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**RESEARCH ARTICLE**

# Morphometric relationships and growth of common stingray, *Dasyatis pastinaca* (Linnaeus, 1758) and marbled stingray, *Dasyatis marmorata* (Steindachner, 1892) in the northeastern Levantine Basin

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**Abstract**

In this study, we determined the relationships between seven morphometric characters of common stingray (*Dasyatis pastinaca*) and the marbled stingray (*Dasyatis marmorata*) from the Northeast Levantine coast of Turkey. A total of 215 samples were obtained by monthly bottom-total weight (TW), disc length (DL), disc width (DW), nose-eye (NE), mouth-width (MW) and nose-mouth (NM) were measured and, analyzed and their relationships were statistically evaluated. In general, the relationships between all the body proportions were highly statistically significant ($p<0.05$), as is usual between body proportions. The length and weight value for *D. pastinaca* and *D. marmorata* were calculated as 14.5-56.4cm and 74.5-5740.0g, and 9.9-41.5cm and 78.98-4500.0g, respectively. The relationships were determined by $TW=0.039*DW^{2.93}$ and $TW=0.002*TL^{3.32}$ for *D. pastinaca* and; $TW=0.048*DW^{2.94}$ and $TW=0.012*TL^{2.74}$ for *D. marmorata*. Length-weight relationships show allometric growth (b=3.31 for *D. pastinaca* and 2.74 for *D. marmorata*). Estimates of the von Bertalanffy growth parameters indicate disc width $DW_{\infty}=58.28$cm, k=0.06 year-1, $t_o=-0.213$year for the combined sexes of *D. pastinaca*; $DW_{\infty}=46.09$cm, k=0.36year-1, $t_o=-0.162$year for all individuals of *D. marmorata*.

**Keywords:** *Dasyatis pastinaca, Dasyatis marmorata*, morphometric, length-weight relationships, growth

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## Introduction

*Dasyatis pastinaca* (Linnaeus, 1758) belongs to the Dasyatidae family (the common stingray) which has spread throughout the northeast Atlantic, the Black Sea and the entire Mediterranean (Serena 2005; Özgür Özbek *et al.* 2015). They are generally found in shallow water, up to 200m in sandy, muddy basements,

and near river mouths and rocky areas (Michael 1993; Yeldan and Avsar 2006). The other species (the marbled stingray) *Dasyatis marmorata* (Steindachner, 1892) of Atlantic origin, is distributed in the waters of Tunisia, Israel, the Mediterranean, and Turkey (Golani and Capape 2004; Ergüden *et al.* 2014; Yemişken *et al.* 2014) and prefer depths of 12 to 65m in sandy and muddy basins (Capape and Zaouali 1995; Serena 2005). The most important feature distinguishing these species from each other is the presence of blue-spotted stains on the dorsal surfaces of *D. marmorata* (Bradai *et al.* 2012). *D. marmorata* has been reported in Turkish waters by Ergüden *et al*. (2014) and Kapiris *et al.* (2014). Several researchers (McEachran and Capape 1984, Gücü and Bingel 1994; Ismen 2003, Filiz and Mater 2002; Yeldan *et al.* 2009; Yıgın and Ismen 2013; Basusta *et al.* 2013; Özgür Özbek *et al.* 2015) studied the age, length distribution, growth, stomach contents, and stock estimations of the *D. pastinaca* species. However, studies on *D. marmorata*, are limited, and they mostly concern their availability and length (Cowley and Compagno 1993; Capape and Zaouali 1995; Yemisken *et al.* 2014; Özgür Özbek *et al.* 2015; Basusta *et al.* 2016). Although it is a given that there are some differences between species in these studies, a comprehensive study of the morphometric characteristics of these species (such as total length, disc length, and disc width) has not yet been done. In the identification of species, the differentiation of stocks, and morphometric measurements and the relationships between them are important for researchers (Cadrin 2000).

There is notable non-target proportional fishing pressure on Chondrichtyes, which are caught by professional demersal fisheries on the western coast of the northeastern Mediterranean (Yeldan *et al.* 2013; Yemisken *et al.* 2014; Basusta *et al*. 2016). Relationships between morphometric values and the growth of species in the northeastern Mediterranean are also described in this study. We further believe that the results of this study will contribute to the study of species identification fisheries and management strategies.

## Materials and Methods

*Study Area*

Specimens were collected by commercial bottom trawlers in Iskenderun Bay in the northeastern Mediterranean Sea (the coastal waters of Turkey) during the period between July 2014 and June 2015 (except February). The bottom trawling was done for 45 minutes in three different depth strata: 0-10m, 10-20m, and 20-50 m Figure 1.

*Sampling methods*

Specimens were sorted from the total catch, counted and identified on board according to Cowley and Compagno (1993) and Golani and Capape (2004) Subsequently, all fish obtained were measured in terms of total length (TL), disc length (DL), disc width (DW), distance from nose to eye (NE), mouth width

(MW), and distance from nose to mouth (NM) to the nearest 0.5cm immediately after capture and weighed (wet weight, TW: ±1.0g). Individuals with broken tails were not evaluated for TL in the present study.

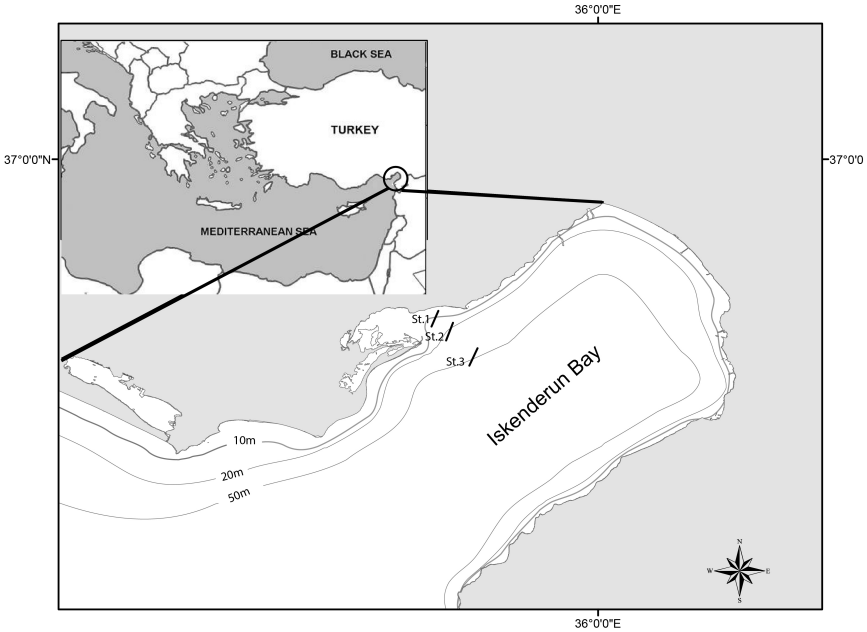


**Figure 1**. The sampling stations in the Northeastern Levantine Basin

*Data analyses*

Length-disc width, length-weight, and width-width relationships were assessed from measurements of total length (TL), disc length (DL), disc width (DW), total wet weight (TW) nose to eye (NE), mouth width (MW), and nose to mouth (NM).

The curve parameters a and b were determined by ln-transformation of raw data. Growth curves obtained from straight line for regression was log Y= log a + b * log X where Y is the dependent variable and X is the independent variable. Therefore, the theoretical equation of the regression relationship yields $Y= aX^b$. A covariance analysis (ANCOVA) was used in the comparison of the regression curves of (DW-TW) relationships of both species. Differences in TL, DL, DW, TW, NE, MW and NM were tested between sexes by independent sample t-test. All the statistical analyses were performed at a significance level of 5% by using SPSS v17 software.

Growth parameters (K) and length infinity ($DW_\infty$) were estimated using the ELEFAN I module of FiSAT-II software (Gayanilo *et al.* 2005). Winter point

(WP) was set as 0.6 and oscillating (C) was set as 0.2 (Pauly 1984). Estimation of the theoretical age parameter ($t_0$) was determined by an empirical equation

$$Log(-t_0) = -0.392 - 0.275\ Log\ (DW_\infty) - 1.038\ K$$

proposed by Pauly (1984) where $DW_\infty$ = asymptotic length, K = coefficient of growth, and $t_0$ = theoretical age at zero length.

## Results

### *Dasyatis pastinaca*

A total of 72 specimens were analyzed, of which 41 individuals were female (57%) and 31 were male (43%).

The descriptive statistics are shown in Table 1. Sexual difference for *D. pastinaca* ($p<0.05$) was only seen in the mean distance from nose to mouth (NM). The DW of *D. pastinaca* ranged from 14.5 to 42.3cm, 35% of which are within 32.1- 40.9cm (Figure 2).

**Table 1.** Descriptive statistics of *D. pastinaca* caught in Iskenderun Bay

| | | N | TW (g) | TL (cm) | MW (cm) | NE (cm) | NM (cm) | DL (cm) | DW (cm) |
|---|---|---|---|---|---|---|---|---|---|
| **Female** | **Mean** | | 1424.4 | 53.6 | 4.1 | 7.8 | 7.4 | 25.9 | 29.9 |
| | **Std Error** | | 243.1 | 3.1 | 0.2 | 0.5 | 0.5 | 1.8 | 1.9 |
| | **Min** | 41 | 74.5 | 28.2 | 1.9 | 2.6 | 2.7 | 12.5 | 14.9 |
| | **Max** | | 5740.0 | 93.4 | 7.7 | 15.5 | 13.5 | 47.9 | 56.4 |
| **Male** | **Mean** | | 895.4 | 48.29 | 4 | 6.8 | 6.2 | 25.8 | 29.3 |
| | **Std Error** | | 108.0 | 2.1 | 0.2 | 0.4 | 0.4 | 1.4 | 1.4 |
| | **Min** | 31 | 93.0 | 27.4 | 1.9 | 3.1 | 2.4 | 12.0 | 14.5 |
| | **Max** | | 2000.0 | 68.9 | 6.1 | 9.5 | 10.0 | 42.5 | 40.2 |
| | ***p value*** | | 0.054 | 0.226 | 0.728 | 0.07 | 0.041* | 0.778 | 0.951 |
| **Total** | **Mean** | | 1196.6 | 51.2 | 4.1 | 7.4 | 6.9 | 25.9 | 29.7 |
| | **Std Error** | | 148.5 | 2 | 0.2 | 0.3 | 0.3 | 1.2 | 1.2 |
| | **Min** | 72 | 74.5 | 27.4 | 1.9 | 2.6 | 2.4 | 12.0 | 14.5 |
| | **Max** | | 5740 | 93.4 | 7.7 | 15.5 | 13.5 | 47.9 | 56.4 |

*$p<0.05$

Regressions of DW-TW, DW-TL, DW-DL, DW-NE, DW-MW, DW-NM and DW-TW were calculated. All regressions are found to be highly significant ($p<0.05$). The $R^2$ values of the DL-DW, DW-TL, and TW-DW relationships were greater than 0.80; however, the $R^2$ values of NE-DW, MW-DW, NM-DW and TW-TL relationships were lower (Figure 3).

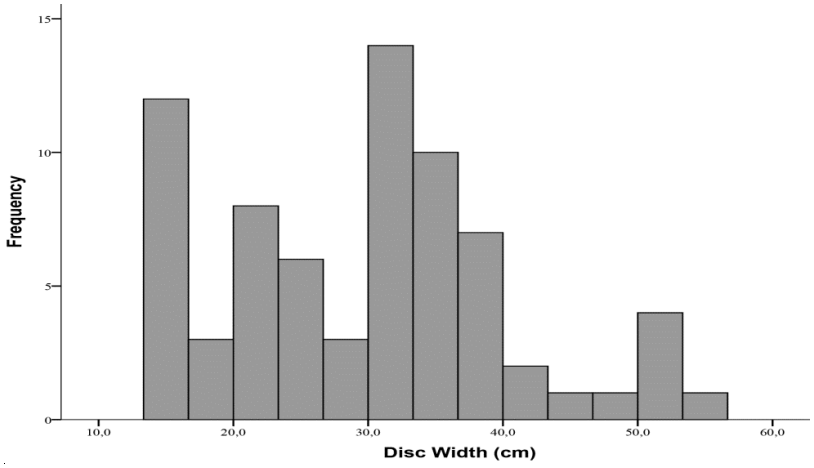


**Figure 2**. Frequency distribution of disc width of *D. pastinaca* for combined sex

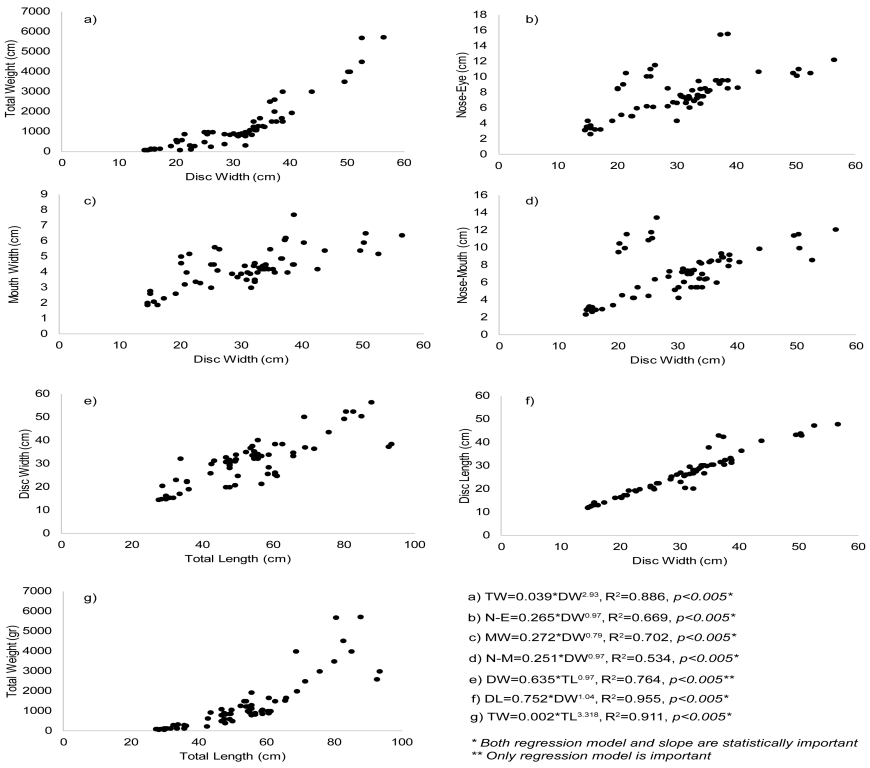


**Figure 3.** Regression relationships of measurements of *D. pastinaca*

The monthly disc width-frequency distribution and von Bertalanffy's disc width growth curves for the total of *D. pastinaca* are given in Figure 4.

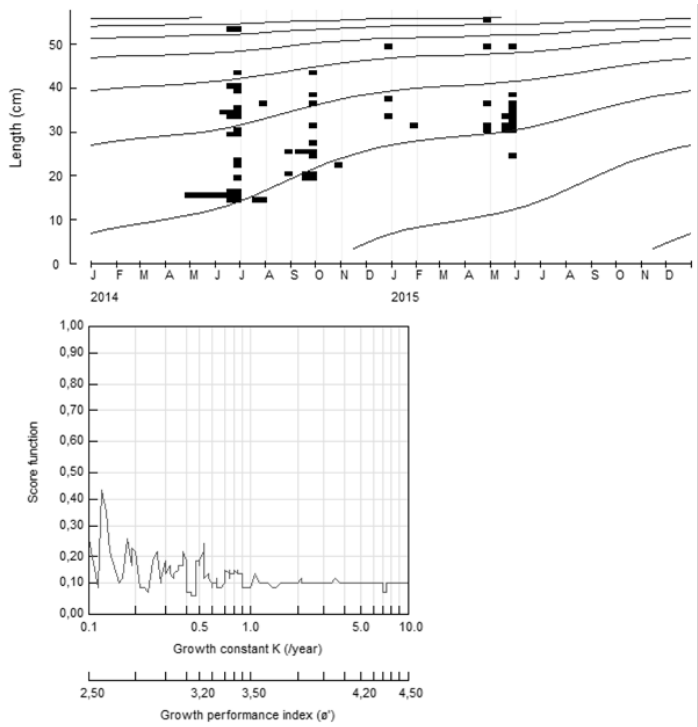


**Figure 4.**Von Bertalanffy's growth plot and K-Scan graph of *D. pastinaca* generated by ELEFAN I module FISAT-II

The growth parameters estimated by ELEFAN I module FISAT-II are as follows: $DW_\infty = 58.28$cm, $k = 0.06$ year$^{-1}$, $t_0 = -0.213$ year and goodness of fit index ($R_n$)=0.209; and the corresponding K-score is 0.672 (Figure 5).

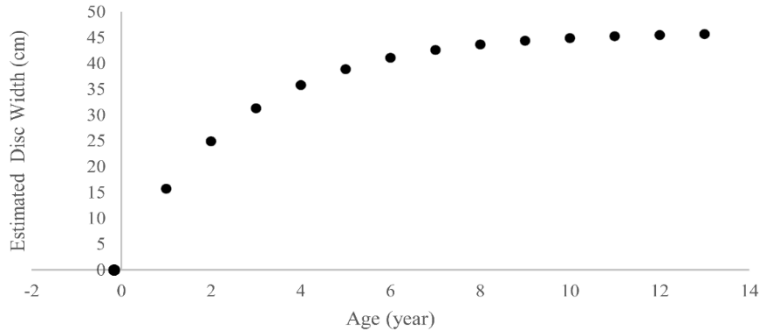


**Figure 5.** Estimated von Bertalanffy growth curve of *D. pastinaca,* for combined sexes

***Dasyatis marmorata***

A total of 143 specimens were measured among which 64 individuals were female (45%) and 79 were male (55%).

**Table 2.** Descriptive statistics of *D. marmorata* caught in Iskenderun Bay

| | | N | Tw (g) | TL (cm) | MW (cm) | NE (cm) | NM (cm) | DL (cm) | DW (cm) |
|---|---|---|---|---|---|---|---|---|---|
| **Female** | **Mean** | | 1223.4 | 55.8 | 4.0 | 7.1 | 6.6 | 30.6 | 27.4 |
| | **Std Error** | | 134.0 | 2.3 | 0.1 | 0.3 | 0.3 | 1.3 | 1.2 |
| | **Min** | 64 | 78.8 | 16.5 | 1.5 | 1.9 | 1.7 | 11.5 | 9.9 |
| | **Max** | | 4500.0 | 86.5 | 5.6 | 10.6 | 10.5 | 51.5 | 41.5 |
| **Male** | **Mean** | | 621.9 | 48.0 | 3.6 | 6.2 | 5.9 | 26.2 | 23.3 |
| | **Std Error** | | 54.1 | 1.4 | 0.1 | 0.2 | 0.2 | 0.7 | 0.7 |
| | **Min** | 79 | 91.0 | 21.2 | 1.9 | 2.9 | 2.5 | 14.2 | 11.9 |
| | **Max** | | 192.0 | 72.2 | 6.0 | 9.2 | 8.5 | 39.4 | 39.2 |
| | ***p value*** | | 0.000* | 0.010* | 0.003* | 0.009* | 0.019* | 0.001 | 0.041* |
| **Total** | **Mean** | | 891.1 | 51.5 | 3.8 | 6.6 | 6.2 | 28.2 | 25.1 |
| | **Std Error** | | 71.3 | 1.3 | 0.1 | 0.2 | 0.2 | 0.7 | 0.7 |
| | **Min** | 143 | 78.8 | 16.5 | 1.5 | 1.9 | 1.7 | 11.5 | 9.9 |
| | **Max** | | 4500.0 | 86.5 | 6.0 | 10.6 | 10.5 | 51.5 | 41.5 |

*$p<0.05$

The descriptive statistics of *D. marmorata* are shown in Table 2. All variables show sexual difference for *D. marmorata* ($p<0.05$). The DW of *D. marmorata* ranged from 9.9 to 42.3 cm, 24% of which falls between 26.1-31.5 cm for combined sexes (Figure 6).

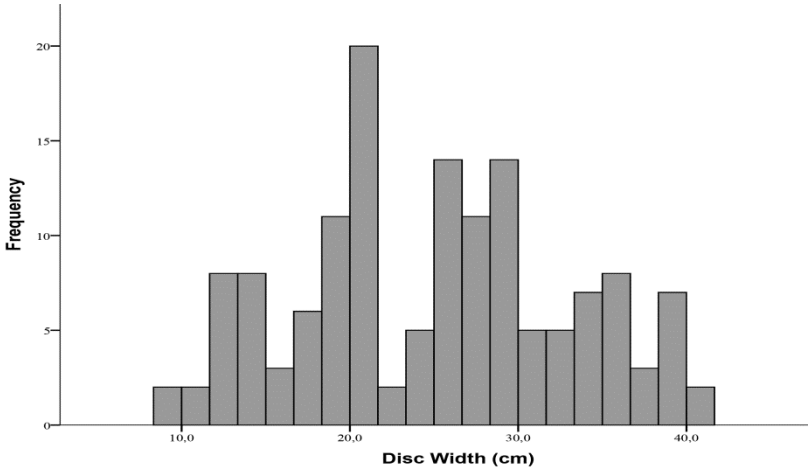


**Figure 6.** Disc width frequency of *D. marmorata* for combined sexes.

The regressions of DW-TW, DW-TL, DW-DL, DW-NE, DW-MW, DW-NM, and L-W were calculated. All relationships were highly significant ($p<0.05$). $R^2$ -values of NM-DW, NE-DW, DW-TL, MW-DW, DL-DW and TW-DW relationships were greater than 0.80; however, the $R^2$ value of TW-TL relationships are lower than 0.80 (Figure 7).

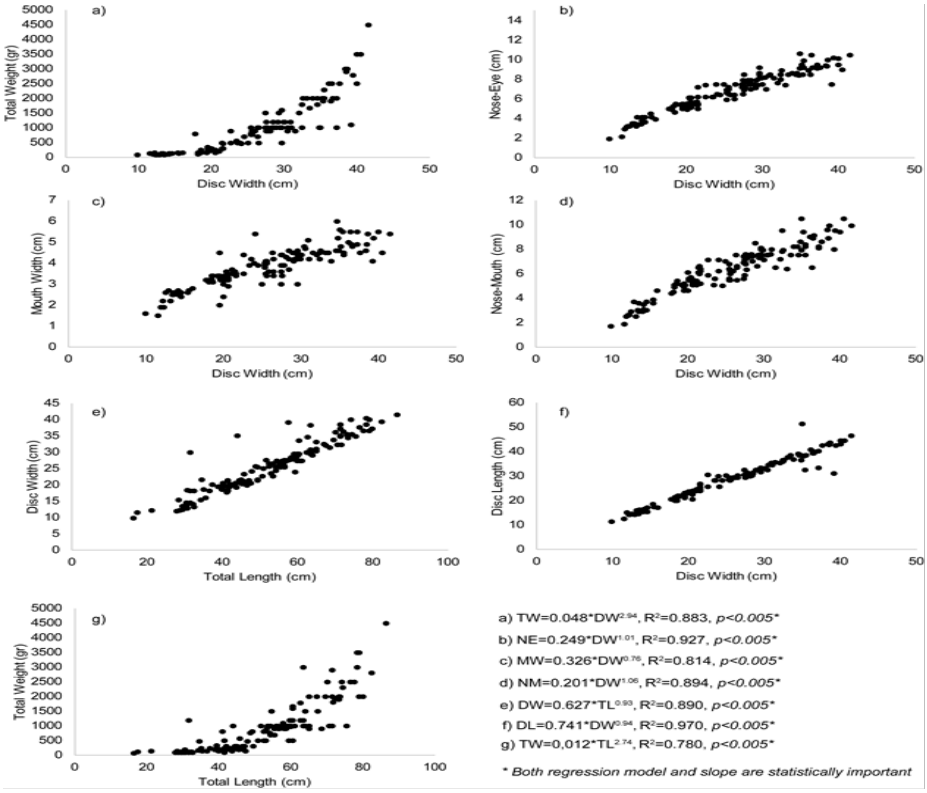


**Figure 7.** Regression relationships of the measurements of *D. marmorata*

The monthly disc width-frequency distribution and von Bertalanffy's disc width growth curves for the total of *D. marmorata* are given in Figure 8.

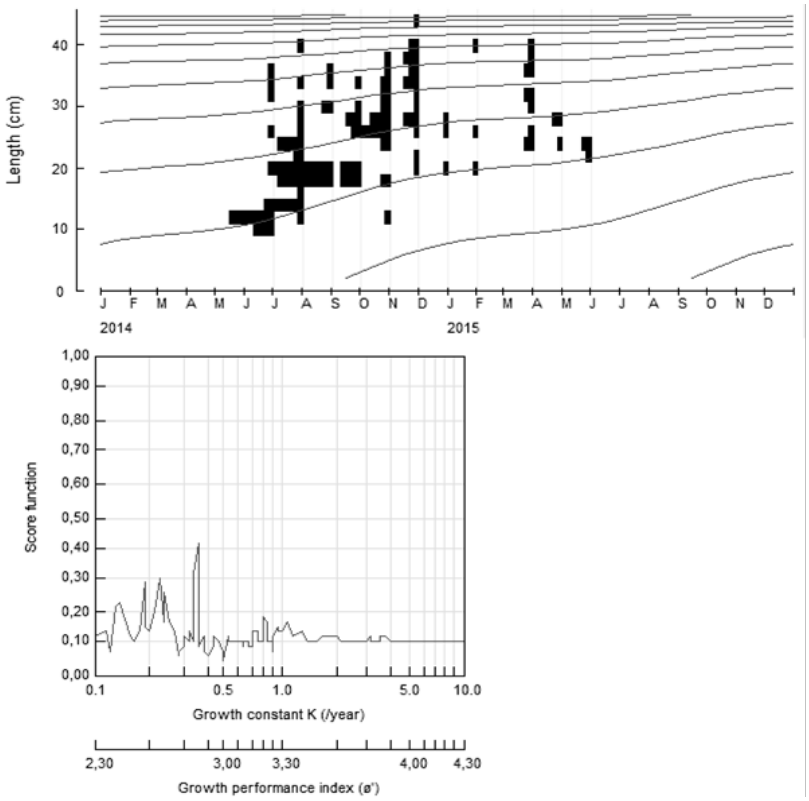


**Figure 8.** von Bertalanffy's growth plot and K-Scan graph of *D. marmorata* generated by ELEFAN

The growth parameters estimated by ELEFAN I module FISAT-II are as follows: $DW_{\infty}$ = 46.09cm (disc width), k = 0.36 year$^{-1}$, $t_0$ = -0.162 year, and goodness of fit index ($R_n$)=0.101; and the corresponding K-score is 0.41 (Figure 9).

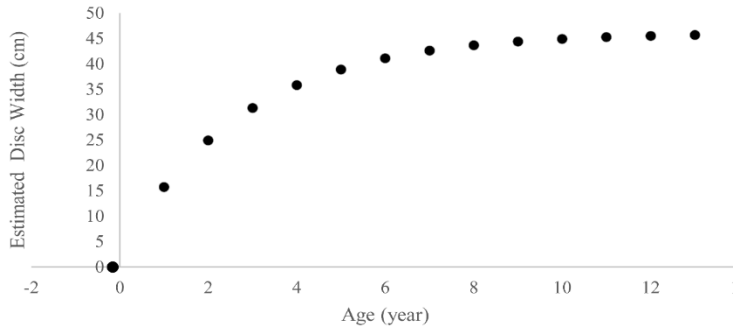


**Figure 9.** Estimated von Bertalanffy's growth curve of *D. marmorata* in Iskenderun Bay with combined sexes

The ANCOVA analysis was performed to determine whether the slopes and intercepts of TW-DW, TL-DW, DL-DW, and TL-TW of both species are different or not (Figure 10). It was found that the slopes of all relationships were significantly different ($p<0.05$). Intercepts of TW-DW and TL-DW were not significantly different ($p>0.05$), yet the intercepts of DL-DW and TL-TW were significantly different ($p<0.05$; see Figure 10).

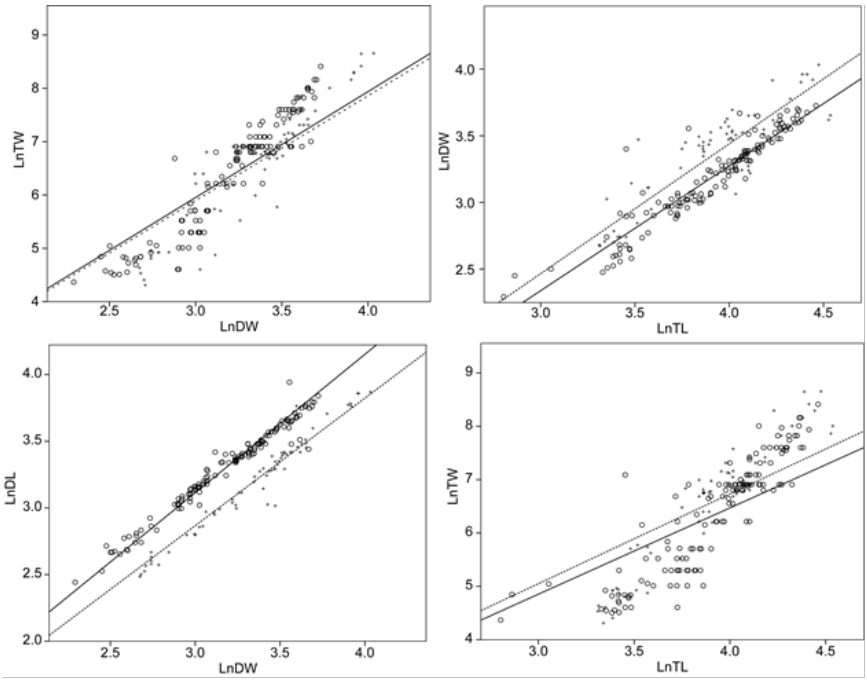


**Figure 10.** The relationships of TW-DW, DW-TL, DL-DW and TW-TL of both species. Black circles and continuous trend lines refer to *D. marmorata* and cross and discrete trend lines to *D. pastinaca*. All values were logarithmically transformed. Slopes of all relationships were statistically significant.

## Discussion

Morphometric measurements play an important role in fisheries and biological studies to define species and distictive characteristics among species (Avsar 2015; Barria *et al.* 2015). In this study, the relationships between some morphometric parameters of two *Dasyatis* species of the Mediterranean (*D. pastinaca*) and the Atlantic (*D. marmorata*) was presented. In the study area, Atlantic originated *D. marmorata* is found to be a more dominant species than *D. pastinaca*. In this study, it was seen that the females of *D. pastinaca* are more dominant than the males (Yeldan and Avsar 2007; Basusta *et al.* 2013; Yıgın and Ismen 2013; Eronat and Ozaydın 2014; Girgin and Basusta 2016) whereas in *D. marmorata*, the males were more dominant (Tables 1 and 2). In both

species, the mean values of morphometric characters of females were higher than males. Various researchers have reported similar characteristic for different species (Feduccia and Slaughter 1974; Serra-Pereir *et al.* 2010). Because *D. marmorata* is newly registered in the northeastern Mediterranean (Cowley and Compagno 1993; Capapé *et al.* 1995, 1996) despite its presence in the eastern Atlantic and eastern Mediterranean (Bilecenoglu *et al.* 2013; Erguden *et al.* 2014), the obtained results were not compared with the results of other studies.

Morphological measurements of fish are important for the calculation of growth rate and parameters. It has been reported that, while TL is used in cartilaginous fishes, measurements such as DW and DL can be used for stingrays because of their tails are broken or torn during hunting (Ishiyama 1951; Natanson 1993; Francis 2006; Serra-Pereira *et al.* 2010; Girgin and Başusta 2016). It is thought that it would be beneficial to use DW and DL measurements instead of TL in order to give better results on stingrays. In this context, the difference between DL-DW and TL-TW were found to be significant (ANCOVA; $p < 0.05$) while the difference between TL-DW and TW-DW were not significant (ANCOVA; $p > 0.05$). In light of these results, DW was used in this study because we believed that it would give more robust results for growth parameters and length-weight relationships.

In studies carried out on growth, reproduction, and morphometric characteristics, TL-TW and TL-DW associations are generally considered to be important components (Du Buit 1975; Nottage and Perkins 1983; Ryland and Ajayi 1984; Coelho and Erzini 2002). In this study, the b value of length-weight relationships were found to be 3.31 in *D. pastinaca* and 2.74 in *D. marmorata*. In many studies conducted on these species in various regions, it is seen that the length-weight relationship values are similar, and the stocks in distinct sections generally show allometric growth (Table 3). The cause of the changes in the value of "b" could be the ecological structures of the studied regions, the periodic food quantity, temperature, the use of different fishing gears, the number of samples, methods and the age classes included in the models (Sparre *et al.* 1989; Moutopoulos and Stergiou 2002; Mendes *et al.* 2004; Froese 2006).

In this study, DW was used instead of TL as suggested by Girgin and Başusta (2016) in the calculation of growth parameters of *D. pastinaca* and *D. marmorata* individuals. In the maximum DW for *D. pastinaca*, the undetectable length was $DW_{\infty} = 58.28$cm, $K = 0.06$ year$^{-1}$, and $t_0 = -0.213$ year. As seen in Figure 4, the model goodness of fit index ($R_n$) = 0.209 and the K-score is 0.672, respectively. Girgin and Basusta, (2016) gives $DW_{\infty} = 104.43$cm, which is higher than in this study. This difference between the growth parameters is thought to be due to the calculation of the age frequencies in the study by Girgin and Başusta (2016), while in this study it was calculated by using the aspect frequency values. For *D. marmorata*, $DW_{\infty} = 46.09$cm, $K = 0.36$ year$^{-1}$, $t_0 =$ $-0.162$ year, and goodness of fit index ($R_n$) = 0.101 and the K-score is 0.41. As

it is a newly registered species in the northeastern Mediterranean region, no study has been conducted regarding growth. Hence, this work has significant importance in terms of initial data collection in this regard.

**Table 3.** Length (L)-weight (W) relationships comparison with previous studies

| Species | N | a | b | $R^2$ | Location | Source |
|---|---|---|---|---|---|---|
| ***D. pastinaca*** | 250 | 0.001 | 3.31 | 0.94 | Eastern Mediterranean | İsmen 2003 |
| | 44 | 0.049 | 2.99 | 0.94 | Western Mediterranean | Morey *et al.* 2003 |
| | 92 | 0.021 | 3.39 | 0.96 | Eastern Adriatic Sea | Pallaoro *et al.* 2005 |
| | 12 | 0.116 | 2.12 | 0.642 | North Aegen Sea | Karakulak *et al.* 2006 |
| | 334 | 0.002 | 3.24 | 0.97 | Northeastern Mediterranean | Yeldan and Avşar 2007 |
| | 71 | 0.001 | 3.55 | 0.957 | North Aegean Sea | Yığın and İsmen 2009 |
| | 78 | 0.011 | 3.46 | 0.97 | Aegean Sea | Eronat and Ozaydın 2014 |
| | 385 | 0.023 | 2.75 | 0.85 | Northeastern Levantine Basin | Özgür Özbek *et al.* 2015 |
| | 417 | 0.042 | 3.32 | 0.84 | Iskenderun Bay | Başusta *et al*. 2012 |
| | 72 | 0.002 | 3.31 | 0.91 | Northeastern Mediterranean | This study |
| ***D. marmorata*** | 21 | 0.002 | 3.23 | 0.857 | Northeastern | Özgür Özbek *et al.* |
| | 143 | 0.012 | 2.74 | 0.780 | Levantine Basin | 2015 |
| | | | | | Northeastern Mediterranean | This study |

The mean measurements of *D. pastinaca* in the northeastern Levantine Basin were reported as TL 57.73cm, DW 36.55cm, DL 34.35cm and W 1957.37g (Özgür Özbek *et al.* 2015); TL 46.90cm and W 993.10g in the eastern Adriatic Sea (Pallaoro *et al.* 2005); TL 61.19cm and W 2445.65g in the Aegean Sea (Eronat and Ozaydın 2014); and TL 24.37cm in Western Europe (Morey *et al.* 2003). In this study, *D. pastinaca* individuals were found to have TL 51.20cm, DW 29.70 cm, and DL 25.90 cm and W was found to be 1196.60g, on average. The measurements of *D. marmorata* in the Levantine Basin were reported as TL 56.84cm, DW 29.97cm, DL 29.24cm, and W 1033.33g (Özgür Özbek *et al.* 2015) while in this study TL was found to be 51.5cm, DW 25.1cm, DL 28.2cm, and W 891.10g. The difference between the studies may be caused by temperature in the living areas of the populations, the amount of nutrients in the environmental factors, and so on.

In two species, for the relations of TL-TW, DW-TW, TL-DW and DL-DW, the $R^2$ values were higher than in other relationships (NW-DW, MW-DW, NE-DW) and all relations were significant ($p<0.05$). The results of morphometric evaluations are not compared with previous studies because such a study has not

been found. Morphometric properties may change depending on ecological conditions and genetic varition.

Consequently, studies on the fisheries of these species are generally insufficient, particularly in the Northeastern Mediterranean. This study provides further information describing growth parameters, morphometric, length-weight relationships and growth of a common and marbled stingray and populations in Iskenderun Bay. It can be expected that the data obtained will support other types of future work such as species identification, growth and stock differentiation.

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# Kuzeydoğu Levant baseninde *Dasyatis pastinaca* (Linnaeus, 1758) ve *Dasyatis marmorata* (Steindachner, 1892) morfometrik ilişkileri ve büyümesi

## Öz

Bu çalışmada, Kuzeydoğu Levanten basinde yaygın *Dasyatis pastinaca* ile *Dasyatis marmorata*'nun yedi morfometrik karakterleri arasındaki ilişkiyi belirledik. Temmuz 2014-Haziran 2015 döneminde aylık alt trolle örneklemelerinde 215 birey elde edilmiştir. Toplam Uzunluk (TL), Toplam Ağırlık (TW), Disk Uzunluğu (DL), Disk Genişliği (DW), Burun Gözü (NE), Ağız Genişliği (MW) ve Burun-Ağız (NM) ölçümleri analiz edilerek, ilişkileri istatistiksel olarak değerlendirildi. Genel olarak, tüm vücut oranları arasındaki ilişkilerin istatistiksel olarak anlamlı olduğu bulundu ($p < 0.05$). *D. pastinaca* ve *D. marmorata*'nın uzunluk ve ağırlık değerleri 14.5-56.4cm; 74.5-5740.0g ve 9.9-41.5cm; 78.98-4500.0g olarak ölçüldü. İlişkiler *D. pastinaca* için $TW=0.039*DW^{2.93}$ ve $T=0.002*TL^{3.32}$ ile *D. marmorata* için $TW=0.048*DW^{2.94}$ ve $TW=0.012 * TL^{2.74}$ belirlendi. Boy-ağırlık ilişkileri allometrik büyümeyi göstermektedir (b=3.31 ve 2.74). von Bertalanffy büyüme parametrelerinin tahminleri, *D. pastinaca*'nın toplamları için disk genişliği $DW_\infty=58.28$cm, $K=0.06$ yıl$^{-1}$, $t_o=-0.213$ yıl olduğu; *D. marmorata*'nın toplam bireyleri için $DW_\infty=46.09$cm, $K=0.36$year$^{-1}$, $t_o=-0.162$ yıl hesaplandı.

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