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Feeding diversity in macroinvertebrate communities: A contribution to estimate the ecological status in shallow waters

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ABSTRACT

The feeding diversity of subtidal samples of macroinvertebrates from Ria Formosa was estimated with Shannon–Wiener information index and complementary evenness. The results were compared with other commonly used methodologies under the European Water Framework Directive, such as diversity indices, AMBI and ITI.

Assuming that in a healthy environment all feeding groups are present, and that no group clearly dominates, the feeding diversity is expected to be maximal and the evenness feeding diversity will be close to 1. In degraded environments some feeding groups might be absent or having low relative abundance, and generally with one or two groups dominating the community. In this way the evenness feeding diversity index would measure deviations from expected values due to a degradation of the environment. Although confirmation of this approach needs to be tested in other shallow waters, the results obtained show interesting features.

To each of the 297 species belonging to the Ria Formosa data matrix a feeding group was assigned, among six groups: surface deposit feeders, subsurface deposit feeders, herbivores, suspension feeders and suspension/deposit feeders (species which have the two feeding modes depending on food availability). The carnivorous, parasites, omnivorous and scavengers were all grouped together, forming the sixth group. Most of the stations of Ria Formosa showed high feeding diversity, which could correspond to a good or high ecological status (ES) except at one location, that occasionally showed low feeding diversity. This poor condition was essentially due to low water renewal and extreme environmental variation of some parameters, such as salinity. At some locations an intermediate feeding diversity was observed mainly due to natural accumulation of organic matter. Other commonly used indices also point out to the same tendencies.

We propose the evenness feeding diversity estimate approach as a practical and apparently robust method to estimate the ES of shallow waters, which can be used together with other common indicators. This approach has also the advantage of showing low sensibility to small samples and to low taxonomic identification effort.

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1. Introduction

The scientific community together with the competent authorities of the Member States of European Union is developing methodologies for defining the reference conditions and the ecological status of the major water bodies in Europe. Several biotic indices are being tested, modified and discussed for different coastal or transitional waters, based on one or more of the ES compartments of the ecosystem. The results obtained are at times contradictory (Gamito, 2008a), with indices showing different discriminating power (Chainho et al., 2007; Dauvin et al., 2007; Pranovi et al., 2007; Munari and Mistri, 2008).

Most of the biotic indexes are based on the Pearson and Rosenberg (1978) model. According to this model, with increasing organic input there is an increase of abundance, biomass and species richness in the first step. This is followed by progressive declination of species richness and biomass when eutrophication increases, while abundance (mainly of type *r* opportunistic species) continues to rise. But the problem is that the tolerant species, which endure these high organic concentrations, may also be tolerant to natural stressors (Dauvin, 2007; Elliott and Quintino, 2007) such as physical stress due to low water hydrodynamics found in some areas of estuaries and coastal lagoons (Gamito, 2006).

In the benthic invertebrates group it is usual to find organisms that feed essentially on detritus or on the bacteria benthic layer in the sediments, and other organisms that filter water to retain the plankton and small detritic suspended particles. Additionally, other organisms can also be found, such as herbivorous or grazers, feeding either on the macroalgae or on the epiphyte layer of the seagrasses, or carnivorous, feeding in other living organisms. Many of these carnivorous may also be necrophagous or scavengers, feeding on dead tissues. They can also be detritus feeders, feeding on small detritus of different origins that tend to accumulate on the sediments, in places with low hydrodynamic activity (Pearson and Rosenberg, 1987; Rosenberg, 2001). It is expected that several feeding groups coexist in the same place, but in different proportions, according to hydrodynamic conditions, which in turn determines the sediment characteristics.

In fact, suspension-feeding animals mostly dominate sandy sediments; deposit feeders dominate muddy sediments (Sanders, 1958), while carnivores and other feeding types occur in both types of sediments (Levinton, 2001). Small sedimentary particles are indicative of a quiet water environment and it is here that fine-grained organic matter tends to settle from the water column. Suspension feeders function poorly in muddy sediments due to the clogging effect of resuspended particles and the destabilizing effect of deposit feeders on the sediment (Rhoads and Young, 1970; Levinton, 2001).

In estuaries and coastal lagoons muddy sediments are characteristic of places with low water currents or with low water renewal, colonized by detritivores of opportunistic *r* type. These areas may be subjected to high physical stress, such as daily high temperature and salinity variation, combined with large fortnightly and seasonal variation (Gamito, 2006). The sediment may therefore be dominated by *r* opportunistic detritivores and their abundant presence may be the result of physical stress and not of organic stress. Thus such harsh conditions prevent the development of other species, usually strong competitors of the K type. Furthermore, some of these strong competitors are top predators that may act as keystone species, regulating the community in a top-down way.

In stressed environments subjected either to anthropogenic action or natural physical stress, it is expected that the diversity of feeding groups decreases. This decrease is perhaps attributable to changes in dominance of the feeding groups, with the presence of all types or the absence of some types. In communities from locations with good ecological conditions presumably all the feeding groups will occur. In sandy sediments the community will be dominated by suspension feeders, and in muddy sediments by detritus feeders. In seagrasses beds, which are very common in healthy estuarine or lagoonal locations (Kemp, 2000), the species richness is usually high and the community might be dominated by detritus feeders, as these locals act as sediment traps, accumulating fine sediments and organic matter.

Having this in mind, the Shannon–Wiener information index (Shannon and Weaver, 1963) and evenness index (Pielou, 1969) were used as a pathway to estimate the feeding diversity of benthic invertebrate communities. The feeding diversity results were then compared with the Infaunal Trophic Index (Word, 1978) and with AMBI index (Borja et al., 2000, 2003), and also with other diversity indices commonly proposed for the ecological status evaluation.

2. Materials and methods

The data set resulted from the compilation of several sampling projects, carried out from 1985 to 1997 in Ria Formosa. This is a shallow coastal lagoon in South Portugal, classified as a Coastal Water body by the Portuguese WFD intercalibration group (Bettencourt et al., 2004). The sampling projects covered different sediment types and different stressed conditions. The data set analysed and discussed in detail in Gamito (2008b) was used to test the feeding diversity index and its applicability under the scope of WFD. In this work, only the subtidal soft-bottom stations were considered (Fig. 1).

Gamito (1997, 2006) sampled five water reservoirs of three salinas, one tidal mill and a fish farm. All the five reservoirs received the same incoming water from a tidal channel from one of the main inlets of Ria Formosa. At each reservoir four to six corers of 0.011 m^2 each were sampled (stations 1–4), depending on their size and shape. Macrofauna was sampled for 2 years, every second month, in 1985 and 1986. Station 5 was sampled from March 1996 to June 1997 every month, where eight corers of 0.011 m^2 each were taken at every sampling occasion. The water reservoirs were about 0.4–1 m deep, with deeper zones near the tidal gates. The fifth water reservoir was approximately 2 m deep.

Calvário (1995) sampled five stations of the Faro channel (stations 5–10), from the inlet waters coming to the city of Faro, in spring, summer, autumn and winter 1989. At each station six samples were taken using a Van Veen grab, covering a total area of 0.3 m^2. The depth of these stations varied from −15 m (stations 6 and 7) to −10 m (stations 8 and 9) and −7 m (station