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Research Article

Crustacean diversity of Ildırı Bay (Izmir, Turkey)

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Abstract

In this study, the crustacean diversity in Ildırı Bay, which is characterized by a high density of aquaculture activity and tourism, was investigated. Sampling was carried out by box-corer during four seasonal cruises (April, July, November 2010, and February 2011) at eight stations. Based on the analyzed samples, Crustacea has been represented with two classes, five orders, 25 families, and 40 species in the study area. Amphipods were the dominant taxon in terms of species richness (15 species), followed by both tanaids (8 species) and decapods (8 species). Although tanaids were the most abundant taxon, decapods had the highest biomass. The most abundant tanaid species was *Chondrochelia savignyi* (Kroyer, 1842). Crustacea abundance was negatively correlated with depth.

Keywords: Amphipod, Benthic, Semi-enclosed water, The Aegean Sea

Introduction

Crustaceans are a critical element of the marine benthic ecosystem in terms of macrofauna diversity and impact assessment. Many studies have been conducted on crustacean species in the Aegean Sea (Geldiay and Kocataş 1970, Geldiay and Kocataş 1973, Katağan 1982, Ergen *et al.* 1988, Kırkım 1998, Katağan *et al.* 2001, Koçak *et al.* 2001, Ateş 2003, Sezgin 2003, Yokeş *et al.* 2007, Anastasiadou *et al.* 2020). These studies and more have been compiled by Bakır *et al.* (2014), who has given a checklist. A total of 1028 Crustacean species was reported along the Aegean Sea coast of Turkey Bakır *et al.* (2014).

The Ildırı Bay is characterized by a high intensity of aquaculture and tourism activities (Demirel 2010, Bengil and Bizsel 2014). The data from The Provincial Agriculture Directorate (TIM) show that 15,690 tonnes of aquaculture fish (sea bream, seabass, and bluefin tuna) are produced by 20 facilities in Ildırı Bay per year (Demirel 2010). There are some studies that investigated the impact of aquaculture on water quality (Basaran *et al.* 2007) and microplankton (Yurga *et al.* 2005) in Ildırı Bay. Apart from research on aquaculture impacts, studies on macrobenthos diversity of the bay are very scarce. The molluscan fauna of Ildırı Bay has been reported by Culha *et al.* (2019) and Dogan *et al.* (2007). Additionally, a new crustacean species (*Ampithoe bizseli*) was reported by Özaydinli and Coleman (2012) during sampling from a floating aquaculture cage in Ildırı Bay. Although no study focuses on the crustacean diversity of Ildırı Bay, there are some studies carried out as complementary of the neighboring areas. Kocataş *et al.* (2001) sampled only one station in Ildırı Bay in his study on the benthic amphipods of Çeşme Peninsula coasts. Mantıkçı (2009) investigated the impact of aquaculture on the macrozoobenthos in Gerence Bay, which is a semi-enclosed marine region as an adjacent site to Ildırı Bay.

The study aims to provide an understanding of the crustacean fauna in Ildırı Bay, which is intensely under the anthropogenic impact. This is the first detailed study on the species composition and diversity of the crustacean fauna of Ildırı Bay.

Material and methods

Study Area

The Ildırı Bay is located at the middle-Western coasts of the Anatolia Peninsula in Turkey. The Çeşme and Karaburun peninsulas surround it. At the bay entrance, some islands separate the bay from Sakız (Chios) Strait (Fig. 1).

Sampling was carried out during four seasonal cruises (April, July, November 2010 and February 2011) aboard the 'R/V DokuzEylül 1' and 'R/V K. Piri Reis', at seven stations (St1-St7) and one reference station (StR). St5 and St7 were closed around the fish cages, while St6 was relatively distant away. The other four stations, St1, St2, St3, and St4, were in the shallower zone where the fish cages were moored previously until the year that the study began (Fig. 1). The bottom substrate characteristics of the study stations were given in Table 1.

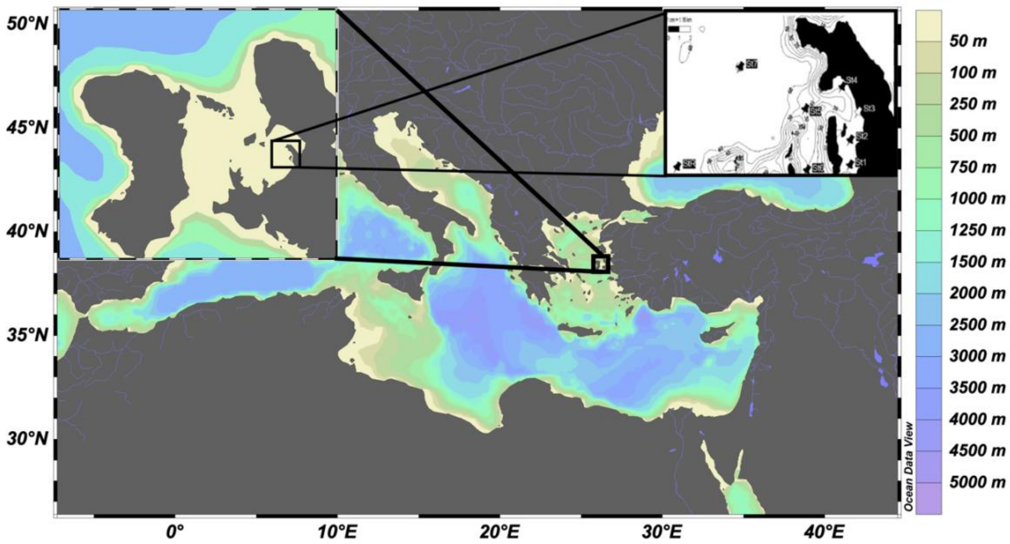

Figure 1. Location of the study area (box on the left) and the stations (box on the right) (map produced based on Schlitzer 2020)

A sampling of macrobenthic fauna

Sediment samples for analyzing macrobenthic fauna were collected using Box Corer with a sampling area of 0.25 m^2. Three subsamples from each sample were collected randomly by using plexiglass sampling cores with 4.5 cm internal diameter. Each subsample was preserved in a plastic vial containing a 4% formalin solution until the microscopic analysis in the laboratory.

Before microscopic analysis, each sample was sieved through a 0.5 mm mesh sieve and stored in a plastic vial in 4% formaldehyde. The samples were then sorted and analyzed under a stereo-microscope. Crustacea specimens were identified to lowest possible taxon level by following the many different monographs, papers, and guides (Bellan-Santini *et al.* 1982, 1989, 1993, 1998, Carpenter and Niem 1998 Kırkım 1998) and current taxonomic status were checked by the World Register of Marine Species (WoRMS Editorial Board 2020). Their wet weight obtained rapidly after blotting the excessive liquids on absorbent paper. The number of individuals per unit area for each taxa (ind. m^{-2}) and their biomass per unit area (g m^{-2}) were determined.

Table 1. Characteristics of sampling stations

Stations	Biotope	Depth
St1	Fine sand, Silt-Clay, Posidonia	15
St2	Fine sand, Silt-Clay, Posidonia	10
St3	Fine sand, Silt-Clay, Posidonia	15
St4	Fine sand, Silt-Clay, Posidonia	20
St5	Coarse and Fine sand, Silt-Clay	50
St6	Coarse and Fine sand, Silt-Clay	50
St7	Fine sand, Silt-Clay	70
StR	Fine sand, Silt-Clay	60

Data analysis

The community parameters of the species were calculated for each station and sampling period. Diversity was calculated using the (log-based) Shannon-Wiener index (H') (Shannon and Weaver 1949), and evenness index (J') was calculated following Pielou (1977).

Cluster analysis was performed using the Bray-Curtis similarity index values (Bray and Curtis 1957) to obtain the degree of similarity in species composition of crustaceans among sampling stations. Prior to this analysis, the data have been transformed (log x+1), according to the procedure described in Clarke and Warwick (2001), for minimizing the influence of dominant and rare taxa. Calculations and analyses were done using the PRIMER v.5 software package. Spearman Rank Order Correlation between crustacean abundance and depth was done using the STATISTICA 8.0 software package.

Results

In the study area, the crustaceans were represented by two classes, five orders, 25 families, and 40 species. Even though Ostracoda are classified as members of meiofauna, they were also included in the analysis, as they retained on the sieves. Systematics of the species found at the study site are presented in Table 2.

Amphipods were the dominant taxon in terms of species richness (15 species), followed by both tanaids (8 species) and decapods (8 species). Cumaceans and isopods were represented by 4 and 3 species, respectively. Although tanaids were the most abundant taxon with 6,180 and./m^2 in total, decapods had the highest biomass (5.73 g/m^2, 42 % of total). Nevertheless, amphipods have the highest species number, which have ranked them as the secondary taxon in terms of both abundance and biomass.

The most abundant tanaid species was *Chondrochelia savignyi* (Krøyer, 1842), with 4,236 and./m^2 in total (Fig. 2). *Chondrochelia savignyi* was found in every sampling periods at St1 and St2, but rarely at St3 and St4. This species was never found at stations that closed to the floating cages offshore.

Three species, *Harpinia dellavallei* Chevreux, 1910, *Perioculodes longimanus angustipes* Ledoyer, 1983, and Agathotanaidae (sp.) were only found in StR. Besides, *Achaeus cranchii* Leach. 1817 was the species found at St7 only in a single sampling period.

Table 2. Systematic of the Crustacea species at the study site

Class	Order	Family	Species
Malacostraca	Amphipoda	Ampeliscidae	*Ampelisca sp.*
			Ampelisca jaffaensis (Bellan-Santini & Kaim-Malka, 1977)
			Ampelisca sarsi (Chevreux 1888)
			Ampelisca truncata Bellan-Santini & Kaim-Malka, 1977
			Ampelisca typica (Bate 1856)
		Phoxocephalida	*Harpinia dellavallei* Chevreux 1910
		Leucothoidae	*Leucothoe sp.*
			Leucothoe oboa Karaman 1971
			Leucothoe venetiarum Giordani-Soika 1950
		Corophiidae	*Leptocheirus longimanus* Ledoyer 1973
		Maeridae	*Maera sp.*
		Aoridae	*Microprotopus cf. maculatus* Norman 1867
		Oedicerotidae	*Perioculodesa equimanus* (Korssman 1880)
			Perioculodes longimanus angustipes Ledoyer 1983
			Synchelidium longidigitatum Ruffo 1947
	Tanaidacea	Agathotanaidae	Agathotanaidae (sp.) 1
		Apseudidae	*Apseudes latreillii* (Milne-Edwards 1828)
		Leptocheliidae	*Heterotanais oerstedii* (Kroyer 1842)
			Chondrochelia savignyi (Kroyer 1842)
		Leptognathiida e	*Araphura brevimanus* (Lilljeborg 1864)
			Akanthophoreus gracilis (Krøyer 1842)
		Tanaidae	*Tanais dulongii* (Audouin 1826)
		Paratanaoidea	*Pseudoparatanais batei* (Sars 1882)
	Cumacea	Nannastacidae	*Campylaspis sp.*
			Cumacea (sp.)
		Leuconidae	*Eudorella truncatula* (Bate 1856)
		Bodotriidae	*Iphinoe sp.*
	Isopoda	Gnathiidae	*Gnathia sp.*
			Gnathia vorax (Lucas 1849)
			Gnathia oxyuraea (Lilljeborg 1855)
	Decapoda	Inachidae	*Achaeus cranchii* Leach 1817
		Paguridae	*Anapagurus sp.*
		Callianassidae	*Callianassa subterranea* (Montagu 1808)
		Ethusidae	*Ethusa mascarone* (Herbst 1785)
		Galatheidae	*Galathea intermedia* Liljeborg 1851
			Paguridae (sp)
		Diogenidae	*Paguristes syrtensis* De Saint Laurent 1971
		Processidae	*Processa cf. canaliculata* Leach 1815
Ostracoda			Ostracoda (sp.) 1
			Ostracoda (sp.) 2

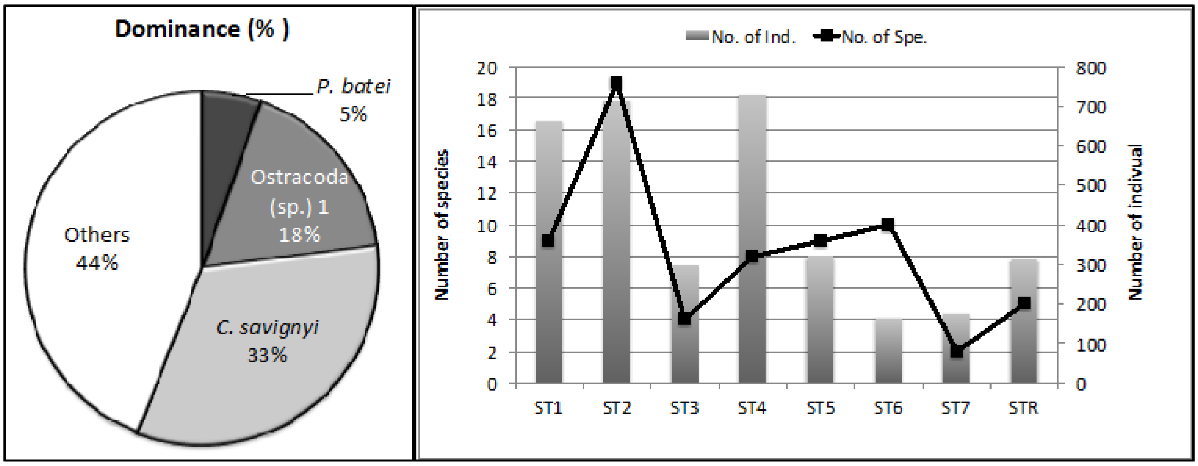

Figure 2. Dominance of species (left); Abundance and composition of the species (right) in Ildırı Bay

Results of Shannon-Wiener diversity and Pielou's evenness indices were presented in Table 3. St2 was the richest station in terms of Crustacea species for all sampling periods except April 2010. Hence, the highest diversity values were obtained in this station, *i.e.*, H'=1.83 and H'=1.67 in July and November 2010, respectively. As a consequence of higher abundance of *C. savignyi* (Kroyer, 1842), the highest abundance values were found at St2 and St4 in July 2010 and February 2011, respectively. No species were detected at stations: N'10-St3, J'10-St7, N'10-St7.
When seasonal data were pooled for each station, St2 had the highest species number (19 species), while St4 had the highest number of individuals (Fig. 2). According to correlation analysis, Crustacea abundance was negatively correlated with depth ($r=-0.5054$, $p<0.05$).
A dendrogram for hierarchical clustering of the Crustacea abundances at the study site, using group-average clustering of Bray-Curtis similarities, is shown in Fig. 3. As seen in this dendrogram, the outer stations (St5, St6, St7 and StR) differentiated from the inner stations (St1, St2, St3, and St4), in terms of abundance of Crustacea species. The similarity between these two groups was lower than 20 %. *C. savignyi* (Kroyer, 1842), Ostracoda (sp.) 1 and *Eudorella truncatula* (Bate, 1856) were mainly responsible for the dissimilarity between the inner and the outer stations. StR differentiated from the other stations in all sampling periods except in July 2010 (J_R) due to presence of *C. savignyi* (Kroyer, 1842).

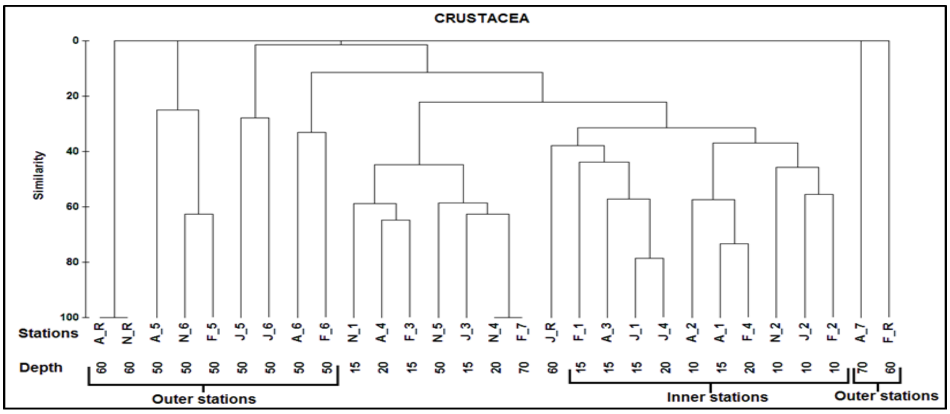

Figure 3. A dendrogram for hierarchical clustering of the crustacean abundances at the study site

Table 3. Community parameters of crustacean species

	Stations	Number of Species	Total Individual	Pielou Evenness	Shannon-Wiener Diversity
	St	S	N(ind./m^2)	J'	H'(loge)
April' 10	1	5	700	0.89	1.43
	2	3	839	0.95	1.04
	3	1	419	0.00	0.00
	4	3	629	1.00	1.10
	5	2	419	1.00	0.69
	6	1	210	0.00	0.00
	7	1	210	0.00	0.00
	R	1	210	0.00	0.00
July' 10	1	2	419	1.00	0.69
	2	9	1205	0.83	1.83
	3	2	419	1.00	0.69
	4	3	301	0.95	1.04
	5	4	231	1.00	1.39
	6	3	208	0.95	1.04
	R	3	629	1.00	1.10
November' 10	1	4	693	0.68	0.94
	2	7	372	0.86	1.67
	4	1	210	0.00	0.00
	5	2	419	1.00	0.69
	6	2	72	1.00	0.69
	R	1	210	0.00	0.00
February' 11	1	3	839	0.95	1.04
	2	10	432	0.62	1.43
	3	3	60	0.95	1.04
	4	5	1779	0.70	1.12
	5	1	210	0.00	0.00
	6	5	165	0.93	1.49
	7	1	140	0.00	0.00
	R	1	210	0.00	0.00

Discussion

In this study, 40 crustacean species were recorded, and amphipods were the dominant taxon in species numbers (15 species). Kocataş et al. (2001), in his study investigating the benthic amphipods of the coast of the Çeşme Peninsula, identified four amphipod species in one station located in Ildırı Bay.

According to Bakır *et al*. (2014), 484 Crustacea species were recorded in the soft substrate in the Aegean Sea in a depth range of 0–100 m. In the same study, the distribution of the Arthropoda species was mapped along the coast of Turkey. According to this map, there are between 60–79 arthropod species in the coastal areas of Ildırı Bay and between 14–24 species in the more exposed areas.

Mantıkçı (2009) found 13 crustacean species in his study investigating fish-farm impact in Gerence Bay, which is adjacent to Ildırı Bay. Only two species, *Tanais dulongii* (Audouin, 1826) and *Callianassa cf. subterranean* (Montagu, 1808)were in common with our study.

Aslan-Cihangir and Panucci-Papadopoulou (2011) reported that depth is an essential factor in peracarid distribution patterns (Robertson *et al.* 1989, Corbera and Cardell 1995, Lourido *et* *al.* 2008) and they found negative correlation ($r=-0.4424$, $p<0.05$) between peracarid abundance and depth. As well as in our study, Crustacea abundance was negatively correlated with depth ($r=-0.5054$, $p<0.05$).

Despite limited knowledge on the bay's biodiversity obtained from the scarce previous study, the contribution of this study, as being the first systematical study, indicated the potential of the region in terms of area.

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