

## Wetland vegetation of the Tarsia Lake Regional Nature Reserve (Calabria, southern Italy)

Giovanni Maiorca<sup>1</sup> , Alessandro Crisafulli<sup>2</sup>, Domenico Puntillo<sup>3</sup>, Giuseppe Signorino<sup>4</sup> & Giovanni Spampinato<sup>5</sup>

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**Abstract.** A phytosociological analysis of Tarsia Lake Regional Nature Reserve was carried out within a research project dealing with the vegetation of southern Italian wetlands. Twenty-four plant communities (19 associations and five communities not yet assigned to formal rank) were attributed to 17 alliances, 14 orders, and 11 classes. Most associations resulted as common in the Mediterranean area; however, as a response to the peculiarity of the local climatic and edaphic factors, some phytocoenoses were found as typical throughout central Europe but not observed in southern Italy, yet. Currently, this area is preserving a considerably interesting flora and vegetation for both naturalistic and phytogeographic reasons. Therefore, an appropriate monitoring and protection plan is needed in order to counteract the ongoing severe anthropogenic pressure.

**Keywords:** Calabria; southern Italy; Tarsia Lake; wetland vegetation.

### Contribución al conocimiento de la vegetación de los humedales de Calabria (sur de Italia): la Reserva Natural Regional del Lago di Tarsia

**Resumen.** Como parte de un plan de investigación para la vegetación de humedales del sur de Italia, se realizó un análisis fitosociológico de la Reserva Natural Regional del Lago de Tarsia. Veinticuatro comunidades (19 asociaciones y cinco comunidades) han sido asignadas a 17 alianzas, 14 órdenes y 11 clases. La mayoría de las asociaciones resultan comunes en el área mediterránea. No obstante, en respuesta a los factores climáticos y edáficos particulares, en el área de estudio hay algunas fitocenosis típicas de Europa central, que aún no se han observado en el sur de Italia. Actualmente, esta área conserva una flora y vegetación de considerable interés naturalista. Por consiguiente, se necesita un plan adecuado de monitoreo y protección para contrarrestar la presión antropogénica severa.

**Palabras clave:** Calabria; sur de Italia; Lago de Tarsia; vegetación de humedales.

### Introduction

Wetland ecosystems include an important piece of European biodiversity. They provide ecological feasibility to a number of habitats, thus allowing, for instance, a remarkable animal species diversity: birds can take advantage of nesting and migratory flyway areas as well as dragonflies and amphibians find suitable living conditions in such places (Silva *et al.*, 2007). As a consequence of a strong climatic variability, the number of wetland types in the Mediterranean area is high, ranging from large river deltas and lagoons along the North shore to salty and temporary marshes in the South, where water occurs only for a few months.

Many plants find suitable living conditions only in wet places, which are therefore unique habitats for protection of rare and threatened plant species and communities, then requiring priority actions for conservation (Silva

*et al.*, 2009; Molina *et al.*, 2009). Unfortunately, over the last 100 years, the Mediterranean coast area has lost about half wetland habitats, as a result of several forms of anthropogenic pressures (Silva *et al.*, 2007). Human-mediated activities also made wetland habitats highly vulnerable to invasion by alien plants (Liendo *et al.*, 2016) and induced palustrine ecosystems to decline (Gigante *et al.*, 2014; Lastrucci *et al.*, 2017).

In order to develop the knowledge on wetlands vegetation, several Italian and European projects and initiatives have been launched, such as MedWet (2018), WetVegEurope (2018), etc. The wetland flora and vegetation of southern Italy have recently induced a deeper scientific interest, and studies have been carried out to increase the knowledge of these particular ecosystems, especially in Sicily (Brullo & Furnari, 1976; Barbagallo *et al.*, 1979; Minissale & Spampinato, 1987; Brullo & Spampinato, 1990; Brullo *et al.*, 1994; Brullo

<sup>1</sup> Regional Agency for Agricultural Development of Calabria (ARSAC). Viale Trieste 95. I-87100 Cosenza. Italy. Email: herbarium.meridianum@gmail.com

<sup>2</sup> Department of Chemical, Biological, Pharmaceutical and Environmental Science, University of Messina. Viale Stagno d'Alcontres 31, I-98166 Messina. Italy. Email: acrisafulli@gmail.com

<sup>3</sup> Natural History Museum and Botanical Garden, University of Calabria. I-87030 Arcavacata di Rende. Italy. Email: domenicopuntillo@virgilio.it

<sup>4</sup> 153 Annandale Rd. SE10 0JY London. United Kingdom. Email: forest.signorino@gmail.com

<sup>5</sup> Department of Agraria, Mediterranean University of Reggio Calabria. Loc. Feo di Vito. I-89124 Reggio Calabria. Italy. Email: gspampinato@unirc.it

& Sciandrello, 2006; Pavone *et al.*, 2007; Sciandrello *et al.*, 2016; Minissale *et al.*, 2017; Guarino *et al.*, 2019), but also in Apulia (Beccarisi *et al.*, 2006, 2007; Ernandes *et al.*, 2006, 2007, 2008, 2017; Di Pietro *et al.*, 2009; Ernandes & Marchiori, 2013) and Campania (La Valva & Astolfi, 1988; Gafta, 1991; Pedrotti & Gafta, 1992; Strumia, 2004).

In Calabria, wetlands have been studied mainly in protected areas (Brullo & Spampinato, 1997, 1999; Brullo *et al.*, 2001, 2003; Bernardo *et al.*, 2002, 2012; Maiorca *et al.*, 2002, 2005, 2007; Caridi *et al.*, 2006; Gargano *et al.*, 2007; Cameriere *et al.*, 2008; Gangale & Uzunov, 2014; Spampinato *et al.*, 2019). Although the number and width of such habitats have been significantly reduced over the last century as a consequence of land reclamation and anthropogenic activities, especially in coastal areas, nevertheless we can still observe some such areas preserving hygrophilous plant communities,

where very rare and peculiar species are growing (Cesca & Peruzzi, 2001; Spampinato *et al.*, 2007).

As a part of a research carried out within the Calabrian wetland vegetation, a specific study was implemented in the marshland of Tarsia Lake Regional Nature Reserve.

## Materials and Methods

### Study area

Tarsia Lake is an artificial basin used for crop irrigation during summer, where hygrophilous vegetation occurs differing from those observable in close places under more natural conditions. It was originated after a dam building in the Middle Valley of the River Crati, close to Tarsia village (Figure 1). A plant biodiversity mapping of Tarsia Lake and neighboring areas had previously carried out (Maiorca *et al.*, 2013; Caridi *et al.*, 2015).



Figure 1. Topographic map of Tarsia Lake area.

The lake supplies water for crop irrigation in the Sibari Plain, primarily citrus orchards. In the past, during the maximum summer flood, the basin covered an area of about 170 hectares, thus supplying a volume of 16 million m<sup>3</sup> of water (maximum depth of the lake: 9 m). Currently, due to salting, the volume decreased to 6 million m<sup>3</sup>, with an average depth of 1.82 m (Infusino *et al.*, 2014). The water level varies according to dam opening and closing over the year. Over winter, the dam is open, and the lake is empty; at the beginning of spring, you can see a wide swamp crossed by the meanders of the Crati River, where the marsh vegetation grows. Then, in March, the dam is closed, and over summer the lake fills up completely. Consequently, only a small surface of the marsh area remains visible. The geological substratum of the Tarsia lake is characterized by Holocene deposits of sand and clay, rarely gravelly (Anon., 1958–1962).

The climate of the study area is typically Mediterranean, the climate diagram (Figure 2) showing an average annual temperature of 16°C and an average annual rainfall of 762.8 mm, especially distributed between autumn and winter, with a summer dryness of 3.5 months (Maiorca *et al.*, 2013). According to Rivas-Martínez (1996–2019), the bioclimate is Mediterranean Pluviseasonal oceanic, with a lower mesomediterranean thermotype and a lower subhumid ombrotpe. For more details, see also Pesaresi *et al.* (2014).

The waters of the lake are generally eutrophic to mesotrophic, with a salt content that may vary depending on weather conditions (Chidichimo, 1991). The seasonality of the Tarsia basin induces periodic cycles of phosphorus accumulation and erosion. Furthermore, these artificial waters, compared to the natural, show a lower susceptibility to eutrophic phenomena due to water withdrawal from the bottom, which allows the mass of water to be renewed (Infusino *et al.*, 2014).

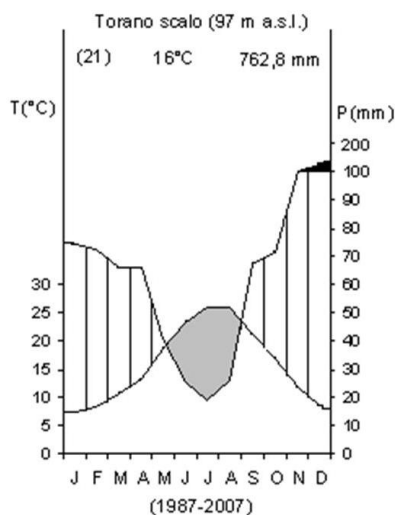


Figure 2. Climate diagram of Torano Scalo meteorological station.

### Data collection and analysis

From 2009 to 2015, 78 unpublished relevés of vegetation were carried out according to the phytosociological method (Pignatti & Mengarda, 1962; Braun-Blanquet, 1964). The phytosociological approach, as well as the correspondence of vegetation to local phyto-toponyms, has been considered as an useful tool for the natural resources management, according to various authors (Brullo *et al.*, 1999; Cano *et al.*, 2017; Piñar Fuentes *et al.*, 2017; Pott, 2011; Spampinato *et al.*, 2017, 2018; Vila-Viçosa *et al.*, 2015).

Major importance was given to the minimum surface of each relevé, in order to avoid detecting ecotones or

mosaics, which are very frequent in wetland vegetation. Abundance coefficients were transformed into the ordinal scale, according to Van der Maarel (1979). The multivariate analysis of relevés was performed using SYN-TAX 2000 software (Podani, 2001). A hierarchical classification method (UPGMA) was performed using the chord distance coefficient as a measure of relevés dissimilarity. A single relevé of *Salicetum albo-brutiae* was reported from literature (Brullo & Spampinato, 1997): it was not included in the cluster analysis. The groups of relevés, resulting from the hierarchical classification, were arranged in seven tables, corresponding to the types of wetland vegetation observed. The syntaxonomical nomenclature followed the Code of Phytosociological Nomenclature (Weber *et al.*, 2000). The syntaxonomical system proposed by Biondi *et al.* (2014) for Italy was mainly adopted, as integrated by Mucina *et al.* (2016). The plants listed in the tables were identified based on Flora d'Italia (Pignatti, 2017-2018). Plant nomenclature was the same as in Bartolucci *et al.* (2018) for native species, and Galasso *et al.* (2018) for the alien species. The non-vascular plant nomenclature was used according to Cortini-Pedrotti (2001-2006) for *Bryophyta*, and Guiry & Guiry (2018) for *Xanthophyceae*. Subspecific names were reported only when differing from nominal.

### Results and Discussion

The hierarchical classification recognized 25 groups of relevés (dissimilarity value: 0,9; Figure 3). 24 groups corresponded to 19 associations and five communities not assigned to formal rank; one group corresponded to a variant of the *Holoschoenetum vulgaris* association (see Table 6). On the whole, 24 plant communities were identified and attributed to 17 alliances, 14 orders, and 11 classes.

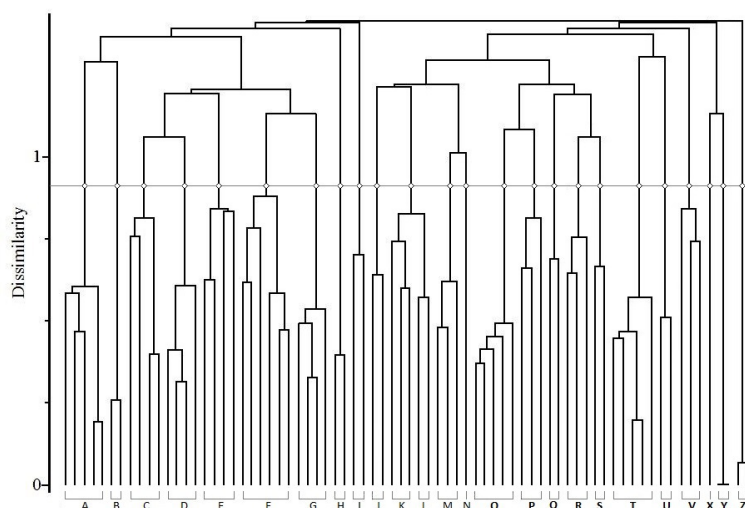


Figure 3. Dendrogram resulting from the cluster analysis of relevés. A, *Riccia glauca* comm.; B, *Botrydium granulati*; C, *Rumici maritimi-Ranunculetum scelerati*; D, *Callitricetum palustris*; E, *Helosciadietum nodiflori*; F, *Filaginello uliginosae-Veronicetum peregrinae*; G, *Limosella aquatica* comm.; H, *Charetum vulgaris*; I, *Isoëtetum duriei*; J, *Polygono salicifolii-Phragmitetum comunis*; K, *Typhetum angustifoliae*; L, *Typho angustifoliae-Schoenoplectetum tabernaemontani*; M, *Typhetum latifoliae*; N, *Sparganium neglectum* comm.; O, *Bidenti tripartitae-Polygonetum mitis*; P, *Galio elongati-Juncetum inflexi*; Q, *Loto tenuis-Paspaleetum paspaloidis*; R, *Holoschoenetum vulgaris*; S, *Holoschoenetum vulgaris* var. with *Juncus inflexus*; T, *Polygono lapathifolii-Xanthietum italicum*; U, *Salix alba* and *Populus alba* comm.; V, *Tamarix africana* comm.; X, *Ceratophylletum demersi*; Y, *Potamogetonetum nodosi*; Z, *Lemnetum gibbae*.

### Submerged, free-floating and rooted-floating aquatic vegetation

***Charetum vulgaris*** Corillion 1957 (Table 1, rel. 1, 2). A submerged aquatic plant community characterised by the dominance of *Chara vulgaris* (*Charophyta*). The *Chara sp.pl.* associations are generally linked to oligo-mesotrophic stagnant waters, shallow (up to 3 m), limpid, and rich in nutrients, but relatively poor in phosphates that inhibit their development (Hrivnák et al., 2005). This association colonises submerged pools in Tarsia Lake over spring, whereas it decreases or disappears over summer due to maximum flooding.

***Lemnetum gibbae*** Miyawaki et J. Tüxen 1960 (Table 1, rel. 3, 4). An annual association of pleustophytic plant, with a thick floating layer of *Lemna gibba*. It is usually located in areas smaller than 1 m<sup>2</sup>. *Lemna gibba* and *Spirodela polyrrhiza* have an ecological optimum in

stagnant eutrophic waters with a high level of phosphates and basic pH (Sburlino et al., 2004). This association is widespread in Europe (Šumberová, 2011a), but it is not common in southern Italy since reported only in Sicily (Brullo et al., 1994) and in Calabria (Crisafulli et al., 2010).

***Ceratophylletum demersi*** Hild 1956 (Table 1, rel. 5). A floating submerged plant community dominated by *Ceratophyllum demersum*, located on the upmost layers of the waterbody. This association shows a summer vegetative development and prefers shallow eutrophic waters, steading or slightly flowing. *Ceratophyllum demersum* is a eurieciuous species that endure a wide range of ecological conditions, as anoxia or high temperature of the water during summer. It is often located on water bodies influenced by human activities causing eutrophication and turbidity of water (Rodwell, 1995; Maiorca et al., 2007).

Table 1. Submerged, free-floating and rooted-floating aquatic vegetation. *Charetum vulgaris* Corillion 1957 (rel. 1,2) (*Charion vulgaris*, *Charetalia hispidae*, *Charetea fragilis*) *Lemnetum gibbae* Miyawaki et J. Tüxen 1960 (rel. 3,4) (*Lemnion minoris*, *Lemnetalia minoris*, *Lemnetea minoris*); *Ceratophylletum demersi* Hild 1956 (rel. 5), *Potamogetonetum nodosi* (Soó 1960) Segal 1964 (rel. 6,7) (*Potamogetonion pectinati*, *Potamogetonetalia pectinati*, *Potamogetonetea pectinati*); *Callitrichetum palustris* (Dihoru 1975 n.n.) Burescu 1999 (rel. 8-11) (*Ranunculion aquatilis*, *Callitricho hamulatae-Ranunculetalia aquatilis*, *Potamogetonetea pectinati*)

Altitude (m asl)	50	50	50	50	50	50	50	50	50	50	50
Plot size (m <sup>2</sup> )	0,5	0,5	0,5	0,5	5	5	5	5	5	5	5
Cover (%)	100	100	100	100	100	90	90	90	90	90	90
Species N.	2	3	2	2	3	2	2	5	4	4	4
Relevé N.	1	2	3	4	5	6	7	8	9	10	11
Characteristics of associations											
<i>Chara vulgaris</i>	4	4	.	.	.	.	.	.	.	.	.
<i>Lemna gibba</i>	.	.	3	4	.	.	.	.	.	.	.
<i>Spirodela polyrrhiza</i>	.	.	3	3	.	.	.	.	.	.	.
<i>Potamogeton nodosus</i>	.	.	.	.	1	4	4	.	.	+	.
<i>Callitriche palustris</i>	.	1	.	.	.	.	.	5	5	4	5
<i>Ceratophyllum demersum</i>	.	.	.	.	4	.	.	.	.	.	.
Other species											
<i>Phragmites australis</i>	.	.	.	.	+	+	+	.	.	.	.
<i>Glyceria notata</i>	.	.	.	.	.	.	.	1	+	.	1
<i>Juncus hybridus</i>	.	.	.	.	.	.	.	2	1	2	.
<i>Paspalum distichum</i>	+	.	.	.	.	.	.	.	+	.	.
<i>Rumex maritimus</i>	.	.	.	.	.	.	.	.	.	+	+
Other species: <i>Veronica anagallis-aquatica</i> + in 2; <i>Scrophularia nodosa</i> +, <i>Symphotrichum squamatum</i> 1 in 8; <i>Helosciadium nodiflorum</i> 1 in 11.											
Localities: 1,2: Marinetto, 30.04.2012; 3,4: C.da Pellizzari, 14.07.2015; 5: Macchia d'Acci, 14.07.2015; 6,7: C.da Pellizzari, 14.07.2015; 8-11: Marinetto, 14.07.2015.											

***Potamogetonetum nodosi*** (Soó 1960) Segal 1964 (Table 1, rel. 6, 7). A rooted-floating aquatic plant community dominated by *Potamogeton nodosus*, which forms a uniform and laminar layer of floating leaves, from which the inflorescences emerge. In Tarsia Lake this phytocoenosis is monospecific and is related to shallow waters, muddy and rich in organic material, slowly flowing but not stagnant (Maiorca et al., 2007). This

association is affected by water level variations, and it is present over summer when the lake is filled up.

***Callitrichetum palustris*** (Dihoru 1975 n.n.) Burescu 1999 (Table 1, rel. 8–11). A submerged plant community dominated by *Callitriche palustris*. In the study area, it is sporadically associated with submerged forms of some helophytes, such as *Veronica anagallis-aquatica* e *Glyceria*

*notata*. This phytocoenosis achieves the highest level of development between late winter to spring. It prefers clear, oligotrophic waters, at pH 7-8, stagnant, or slow-flowing (Schotsman, 1967). In spring, *Callitriche palustris* grows on very damp muds showing a particular emerged *habitus*.

### Thallophytic communities on silty soils

***Riccia glauca*** community (Table 2, rel. 1–5). A bryophyte-dominated community characterized by *Riccia glauca*, associated with *Physcomitrella patens*, *Sphaerocarpus globosus*, and *Physcomytrium pyriforme*. This is a pioneer community growing in spring on eutrophic silty loams with basic pH, very damp but not submerged. This community shows similarities with *Riccio cavernosae-Physcomitrelletum patentis* All. ex v. Hübschm. 1957 corr. v.d. Dunk 1972, widespread in European countries and also re-

ported in northern Italy (Cortini Pedrotti & Aleffi, 1990), and in other Italian associations with *Riccia sp. pl.* (Puglisi et al., 2015).

***Botrydium granulati*** Hübschmann 1957 (Table 2, rel. 6, 7). A phytocoenosis spread on silty soils, characterised by the dominance of *Botrydium granulatum* (*Ochrophyta*), with a sporadic presence of *Riccia glauca*. *Botrydium granulatum* is widespread in irrigated soils, banks of ponds, lakes, and rivers of central Europe (Ettl, 1978). In the study area, this phytocoenosis come into contact with *Riccia glauca* communities, sharing many ecological characteristics. However, *Botrydium granulati* needs more humidity or a longer period of water submersion. This association is known for northern Italy (Cortini Pedrotti & Aleffi, 1990) and Abruzzo (Aleffi, 1992) and it is reported for the first time in Calabria.

Table 2. Thallophytic communities on silty soils. *Riccia glauca* comm. (rel. 1-5); *Botrydium granulati* Hübschmann 1957 (rel. 6,7) (*Physcomitrellion patentis*, *Diplophylletalia albicantis*, *Cladonio digitatae-Lepidozietea reptantis*)

Plot size (dm <sup>2</sup> )	1	1	1	4	4	4	4
Altitude (m asl)	53	53	53	53	53	53	53
Cover (%)	80	90	90	100	100	40	80
Species N.	7	6	6	6	6	6	5
Relevé N.	1	2	3	4	5	6	7
Characteristics of associations or communities							
<i>Riccia glauca</i>	2	2	1	4	5	1	1
<i>Physcomitrella patens</i>	.	3	2	2	2	.	.
<i>Botrydium granulatum</i>	.	.	.	.	.	4	5
Characteristics of upper units							
<i>Physcomytrium pyriforme</i>	3	3	3	4	3	.	.
<i>Sphaerocarpos michelii</i>	1	2	2	.	1	.	.
Other species							
<i>Veronica peregrina</i> (seedlings)	+	1	1	+	+	+	+
<i>Gnaphalium uliginosum</i>	+	.	.	+	+	.	.
<i>Juncus hybridus</i>	+	+	+	.	.	.	.
<i>Myosurus minimus</i>	.	.	.	.	.	1	+
<i>Veronica anagallis-aquatica</i> (seedlings)	.	.	.	.	.	+	+
<i>Cardamine parviflora</i>	.	.	.	.	+	+	.
Other species: <i>Spergularia bocconeii</i> + in 1; <i>Callitriche palustris</i> 2 in 4; <i>Nostoc</i> sp. + in 5.							
Localities: 1-7: Marinetto, 30.04.2012.							

### Pioneer ephemeral vegetation of temporary ponds and muds

***Isoetum duriei*** Br.-Bl. 1935 (Table 3, rel. 1, 2). A spring-time temporary plant community dominated by *Isoetes duriei* and *I. histrix*. It is localized on small surfaces, fast drying in spring. This phytocoenosis is linked to a Mesomediterranean bioclimate with a circum-Mediterranean distribution (Brullo & Minissale, 1998). It has been detected on acidic soil in small damp depressions inside the garrigues with *Cistus monspeliensis*, surrounding the lake.

***Filaginello uliginosae-Veronicetum peregrinae*** Molero Brion. & Romo 1988 (Table 3, rel. 3–8). Hygro-Nitro-

philous paucispecific vegetation growing in spring on moist sandy silts structured by annual species, where the neophyte *Veronica peregrina* shows high coverage values. In summer, this association should be replaced by the *Bidentetea* plant communities on drained soil, but this does not happen to the study area due to the summer submersion of the lake shores (Figure 3). This phytocenosis, described in Catalonia (Molero Briones & Romo, 1988), was not yet known in Italy, although *Veronica peregrina* is already known to the flora of many Italian regions (Galasso et al., 2018).

***Limosella aquatica*** community (Table 3, rel. 9–12). *Limosella aquatica* is an annual plant growing on muddy margins of ponds and lakes, ditches and streams, along paths and in

temporary pools (Ali & Rhazi, 2010). It prefers mesotrophic to eutrophic substrata rich in nourishing elements. This community shows floristic affinities with the associations of the *Nanocyperetalia* found in this area. However, there are no characteristic species of *Limosella aquatica* associations

known to European territory with temperate bioclimates. In these territories *Limosella aquatica* characterizes many communities distributed on marshy environments, often peaty, or along the rills and the bays of lakes with weakly flowing waters (Brullo & Minissale, 1998).

Table 3. Pioneer ephemeral vegetation of temporary ponds and muds. *Isoëtum duriei* Br.-Bl. 1935 (rel. 1,2) (*Isoëtium duriei*, *Isoëtetalia duriei*, *Isoëto-Nanojuncetea*); *Filaginello uliginosae-Veronicetum peregrinae* Molero Brion. & Romo 1988 (rel. 3-8) (*Nanocyperion flavescens*, *Nanocyperetalia flavescens*, *Isoëto-Nanojuncetea*); *Limosella aquatica* comm. (rel. 9-12) (*Eleocharition soloniensis*, *Nanocyperetalia flavescens*, *Isoëto-Nanojuncetea*).

Altitude (m asl)	60	60	53	54	54	53	53	53	53	53	53	53
Plot size (m <sup>2</sup> )	0	0	1	1	1	1	1	1	1	1	0	0
Exposure	E	SE	-	-	-	-	-	-	-	-	-	-
Slope (°)	8	5	-	-	-	-	-	-	-	-	-	-
Cover (%)	40	70	50	80	90	70	70	80	50	30	75	50
Species N.	3	8	11	14	18	9	7	6	8	6	6	6
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12
Characteristics of associations and communities												
<i>Isoëtes duriei</i>	1	2	.	.	.	.	.	.	.	.	.	.
<i>Isoëtes histrix</i>	.	+	.	.	.	.	.	.	.	.	.	.
<i>Veronica peregrina</i>	.	.	3	4	4	4	3	5	1	+	2	1
<i>Gnaphalium uliginosum</i>	.	.	+	.	+	+	2	3	.	.	.	.
<i>Limosella aquatica</i>	.	.	.	.	.	.	.	.	3	3	3	3
Characteristics of upper units												
<i>Juncus hybridus</i>	.	.	4	4	2	+	1	.	1	1	3	2
<i>Alopecurus aequalis</i>	.	.	2	2	1	+	.	2	.	1	1	+
<i>Myosurus minimus</i>	.	.	.	3	3	.	.	.	+	.	.	.
<i>Spergularia bocconei</i>	.	.	.	1	1	+	.	.	.	.	.	.
<i>Mentha pulegium</i>	.	.	.	+	.	.	.	.	.	.	.	.
<i>Aira elegantissima</i>	+	.	.	.	.	.	.	.	.	.	.	.
<i>Juncus capitatus</i>	.	+	.	.	.	.	.	.	.	.	.	.
Other species												
<i>Rumex maritimus</i>	.	.	+	1	+	1	1	1	1	1	.	.
<i>Veronica anagallis-aquatica</i>	.	.	+	1	+	2	1	1	1	.	+	1
<i>Cardamine parviflora</i>	.	.	1	2	2	1	2	2	+	.	.	.
<i>Callitriche palustris</i>	.	.	.	+	.	.	.	.	1	1	1	1
<i>Medicago polymorpha</i>	.	.	+	.	2	.	.	.	.	.	.	.
<i>Trifolium campestre</i>	.	.	.	+	+	.	.	.	.	.	.	.
<i>Calendula arvensis</i>	.	.	.	+	+	.	.	.	.	.	.	.
<i>Trifolium nigrescens</i>	.	.	.	+	1	.	.	.	.	.	.	.
<i>Trifolium resupinatum</i>	.	.	.	.	2	1	+	.	.	.	.	.

Other species: *Euphorbia helioscopia* + in 1; *Sherardia arvensis*, *Serapias lingua*, *Bellis annua*, *Lysimachia arvensis* and *Selaginella denticulata* + in 2; *Helosciadium nodiflorum* and *Rorippa palustris* +, *Juncus articulatus* 1 in 3; *Nasturtium officinale* + in 4; *Poa annua*, *Raphanus raphanistrum* and *Rhagadiolus stellatus* +, *Trifolium fragiferum* 3 in 5.

Localities: 1,2: provincial road 197, Km 1, 22.01.2012; 3: Marinetto, 18.03.2009; 4,5: Casa Scarola, 16.04.2009; 6-12: Marinetto, 30.04.2012.

### Hygro-nitrophilous pioneer vegetation of muddy-sandy river-bed

***Bidenti tripartitae-Polygonetum mitis*** (Roch. 1951) T. Tüxen 1979 (Table 4, rel. 1–5). A nitrophilous therophytic plant community, observed in summer, on loamy and wet soils with high water availability. In the study area, it is characterized by *Bidens frondosa*, as a variant of the *Bidenti tripartitae-Polygonetum mitis* association, reported for most of Italian territory (Pedrotti, 1988; Venanzoni & Gigante, 2000) and in Calabria, for the mouth of the Crati river (Maiorca et al., 2005, 2007). In addition to *Bidens frondosa*, this association is enriched with alien species, such as

*Eclipta prostrata*, *Symphytotrichum squamatum*, and *Cyperus eragrostis*.

***Rumici maritimi-Ranunculetum scelerati*** Oberdorfer 1957 (Table 4, rel. 6–9). It is an annual therophytic association growing from spring to summer on clayey-muddy soils, dry in summer, and with high levels of nitrates, as well as many other *Bidentetea* associations (Biondi et al., 2014). *Ranunculus sceleratus* and *Rumex maritimus* are abundant together with many other less widespread species, among which the rare euro-Asiatic *Cardamine parviflora* should be remembered. *Rumici maritimi-Ranunculetum scelerati* is well distributed in Eurasian countries, mainly in eastern Europe (Šumberová, 2011b).

Table 4. Hygro-nitrophylous pioneer vegetation of muddy-sandy river-bed. *Bidenti tripartitae*-*Polygonetum mitis* (Roch. 1951) T.Tüxen 1979 var. with *Bidens frondosa* (rel. 1-5), *Rumici maritimi*-*Ranunculetum scelerati* Oberdorfer 1957 (rel. 6-9) (*Bidention tripartitae*, *Bidentetalia tripartitae*, *Bidentetea tripartitae*); *Polygono lapathifolii*-*Xanthietum italicum* Pirola & Rossetti 1974 (rel. 10-14) (*Chenopodion rubri*, *Bidentetalia tripartitae*, *Bidentetea tripartitae*)

Altitude (m asl)	54	54	54	54	54	53	53	53	53	58	58	55	55	55
Plot size (m <sup>2</sup> )	15	15	15	15	15	25	25	25	25	25	25	25	25	25
Cover (%)	80	80	90	90	80	80	95	100	100	80	80	90	90	80
Species N.	16	13	16	15	16	10	12	13	12	12	12	11	10	11
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Characteristics of associations														
<i>Persicaria dubia</i>	2	1	1	1	2	.	.	.	.	.	.	.	.	.
<i>Bidens frondosa</i>	4	4	2	3	2	.	.	.	.	.	.	.	.	.
<i>Rumex maritimus</i>	.	.	.	.	.	4	3	3	4	.	.	.	.	.
<i>Ranunculus sceleratus</i>	.	.	.	.	.	+	3	4	2	.	.	.	.	.
<i>Alopecurus aequalis</i>	.	.	.	.	.	1	3	3	2	.	.	.	.	.
<i>Xanthium italicum</i>	.	.	.	.	.	.	.	.	.	3	4	4	3	2
Characteristics of upper units														
<i>Persicaria lapathifolia</i>	2	1	1	2	1	.	.	.	.	+	2	2	1	3
<i>Rumex sanguineus</i>	1	1	2	1	2	.	.	.	.	.	.	.	.	.
<i>Rumex crispus</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Dittrichia viscosa</i>	.	.	.	.	.	.	.	.	.	2	3	3	4	2
<i>Artemisia verlotiorum</i>	.	.	.	.	.	.	.	.	.	2	2	3	1	1
<i>Bidens tripartita</i>	.	.	.	.	.	.	.	.	.	1	+	+	1	2
<i>Tussilago farfara</i>	.	.	.	.	.	.	.	.	.	+	+	+	1	+
Other species														
<i>Mentha aquatica</i>	2	2	2	2	2	.	.	.	.	+	+	1	.	1
<i>Holcus lanatus</i>	1	1	+	1	+	.	.	.	.	+	1	1	+	+
<i>Paspalum distichum</i>	.	.	+	.	+	.	2	+	.	.	.	.	.	.
<i>Symphyotrichum squamatum</i>	2	1	1	2	2	1	.	.	.	.	.	.	.	.
<i>Cyperus eragrostis</i>	2	2	3	3	2	.	.	.	.	.	.	.	.	.
<i>Eclipta prostrata</i>	1	+	1	2	1	.	.	.	.	.	.	.	.	.
<i>Juncus inflexus</i>	1	2	1	1	1	.	.	.	.	.	.	.	.	.
<i>Lycopus europaeus</i>	1	+	+	1	1	.	.	.	.	.	.	.	.	.
<i>Juncus hybridus</i>	.	.	.	.	.	2	1	1	2	.	.	.	.	.
<i>Glyceria notata</i>	.	.	.	.	.	.	2	1	+	.	.	.	.	.
<i>Callitriche palustris</i>	.	.	.	.	.	+	2	1	+	.	.	.	.	.
<i>Helosciadium nodiflorum</i>	.	.	.	.	.	1	2	+	+	.	.	.	.	.
<i>Potentilla reptans</i>	1	1	+	+	1	.	.	.	.	.	.	.	.	.
<i>Veronica peregrina</i>	.	.	.	.	.	3	+	+	2	.	.	.	.	.
<i>Equisetum telmateia</i>	.	.	.	.	.	.	.	.	.	+	1	1	+	+
<i>Prunella vulgaris</i>	.	.	.	.	.	.	.	.	.	+	+	+	.	+
<i>Veronica anagallis-aquatica</i>	.	.	.	.	.	.	2	2	2	.	.	.	.	.
<i>Juncus articulatus</i>	.	.	.	.	.	.	1	1	.	.	.	.	.	.
<i>Eupatorium cannabinum</i>	.	.	.	.	.	.	.	.	.	1	.	.	+	+
<i>Cardamine parviflora</i>	.	.	.	.	.	3	.	.	1	.	.	.	.	.
<i>Catabrosa aquatica</i>	.	.	.	.	.	.	1	2	.	.	.	.	.	.
<i>Trifolium fragiferum</i>	1	.	1	+	.	.	.	.	.	.	.	.	.	.
<i>Clinopodium vulgare</i> subsp. <i>arundanum</i>	.	.	.	.	.	.	.	.	.	+	+	+	.	.
<i>Polypogon monspeliensis</i>	+	+	.	.	+	.	.	.	.	.	.	.	.	.

Other species: *Cynodon dactylon* +, *Verbena officinalis* 1 in 1; *Melissa officinalis* subsp. *altissima* + in 3; *Cynodon dactylon* +, *Melissa officinalis* subsp. *altissima* 1 in 4; *Cynodon dactylon* + in 5; *Nasturtium officinale* + in 6; *Trifolium resupinatum* + in 8; *Berula erecta* and *Myosurus minimus* + in 9; *Pulicaria dysenterica* 1 in 3, + in 5; *Epilobium hirsutum* + in 11, 13.

Localities: 1-5: Casa Scarola, 14.07.2015; 6-9: Marinetto, 03.04.2009; 10,11: Masseria Rizzuti, 14.07.2015; 12-14: Macchia d'Acci, 14.07.2015.

Table 5. Marsh vegetation. *Polygono salicifolii-Phragmitetum comunis* Barbagallo, Brullo & Furnari 1979 (rel. 1,2), *Typhetum angustifoliae* (Allorge 1921) Pignatti 1953 (rel. 3-5), *Typho angustifoliae-Schoenoplectetum tabernaemontani* Br.-Bl. & Bolòs 1957 (rel. 6,7), *Typhetum latifoliae* Nowiński 1930 (rel. 8-10) (*Phragmition communis*, *Phragmitetalia australis*, *Phragmito australis-Magnocaricetea elatae*); *Sparganium neglectum* comm. (rel. 11) (*Glycerio fluitantis-Sparganion neglecti*, *Nasturtio officinalis-Glyceretalia fluitantis*, *Phragmito australis-Magnocaricetea elatae*); *Helosciadietum nodiflori* Maire 1924 (rel. 12-15) (*Apion nodiflori*, *Nasturtio officinalis-Glyceretalia fluitantis*, *Phragmito australis-Magnocaricetea elatae*).

Altitude (m asl)	53	55	52	55	55	52	52	53	53	53	55	53	53	53	53	
Plot size (m <sup>2</sup> )	30	30	15	15	15	10	10	15	15	15	5	15	15	25	25	
Cover (%)	100	100	100	100	100	90	90	100	100	100	90	80	80	100	80	
Species N.	6	5	15	11	7	12	8	11	12	10	12	4	6	8	7	
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Characteristics of associations and communities																
<i>Phragmites australis</i>	5	5	1	+	.	.	.	+	+	.	.	.	.	.	.	.
<i>Persicaria decipiens</i>	2	2	3	1	1	1	2	2	1	1	.	.	.	.	.	.
<i>Typha angustifolia</i>	.	.	5	5	5	4	4	.	.	.	.	.	.	.	.	.
<i>Schoenoplectus tabernaemontani</i>	.	.	.	.	.	2	3	.	.	.	.	.	.	.	.	.
<i>Typha latifolia</i>	.	.	.	.	.	.	+	3	4	4	2	.	.	.	.	.
<i>Sparganium neglectum</i>	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.
<i>Helosciadium nodiflorum</i>	+	.	1	.	.	.	.	.	+	+	1	1	1	1	1	+
<i>Veronica anagallis-aquatica</i>	.	.	.	.	.	.	.	.	.	.	.	3	2	5	5	.
Characteristics of upper units																
<i>Galium palustre</i> subsp. <i>elongatum</i>	.	2	2	+	2	1	2	1	1	2	3	.	.	.	.	.
<i>Mentha aquatica</i>	2	.	1	.	1	+	.	1	1	2	2	.	.	.	.	.
<i>Lycopus europaeus</i>	+	.	1	.	.	.	.	+	1	+	1	.	.	.	.	.
<i>Alisma plantago-aquatica</i>	.	.	.	.	.	2	.	2	.	1	.	.	.	.	.	.
<i>Lythrum salicaria</i>	.	.	.	1	.	.	.	2	1	1	.	.	.	.	.	.
<i>Glyceria notata</i>	.	.	1	.	.	1	.	.	.	.	.	.	1	3	+	.
<i>Nasturtium officinale</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Other species																
<i>Paspalum distichum</i>	.	.	1	2	1	3	3	+	1	.	.	.	1	3	+	.
<i>Symphyotrichum squamatum</i>	.	+	+	1	.	.	1	.	1	1	.	.	.	.	.	.
<i>Rumex maritimus</i>	.	.	3	1	+	.	.	+	+	.	.	.	.	.	.	.
<i>Lythrum junceum</i>	.	.	+	+	.	+	.	+	.	1	.	.	.	.	.	.
<i>Alopecurus aequalis</i>	.	.	.	.	.	.	.	.	.	.	.	2	3	.	.	.
<i>Polypogon monspeliensis</i>	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.
<i>Juncus hybridus</i>	.	.	.	.	.	.	.	.	.	.	.	3	+	1	2	.
<i>Potentilla reptans</i>	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.
<i>Rumex sanguineus</i>	+	.	.	.	.	+	1	.	.	.	1	.	.	.	1	+
<i>Equisetum palustre</i>	.	.	+	.	.	.	.	2	.	1	3	.	.	.	.	.

Other species: *Holcus lanatus* + in 2; *Agrostis stolonifera* 1 in 3; *Cyperus badius* + in 4; *Epilobium tetragonum* + in 6; *Cirsium creticum* subsp. *triumfettii* and *Lotus pedunculatus* 1, *Epilobium hirsutum* 2 in 11; *Juncus articulatus* 1 in 14.

Localities: 1: Gambarella, 03.07.2009; 2: between Tarsia cemetery and Marinetto, 10.09.2010; 3: Macchia d'Acci, 02.07.2009; 4,5: Between Tarsia cemetery and Marinetto, 03.07.2009; 6,7: Parco di Rende, 10.09.2010; 8-10: Casa Scarola, 14.07.2015; 11: Between Tarsia cemetery and Marinetto, 03.07.2009; 12: Gambarella, 16.04.2009; 13-15: Marinetto, 03.04.2009.

***Polygono lapathifolii-Xanthietum italicum*** Pirola & Rossetti 1974 (Table 4, rel. 10–14). Annual vegetation dominated by *Xanthium italicum*, which several species are associated with, showing low values of coverage, such as *Persicaria lapathifolia*, *Dittrichia viscosa*, *Artemisia verlotiorum*, and *Bidens tripartita*. It is a late-summer therophytic community growing on alluvial soils characterized by sandy or sandy-loam soil rich in nitrogen (Biondi *et al.*, 2004). It is a pioneer plant community, which needs the soil to be periodically plowed in order to prevent competition with the perennial vegetation. This condition is guaranteed by periodic floods, which also carry organic deposits, which are essential for the development of this annual association.

## Marsh vegetation

***Polygono salicifolii-Phragmitetum comunis*** Barbagallo, Brullo & Furnari 1979 (Table 5, rel. 1, 2). A paucispecific community dominated by the common reed (*Phragmites australis*). This association was reported for Sicily (Barbagallo *et al.*, 1979), later found in Calabria, close to the Crati river mouth (Maiorca *et al.*, 2005; 2007). The common reed is a helophyte with a considerable ecological value (Landucci *et al.*, 2013), it grows in various marshy environments: ditches with stagnant or slowly flowing water; banks of lakes with eutrophic waters; lagoons and water bodies with strong salinity oscillations. In the study area, this association were found on all the shores, especially where the river is tributary to



the lake. The *Polygono salicifolii-Phragmitetum* differs from the related *Phragmites australis* communities because it prefers unsalted and slightly stagnant waters.

***Typhetum angustifoliae*** (Allorge 1921) Pignatti 1953 (Table 5, rel. 3–5). Marsh vegetation dominated by *Typha angustifolia*

growing together with other helophytes on muddy waters and loam substrates, and tolerates wide changes of water level. In the study area, *Typhetum angustifoliae* showed the same distribution of the common reed communities, as it is in catenal contact with the *Polygono salicifolii-Phragmitetum* in the most submerged areas.

Table 6. Damp meadow vegetation. *Loto tenuis-Paspaleum paspaloidis* Biondi, Casavecchia & Radetic 2002 (rel. 1-4) (*Paspalo distichi-Agrostion semiverticillatae*, *Holoschoenetalia vulgaris*, *Molinio-Arrhenatheretea*); *Galio elongati-Juncetum inflexi* Minissale & Spampinato 1985 (rel. 5-7), *Holoschoenetum vulgaris* Br.-Bl. ex Tchou 1948 (rel. 8-14; var with *Juncus inflexus*, rel. 8,9) (*Agrostio stoloniferae-Scirpoidion holoschoeni*, *Holoschoenetalia vulgaris*, *Molinio-Arrhenatheretea*)

Altitude (m asl)	53	53	53	53	52	58	58	52	52	54	54	58	58	58
Plot size (m <sup>2</sup> )	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Coverage (%)	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Species N.	22	16	17	11	25	21	16	19	15	15	16	21	14	15
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Characteristics of associations														
<i>Lotus tenuis</i>	1	1	.	1	.	.	.	.	.	.	.	.	.	.
<i>Paspalum distichum</i>	4	2	5	5	.	.	1	.	.	.	.	.	2	2
<i>Juncus inflexus</i>	.	.	.	1	4	4	5	3	2	.	.	.	.	.
<i>Galium palustre</i> subsp. <i>elongatum</i>	.	.	2	.	1	+	3	2	2	1	2	+	.	.
<i>Scirpoides holoschoenus</i>	.	.	1	2	.	.	.	4	4	5	4	5	4	5
Characteristics of upper units														
<i>Potentilla reptans</i>	.	.	3	2	2	1	1	1	1	1	1	1	3	2
<i>Trifolium repens</i>	5	3	1	.	2	1	.	.	.	.	+	2	2	1
<i>Trifolium fragiferum</i>	3	5	.	.	1	2	+	1	2	.	.	1	.	.
<i>Lotus pedunculatus</i>	.	.	.	.	2	2	+	+	+	.	+	.	.	.
<i>Mentha longifolia</i>	.	.	.	.	2	+	.	+	.	.	2	1	+	.
<i>Plantago major</i>	.	1	.	.	+	+	.	.	.	.	+	.	.	.
<i>Holcus lanatus</i>	.	.	+	.	1	.	+	1	.	.	.	.	.	.
<i>Agrostis stolonifera</i>	.	.	.	.	.	.	.	1	2	2	.	.	.	.
<i>Carex otrubae</i>	.	.	.	.	.	1	.	.	.	.	.	1	.	.
<i>Trifolium lappaceum</i>	.	.	.	.	.	.	.	.	.	.	.	.	+	1
<i>Juncus effusus</i>	.	.	.	.	.	.	.	+	.	.	.	.	.	.
<i>Bromus commutatus</i>	.	.	.	.	.	.	+	.	.	.	.	.	.	.
<i>Polypogon monspeliensis</i>	.	.	+	.	.	.	1	.	.	.	.	.	.	.
<i>Mentha pulegium</i>	1	+	.	.	.	1	.	.	.	.	.	.	.	.
Other species														
<i>Symphyotrichum squamatum</i>	1	1	3	1	1	+	2	1	+	2	.	+	1	+
<i>Lythrum junceum</i>	+	1	+	1	+	.	.	1	+	1	.	.	.	+
<i>Mentha aquatica</i>	1	1	.	.	3	+	1	1	3	2	.	.	.	1
<i>Lycopus europaeus</i>	.	.	2	1	2	1	.	3	1	.	.	1	+	1
<i>Cirsium creticum</i> subsp. <i>triumfettii</i>	2	.	.	.	4	1	2	.	+	.	1	1	.	.
<i>Rumex sanguineus</i>	1	.	.	.	2	1	2	.	.	.	1	1	.	.
<i>Pulicaria dysenterica</i>	.	.	.	.	+	+	.	2	.	2	.	.	.	.
<i>Torilis arvensis</i>	.	.	2	.	+	.	+	+	1	.	3	3	.	.
<i>Verbena officinalis</i>	+	1	.	.	+	.	.	.	.	.	+	1	1	1
<i>Cynodon dactylon</i>	2	1	.	.	.	.	.	.	.	1	2	1	.	.
<i>Centaurium erythraea</i>	.	1	.	.	.	.	.	.	.	1	.	.	1	+
<i>Trifolium squamosum</i>	.	.	+	.	.	.	.	.	.	1	1	2	.	.
<i>Daucus carota</i>	.	.	.	.	+	1	.	.	.	.	+	1	.	.
<i>Daucus broteroi</i>	.	.	.	.	.	.	.	.	.	.	+	1	.	+



*stolonifera* and *Juncus inflexus*) are also frequent and characterize the variant with *Juncus inflexus* (Tab. 6, Rel. 8, 9). The *Holoschoenetum vulgaris* prefers the base-

rich soils (García *et al.*, 2016) and tolerates temporary periods of dryness since demanding less water than other *Holoschoenetalia* plant communities.

Table 7. Riparian thickets and woods. *Tamarix africana* comm. (rel. 1-3) (*Tamaricion africanae*, *Tamaricetalia africanae*, *Nerio oleandri-Tamaricetea africanae*); *Salix alba* and *Populus alba* comm. (rel. 4-5) (*Populion albae*, *Populetales albae*, *Salicium purpureae-Populetea nigrae*); *Salicetum albo-brutiae* Brullo & Spampinato 1997 (rel. 6) (*Salicion albae*, *Salicetalia purpureae*, *Salicetea purpureae*)

Altitude (m asl)	55	55	55	55	55	60
Plot size (m <sup>2</sup> )	50	50	50	100	100	100
Tree cover (%)	-	-	-	80	80	100
Shrub cover (%)	100	100	100	20	20	50
Herb cover (%)	45	45	35	80	80	60
Species N.	14	9	8	18	17	17
Relevé N.	1	2	3	4	5	6
Characteristics						
<i>Tamarix africana</i>	5	5	4	.	1	+
<i>Vitex agnus-castus</i>	+	.	2	.	.	.
<i>Salix brutia</i>	.	.	.	.	.	2
<i>Salix alba</i>	.	.	.	4	4	5
<i>Populus alba</i>	.	.	.	2	3	.
<i>Populus nigra</i>	.	.	.	2	.	1
<i>Salix alba</i> (shrubs)	.	1	1	.	.	.
<i>Salix purpurea</i>	.	.	.	.	.	2
<i>Equisetum telmateia</i>	.	.	.	4	4	.
<i>Clematis vitalba</i>	.	.	.	.	1	3
<i>Carex pendula</i>	.	.	.	+	1	.
<i>Hypericum hircinum</i> subsp. <i>majus</i>	.	.	.	+	+	.
<i>Angelica sylvestris</i>	.	.	.	+	1	.
<i>Rumex sanguineus</i>	.	.	.	.	.	+
<i>Vitis vinifera</i>	.	.	.	.	.	1
<i>Eupatorium cannabinum</i>	.	.	.	1	1	.
<i>Mentha aquatica</i>	.	.	.	1	+	.
Other species						
<i>Rubus ulmifolius</i>	2	3	3	.	.	2
<i>Brachypodium sylvaticum</i>	2	.	.	.	.	3
<i>Equisetum ramosissimum</i>	1	.	.	.	.	1
<i>Phragmites australis</i>	.	1	.	.	.	1
<i>Holcus lanatus</i>	.	.	.	2	1	.
<i>Prunella vulgaris</i>	.	.	.	1	1	.
<i>Samolus valerandi</i>	.	.	.	1	1	.
<i>Doronicum orientale</i>	.	.	.	+	1	.
<i>Clinopodium vulgare</i> subsp. <i>arundanum</i>	.	.	.	+	+	.
<i>Potentilla reptans</i>	.	.	.	+	1	.
<i>Torilis arvensis</i>	.	1	1	.	.	.
<i>Scirpoides holoschoenus</i>	1	.	1	.	.	.
<i>Cynodon dactylon</i>	1	1	.	.	.	.

Other species: *Cytisus villosus*, *Euphorbia hirsuta*, *Melica arrecta* and *Melissa officinalis* subsp. *altissima* +, *Crataegus monogyna*, *Euphorbia characias* and *Oloptum miliaceum* 1 in 1; *Carex hirta*, *Galium palustre* subsp. *elongatum* and *Mentha longifolia* 1 in 2; *Asparagus acutifolius* +, *Rosa sempervirens* 2 in 3; *Trifolium pratense* +, *Lythrum junceum* and *Epilobium hirsutum* 1 in 4; *Tussilago farfara* + in 5; *Arum italicum* and *Rubia peregrina* +, *Convolvulus sylvaticus* and *Chaerophyllum temulum* 1, *Polypogon viridis* 2 in 6.

Localities: 1: Gambarella, 02.07.2009; 2,3: Case Gualdo, 03.07.2009; 4,5: Case Gualdo, 30.04.2012; 6: Tarsia Lake, Brullo & Spampinato, 1997.

## Riparian thickets and woods

***Tamarix africana*** community (Table 7, rel. 1-3). A shrubby community with *Tamarix africana*, *Vitex agnus-castus* floristically very poor. It is mainly found in several creeks of Tarsia Lake on alluvial deposits with a fine loamy-sandy texture. This plant community shows similarities with the *Tamarix africanae-Vitacetum agnicasti*, widespread along with the halophilous coastal environments of Calabria (Brullo & Spampinato, 1997; Maiorca et al., 2007).

***Salix alba-Populus alba*** community (Table 7, rel. 4, 5). A riparian plant community dominated by *Salix alba* and *Populus alba*. In the undergrowth, several hygrophilous species of the *Populetales albae* order occur. In the study area, riparian woods are rare and occur only in the narrow gorges crossed by short streams flowing in the western side of the lake. This pioneer forest community is subjected to periodical and destructive flooding, but it is able to recolonize alluvial sediments quickly.

***Salicetum albo-brutiae*** Brullo e Spampinato 1997 (Table 7, rel. 6). A shrubby or arborescent plant community dominated by *Salix alba* and other willows, such as *Salix brutia* and *Salix purpurea* (Brullo & Spampinato, 1997). The herbaceous layer consists of a few typical species of

open swamp habitats. The *Salicetum albo-brutiae* occurs on floods with a fine silty-sandy texture along the banks of the Crati River before it enters the Tarsia Lake.

## Syndinamism

The phytocoenoses around the Tarsia Lake, although subjected to a considerable anthropogenic disturbance, are well floristically and ecologically characterized. Their presence depends on the degree of edaphic humidity linked to filling and emptying the lake through the opening and closing of the dam.

**Spring vegetation of temporary ponds and muds geosigmetum.** This vegetation occurs in winter or spring on muddy sediments when the lake is empty (Figure 4). The *Rumici maritimi-Ranunculetum scelerati* grows on the water-saturated muds and it is the most widespread plant community from winter to spring. The *Filaginello uliginosae-Veronicetum peregrinae* develops in the driest muds. In the pools with water, the *Charetum vulgaris* algal community is found; on the contrary, the *Helosciadietum nodiflori* is presenting on the muds submerged by a few centimeters of water. All these plant communities form a mosaic with the thallophytic communities on silty soils (*Riccia glauca* community; *Botrydium granulati*) or with *Limosella aquatica* communities on sandy soil.

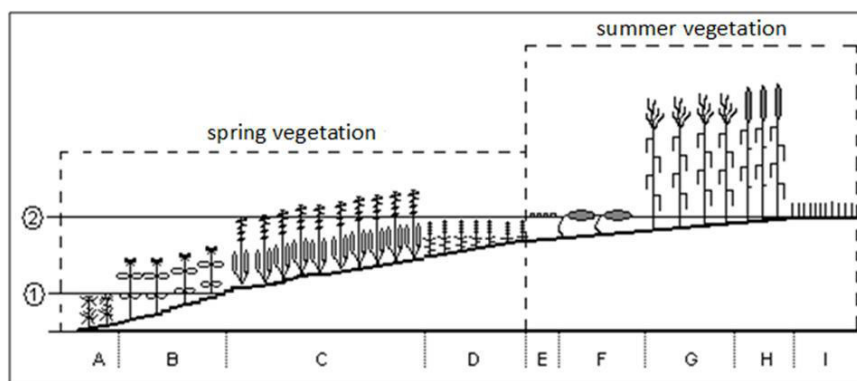


Figure 4. Transect of the main aquatic and marsh communities related to the water level during spring (1) and summer (2). A, *Charetum vulgaris*; B, *Helosciadietum nodiflori*; C, *Rumici maritimi-Ranunculetum scelerati*; D, *Filaginello uliginosae-Veronicetum peregrinae*; E, *Lemnetum gibbae*; F, *Potamogetonum nodosi* and/or *Ceratophylletum demersi*; G, *Polygono salicifolii-Phragmitetum communis*; H – *Typha sp.pl.* associations; I, *Bidenti tripartitae-Polygonetum mitis* and damp meadows of the *Molinio-Arrhenatheretea* class.

**Summer aquatic and marsh vegetation geosigmetum.** Due to lake filling during the summer, the muddy communities disappear. On the other hand, this allows for a greater development of aquatic vegetation (Figure 4). On the lake's surface, we can see the *Lemnetum gibbae* free-floating aquatic vegetation, whereas in the waters, the rooted-floating vegetation, such as the *Ceratophylletum demersi* and *Potamogetonum nodosi*, occurs. Over the river banks, the marsh plant communities characterised by helophytes are widespread (*Polygono salicifolii-Phragmitetum comunis*, *Typhetum angustifoliae*, *Typhetum latifoliae*). They are replaced

by damp meadows on the humid ground (*Loto tenuis-Paspaleum paspaloidis*; *Galio elongati-Juncetum inflexi*, *Holoschoenetum vulgaris*). On muddy sediments rich in nutrients and dry in the summer, the associations of the *Bidentetea tripartiti* class occur, such as the *Bidenti tripartitae-Polygonetum mitis*.

**Riparian woods and thickets geosigmetum.** The riverbank vegetation on alluvial soils along the banks of the Crati River, next Tarsia Lake, is formed by a pioneer willow shrub vegetation of the *Salicetum albo-brutiae*. However, the proximity of the watercourse to

crops or pastures does not allow the development of a large hygrophilous riparian forest community. Along short streams flowing in narrow gorges before entering the lake, sometimes dry in the summer, the hygrophilous riparian woods of the *Populetaia albae* are present. Instead, *Tamarix africana* thickets occur on alluvial and sandy sediments located at the mouth of these small streams.

## Conclusions

The vegetation study is fundamental in the management and planning of natural resources for the identification and assessment of habitats and to ensure and support the effectiveness of conservation activities. Our study highlighted and characterized many plant communities referable to natural or semi-natural habitats, according to the European Directive 92/43/EEC (Biondi *et al.*, 2009, 2012; Zivkovic *et al.*, 2017) (Table 8). Among those habitats, the most important for biodiversity conservation are “3170\*, Mediterranean temporary ponds” and “3130 - Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*”, both typical of temporarily flooded pools. Significant areas are occupied by habitats “3150, Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation” widespread on most of the lake’s waters and “6420, Mediterranean tall humid herb grasslands of the *Molinio-Holoschoenion*”.

On the whole, the marsh vegetation of Tarsia Lake presents a high spatial heterogeneity and brings together

a complex mosaic of phytocoenoses according to changes in the water regime and to water availability. Some detected phytocoenoses are of particular interest because they are located at the border of the distribution range, such as *Limosella aquatica* and *Botrydium granulati* communities, which are common in the temperate European territories, while becoming rare in the Mediterranean environment. The peculiar mesoclimatic conditions characterizing the study area probably favor the presence of these phytocoenoses as well as *Filaginello uliginosae-Veronicetum peregrinae* and *Rumici maritimi-Ranunculetum scelerati* associations.

The importance of Tarsia Lake wetlands has been recognized at Community level with the establishment of the SCI “Lago di Tarsia - IT9310055” and at the local level with the Regional Nature Reserve “Lago di Tarsia”, aimed at protecting the habitats of the marshlands for the conservation of very rare plant and animal species in southern Italy.

Wetlands in Mediterranean are recognized as an important part of biodiversity, often subjected to threats and destruction, and reduced to a few areas strongly threatened by anthropogenic actions. In Italy, Calabria does not escape this situation, because about 90% of wetlands have disappeared over the last century (Spampinato *et al.*, 2007). Our study confirms that artificial lakes can be crucial in order to increase humid habitats and to partially compensate for the loss of natural wetlands. The Tarsia Lake preserves flora and vegetation of considerable naturalistic interest, which the predisposition of an adequate program of monitoring and protection is required.

Table 8. Habitats of Community Interest according to European Directive 92/43/EEC.

Natura 2000 Habitat	Syntaxon
3150 Natural eutrophic lakes with <i>Magnopotamion</i> or <i>Hydrocharition</i> -type vegetation	<i>Ceratophylletum demersi</i> <i>Lemnetum gibbae</i> <i>Callitrichetum palustris</i> <i>Potamogetonetum nodosi</i> <i>Callitrichetum palustris</i>
3130 Oligotrophic to mesotrophic standing waters with vegetation of the <i>Littorelletea uniflorae</i> and/or of the <i>Isoëto-Nanojuncetea</i>	<i>Filaginello uliginosae-Veronicetum peregrinae</i> <i>Limosella aquatica</i> community
3170 Mediterranean temporary ponds (priority habitat)	<i>Isoëtetum duriei</i>
3270 Rivers with muddy banks with <i>Chenopodium rubri</i> p.p. and <i>Bidention</i> p.p. vegetation	<i>Bidenti tripartitae-Polygonetum mitis</i> <i>Rumici maritimi-Ranunculetum scelerati</i> <i>Polygono lapathifolii-Xanthietum italici</i>
6420 Mediterranean tall humid herb grasslands of the <i>Molinio-Holoschoenion</i>	<i>Holoschoenetum vulgaris</i> <i>Loto tenuis-Paspaleum paspaloidis</i> <i>Galio elongati-Juncetum inflexi</i>
92A0 <i>Salix alba</i> and <i>Populus alba</i> galleries	<i>Salicetum albo-brutiae</i> <i>Salix alba</i> and <i>Populus alba</i> community
92D0 Southern riparian galleries and thickets ( <i>Nerio-Tamaricetea</i> and <i>Securinegion tinctoriae</i> )	<i>Tamarix africana</i> community

**Syntaxonomical scheme**

- CHARETEA FRAGILIS* F. Fukarek ex Krausch 1964  
*Charetalia hispidae* Sauer ex Krausch 1964  
*Charion vulgaris* (Krause ex Krause & Lang 1977) Krause 1981  
*Charetum vulgaris* Corillion 1957
- LEMNETEA MINORIS* Tüxen ex O. Bolòs & Masclans 1955  
*Lemnetalia minoris* Tüxen ex O. Bolòs & Masclans 1955  
*Lemnion minoris* Tüxen ex O. Bolòs & Masclans 1955  
*Lemnetum gibbae* Miyawaki et J. Tüxen 1960
- POTAMOGETONETEA PECTINATI* Klika in Klika & Novák 1941  
*Potamogetonetalia pectinati* Koch 1926  
*Potamogetonion pectinati* Libbert 1931  
*Ceratophylletum demersi* Hild 1956  
*Potamogetonetum nodosi* (Soó 1960) Segal 1964  
*Callitricho hamulatae-Ranunculetalia aquatilis* Passarge ex Theurillat in Theurillat et al. 2015  
*Ranunculion aquatilis* Passarge ex Theurillat in Theurillat et al. 2015  
*Callitrichetum palustris* (Dihoru 1975 n.n.) Burescu 1999
- CLADONIO DIGITATAE-LEPIDOZIETEA REPTANTIS* Ježek et Vondráček 1962  
*Diplophylletalia albicantis* Philippi 1963  
*Physcomitrellion patentis* Hübschmann 1957  
*Riccia glauca* community  
*Botrydium granulatatum* Hübschmann 1957
- ISOËTO-NANOJUNCETEA* Br.-Bl. et Tx. in Br.-Bl. et al. 1952  
*Isoëtetalia durieui* Br.-Bl. 1936  
*Isoëtium durieui* Br.-Bl. 1936  
*Isoëtetum duriei* Br.-Bl. 1935  
*Nanocyperetalia flavescens* Klika 1935  
*Nanocyperion flavescens* Koch 1926  
*Filaginello uliginosae-Veronicetum peregrinae* Molero Brion. & Romo 1988  
*Eleocharition soloniensis* Philippi 1968  
*Limosella aquatica* community
- BIDENTETEA TRIPARTITAE* Tüxen, Lohmeyer & Preising ex Von Rochow 1951  
*Bidentetalia tripartitae* Br.-Bl. & Tüxen ex Klika in Klika & Hadac 1944  
*Bidention tripartitae* Nordhagen ex Klika et Hadac 1944  
*Bidenti tripartitae-Polygonetum mitis* (Roch. 1951) T. Tüxen 1979  
 var. with *Bidens frondosa*  
*Rumici maritimi-Ranunculetum scelerati* Oberdorfer 1957  
*Chenopodion rubri* (Tüxen 1960) Hilbig & Jage 1972  
*Polygono lapathifolii-Xanthietum italici* Pirola & Rossetti 1974
- PHRAGMITO AUSTRALIS-MAGNOCARICETEA ELATAE* Klika in Klika & Novák 1941  
*Phragmitetalia australis* Koch 1926  
*Phragmition communis* Koch 1926  
*Polygono salicifolii-Phragmitetum comunis* Barbagallo, Brullo & Furnari 1979  
*Typhetum angustifoliae* (Allorge 1921) Pignatti 1953  
*Typho angustifoliae-Schoenoplectetum tabernaemontani* Br.-Bl. & Bolòs 1957  
*Typhetum latifoliae* Nowiński 1930  
*Nasturtio officinalis-Glyceretalia fluitantis* Pignatti 1953  
*Glycerio fluitantis-Sparganion neglecti* Br.-Bl. & Sissingh in Boer 1942  
*Sparganium neglectum* community  
*Apion nodiflori* Segal in Westhoff et Den Held 1969  
*Helosciadietum nodiflori* Maire 1924
- MOLINIO-ARRHENATHERETEA* Tüxen 1937  
*Holoschoenetalia vulgaris* Br.-Bl. ex Tchou 1948  
*Paspalo distichi-Agrostion semiverticillatae* Br.-Bl. in Br.-Bl., Roussine & Nègre 1952  
*Loto tenuis-Paspaleum paspaloidis* Biondi, Casavecchia & Radetic 2002  
*Agrostio stoloniferae-Scirpoidion holoschoeni* De Foucault 2012  
*Galio elongati-Juncetum inflexi* Minissale & Spampinato 1985  
*Holoschoenetum vulgaris* Maire 1924
- NERIO OLEANDRI-TAMARICETEA AFRICANAE* Br.-Bl. & O. Bolòs 1958  
*Tamaricetalia africanae* Br.-Bl. & O. Bolòs 1958 em. Izco, Fernández-González & A. Molina 1984

*Tamaricion africanae* Br.-Bl. & O. Bolòs 1958

*Tamarix africana* community

*SALICI PURPUREAE-POPULETEA NIGRAE* Rivas-Martínez & Cantó ex Rivas-Martínez, Bascónes, T.E. Díaz, Fernández-González & Loidi 2001

*Populetalia albae* Br.-Bl. xx Tchou 1948

*Populion albae* Br.-Bl. ex Tchou 1948

*Salix alba* and *Populus alba* community

*Salicetalia purpureae* Moor 1958

*Salicion albae* Soó 1930

*Salicetum albo-brutiae* Brullo & Spampinato 1997

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