iScience, Volume *24*

Supplemental information

Plastic cell morphology changes during dispersal

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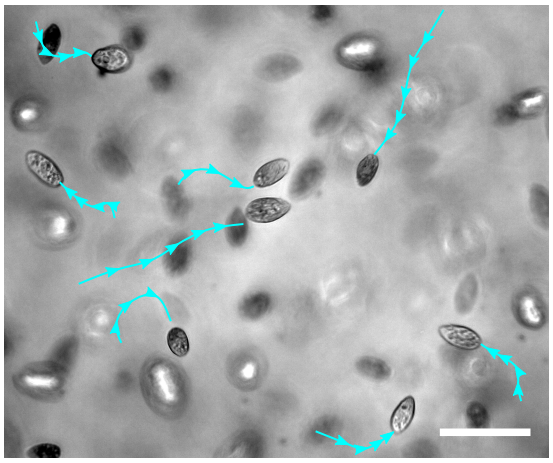
Figure S1

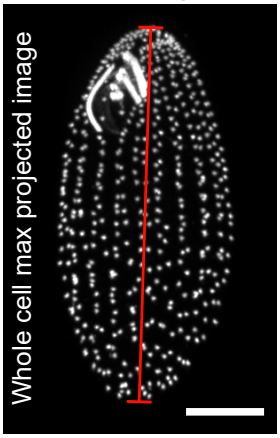
A

Code	TSC ID	Collection date	Code	TSC ID	Collection date
D1	SD01546	21/08/2002	D12	SD01556	26/08/2008
D2	SD01547	21/08/2002	D13	SD01555	26/08/2008
D3	SD01548	01/06/2003	D14	SD01554	26/08/2008
D4	SD01549	01/06/2003	D15	SD01560	24/07/2009
D5	SD01550	01/06/2003	D16	SD01559	24/07/2009
D6	SD01551	01/06/2003	D17	SD01561	24/07/2009
D7	AK III	Not known	D18	SD01562	24/07/2009
D8	SD01553	30/07/2008	D19	SD01564	25/07/2009
D9	SD01552	29/07/2008	D20	SD01563	25/07/2009
D10	SD01557	22/07/2009	D21	SD01565	25/07/2009
D11	SD01558	24/07/2009	D22	SD01566	25/07/2009

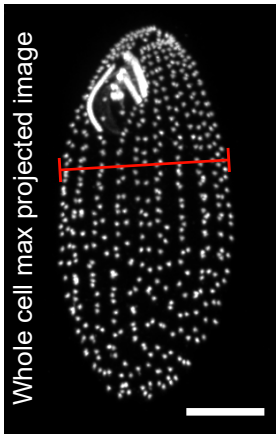
B Cell swim speed



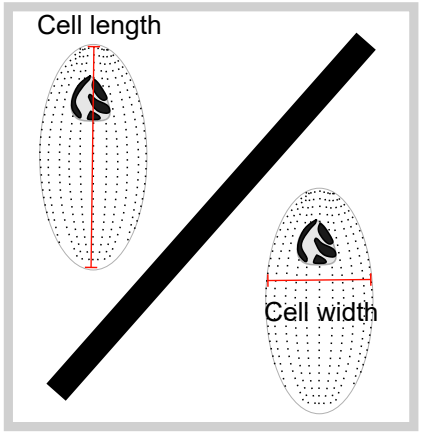
C Cell length



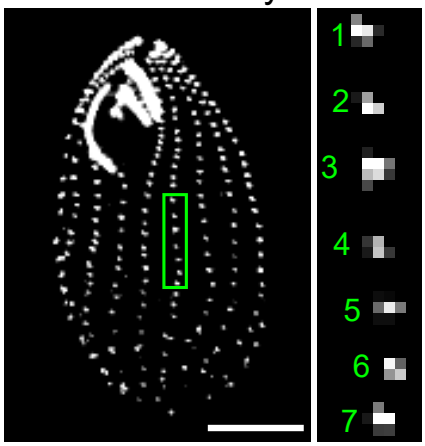
D Cell width



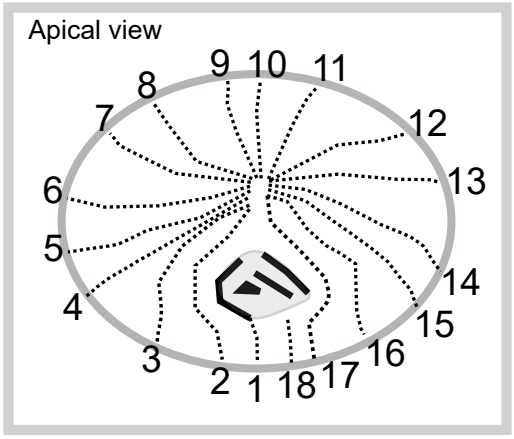
E Cell aspect ratio



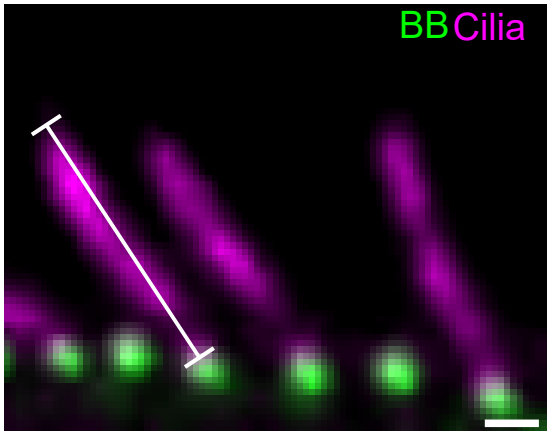
F BB density



G BB row number



H Cilia length



I Average morphology

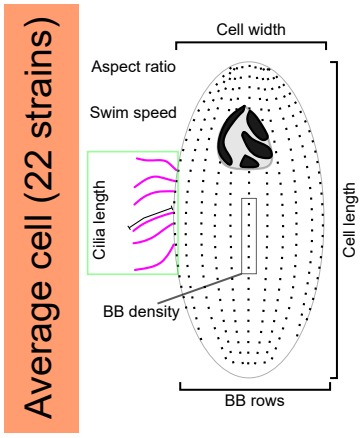


Figure S1. Measurement methods and parameters for *T. thermophila* strains

(A) We present here the codes of our 22 strains with the associated reference number of the Tetrahymena Stock Center (https://tetrahymena.vet.cornell.edu) and the dates at which Dr. Paul Doerder collected them in the field.

(B-H) Graphical representations of the techniques used in the 22 *T. thermophila* strains to measure morphological parameters (see methods). (B scale bar, 100 µm, C, D, and F scale bars, 10 µm. H scale bar, 1 µm).

(I) Graphical representations of all morphological parameters measured in each of the 22 *T. thermophila* strains.

Figure S2

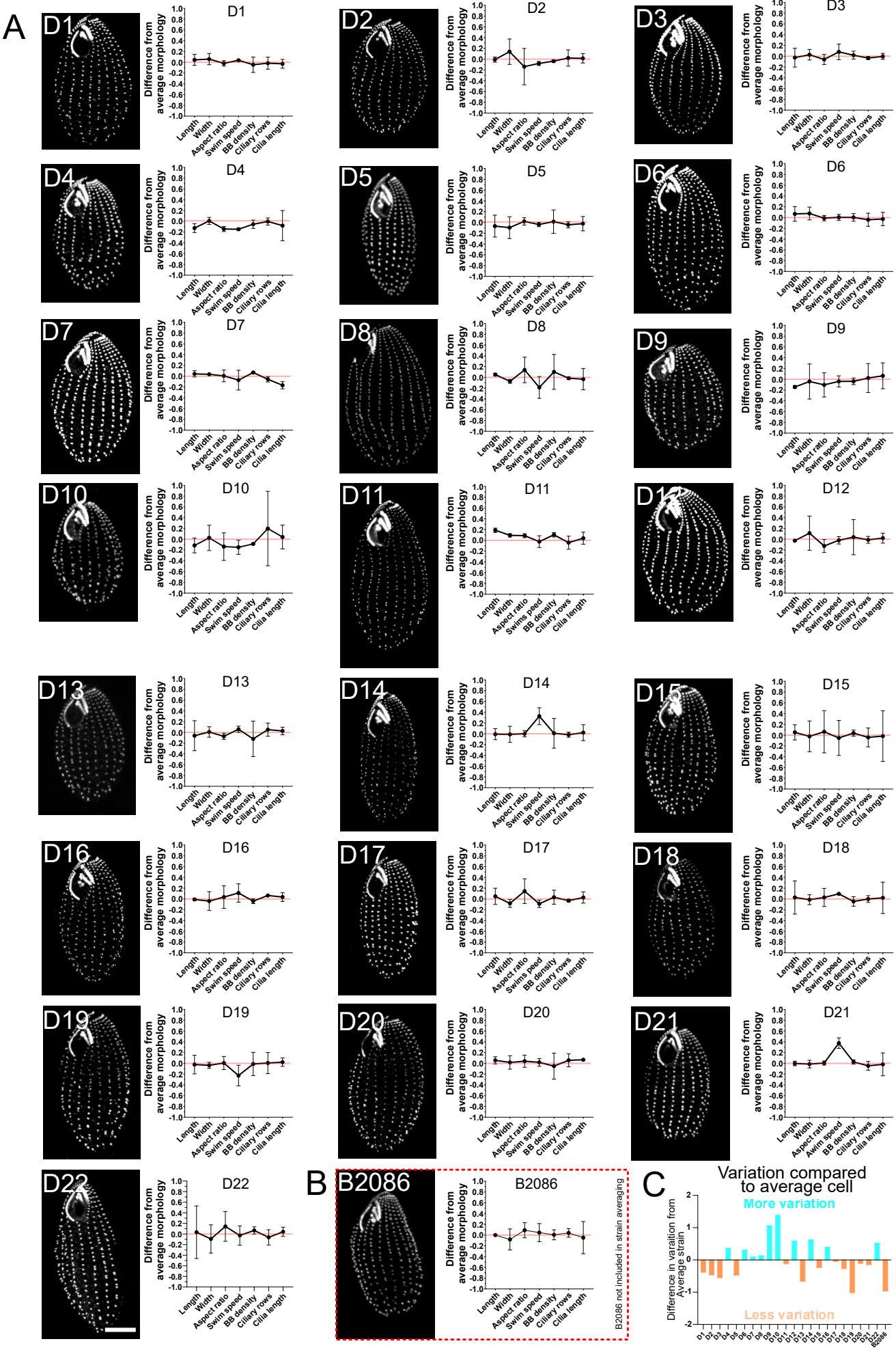

A
D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
D11
D12
D13
D14
D15
D16
D17
D18
D19
D20
D21
D22
B
B2086
B2086 not included in strain averaging
C
Variation compared to average cell
More variation
Less variation
Difference in variation from Average strain
Difference from average morphology
Length
Width
Aspect ratio
Swim speed
BB density
Ciliary rows
Cilia length

Figure S2. *T. thermophila* strains exhibit unique morphologies and levels of variation

(A) Representative BB (α-TtCen1; greyscale) and cell morphology for each of the 22 *T. thermophila* strains display unique morphological differences (scale bar, 10 μm). Graphs to the right of each image show the individual strain's morphologies normalized to the inter-strain average (red line).

(B) Representative BB (α-TtCen1; greyscale) and cell morphology of the B2086 lab strain B2086 (scale bar, 10 μm). Graph to the right of the image shows B2086 morphologies normalized to the inter-strain average (red dotted line). B2086 was not included in the inter-strain average.

(C) Bar chart indicates the sum of standard deviations for all morphological parameters for individual strains normalized to the inter-strain mean. Red bars indicate the strains with values above the average morphological variation, blue bars indicate strains with values below the average morphological variation.

Figure S3

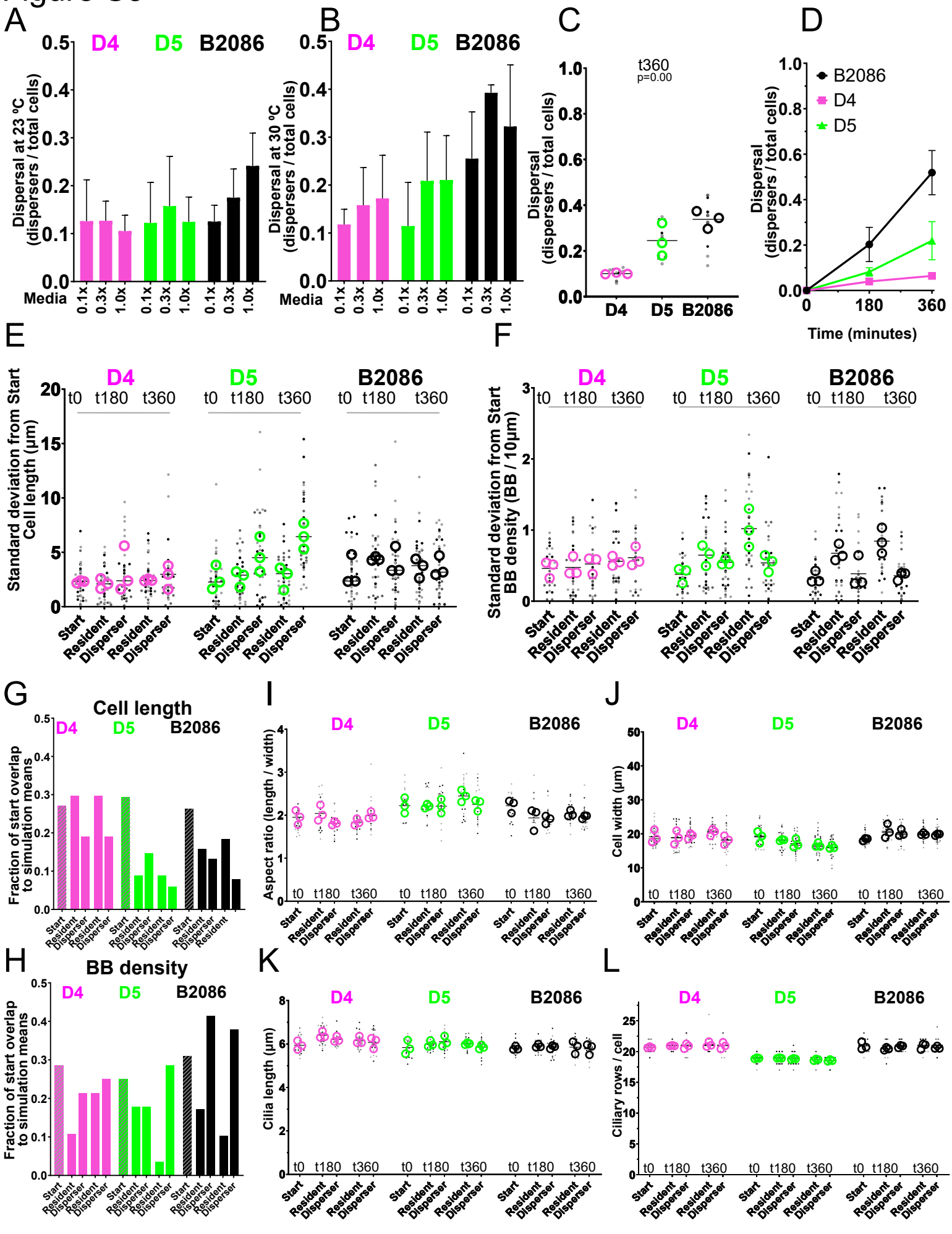

A
B
C
D
E
F
G
H
I
J
K
L
D4
D5
B2086
Dispersal at 23 ºC (dispersers / total cells)
Dispersal at 30 ºC (dispersers / total cells)
Media
0.1x
0.3x
1.0x
t360
p=0.00
Dispersal (dispersers / total cells)
B2086
D4
D5
Time (minutes)
Standard deviation from Start Cell length (µm)
Standard deviation from Start BB density (BB / 10µm)
t0
t180
t360
Start
Resident
Disperser
Cell length
BB density
Fraction of start overlap to simulation means
Aspect ratio (length / width)
Cell width (µm)
Cilia length (µm)
Ciliary rows / cell

Figure S3. BB and cilia density and cell length increase in faster dispersing cells

(A) Dispersal rate over 6 hrs in two-patch system for low dispersal (D4), high dispersal (D5), and very high dispersal (B2086) at 23°C were conducted in SPP (growth media) concentrations of 0.1X, 0.3X and 1.0X. A consistent increase in dispersal in particular media concentration for all strains was not observed. Bars indicate means and error bars indicate standard deviation.

(B) Dispersal rate over 6 hrs in two-patch system for low dispersal (D4), high dispersal (D5), and very high dispersal (B2086) at 30°C were conducted in SPP (growth media) concentrations of 0.1X, 0.3X and 1.0X. All three strain show slight preference for 0.3X or 1.0X media concentrations. Because higher dispersal fractions were observed at 30°C (compared to 23°C), all further dispersal experiments were conducted at 30°C in 0.3X SPP. Bars indicate means and error bars indicate standard deviation.

(C) Dispersal rate over 6 hrs in two-patch system for low dispersal (D4), high dispersal (D5), and very high dispersal (B2086) *T. thermophila* strains show differences in dispersal ($p<0.0001$). Data is represented as the strain mean (black bar), the experimental means (hollow circles), and the technical replicates within experiments (dots).

(D) Time course of dispersal rate at 0, 180 and 360 min in two-patch system for low dispersal (D4), high dispersal (D5), and very high dispersal (B2086) *T. thermophila* strains. Data is represented as the strain mean and standard deviation (colored circle and error bars) for 3 biological replicates.

(E) Standard deviation in cell length between Start and resident and disperser cells is unchanged in D4 (ANOVA $p=0.30$, Dunett's multiple comparison test $p=0.98$, 0.36, 0.99, 0.66). D5 t360 disperser cell length SD is higher (ANOVA $p=<0.01$, Dunett's multiple comparison test $p=0.99$, <0.01, 0.99, <0.01). B2086 cell length SD is unchanged (ANOVA $p=<0.33$, Dunett's multiple comparison test $p=0.18$, 0.33, 0.88, 0.89). Data is represented as the strain mean

(black bar), the experimental means (hollow circles), and SD in cell length of individual cells (dots).

(F) Standard deviation in BB density between Start and resident and disperser cells is unchanged in D4 (ANOVA p=0.51, Dunett's multiple comparison test p=0.99, 0.96, 0.69, 0.33). D5 t360 resident BB density SD is higher (ANOVA p=<0.01, Dunett's multiple comparison test p=0.06, 0.36, <0.01, 0.41). B2086 t180 and t360 resident BB density SD is lower (ANOVA p=<0.01, Dunett's multiple comparison test p=<0.01, 0.93, <0.01, 0.99). Data is represented as the strain mean (black bar), the experimental means (hollow circles), and SD in BB density of individual cells (dots).

(G) The fraction of all cell length measurements in the Start condition that overlap with condition means (defined as 95% confidence interval) in Start, t180 Resident, t180 Disperser, t360 Resident, t360 are represented as a bar graph.

(H) The fraction of all cell BB density measurements in the Start condition that overlap with condition means (defined as 95% confidence interval) in Start, t180 Resident, t180 Disperser, t360 Resident, t360 are represented as a bar graph.

(I) Cell aspect ratio in D4 disperser cells relative to residents is increased at 180 min (p<0.0001) and at 360 min (p=0.01), is unchanged in D5 disperser cells at 180 min (p=0.95) and increased at 360 min (p=0.02) and remains the same in B2086 cells at 180 min (p=0.65) and at 360 min (p=0.20). Data is represented as the strain mean (black bar), the experimental means (hollow circles), and the aspect ratio of individual cells (dots).

(J) Cell width in D4 disperser cells relative to residents is unchanged at 180 min (p=0.18) and increased at 360 min (p<0.0001), cell width in D5 disperser cells is unchanged at 180 min (p=0.06) and 360 min (p=0.33) and remains the same in B2086 cells at 180 min (p=0.34) and

360 min (p=0.72). Data is represented as the strain mean (black bar), the experimental means (hollow circles), and the width of individual cells (dots).

(K) Cilia length in D4 disperser cells relative to residents is increased at 180 min (p=0.03) and unchanged at 360 min (p=0.34), is unchanged in D5 disperser cells at 180 min (p=0.17) and is decreased at 360 min (p=0.04) and remains the same in B2086 cells at 180 min (p=0.57) and at 360 min (p=0.45). Data is represented as the strain mean (black bar), the experimental means (hollow circles), and the mean cilia length of individual cells (dots).

(L) The number of ciliary rows in D4 disperser cells relative to residents is unchanged at 180 (p=0.63) and 360 (p=0.35) min, is unchanged in D5 disperser cells at 180 (p=0.54) and 360 (p=0.43) min and remains the same in B2086 cells at 180 min (p=0.07) and 360 (p=0.35) min. Data is represented as the strain mean (black bar), the experimental means (hollow circles), and the number of ciliary rows of individual cells (dots).

Figure S4

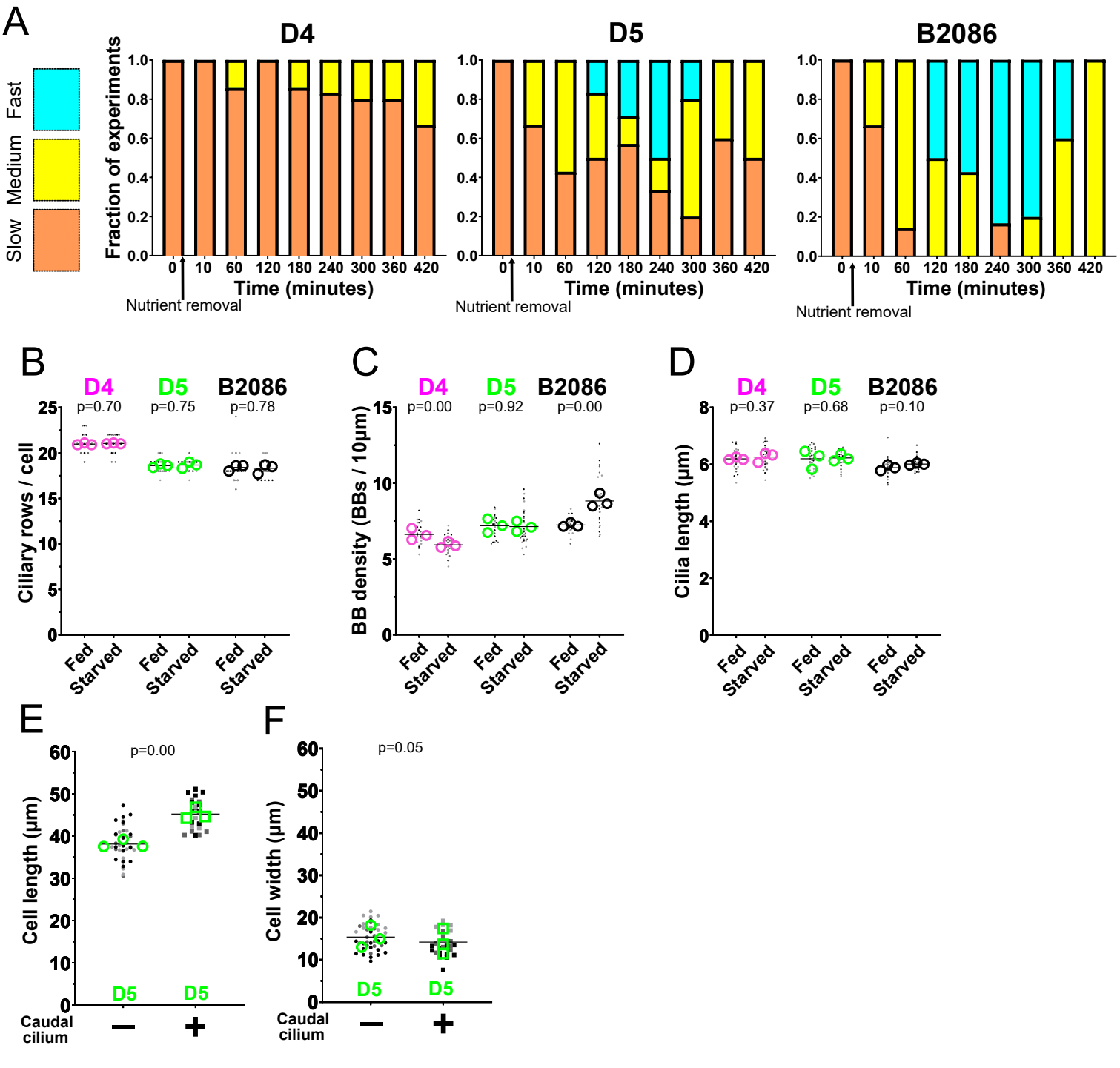

A
Fast
Medium
Slow
D4
D5
B2086
Fraction of experiments
1.0
0.8
0.6
0.4
0.2
0.0
0
10
60
120
180
240
300
360
420
Time (minutes)
Nutrient removal
B
D4
D5
B2086
p=0.70
p=0.75
p=0.78
Ciliary rows / cell
25
20
15
10
5
0
Fed
Starved
C
p=0.00
p=0.92
p=0.00
BB density (BBs / 10µm)
15
10
5
0
D
p=0.37
p=0.68
p=0.10
Cilia length (µm)
8
6
4
2
0
E
p=0.00
Cell length (µm)
60
50
40
30
20
10
0
D5
Caudal cilium
−
+
F
p=0.05
Cell width (µm)

Figure S4. *T. thermophila* strains exhibit swimming responses to nutrient deprivation

(A) Starved cells were observed to determine when they first displayed fast swim speeds. For each timepoint, the relative swim speed for the entire population was visually judged and recorded to be either slow, medium, or fast. The most common timepoint where fast swimming was observed was 240 min post starvation (D4=0% of experiments, D5=50% of experiments, B2086 83% of experiments). Data is represented by colored bars that indicate the fraction of experiments (7 biological replicates) where cells with Slow (blue), Medium (green), or Fast (orange) swimming behaviors are observed.

(B) Ciliary row number per cell does not change after starvation (D4, $p=0.70$; D5, $p=0.75$; B2086, $p=0.78$). Data is represented as strain mean (black bar), the experimental means (hollow circles), and the number of ciliary rows in an individual cell (dots).

(C) BB density is differentially changed in each strain, D4 decreases ($p<0.0001$), D5 is unchanged ($p=0.92$), and B2086 increases ($p<0.0001$). Data is represented as strain mean (black bar), the experimental means (hollow circles), and mean BB density of an individual cell (dots).

(D) Cilia length does not change after starvation for any strain (D4 $p=0.37$; D5 $p=0.61$; B2086 $p=0.10$). Data is represented as strain mean (black bar), the experimental means (hollow circles), and mean cilia length of an individual cell (dots).

(E) Starved D5 cells possessing a caudal cilium are longer than starved D5 cells without a caudal cilium ($p<0.0001$). Data is represented as the morphotype mean (black bar), the experimental means (hollow circles/squares), and the length of individual cells (dots).

(F) Starved D5 cells with a caudal cilium are 10% narrower than starved D5 cells without a caudal cilium ($p=0.05$). Data is represented as the morphotype mean (black bar), the experimental means (hollow circles/squares), and the width of individual cells (dots).