

## Supplementary Materials

References for all data that are used in the Supplementary Materials are listed in the Supplementary References.

### Supplement 1. Diel and seasonal changes of the downstream migration in a natural river and water reservoir

**Table S1.** Mean relative concentrations of migrants during the day and night.

Locality	Family	Number of Fish, ind.	C <sub>d</sub>	C <sub>n</sub>	p	t
River	Cyprinidae	226	0.053	0.947	0.0000	42.42
	Percidae	300	0.120	0.880	0.0000	28.64
Reservoir	Cyprinidae	1091	0.457	0.542	0.0866	1.71
	Percidae	1432	0.497	0.503	0.7481	0.32

Note: Data for Figure 1. Results of chi-squared test. C<sub>d</sub>, during the day; C<sub>n</sub>, during the night. C<sub>d</sub> + C<sub>n</sub> = 100%.

**Table S2.** Seasonal patterns of the downstream migration of cyprinids and percids in the Upper Volga.

Month	Decade	Cyprinids	Percids
1	2	0	0
2	1	0	0
3	1	0	0
3	3	0	0
4	2	0	0
4	3	0	0
5	1	0	0
5	2	0.82	0
5	3	15.71	10.10
6	1	100.00	100.00
6	2	62.38	60.36
6	3	0.00	0.00
7	1	54.88	0.00
7	2	65.31	0.00
7	3	27.89	0.00
8	1	0	0.00
8	2	0	0.00
8	3	0	4.89
9	1	0	0
9	2	0	0
9	3	0	0
10	1	0	0
10	2	0	0
11	2	0	0
12	1	0	0

Note: Data for Figure 2. Concentrations are expressed as a percentage of max value.

**Table S3.** Statistics for the seasonal dynamics of the concentration of migrants in the Upper Volga River.

Variable	Concentration
Max. negative difference	0.00

Max. positive difference	0.16
<i>p</i> -value	<i>p</i> > 0.10
Mean Cyprinidae	13.8
Mean Percidae	7.01
Std. dev. Cyprinidae	27.32
Std. dev. Percidae	22.86
Valid N Cyprinidae	25
Valid N Percidae	25

Note: Data for Figure 3. Results of the Kolmogorov–Smirnov test) by variable “families”.

**Table S4.** Relative concentrations (%) of the young Cyprinidae and Percidae in the migration habitats and habitats of residence in the Ivan’kovskoe Reservoir in June–September 1992.

Data	Cyprinidae (Total Number 1317 ind.)		Percidae (Total Number 1732 ind.)	
	Residence	Migration	Residence	Migration
15 Jun	99.9	0.1	0.0	100.0
20 Jun	95.5	4.5	21.6	78.4
25 Jun	95.6	4.4	0.0	100.0
1 Jul	95.1	4.9	21.4	78.6
6 Jul	99.6	0.4	32.7	67.3
10 Jul	99.1	0.9	0.0	100.0
20 Jul	99.5	0.5	45.5	54.5
30 Jul	97.8	2.2	46.8	53.2
10 Aug	99.5	0.5	48.6	51.4
16 Aug	99.3	0.7	48.1	51.9
26 Aug	99.7	0.3	42.4	57.6
5 Sep	98.4	1.6	0.0	100.0
15 Sep	93.0	7.0	39.0	61.0
22 Sep	97.0	3.0	49.4	50.6
Mean	97.8	2.2	28.2	71.8

Note: Data for Figure 4.

**Table S5.** Significance of differences between relative concentrations of Cyprinidae and Percidae in the migration habitats and habitats of residence.

Wilcoxon Matched Pairs Test Results				
Paired Variables (Compared Groups)	Valid N	T	Z	<i>p</i>
Cyprinidae vs. Percidae, habitat of residence	14	0.00	3.30	0.0010
Cyprinidae vs. Percidae, migration habitat	14	0.00	3.30	0.0010
Cyprinidae (residence) vs. Cyprinidae (migration)	14	0.00	3.30	0.0010
Percidae (residence) vs. Percidae (migration)	14	0.00	3.30	0.0010
Cyprinidae (residence) vs. Percidae (migration)	14	10.00	2.67	0.0076
Cyprinidae (migration) vs. Percidae (residence)	14	10.00	2.67	0.0076

Note: Data for Figure 4. Results from the Wilcoxon matched pairs test. Marked tests are significant at *p* < 0.05000.

**Supplement 2. Analysis of the diel and seasonal patterns of emigration of young cyprinids and percids from water reservoirs**
**Table S6.** Diel changes of the relative concentration (% max) of the early larvae of Cyprinidae and Percidae migrating in the Upper Volga and from Ivan'kovskoe Reservoir.

Time, h	Upper Volga		Ivan'kovskoe Reservoir	
	Cyprinidae, Total Number 222 ind.	Percidae, 263 ind.	Cyprinidae, 166 ind.	Percidae, 532 ind.
12	0.0	0.0	0.0	39.8
14	0.0	0.0	0.0	20.2
16	0.0	0.0	7.2	60.4
18	0.0	0.0	0.0	89.8
20	0.0	1.4	0.0	10.2
22	30.3	50.4	49.8	100.0
0	100.0	100.0	100.0	80.2
2	49.9	40.2	78.8	39.8
4	0.0	0.0	10.7	60.0
6	0.0	0.0	0.0	30.4
8	0.0	0.0	0.0	0.0
10	0.0	0.0	3.0	49.5
12	0.0	0.0	0.0	39.7

Note: Data for Figure 5.

**Table S7.** Diel changes in the concentration of Cyprinidae and Percidae migrants in the Upper Volga and Ivan'kovskoe Reservoir.

Variable	Cyprinidae	Percidae
Max. negative difference	-0.23	<b>-0.69</b>
Max. positive difference	0	<b>0</b>
p-value	<i>p</i> > 0.10	<i>p</i> < 0.005
Mean river	13.8	<b>14.8</b>
Mean reservoir	19.2	<b>47.7</b>
Std. dev. river	30.10	<b>30.70</b>
Std. dev. reservoir	34.25	<b>30.00</b>
Valid N river	13	<b>13</b>
Valid N reservoir	13	<b>13</b>

Note: Data for Figure 5. Results of Kolmogorov–Smirnov Test. By variable habitat. Marked tests are significant at *p* < 0.05000.

**Table S8.** Number of caught fish (ind., according to species) in the Upper Volga and Ivan'kovskoe reservoir.

Species	Locality	
	River	Reservoir
Roach	154	54
Bream	23	45
Bleak	45	67
All Cyprinids	222	166
Perch	240	150
Zander	23	382
All Percids	263	532

Note: Data for Figure 5.

**Table S9.** Seasonal changes of the relative concentrations (% max) of Cyprinidae and Percidae emigrating from the Ivan'kovskoe Reservoir.

Month	Decade	Cyprinidae, Total Number 2667 ind.	Percidae, 1647 ind.
1	1	1.0	2.3
1	2	0.0	5.0
1	3	0.1	6.1
2	1	0.0	0.0
2	2	0.2	2.1
2	3	0.0	4.8
3	1	0.0	0.5
3	2	0.9	0.5
3	3	0.0	3.7
4	1	0.0	3.6
4	2	0.0	10.4
4	3	0.0	8.1
5	1	1.1	3.7
5	2	1.9	0.4
5	3	3.4	0.0
6	1	49.3	30.2
6	2	100.0	70.4
6	3	91.5	100.0
7	1	79.7	69.7
7	2	20.2	20.3
7	3	9.7	1.6
8	1	0.0	4.2
8	2	0.0	3.3
8	3	14.2	2.2
9	1	7.6	14.6
9	2	1.2	25.4
9	3	0.0	12.5
10	1	0.0	9.8
10	2	0.0	6.0
10	3	0.0	14.5
11	1	2.3	5.1
11	2	0.0	10.5
11	3	1.0	4.7
12	1	0.0	9.8
12	2	0.0	9.4
12	3	0.0	0.0

Note: Data for Figure 6.

**Table S10.** Comparison of seasonal changes of the Cyprinidae and Percidae emigration from the Ivan'kovskoe Reservoir.

Pair of Variables	Wilcoxon Matched Pairs Test Results			
	Valid N	T	Z	p-value
Cyprinidae vs. Percidae	34	159	2.368	0.0179

Note: Data for Figure 6. Results of Wilcoxon matched pairs test. Marked tests are significant at  $p < 0.05000$ .

**Table S11.** Sample sizes (ind.) for the main species of Cyprinidae and Percidae.

Species	Sample Size, ind.		
	1979–80	1989–90	Total
Bleak	485	892	1377
Bream	160	749	908
Roach	49	332	381
All Cyprinidae	694	1973	2667
Zander	147	259	406
Perch	407	691	1098
Ruff	144	0	144
All Percidae	697	950	1647

Note: Data for Figure 6.

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**Supplement 3. Seasonal changes of the young fish migration through the dams and shipping locks**

**Table S12.** Concentrations (ind./1000 m<sup>3</sup>) of Cyprinidae and Percidae migrants through the power plant water intake and shipping lock of the Sheksninskoe Reservoir.

Months	Decade	Cyprinidae		Percidae	
		Power plant	Shipping lock	Power plant	Shipping lock
1	1	0.0	—	1.0	—
1	2	0.1	—	0.7	—
1	3	0.0	—	1.4	—
2	1	0.0	—	0.6	—
2	2	0.0	—	0.5	—
2	3	0.0	—	0.5	—
3	1	0.2	—	0.2	—
3	2	0.0	—	0.4	—
3	3	0.0	—	0.4	—
4	1	0.0	—	0.2	—
4	2	0.0	—	0.1	—
4	3	0.1	0.0	0.1	0.0
5	1	0.0	0.1	0.1	0.2
5	2	0.3	0.2	1.1	0.4
5	3	0.0	0.3	0.1	0.3
6	1	0.0	15.0	650.0	6.0
6	2	0.3	31.3	255.0	263.0
6	3	12.7	33.8	522.5	201.5
7	1	0.7	9.0	1362.0	4.0
7	2	0.0	0.0	167.5	0.0
7	3	1.3	1.2	65.0	55.0
8	1	2.8	9.1	66.0	172.5
8	2	2.0	0.1	13.0	3.5
8	3	0.6	0.5	64.0	1.5
9	1	0.5	0.2	36.0	0.6
9	2	0.5	0.0	150.4	0.3
9	3	0.7	0.0	0.8	0.5
10	1	0.3	0.0	2.5	0.5
10	2	0.2	0.1	2.0	0.2
10	3	0.1	0.0	1.5	0.0
11	1	0.0	—	0.2	—
11	2	0.0	—	0.1	—
11	3	0.2	—	0.8	—
12	1	0.0	—	47.0	—
12	2	0.0	—	0.7	—
12	3	0.0	—	0.7	—

Note: Data for Figure 7.

**Table S13.** Difference between concentrations of cyprinids and percids migrating through the power plant and shipping lock.

Wilcoxon Matched Pairs Test Results				
Pair of Variables for Each Fish Family (migration route)	Valid N	T	Z	p
Cyprinidae (power plant) vs. Cyprinidae (shipping lock)	19	91.5	0.141	0.8880
Cyprinidae (power plant) vs. Percidae (power plant)	36	1.0	5.216	<0.0001
Cyprinidae (power plant) vs. Percidae (shipping lock)	19	25.0	2.817	0.0048
Cyprinidae (shipping lock) vs. Percidae (power plant)	19	5.0	3.622	0.0003
Cyprinidae (shipping lock) vs. Percidae (shipping lock)	16	24.0	2.275	0.0229
Percidae (power plant) vs. Percidae (shipping lock)	19	28.0	2.696	0.0070

Note: Data for Figure 7. Results of Wilcoxon matched pairs test. Marked tests are significant at  $p < 0.05000$ .

**Table S14.** Number of sampled fish (by species of cyprinids and percids) emigrating through the power plant and shipping lock.

Species	Number of Emigrants, ind.		
	Power plant	Shipping lock	Total
Roach	79	346	425
Bleak	298	465	763
Bream	43	67	110
All Cyprinidae	420	878	1298
Perch	22,059	5438	27,497
Zander	2469	203	2672
All Percidae	24,528	5641	30,169

Note: Data for Figure 7.

**Supplement 4. Analysis of migration's intensity of cyprinids and percids**
**Table S15.** Migration index for common and frequently found fishes in reservoirs.

Species	Reservoirs							
	Sheksninskoe	Ivan'kovskoe	Ozerninskoe	Volgogradskoe	Kapchagajskoe	Ust'-Khangatskoe	Al. Stambolijski	Mostiste
European perch <i>Perca fluviatilis</i> Linnaeus	0.5	0.6	1.0	0.9	0.8	0.8	-	0.8
Zander <i>Stizostedion lucioperca</i> (Linnaeus)	1.0	1.0	0.4	0.9	1.0	-	1.0	0.7
Volga zander <i>Stizostedion volgense</i> (Gmelin)	*	*	-	0.6	-	-	-	-
Ruffe <i>Gymnocephalus cernuus</i> (Linnaeus)	0.7	0.6	0.6	0.6	-	-	1.0	1.0
Roach <i>Rutilus rutilus</i> (Linnaeus)	0.1	0.1	0.2	0.3	*	0.1	-	0
Bream <i>Abramis brama</i> (Linnaeus)	0.2	0.8	0	0	0.6	-	-	0.4
Bleak <i>Alburnus alburnus</i> (Linnaeus)	0.3	1.0	0.2	0.3	-	-	-	*
Silver bream <i>Blicca bjoerkna</i> (Linnaeus)	0.5	0.5	*	0.2	-	-	-	-
Carp <i>Cyprinus carpio</i> Linnaeus	-	-	-	*	0.5	-	0	-

Note: Data for Figure 8. Asterisk (\*) means species not common in the reservoir; line means species not found.

**Table S16.** Comparison of the indices of migration in cyprinids and percids.

Mann–Whitney U Test Results	
Variable	Migration index
Rank sum—Percidae	613.5
Rank sum—Cyprinidae	247.5
U	37.5
Z	4.49
p-value	0.000007
Z-adjusted	4.52
p-value	0.000006

Valid N Percidae	21
Valid N Cyprinidae	20
2*1sided exact <i>p</i>	0.000001

Note: Data for Figure 8. Results of Mann–Whitney U Test with continuity correction. By variable “migration index”. Marked tests are significant at  $p < 0.05000$ .

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## Supplementary References

Pavlov, D.S.; Nezdolii, V.K., Khodorevskaya, R.P.; Ostrovskii, M.P.; Popova, I.K. *Downstream Migration of Young Fish in the Volga and Ili Rivers*; Nauka: Moscow, Russia, 1981; pp. 1-320. (in Russian).

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