Length-Weight Relationship of Fishes Caught in the Itaipu Reservoir, Paraná, Brazil

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Abstract

Parameters and related statistics of the length-weight relationship of the form $W=aL^b$ are presented for 72 species of fish caught in the area of the Itaipu Reservoir in Paraná, Brazil. The b values varied between 2.34 and 3.35, with the mean b=2.986 (s.d.=0.230) not significantly different from 3.0 (df=7, p=0.05).

Introduction

Basic information such as knowledge on parameters that relate weight to length of fish is scanty, even though it is of great importance in studies on fisheries biology (Vazzoler 1996) and on the evaluation of fish stocks (Entsua-Mensah et al. 1995). Among its most frequent uses, Pauly (1993) notes the importance of length-weight relationships (LWR) in the calculation of the fish's average weight at a certain length class and the conversion of an equation of growth in length into an equation of growth in weight, besides morphological comparisons between populations of the same species or between species. Such applications are evident in the work of Kulbicki et al. (1993), Almeida et al. (1995), Stergiou and Politou (1995), and Petrakis and Stergiou (1995), among others.

The mathematical parameters of the relationship between the length and the weight of fish furnish further information on the weight variation of individuals in relation to their length (condition factor, k). This factor estimates the general well-being of the individual and is frequently used in three cases: (1) comparison of two or more co-specific populations living in similar or different conditions of food, density or climate, among others; (2) determination of the period and duration of gonadal maturation; and (3) observation of the increase or decrease in feeding activity or population changes, possibly due to modifications in food resources (Weatherley and Gill 1987).

Generally, a growth model in fish follows the "cube law" and hence the use of Fulton's condition factor or the isometric factor ($k = W/L^b$), attributing to the weight-length exponent b a value equal to 3 (Gulland 1983). In this case the body form maintains a constant proportion to length (Weatherley and Gill 1987). However, Braga (1986) states that Fulton's condition factor is only adequate for the comparison of fish of the same size, while the allometric condition factor, which occurs when $b \neq 3$, is valid for the study of fish of any range of length although at the same stage of development. Vazzoler (1996) states that it is inadvisable to use Fulton's condition factor and affirms that the determination of the value of b is necessary in the use of the allometric condition factor so that results may be reliable.

The present research work aims at making available estimates of the LWR parameters for 72 species of fish caught in the area of the Itaipu Reservoir.

Materials and Methods

Individual measurements of total length (TL) and standard length (SL) in cm and of total weight (W) in g were obtained from November 1983 to October 1989. Sampling was carried out in 11 stations, 3 in the principal channel of the Itaipu Reservoir (municipalities of Guaíra, Santa Helena and Foz do Iguaçu, state of Paraná, Brazil), 4 in the tributaries of the left shore (Rivers Ocoí, São Francisco Falso, São Francisco Verdadeiro and Arroio Guaçu), 2 in the River

Paraná (one upstream and the other downstream of the Itaipu Reservoir) and 2 in the tributaries of the River Paraná (Rivers Iguatemi and Piquiri) (Fig. 1).

Fishing equipment, exposed for 24 hours and checked at periods of 8-12 hours, consisted of simple gillnets and trammel nets with mesh size from 3 to 16 cm at opposite knots, and boulters with 30 and 50 fishing hooks.

Initially, data analysis consisted of a graphic visualization of the relationship between standard length and total weight. Subsequently, regression by the least-squares method for the determination of parameters and related statistics of the LWR whose variables were previously transformed into logarithms ($\ln W = \ln a + b \ln SL$). The individual species and average value for b was tested to verify whether it was significantly different from 3 using t-test at the 0.05 significance level.

Results and Discussion

The species studied correspond to 96.6% in number and 88.9% in weight of total fish captured in the area of the Itaipu Reservoir from November 1983 to October 1989 (Benedito-Cecilio 1994). Table 1 gives a summary of the results of the analysis.

The number of individuals varied from 25 in the case of *Pachiurus bonariensis* to 12 867 for *Auchenipterus nuchalis.* Values of r^2 ranged from 0.81 for *Apareiodon affinis* to 0.99 in the case of *Salminus maxillosus*, *Brycon orbignyanus*, *Serrasalmus spilopleura* and *Loricaria prolixa*, with all regressions highly significant

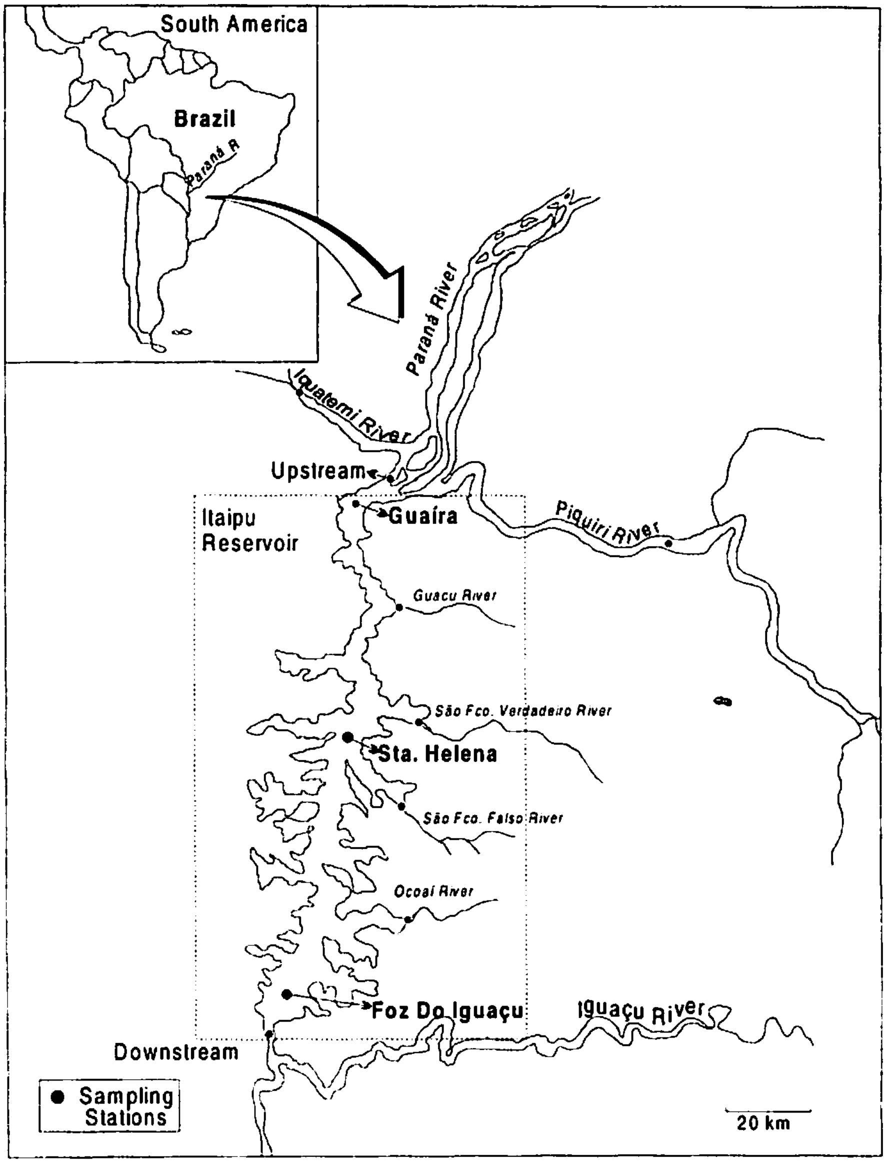

Fig. 1. Site of sampling stations in the area of the Itaipu Reservoir, Paraná, Brazil.

Table 1. Number of individuals (n), minimum, maximum and mean standard lengths (cm) and parameters of the length-weight relationship for species caught in the Itaipu Reservoir from November 1983 to October 1989. Species with asterisk indicate total length was used rather than standard length; b values in italic.

Family/Species	*n*	Standard length mean	s.d.	min	max	TL/LS	Length-weight relationship *a*	*b*	s.e.(*b*)	r^2
Family Engraulidae										
Lycengraulis grossidens	47	13.1	1.19	11.1	17.6	1.23	0.0388	*2.62*	0.13	0.90
Family Characidae										
Astyanax bimaculatus	2587	8.0	1.32	5.4	13.6	1.26	0.0388	*2.88*	0.07	0.90
Astyanax fasciatus	224	9.1	1.39	7.0	13.2	1.25	0.0307	*2.88*	0.05	0.94
Acestrorhynchus lacustris	1617	16.5	3.22	10.4	26.4	1.19	0.0062	*3.26*	0.01	0.96
Galeocharax knerii	1027	14.8	3.25	7.4	24.0	1.20	0.0091	*3.18*	0.07	0.97
Salminus maxillosus	503	37.6	12.53	12.6	77.3	1.20	0.0110	*3.16*	0.01	0.99
Brycon orbignyanus	102	26.3	11.50	11.3	62.5	1.21	0.0129	*3.14*	0.02	0.99
Serrasalmus marginatus	2468	13.1	3.19	4.4	24.1	1.22	0.0162	*3.23*	0.01	0.98
Pygocentrus nattereri	41	29.4	2.23	24.0	33.3	1.17	0.0269	3.23	0.16	0.91
Serrasalmus spilopleura	122	11.6	4.15	5.1	25.0	1.22	0.0149	*3.34*	0.03	0.99
Myloplus levis	79	15.4	5.55	5.4	30.1	0.87	0.0517	2.95	0.05	0.98
Family Curimatidae										
Cyphocharax modesta	368	11.0	2.16	6.5	15.5	1.26	0.0353	*2.90*	0.03	0.96
Cyphocharax nagelii	94	10.3	2.05	6.7	14.4	1.26	0.0346	*2.86*	0.05	0.97
Leporellus vittatus	288	12.4	2.36	9.0	24.5	1.23	0.0243	2.92	0.05	0.92
Leporinus elongatus	370	23.4	6.93	8.6	51.7	1.22	0.0219	3.00	0.03	0.97
Leporinus friderici	954	18.7	4.61	7.9	37.0	1.24	0.0152	*3.14*	0.01	0.98
Leporinus obtusidens	318	21.8	6.38	7.5	40.0	1.23	0.0171	*3.12*	0.02	0.98
Leporinus octofasciatus	166	13.6	3.35	9.1	23.5	1.27	0.0152	*3.13*	0.03	0.98
Leporinus amblyrhynchus	70	10.9	0.84	9.2	13.6	1.24	0.0747	*2.40*	0.10	0.89
Leporinus lacustris	57	12.7	2.87	7.0	16.8	1.24	0.0201	*3.19*	0.06	0.98
Prochilodus lineatus	3719	29.1	6.59	5.9	54.2	1.23	0.0212	*3.07*	0.01	0.97
Schizodon borellii	1066	21.3	3.42	8.2	38.4	1.19	0.0182	*3.08*	0.02	0.94
Schizodon nasutus	301	19.6	5.13	10.2	33.6	1.22	0.0155	*3.04*	0.02	0.99
Schizodon altoparanae	330	20.0	3.04	8.9	31.2	1.20	0.0101	*3.26*	0.05	0.92
Schizodon cf platae	52	29.8	2.69	25.4	35.7	1.19	0.0368	2.78	0.16	0.86
Steindachnerina insculpta	5833	9.6	1.14	6.2	14.4	1.26	0.0268	2.99	0.02	0.86
Family Hemiodontidae										
Apareiodon affinis	164	11.2	1.05	7.4	13.5	1.19	0.0720	*2.42*	0.09	0.81
Hemiodus orthonops	38	20.9	1.87	16.7	24.6	1.23	0.0238	2.93	0.22	0.83
Parodon tortuosus	65	11.9	1.68	9.2	15.5	1.21	0.0362	*2.81*	0.10	0.93
Family Erythrinidae										
Hoplias aff malabaricus	604	25.8	6.49	9.6	48.6	1.22	0.0136	*3.12*	0.03	0.96
Family Cynodontidae										
Rhaphiodon vulpinus	1420	36.7	6.70	13.9	64.0	1.12	0.0031	*3.23*	0.02	0.95
Family Gymnotidae										
*Gymnotus carapo**	70	23.7	4.33	18.5	42.0		0.0031	3.02	0.10	0.93
Family Sternopygidae										
*Eigenmannia trilineata**	36	22.6	4.00	16.5	31.5		0.0055	*2.66*	0.15	0.90
*Eigenmannia virescens**	124	22.7	4.26	12.7	37.5		0.0172	*2.45*	0.07	0.90
Family Apteronotidae										
Apteronotus albifrons	26	28.4	7.20	20.3	47.5	1.65	0.0029	3.07	0.22	0.89
Apteronotus sp.	190	25.0	3.39	16.7	31.7	1.08	0.0088	2.65	0.08	0.87
Family Rhamphichthyidae										
*Rhamphichthys rostratus**	37	72.8	16.59	30.0	103.0		0.0020	2.94	0.16	0.90
Family Doradidae										
Pterodoras granulosus	1651	25.7	9.55	5.1	53.2	1.26	0.0365	*2.88*	0.01	0.97
Rhinodoras dorbignyi	164	12.1	2.65	7.1	19.5	1.22	0.0203	3.06	0.06	0.93
Trachydoras paraguayensis	2491	8.3	0.95	5.3	12.0	1.25	0.0339	*2.48*	0.21	0.89
Family Auchenipteridae										
Auchenipterus nuchalis	12867	16.6	2.54	8.4	27.0	1.20	0.0150	*2.96*	0.01	0.89
Parauchenipterus galeatus	3578	13.4	1.92	6.6	22.0	1.22	0.0337	2.99	0.02	0.90
Family Ageneiosidae										
Ageneiosus brevifilis	32	32.4	9.72	17.5	53.2	1.16	0.0200	2.98	0.07	0.98
Ageneiosus ucayalensis	2476	17.7	2.91	11.1	32.4	1.22	0.0107	*2.97*	0.02	0.93
Ageneiosus valenciennesi	88	22.3	4.75	10.4	31.6	1.21	0.0067	*3.19*	0.06	0.97

continued

Table 1. (continued)

Family/Species	n	Standard Length mean	s.d.	min	max	TL/LS	Length-weight relationship a	b	s.e.(b)	r^2
Family Pimelodidae										
Iheringichthys labrosus	3215	15.3	3.22	7.3	26.2	1.27	0.0087	3.23	0.0	0.97
Pimelodella spp.	128	11.7	1.53	7.4	16.0	1.26	0.0275	2.68	0.08	0.91
Pimelodus maculatus	1474	19.7	5.51	8.3	36.0	1.25	0.0161	3.08	0.01	0.98
Pmelodus ornatus	31	23.5	5.75	9.0	38.5	1.19	0.0119	3.145	0.09	0.98
Pimelodus spp.	119	14.9	4.93	8.0	28.6	1.24	0.0110	3.18	0.07	0.94
Zungaro zungaro	54	26.8	9.50	16.0	52.0	1.21	0.0160	3.16	0.07	0.98
Rhamdia spp.	33	16.8	4.20	10.2	25.2	1.22	0.0234	2.92	0.13	0.94
Hemisorubim platyrhynchos	184	30.8	6.51	17.9	52.5	1.19	0.0131	3.02	0.04	0.96
Paulicea luetkeni	350	43.1	11.51	18.0	97.5	1.21	0.0281	2.94	0.03	0.97
Pseudoplatystoma corruscans	347	59.4	15.00	22.3	114.0	1.15	0.0059	3.16	0.03	0.97
Sorubim lima	79	34.8	7.27	16.8	50.4	1.16	0.0109	2.94	0.08	0.95
Pinirampus pirinampu	466	38.6	11.62	14.9	77.4	1.24	0.0072	3.18	0.02	0.98
Family Hypophthamidae										
Hypophthalmus edentatus	10154	26.6	3.79	9.6	44.6	1.19	0.0075	3.08	0.01	0.95
Family Loricariidae										
Hypostomus spp.	1403	14.7	5.33	5.8	43.6	1.35	0.0290	2.99	0.01	0.97
Megalancistrus aculeatus	76	27.9	8.29	8.6	44.6	1.33	0.0239	3.10	0.05	0.98
Rhinelepis aspera	173	30.5	3.18	20.0	37.2	1.28	0.0873	2.70	0.07	0.89
Loricaria prolixa	28	27.5	9.75	11.0	45.2	1.16	0.0032	3.23	0.06	0.99
Loricaria sp.	1241	21.3	2.84	10.0	27.2	1.14	0.0020	3.35	0.02	0.96
Loricariichthys sp.	4905	20.9	2.66	11.8	33.0	1.14	0.0030	3.25	0.01	0.93
Loricariichthys platymetopon	225	19.4	3.90	11.5	29.0	1.16	0.0048	3.17	0.04	0.96
Family Sciaenidae										
Pachyurus bonariensis	25	16.8	2.48	12.0	22.6	1.23	0.0304	2.82	0.19	0.90
Plagioscion squamosissimus	7200	22.6	4.40	6.8	47.9	1.22	0.0157	3.09	0.01	0.97
Family Cichlidae										
Crenicichla nierderleinii	343	12.7	1.84	7.6	18.5	1.19	0.0330	2.74	0.04	0.92
Crenicichla haroldoi	43	10.9	1.67	8.9	16.1	1.21	0.0370	2.71	0.12	0.93
Crenicichla britskii	64	10.8	1.87	8.1	16.1	1.21	0.1039	2.34	0.12	0.88
Satanoperca pappaterra	153	12.2	2.76	5.9	14.4	1.27	0.0284	3.13	0.03	0.98
Family Archiridae										
Catathyridium jenynsii	57	14.5	4.88	5.5	25.0	1.24	0.0354	3.09	0.06	0.98

($p<0.001$). The *b* values ranged from 2.34 for *Crenicichla britskii* to 3.35 for *Loricaria* sp.

Fig. 2 shows the distribution of exponents of the weight-length relationship for the 72 species under analysis. A tendency towards normality for this type of distribution may be noted, as has been affirmed by Carlander (1969). However, asymmetry to the left is determined ($G_1=-0.9877$) in the mesocurtic curve ($G_2=0.5652$). The average value of *b* was 2.986 (s.d.=0.230) and not significantly different from 3 (t-test, df=71, p=0.05). This value corresponds to that found by Petrakis and Stergiou (1995) and Entsua-Mensah et al. (1995) for average

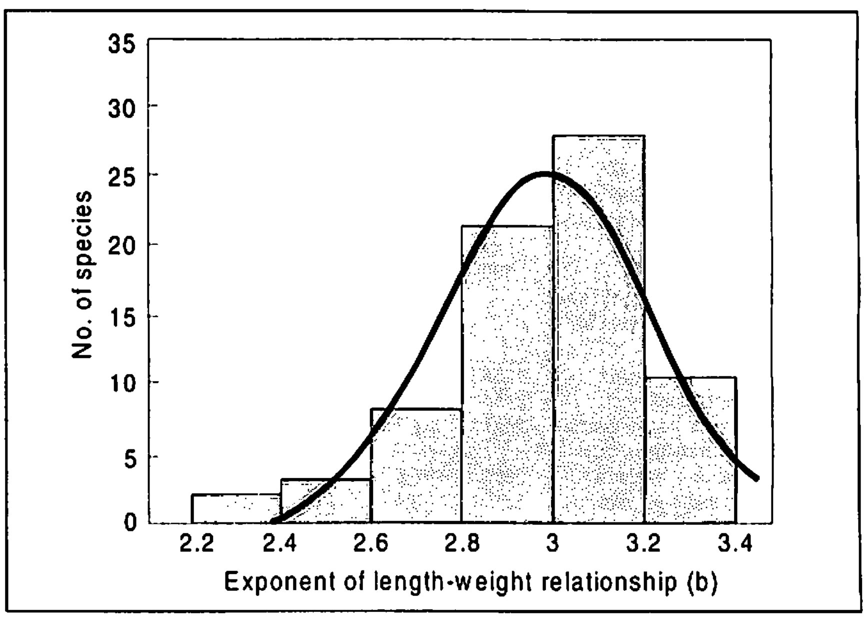

Fig. 2. Distribution of b values of the length-weight relationship.

values of b they analyzed (2.987 and 2.98, respectively). On the other hand, Torres (1992) recorded an average value of b = 3.112 for 40 species of Lake Kariba, Africa, which is significantly higher than 3.

In the analysis of each species it was established that the majority (52) had values of b significantly different from 3. This proves the indispensible use of the allometric condition factor in these cases. According to Braga (1986), in the case of these species, k does not vary with fish length. This is a basic premise emphasized by Weatherley and Gill (1987). The correct interpretation of the parameters resulting from the length-weight relationship of the species will disclose information that is useful to the study of fishing biology and management. In this case it should be emphasized that the application of the results of the above-mentioned regressions should be restricted to specimens of the respective species that present standard length within the range of values described in this study.

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