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# The Response of *Apseudopsis latreillii* (Milne-Edwards, 1828) (Crustacea, Tanaidacea) to Environmental Variables in the Dardanelles

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**Abstract**

The tanaid, *Apseudopsis latreilli* (Milne- Edwards, 1828) is a common crustacean species on the soft bottoms of the Mediterranean ecosystems and occurs in both clean and polluted environments. This study was aimed to determine the sensitive state of tanaid, *A. latreilli* to the environmental variables observed on the soft bottoms of the Dardanelles. *A. latreillei* abundance at the sites was analysed in comparision with the organic matter content in sediment and the environmental variables in the study area. A total of 1406 specimens of *A. latreillii* was recorded during the study. The highest dominance value (Di=30.37%) was for Kepez Harbour where the amount of organic matter was 25.50±12.09% in the sediment. The highest value of dominance according to the sampling seasons was 56.75% for Autumn 2008 (organic matter=21.7±7.99%). The highest sand rate (99.59%) in the sediment was found at the Eceabat sampling point. The highest positive correlation ($r=0.349$, $P<0.05$) was observed between gravel content (%) measured at the sites and total abundance (ind.0.09 $m^{-2}$).

*Keywords*: *Apseudopsis latreillii*, tanaidacea, crustacea, abundance, environmental variables, the Dardanelles, Turkey.

**Çanakkale Boğazı'ndaki Çevresel Değişkenlere *Apseudopsis Latreillii* (Milne- Edwards, 1828) (Crustacea, Tanaidacea)'nin Tepkisi**

**Özet**

Tanaid, *Apseudopsis latreillii* (Milne- Edwards, 1828) Akdeniz Ekosistemi'nin yumuşak zeminlerindeki yaygın bir krustase türüdür ve hem temiz hem de kirli çevrelerde ortaya çıkar. Bu çalışmanın amacı Çanakkale Boğazı'nınyumuşak zeminlerinde gözlenen çevresel değişkenlere tanaid, *A. latreillei*'nin duyarlılık durumunu belirlemektir. İstasyonlardaki *A. latreillii* bolluğu çalışma alanında sedimentteki organik madde ve çevresel değişkenler karşılaştırılarak analiz edilmiştir. Çalışma boyunca toplam 1406 *Apseudopsis latreillii* bireyi kaydedilmiştir. *A. latreillii*' nin en yüksek baskınlık değeri (b=%30,37) sedimentteki organik madde miktarının %25,50±12,09 olduğu Kepez Limanı için bulunmuştur. Örnekleme mevsimlerine göre en yüksek baskınlık değeri Ağustos 2008 (organik madde %21,7±7,99) için %56,75'ti. Sedimentteki en yüksek kum oranı (%99,59) Eceabat örnekleme noktasında bulunmuştur. En yüksek pozitif ilişki ($r=0.349$, $P<0,05$) sitelerde ölçülen çakıl içeriği (%) ile toplam bolluk (birey.0,09 $m^{-2}$) arasında gözlemlenmiştir.

*Anahtar Kelimeler*: *Apseudopsis latreillii*, tanaidacea, crustacea, bolluk, çevresel değişkenler, Çanakkale Boğazı, Türkiye.

## Introduction

The soft-bottoms are mostly occupied by polychaeta species, while hard-bottom communities are dominated by crustaceans (Conides *et al*., 1999; Serrano Samaniego, 2012). Dynamics of benthic communities are depended on physical factors such as sediment characteristics and environmental variables (Ellis *et al*., 2000; Guerra-García and García-Gómez, 2009). The Macrobenthos of soft-bottoms is a significant element of marine environments (Jayaraj *et al*., 2008). Benthic groups are mostly known as bio-indicators for aquatic monitoring because they respond quickly to environmental variables such as oxygen level (Chapelle and Peck, 2004) and sediment particle size (Moreira *et al*., 2008; Lourido *et al*., 2008).

Correlations between the physical characteristics of the sediment and the structures of the benthic community are significant (Fresi *et al*., 1983; Conradi and López-González, 2001). Therefore, correlation between the environmental variables and faunal data is essential (Ansari and Abidi, 1993).

Peracarid crustaceans play a significant role in the structuring of benthic assemblages and are affected by organic pollution at the coastal areas (De Grave, 1999; Tomassetti *et al*., 2009; de la Ossa Carretero *et al*., 2010). The relationships between benthic peracarid crustaceans and the variables in marine environments have been approached extensively in relevant literature (Lourido *et al*., 2008; Moriera *et al*., 2008; de la Ossa Carretero *et al*., 2010). Peracarid crustaceans can comprise the dense populations on soft-bottoms in marine environments (Cunha *et al*., 1999; Lourido *et al*., 2008) and are known among the most sensitive organisms to changes in environmental variables (Sánchez-Moyano and García- Gómez, 1998; Dauvin *et al*., 2007). Some species of peracarid crustaceans are indicators of environmental changes in soft bottom monitoring programmes (Tomasetti *et al*., 2009). The tanaid, *Apseudopsis latreillii* is one of these indicators and lives in sandy and muddy bottoms in depths ranging between 0 and 138 m (Bakalem *et al*., 2009; Bouchet and Sauriau, 2008; Lourido *et al*., 2008). *Apseudopsis latreillii* creates dense populations in the Mediterranean Sea and the eastern Atlantic Ocean and its reaction to enviromental changes is controversial, since it has also been mentioned as a tolerant species in different literatures (Grall and Glémarec, 1997; de Juan *et al*., 2007; De la Ossa Carretero *et al*., 2010). It occurs under stones, in rock crevices, muddy gravel, kelp holdfasts, and meadows (Holdich and Jones, 1983). Crustaceans such as amphipods and tanaids have high sensitivity to organic matter in sediment and in soft bottoms and tanaid community was dominated by *Apseudopsis latreillii* (de la Ossa Carretero *et al*., 2011). *A. latreillii* is specified by some authors (Sanz-Lázaro and Marín, 2006; Simboura and Reizopoulou, 2007; Bouchet and Sauriau, 2008) as an indicator of pollution but, recently, several studies showed that this species does not prefer the polluted sediments (Guerra-García *et al*., 2003; Lourido *et al*., 2008; Moreira *et al*., 2008; de la Ossa Carretero *et al*., 2010). This tanaid species was previously reported as a species of high sensitivity to organic matter in sediment by de la Ossa Carretero *et al*. (2010), even though it occasionally is reported as a tolerant species in previous literatures by Sanz-Lázaro and Marín (2006) and Bouchet and Sauriau (2008).

The aim of this study is to determine the abundance of tanaid, *A. latreillii* found on the soft-bottoms of the Dardanelles coast in relation to organic enrichment and sedimantation and its response to environmental variables.

## Material and Methods

### Sampling Sites

Sampling area is located at the coastal waters of the Dardanelles where the coastline is 63 km. Eight sites were sampled during the study. GPS coordinates of the sampling sites are: Gelibolu (location 1, 40°40′617″N 26°66′692″E), Lapseki (location 2, 40°34′661″N 26°67′985″E), Çanakkale (location 3, 40°15′474″ N 26°40′879″ E), Kilya Inlet (location 4, 40°20′472″N 26°36′117″E), Eceabat (location 5, 40°18′253″N 26°36′046″E), Kilitbahir (location 6, 40°15′048″N 26°37′878″E), Kepez Harbour (7, 40°10′360″N 26°37′339″E), Dardanos (8, 40°07′493″N 26°35′806″E) (Figure 1).

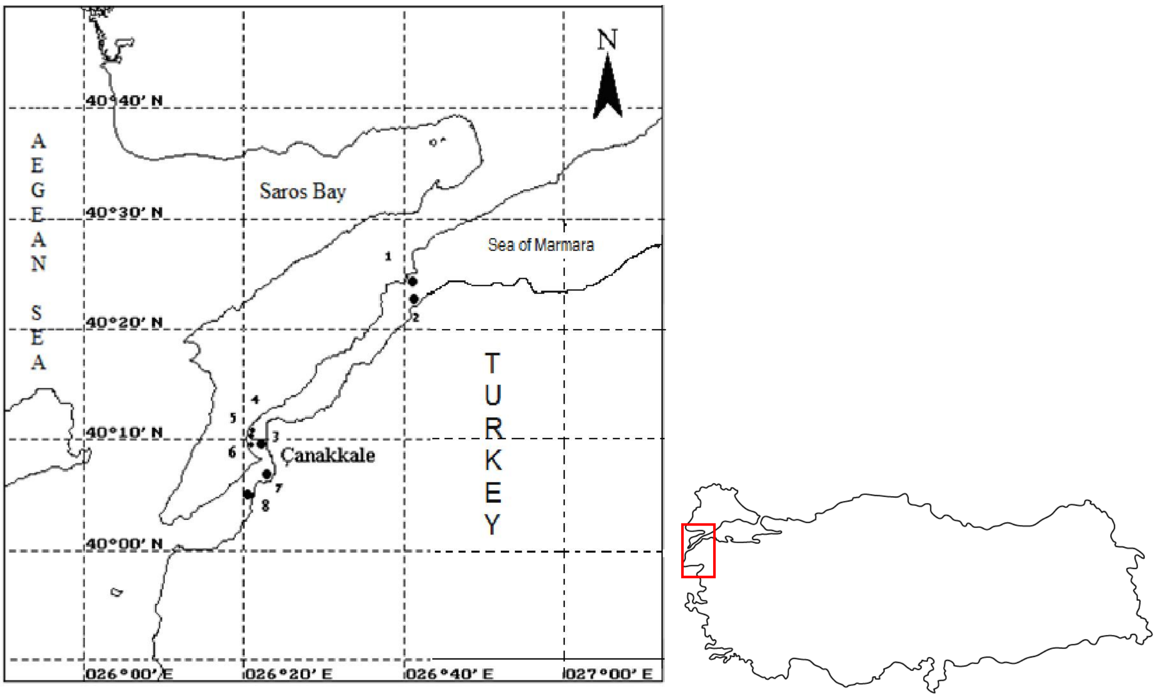


**Figure 1.** Map showing the sampling sites.

### Sampling Techniques

Two transects (0.5, 2 and 4 m) of samples were collected at each station in July 2008, November 2008, February 2009, and April 2009 by means of a frame quadrat system of 30×30 cm (its representative area is 0.9 $m^2$).

### Laboratory Analysis

The samples collected were sieved through a 0.5 mm mesh and preserved in a seawater-formalin solution of 5%. *Apseudopsis latreillii* specimens were then identified and counted, using a stereomicroscope. Additional sediment and seawater samples were taken for analysis of abiotic variables such as temperature, salinity, dissolved oxygen, organic matter and mean particle size of the sediment. Dissolved oxygen, water temperature, and salinity were measured using a YSI 556 model MPS on site. In analyses of sediment granulometry, a series of the sieve set ranging from 63 µm to 20 mm was used. The amounts of sediment in each sieve were classified into four groups (silt-clay fraction, <63 µm; fine sands, >63 µm and <0.25 mm; coarse sands, >0.25 and <0.50 mm; and very coarse sands, >0.5 mm) for analysis. The organic matter in sediment was determined by the high temperature oxidation method adopted by Craft *et al.* (1991). In addition to loss of ignition at 550°C using a furnace, organic carbon and total nitrogen were also determined by the high temperature oxidation method. The loss of ignition method involves placing a weighed dry material in a furnace that is slowly heated to 550°C, then held one to two hours at this constant temperature. A clean sand sample was also tested to compare with results obtained from the sediment samples.

### Statistical Analysis

The data of abundance was analysed using Bray Curtis similartiy index. The data on relationships between the abundance and environmental variables were analysed by calculating the non-metric Multi Dimensional Scaling (MDS). For statistical analyses, IBM SPSS Statistic 20 and Minitab 16 were used. Correlation between total abundances of *Apseudopsis latreillii*, sediment characteristics and organic matter in sediment were determined using Pearson's correlation coefficient (r). Abundance was calculated as the number of individuals in each 0.09 $m^2$ quadrate. Friedman's test was adopted to see the seasonal changes in particle size. Friedman's test formula was presented below.

$$F_D = [12 / (b\times t\times (t+1))] \times \Sigma[(S_j)^2-(3\times b\times (t+1))]$$

where, b is the number of sampling stations (8) and t is the number of seasons (4) in the study $S_j$ : standart deviation of the data set.

## Results

### Abiotic Data

Temperature, salinity, and dissolved oxygen (DO) values in the study area changed seasonally. During the study, the mean oxygen values of sea water at the sites were between 6.18 and 7.96. The highest value (9.79 mg $L^{-1}$) of DO was recorded at Canakkale point in April 2009. Lapseki sampling point had the lowest value (3.68 mg $L^{-1}$) in July 2008.

The salinity values measured at the sampling points ranged between 24.55 and 28.87‰. Considering average salinity values for sampling periods, the highest value (28.87‰) was observed at Dardanos site. Average temperature values of sea water measured in the study area was between 15.59 and 16.45°C. Average value of seawater temperature among the sites and sampling periods was 16.02°C (±5.82). Kilya station had the highest value with 26.77°C in July 2008, and Gelibolu point had the lowest value (8.87°C) in February 2009. Table 1 shows all the physical and chemical data.

### Sediment Characteristics

For all sampling periods and sites, average value of organic matter in sediment (SOM%) was 2.85±2.16%. The highest value (9.86%) of SOM was observed at Lapseki site in April 2009. The lowest SOM (0.55%) was measured at the Kilitbahir site since a strong current in the strait is close to this point. The granulometry of sediment was homogeneous for all sites with dominance of sand. Most sites had sand content higher than 90%.

According to the result of Friedman's test, particle size was significantly different among the sampling sites ($F=86.375 > \chi^2(0.05; 8) = 15.507$). This shows the mean values ±standard deviation of the % of organic matter (OM), the particle size (<63 µm) of sediments sampled, dissolved oxygen, salinity, and temperature measured.

Coefficient of homogeneity (1.75) for Gelibolu and Canakkale sites was ~~is~~ 2.42, Dardanos site 1.63; Kepez Harbour 5.14, Lapseki site 1.73, Kilitbahir site 2.61, Eceabat sampling site 1.90, Kilya Inlet was ~~were~~ calculated as 1.73. The substrate, except for the Kepez Harbour, can be classified as uniform. While the European coast of the Dardanelles had a mean grain diameter value of 476 µm, the value for the Anatolian coast was 663 µm.

Eceabat site has the highest value (99.59%) of sand content while the lowest value (73.01%) was recorded for Kepez Harbour. This fine grain size of sediments in the sampling leads to easy deposition. While Kepez Harbour has the highest rate of gravel (26.96%), the lowest ratio (0.15%) was found at Eceabat site (Table 2).

Mean values ± standard deviation of the % of organic matter (OM), the grain size (<63 µm) of

**Table 1.** The physical and chemical variables measured in the study area

| Sampling Time | Summer 2008 | | | | | Autumn 2008 | | | | | Winter 2009 | | | | | pring 2009 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Variables | | | | | | | | | | | | | | | | | | | |
| Sites | $O_2$ mg/L | T (°C) | S (‰) | pH | EC mS/cm | $O_2$ mg/L | T (°C) | S (‰) | pH | EC mS/cm | $O_2$ mg/L | T (°C) | S (‰) | pH | EC mS/cm | $O_2$ mg/L | T (°C) | S (‰) | pH | EC mS/cm |
| Çanakkale | 4.19 | 23.7 | 23.3 | 8.21 | 53.78 | 5.00 | 15.25 | 25.6 | 8.32 | 32.69 | 9.63 | 9.18 | 27.8 | 5.30 | 30.40 | 9.79 | 14.26 | 24.4 | 7.07 | 30.50 |
| Lapseki | 3.68 | 24.57 | 22.6 | 8.15 | 51.56 | 3.34 | 15.70 | 24.6 | 8.25 | 31.83 | 9.65 | 9.31 | 27.4 | 6.40 | 30.05 | 8.72 | 13.68 | 23.6 | 6.85 | 29.61 |
| Gelibolu | 5.58 | 25.03 | 22.8 | 8.33 | 53.08 | 5.56 | 16.17 | 25.5 | 8.51 | 33.17 | 9.61 | 8.87 | 27.6 | 7.48 | 33.17 | 8.13 | 13.10 | 24.3 | 6.50 | 29.60 |
| Kilya Inlet | 8.46 | 26.77 | 23.1 | 8.53 | 53.57 | 5.90 | 16.30 | 25.7 | 8.55 | 33.61 | 9.25 | 9.24 | 26.5 | 7.55 | 29.07 | 7.95 | 13.50 | 23.3 | 6.48 | 28.84 |
| Eceabat | 7.40 | 25.60 | 22.9 | 8.39 | 53.19 | 6.01 | 16.01 | 25.5 | 8.46 | 33.13 | 9.56 | 9.24 | 27.4 | 8.09 | 29.98 | 8.90 | 13.31 | 24.2 | 6.52 | 29.62 |
| Kilitbahir | 5.16 | 25.1 | 23.1 | 8.31 | 53.37 | 5.68 | 16.37 | 25.6 | 8.33 | 33.50 | 9.20 | 9.12 | 27.6 | 8.79 | 30.10 | 8.90 | 13.23 | 24.3 | 7.05 | 29.70 |
| Kepez Harbour | 5.14 | 24.39 | 23.5 | 8.30 | 54.93 | 5.28 | 16.22 | 26.1 | 8.45 | 33.96 | 5.68 | 9.65 | 28.3 | 5.44 | 31.21 | 8.65 | 14.10 | 24.8 | 6.74 | 30.97 |
| Dardanos | 6.49 | 24.36 | 28.1 | 8.44 | 64.32 | 5.83 | 16.07 | 30.5 | 8.70 | 38.93 | 7.94 | 9.61 | 28.3 | 5.13 | 35.31 | 8.04 | 15.75 | 28.6 | 6.88 | 36.32 |

$O_2$ (mg/L): Dissolved oxygen; T (°C): Seawater temperature; S (ppt): Seawater salinity; pH: Activity of the hydrogen ion; EC (mS/cm): Conductivity.

**Table 2.** The sediment characteristics of the sampling sites

| Sites | Sand content (%) | Mud (caly+silt) content (%) | Gravel (%) |
|---|---|---|---|
| Gelibolu | 93.22 | 0.44 | 6.30 |
| Çanakkale | 89.76 | 0.05 | 10.19 |
| Eceabat | 99.59 | 0.26 | 0.15 |
| Kilya Inlet | 91.64 | 0.19 | 8.15 |
| Dardanos | 98.91 | 0.77 | 0.32 |
| Lapseki | 97.23 | 0.09 | 2.68 |
| Kilitbahir | 83.11 | 0.13 | 16.75 |
| Kepez Harbour | 73.01 | 0.04 | 26.96 |

sediments sampled, dissolved oxygen, salinity, and temperature measured for sampling sites were presented in Table 3.

### Relationships Between the *Apseudopsis latreillii* Abundance and Environmental Variables

A total of 1406 specimens of *A. latreillii* was identified on soft bottoms of the depth between 0 and 5 m at the 8 different points located in the Dardanelles (Figure 2, Table 4).

By the time of sampling, the highest number (798 ind.0.09 $m^{-2}$) of individuals was observed in autumn when the average amount of organic matter was 21.7±7.99%. The number of specimen was 136 (ind.0.09 $m^{-2}$) in spring when the amount of organic matter in sediments was the highest (54.2±21.2%) (Figure 2).

When the abundance values for the sampling stations are considered seperately, the highest value (365 ind.0.09 $m^{-2}$) was recorded in Kepez Harbour point (Figure 3). The amount of organic matter in the

**Table 3.** Average values ± standard deviation of the % of organic matter (OM), the grain size (< 63 µm) of sediments sampled, dissolved oxygen, salinity, and temperature measured

| Sampling point | OM (%) | Grain size (µm) | Dissolved Oxygen (mg/L) | Salinity (ppt) | Temperature (°C) |
|---|---|---|---|---|---|
| Kilitbahir | 24.40±15.73 | 636±133 | 7.24±1.82 | 25.15±1.66 | 15.95±5.87 |
| Eceabat | 24.02±13.58 | 364±74 | 7.96±1.37 | 25±1.66 | 16.04±6.02 |
| Kilya Inlet | 24.07±18.99 | 465±346 | 7.89±1.23 | 24.65±1.47 | 16.45±6.46 |
| Gelibolu | 25.43±15.02 | 437±50 | 7.22±1.73 | 25.05±1.75 | 15.79±5.92 |
| Lapseki | 37.22±35.60 | 342±83 | 6.34±2.85 | 24.55±1.79 | 15.81±5.55 |
| Çanakkale | 24.40±15.73 | 1027±198 | 7.13 ±2.57 | 25.27±1.66 | 15.59±5.21 |
| Kepez Harbour | 25.50±12.09 | 1046±74 | 6.18±1.43 | 25.67±1.77 | 16.09±5.34 |
| Dardanos | 50.12±19.45 | 235±390 | 7.07±0.94 | 28.87±0.95 | 16.44±5.24 |

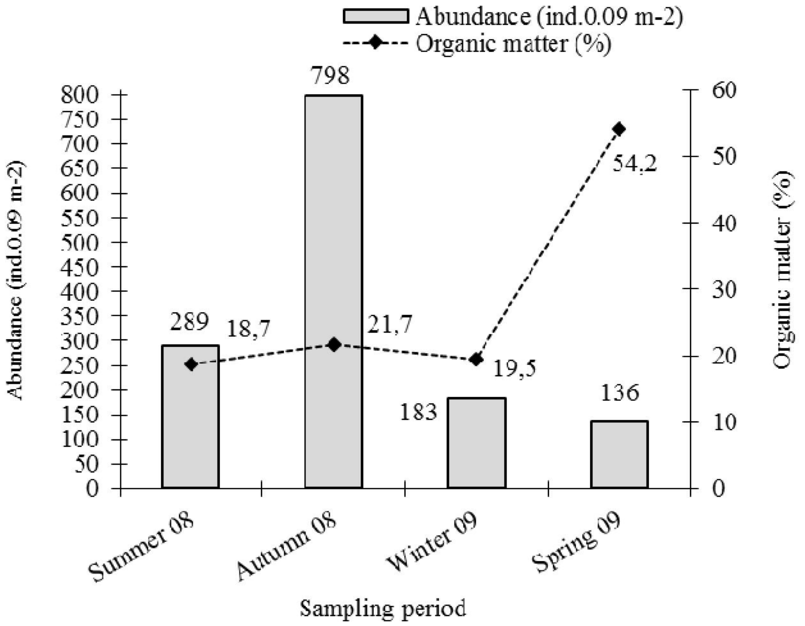


**Figure 2.** Mean values of organic matter (%) in sediment and abundance for the sampling periods.

**Table 4.** Total number of individual (**Σ**) and dominance (Di%) values of *A. latreillii* found at sampling sites and periods

| | Stations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Period | Kilitbahir | Eceabat | Kilya Inlet | Gelibolu | Lapseki | Çanakkale | Kepez Harbour | Dardanos | Σ | Di% |
| Summer 08 | 15 | 176 | 0 | 0 | 5 | 33 | 40 | 20 | 289 | 0,21 |
| Autumn 08 | 84 | 194 | 18 | 8 | 20 | 10 | 365 | 99 | 798 | 0,57 |
| Winter 09 | 72 | 20 | 5 | 3 | 16 | 24 | 12 | 31 | 183 | 0,13 |
| Spring 09 | 36 | 1 | 0 | 0 | 1 | 10 | 10 | 78 | 136 | 0,1 |
| Σ | 207 | 391 | 23 | 11 | 42 | 77 | 427 | 228 | 1406 | |
| Di% | 0.15 | 0.28 | 0.02 | 0.78 | 0.03 | 0.05 | 30.37 | 0.16 | | |

sediment measured for Kepez Harbour was 25.50±12.09%. Gelibolu site had a mean amount of organic matter of 25.43±15.02%, and it had the lowest specimen number (11 ind.0.09 $m^{-2}$). Although Dardanos point is the most critical place in terms of the accumulation of organic matter in sediments (mean value 50.12±19.45%), it has a high number of individuals (228 ind.0.09 $m^{-2}$) (Figure 4). In addition, on the basis of the sampling period, the maximum number of the specimens (N=365 ind.0.09 $m^{-2}$) was observed in Kepez Harbour site. Dominance (Di%) values of *A. latreillii* based on the sampling points ranged between 0.02 and 30.37 (Table 4).

With respect to sampling points, Kepez Harbour station had the maximum particle size (1046 µm), similarly, the number of individuals was highest (427 ind.0.09 $m^{-2}$) at this site. Conversely, while sediment particle size measured for Çanakkale station was 1027 µm, the abundance was recorded as 77 ind.0.09 $m^{-2}$ (Figure 5).

Depending on the sand content, Eceabat site had the highest sand content of 99.59% and total abundance value for this site was 391 ind.0.09 $m^{-2}$. Gravel rate of the stations ranged between 0.32% in Dardanos site and 26.96% in Kepez Harbour. Although the gravel ratio for Dardanos point was the lowest, abundance value recorded was quite high (228 ind.0.09 $m^{-2}$) when compared to other sites. As a result of the analysis related to mud content (silt+clay) in the sediments of the sampling stations, Gelibolu site had a high value of 0.44% and it had the lowest number of individuals (11 ind.0.09 $m^{-2}$). Dardanos site with 228 specimens of *A. latreillii* had the maximum mud content (0.77%). Nevertheless, the maximum number of the individual was found at Kepez Harbour point with the low clay content ratio

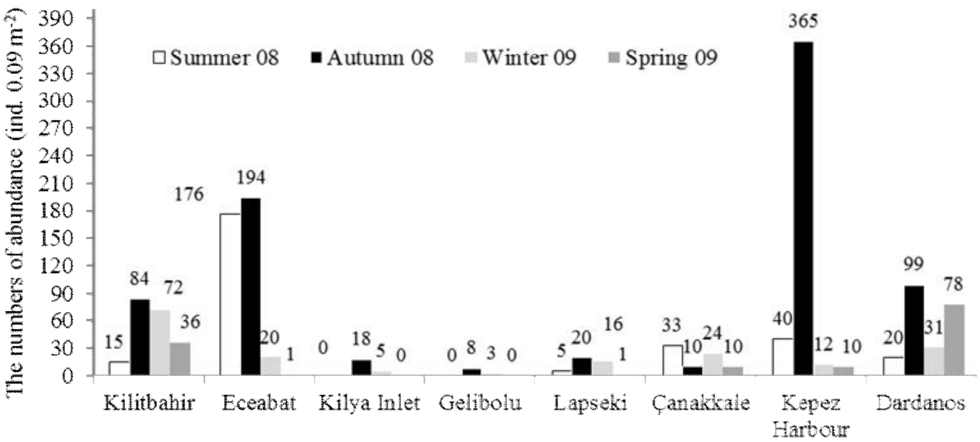


**Figure 3.** The abundance (ind.0.09 $m^{-2}$) values of *A. latreillii* at the sampling sites by the periods

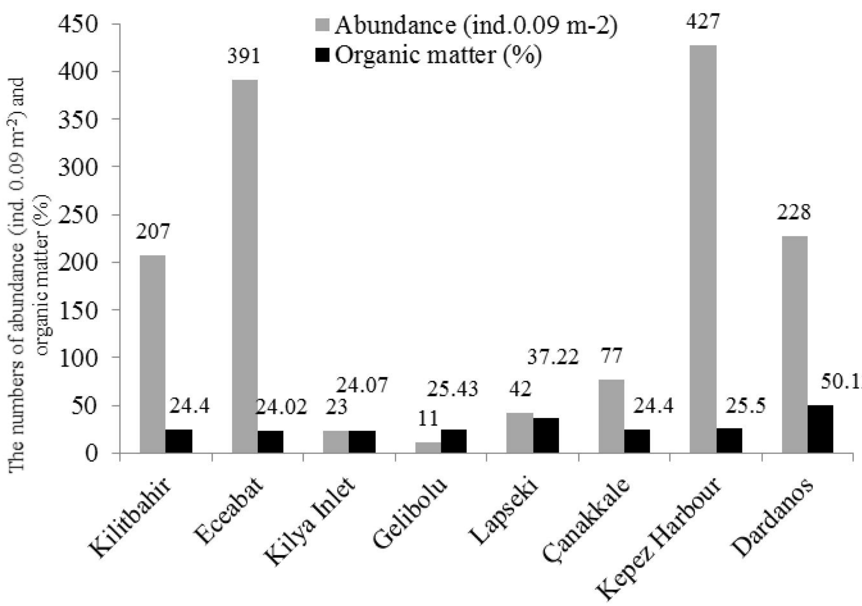


**Figure 4.** Mean values of organic matter (%) in sediment and abundance for the sites.

(0.04%) (Table 2).

Calculation of Pearson's correlation coefficient (r) between biotic (abundance ind. $br^{-2}$) data and the variables such as particle size of sediment, organic matter (%) in sediment, temperature, oxygen, salinity, BOD and COD revealed a statistically non-significant correlation (P<0.05). With respect to the sampling period, a negative correlation was found between the abundance (ind. $br^{-2}$) of *A. latreillii* and the organic matter in sediment (r=-0.411; P<0.05). With regard to the sites, the correlation between total abundance (ind.$br^{-2}$) and organic matter (%) in sediment is $r_s$ = -0.027 (P<0.05). On the other hand, the most influential variable on the abundance of *A. latreillii* is gravel content (%) in sediment (r=0.349; P<0.05). Sand content (%) in sediment showed a negative correlation (r=-0.353; P<0.05) with total abundance (ind.$br^{-2}$) (Table 5). In this context, our result is similar to the result (r=-0.059) for median sand of de-la-Ossa-Carretero *et al.*(2010). According to Pearson's coefficient, the correlation between sediment particle size (µm) and total abundance (ind. $m^{-2}$) in the sampling sites was low (r=0.231; P<0.05). A positive relationship was found between the total abundance and the temperature and salinity values of the sea water. However, the correlation (r) between the total abundance and the mean oxygen values measured in sea water is negative (r=-0.116; P<0.05). Similarly, a negative correlation (r=-0.028; P<0.05) was between the abundance and mud content in sediment. Similar negative relationships were observed between the total abundance and BOI and COD (Table 5). According to the results of the MDS analysis, abundance was in positive correlation with particle and gravel size. Oxygen and salinity were related among themselves. Sand and silt were negatively correlated with abundance (Figure 6). Considering the abundance and physical variables, Dardanos, Eceabat and Lapseki sites were most similar to each other. Likewise, Kepez Harbour and Kilitbahir points were similar with each other (Figure 7).

According to the results of the Bray-Curtis similarity index, winter and spring 2009 shared the

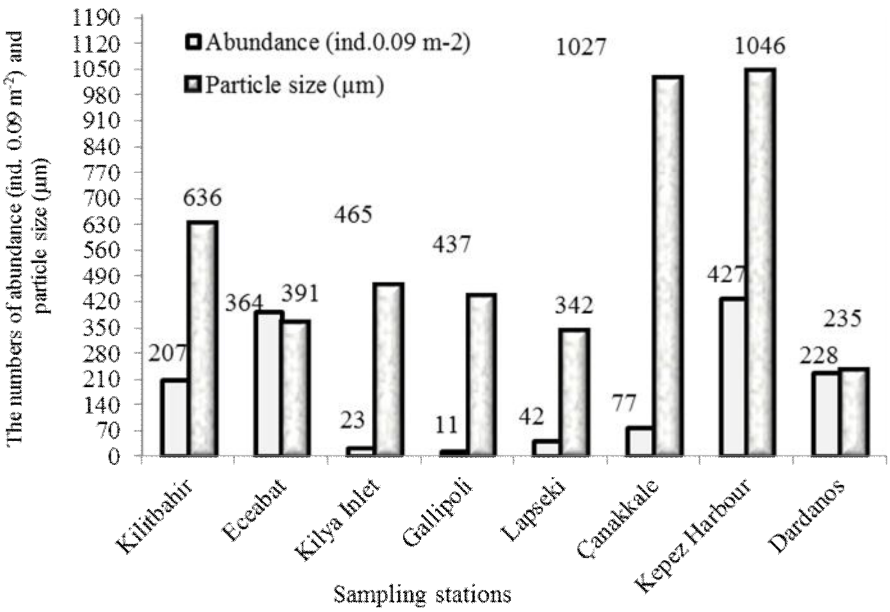


**Figure 5.** Mean values of particle size (µm) in sediment and abundance at the sampling points.

**Table 5.** Pearson correlation values between total abundance (ind.0.09 $m^{-2}$) and environmental variables in the study area

| Environmental variables | Abundance (ind. $m^{-2}$) |
|---|---|
| *Water* | |
| Salinity (ppt) | 0.281 |
| Oxygen (mg/L) | -0.116 |
| Temperature (°C) | 0.239 |
| BOD (mg $L^{-1}$) | -0.48 |
| COD (mg $L^{-1}$) | -0.53 |
| *Sediment* | |
| Mud (silt+clay)% | -0.028 |
| Sand (%) | -0.353 |
| Gravel (%) | 0.349 |
| Organic matter (%) | -0.027 |

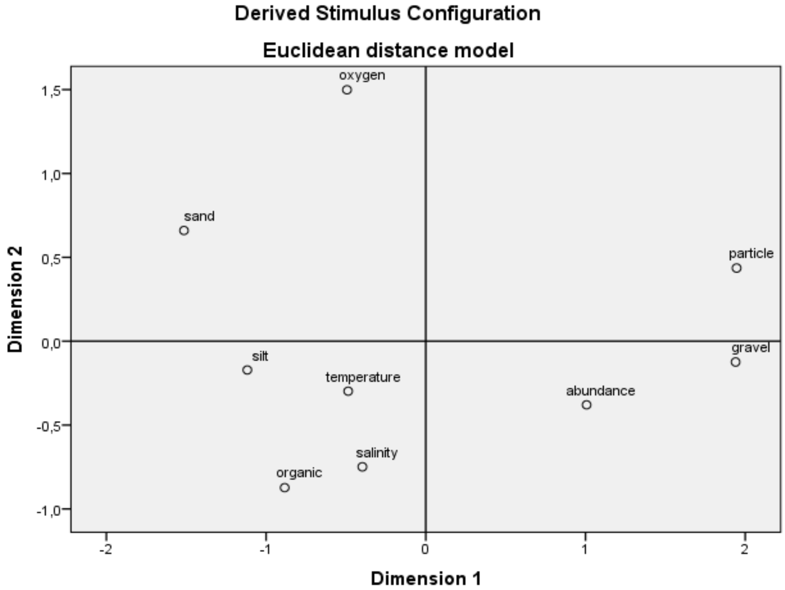


**Figure 6.** Multidimensional scaling plot showing the similarity among the physical variables. (Stress = 0.141)

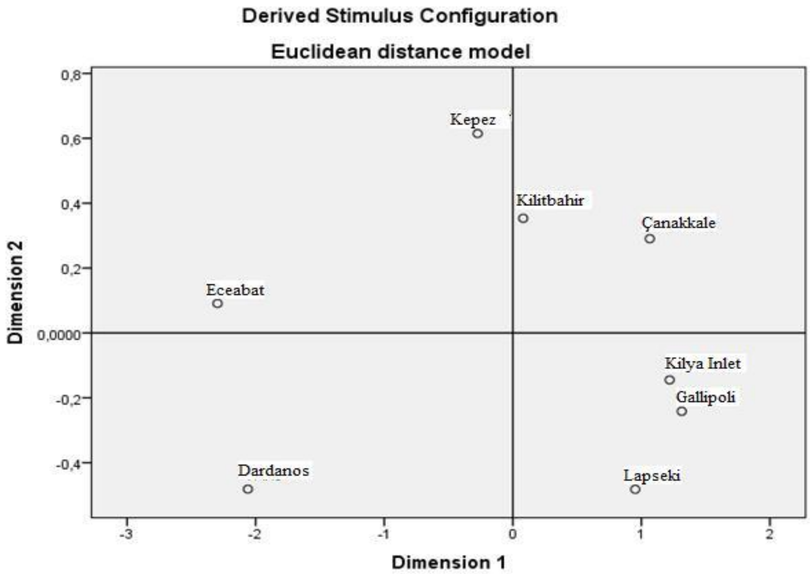


**Figure 7.** Multidimensional scaling plot showing the similarity among the sampling sites. (Stress = 0.007).

same similarity groups with a value of 55%. The second highest similarity (49%) was between summer and autumn 2008 groups (Figure 8). Bray-Curtis similarity analysis showed that the highest similarity was found between Kilitbahir and Dardanos points with a value of 76%. The second highest value (70%) was between Kilya Inlet and Lapseki stations. The lowest value (53%) was observed between Lapseki and Çanakkale sites (Figure 9).

## Discussion

The environmental variables such as salinity, granulometry and organic content in sea water have been known as the most important factors affecting abundance and diversity of macrobenthic communities (Sánchez-Moyano and García-Asencio, 2010). Grain size is, among others, one of the most important factors as well (Lourido *et al*., 2008). Prior studies showed that the variations on the bottom can create strong effects regarding the community structure and characteristics of the benthic species (Moriero *et al*., 2008; Sánchez-Moyano and García-Asencio, 2010; de la Ossa Carretero *et al*., 2011). Crustaceans significantly exhibit the differences among the localities and are defined as indicator in

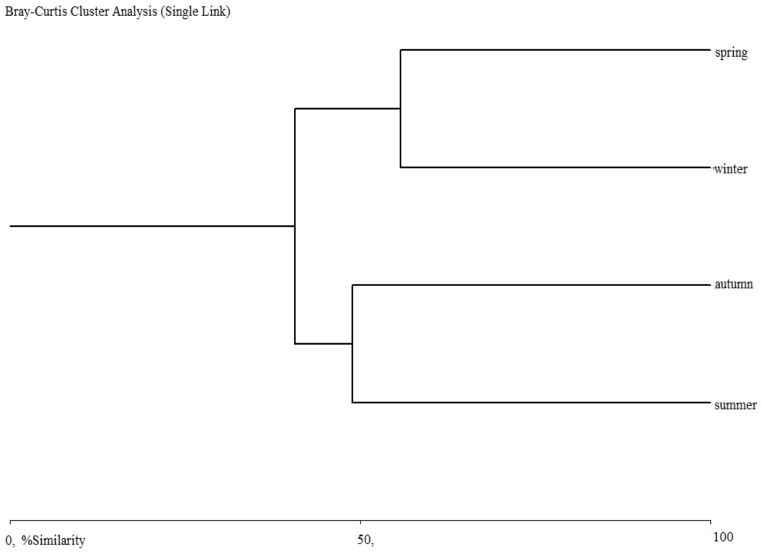


**Figure 8.** Results of Bray-Curtis Cluster Analysis for the sampling periods.

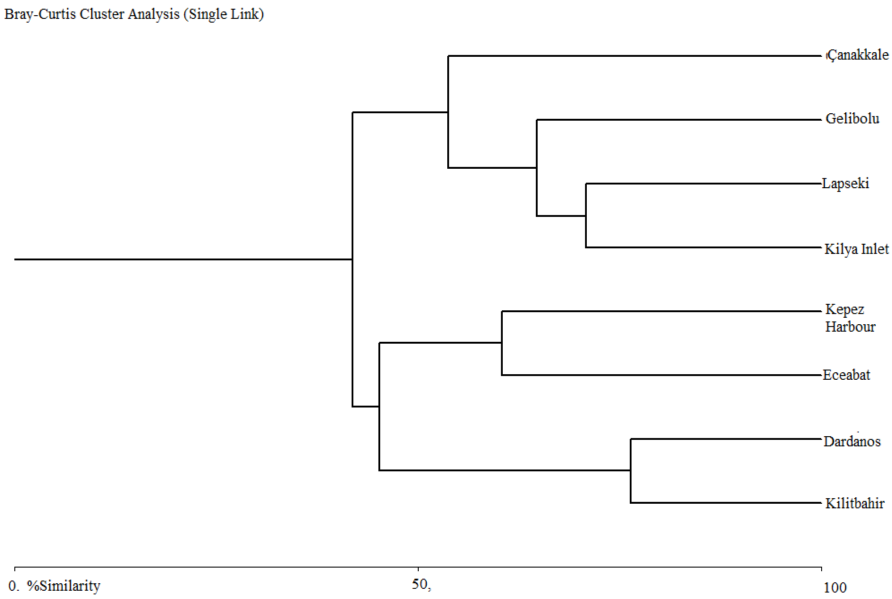


**Figure 9.** Results of Bray-Curtis Cluster Analysis for the sampling sites.

characterization of the studies of marine environments' quality carried out on the soft bottoms (Doğan *et al*., 2005).

Sezgin *et al*. (2007) reported that *A. latreillii* was the most abundant species found on unpolluted soft-bottoms of Saros Bay located in the northeastern Aegean Sea. Bouchet and Saurian (2008) found *A. latreillii* (N=90 ind.) at an unpolluted site with soft-bottom. The dominance value of *A. latreillii* recorded on soft-bottoms of Algires coast (the southern Mediterranean) was 5.6% (Bakalem *et al*., 2009). Unusually, the specimens of *A. latreillii* were found on hard-bottoms in various localities of the Aegean Sea (Antoniadou and Chintiroglou, 2005; Conides *et al*., 1999).

Doğan *et al*. (2005) pointed that crustaceans were more in terms of the number of species in spring (44 species) than other seasons in the polluted and unpolluted areas of İzmir Bay (the eastern Aegean Sea). Besides, the same authors indicated an increase in the outer part of the bay and adversely a significant decrease in the inner-most stations considering the number of species and specimens of the groups found in the area cited. We recorded the maximum values of *A. latreillii* populations in both poor and rich sites in terms of organic matter.

Dense populations of *A. latreillii* were previously presented in relevant works (Guerra-García *et al*., 2003; Guerra-García and García-Gómez 2004; Lourido *et al*., 2008; Moreira *et al*., 2008; de la Ossa Carretero *et al*., 2010; Esquete *et al*., 2011; de la Ossa Carretero *et al*., 2011). Guerra-García *et al*.

(2003) found a total of 504 specimens of tanaid, *Apseudopsis latreillii* especially in the first 2 cm deep (N=278 ind.) containing the organic matter of average 6.30% on polluted bottoms of the Ceuta Harbour (the southern Spain). According to Guerra-García *et al.* (2003), the ratio of silt-clay and the total organic matter in the sediment were the major factors affecting the vertical dispersion of the species. *Apseudopsis latreillii* is capable of achieving penetration in the deeper layers through its active excavation. The most conspicuous variable affecting the abundace in our study was gravel size in sediment as was also stated by Lourido *et al.* (2008).

Lourido *et al.* (2008), found dense population (N=11.291 ind., 20.6% of the total abundance) of *A. latreillii* on the Ría de Aldán coast (the northwestern Spain, eastern Atlantic). The same authors noted that the majority of individuals (N=5321 ind.) was recorded at the sampling point with a sand content of 86.4% and the amount of organic matter in sediments of 1.1%. Furthermore, they mentioned that no individual was recorded in the two sites with high rates of organic matter (10.8-9.0%). Conversely, sand contents (%) of these sites cited were 26.6% and 34.8%, respectively. *A. latreillii* may tolerate organic pollution in the sediments with low concentrations of organic matter and it comprises dense populations (Lourido *et al*., 2008). In our study, we found dense populations of *A. latreillii* at the sites where organic matter is around 24-25%. Lourido *et al*. (2008) also stated that no individuals were found at the sites with lowest (26.6%) and highest (98.0%) sand content. The highest number of specimen (5321 ind.$br^{-2}$) was recorded at the point with a gravel content of 8.1%. Furthermore, they found a high number (689 ind.$br^{-2}$) of *A. latreillei* individuals at the station with highest rate of gravel (52.7%) and they didn't record any specimen at the points with the highest (69.4%) and lowest (1.6%) values of clay+silt in sediment. Furthermore, according to Lourido *et al*. (2008), sediment particle size and depth had the highest correlation with faunistic data.

Moreira *et al*. (2008) found a total of 5926 individuals of *A. latreillii* on the soft-bottoms of Ensenada de Baiona (Galicia, the northwestern Spain) and pointed that most of individuals (N=3479 ind.) were recorded at a station with a gravel sediment but, value of organic matter measured at this point and its sediment characteristic were not presented in detailed. The same authors stated that no individual was recorded at the stations with the highest (12.05%) and lowest (1.32%) values of organic matter, while the second station with more specimens (10. station, N=1896 indv.) has a organic matter value of 2.20% and the sand content recorded at this station was 88.94%. Moreover, considering the percents of the sediment of sand, gravel, and mud content in sediment, no *A. latreillii* specimens were recorded for the minimum and maximum levels of the ratios. We consider that our data about the abundance and sediment chracteristics data are significantly different from the results of Moreira *et al*. (2008)'s work. Coversely, we may point out that Lourido *et al.* (2008)'s results as regard to the relations between sediment particle size and abundace are roughly similar to our results. However, in our study, the highest values for dominance were recorded for the maximum ratios of sand, gravel, and mud content analysed. Accordingly, sediment characteristics are crucial in the number of individuals. We also note that the number of individuals recorded at sites with a high similar manner is same for the stations with high percentages of sand and gravel.

Recently, de-la-Ossa-Carretero *et al*. (2011) found a weak correlation (r=0.043) between mud content % and organic matter % in the sediment and stated that *A. latreillii* was the most common species of tanaids at the different depths (0-200-1000 m) of the soft-bottoms of Valencia coast (the eastern Spain). The same authors pointed out that the study area was characterized by fine-sand with grain size between 0.125 and 0.25 mm. They didn't record a significant correlation between all variables.

Doğan *et al*. (2008) found the highest number (N=92 ind./0.1 $m^{-2}$) of *A. latreilii* in summer on soft-bottoms of İzmir Bay (the eastern Aegean Sea) and described the bottom characterization as mostly mudy and sandy mudy. In addition, they did not engage any particle size analysis in regard to the bottom structure. However, it is known that the sediment granulometry is a significant factor in abundance of *A. latreillii* (de-la-Ossa-Carretero *et al*., 2010). Ersoy Karaçuha *et al.* (2009) recorded a total of 206 specimens of *A. latreillei* occurring in *Zostera marina* L. and Z. *noltii* Hornem meadows in unpolluted areas of the Sinop Peninsula coast (the southern Black Sea). Recently, Esquete *et al*. (2011) reported that *A. latrellii* was dominant (the dominance among other peracarids, Di%=40.2) inside *Z. marina* and *Z. noltii* meadows in a protected area under human's influence of O Grove Inlet (the northern Iberian Peninsula).

Fernandez-Gonzalez and Sanchez-Jerez (2011) defined that the abundance of *A. latreillii* was higher in unpolluted areas where a sediment of fine sand was observed and negatively affected to high percentages of organic matter in sediment. Dominant tanaid species was *A. latreillii* in Ceuta Harbour (the northwestern Africa) and its average abundance (in a square of 0.15 $m^2$) was 168.07 for the outer region and 15.50 the inner part, respectively (Guerra-García and García-Gómez, 2004). Guerra-García and García-Gómez (2004) noted that the amount of organic matter measured in sediment ranged from 0.8-13.9% in Ceuta Harbour.

Guerra-García and García-Gómez (2004) signified that the most common crustacean species in the harbour was *A. latreillii* (especially at the inner parts, N=168 ind.) and it is related to sediments containing less sand and higher concentrations of organic matter. According to Guerra-García and

García-Gómez (2004), the status of high values (6.9-9.1 $mgL^{-1}$) of oxygen can be explained by the fact that the renewal of water in the harbor.

Recently, a specific paper on *A. latreilii*'s population stucture on the Castellon shores (the northeastern Spain) was presented by de la Ossa Carretero *et al*. (2010). de la Ossa Carretero *et al*. (2010) defined 6006 individuals of *A. latreillii* and detected the highest number (N=1033 ind. $m^{-2}$) of specimens at the outer station located at a depth of 1000 m. Moreover, the ratio of coarse sand in sediment has a remarkable negative correlation with total abundance of *A. latreillii* and this shows that the individual density is highest in soft sand. The density of *A. latreillii* is low in the sites with a high accumulation of organic matter in sediments and its immature specimens are sensitive to sewage disposals (de la Ossa Carretero *et al*., 2010). The same authors found no significant difference ($r_s$= 0.035) between organic matter in sediment and abundance of species in their study area.

Yet, *Apseudopsis latreillii* have been described as indicator of pollution in previous studies (Sanz-Lázaro and Marín, 2006; Simboura and Reizopoulou, 2007; Bouchet and Sauriau, 2008). On the contrary, our results clarify that this tanaid species was the most abundant especially in an unpolluted area (Kepez Harbour site). In addition, as stated, in Dardanos station with the highest value of organic matter in sediments large amounts of the individuals were recorded. Grain size of the sediment is an important factor in the density of this species. *Apseudopsis latreillii* is dense on the bottoms dominated by soft sand (Lourido *et al*., 2008; de la Ossa Carretero *et al*., 2010).

De la Ossa Carretero *et al*. (2010) stated that sediment variety characterizes biotopes, and mostly, peracarid crustaceans search actively for food in sediments, the burrowing action is a key element which is directly related to food in the sediment.

Since sediments show fine alterations, no relation is observed between particle size and sewage pollution. This manner could clarify the decrease in abundance of *A. latreillii* occurring near the sites where wastes are observed (de la Ossa Carretero *et al*., 2010).

For our study, even though the gravel size in sediment was the greatest factor affecting the total abundance, we think that other environmental variables have an effect on the abundance as well. Additionally, the changes in water temperature, currents, and freshwater input from inlands can change the impact on abundance of environmental variables. The Dardanelles is affected at least by pollution because of small urbanized areas located on its coast. The amount of organic matter in sediment of the Black Sea and the Marmara and Aegean probably changes with the convection dynamics. North-east wind is generally effects strong currents in the system which leads to removal of organic matter in the sediment of the study area. We may point out that the organic matter content is high especially in the parts of the residential area of the Dardanelles at nights. Due to the influence of strong wind and currents this impact may disappear over time.

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