SUPPLEMENTAL MATERIALS

Movie S1. Flagellar beat pattern of a wild-type cell. Playback speed is 15fps.

Movie S2. Flagellar beat pattern of a *bop5-3* mutant. Playback speed is 30fps.

Movie S3. Flagellar beat pattern of *pf9-3* mutant. Playback speed is 30fps

Movie S4. Phototaxis of wild-type and *bop5-3.*

Table S1. Statistical analysis of forward swimming velocities.

	wild-type	*pf9-3*	*bop5-1*	*bop5-3*	*bop5-4*	*bop5-6*	*bop5-3 ::IC138 2D1*	*bop5-3 ::IC138 2E1*
wt	NA	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
pf9-3		NA	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
bop5-1			NA	<0.005	<0.005	<0.005	<0.005	<0.005
bop5-3				NA	<0.005	<0.005	<0.005	<0.005
bop5-4					NA	<0.005	<0.005	<0.005
bop5-6						NA	<0.005	<0.005
Bop5-3 ::IC138 2D1							NA	**0.832**

The swimming velocities of all strains shown in Figure 4A were compared using F-tests and T-tests, and the P values are shown here. The samples were scored as significantly different at P values less than 0.005. Because of the large sample sizes (N=190 to 552), small but significant differences were noted between all strains with respect to swimming velocities. The IC138 rescued strains are significantly faster than the *bop5-3* mutant (and other *bop5* mutants), not significantly different from one another, and slightly but significantly slower than wild-type.

Table S2. Statistical analysis of *in vitro* microtubule sliding velocities

	wild-type	*ida2-6*	*bop5-1*	*bop5-3*	*bop5-4*	*bop5-6*	*bop5-3 ::IC138 2D1*	*bop5-3 ::IC138 2E1*
wt	*NA*	<0.005	<0.005	<0.005	<0.005	<0.005	**0.007**	**0.036**
ida2-6		NA	**0.263**	**0.581**	**0.142**	**0.600**	<0.005	<0.005
bop5-1			NA	**0.513**	<0.005	**0.515**	<0.005	<0.005
bop5-3				NA	**0.013**	**0.991**	<0.005	<0.005
bop5-4					NA	**0.012**	<0.005	<0.005
bop5-6						**NA**	<0.005	<0.005

The *in vitro* microtubule sliding velocities of all strains shown in Figure 4C were compared using T-tests and the P values are shown here. Samples were scored as significantly different at P values less than 0.005. All of the mutants are significantly slower than wild-type. The differences in sliding velocities between the mutant strains are not statistically significant, except for the difference between *bop5-4* and *bop5-1*. The sliding velocities of the IC138 rescued strains are significantly faster than *bop5-3*.

Table S3. Additional waveform parameters.

	Significantly influenced by flagellar length?	**Wild-type**	***bop5-3***	***ida3***
Avg. propagation speed of R bend (μm/s)*	Yes	1449.7 +/- 240.2	1074.8 +/- 198.5	1140.2 +/- 111.0
Avg. propagation speed of P bend (μm/s)	Yes	1411.7 +/- 191.8	1240.4 +/- 268.8	1506.0 +/- 191.6
Avg. min. (R) curvature-physical (rad/μm)+	Yes	-0.55 +/- 0.08	-0.60 +/- 0.04	-0.50 +/- 0.06
Avg. max. (P) curvature-physical (rad/μm)+	No	0.20 +/- 0.04	0.18 +/- 0.03	0.22 +/- 0.03
Initial delay between P and R bends (cyc)+	N/A	0.44 +/- 0.02	0.40 +/- 0.07	0.32 +/- 0.04

Parameters where values for *bop5-3* and *ida3* were significantly different from wild-type are marked with an asterisk. Parameters where values for *bop5-3* and *ida3* were significantly different from each other are marked with a plus sign ($p < 0.05$).