosus L. 1.2; Carex flacca Schreb. subsp. flacca 1.2; Juncus bufonius L. 1.2; Callitriche brutia Petagna +.2; Holcus lanatus L. +.
Tab. 8 - Rel. 15: Galium palustre L. 2a.1; Rel. 16: Juncus bulbosus L. 1.2; Myosotis laxa Lehm. subsp. cespitosa (Schultz) Hyl. ex Nordh. +.2; Rel. 17: Carex flacca Schreb. subsp. flacca +.2; Rel. 23: Bellis annua L. +; Rel. 25: Veronica serpyllifolia L. 2b.1; Lythrum junceum Banks et Sol. +; Rel. 29: Juncus bufonius L. r; Carex hirta L. +.2; Rel. 30: Juncus pygmaeus Rich. ex Thuill. +; Isolepis cernua (Vahl) Roem. et Schult. +; Rel. 31: Isoëtes histrix Bory +.
Tab. 9 - Rel. 32: Juncus conglomeratus L. 1.3; Carex caryophyllea Latourr. +; Danthonia decumbens (L.) DC. +; Rel. 36: Cynosurus polybracteatus Poir. +; Rel. 38: Callitriche palustris L. +; Rel. 39: Holcus mollis L. subsp. mollis +; Agrostis capillaris L. +; Rel. 42: Alisma lanceolatum With. 1.1; Portulaca oleracea L. r; Rel. 43: Lythrum portula (L.) D.A. Webb +; Lythrum junceum Banks et Sol. +; Rel. 50: Carex flacca Schreb. subsp.flacca +;Rel. 52: Hieracium piloselloides Vill. +.