Flagellar number governs bacterial spreading and transport efficiency

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Peritrichous bacteria synchronize and bundle their flagella to actively swim while disruption of the bundle leads to a slow motility phase with a weak propulsion. It is still not known whether the number of flagella represents an evolutionary adaptation towards optimizing bacterial navigation. Here, we study the swimming dynamics of differentially flagellated *Bacillus subtilis* strains in a quasi-two-dimensional system. We find that decreasing the number of flagella N_f reduces the average turning angle between two successive run phases and enhances the run time and the directional persistence of the run phase. As a result, having less flagella is beneficial for long-distance transport and fast spreading, while having a lot of flagella is advantageous for the processes which require a slower spreading, such as biofilm formation. We develop a two-state random walk model that incorporates spontaneous switchings between the states and yields exact analytical expressions for transport properties, in remarkable agreement with experiments. The results of numerical simulations based on our two-state model suggest that the global efficiency of searching and exploring the environment is optimized at intermediate values of N_f . The optimal choice of N_f, for which the search time is minimized, decreases with increasing the size of the environment in which the bacteria swim [1]. We stained flagella to investigate the bacterial motility in more detail and find out bacillus can make several bundles during run phase. Number of bundles are independent of the flagellar number and formation of three bundles is always the most probable case. The projected angle between bundles on the observation plane widens with the number of flagella which leads to a slight modification of the effective cell aspect ratio while there is no significant trend in the other bundle properties.

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