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ENVIRONMENTAL MICROBIOLOGY

Marine phosphate stress is PhoX-rated

Determining how phosphate availability controls bacterial growth is important to our understanding of global geochemical cycles. In a study published in *The ISME Journal*, Sebastian and Ammerman identify PhoX, an alkaline phosphatase that is widespread in ecologically important groups of marine bacteria, as a marker for inorganic phosphate (P_i) stress.

Because the upper layers of the oceans are depleted for dissolved P_i, planktonic bacteria have been forced to adopt different strategies to cope with phosphate starvation. In *Escherichia coli*, such starvation results in activation of the Pho regulon. This regulon encodes proteins that are important for P_i scavenging, including the alkaline phosphatase PhoA, which hydrolyses phosphate esters in the periplasm to release P_i. Alkaline phosphatase activity is a useful measure of P_i deficiency in marine microbial communities. However, metagenomic studies have so far failed to identify PhoA homologues, suggesting that alternative alkaline phosphatases might be present.

Sebastian and Ammerman searched the marine metagenomic Global Ocean Sampling (GOS) database and found that *phoA* homologues were present in only a few marine bacterial lineages (including the Gammaproteobacteria and Bacteroidetes). However, analysis of sequences from the GOS database and a marine PCR survey identified more than 470 homologues to *phoX*, another alkaline phosphatase that shares no homology with *phoA*. These *phoX*-like sequences were widespread among diverse bacterial phyla. Phosphate starvation of the marine bacteria *Silicibacter pomeroyi* and *Roseobacter denitrificans* led to a strong induction of alkaline phosphatase activity and an increase in the expression of chromosomally encoded *phoX*. Interestingly, *R. denitrificans* carries a second *phoX* gene on its pTB1 megaplasmid. However, only weak expression of this *phoX* copy was observed and the gene was not responsive to P_i. Mutational inactivation of *phoX* in *S. pomeroyi* caused a tenfold decrease in the induction of alkaline phosphatase activity following P_i starvation.

Analysis of two marine metatranscriptomic data sets and their corresponding metagenomes revealed that *phoX* is more abundant than *phoA* in oligotrophic environments, which are characterized by a low abundance of dissolved nutrients and high oxygen levels. However, in certain bacteria, such as the Bacteroidetes, *phoA* was found to be important for the P_i stress response. Such heterogeneity in the P_i stress responses in marine bacteria underlines the importance of identifying additional molecular markers, such as *phoX,* to better understand phosphate control in global biogeochemical cycles.

phoX may be more widespread than *phoA* because PhoX is activated by the binding of Ca^{2+}, whereas PhoA relies on Zn^{2+} for activation. In marine environments, Zn^{2+} often occurs at subnanomolar concentrations, which would favour the use of PhoX by bacteria rather than PhoA. Further work is needed to determine if this is indeed the case.

Andrew Jermy

> “...*phoX* is more abundant than phoA in oligotrophic environments...”

ORIGINAL RESEARCH PAPER Sebastian, M. & Ammerman J. W. The alkaline phosphatase PhoX is more widely distributed in marine bacteria than the classical PhoA. *ISME J.* 12 Feb 2009 (doi:10.1038/ismej.2009.10)