Supplementary Materials

Supplementary Materials and Methods

Larval sampling

Coilia nasus larvae were collected using a conical trawl net (0.9 m mouth diameter, 3.0 m length, and 0.6 mm mesh size) at Chongming, Nanjing, and Anqing (Huang et al., 2014). During each sampling event, the net was set beside a fishing boat and towed horizontally upstream parallel to the riverbank at a speed of ~2.5 km h^{-1} for 10–15 min during the day. Five-to-eight tows were conducted during each sampling event to ensure enough larvae were collected. Sampling at Jingjiang was conducted using an ichthyoplankton trap net (rectangular mouth of 3.0 m^2 (width×height: 2×1.5 m), 3.5 m length, and 0.6 mm mesh size), originally designed to collect larvae every 5 d during May-August to analyze the temporal dynamics of larval growth. In this study, we selected samples at dates close to those at Chongming with an interval of about 20 d. The net was deployed 5–10 m from the riverbank at a water depth of ~2.0 m with the net mouth open in the upstream direction (Huang et al., 2014; Song et al., 2018). The net-end opened to a 40×30×30 cm cage with a 0.5 mm mesh size. The net was set from 7:30 am to 1:30 pm. Specimens were collected from the cage and processed every 2 h during the sampling hours. Both the conical trawl net and ichthyoplankton trap net had the same mesh size and were operated in similar habitats near the riverbank to collect mainly pelagic larvae. We assumed similar sampling efficiency between the two nets, but this was not tested. A mechanical flow meter (Modal 23.090, KC Denmark A/S Research equipment, Sikeborg, Denmark) was set at the mouths of the conical trawl net and ichthyoplankton trap net to measure filtered water volume over the course of sampling. Collected larvae were immediately fixed in 5% borax-buffered formalin solution for 2.5 h, rinsed with purified water, and preserved in 75% neutral ethanol. In the laboratory, we counted and identified all *C. nasus* larvae following Zhang et al. (2009) and Xu et al. (2011). Larval density was calculated as number of individuals per 100 m^3 of filtered water. The *C. nasus* larvae collected at a sampling reach in a day were pooled. A "sample" was defined as the combined collections of *C. nasus* larvae at a sampling reach on a sampling date.

Environmental factors

Daily water temperature data were obtained from the Jiujiang Meteorological Station (29°43′54.30″N, 115°58′50.30″E; 145 km upstream of Anqing, Figure 1). Daily water discharge at the Datong Hydrological Station (30°48′45.9″N, 117°44′22.99″E; ~75 km below Anqing, Figure 1A) was obtained from the China Hydrology Information Network (http:// xxfb.hydroinfo.gov.cn/ssIindex.html).

Otolith analysis

We selected a minimum of 100 *C. nasus* larvae (if available) from each sample at each site for otolith analysis. Each larva was classified into one of the three ontogenetic stages, i.e., preflexion, flexion, and postflexion. To aid in classification, we measured body length (BL, 0.1 mm) based on notochord length (NL) for preflexion and flexion larvae and standard length (SL) for postflexion larvae. We then

divided all larvae into 1 mm BL groups. Otoliths were then analyzed from at least three larvae from each group if available. All otolith sagittae were extracted, processed, and mounted on glass slides in transparent enamel resin. For each fish, we measured otolith radius (R, 0.01 μm) and core diameter (0.01 μm), counted all daily increments, and measured all daily increment widths (0.01 μm). Independent determination of daily increments was performed a minimum of one week following the initial estimation. Because the first daily increment is typically formed 3 days post hatching (Huang et al., 2014), larval age was calculated as the number of increments plus 3 d, and hatch date was calculated by subtracting age from the date of capture. Otolith measurements were made using the Jiseki ARP/W Image Analysis System (v5.20) (Ratoc System Engineering Company, Tokyo, Japan) (Huang et al., 2014; Song et al., 2018).

For each sample, the relationship between age (d) and BL (mm) was calculated using linear regression (Supplementary Table S1). We used this function to convert BL to daily age for individuals with measured BL but no age. For each sample, hatch date frequency (%) was determined, and this value was multiplied by larval density to estimate the abundance of larvae born on each hatch date. Fish abundance for each hatch date at each sampling site was then pooled across all samples in each year. Hatch date frequency distributions were constructed as a weighting factor using overall abundance of fish at each hatch date (Wright & Bailey, 1999). For most sites, hatch date frequency histograms over time roughly showed clear modal dynamics, with the peak hatching period at each section visually identified by the highest peak group. We then extracted data from the otolith-analyzed larvae, with hatch dates corresponding to the peak hatching period at each site, for analysis of among-site differences in growth.

Two-way analysis of variance (ANOVA) was conducted to test the effects of sampling site and year on widths of each growth increment of otoliths. We used $P<0.05$ for significance in all statistical tests. At each sampling site each year, the BL-at-age relationship was fitted using linear regression. The slopes of the linear regression function were a mathematical representation of the daily growth rate of larvae. We used analysis of covariance (ANCOVA) to test the effects of sampling site and year on the slopes, expressed as BL×site or BL×year interaction terms (i.e., slopes) in the models. ANCOVA was also conducted for pairwise comparisons of the slopes between each of the regressions. To address the potential problem of running multiple comparisons, we adjusted the significance level for pairwise comparisons to $P=0.05/16$, where 16 is the number of comparisons made based on Bonferroni correction (Rice, 1989; Xie & Watanabe, 2007). Data such as BL, water temperature, and discharge are presented as range and mean±standard deviation (SD).

A power regression was fitted for the BL and otolith radius (R) relationship:

$$BL=aR^b \quad (1)$$

where a and b are the parameters. For comparison, the BL and R data were log-transformed and then one-way ANCOVA was used to compare the R-BL relationships of larvae from the four sampling sites each year. The relationships among sites did not differ in 2009 ($F=2.198$, $P=0.088$) and 2010 ($F=0.449$, $P=0.639$).

Therefore, daily growth rates among larval groups from different sites were compared based on differences in increment widths-at-age.

Two-way ANOVA was used to test the effects of sampling reach (i.e., Chongming, Jingjiang, Nanjing, and Anqing) and year (2009 and 2010) on water temperature and water discharge experienced by the larvae, respectively. When the effects were significant, the Tukey multiple comparison test was used to determine significant differences between means. A multivariate linear regression model was applied to fit the relationship between water temperature and discharge (independent variables) and growth rate (dependent variable).

Gut fullness and content analyses

In total, 50–100 larvae (BL range 9.0–21.0 mm) were subsampled from the peak hatch period of each sampling reach in each year for gut content analysis (Supplementary Table S3). For each fish, the entire digestive tract was removed and longitudinally dissected using a fine needle under a stereomicroscope. Gut fullness was visually assessed and categorized as 0 (empty), 1 (≤25% full), 2 (≤50% full), 3 (≤75% full), 4 (full), or 5 (distended with thin intestine wall) (Song et al., 2018; Suntsov & Brodeur, 2008). We estimated feeding incidence proportionally as the number of fish with food relative to the total number of larvae analyzed.

Gut contents were teased out and immersed in a 30% glycerin mixture on glass slides. Prey items were identified to the lowest possible taxonomic level and enumerated. Importance of prey items was evaluated as a percentage composition by number (N%, number of a given prey item with respect to total number of all prey items in gut) and percentage of frequency (F%, percentage of guts in which a certain prey item occurred). The relative importance index (IRI) of a prey item was calculated by multiplying the N% and F% of such prey. Differences in diet composition among sampling sites and between years were illustrated by principal component analysis (PCA) using the IRI of each prey item. Fish larvae occasionally appeared in the guts of *C. nasus* larvae, but with a low IRI, and thus their IRIs were excluded from PCA.

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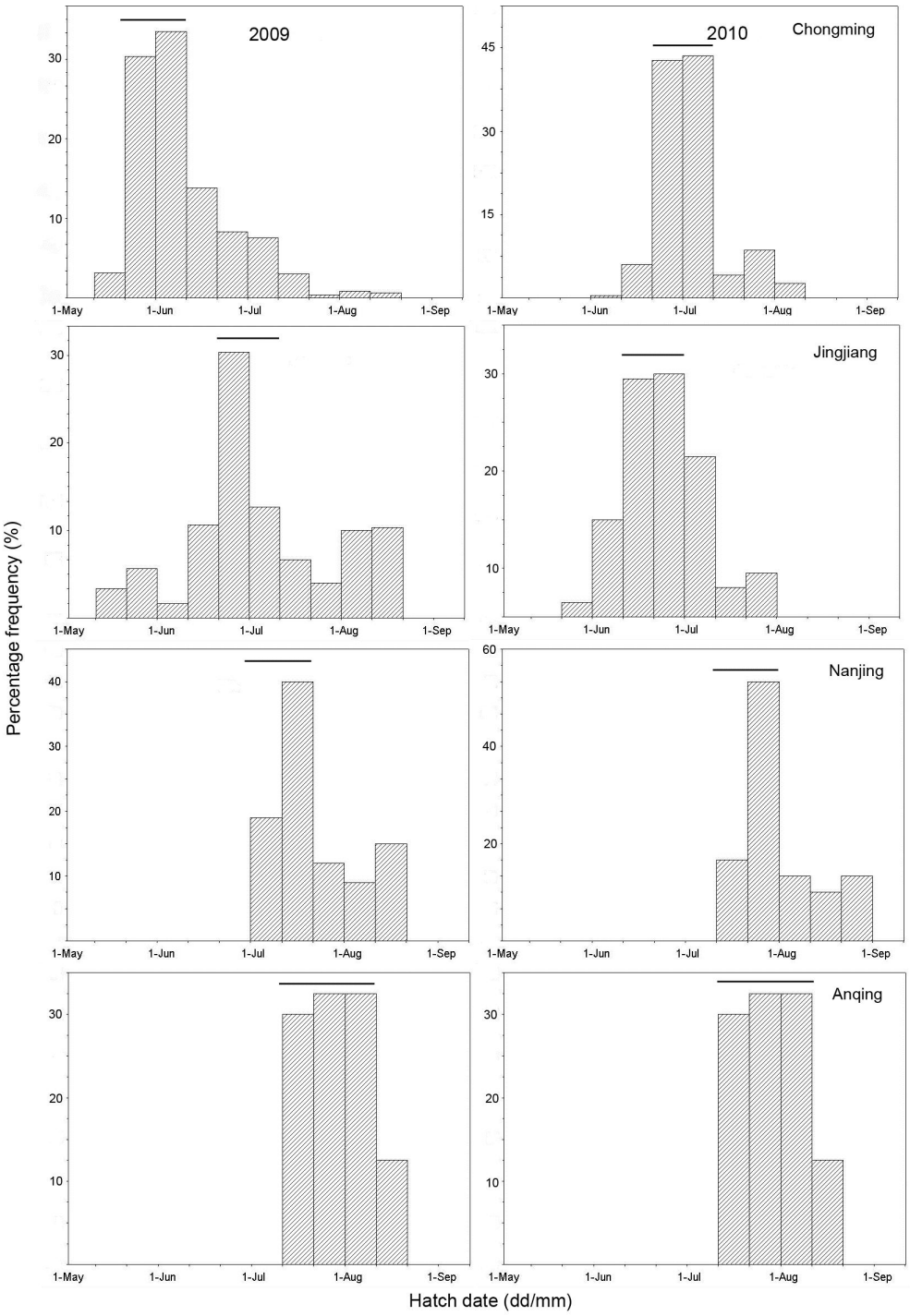
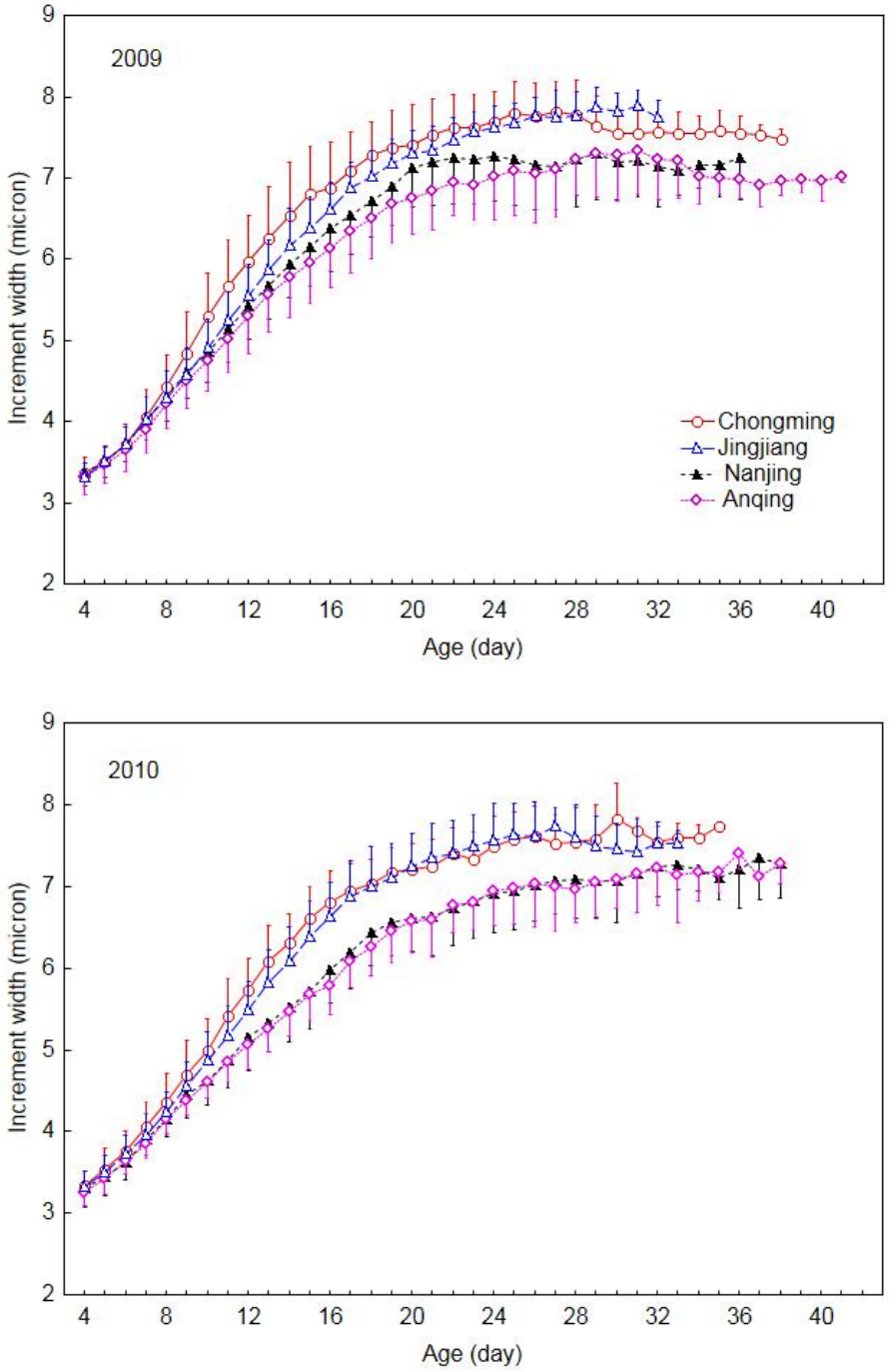
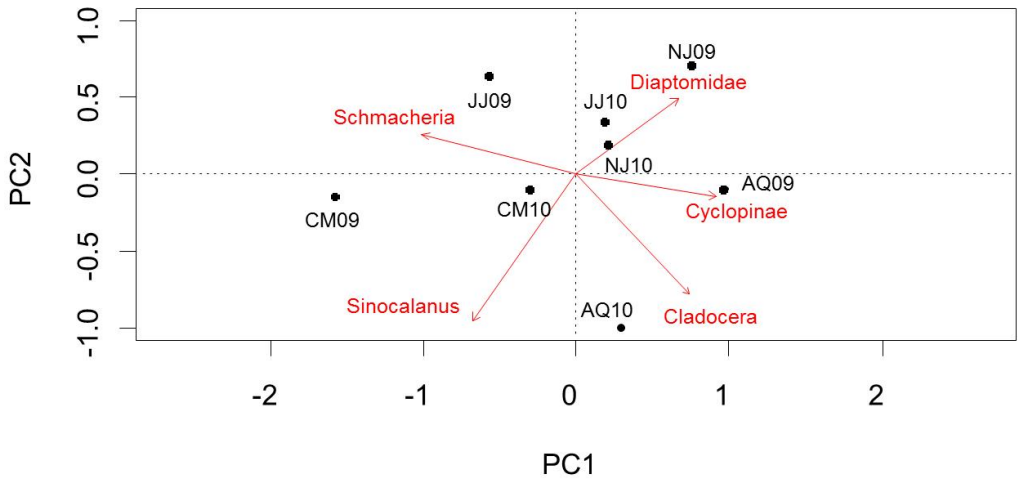


Supplementary Figure S1. Hatch date frequency distribution of *Coilia nasus* larvae at Chongming, Jingjiang, Nanjing, and Anqing in the Yangtze River in 2009 and 2010. Lines above bars indicate peak hatching period.



Supplementary Figure S2. Otolith increment width profiles of *C. nasus* larvae at Chongming, Jingjiang, Nanjing, and Anqing in the Yangtze River in 2009 (A) and 2010 (B). Error bars represent SD.



Supplementary Figure S3. Biplots of first two axes of PCA ordination of diet composition in guts of *C. nasus* larvae from Chongming, Jingjiang, Nanjing, and Anqing in the Yangtze River in 2009 and 2010. Scores of prey items (arrows) and samples (black circles), CM09 and CM10, JJ09 and JJ10, NJ09 and NJ10, and AQ09 and AQ10 indicate larvae collected at Chongming, Jingjiang, Nanjing, and Anqing in 2009 and 2010, respectively.

Supplementary Tables

Supplementary Table S1. Catch statistics of *C. nasus* larvae from the Yangtze River in 2009 and 2010. Data include total sample size of fish (*n*), number of measured larvae (n_1), mean±SD (range) of body length (BL, mm), number of larvae used for otolith analyses (n_2), age range (d), and age-BL regressions (i.e., growth) with corresponding r^2 values.

		Sampling		BL		Otolith analysis		
Sites	Year	Date	*n*	n_1	Mean ± SD (range)	n_2	Age range (d)	Age-BL regression (r^2)
Chongming	2009	12-Jun	3525	240	14.2 ± 3.9 (5.4–23.4)	74	7–29	BL = 1.71+ 0.80Age (0.98)
		5-Jul	2600	200	16.7 ± 5.0 (6.8–26.6)	76	5–39	BL = 2.83 + 0.67Age (0.96)
		25-Jul	923	200	16.6 ± 4.7 (7.7–26.6)	77	11–36	BL = 1.52 + 0.67Age (0.97)
		29-Aug	230	134	16.6 ± 3.9 (9.7–23.0)	66	13–43	BL = 4.32 + 0.52 Age (0.92)
Jingjiang	2009	6-Jun	691	102	13.5 ± 2.6 (8.5–22.3)	44	12–26	BL = 2.86 + 0.64 Age (0.95)
		5-Jul	838	104	16.4 ± 3.6 (9.4–24.5)	49	12–35	BL = 3.47 + 0.64Age (0.94)
		15-Jul	4001	205	16.3 ± 3.3 (9.2–25.1)	48	10–28	BL = 2.55 + 0.74Age (0.95)
		5-Aug	955	103	17.0 ± 4.3 (8.8–25.7)	41	13–33	BL = 2.25 + 0.70Age (0.98)
		31-Aug	1967	298	17.4 ± 3.4 (9.9–26.9)	49	13–36	BL = 4.43 + 0.57Age (0.93)
Nanjing	2009	18-Jun	0					
		19-Jul	46	46	12.1 ± 3.6 (8.2–21.6)	36	9–26	BL = 2.30 + 0.67Age (0.97)
		6-Aug	2162	241	17.1 ± 3.8 (8.4–25.2)	64	11–38	BL = 3.48 + 0.58Age (0.98)
		3-Sep	699	127	16.4 ± 3.2 (10.5–23.1)	56	13–38	BL = 3.06 + 0.58Age (0.96)
		19-Sep	111	111	16.2 ± 2.6 (10.2–21.1)	46	13–34	BL = 3.65 + 0.55Age (0.95)
Anqing	2010	24-Jul	0					
		9-Aug	468	125	18.1 ± 2.9 (10.6–25.1)	56	13–37	BL = 3.53 + 0.57Age (0.94)
		25-Aug	651	200	16.8 ± 4.0 (8.9–25.3)	70	8–39	BL = 3.68 + 0.60Age (0.98)
		16-Sep	125	109	19.2 ± 3.5 (10.4–25.5)	54	13–42	BL = 3.63 + 0.55Age (0.97)
Chongming	2010	25-May	0					
		24-Jun	106	71	11.9 ± 2.0 (7.8–16.3)	30	10–15	BL = 1.55 + 0.87Age (0.86)

		22-Jul	2346	209	17.6 ± 3.7 (8.7–26.2)	64	9–35	BL = 3.55+ 0.65 Age (0.98)
		22-Aug	362	108	19.2 ± 3.1 (10.5–25.2)	61	10–38	BL = 4.08 + 0.55Age (0.95)
Jingjiang	2010	1-Jun	12	12	16.1 ± 1.5 (13.9–18.2)			
		20-Jun	148	141	14.4 ± 1.9 (10.6–21.9)	27	12–25	BL = 3.86 + 0.63Age (0.93)
		5-Jul	2875	251	18.0 ± 3.4 (9.3–26.2)	47	13–41	BL = 3.75 + 0.62Age (0.97)
		20-Jul	3513	201	18.1 ± 3.7 (8.9–26.1)	56	11–33	BL = 3.88 + 0.64 Age (0.97)
		18-Aug	537	101	20.4 ± 3.0 (11.2–26.7)	31	18–41	BL = 4.33 + 0.59Age (0.95)
Nanjing	2010	14-Aug	812	207	15.3 ± 3.7 (6.9–23.3)	58	11–35	BL = 2.41 + 0.62Age (0.98)
		7-Sep	276	138	13.8 ± 4.4 (7.1–25.6)	54	12–39	BL = 1.55 + 0.61Age (0.99)
Anqing	2010	16-Aug	195	167	17.4 ± 3.9 (8.1–25.9)	59	14–39	BL = 2.89 + 0.59Age (0.96)
		6-Sep	0					

Supplementary Table S2. Peak hatching data on *C. nasus* larvae and ANCOVA of BL-at-age relationships of larvae at Chongming, Jingjiang, Nanjing, and Anqing in the Yangtze River in 2009 and 2010.

				Water temperate (°C)		Water discharge (100m^3/s)	
Site	Year	Peak hatch period	N	Range	Mean ± SD	Range	Mean ± SD
Chongming	2009	20 May–20 Jun	110	20.5–28.5	24.50 ± 2.46	302–399	354.3 ± 32.9
	2010	10 Jun–10 Jul	65	22.0–27.5	24.92 ± 1.68	455–654	545.7 ± 73.0
Jingjiang	2009	10 Jun–10 Jul	86	25.0–29.5	27.77 ± 1.22	317–444	364.3 ± 36.0
	2010	10 Jun–10 Jul	81	22.0–27.5	24.92 ± 1.68	455–654	545.7 ± 73.0
Nanjing	2009	30 Jun–20 Jul	98	26.9–30.0	28.57 ± 0.73	327–444	399.1 ± 27.5
	2010	20 Jul–10 Aug	67	25.7–29.1	27.49 ± 1.05	569–638	614.6 ± 19.2
Anqing	2009	10 Jul–10 Aug	96	27.2–30.0	28.72 ± 0.85	386–444	411.5 ± 14.4
	2010	6 Jul–5 Aug	59	25.7–29.1	27.20 ± 0.84	557–638	613.8 ± 21.8

Analysis of covariance (ANCOVA)

Factors	*df*	MS	*F*	*p-value*
Age (covariate)	1	11188.82	20840	0
Sampling site	3	0.31	0.57	0.635
Year	1	2.22	4.13	0.043
Sampling site × age	3	19.02	35.43	0
Year × age	1	9.7	18.07	0
Sampling site × year × age	3	2.34	4.37	0.005
Error	649	0.54		

Supplementary Table S3. Number of individuals and body length range and mean±SD (BL, mm) of *C. nasus* larvae analyzed for gut fullness and diet composition in the Yangtze River in 2009 and 2010. Importance of prey items is expressed by IRI.

Sampling site	Chongming		Jingjiang		Nanjing		Anqing	
Year	2009	2010	2009	2010	2009	2010	2009	2010
Number	100	50	100	100	80	50	100	50
Body length (mm)								
Range	9.5–20.8	10.7–20.8	9.9–19.7	10.4–21.5	9.4–21.6	9.7–20.8	12.5–21.8	9.1–21.1
Mean ± SD	14.7 ± 2.8	15.8 ± 2.2	15.6 ± 1.9	16.9 ± 2.5	14.8 ± 3.1	14.7 ± 2.7	17.4 ± 2.3	16.1 ± 3.1
Diet composition								
Number	30	30	30	30	30	30	30	30
Prey items	IRI	IRI	IRI	IRI	IRI	IRI	IRI	IRI
Schmacheria	**8487.0**	**4373.5**	**5613.2**	**3201.9**	**1747.4**	**2800.0**	**2002.4**	**1242.0**
S. forbesi	3286.0	1588.7	1202.8	164.3	461.3	80	614.8	–
S. inopinus	2.8	–	–	–	–	–	–	–
Schmacheria sp.	3157.0	1513.0	2641.5	1915.5	717.6	2560	679.6	1242.0
Sinocalanus	291.0	170.2	14.2	18.8	4.7	40	4.0	223.7
S. dorri	67.2	–	–	–	4.7	40	4.0	73.1
Sinocalanus sp.	98.0	170.2	14.2	18.1	–	–	–	41.1
Diaptomidae	2.8	85.1	2.4	42.3	512.6	6.7	364.1	–
Cyclopinae	2.8	**1404.3**	**735.8**	**1901.4**	**1607.6**	**1493.3**	**1638.3**	**1780.8**
Mesocyclops sp.	–	14.2	28.3	469.5	461.3	13.3	400.5	–
Thermocyclops sp.	2.8	78.0	–	4.7	28.0	–	80.9	–
Cyclopoida spp.	–	628.8	566.0	600.9	251.6	1900	311.5	1780.8
Cladocera	25.2	264.8	94.3	225.4	**461.3**	**300**	1407.8	**1155.3**
Larvae	–	–	–	–	41.9	–	24.3	–