

Research article**Investigation of length-weight relationship and condition factor of round Sardinella, *Sardinella aurita* Valenciennes, 1847 in the Northeastern Mediterranean****Deniz ERGÜDEN^{1,5,*}, Sibel ALAGÖZ ERGÜDEN^{2,5}, Deniz AYAS^{3,4,5}**¹ Iskenderun Technical University, Faculty of Marine Sciences, Iskenderun, Hatay, Türkiye² Çukurova University, Imamoglu MYO, Balcalı, Adana, Türkiye³ Mersin University, Fisheries Faculty, 33160, Yenişehir, Mersin, Türkiye⁴ Mersin University Marine Life Museum, 33160, Yenişehir, Mersin, Türkiye⁵ Mersin University Marine Sciences Application and Research Center (MarineS-ARC), 33840, Aydıncık, Mersin, TürkiyeCorresponding Author e-mail: deniz.erguden@iste.edu.tr

Abstract: A total of 232 round sardinella, *Sardinella aurita* Valenciennes, 1847, were caught in the Mersin Bay from September to October 2023 using a commercial purse seine. Length-weight relationships (LWRs), sex ratio, and condition factor of the round sardinella fish specimens were investigated. The sex ratio (females: males) was 1:1.05. The individuals ranged from 11.0 to 21.5 cm in length, and the total weight of the specimens ranged from 15.4 to 126.2 g. Positive allometric growth was observed for females, males, and both sexes. The values of the exponent b of the LWRs were 3.210 for females and 3.324 for males. Fulton's condition factor (K) values for female (1.108) and male (1.082) specimens also showed no significant variations ($P>0.05$). This study provides detailed length-weight relationship and condition data for the *S. aurita* population from Mersin Bay, and also compares the population characteristics of this species with previous reports. These results will contribute to regional fisheries knowledge and database records in the northeastern Mediterranean.

Keywords: Round sardinella, length and weight parameters, condition, Mersin Bay, Türkiye

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Introduction

The length-weight relationships (LWRs) and condition factor are important tools in fisheries biology, management, and stock assessment to estimate standing stock biomass. The length-weight relationships have several applications. These data allow comparisons of growth patterns among regions and provide valuable information for stock assessment studies (Moutopoulos & Stergiou, 2002; Gonzalez Acosta et al., 2004). In addition, length-weight relationships and condition factor are important for fisheries because they help determine appropriate harvest size and timing.

The round sardinella, *Sardinella aurita*, is a marine pelagic fish that is widely distributed throughout tropical and subtropical seas, including the entire Mediterranean and Black Seas (Froese & Pauly, 2026). The round sardinella, a pelagic species, is one of the most important fish in the Mediterranean Sea. This species is found inshore and near the surface to the edge of the shelf. It feeds mainly on zooplankton, including copepods, and also on mysid larvae (Whitehead, 1985; Bianchi et al., 1999).

There are few studies on length-weight or weight-length relationship parameters of fishes in the northern Aegean Sea (Karakulak et al., 2006; Cengiz,

2013) and Marmara Sea (Keskin & Gaygusuz, 2010; Bok et al., 2011) marine waters of Türkiye. However, there are many studies on length-weight relationships for sardine fish species from the eastern Adriatic waters (Sinovčić, 2004; Dulčić & Glamuzina, 2006) and western (Merella et al., 1997), central (Falsone et al., 2022), and eastern Mediterranean (Mehanna and Salem, 2011; Raouf et al., 2017; Mehanna & Farouk, 2021; Ragheb, 2023; Elsira et al., 2025) and Aegean Sea (Petrakis & Stergiou, 1995; Stergiou & Moutopoulos, 2001; Koutrakis & Tsikliras, 2003; Moutopoulos et al., 2013).

Fish length and weight are also used to estimate Fulton's condition factor (K), which provides information about an individual fish's health. The condition factor provides an indication of the fish's well-being and variations in energy reserves over time. *K* values vary with sexual maturity, food availability, and environmental conditions (Raouf et al., 2017).

The present study aimed to investigate the length-weight relationships and condition for the round sardinella population collected from the northeastern Mediterranean coast of Türkiye. Information on the length-weight relationship and condition of *S. aurita* in Mersin Bay is still limited. Thus, this study will make a significant contribution to scientific and fisheries management practices related to *S. aurita*.

Material and Methods

The study was carried out on the Karaduvar coast in Mersin Bay. A total of 232 *Sardinella aurita* individuals (both sexes combined) were collected using a commercial purse seine at depths of 20-40 m from September to October 2023 (Fig. 1). The measurements, including total length to the nearest millimeter (mm) and total weight to the nearest 1.0 gram, of the fish, were recorded for each specimen. The relationship between length and weight was described by the power equation ($W = aL^b$), where *W* is the total weight (g), and *L* is the total length (cm), *a* and *b* are the constants. The coefficient of determination (r^2) was used as an indicator of the quality of the linear regression. Confidence intervals (CI) were calculated for the slope to see if it was statistically different from 3.

The growth type is either isometric ($b=3$) or allometric. In this case, it can be negative allometric ($b < 3$) or positive allometric ($b > 3$) (Froese, 2006). The values of the constants *a* and *b* were calculated by the logarithmic transformation of the above equation: $\log W = \log a + b \log L$. The *b* value for each group was tested using a t-test at the 0.001 significance level to determine whether it differed significantly from 3. All statistical analyses were performed using SPSS 22.0 at a significance level of $\alpha = 0.05$.

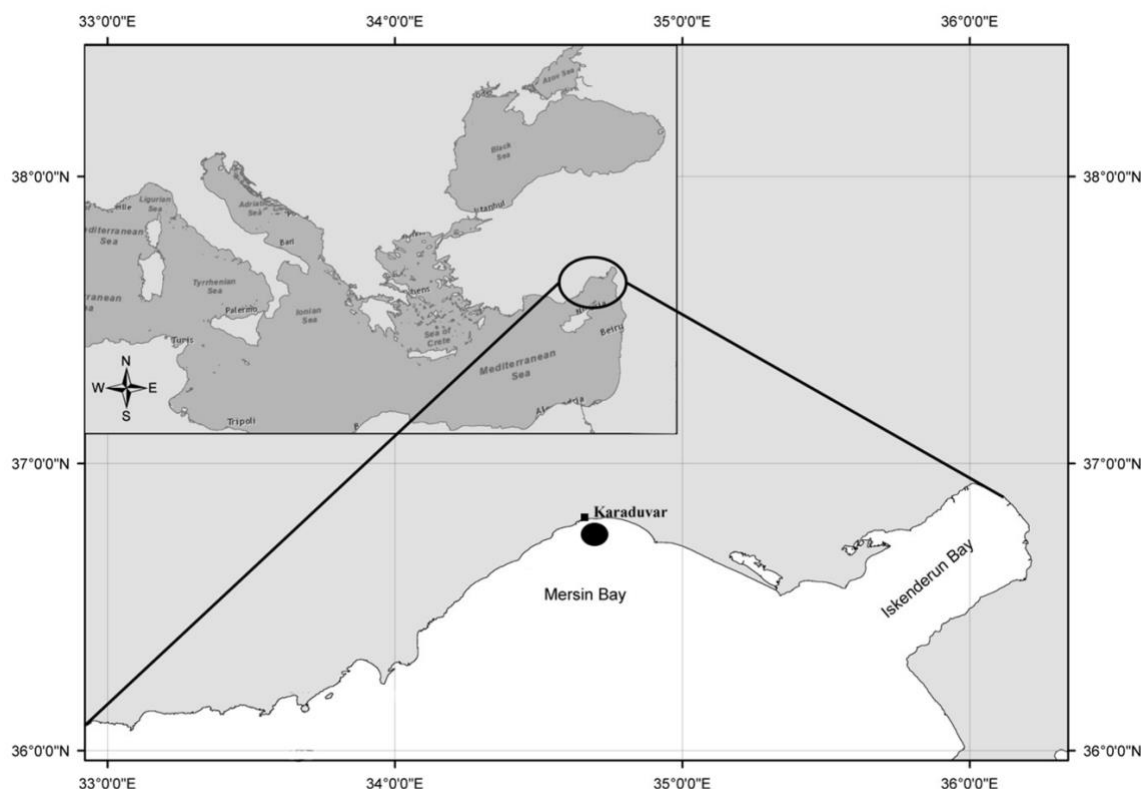


Figure 1. Sampling area (●) of round sardinella, *Sardinella aurita* in Mersin Bay

Fulton's condition factor (K) was determined using the following formula: $K = (W/L^3) \times 100$. Where W: total body weight in grams, L: total body length in centimeters.

Results

A total of 232 specimens of *S. aurita* were examined, with 48.7% (n=113) female and 51.3% (n=119) male. The ratio of females to males was 1:1.05. Total length ranged from 11.0–21.0 cm in females, 11.2–21.5 cm in males, and 11.0–21.5 cm in all individuals combined. Length-frequency indicated that the 11.5 cm length classes had the highest number in female specimens and the 14.0 cm length classes in male specimens, respectively (Fig. 2). Total weight values for females were 15.5–116.6 g for males, 15.4–126.2 g and for both sexes, 15.4–126.2 g.

The detailed estimated parameters of the length-weight relationships are given in Table 1. There was no significant difference between the length of female and male individuals ($P>0.05$). The growth was positive allometric for the Mersin Bay population of *S. aurita*, and the b values ranged from 3.210, 3.324, and 3.264 for females, males, and both sexes (Table 1). All regression values were found to be highly significant ($P<0.05$), and the values of the coefficient of determination (r^2) were greater than 0.95 for all groups.

The length-weight relationships for females, males, and both sexes were calculated as $W=0.0062xL^{3.210}$ ($r^2= 0.972$), $W= 0.0045xL^{3.324}$ ($r^2= 0.971$), and $W=0.0053xL^{3.264}$ ($r^2= 0.971$) (Fig. 3).

K values were also calculated. K values for females, males, and both sexes were observed as 1.108 ± 0.111 , 1.082 ± 0.113 , and 1.095 ± 0.113 , respectively. K values also showed no significant variations ($P>0.05$).

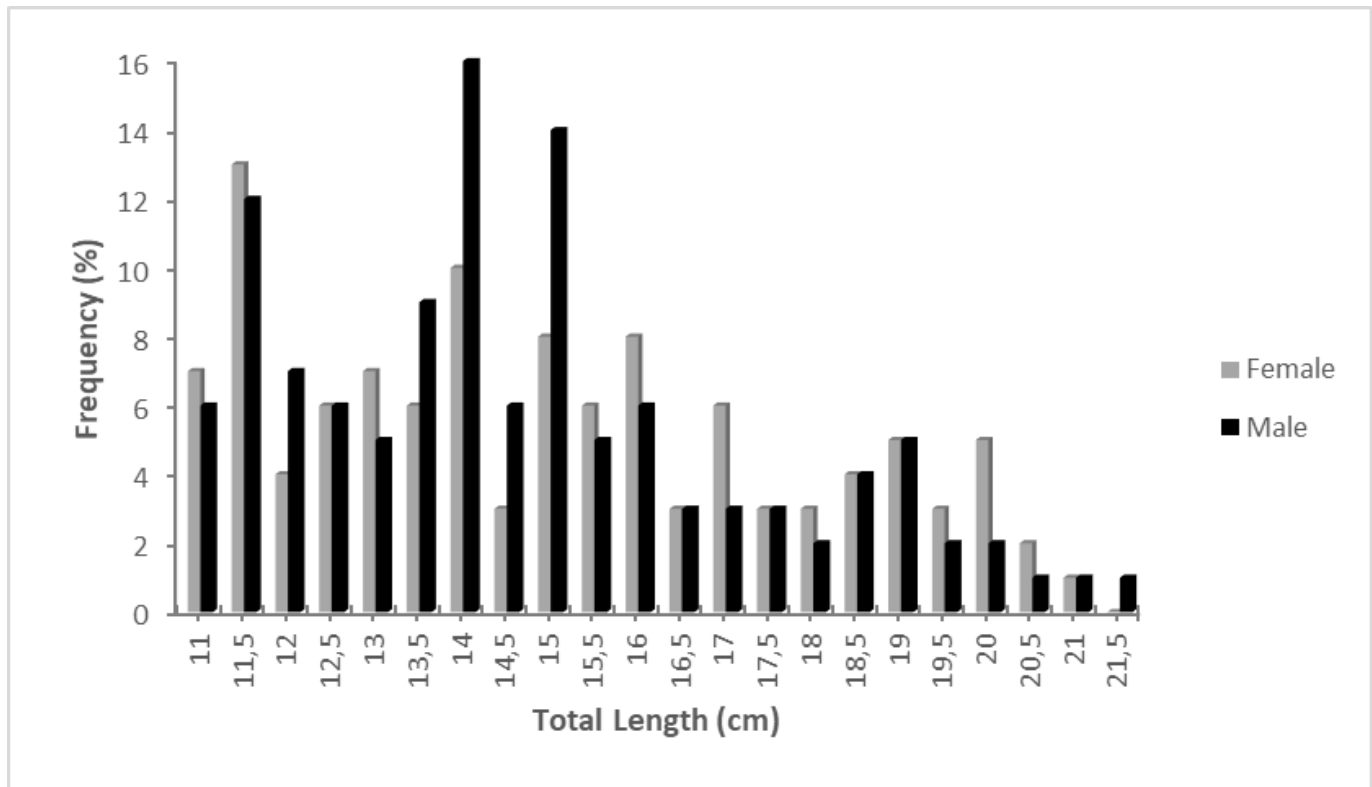


Figure 2. Total length (cm) frequency of female and male specimens of *Sardinella aurita*, from the northeastern Mediterranean, Türkiye

Table 1. Descriptive statistics and estimated parameters of length-weight relationships for *Sardinella aurita* from Mersin Bay (Northeastern Mediterranean, Türkiye) (a: intercept, b: slope, S.E.: Standard error, C.I.: Confidence interval, r^2 : Coefficient of determination, G: Type of growth)

Sex	n	Total Length (cm)	Weight (g)	Parameters of the relationship					
		Lmin-Lmax (Mean $\pm$ SD)	Wmin-Wmax (Mean $\pm$ SD)	a	b	SE of b	95% C.I. of b	r^2	G
Female	113	11.0-21.0 (15.14 $\pm$ 2.795)	15.5-116.6 (43.36 $\pm$ 25.876)	0.0062	3.210	0.052	3.108-3.313	0.972	A+
Male	119	11.2-21.5 (14.81 $\pm$ 2.253)	15.4-126.2 (39.55 $\pm$ 24.488)	0.0045	3.324	0.053	3.220-3.429	0.971	A+
Both	232	11.0-21.5 (14.97 $\pm$ 2.663)	15.4-126.2 (41.40 $\pm$ 25.192)	0.0053	3.266	0.037	3.194-3.339	0.971	A+

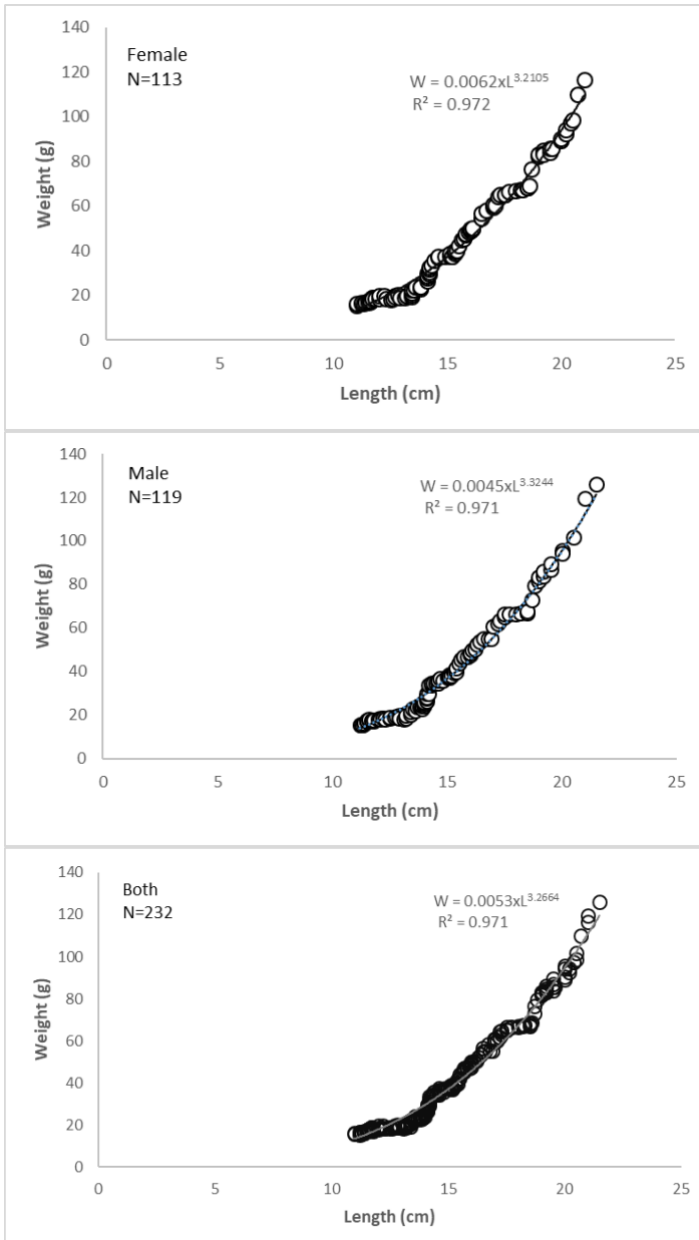


Figure 3. Length–weight relationships of *Sardinella aurita* females, males and both sexes from Mersin Bay, Northeastern Mediterranean coast of Türkiye

Discussion

This study reported the length–weight relationship and condition factor of *S. aurita* in Mersin Bay. Among the collected *S. aurita* females and males, the lengths ranged from 11.0 to 21.0 and 11.2 to 21.5 cm, respectively. The maximum total length recorded in the combined sample was 21.5 cm. The closest matches to the maximum length values in our study are those reported by Ragheb (2023) and Elsira et al. (2025), which reported the total lengths of *S. aurita* from the Egyptian Mediterranean waters (southeastern Mediterranean), respectively. The length values given for other regions are either smaller

or larger than those in our study. These values are detailed in Table 2. These differences may be related to sampling season, sample size, and environmental conditions.

The round sardinella *S. aurita* length class sample ($n = 232$) had the highest frequency centered on the length class 11.5 cm for females and 14 cm for males. Most individuals fall within the 14.0–15.0 cm range, with a maximum length of approximately 21.0 cm for females and 21.5 cm for males (Fig. 2).

Many studies on length–weight relationships were estimated for these round sardine species living in the Adriatic and western and eastern Mediterranean waters (Table 2). But none are available for length–weight and condition for the northeastern Mediterranean coasts of Türkiye (Mersin Bay). The comparison of length–weight studies conducted in the previous Adriatic and Mediterranean Sea records are given in Table 2.

The values of the exponent b provide information on fish growth. In this study, positive allometric (+) growth was observed for females, males, and both sexes. The values of b for all groups were within the expected ranges of 2.5–3.5 (Froese, 2006). Similar growth patterns were reported for *S. aurita* populations. Sinovčić (2004), Dulčić & Glamuzina (2006), Mater et al (2003), Karakulak et al. (2006), Keskin & Gaygusuz (2010), and Cengiz (2013) reported positive allometry for *S. aurita* from the Adriatic waters (Croatia) and northern Aegean Sea (Izmir Bay, Gökceada Island, Gallipoli Peninsula, and Dardanelles) and Erdek Bay (Sea of Marmara), Türkiye. However, different growth patterns were declared for *S. aurita* populations. Petrakis and Stergiou (1995), Stergiou & Moutopoulos (2001), Koutrakis & Tsikliras (2003), Bok et al. (2011), Mehanna & Salem (2011), Raouf et al. (2017), and Mehanna & Farouk (2021) reported negative allometry for *S. aurita* from the Greek waters (Aegean Sea, Greece), the northern Sea of Marmara (Türkiye), and the coast of Tunisia and Egypt (eastern Mediterranean). Almost isometric growth has also been stated by Merella et al. (1997) from the Balearic Island (Spain), Moutopoulos et al. (2013) from the Korinthiakos Gulf, Greece (Aegean Sea), Falsone et al. (2022) from the western coast of Sicily (Central Mediterranean Sea), Ragheb (2023), and Elsira et al. (2025) from the Mediterranean waters of Egypt (southeastern Mediterranean). Some of the results of our study for both sexes differ from these values. These differences may be correlated with sampling

area, age, sex, and other factors, for example, habitat, and degree of stomach fullness.

For the Karaduvar (Mersin) population of *S. aurita*, the data were not representative for all months within a year. Thus, these data should be considered to represent only a particular season or time of year. According to Bagenal and Tesh (1978) and Goncalves

et al. (1997), the parameters of *b* generally do not vary significantly throughout the year, unlike parameter *a*, which may vary seasonally, daily, and between habitats. According to Tesch (1971), many factors are known to influence the length-weight relationship in fishes, including growth phase, season effect, size range, and general fish condition.

Table 2. Biogeographic comparison of length-weight relationship parameters for *Sardinella aurita* in the Adriatic and Mediterranean waters (L: Length; TL: Total Length; FL: Fork Length)

Reference	Locality	Country	Sex	n	Type of Length	L _{min} -L _{max}	a	b	r ²
Merella et al. (1997)	Balearic Island	Spain	Both	13	TL	15.1-23.8	0.00680	2.990	0.986
Petrakis & Stergiou (1995)	Greek waters (G. S. Ewoikos)	Greece	Both	24	FL	16.2-22.0	0.01799	2.840	0.890
Stergiou & Moutopoulos (2001)	Greek marine waters (Cyclades)	Greece	Both	18	TL	23.2-29.0	0.01571	2.804	0.860
Koutrakis & Tsikliras (2003)	Strymon estuary, NW Aegean	Greece	Both	19	TL	2.06-24.0	0.00870	2.950	0.998
Mater et al. (2003)	İzmir Bay, Aegean Sea	Türkiye	Both	323	FL	13.0-21.4	0.00680	3.229	0.910
Sinovčić (2004)	Eastern Adriatic Sea	Croatia	Both	645	TL	8.00-17.0	0.00430	3.120	0.792
Dulčić & Glamuzina (2006)	River Cetina estuary, middle Adriatic	Croatia	Both	22	TL	6.60-17.0	0.00400	3.160	0.995
Karakulak et al. (2006)	Gökceada Island (northern Aegean Sea)	Türkiye	Both	50	TL	16.4-26.2	0.00620	3.076	0.907
Keskin & Gaygusuz (2010)	Erdek Bay (Sea of Marmara)	Türkiye	Both	24	TL	4.6-6.8	0.00310	3.439	0.805
Bok et al. (2011)	Northern Sea of Marmara	Türkiye	Both	16	TL	9.9-16.8	0.03330	2.272	0.877
Cengiz (2013)	Gallipoli Peninsula and Dardanelles (northern Aegean Sea)	Türkiye	Both	26	TL	16.4-24.6	0.00140	3.280	-
Mehanna & Salem (2011)	El-Arish waters (Southeastern Mediterranean)	Egypt	Both	1200	TL	7.8-22.7	0.0014	2.754	0.940
Moutopoulos et al. (2013)	Korinthiakos Gulf (Central Greece)	Greece	Both	73	TL	11.6-36.0	0.00670	3.022	0.997
Raouf et al. (2017)	Northern Tunisia Coast (Mediterranean Sea)	Tunisia	Both	68	TL	14.4-24.5	0.0180	2.690	0.780
Mehanna & Farouk (2021)	off the coast of Egypt	Egypt	Both	870	TL	8.1-23.0	0.0149	2.745	0.940
Falsone et al. (2022)	off the south-western coast of Sicily (Central Mediterranean Sea)	Italy	Both	136	TL	9.5-17.0	0.00650	3.025	0.920
Ragheb (2023)	Mediterranean waters off Alexandria	Egypt	Both	756	TL	9.0-21.0	0.00790	2.991	0.995
Elsira et al. (2025)	Egyptian Mediterranean water	Egypt	Both	1555	TL	7.8-21.2	0.0070	3.012	0.956
This study	NE Mediterranean Sea	Türkiye	Both	232	TL	11.0-21.5	0.0053	3.266	0.971

K, an expression of the relative fatness of fish, indicates the interaction between biotic and abiotic factors and the fish condition. Females were the best performers, with a K value for females, males, and both sexes being 1.108, 1.082, and 1.095, respectively. A K value of around 1 generally indicates

that the fish are in normal or good physiological condition.

In conclusion, the present study was a contribution to our knowledge of some basic essential information (length-weight, relationships, and condition) of the round sardinella *S. aurita* from Mersin Bay (northeastern Mediterranean, Türkiye). These results

will be useful for the fishery management of the northeastern Mediterranean and will contribute to the FishBase database.

Ethical Approval

Fish samples were obtained from commercial catches; therefore, no live animal experimentation was conducted, and ethical approval was not required.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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