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Research Article

Length-Weight Relationships and Growth Patterns of Eight Indigenous Fish Species from Lancang River, Southwest China

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The Lancang-Mekong River watershed has extremely high fish biodiversity. With the rapid population growth and economic development in the river basin, fish diversity and fishery resources of this river are experiencing serious threats. Basic biological information on most fish species in the Lancang River, required to improve conservation in this area, is limited. This study aimed to provide new estimates of length-weight relationships (LWRs) by using the linear regression of $W = aL^b$ for eight indigenous fish species from the Lancang River, Southwest China. From 2018 to 2021, 534 specimens belonging to 3 families and 8 genera were collected using various types of fishing techniques. Standard length (SL) and body weight (BW) of each specimen were measured to the nearest 0.1 cm and 0.1 g, respectively. This study presents the first public records of LWR parameters of *Schizothorax lissolabiatus*, *Poropuntius huangchuchieni*, *Tor sinensis*, *Scaphiodonichthys acanthopterus*, *Mystacoleucus lepturus*, *Hemiculterella macrolepis*, *Glyptothorax lampris*, and *Schistura porthos*. The range of b values for the LWRs was 2.5378–3.1732, and the r^2 values for all LWRs estimates ranged from 0.9102 to 0.9952. Intraspecific difference of b values across population and/or season was observed in *S. lissolabiatus*, *T. sinensis*, *P. huangchuchieni*, *S. acanthopterus*, and *M. lepturus*. The range of mean condition factor (K) and mean relative weight (W_r) was 0.97–2.39 and 100.29–108.18, respectively. This study updated information for FishBase and provided new record of maximum standard length for five species, namely, *S. lissolabiatus*, *P. huangchuchieni*, *T. sinensis*, *S. acanthopterus*, and *M. lepturus*. The findings of this study are essential for the management and conservation of locally indigenous fish and fisheries.

1. Introduction

The Lancang-Mekong River is the longest river in Southeast Asia. As a longitudinally important international river, the Lancang-Mekong River watershed covers various landscape types and has extremely high fish biodiversity [1]. It is the second river with the highest freshwater biodiversity worldwide only after the Amazon River, having an estimated 890 species of freshwater fish [2, 3]. Nearly 200 fish species have been recorded in the river within China, most of which are indigenous species [1]. However, with the rapid population growth and economic development of countries in the river basin, especially the cascade development of the substantial hydropower resources in the upper and middle reaches, fish diversity and fishery resources of the Lancang River are experiencing serious threats. Habitat loss and fragmentation, water pollution, overfishing, and alien species invasion are the main threats and have resulted in significant decline in fish diversity and homogenization of fish assemblages [4–6]. Despite these threats on local fish communities, basic biological information on most indigenous fish species in the Lancang River is limited [3]. It is necessary to explore fish biology, population dynamics, and fish diversity of Lancang River to implement conservation and management measures for the protection of local fish assemblages.

Length-weight relationships (LWRs) are important in fish biology, ecology, fishery management, and conservation. They allow the determination of fish weight from length or vice versa, facilitating the production evaluation of fish populations and providing information on growth patterns [7, 8]. Furthermore, LWRs facilitate biometric and morphological comparisons between fish species in the same taxonomic group or between fish populations from different regions or time periods [9, 10]. The "b" value calculated from length-weight relationship is usually used to describe the growth patterns of fish. When it does not differ significantly ($P > 0.05$) from the ideal value ($b = 3$), weight growth is considered isometric, indicating that a fish proceeds in the "same" dimension as the cube of length. Otherwise, weight gain is allometric, including positive ($b > 3$) and negative ($b < 3$) [11]. The condition factor (K) is another index calculated from length and weight measurements that reflects the energy and nutritional status of fish at the individual level [12]. It is usually used to assess the fullness, nutrition, and the effect of environmental variability on fish and can be used as an effective, readily available indicator of population status [13–15]. Relative weight (W_r) is another popular method for assessing the condition of freshwater fish, reflecting ecological and physiological optimality within fish population, and this index validates direction comparison of individuals condition across populations [10, 16, 17].

Indigenous fishes in the Lancang River are important components of the local biodiversity and aquatic food webs. Some indigenous fishes are important components of local fisheries, such as *Schizothorax lissolabiatus*, *Tor sinensis*, and *Mystacoleucus lepturus* [18, 19]. However, there are few data about their biological traits. Little information is available on the LWR and growth pattern of these fishes. To expand the biological knowledge of these species and provide basic data for conservation, this study provides the LWRs, condition factors, and relative weights of eight indigenous species belonging to three families from the Lancang River for which there is no information regarding the LWR, even in FishBase [20].

2. Materials and Methods

2.1. Study Area and Sample Collection. Samples were collected from the Lancang River and their tributaries (i.e., Jidu, Weiyuan, Buyuan, and Nanla rivers) in Southwest China from November 2018 to September 2021 (Figure 1, Table 1). Drift gillnets (20–40 m long, 1–3 m high, and mesh size of 1–5 cm), trap nets (20 m × 50 cm × 50 cm, mesh size: 1 cm), and electrofishing (20 A, 1 V, 3000 W) were used to obtain fish samples. After they were caught, the specimens were identified to the species level according to the Fishes of Yunnan, China [18, 19], and Checklist of Fishes of Yunnan [21]. All scientific names were checked against FishBase [20]. For each individual, standard length (SL, cm) was measured to the nearest 0.1 cm using a fish measuring board, and body weight (BW, g) was measured to the nearest 0.1 g using an electronic balance (Lichen, TD50002A). All handling procedures were performed according to the Laboratory Animal Administration Regulations of China.

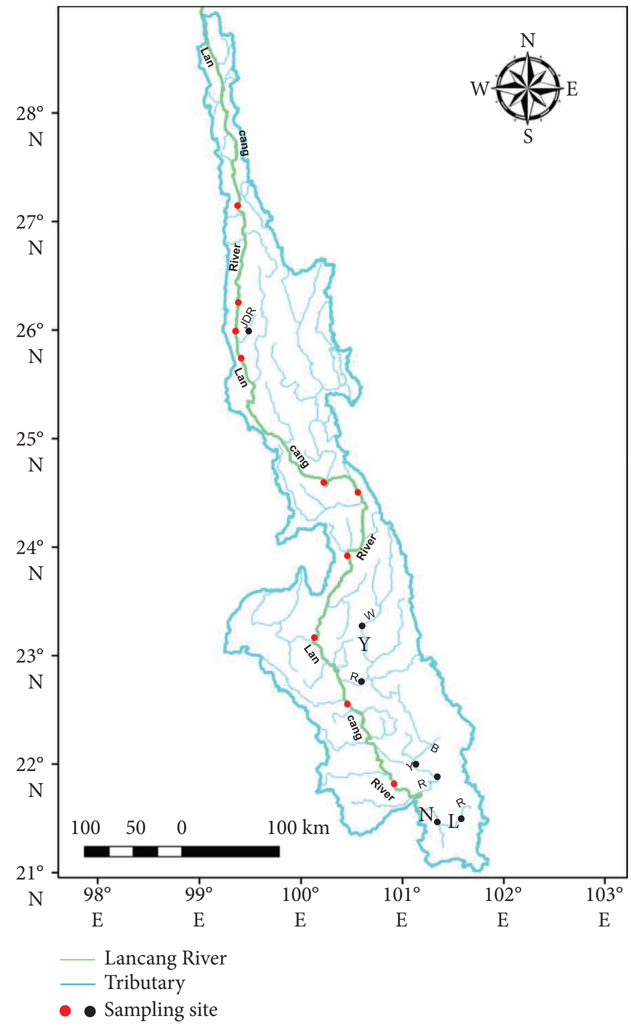

Figure 1: Sampling sites of the Lancang River and their tributaries. The area enclosed by the blue contour line is the Lancang River basin. JDR, Jidu River; WYR, Weiyuan River; BYR, Buyuan River; NLR, Nanla River.

The LWRs were calculated using the power function. Condition factor (K) and relative weight (W_r) were used to assess condition of individuals of the eight fish species. Equations used to calculate these indices were expressed as follows:

$$W = \mathrm{a}L^{b}, \tag{1}$$

$$K = \frac{100W}{L^{3}}, \tag{2}$$

$$W_r = \frac{100W}{\left(\mathrm{a}L^{b}\right)}, \tag{3}$$

where (1) is used to calculate LWRs, (2) is used to calculate the condition factor, and (3) is used to calculate the relative weight and W is the body weight (BW, g), L is the standard length (SL, cm), a is the intercept of the regression, b is the allometric coefficient, K is the condition factor, and W_r is the relative weight. According to Froese [10], prior to the

Table 1: Sampling sites and dates of the eight fish species from the Lancang River, China.

Family	Species	Sampling river U	Sampling river M	Sampling river D	Sampling time
Cyprinidae	*Schizothorax lissolabiatus* Tsao, 1964	○	○		Oct.–Dec., 2019; Apr.–Jun., 2020
	Poropuntius huangchuchieni (Tchang, 1962)		○	○	Apr.-May, 2019; Aug.–Oct., 2019
	Tor sinensis Wu, 1977		○	○	Apr.-May, 2020; Jul.-Aug., 2020
	Scaphiodonichthys acanthopterus (Fowler, 1934)		○	○	Apr.-May, 2021; Jul.-Aug., 2021
	Mystacoleucus lepturus Huang, 1979			○	Apr.-May, 2020; Jul.-Aug., 2020
	Hemiculterella macrolepis Chen, 1989			○	May, 2021
Nemacheilidae	*Schistura porthos* Kottelat, 2000			○	Apr.–Jun., 2021
Sisoridae	*Glyptothorax lampris* Fowler, 1934	○	○		Dec. 2018–Jan. 2019

Specimens were collected from the mainstream and tributaries of the Lancang River. U, including upper stream of the Lancang River, Jidu River; M, including middle stream of the Lancang River, Weiyuan River; D, including downstream of the Lancang River, Buyuan River and Nanla River; ○, fishes were collected.

regression analysis of BW on SL, logarithmic transformation was performed and log-log plots of length and weight were used to eliminate outliers. No outliers were found, so the log-log plots were not shown in the study. Parameters a and b were estimated using linear regression analysis based on 10 logarithms: log $BW = \log\ a + b\ \log\ SL$. Coefficient of determination (r^2) calculated from the regression analysis was used to evaluate the fit of LWR estimate. The 95% confidence interval (Cl) of parameters a and b was estimated.

2.2. Significance Testing. The covariance analysis (ANCOVA) method was used to test whether there were seasonal differences of the allometric coefficient b. Independent samples t-test was performed among sampling seasons to determine the intraspecific difference of K and W_r. Significant variation in the estimates of b of the length-weight relationship was compared with the expected value (ideal value $b = 3$) and was tested by t-test. The equation used to compute the t-statistic is

$$\hat{t} = \frac{s.d.(x)}{s.d.(y)} \times \frac{|b-3|}{\sqrt{1-r^2}} \times \sqrt{n-2}, \quad (4)$$

where $s.d._{(x)}$ is the standard deviation of log SL values, $s.d._{(y)}$ is the standard deviation of log BW values, b is the allometric coefficient, r^2 is the coefficient of determination, and n is the number of specimens used in the computation. The value of "b" differs from 3 if $\hat{t}$ is greater than the tabled value of t for $n-2$ d.f. [11]. All analyses were performed using IBM SPSS Statistics software (version 25.0; SPSS Inc. Ltd.) and Excel (Microsoft Office, 2021) at a significance level of 0.05.

3. Results and Discussion

3.1. Length and Weight Analysis. In total, 534 specimens belonging to three families, eight genera, and eight species were collected and studied for their LWRs and growth patterns. The fish species were *S. lissolabiatus*, *Poropuntius huangchuchieni*, *T. sinensis*, *Scaphiodonichthys acanthopterus*, *M. lepturus*, *Hemiculterella macrolepis*, *Schistura porthos*, and *Glyptothorax lampris*. The LWRs for the eight species were reported for the first time to FishBase. Moreover, the new maximum standard length for 5 fish species, namely, *S. lissolabiatus*, *P. huangchuchieni*, *T. sinensis*, *S. acanthopterus*, and *M. lepturus*, was also reported for the first time to FishBase [20]. The sample size; size range of SL and BW; length-weight relationship parameters a and b and their 95% confidence interval; coefficient of determination r^2; and growth pattern are given in Table 2.

According to the findings of this study, all fish species analyzed showed a strong correlation between length and weight. Statistical length-weight relationships for all eight fish species were highly significant ($P < 0.001$), with all r^2 values greater than 0.90, indicating that the LWR estimates for all species fit well and were highly reliable. The values of parameter b for all 8 species ranged between 2.5378 and 3.1732 and remained within the expected range of 2.5–4.0 [10]. The b values of the LWRs of *S. lissolabiatus* and *T. sinensis* in this study differed from those of other populations [22, 23], indicating an intraspecific difference among different geographic populations. Intraspecific differences of the b values and growth patterns in different seasons were also observed in this study. The b value of *S. lissolabiatus* in spring was significantly higher than that in autumn (ANCOVA, $F = 16.179$, $P < 0.001$). It showed positive allometric growth in spring (t-test, $t = 0.403$, $P < 0.05$) and isometric growth in autumn (t-test, $t = 1.346$, $P > 0.05$). For *P. huangchuchieni*, the b value of this fish in spring was significantly lower than that in autumn (ANCOVA, $F = 23.759$, $P < 0.001$). Growth pattern of this fish was negative allometric in spring (t-test, $t = 3.454$, $P < 0.05$) while positive allometric in autumn (t-test, $t = 3.802$, $P < 0.05$). The b value of *S. acanthopterus* in spring was lower than that in summer (ANCOVA, $F = 4.102$, $P < 0.05$), and the growth pattern of this fish in spring was negative allometric in spring (t-test, $t = 2.357$, $P < 0.05$) and isometric in summer (t-test, $t = 1.654$, $P > 0.05$). For *M. lepturus*, this b value in spring was larger than that in summer (ANCOVA, $F = 1.939$, $P < 0.05$); this fish showed isometric growth pattern in spring (t-test, $t = 2.357$, $P > 0.05$) and negative allometric growth pattern in summer (t-test, $t = 1.654$, $P < 0.05$). These seasonal variations in the b value and related growth pattern may relate to differences in the sampling season, developmental phases, and stomach fullness of fishes at the time [10, 11]. Besides, some other factors would affect the b parameter, for example, sex [24], size classes [25], different time periods [26, 27], or even different geographic populations [28]. To increase the

Table 2: Descriptive statistics and estimated parameters of LWR ($BW = a\ SL^b$) for eight indigenous fish species sampled in the Lancang River, Southwest China, from 2018 to 2021.

Family	Species	Dates	n	SL Range	SL Mean ± S.D.	BW Range	BW Mean ± S.D.	a	95% Cl of a	b	95% Cl of b	r^2	Growth pattern
Cyprinidae	*Schizothorax lissolabiatus* Tsao, 1964*	Spr.	34	3.5–**26.0**	14.1 ± 5.2	0.8–338.1	70.72 ± 32.3	0.0108	0.0080–0.0136	3.1732	3.0732–3.2733	0.9918	P
		Aut.	116	4.3–25.4	10.2 ± 4.58	1.4–292.8	53.85 ± 30.0	0.0173	0.0151–0.0196	2.9617	2.9054–3.0181	0.9893	I
	Poropuntius huangchuchieni (Tchang, 1962)*	Spr.	65	7.5–18.0	10.21 ± 2.32	10.3–120.6	26.8 ± 21.41	0.0407	0.0263–0.0551	2.7329	2.5796–2.8862	0.9528	N
		Aut.	30	4.5–**27.0**	10.62 ± 6.23	1.8–430.5	101.26 ± 59.67	0.0140	0.0113–0.0168	3.1570	3.0716–3.2425	0.9952	P
	Tor sinensis Wu, 1977*	Spr.	35	7.9–**79.2**	20.59 ± 7.91	9.5–9298.0	2221.05 ± 759.80	0.0203	0.0033–0.0372	3.0031	2.7109–3.2954	0.9720	I
		Sum.	29	5.7–78.5	21.93 ± 8.38	4.4–8120.3	1692.88 ± 560.73	0.0314	0.0159–0.0469	2.8725	2.7074–3.0376	0.9858	I
	Scaphiodonichthys acanthopterus (Fowler, 1934)*	Spr.	24	3.4–**43.3**	12.98 ± 6.42	0.7–1713.9	143.28 ± 80.71	0.0306	0.0205–0.0406	2.8503	2.7183–2.9824	0.9891	N
		Sum.	41	5.0–34.0	13.6 ± 7.07	2.9–719.7	263.68 ± 120.4	0.0149	0.0076–0.0223	3.1587	2.9647–3.3527	0.9653	I
	Mystacoleucus lepturus Huang, 1979*	Spr.	31	4.5–**17.4**	6.49 ± 1.05	1.8–65.7	6.14 ± 3.23	0.0276	0.0101–0.0450	2.8475	2.5078–3.1871	0.9102	I
		Sum.	25	4.5–9.1	6.34 ± 0.91	2.7–17.2	4.81 ± 1.91	0.0424	0.0227–0.0621	2.5378	2.2855–2.7900	0.9493	N
	Hemiculterella macrolepis Chen, 1989*	Spr.	40	6.0–10.0	8.0 ± 1.07	2.1–9.0	5.1 ± 1.77	0.0171	0.0127–0.0215	2.7225	2.5987–2.8463	0.9815	N
Nemacheilidae	*Schistura porthos* Kottelat, 2000*+	Spr.	31	5.4–7.9	6.7 ± 0.62	2.5–8.1	4.8 ± 1.36	0.0138	0.0102–0.0175	3.0723	2.9336–3.2110	0.9861	I
Sisoridae	*Glyptothorax lampris* Fowler, 1934*	Win.	33	4.5–10.0	6.0 ± 1.30	1.9–14.5	4.0 ± 2.68	0.0305	0.0235–0.0374	2.6632	2.5345–2.7920	0.9826	N

*Newly recorded LWR to FishBase; +tentative estimation due to limited size range; bold, new maximum record of standard length to FishBase; n, sample size; a and b, regression parameters; Cl, confidence limits; r^2, coefficient of determination; P, positive allometric growth; I, isometric growth; N, negative allometric growth; S.D., standard deviation (SL, cm; BW, g).

Table 3: Condition factors (K) and relative weight (W_r) for eight fish species sampled in the Lancang River, Southwest China, from 2018 to 2021.

Family	Species	Dates	n	K range	K mean ± S.D.	W_r range	W_r mean ± S.D.
Cyprinidae	*Schizothorax lissolabiatus* Tsao, 1964	Spr.	34	0.93–2.28	1.69 ± 0.25	69.53–127.26	100.35 ± 13.48
		Aut.	116	1.00–2.31	1.62 ± 0.19	64.28–145.51	101.73 ± 11.98
	Poropuntius huangchuchieni (Tchang, 1962)	Spr.	65	1.59–2.99	2.22 ± 0.30	73.34–132.99	100.63 ± 12.65
		Aut.	30	1.59–2.77	1.99 ± 0.29	81.19–129.50	100.29 ± 12.20
	Tor sinensis Wu, 1977	Spr.	35	1.18–4.28	2.15 ± 0.84	57.44–208.93	104.89 ± 14.07
		Sum.	29	1.68–3.66	2.20 ± 0.51	82.72–168.54	101.90 ± 22.33
	Scaphiodonichthys acanthopterus (Fowler, 1934)	Spr.	24	1.40–2.91	2.14 ± 0.35	71.04–134.84	100.69 ± 15.15
		Sum.	41	1.20–6.40	2.39 ± 1.19	48.14–291.39	108.18 ± 25.11
	Mystacoleucus lepturus Huang, 1979	Spr.	31	1.43–2.70	2.09 ± 0.30	68.27–131.20	100.73 ± 14.41
		Sum.	25	1.47–2.16	1.83 ± 0.19	87.89–118.32	100.35 ± 8.30
	Hemiculterella macrolepis Chen, 1989	Spr.	40	0.85–1.10	0.97 ± 0.06	90.54–111.10	100.48 ± 5.23
Nemacheilidae	*Schistura porthos* Kottelat, 2000	Spr.	31	1.48–1.71	1.59 ± 0.05	94.26–108.32	100.43 ± 3.40
Sisoridae	*Glyptothorax lampris* Fowler, 1934	Win.	33	1.37–2.04	1.69 ± 0.16	88.00–114.93	100.47 ± 6.94

S.D., standard deviation.

reliability of description of the isometric or allometric growth of fish based on the average b value, all the aforementioned factors were recommended to consider [10].

3.2. Condition Factor and Relative Weight Analysis. Condition factors (K) of the eight fish species ranged from 0.85 to 6.40 (Table 3). The lowest mean condition factor was observed in *H. macrolepis* in spring, with a mean value of 0.97 ± 0.06, while the highest mean condition factor was observed in *S. acanthopterus* in summer, with a mean value of 2.39 ± 1.19. Independent samples t-test showed that the condition factors of *P. huangchuchieni* and *M. lepturus* in spring were significantly different from those in summer ($P < 0.05$), respectively. No significant differences were observed in *S. lissolabiatus*, *T. sinensis*, and *S. acanthopterus* across sampling seasons, respectively ($P > 0.05$). This seasonal difference may relate to their growth periods at the sampling time [10]. For *P. huangchuchieni* and *M. lepturus*, their breeding season was in spring, mainly from April to May [18, 19], and they gained weight as the gonads mature in spring, so their K mean values in spring were higher and different from summer. As for *S. lissolabiatus* and *S. acanthopterus*, the reproductive season was mainly in March and April, and for *T. sinensis*, it was mainly in November and December [18, 19]; their reproductive season ended or had not come at the sampling time, and no seasonal differences of fitness for these three fishes were observed. Besides, fishing pressure could also affect their condition factor because *S. lissolabiatus*, *T. sinensis*, and *M. lepturus* were important components of local fisheries [18, 19]. According to Haberle et al. [29], the body length, body weight, and average condition factor increased with an increase in fishing pressure but decreased with an increase in population abundance. Differences of condition factor of *H. macrolepis*, *S. porthos*, and *G. lampris* across sampling seasons were not discussed because these fishes were captured only in one season.

Relative weight (W_r) conveys important physiological components of fish life history (e.g., lipid storage, body morphology, and growth rate) and offers a strong, accessible metric for managers to assess the overall health and fitness of fish populations, as well as population-level responses to ecosystem disturbances [30]. According to Anderson and Neumann [31], a relative weight (W_r) of an individual or population less than 100 may indicate problems, such as low prey availability or high predation pressure; a relative weight (W_r) greater than 100 indicates sufficient prey or low predation pressure. The mean relative weight range of the eight fish species analyzed ranged from 100.29 to 108.18 (Table 3), indicating a balance between prey availability and predator density of these fish populations in their habitat. Also, there was no significant difference of relative weight across sampling seasons for 5 fish species, namely, *S. lissolabiatus*, *P. huangchuchieni*, *T. sinensis*, *S. acanthopterus*, and *M. lepturus* (all $P > 0.05$). Because there was only one-season dataset, differences of relative weight of *H. macrolepis*, *S. porthos*, and *G. lampris* across seasons were not discussed.

4. Conclusions

This study provides a basic understanding of the LWRs and condition factors of eight fish species indigenous to the Lancang River and their tributaries in Yunnan Province, China. LWRs for the eight species are published herein for the first time for the FishBase. New records of maximum standard length for five fish species were recorded. Since some indigenous fishes analyzed are important components of local fisheries, such as *S. lissolabiatus*, *T. sinensis*, or *M. lepturus*, our results will be useful resource for future fisheries research evaluating the health status of these populations. Besides, indigenous fishes in the Lancang River are important components of the local biodiversity and aquatic food webs. However, differences across fishing gears, size ranges, reproductive stage, and sexes were not evaluated in the present study. Further research involving the factors that affect fish growth is required to provide additional valuable information for local fish conservation and fishery management. We suggest that further studies include long-term monitoring of fish resources; conduct community and population dynamics analysis; comprehensively evaluate the relationship between aquatic environment and fishery resources; and, based on these research studies, conduct scientific fishery stocking and fishing management to ensure that the river has sustainable fishery production while supporting other ecological service functions.

Data Availability

The data used to support the findings of this study are available from the corresponding authors upon reasonable request.

Disclosure

Huiping Ding and Tian Zhong are co-first authors.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Authors' Contributions

Huiping Ding and Tian Zhong contributed equally to this work.

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References

[1] Y. X. Hong, W. Q. Shi, Y. C. Chen et al., "Succession of fish community in the mainstream of Lancang River during cascade hydropower development," *Acta Ecologica Sinica*, vol. 41, no. 1, pp. 235–253, 2021.

[2] W. J. Rainboth, C. Vidthayanon, and D. Y. Mai, *Fishes of the Greater Mekong Ecosystem with Species List and Photographic Atlas*, Miscellaneous Publications, Museum of Zoology, University of Michigan, Ann Arbor, MI, USA, 2012.

[3] L. Xueqing, S. Heying, H. Dekui, and C. Yifeng, "Freshwater fish diversity in the upper and middle reaches of the Lancang-Mekong River," *Biodiversity Science*, vol. 27, no. 10, pp. 1090–1100, 2019.

[4] C. Zhang, L. Y. Ding, C. Z. Ding, L. Q. Chen, J. Sun, and X. Jiang, "Responses of species and phylogenetic diversity of fish communities in the Lancang River to hydropower development and exotic invasions," *Ecological Indicators*, vol. 90, pp. 261–279, 2018.

[5] J. P. Li, S. K. Dong, M. C. Peng et al., "Effects of damming on the biological integrity of fish assemblages in the middle Lancang-Mekong River basin," *Ecological Indicators*, vol. 34, pp. 94–102, 2013.

[6] P. B. Ngor, P. Legendre, T. Oberdorff, and S. Lek, "Flow alterations by dams shaped fish assemblage dynamics in the complex Mekong-3S river system," *Ecological Indicators*, vol. 88, pp. 103–114, 2018.

[7] S. A. Chen, H. P. Ding, Z. Z. Zhang, N. Yao, C. X. Xie, and D. P. Li, "Length-weight relationships of three species in northern China," *Journal of Applied Ichthyology*, vol. 34, no. 5, pp. 1214-1215, 2018.

[8] Z. Zhang, H. Ding, W. Wang, F. Chen, D. Huang, and Z. Yang, "Length-weight and length-length relationships of four fish species from the middle reaches of the Minjiang River, southwest China," *Journal of Applied Ichthyology*, vol. 33, no. 6, pp. 1296–1298, 2017.

[9] E. Çiçek, B. Seçer, S. Sungur, S. Öztürk, and H. Bahçeci, "Length-weight relationships and condition factors of 28 fish species belonging to Leuciscidae (Cypriniformes) from Turkey," *Journal of Applied Ichthyology*, vol. 38, no. 3, pp. 364–367, 2022.

[10] R. Froese, "Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations," *Journal of Applied Ichthyology*, vol. 22, no. 4, pp. 241–253, 2006.

[11] D. Pauly, *Fish Population Dynamics in Tropical Waters: A Manual for Use with Programmable Calculators*, International Center for Living Aquatic Resources Management, Manila, Philippines, 1984.

[12] Q. Dai, J. H. Dai, C. Li, Z. J. Liu, and Y. Z. Wang, "Discussion on relative fatness," *Chinese Journal of Applied and Environmental Biology*, vol. 12, no. 5, pp. 715–718, 2006.

[13] E. D. Le Cren, "The length weight relationship and seasonal cycle in gonad weight and condition in Perch (*Perca fluviatilis*)," *Journal of Animal Ecology*, vol. 20, no. 2, pp. 12–16, 1951.

[14] M. Lizama, A. M. Ambrósio, and A. M. Ambrósio, "Condition factor in nine species of fish of the Characidae family in the upper Paraná River floodplain, Brazil," *Brazilian Journal of Biology*, vol. 62, no. 1, pp. 113–124, 2002.

[15] R. D. Stevenson and W. A. Woods, "Condition indices for conservation: new uses for evolving tools," *Integrative and Comparative Biology*, vol. 46, no. 6, pp. 1169–1190, 2006.

[16] G. J. Wege and R. O. Anderson, "Relative weight (Wr): a new index of condition for largemouth bass," in *New Approaches to the Management of Small Impoundments*, G. D. Novinger and J. G. Dillard, Eds., pp. 79–91, American Fisheries Society, Special Publication 5, Bethesda, MD, USA, 1978.

[17] B. R. Murphy, M. L. Brown, and T. A. Springer, "Evaluation of the relative weight (W_r) index, with new applications to walleye," *North American Journal of Fisheries Management*, vol. 10, no. 1, pp. 85–97, 1990.

[18] X. L. Chu and Y. R. Chen, *The Fishes of Yunnan, China. Part 1 Cyprinidae*, Science Press, Beijing, China, 1989.

[19] X. L. Chu and Y. R. Chen, *The Fishes of Yunnan, China. Part 2*, Science Press, Beijing, China, 1990.

[20] R. Froese and D. Pauly, "FishBase," 2023, https://www.fishbase.se/search.php.

[21] X. Y. Chen, "Checklist of fishes of yunnan," *Zoological Research*, vol. 34, no. 4, pp. 281–343, 2013.

[22] H. Xiao and Y. G. Dai, "Age structure, growth and life-history pattern of *Schizothorax lissolabiatus* in Beipan River," *Chinese Journal of Ecology*, vol. 30, no. 3, pp. 539–546, 2011.

[23] F. J. Huang, "The studies on the biology and stock biomass of tor sinensis of lancang river," [Dissertation], Southwest University, Chongqing, China, 2013.

[24] J. C. Compaire and M. C. Soriguer, "Length-weight relationships of seven fish species from tidepools of an intertidal rocky shore in the Gulf of Cadiz, Spain (NE Atlantic)," *Journal of Applied Ichthyology*, vol. 36, no. 6, pp. 852–854, 2020.

[25] R. S. Santos, S. J. Hawkins, and R. D. M. Nash, "Reproductive phenology of the Azorean rock pool blenny a fish with alternative mating tactics," *Journal of Fish Biology*, vol. 48, no. 5, pp. 842–858, 1996.

[26] L. Sun, F. Zhao, S. Wang, Y. Wang, G. Yang, and P. Zhuang, "Growth and feeding ecology of juvenile Chinese sturgeon, *Acipenser sinensis*, in the Yangtze Estuary," *Journal of Applied Ichthyology*, vol. 35, no. 1, pp. 47–53, 2019.
[27] A. S. Douligeri, A. Ziou, A. Korakis et al., "Notes on the summer life history traits of the non-native pumpkinseed (*Lepomis gibbosus*) (Linnaeus, 1758) in a high-altitude artificial lake," *Diversity*, vol. 15, no. 8, p. 910, 2023.
[28] M. Singh and M. Serajuddin, "Length-weight, length-length relationship and condition factor of *Channa punctatus* collected from three different rivers of India," *Journal of Entomology and Zoology Studies*, vol. 5, no. 1, pp. 191–197, 2017.
[29] I. Haberle, L. Bavčević, and T. Klanjscek, "Fish condition as an indicator of stock status: insights from condition index in a food- limiting environment," *Fish and Fisheries*, vol. 24, no. 4, pp. 567–581, 2023.
[30] T. Copeland, B. R. Murphy, and J. J. Ney, "A comparison of relative weight and nutritional status among four fish species in two impoundments," *Journal of Freshwater Ecology*, vol. 23, no. 3, pp. 373–385, 2008.
[31] R. O. Anderson and R. M. Neumann, "Length, weight and associated structural indices," in *Fisheries Techniques*, B. R. Murphy and D. W. Willis, Eds., pp. 447–482, American Fisheries Society, Bethesda, MD, USA, 2nd edition, 1996.