

Research Article

Length-Weight Relationships of Eight Fish Species in the World's Largest Water Diversion Project

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Received 2 February 2023; Revised 28 February 2023; Accepted 12 June 2023; Published 27 June 2023

Academic Editor: Hamed Ghafarifarsani

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The study provides the length-weight relationships (LWRs) for eight fish species, viz. *Hemiculter bleekeri*, *H. leucisculus*, *Opsariichthys bidens* (Xenocyprididae), *Carassius auratus*, *Cyprinus carpio* (Cyprinidae), *Pseudorasbora parva* (Gobionidae), *Acanthorhodeus chankaensis*, and *Rhodeus ocellatus* (Acheilognathidae), in the world's largest water diversion project, namely, the middle route of South-to-North Water Diversion Project (SNWDP). Fish specimens were sampled by benthic fyke-nets, gillnets, multimesh gillnets, and electrofishing equipment seasonally from 2015 to 2020. The coefficient of determination (r^2) was ranging from 0.964 (*R. ocellatus*) to 0.986 (*H. leucisculus*), and the b values for the eight species were within range of 2.5–3.5. Also, our study updates the information on the maximum total length for four species (*H. bleekeri*, *H. leucisculus*, *A. chankaensis*, and *O. bidens*).

1. Introduction

The middle route of South-to-North Water Diversion Project (SNWDP) is the world's largest interbasin water diversion project (32°40'–39°58'N, 111°42'–116°16'E), which originates from Danjiangkou Reservoir and flows northward to Beijing through a 1276 km open canal. When the main canal extends to North China, it passes through the subtropical monsoon humid climate zone and the temperate monsoon climate zone, and the average annual precipitation and the annual air temperature are 542–1173 mm and 14.6–21.2°C, respectively [1, 2]. The main canal is also the largest artificial river ecosystem in the world, the ecosystem is in its early stages, and the ecosystem balance has not been established. The fish community structure is simple which has relatively few fish species, and dominated by small fishes, and the species diversity is low. The development of fish community function is lagging behind, and the top-down effects of the ecosystem is weak. Therefore, it is very necessary to explore fish diversity, biology, and population dynamics for better conservation in this project [3, 4].

The length-weight relationships (LWRs) of fish species are important for estimating the weight of a specimen from the length, and the reverse is also true [5, 6]. Together with data on growth rates, sex ratio, length-at-age, fecundity, size at first maturity, spawning stock biomass, and recruitment, LWRs can greatly assist in the research of population status and management [3]. In this study, the LWRs for eight species from the middle route of SNWDP are presented. The results can provide basic biological and scientific knowledge on the fish ecological regulation for the administrative department.

2. Materials and Methods

We used benthic fyke-nets (mesh size: knot to knot, 5 mm), gillnets (mesh size: knot to knot, 60, 80, and 100 mm), multimesh gillnets (mesh size: according to European standard, 5–55 mm), and electrofishing equipment (36 V, 12 A) to collect seasonal samples of fish between 2015 and 2020. A total of ten sampling sites distribute along the main canal, which are Dengzhou section (32°43'6"N,

TABLE 1: Descriptive statistics and estimated parameters of length-weight relationships for the eight fish species in the middle route of SNWDP.

Families	Species	<i>n</i>	Total length (cm)				Weight (g)				Parameters			
			Min	Max	Min	Max	Min	Max	<i>a</i>	95% CL of <i>a</i>	<i>b</i>	95% CL of <i>b</i>	<i>r</i> ²	
Xenocyprididae	<i>Hemiculter bleekeri</i> *	409	6.8	25.2	1.7	150.3	0.00421	0.00365~0.00486	3.213	3.158~3.268	0.970			
	<i>Hemiculter leucisculus</i> *	785	6.5	29.0	1.8	232.3	0.00577	0.00537~0.00621	3.082	3.056~3.108	0.986			
	<i>Opsarichthys bidens</i> *	208	4.6	26.1	0.6	261.1	0.00372	0.00321~0.00431	3.341	3.286~3.397	0.986			
Cyprinidae	<i>Carassius auratus</i>	520	5.8	44.8	2.4	1598.6	0.00965	0.00816~0.01142	3.205	3.153~3.257	0.966			
	<i>Cyprinus carpio</i>	77	16.8	72.0	53.2	6738.8	0.01130	0.00695~0.01836	3.078	2.945~3.210	0.966			
Gobiionidae	<i>Pseudorasbora parva</i>	347	2.3	10.5	0.1	13.6	0.00654	0.00603~0.00710	3.206	3.158~3.253	0.980			
Acheilognathidae	<i>Acanthorhodeus chankaensis</i> *	24	7.2	14.4	5.4	48.1	0.01355	0.00788~0.02331	3.069	2.838~3.299	0.971			
	<i>Rhodeus ocellatus</i>	38	3.5	8.2	0.8	7.9	0.01534	0.01067~0.02206	2.996	2.802~3.190	0.964			

Note. N: sample size; min and max: minimum and maximum; *a* and *b*: intercept and slope; *r*²: coefficient of determination; CL: confidence interval. *New maximum total length record in FishBase.

111°50'39"E), Zhenping section (32°56'55"N, 112°16'11"E), Lushan section (33°47'0"N, 112°59'22"E), Wenxian section (34°55'2"N, 113°10'14"E), Cixian section (36°15'15"N, 114°19'52"E), Xingtai section (37°10'17"N, 114°33'29"E), Yuanshi section (37°42'47"N, 114°28'6"E), Xiheishan section (39°4'46"N, 115°23'54"E), Laizhuo section (39°29'16"N, 115°44'45"E), and Huinanzhuang section (39°31'48"N, 115°48'35"E) from south to north.

Total length (TL) and body weight (W) were measured with 0.1 cm and 0.1 g accuracy, respectively. The estimation of LWRs was calculated as $\log(W) = \log(a) + b \log(L)$, where W is the body weight (g) and L is the total length (cm). The parameters and statistical test were analyzed by using R software (version: 4.1.1). Prior to regression analysis, outliers were detected and removed by using log-log plots [3]. The 95% confidence limits for a and b (95% CL) were determined for the parameters, as well as the coefficients of determination (r^2). When $r^2 < 0.95$, the regression was repeated after removing outliers [3, 7].

In addition, ethics approval for all experiments and handling of fishes in our study complied with the animal welfare regulations of the Government of China and followed the ethical rules of the Institutional Animal Care and Use Committee of the Institute of Hydrobiology, CAS (Approval ID: Keshuizhuan 08529).

3. Results

The results of LWRs and descriptive statistics are presented in Table 1. The regressions for all fish species were statistically significant ($P < 0.01$), with the coefficient of determination (r^2) ranging from 0.964 to 0.986. Based on FishBase data (<https://www.fishbase.org>, version: 08/2022), our study updates the information on the maximum total length for four species, including *Hemiculter bleekeri*, *H. leucisculus*, *Acanthorhodeus chankaensis*, and *Opsariichthys bidens*.

4. Discussion

In this study, the r^2 values of all fish species were >0.95 and the range of b values was between 2.996 and 3.341, which was consistent with the expected range of 2.5–3.5 [3]. Many factors, such as growth phase, gender, food, fishing behavior, seasonality, and temperature, may lead to the differences of LWRs [3, 5, 6]. However, abovementioned factors were not taken into account in this study. New records of maximum total lengths of four species are recorded for FishBase [8], of which the *H. bleekeri* recorded in FishBase was 20.2 cm, new record is 25.2 cm, *H. leucisculus* recorded 27.4 cm, new record is 29.0 cm, *A. chankaensis* recorded 13.5 cm, new record is 14.4 cm, and for *O. bidens* recorded 21.9 cm, new record is 26.1 cm. This study provides scientific data on LWRs for eight fish species, which can be useful for fish resource conservation and management in the middle route of SNWDP.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

This study was funded by the National Key Research and Development Project (Grant no. 2021YFC3200902) and the China National Critical Project for Science and Technology on Water Pollution Prevention and Control (Grant no. 2017ZX07108-001).

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