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Short Communication

Length-Weight Relationship Parameters of Tropical Coral Reef Fishes in the South China Sea

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Authors' Contribution
JZ, KZ, ZC and YJ conceived and designed the study. JZ, ZC, YJ, YG and WY organized the database and performed the statistical analysis. JZ, KZ and YC wrote the manuscript.

Key words
Anterior gradient homolog 2, Red fluorescent protein, Recombinant expression, *Escherichia coli*

ABSTRACT

The present study reports the length-weight relationship parameters of dominant coral reef fish species in the South China Sea. The specimes were collected by hand-line in the lagoons of five representative coral reefs during June 2013 to September 2018. According to FishBase, this study provides first report on LWR of six studied species and practically available parameters on LWR for three species. The estimated b values ranged between 2.218 (*Parapercis millepunctata*) to 3.308 (*Halichoeres hartzfeldii*) and the corresponding a values ranged between 3.98×10^{-6} (*H. hartzfeldii*) to 6.00×10^{-4} (*P. millepunctata*). In five coral reefs, the means of b was significantly smaller than 3. There was significant negative linear correlation between lg$a$ and b.

Tropical coral reefs are critically important for the ecosystem goods and services (Moberg and Folke, 1999). They cover less than one percent of the ocean floor, nevertheless almost a third of the world's marine fish species are found on coral reefs. Coral reefs are the most distinctive ecosystem in the South China Sea (SCS). Due to climate change and human impacts, fish communities of coral reefs are in serious decline (Hughes *et al*., 2003). Conserving fish community was priorities for restoring biodiversity and ecological function of coral reef ecosystem (Zhao *et al*., 2012; Zhang *et al*., 2016). The length–weight relation (LWR) of fish was very imporpant biological data for understanding fish survival, growth, reproduction stock biomass, and so on (Froese, 2006; Quang, 2018). Likewise, estimation of particularly the standing stock, yield and biomass of a fish population, requires both length and weight data. Particularly, LWR are very useful to determine weight and biomass when only length is available in fishery research (Egerton *et al*., 2018). Thus, the objective of our study was to introduce data of LWR for tropical coral reef fish caught in the SCS, supplementing database and accumulating basic data for conservation of fish.

Materials and methods

Fish specimens were collected by hand-line in the lagoons of five coral reefs (Yongshu Reef, Meiji Reef, Zhubi Reef, Chenhang Island, Zhaoshu Island) in the SCS from June 2013 to September 2018. The specifications of the hand-line were as follows: line diameter 0.33 mm, nylon material, hook size 30×12 mm, working depth 10–40 m. Hand-lining was conducted during 07:00–22:00. After catching specimens, all specimens were identified, counted, and recorded. Each specimen was identified to the lowest practical taxon using morphological characteristics. All specimens were immersed in seawater and frozen to -40°C for shore–based analysis, where body length (BL, mm) and wet body weight (BW, 0.01 g) were taken.

The parameters of the LWR $W=aL^b$ were estimated using the transformed logarithmic expression, $\lg W = \lg a + b \lg L$ where, W is the wet body weight (g), L is the body length (mm), a is the intercept and b is the slope (Froese, 2006). Prior to regression analysis, outliers in the log–log plots were evaluated and removed from the data. Data calculation and statistical analysis were done at a level of significance of 0.05 with Microsoft Excel 2016 (Microsoft, Inc., USA) and SigmaPlot14.0 (Systat Software, Inc., USA).

Results

According to FishBase, our study provides first reports on LWRs for *Apogonichthyoides taeniatus*, *Halichoeres hartzfeldii*, *Myripristis vittata*, *Parapercis millepunctata*, *Pentapodus nagasakiensis* and *Sargocentron cornutum*. In addition, in fishbase the parameters of LWRs for

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Cephalopholis leopardus, *Cheilinus fasciatus* and *Malacanthus brevirostris* are unavailable because there is one specimens and supposed *b* value (*b*=3). Therefore, our study also provieds practically available parameters on LWRs for *C. leopardus*, *C. fasciatus* and *M. brevirostris*.

A total of 152 reef fish specimes of above nine species belonging to nine genera seven families two orders were analyzed (Table I). The statistical results of *LWR*s estimates are given in the Table II. The values of *a* and *b* obtained from the relationships was 3.92×10^{-5} and 2.962 for *A. taeniatus*, 1.00×10^{-4} and 2.693 for *C. leopardus* (mixed), 5.36×10^{-5} and 2.892 for *C. fasciatus*, 5.02×10^{-6} and 3.262 for *H. hartzfeldii*, 1.79×10^{-5} and 2.830 for *M. brevirostris*, 2.00×10^{-4} and 2.592 for *M. vittata*, 6.00×10^{-4} and 2.218 for *P. millepunctata*, 2.87×10^{-5} and 2.945 for *P. nagasakiensis*, 5.89×10^{-5} and 2.837 for *S. cornutum*, respectively. In our study, linear equation W=aL+b was also good at fitting the relationship between W and L for *P. millepunctata* (W=0.549L-39.64, a: 0.529–0.568, b: -42.16 – -37.13, R^2: 0.990).

The relationships between lg*a* and *b* for dominnat fish in the lagoon of five representative coral reefs in the SCS were summarized. In Zhaoshu Island, Chenhang Island, ZhuBi Reef, Meiji Reef and Yongshu Reef, 139 specimens (9 species), 1069 specimens (10 species), 1357 specimens (17 species), 926 specimens (19 species) and 2273 specimens (25 species) were respectively collected during June 2013 to September 2018 (Table III).

Table I.- Specimens information on coral reef fishes, South China Sea.

Species	Order	Family	Sample lagoon	Coordinate	Sample date
A. taeniatus	Perciformes	Apogonidae	Meiji Reef	9°54′N, 115°32′E	28–30/4/2018
C. leopardus	Perciformes	Serranidae	Yongshu Reef	9°37′N, 112°58′E	6–9/9/2018
C. fasciatus	Perciformes	Labridae	Meiji Reef	9°54′N, 115°32′E	6/12/2016
H. hartzfeldii	Perciformes	Labridae	Yongshu Reef	9°37′N, 112°58′E	6–9/9/2018
M. brevirostris	Perciformes	Malacanthidae	Yongshu Reef	9°37′N, 112°58′E	6–9/9/2018
M. vittata	Beryciformes	Holocentridae	Yongshu Reef	9°37′N, 112°58′E	12/4/2016
P. millepunctata	Perciformes	Pinguipedidae	Yongshu Reef	9°37′N, 112°58′E	6–9/9/2018
P. nagasakiensis	Perciformes	Nemipteridae	Chenhang Island	16°27′N, 111°43′E	10–11/5/2018
S. cornutum	Beryciformes	Holocentridae	Zhaoshu Island	16°58′N, 112°16′E	13/5/2018

Remark: *C. leopardus* specimens consistes of 18 females and 17 males.

Table II.- Estimated parameters of body length–body weight relationship of nine coral reef fishes, South China Sea.

Species	N	*BL* range /mm	*BW* range/g	*a*	95% CL of *a*	*b*	95% CL of *b*	R^2
A. taeniatus	17	78–99	15.53–33.13	3.92E-5	7.34E-6–7.10E-5	2.962	2.783–3.142	0.955
C. leopardus/Mixed	35	72–109	12.04–35.64	1.00E-4	5.92E-5–1.41E-4	2.693	2.618–2.769	0.977
C. leopardus/F*	18	72–103	12.04–31.08	4.91E-5	2.17E-5–7.65E-5	2.891	2.768–3.015	0.972
C. leopardus/M**	17	82–109	17.40–35.64	2.00E-4	1.13E-4–2.87E-4	2.594	2.492–2.696	0.978
C. fasciatus	20	124–179	60.00–172.83	5.36E-5	3.78E-5–6.95E-5	2.892	2.834–2.951	0.993
H. hartzfeldii	8	112–163	26.40–82.64	5.02E-6	1.36E-6–8.68E-6	3.262	3.117–3.407	0.993
M. brevirostris	17	157–204	29.88–61.16	1.79E-5	9.39E-6–2.64E-5	2.830	2.739–2.931	0.985
M. vittata	19	95–165	27.43–119.00	2.00E-4	1.09E-4–2.91E-4	2.592	2.504–2.679	0.980
P. millepunctata	10	117–149	24.42–41.92	6.00E-4	4.00E-4–8.00E-4	2.218	2.138–2.298	0.988
P. nagasakiensis	17	127–172	48.25–108.01	2.87E-5	2.49E-5–3.26E-5	2.945	2.918–2.972	0.979
S. cornutum	9	115–152	41.40–92.90	5.89E-5	2.67E-5–9.11E-5	2.837	2.726–2.948	0.991

Remark: Mixed denotes parameters of LWR, regardless of sex. F* and M** respectively denote parameters of LWR from female and male specimens. N denotes specimens size.

Table III.- Dominant reef fish species in five representative coral reefs, South China Sea.

Coral reef	Dominant species
Zhaoshu Island	*Cephalopholis urodeta, Gnathodentex aureolineatus, Gymnocranius euanus, Lethrinus rubrioperculatus, Lethrinus semicinctus, Myripristis murdjan, M. vittata, Parupeneus trifasciatus, S. cornutum*
Chenhang Island	*C. leopardus, Cephalopholis spiloparaea, Cheilinus chlorourus, Epinephelus merra, G. aureolineatus, L. rubrioperculatus, Oxycheilinus celebicus, P. trifasciatus, Pentapodus caninus, P. nagasakiensis*
Zhubi Reef	*A. taeniatus, C. leopardus, C. urodeta, C. chlorourus, C. fasciatus, E. merra, Epinephelus quoyanus, Epinephelus spilotoceps, G. aureolineatus, Lutjanus gibbus, Lutjanus kasmira, Melichthys vidua, Monotaxis grandoculis, P. trifasciatus, P. caninus, Scolopsis lineata, Scolopsis margaritifer*
Meiji Reef	*A. taeniatus, C. chlorourus, C. fasciatus, Ctenochaetus striatus, E. merra, Gerres filamentosus, Halichoeres hortulanus, Lethrinus atkinsoni, Lethrinus microdon, Lethrinus obsoletus, L. rubrioperculatus, L. gibbus, L. kasmira, Lutjanus sebae, Lutjanus spilurus, Mulloidichthys vanicolensis, P. caninus, S. cornutum, S. lineata*
Yongshu Reef	*Aphareus furca, Balistapus undulatus, C. leopardus, Cephalopholis sonnerati, C. spiloparaea, C. urodeta, G. aureolineatus, H. hartzfeldii, L. kasmira, M. brevirostris, M. vidua, M. grandoculis, Myripristis botche, M. murdjan, M. vittata, Odonus niger, Paracaesio sordida, Parapercis hexophtalma, P. millepunctata, P. trifasciatus, Pristipomoides multidens, Sargocentron caudimaculatum, Scarus dimidiatus, Scarus globiceps, Sufflamen chrysopterum*

Table IV.- Characteristics of *b* and lg*a* of dominant reef fish in five representative coral reefs, South China Sea.

Coral reef	Range of sample size	*b*		lg*a*	
		Mean	Range	Mean	Range
Zhaoshu Island	8 (*M. vittata*)–28 (*G. aureolineatus*)	2.881±0.331	2.142-3.311	−4.338±0.741	−5.319-−2.745
Chenhang Island	8 (*C. chlorourus*)–380 (*P. caninus*)	2.950±0.235	2.613-3.478	−4.515±0.514	−5.685-−3.699
Zhubi Reef	9 (*C. fasciatus*)–502 (*P. caninus*)	2.933±0.241	2.473-3.479	−4.431±0.492	−5.512-−3.523
Meiji Reef	8 (*C. striatus*)–283 (*E. merra*)	2.810±0.286	2.434-3.590	−4.149±0.624	−5.838-−3.301
Yongshu Reef	8 (*H. hartzfeldii*)–731 (*G. aureolineatus*)	2.982±0.148	2.656-3.294	−4.523±0.322	−5.239-−4.000

The mean and range of *b* and lg*a* were shown in the Table IV. For five coral reefs, the means of *b* was significantly smaller than 3 (T test, $P<0.05$). There was significant negative linear correlation between lg*a* and *b* (Fig. 1). In the the Nansha Islands, the slope of the linear expression between lg*a* and *b* increased with the latitude (Fig. 2). However, in the Zhongxisha Islands, the slope decreased with the latitude. The relationship between the intercept and the latitude was the opposite of that between the slope and the latitude (Fig. 2).

Discussion

The diversity of fishes found on the coral reefs are overwhelming. The conservation of coral reef fishes is a top priority. For nine species in our study, no reliable database on LWR exists in science literature. Although, the sample size of these species was relatively small. Maybe these species are not common species. Fish LWRs are influenced by a series of factors sucn as sex, size range, growth phase, stomach fullness, gonad maturity, habitat, and so on (Froese, 2006; Sher *et al*., 2018). For *C. leopardus*, the *a* and *b* values of LWRs from female specimens were different from that of male. For *P. millepunctata*, the estimated *b* value was without the anticipated range 2.5–3.5, which may be related to the narrow size ranges. This study provides first reports on available parameters of LWRs for nine coral reef fish in the SCS, which will be useful to conserve coral reef fish. In this study, the change between lg*a* and *b* also presents a significant negative linear change relationship. When *b* decreases, the lg*a* increases according to a certain linear relationship. In addition, from the relationship between the slopes of linear expressions between lg*a* and *b* and latitude, the (lg*a*)/*b* ratio may be connected with fish body density and environment (Li *et al*., 2011).

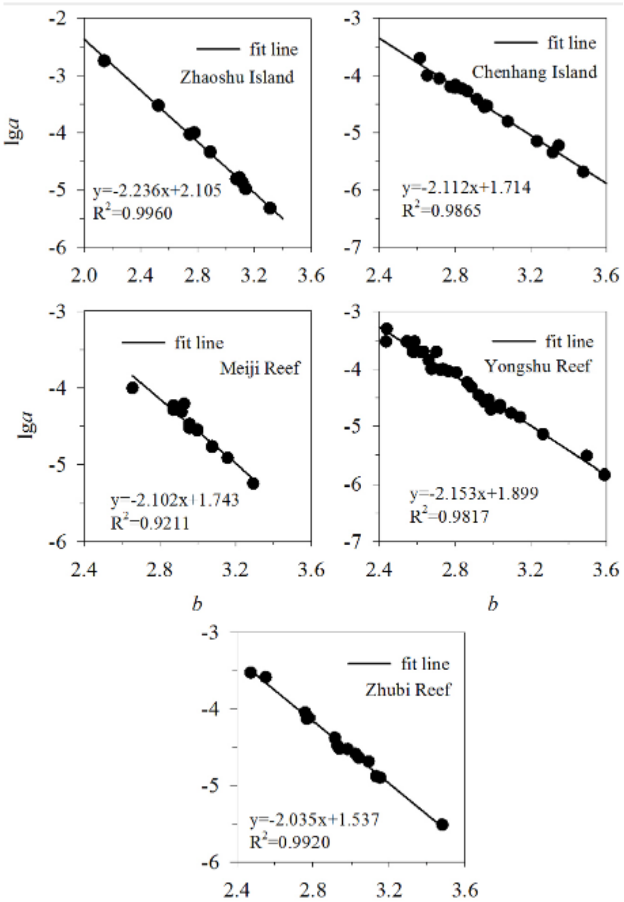

Fig. 1. Negative linear relationship between lg*a* and *b* for main coral reef fish in Zhaoshu Island, Chenhang Island, Yongshu Reef, Meiji Reef and Zhubi Reef in the South China Sea.

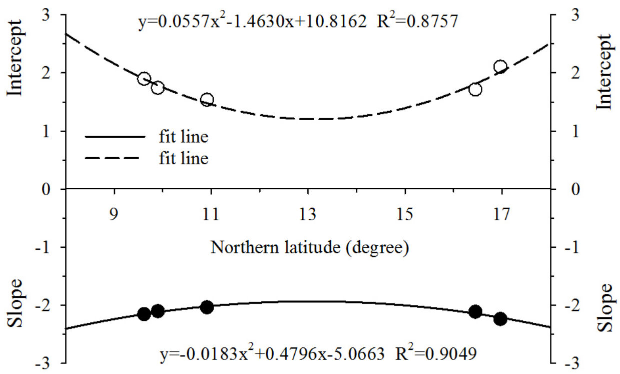

Fig. 2. The slope and intercept of linear relationship between lg*a* and *b* for main coral reef fish versus the latitudes of coral reef in the South China Sea.

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Statement of conflict of interest

The authors declare no conflict of interest.

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