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Research Article **Araştırma Makalesi**

Substrate Selection Characteristics of Hydrozoan Polyps (Cnidaria) in Antalya Bay

Antalya Körfezi'nde Hidrozoan Poliplerinin (Cnidaria) Substrat Seçim Özellikleri

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Abstract: This study was conducted to determine the substrate preferences of hydroid polyps sampled in eight different stations on the coastline of Antalya Bay. Sampling was performed by freedive to identify the hydroid polyp fauna and certain physicochemical (salinity, temperature, dissolved oxygen, electrical conductivity, chl-a) and biological characteristics were determined. A total of 35 hydroid species were identified as epiphytic, epilithic and epizoic in the region.
The most commonly preferred substrates by the species were; rocks (20 species), *Ellisolandia elongata* (J.Ellis & Solander) K.R.Hind & G.W.Saunders, 2013 (18 species), *Balanus* sp. Costa, 1778 (9 species), macroalgae *Posidonia oceanica (Linnaeus) Delile, 1813, and* leaves (8 species). Among all species, one species prefers just epilithic substrates, four species prefer only epizoic substrates, and seven species prefer only epiphytic substrates. *Acauloides ammisatum, Eudendrium sp., Turritopsis. nutricula, Pennaria. disticha, Clytia noliformis, Halecium tenellum, Halopteris diaphana, Dynamena disticha and Salacia desmoides* are found in all substrate types (EP,EZ,EL).

Keywords
- Antalya Bay
- Aquatic Invertebrate
- Benthos
- Hydrozoa
- Substrate selection

Özet: Bu çalışma, Antalya Körfezi kıyısındaki sekiz farklı istasyondan örneklenen hidroid poliplerinin substrat tercihlerini belirlemek amacıyla yapılmıştır. Örneklemeler, serbest dalış yapan dalgıçlar tarafından gerçekleştirilmiş olup, hidroid polip faunasını ve bazı fizikokimyasal ve biyolojik özellikler (tuzluluk, sıcaklık, çözünmüş oksijen, elektriksel iletkenlik, klorofil-a) belirlenmiştir. Bölgede epifitik, epilitik ve epizoik olarak tanımlanan toplam 35 hidroid türü tespit edilmiştir. Türler tarafından en çok tercih edilen substratlar şunlardır: kayalar (20 tür), *Ellisolandia elongata* (J.Ellis & Solander) K.R.Hind & G.W.Saunders, 2013 (18 tür) ve *Balanus* sp. Costa, 1778 (9 tür) ile Posidonia *oceanica* (Linnaeus) Delile, 1813 makroalginin yaprakları (8 tür). Tüm türler arasında, bir tür sadece epilitik substratları tercih ederken, dört tür sadece epizoik substratları tercih ettiği ve yedi türün de sadece epifitik substratları tercih ettiği belirlenmiştir. *Acauloides ammisatum, Eudendrium sp., Turritopsis. nutricula, Pennaria. disticha, Clytia noliformis, Halecium tenellum, Halopteris diaphana, Dynamena disticha ve Salacia desmoides* türleri, tüm substrat türlerini tercih ettikleri (EP, EZ, EL) belirlenmiştir.

Anahtar kelimeler
- Antalya Körfezi
- Sucul Omurgasız
- Bentoz
- Hydrozoa
- Substrat seçimi

1. INTRODUCTION

Hydroids move, but to a limited extent with their tentacles and survive in the benthic zone by maintaining a fixed position on the substrate to which they are attached. They are mostly found on hard substrates such as rocks, stones, on mollusc shells or within marine plants, and occasionally on soft sediments (Morri et al.,1991; Puce et al., 2005). Due to their habitat preference and distribution on hard substrates, hydroid polyps also cause biofouling on artificial surfaces used by humans such as boats, ships, ropes, and buoys and often eliminated using methods such as toxic paints, sanding, and freshwater washing (Guenther et al., 2010; Gutierre, 2012).

Because of their fast settlement and rapid growth, hydroids are among the earliest metazoans to colonize newly available substrates. Following settlement and growth stage, hydroids are often displaced by other organisms with larger and rigid structures, such as macro algae, sponges, polychaetes, barnacles, bryozoans, molluscs, and ascidians (Puce et al., 2008). During this displacement stage, a secondary settlement takes place, involving the process of epibiosis and recolonization of the substrate at a higher level (Boero, 1984). When solitary hydroids settle on hard substrates, their basal disc secures them to the substrate. Then they settle on soft substrates, where their basal structures are pointed with filamentous rootlets. Both types of basal structures support a pedicel, also known as a hydrocaulus, that has a body or hydranth, with an apical mouth that is often encircled by tentacles (Bouillon et al., 2004).

Hydroid polyps have epibiont relationships with organisms such as Porifera, Cnidaria, Bryozoa, Annelida, and Mollusca (Puce et al., 2008). There are also records showing that hydroid polyps occasionally engage in epibiontic relationships with some fish species such as seahorses and Syngnathidae species (Monti et al., 2018). Some species of Hydrozoa have symbiotic relationships with spesific animal groups such as *Dicoryne* sp. which has symbiotic relationships with sponges and gastropods, Hydractiniidae and Cytaeididae families have relationships with gastropods and barnacles, *Eugymnanthea sp.* with bivalves etc. (Puce et al., 2008). Hydroid polyps establish parasitic relationships with other marine species such as *Crassostrea virginica* (Gmelin, 1791), *Mytilus galloprovincialis* Lamarck, 1819, and *Tivela mactroides* (Born, 1778). This species could pose an economic threat to the mussel industry (Rayyan et al., 2002, 2004; Govindarajan et al., 2005).

Hydroids can be found on various organisms as fouling, but they can also serve as substrates for diatoms, foraminifera, and sessile ciliates (Di Camillo et al, 2006-2008; Bavestrello et al, 2008, Gorelova et al, 2013). Furthermore, amphipods and crustaceans also live parasitically on hydroid polyps and feed on them (Guerra- Garcia and Tierno de Figueroa, 2009).

Hydrozoan members generally feed as carnivores through active predation, feed primarily on small crustaceans, as well as protozoa, phytoplankton, dissolved organic matter and rarely feed on fecal pellets, organic matter, and microalgae (Orejas et al., 2013). Due to their feeding characteristics, they can exert predation pressure on crustaceans such as copepods and nauplii larvae, fish larvae, and other planktonic organisms in the areas where they are distributed (Gili & Hughes, 1995; Bouillon et al., 2004).

Sessile benthic species and assemblages can be described as effective bioindicators due to their responsiveness to environmental changes and useful tool for assessing the status of the marine environment (Roveta et al., 2022). The assemblages of benthic hydrozoans that are in both naturally and disturbed areas have some unique characteristics that would make them a possible bioindicator group (Yilmaz et al., 2020). Additionally, monitoring plans usually focus on benthic taxa abundance and diversity to get information on habitats and ecosystems (EC, 2000; Yilmaz et al., 2020).

The impact of hydroid polyps on human health has also been studied. It has been reported that colonies of *P. disticha* in particular can cause symptoms such as redness, swelling, and itching on human skin (Tezcan & Sarp, 2012).

The research "Invertebrate Bottom Animals of the Bosphorus and Islands Shores" by Demir (1952) was the first research to examine hydroid polyps in Türkiye’s coastal regions. Despite several subsequent systematic studies, there is currently no specific work available regarding their substrate preferences from Türkiye until the present study (Albayrak & Balkıs, 2000; Şaşı & Balık, 2002; Çınar et al., 2011; İşinibilir et al., 2010; Ergüden et al., 2014; Çınar et al., 2014; İşinibilir et al., 2015; Yılmaz et al., 2017; İşinibilir et al, 2017). In Türkiye, *C. hummelincki, M. philippina, C. eximia,* and *E. merulum* have been identified as other species demonstrating characteristics of alien invasive species for the Turkish coasts (Çınar et al., 2014). According to Killi et al.'s study "Risk screening of potential invasiveness of non-native jellyfishes in the Mediterranean Sea" (2020), *Clytia brevithecata* (syn. C. hummelincki) has a high risk of becoming invasive in Türkiye and the Mediterranean region. The same study indicates that the invasiveness risk for both *Clytia linearis* and *Coryne eximia* is substantial.

We hypothesize that the observed distribution of hydroid species across different substrates reflects adaptation to varying environmental conditions. Furthermore, the identification of species exclusive to certain substrate types (epilithic, epizoic, and epiphytic) suggests niche specialization within the hydroid community. To test this hypothesis, we anticipate finding correlations between physicochemical parameters such as salinity, temperature, dissolved oxygen, electrical conductivity, and chl-a, and the prevalence of hydroid species on specific substrates. The aim of the study is to determine the substrate preferences of hydroid polyps distributed along the coasts of Antalya Bay and to display data on their distribution.

2. MATERIAL and METHODS

Samplings were carried out at 8 selected sampling locations along the coast of Antalya Bay between February 2016 and October 2016 (Figure1). During fieldwork, temperature (°C), salinity (ppt), dissolved oxygen (mg/L), electrical conductivity (EC) and pH values were measured in situ using YSI probe at the 0-10 meter depths. Sampling was carried out through free dives and performed by randomly collecting samples using a knife and spatula from the substrate (Piraino et al., 2013). A Hensen type plankton net with 55 µm mesh opening and 17 cm front mouth diameter was used for zooplankton sampling. For fifty meters off the coast, horizontal draws were carried out. The calculations done according to Erdoğan, 2011;

$$Individual\ /\ m^3 = \frac{Number\ of\ organisms\ in\ 1\ ml\ concentrated\ sample}{\frac{Amount\ of\ sea\ water\ filtered\ (ml)}{Concentrated\ sample\ (ml)}}\ x\ 10^6$$

Chl-a levels were analysed with the following methods described by Bartram & Ballance (1996), Wetzel & Likens (2000). The Chl-a content was calculated in µg/L (micrograms per liter). The confirmed value of Chl-a (chlorophyll-a) was determined using the equation (chlorophyll-a)-(pheophytin-a).

Chlorophyll-a (mg/m^3) = (26.73 (663a - 665b) × Pv) / (Sv × I) (3.1)

Pv: the volume of acetone extract (mL), Sv: the volume of filtered seawater, and I: the path length of the spectrophotometer cell (cm)

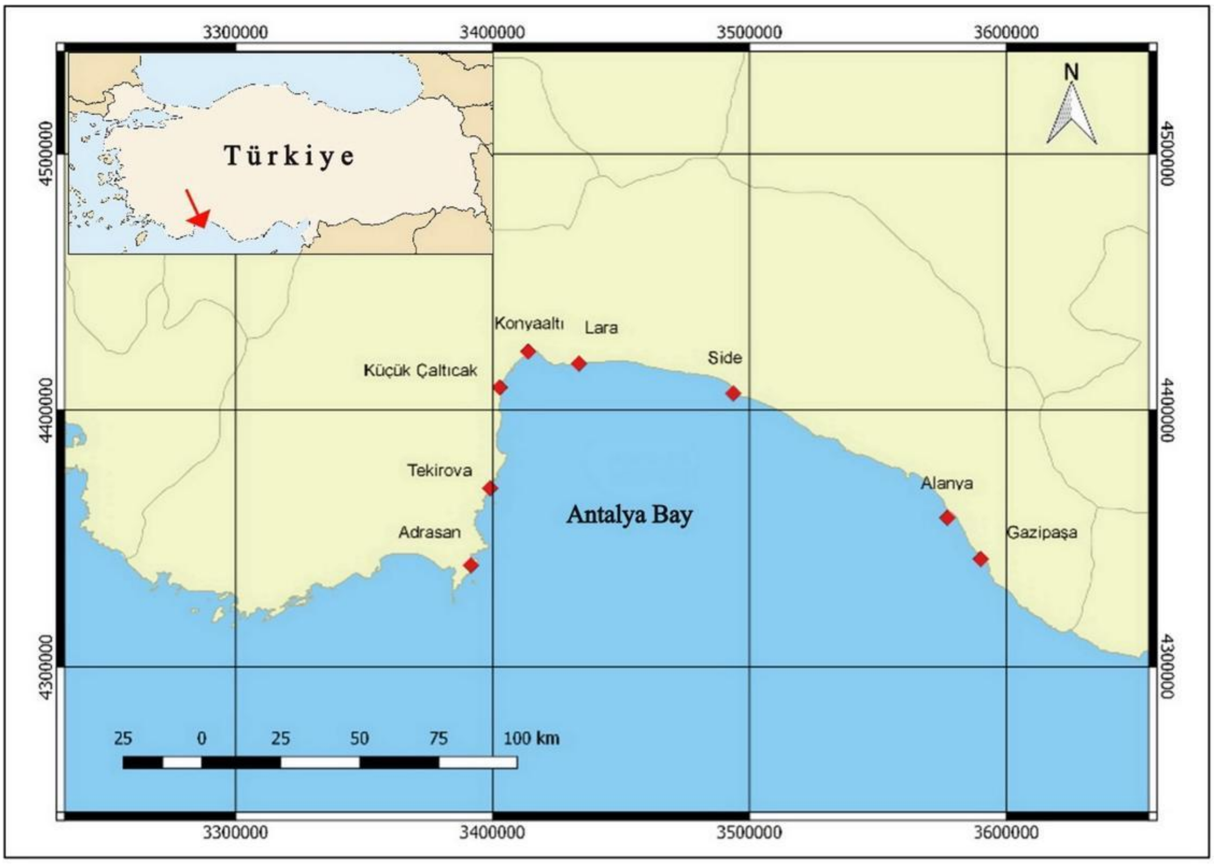

Figure 1. Map of the study area.

The samples collected from the study area as displayed in Figure 1, were transferred to plastic containers (5 liters in volume) containing 4% formalin solution (Seawater-Formaldehyde) and brought to the Faculty of Eğirdir Fisheries for further analysis. In the laboratory, samples were immersed in flowing water for 30 minutes and were separated from substrate using forceps under a stereo binocular microscope. The number of polyps was determined and categorized as 1 to 4, and they were transferred to sealed containers of 5, 10, and 50 ml in volume. The containers were labeled and sealed with parafilm, and the specimens were fixed in a 4% formalin solution. The species diagnoses were made based on studies of Riedl 1983, Boero & Morri 1986, Svoboda & Cornelius 1991, Morri & Bianchi 1999, Schuchert 2001 a,b, Schuchert 2003, 2004, 2006, Bouillon et al., 2004, Nawrocki et al., 2010, Schuchert & Geneve 2010. Statistical analyses were performed Duncan test and PCA analysis (Feulilloley et al., 2021) using the Jump software package.

3. RESULTS and DISCUSSION

3.1. Substrate selection by hydroid polyps

The study revealed the substrate selection of hydroid polyps distributed in the Gulf of Antalya. In terms of their substrate-type selectivity, hydroids have been classified into three different groups as epiphytic, epilithic, and epizoic (EP, EL, EZ). When evaluating the substrate preferences of the species listed in Table 1, it is observed that the most commonly encountered substrates are rock (20 species), *E. elongata* (18 species), *Balanus* sp. (9 species) and *P. oceanica* (8 species). When considering the substrate choices of these species, the preference for rocks can be explained by the reliable and steady base that they provide. Plants, on the other hand, might use a camouflage strategy to avoid predators. However, the gain of mobility due to epizoic preferences may give a feeding advantage. It has been determined that 9 species (*A. ammisatum, Eudendrium* sp.*, T. nutricula, P. disticha, C. noliformis, H. tenellum, H. diaphana, D. disticha, S. desmoides*) are found in all substrate types (Table 1). This situation may be to their advantage, therefore these species do not exhibit substrate selectivity. Broader distribution is thought to be more likely for species with poor substrate selectivity.

Table 1. The substrate selections by hydroid polyps.

Substrate/ Taxon	*Acauloides ammisatum* (Bouillon, 1965)	*Amphinema rugosum* (Mayer, 1900)	*Amphinema* sp. Haeckel, 1879	*Dicoryne conferta* (Alder, 1856)	*Eudendrium* sp. Ehrenberg, 1834	*Eudendrium capillare* (Pallas, 1776)	*Eudendrium merulum* (Watson, 1985)	*Eudendrium simplex* (Pieper, 1884)	*Hydractinia aculeata* (Wagner, 1833)	*Turritopsis nutricula* (McCrady, 1857)	*Coryne eximia* (Allman, 1859)	*Pennaria disticha* (Goldfus, 1820)	*Clytia* sp.Lamouroux, 1812	*Clytia gracilis* (Sars, 1850)	*Clytia hemisphaerica* (Linnaeus,1767)	*Clytia brevithecata* (Thorneley,1900)	*Clytia linearis* (Thorneley, 1900)	*Clytia noliformis* (McCrady, 1859)	*Laomedea angulata* (Hincks, 1861)	*Laomedea flexuosa* (Alder, 1857)	*Laomedea* sp.Lamouroux, 1812	*Orthopyxis integra* (MacGillivray, 1842)	*Halecium tenellum* (Hincks, 1861)	*Halecium* sp. Oken, 1815	*Scandia gigas* (Pieper, 1884)	*Monotheca obliqua* (Johnston,1847)	*Macrorhynchia philippina* Kirchenpauer, 1872	*Aglaophenia picardi* Svoboda,1979	*Halopteris diaphana* (Heller, 1868)	*Hydrodendron mirabile* (Hincks, 1866)	*Dynamena disticha* (Bosc, 1802)	*Salacia desmoides* (Torrey,1902)	*Salacia* sp.Lamouroux, 1816	*Sertularella* sp.Gray, 1848	*Sertularella ellisii* (Deshayes & Milne Edwards, 1836)
Epiphytic																																			
Padina pavonica (Linnaeus) Thivy, 1960												X				X				X									X	X					
Ellisolandia elongata (J.Ellis & Solander) K.	X				X					X				X	X	X	X	X		X	X		X	X	X					X	X	X		X	X
Posidonia oceanica (Linnaeus) Delile, 1813	X	X										X				X										X		X			X			X	
Epizooic																																			
Cnidaria																																			
Pennaria disticha													X		X																	X			
Gastropoda																																			
Patella caerulea Linnaeus, 1758			X	X																		X													
Conus ventricosus Gmelin, 1791				X		X																													
Arthropoda																																			
Balanus sp. Costa, 1778	X							X	X	X	X	X							X								X					X			
Mollusca																																			
Spondylus spinosus Schreibers, 1793									X																								X		
Chama pacifica Broderip, 1835					X																								X		X			X	
Mytilus galloprovincialis Lamarck, 1819												X						X					X												
Epilytic																																			
Rock	X				X	X	X			X		X	X	X	X	X		X	X			X	X				X	X	X		X	X			X

3.2. Physicochemical variables

Statistical analysis (Duncan test), of the annual average values of some environmental variables (pH, Temperature, Dissolved Oxygen, Salinity, EC) measured throughout the year are given in Figures 2-7. Among all sampling areas, only the Konyaaltı sampling locations were found significantly different in terms of pH, Salinity and EC ($P<0.05$) (Figures 3, 4, 6). The fresh water supply that enters from the bottom in the Konyaaltı area, which explains this variance. The greatest salinity reading (39.20 ppt) was recorded in Side during the fall. The contained and shallow structure of Side Harbor in conjunction with the autumn's maximum evaporation rate contribute to the elevated saline levels (Figure 3). Chlorophyll-a values were found to be highest in Alanya (11 mg/m³) and lowest in Konyaaltı sampling location (2.2 mg/m³) throughout the year (Figure 7). Among the physicochemical variables, the pH value exhibits the smallest range of variation. Compared to freshwater environments, marine environments demonstrate greater pH stability (Geliday & Kocataş, 2005). In the measurements conducted, the pH value reached its lowest point at 7.33 (Konyaaltı, summer) and its highest point at 8.44 (Side, autumn).

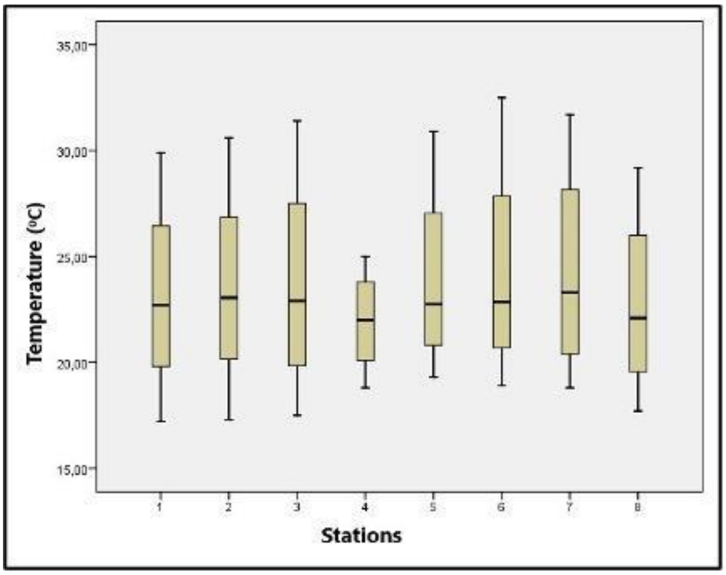

Figure 2. Annual variation graph of sea water temperature at sampling locations.

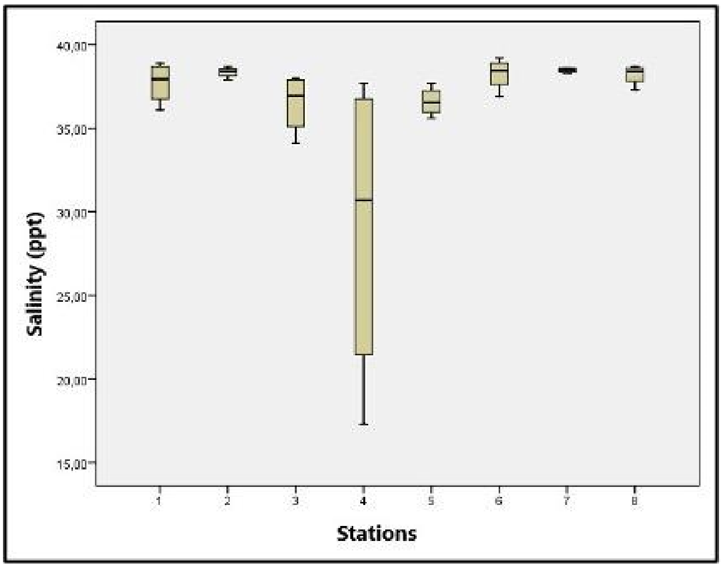

Figure 3. Annual variation graph of salinity values at sampling locations.

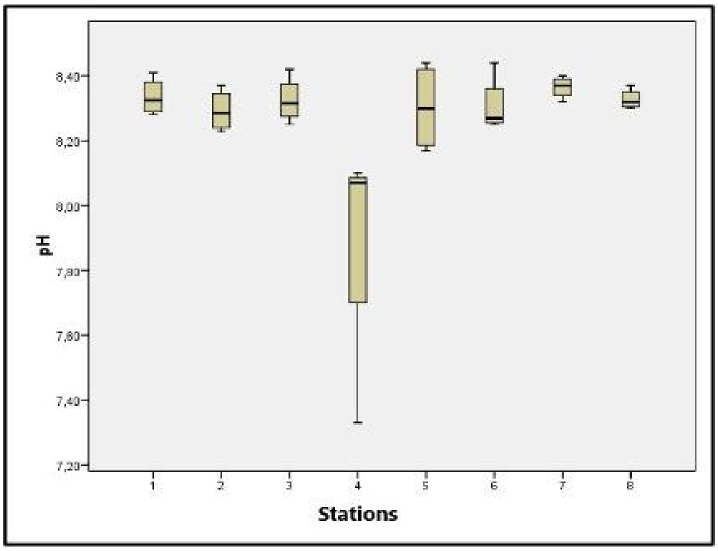

Figure 4. Annual variation graph of pH values at sampling locations.

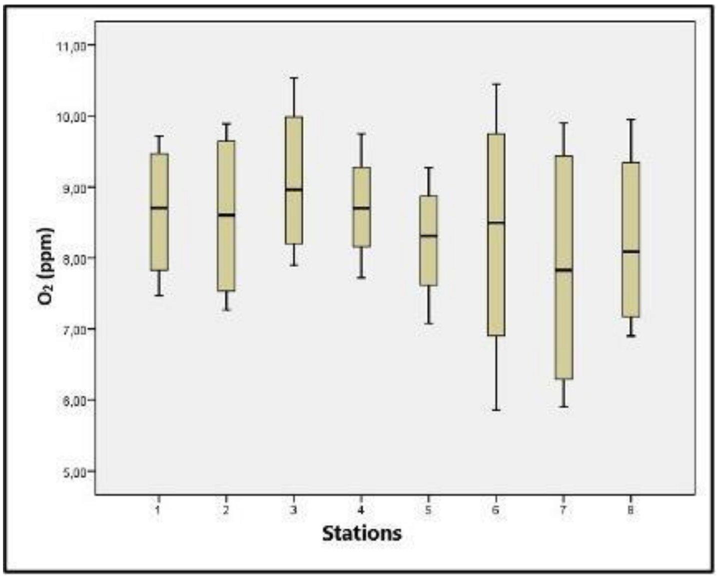

Figure 5. Annual variation graph of dissolved oxygen values at sampling locations.

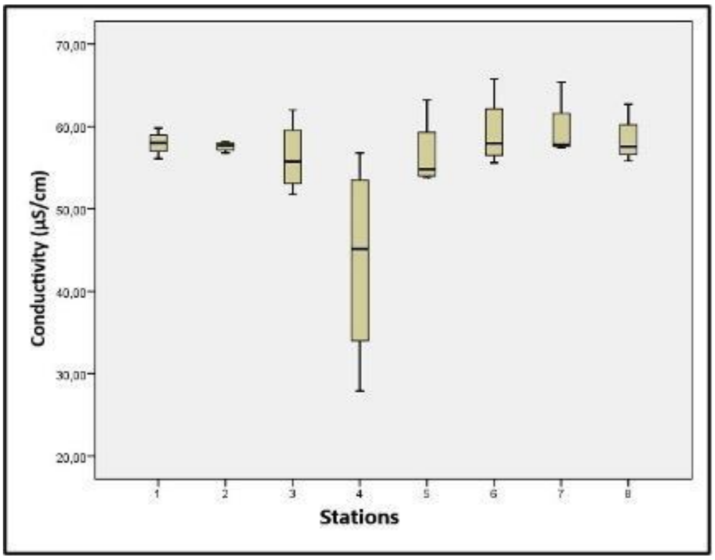

Figure 6. Annual variation graph of Conductivity values at sampling locations.

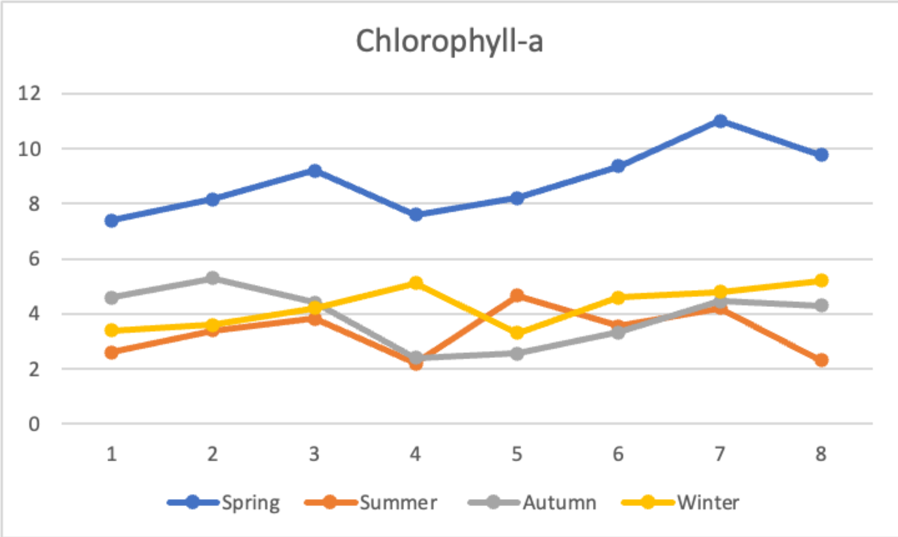

Figure 7. Annual variation graph of Chlorophyll-a values at sampling locations.

PCA analysis showed that physicochemical variables such as oxygen - oxygen saturation and chlorophyll-a have a positive correlation with one another and a negative correlation with zooplankton which is accurate since zooplankton consumes oxygen. Salinity, pH, and EC have negative correlation with temperature. The findings of the PCA analysis between stations and physicochemical parameters show that all seven stations are positioned centrally. On the other hand, the Konyaaltı station is positioned differently from all the others, which validates the earlier findings (Figure 8). All sampling locations show comparable physicochemical features, with the exception of Konyaaltı where the statistical discrepancy is ascribed to Konyaaltı's freshwater inflow. Large water masses like seas are known to fluctuate relatively little while there are clear regional differences.

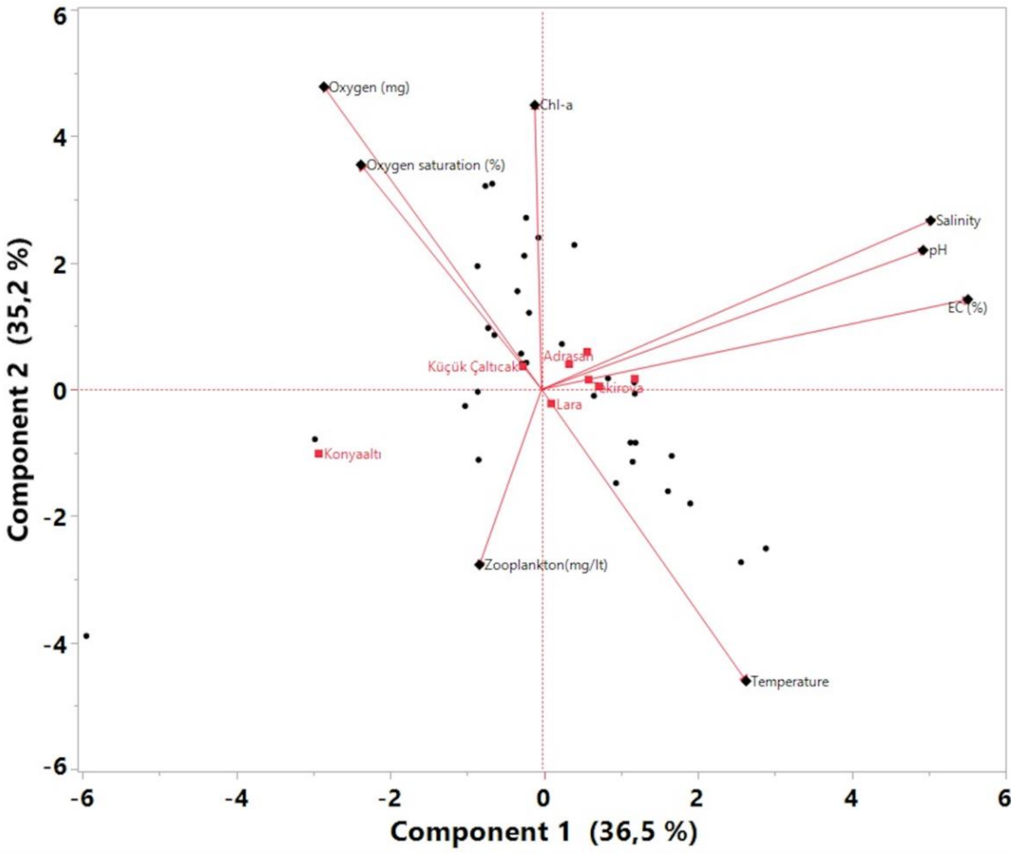

Figure 8. PCA Analysis between physicochemical parameters and stations.

Examining the PCA analysis results, it is observed that hydroid polyp species are more centrally settled in contrary to physicochemical factors (Figure 9). This indicates that the distribution of species may not be primarily influenced by physicochemical parameters. The following species which are more affected by physicochemical factors than others: *Clytia* sp., *E. rameum*, *H. aculeata*, *C. noliformis*, *M. philippna*, *Eudendrium* sp. and *C. brevithecata*, showed that the distribution of these species are related with oxygen, oxygen saturation and Chl-a. *A. ammisatum* and *C. eximia* are related to zooplankton biomass positively; they both have short pedicels and athecata, which may be the reason why they are challenged to catch zooplankton. *A. rugosum* is strongly related and *Clytia* sp., *C. hemisphaerica*, *Salacia* sp., *H. tenellum* and *O. integra* are related to temperature. *D. disticha*, *M. obliqua*, *E. merulum*, *Scandia* sp., and *C. brevithecata* are related to salinity, pH and EC. It is evident from the literature that *A. rugosum* prefers high temperatures because its seasonality is July in the Mediterranean (Bouillon et al., 2004).

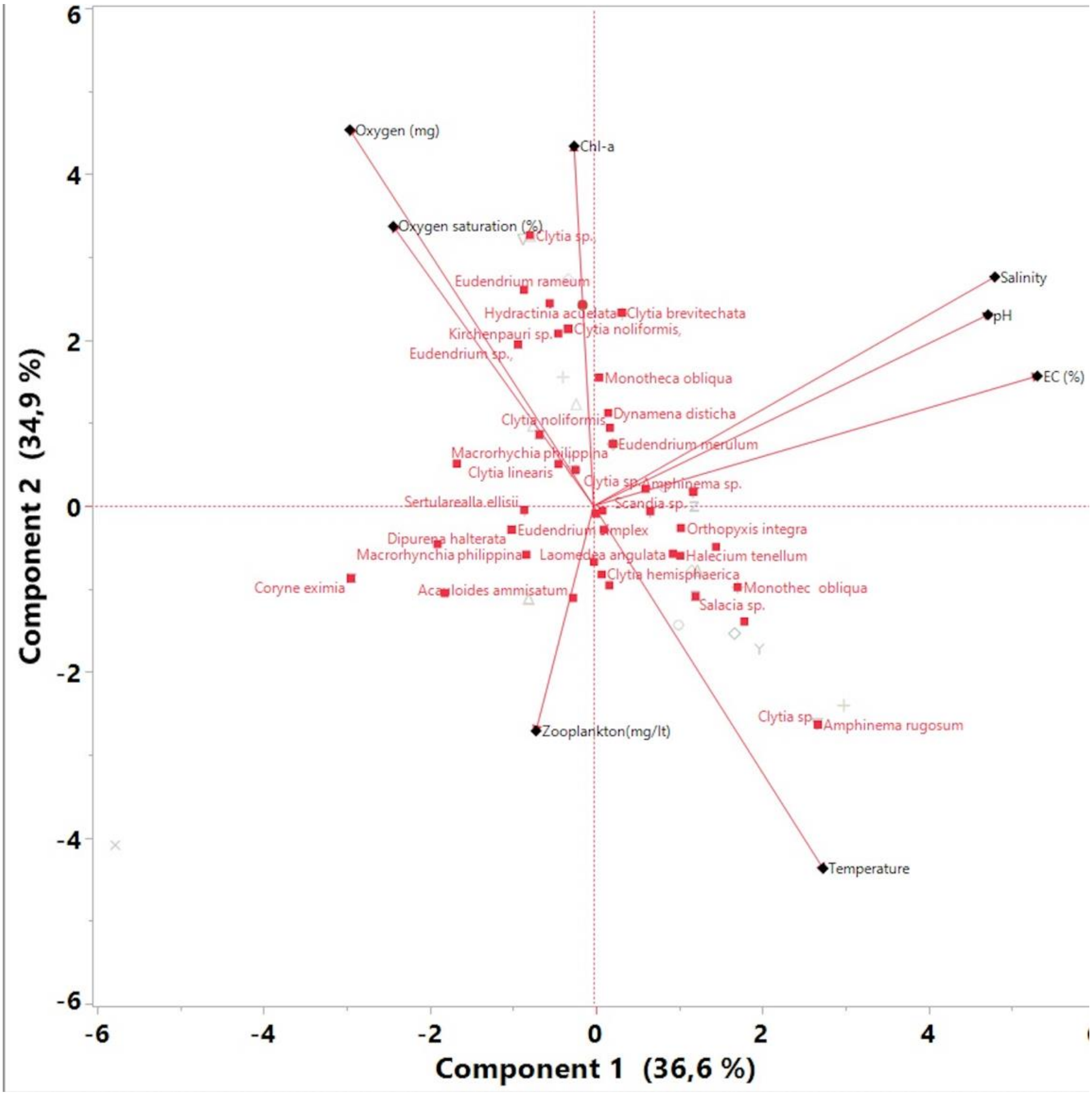

Figure 9. PCA analysis between physicochemical parameters and species.

The present study indicates that some species substrate preferences deviate from published research. Here are the 11 species that are listed differently from those in the literature; İşinibilir et al., (2015) found *Amphinema rugosum* on the coasts of Türkiye throughout the year, and it was reported that this species prefers algae, bryozoans and mollusc shells as substrates (Gravili et al., 2015). In our study, *A. rugosum* was found only as an epiphyte. *Hydrodendron mirabile* is also known to be distributed on algae, *Posidonia oceanica*, sponges, and bryozoans (Boullion et al., 2004; Gravili et al., 2015). However, in our study it was only observed as an epiphyte. *Eudendrium capillare* was only observed on the epilithic substrate during the winter season, but in the present work, it was observed to select *P. oceanica* rhizomes, other hydroids, bryozoans, and bivalves as substrates in addition to rocky areas (Gravili et al., 2015). The sampling strategy might be responsible for these different substrate choices. Finding the hydrozoans is a challenge, thus sampling techniques are essential. In addition to not being visible to the naked eye, divers must anticipate their potential locations. The diver conducting the sampling could have a complete impact on the outcomes (Bouillon et al., 2004).

According to Çınar et al. (2014), *P. disticha* is reported to be distributed only in the Mediterranean region of the Turkish coasts and sampled on hard substrates. Yet Gülşahin (2013) reported the species from the Fethiye coast in their study. Bouillon et al. (2004) stated that the species is present from November to April. In our study, the species was encountered on epiphytic, epizoic, and epilithic substrates in all seasons.

Macrorhynchia philippina, was reported as epiphytic on red algae and Sargassum spp. (Oliveira & Marquez, 2011). This species was observed to be epiphytic on *Posidonia oceanica* in this study. The present study showed a preference for epilithic and epizoic substrates, which adds to our knowledge of its substrate preferences. The results could have been different due to the lack of studies conducted with these species. Additional studies need to be carried out and the findings about the substrate preferences need to be reported in the literature to further discuss the results obtained from the present study.

Clytia linearis, recorded by Billard in 1926 on the Egyptian coast, is a Lessepsian species that entered the Mediterranean system through the Suez Canal. Gravili et al. (2015) reported the presence of *C. linearis* along the Italian coasts, where it was found on algae, *Posidonia oceanica on* sponges and bryozoans throughout the year. In previous records from the Turkish coasts, especially in the Aegean Sea, this species was mostly observed in rocky habitats and as an epiphyte on *P. oceanica* (Çınar et al., 2014; Bouillon et al., 2004). In our study this species was found also mainly in rocky habitats and epiphyte on *P. oceanica.*

Scandia gigas is known to have a distribution range from January to November, and it is found on algae, anthozoans, polychaetes, and mollusk shells (Gravili, 2015). In this study, it was exclusively encountered as an epiphytic species on *P. oceanica* in Konyaaltı during the spring season.

Laomedea flexuosa is reported to have a distribution along the Aegean and Marmara coasts of Türkiye. While it is generally stated to prefer brown algae as substrates (Marfenin & Belorustseva, 2008; Çınar et al., 2014), this study determined that it mostly prefers *Jania rubens* species of calcareous algae

Orthopyxis integra, recorded from the coasts of the Aegean and Marmara Seas, was encountered in all samples except during the winter season in this study, showing distribution on epilithic, and epizoic (*Patella caerulea* shells) substrates (Çınar et al., 2014). This species, recorded from the coasts of Italy, exhibits a wide substrate selection, including algae, phanerogams, bryozoans, other hydroids, mollusk shells, sponges, and is encountered throughout the year (Gravili et al., 2015).

Hydrodendron mirabile, another hydrozoan species, is known to have distribution on algae, *Posidonia oceanica*, sponges, and bryozoans. The previous studies reported that this species was exclusively observed in an epiphytic form (Bouillon et al., 2004; Gravili et al., 2015). The sampling strategy might be responsible for these different substrate choices as explained before.

The literature reports that *Eudendrium simplex* is generally found on *P. oceanica* in shallow waters and it is also known to occur on sponges, mollusk shells, barnacles, and can exhibit an epiphytic lifestyle (Oliviera & Marquez, 2007; Gravili et al., 2015). The different substrate selections may be due to the sampling approach.

The presence of different substrates in the environment and their density directly affect the occurrence of hydroid species (Boullion et al, 2004). The larvae of *Eudendrium glomeratum* Picard, 1952 have also been shown in laboratory trials to settle more frequently on carbonate substrates (marble) than granitic ones (quartz) (Bavestrello et al., 2000). Furthermore, hydroids are recognized for their capacity to develop as epibionts on various organisms, including macroalgae and other metazoans, including Crustacea, Echinodermata, Porifera, Bryozoa, and Mollusca (Roveta et al., 2022).

In this study, results on the distribution areas and substrate preferences of hydroid polyps in the Gulf of Antalya were presented. Numerous further studies need be carried out on this group, which is seen in marine areas, to reveal both systematic and substrate selection and habitat characteristics. With this study, general information about hydroids is presented.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AUTHOR CONTRIBUTIONS

Fiction: SOKY, FK; Literature: SOKY, FK; Methodology: SOKY, FK; Performing the experiment: SOKY, FK; Data analysis: SOKY, FK; Manuscript writing: SOKY, FK, Supervision: SOKY, FK All authors approved the final draft.

ETHICAL STATEMENTS

Local Ethics Committee Approval was not obtained because experimental animals were not used in this study.

DATA AVAILABILITY STATEMENT

Data supporting the findings of the present study are available from the corresponding author upon reasonable request.

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