

Strategies of adaptation to an extreme environment: the case of *Alvinella pompejana*

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Deep-sea hydrothermal vents are a challenging habitat for metazoan life forms because of the high pressure, the high temperature, the high concentrations of toxic chemical compounds and the extreme physico-chemical gradients that occur over short spatial and temporal scales. Strategies of adaptation to this extreme environment have been studied in a variety of vent organisms, but the polychaete worm *Alvinella pompejana* is considered as the most intriguing because of its ability to survive high temperatures (up to 80°C) on active chimney walls. This animal was thus described as the most thermotolerant marine metazoan. However, this view is debated because of the uncertainties in precisely assessing the *in situ* conditions to which *A. pompejana* is really exposed, and because of the relatively low thermal stability of different metabolic enzymes. What are the strategies allowing *A. pompejana* to inhabit high temperature chimney walls? Extra-cellular matrices, such as the tube, in which this animal spends most of its time, and its cuticle, composed of the most thermostable collagen known, might have a critical role in this thermotolerance. In addition, recent data suggest that tubes might be particularly important in modifying the architecture of the worms colonies, redirecting vent fluids, and creating a multitude of micro-niches with moderate conditions. The high thermophily of *A. pompejana* raises another question regarding its dispersal and colonization abilities. If this species prefers high temperature environments, how is it able to face the abyssal conditions while dispersing? Indeed, this species is spread over a range of 4000 km along the East Pacific Rise, with hydrothermal chimneys occurring every 10 to 100 kilometers. Dispersal is thus essential for the maintenance of the species. Embryonic life appears to be strikingly different from the adult life, since early embryos do not survive temperatures above 20°C. At abyssal temperature, development is arrested but warmer water might trigger the developmental program once embryos arrive near a new vent, after a period of arrested development during transport by deep-sea currents. Therefore, not only this species is adapted to its extremely high temperature environment through molecular mechanisms, but also at the scale of the whole organism through a dual strategy during its life-cycle. A genomic approach is now being developed in this species. It may reveal novel molecules, metabolic pathways that stabilise cellular macromolecules, and identify non-conventional protection systems. EST data will soon allow the development of microarray approaches characterizing the global stress response pathways to environmental injuries. Mechanisms allowing organisms to cope with other sources of stress such as pressure or high sulphide concentration at different stages of the life-cycle might also be addressed through the use of the sequenced genes with microarray technology.

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