Electronic supplementary material

Wong JY, Chan BKK, Karen Chan KY. 2020 Swimming kinematics and hydrodynamics of barnacle larvae throughout development. *Proc. R. Soc. B* 20201360.

Supplementary methods

Depth of field estimation

The depth of view (T) can be estimated based on the magnification (m) of image. With the knowledge of the sensor pixel size and the actual size of the nauplius, we calculated m from the ratio of image size on camera sensor to object size. T was calculated as:

$$T = \frac{2CN(1+m)}{m^2}$$

Where N = f-number, C = circle of confusion (pixel size on the camera sensor (10μm) is applied)

This approach gave an estimate of 21-31 μm and 20-23 μm for naupliar videos and cyprid videos, respectively.

Supplementary table

Table S1: Morphometric, kinematic, and hydrodynamic comparisons of barnacle larvae through development. Values are mean ± SE, *n* = 5, unless otherwise stated. Total length was used for larval length measurement. Width refers to head shield width and carapace width in nauplii and cyprids, respectively. Angular speeds are reported for mid-power stroke and mid-recovery stroke for each larval stage/ phase separated by a semicolon. The radius of the area of influence was normalized by average larval length. II to VI = naupliar stages II to VI; Cyp = cyprid; *Re* = Reynolds number; T_P = power stroke duration; T_R = recovery stroke duration; ant1= antennule; ant2 = antenna; mand = mandible; thp1 to thp6 = thoracopod 1 to 6; N_{jump} = jump number; *St* = Strouhal number; *J* = advance ratio.

Table 1

	II	III	IV	V	VI	Cyp
Morphometrics						
Length (µm)	476±13	562±3	614±4	693±6	798±6	429±13
Width [a] (µm)	205±5	244±3	273±3	315±5	351±9	141±10
Kinematics						
Re	0.6±0.1	0.9±0.2	1.1±0.2	1.6±0.3	2.5±0.2	2.9±0.6
Frequency (Hz)	6.1±0.5	6.3±0.7	6.4±0.4	5.6±0.6	6.0±0.2	15.4±1.8
T_P (ms)	108.5±4.7	93.7±10.2	96.6±8.3	110.9±12.7	103.3±5.1	50±7.7
T_R (ms)	91.2±5.6	74.3±6.6	91.2±5.2	86.9±6.3	97.5±6.3	17.7±2.3
T_P:T_R	1.2±0.0	1.3±0.1	1.1±0.1	1.3±0.1	1.1±0.1	2.8±0.2
Amplitude (°)						
ant1	33.3±3.4	23.6±3.2	20.0±2.2	22.7±2.2	21.5±2.8	-
ant2	78.3±2.5	72.5±5.5	72.5±7.6	68.5±3.0	65.6±5.2	-
mand	34.3±4.3	47.0±4.8	40.8±3.1	48.5±3.4	42.0±6.3	-
thp1 [b]	-	-	-	-	-	95.8-100.1
thp2 [b]	-	-	-	-	-	131.9-138.5
thp3 [b]	-	-	-	-	-	130.0-149.1
thp4 [b]	-	-	-	-	-	122.8-129.6
thp5 [b]	-	-	-	-	-	103.1-133.8
thp6 [b]	-	-	-	-	-	100.5-117.4
Angular speed (°/ms)						
ant1	0.7±0.1; 0.7±0.1	0.6±0.1; 0.6±0.1	0.5±0.0; 0.6±0.1	0.4±0.1; 0.4±0.1	0.4±0.0; 0.5±0.1	-
ant2	1.8±0.1; 1.6±0.1	1.8±0.3; 1.7±0.3	1.6±0.2; 1.6±0.2	1.4±0.2; 1.1±0.1	1.4±0.2; 1.3±0.1	-
mand	0.9±0.2; 0.7±0.1	1.3±0.2; 0.8±0.2	1.3±0.2; 0.8±0.1	1.5±0.3; 0.7±0.1	1.2±0.2; 0.7±0.1	-
thp1 [c]	-	-	-	-	-	18.6; 16.0
thp2 [c]	-	-	-	-	-	13.7; 18.3
thp3 [c]	-	-	-	-	-	20.7; 18.4
thp4 [c]	-	-	-	-	-	18.3; 18.4
thp5 [c]	-	-	-	-	-	22.7; 18.4
thp6 [c]	-	-	-	-	-	23.2; 14.9
Hydrodynamics						
Normalized radius of area of influence	0.54±0.02	0.56±0.03	0.58±0.02	0.59±0.02	0.62±0.02	0.86±0.07
N_{jump}	1.8±0.1	1.1±0.1	1.0±0.1	0.9±0.1	0.6±0.0	1.0±0.2
St [a]	1.50±0.13	1.87±0.48	1.70±0.30	1.33±0.15	1.12±0.11	0.74±0.12
J [a]	0.27±0.02	0.21±0.03	0.25±0.06	0.26±0.03	0.31±0.02	0.11±0.02

[a] n =3 for cyprid
[b] n =2
[c] n =1

Supplementary figures

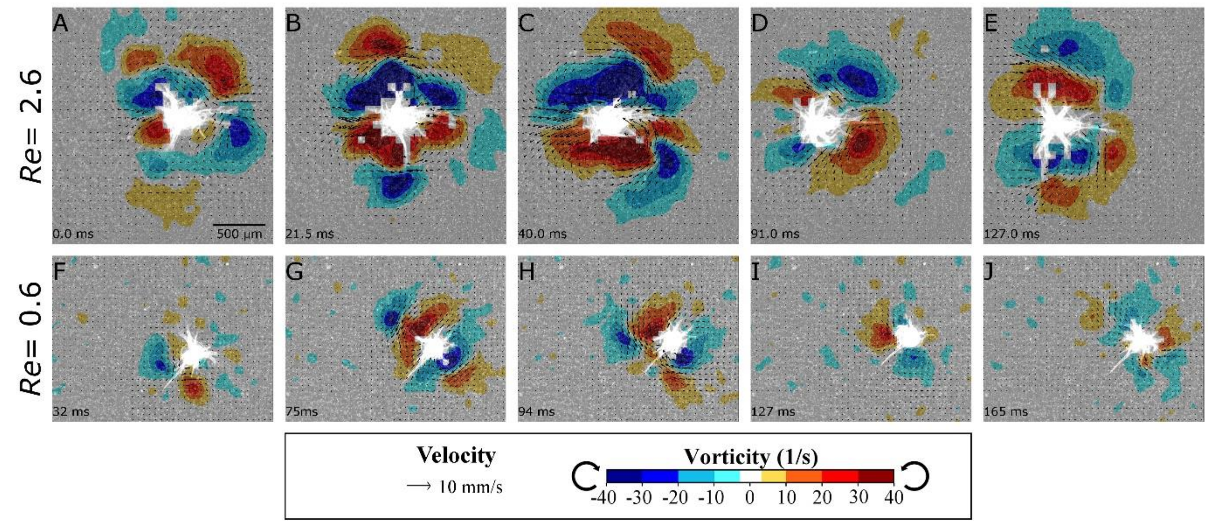

Figure S1: Snapshots of vorticity fields around nauplii swimming in different *Re*, taken from ventral view. Velocity vectors were overlaid. (A-E) Nauplius swam in *Re* of 2.6 (same as Figure 4A-E), from power to recovery stroke. (F-J) Nauplius swam in *Re* of 0.6.

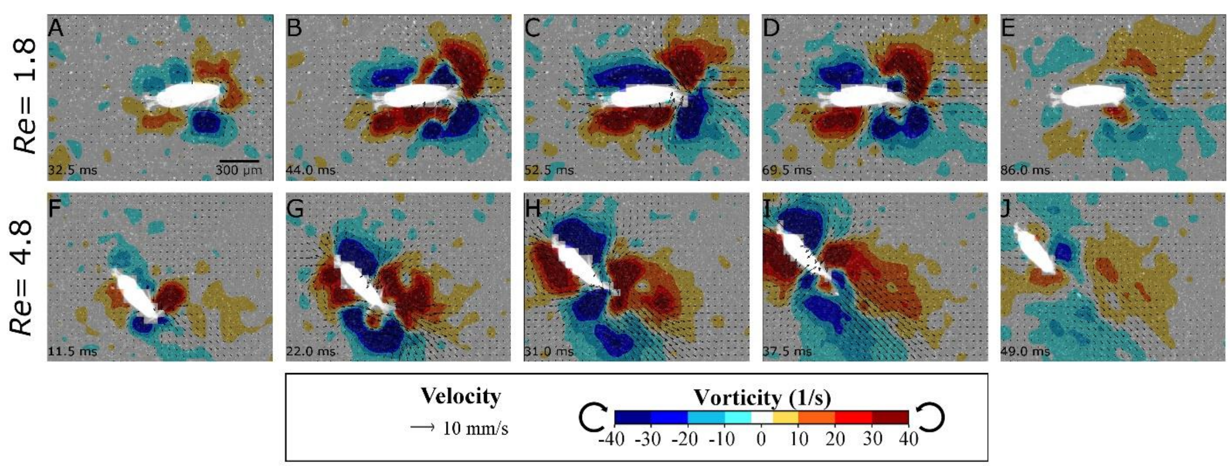

Figure S2: Snapshots of vorticity fields around cyprids swimming in different *Re,* taken from dorsal view. Velocity vectors were overlaid. (A-E) Cyprid swam in *Re* of 1.8 (*Re* = 2.3 if antennules' length included in characteristic length), from power to recovery stroke. (B-C) Cyprid swam in *Re* of 4.8 (*Re* = 6 if antennules' length included in characteristic length; same as Figure 4F-J).

Supplementary videos

Video S1: Movement tracking of swimming *Capitulum mitella* nauplius VI from ventral view (50× slow motion). Available at: https://osf.io/24epw/

Video S2: Movement tracking of swimming *Capitulum mitella* cyprid from dorsal view (100× slow motion). Available at: https://osf.io/56cdq/

Video S3: Velocity and vorticity fields around swimming *Capitulum mitella* nauplius VI from ventral view (50× slow motion; same individual as in Video S1). Nauplius swam in *Re* of 2.6. Available at: https://osf.io/z2jfn/

Video S4: Velocity and vorticity fields around swimming *Capitulum mitella* cyprid from dorsal view (100× slow motion; same individual as in Video S2). Cyprid swam in *Re* of 4.8. Available at: https://osf.io/ufx6d/

Video S5: Separation of velocity stagnation points from vorticity maximums/ minimums in trailing viscous wake vortices of cyprid (1000x slow motion). Individual used is identical to the one in Video S4. Available at: https://osf.io/t23m5/

Video S6: Velocity and vorticity fields around swimming *Capitulum mitella* nauplius III from ventral view (50× slow motion). Nauplius swam in *Re* of 0.6. Available at: https://osf.io/bre5g/

Video S7: Velocity and vorticity fields around swimming *Capitulum mitella* cyprid from dorsal view (100× slow motion). Cyprid swim in *Re* of 1.8. Available at: https://osf.io/ms4xq/