Original scientific article
Received: 2013-06-11

UDK 574.587:59(450.367)

MACROZOOBENTHIC COMMUNITIES IN THE REGIONAL NATURAL RESERVE OF ISONZO RIVER MOUTH (NORTH-EAST ITALY): FIRST RESULTS OF A LEAF BAG TECHNIQUE STUDY

Morana RUZIČ, Marco BERTOLI & Elisabetta PIZZUL
University of Trieste, Department of Life Sciences, I-34127 Trieste, Via L. Giorgieri 10, Italy
E-mail: pizzul@units.it

Fabio VIGNES & Alberto BASSET
University of Salento, Department of Biological Science and Technologies, I-73100 Lecce, Via Monteroni, Italy

ABSTRACT

The Regional Natural Reserve of the Isonzo River Mouth is an Italian coastal area, where biodiversity reaches high levels. Four sampling sites were chosen and seasonal samplings were conducted (autumn 2009 and spring 2010) using a non invasive sampling strategy (leaf bag technique) for studying both detritus processing and colonization by macrobenthic invertebrates. The main chemical and physical water parameters were monitored in the water column. Intra- and inter- seasonal differences of the total number, taxa composition, and the vegetable organic matter decomposition rates were investigated. Diptera Chironomidae was the dominant taxon in both seasons, followed by Crustacea. Significant differences were found for used community descriptors (total number, number of taxa). Decomposition rates showed significant seasonal differences.

Key words: macrobenthic invertebrates, decomposition process, leaf bag technique, freshwater ecosystems, *Phragmites australis*, North East Italy

COMUNITÀ MACROZOOBENTONICHE NELLA RISERVA NATURALE REGIONALE DELLA FOCE DELL'ISONZO (NORD EST ITALIA): PRIMI RISULTATI DI UNO STUDIO CON LA TECNICA DEI PACCHETTI FOGLIARI

SINTESI

La Riserva Naturale Regionale della Foce dell'Isonzo è un'area costiera italiana, dove la biodiversità raggiunge livelli molto elevati. Sono state scelte quattro stazioni di campionamento, presso le quali sono stati condotti campionamenti stagionali (autunno 2009 e primavera 2010) utilizzando un metodo non invasivo (tecnica dei pacchetti fogliari), al fine di studiare sia i processi a carico del detrito che la colonizzazione da parte dei macroinvertebrati bentonici e sono stati monitorati i principali parametri chimico-fisici nella colonna d'acqua. Sono state indagate le differenze significative a carico del numero totale di organismi rinvenuti, del numero di taxa osservati e dei tassi di decomposizione della sostanza organica vegetale. I Diptera Chironomidae sono risultati essere il taxon dominante in entrambe le stagioni di campionamento, seguiti dai Crostacei. È stato possibile evidenziare differenze significative per i descrittori della comunità macrozoobentonica (numero totale e numero di taxa osservati). Inoltre, è stato possibile evidenziare differenze significative interstagionali pre i tassi di decomposizione.

Parole chiave: macroinvertebrati bentonici, precessi decompostiivi, pacchetti fogliari, ecosistemi dulciaquicoli, *Phragmites australis*, Nord-Est Italia

INTRODUCTION

Temporary freshwaters are widely spread in the world occupying a large portion of inland waters. These areas play an important role as stopover sites and breeding/wintering areas for many bird species and other vertebrates (Bazzanti *et al*., 1996) and provide suitable habitats for a large number of aquatic plants and invertebrate species, including rare or endangered ones (Bazzanti *et al*., 2000). Recently, wetlands received a greater public and political attention (Gilbert *et al*., 2004), that led to a greater interest for recovery, and conservation of these areas. The Regional Natural Reserve of the Isonzo River Mouth is an example of these situations: the Reserve is the result of some environmental restoration interventions, and it was officially established in 1996. It is the northernmost wetland in the Mediterranean area and it separates the low and sandy shores of the Veneto Region from the high and rocky coasts of Istria and Dalmatia. This geographical context generates many habitats and biodiversity reaches high levels (Perco *et al*., 2006). Due to these characteristics, the Regional Natural Reserve of the Isonzo River Mouth was included in a Site of Community Importance (SCI IT3330005) and in a Special Protection Area (SPA IT3330005).

In wetlands the macrobenthic invertebrates play a central role in many ecological processes, as in other aquatic ecosystems (Mc Call & Soster, 1990; Griffiths, 1991): they are key contributors to chemical fluxes over the sediment-water interface and represent a well established response model to anthropogenic pressures (Cook, 1976; Aller & Aller, 1998). Besides, these organisms cover all trophic functions and are trophic resources for birds and fishes. Therefore, the macrobenthic invertebrates are useful to understand state and type of resources (Cummins, 1974; Metcalfe-Smith, 1994).

Some studies on the macrobenthic fauna were conducted in the Natural Reserve of the Isonzo River Mouth, both in freshwater and salt marshes (Stoch, 1995; Pizzul, *et al*., 2008; Boggero *et al*., 2011), but an artificial substrate technique was never used before. The leaf bag technique is world-wide accepted as a quantitative approach to the study of both detritus processing and colonization by macrobenthic invertebrates (Petersen & Cummins, 1974; Mancinelli *et al*., 2005), as it simulates natural accumulation of vegetable detritus. Colonisation and decomposition studies have been done in lotic environments (Robinson & Jolidon, 2005; Fenoglio *et al*., 2006) as well as in lentic (Pope *et al*., 1999) and transitional waters (Mancinelli *et al*., 2005; Sangiorgio *et al*., 2008).

In this paper we describe a study which used the leaf bag technique to investigate the macrobenthic invertebrates communities living in a portion of the Reserve. Our first aim was to obtain new information about these communities and ensure a first set of data about organic matter decomposition rates of this area. Secondly we tried to develop a low impact sampling design to reduce sampling disturbance in the study area, according to the management policies of the Reserve, using the leaf bag technique as a non-invasive sampling method. A comparison with a dataset obtained in the same basin using previous box corer samplings (Boggero *et al*., 2011), was also carried out.

MATERIAL AND METHODS

Study area

The study was conducted in an enclosed basin that spreads on a surface of about 30 ha, resulting from environmental recovery management. The basin is enclosed by an embankment and it is supplied by an artesian well and rainwater. The western portion of this area is a damp pasture, and the eastern portion is a reed bed (*Phragmites australis*) (Fig. 1). Some islets are placed in the inner section of the area: the largest one is planted with *Populus nigra*, *Alnus glutinosa* and *Salix* sp. This area can be described as a "temporary autumnal pool" (Wiggins *et al*., 1980): the basin dries up during summer (approximately from the beginning of June up to October), and it is flooded again with water from the beginning of the autumn. Waters are classified from limnic to oligohaline (Stoch, 1995).

According to management policies, the human disturbance (presence of visitors and personnel) is very limited, because this area provides a stopover site for many bird species. However, some management actions are conducted: the vegetation growth control is

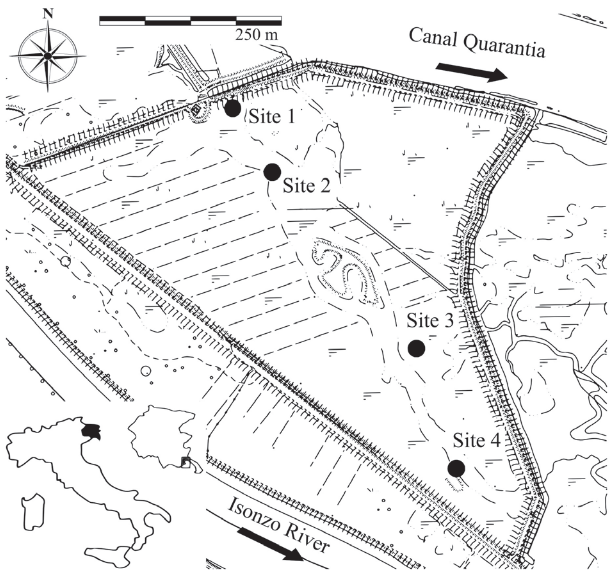

Fig. 1: Study area and sampling sites (region Friuli Venezia Giulia, Italy; modified)
Sl. 1: Preučevano območje in lokacije vzorčenja (regija Furlanija-Julijska krajina, Italija; prirejeno)

performed both passively (grazing Camargue horses and periodically cattle) and actively (using machines), while the water level is controlled only with a flap sluice gate connecting the basin with a branch of the Isonzo River (Canal Quarantia). This gate is occasionally open in summer for a few days (usually late July/mid August) to ease the up drying of the basin. The water level control is done for ecological reasons (Pizzul *et al*., 2008) and it allows the nutrients remineralisation (Street, 1982).

Sampling design

This study was carried out from October 2009 to July 2010 at four sampling sites that were geo-referenced with GPS (UTM coordinates) (Fig. 1, Tab. 1). The selection of these sites was based on different vegetation cover, depth and duration of wet phase. The station 1 was placed near the sluice gate and close to the reeds; the station 2 was located near a little islet, and site 3 in the central zone of the basin. The last sampling site was placed near the reeds in a portion of the study area that dries up first during summer period (Boggero *et al*., 2011). At every sampling site, the substratum was found to be sand or mud.

The main chemical-physical water parameters (Directive 2000/60/CE), as pH, conductivity (mS cm^{-1}), temperature (°C) and dissolved oxygen (mg l^{-1}), were monthly recorded (approximately 1/3 depth from bottom) at each sampling site. At the same time, the depth (cm) was detected with a measuring rod.

In order to conduct seasonal sampling campaigns (October-December 2009; April-July 2010) leaf bags were prepared with *Phragmites australis*, according to the methods reported by Basset *et al*. (2006). The leaves were harvested in late summer-early autumn 2009. After drying, the leaves were reduced to fragments about 10 cm long and 3.000 ± 0.001 g of oven-dried leaves (60 °C for 72 h) were then inserted in nylon fibre bags (0.5 cm mesh size). 48 units were built and organised in subsamples made with four bags. Three subsamples were seasonally placed at every site, in order to collect them separately at 15, 30 and 45 days after laying. This sampling frequency was determined in agreement with the managers of the Reserve to minimize the disturbance within the study area. Once collected, samples were placed in polyethylene bags and transported to the laboratory, where macrobenthic invertebrates have been separated from the leaves. The leaves were dried again at 60 °C for 72 h to measure the residual dry weight and to calculate the organic matter decomposition rates (k; d^{-1}), according to a negative exponential model ($W_t = W_0\ e^{-kt}$) (Olson, 1963), converted to a linear one by logarithmic transformation (Bärlocher, 2005). The organic matter decomposition rates were analysed both inter- and intra-season, comparing slopes of the resulting regression lines. Comparisons were made using the ANCOVA (Zar, 1984; Bärlocher, 2005).

The macrobenthic invertebrates, separated from the leaves, were placed in a 4 % formalin solution. After washing, they were sorted and determined, where possible, up to the level of family or genus (Basset *et al*., 2006). Diptera Chironomidae were determined to the subfamily level. After determination, the samples were preserved in a 70 % alcohol solution.

The total number and the number of observed taxa were used as community descriptors. Two-way ANOVA (factors: season, site) was performed to test spatial and seasonal effects on communities. The normal distribution of data was assessed by Shapiro-Wilks test, while

Tab. 1: Mean values and standard deviations (± S.D.) of chemical-physical water parameters measured during the sampling operations
Tab. 1: Povprečne vrednosti in standardna odstopanja (± S.D.) kemičnih in fizikalnih lastnosti vode, izmerjena med vzorčenji

	Sampling site	1	2	3	4
U.T.M coordinates	Northing 33 T	5067699.47	5067605.64	5067349.38	5067140.24
	Easting	383832.23	383897.48	384063.44	384187.07
Autumn	Depth (cm)	35.00 ± 8.89	40.00 ± 2.00	32.33 ± 4.51	18.50 ± 6.14
	T (°C)	12.07 ± 3.88	12.10 ± 4.64	11.33 ± 3.76	10.83 ± 3.02
	D.O. (ppm)	3.75 ± 2.56	4.63 ± 2.91	5.38 ± 3.58	3.70 ± 0.64
	Cond (mS cm^{-1})	2.86 ± 1.09	3.10 ± 0.97	2.67 ± 0.60	1.55 ± 0.09
	pH	7.25 ± 0.48	7.25 ± 0.13	7.44 ± 0.65	6.75 ± 0.18
Spring	Depth (cm)	40.67 ± 6.03	42.47 ± 1.86	41.33 ± 7.77	18.17 ± 0.10
	T (°C)	19.73 ± 4.56	19.63 ± 5.32	19.30 ± 5.34	17.33 ± 3.96
	D.O. (ppm)	4.50 ± 2.56	4.82 ± 1.34	4.17 ± 1.65	1.54 ± 0.59
	Cond (mS cm^{-1})	2.77 ± 0.27	3.14 ± 0.76	2.84 ± 0.41	1.97 ± 0.16
	pH	7.87 ± 0.97	8.24 ± 0.30	7.59 ± 0.43	7.38 ± 0.46

the homogeneity of variance was tested using Brown & Forsythe test. Post-hoc comparisons were made with LSD-Fisher test. Finally, samples collected during this work were compared to those collected with a manual box-corer in spring one year before (Boggero *et al*., 2011). For this comparison we used the Sörensen index (Sörensen, 1948).

RESULTS

Mean values and standard deviations of the observed chemical-physical water parameters are reported in Table 1. The water depth was generally higher during spring, due to high rainfall, and it started to decrease at the beginning of summer, when the drying up occurred. This process could be forced by the personnel, opening the flap sluice gate near site 1. The water depth values were lower during autumn, when the flooding phase follows the summer dry phase. At site 4, the depth values were always lower than in the other sites, because this portion of the basin dries up first during the summer period. Temperature was higher in spring, while pH and conductivity were always within a narrow range of values. Due to the low values of conductivity, the water basin should be classified from limnic to oligohaline, as described by Stoch (1995). Dissolved oxygen values were slightly higher in autumn.

The values of vegetable organic matter decomposition rates (k) are reported in Table 2. The statistical comparisons between decomposition rates (ANCOVA) showed no major intra-seasonal differences among the sites neither in autumn nor in spring ($p > 0.05$; d.f. = 12). The comparison between the inter-seasonal decomposition rates showed highly significant differences ($p < 0.0001$; d.f. = 62): in spring, the decay was faster than in autumn (Tab. 2, Fig. 2).

The macrobenthic portion of the samples counts 3582 individuals of which 958 were found in autumn and 2624 in spring, respectively, belonging to 15 and 20 taxa (Tab. 3). The communities appeared to consist mostly of Hexapods and Crustacea in all sites and in both seasons. Insects were almost entirely represented by Diptera Chironomidae belonging to the subfamily of Chironominae: they represented at least 94.7 % of the Hexapods observed in autumn and at least 86.7 % of those observed in spring, whereas the subfamilies Tanypodinae and Orthocladiinae showed much lower frequencies. Among Diptera, Ceratopogonidae were relatively abundant in site 1 (respectively 2.8 and 5.8 % of the total in autumn and spring). Three families of Coleoptera (Haliplidae, Dityscidae and Hydrophilidae) were found in the spring samples, particularly in site 4. All Crustaceans belonged to the Class Ostracoda and to the families Gammaridae and Asellidae; the latter taxon was mainly present both in autumn and in spring in site 4. In the same site and in both seasons, the Gastropoda belonging to the Planorbidae family were found with higher frequencies than in the other sampling sites.

A specimen belonging to the Class Polychaeta (*Hediste diversicolor*) was observed only in spring at site 1. Probably, it entered the Reserve through the flap sluice gate, because this organism is not typical of freshwater environments. The Phylum Nematoda was observed only in spring, and other taxa were found only occasionally. The values of total number of the observed macrobenthic invertebrates and of the taxa number for the studied communities are represented in Figure 3.

The ANOVA carried out against the community descriptors (total number and number of taxa) has shown significant differences between the two seasons (total number: d.f. = 7, $F = 3.71$, $p < 0.02$; number of taxa: d.f. = 7, $F = 5.15$, $p < 0.01$). The total number of individuals found in spring was always higher than in autumn, but the post-hoc tests showed a significant increase in the abundance only for site 4 ($p < 0.01$). The diversity, expressed by the number of collected taxa, was higher in spring than in autumn, and seasonal differences were found to be significant ($p < 0.05$) for all sites, except site 1. The highest values of taxa number were recorded during spring (Fig. 3) at site 1, 3 and 4 placed near a *Phragmites australis* reed bed. In particular during spring, the site 4 had a green cover characterized by rooted helophytes and emerging hydrophytes.

Tab. 2: Values of the vegetable organic matter decomposition rates (k) (mean values ± S.D.) for every sampling site and season
Tab. 2: Vrednosti stopnje razgradnje rastlinske organske snovi (k) (povprečne vrednosti ± S.D.) po posamični lokaciji in letnem času vzorčenja

	Autumn				Spring			
Sampling site	**k (d^{-1})**	**r**	**N**	**d.f.**	**k (d^{-1})**	**r**	**N**	**d.f.**
1	0.0062 ± 0.0009	0.868	16	14	0.0126 ± 0.0010	0.961	16	14
2	0.0061 ± 0.0009	0.876	16	14	0.0139 ± 0.0009	0.971	16	14
4	0.0067 ± 0.0009	0.897	16	14	0.0151 ± 0.0007	0.985	16	14
5	0.0072 ± 0.0009	0.911	16	14	0.0147 ± 0.0007	0.984	16	14
Mean k	0.0066 ± 0.0004	0.886	64	62	0.0141 ± 0.0004	0.972	64	62

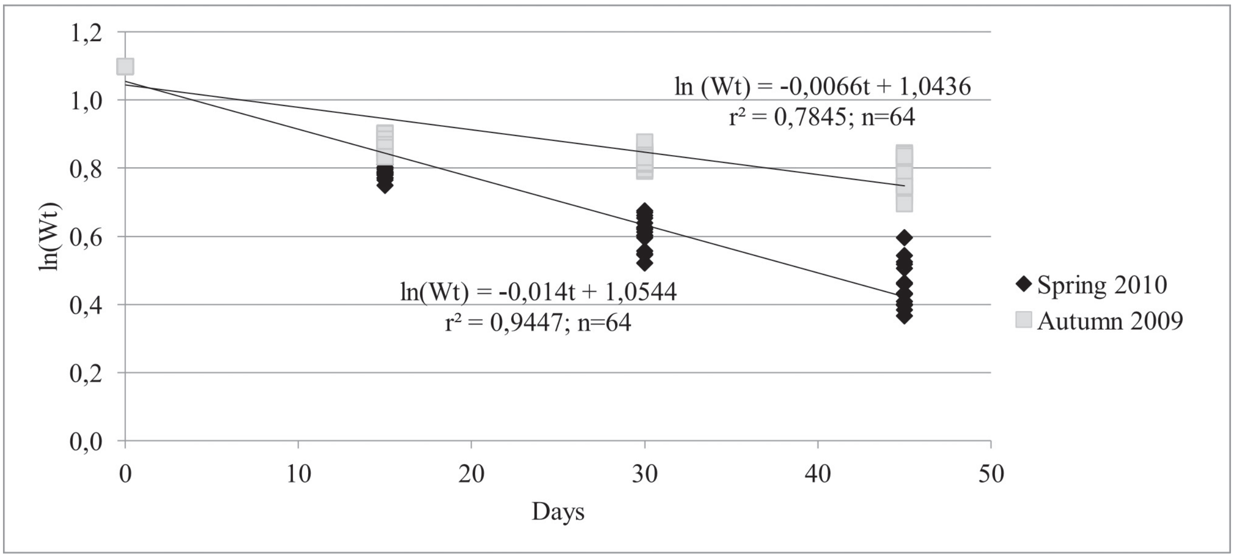

***Fig. 2:** Comparison of vegetable organic matter decomposition rates (k) between the two sampling seasons (autumn 2009 and spring 2010)*
***Sl. 2:** Primerjava stopnje razgradnje rastlinske organske snovi (k), izmerjene v dveh vzorčevalnih sezonah (jesen 2009 in spomlad 2010)*

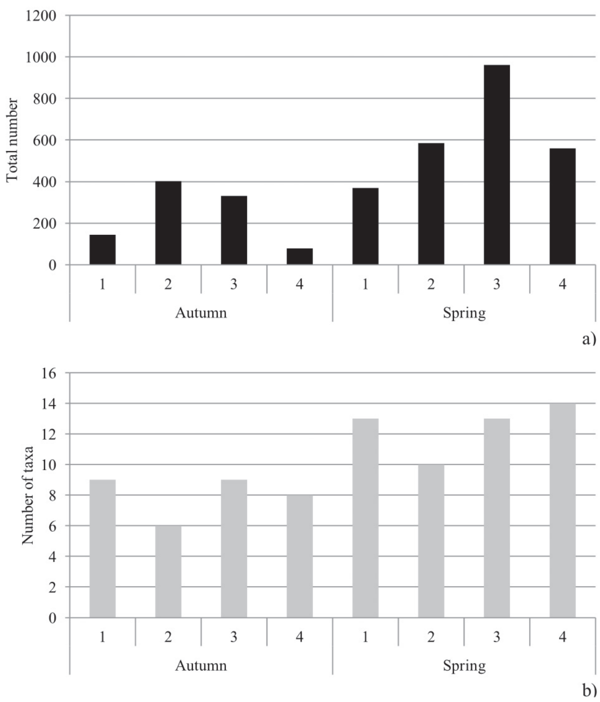

***Fig. 3:** (a) Mean values of the total number and (b) of the number of taxa observed for macrobenthic invertebrates collected at every sampling station during the sampling seasons (autumn 2009 and spring 2010)*
***Sl. 3:** (a) Povprečno skupno število taksonov in (b) povprečno število taksonov v združbah makrobentoških nevretenčarjev, zajetih na vsaki lokaciji vzorčenja jeseni 2009 in spomladi 2010*

A qualitative comparison was made between our data and the data obtained from box corer samples collected by Boggero *et al*. (2011) during the previous year in the same sampling sites (Fig. 4). With both methods, Hexapod appears to be the dominant taxon, in particular Diptera Chironomidae of the Chironominae subfamily. However, in the samples collected using leaf bags, Crustacea was the second taxon in abundance while Oligochaeta was the third one, while an inverted frequency ratio of these two classes was observed in the samples collected with box corer, where the Class Oligochaeta is well represented, in particular in site 1. The application of the Sörensen index, to data observed at each site, provided values ranging between 0.60 (site 2) and 0.69 (sites 3 and 4), indicating a good overlapping of the community composition observed by the analysis of the samples collected with the two sampling techniques (box corer and leaf bags).

DISCUSSION AND CONCLUSIONS

The study area is an ecosystem that includes different microhabitats, with quite complex dynamics. It is a human managed ecosystem with a high naturalistic value and different conservation constraints. It represents a natural laboratory in which the effect of conservation management strategies on communities of macrobenthic invertebrates could be directly observed.

The chemical and physical water parameters observed in this study show values close to those recorded from Boggero *et al*. (2011) in the same sites. The mean annual conductivity allows us to define this ecosystem from limnic to oligohaline suggesting a very low influence of seawater infiltration. Due to the shallowness of the ecosystem, the sediment probably greatly affects the water column processes. Dissolved oxygen in water was found permanently under saturation values and this fact is supposed to be strictly influenced by red--ox conditions and by deposition of an organic layer on the bottom sediment. At a roughly sensorial testing the sediment's colour and smell during the sampling operations suggested that anoxic processes probably prevailed at the sediment-water interface, thus influencing nutrient remineralisation. Although we did not measure the dissolved nutrient concentration in water, we suppose that it could be greatly affected by the avifauna, massively present especially during wintering, as well as by the constant presence of horses and occasionally cattle, both used as a system of passive vegetation growth control (Rooney & Bayley, 2012).

In our study, the values of vegetable organic matter decomposition rates showed no major intra-seasonal differences among the sites, neither in autumn nor in spring. This fact leads to the conclusion that, seasonally, the decay of vegetable organic matter is likely regulated by a similar decomposing rate for the whole area. The decomposition rate measured in spring doubled the value measured in autumn. The inter-seasonal differences observed in decomposition rates suggest that temperature is the main factor influencing this process, as already observed by various Authors in different environments (Petersen & Cummins, 1974; Pope *et al*., 1999; Alemanno *et al*., 2007; Sangiorgio *et al*., 2008). Faster rates of leaf breakdown were observed for different leaf types during warmer seasonal periods (Webster & Benfield, 1986). The differences are in line with the patterns of variation of *Pragmites australis* decomposition in relation to certain abiotic ecosystem characteristics, including water temperature, as also observed by Sangiorgio *et al*. (2008) in transitional ecosystems. Besides, Dudgeon (1982) showed that high water temperature increases microbial processes during decomposition, and the leaves serve as a major energy source for invertebrates in aquatic ecosystems.

However, we cannot exclude that other factors could influence decomposition rates in our system, such

Tab. 3: Frequencies (%) of the sampled taxa, belonging to the following Phyla: Nematoda, Mollusca, Anellida, Arthropoda and to Subphylum Crustacea
Tab. 3: Prisotnost posamičnih taksonov (v %), ki pripadajo naslednjim deblom: Nematoda, Mollusca, Anellida, Arthropoda in poddeblu Crustacea

	Autumn				**Spring**			
Taxon/Sampling site	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Nematoda					1.09	0.67	2.2	0.18
Physidae			0.3				0.1	
Planorbidae		0.25		2.53		0.8	0.1	4.17
Hediste diversicolor					1.63			
Tubificidae	1.38		0.3		7.07	6.27	7.97	15.76
Naididae	2.07				1.63	2.13	1.05	1.45
Hirudinea							1.05	
Ostracoda	30.34	8.71	34.64	7.59	16.03	7.87	15.3	7.25
Asellidae	0.69	0.75		15.19	0.27	2.13	3.04	9.06
Gammaridae		0.5	1.2		23.1	21.33	0.21	
Sympetrum sp.					0.27			
Corixidae	0.69							
Haliplidae								0.91
Dytiscidae								3.44
Hydrophilidae				1.27	0.54	0.4		2.17
Ceratopogonidae	2.76		0.3		5.71		0.1	0.54
Chironominae	61.38	89.8	62.65	69.62	42.39	58.4	68.76	54.71
Orthocladiinae							0.1	
Tanypodinae	0.69			1.27	0.27			0.18
Tabanidae			0.3	2.53				0.18
Ecnomidae			0.3					

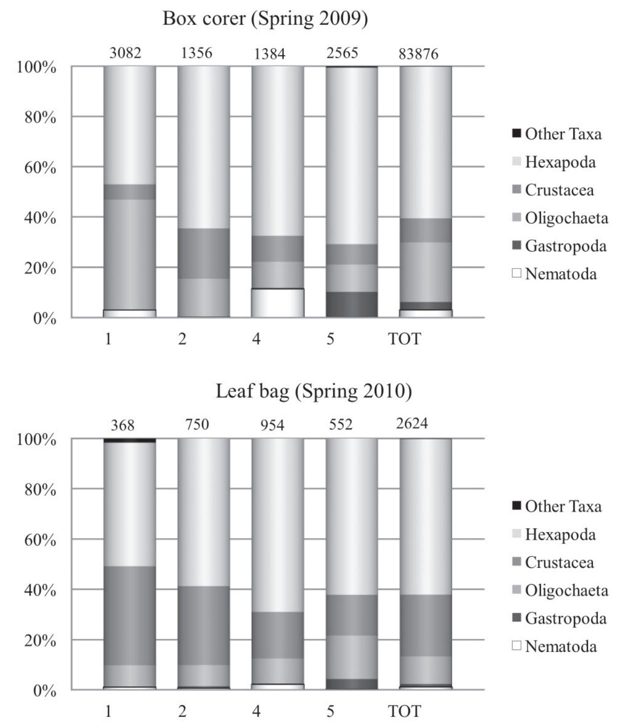

Fig. 4: Comparison of frequency percentages of the taxa found with box corer (Boggero** et al.**, 2011) and leaf bags

Sl. 4: Primerjava prisotnosti posamičnih taksonov (v %), vzorčenih s korerjem (Boggero** et al.**, 2011) in listnimi vrečami

as salinity (Reice & Herbst, 1982), pH (Thompson & Barlocher, 1989), dissolved oxygen (Rubbo *et al*., 2008) and nutrients (Sharma & Gopal, 1982; Alemanno *et al*., 2007).

As previously mentioned, an active management of the area is carried out: the water level inside the reservoir is controlled by opening the flap sluice gate near site 1 in the summer period. The timing of this operation depends on the ecological circumstances, and it has different consequences, as it allows the remineralisation of organic nutrients in substratum and contributes to avoid severe anoxic conditions (Street, 1982), as well as it affects the vegetation quality control (van der Valk, 1990) and the biodiversity of both biomass and macrobenthic invertebrate communities (Pizzul *et al*., 2008).

The inter-seasonal differences among these communities regard mainly the number of taxa and the abundance that are always lower in autumn. This is certainly due to seasonality and to the life cycles of the different organisms (Ghetti & Bonazzi, 1981), but also depends on the completion of the re-colonisation process that occurs in autumn, following the summer dry phase. The presence of vegetation can affect the abundances of certain taxa (Trigal-Domínguez *et al*., 2009) such as Asellidae (Stoch, 2002; Siligardi *et al*., 2007) and Gastropoda belonging to the Planorbidae family, and it can lead to an increase of predators (Capitulo *et al*., 2001) such as Coleoptera Hydrophilidae, which was observed at higher percentage frequencies precisely at this site. The spring data agree with previous observations made at the same sampling sites by Boggero *et al*. (2011) that, however, reported the highest values of taxa number at the sites 1 and 4.

Data gained on the spring community appear to be comparable with those obtained with a different collecting technique by Boggero *et al*. (2011), and this despite the leaf bag technique is known to be potentially selective for certain taxa (Basset *et al*., 2006). This fact could partially explain differences between the two studies in the observed frequencies of some taxa, *i.e.* Oligochaeta, whose lower abundance in leaf bags compared to box corer samples is probably related to the organisms' habits. Oligochaeta are more sedentary and tied to the sediment quality compared to other taxa such as Chironomids. Nevertheless, similarity index suggests a good overlapping of the community composition with values ranging from 0.60 to 0.69. The dominance of Chironomids and a lower presence of Oligochaeta have been also observed by Pope *et al*. (1999) in a leaf packs colonization study in a small oligotrophic lake, while according to Chauvet (1993) Oligochaeta use vegetable materials as microhabitat that provides shelter and food.

The analysis of the number of collected taxa suggests an increase in biodiversity mainly in spring at the end of a stable wet phase. The following dry phase during summer is probably the reason of the biodiversity reduction in autumn. Sites 1 and 4 that are near a reed bed show higher diversity values (number of taxa). This could be due to different effects induced on local chemical parameters regulated by vegetation. An increase in oxygen availability at the sediment water interface or an increase in habitat diversification could be the possible reasons (Claret *et al*., 1999).

The results obtained in this study confirm previous observations concerning the structure of macrobenthic communities inhabiting the studied area, and they increase the available information with new data. In particular, this study provides the first dataset of macrobenthic communities using the leaf bag technique and the first values of vegetable organic matter decomposition rate for this Natural Reserve. The comparison among data sets obtained on a larger time scale, including several years of sampling, to check how factors can affect the community is therefore of particular interest. For example, annual differences should be related to different duration of the dry and flooding phases in the area, also considering the effects of the management operations. Finally, our study shows that the application of the leaf bag technique, although potentially selective toward certain taxa, fulfils the needs of macrobenthic community characterization according to the operational constraints provided in areas with the conservation purposes, such as in the Natural Reserve of the Isonzo River Mouth.

ACKNOWLEDGEMENTS

We would like to thank the Director of the Regional Natural Reserve of the Isonzo River Mouth, Prof. Fabio Perco, Mr. Silvano Candotto, Mr. Ignazio Zanutto and the staff of the Reserve.

MAKROZOOBENTOŠKE ZDRUŽBE V REGIJSKEM NARAVNEM REZERVATU OB USTJU SOČE (SEVEROVZHODNA ITALIJA): PRVI REZULTATI NEINVAZIVNE METODE LISTNATIH VREČ

Morana RUZIČ, Marco BERTOLI & Elisabetta PIZZUL
University of Trieste, Department of Life Sciences, I-34127 Trieste, Via L. Giorgieri 10, Italy
E-mail: pizzul@units.it

Fabio VIGNES & Alberto BASSET
University of Salento, Department of Biological Science and Technologies, I-73100 Lecce, Via Monteroni, Italy

POVZETEK

V vsakem sladkovodnem ekosistemu je makrobentoška favna osnovna trofična skupina v procesu kroženja snovi in pretoka energije. Preučevanja združb makrobentoških nevretenčerjev zato ne smemo prezreti zlasti pri pripravi strategije upravljanja zavarovanih območij. Regionalni naravni rezervat ob ustju Soče je italijansko obalno območje z veliko biotsko raznovrstnostjo, v katerem lahko upravljanje pomembno vpliva na makrobentoško favno. Da bi slednjo preučili v skladu s smernicami za ohranjanje prostoživečih vrst v rezervatu, se pravi s kar najmanjšimi posegi v naravno okolje, smo uporabili neinvazivno metodo vzorčenja (metoda listnatih vreč).

*Po predhodnem opazovanju pokrovnosti vegetacije, globine in obdobij vlažnega vremena smo izbrali 4 lokacije vzorčenja in izvedli vzorčenje v dveh letnih časih (jesen 2009, pomlad 2010) z uporabo metode listnatih vreč iz trstičja (*Phragmites australis*). Izmerili smo osnovne kemične in fizikalne lastnosti vodnega stolpca. Preučili smo razlike med rezultati, izmerjenimi v istem letnem času, ter razlike med rezultati, izmerjenimi v različnih letnih časih, in sicer glede skupnega števila taksonov, taksonomske sestave združb makrobentoških nevretenčarjev in stopnje razgradnje rastlinske organske snovi. V obeh letnih časih so v združbah prevladovale ličinke trzač (družina Chironomidae), sledili so raki (Crustacea). Največ maloščetincev (Oligochaeta) je bilo v spomladanskem času. Značilne razlike med posameznimi letnimi časi in med lokacijami smo odkrili pri deskriptorjih bentoških združb; skupno število taksonov in biotska raznovrstnost (izražena s številom taksonov) sta višja spomladi. To bi lahko bilo povezano z življenjskim ciklom makrobentoških nevretenčarjev, z obdobjem poplavljenosti preučevanega območja in s koncem rekrutiranja, do katerega pride jeseni, po poletnem suhem obdobju. Stopnja razgradnje rastlinske organske snovi je bila spomladi dvakrat višja kot jeseni. Razlike med spomladansko in jesensko stopnjo razgradnje nakazujejo, da na proces razgradnje najbolj vpliva temperatura.*

Z raziskavo smo potrdili ugotovitve nekaterih predhodnih opazovanj v rezervatu, stare podatke nadgradili z novimi ter s tem postavili temelje za bodoče večletno preučevanje.

Ključne besede: makrobentoški nevretenčarji, proces razgradnje, metoda listnatih vreč, sladkovodni ekosistemi, *Phragmites australis*, severovzhodna Italija

REFERENCES

Alemanno, S., G. Mancinelli & A. Basset (2007): Effects of invertebrate patch use behavior and detritus quality on reed leaf decomposition in aquatic system: a modelling approach. Ecol. Model., 205, 492–506.

Aller, R. C. & J. Y. Aller (1998): The effect of biogenic irrigation intensity and solute exchange on diagenetic reaction rates in marine sediments. J. Mar. Res., 56, 905–936.

Bärlocher, F. (2005): Leaf mass loss estimated by litter bag technique. In: Graça, M. A. S., F. Bärlocher & M. Gressner (eds): Methods to study litter decomposition: A practical guide. Springer, Dordrecht, pp. 37–42.

Basset, A., F. Sangiorgio & L. Sabetta (2006): Handbook for the application of body size descriptors to monitoring safety of transitional ecosystems. TW ReferenceNet - EU INTERREG III B Project 3B073. Management and sustainable development of protected transitional waters. Partner1LP - University of Lecce, Lecce, 74 p.

Bazzanti, M., S. Baldoni & M. Seminara (1996): Invertebrate macrofauna of a temporary pond in Central Italy: composition, community parameters and temporal succession. Arch. Hydrobiol., 137, 77–94.

Bazzanti, M., M. Seminara, S. Baldoni & A. Stella (2000): Macroinvertebrates and enviromental factors of some temporary and permanent ponds in Italy. Vehr. int. Verein. theor. angew. Limnol., 27, 936–941.

Boggero, A., F. Vales, M. Bertoli & E. Pizzul (2011): Primi risultati riguardanti lo studio delle comunità macrozoobentoniche nella Riserva Regionale della Foce dell'Isonzo (Friuli Venezia Giulia, Nord-Est Italia). Studi Tridentini di Scienza Naturali, vol. 89, 83–87.

Capitulo, A. R., M. Tangorra & C. Ocon (2001): Use of benthic macroinvertebrates to assess the biological status of Pampean streams in Argentina. Aquat. Ecol., 35, 109–119.

Chauvet, E. (1993): Breakdown and Invertebrate colonization of leaf litter in two contrasting streams: significance of Oligochaetes in large rivers. Can. J. Fish. Acquat. Sci., 50, 488–495.

Claret, C., P. Marmonier, M. J. Dole-Olivier & E. Castella (1999): Effects of management works on the interstitial fauna of floodplain aquatic systems (River Rhone, France). Biodiversity Conserv., 8 (9), 1179–1204.

Cook, S. E. (1976): Quest for an index of community structure sensitive to water pollution. Environ. Pollut., 11, 268–287.

Cummins, K. W. (1974): Structure and function of stream ecosystems. Bioscience, 24, 631–641.

Directive 2000/60/EC of the European Parliament and the Council of 23rd October 2000 establishing a framework for community action in the field of water policy. Official Journal, Vol. OJ L 327, 22.12.2000, pp. 1–73.

Dudgeon, D. (1982): An investigation of physical and biotic processing of two species of leaf litter in Tai Po Kau forest stream, New Territories, Hong Kong. Arch. Hydrobiol., 96, 1–32.

Fenoglio, S., T. Bo, M. Cucco & G. Malacarne (2006): Leaf break down patterns in a NW Italian stream: effect of leaf type, environmental conditions and patch size. Biologia, Bratislava, 61 (5), 555–563.

Ghetti, P. F. & G. Bonazzi (1981): I macroinvertebrati nella sorveglianza ecologica dei corsi d'acqua. Manuali di utilizzazione degli indicatori biologici di qualità delle acque. Consiglio Nazionale delle Ricerche AQ/1/127, Verona, 181 p.

Gilbert, A. J., H. Goosen, P. van Der Werff (2004): Management of Wetlands. Reg. Environ. Change, 4, 77–78.

Griffiths, R. W. (1991): Environmental quality assessments of the St. Clair River as reflected by the distribution of benthic macroinvertebrates in 1985. Hydrobiologia, 219, 143–164.

Mancinelli, G., L. Sabetta & A. Basset (2005): Short--term patch dynamics of macroinvertebrate colonization on decaying reed in a Mediterranean lagoon (Lake Alimni Grande, Apulia, SE Italy). Mar. Biol., 148, 271–283.

McCall, P. L. & F. M. Soster (1990): Benthos response to disturbance in western Lake Erie: regional faunal surveys. Can. J. Fish. Aquat. Sci., 47, 1996–2009.

Metcalfe-Smith, J. L. (1994): Biological Water Quality Assesment of Rivers: Use of Macroinvertebrate Communities. In: Calow, P. & G. E. Petts (eds): The rivers handbook, vol. 2. Blackwell Science, London, pp. 144–170.

Olson, J. S. (1963): Energy storage and the balance of producers and decomposers in ecological systems. Ecology, 44 (2), 322–331.

Perco, F., P. Merluzzi & K. Kravos (2006): La foce dell'Isonzo e l'Isola della Cona. Edizioni della Laguna, Mariano del Friuli (GO), 144 p.

Petersen, R. C. & K. W. Cummins (1974): Leaf processing in a woodland stream. Freshw. Biol., 4, 343–368.

Pizzul, E., S. Guiotto & G. A. Moro (2008): Osservazioni sulle comunità macrozoobentoniche dell'Isola della Cona (Friuli Venezia Giulia, Nord-Est Italia). Annales, Ser. Hist. Nat., 18 (1), 79–90.

Pope, R. J., A. M. Gordon & N. K. Kaushik (1999): Leaf litter colonization by invertebrates in the littoral zone of a small oligotrophic lake. Hydrobiologia, 392, 99–112.

Reice, S. R. & G. Herbst (1982): The role of salinity in decomposition of leaves of *Phragmites australis* in desert streams. J. Arid Environ., 5, 361–368.

Robinson, C. T. & C. Jolindon (2005): Leaf breakdown and the ecosystem functioning of alpine streams. J. N. Am. Benthol. Soc., 24, 495–507.

Rooney, R. C. & S. E. Bayley (2012): Community congruence of plants, invertebrates and birds in natural and constructed shallow open-water wetlands: Do we need to monitor multiple assemblages? Ecol. Indic., 20, 42–50.

Rubbo, M. J., L. K. Belden & J. M. Kiesecker (2008): Differential responses of aquatic consumers to variations in leaf-litter inputs. Hydrobiologia, 605, 37–44.

Sangiorgio, F., A. Basset, M. Pinna, L. Sabetta, M. Abbiati, M. Ponti, M. Minocci, S. Orfanidis, A. Nicolaiou, S. Moncheva, A. Trayanova, L. Georgescu, S. Dragan, S. Beqiraj, D. Koutsoubas, A. Evagelopoulos & S. Reizopoulou (2008): Environmental factors affecting *Phragmites australis* litter decomposition in Mediterranean and Black Sea transitional waters. Aquatic Conserv. Mar. Freshw. Ecosyst., 18, 16–26.

Sharma, K. P. & B. Gopal (1982): Decomposition and nutrient dynamics in *Thypha elephantine* Robx. under different water regimes. In: Gopal, B., R. E. Turner, R. G. Wetzel & D. F. Whigham (eds): Wetlands ecology and management. International Science, Jaipur, pp. 321–335.

Siligardi, M., S. Bernabei, C. Cappelletti, E. Chierici, F. Ciutti, F. Egaddi, A. Franceschini, B. Maiolini, L. Mancini, M. R. Minciardi, C. Monauni, G. L. Rossi, G. Sansoni, R. Spaggiarri & M. Zanetti (2007): I.F.F. – Indice di Funzionalità Fluviale. APAT, Ministero dell'Ambiente e della Tutela del Territorio e del Mare, APPA Trento. Lineagrafica Bertelli Editori, Trento, 340 p.

Sörensen, T. (1948): A method of establishing groups of equal amplitude in plant sociology based on similarity of species content. K. Danske Vidensk. Selsk. Biol. Skr., 4, 1–34.

Stoch, F. (1995): Indagine ecologico-faunistica sui popolamenti ad entomostraci di alcuni stagni di acqua salmastra dell'Isola della Cona (foce del Fiume Isonzo, Italia nordorientale). Gortania, Atti Mus. Friul. St. Nat., 16, 151–173.

Stoch, F. (2002): Torrenti montani. La via delle correnti. Quaderni habitat. Ministero dell'Ambiente e della Tutela del Territorio. Museo Friulano di Storia Naturale, Udine, 159 p.

Street, M. (1982): The use of waste straw to promote the production of invertebrate foods for waterfowl in man-made wetlands. In: Scott, D. A. (ed): Managing wetlands and their birds. Proceedings of the Third Technical Meeting on Western Palearctic Migratory Bird Management. International Waterfowl Research Bureau, Slimbridge, pp. 98–103.

Thompson, P. L. & F. Bärlocher (1989): Effect of pH on the leaf breakdown in streams and in the laboratory. J. N. Am. Benthol. Soc., 8, 203–210.

Trigal-Domínguez, C., C. Fernández-Aláez & F. García-Criado (2009): Habitat selection and sampling design for ecological assessment of heterogeneous ponds using macroinvertebrates. Aquat. Conserv. Mar. Freshwat. Ecosyst., 19, 786–796.

van der Valk, A. G. (1990): Response of wetland vegetation in water level. International Workshop on Wetland Management and Restoration, Falköping, Sweden, 12–15 September 1990, 16 p.

Webster, J. R. & E. F. Benfield (1986): Vascular plant breakdown in freshwater ecosystems. Annu. Rev. Ecol. Syst., 17, 567–594.

Wiggins, G. B., R. J. Mackay & I. M. Smith (1980): Evolutionary and Ecological strategies of animals in annual temporary pools. Arch. Hydrobiol., Suppl. 58, 97–206.

Zar, J. H. (1984): Biostatistical Analysis 2nd edition. Prentice-Hall, International Inc., New Jersey, 718 p.