鱼类体重、体长及寿命的种间尺度关系研究

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摘要：本文首先呈现出来自文献以及 FishBase 的关于鱼类体长、体重以及寿命的数据，包括 69 个科 195 种。文章与种内体重-体长关系（$W\sim L^{3.0}$）对比，对种间关系做统计分析，发现体重是提倡的 2.5 次幂函数（$W\sim L^{2.5}$）。另外，寿命与体长也呈现出微弱的幂函数关系($S\sim L^{0.525}$)。

关键词：体长；鱼类；寿命；尺度关系

Interspecific Scaling Relationships of Fishes Among Weight, Length, and Longevity

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Abstract

This paper presents data of length, weight, and longevity gathered from literature and FishBase belonging to 195 fish species and 69 families. Compared with intraspecific weight-length relationship ($W\sim L^{3.0}$), interspecific weight scales as 2.5-power of length ($W\sim L^{2.5}$). Additionally, interspecific longevity also shows a weak power-relationship with body length ($S\sim L^{0.525}$).

Key Words: Body size; fish; longevity; scaling relationship.

Introduction

Relationships among weight, length and longevity are very useful for fisheries researches, and also they are the most important allometric relationships in living organisms (Kozlowski and Weiner 1997, West et al. 1999, Kozlowski and Gawelczyk 2002). Weight-length

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relationships can allow the conversion of growth-in-length equations to growth-in-weight for use in stock assessment models, and support the estimation of biomass from length observations (Gonçalves et al. 1996, Froese and Pauly 1998, Moutopoulos and Stergiou 1998, Stergiou and Moutopoulos 2001). While, relationships between longevity and body size can determine the dynamics and age structure of shoals (Molles 2000). They are one kernel of FishBase (Froese and Pauly 1998) and have important practical significances. In this paper we gathered data from FishBase (www.fishbase.org), *Fauna Sinica* (Li and Wang 1995, Zhang 2001, Chen 2002, Su and Li 2002), and others (Carey and Judge 2000) for 195 fish species in 69 families.

Materials and Methods

Morphological and physiological traits of living organisms correlate with body size as a power equation, $Y=aX^b$, which can be linear regression after logarithmic transformation. These allometric scaling relationships result from the hierarchical fractal-like nature of organisms (West et al. 1997). Relationships between body weight (W) and body length (L), and between longevity (S) and body length can also be derived as two linear regressions: $\log[W]=\log[a]+b*\log[L]$ and $\log[S]=\log[c]+d*\log[L]$ (Kozlowski 1996). For all these relationships presented here, length has been expressed in centimeter (cm), weight in kilogram (kg), and longevity in year (yr). Length and weight are the averaging amount of adult fish, and longevity is defined as the maximal age captured.

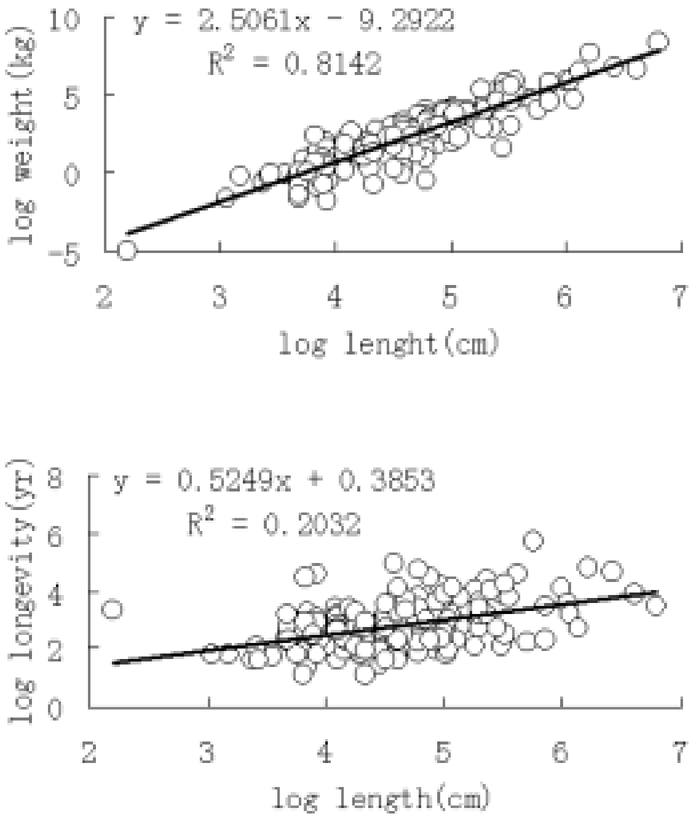

Fig. 1. Logarithmic plots of weight and longevity versus length for 195 fish species.

Results and Discussion

Data of 195 fish species belonging to 69 families is listed in Table 1, in which Class Cephalospidomorphi has three species (1.54%), Class Chondrichthyes 13 species (6.67%), and Class Osteichthyes 179 species (91.8%). In terms of families, Coregonidae, Centrarchidae, Cyprinidae, Gadidae, and Pleuronectidae dominate the records of species, with 20 (10.3%), 14 (7.2%), 11 (5.6%), 10 (5.1%), and 10 (5.1%), respectively.

By logarithmic conversion, we obtain the linear regression functions, shown in Fig. 1 (log[W]=2.5*log[L]-9.3, r^2=0.81; log[S]=0.4+0.5*log[L], r^2=0.2). Therefore, we have W(g)=0.09L(cm)$^{2.5}$ and S(yr)=1.47L9(cm)$^{0.525}$. The value of the slope of log[W] against log[L] is 2.5, and similar to the value of birds 2.447 (Lee et al. 1999). This result suggest that body mass or weight of vertebrates, interspecific allometry, scales as 2.5-power of body length. As for intraspecific allometry, Stergiou and Moutopoulos (2001) have indicated that this slope should be 3.0 with confidence for fish species. These two slopes may be underlying results of metabolic rates (B~W$^{3/4}$ for interspecific; B~W$^{2/3}$ for intraspecific).

Longevity has a weak correlation with body size (r^2=0.2). Gillooly et al. (2001) suggested that longevity should be the reciprocals of metabolic rates per unit mass, and hence we have S~W$^{1/4}$~L$^{0.625}$, which has an obvious difference with our result (S~L$^{0.525}$). Longevity, as an important life history trait, cannot be simply estimated by West's theoretical framework (West et al. 1997). Many scientists have doubted this framework (personal communication with J. Kozlowski). These interspecific Allometries may be a by-product of size optimizations (Kozlowski and Weiner 1997), and needs additional researches.

Table 1. Data of body length (L), weight (W), and longevity (S) for 195 fish species.

Species	L, cm	S, yr	W, kg	Species	L, cm	S, yr	W, kg
Abramis brama	82	17	6.01	Acipenser brevirostrum	143	67	23
Acipenser fulvescens	274	97	125	Acipenser medirostris	213	80	159
Acipenser oxyrhnchus	403	60	368	Acipenser transmontanus	610	104	816
Alosa pseudoharengus	40	9	0.2	Alosa saqidissima	76	11	5.5
Ambloplites rupestris	43	10	1.36	Ameriurus melas	66	10	3.62
Ameriurus natalis	47	4	1.92	Amia calva	109	12	9.75
Amiurus catus	55	8.1	2.74	Amphiodon alosoides	52	14	1.72
Amphistichus argenteus	43	6	2	Anguilla anguilla	133	88	6.599
Anguilla rostrata	152	43	7.33	Anoplopoma fimbrim	120	114	57
Aplodinotus grunniens	95	10	24.7	Archoplites interruptus	73	6	1.44
Archosargus probatocephalus	91	6	9.63	Bagrus bayad	72	17	5.9
Brosme brosme	120	20	30	Cantharus vulgaris	60	5	1.22
Carassius auratus	59	30	3	Carcharhinus leucas	350	32	316.5
Carcharhinus obscurus	420	35	346.5	Carpiodes carpio	64	10	4.59
Catostomus catostomus	64	20	3.3	Catostomus commersorii	64	12	2.94
Caulodatilus princeps	102	13	5.76	Centrarchus macropterus	29.2	5	0.56

Centropornus undecimalis	140	7	24.3	Ceratodus forsteri	170	19.7	40
Cetorhinus maxims	900	32	4000	Cheilotrema saturnum	45	3	0.7
Chrysichthys auratus	35	5.8	0.9	Clarias lazera	170	16.2	60
Clupea harengus	45	11	1.05	Conger conger	300	9	110
Coregonus clupeaformis	100	50	19	Cynoscion macdonaldi	200	15	100
Cynoscion nobilis	166	10	41	Cyprinus carpio	120	47	37.3
Distichodus niloticus	83	7.5	6.2	Dorosoma cepedianum	57	10	1.98
Electrophorus electricus	250	11.5	20	Embiotoca jacksoni	39	10	0.7
Eopsetta jordani	70	25	3.6	Epinephelus gigas	150	50	60
Esox lucius	137	10	28.4	Esox masquinongy	183	30	31.8
Esox niger	99	9	4.25	Gadus morhua	200	25	96
Gadus virens	130	25	32	Galeichthys felis	70	7	5.5
Galeocerdo cuvier	740	50	807.4	Galeorhinus australis	193	55	44.7
Germo alalunga	140	9	60.3	Ginglymostoma cirratum	430	25	109.6
Glyptocephalus cynoglossus	60	25	2.5	Gymnotus electricus	250	12.6	20
Haemulon sciurus	46	12	0.75	Hexanematichthys felis	70	7	5.5
Hiodon tergisus	47	10	0.907	Hippoglossus hippoglossus	240	50	320
Hippoglossus stenolepis	258	42	363	Huso huso	500	118	2072
Hydrocyon brevis	86	4.2	8.25	Hydrocyon forskalii	78	7.9	15.5
Hyperopisus bebe	51	10	1	Ictalurus catus	95	8.1	9.75
Ictalurus melas	66	10	3.62	Ictiobus bubalus	112	15	37.3
Ictiobus cyprinellus	123	20	31.9	Istiophorus americanus	315	305	58.1
Istiophorus platypterus	348	10	100.2	Lampetra fluviatilis	50	10	7
Lampetra tridentata	76	9	0.5	Lates niloticus	193	7.8	200
Lepibema chrysops	45	9	3.09	Lepisosteus osseus	200	36	22.8
Lepisosteus platostomus	88	20	2.6	Lepomis auritus	30.5	8	0.79
Lepomis cyanellus	31	5	0.96	Lepomis gibbosus	40	13	0.63
Lepomis macrochirus	41	10	2.15	Lepomis megalotis	24	6	0.79
Leucichthys sardinella	47	26	0.555	Leuciscus cephalus	60	22	8
Leuciscus idus	76	18	4	Leuciscus leuciscus	40	16	1
Limanda aspera	47	26	0.425	Lophius americanus	120	30	0.6
Lota lota	152	20	34	Lucioperca lucioperca	130	16	15
Lutjanus griseus	89	21	20	Lutjanus synagris	60	10	3.53
Macrozoarces americanus	110	17	5.436	Malopterurus electricus	122	10	20
Marcusenius isidori	9	29	0.007	Megalops cyprinoides	150	44	18
Melanogrammus aeglefinus	100	20	16.8	Menticirrhus undulatus	71	8	3.9
Merlangius merlangus	70	20	3.11	Merluccius merluccius	140	20	15
Micropterus coosae	47	10	3.71	Micropterus dolomieu	69	14	5.41
Micropterus punctulatus	63.5	7	4.65	Micropterus salmoides	97	23	10.1
Molva molva	200	25	45	Morone americana	49.5	7	2.2
Morone interrupta	46	7	11	Morone labrax	103	15	12
Morone saxatilis	200	30	57	Mugil cephalus	120	16	8

Neoplatycephalus macrodon	65	12	3	Neothunnus macropterus	239	8	200
Noemacheilus barbatulus	21	6	0.2	Oncorhynchus clarki	99	10	18.6
Oncorhynchus gorbuscha	76	3	6.8	Oncorhynchus keta	100	6	15.9
Oncorhynchus mykiss	120	11	25.4	Oncorhynchus nerka	84	7	7.71
Oncorhynchus tshawytscha	150	9	61.4	Ophiodon elongatus	152	16	59.1
Osteoglossam bicirrhosum	120	6.5	4.6	Paralabrax clathratus	72	20	7
Paralabrax nebulifer	67	31	5.98	Paralichthys californicus	152	6	33
Perca flavescens	50	11	1.91	Perca fluviatilis	51	22	4.75
Petromyzon marinus	120	9	2.5	Phycis blennoides	110	20	3.54
Pilodictis olivaris	155	20	55.8	Platichthys stellatus	91	24	9.1
Pleuronectes platesca	100	50	7	Pogonias crornis	170	43	51.3
Polyodon spathula	221	55	90.7	Polypterus senegalus	50.5	10	0.178
Pomoxis annularis	53	10	2.35	Pomoxis nigromaculatus	49	15	2.72
Pontinus clemensi	54.9	8	2.55	Prosopium cylindraceum	59	16	2.72
Prosopium williamsoni	70	14	2.92	Protopterus annectens	100	18	4
Pseudopleuronectes americanus	64	10	3.6	Ptychocheilus oregonensis	63	11	13
Raja clavata	105	12	18	Reporhamphus melanochir	52	10	0.6
Rhombus maximus	100	26	25	Roncador stearnsi	70	15	4.8
Rutilus rutilus	46	14	1.84	Salmo clarki	99	10	18.6
Salmo fario	100	5	20	Salmo salar	150	13	46.8
Salmo trutta	140	38	50	Salvelinus alpinus	107	40	15
Salvelinus fontinalis	86	7	9.39	Salvelinus malma	127	20	18.3
Salvelinus namaycush	150	50	32.7	Sardinops caerulea	39.5	25	0.486
Scardinius erythrophthalmus	51	19	2.097	Schilbe mystus	40	9.7	0.25
Sciaenops ocellata	155	7	45	Scomber scombrus	60	17	3.4
Scomberomorus maculatus	91	5	5.89	Scyliorhinus caniculus	100	10	1.32
Sebastes aleutianus	97	140	0.9	Sebastes alutus	51	100	1.4
Sebastes diploproa	46	84	0.81	Sebastes marinus	100	60	15
Sebastes mentella	75	15	6	Semotilus corporalis	51	6	1.61
Seriola dorsalis	250	12	96.8	Solea solea	70	27	3
Solea vulgaris	70	8	3	Sphyraena argentea	145	11	12
Spondyliosoma cantharus	60	15	1.22	Squalus acanthias	160	60	9.1
Stenotomus chrysups	46	19	2.06	Stereolepis gigas	250	70	255.6
Stizostedion canadense	76	7	3.96	Stizostedion vitreum	107	29	11.3
Synodontis schall	49	12	0.5	Tautoga onitis	91	34	11.3
Tetraodon fahaka	43	5.9	1	Theragra chalcogramma	91	15	1.4
Thunnus thynnus	458	15	684	Thymallus signifer	76	18	3.83
Thymallus vulgaris	60	14	6.7	Triaenodan obesus	213	25	18.3
Triakis semifasciata	198	30	18.4	Trichiurus lepturus	234	15	5
Urophycis tenuis	133	10	21				

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