Length-Weight Relationships of Freshwater Fishes in Greece

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Abstract

Length-weight relationships were calculated for nine fish species from Lake Volvi (Macedonia, Hellas), caught with gillnets of five different mesh sizes between October 1995 and October 1996. In addition, length-weight relationships for 24 Greek freshwater fish species and one hybrid were also obtained from the literature. The values of the exponent of the length-weight relationships for all fish species examined ranged between 2.14 and 3.70 (mean = 3.12; SE = 0.032), and the median value was 3.19.

Introduction

In fisheries research, length-weight relationships are important for the estimation of weight where only length data are available and as an index of the condition of the fish (Pauly 1993; Petrakis and Stergiou 1995; Goncalves et al. 1997). In this study, the parameters of the length-weight relationships for nine fish species collected from Lake Volvi are estimated. In addition, the parameters of the length-weight relationships for 24 Greek freshwater fish species and one hybrid collected from the literature are also presented.

Materials and Methods

Samples were collected monthly from October 1995 to October 1996 from Lake Volvi (Macedonia, Hellas), using gillnets of mesh sizes 14, 18, 22, 26 and 30 mm (nominal bar length). Each net was 100 m long and 2 m deep. All fish were preserved in 10% formalin solution immediately after capture. In the laboratory, the total length was measured to the nearest mm and the total weight was weighed to the nearest g.

The parameters a and b of the length-weight relationship ($W=aL^b$) were calculated for each species (after log-transformation). All weights are expressed in g and all lengths in cm.

Results and Discussion

A total of nine species were caught in Lake Volvi, namely: *Abramis brama, Alburnus alburnus, Alosa macedonica, Carassius auratus gibelio, Chalcalburnus chalcoides, Cyprinus carpio, Rutilus rutilus, Scardinius erythrophthalmus* and *Vimba melanops*. The parameters a and b of the length-weight relationships are shown in Table 1. The sample size ranged from 11 individuals for *C. carpio* to 4 825 for *A. macedonica*. The values of b ranged from 2.67 for *A. alburnus* to 3.48 for *S. erythrophthalmus*.

The values of the parameters of the length-weight relationships of the 24 Greek freshwater fish species and one hybrid (from ten lakes, seven rivers and two lagoons), collected from the literature (a total of 85 length-weight relationships) are shown in Table 2.

Overall (Tables 1 and 2), the value of b ranged from 2.14 for *Leuciscus 'svallize'* of Lake Kremasta, to 3.70 for female *A. alburnus* of Lake Mikri Prespa. The

Table 1. Parameters of the relationships ($W=aL^b$) between total weight (in g) and total length (in cm) of nine fish species, collected monthly from October 1995 to October 1996, from Lake Volvi. N, sample size; min and max, minimum and maximum total lengths in cm, respectively; SE(b), standard error of b; r, correlation coefficient.

Species[1]	N	Length		a	b	SE(b)	r
		min	max				
Abramis brama	449	10.7	30.5	0.0111	2.97	0.036	0.97
Alburnus alburnus	86	9.4	15.6	0.0185	2.70	0.127	0.92
Alosa macedonica	4825	8.3	21.4	0.0176	2.71	0.011	0.96
Carassius auratus gibelio	102	8.2	25.2	0.0142	3.11	0.057	0.98
Chalcalburnus chalcoides	67	12.9	21.5	0.0029	3.41	0.076	0.98
Cyprinus carpio	11	7.8	18.1	0.0383	2.67	0.090	0.99
Rutilus rutilus	4338	9.3	26.0	0.0074	3.14	0.013	0.96
Scardinius erythrophthalmus	75	10.6	21.1	0.0036	3.48	0.057	0.99
Vimba melanops	22	14.5	22.8	0.0043	3.33	0.132	0.98

[1] Species are listed alphabetically. Species names according to Economidis and Sinis (1982) and Economidis (1991).

Table 2. Parameters of the relationships ($W=aL^b$) between weight (in g) and length (in cm) of 24 Greek freshwater fish species and one hybrid, from ten lakes, seven rivers and two lagoons, collected from the literature. F, frequency of sampling (M, monthly; B, bimonthly; S, seasonal; O, one single sampling; U, undefined); sex (M, male; F, female; I, immature fish; C, sexes combined); weight (total, TW; net, NW); length (fork, FL; standard, SL; total, TL); N, sample size; length characteristics (min and max, minimum and maximum lengths in cm, respectively); SE(b), standard error of b; r, correlation coefficient.

Species	F	Sex	Weight	Length	N	Length characteristics		a	b	SE(b)	r	Area/Sampling period	Reference
						min	max						
Abramis brama	M	M	TW	FL	655	11.7	32.0	0.0082	3.18	-	-	Lake Volvi /Jan-Dec 1990	Valoukas et al. (1996)
Abramis brama	M	F	TW	FL	654	11.9	36.3	0.0075	3.21	-	-	Lake Volvi /Jan-Dec 1990	Valoukas et al. (1996)
Alburnus alburnus	M	M	TW	TL	1 403	-	-	0.0049	3.23	0.035	0.93	Lake Koronia /Apr 1986-Sep 1988	Politou (1993)
Alburnus alburnus	M	F	TW	TL	1 522	-	-	0.0029	3.43	0.027	0.95	Lake Koronia /Apr 1986-Sep 1988	Politou (1993)
Alburnus alburnus	M	C	TW	TL	2 925	7.7	15.4	0.0038	3.33	0.019	0.95	Lake Koronia /Apr 1986-Jan 1988	Politou (1993)
Alburnus alburnus	U	M	-	FL	78	7.5	17.5	0.0021	3.64	-	0.97	Lake Mikri Prespa /Mar-Jun 1985	Crivelli and Dupont (1987)
Alburnus alburnus	U	F	-	FL	200	7.5	17.5	0.0018	3.70	-	0.98	Lake Mikri Prespa /Mar-Jun 1985	Crivelli and Dupont (1987)
Alosa macedonica	O	M	NW	TL	123	10.1	18.0	0.0179	2.66	0.056	0.97	Lake Volvi /Jun 1978	Sinis (1981)
Alosa macedonica	O	F	NW	TL	212	11.1	23.0	0.0168	2.69	0.037	0.98	Lake Volvi /Jun 1978	Sinis (1981)
Alosa macedonica	O	C	NW	TL	335	10.1	23.0	0.0157	2.72	0.024	0.98	Lake Volvi /Jun 1978	Sinis (1981)
Aphanius fasciatus	M	M	NW	TL	418	2.2	6.8	0.0094	3.31	0.035	0.97	Messolonghi lag. (Rebakia) /Apr 1989-Jan 1991	Leonardos (1996)
Aphanius fasciatus	M	F	NW	TL	493	2.0	7.0	0.0088	3.45	0.015	0.99	Messolonghi lag. (Rebakia) /Apr 1989-Jan 1991	Leonardos (1996)
Aphanius fasciatus	M	C	NW	TL	911	2.0	7.0	0.0088	3.43	0.015	0.99	Messolonghi lag. (Rebakia) /Apr 1989-Jan 1991	Leonardos (1996)
Aphanius fasciatus	M	M	NW	TL	218	2.0	5.0	0.0097	3.22	0.030	0.99	Etolikon lag. (Astrovitsa) / Apr 1989-Jan 1991	Leonardos (1996)
Aphanius fasciatus	M	F	NW	TL	233	2.6	7.2	0.0087	3.45	0.040	0.99	Etolikon lag. (Astrovitsa) / Apr 1989-Jan 1991	Leonardos (1996)
Aphanius fasciatus	M	C	NW	TL	451	2.0	7.2	0.0086	3.45	0.015	0.99	Etolikon lag. (Astrovitsa) / Apr 1989-Jan 1991	Leonardos (1996)
Aphanius fasciatus	M	M	NW	TL	293	2.0	5.8	0.0100	3.09	0.040	0.97	Messolonghi lag. (Alykes) / Apr 1989-Jan 1991	Leonardos (1996)
Aphanius fasciatus	M	F	NW	TL	316	2.2	6.4	0.0100	3.16	0.035	0.98	Messolonghi lag. (Alykes) / Apr 1989-Jan 1991	Leonardos (1996)
Aphanius fasciatus	M	C	NW	TL	648	2.0	6.4	0.0100	3.18	0.025	0.98	Messolonghi lag. (Alykes) / Apr 1989-Jan 1991	Leonardos (1996)
Atherina boyeri	U	C	TW	TL	2 543	-	-	0.0049	3.21	-	0.98	Lake Trichonis /1988-90	Stoumboudi et al. (1997)
Barbus albanicus	S	M	-	FL	149	5.0	20.1	0.0169	2.94	-	0.98	Lake Kremasta /Feb-Nov 1982	Daoulas and Economidis (1989)
Barbus albanicus	S	F	-	FL	175	5.0	28.8	0.0178	2.95	-	0.98	Lake Kremasta /Feb-Nov 1982	Daoulas and Economidis (1989)
Barbus cyclolepis	B	M	-	FL	-	5.0	26.0	0.0583	2.43	-	0.94	Rihios Stream /Feb-Dec 1984	Neophitou (1987)
Barbus cyclolepis	B	F	-	FL	-	5.0	26.0	0.0080	3.16	-	0.98	Rihios Stream /Feb-Dec 1984	Neophitou (1987)
Barbus prespensis	M	C	-	FL	144	8.0	30.0	0.0082*	3.20	-	0.99	Lake Mikri Prespa /Apr-Jun 1984,1985,1990-1994	Crivelli et al. (1996)
Chalcalburnus belvica	M	M	NW	FL	183	10.2	13.6	0.0058	3.23	0.070	0.96	Lake Mikri Prespa /Jul 1990-Jun 1991	Sinis and Petridis (1995)
Chalcalburnus belvica	M	F	NW	FL	186	10.6	22.0	0.0046	3.30	0.035	0.99	Lake Mikri Prespa / Jul 1990-Jun 1991	Sinis and Petridis (1995)
Chalcalburnus belvica	M	C	NW	FL	369	10.2	22.0	0.0067	3.18	0.030	0.98	Lake Mikri Prespa / Jul 1990-Jun 1991	Sinis and Petridis (1995)
Chalcalburnus chalcoides	M	M	NW	FL	90	9.1	20.0	0.0037	3.40	-	0.98	Lake Volvi /Sep 1983-Oct 1984	Kokkinakis (1992)
Chalcalburnus chalcoides	M	F	NW	FL	280	11.1	26.0	0.0035	3.41	-	0.98	Lake Volvi / Sep 1983-Oct 1984	Kokkinakis (1992)
Chalcalburnus chalcoides	M	C	NW	FL	370	9.1	26.0	0.0039	3.38	-	0.98	Lake Volvi / Sep 1983-Oct 1984	Kokkinakis (1992)
Chalcalburnus chalcoides	M	M	NW	FL	260	9.1	20.0	0.0026	3.56	-	0.99	Lake Vistonis / Sep 1983-Oct 1984	Kokkinakis (1992)
Chalcalburnus chalcoides	M	F	NW	FL	253	9.1	24.0	0.0031	3.49	-	0.99	Lake Vistonis / Sep 1983-Oct 1984	Kokkinakis (1992)
Chalcalburnus chalcoides	M	C	NW	FL	513	9.1	24.0	0.0029	3.52	-	0.99	Lake Vistonis / Sep 1983-Oct 1984	Kokkinakis (1992)
Cyprinus carpio	U	M	-	TL	21	-	-	0.0474**	2.65	-	-	Lake Vistonis /Sep-Dec 1973	Tsimenidis (1976)
Cyprinus carpio	U	F	-	TL	34	-	-	0.0140**	2.99	-	-	Lake Vistonis /Sep-Dec 1973	Tsimenidis (1976)
Coregonus lavaretus	O	M	NW	FL	58	24.3	33.8	0.0174	2.86	0.175	0.91	Lake Tavropos /Nov 1987	Sinis and Petridis (1993)
Coregonus lavaretus	O	F	NW	FL	66	24.3	33.8	0.1203	2.27	0.140	0.89	Lake Tavropos /Nov 1987	Sinis and Petridis (1993)
Coregonus lavaretus	O	M	NW	FL	69	24.3	34.8	0.0126	2.95	0.135	0.94	Lake Vegoritis /Nov 1987	Sinis and Petridis (1993)
Coregonus lavaretus	O	F	NW	FL	58	24.3	34.8	0.0097	3.02	0.160	0.93	Lake Vegoritis /Nov 1987	Sinis and Petridis (1993)
Knipowitschia caucasica	M	M	NW	TL	230	-	2.91	0.0040	3.25	0.008	0.86	Evros River (Delta) /Feb 1983-Feb 1984	Kevrekidis et al. (1990)

Species	F	Sex	Weight	Length	N	Length characteristics		a	b	SE(b)	r	Area/Sampling period	Reference
						min	max						
Knipowitschia caucasica	M	F	NW	TL	158	-	4.11	0.0034	3.43	0.009	0.93	Evros River (Delta) / Feb 1983-Feb 1984	Kevrekidis et al. (1990)
Knipowitschia caucasica	M	I	NW	TL	9	1.28	1.70	0.0031	2.79	0.409	0.67	Evros River (Delta) / Feb 1983-Feb 1984	Kevrekidis et al. (1990)
Knipowitschia caucasica	M	C	NW	TL	397	1.28	4.11	0.0034	3.46	0.004	0.91	Evros River (Delta) / Feb 1983-Feb 1984	Kevrekidis et al. (1990)
Ladigesocypris ghigii	M	M	TW	-	133	-	-	0.0109	3.22	-	0.98	Loutani stream (Rhodes)/Feb 1991-Jan 1992	Corsini and Karantoni (1993)
Ladigesocypris ghigii	M	F	TW	-	132	-	-	0.0116	3.19	-	0.99	Loutani stream (Rhodes)/ Feb 1991-Jan 1992	Corsini and Karantoni (1993)
Ladigesocypris ghigii	M	M	TW	-	146	-	-	0.0128	3.14	-	0.99	Gadoura stream (Rhodes)/ Feb 1991-Jan 1992	Corsini and Karantoni (1993)
Ladigesocypris ghigii	M	F	TW	-	94	-	-	0.0137	3.12	-	0.99	Gadoura stream (Rhodes)/ Feb 1991-Jan 1992	Corsini and Karantoni (1993)
Leuciscus cephalus	U	C	-	FL	489	8.9	30.5	0.0027	3.44	-	0.99	Rihios Stream /Apr-Jun 1984	Neophitou (1988)
Leuciscus cephalus	M	C	TW	SL	220	0.92	6.01	0.0123	3.23	-	0.99	Myrtia Stream /May 1989-May 1990	Economou et al. (1991a)
Leuciscus 'svallize'	O	M	TW	FL	36	7.0	20.0	0.0946	2.29	-	0.97	Lake Kremasta /Feb 1982	Economou et al. (1991b)
Leuciscus 'svallize'	O	F	TW	FL	88	7.0	20.0	0.0280	2.72	-	0.95	Lake Kremasta /Feb 1982	Economou et al. (1991b)
Leuciscus 'svallize'	O	M	TW	FL	145	7.0	21.0	0.0419	2.55	-	0.94	Lake Kremasta /Apr 1982	Economou et al. (1991b)
Leuciscus 'svallize'	O	F	TW	FL	146	7.0	21.0	0.0067	3.23	-	0.96	Lake Kremasta /Apr 1982	Economou et al. (1991b)
Leuciscus 'svallize'	O	M	TW	FL	111	4.0	21.0	0.0117	3.04	-	0.99	Lake Kremasta /Jun 1982	Economou et al. (1991b)
Leuciscus 'svallize'	O	F	TW	FL	97	4.0	21.0	0.0106	3.08	-	0.99	Lake Kremasta /Jun 1982	Economou et al. (1991b)
Leuciscus 'svallize'	O	M	TW	FL	111	6.0	19.0	0.0185	2.86	-	0.99	Lake Kremasta /Aug 1982	Economou et al. (1991b)
Leuciscus 'svallize'	O	F	TW	FL	130	6.0	19.0	0.0150	2.93	-	0.99	Lake Kremasta /Aug 1982	Economou et al. (1991b)
Leuciscus 'svallize'	O	M	TW	FL	47	7.0	22.0	0.0125	3.01	-	0.99	Lake Kremasta /Nov 1982	Economou et al. (1991b)
Leuciscus 'svallize'	O	F	TW	FL	137	7.0	22.0	0.1317	2.14	-	0.96	Lake Kremasta /Nov 1982	Economou et al. (1991b)
Perca fluviatilis	U	C	TW	TL	317	13.0	22.9	0.0229	2.83	-	0.93	Lake Doirani /1989-1992	Neophitou (1993b)
Perca fluviatilis	U	C	NW	SL	709	6.2	20.3	0.0127	3.17	-	-	Lake Koronia /1975-1976	Papageorgiou (1977)
Pseudorasbora parva	U	C	-	FL	245	6.1	9.5	0.0078	3.27	-	0.99	Lake Mikri Prespa /Apr-Jun 1984, Apr-Jun 1985, 1990-1992	Rosecchi et al. (1993)
Phoxinellus pleurobipunctatus	B	M	TW	FL	450	5.5	18.0	0.0110	3.08	-	-	Lake Kremasta /Feb-Nov 1982	Daoulas et al. (1987)
Phoxinellus pleurobipunctatus	B	F	TW	FL	598	4.0	22.0	0.0121	3.04	-	-	Lake Kremasta /Feb-Nov 1982	Daoulas et al. (1987)
Rutilus rubilio	M	M	TW	FL	161	8.0	18.0	0.0060	3.30	0.006	0.98	Lake Trichonis /Mar-May 1978	Daoulas (1981)
Rutilus rubilio	M	F	TW	FL	246	8.0	26.0	0.0200	3.00	0.003	0.98	Lake Trichonis /Mar-May 1978	Daoulas (1981)
Rutilus rubilio	M	M	TW	FL	163	9.0	20.0	0.0100	3.30	0.003	0.99	Lake Trichonis /Jun-Aug 1978	Daoulas (1981)
Rutilus rubilio	M	F	TW	FL	208	8.0	23.0	0.0060	3.30	0.002	0.99	Lake Trichonis /Jun-Aug 1978	Daoulas (1981)
Rutilus rubilio	M	M	TW	FL	138	9.0	18.0	0.0095	3.20	0.006	0.98	Lake Trichonis /Sep-Nov 1978	Daoulas (1981)
Rutilus rubilio	M	F	TW	FL	144	5.0	20.0	0.0080	3.30	0.004	0.98	Lake Trichonis /Sep-Nov 1978	Daoulas (1981)
Rutilus rubilio	M	M	TW	FL	122	11.0	18.0	0.0111	3.20	0.008	0.98	Lake Trichonis /Dec-Feb 1978-1979	Daoulas (1981)
Rutilus rubilio	M	F	TW	FL	147	11.0	20.0	0.0079	3.20	0.004	0.98	Lake Trichonis /Dec-Feb 1978-1979	Daoulas (1981)
Rutilus rubilio	M	C	TW	FL	768	12.0	21.0	19.364 ?	3.14	-	0.93	Lake Pamvotis /Nov 1983-Dec 1984	Neophitou et al. (1989)
Rutilus rubilio	U	C	-	FL	501	6.0	20.0	0.0074	3.32	-	0.99	Lake Mikri Prespa /Mar-Jun 1985	Crivelli and Dupont (1987)
R.rubilio x A.albumus	U	M	-	FL	43	10.6	18.5	0.0100	3.11	-	0.97	Lake Mikri Prespa /Mar-Jun 1985	Crivelli and Dupont (1987)
R.rubilio x A.albumus	U	F	-	FL	87	10.6	18.5	0.0054	3.33	-	0.97	Lake Mikri Prespa /Mar-Jun 1985	Crivelli and Dupont (1987)
Rutilus rutilus	O	M	TW	TL	97	7.2	23.0	0.0356	3.40	-	0.99	Lake Volvi /Mar 1978	Papageorgiou (1979)
Rutilus rutilus	O	F	TW	TL	136	7.2	23.0	0.0215	3.61	-	0.98	Lake Volvi /Mar 1978	Papageorgiou (1979)
Salaria fluviatilis	M	M	TW	TL	409	2.0	7.0	0.0068**	3.33	-	0.99	Lake Trichonis /Sep 1988-Apr 1991	Psarras et al. (1997)
Salaria fluviatilis	M	F	TW	TL	441	2.0	7.0	0.0102**	3.08	-	0.97	Lake Trichonis /Sep 1988-Apr 1991	Psarras et al. (1997)
Salmo trutta fario	M	C	-	SL	1 074	4.1	24.0	0.0041**	2.95	-	-	Aspropotamos Stream /Mar 1981-Feb 1982	Papageorgiou et al. (1983)
Salmo trutta	M	M	TW	TL	180	5.0	31.0	0.0194	2.86	-	0.98	Acheloos River /1978-1981	Klossa-Kilia (1990)
Salmo trutta	M	F	TW	TL	128	9.0	29.0	0.0214	2.82	-	0.95	Acheloos River /1978-1981	Klossa-Kilia (1990)
Tinca tinca	M	C	NW	FL	763	-	29.0	0.0295	2.80	-	0.98	Lake Pamvotis /Mar-Oct 1988	Neophitou (1993b)

Species are listed alphabetically * Type of logarithm not specified, most probably natural ** Type of logarithm not specified, most probably base 10 ? Most probably misreported

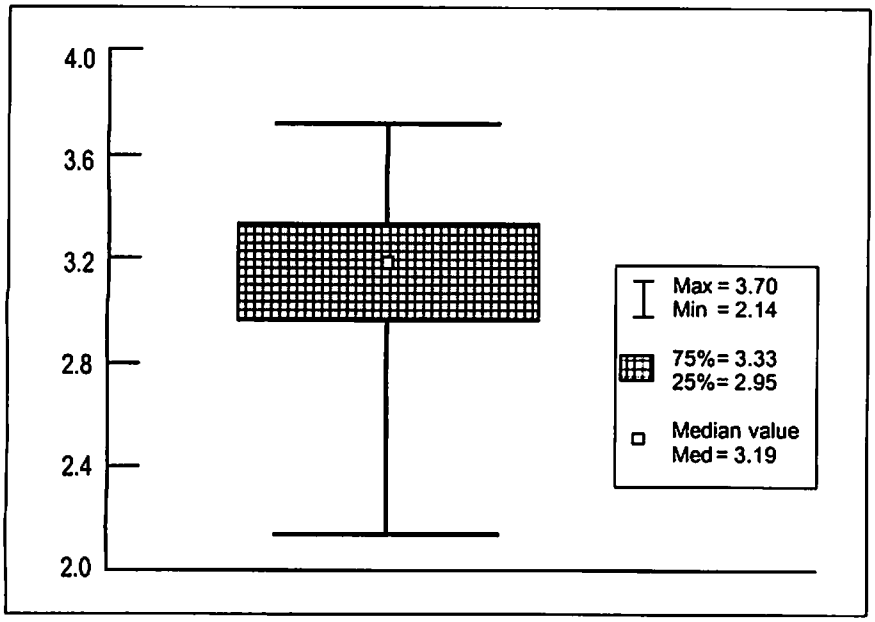

Fig. 1. Box-Whisker plot of the exponent b of the length-weight relationships ($W=aL^b$) for all species examined (for values see Tables 1 and 2). The small open square inside the box represents the median value, the vertical line represents the minimum and the maximum values and the central box covers 50% of b values.

mean value of **b** for all species was 3.119 (SE = 0.032), the median value of **b** was 3.185 and 50% of the **b** values ranged between 2.950 and 3.325 (Fig. 1).

Some aspects are worthy of mention for Lake Volvi (Tables 1 and 2). The value of **b** did not change over time for *A. macedonica* (2.72 in 1978 and 2.71 in 1995-1996) and *C. chalcoides* (3.38 in 1983-1984 and 3.41 in 1995-1996). However, in the case of *A. macedonica* the estimate for 1978 was based on net weight and one sampling event whereas that for 1995-1996 was based on total weight and monthly sampling. Similarly, for *C. chalcoides*, the estimate in 1983-1984 was based on net weight and fork length while that for 1995-1996 was based on total length and total weight.

In contrast, the values of **b** for *A. brama* and *R. rutilus* seems to have changed considerably. For *A. brama*, the value of **b** decreased from 3.18 to 3.21 (depending on sex) in 1990 to 2.97 (for the sexes combined) in 1995-1996. This may be attributed to the use of fork length in the former period as opposed to the use of total length in latter one (Tables 1 and 2). For *R. rutilus* the value of **b** also decreased from 3.40 to 3.61 (depending on sex) in 1978 (one sampling event) to 3.14 (sexes combined, monthly sampling) in 1995-1996.

Finally, the value of **b** for *A. alburnus* is considerably lower for Lake Volvi than for the nearby Lake Koronia (2.70 and 3.33, respectively).

Such changes in the values of **b** may be attributed either to differences in methodology, as described previously, or to factors like overfishing, food competition and trophic potential of the lakes, and require further study.

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