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NOTE

Size structure of Areolate grouper (*Epinephelus areolatus*) from the Saudi coast of the Arabian Gulf

Jesusito A. Vicente*

Pangasinan State University, Binmaley Campus, Binmaley 2417, Pangasinan, Philippines

ABSTRACT. Areolate grouper, *Epinephelus areolatus*, is one of the reef-associated fish species which is highly sought-after in the seafood trade. Consequently, a high market demand resulted to overexploitation and population decline of the species in the wild. This paper aimed to determine the size structure of *E. areolatus* from the Arabian Gulf. A total of 355 specimens of *E. areolatus* collected over the 12-month sampling period revealed high proportions of females observed throughout the year and in size class. Males (29.3 cm, 358.44 g) were bigger and heavier than females (28.8 cm, 326.66 g). The 'b' values ranging from 2.86 to 2.88 indicated negative allometric growth. The relationship between length and weight showed significant positive correlations with $p < 0.0000$ and r^2 values ranging between 96.05-97.12%.

Key words: Arabian Gulf, areolate grouper, length-weight relationship.

Estructura de talla del mero areolado (*Epinephelus areolatus*) de la costa saudí del Golfo Arábigo

RESUMEN. El mero areolado, *Epinephelus areolatus*, es una de las especies de peces asociadas a los arrecifes que es muy buscada en el comercio de productos del mar. Consecuentemente, una alta demanda de mercado resultó en la sobreexplotación y la disminución de la población de la especie en la naturaleza. Este trabajo tuvo como objetivo determinar la estructura de tamaño de *E. areolatus* del Golfo Arábigo. Un total de 355 muestras de *E. areolatus* recolectadas durante 12 meses de muestreo revelaron altas proporciones de hembras durante todo el año y en la clase de talla. Se observa que los machos (29,3 cm, 358,44 g) fueron más grandes y pesados que las hembras (28,8 cm, 326,66 g). Los valores de "b" que oscilan entre 2,86 y 2,88 indicaron un crecimiento alométrico negativo. La relación entre longitud y peso mostró correlaciones positivas significativas con $p < 0,0000$ y valores de r^2 que oscilaron entre 96,05-97,12%.

Palabras clave: Golfo Arábigo, mero areolado, relación largo-peso.

*Correspondence:
jesusito.vicente@gmail.com

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Areolate groupers, *Epinephelus areolatus* (Forsskål, 1775), are reef-associated fishes found mainly on depths ranging from 6-200 m (Froese and Pauly 2013). They are usually inhabitants of seagrass beds or fine sediment bottoms near rocky reefs, dead coral, or alcyonarians, in shallow continental shelf waters (Tupper and Sheriff 2008; Froese and Pauly 2013; Sanaye 2014). Despite the wide distribution of Family Epinephilidae, this species is found only in the Indo-Pacific region (Russell and Houston, 1989; Heemstra and Randall 1993; Ottolenghi et al. 2004; Sanaye 2014) (Figure 1). Areolate

groupers are important fisheries and aquaculture species. Together with other grouper species, they are considered most highly sought-after food fishes in the seafood trade (Kuo 1995; Sadovy et al. 2003). However, the high demand of grouper in the market generated a negative ecological impact. It is the most

intensively exploited group in the live fish trade, implying that this group is heavily overfished (Morris et al. 2000). Studies reveal that trade often follows a pattern of sequential overexploitation where the most sought species is targeted and fished out first before the less valuable species (Johannes and Riepen 1995; Sluka 1997). Barrowman and Myers (1996) and Reinert et al. (2005) indicated that the removal of considerable number of sexually mature fish in the stock would compromise the overall stock reproductive output, especially the species forming concentrated and brief spawning aggregations (Sadovy and Domeier 2005), such as this group. Population decline was already observed in some areas and is attributed to overfishing, habitat degradation and pollution, destructive fishing techniques, high export demand, etc. (Johannes 1997; Sadovy 2000). Together with the compounding effect brought about by natural and anthropogenic causes, stocks cannot sustain their population. As a result, natural stocks are depleted or even worse, some species are threatened to become extinct. At present, some species of groupers are already considered 'threatened organisms' according to IUCN categories and criteria.

In the region, fisheries are considered as the most important natural resource next to oil (Carpenter et al. 1997). In Saudi Arabia, production figures reveal an increasing trend from 1996 to 2005 (Ministry of Agriculture Saudi Arabia, 2007). Only in 2005, a total of 74,779 t of seafood products were produced from traditional fishing, industrial fishing, fresh and marine aquaculture. Nearly three-fourths (70.5%) of total catch contributed from traditional fishing. Industrial fishing and aquaculture account only for 10.2% and 19.2%, respectively. There are two main grouper species commonly sold in the market, namely *E. coiodes* and *E. areolatus.* Their prices range from USD 15-25 and USD 8-11 kg^{-1}, respectively.

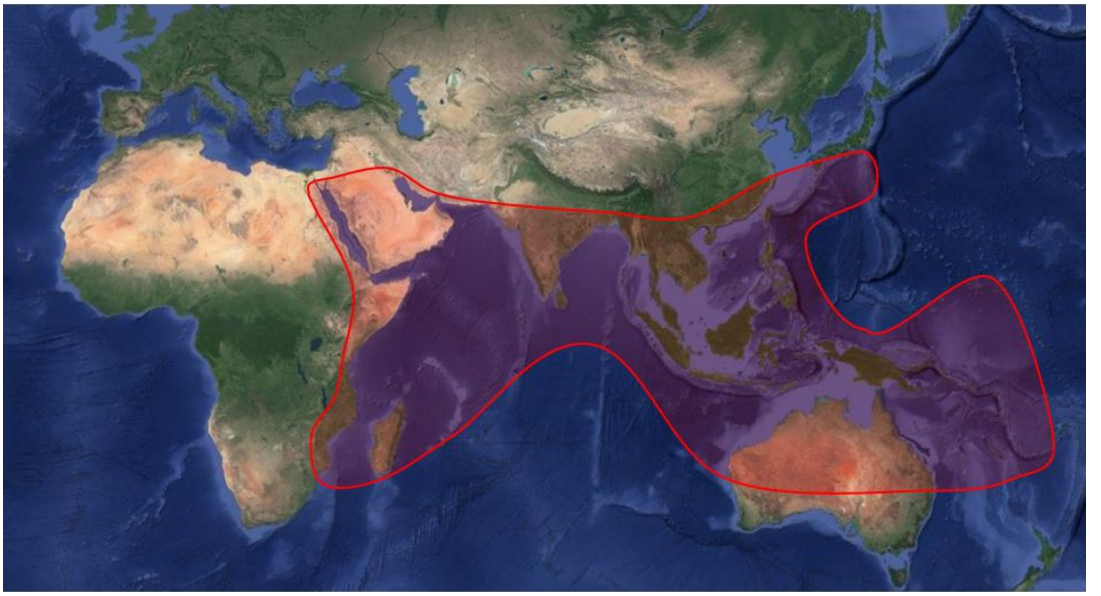

Figure 1. Geographical distribution of *Epinephelus areolatus*.

The purpose of this study was to determine the size structure of areolate grouper, *E. areolatus* from the Arabian Gulf. It particularly focuses on the length-weight relationship which can be a useful tool in management and conservation of the species in area.

Specimens of *E. areolatus* were collected on a monthly basis from Jubail Fish Market and Auction Center, a major fish landing site on the eastern province of Saudi Arabia, western part of the Arabian Gulf. A total of 355 samples were collected over the 12-month sampling period from February 2014 to January 2015. The relationship between total length (TL) and whole-body weight (BW) of *E. areolatus* was analyzed by measuring length and weight of the specimens. The statistical relationship between these parameters of fishes was determined by using the parabolic equation formulated by Froese (2006) as follows:

$$W = aL^b$$

where, W = weight of fish (g), L = length of fish (mm), a = constant and b = an exponential expressing relationship between length-weight. Such relationship when converted into the logarithmic form gives a straight-line relationship graphically. The same equation mentioned above is written in logarithmic form as:

$$\text{Ln } W = \text{Ln } a + b*\text{Ln } L$$

where, b and the coefficient of determination r^2 were estimated at 95% confidence limit. Statistical analyses were computed using EXEL STAT for Windows (XLSTAT 2007).

The length of the gathered samples ranged between 17.1-47.1 cm, with the mean length of 28.95 cm. The weight ranged between 58.10-1,343.43 g, with the mean of 334.80 cm. It was further observed that males (29.3 cm, 358.44 g) were bigger and heavier than females (28.80 cm, 326.66 g). Maximum length and weight reported in other areas were as follows: 50.5 cm and 1.94 kg in Egypt (Abd-Allah et al. 2015), 29.5 cm in the Philippines (Gumanao et al. 2016), 49.5 cm and 1.5 kg in India (Nair et al. 2021), and 30.2 cm and 0.38 kg in Indonesia (Fadli et al. 2022).

The 'b' value was 2.88 for males while for females it was 2.86, and for combined sexes it was 2.87. Results indicated that the weight of *E. areolatus* increased with the increasing length (Figure 2). Analysis of regression shows that there was a significant relationship between the two variables with $p < 0.0000$ and r^2 values ranging between 96.05-97.12%. Typically, growth in fish is explained by von Bertallanfy curve (Hopkins 1992; Pauly 1994; Jobling 2002) represented by an asymptotic sigmoid curve in many species (Ricker 1979). In reef fishes like *E. areolatus*, fast growth is exhibit during pelagic and juvenile stages, however, it slows down during transitions into adulthood to apportion more energy for breeding (Jobling 1994; Hutchings 2003; Claro and Garcia-Arteaga 2014). In the present study, computed 'b' values were 2.87 (combined sexes), 2.88 (males) and 2.86 (females). This is an indication that the fish shows a negative allometric growth implying that the parts of the fish grow slower compared to its body as a whole. This growth performance index is similar to the studies conducted from the Gulf of Suez (2.83), north coast of Aceh, Indonesia (2.86-3.31), southwest coast of India (2.95-3.2) and Davao Gulf, Philippines (3.03) (Abd-Allah et al. 2015; Gumanao et al. 2016; Nair et al. 2021; Fadli et al. 2022).

The relationship between length and weight showed a positive correlation, suggesting that the weight of *E. areolatus* increased with the increasing length. According to Jennings and Polunin (1997), this relationship is a morphometric measurement of how a species allocates mass allometrically. The association between the two variables can be useful to estimate standing crop biomass (Abd-Allah et al. 2015), assess species fitness overtime (Bolger and Connolly 1989) and provides information on production capabilities (Jobling 2002).

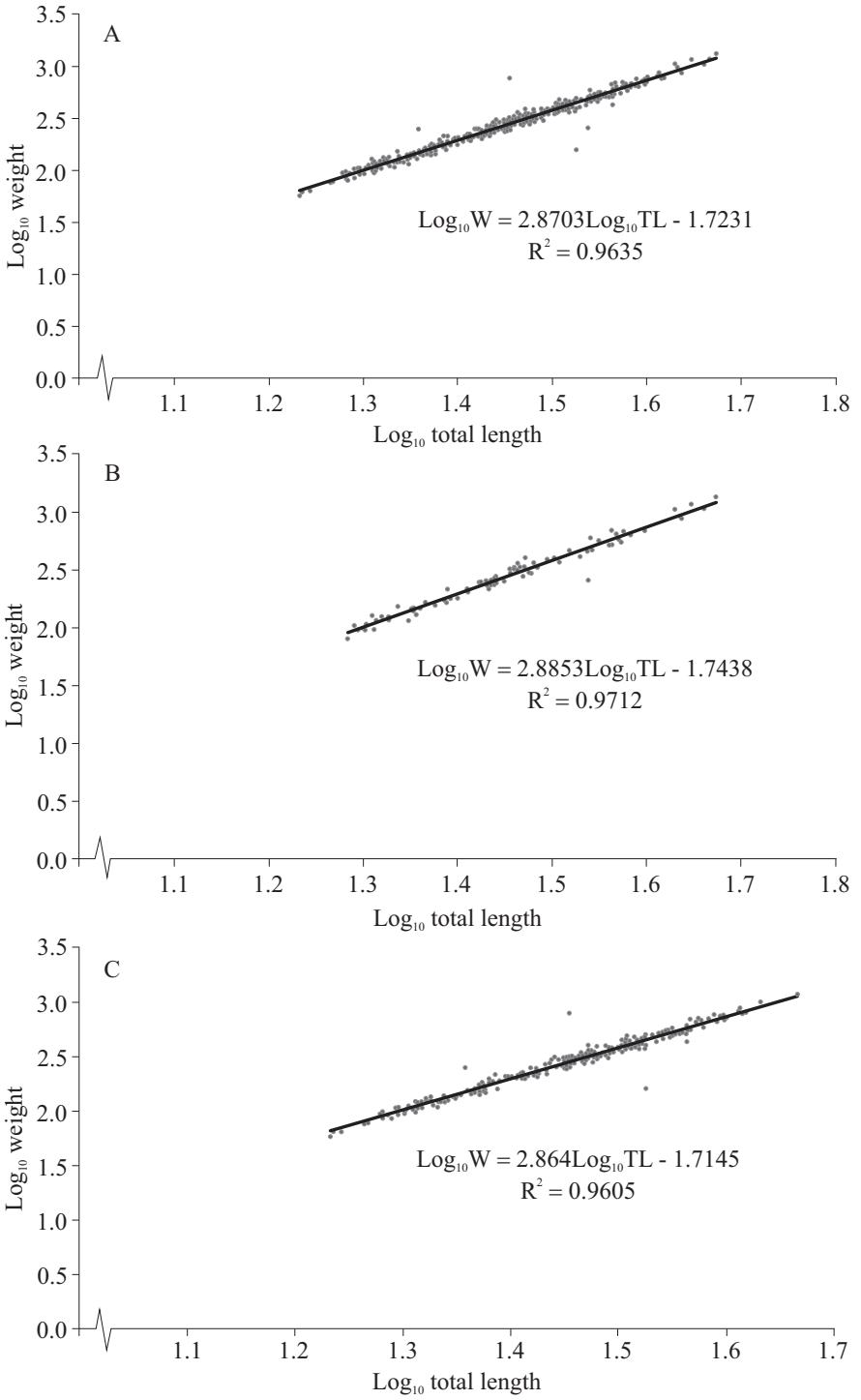

Figure 2. Length-weight relationship of *Epinephelus areolatus* from the Arabian Gulf, n = 355 (n_{male}= 91, n_{female} = 264). A) Combined sexes. B) Male. C) Female.

Similar to the reproductive capability of a species, growth is largely associated with the prevailing local environmental circumstances (Roff 2000). Many studies have uncovered that the pronounced growth variability within and between populations is due to the combination of both genetic and environmental factors such as temperature, photoperiod, pH, salinity, and food availability (Werner and Gilliam 1984; Manooch 1987; Conover 1990; Sadovy et al. 1992; Sale 1998; Lombardi-Carlson et al. 2008; Munday et al. 2008; Claro and Garcia-Arteaga 2014).

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