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RESEARCH ARTICLE

Spatio-temporal patterns of abundance, biomass and length-weight relationships of *Dasyatis* species (Pisces: Dasyatidae) in the Gulf of Antalya, Turkey (Levantine Sea)

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Abstract

The present paper reports the abundance and biomass of *Dasyatis centroura* (Mitchill, 1815), *D. marmorata* (Steindachner, 1892), *D. pastinaca* (Linnaeus, 1758), and *D. tortonesei* Capapé, 1975 at various depth levels and seasons in the Gulf of Antalya, and total length-weight (TL-W), disc length–weight (DL-W) and disc width–weight (DW-W) relationship of 391 individuals of *D. pastinaca*, 21 individuals of *D. marmorata,* and five individuals of *D. centroura,* caught in trawling surveys. A total of 116 hauls were carried out, between August 2009 and April 2010 seasonally in the Gulf of Antalya, at six stations and six depth levels (25, 50, 75, 100, 150, 200 m) using a commercial bottom trawl. *Dasyatis* species were sampled from 65 hauls and the frequency of occurrence was 56.03% for *D. pastinaca*, 11.21% for *D. marmorata*, 2.59% for *D. centroura* and 0.86% for *D. tortonesei*. The overall mean abundance and biomass was 55.32 ind./km^2 and 107.53 kg/km^2 for *D. pastinaca*; 2.54 ind./km^2 and 2.56 kg/km^2 for *D. marmorata*, 0.50 ind./km^2 and 25.97 kg/km^2 for *D. centroura* and 0.25 ind./km^2 and 1.34 kg/km^2 for *D. tortonesei*. The general *TL-W*, *DL-W* and *DW-W* were described by the equations: $W = 0.023*TL^{2.76}$; $W = 0.0999*DL^{2.74}$ and $W = 0.037*DW^{2.97}$ for *D. pastinaca;* $W = 0.002*TL^{3.23}$; $W = 0.034*DL^{3.02}$ and $W = 0.0045*DW^{3.59}$ for *D. marmorata*; and $W = 0.00001*TL^{4.04}$; $W = 1.481*DL^{2.16}$ and $W = 0.141*DW^{2.59}$ for *D. centroura.*

Keywords: stingray, *Dasyatis,* seasonal trawl survey, Antalya, Mediterranean Sea

Introduction

According to Bradai *et al.* (2012), four *Dasyatis* species are living in the Mediterranean Sea and these are *Dasyatis centroura* (Mitchill, 1815), *D. marmorata* (Steindachner, 1892), *D. pastinaca* (Linnaeus, 1758), and *D.*

tortonesei Capapé, 1975. Previously, the taxonomic status of *D. tortonesei* was not accepted to be stable and *D. marmorata* recognized as the synonym of *Dasyatis chrysonota* (Smith 1828) by some authors (Serena 2005 and references therein). Following the reviews of Bradai *et al.* (2012), we consider them as valid species in this paper.

The roughtail stingray, *D. centroura* can be found in the eastern and western Atlantic including the whole Mediterranean Sea but absent in the Black Sea. It is a demersal species found on sandy and muddy bottoms from shallow waters to 200 m (Başusta and Sulikowski 2012; Serena 2005 and references therein). It is incidentally caught by trawl and artisanal (trammel and longlines) fisheries (Serena 2005). The wings of the species are marketed fresh, smoked, dried-salted and used for fishmeal and oil (Bigelow and Schroeder 1953). It is listed as 'Near Threatened' in the Mediterranean Regional Red List and 'Least Concern' in the Global Red List of IUCN (Abdul Malak *et al*. 2011). It is ovoviviparous and matures at 66-100 cm TL. Gestation period lasts for about four months. It is the largest stingray found within the Eastern Atlantic and the maximum width of disc is reported as 260 cm (Dulcic *et al*. 2003) and weight as 300.0 kg (Bernardes *et al.* 2005).

The marbled stingray, *D. marmorata*, differs by its coloration which has conspicuous bright blue blotches and branching lines on a golden background on the dorsal surface and also by the ratio between disc length and disc width (Cowley and Compagno 1993; Bradai *et al.* 2012). Bradai *et al.* (2012) considered *D. marmorata* as a species of western Africa and the Mediterranean and all records of *D. chrysonata* in the Mediterranean as *D. marmorata*. According to this consideration, the species is present in Tunisia, Israel and Turkey (Maurin and Bonnet 1970; Capapé and Zaouali 1992, 1995; Golani and Capapé 2004; El Kamel *et al*. 2009; Ergüden *et al.* 2014; Bilecenoğlu 2014; Yemişken *et al.* 2014). It is a benthic species living on continental shelf between the depths of 12 to 65 m on sand and muddy bottoms (Capapé and Zaouali 1995). It is occasionally caught by bottom trawl fisheries and listed as 'Data Deficient' both in the Mediterranean Regional Red List and Global Red List of IUCN (Abdul Malak *et al*. 2011). It is ovoviviparous and gestation lasts for about three months. Females mature at 32 cm and males at 30 cm TL. The maximum total length is reported as 60 cm and width of disc as 30 cm (Capapé and Zaouali 1995; Serena 2005).

The common stingray, *D. pastinaca*, is found in the Northeast Atlantic and whole Mediterranean Sea including the Black Sea (Serena 2005). It is found over sandy and muddy bottoms, sometimes in estuaries and near rocky reefs from shallow waters to 200 m (Michael 1993). It feeds on bottom fish, crustaceans and mollusks (Muus and Nielsen 1999). It is an occasional bycatch in bottom trawl and gillnet fisheries (Serena 2005). The wings of the species are marketed smoked, dried-salted and also used for fishmeal and oil (JICA 1993;

Muus and Nielsen 1999). It is listed as 'Near Threatened' in the Mediterranean Regional Red List and 'Data Deficient' in the Global Red List of IUCN (Abdul Malak *et al*. 2011). It exhibits ovoviviparity and gestation period is about 4 months producing 4-7 youngs. Females mature at 38 cm and males at 32 cm disc width. The maximum width of disc is reported as 140 cm and total length as 250 cm (Serena 2005).

The tortonese stingray, *D. tortonesei*, was previously not considered as a valid species (Compagno 1999; Serena 2005), however further investigations have demonstrated the distict morphometric, meristic, anatomic and parasitologic characteristics of this species (Bradai *et al.* 2012; Saadaoui 2010). It is known only from the Mediterranean Sea (Compagno 1999) and Kabasakal (2002) recorded it from the Turkish water. It is found over sandy and muddy bottoms and feeds on bottom-living invertebrates and fish. It exhibits ovoviviparity, producing about 6 to 9 youngs, and gestation period is about 4 months. The maximum width of disc is reported as 80 cm (McEachran and Capapé 1984).

There is no study on the abundance or biomass of *Dasyatis* species in the Gulf of Antalya. The studies reporting the presence or CPUE/CPUA values of *Dasyatis* species in trawl hauls from Turkey is mostly concentrated in the Gulfs of İskenderun and Mersin (JICA 1993; Gücü and Bingel 1994; Başusta and Erdem 2000; Salihoğlu and Mutlu 2000; Başusta 2002; Yeldan and Avşar 2006; Yeldan *et al.* 2013; Bilecenoğlu 2014; Ergüden *et al.* 2014; Yemişken *et al.* 2014). In the present study, the status of the stocks of *Dasyatis* species are set forth depending on seasons, depth levels and stations in the Gulf of Antalya and these are the first data from the region.

Deval *et al.* (2014) reported the length–weight relationship (LWR) of *D. centroura* from the Gulf of Antalya, however there is no study for the other *Dasyatis* species in the region. Age, growth and reproduction data of these species from other regions were reported by İşmen (2003), Karakulak *et al.* (2006), Yeldan and Avşar (2007), Yeldan *et al.* (2009), Başusta *et al.* (2012, 2013), Başusta and Sulikowski (2012), and Yığın and İşmen (2012) from Turkey.

Materials and Methods

This research was carried out between August 2009 and April 2010, seasonally in the Gulf of Antalya, between the depths of 25- 200 m, using a commercial bottom trawl.

Study Area

The Gulf of Antalya is located in the Northeastern Levantine Basin and is characterized by high temperature, salinity and oligotrophy (Figure 1).

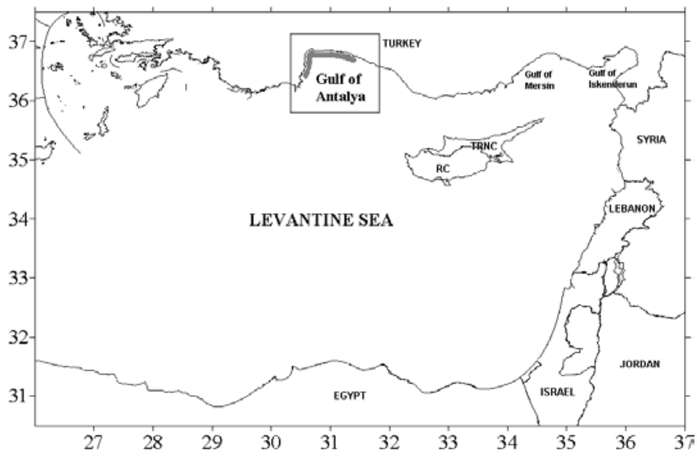

Figure 1. Map of the Gulf of Antalya-Turkey (NE Mediterranean Sea), showing the sampling area in grey color inside the rectangle (Turkish Republic of Northern Cyprus (TRNC), Republic of Cyprus (RC))

The geographical coordinates of 29 trawling areas at six stations vary between N36° 52´ 485 - 36° 23´ 000 - E31° 32´ 322 - 30´ 29´ 488 (Figure 2). Samplings were carried out at six depth levels (25, 50, 75, 100, 150, 200 m) at stations A and B. Because of the narrow and steep continental shelf, trawling at 150 and 200 m depth levels, however, could not be realized at stations C, D and E and 200 m at station F. The research was conducted seasonally, both in "closed fishing" season (August, 2009) and "open fishing" seasons (November, 2009; February, 2010 and April, 2010) and both in the no-trawl zones and open areas.
Turkish national regulation on commercial fisheries (3/1) covers a complex scheme of open/closed zones and seasons for trawl fisheries (Anonymous 2012). Bottom trawling is prohibited within 2 NM off the coast and between 15th April - 25th September in territorial waters where trawling is permitted.

Since 2005 till today, all sorts of trawling activities are also prohibited in territorial waters off Antalya Province, Side District, Selimiye Lighthouse (36º45,928´ N- 31º 23,092´ E) and Alanya, Gazipaşa District, Kesik Cape (36º 09,964´ N- 32º23,418´ E) where the station A is located and also the month of the Manavgat River (covers the area marked with long lines in Figure 2). The main commercial trawl area in the Gulf of Antalya is represented by station B where two main streams reach the sea. Stations C and D are located off the yacht marina and Great Harbor of Antalya, respectively, and both are closed zones for trawling. At Stations E and F, 25 and 50 m depth levels are located within and 75, 100 and 150 m are outside 2 NM off the coast.

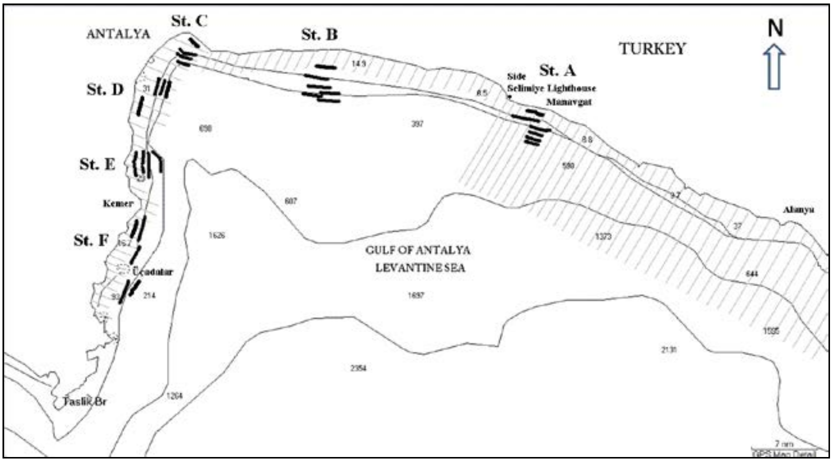

Figure 2. Map of the Gulf of Antalya- Turkey (NE Mediterranean Sea) showing the six sampling stations (named A, B, C, D, E, F from east to west) and the location and depth levels of 29 trawl hauls. The areas marked with grey lines showing "no-trawl zones".

Sampling Methods

A total of 116 hauls were carried out at the depths of 25, 50, 75, 100, 150, 200 m, at six stations seasonally. The duration of each haul was limited to an hour. Trawling was carried out by a commercial fishing vessel "Akyarlar" which was 24.80 m long with 450 HP engine. The cod-end mesh size was 22 mm (knot to knot). The samples were collected daytime with 2.5 NM/h average towing speed.

Dasyatis specimens were sorted from the total catches, counted and identified according to Cowley and Compagno (1993) and Golani and Capapé (2004) on board. Subsequently, all fish obtained were measured (total length (TL), disc length (DL), and disc width (DW)) to the nearest 0.5 cm immediately after capture, and weighed (Wet Weight, WW: ±1.0 g). Individuals with broken tails were not evaluated for TL in the present study. The specimens were released back to the sea after measured.

Data Analyses

The stock amount was calculated according to the swept area method; the abundance and catch weight (Cw) divided by the swept area (a) for each species and for each haul (Spare and Veneme 1992).

The swept area (a) for each hauling was estimated thus: a = D.h.X (h: length of the head-rope, D: cover of distance, X: fraction of the headrope length which was equal to the width of the path swept by the trawl (accepted as 0.5)). The coordinates of the trawl operation were recorded by 30 seconds intervals by

GPS and the cover of distance was calculated by summing the distances between the recorded coordinates.

Abundance (number of individuals per km^2) and biomass (g per km^2) per sampling was calculated, and the mean values were computed for each season, station and depth level. Length–weight relationships were assessed from measurements of total length (TL), disc length (DL), disc width (DW) and total wet weight (g) and the curve parameters a and b were determined by *log*-transformation of raw data. Growth curves obtained from straight line for regression between total weight and length was: *log* W= *log* a + b * *log* L, where W is the weight of the fish in grams (dependent variable), L is the total length (TL), disc length (DL), disc width (DW) in cm (independent variable), a is the regression constant related to body form and b is the regression coefficient indicating isometric growth when equal to 3. The theoretical equation of the length-weight relationship followed the power function of the form: $W= aL^b$, where W is wet weight (g) and L is the total length (TL), disc length (DL), disc width (DW) in cm. All the statistical analyses were considered at significance level of 5% ($p<0.05$).

Differences in total length and weight of the specimens and mean biomass per abundance were tested among seasons, stations and depth levels by one-way Analysis of Variance (ANOVA). Fisher's LSD (Least Significant Difference) test was used for pairwise comparison among seasons, stations and depth levels by using STATISTICA software package (Version 7; Statsoft 2004).

Results

During the entire research period 391 individuals of *D. pastinaca*, 21 individuals of *D. marmorata*, five individuals of *D. centroura*, and two individuals of *D. tortonesei* were collected. *Dasyatis* species were found in 65 of 116 hauls and the frequency of occurrence was 56.03% for *D. pastinaca*, 11.21% for *D. marmorata*, 2.59% for *D. centroura* and 0.86% for *D. tortonesei*. The overall mean abundance and biomass was 55.32 ind./km^2 and 107.53 kg/km^2 for *D. pastinaca*; 2.54 ind./km^2 and 2.56 kg/km^2 for *D. marmorata*, 0.50 ind./km^2 and 25.97 kg/km^2 for *D. centroura* and 0.25 ind./km^2 and 1.34 kg/km^2 for *D. tortonesei* (Table 1).

The bathymetric distributions of four *Dasyatis* species varied among species. While *D. pastinaca* was abundant in all six depth levels (25 to 200 m), *D. marmorata* was found between 25 -100 m, *D. centroura* at 25-50 m and *D. tortonesei* only at 25 m depth level (Table 2). The highest mean abundance and biomass values were recorded at 50 m depth for *D. pastinaca*, *D. marmorata*, and *D. centroura*. The bathymetric variations in the mean abundance and biomass were significant ($p< 0.05$) for *D. pastinaca*, and *D. marmorata*. According to the results of the Fisher's LSD (Least Significant Difference) test for pairwise comparison, the mean abundance and biomass in the shallow (25, 50 m) waters differed significantly from waters deeper than 50 m ($p < 0.05$). The frequency of occurrence generally decreased from shallow to deep waters for *D. pastinaca*, however it was highest at 50 m for *D. marmorata* and *D. centroura* and decreased at deeper waters. The mean biomass per abundance showed significant bathymetric difference only for *D. marmorata* and the difference among depth levels were only significant between 50 m and 75, 100 m depths ($p < 0.05$).

Table 1. The mean abundance (ind./km^2) and biomass (kg/km^2) of four *Dasyatis* species caught in the Gulf of Antalya (Mean abundance (ind./km^2(±se)), mean biomass (kg/km^2(±se)), CPUE (Catch Per Unit Trawling Effort (ind./hour (±se), kg/hour (±se)), frequency of occurrence (F%)).

	No. of hauls	ind./km^2 (±se)	kg/km^2 (±se)	ind./hour (±se)	kg/hour (±se)	F%	W/N
D. pastinaca	116	55.32±8.52	107.53±17.70	71.75±12.37	137.77±24.29	56.03	1.94
D. marmorata	116	2.54±0.75	2.56±0.92	2.57±0.75	2.52±0.89	11.21	1.01
D. centroura	116	0.5±0.3	25.97±15.64	0.52±0.31	27.6±16.91	2.59	51.94
D. tortonesei	116	0.25±0.25	1.34±1.34	0.24±0.24	1.31±1.31	0.86	5.36

The spatial distributions of four *Dasyatis* species also varied among six stations in the Gulf of Antalya. *D. pastinaca* was abundant in all six stations. However, *D. marmorata* was absent in the eastern stations (St. A and St. B); *D. centroura* was found in three western stations (St. D, E, F) and *D. tortonesei* only in the St. E (Table 3). The mean abundance and biomass were highest in St. C for *D. pastinaca* and St. D for *D. centroura.* The highest abundance of *D. marmorata* was found in St. E and highest biomass in St. D. The variation in the mean abundance and biomass among stations were significant ($p < 0.05$) only for *D. pastinaca*. The frequency of occurrence of *D. pastinaca* was highest inside the Gulf (St.C and St.D) and lowest in the eastern stations (St. A and St. B). However it was highest in the St. E for *D. marmorata;* St. E and St. D for *D. centroura*. The mean biomass per abundance showed significant difference among stations for *D. pastinaca* and *D. marmorata* ($p < 0.05$). The ratio was highest in St. E for *D. pastinaca* and St. D for *D. marmorata*.

There were no seasonal variations in the mean abundance and biomass of the four *Dasyatis* species ($p > 0.05$). *D. pastinaca* and *D. marmorata* were found in all seasons. However, *D. centroura* was absent in summer and *D. tortonesei* was sampled only in autumn (Table 4).

Table 2. The mean abundance (ind./km^2) and biomass (kg/km^2) of four *Dasyatis* species caught in the Gulf of Antalya according to depth levels (Mean abundance (ind./km^2 (±se)), percentage (%), mean biomass (kg/km^2 (±se)), CPUE (Catch Per Unit Trawling Effort (ind./hour (±se), kg/hour (±se), frequency of occurrence (F%), mean biomass/ mean abundance (W/N)).

	Depth (m)	No. of hauls	ind./km^2 (±se)	ind./hour (±se)	%	kg/km^2 (±se)	kg/hour (±se)	%	F%	W/N
D. pastinaca	25	24	86.78±17.49	121,37±24,08	32.46	142.82±28.72	218,26±60,58	27.48	91.67	1.65
	50	24	89.14±24.80	83,35±22,96	33.34	185.99±60.75	173,90±56,07	35.79	70.83	2.09
	75	24	32.67±11.37	38,97±13,69	12.22	64.78±23.02	75,74±27,79	12.47	41.67	1.98
	100	24	57.29±21.97	101,16±45,03	21.43	122.18±41.53	193,80±73,34	23.51	58.33	2.13
	150	12	1.10±1.10	1.00±1.00	0.2	5.97±5.97	5,45±5,45	0.57	8.33	5.45
	200	8	2.85±2.85	4,35±4,35	0.36	2.85±2.85	4,35±4,35	0.18	12.50	1.00
D. marmorata	25	24	3.55±1.89	3,63±1,92	29	4.04±2.84	4,02±2,74	32.71	16.67	1.14
	50	24	7.38±2.71	7,08±2,58	60.24	7.35±3.17	7,03±3,07	59.47	29.17	1.00
	75	24	0.84±0.84	1,29±1,29	6.83	0.46±0.46	0,71±0,71	3.73	4.17	0.55
	100	24	0.48±0.48	0,40±0,40	3.94	0.51±0.51	0,42±0,42	4.1	4.17	1.05
	150	12	0	0	0	0	0	0	0	0
	200	8	0	0	0	0	0	0	0	0
D. centroura	25	24	0.59±0.59	0,58±0,58	24.54	23.73±23.73	23,27±23,27	18.91	4.17	40.00
	50	24	1.82±1.31	1,93±1,37	75.46	101.78±70.82	110,11±77,30	81.09	8.33	55.78
	75	24	0	0	0	0	0	0	0	0
	100	24	0	0	0	0	0	0	0	0
	150	12	0	0	0	0	0	0	0	0
	200	8	0	0	0	0	0	0	0	0
D. tortonesei	25	24	1.19±1.19	1,16±1,16	100	6.47±6.47	6,34±6,34	100	4.17	5.45
	50	24	0	0	0	0	0	0	0	0
	75	24	0	0	0	0	0	0	0	0
	100	24	0	0	0	0	0	0	0	0
	150	12	0	0	0	0	0	0	0	0
	200	8	0	0	0	0	0	0	0	0

Table 3. The mean abundance (ind./km^2) and biomass (kg/km^2) of four *Dasyatis* species caught in the Gulf of Antalya according to stations (Mean abundance (ind./km^2(±se)), percentage (%), mean biomass (kg/km^2(±se)), frequency of occurrence (F%), mean biomass/ mean abundance (W/N)).

	St.	No. of hauls	ind./km^2(±se)	%	kg/km^2(±se)	%	F%	W/N
D. pastinaca	A	24	22.99±6.90	8.6	38.22±14.66	7.35	37.50	1.66
	B	24	16.57±5.96	6.2	31.21±12.29	6.01	33.33	1.88
	C	16	134.97±42.06	33.65	250.91±89.33	32.19	81.25	1.86
	D	16	103.04±25.43	25.69	212.40±51.41	27.25	81.25	2.06
	E	16	65.05±17.43	16.22	154.72±42.68	19.85	75.00	2.38
	F	20	30.95±12.21	9.65	45.92±17.80	7.36	50.00	1.48
D. marmorata	A	24	0	0	0	0	0	0
	B	24	0	0	0	0	0	0
	C	16	2.56±2.56	13.94	1.15±1.15	6.22	6.25	0.45
	D	16	5.47±2.58	29.72	6.53±3.67	35.23	25.00	1.20
	E	16	5.65±2.66	30.71	5.73±3.26	30.88	31.25	1.01
	F	20	3.77±2.25	25.64	4.10±3.36	27.67	15.00	1.09
D. centroura	A	24	0	0	0	0	0	0
	B	24	0	0	0	0	0	0
	C	16	0	0	0	0	0	0
	D	16	1.74±1.74	48.07	68.22±68.22	36.24	6.25	39.12
	E	16	0.89±0.89	24.54	35.60±35.60	18.91	6.25	40.00
	F	20	0.79±0.79	27.39	67.56±67.56	44.85	5.00	85.00
D. tortonesei	A	24	0	0	0	0	0	0
	B	24	0	0	0	0	0	0
	C	16	0	0	0	0	0	0
	D	16	0	0	0	0	0	0
	E	16	1.78±1.78	100	9.70±9.70	100	6.25	5.45
	F	20	0	0	0	0	0	0

Table 4. The mean abundance (ind./km^2) and biomass (kg/km^2) of four *Dasyatis* species caught in the Gulf of Antalya according to seasons (Mean abundance (ind./km^2(±se)), percentage (%), mean biomass (kg/km^2(±se)), frequency of occurrence (F%), mean biomass/ mean abundance (W/N)).

	Season	No. of hauls	ind./km^2(±se)	%	kg/km^2(±se)	%	F%	W/N
D. pastinaca	Summer	29	82.73±23.82	37.38	160.42±53.42	37.3	58.62	1.94
	Autumn	29	38.85±10.22	17.55	83.09±22.24	19.32	55.17	2.14
	Winter	29	35.13±10.36	15.87	66.56±23.66	15.47	48.28	1.89
	Spring	29	64.58±18.93	29.19	120.04±32.46	27.91	62.07	1.86
D. marmorata	Summer	29	1.85±1.47	18.24	1.01±0.73	9.85	6.90	0.54
	Autumn	29	3.21±1.71	31.66	3.22±1.96	31.53	13.79	1.00
	Winter	29	1.65±0.93	16.24	1.03±0.63	10.05	10.34	0.62
	Spring	29	3.44±1.77	33.86	4.97±2.93	48.57	13.79	1.45
D. centroura	Summer	29	0	0	0	0	0	0.00
	Autumn	29	0.49±0.49	24.54	19.64±19.64	18.91	3.45	40.00
	Winter	29	0.55±0.55	27.39	46.59±46.59	44.85	3.45	85.00
	Spring	29	0.96±0.96	48.07	37.64±37.64	36.24	3.45	39.12
D. tortonesei	Summer	29	0	0	0	0	0.00	0.00
	Autumn	29	0.98±0.98	100	5.35±5.35	100	3.45	5.45
	Winter	29	0	0	0	0	0.00	0.00
	Spring	29	0	0	0	0	0.00	0.00

The mean abundance and biomass of *D. pastinaca* were highest in summer followed by spring, autumn and winter. The frequency of occurrence was highest in spring following by summer, autumn and winter. The mean biomass per abundance was highest in autumn; however, there was no difference seasonally ($p > 0.05$).

The highest abundance and biomass of *D. marmorata* was found in spring and the frequency of occurrence was highest in spring and autumn. The mean biomass per abundance was also highest in spring however; there was no seasonal difference ($p > 0.05$).

The mean abundance of *D. centroura* was also highest in spring; however the mean biomass and the mean biomass per abundance were highest in winter. There was no seasonal difference ($p > 0.05$). Descriptive statistics for *D. pastinaca, D. marmorata, D. centroura,* and *D. tortonesei* were given in Table 5.

For the comparison of the length-weight relationship parameters with previous and future studies, both the general total length (TL) - wet weight (W); disc length (DL) - wet weight (W) and disc width (DW) - wet weight (W) relationships were calculated. All relationships were highly significant ($p < 0.001$) except for the relationships of *D. centroura.* R^2-values of *DL-W* and *DW-W* relationships were greater than 0.90; however the R^2-values of *TL-W* relationships were lower (Table 6).

Table 5. Descriptive statistics for *D. pastinaca, D. marmorata, D. centroura,* and *D. tortonese* (N: sample size; min: minimum; max: maximum; S.D.: standard deviation)

Species	N	Length of Disc (cm)				Width of Disc (cm)				Weight (g)				N	Total Length (cm)			
		Mean	S.D.	Min.	Max	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.		Mean	S.D.	Min.	Max.
D. pastinaca	391	34.35	9.59	11.5	385	57.73	9.42	12.0	69.5	1957.37	1698.26	50.0	10300.0	385	57.73	16.03	25.0	130.0
D. marmorata	21	29.24	6.13	20.0	21	56.84	5.31	23.0	40.0	1033.33	652.56	250.0	2250.0	21	56.84	10.32	40.0	74.50
D. centroura	5	123.80	36.83	73.0	4	262.38	34.16	86.0	170.0	52650.00	27227.97	13250.0	85000.0	4	262.38	41.50	207.50	307.00
D. tortonesei	2	50.50	14.85	40.0	2	85.00	12.73	43.0	61.0	5450.00	4737.62	2100.0	8800.0	2	85.00	18.38	72.00	98.00

Table 6. L-W relationship parameters for *D. pastinaca, D. marmorata,* and *D. centroura* (N: sample size; DL = length of disc (cm); DW = width of disc (cm); TL= total length (cm); W: weight (g); a = intercept; b = slope of the linear regressions; S.E.: standard error; C.I.: confidence interval; r^2 = coefficient of determination)

Species	N	LWR parameters (DL-W)						LWR parameters (DW-W)						N	LWR parameters (TL-W)					
		a	*b*	SE (b)	95% C.I. (b)		r^2	a	b	SE (b)	95% C.I. (b)		r^2		*a*	*b*	SE (b)	95% C.I. (b)		r^2
D. pastinaca	391	0.100	2.740	0.039	2.664	2.816	0.928	0.037	2.966	0.038	2.891	3.042	0.939	385	0.023	2.755	0.059	2.638	2.871	0.850
D. marmorata	21	0.034	3.021	0.181	2.641	3.400	0.936	0.004	3.592	0.226	3.118	4.066	0.930	21	0.002	3.233	0.303	2.599	3.867	0.857
D. centroura	5	1.481	2.158	0.302	1.196	3.120	0.944	0.141	2.590	0.239	1.828	3.352	0.975	4	0.00001	4.039	1.304	-1.573	9.651	0.827

The differences in disc length (DL) and disc width (DW) of the specimens of *D. pastinaca* were statistically significant among stations and depth levels ($p < 0.05$) and total length (TL) and wet weight (W) only among depth levels ($p < 0.05$), but not significant between seasons ($p > 0.05$). According to the results of the Fisher's LSD test for pairwise comparison, there were bathymetric differences only between 25m and other depth levels. The mean values were lower at 25 m depth. The mean values were also lower in Sts.A, B and F comparing to Sts.C, D and E.

The differences in disc length (DL), disc width (DW), and wet weight (W) of the specimens of *D. centroura* and *D. marmorata* were not statistically significant among seasons, stations and depth levels ($p > 0.05$). Only seasonal difference of the total length (TL) of *D. marmorata* was found to be significant ($p < 0.05$), due to the higher values in spring.

Discussion

The four species in the genus *Dasyatis* typically inhabits sandy or muddy habitats shallower than 100 m in the coastal waters of the Gulf of Antalya. In all the Mediterranean, they are not sought after by commercial fisheries, but are taken in large numbers as bycatch and utilized for food, fishmeal, and liver oil (Bigelow and Schroeder 1953; Damalas and Vassilopoulou 2009; Serena 2005). However *Dasyatis* species are not utilized in Turkey (Gurbet *et al*. 2013; JICA 1993; Yemişken *et al.* 2014). Their population is apparently dwindling across their range, though there is not yet sufficient data to assess (Abdul Malak *et al*. 2011; Bradai *et al.* 2012).

Previously, the presence of *D. pastinaca* in trawl hauls in the Mediterranean Basin was reported from the Black Sea (Bat *et al.* 2005; Prodanov *et al.* 1997; Zaitsev and Alexandrov 1998), Marmara Sea (JICA 1993), Aegean Sea (JICA 1993; Kallianiotis *et al*. 2000; Damalas and Vassilopoulou 2009, 2011), Eastern Mediterranean Sea (Başusta *et al*. 2002; Başusta and Erdem 2000; Gücü and Bingel 1994; JICA 1993; Salihoğlu and Mutlu 2000; Yeldan and Avşar 2006; Yeldan *et al.* 2013; Yemişken *et al.* 2014), Central Mediterranean Sea (Bottari *et al.* 2014; Mulas *et al.* 2011; Ordines *et al.* 2011; Relini *et al.* 2010; Saadaoui *et al.* 2013), Adriatic Sea (Pallaoro *et al.* 2005; Santic *et al.* 2011) and Western Mediterranean Sea (Massuti and Moranta 2003; Morey *et al.* 2003).

There has been no study on the abundance or biomass of *Dasyatis* species in the Gulf of Antalya. This is also the first study reporting Catch per Unit Trawling Area (CPUA: ind./ km^2; kg/km^2) and Catch per Unit Trawling Effort (CPUE: ind./hour; kg/hour) values for *D. marmorata, D. centroura,* and *D. tortonesei* from Turkey. The studies reporting the presence or CPUE/CPUA values of *Dasyatis* species in trawl hauls from Turkey is mostly concentrated in the Gulfs of İskenderun and Mersin. The studies reporting the CPUE/CPUA values of *D.*

pastinaca in trawl hauls compared to the present results are given in Table 7. For comparison, the overall average abundance and biomass of *D. pastinaca* were calculated according to the CPUA (ind./ km^2; kg/km^2) and CPUE (ind./hour; kg/hour) for each and overall depth levels.

The highest CPUE/CPUA values for *D. pastinaca* was reported from the western Mediterranean coast of Turkey which also covers the Gulf of Antalya and the second from the Marmara Sea (JICA 1993). The present study reports the third highest CPUE/CPUA values for *D. pastinaca*. Much higher values reported by JICA (1993) in the same region could be interpreted as the decrease of the stock in 17 years. Lower values reported from Mersin and İskenderun Bays, Cyprus and Central Aegean Sea, however, could be due to the higher oligotrophic conditions in the eastern Levantine and also higher fishing pressure in the regions.

D. marmorata was previously known to be caught only in Tunisia (Maurin and Bonnet 1970;Capapé and Zaouali 1992, 1995; El Kamel *et al*. 2009) and Israel (Golani and Capapé 2004). More recently, Bilecenoğlu (2014), Ergüden *et al.* (2014) and Yemişken *et al.* (2014) reported records of the species caught off the Mediterranean coast of Turkey. With special regard to Turkish waters, it was recorded from Adana, Mersin and İskenderun from depths ranging from 17 to 32 m. The present study reports the first record of *D. marmorata* in the Gulf of Antalya and also the widest depth range from 25 to 100 m. It is the deepest record of the species in the Mediterranean Sea.

Table 7. Comparison of the mean abundance and biomass of *D. pastinaca* to the previous studies (CPUA= Catch per Unit Trawling Area (ind./km^2, kg/km^2); CPUE= Catch per Unit Trawling Effort (ind./time, kg/time))

Location	Date	Depth (m)	CPUA-CPUE	Source
Sea of Marmara	Spring, 1992	20-100 m	40.6 kg/km^2	JICA (1993)
Sea of Marmara	Spring, 1992	101-200 m	162 kg/km^2	JICA (1993)
Sea of Marmara	Winter, 1991/92	20-100 m	231.1 kg/km^2	JICA (1993)
Sea of Marmara	Winter, 1991/92	101-200 m	306.2 kg/km^2	JICA (1993)
N Aegean Sea	Summer, 1991	20-100 m	38.6 kg/km^2	JICA (1993)
N Aegean Sea	Winter, 1991/92	20-100 m	27.4 kg/km^2	JICA (1993)
N Aegean Sea	Winter, 1991/92	101-200 m	85.3 kg/km^2	JICA (1993)
S Aegean Sea	Spring, 1992	20-100 m	24.4 kg/km^2	JICA (1993)
S Aegean Sea	Spring, 1992	101-200 m	20.5 kg/km^2	JICA (1993)
W Mediterranean Sea	Spring, 1992	101-200 m	440.2 kg/km^2	JICA (1993)
W Mediterranean Sea	Winter, 1991/92	101-200 m	1307.8 kg/km^2	JICA (1993)
E Mediterranean Sea	Summer, 1991	101-200 m	145.5 kg/km^2	JICA (1993)
E Mediterranean Sea	Autumn, 1992	20-100 m	174 kg/km^2	JICA (1993)
All areas surveyed	Spring, 1992	101-200 m	83.4 kg/km^2	JICA (1993)
All areas surveyed	Autumn, 1992	20-100 m	44.2 kg/km^2	JICA (1993)
All areas surveyed	Winter, 1991/92	20-100 m	90.2 kg/km^2	JICA (1993)
All areas surveyed	Winter, 1991/92	101-200 m	278.9 kg/km^2	JICA (1993)
İskenderun / Mersin Bays- Turkey (NE Med. Sea)	Oct. 1983	55-78	762 g/hour	Gücü and Bingel (1994)
Mersin Bay- Turkey (NE Med. Sea)	Oct. 1983	14-59	1606 g/hour	Gücü and Bingel (1994)
Mersin Bay- Turkey (NE Med. Sea)	Oct. 1983	8-15	3900 g/hour	Gücü and Bingel (1994)
Mersin Bay- Turkey (NE Med. Sea)	Oct. 1983	13-36	2867 g/hour	Gücü and Bingel (1994)
İskenderun Bay- Turkey (NE Med. Sea)	Oct. 1983	7-33	2353 g/hour	Gücü and Bingel (1994)
Mersin Bay- Turkey (NE Med. Sea)	Oct. 1983	15-35	8224 g/hour	Gücü and Bingel (1994)
Mersin Bay- Turkey (NE Med. Sea)	May 1984	27-60	4836 g/hour	Gücü and Bingel (1994)
Mersin Bay- Turkey (NE Med. Sea)	May 1984	7-30	4463 g/hour	Gücü and Bingel (1994)
Mersin Bay- Turkey (NE Med. Sea)	May 1984	22-37	38402 g/hour	Gücü and Bingel (1994)
Mersin Bay- Turkey (NE Med. Sea)	Oct.1984	7-46	338 g/hour	Gücü and Bingel (1994)
Mersin Bay- Turkey (NE Med. Sea)	Oct.1984	7-17	1489 g/hour	Gücü and Bingel (1994)
Mersin Bay- Turkey (NE Med. Sea)	Oct.1984	25-45	875 g/hour	Gücü and Bingel (1994)
İskenderun Bay- Turkey (NE Med. Sea)	Nov. 1996	63-61	180 g/30 min	Salihoğlu and Mutlu (2000)
İskenderun Bay- Turkey (NE Med. Sea)	Nov. 1996	20-22	350 g/30 min	Salihoğlu and Mutlu (2000)
N Cyprus (NE Med. Sea)	Nov. 1996	70-76	170 g/30 min	Salihoğlu and Mutlu (2000)
Average of 14 hauls in İskenderun and Mersin Bays and North Cyprus (NE Med. Sea)	Nov. 1996	14-90	58 g/hour	Salihoğlu and Mutlu (2000)

Table 7. Continued

Location	Date	Depth (m)	CPUA-CPUE	Source
Mersin Bay- Turkey (NE Med. Sea)	23 July 1996	25-50	1350 g/30 min	Salihoğlu and Mutlu (2000)
Mersin Bay- Turkey (NE Med. Sea)	29 Aug. 1996	50-100	3000 g/30 min	Salihoğlu and Mutlu (2000)
Mersin Bay- Turkey (NE Med. Sea)	16 Oct. 1996	0-25	275 g/30 min	Salihoğlu and Mutlu (2000)
Average of 5 hauls in Mersin Bay- Turkey	July- Dec.1996	0-25	85 g/30 min	Salihoğlu and Mutlu (2000)
Average of 5 hauls in Mersin Bay- Turkey	July- Dec.1996	25-50	270 g/30 min	Salihoğlu and Mutlu (2000)
Average of 4 hauls in Mersin Bay- Turkey	July- Dec.1996	50-100	750 g/30 min	Salihoğlu and Mutlu (2000)
Average of 14 hauls in Mersin Bay- Turkey	July- Dec.1996	0-100	341 g/hour	Salihoğlu and Mutlu (2000)
Mersin Bay- Turkey (NE Med. Sea)	28 Sep. 1998	25-50	930 g/30 min	Salihoğlu and Mutlu (2000)
Mersin Bay- Turkey (NE Med. Sea)	23 Oct. 1998	25-50	550 g/30 min	Salihoğlu and Mutlu (2000)
Average of 18 hauls in Mersin Bay- Turkey	April- Oct.1998	0-100	78 g/hour	Salihoğlu and Mutlu (2000)
Mersin Bay- Turkey (NE Med. Sea)	22 June 1999	50-100	1500 g/30 min	Salihoğlu and Mutlu (2000)
Average of 12 hauls in Mersin Bay- Turkey	March-June 1999	0-100	125 g/hour	Salihoğlu and Mutlu (2000)
Average of 462 hauls in Central Aegean Sea	1995-2006		0.80 ind/hour- 2.44 kg/hour	Damalas and Vassilopoulou (2009)
Average of 214 hauls in Central Aegean Sea	1995-2000	50-339	0.06 ind/hour- 0,24 kg/hour	Damalas and Vassilopoulou (2011)
Average of 121 hauls in Central Aegean Sea	2003-2006	50-339	0.06 ind/hour- 0,12 kg/hour	Damalas and Vassilopoulou (2011)
İskenderun Bay- Turkey (NE Med. Sea)	2004	10-20	27 ind/hour- 11.59 kg/hour	Yeldan *et al.* (2013)
İskenderun Bay- Turkey (NE Med. Sea)	2005	10-20	39 ind/hour- 12.41 kg/hour	Yeldan *et al.* (2013)
İskenderun Bay- Turkey (NE Med. Sea)	2006	10-20	36 ind/hour- 11.87 kg/hour	Yeldan *et al.* (2013)
İskenderun Bay- Turkey (NE Med. Sea)	2007	10-20	49 ind/hour- 16.00 kg/hour	Yeldan *et al.* (2013)
İskenderun Bay- Turkey (NE Med. Sea)	2008	10-20	61 ind/hour- 23.54 kg/hour	Yeldan *et al.* (2013)
İskenderun Bay- Turkey (NE Med. Sea)	2009	10-20	48 ind/hour- 13.81 kg/hour	Yeldan *et al.* (2013)
İskenderun Bay- Turkey (NE Med. Sea)	2010	10-20	50 ind/hour- 20.20 kg/hour	Yeldan *et al.* (2013)
İskenderun Bay- Turkey (NE Med. Sea)	2011	10-20	30 ind/hour-7.94 kg/hour	Yeldan *et al.* (2013)
Average of 58 hauls in İskenderun Bay- Turkey	2004-2011	10-20	42.5 ind/hour- 14.67 kg/hour	Yeldan *et al.* (2013)
Average of 24 hauls in Gulf of Antalya - Turkey	Aug. 2009- April 2010	25	86.78 ind/km^2- 142.82 kg/km^2 121.37 ind/hour- 218.26 kg/hour	Present Study
Average of 24 hauls in Gulf of Antalya - Turkey	Aug. 2009- April 2010	50	89.14 ind/km^2- 185.99 kg/km^2 83.35 ind/hour- 173.90 kg/hour	Present Study
Average of 24 hauls in Gulf of Antalya - Turkey	Aug. 2009- April 2010	75	32.67 ind/km^2- 64.78 kg/km^2 38.97 ind/hour- 75.74 kg/hour	Present Study
Average of 24 hauls in Gulf of Antalya - Turkey	Aug. 2009- April 2010	100	57.29 ind/km^2- 122.18 kg/km^2 101.16 ind/hour- 193.80 kg/hour	Present Study
Average of 12 hauls in Gulf of Antalya - Turkey	Aug. 2009- April 2010	150	1.10 ind/km^2- 5.97 kg/km^2 1.00 ind/hour- 5.45 kg/hour	Present Study
Average of 8 hauls in Gulf of Antalya - Turkey	Aug. 2009- Aprzil 2010	200	2.85 ind/km^2- 2.85 kg/km^2 4.35 ind/hour- 4,35 kg/hour	Present Study
Average of 116 hauls in Gulf of Antalya - Turkey	Aug. 2009- April 2010	25-200	55.32 ind/km^2- 107.53 kg/km^2 71.75 ind/hour- 137.77 kg/hour	Present Study

Serena (2005) stated that *D. pastinaca* reaches up to 140 cm DW and 250 cm TL. Our study reports the highest TL for *D. pastinaca* as 130 cm. Saadaoui *et al.* (2013) reported the highest DW value as 70 cm from the Central Mediterranean Sea, which is very similar to the max. DW value (69.5 cm) in the present study. Pallaoro *et al.* (2005) reported the highest DL value as 95.2 cm in the Adriatic Sea, which is probably the largest recorded specimen in the Mediterranean Sea.

While studies suggest that *D. centroura* can grow even larger, there is no recorded measurement larger than 260 cm DW in the literature (Dulcic *et al*. 2003). Başusta and Sulikowski (2012) reported the oldest estimated age from the İskenderun Bay as 24 years for the specimen at 179 cm DW which is very similar to the max. DW value (170 cm) in the present study.

The maximum total length of *D. marmorata* was reported as 85.7 cm (Capapé 1990) and width of disc as 60.5 cm (El Kamel *et al.* 2009) from Tunisia. The max. length values (74.5 cm TL, 40 cm DW, and 41 cm DL) found in this study are the highest records for Turkey and the E Mediterranean Sea.

The parameters for *D. tortonesei* are only available from Tunisia in the literature so the values given in this study are the first records for Turkey and the E Mediterranean Sea.

The parameter b represents growth allometric rate, and indicates isometric growth when equal to 3. The slopes of length–weight relationships varied widely between ecosystems. Various factors may be responsible for the differences in parameters of the length-weight relationships, such as temperature, salinity, food (quantity, quality and size), sex, time of year and stage of maturity (Pauly 1984; Weatherley and Gill 1987).

The spatial distributions of the *Dasyatis* species varied among the stations in the Gulf of Antalya. *D. pastinaca* was abundant in all six stations. However, the possible fishing effect can be seen in St.B with the lowest mean abundance, biomass and frequency of occurrence values. All sorts of trawling are prohibited in St.A since 2005 till today. Slightly higher abundance and biomass in St.A compared to St.B, which is the main commercial trawl area of the Gulf, may be interpreted as the recovery of the "no-trawl zone". *D. pastinaca* was also reported to move the estuaries to birth giving (Capapé *et al*. 2004; El Kamel *et al*. 2009). So, possibly it may prefer St. A as breeding ground where is the mouth of the Manavgat River. The mean abundance and biomass of *D. pastinaca* were highest inside the Gulf (St. C and St. D) where are closed zones for trawl. However larger individuals were found to occur in St. E where is close to the tuna farm, which may attract the larger individuals. Ozgur Ozbek *et al.* (2013) also reported the presence of larger individuals of *Epinephelus aeneus* in St. E in the Gulf of Antalya, presenting the highest percentage of the mature males. Although the depth levels of 75, 100 m of St. E were located outside 2 NM off the coast, due to the limited trawl area; commercial trawlers generally do not prefer this area for trawl. *D. marmorata*, *D. centroura* and *D. tortonesei* were absent in the eastern stations (St. A and St. B) where the salinity is lower comparing to the west due to three main streams and Manavgat River reaching the sea. Smaller individuals of D. *marmorata* were found in St. C where is the inner gulf that maybe preferring as a nursery area. *D. centroura* was only found in the western stations (St. D, E, F) and *D. tortonesei* only in the St. E. They are rare species in the region so more studies are necessary to evaluate their distribution.

The impact of fishing on chondrichthyan stocks around the world is currently the focus of considerable international concern. Most chondrichthyan populations are of low productivity relative to teleost fishes and when taken as by-catch, they are often subjected to high fishing mortality. At the species level, fishing may alter size structure and population parameters in response to changes in species abundance (Stevens *et al.* 2000).

Conclusion

From the present study, it could be concluded that *D. pastinaca* is captured commonly, *D. marmorata* rarely and *D. centroura* and *D. tortonesei* very rarely in the Gulf of Antalya (NE Mediterrranean Sea). The high catchability of these species shows that trawling seem to represent a risk for the population of these species in the Gulf of Antalya. There is insufficent scientific data to prepare a sustainable management for the demersal resources in the Gulf of Antalya. So, it is essential to determine the spawning and nursery grounds of the demersal species and declare these areas “No Take Zones” which is going to affect postively not only the species but also the whole ecoystem they live in.

More detailed studies are necessary on the biology and ecology of the *Dasyatis* species in the region; however, this is the most detailed study on spatio-temporal distribution and length-weight relationship of *Dasyatis* species. The results of this study are thought to be useful for future decisions on declaration of “No Take Zones” or protected areas in the Gulf of Antalya and considered to make a major contribution to future studies.

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Antalya Körfezi’nde iğneli vatoz türlerinin (Pisces: Dasyatidae) bolluk, biyokütle ve boy-ağırlık ilişkisinin mevsimsel ve mekansal değişimi

Özet

Bu çalışmada *Dasyatis centroura* (Mitchill, 1815), *D. marmorata* (Steindachner, 1892), *D. pastinaca* (Linnaeus, 1758) ve *D. tortonesei* Capapé, 1975)’nin Antalya Körfezi’nde mevsim, istasyon ve derinliklere göre bolluk ve biyokütlesi ve elde edilen 391 birey *D. pastinaca*, 21 birey *D. marmorata* ve beş birey *D. centroura*’nın boy-ağırlık ilişkileri bildirilmektedir. Ağustos 2009- Nisan 2010 tarihleri arasında mevsimsel olarak, altı istasyonda ve altı farklı derinlikte (25, 50, 75, 100, 150, 200 m), toplam 116 trol çekiminin 65’inde *Dasyatis* türleri örneklenmiş olup, ortalama bolluk ve biyokütle *D.*

pastinaca için 55,32 birey/km^2, 107,53 kg/km^2; *D. marmorata* için 2,54 birey/km^2, 2,56 kg/km^2; *D. centroura* için 0,50 birey/km^2, 25,97 kg/km^2 ve *D. tortonesei* için 0,25 birey/km^2, 1,34 kg/km^2 olarak hesaplanmıştır. Boy-ağırlık ilişklerine ait denklemler (total boy (TL), disk boyu (DL), disk eni (DW), ağırlık (W)), *D. pastinaca* için $W = 0{,}023*TL^{2,76}$, $W = 0{,}0999*DL^{2,74}$ ve $W = 0{,}037*DW^{2,97}$; *D. marmorata* için $W = 0{,}002*TL^{3,23}$, $W = 0{,}034*DL^{3,02}$ ve $W = 0{,}0045*DW^{3,59}$; *D. centroura* için $W = 0{,}00001*TL^{4,04}$, $W = 1{,}481*DL^{2,16}$ ve $W = 0{,}141*DW^{2,59}$ olarak ifade edilmiştir.

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