Journal of Applied Ichthyology

J. Appl. Ichthyol. (2012), 1–3

ISSN 0175–8659

Received: July 24, 2011
Accepted: December 31, 2011
doi: 10.1111/j.1439-0426.2012.01961.x

Technical contribution

Growth, length–weight relationship and biological information on the clearhead icefish (*Protosalanx hyalocranius* Abbott, 1901) in Lake Khanka (Xingkai)

By F. J. Tang[1,2,3]*, W. Liu[2]*, J. Wang[2], R. Froese[4] and S. Xie[1]

[1]*Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan, China;* [2]*Heilongjiang River Fisheries Research Institute of Chinese Academy of Fishery Sciences, Harbin, China;* [3]*Graduate School of Chinese Academy of Sciences, Beijing, China;* [4]*Helmholtz Centre for Ocean Research, Kiel, Germany*

Summary

This paper reports the growth pattern and length-weight relationship and summarizes biological data for the clearhead icefish (*Protosalanx hyalocranius*) in Lake Khanka (Xingkai), on the border between China and Russia. The von Bertalanffy growth was estimated as $SL = 20.3(1 - e^{-2.93\ (t - 0.21)})$. The length-weight relationship was $W = 0.00448\ SL^{2.99}$ for juveniles, and $W = 0.000896\ SL^{3.59}$ for adults. *P. hyalocranius* mature in December and spawn in January, when the lake is still covered with ice, then die after spawning. The larvae hatch in March. Juveniles feed mainly on zooplankton whereas adults also feed on other fishes.

Introduction

The clearhead icefish (*Protosalanx hyalocranius*) inhabits mainly coastal areas and adjacent freshwaters in eastern Asia (Xie and Xie, 1997). As a commercially important fish with a longevity of 1 year, it was widely introduced in northern China (Xie, 1996). *Protosalanx hyalocranius* was introduced unintentionally into Lake Khanka in 2000, and became commercially important there in 2007 (Tang et al., 2011).

Aim of the study was to provide biological information and length-weight relationships for juvenile and adult stages of *P. hyalocranius* in Lake Khanka. A short summary of biological information from the Chinese literature about the species is also presented.

Materials and methods

Protosalanx hyalocranius were sampled monthly from June 2010 to March 2011 in Lake Khanka (45°15′49.12″–45°15′8.62″N; 132°02′35.22″–132°01′7.73″E). A seine net (200 m length, 8 m width, 2 mm mesh sizes) was used for sampling in the ice-free months of 2010 (mid-June through November), and four gill-nets (30 m length; 3 m depth; mesh sizes of 1.0, 1.5, 2, 2.3 cm between knots, respectively) were used simultaneously in the ice-covered period of 2010 to 2011 (December through March).

Protosalanx hyalocranius died immediately at catch. The specimens were then measured for standard length (to the nearest 0.1 cm, SL) and weighed (to the nearest 0.01 g, *W*). The parameters *a* and *b* of the formula $W = aSL^b$ (Le Cren, 1951) were estimated for juveniles and adults by linear regression after a logarithmic transformation of the variables.

In northeastern China, *P. hyalocranius* spawn mainly in early and mid-January. As incubation lasts about 50 days (Xie et al., 2001), it was therefore assumed that larvae were born on 1 March. Age of an individual was assigned as the number of days from 1 March to time of capture divided by 365. Length-at-age data were used from the 20 longest specimens each month, thus excluding small individuals that may have been born at a later date.

Results and discussion

Altogether 1516 specimens (more than 100 specimens per month) were sampled and analyzed. Plotting of log-transformed weight over length values (Fig. 1) revealed a growth stanza (Froese, 2006) at about 9 cm length, coinciding with the onset of gonad development (Zhang et al., 1981). We therefore calculated length-weight relationships for juveniles, adults, and all individuals, respectively (Table 1). The high exponent ($b = 3.59$) for adults indicates that, because of gonad development (Xie et al., 2001), they gain considerably more

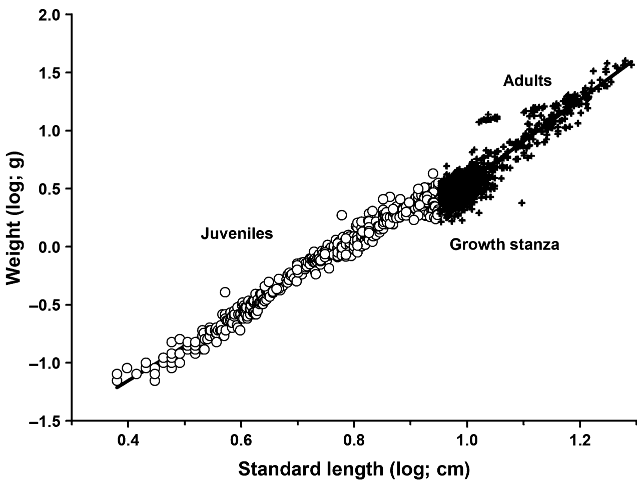

Fig. 1. Log–log plot of weight over length for the clearhead icefish *Protosalanx hyalocranius*. A growth stanza occurs at about 9 cm SL (log = 0.95), with the onset of gonad development. The slope of the regression for adults ($b = 3.59$, 3.51–3.67) is significantly steeper than the slope for juveniles ($b = 2.99$, 2.95–3.01)

*These authors contributed equally to this work.

Table 1
Length-weight relationships parameters of clearhead icefish (*Protosalanx hyalocranius*) in Lake Khanka (Xingkai), China

	Length (cm)		Parameters of the relationship			
Life stage	Min.	Max.	n	*a* (±95%)	*b* (±95%)	r^2-value
Juveniles (< 9 cm SL)	2.4	8.96	581	0.00448 (0.002421–0.00477)	2.99 (2.95–3.02)	0.981
Adults (≥ 9 cm SL)	9.0	19.5	890	0.000896 (0.000737–0.00109)	3.59 (3.51–3.67)	0.892
All individuals	2.4	19.5	1471	0.00492 (0.00462–0.00525)	2.89 (2.86–2.92)	0.961

n, number of fish in analysis; max, maximum standard length; min, minimum length; *a*, constant of the relationship; *b*, slope of the relationship; *a* and *b* ± 95% confidence level; r^2, coefficient of determination.

Table 2
Length-weight relationship parameters of clearhead icefish (*Protosalanx hyalocranius*) in several other Chinese inland waters. Parameter *a* was transformed from mm to cm (Froese, 2006) for easy comparison

	Length (cm)		Parameters of the relationship			
Waters	Min.	Max.	n	*a*	*b*	r^2-value
Taihu Lake (Wang and Jiang, 1992)	1.6	19.7	1200	0.00343	2.94	0.999
Shuifeng Reservoir (Tang et al., 2003)						
Generation born in 1998	7.4	17.5	386	0.00484	3.09	0.825
Generation born in 1999	8.0	18.8	564	0.00175	3.38	0.877
Generation born in 2000	2.7	16.1	962	0.02825	2.97	0.875
Guandaohe Reservoir (Wu et al., 1998)	1.9	19.0	336	0.00184	3.18	unavailable

weight than is suggested by their increase in length. The difference in slope between juveniles and adults is significant, as can be seen from the non-overlapping confidence limits (Table 1).

Fitting a von Bertalanffy growth function to the observed length-at-age data resulted in $SL = 20.3(1 - e^{-2.93\ (t\ -\ 0.21)})$ (n = 160, r^2 = 0.932, 95% CL of L_∞ = 18.7–21.9; 95% CL of K = 2.32–3.54). We previously collected a female of 22.5 cm SL in Lake Khanka in March 2010, close to our L_∞ estimate and setting a new maximum length record for the species. Wang and Jiang (1992) also reported an asymptotic length of 22.0 cm for Lake Taihu. Their estimate of K = 0.147 refers to months as unit of time. Transferred to years this is K = 1.76. Our estimate of K = 2.93 seems more appropriate for a species that approaches its maximum length within one year: the age at 95% L_∞ can be obtained from $t_{95} = -\ln(1-0.95)/K + t_0 = 1.2$ (0.8–1.5) years. Thus, with the confidence limits of K, the independently known longevity of one year is included in the time span where 95% of asymptotic length is reached.

Length–weight relationships of *P. hyalocranius* were reported from other waters, i.e. Lake Taihu (Wang and Jiang, 1992), Shuifeng Reservoir (Tang et al., 2003) and Guandaohe Reservoir (Wu et al., 1998), see Table 2. Similar to our results, the estimate for adults of the generation born in 1999 in the Shuifeng Reservoir shows an increased exponent (b = 3.38), whereas the two estimates that include juveniles and adults show exponents around 3.0.

Fundamental biological data of *P. hyalocranius* are rare. It is a carnivorous fish, with the early juveniles feeding mainly on zooplankton, changing to feed mainly on fish and shrimps as they become larger (Zhang et al., 1981; Zhu, 1985).

Our investigation of *P. hyalocranius* maturation revealed that the secondary sexual character of males, i.e. a row of scales above the anal fin, appeared in mid-October. In most fishes the gonads developed to stages III and IV in early December and to stages IV and V in early January, with subsequent spawning, presumably at a sex ratio of 1:1 as reported in other waters (Zhang et al., 1981; Sun and Zhao, 1989; Xu et al., 2000; Xie et al., 2001). Mature females were reported as ranging from 9.0 to 21.0 cm SL (Zhang et al., 1981), similar to our results. Absolute fecundity was reported to range from 3090 to 34 520 eggs (Zhang et al., 1981), with relative fecundity ranging from 340 to 1290 eggs per gram body weight (Xie et al., 2001), and the mature egg diameter from 0.80 to 1.06 mm (Xie et al., 2001).

As previously noted (Wang and Jiang, 1992), commercial catches of this species can be improved if fishing starts at the peak of the *P. hyalocranius* growth rate (Froese et al., 2008), which according to our analysis is in October and November.

Acknowledgements

We wish to express our sincere gratitude to Zhou Dahai and Wang Xihai for their important support in specimen sampling. This research was supported by ''The Central-Level Non-profit Scientific Research Institutes Special Funds of China'' (Grant number 201014) and the National Basic Research Program of China (973 Program, no. 2009CB119200).

References

Froese, R., 2006: Cube law, condition factor, and weight-length relationships: history, meta-analysis and recommendations. J. Appl. Ichthyol. **22,** 241–253.

Froese, R.; Stern-Pirlot, A.; Winker, H.; Gascuel, D., 2008: Size matters: how single-species management can contribute to ecosystem-based fisheries management. Fish. Res. **92,** 231–241.

Le Cren, E. D., 1951: The length–weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). J. Anim. Ecol. **20,** 201–219.

Sun, G. Y.; Zhao, Z. L., 1989: A preliminary study of ecology of *Protosalanx hyalocranius* in Yangtze River estuary and nearby marine waters. Trans. Ocean Limin. **4,** 76–79 (In Chinese; English abstract).

Tang, Z. P.; Xie, H.; Xie, Y. H.; Li, X. Y.; Cui, S. F., 2003: Growth and population structure of *Protosalanx hyalocranius* in Shuifeng Reservior, Liaoning, China. J. Dalian Fish. Univ. **3,** 164–169 (In Chinese; English abstract).

Tang, F. J.; Liu, W.; Wang, J. L.; Xie, S. G., 2011: Fish composition in Lake Xingkai (Khanka) and Lake Mini-xingkai. Chinese J. Fish. **24,** 40–47 (In Chinese; English abstract).

Wang, Y. F.; Jiang, Q. W., 1992: Research of growth properties of *Protosalanx hyalocranius* Abbott. J. Lake Sci. **4,** 56–62 (In Chinese; English abstract).

Wu, H. J.; Xu, M. S.; Zhou, Z. H., 1998: The biological effect of transplanting *Protosalanx hyalocranius* in Guandaohe reservoir: growth. J. Lake Sci. **10,** 75–79 (In Chinese; English abstract).

Xie, Y. H., 1996: Reproductive characteristics of large icefish (*Protosalanx hyalocranius*) and the stocking measurements. Reservoir Fish. **81,** 6–8 [In Chinese].

Xie, Y. H.; Xie, H., 1997: Classification, distribution and population ecology of Salangidae fishes. Chinese J. Fish. **2,** 11–19 (In Chinese; English abstract).

Xie, H.; Tang, Z. P.; Xie, Y. H.; Li, B.; Li, X. Y.; Yuan, F. R.; Duan, K. M.; Sun, Y. Q., 2001: Aspects of reproductive biology of large icefish (*Protosalanx hyalocranius*) in Shuifeng Reservoir. J. Dalian Fish. Univ. **2,** 79–86 (In Chinese; English abstract).

Xu, M. S.; Wu, H. J.; Liu, Y. J.; Zhang, L. L., 2000: Biological effect of transplanting *Protosalanx hyalocranius* in Guandaohe reservoir (III): propagation behavior. J. Lake Sci. **12,** 94–96 (In Chinese; English abstract).

Zhang, K.X.; Zhuang, D.D.; Zhang, L.; Gao, C.L.; Zhang, J. Y.; Xu, A.Z., 1981: On the *Protosalanx hyalocranius* and its propagation in Hongze Lake. J. Fish. China **5,** 29–39 (In Chinese; English abstract).

Zhu, C. D., 1985: A preliminary study on growth and feeding habits of icefish in Taihu Lake. J. Fish. China **9,** 275–287. (In Chinese; English abstract).

Author's address: Songguang Xie, Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan 430072, China.
E-mail: xiesg@ihb.ac.cn