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# The Seasonally Determination of Disc Diameter-Weight Relationship of Moon Jellyfish *Aurelia aurita* in the Black Sea Coasts of Turkey

# Türkiye'nin Karadeniz Kıyılarındaki Ay Denizanası (*Aurelia aurita*)'nın Çap-Ağırlık İlişkisinin Mevsimsel Olarak Belirlenmesi

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## ABSTRACT

In this study, seasonal disc diameter-weight relationship of moon jellyfish (*Aurelia aurita*) were determined in the Black Sea coasts of Turkey. The samples of jellyfish were collected monthly from Sinop coasts in the southern Black Sea between December 2012 and November 2013 with plankton net. A total 1358 moon jellyfish were measurement in the study. Mean length and weight of all individuals were established, 8.3±0.10 cm and 43.2±1.58 g respectively. Disc diameter-weight relationship of moon jellyfish were calculated as $W_w=0.1207L^{2.5887}$ for general, $W_w=0.1251L^{2.5567}$ for autumn, $W_w=0.0815L^{2.7181}$ for winter, $W_w=0.1012 L^{2.6813}$ for spring and $W_w=0.1289L^{2.6844}$ for summer. The results showed that "a" and "b" value of moon jellyfish varied with seasons in the Black Sea coasts.

**Keywords:** Moon jellyfish, *Aurelia aurita,* Disc diameter-weight relationship, Season, Black Sea

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## ÖZET

Bu araştırmada Türkiye'nin Karadeniz kıyılarındaki ay denizanası (*Aurelia aurita*)'nın mevsimsel olarak çap-ağırlık ilişkileri belirlenmiştir. Denizanası örnekleri aylık olarak Aralık 2012-Kasım 2013 tarihleri arasında Güney Karadeniz'in Sinop kıyılarından plankton ağı ile toplanmıştır. Çalışmada 1358 adet denizanasının çap ve ağırlığı ölçülmüştür. Tüm denizanaları için ortama boy ve ağırlıkları 8.3±0.10 cm ve 43.2±1.58 g olarak tespit edilmiştir. Denizanalarının çap-ağırlık ilişikleri tümü için $W_w=0.1207L^{2.5887}$, sonbahar için $W_w=0.1251L^{2.5567}$, kış için $W_w=0.0815L^{2.718}$, ilkbahar için $W_w=0.1012\ L^{2.6813}$ ve yaz için $W_w=0.1289L^{2.6844}$ olarak hesaplanmıştır. Bu sonuçlar Karadeniz kıyılarındaki ay denizanasının "a" ve "b" değerlerinin mevsimsel olarak değiştiğini göstermiştir.


**Anahtar sözcükler**: Ay deniz anası, *Aurelia aurita,* Çap-Ağırlık ilişkisi, mevsim, Karadeniz

## 1. INTRODUCTION

The moon jellyfish *Aurelia aurita* is an important macrogelatinous zooplankton species of the world's marine systems. This species of zooplankton has received quite a lot of interest from the scientific and other people due to its major role in pelagic ecosystems (Möller, 1980; Mutlu, 2001). This jelly is important predator on small pelagic fish, fish larvae and eggs in the Black Sea (Mutlu, 1999; Shiganova and Bulgakova, 2000; Birinci-Özdemir et al., 2014).

The scyphomedusa moon jellyfish is a widespread macrozooplankton organism in coastal water and shelf sea (Schroth et al., 2002). In much more attention is recently being devoted to jellyfish than previously, possibly because of some spectacular outbreaks, such as for example in the Black Sea ecosystem (Weisse and Gomoiu, 2000).

Moon jellyfish is very common in the mixed layer down to the sub-thermocline region in the Black Sea. Small individuals are mostly found above the thermocline, while larger individuals up to 40 cm are found just below it (Mutlu, 1999, Kideys and Romanova, 2001). Jellyfish have effected commercial and economical fisheries (Kingsford et al., 2000; Özdemir et al., 2014). As a result, it can be expected that studies of the life history, biology, population dynamic and ecology of jellyfish are likely to be intensified.

Most of these studies require estimates of population parameters (i.e., growth, age, condition factor, the relationship between disc diameter and weight), which then allows mortality rates to be inferred (Palomare and Pauly, 2009). Length-weight relationships are widely used in aquatic organism especially fishes applications and marine systems management. Consequently, variability in size has important implications for diverse aspects of marine science and population dynamics (Erzini, 1994). Studies concerning moon jellyfish at the Turkish coasts of Black Sea (Mutlu et al., 1994; Mutlu, 2001; Mutlu, 2007; Bat et al., 2009) have reported on spatial distribution, relationship of length-weight and morphometry of *A. aurita*. On the other hand, there are scarce studies on population dynamics (such as asymptotic length $L\infty$, growth coefficient K, total mortality

coefficient Z and natural mortality rate M) of moon jellyfish. The studies are essential for other jellyfish and aquatic organism. In this study disc diameter-weight relationships of moon jellyfish were determined seasonally.

## 2. MATERIAL AND METHOD

Samples were collected monthly between December 2012 and November 2013 from Sinop coasts in the southern Black Sea of Turkey (Fig 1). Sampling of moon jellyfish was carried out using R/V "Seydi Ali Reis" and a commercial fishing boat. All samples were obtained during daytime.

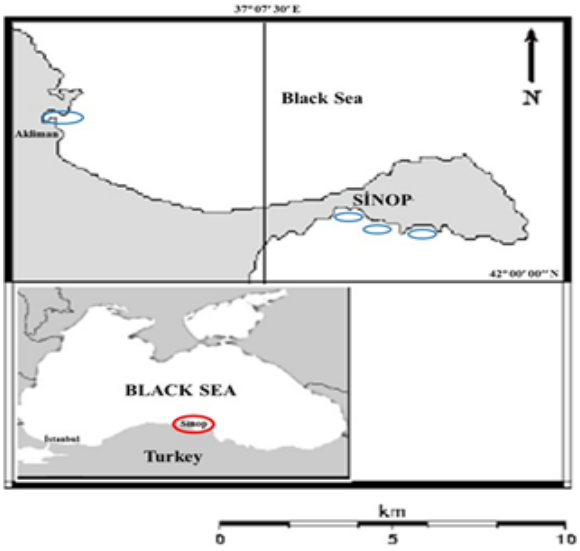


**Figure 1.** Sampling areas

Hauls were taken from the bottom to surface using a standard plankton nets (50 cm diameter mouth opening, 500 µm mesh size for horizontal hauls, 210 µm mesh size for vertical hauls). Water depth was 1-45 m and the boat's speed 2,5 knot. At the end of each haul, nets were exteriorly washed and their cod-end contents were washed through a 2 mm sieve to retain the jellyfish. Disc diameters of specimens were measured to the nearest millimeter and weight were determined individual displacement volumes (ml). Weight was given as wet weight (g);
1 g = 0.962 volume (ml) (~1 ml) (Kideys and Romanova, 2001).
The disc diameter-weight relationship (DWR) of moon jellyfish was determined using the equation; $W_w=aL^b$ (Pauly, 1984). The parameters a (intercept, condition factor) and b (slope, indicating growth type) of the disc diameter-weight relationship (DWR) were estimated by least square regression.
Slope and intercept of the volume (wet weight) to length (disc diameter) relationship was tested using ANCOVA. The ANOVA were used for statistical analyze of seasonal condition factor.

## 3. RESULTS

A total 1358 moon jellyfish *A. aurita* specimens were sampled by plankton net and analyzed in the study. Moon jellyfish sampled ranged in size from 1.5 to 26 mm of total length, and weighed between 1.1 and 543 g. The highest rate were established 7.5 mm diameter group (30%), 10 mm diameter group (22%) and 5 mm diameter group (20%) respectively, while the lowest rate were determined 27.5 mm diameter group (1%) for *A. auirta* in general. Seasonally and generally disc diameter frequency distribution of moon jellyfish were showed in Fig 2.
Mean disc diameter and weight of all individuals were estimated 8.3 ± 0.10 cm and 43.2 ± 1.58 g, respectively. Disc diameter and weight data of *A. aurita* was changed seasonally. Minimum and maximum values of each parameter were also given in parentheses (Table 1).

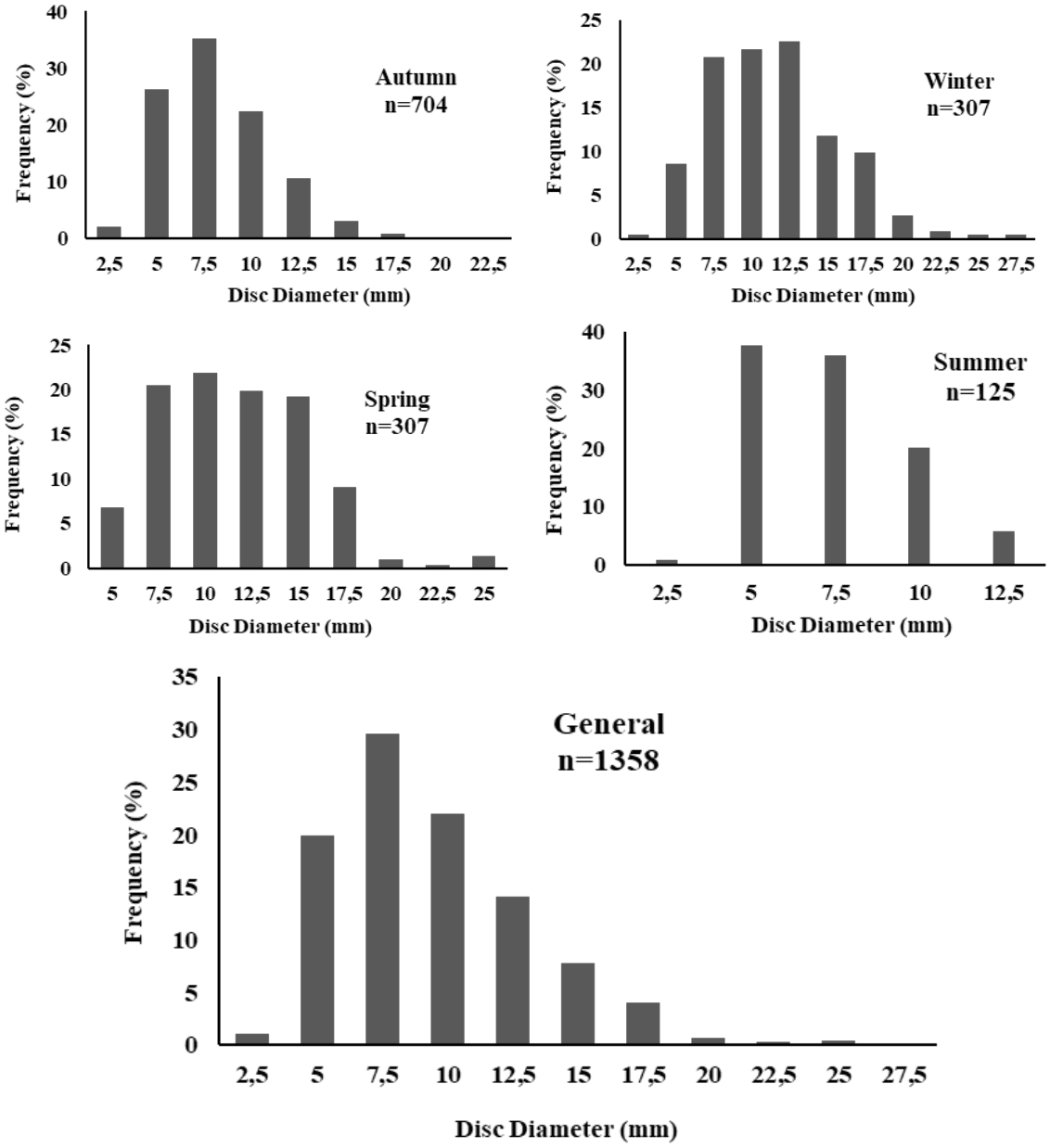


**Fig 2.** Seasonally and general disc diameter frequency distribution of *A. aurita.*

**Table 1.** Seasonal disc diameter and weight of moon jellyfish *Aurelia aurita* (min-max)

| Seasons | n | Mean Diameter (cm) | Mean Weight (g) |
|---|---|---|---|
| Autumn | 704 | 7.0 ± 0.10 (2.1-20.4) | 25.2 ± 1.10 (0.3-319.4) |
| Winter | 222 | 10.4 ± 0.28 (2.5-26.0) | 67.8 ± 5.15 (1.1-523) |
| Spring | 307 | 10.5 ± 0.22 (3.1-24.6) | 75.4 ± 4.54 (2.7-543) |
| Summer | 125 | 6.1 ± 0.19 (1.5-12.3) | 21.9 ± 1.93 (1.09-108.8) |
| **All** | **1358** | **8.3 ± 0.11 (1.5-26.0)** | **43.2 ± 1.58 (1.1-543)** |

A significant difference was detected especially in May, June July and months of autumn (ANOVA, $P < 0.05$). The test of homogeneity of slopes and differences between slopes were not found to be statistically significant (ANOVA, $P > 0.05$). Significantly difference was found for the DWR among seasons (ANCOVA of log-transformed data, $P < 0.001$).

The DWR of moon jellyfish could be fitted to a power function of the form $Ww = a L^b$ (Fig 3). Note that although the curve fit was generally good, individual data points may deviate from the curve by a factor of up to 2.

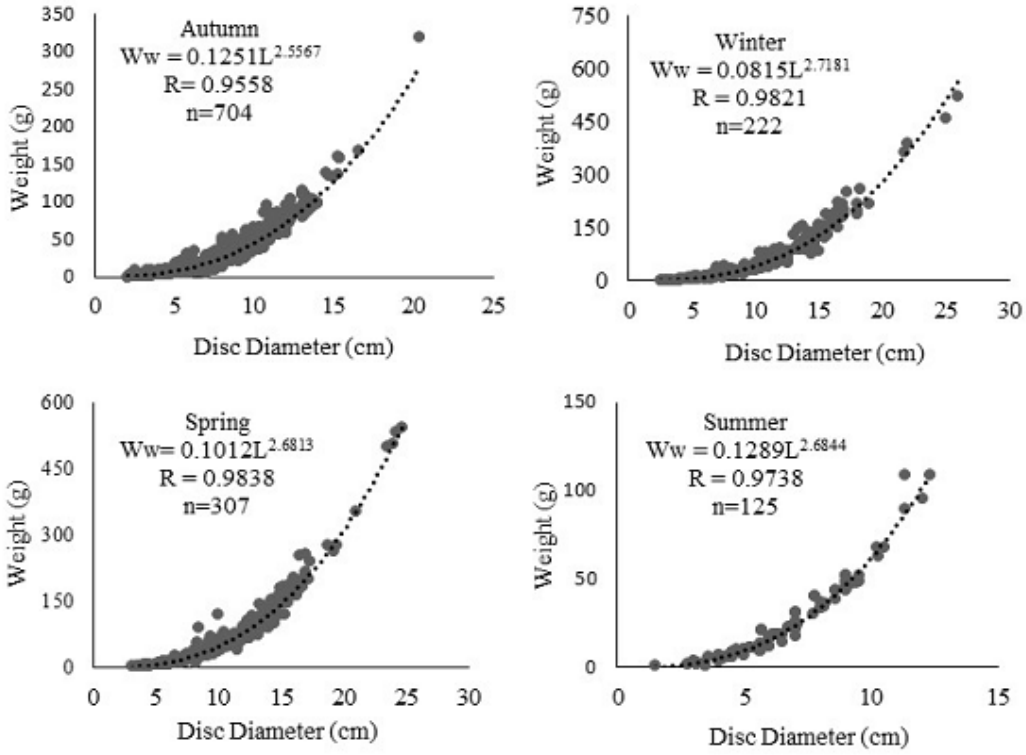


**Figure 3.** DWR graphics of moon jelly fish *Aurelia aurita* seasonally

The diameter and weight, parameters of DWR ("a" and "b"), 95% confidence intervals of "b" and the coefficient of determination (R) are given seasonal moon jellyfish in Table 2. In the present study, "b" (based on disc diameter) of moon jellyfish varied from a minimum of 2.5567 for autumn season to a maximum 2.7181 for spring season. The "R" values of moon jellyfish ranged from 0.96 to 0.98. All "b" values of moon jellyfish were significant ($P < 0.05$), with all R values > 0.96. The highest condition factor were in autumn and summer seasons (Table 2).

**Table 2.** The DWR parameters of moon jelly fish *Aurelia aurita* for the seasonally (A: allometric)

| Seasons | a | b | 95% Confidence interval of b | Standard error of b | R | Growth type | P |
|---|---|---|---|---|---|---|---|
| Autumn | 0.1251 | 2.5567 | 2.4984 - 2.6149 | 0.0296 | 0.96 | -A | < 0.05 |
| Winter | 0.0815 | 2.7181 | 2.6489 - 2.7878 | 0.0351 | 0.98 | -A | < 0.05 |
| Spring | 0.1012 | 2.6813 | 2.6262 - 2.7364 | 0.0280 | 0.98 | -A | < 0.05 |
| Summer | 0.1289 | 2.6844 | 2.5727 - 2.7960 | 0.0564 | 0.97 | -A | < 0.05 |
| **All** | **0.1217** | **2.5887** | **2.5551 - 2.6223** | **0.0171** | **0.97** | **-A** | **< 0.05** |

## 4. DISCUSSION AND CONCLUSION

Climatic change, anthropogenic pollution, exploitation of fish stocks have effected increasing jellyfish blooms. Biomass of moon jellyfish was reported rising in Black Sea (Daskalov et al., 2007; Bat et al., 2007). The predatory impact of the moon jellyfish and its effect on the planktonic community is far from understood. Therefore, more ecological studies, on population dynamic, fluctuations of abundance and biomass are needed to better understand the mechanisms causing jellyfish blooms.

Comparison of DWR parameters of moon jellyfish in the Black Sea were given in Table 3. In the present study, DWR parameters showed difference from other studies in the Black Sea (Tuncer, 1990; Weisse and Gomoiu, 2000; Mutlu, 2001; Bat et al., 2009; Birinci-Özdemir, 2011). "a" and "b" value differences have been reported for moon jellyfish in different regions and seasons. Black Sea ecosystem changes have affected the jellyfish growth. The differences of *a* and *b* values of aquatic organism might have been changed by several ecological factors, such as growth increment, differences in feeding, quality and quantity of food, differences in the sampling periods, stage of maturity, as well as environmental conditions, temperature, salinity and seasonality differences in the number of specimens examined (Tesch, 1971; Pauly, 1984; Wootton, 1990; Froese, 2006).

Temperature and food are determining factors growth of moon jellyfish. Higher growth rate is parallel with increasing of this factors (Möller and Riisgard 2007; Webster & Lucas 2012).

Bloom of moon jellyfish usually is in spring seasons but we found reproductive period as autumn and summer depend on condition factor (parameter a) of moon jellyfish. It is thought to be predation pressure of moon jellyfish on zooplankton and ichthyoplankton in this periods.

It is important that the size and weight of the samples are made to follow the sampling process. However, making measurements on the boat in difficult weather conditions is sometimes inconvenient. In sampling this will alleviate the workload in the sample measurements while providing both temporal gain. This study presents the first data on seasonally DWR for moon jellyfish from southern Black Sea coast of Turkey.

**Table 3.** Comparison of moon jellyfish *Aurelia aurita* disc diameter (D), wet weight (g) and DWR parameters in the Black sea

| **Authors** | **Area** | **(Max-Min-Mean)** | | **n** | **a** | **b** | **R** |
|---|---|---|---|---|---|---|---|
| | | **D (cm)** | **Ww (g)** | | | | |
| Tunçer (1990) | Eastern Black Sea-Turkey | 17.5–2.5–9.3 | 147.6–3.53–52.7 | 32 | 0.210 | 1.880 | 0.92 |
| Weisse & Gomoiu (2000) | Northwestern Black Sea-Romania & Bulgaria | 17– * – * | * | 737 | 0.852 | 2.940 | * |
| Mutlu (2001) | Black Sea-Turkey | 43 – * – * | * | 243 | 0.120 | 1.790 | 0.89 |
| Bat et al (2009) | Southern Black Sea-Turkey | 26–1.2–6.5 | * – * – 31.3 | 351 | 0.277 | 2.182 | 0.94 |
| Birinci-Özdemir (2011) | Southern Black Sea-Tukey | 21–1.2 – * | * | 256 | 0.289 | 2.165 | 0.93 |
| Present study (2018) | Southern Black Sea-Turkey | 26–1.5–8.3 | 543–0.3–43.2 | 1358 | 0.121 | 2.588 | 0.97 |

** No data.*

In conclusion, it is considerable determination of biology, ecology, life cycle, population dynamics and distribution of moon jellyfish increasing in Black Sea with climatic changing. This study revealed seasonal DWR of moon jellyfish in Black sea. In addition to this study data ecological status and environmental conditions causing bloom of moon jellyfish should be investigated. There needs to be more fundamental research on polyp stage, ecology and ecosystem roles of jellyfish in the Black Sea.

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