Trematodes on acid: editorial comment on the feature article by Guilloteau et al.

Thorsten B. H. Reusch¹

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The field of ocean acidification (OA) research is moving rapidly, moving from studying first-order direct effects of lowered pH and carbonate ion concentration impinging directly upon organismal physiology to ask how species interactions are modified. How host–parasite interactions may be modulated by ocean acidification is currently largely unknown, in particular for macroparasites (=metazoan animal parasites). This is unfortunate, given that these interactions are among the strongest biological interactions in all ecosystems, while their food web role, in particular in coastal systems, is often neglected (but see Kuris et al. 2008).

Digenean trematodes are one of the most abundant and diversified groups of macroparasites worldwide, displaying a breathtaking diversity of two- or three-phasic life cycles (Galaktionov and Dobrovolskij 2003). Often, the first intermediate host is a mollusc (snail or bivalve), followed by a fish as second intermediate host, and a mammal or bird species as third and definitive host where sexual reproduction takes place. In this issue of Marine Biology, the study by Guilloteau et al. (2016) focused on the mollusc host phase where the infective parasite stages rapidly multiply via clonal proliferation, a critical step for generating millions of free-swimming cercariae. Note that in the case of the two model species in the study by Guilloteau et al. (2016) cercariae leave out the 2nd intermediate host and encyst directly on benthic surfaces to become

metacercariae, awaiting ingestion by the definitive host. For the first time, Guilloteau and co-authors studied how OA would alter the performance of infective stages within snails. They found that lower pH increased the production of cercariae in both species, with a possible trade-off of smaller sizes over a 2-month experimental period. The longevity of encysted metacercariae assessed over a 30-day interval was reduced in the one (*Philophthalmus*) but not in the other species (*Parorchis*). These strong species-specific effects highlighted that currently, no generalizations are possible with respect to OA effects on marine trematodes.

As a fascinating zoological curiosity, their model species *Philophthalmus* and *Parorchis* display caste diversification. Some individuals develop into smaller morphotypes that defend the larger clonal proliferators against competing trematode species (so-called soldiers). As a result of experimental ocean acidification, the cast ratios were biased towards fewer defensive stages, again an effect that was species specific. *Philophthalmus* showed the highest proportion of small ‘soldier’ morphotypes at intermediate acidification levels, while in *Parorchis*, fewer defensive stages were found at the lowest pH. The observed effects most likely have consequences for parasite transmission rates and hence for the prevalence of these species within the diverse host species.

Taken together these results highlight both the need to address how the inevitable progression of dissolved CO₂ into the ocean as a result of anthropogenic burning of fossil fuels alters species interactions beyond competition (James et al. 2014), grazing (Borell et al. 2013) and predation (Kroeker et al. 2014), namely the neglected field of host–parasite interactions. Another valuable next step would be to assess the long-term evolutionary consequences of acidification on the equilibrium of hosts and parasites (Sunday

Responsible Editor: U. Sommer.

✉ Thorsten B. H. Reusch
TReusch@geomar.de

¹ Evolutionary Ecology, GEOMAR Helmholtz Centre for Ocean Research Kiel, 24105 Kiel, Germany

et al. 2014), as well as including more than one component of global change, i.e. warming and acidification. Finally, such experimental data are urgently needed to complement epidemiological assessments on the possible increase of marine disease as a consequence of global change.

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