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Cyperus-dominated vegetation in the eastern Po river

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Abstract

The ephemeral vegetation dominated by *Cyperus* sp. pl. was surveyed and analyzed along the eastern trait of the Po River (Po Plain, Italy). Two formerly described communities were recognized: *Cyperetum esculenti* and *Amaranthus tuberculatus*-phytocoenon. A third greater cluster is assigned to a new association: *Cyperetum micheliano-glomerati*. It is characterized by *Cyperus glomeratus*, *C. michelianus*, *C. odoratus* and *C. squarrosus*, that have been detected on over 75 % of the relevés. The main floristic and ecological traits of these detected vegetation types are discussed.

Keywords

Bidention, *Chenopodion rubri*, *Cyperaceae*, Italy, phytosociology, therophytes

Introduction

The biodiversity changes caused by human activities are global-scale phenomena; invasive alien species (IAS) threat the diversity in the European countries from a biological and ecosystemic perspective. Following the milestone set by the DAISIE Project (an overview is in Lambdon et al. 2008), many European researchers have been involved in expanding the knowledge of local and national invasive alien plants (e.g. for Italy, Galasso et al. 2018). The invasiveness of a single alien species may cause different impacts, due to the different degrees of resistence or resilience shown by habitats and phytocoenoses (Richardson and Pyšek 2006). Nowadays a major challenge is to clarify the impact of invasive alien plants on the natural habitats, merging the data on number and invasiveness of the alien species and relating them to the vulnerability of those habitats.

The Po Plain, in Northern Italy, is one of the European territories most invaded by alien plant species (EEA 2015). The Po river bed acts as habitat corridor, so that many alien pioneer species easily become invasive. Many alien plants are typical of riverine environments and cannot expand beyond the embankments; other ruderal and synanthropic entities are characteristic of the crops, located either between the embankments or out of them, e.g. the poplar clone crops.

Some case studies showed that riparian invasive plants can change the natural habitats: fast-growing trees and shrubs can affect river biodynamics, sedimentation and erosion processes (van Oorschot et al. 2017). Perennial tall herbs as *Reynoutria* spp. and annual vines as *Humulus japonicus* or *Sicyos angulatus* can create dense canopies that outcompete other species (Gerber et al. 2008; Balogh and Dancza 2008; Zhao et al. 2019).

The late summer vegetation of the Po river bed is composed of a set of generalist, nitrophilous species, mixed with other taxa that show peculiar ecological preferences, especially about water availability and substrate texture. These surfaces are free from running waters only for few months or weeks a year: therefore, the plants colonizing them need to start and complete their life cycle during this short time available. The weather trends and the sediments storage caused by floods influence the extent and duration of water-free surfaces from year to year, as well as the cover of late-summer pioneer vegetation. This is a suitable environment for therophytes, like annual *Cyperus* species, *Echinochloa crus-galli*, *Eragrostis pectinacea*, *Lindernia dubia*, *Panicum dichotomiflorum*, *Portulaca oleracea*, *Rorippa palustris*. These taxa release a stable seed stock in the ground, that is ready to germinate as soon as possible (van der Walk 1981; Assini 2001). Despite the relate dynamics of spreading and recolonisation are various

and unpredictable, a significant advantage is given by the ability to germinate before the water fully recedes (Abernethy and Willby 1999).

The genus *Cyperus* in Italy includes about 30 species. Many of these are expanding their distribution range, favoured by global warming. These taxa develop late in the season, when the river bed partially emerge from the water due to the decreasing flow, and/or when the waters of the rice-fields are heated enough by the sun. Ten *Cyperus* species grow along the Po river in the study area (Pellizzari and Verloove 2017). Among them *C. flavescens*, *C. fuscus* and *C. michelianus* are native. *C. eragrostis*, *C. odoratus* and *C. squarrosus* are neophytes from tropical America (Petrik 2003; Verloove 2014). *C. microiria* is native to eastern Asia (Verloove 2014). *C. difformis, C. esculentus* and *C. glomeratus* are paleo-subtropical species, native in some Mediterranean areas, but considered as aliens in Italy (Galasso et al. 2018). They are spreading in temperate areas.

This work aims to analyse the ephemeral late-summer vegetation dominated, or mainly characterized, by *Cyperus* sp.pl. Those types are threatened by a pool of Invasive Alien Species (Janssen et al. 2016) and poorly known in the study area. Few types of ephemeral vegetation of river beds are recognized in the Po Plain, representing the main vegetation aspects at the minimum river flow (Sartori and Bracco 1995). These types develop on stretches of the river bed, like oxbows, that are submerged during most of the year, but that in summer are separated from the main course by islands or sand banks, so that they completely dry. Some of these communities are dominated by low-grown species and mainly ascribed to the *Cyperetum flavescentis* (*Nanocyperetalia*, *Isoëto-Nanojuncetea*) (Biondi et al. 1997; 1999; Assini et al. 2010). Other communities are featured by medium and tall-size therophytes and were framed in the *Bidentetalia tripartitae* and *Bidentetea* (Biondi et al. 2003; 2012; Bolpagni 2013b). Outside the Po Plain, the main studies to the hygro-nitrophilous annual vegetation are focused on communities dominated by native species, in which the flatsedges and galingales usually play a minor role (Felzines and Loiseau 2005; de Foucault 2013 a, b; Rennwald 2000; Schneider-Binder 2020). The scheme of Brullo and Minissale (1998) for the Western Palaearctic region needs to be upgraded by a large amount of new data, mainly for France and Spain, but also for the Italian Peninsula (Deil 2005). Only few papers, however, refer to the Po river traits.

Materials and methods

Study area

The Po river stretches for 652 km in Northern Italy, from Western Alps to the Adriatic Sea. It receives the last left tributary (Mincio river) 156 km upstream of the mouth, while the final right-handed tributary (Panaro river) 107 km upstream of the mouth. In this trait the river has flooded six times in the last two centuries (Turitto et al. 2004). After the last disastrous flood occurred in 1951, the main river bed has been permanently embanked and periodically dredged. The bends, banks and oxbows located in the upstream traits of the Po river can foster the natural ephemeral vegetation; the downstream river management as a stabilized channel, partially precludes spatial heterogeneity and habitats diversity (Shankman 1996). The relevés were carried out along the main course of the Po river, between Sermide and Panarella, upstream to the river channelization into the Po Delta branches (Fig. 1).

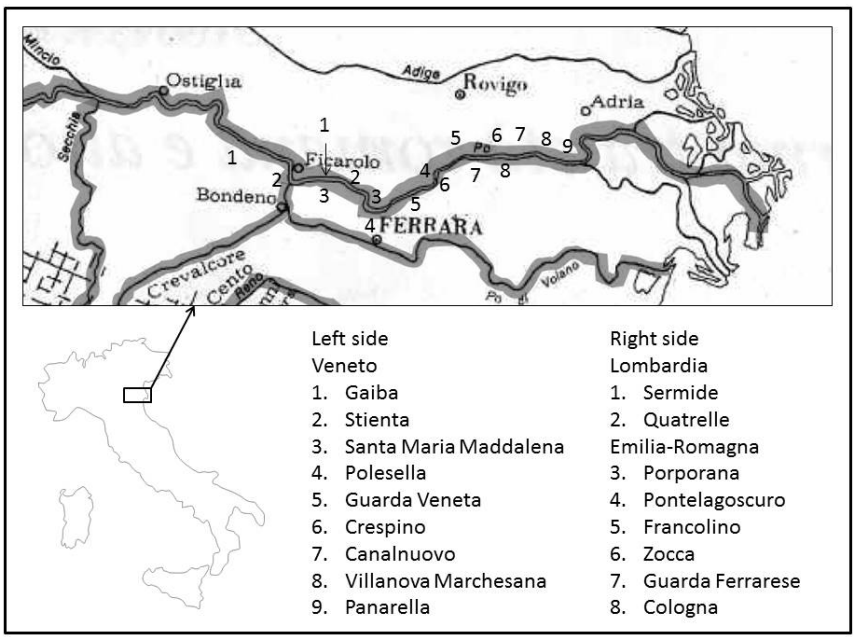

Figure 1. Study area and relevé locations.

The riverine environment is very homogeneous, due to the stabilization of the embankments, which are over 10 m high. It is distinct from the surrounding plain, lower in elevation and widely ploughed and cultivated. In the final portion of the Po river, two annual maximums are detectable in the water flow, in May and in November, respectively. From the end of May the hydrometric levels start decreasing to the minimum, which is usually reached in August, and then grow back. The decrease in solid transport due to decreasing flow significantly affects the fluvial ecosystem, causing a strong lowering of the river bed, and a widespread coastal erosion by the Adriatic Sea. The restrained summer flow and the increasing groundwater pumping for agricultural and industrial uses have led to the intrusion of salt groundwater up to 20 km in the inland (Tornatore 2008).

Following the application to Italy of the wordlwide bioclimatic classification (Rivas Martinez et al. 2011), the study area belongs to the Temperate (steppic) Macrobioclimate. The Bioclimate shifts from continental westwards to steppic eastwards. The ombrotype is lower subhumid and the thermotype is upper mesotemperate (Pesaresi et al. 2017).

Field survey

132 original relevés were done from August to October 2016, according to the phytosociological approach (Braun-Blanquet 1964; Biondi 2011). Date and location of each relevé are listed in Appendix I. Species names follow the italian checklists (Bartolucci et al. 2018; Galasso et al. 2018). Syntaxonomy follows Biondi et al. (2014).

Data analysis

The species that appeared only in 1 or 2 relevés were removed from the original matrix. The two matrixes were compared through Euclidean distance, then the reduced matrix (132 relevés for 45 species) was subjected to cluster analysis using an average-linkage algorithm in the software Cluster, version 3.0 (Stanford University 1999). The corresponding dendrogram was obtained using JavaTreeView (Saldanha 2004).

To underline the main ecological features of each observed vegetation type, the Ellenberg indicator values were calculated for each obtained cluster, and then the ecograms and the mean indicator values were compared (Pignatti et al. 2005). Life forms (Raunkiaer 1934) and chorological spectra were also calculated for each one of the three groups. The chorotypes follow Pignatti et al. (2017-2019). Archaeophytes (A) and neophytes (N) were detected according to Galasso et al. (2018).

Results

Three main groups were obtained from the cluster analysis, each one corresponding to a distinct vegetation type (Fig. 2).

The groups 1 and 2 are distinct from the last big cluster. The group 1 includes relevés dominated by *Cyperus esculentus*, with a constant presence of *Amaranthus tuberculatus*, *Xanthium italicum* and *Portulaca oleracea* (Tab. 1). This vegetation type develops mainly along the sand bank borders, that are uncovered by the water and hard dried in summer. *C. esculentus* is able to colonize this environment

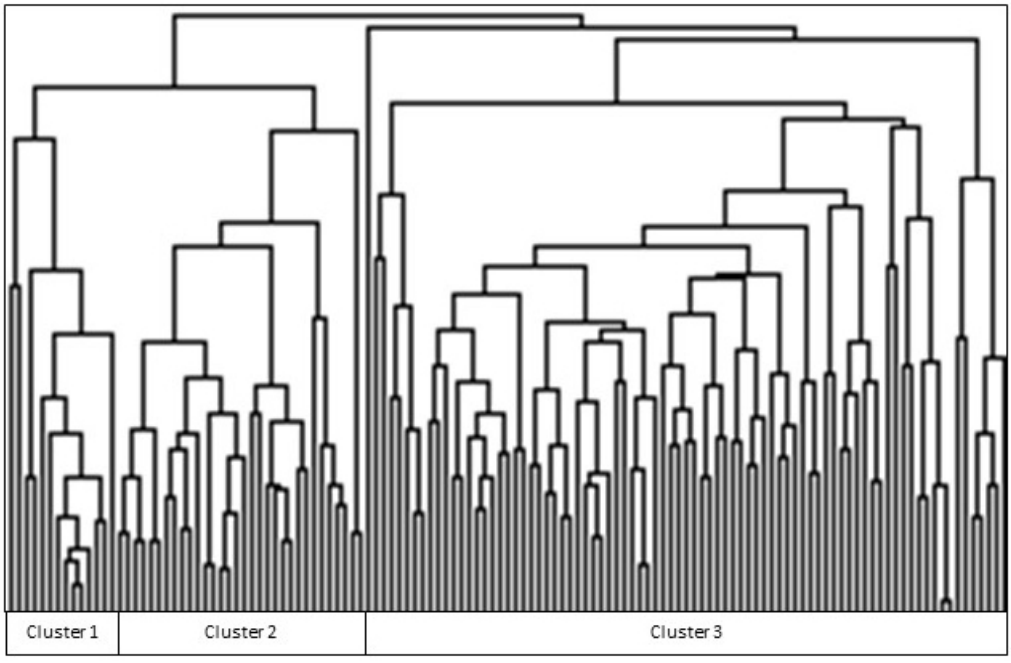

Figure 2. The dendrogram resulting from the cluster analysis. Each group is described in the text.

Table 1. *Cyperetum esculenti* Wisskirchen 1995.

Relevé number	84	49	103	76	67	27	19	21	20	22	34	80	86	47
Cover %	100	80	100	90	70	100	70	80	80	80	80	100	50	90
surface sq.m	8	10	10	8	10	12	4	6	4	8	10	10	8	8
Species number	11	14	11	10	6	7	3	6	4	5	5	6	5	10
Cyperus esculentus L.	4	2	3	4	3	3	4	4	4	4	4	4	3	4
Amaranthus tuberculatus (Moq.) J.D. Sauer	2	1	2	2	.	3	1	2	1	2	2	2	1	2
Xanthium italicum Moretti	1	1	2	3	1	2	.	1	2	2	2	3	1	1
Portulaca oleracea L.	.	1	2	2	1	.	2	+	1	+	2	1	2	1
Echinochloa crus-galli (L.) P. Beauv. subsp. *crus-galli*	3	2	3	1	1	.	.	.	.	.	1	.	.	.
Cyperus glomeratus L.	2	2	2	2	.	.	.	.	.	.	.	1	.	.
Cyperus squarrosus L.	2	3	1	.	.	1	.	.	.	+	.	.	.	.
Eragrostis pectinacea (Michx.) Nees	.	.	2	2	1	.	.	.	.	.	.	2	2	.
Panicum dichotomiflorum Michx.	1	.	2	2	.	.	.	.	.	.	.	.	.	+
Persicaria lapathifolia (L.) Delarbre	.	.	1	1	.	.	.	1	.	.	.	.	.	1
Cyperus fuscus L.	2	1	1	.	.	.	.	.	.	.	.	.	.	.
Cyperus michelianus (L.) Delile	.	2	.	.	.	+	.	.	.	.	.	.	.	.
Bidens frondosa L.	.	1	.	1	.	.	.	.	.	.	.	.	.	.
Sicyos angulatus L.	.	1	.	.	.	1	.	.	.	.	.	.	.	.
Lindernia dubia (L.) Pennell	+	1	.	.	.	.	.	.	.	.	.	.	.	.
Salix alba L. (pl.)	.	.	.	.	.	+	.	.	.	.	.	.	.	1
Sporadic species	2	2	.	.	1	.	.	1	.	.	.	.	.	3

defending from surface dryness by means of deep and long rhyzomes. These stands develop further high from the water than those of the *Polygono lapathifolii-Xanthietum italici*, which grows in the same sandy substrates (Bolpagni 2013b). Annual flatsedges, like other silty-clay substrate species (e.g. *Lindernia dubia*, *Eclipta prostrata*) are almost absent. These communities are ascribable to the *Cyperetum esculenti*, present in the middle-European river beds, e.g. in Germany (Wisskirchen 1995), and France (Felzines and Loiseau 2005). In Italy it was detected along the Po river in Lombardy and Emilia-Romagna (Bolpagni 2014; Braghiroli and Bolpagni 2016), and along the Tiber river (Lastrucci et al. 2012).

The group 2 gathers 32 relevés dominated by *Amaranthus tuberculatus*, a north-American dioecious amaranth, that has recently become invasive in Italy, where it grows in many disturbed habitats (Iamonico 2015). Its distribution is not influenced by sediment texture, though it often grows on sandy substrates. Similar communities were considered as a form of the pebbly-sandy shore community *Polygono hydropiperis-Bidentetum tripartitae* (Pellizzari 2009). In the present analysis, we follow the attribution to an *Amaranthus tuberculatus*-phytocoenon, characterized by this species and a pool of alien pioneer entities, much of them are typical of *Bidentetalia* (Bolpagni 2013b; Braghiroli and Bolpagni 2016). The cluster is characterized also by the high frequence of four flatsedge species (*Cyperus squarrosus*, *C. michelianus*, *C. esculentus* and *C. odoratus*) (Tab. 2).

The last big cluster (group 3) is interpretable as a single vegetation type, able to grow on medium-fine substrates. This cluster is very homogeneous, especially in its central part. The most frequent species of this group is *Cyperus glomeratus* (100 %), followed by *C. odoratus*, *Echinochloa crus-galli*, *C. michelianus*, *C. squarrosus* and *Amaranthus tuberculatus*, all reaching over 75 %.

The average species number of the whole group results in 11.5; some relevés, to the left side of the group, are slightly different based on the higher average number (12.6), due to the presence of *Amaranthus tuberculatus*, *Eragrostis pectinacea*, *Portulaca oleracea* and other species that document a major disturbance, while other *Cyperus* species play a minor role.

The central part of the cluster represents the typical aspect of the community: *C. odoratus*, *C. michelianus* and *C. squarrosus* may show equal or higher cover than *C. glomeratus*. *Lindernia dubia* and *Panicum dichotomiflorum* are also frequent species, when *Amaranthus tuberculatus* decreases and runs out (Tab. 3).

Given the homogeneity and distictiveness of this big cluster, a new association is described: *Cyperetum micheliano-glomerati* ass. nova *hoc loco* (*Bidention*, *Bidentetalia*, *Bidentetea*). (*Holotypus*: rel. 89* tab. 3, Porporana – FE, 2016 09 12). Its characteristic species are *C. glomeratus*, *C. michelianus*, *C. odoratus*, *C. squarrosus*. The vegetation type appears as therophytic fringes or meadows, which are frequently arranged in two layers. These flatsedge meadows are very dense along the gentle slopes and

Table 2. *Amaranthus tuberculatus* – phytocoenon.

Relevé number	31	28	30	29	41	40	18	14	6	7	45	25	24	26	23	13	3	43	44	32	33	35	36	38	39	59	8	17	4	1	62	61
Cover %	100	80	90	90	90	80	100	90	90	100	90	90	80	90	80	90	90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Surface sq.m	12	20	12	20	8	6	8	10	10	10	10	12	10	10	12	10	10	10	8	16	14	12	10	12	12	6	10	10	10	10	16	12
Species number	12	10	13	11	8	10	5	8	9	7	11	6	6	8	7	3	9	13	10	13	11	8	11	8	10	11	5	5	7	7	8	9
Amaranthus tuberculatus (Moq.) J.D. Sauer	4	3	4	4	3	2	2	2	2	3	2	3	3	4	4	5	3	3	3	2	3	3	2	2	2	1	1	4	3	4	5	5
Cyperus michelianus (L.) Delile	1	1	2	1	2	2	1	2	2	2	2	.	.	2	2	1	1	2	1	2	1	2	1	3	3	4	5	3	4	2	1	1
Cyperus squarrosus L.	2	2	2	1	2	3	3	3	3	3	3	4	3	2	1	1	2	1	1	3	2	2	2	3	3	.	.	.	.	.	1	2
Cyperus esculentus L.	2	1	1	1	2	2	3	3	1	2	2	1	1	1	1	.	.	1	.	1	2	1	1	.	.	.	.	.	.	.	.	.
Cyperus odoratus L.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	1	3	4	3	1	3	4	3	2	1	1	.	1	+	.	1
Species of higher syntaxa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Echinochloa crus-galli (L.) P. Beauv. subsp. *crus-galli*	1	.	.	.	+	1	.	.	1	1	+	.	.	.	.	.	1	2	.	1	+	.	+	.	+	2	.	1	+	1	.	.
Rorippa palustris (L.) Besser	1	2	1	1	2	2	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	1	.	.	.	.	.	.
Persicaria lapathifolia (L.) Delarbre	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	1	2	2	1	1	+	.	.	.	.	+	.	.	.
Bidens frondosa L.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	1	1	.	+	.	1	+	+	.	.	1	.	.
Xanthium italicum Moretti	.	.	.	.	.	.	+	.	.	.	.	.	.	1	1	.	1	1	1	+	.	.	.	.	.	1	.	.	.	.	.	.
Cyperus glomeratus L.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.	.	2	2
Persicaria maculosa Gray	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	2
Lycopus europaeus L.	1	+	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.
Rorippa prostrata (J.P.Bergeret) Schinz & Thell.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	1	.	1	.	.	.	.	.	.	.
Ranunculus sceleratus L.	+	+	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bidens vulgata Greene	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Panicum dichotomiflorum Michx.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Bidens connata Muhl. ex Willd.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Mollugo verticillata L.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Other species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Portulaca oleracea L.	1	+	1	+	3	2	.	.	.	.	.	.	.	.	.	.	+	1	.	1	2	2	2	1	2	.	+	.	.	.	.	.
Lindernia dubia (L.) Pennell	+	.	1	1	1	2	.	.	.	.	1	.	.	.	.	.	.	1	1	1	1	1	1	2	1	1	.	.	.	.	.	.
Salix alba L. (pl.)	.	.	.	.	.	.	.	1	.	.	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	2	2
Paspalum distichum L.	.	.	.	.	.	.	.	.	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
Artemisia annua L.	.	.	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.
Lythrum salicaria L.	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eclipta prostrata (L.) L.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 2. Continuation.

Relevé number	31	28	30	29	41	40	18	14	6	7	45	25	24	26	23	13	3	43	44	32	33	35	36	38	39	59	8	17	4	1	62	61
Cover %	100	80	90	90	90	80	100	90	90	100	90	90	80	90	80	90	90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Surface sq.m	12	20	12	20	8	6	8	10	10	10	10	12	10	10	12	10	10	10	8	16	14	12	10	12	12	6	10	10	10	10	16	12
Species number	12	10	13	11	8	10	5	8	9	7	11	6	6	8	7	3	9	13	10	13	11	8	11	8	10	11	5	5	7	7	8	9
Sicyos angulatus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1
Ludwigia peploides (Kunth) P.H.Raven subsp. *montevidensis* (Spreng.) P.H.Raven	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chenopodium album L. subsp. *album*	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sporadic species	1	.	2	.	.	1	.	.	.	.	2	.	1	.	.	.	1	1	1	.	.	.	.	.	.	1	.	.	.	.	.	.

sparser on the dry bottom of the oxbows, marked by the characteristic polygonal muds. The upper level contacts of the community are often several communities of *Bidention* or *Chenopodion rubri*, such as the *Amaranthus tuberculatus*-phytocoenon or the *Cyperetum esculenti*, whilst the lower level contacts are carpets of *Eclipta prostrata*, *Lindernia dubia* or rarely *Ludwigia peploides* subsp. *montevidensis*. These reptohelophytic species tend to grow also into a shallow water layer.

The main ecological traits of the observed vegetation types are confirmed by the comparison of the mean Ellenberg values calculated for each group of relevés (Tab. 4). The ecograms are basically similar, with all the vegetation types showing high values for light, temperature and moisture; the indicator values for continentality, soil reaction and nutrients are lower (Fig. 3). The *Amaranthus tuberculatus*-phytocoenon shows the highest N value (6.25), due to the presence of a pool of summer-annual weeds, that also colonize crops and poplar plantations of the Po plain.

The *Cyperetum micheliano-glomerati* shows the highest moisture index (7.89). It is characterized also by high light and temperature, due to its tendency to grow in the lowest parts of the dried river bed, that are far from temporary shading effects.

The three recognized vegetation types show the typical traits of the pioneer ephemeral vegetation, as it is clearly showed by the life form spectra, that are dominated by therophytes (Fig. 4). *Cyperus glomeratus*, often a helophyte in reedbeds, behaves as annual in the surveyed environments, spreading from the spring seed stock. The bar graph data include the sporadic species. If these are neglected, the therophyte rate rises on *Cyperetum micheliano-glomerati* from 64% to 89.2%.

In the chorological spectra, neophytes are the main groups (*Cyperetum esculenti* 52%; *Amaranthus*-phytocoenon 43.6%; *Cyperetum micheliano-glomerati* 45.3%), but also the other major groups have a wide distribution (Cosmopolitan/Subcosmopolitan, Eurasian incl. Palaeotemperate) (Fig. 5).

Discussion and conclusions

Both *Cyperetum esculenti* and *Amaranthus tuberculatus*-phytocoenon, as the above mentioned *Polygono-Xanthietum*, *Polygono-Chenopodietum* known from Lombardy (Sartori and Bracco 1995; Assini et al. 2010) and *Echinochloo-Polygonetum lapathifolii* known from Tuscany (Lastrucci et al. 2014), are included in the *Chenopodion rubri* of *Bidentetalia* and *Bidentetea tripartitae*. Felzines and Loiseau (2005) suggest to divide the *Chenopodion rubri* in three sub-alliances. One of these, *Eragrostienion pilosae*, is also characterized by *Cyperus esculentus* and *Eragrostis pectinacea*, and includes the *Cyperetum esculenti*.

The *Amaranthus tuberculatus*-phytocoenon could provide the basis for the description of a new association, dominated by the wide spectrum weed *A. tuberculatus*,

Table 3. *Cyperetum micheliano-glomerati* ass. nova (part I).

Relevé number	117	85	73	74	102	121	120	119	107	108	70	104	69	89*	105	72	65	106	79	99	83	71	42	127	58	56	57
Cover %	100	90	100	100	90	100	90	80	100	90	100	100	100	90	100	100	90	100	100	80	100	100	100	100	100	90	100
Surface sq.m	4	10	8	12	8	10	10	8	20	10	8	14	10	10	10	14	12	20	20	10	12	12	12	16	16	12	12
Species number	13	15	11	15	13	14	12	8	13	14	11	13	16	12	14	9	12	13	10	18	14	12	10	11	7	7	8
Character species																											
Cyperus glomeratus L.	3	4	3	3	3	4	3	3	4	2	3	4	4	3	4	4	3	4	5	3	4	2	3	2	2	3	2
Cyperus odoratus L.	2	1	.	1	1	1	.	.	2	3	2	2	2	2	2	3	2	2	2	2	3	3	2	2	3	2	2
Cyperus michelianus (L.) Delile	1	1	1	.	.	1	.	.	1	2	1	2	2	2	2	2	2	2	1	2	2	3	3	4	4	4	3
Cyperus squarrosus L.	.	2	2	.	1	1	2	2	2	1	2	2	2	1	2	1	1	1	.	1	1	2	2	2	1	1	2
Alliance, order, class species																											
Echinochloa crus-galli (L.) P. Beauv. subsp. *crus-galli*	1	.	2	2	.	2	2	1	1	1	.	1	+	1	2	1	2	2	2	+	2	2	1	1	1	+	.
Amaranthus tuberculatus (Moq.) J.D. Sauer	1	3	4	2	2	3	2	2	.	.	1	1	2	1	1	1	2	1	2	2	2	1	2	+	.	1	2
Lindernia dubia (L.) Pennell	.	1	.	1	2	.	.	.	1	2	1	1	1	2	2	2	2	1	2	2	2	2	1	+	.	.	.
Panicum dichotomiflorum Michx.	2	+	2	1	1	.	.	.	+	1	.	1	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.
Xanthium italicum Moretti	.	.	.	2	1	.	+	.	+	.	2	.	+	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Portulaca oleracea L.	.	.	2	2	3	2	+	2	.	.	.	1	+	.	.	.	+	.	.	+	.	+	.	1	.	.	.
Persicaria lapathifolia (L.) Delarbre	1	.	.	1	+	1	+	1	.	.	.	.	.	+	.	.	1	+	1	.	.	.	.	.	.	.	.
Cyperus esculentus L.	.	.	.	2	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Bidens vulgata Greene	1	.	1	.	.	+	.	.	1	+	+	.	.	.	+	.	.	+	+	1	.	2	1	.	.	.	.
Artemisia annua L.	.	+	+	+	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.
Bidens connata Muhl. ex Willd.	+	.	.	1	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.
Rorippa palustris (L.) Besser	.	+	1	.	.	+	.	.	.	1	.	.	+	.	+	.	.	.	.	2	1	.	+	.	.	.	.
Lycopus europaeus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Bidens frondosa L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Ranunculus sceleratus L.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	+	.	.	.	.	.	.
Persicaria dubia (Stein.) Fourr.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Other species																											
Cyperus fuscus L.	1	1	.	2	2	2	3	3	4	3	2	2	2	2	1	2	2	4	3	1	1	1	.	.	.	.	.
Eragrostis pectinacea (Michx.) Nees	.	2	1	3	1	2	2	2	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salix alba L. (pl.)	.	.	.	.	.	.	.	.	1	.	.	2	1	.	1	.	.	2	.	2	1	.	.	.	.	2	1
Cyperus difformis L.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	+	.	.	.
Cyperus microiria Steud.	.	.	.	1	1	2	1	.	.	1	1	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Eclipta prostrata (L.) L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	1	.	.	.	.	.	.
Ammannia coccinea Rottb.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Sicyos angulatus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Sporadic species	2	3	.	.	.	.	1	.	1	1	.	.	2	1	3	.	.	.	.	1	.	1	1	.	2	.	1

Table 3. *Cyperetum micheliano-glomerati* ass. nova (part II).

Relevé number	109	111	63	64	46	48	50	66	54	55	81	75	116	95	101	98	94	93	92	91	113	100	110	96	97	60	82	115
Cover %	100	70	80	90	100	100	90	70	100	100	90	90	90	90	90	100	100	95	100	100	100	90	100	100	100	100	100	100
Surface sq.m	12	10	8	12	8	10	14	10	10	14	10	10	6	12	10	12	16	10	12	16	14	10	12	14	16	20	14	16
Species number	12	9	7	10	14	12	11	10	7	8	10	13	15	15	13	15	13	13	12	15	13	17	11	15	13	6	11	14
Character species																												
Cyperus glomeratus L.	2	2	3	3	2	1	2	3	3	2	3	3	3	3	2	3	3	2	2	3	2	3	2	3	4	3	3	2
Cyperus odoratus L.	3	1	1	2	1	2	1	.	.	.	.	1	3	3	2	2	2	2	1	2	3	2	2	2	1	2	3	3
Cyperus michelianus (L.) Delile	2	2	.	1	1	3	2	2	4	3	3	2	1	2	1	1	4	4	5	2	1	1	4	2	3	1	3	3
Cyperus squarrosus L.	3	3	2	3	2	2	2	2	1	2	2	2	2	2	1	3	.	1	.	1	4	2	2	1	2	.	.	1
Alliance, order, class species																												
Echinochloa crus-galli (L.) P. Beauv. subsp. *crus-galli*	2	1	2	2	2	2	3	+	1	1	2	1	1	1	2	2	2	3	2	2	+	1	2	2	2	2	1	2
Amaranthus tuberculatus (Moq.) J.D. Sauer	2	2	2	2	3	3	2	2	2	3	3	2	2	2	1	2	1	2	1	3	2	2	1	2	1	4	3	2
Lindernia dubia (L.) Pennell	.	+	2	2	1	1	1	1	+	+	1	.	1	1	2	1	1	1	2	2	1	2	.	1	2	.	1	1
Panicum dichotomiflorum Michx.	.	.	.	.	.	.	.	.	.	.	2	2	2	1	2	1	+	.	1	2	1	2	2	2	2	2	2	1
Xanthium italicum Moretti	1	.	.	.	1	.	.	.	.	.	.	1	+	.	+	1	1	+	+	1	1	1	1	1	1	.	2	+
Portulaca oleracea L.	1	+	1	1	1	2	.	+	.	.	.	1	1	+	.	1	+	.	.	1	.	.	.	.	.	.	.	+
Persicaria lapathifolia (L.) Delarbre	1	1	.	+	1	.	.	.	.	.	.	1	+	1	+	1	1	1	2	2	2	1	1	1	1	.	1	1
Cyperus esculentus L.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	2	1	2	1	.	.	.
Bidens vulgata Greene	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	2	2	+	1	1	.	1	1
Artemisia annua L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bidens connata Muhl. ex Willd.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	.	.	1	1	.	.	.	.	.	.
Rorippa palustris (L.) Besser	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Lycopus europaeus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.
Bidens frondosa L.	.	.	.	.	.	1	1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus sceleratus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Persicaria dubia (Stein.) Fourr.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Other species																												
Cyperus fuscus L.	1	.	.	1	+	1	2	.	.	.	1	1	1	1	3	3	2	1	2	2	.	1	.	1	3	.	.	.
Eragrostis pectinacea (Michx.) Nees	.	.	.	.	.	1	1	1	.	.	.	3	.	2	1	2	.	.	+	1	.	.	.	.	.	.	.	.
Salix alba L. (pl.)	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyperus difformis L.	.	.	.	.	.	.	2	.	.	.	.	.	1	1	1	.	2	1	.	.	.	.	.	1	.	.	.	1
Cyperus microiria Steud.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	1	1	1	.	1	.	.	.	.	.	.
Eclipta prostrata (L.) L.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2
Ammannia coccinea Rottb.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sicyos angulatus L.	.	.	.	.	.	1	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sporadic species	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 3. *Cyperetum micheliano-glomerati* ass. nova (part III).

Relevé number	90	52	51	53	68	136	134	130	131	133	128	126	78	77	129	132	11	12	10	15	16	114	112	135	125	124	123	122
Cover %	100	100	90	100	70	90	100	80	100	100	100	100	100	100	100	80	80	100	75	90	90	100	100	80	80	100	100	90
Surface sq.m	12	16	20	10	12	12	10	12	16	12	16	20	12	10	14	10	10	10	8	8	8	10	10	10	10	12	8	10
Species number	9	15	14	11	11	14	13	11	12	11	13	9	12	7	12	10	11	9	5	4	4	14	13	12	10	10	8	14
Character species																												
Cyperus glomeratus L.	2	3	2	3	3	4	1	3	2	3	2	1	5	5	4	4	4	4	3	4	4	2	3	2	2	1	1	2
Cyperus odoratus L.	3	2	2	3	2	2	3	3	2	2	1	1	2	1	3	2	.	.	.	1	1	2	2	3	3	2	4	3
Cyperus michelianus (L.) Delile	3	2	3	2	1	3	2	2	4	4	5	5	1	.	2	.	1	.	1	2	1	.	1	.	.	.	.	.
Cyperus squarrosus L.	.	1	1	.	2	2	4	2	4	.	2	2	.	.	1	1	.	.	.	.	.	3	.	4	4	5	4	3
Alliance, order, class species																												
Echinochloa crus-galli (L.) P. Beauv. subsp. *crus-galli*	2	2	1	2	.	.	3	2	1	2	1	.	3	3	1	.	2	1	.	.	.	1	1	2	1	2	2	2
Amaranthus tuberculatus (Moq.) J.D. Sauer	3	2	2	2	1	.	+	.	.	.	+	.	1	.	+	.	.	1	.	.	.	2	2	.	.	.	.	.
Lindernia dubia (L.) Pennell	2	1	1	1	.	+	1	+	.	+	2	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Panicum dichotomiflorum Michx.	1	.	.	.	.	.	2	1	1	2	2	1	2	1	2	1	.	.	.	.	.	3	3	1	1	2	3	2
Xanthium italicum Moretti	.	1	2	+	1	+	2	1	2	1	2	+	.	1	.	.	.	.	.	.	.	3	2	1	1	2	1	1
Portulaca oleracea L.	.	1	1	1	+	1	1	.	1	+	+	1	1	.	.	.	.	.	.	.	.	.	1	1	1	1	+	1
Persicaria lapathifolia (L.) Delarbre	2	1	.	.	.	+	.	.	.	1	1	.	.	1	.	.	.	.	.	.	.	1	1	.	.	.	1	1
Cyperus esculentus L.	.	2	2	1	.	.	1	1	+	.	1	.	.	.	.	.	1	1	1	1	1	2	2	1	.	1	.	1
Bidens vulgata Greene	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	.	.	.	.	.
Artemisia annua L.	.	+	.	.	.	1	1	1	.	+	+	1	.	.	1	1	.	.	.	.	.	.	.	+	.	.	.	.
Bidens connata Muhl. ex Willd.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.
Rorippa palustris (L.) Besser	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.
Lycopus europaeus L.	.	.	.	.	.	1	.	1	+	.	.	.	.	.	+	2	1	+	.	.	.	.	.	.	.	+	.	.
Bidens frondosa L.	.	.	+	.	.	.	.	.	.	.	.	.	5	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus sceleratus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Persicaria dubia (Stein.) Fourr.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	.	.	.	.	.	1	.	.	.	+	.	.
Other species																												
Cyperus fuscus L.	.	.	1	2	.	.	.	.	.	.	.	.	2	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
Eragrostis pectinacea (Michx.) Nees	.	2	2	2	2	1	.	.	1	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Salix alba L. (pl.)	.	.	.	.	1	1	.	.	.	.	.	.	.	.	1	+	1	+	2	.	.	.	.	.	.	.	.	.
Cyperus difformis L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	1	2	.	.	2
Cyperus microiria Steud.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	2
Eclipta prostrata (L.) L.	.	.	+	.	.	+	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	+	.	.	.
Ammannia coccinea Rottb.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	3	.	.	.	.	.
Sicyos angulatus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sporadic species	1	2	.	.	2	1	1	.	.	.	.	.	.	.	.	.	5	3	1	.	.	.	.	1	1	.	.	1

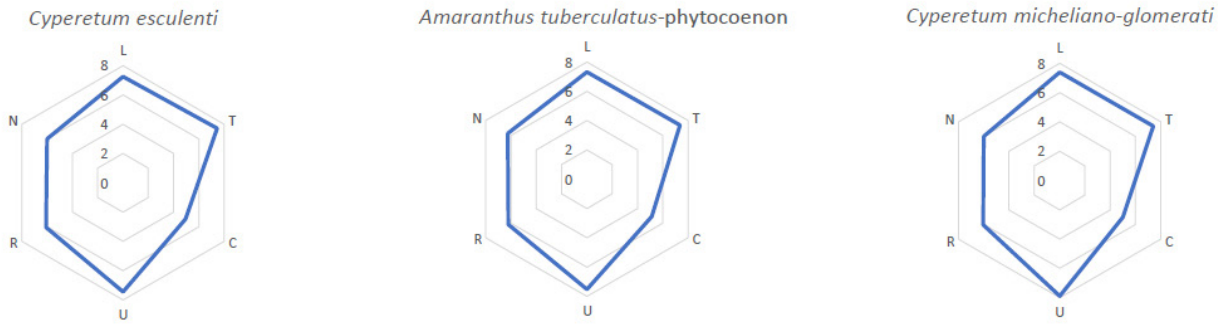

Figure 3. Ecograms for the three vegetation types detected through the analysis.

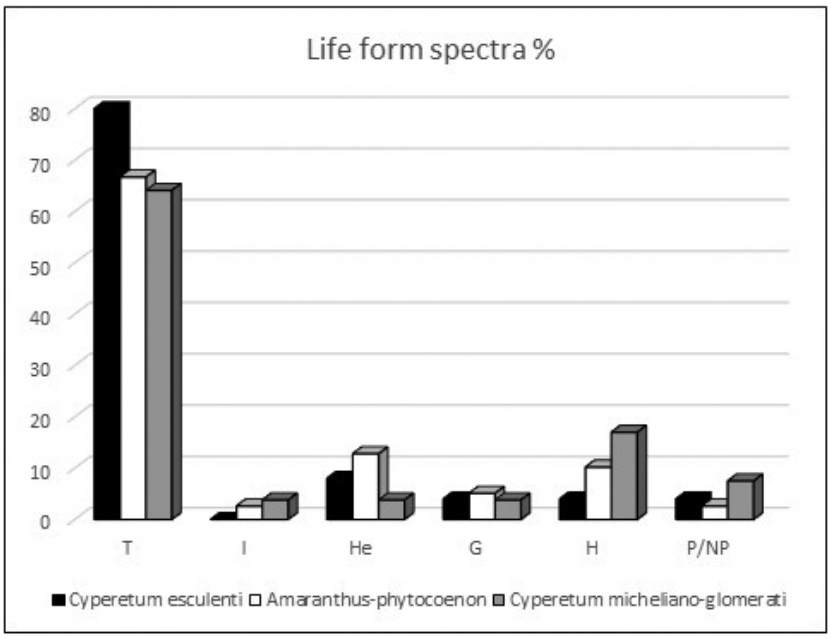

Figure 4. Life forms spectra of the three vegetation types detected through the analysis.

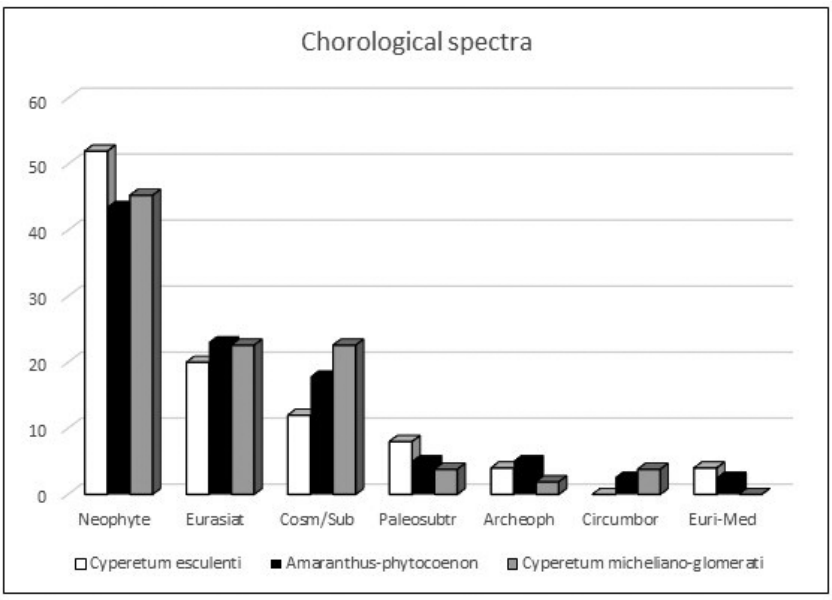

Figure 5. Chorological spectra of the three vegetation types detected through the analysis.

Table 4. Mean values of the Ellenberg-Pignatti Indexes for the three groups.

	L	T	C	U	R	N
Cyperetum esculenti	7.25	7.44	4.93	7.44	6.08	6
Amaranthus tuberculatus-phytocoenon	7.32	7.36	5.12	7.52	6.21	6.25
Cyperetum micheliano-glomerati	7.39	7.4	5	7.89	6.04	6

but it is difficult to identify a clear combination of constant species. Due to its size (sometimes over 2 m) and invasiveness, that weed outcompetes the dominant and characteristic species of all *Bidention*-communities, whose cover values seem underestimated. *C. michelianus* and *C. squarrosus* are able to grow under the thick layers of *Amaranthus*, unlike, for instance, *C. glomeratus*. To assign this community to a subassociation or variant of *Polygono hydropiperis-Bidentetum tripartitae* could mean to underrate the role of *A. tuberculatus*; conversely, to tipify a new association could mean too emphasize it. The relatively low number of *Bidention* different communities is related to a large variation of each type, under the aspect of species composition, physiognomy and anthropic pressures (Neacşu and Arsene 2017). Further data and a comparison with other situations outside of the river bed (such as crops or disturbed areas, in which *A. tuberculatus* is equally invasive), are needed for the institution of a new syntaxon (Costea et al. 2005).

The palaeosubtropical species *Cyperus glomeratus* and *C. michelianus* give the name to the newly described association *Cyperetum micheliano-glomerati*, for which also the American neophytes *C. odoratus* and *C. squarrosus* are listed as character species. The highlighting of the palaeosubtropical entities (Fig. 5) is seen as an opportunity for reconsidering the status of *Cyperus glomeratus* compared to *C. michelianus*. Both are native from Eastern European/Western Asian areals, and nowadays the first is also considered native in Italy by Euro+Med Database (Jimenez-Mejas and Luceño 2011) and IUCN (Kavak 2014). The European distribution ranges of the first two flatsedges are considerably overlapping. Outside Europe, *C. michelianus* is nowadays widespread in Africa and southern Asia (Lansdown 2014), while *C. glomeratus* is common further north, up to Korea and Japan (Kavak 2014). Linnaeus (1756) described *C. glomeratus* based on an Italian specimen (Peruzzi et al. 2008); *C. australis* Schrad. is a later synonymous of *C. glomeratus* (Govaerts and Simpson 2007). The species was widespread, although rare, and not strictly linked to rice fields. Indeed, this habitat favoured different species as *C. difformis* and *C. fuscus*, both assigned to subgenus *Anosporum*: their C3 photosynthetic pathway gives them an ecological advantage in habitats flooded for long time (Matsunaka 1983; Pellizzari and Verloove 2017).

C. glomeratus has a wide ecological amplitude. In addition to the presence in the studied late summer vegetation, it plays an active role in building helophytic fringes of *Phragmition*, along rivers and around lakes, in fresh or brackish waters (Bragato et al. 2006; Biondi et al. 2009). Along the Chienti river (Marche), a *C. glomeratus*-dominated community was framed into the *Magnocaricion* (Crisanti and Taffetani 2015). Another *C. glomeratus*-community found along the Po river was framed into the *Chenopodion rubri* (Sartori and Bracco 1996; Pellizzari 2009; Assini et al. 2010). Other *C. glomeratus*-dominated communities were ascribed either to the *Bidention* or to the *Nanocyperion*, e.g. along the Po river up to the Venetian Delta (Marconato et al. 2014). At Lake Pistono (Piedmont), some seasonally flooded muddy shores host flatsedge communities: *Cyperetum flavescentis* close to the water and a *Bidention*-community with *C. glomeratus* in less flooded sites (Tisi et al. 2007). A *C. glomeratus*-community of *Nanocyperion* can be found in two sites in Lombardy; it is dominated by *C. glomeratus*, *C. fuscus* and *C. michelianus* (FLA 2008). In these cases native species are dominant, unlike along the Po river. In Slovakia, *C. glomeratus* was reported in the Danube river beds in the middle 19th century, and was recently rediscovered in few sites. Here the species characterizes an ephemeral, two-layered vegetation type, with features of both *Nanocyperion* and *Bidention*, interpreted as a highly ruderal facies of *Cyperetum micheliani* (see below: Meleckova et al. 2016). Downstream along the Danube river, from the Eastern Wallachia to the Delta, both *C. glomeratus* and *C. michelianus* are characteristic of the macrophytes riparian vegetation (Stankovic et al. 2015).

The second characteristic species of *Cyperetum micheliano-glomerati* is another linnean species from Italy, *Cyperus michelianus*. It is diagnostic of several European plant communities. Lacking of Western taxa, some of these (*Cyperetum micheliani*, *Lindernio–Dichostylidetum michelianae*) are clearly continental, known from Central and Eastern Europe (Trpin et al. 1996; Jasprica et al. 2003; Šumberová 2011; Dubina et al. 2015). Except for *Cyperus fuscus*, the diagnostic species of *Cyperetum micheliani* sensu Šumberová (2013) are rare or completely missing along the Po river. Other communities characterized by *C. michelianus* develop in the Atlanto-Mediterranean range, i.e. in France and Spain (Corillion 1971; de Foucault 2013b; Cochard and Guitton 2014; Renaux 2014; Rivas-Martinez et al. 1980 ; Camacho et al. 2009). In Emilia-Romagna, along and near the Secchia river, the *Crypsio schoenoidis-Cyperetum micheliani* grows on silty-clay soils (EGPB Emilia Centrale 2013). Within the study area of this work, a *C. michelianus*-community of *Heleochloo-Cyperion* was detected at first (Pellizzari 2009). Based on the results of this study, it can be assigned to

the new described association, that reports in the same habitat *C. glomeratus* and *C. michelianus* together with *C. squarrosus* and *C. odoratus*. The last one peculiar species was recently discovered during an investigation of the Po river bed, and in several herbarium specimen (Verloove 2014). In particular, some of them were correctly identified after a former attribution to *Cyperus strigosus* (Lastrucci et al. 2016; Pellizzari and Verloove 2017). *C. odoratus* is naturalizing at least in three different European areas (Verloove 2014): a) the Po river in Italy; b) along the Danube river in Serbia, and in its Delta in Romania (Anastasiu and Negrean 2006); c) in NE Spain, along the Segre river down to the confluence with the Ebro. Nowadays *C. odoratus* is rather common in the Po river beds of Lombardy (Galasso and Banfi 2015), Emilia-Romagna (Verloove 2014), Veneto (Masin et al. 2015) and Tuscany (Lastrucci et al. 2016; 2017).

The last species, *C. squarrosus*, reached the Po plain in the late 19th century (Cavara 1899), but its spread began in the muddy river beds and ponds only in the last years (Bolpagni 2013 a,b).

Despite a resemblance with the *Cyperetum micheliani* identified along the Danube river in Slovakia and Hungary, the *Cyperetum micheliano-glomerati* is rather different. In fact, the communities that grow along the Po river have a higher total cover (often 100 %) and are characterised by a pool of *Cyperus* species. This is a peculiarity of such vegetation. Along the Po river, near Mantua, no aspects simultaneously dominated by different *Cyperus* species were found: similar situations were dominated by a larger neophyte set, mainly composed by graminoid grasses (*Echinochloa crus-galli*, *Panicum* sp. pl., *Paspalum distichum*) (Bolpagni 2013b). The only abundant flatsedge was *C. squarrosus*, and that suggested to frame those communities, in which *C. glomeratus* and *C. difformis* played a minor role, in the *Nanocyperion*. Communities of the *Nanocyperion flavescentis* are composed of native species and clearly different from the newly typified community. Here, only *C. flavescens* is characteristic of alliance, while *C. fuscus* and *C. michelianus* are characteristic of order (Brullo and Minissale 1998).

The following observations support the inclusion of the *Cyperetum micheliano-glomerati* in the *Bidention* (*Bidentetea*):

1. A major role, together with *Cyperus* spp., played by characteristic species of *Bidention* and of higher syntaxonomic units (*Echinochloa crus-galli*, *Amaranthus tuberculatus*, *Lindernia dubia*, *Persicaria lapathifolia*, *Panicum dichotomiflorum*, *Bidens connata*, *B. frondosa*, etc.);
2. The alien origin of some pioneer species, that witness both high soil eutrophication and disturbance of the regular flooding, able to carry seed stocks;
3. The fine particle size of silty-clay substrates, compared with that of contact communities of *Chenopodion rubri*.

According to Biondi et al. (2012), communities of *Cyperetum micheliano-glomerati* are referable to the habitat 3270 "Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation" (CORINE Biotopes 22.33 and 24.52; EUNIS C3.52 and C3.53). In Italy this habitat is widespread and typically invaded by alien plants, much of which are of tropical and subtropical origin (Zivkovic and Biondi 2010). The next goal will be to clarify the synecology of these alien, often invasive entities (Assini et al. 2010).

The human impacts drastically changed the final stretch of the Po River bed, so that it is very homogeneous and artificial. The late summer ephemeral vegetation is easily replaced by long-lasting secondary vegetation or directly destructed. That underlines the rareness and fragility of such habitat (Bolpagni 2013b; Ditetova et al. 2016). The typified *Bidention*-community expresses an aspect of conservation interest, in spite of its alien species richness. Anyway it is lower, if compared with the other aspects framed in the *Chenopodion rubri*. The *Cyperetum micheliano-glomerati* preserves the natural traits and plays an important ecological role when compared to the artificially managed river beds and river banks.

Syntaxonomic scheme

BIDENTETEA TRIPARTITAE Tüxen, Lohmeyer et Preising ex von Rochow 1951
BIDENTETALIA TRIPARTITAE Br.-Bl. et Tüxen ex Klika in Klika et Hadač 1944
Chenopodion rubri (Tüxen 1960) Hilbig et Jage 1972
Eragrostienion pilosae Felzines et Loiseau 2005
Cyperetum esculenti Wisskirchen 1995 [cluster 1]
Amaranthus tuberculatus-phytocoenon Bolpagni 2013 [cluster 2]
Bidention tripartitae Nordhagen 1940 em. Tüxen in Poli et J. Tüxen 1960
Cyperetum micheliano-glomerati ass. nova [cluster 3]

Other syntaxa quoted in the text

Crypsio schoenoidis–Cyperetum micheliani Martinez Parras, Peinado Lorca, Bartolomé Esteban et Molero Mesa 1988; *Cyperetum flavescentis* W. Koch ex Aichinger 1933; *Cyperetum micheliani* Horvatic 1931; *Echinochloo–Polygonetum lapathifolii* Soó et Csürös 1974; *Lindernio–Dichostylidetum michelianae* Slavnic 1951; *Nanocyperion flavescentis* Koch ex Libbert 1932; *Polygono-Chenopodietum* Lohmeyer 1970; *Cyperus glomeratus*-variant; *Polygono hydropiperis–Bidentetum tripartitae* Lohm. in Tüxen 1950; *Polygono lapathifolii–Xanthietum italici* Pirola et Rossetti 1974.

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Appendixes

Appendix I – Site and date of the phytosociological relevés (WGS 84)

Rels. 1-17: 08/08/2016; Pontelagoscuro, FE; Latitude N 44°53'08.65, Longitude E 11°37'37.31.

Rels. 18-22: 08/08/2016; S. Maria Maddalena, RO; Latitude N 44°53'27.07, Longitude E 11°36'00.31.

Rels. 23-27: 10/08/2016; Francolino, FE; Latitude N 44°53'41.31, Longitude E 11°38'44.29.

Rels. 28-31: 10/08/2016; Guarda Ferrarese, FE; Latitude N 44°57'40.63, Longitude E 11°46'53.75.

Rels. 32-39: 16/08/2016; Between Polesella and Canaro, RO; Latitude N 44°56'22.19, Longitude E 11°44'28.77.

Rels. 40-41: 16/08/2016; Guarda Veneta, RO; Latitude N 44°58'37.86, Longitude E 11°48'00.81.

Rels. 42-44: 25/08/2016; Zocca, FE; Latitude N 44°55'40.14, Longitude E 11°44'30.25.

Rels. 45-53: 25/08/2016; Cologna, FE; Latitude N 44°58'24.80, Longitude E 11°55'01.79.

Rels. 54-60: 25/08/2016; Coronella di Cologna, FE; Latitude N 44°58'23.23, Longitude E 11°52'54.72.

Rels. 61-62: 30/08/2016; Stienta, RO; Latitude N 44°56'22.94, Longitude E 11°31'52.45.

Rels. 63-65: 30/08/2016; Gaiba (Surchio W), RO; Latitude N 44°56'23.50, Longitude E 11°29'25.68.

Rels. 66-68: 30/08/2016; Gaiba sand bank, RO; Latitude N 44°56'24.36, Longitude E 11°29'38.69.

Rels. 69-72: 30/08/2016; Gaiba (Surchio E), RO; Latitude N 44°56'26.02, Longitude E 11°29'42.84.

Rel. 73: 05/09/2016; Crespino, RO; Latitude N 44°58'34.37, Longitude E 11°52'32.52.

Rels. 74-83: 05/09/2016; Canalnovo, RO; Latitude N 44°58'54.23, Longitude E 11°56'40.00.

Rel. 84: 05/09/2016; Villanova Marchesana, RO; Latitude N 44°59'19.04, Longitude E 11°57'50.18.

Rels. 85-86: 05/09/2016; Panarella, RO; Latitude N 44°58'54.36, Longitude E 12°04'29.79.

Rels. 89-101: 12/09/2016; Porporana (oxbow W), FE; Latitude N 44°56'01.32, Longitude E 11°27'54.69.

Rels. 102-103: 12/09/2016; Porporana riva Po, FE; Latitude N 44°56'03.30, Longitude E 11°27'46.64.

Rels. 104-118: 12/09/2016; Porporana (oxbow E), FE; Latitude N 44°56'06.64, Longitude E 11°28'28.58.

Rels. 119-122: 29/09/2016; Quatrelle, MN; Latitude N 44°57'16.84, Longitude E 11°25'28.87.

Rels. 123-136: 29/09/2016; Sermide, MN; Latitude N 45°00'24.66, Longitude E 11°18'21.31.

Appendix II – Sporadic species

Table 1: *Cyperetum esculenti*

Rel. 84: *Bidens vulgata* 1; *Artemisia annua* +.

Rel. 49: *Eclipta prostrata* 1; *Lycopus europaeus* 1.

Rel. 67: *Persicaria maculosa* 2.

Rel. 21: *Polygonum arenastrum* +.

Rel. 47: *Digitaria sanguinalis* 2; *Paspalum distichum* 2; *Cyperus odoratus* 1.

Table 2: *Amaranthus tuberculatus*-phytocoenon

Rel. 31: *Amaranthus blitum* +.
Rel. 30: *Abutilon theofrasti* +; *Heteranthera reniformis* +.
Rel. 40: *Atriplex prostrata* 1.
Rel. 45: *Urtica dioica* 1; *Veronica* cfr. *peregrina* +.
Rel. 24: *Phalaris arundinacea* 1.
Rel. 3: *Phragmites australis* +.
Rel. 43: *Polygonum arenastrum* +.
Rel. 44: *Convolvulus sepium* 1.
Rel. 59: *Eragrostis pectinacea* 2.

Table 3: *Cyperetum glomerato-micheliani*

Rel. 117: *Bidens cernua* 3; *Ludwigia peploides* 2; *Eclipta prostrata* 1.
Rel. 85: *Cyperus flavescens* 1; *Urtica dioica* 1; *Amorpha fruticosa* (pl.) +; *Ranunculus sceleratus* +.
Rel. 120: *Cyperus difformis* 1; *Veronica beccabunga* +.
Rel. 107: *Mentha aquatica* +.
Rel. 108: *Mentha aquatica* 1.
Rel. 69: *Mollugo verticillata* +; *Persicaria maculosa* +.
Rel. 89: *Rorippa sylvestris* 2.
Rel. 105: *Alisma plantago-aquatica* +; *Heteranthera reniformis* +; *Veronica anagallis-aquatica* +.
Rel. 99: *Veronica anagallis-aquatica* +.
Rel. 71: *Humulus japonicus* 1.
Rel. 42: *Persicaria maculosa* 1.
Rel. 58: *Phalaris arundinacea* +; *Rubus caesius* +.
Rel. 57: *Phalaris arundinacea* 1.
Rel. 46: *Chenopodium album* 1; *Digitaria sanguinalis* 1; *Solanum nigrum* 1.
Rel. 90: *Rorippa sylvestris* +.
Rel. 52: *Digitaria sanguinalis* 2; *Cyperus eragrostis* 1.
Rel. 68: *Digitaria sanguinalis* 2; *Mollugo verticillata* 1.
Rel. 136: *Mollugo verticillata* 1.
Rel. 134: *Bidens tripartita* 1.
Rel. 11: *Juncus effusus* 1; *Lythrum salicaria* 1; *Paspalum distichum* 1; *Phalaris arundinacea* 1; *Populus canadensis* (pl.) 1.
Rel. 12: *Lythrum salicaria* 2; *Phalaris arundinacea* 2; *Paspalum distichum* 1.
Rel. 10: *Populus canadensis* (pl.) 1.
Rel. 135: *Urtica dioica* +.
Rel. 125: *Urtica dioica* +.
Rel. 122: *Persicaria maculosa* +.