



Meroplankton Composition of a Low Productive Lagoon System (Köyceğiz-Dalyan): Temporally but Not Spatially Variations

Az Verimli bir Lagün Sisteminin (Köyceğiz-Dalyan) Meroplankton Kompozisyonu: Uzamsal Olmayan Zamansal Varyasyonlar

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ABSTRACT

Seasonal meroplankton abundances of Köyceğiz-Dalyan Lagoon System were examined in this study. Also, changes in the diversity and abundance of meroplanktonic larvae because of the different two salinity layers of the system were investigated. Meroplankton samples were taken by Unesco standart plankton net with 200 micrometer mesh size horizontally from three stations. Temporal and spatial differences in the abundance of meroplankton groups were examined by permutational multivariate analysis of variance (PERMANOVA). Environmental parameters which are temperature, salinity and dissolved oxygen were measured from the surface. Meroplankton groups of the study area were nauplius, zoea, cyprid larva, stomatopod larva, hydrozoan larva, ephyra, polychaeta larva, fish egg, fish larva and gastropod larva. Meroplankton and holoplankton abundances showed two peaks in April and October. There were statistically significant differences in the abundance of meroplankton amongst seasons especially between summer-winter and winter-spring. In October and November Mediterranean water enters the Köyceğiz-Dalyan Lagoon System through the bottom of the system, whereas in winter and spring, the lagoon and coastal zone were under the influence of Lake Köyceğiz.

Key Words

Meroplankton, lagoon, seasonal abundance.

ÖZ

Bu çalışmada Köyceğiz-Dalyan Lagün Sisteminin mevsimsel meroplankton bollukları incelenmiştir. Ayrıca, sistemin farklı tuzluluk tabakası nedeniyle meroplanktonik larvaların çeşitliliği ve bolluğundaki değişiklikler araştırılmıştır. Meroplankton örnekleri üç istasyondan horizontal olarak 200 mikrometre göz açıklığına sahip Unesco standart plankton ağı ile alınmıştır. Meroplankton gruplarının bolluğundaki geçici ve uzamsal farklılıklar permütasyonel çok değişkenli varyans analizi (PERMANOVA) ile incelenmiştir. Çevresel parametrelerden yüzey suyu sıcaklık, tuzluluk ve çözülmüş oksijen değerleri ölçülmüştür. Çalışma alanının meroplankton grupları nauplius, zoea, cyprid larva, stomatopod larva, hidrozoan larva, ephyra, poliket larva, balık yumurtası, balık larvası ve gastropod larvasıdır. Meroplankton ve holoplankton bollukları Nisan ve Ekim aylarında olmak üzere iki kez pik yapmıştır. Meroplankton bolluğu, özellikle yaz-kış ve kış-ilkbahar mevsimleri arasında istatistiksel olarak anlamlı farklılıklar göstermiştir. Ekim ve Kasım aylarında Akdeniz suyu lagün sisteminin dip kısmından Köyceğiz-Dalyan Lagün Sistemine girerken, kış ve ilkbaharda lagün ve kıyı bölgesi Köyceğiz Gölü'nün etkisi altındadır.

Anahtar Kelimeler

Meroplankton, lagün, mevsimsel bolluk.

Article History: Received: Jun 16, 2020; Revised: Jul 24, 2020; Accepted: Aug 13, 2020; Available Online: Sep 28, 2020.

DOI: <https://doi.org/10.15671/hjbc.753642>

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INTRODUCTION

Pelagic larvae of nektonic and benthic animals so called meroplankton may have great abundance and diversity both in marine and freshwater environments [1]. Meroplankton have also an important trophic role especially for marine coastal plankton. Meroplankton abundances are controlled by water temperature, spawning period, phytoplankton and zooplankton availability, duration of pelagic stage, length of pelagic stage and water currents [1]. For instance, warmer surface temperature shortens the larval period [2]. Also, if plenty of food is available meroplankton survival increase [3]. Feeding of meroplanktonic larvae depends on plankton density and hence the phytoplankton blooms [4]. Most meroplanktonic larvae feed on phytoplankton, but some crustacean and polychaeta larvae are predatory [5]. In coastal areas, changes in meroplankton abundance may affect trophic relationship of plankton and density of benthic community especially in spring and summer [6].

Studies on meroplanktonic larvae have been largely neglected in Turkey. Uysal and Murina [7] reported monthly meroplankton composition of Mersin Bay in

1998. İşinibilir [8] noted the abundance of holoplankton and meroplankton groups in northern Aegean Sea in August 2001. Üstün [9] mentioned the seasonal density of meroplankton when investigating zooplankton abundances of Hamsilos Bay, Sinop, Turkey. Killi and Sağdıç [10] provided information about the presence and abundance of meroplankton in Güllük Bay. Any study was not found on meroplankton diversity of the Köyceğiz-Dalyan Lagoon System. This system which has two salinity layers hosts both freshwater and marine species so, it is expected that meroplankton diversity of the lagoon is high.

The aim of this study was to describe how the composition of the meroplankton community and its contribution to total zooplankton varies on a seasonal basis in a special lagoon system. Also, meroplankton and holoplankton abundances of the region were compared. Köyceğiz-Dalyan Lagoon System is effected by both terrestrial and marine environments. Also, the lagoon which include the spawning area of *Caretta caretta* and Kaunos Ruins is important in terms of history and touristic [12]. Coastal and estuarine regions, which differ from open ocean ecosystems due to seasonal inputs affect the larval stages of benthic organisms. Therefore, the



Figure 1. Köyceğiz-Dalyan Lagoon System and sampling stations (highlighted in yellow).

effect of environmental parameters of an important lagoon area of Turkey, on the distribution of meroplankton was revealed.

MATERIALS and METHODS

Study area comprises Dalyan channels, Lake Alagöl and İztuzu Beach in Köyceğiz-Dalyan Lagoon System. The system is a protected natural reserve in the Muğla province, south-western Turkey [11]. There are two water layers due to the salinity in the lagoon. One of the layers is deep water from the Mediterranean and the other is surface water from Köyceğiz Lake [12].

Sampling operations were conducted on a seasonal basis in August, October, December in 2016 and April in 2017 at three stations in Köyceğiz-Dalyan Lagoon System. Station 1 is in the Dalyan channels, station 2 is in the İztuzu Beach and station 3 is in Alagöl Lake (Figure 1). In December, no efficient sampling could be done from station 2 as the sea water was drawn. Meroplankton samples were taken by Unesco standart plankton net with 200 micrometer mesh size horizontally. The samples taken were placed in plastic jars and 5% formaldehyde solution was added as fixing solution. The samples were counted under Olympus SZX16 stereo microscope and photographed. Abundances of the meroplankton groups were calculated as follows.

$$X = a/V$$

X= Abundance of a meroplankton group in the cubic meters.

a= Count of a meroplankton group in one sample.

V= Volume of filtered water.

Environmental parameters (temperature, salinity and dissolved oxygen) were measured with YSI 556 Multiprobe System at the surface.

Temporal and spatial differences in the abundance of meroplankton groups were examined by permutational multivariate analysis of variance (PERMANOVA) using PERMANOVA+ v1.0.1 for PRIMER version 6.1.11 (PRIMER-E Ltd, Plymouth, UK) [13]. This was based on a two-way (fully-crossed) design, which included the fixed factors Season and Location. The analysis was run on a Euclidean distance measure following normalisation of the data. Data were used to obtain a distance matrix, which was subjected to 9999 permutations of the raw data and tested for significance including a posteriori pair-wise comparisons evaluated at $\alpha = 0.05$.

RESULTS and DISCUSSION

In August, surface water temperatures were high at all stations and mean temperature was 29.07°C. In other seasons, mean temperatures were 24.27°C, 14.8°C and 21.23°C, respectively. Water temperature values were found above 20°C in August, October and April. Maximum temperature was measured as 29.4°C in August at station 2. Minimum temperature was 11.2°C in December at station 3. Salinity was highly variable among seasons and stations as well. In August, salinity of station 3 was 20.79 ppt but in December and April, salinity values were 6.02 ppt and 6.96 ppt, respectively in this station. These values showed that Mediterranean waters entered to the lagoon system in summer and autumn even at station 3. According to Gürel [12], in October and November when strong winds and waves come from the Mediterranean Sea, Mediterranean water enters the Köyceğiz-Dalyan Lagoon System through the bottom of the system. However, in winter and spring, salinity of the lagoon decreased and also at station 2, which salinity of 20-22 ppt, was under the influence of the lagoon. Dissolved oxygen values were varied between minimum 4.62 (station 1, October) and maximum 8.94 mg/l (station 1, December). Mean DO values of the stations were 6.35 ppt, 6.41 ppt and 6.95 ppt, respectively. Seasonal variation of these two different water bodies also

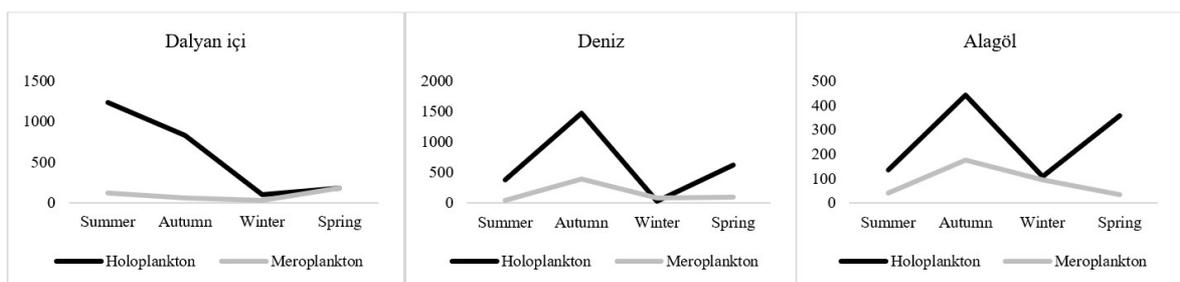


Figure 2. Holoplankton and meroplankton abundances of the stations according to the seasons.

affects the distribution of planktonic groups. Because of the water flowing towards from the sea to the lagoon in summer months marine copepod species were observed densely at station 1. In October, it was observed that copepods showed high abundance (929 ind./m³) at station 2 with high salinity (34.27‰). Although salinity of the station 1 was 29.13 ppt in October, it was found low numbers of copepods because of the water flow from Lake Köyceğiz. According to Gürel [12], the lagoon was under the influence of the lake during the winter months. It was determined that salinities of all the stations were low in December.

Meroplankton groups of the study area were nauplius, zoea, cyprid larva, stomatopod larva, hydrozoan larva, ephyra, polychaeta larva, fish egg, fish larva and gastropod larva. Meroplankton and holoplankton abundances showed two peaks in April and October (Figure 4). In August, dominant meroplankton groups were nauplius at station 1 and fish eggs at station 2. Fish eggs were only observed in the meroplankton samples at station 3. Nauplius increased at station 2 with 134 ind./m³ abundance in October. Also, gastropod larvae were the most common meroplankton in all stations in October.

Gastropod larvae continued to dominate in December as well. Especially, at stations 2 and 3, gastropod larvae were only meroplankton group as the abundances of 80 ind./m³ and 94 ind./m³, respectively. In April, nauplius increased in all stations. Fish larvae were also other meroplankton groups, which showed high abundances at especially stations 1 and 2. Crustacean nauplius is the most abundant type of multicellular animal on earth [14]. Nauplii feed on small dinoflagellates, diatoms and other microplankton [15]. In this study, it was observed

that nauplii increased in April and October when dinoflagellates and diatoms increased. Zoeas were *Callinectes sapidus* larva, which are commonly distributed in the Köyceğiz-Dalyan Lagoon System [16]. Ephyras belonging to *Phyllorhiza punctata* was recorded in the Lake Sülüngür that is located inside the lagoon for the first time in 2011 [17]. Since then, *P. punctata* has been observed in 2013, 2017 and 2018 in the lake (own unpublished data). Ephyras were found in August in this study and the medusa were determined in September and October in the lake [17]. It could be suggested that ephyras and planulae entered to the lagoon system from the Mediterranean Sea by the currents. *P. punctata*, which prefers lagoon systems settled successfully in the Lake Sülüngür – an important habitat of many fish species. *P. punctata* also feeds on fish eggs and larvae. Stomatopod larva found only in August at station 1 belong to Mantis shrimp, which lives in silty sands and sandy muds [18; 19].

In this study, plankton composition of the area was low in point of both species' diversity and abundances. The small number of phytoplanktonic species and low abundance values affect zooplankton distribution and abundance. Thus, according to Gürel [12] chlorophyll-a values of the lagoon system are low and hence Köyceğiz Lake is very poor in terms of zooplankton [20]. Diversity and abundance of phytoplankton and zooplankton were low in this study as well. Holoplankton showed peaks in summer-autumn at station 1 and spring-autumn at the other stations. While copepods were the dominant zooplankton group, among phytoplankton, diatoms and

Table 1. PERMANOVA results on the differences in abundance of meroplankton groups by season and location. Statistically significant (and ecologically relevant) effects in bold ($\alpha = 0.05$) including those for a posteriori pair-wise comparisons (# = permutational value based on 9999 permutations).

Source of variation	df	MS	F#	t#	p#
Location	2	12.521	1.4531		0.1922
Season	3	10.369	1.2033		0.0236
Summer vs Autumn	1			1.1722	0.0899
Summer vs Winter	1			1.1433	0.0372
Summer vs Spring	1			1.1506	0.1919
Autumn vs Winter	1			1.2947	0.1647
Autumn vs Spring	1			1.0997	0.3454
Winter vs Spring	1			1.9504	0.0327

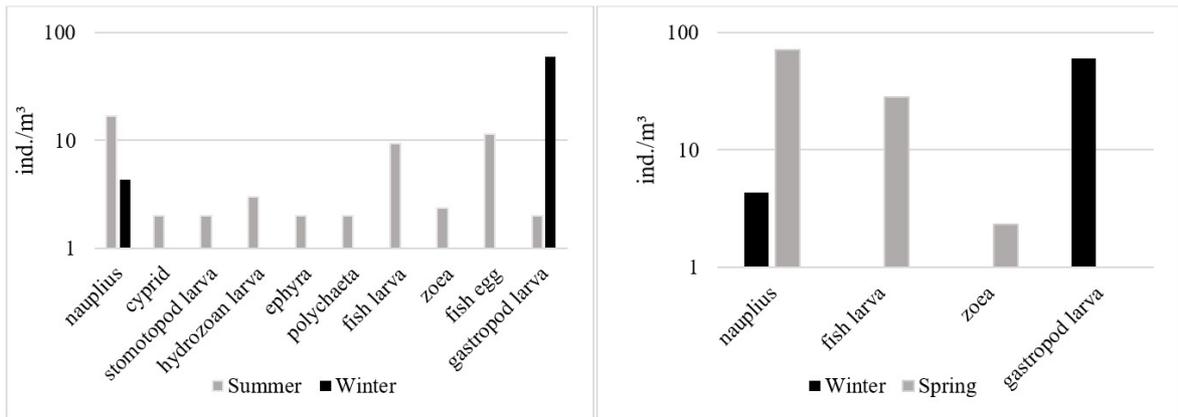


Figure 3. Mean abundances of the stations according to PERMANOVA results on the differences of the seasons.

dinoflagellates were found in high abundances in October and April, respectively. Diatoms reached 715 ind./m³ abundance in October at station 1. Abundances of rotifers were high in summer at station 1 and in spring at stations 2 and 3. The high number of rotifers at the station 2 in the spring confirms the flow from Köyceğiz lake towards the sea.

There were statistically significant differences in the abundance of meroplankton amongst seasons (Table 1, Figure 5). In winter, it was determined only nauplii and gastropod larvae in the samples. Dinoflagellates and diatoms were not observed and also zooplankton abundances highly decreased in December. Therefore, meroplankton abundances and diversity are very low in this season. Further, in December sampling operation could not be done at station 2, which was under effect of the water from the lagoon.

In Güllük Bay near the Boğaziçi Lagoon (Milas, Muğla), eight meroplanktonic larval groups were determined and meroplankton as the second group after copepods in November, December and February was important component of zooplankton in the area (unpublished data). Similarly, meroplankton was the second group after copepods in summer and autumn in Hamsilos Bay, Sinop, Turkey [9]. Meroplankton consisted of nauplius, zoea, fish eggs and larvae, mysis, stomatopod and echinopluteus larvae in the surface water of Güllük Bay during April-October 2017 [10]. Abundance of meroplankton increased in May and June, and decreased in July and August in Güllük Bay, which is an important region in terms of richness both in holoplankton and meroplankton diversity and abundance because of high marine production [10]. Conversely, the Köyceğiz-Dalyan Lagoon System is not that productive most probably due to two water layers where one of the

layers is from Köyceğiz Lake to the Mediterranean and the other is from the Mediterranean to the lake [12]. Accordingly, it can be suggested that the salinity changes affected distribution of zooplankton [e.g. 21 and sulfur sources in the Köyceğiz-Dalyan Lagoon System the apparently limit plankton abundances in the lagoon [20].

In conclusion, the meroplankton abundances of the Köyceğiz-Dalyan Lagoon System was not high and meroplankton diversity was changed by the seasons. In the future, it is necessary to examine the meroplankton and holoplankton density of this important lagoon system with long-term studies.

Acknowledgments

This study covers part of a project which was supported by the Muğla Sıtkı Koçman University Scientific Research Project Coordination Unit with project number 16/088.

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