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430056 430223

Leptobotia elongata

2007 ~ 2009

76 ~ 480 mm 5 ~ 2 002 g

158.7 ±54.8 mm 72.4 ±148.8 g 90 ~ 210 mm 77.9%

n = 277 *L* mm *W* g $W = 7.28 \times 10^{-6} L^{3.09}$ R^2 = 0.95 $P < 0.01$ *n* = 277 L_{∞} 555 mm k 0.17/a Pauly *M* 0.37

Z 1.23 0.70 0.43

2007 2008 2009

2 544 /km 0.75 t/km 2 405 /km 0.42 t/km 7 245 /km 1.63 t/km 4 065 /km 0.93 t/km 480 mm

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Estimating Population Parameters and Abundance of Elongate Loach (*Leptobotia elongata*) in the Jiangjin Section of the Upper Yangtze River

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Abstract: Elongate Loach (*Leptobotia elongate*) is endemic to the upper Yangtze River. It has been threatened by overfishing and dam construction, and evaluated as being endangered in China Species Red List. To understand its population dynamics after the Three Gorges Reservoir was impounded, the catch and time series length-frequency data were used to estimate growth and mortality parameters, population abundance and resources utilization of Elongate Loach based on surveys in the Jiangjin section of the upper Yangtze River conducted in 2007 2009 (Fig. 1). Elongate Loach ranged from 76 to 480 mm in length and 5 to 2002 g in weight, with an average length of 158.7 ±54.8 mm and an average weight of 72.4 ±148.8 g (n = 277). The length group of 90 210 mm dominated the catches (77.9% of the total number) (Fig. 2). The length (L, mm)-weight (W, g) relationship of Elongate Loach was well-fit with a power function, $W = 7.28 \times 10^{-6} L^{3.09}$ ($R^2 = 0.95$, $P < 0.01$, $n = 277$) (Fig. 3). Asymptotic length (L_{∞}) and growth constant (k) were estimated using length frequency data as 555 mm and 0.17/a, respectively. Natural mortality was estimated as 0.37 using the empirical formula proposed by Pauly. The total mortality was estimated using a length-converted catch curve analysis as 1.23 (Table 1). The exploitation rate observed in the Jiangjin section was 0.70, higher than the estimated maximum exploitation rate (0.43), which indicated that it was overfished for Elongate Loach (Fig. 4). Population abundance of Elongate Loach in the Jiangjin section estimated by length-structured virtual population analysis was 2 544 ind/km (0.75 t/km) in 2007, 2 405 ind/km (0.42 t/km) in 2008, and 7 245 ind/km (1.63 t/km) in 2009, respectively, with an average of 4 065 ind/km (0.93 t/km) (Fig. 5). Compared with the earlier studies (Table 2), a new maximum length (480 mm) of Elongate Loach was recorded; the estimated total mortality and exploitation rate of Elongate Loach in this study were higher, which was likely caused by the higher fishing effort in the Jiangjin section. Long-term population dynamics monitoring, closed fishing, and artificial enhancement and releasing were suggested to improve the resources.

Key words: Population parameters; Growth; Mortality; Population abundance; Stock assessment; Elongate Loach, *Leptobotia elongata*

Fahrig 2003 2005

Morita et al. 2009 Esguicero et al. 2010

2005

Park et al. 2003 Xie 2003

Gao et al. 2009 *Leptobotia elongata* 2005

Yuan et al. 2010 20 80

2004 2007

2001 Liu et al.

2004 2012

2007 ~ 2009

1994

1 mm

L *L*Nj

YP2000

1 g *W*

1

1.1

2007 ~ 2009 10

12 h 18:00

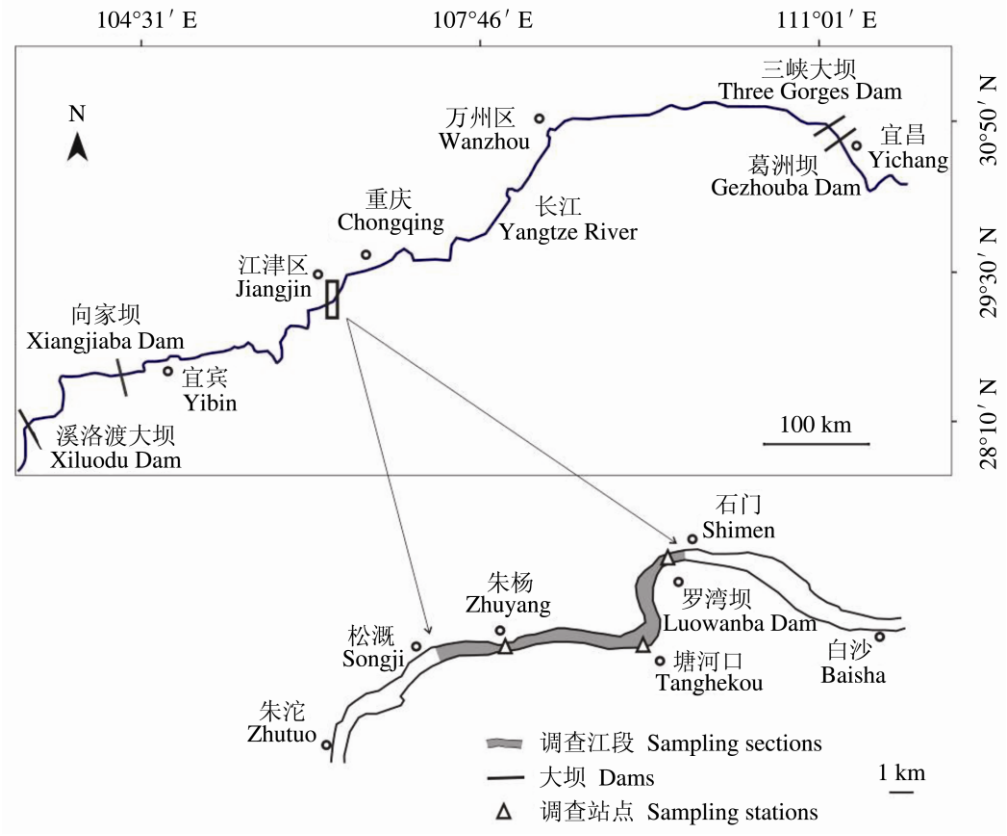
5 ~ 7 9 ~ 11 6:00

7 ~ 10 d **1.2**

15 km 1 - Keys 1928 *W* =

3 ~ 6 cm aL^b *t* b 3

2 cm 3 Richer



1

Fig. 1 Location of the Jiangjin section in the upper Yangtze River and sampling stations

1975 von Bertalanffy
$L_Đ$ k
Powell-Wetherall plot
ELEFAN Z
L_{50}
converted-length catch curve
Gayanilo et al. 2005 t_0
Pauly 1979 M Pauly 1980
$\acute{u}$ Munro et al. 1983
lg t_0 = 0.3922 0.2752 lg$L_Đ$
1.038 lgk lg$M$ = 0.0066 0.279 lg$L_Đ$ +
0.6543 lgk + 0.4634 lg$T$ $\acute{u}$= lgk + 2 lg$L_Đ$
$L_Đ$ cm T
18.4 2013
$F = Z$ M $E =$
F/Z Beverton-Holt
relative yield per recruit Y/R /
relative biomass per
recruit B/R / Gayanilo
et al. 2005 E_{max} E_{10}
“ ” E_{50}
50%

1.3

Y $Y =$ $Y_i = x_i \cdot f_i \cdot t_i$
i P_i i
Y_i i x_i i
[/ d] f_i
i ,
11 5
3 3 t_i i
d 2 ~ 4
7 ~ 8 200 d
FiSAT
length-structured virtual
population analysis Gayanilo et al. 2005
F_t 0.5
2013

2

2.1

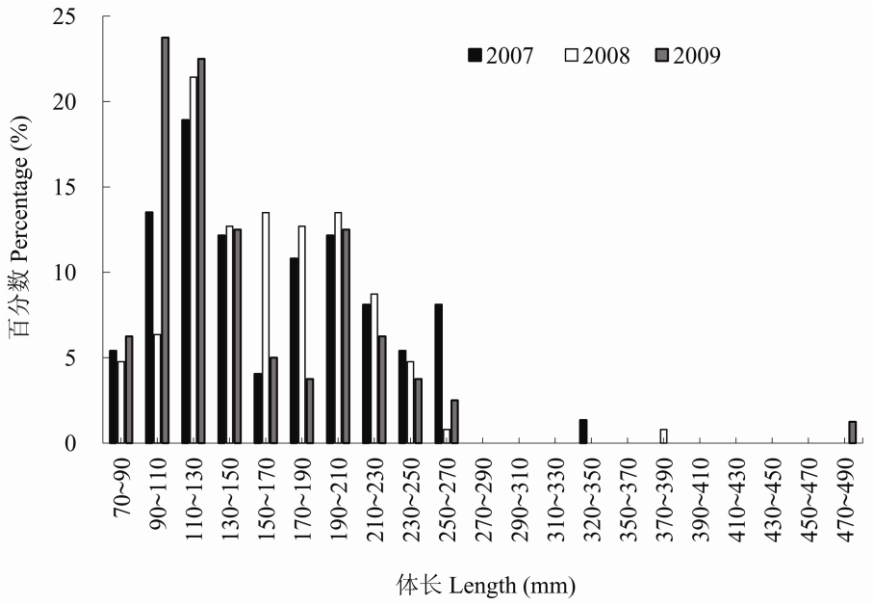
277
76 ~
480 mm 158.7 ±54.8 mm
90 ~ 210 mm 77.9%
2 250 mm 16.8% 270 mm
1.1% 5 ~ 2 002 g
72.4 ±148.8 g
200 g 96.8%
100 g 77.9% 50 g
56.8%

2.2

L LNj
LNj = L +111.30 3 R^2 = 0.995 P < 0.01
n = 277
$W = 7.28 \times 10^{-6} L^{3.09}$ $R^2 = 0.95$ $P < 0.01$
$n = 277$ 3 $W = 1.63 \times 10^{-6} LNj^{3.27}$ $R^2 = 0.95$
$P < 0.01$ $n = 277$ - b 3
$t = 2.15 < t_{0.01(277)} = 2.60$
von
Bertalanffy
Powell-Wetherall plot ELEFAN
$L_Đ$ = 555 mm k =
0.17/a t_0 = 0.84 $\acute{u}$= 2.72
5.79
375.4 mm 656.56 g
$L_t = 555[1 - e^{-0.17(t + 0.84)}]$ $W_t = 2198.8[1 - e^{-0.17(t + 0.84)}]^{3.09}$

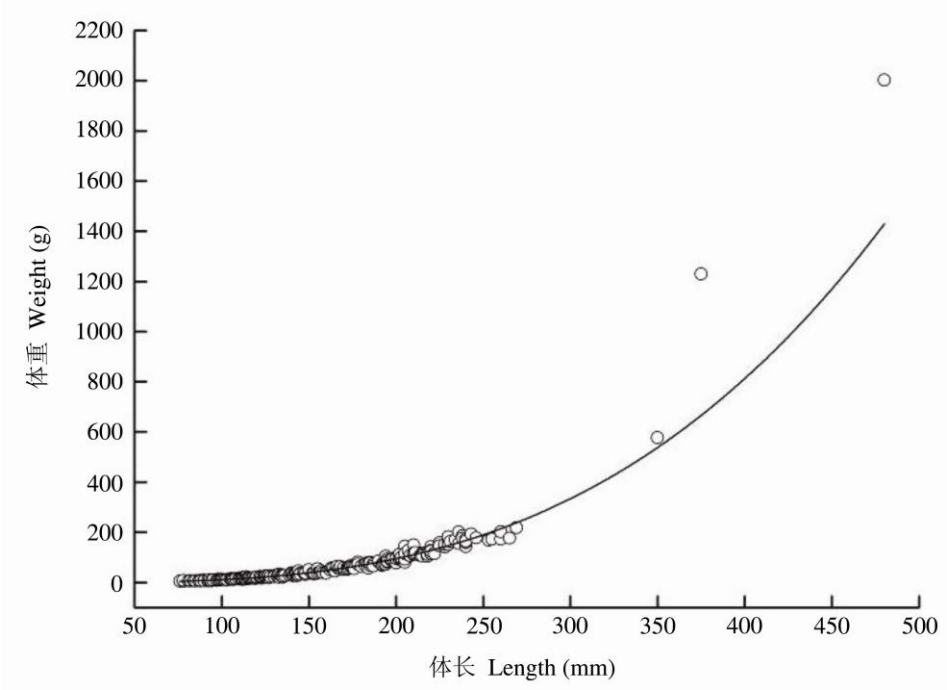
2.3

Pauly
M = 0.37
1 Z = 1.23
F = 0.86 E =
0.70 L_{50} = 97.8 mm Beverton-Holt
4 E_{10} = 0.36
E_{50} = 0.27 E_{max} = 0.43



2

Fig. 2 Length composition of Elongate Loach in the Jiangjin section of the upper Yangtze River



3

Fig. 3 Relationship between length and weight of Elongate Loach

0.70 0.43 3.8%

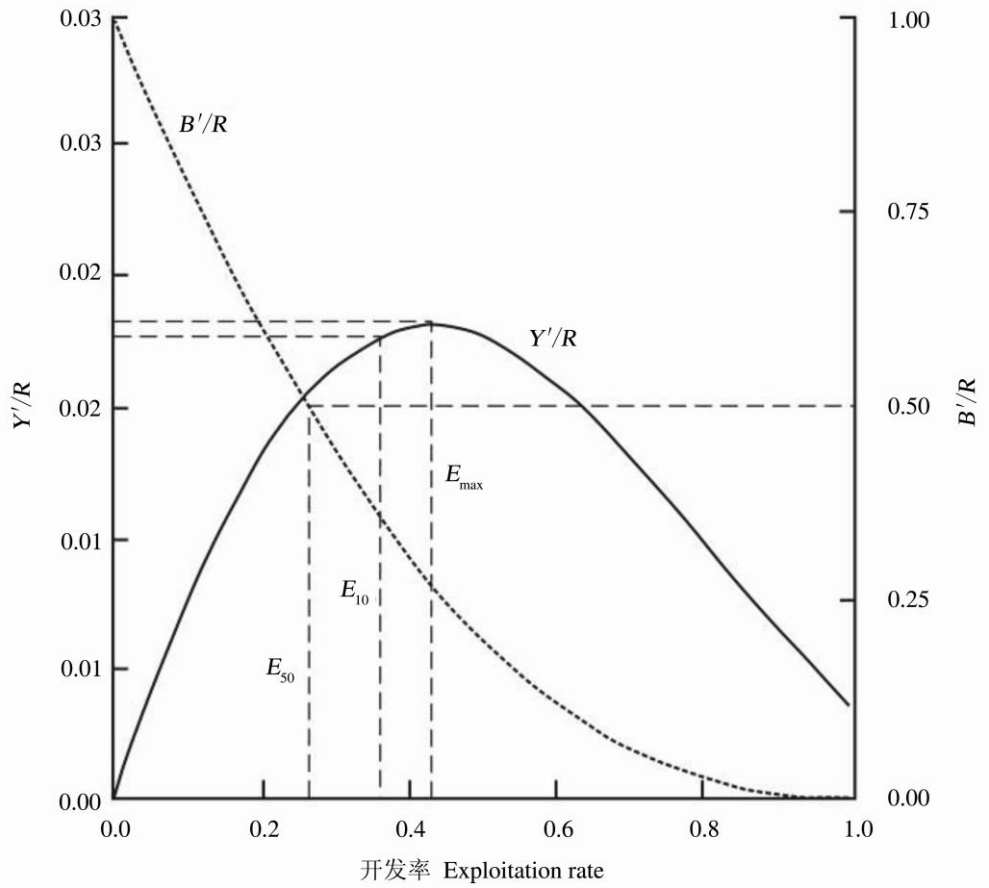
2.4 1.8% 3.5% 1.8%

2007 ~ 2009 1.1% 4.2% 2007

1 2007 ~ 2009

Table 1 Mortality and exploitation rates of Elongate Loach in the Jiangjin section of the upper Yangtze River in 2007 ~ 2009

Year	Total mortality *Z*	Natural mortality *M*	Fishing mortality *F*	Exploitation rate *E*
2007	0.90	0.37	0.53	0.59
2008	1.35	0.37	0.98	0.73
2009	1.01	0.37	0.64	0.63
Total	1.23	0.37	0.86	0.70



4 *YNR* / *BNR* /

Fig. 4 Relative yield per recruit (*YNR*) and biomass per recruit (*BNR*) curves of Elongate Loach in the Jiangjin section of the upper Yangtze River

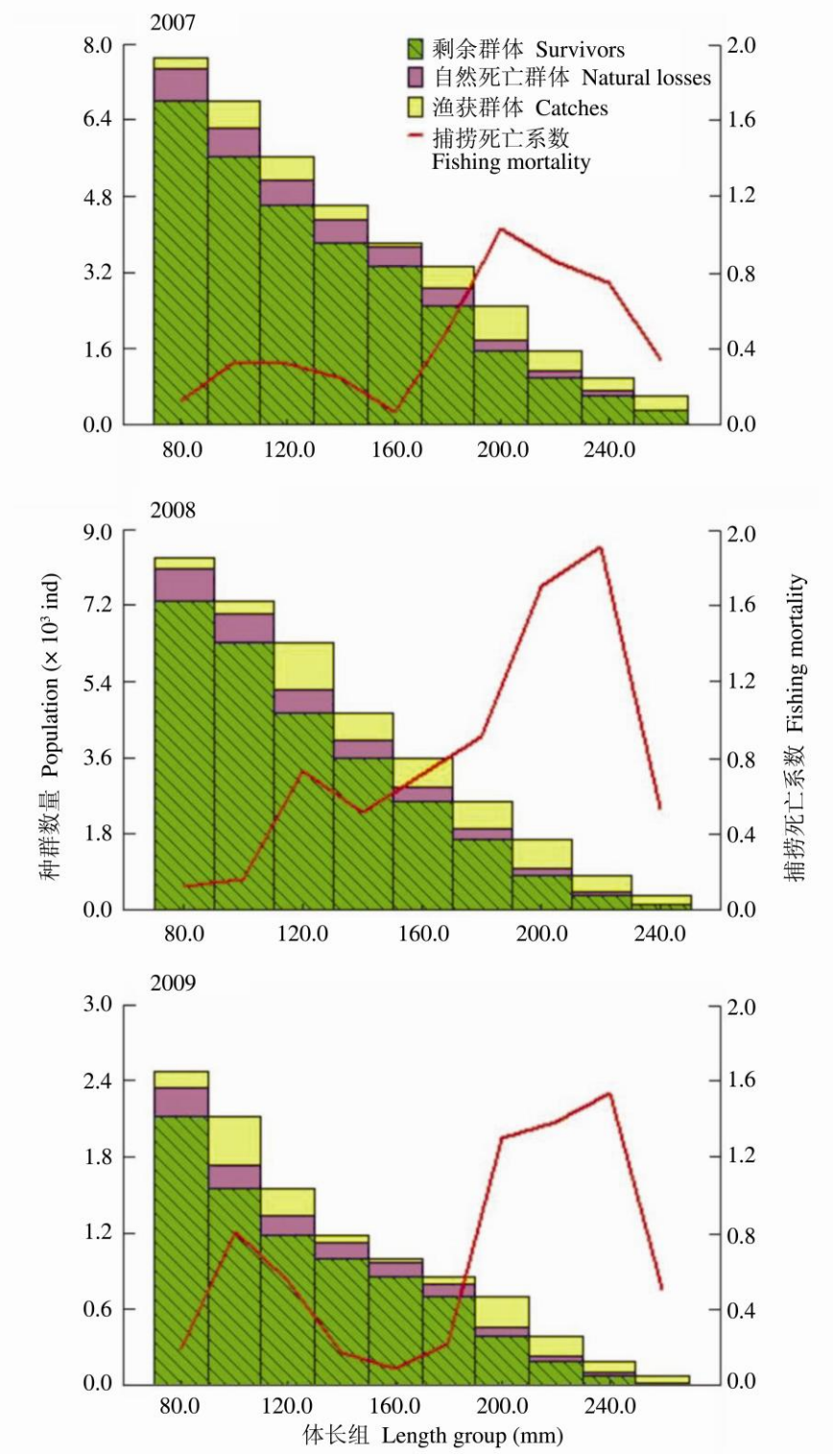
0.3% 2008 2009 0 2007 ~ 2009

F_t

2007 ~ 2009 3 775 0.356 0 0.539 5 0.526 5 2007 ~ 2009

4 944 14 641 7 787 38 166 11.31 t

36 077 6.36 t 108 674 24.39 t



5 2007 ~ 2009

Fig. 5 Length-structured virtual population analysis for Elongate Loach in 2007 ~ 2009

60 973 14.02 t 5 $L_Þ$ L_{max}
2007 ~ 2009 $\lg L_Þ = 0.044 + 0.9841 \lg L_{max}$
2 544 /km 0.75 t/km 2 405 /km 0.42 t/km $L_Þ$
7 245 /km 1.63 t/km 4 065 /km 500 mm 2013
0.93 t/km $L_Þ$ 656 mm
555 mm Froese 2000

3

- b

3.1

b 3

Pauly 1984 b
3.09 3
2013
2011 Johnson et al. 2013 Z E
2013

k $e^{-k} < 1$ von
Bertalanffy
M/k 1.5 ~ 2.5 M
1995 e^{-k} = 2013
0.84 M/k = 2.29 k M

$L_Þ$ 500 mm $\acute{u}$
3 $L_Þ$< 250 mm
2 $\acute{u}$< 2 2013
480 mm 560 mm 2 002 g
Froese 2000

2

Table 2 Comparison of estimated population parameter of Elongate Loach

Stock	Length (mm)	$L_Þ$ (mm)	k (1/a)	$\acute{u}$	b	Z	M	E	Reference
Jinsha River (1998 ~ 1999)	116 ~ 470	ð	ð	ð	3.30	ð	ð	ð	2007
Upper Yangtze (2007)	87 ~ 382	ð	ð	ð	ð	ð	ð	ð	2012
Upper Yangtze (2010 ~ 2012)	59 ~ 461	656	0.15	2.81	3.02	0.85	0.33	0.62	2013
Jiangjin (2007 ~ 2009)	76 ~ 480	555	0.17	2.72	3.09	1.23	0.37	0.70	This study

$L_Þ$. k. $\acute{u}$ b. - *Z.* *M.* *E.*
“ — ”

$L_Þ$. Asymptotic length; k. Growth constant; $\acute{u}$ Index of growth performance; b. Exponent of a length-weight relationship. *Z.* Total mortality; *M.* Natural mortality; *E.* Exploitation rate; ñð ò s i hg data is not available.

Hypophthalmichthys molitrix $\acute{u}$= 3.31 $L_{Ð}$= 103 7 mm k = 0.19/a 2013 *Coreius heterokon* $\acute{u}$= 2.92 $L_{Ð}$= 600 mm k = 0.23/a 1999 *C. guichenoti* $\acute{u}$= 2.81 $L_{Ð}$= 568 mm k = 0.20/a 2014a

3.2

2004 2004

2005

0.3% 0.4% 2014

2015

2005

2013

3% 2014b

2014

3% 9% 2013

2015

2015

2007 ~ 9

4 065 /km 0.93 t/km

Froese Binohlan 2000

L_{opt}

L_m lgL_{opt} = 1.053 lgL_m 0.056 5 175 mm 2013 178.8 mm 97.8 mm 0.70 0.43

Esguicero A L H, Arcifa M. 2010. Fragmentation of a neotropical migratory fish population by a century-old dam. Hydrobiologia, 638(1): 41 ï53.

Fahrig L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution, and Systematics, 34: 487 ï515.

Froese R, Binohlan C. 2000. Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data. Journal of Fish Biology, 56(4): 758 ï773.

Gao X, Brosse S, Chen Y B, et al. 2009. Effects of damming on population sustainability of Chinese sturgeon, *Acipenser sinensis*: evaluation of optimal conservation measures. Environmental Biology of Fishes, 86(2): 325 ï336.

Gayanilo F C Jr, Sparre P, Pauly D. 2005. FAO-ICLARM Stock Assessment Tools II (User's Guide). Rome: World Center, FAO.

Johnson M G, Tamatamah A R. 2013. Length frequency distribution, mortality rate and reproduction biology of Kawakama (*Euthynnus affinis* Cantor, 1849) in the coastal waters of Tanzania. Pakistan Journal of Biological Sciences, 16(21): 1270 ï1278.

Keys A B. 1928. The weight-length relation in fishes. Proceedings of the National Academy of Sciences, 14(12): 922 ï925.

Liu G, Zhou J, Zhou D. 2012. Mitochondrial DNA reveals low

population differentiation in elongate loach, *Leptobotia elongata* (Bleeker): implications for conservation. Environmental Biology of Fishes, 93(3): 393 i402.

Morita K, Morita S H, Yamamoto S. 2009. Effects of habitat fragmentation by damming on salmonid fishes: lessons from white-spotted charr in Japan. Ecological Research, 24(4): 711 i722.

Munro J L, Pauly D. 1983. A simple method for comparing the growth of fishes and invertebrates. Fishbyte, 1(1): 5 i6.

Park Y S, Chang J B, Lek S, et al. 2003. Conservation strategies for endemic fish species threatened by the Three Gorges Dam. Conservation Biology, 17(6): 1748 i1758.

Pauly D. 1979. Gill size and temperature as governing factors in fish growth: a generalization of von Bertalanffy's growth formula. Kiel: Berichte aus dem Institut fuer Meereskunde an der Christian iAlbrechts iUniversitaet.

Pauly D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. ICES Journal of Marine Science, 39(2): 175 i192.

Pauly D. 1984. Fish Population Dynamics in Tropical Waters: A Manual for Use with Programmable Calculators (ICLARM Studies and Reviews 8). Manila, Philippines: International Center for Living Aquatic Resources Management.

Richer W E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations (Bulletin 191 of the Fisheries Research Board of Canada). Caldwell, New Jersey: Blackburn Press.

Xie P. 2003. Three-Gorges Dam: risk to ancient fish. Science, 302(5623): 1149 i1150.

Yuan Y, Yang H, Gong S Y, et al. 2010. Threatened fishes of the world: *Leptobotia elongata* Bleeker, 1870 (Bottiinae). Environmental Biology of Fishes, 87(4): 295 i296.

, , . 2005.
. , 22(2): 21 i24.

. 1994. . : .

, , , . 2015.
. ,
24(8): 1358 i1365.

, . 2005. .
, 13(5): 367 i375.

, , , . 2013.
. , 22(11): 1449 i1457.

, . 2001. .
, 25(4): 422 i424.

, , , . 2007. .
, 27(3): 29 i31.

, , , . 2004.
. , 28(1): 96 i100.

. 2012. *Leptobotia elongata*
. : .

. 2004.
. , 24(4): 12 i16.

, , , . 2005. .
, 29(6): 708 i711.

, , , . 2014.
. , 33(5): 762 i767.

, , , . 2013.
. , 22(10): 1305 i1312.

, . 2004. : . :
.

, , , . 2015.
. , 39(5): 954 i964.

, , , . 2013. FiSATII
. , 9(4): 94 i98.

, , , . 2011.
. , 32(3): 99 i103.

, , , . 2013.
. : , 35(3): 28 i35.

, , , . 2014a.
. , 49(6): 852 i859.

, , , . 2014b.
. : , 38(3): 94 i102.

, , , . 2014.
. , 33(6): 1565 i1572.

, , , . 2015. 175 m
. ,
35(15): 5064 i5075.

. 1995. . : .

, . 1999. .
, 22(6): 577 i583.