(Supplementary information)
Resource limitation and population fluctuation drive spatiotemporal order in microbial communities

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1 Global order

The Figure S1 (a) and (b) is showing plot of global nematic order with respect to horizontal axis for different value of C_0 at fixed $D = 10$ and for different value of D at fixed $C_0 = 100$ respectively.The Figure S1 (c) and (d) is showing plot of global nematic order with respect to vertical axis for different value of C_0 at fixed $D = 10$ and for different value of D at fixed $C_0 = 100$ respectively.

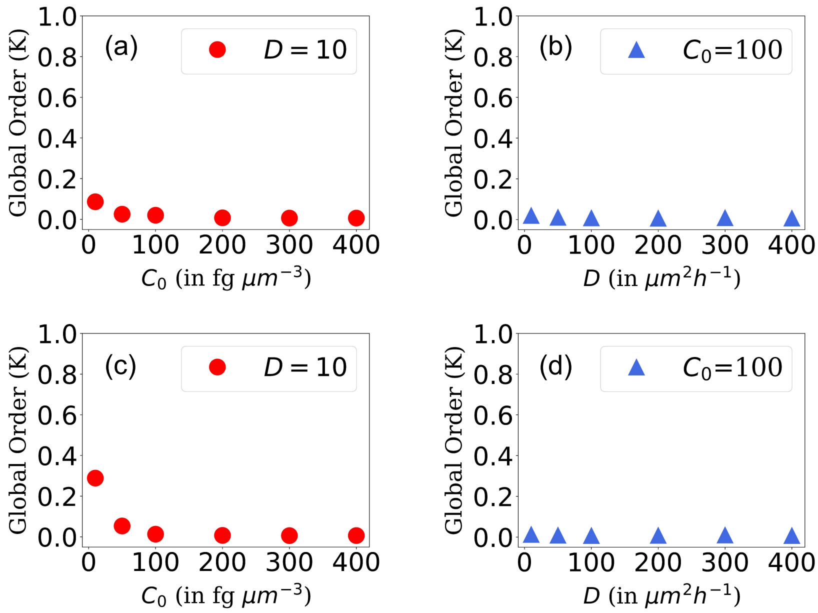

Figure S1: Global nematic order for different C_0 and D value with respect to horizontal-axis: a) For different value of C_0 at fixed $D = 10$ b) For different value of D at fixed $C_0 = 100$. Global nematic order for different C_0 and D value with respect to vertical-axis: a) For different value of C_0 at fixed $D = 10$ b) For different value of D at fixed $C_0 = 100$ Standard errors are equal to the marker size of the plot.

2 Nematic Domain size

In Figure S2 (a) and (b), we plotted the local nematic order of colony cells with an increase in the domain size (r_{cut}) for different C_0 values at a fixed $D = 10$, and for different D values at a fixed $C_0 = 100$, respectively.

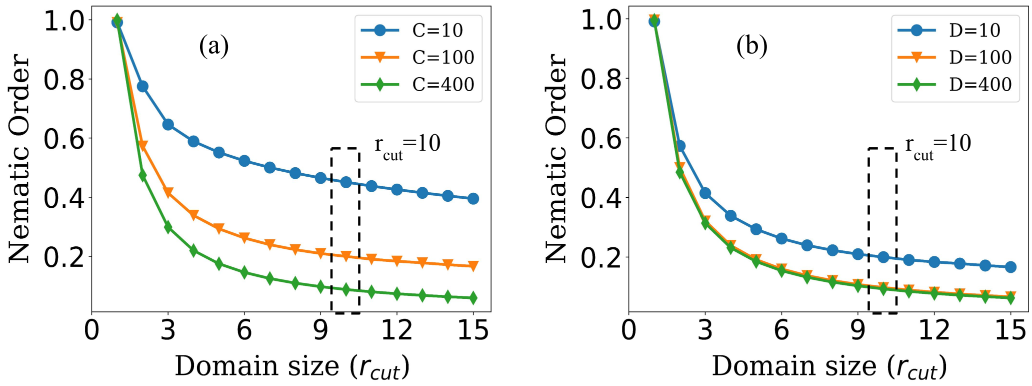

Figure S2: Nematic order for different C_0 and D values with increase in the domian size (r_{cut}): a) For different C_0 value at fixed $D = 10$, b) For different D value at fixed $C_0 = 100$.

3 Orientation heat map and Angular Distribution

In Figure S3 (a) and (b), we have plotted the heat map of angles assigned to each cell in the colony where each point represent the spatial position of the cell in the simulated colony for ($D = 10$, $C_0 = 10$) and ($D = 10$,$C_0 = 200$) values respectively. In Figure S3 (c) and (d), we have plotted the normalized histogram plot of angular distribution of simulated colony cells for ($D = 10$, $C_0 = 10$) and ($D = 10$,$C_0 = 200$) respectively.

4 Orientational autocorrelation

In Figure S4 (a) and (b), we plotted the spatial orientational autocorrelation function with an increase in the radial distance (r) for different C_0 values at a fixed $D = 10$, and for different D values at a fixed $C_0 = 100$. The spatial orientational autocorrelation function $I(\vec{r},t) = \langle \vec{u}(\vec{r}+\vec{r},',t) \cdot \vec{u}(\vec{r},',t) \rangle_{\vec{r},'}$ quantifies the range over which cells share a common orientation. Here, $\vec{u}(\vec{r},',t)$ represents the orientation vector of a particular cell, and $\vec{u}(\vec{r}+\vec{r},',t)$ represents the orientation vector of the cell at a distance $|\vec{r}|$ from $\vec{u}(\vec{r},',t)$. The angular brackets denote averaging over all angles and around each cell. Instead of calculating $I(\vec{r},t)$ at a distance $|\vec{r}|$ from the cell, we calculate it in the ring region from $|\vec{r}|$ to $(|\vec{r}| + dr)$ (where $dr = d_0 = 1\mu m$) from the orientation of the cell $\vec{u}(\vec{r},',t)$.

As observed in Figure S2 (a) and (b), increasing the domain size initially decreases the nematic order, but it stabilizes as the domain size further increases. This stability suggests that additional cells randomly added to the region maintain the overall colony order. Similarly, the correlation plot in Figure S4 (a) and (b) demonstrates that with an increase in the distance from the cell, cell ordering decreases but eventually stabilizes. Moreover, higher concentration values lead to faster decay of correlation compared to lower nutrient values, consistent with the trends observed in Figure S2 (a) and (b). Higher nutrient concentrations result in faster decay due to the denser and more disordered alignment of cells in the colony. Similarly, higher nutrient diffusion values lead to more rapid decay of colony correlation values with increasing radial distance.

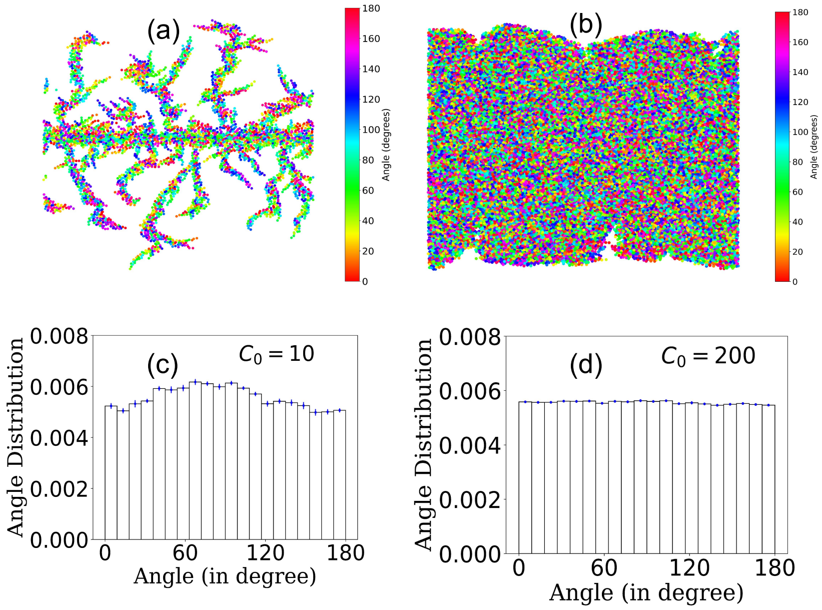

Figure S3: Heat map of orientations of the simulated colony cells for different C_0 and D value : a) ($D = 10$, $C_0 = 10$) b) ($D = 10$, $C_0 = 200$). Ensembled averaged normalized histogram plots of angle distribution for different C_0 and D value : c) ($D = 10$, $C_0 = 10$) d) ($D = 10$, $C_0 = 200$). Error bar correspond to standard error.

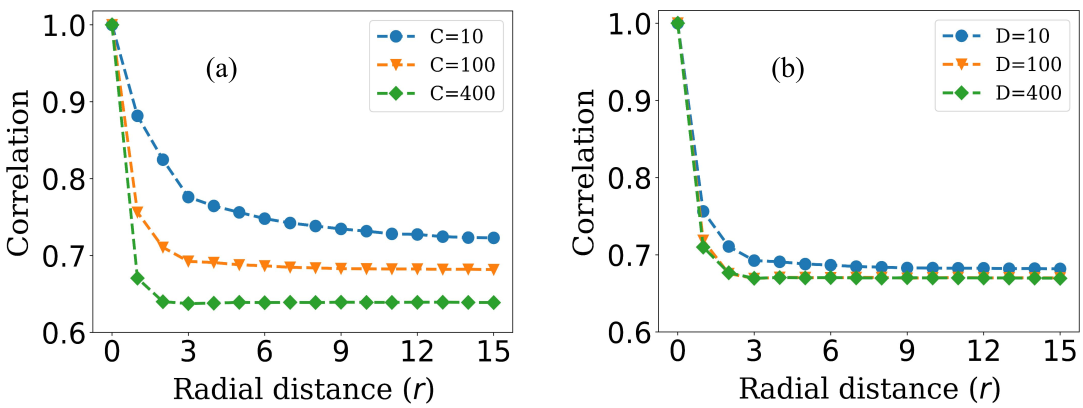

Figure S4: Correlation plot for different C_0 and D values with increase in the radial distance (r): (a) For different C_0 value at fixed $D = 10$, (b) For different D value at fixed $C_0 = 100$