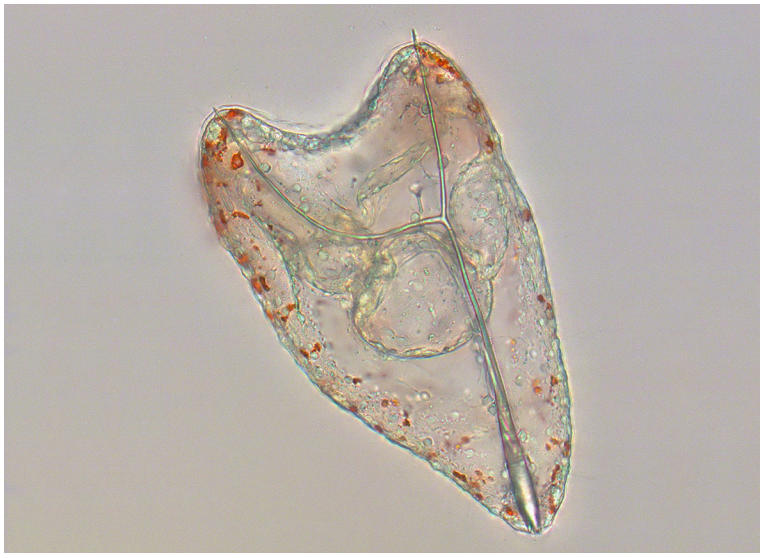
INSIDE JEB

# Alkaline guts protect sea urchin larvae from infection



A 4-day-old purple sea urchin (*Strongylocentrotus purpuratus*) larva. Photo credit: Marian Y. Hu.

Stomachs are one of the first lines of defence against infection. Whatever we consume usually comes with a dusting of bugs and fungi from our surroundings, and digestive systems tend to be prepared for this unwanted seasoning. Meike Stumpp, from Christain-Albechts University of Kiel, Germany, explains that the stomach contents of mammals are usually strongly acidic, to destroy infections, while insect digestive tracts favour more alkaline conditions. The midguts of minute sea urchin larvae drifting in the currents are also extremely alkaline, which made Stumpp, Marian Hu and their colleagues wonder whether the mini sea urchins' basic guts might protect them from infection and whether ocean acidification might leave the youngsters more vulnerable to infection.

Knowing that the larvae of purple sea urchins (*Strongylocentrotus purpuratus*) are susceptible to *Vibrio diazotrophicus* infections, the team decided to investigate how well that bacteria and other sea-borne bacteria causing infections fared when grown at pH values ranging from 5 to 9. Not surprisingly, the bacteria all thrived at pH 8, although *V. diazotrophicus* was the most vulnerable at the extreme pH values. Its growth rate plummeted by 60% at pH 9, so a high pH in the gut should definitely offer the larvae some protection from an infection picked up via their diet.

Next, the team tested how the pH of the larvae's midguts varied as they battled *V. diazotrophicus* infections, and found that the heaviest infection initially sent the larvae's gut pH plummeting, from ∼9.15 to 8.8, recovered a couple of hours later and then suffered a series of additional setbacks over the following 30 h. And, when Stumpp investigated how the miniature sea urchins were adjusting the pH of their midguts in response to the infection, she found that levels of two key pH-regulating proteins – an $Na^+/K^+$-ATPase and an $Na^+/H^+$ exchanger – increased, with the ATPase doubling while the exchanger increased more than 40 times. In addition, Stumpp prevented the larvae from activating the pH-raising proteins during a *V. diazotrophicus* infection, and this time the larvae's mortality rate more than doubled; the larvae's alkaline guts protect them from potentially lethal bacterial infections. Finally, the team tested the youngsters' resilience to infection as they simulated increasing ocean acidity, and they were impressed to see that the guts of the larvae only became slightly more acidic, dropping to pH 8.38 when the larvae were growing in pH 7.4 seawater. The young sea urchins from more acidic seawater were also equally effective at managing an infection as their siblings from normal seawater, increasing their midgut pH by 0.4 in response to an infection.

Sea urchin larvae depend on their alkaline midguts for protection from infection, and this line of defence should not be lost as oceans continue to acidify. However, Hu explains that the minute larvae have to consume more energy to resist the impact of ocean acidification on their digestive system, and he adds, 'that may, in the long run, have negative impacts on their fitness'.

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**Stumpp, M., Petersen, I., Thoben, F., Yan, J.-J., Leippe, M. and Hu, M. Y.** (2020). Alkaline guts contribute to immunity during exposure to acidified seawater in the sea urchin larva. *J. Exp. Biol.* **223**, jeb222844. doi:10.1242/jeb.222844

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