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Short Communication

Length-Weight relationships of nine goatfish species (Teleostei: Mullidae) from the Persian Gulf and Oman Sea

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Abstract: Goatfishes (Teleostei, Mullidae) are one group of mainly coastal fishes that form an important part of food chains, and also have commercial value. Mathematical models of fish growth provide an objective and practical method for description of growth parameters and estimation of fish weight at different time series. This study presents and describes length-weight relationships for nine goatfish species belonging to three genera of *Mulloidichthys*, *Parupeneus* and *Upeneus* collected from the Persian Gulf and Oman Sea. The slope (b) of LWRs for all mullid species fell within the expected range of 2-4 varying from 2.370 for *Parupeneus heptacanthus* to 3.179 for *Upeneus vittatus* based on total length and from 2.391 for *U. sundaicus* to 3.804 for *P. rubescens* based on standard length, and r^2 values ranged from 0.927 for *U. tragula* to 0.992 for *U. pori*. All the LWRs were highly significant, with $P<0.005$.

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Introduction

Mathematical models of fish growth provide an objective and practical method for describing growth parameters and estimating fish weight at different time series (Silva et al., 2015). A precise and accurate length-weight relationship (LWRs) equation allows for the conversion of growth-in-length to growth-in-weight in fish stock assessment models and also estimation of biomass from the length frequency distribution, condition factor, and morphological characteristics of different fish populations (Silva et al., 2015). The relationship equation also is an important aquaculture management tool. LWRs are commonly used as a fundamental tool for estimation of weight and biomass of the species understudies, where weighing fish in the field is often not possible to provide sufficient precision for LWR estimates (Esmaeili and Ebrahimi, 2006; Esmaeili et al., 2014; Hossain and Sultana, 2014; Sadeghi and Esmaeili, 2018). Also, in conjunction with several other parameters (e.g. sex ratio, age at first maturity, longevity, and fecundity), LWR can be used in population dynamics studies. Length and weight are biometric data easily taken and available in most datasets from monitoring studies (Zuchi et al., 2020).

This relationship is generally expressed by the equation $W = aL^b$. In this formula, coefficient a describes body shape, and coefficient b gives information about the balance of the dimensions. Values of b can be smaller than 3 (negative allometry = the fish grows faster in weight than in length), bigger than 3 (positive allometry = the fish grows faster in length than in weight), or equal to 3 (isometry) (Koutrakis and Tsikliras, 2003; Froese, 2006).

Despite the usefulness and significance of the length-weight relationship in fisheries management programs and the economic importance of mullid fishes, little comparative information on these parameters is available for these fishes in the Persian Gulf and Oman Sea.

Goatfishes are predominantly benthivorous fishes that inhabit marine and brackish waters above sandy

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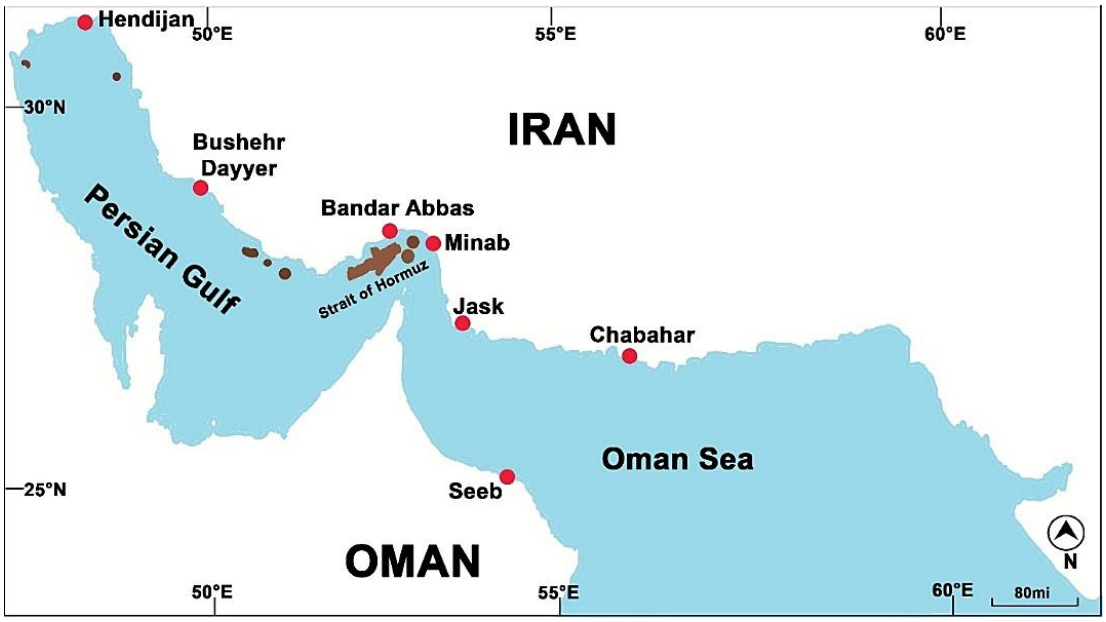

Figure 1. Map of study area showing the location of the Persian Gulf and the Oman Sea.

to muddy bottoms and coral reefs. They are distributed worldwide in tropical, subtropical, and temperate habitats between the upper littoral and the upper slope (Uiblein, 2007; Echreshavi et al., 2021). Mullids comprise an important part of food chains in coastal ecosystems and have commercial value in many regions worldwide (Pavlov, 2012). They are valuable fishes in ecosystem monitoring and management programs because they are sensitive to human-induced activities such as fisheries and habitat modification (Uiblein, 2007; Echreshavi et al., 2021).

The present study was conducted to determine the length-weight relationship parameters for nine mullids, *Mulloidichthys vanicolensis* (Valenciennes, 1831), *Parupeneus heptacanthus* (Lacepède, 1802), *P. margaritatus* Randall & Guézé, 1984, *P. rubescens* (Lacepède, 1801), *Upeneus doriae* (Günther, 1869), *U. pori* Ben-Tuvia & Golani, 1989, *U. sundaicus* (Bleeker, 1855), *U. tragula* Richardson, 1846, and *U. vittatus* (Forsskål, 1775) collected from the Persian Gulf and the Oman Sea.

Materials and methods

The fishes were collected from seven localities in the Persian Gulf and Oman Sea, including Hendijan (29°94'N, 49°62'E), Dayyer (27°49'N, 51°56'E), Bandarabbas (27°10'N, 56°16'E), Minab (26°54′N, 56°41′E), Jask (25°41'N, 57°53'E) Chabahar (25°21'N, 60°36'E) and Seeb (23°43′N, 58°11′E), using artisanal fishing gear (gill net and trammel net) (Fig. 1). The sampling was done between August 2017 and February 2022. Fish species were identified (Fig. 2) according to Ben-Tuvin and Kissil (1998), Randall and Kulbicki (2006), Barman et al. (2007), and Uiblein and Heemstra (2010). The identifications were confirmed by DNA barcoding.

The collected specimens were fixed in 70% alcohol. The total length (TL), and Standard length (SL) of the specimens were measured to the nearest 0.1 mm using digital calipers attached to the computer. Using a digital electronic balance, the specimens were weighed to the nearest 0.01 g (total weight, TW). The relationship between length and weight was estimated using the formula of $W = aL^b$, where W is the total weight (g) and TL is the total length (cm). The parameters a and b were calculated by functional regression. The b-value for each species was tested by t-test at the 0.005 significance level to verify that it was significantly different from isometric growth (Beverton and Holt, 1996; Froese, 2006). The LWR helps to determine whether it is an isometric (b=3) or an allometric growth pattern (positive if b>3 or negative if b<3) (Morey et al., 2003). The extent of association between the variables were computed by

Table 1. Descriptive statistics and parameters of LWRs for nine fish species from the Persian Gulf and the Oman Sea.

Species	TL/SL	N	TL/SL range (cm)	W range (g)	a	95% CI of a	b	95% CI of b	r^2
M. vanicolensis	TL	30	21.79-31.03	126.20-330.45	0.0223	0.0112-0.0444	2.822	2.613-3.031	0.965
	SL	30	17.91-24.67		0.0216	0.0119-0.0390	3.021	2.830-3.213	0.974
P. heptacanthus	TL	30	17.44-25.51	68.18-229.40	0.0111	0.00543-0.02281	2.370	2.161-2.578	0.951
	SL	30	13.56-20.92		0.00479	0.00177-0.01298	3.584	3.269-3.899	0.951
P. margaritatus	TL	35	19.46-37.46	147.90-600.21	0.0224	0.0113-0.0524	2.815	2.574-3.055	0.945
	SL	35	17.26-26.84		0.0647	0.02168-0.05171	2.938	2.564-3.311	0.971
P. rubescens	TL	30	24.85-42.60	218.30-998.65	0.0296	0.0163-0.0537	2.796	2.627-2.965	0.976
	SL	30	19.59-29.65		0.002809	0.00133-0.00592	3.804	3.571-4.037	0.976
U. doriae	TL	55	10.55-22.60	12.42-82.40	0.0205	0.0124-0.0339	2.788	2.596-2.979	0.941
	SL	55	8.71-15.18		0.01139	0.006784-0.01915	3.321	3.103-3.539	0.946
U. pori	TL	30	18.21-27.62	90.50-247.21	0.09001	0.00709-0.01141	2.388	2.312-2.464	0.993
	SL	30	14.41-20.21		0.03588	0.02666-0.04827	2.941	2.837-3.045	0.992
U. sundaicus	TL	30	17.26-29.84	91.40-255.13	0.04999	0.002611-0.09571	2.809	2.612-3.006	0.927
	SL	30	12.64-25.75		0.03793	0.05411-0.02652	2.391	2.276-2.507	0.956
U. tragula	TL	30	11.53-25.17	90.60-398.49	0.03643	0.005688-0.09571	2.550	2.400-2.699	0.942
	SL	30	9.03-21.65		0.01770	0.02704-0.01158	2.406	2.253-2.559	0.927
U. vittatus	TL	30	13.66-21.70	37.20-140.25	0.00761	0.00401-0.0144	3.179	2.961-3.398	0.969
	SL	30	11.73-16.00		0.00104	0.000419-0.00259	3.252	2.907-3.596	0.958

determining the regression coefficient (r^2) and its significance level and confidence limit of 95% of parameters a and b were calculated.

Results

Parameters of length-weight relationships for the nine studied species of mullids, including the length and weight ranges, and the equation parameters a and b, together with their 95% confidence intervals and the coefficient of determination, are given in Table 1. LWRs were significant for all species ($P<0.005$) with high correlation coefficients with $r^2 \geq 0.927$. The slope (b) of LWRs for all mullid species fell within the expected range of 2-4, varying from 2.370 for *P. heptacanthus* to 3.179 for *U. vittatus* based on TL (Table 1) and from 2.391 for *U. sundaicus* to 3.804 for *P. rubescens* based on SL (Table 1).

Discussion

The b-value of length-weight relationships based on TL from 2.370 for *P. heptacanthus* to 3.179 for *U. vittatus* based on SL and from 2.391 for *U. sundaicus* to 3.804 for *P. rubescens* is within the expected range of 2-4 (Bagenal and Tesch, 1978). This parameter is usually encountered in fin fishes, which lie between 2 and 4 according to Bagenal and Tesch (1978) or 2.5 and 3.5 based on Froese (2006). According to Carlander (1977), the values of b<2.5 or >3.5 are frequently caused by samples with narrow size ranges. For length-weight relationships, the value of parameter b depends primarily on the shape and fatness of the fish species (Gubiani and Agostinho, 2009). *Parupeneus heptacanthus* presented a b value of 2.370 (based on TL), which shows an over-proportional length increase relative to weight growth. According to Froese (2006), it is reflected when b<2.5 (Froese, 2006). However, *P. rubescens* presented b-value of 3.804 (based on SL) that reveals an over-proportional increase in weight relative to growth in length. In addition, *U. sundaicus* with b-value of 2.391 (SL) is characterized by having a moderately elongated body compared to other studied goatfishes (Fig. 2), which shows the effect of its body form on the b value. In contrast, *P. rubescens* has a deep body with a high b-value of 3.804 (based on SL).

It has been already reported that variation in b-value in fishes might be due to several factors, including species, sample size, fish length (TL, SL, FL), season, habitat, sex, gonad maturity, diet, stomach fullness, health, preservation techniques and locality (Le-Cren, 1951; Esmaeili, 2001; Froese, 2006; Lakshmikanth et al., 2021). Differences in the LWRs could be due to the combination of one or more of the above factors. Goatfishes of the family Mullidae are characterized by having a moderately elongated and somewhat compressed body (size to 50 cm).

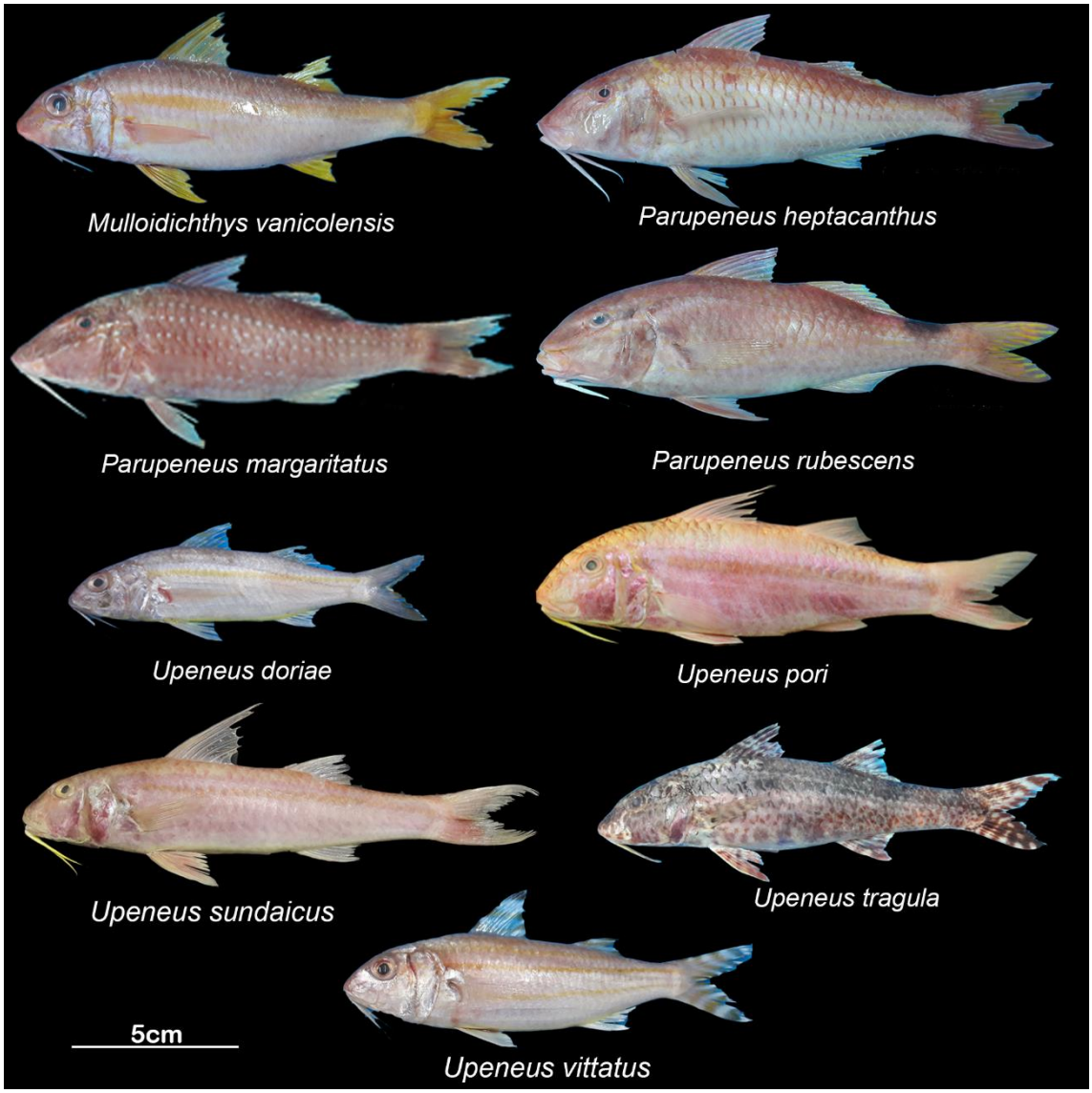

Figure 2. Studied mullid species from the Persian Gulf and the Gulf of Oman.

In conclusion, this study provides basic information on LWRs of nine goatfishes species from the Persian Gulf and the Oman Sea, with a b value within the expected range of 2-4, which will be useful in their fisheries and conservation management.

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