



Integrating parasitology and marine ecology: Seven challenges towards greater synergy



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ABSTRACT

Despite their very different historical origins as scientific disciplines, parasitology and marine ecology have already combined successfully to make important contributions to our understanding of the functioning of natural ecosystems. For example, robust assessments of the contribution of parasites to ecosystem biomass and energetics, and of their impact on community-wide biodiversity and food web structure, have all been made for the first time in marine systems. Nevertheless, for the marriage between parasitology and marine ecology to remain fruitful, several challenges must first be overcome. We discuss seven such challenges on the road to a greater synergy between these disciplines: (1) Raising awareness of parasitism as an ecological force by increasing the proportion of articles about parasites and diseases in marine ecology journals; (2) Making greater use of theory and conceptual frameworks from marine ecology to guide parasitological research; (3) Speeding up or at least maintaining the current rate at which marine parasites are found and described; (4) Elucidating a greater proportion of life cycles in all major groups of marine parasites; (5) Increasing the number of host–parasite model systems on which our knowledge is based; (6) Extending parasitological research offshore and into ocean depths; and (7) Developing, as needed, new epidemiological theory and transmission models for the marine environment. None of these challenges is insurmountable, and addressing just a few of them should guarantee that parasitology and marine ecology will continue to join forces and make further substantial contributions.

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1. Introduction

The history of marine ecology as a scientific discipline has always been closely linked with the exploration of the oceans. From the

Challenger expedition in the 1870s to modern research cruises, from the first undersea walk by a diver wearing a heavy copper helmet to the use of scuba and submersibles, research in marine ecology and oceanography has always been associated with adventure and big equipment. Marine ecology has matured as a discipline by developing its own theoretical framework, overlapping in part with general ecological theory but also accounting for the unique features of the marine

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environment. In contrast, parasitology emerged mostly as a discipline of the health sciences, with strong ties to medicine and veterinary science, and with the goal of controlling diseases of humans and domestic animals. When focused on wildlife, parasitology was long dominated by a basic natural history approach, consisting in the discovery and taxonomic description of parasite species and the elucidation of their life cycles. It is only in the last few decades that the rise of epidemiological theory and the influence of general ecological theory have impacted the ecological branch of parasitology and allowed it to develop into a more rigorous, hypothesis-driven science.

Based on their very different historical origins as scientific disciplines, it is difficult to imagine two more distinct research traditions than those of parasitology and marine ecology. Yet, the two have already combined successfully to make important contributions to our understanding of the functioning of natural ecosystems, as the following three examples illustrate. Firstly, the quantitative demonstration that parasites account for a significant proportion of the biomass and productivity of natural ecosystems was first achieved in marine habitats (Kuris et al., 2008). Secondly, the first experimental confirmations that single parasite species can have community-wide impacts, by modifying the activity of ecosystem engineers or key grazers and indirectly affecting the density and diversity of other free-living species of algae or invertebrates, were also achieved in marine systems (Thomas et al., 1998; Mouritsen and Poulin, 2005; Wood et al., 2007). Thirdly, the first and still the most thorough assessments of the impacts of parasitism on the structure and complexity of entire food webs were also performed in marine communities (Huxham et al., 1995; Thompson et al., 2005; Lafferty et al., 2006; Dunne et al., 2013). These are all important advances for ecology in general, and all came from the study of parasites in the marine realm. In addition, the work of parasitologists has also contributed to 'applied' marine ecology, such as through the use of parasites as biological tags for discrimination of commercial fish stocks (MacKenzie, 2002; Poulin and Kamiya, 2014) or the development of control measures against disease in aquaculture (e.g., Pike and Wadsworth, 1999).

Despite these achievements, the continued synergy between parasitology and marine ecology is faced with some serious current or near-

future obstacles. Here, we identify seven such challenges on the road toward greater integration of the two disciplines. For each of these, we highlight the problem and propose a solution. None of these impediments is insurmountable, but measures must be taken now to ensure that parasitology and marine ecology can continue to team up to further our understanding of the functioning of oceanic ecosystems.

2. Challenge one: research on parasites lacking from marine ecology journals

Estimates of parasite biodiversity indicate that perhaps as much as half of the species on Earth are parasites (Windsor, 1998; Poulin and Morand, 2000, 2004; de Meeûs and Renaud, 2002). Because a large proportion of them are aquatic during at least part of their life cycle, we would certainly expect that in the absence of taxonomic or other biases, parasites and the diseases they cause should receive at least equal attention in journals specializing in marine ecology as they do in more general ecological journals. This is the null expectation assuming that researchers focus on different biotic processes (predation, competition, parasitism, etc.) independently of the type of environment (terrestrial, freshwater, marine) in which they work.

Sadly, this is not the case. A survey of publication trends over the past decade indicates that articles on parasites or diseases are underrepresented in journals dedicated to marine ecology compared to journals of ecology in general (Fig. 1). On average, more than 10% of articles published annually in general ecological journals concern parasites and diseases, whereas this number is less than 5% for marine ecology journals. One strongly suspects that the same clear discrepancy would emerge from an analysis of papers presented at conferences of general ecology versus those presented at conferences of marine ecology.

Further evidence for the notion that parasites and diseases as important ecological forces has been slow to take hold in marine ecology comes from the fact that they are only mentioned in some of the most recent marine ecology textbooks. Indeed, some influential texts in marine ecology in the 1990s did not list either parasites or diseases in their subject index (e.g., Mann and Lazier, 1996; Barnes and Hughes, 1999; Mann, 2000), or only mentioned them very briefly (Nybakken, 1993; Levinton, 1995). In contrast, more recent books provide at least some content on marine parasites and the diseases they cause (e.g., Bertness et al., 2001; Castro and Huber, 2009; Speight and Henderson, 2010; Kaiser et al., 2011). Nevertheless, an informal look at the syllabus or course manual of university courses in marine biology or marine ecology that are accessible online indicates that most do not even mention the word "parasite". Sheltering the next generation of marine ecologists from parasites represents a major impediment to the advancement of marine ecological parasitology. For the idea that "parasites matter" to get across to young marine ecologists, so that it may enter the scope of their current and future research, it first has to become established in their field. The study of parasites needs to gain a stronger foothold in marine ecology if the two disciplines are to continue to yield new and important insights. This does not necessarily demand active lobbying by parasitologists. Instead, parasitologists should simply consider marine ecology journals as potential outlets for their work, and occasionally present their findings at marine ecology conferences. Raising the parasite content of journals and conferences could be achieved in just a few years, and the greater exposure would probably be the best way to increase awareness of parasitism as an important biotic process among marine ecologists.

3. Challenge two: marine ecology concepts ignored in parasitological research

Marine ecologists might pay little attention to parasites, but they are not the only ones to blame for the limited synergy between parasitology and marine ecology. Parasitologists are just as guilty of ignoring key concepts and theory in marine ecology. Research in most disciplines at any

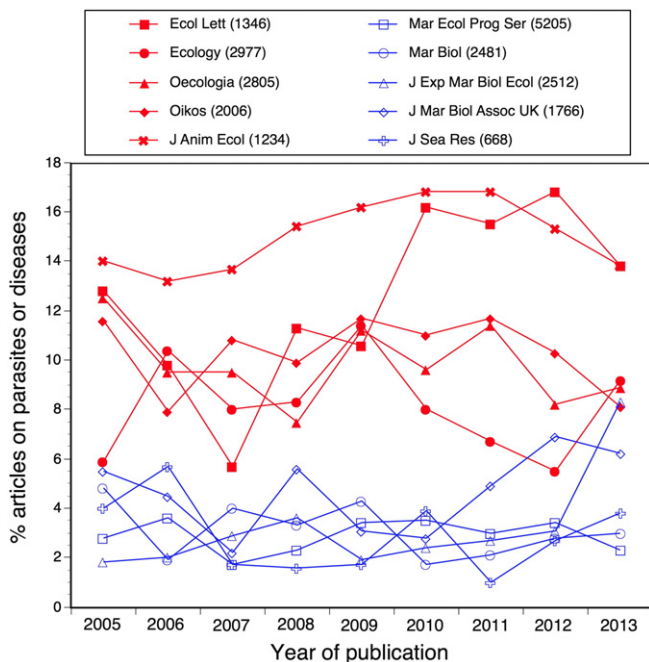


Fig. 1. Annual proportion of articles on parasites or diseases published in general ecological journals (filled symbols) and in journals of marine ecology or biology (open symbols) in the period 2005–2013. The data come from a search of the Web of Science™ using the keywords "parasit*" or "disease*". Numbers in parentheses following journal names indicate the total number of articles published in each journal during that period.

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