Exhalant jet speed of single-osculum explants of the demosponge Halichondria panicea and basic properties of the sponge-pump - DTU Orbit (30/01/2019)

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Sponges are modular organisms in which each aquiferous module draws water through a canal system by means of pumping units (choanocyte chambers, CC), and the filtered water leaves the module as an exhalant jet through a single opening (osculum). A constant density of CCs in sponges would imply that the filtration rate must be proportional to the sponge volume, but it is less obvious how the osculum cross-sectional area (OSA) scales to sponge volume. Here, we present data obtained on single-osculum sponge explants (i.e. single aquiferous modules) of the demosponge Halichondria panicea to gain insight into important basic properties of the sponge-pump. In the experimental study of 27 explants (volume $V_s=14$ to $1977\text{mm}^3$), osculum cross sectional area (OSA), exhalant jet speed ($U_0$) and filtration rate ($F=\text{OSA} \times U_0$) were measured. The observed scaling with size ($\text{OSA} \sim V_s^{0.66}$; $U_0 \sim \text{OSA}^{0.45}$; $F \sim \text{OSA}^{1.45}$) was found to be close to that inferred from the hypothesis of volume based CC density. Thus, the volume-specific filtration rate (= pumping rate) could be approximated as $F \text{ (mlmin}^{-1})=2.3V_s \text{ (cm}^3)\text{) which is of the same order of magnitude as that of the demosponge Haliclon urceolus, $F \text{ (mlmin}^{-1})=3.5V_s \text{ (cm}^3)\text{). This suggests that for the two sponge species CCs are very likely of similar size, with similar individual pumping rate, and of similar uniform distribution over the sponge volume. By comparing the observed increase of $U_0$ with increasing OSA to literature data on other leuconoid sponge species this revealed a power function with an identical exponent 0.45 and maximum values of $U_0=6$ to $8\text{cm}^{-1}$. This indicates that $U_0$ of a single-osculum explant, or $U_0$ of an individual osculum in a multi-oscula sponge approaches an upper limit as the sponge grows, implying that a module of a multi-oscula sponge may increase only to a certain size. Time-lapse video-microscope recordings of sponge explants showed temporal variation in OSA during spontaneous contractions. Exposure to a neurotransmitter (GABA) as well as overloading with ink particles triggered contractions that correlated with both decreasing OSA and $U_0$ that eventually became zero. Video-microscope recordings revealed that it was contraction of the endopinacoderm lining the excurrent canals that effectively restricted or stopped the water flow.

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