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Environmental parasitology: Parasites as accumulation bioindicators in the marine environment

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ABSTRACT

Parasites can be used as effective monitoring tools in environmental impact studies as they are able to accumulate certain pollutants (e.g. metals) at levels much higher than those of their ambient environment and of free-living sentinels. Thus, they provide valuable information not only about the chemical conditions of their and their hosts' environment but also deliver insights into the biological availability of allochthonous substances. While a large number of different freshwater parasites (mainly acanthocephalans and cestodes) were investigated in terms of pollutant bioaccumulation, studies based on marine host–parasites systems remain scarce. However, available data show that different marine parasite taxa such as nematodes, cestodes and acanthocephalans exhibit also an excellent metal accumulation capacity.

The biological availability of metals and their uptake routes in marine biota and parasites differ from those of freshwater organisms. We assume that a large part of metals and other pollutants are also taken up via the digestive system of the host. Therefore, in addition to environmental conditions the physiology of the host also plays an important role for the accumulation process. Additionally, we highlight some advantages in using parasites as accumulation indicators in marine ecosystems. As parasites occur ubiquitously in marine food webs, the monitoring of metals in their tissues can deliver information about the spatial and trophic distribution of pollutants. Accordingly, parasites as indicators offer an ecological assessment on a broader scale, in contrast to established free-living marine indicators, which are mostly benthic invertebrates and therefore limited in habitat distribution. Globally distributed parasite taxa, which are highly abundant in a large number of host species, are suggested as worldwide applicable sentinels.

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1. Introduction

Continuously rising pollutant emissions on a global scale lead to an increase of contamination levels in marine ecosystems (Halpern et al., 2008). Elevated concentrations of metals and various organic compounds in the sea are usually of anthropogenic origin, for example due to oil industry (e.g. oil spills, National Research Council, 2003) or ocean dumping (Zutshi and Prasad, 2008). These contaminations can severely affect biota as well as the entire function and integrity of marine ecosystems (Mayer-Pinto et al., 2010; Perez-del-Olmo et al., 2009). Depending on their category or chemical properties, allochthonous substances behave very specifically if released to the marine environment. While some can persist as inert components in the system which are not taken up by organisms, others are biologically available,

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i.e. they will be accumulated by organisms and lead to acute and chronic toxic effects (Merian, 2004). Therefore, monitoring of contamination levels of pollutants (such as priority substances or emergent pollutants) is highly needed not only from an ecological but also from a public health point of view, as marine ecosystems represent a large source of food for the human population (Belton and Thilsted, 2014). The most relevant groups of pollutants are represented by toxic metals and their compounds, pesticides and pharmaceutics, polychlorinated biphenyls (PCBs) and petroleum aromatic hydrocarbons (PAHs) (Khan and Thulin, 1991).

Direct analysis of pollutants in different environmental matrices such as water, sediment and suspended particulate matter usually shows if a pollutant of interest is present in an ecosystem. It cannot, however, deliver information about the biological availability of the target substance, and as some of these compounds occur in critically low concentrations, it is sometimes even impossible to detect them using conventional analytical techniques. In order to overcome these limitations different organisms, so called sentinels or accumulation bioindicators, are commonly applied in environmental impact studies (e.g. Amoozadeh et al., 2014; Zhou et al., 2008). Accumulation indicators are organisms which are able to concentrate certain substances in their tissues to levels significantly higher than those in the ambient environment (Beeby, 2001). Thereby, they provide valuable information about the chemical state of their habitats and similarly deliver insights into the biological availability of target substances.

For monitoring purposes in marine systems a large number of free living organisms is already established as sentinels, among them planktonic organisms (Zhou et al., 2008), molluscs (Azarbad et al., 2010; Boening, 1999), annelids (Amoozadeh et al., 2014; Reish and Gerlinger, 1997), crustaceans (Klerks et al., 2007; Pourang and Dennis, 2005; Raissy et al., 2011; Reis et al., 2011; Vidal-Martínez et al., 2006), fish (Van der Oost et al., 2003) and mammals (Becker, 2000; Cáceres-Saez et al., 2013). These organisms do not only represent the most important groups of marine biota but they are also intimately connected with each other due to trophic interactions allowing us to estimate pollutant biomagnification along food webs (Fig. 1). Additionally, during the last two decades intensive research in the field of environmental parasitology demonstrated that also several parasites can be used as accumulation bioindicators at least for metals (Le et al., 2014; Sures, 2003, 2005; Vidal-Martínez et al., 2010). For example, in field studies metal concentrations in parasites exceeded many times those in host tissues, in the ambient environment or in other free-living sentinels (Sures et al., 1999). Based on the current knowledge about their pollutant accumulation capacity, acanthocephalans and cestodes appear to be the most promising groups of parasites as sentinels (Sures, 2004a,b; Vidal-Martínez et al., 2010). Due to their high accumulation capacity, several parasites (e.g. acanthocephalans) can even reduce pollutant burdens in host tissues (Filipović Marijić et al., 2014; Sures and Siddall, 1999; Sures et al., 2003). Accumulation studies regarding other endoparasitic groups (e.g. nematodes, digeneans) or ectoparasites (e.g. monogeneans, parasitic crustaceans) remain scarce until now. Moreover, most of the available data so far focus on host–parasite systems in fresh water ecosystems, whereas marine parasites remain less intensively investigated (Sures, 2005).

For biomonitoring purposes the selected parasite or host–parasite system should fulfill basic requirements in order to be established as a suitable accumulation indicator. Sures (2003) suggested and discussed

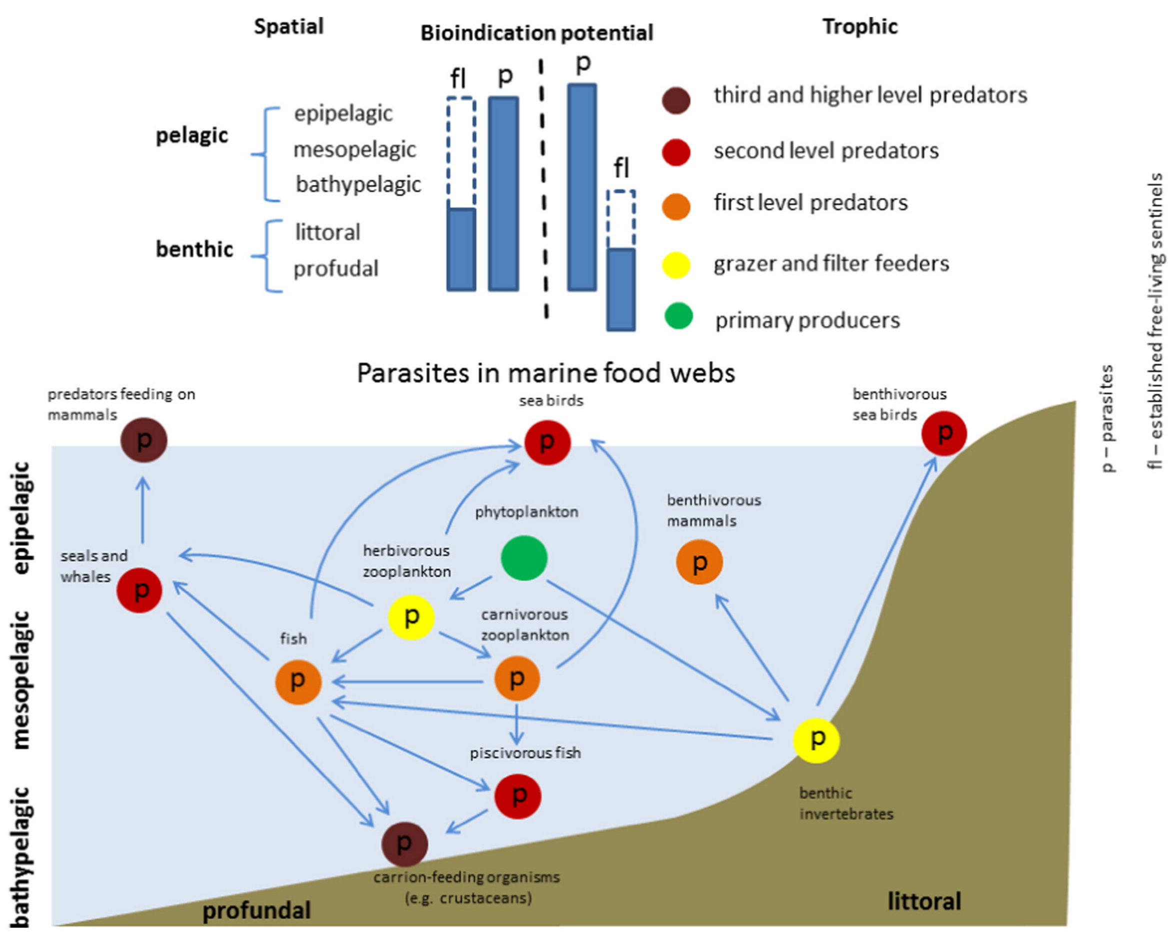

Fig. 1. Spatial and trophic distribution of parasites in marine ecosystems and their bioindication potential in comparison to established free-living sentinels. Figure modified from AMAP (1998).