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Age and Growth of *Oxygymnocypris stewartii* (Cyprinidae: Schizothoracinae) in the Yarlung Tsangpo River, Tibet, China

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Bin Huo, Cong-Xin Xie, Bao-Shan Ma, Xue-Feng Yang, and Hai-Ping Huang (2012) Age and growth of *Oxygymnocypris stewartii* (Cyprinidae: Schizothoracinae) in the Yarlung Tsangpo River, Tibet, China. *Zoological Studies* **51**(2): 185-194. To better understand the biology of *Oxygymnocypris stewartii* and its relationship with management considerations, the age and growth of *O. stewartii* were examined using sectioned otoliths of 712 specimens collected from Aug. 2008 to Aug. 2009. The standard length (SL) ranged 45-587 mm. The location of the 1st annulus was validated by a daily growth increment (DGI) analysis of otoliths. Monthly changes in the marginal increment ratio of the otoliths with 1-8 annuli indicated that an annulus forms once a year, from Mar. to June. The index of the average percentage error (IAPE) of the sectioned otoliths was 0.5%, and the coefficient of variation (CV) for the age estimation was 0.7%. Estimated ages ranged 3-17 yr for males, 2-25 yr for females, and 1-6 yr for those of undetermined sex. The SL-BW relationship was described as BW = 6.108 × 10^{-6} $SL^{3.126}$ for females, BW = 9.872 × 10^{-6} $SL^{3.052}$ for males, and BW = 3.203 × 10^{-5} $SL^{2.821}$ for undetermined. The von Bertalanffy function was used to model the observed length-at-age data as L_t = 526.8 {1 - exp[-0.141 (t - 0.491)]} for males, and L_t = 618.2 {1 - exp[-0.106(t - 0.315)]} for females. Females grew at a slower rate but attained a larger size than males. Knowledge of this species' characteristics of slow growth and a long life will be useful for establishing reasonable management practices for its conservation.
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Key words: Age, Growth, Otolith, *Oxygymnocypris stewartii*, Tibet.

The subfamily Schizothoracinae is the predominant group of endemic fishes living in high-elevation rivers and lakes on the Qinghai-Tibetan Plateau (Cao et al. 1981). They are found in very localized populations. Another characteristic of these species is that they are affected by anthropogenic pressures of indiscriminate fishing, habitat modification resulting from dam construction, and biological invasions. In view of such alterations to the environment, it has become a priority to make efforts towards better understanding the biology of the subfamily Scizothoracinae and its relationship with management considerations.

Among the Schizothoracinae fishes inhabiting in the Yarlung Tsangpo River, *Oxygymnocypris stewartii* is one of the endemic species that lives only in the clear, cool waters at elevations of 3600-4200 m (Wu and Wu 1992, Chen and Cao 2000). Moreover, as a result of the extreme plateau environment, such as low temperatures and poor food availability, *O. stewartii* is slow-growing and long-lived. These characteristics of a limited distribution, slow growth, and long life make *O. stewartii* populations particularly vulnerable to excessive exploitation. However, the rapidly increasing demands for fish attributed to enhanced immigration and gradual changes in many traditional customs have led to the overexploitation of fish resources. The immoderate exploitation has ultimately resulted in *O. stewartii* populations rapidly declining, and this species is listed in the

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IUCN's *Red List of Threatened Species* as a near-threatened fish (Ng 2010). However, attempts to develop effective population management strategies have been obstructed by a lack of basic biological information. The available information mainly focuses on its taxonomy (Lloyd 1908, Cao and Deng 1962), its origin and evolution (Cao et al. 1981), and aspects of its phylogenetic development and biogeography (Chen 1998, Chen 2000, He and Chen 2007). There have been few studies on the otolith microstructure, age and growth of *O. stewartii* (Jia and Chen 2009 2011).

Accurate age determination and estimates of growth and mortality parameters are fundamental requirements for understanding population dynamics and provide essential data needed to maintain sustainable yields by fisheries (Campana and Thorrold 2001). Results from the only 2 studies of age and growth of *O. stewartii* (Jia and Chen 2009 2011) validated the periodicity of otolith increment formation. However, no studies have provided evidence to validate the 1st annual ring or the precision of aging methods. This is often an overlooked but necessary component of any aging study (Campana 2001). The objectives of this study were first to describe annulus characteristics of otoliths, second to validate annuli and verify annual periodicity in otoliths, and finally to estimate the age and growth of *O. stewartii*.

MATERIALS AND METHODS

In total, 712 *O. stewartii* individuals were obtained from the Yarlung Tsangpo River and a tributary (Xiang Qu) monthly from Aug. 2008 to Aug. 2009 by means of floating gillnets, bottom gillnets, and trap nets (Fig. 1). More than 30 fish were collected each month. The standard length (SL) of each fresh specimen was measured to the nearest 1 mm using a tapeline, and body weight (BW) was measured to the nearest 0.1 g with an electronic balance. Lapillus otoliths were extracted from each fish, washed with 95% ethanol, air-dried, and then stored in labeled tubes.

Both right and left lapillus otoliths were removed from each individual, but usually just the left otolith was used for the analysis. Otoliths were mounted with the ventral face on a glass slide using thermoplastic glue, with the dorsoventral axis perpendicular to the slide plane. The otoliths were then ground from the dorsal face using wet sandpaper (600-1500 grit) and polished with alumina paste (3 μm) until the core was visible under a compound microscope. The otoliths were removed by dissolving the glue with xylene, and then the otoliths were re-affixed to the glass slides using nail polish, with the polished face down. The ventral face was then ground and polished until the core was exposed again.

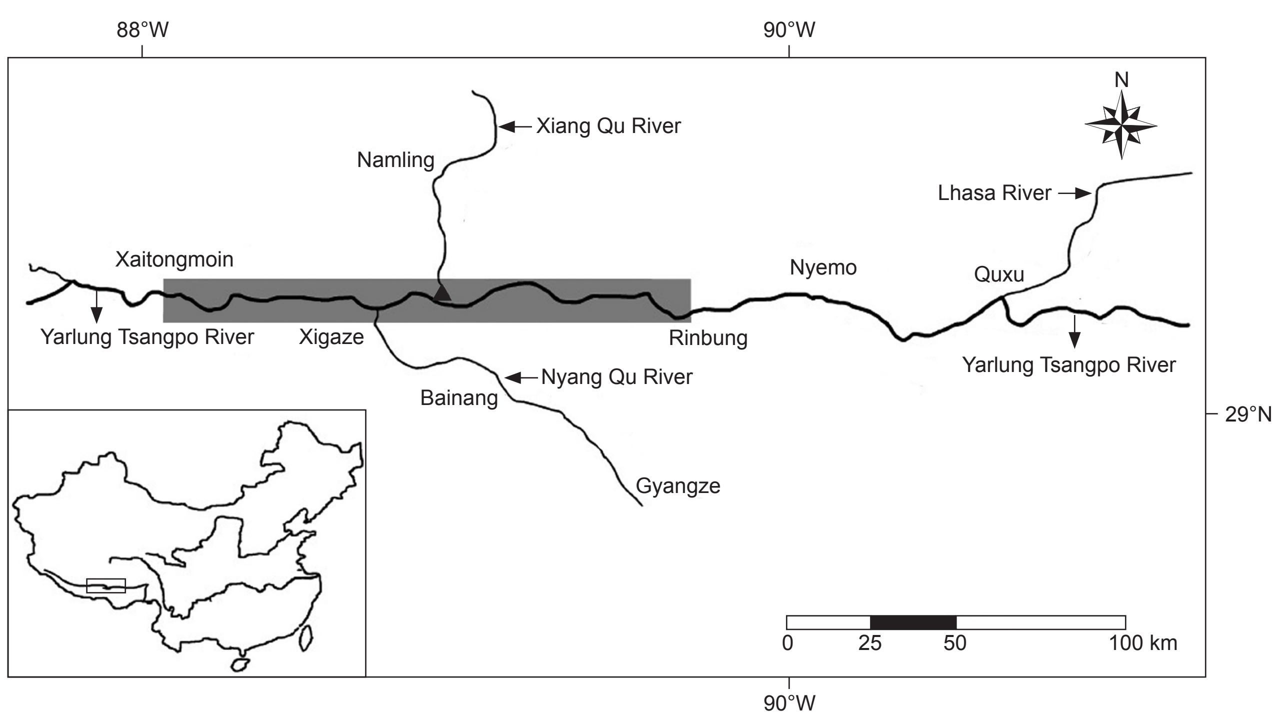

Fig. 1. Sampling locations of *Oxygymnocypris stewartii* in the Yarlung Tsangpo River.

The presumed daily growth increments (DGIs) of otoliths of 6 young fish of 45-63 mm SL (5 individuals caught on 4 Jan. 2009 and 1 individual caught on 23 Feb. 2009) were counted, and the radius of the otoliths was measured along the posterior axis (Sequeira et al. 2009). The DGI periodicity was validated to be daily (Jia and Chen 2009).

A marginal increment ratio (MIR) analysis was used to verify the period of opaque zone formation in the otoliths. Monthly variations of the MIR (1-8 annuli) were established using the following equation:

$$MIR = (R - R_n) / (R_n - R_{n-1});$$

where R is the otolith radius, R_n is the distance from the focus to the outer edge of the last annulus formed, and R_{n-1} is the distance from the focus to the outer edge of the penultimate complete annulus (Haas and Recksiek 1995). Measurements were conducted along the posterior growth axis using an image analysis system (Leica Application Suite EZ, Heerbrugg, Switzerland) with a direct data feed between the dissecting microscope (Leica EZ 4D) and a computer.

Each fish was assigned to an age class assuming 1 Mar. as the birth date, which approximately corresponds to the peak spawning season. A new ring mark found on the otolith of a fish captured before 1 Mar. was not considered to be an annulus in the age assignment, whereas when a fish sampled after the assumed birth date had no new ring mark, an annulus that was supposed to have formed was considered in the age estimation (Granada et al. 2004).

Otolith readings were made along the posterior growth axis. The reader had no prior knowledge of the length, sex, or time of capture before the age estimation. All ages were determined twice by the same interpreter after a considerable time (3 wk). Readings were only accepted if both counts by the same examiner were in agreement. If the 2 readings differed, then the otolith was recounted, and the final count was then accepted as the agreed age. If the 3rd reading had no consensus with either of the previous 2 readings, the sample was discarded.

SL-BW relationgships were calculated by the power relationship: $BW = a \times SL^b$; where a and b are parameters. The standard von Bertalanffy growth function (von Bertalanffy 1938) was used to describe the observed body length-at-age using the following formula:

$$L_t = L_\infty \{1 - \exp[-k (t - t_0)]\};$$

where L_∞ is the asymptotic body length-at-age, which represents the average body length-at-age individuals would attain if they grew indefinitely, k is the growth coefficient, and t_0 is the age at length 0.

The growth performance index, Ø ($Ø = \log_{10}k + 2\log_{10}L_\infty$), was calculated to compare the growth parameters obtained in the present paper with values reported by other authors for schizothoracine fishes (Munro and Pauly 1983).

The index of the average percentage error (IAPE) and coefficient of variation (CV) were calculated to measure the ageing precision between the 2 readings. The equations (Campana 2001) are expressed as follows:

$$IAPE = \frac{1}{N}\sum_{j=1}^{N}\left(\frac{1}{R}\sum_{i=1}^{R}\frac{\left|X_{ij} - X_j\right|}{X_j}\right) \times 100\%, \text{ and}$$

$$CV = \frac{1}{N}\sum_{j=1}^{N}\left(\frac{\sqrt{\sum_{i=1}^{R}\frac{(X_{ij} - X_j)^2}{R - 1}}}{X_j}\right) \times 100\%;$$

where N is the number of fish aged, R is the number of times each fish is aged, X_{ij} is the ith age determination of the jth fish, and X_j is the mean age calculated for the jth fish.

The BW-SL relationship and von Bertalanffy function were calculated by a non-linear regression analysis (the Levenberg-Marquardt method; Levenberg 1944). The difference in the BW-SL relationship between the sexes was compared by an analysis of covariance (ANCOVA). Deviation of the allometric coefficient, b, from the theoretical value of isometric growth (b = 3) was tested by a t-test (Pauly 1984). A residual sum of squares analysis (ARSS) was used to determine whether any significant difference existed in the von Bertalanffy equations for males and females (Chen et al. 1992).

The analysis was carried out using SPSS 16.0 (Chicago, IL, USA), Originpro 8.0 (Originlab, Northampton, USA), Microsoft Excel 2003 (Redmon, WA, USA), and Photoshop CS4 Extended (Adobe, San Jose, USA). Statistical significance was accepted when $p < 0.05$.

RESULTS

Length-frequency distributions

Of the 712 *O. stewartii* sampled, 373 were females with SLs of 116-587 mm, 206 were males with SLs of 167-455 mm, and 133 were an undetermined sex with SLs of 45-260 mm. Length-frequency distributions signnificantly differed between sexes (Kolmogorov-Smirnov; $D = 4.371$, $p < 0.001$) (Fig. 2). SLs of the captured fish were mainly 100-450 mm (87.5%), and females were significantly larger than males.

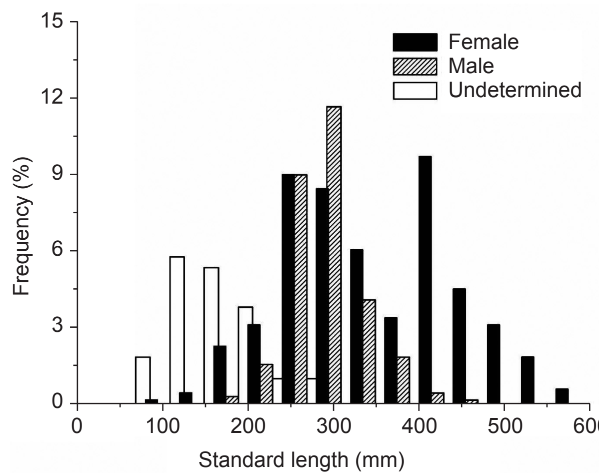

Fig. 2. Distributions of the standard length frequency of *O. stewartii*.

Age validation and annual periodicity

The lapilli of 6 young *O. stewartii* with SLs ranging 44.5-63.2 mm showed the typical pattern of translucent and opaque zones, which were respectively equivalent to the accretion and discontinuous zones, composing a daily growth increment (Fig. 3). A continuous series of concentric rings of declining size ranging from 4.6 to 0.5 μm was observed from the core to the otolith margin. The 6 young specimens showed no transition zones (annuli). The estimated ages were 178-202 (195 ± 9) d, which validated the 6 specimens to be young-of-the-year (YOY) fish. The mean radius of the lapilli was 669.97 (standard deviation (S.D.) = 71.29) μm, while that of the 1st annulus was 676.04 (S.D. = 64.61) μm for older fish.

For otolith sections with 1-8 annuli, monthly changes of the MIR gradually increased from June to Jan., and appeared to peak at 0.815 in Jan. followed by a gradual decrease to 0.482 in May (Fig. 4). Significant differences were found in MIR values among months (one-way ANOVA, $F = 13.326$, $p < 0.001$). Tukey's post-hoc pairwise comparisons revealed that the MIR in Jan. significantly differed from those from Mar. to June ($p < 0.001$). These results indicated that the opaque band of the otoliths was laid down once a year from Mar. to June.

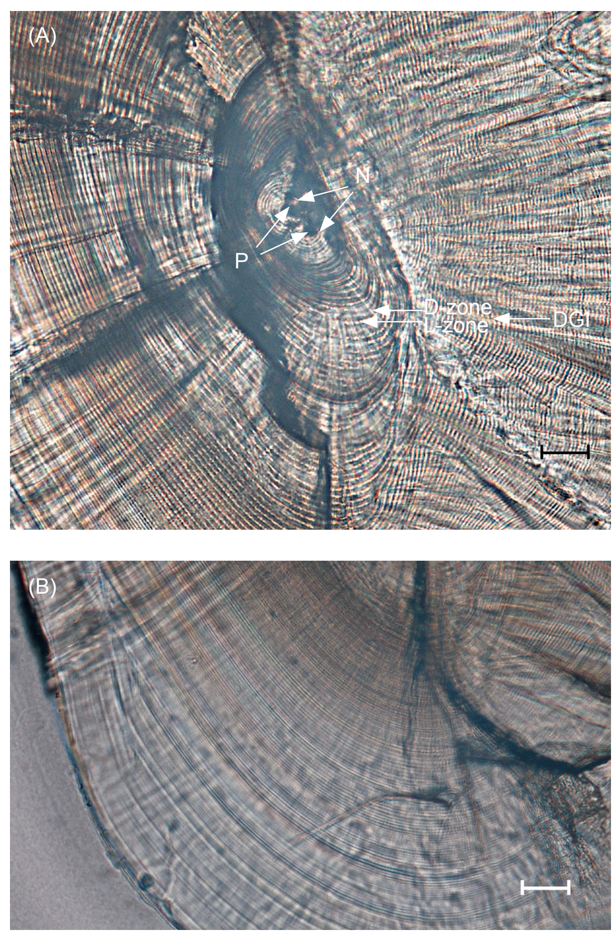

Fig. 3. Daily growth increments (DGIs) in the lapillus of *O. stewartii* with 45 mm SL. (A) Daily growth increments of core region, scale bar = 20 μm. (B) Daily growth increments of peripheral area, scale bar = 20 μm. N, nucleus; P, primordial; L-zone, translucent zone; D-zone, opaque zone.

Age structure

Sectioned otoliths of *O. stewartii* showed the typical pattern of teleosts under transition light, with an alternating sequence of broad opaque and narrow hyaline bands that became progressively narrower and of similar widths as the number of bands increased (Fig. 5). Of the 712 otoliths examined, only 10 (approximately 1.4%) were discarded due to fragmentation and unidentifiable annulus deposition. The reliablility of the age estimates had low IAPEs (0.5%) and CVs (0.7%), reflecting concordance in the readings. The estimated age ranged 1-25 yr. Registered ages of fish of undetermined sex ranged 1-6 yr, males ranged 3-17 yr, and females ranged 2-25 yr. The maximum estimated ages were 17 yr (455 mm SL) for males and 25 yr (502 mm SL) for females.

Standard lengths at age of the 712 specimens are given in table 1. Significant variation was observed in the SL of individuals at the same age, and the variation increased with elapsed years.

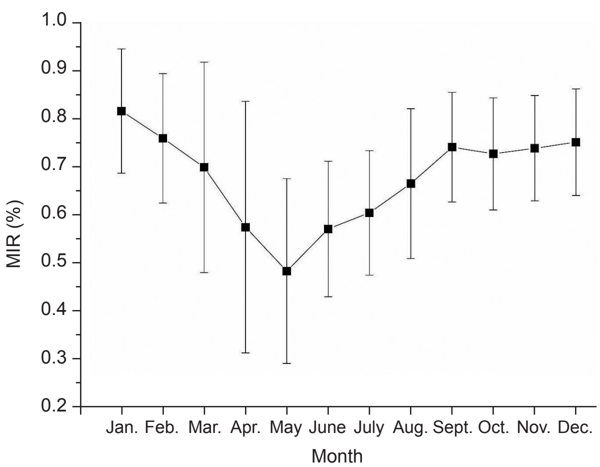

Fig. 4. Mean monthly MIR for *O. stewartii* lapillus otoliths with 1-8 annuli, error bars represent the S.D.

SL-BW relationships

SL-BW relationships were separately calculated for males, females, and undetermined (Fig. 6). Significant differences were found in SL-BW relationships between sexes (ANCOVA, $F = 14.764$, $p < 0.0001$). The regression equations are shown as follows:

Female BW = 6.108×10^{-6} SL$^{3.126}$ ($R^2 = 0.955$, $n = 373$);

Male BW = 9.872×10^{-6} SL$^{3.052}$ ($R^2 = 0.957$, $n = 206$); and

Undetermined: BW = 3.203×10^{-5} SL$^{2.821}$ ($R^2 = 0.981$, $n = 133$).

The allometric index value (b) obtained from the function significantly differed from 3 for females (t-test, $t = 6.011$, $p < 0.01$) and exhibited no statistical difference from 3 for males (t-test, $t = 1.972$, $p > 0.05$).

Growth

The mean length-at-age did not significantly differ between sexes for age classes 3-5 (unpaired t-test, all $p > 0.05$). Therefore, the length-at-

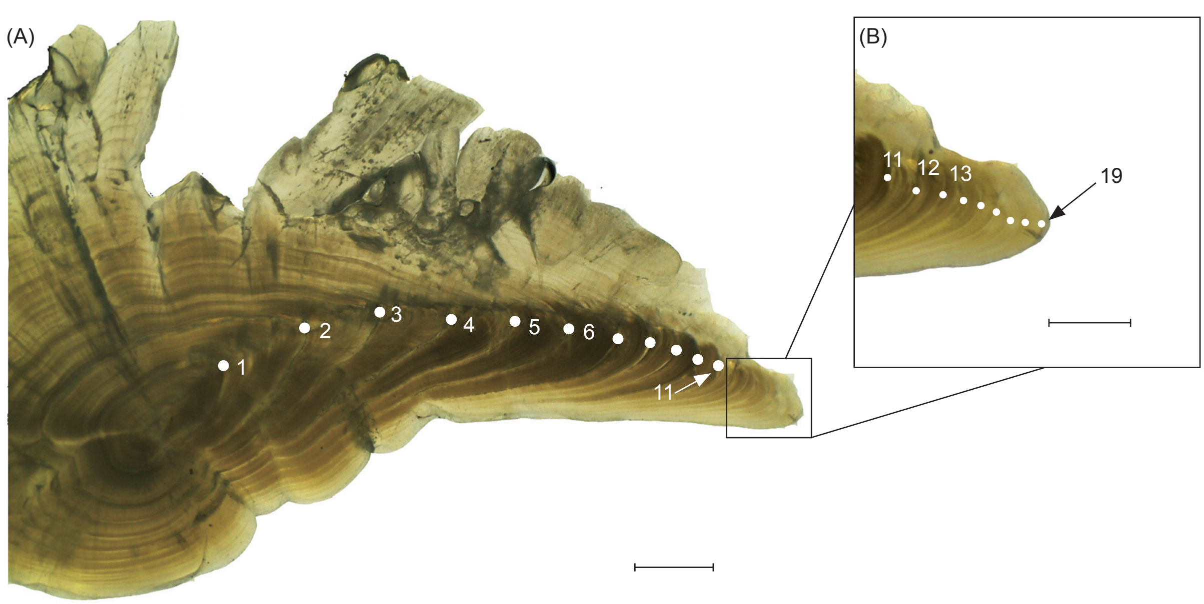

Fig. 5. Sectioned lapillus of *O. stewartii* with mm SL, estimated to be 19 yr old under transmitted light using the dissecting microscope. Dots represent annuli. Scale bars: A = 0.5 mm; B = 0.3 mm.

age data of undetermined specimens (except for two 6-yr-old individuals) were included in the von Bertalanffy models for both sexes. The von Bertalanffy functions fitted to the observed length-at-age are given as follows:

L_t = 526.8 {1 - exp[-0.141(t - 0.491)]} (R^2 = 0.893) for males and

L_t = 618.2 {1 - exp[-0.106(t - 0.315)]} (R^2 = 0.911) for females.

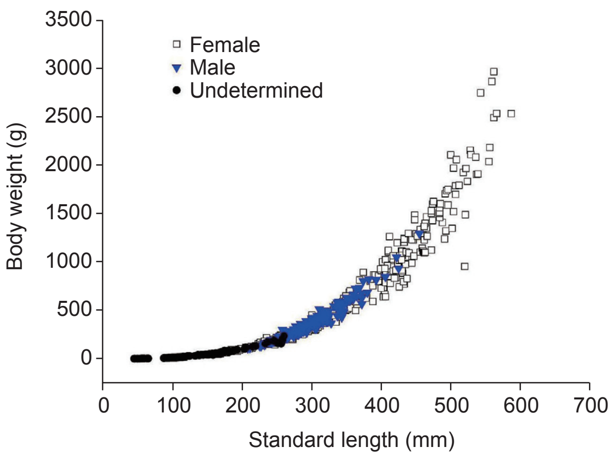

Fig. 6. Length-weight relationships of *O. stewartii*.

The growth curve described a trend of relatively slow growth based on the obseved length-at-age data between sexes (Fig. 7). Growth parameters suggested that the growth rate of females was lower than that of males. The length-at-age rapidly increased during the 1st 4 yr (Table 1, Fig. 7). The growth performances indices (Ø) of *O. stewartii* were 4.6076 for females and 4.5925 for males.

DISCUSSION

Based on the capture date (4 Jan. and 23 Feb.) and the hatching time (1 Mar.), the daily growth increnements of YOY fish were supposededly about 300 or 360. However, DGIs of only 178-202 were observed in this study. This phenomenon was also mentioned in other

Table 1. Number of specimens and Mean ± S.D. and range of standard length at age of *O. stewartii*

Age (yr)	Female			Male			Undetermined		
	n	Mean ± S.D. (mm)	Range (mm)	*n*	Mean ± S.D. (mm)	Range (mm)	*n*	Mean ± S.D. (mm)	Range (mm)
1							14	44.5-87.1	56.4 ± 11.0
2	1	116	116				14	87.1-124.0	103.8 ± 8.7
3	14	151-199	171.6 ± 14.6	3	167-211	183.7 ± 23.9	89	87.9-205	142.9 ± 30.3
4	42	184-273	234.6 ± 23.1	21	208-273	244.4 ± 16.0	7	151-233	194.7 ± 31.6
5	70	210-327	273.4 ± 25.4	66	239-312	275.2 ± 16.7	6	237-258	250.8 ± 8.4
6	55	253-409	318.9 ± 29.8	58	249-363	296.9 ± 23.1	2	246-260	253.0 ± 9.9
7	33	280-440	344.1 ± 34.3	29	263-365	313.2 ± 25.2			
8	14	245-483	372.7 ± 59.5	7	323-393	353.9 ± 24.8			
9	21	351-520	425.8 ± 36.0	7	324-382	351.1 ± 21.1			
10	11	388-556	449.6 ± 46.7	3	343-369	352.3 ± 14.5			
11	6	405-488	429.0 ± 30.3	1	374	374			
12	20	378-521	436.4 ± 41.7	1	350	350			
13	26	349-528	432.4 ± 38.1	2	365-372	368.5 ± 4.9			
14	23	396-524	444.3 ± 34.2	3	406-425	417.7 ± 10.2			
15	9	410-555	467.2 ± 42.8						
16	4	426-508	470.0 ± 34.8						
17	3	493-562	517.0 ± 39.0	1	455	455			
18	2	485-518	501.5 ± 23.3						
19	2	444-507	475.5 ± 44.5						
20	6	504-587	541.8 ± 30.4						
21	2	539-559	549.0 ± 14.1						
22	2	537-562	549.5 ± 17.7						
23									
24	2	496-536	516 ± 28.3						
25	1	502	502						

Scizothoracinae fishes. Numbers of DGIs within the 1st annulus were 137-154 in *Ptychobarbus dipogon* (Li et al. 2009), 121-184 in *O. stewartii* (Jia and Chen 2009), and 130-168 in *Schizothorax o'connori* (Ma et al. 2011). The daily width increment declined from 4.6 to 0.5 μm between the core and the otolith margin for YOY fishes. The variability in the daily width increment may be related to several factors, especially the water temperature (Marshall and Parker 1982, Neilson and Geen 1982, Campana 1984). The variation in the daily width increment within the annulus was consistent with that of water temperature. The daily width increment declined near the translucent zone when water temperatures decreased indicating that *O. stewartii* growth became slower at that time (Jia and Chen 2009). Translucent zones representing slow or no growth periods in the year may be composed of many fine increments, but these increments were too fine to be seen under a light microscope. Therefore, the above-described phenomenon could be attributed to the theoretical resolution limit of the light microscope (Campana and Neilson 1985). Perhaps, a scanning electron microscope would be a more-accurate method.

Identification of the 1st or innermost growth increment is an important component of any age validation study. Validation of the 1st increment is a mandatory adjunct to an age determination; without a correctly defined starting point, age determinations will be consistently wrong by a constant amount. In species with a clearly interpretable otolith microstructure, daily increment

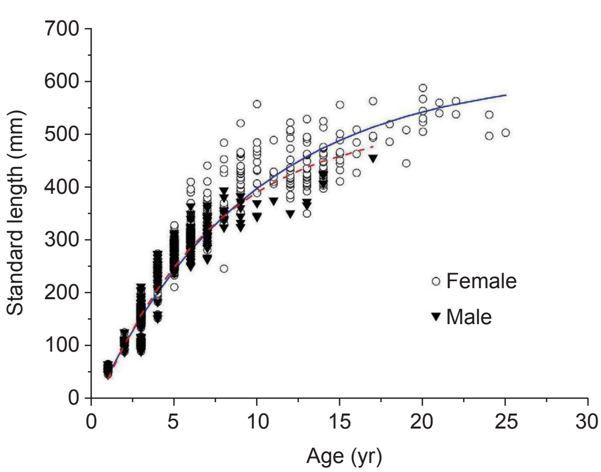

Fig. 7. The von Bertalanffy growth curve of *O. stewartii* with the observed standard length at age estimated from otoliths. The length-at-age data of the undetermined specimens were included in models fitting both sexes (except for two 6 yr old individuals)

counts can often be used to confirm the identity of the 1st annulus (Waldron 1994, Lehodey and Grandperrin 1996). DGIs can be used to estimate the expected radius of the 1st annulus in otoliths (Campana 2001). In this study, the mean radius of older fish approached that of the 1st annulus in YOY fish, indicating that the 1st annulus of lapilli was validated in *O. stewartii*.

Mechanisms of growth increment formation are poorly understood. There are several possible explanations for band formation; temperature, feeding regimes, and the reproductive cycle may be factors affecting growth increment formation (Beckman and Wilson 1995, Morales-Nin 2000, Tserpes and Tsimenides 2001, Grandcourt et al. 2006, Liu et al. 2009). In this study, deposition of the opaque zone in otoliths of *O. stewartii* occurred in the spring and early summer, whereas the hyaline zone was formed in winter months. A similar phenomenon for Scizothoracinae fishes was also demonstrated for *O. stewartii* (Jia and Chen 2009), *P. dipogon* (Li et al. 2009), *S. waltoni* (Qiu and Chen 2009), and *S. o'connori* (Ma et al. 2011). Deposition of the opaque zone occurs from Mar. to June (Fig. 4), corresponding to the reproductive activity and water temperature variations, and deposition of the hyaline zone occurs during winter months, when there is reduced metabolic activity. Formation of the opaque zone in otoliths of *O. stewartii* appeared to be partially associated with reproductive activity. Peak reproductive activity (which occurs in Mar., unpubl. data) may promote a redirection of energy to reproduction, with a consequent reduction in somatic growth, which could possibly affect the physiology of otolith growth. Moreover, formation of the opaque zone in otoliths of *O. stewartii* may be partially related to water temperature. The average water temperature around the Xigaze is 2°C in Feb., rising abruptly to 15°C in June (Li et al. 2010). This abrupt rise in water temperature could cause changes in metablolic activities of fish and could result in opaque zone deposition. Similar influences by reproducion and water temperature on other fishes were reported in past studies (Morales-Nin and Ralston 1990, Mann and Buxton 1997, Pajuelo et al. 2003, Bustos et al. 2009). Also, in a review of otolith studies including 94 species from 36 families, Beckman and Wilson (1995) found that the formation of opaque and hyaline zones might be related to water temperatures and spawning activity. Thus, formation of the annulus in otoliths of *O. stewartii* could be due to an interaction between water temperature and reproduction.

The maximum ages estimated for *O. stewartii* in this study were 25 yr for females and 17 yr for males, which were comparable to values obtained by Jia and Chen (2011) for both sexes, indicating that females live longer than males. Li and Chen (2009) recorded 45 yr for females and 24 yr for males of *P. dipogon* based on an interpretation of sectioned otoliths. Chen et al. (2009) found 18 yr for females and 16 yr for males of *S. younghusbandi younghusbandi* by means of otoliths. Yao et al. (2009) obtained 24 yr for females and 18 yr for males of *S. o'connori* using otoliths. Ma et al. (2010) also reported 50 yr for females and 40 yr for males of *S. o'connori* based on otolith observations. Those studies revealed that great longevity is a common trait in schizothoracine fishes.

Comparing results of the growth of *O. stewartii* with those of Jia and Chen (2011), the *k* value obtained in this study was smaller (Table 2). Differences among all of the estimated parameters could be attributed to several factors: (1) different sampled locations, (2) different age groups employed to fit the VBGF function (the previous study used 1-6 age groups), and (3) different size distributions.

The growth performance indices (Ø) of *O. stewartii* were larger than those of other schizothoracines (Table 2), indicating that the growth of *O. stewartii* is relatively greater than other fishes of the Schizothoracinae, which inhabit the same elevatons and region. These growth differences might be related to feeding (Jia and Chen 2011). Carnivorous fishes can obtain more energy than that gained by other feeding habits (Hofer et al. 1985). *O. stewartii* is piscivorous, and its food could contain more energy than that of other Schizothoracinae fishes mentioned above.

The von Bertalanffy growth coefficient (*k*) is a useful index for addressing the potential vulnerability of stocks to excessive mortality (Musick 1999). Comparing the parameters of some Schizothoracinae fishes, Li and Chen (2009) suggested that they are slow-growing species with *k* values of around 0.1. Slow-growing, long-lived fishes tend to be particularly vulnerable to excessive exploitation and exhibit rapid stock collapse, after which population turnover may be lower than expected, and their responses to rehabilitation measures slower than predicted (Musick 1999). In this study, the estimated maximum age was 25 yr, and the *k* value was around 0.1, indicating that *O. stewartii* is a slow-growing, long-lived species. Therefore, it is essential to establish reasonable management practices for this species to allow for its sustainable use. First, more scientific work such as biological studies, resource investigations, and life history studies should be vigorously carried out in the near future to accumulate fundamental biological data in order to properly manage this species; and 2nd, based on these data, new fishery regulations should be established, and the effectiveness of these regulations assessed by the continuous monitoring of stocks. These new fishery regulations should focus on a sustainable fishing intensity, a minimum catch size, and proper fishing methods to prevent overfishing. Prohibiting fishing and marketing during the spawning season may be 1 way to protect the older classes of *O. stewartii*; finally, local governments should properly

Table 2. Comparison of growth characters of Schizothoracinae fishes in different studies

Species	Region	Age material	Sex	L_∞ (mm)	k (year^{-1})	t_0	Ø	Sources
Schizothorax o'connori	Yarlung Tsangpo River	Otolith	F	492.4	0.1133	-0.5432	4.4389	Yao et al. (2009)
			M	449.0	0.1260	-0.4746	4.4049	
	Yarlung Tsangpo River	Otolith	F	576.9	0.081	-0.946	4.4307	Ma et al. (2010)
			M	499.7	0.095	-0.896	4.3751	
Schizothorax waltoni	Yarlung Tsangpo River	Otolith	F	691.1	0.056	-2.466	4.4273	Qiu and Chen (2009)
			M	689.8	0.051	-3.257	4.3850	
Ptychobarbus dipogon	Lhasa River	Otolith	F	598.66	0.0898	-0.7261	4.5076	Li and Chen (2009)
			M	494.23	0.1197	-0.7296	4.4659	
Schizothorax younghusbandi	Yarlung Tsangpo River	Otolith	F	471.4	0.0789	0.2	4.2439	Chen et al. (2009)
younghusbandi	Lhasa River		M	442.7	0.0738	-1.4	4.1603	
Oxygymnocypris stewartii	Yarlung Tsangpo River	Otolith	F	877.4821	0.1069	0.5728	4.9153	Jia and Chen (2011)
			M	599.3939	0.1686	0.6171	4.7823	
	Yarlung Tsangpo River	Otolith	F	618.2	0.106	0.315	4.6076	Present study
			M	526.8	0.141	0.491	4.5926	

guide local customs like “Releasing Day” to protect spawning populations and recruitment.

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