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Araştırma Makalesi / Research Paper

Water Mite (Acari, Hydrachnidia) Fauna of Kargı Stream (Antalya-Turkey) and Their Relationships with Physicochemical Variables

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ABSTRACT

This study was carried out in Kargı stream where located in Alanya district of Antalya province. Seven stations were chosen on the stream, Hydrachnidia (water mite) and water samples were taken from all stations between July 2014-April 2015 seasonally. Cl^-, NH_4^+-N, NO_2^--N, NO_3-N, PO_4-P, biological oxygen demand of the water samples were analyzed in the laboratory. Water temperature, pH, dissolved oxygen, and electrical conductivity were measured during sampling in situ. As a result, a total of 32 taxa were detected, 9 taxa from Hygrobatidae, 8 taxa from Torrenticolidae, 6 taxa from Sperchontidae, 3 taxa from Lebertidae, 3 taxa from Hydryphantidae, 1 taxa from Aturidae, 1 taxa from Hydrodromidae and 1 taxa from Mideopsidae. Canonical Correspondence Analysis was applied to determine the relationships between the water mite fauna and physicochemical variables. Accordingly, pH, water temperature and biological oxygen demand were found as the most effective factors on distribution of water mite assemblages. This study represents the first effort for determining Kargı Stream of water mite fauna. So, all listed the species are firstly reported for the region.

Keywords: Fauna, Water mite, Hydrachnidia, CCA, Kargı Stream.

Kargı Çayı (Antalya-Turkey) Su Kenesi (Acari, Hydrachnidia) Faunası ve Çevresel Değişkenlerle İlişkisi

ÖZ

Bu çalışma Antalya İli Alanya Ilçesi'nde yer alan Kargı Çayı'nda gerçekleştirilmiştir. Seçilen yedi istasyondan, Temmuz 2014- Nisan 2015 tarihleri arasında mevsimsel peryotlarla su ve Hydrachnidia (su kenesi) örnekleri alınmıştır. Alınan su örneklerinin Cl^-, NH_4^+-N, NO_2^--N, NO_3-N, PO_4-P, biyolojik oksijen ihtiyacı değerleri laboratuvarda analiz edilirken, su sıcaklığı, pH, çözünmüş oksijen ve elektriksel iletkenlik değerleri örnekleme sırasında in situ olarak ölçülmüştür. Sonuç olarak, toplam 32 takson belirlenmiştir. Bu taksonların 9'u Hygrobatidae, 8'i Torrenticolidae, 6'sı Sperchontidae, 3'ü Lebertidae, 3'ü Hydryphantidae, 1'i Aturidae, 1'i Hydrodromidae ve 1'i Mideopsidae familyasına aittir. Su akar faunası ve çevresel değişkenler arasındaki ilişkiler Kanonik Uyum Analizi kullanılarak belirlenmiştir. Bu analiz sonuçları, pH, su sıcaklığı ve biyolojik oksijen ihtiyacının su akarı topluluklarının dağılımında en etkili faktörler olduğunu göstermiştir. Bu çalışma, Kargı Çayı su akarı faunasının belirlenmesine yönelik yapılmış ilk çalışmadır. Bu nedenle belirlenen türler çalışma alanı için yeni kayıt niteliğindedir.

Anahtar Kelimeler: Fauna, Su akarı, Hydrachnidia, CCA, Kargı Çayı.

INTRODUCTION

The Hydrachnidia (water mites), also called Hydrachnellae, Hydracarina, Hydrachnida, represent the most important group of the Arachnida in freshwater ecosystems. Originating from terrestrial ancestors, they have colonized all kinds of freshwater habitats. Water mites are extremely varied both in lotic and lentic habitats, as well as in springs and interstitial waters (Di Sabatino et al., 2000, 2003; Smith et al., 2001). Over 6,000 species have been defined worldwide, representing 57 families, 81 subfamilies and more than 400 genera (Di Sabatino et al., 2008).

Water mites are well known as indicators of ecosystem disturbance, directly Because of their sensitivity to reflect natural changes and human induced Environmental stresses in freshwater habitats, and indirectly, as important constituents in natural communities (Di Sabatino et al., 2000; Dohet et al., 2008; Więcek et al., 2013).

There are various researches about water mite fauna of Turkey and the relationships between these organisms and physicochemical variables. Approximately 260 species of water mites have been identified for our country until today (Özkan, 1981, 1982; Erman and Özkan, 1997; Tuzovskij and Gerecke, 2003; Boyacı and Özkan, 2004; Erman et al., 2006, 2010; Pešić and Turan, 2006; Boyacı and Özkan, 2007; Ascı et al., 2011; Bursalı et al., 2011; Gülle et al., 2011; Boyacı et al., 2010, 2012a, 2012b, 2012c; Esen et al., 2012; Esen and Erman, 2012, 2013; Esen et al., 2013).

The purposes of this study were to determine water mite fauna (Hydrachnidia) of Kargı Stream and to explain the relationships between these organisms and the physicochemical variables.

MATERIAL AND METHOD

The current study was conducted on Kargı Stream where is located in Alanya district of Antalya city (Turkey). The length of this stream is approximately 45 km. Seven stations were chosen on the stream and samples were taken seasonally (between July 2014-April 2015). The first station was located in spring area while the last station was located in the eustarine zone (Figure 1).

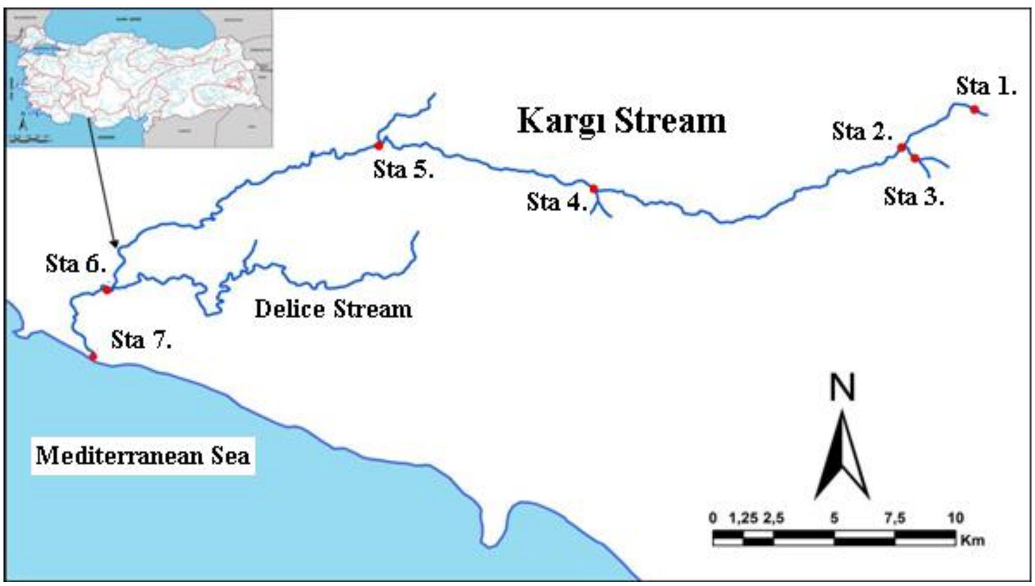

Figure 1. The study area and stations

Samples were collected from each station by using a hand net, washed through a sieve series and sorted in the field from living material, preserved in Koenike's fluid. Water mites were identified to species level by utilizing from Viets (1936, 1956), Lundblad (1956), Besseling (1964), Szalay (1964), Cook (1974) and Bader (1975). Water temperature, pH, dissolved oxygen (DO), and electrical conductivity were measured during sampling in situ by using portable multiparameter equipment. Cl^-, NH_4^+-N, NO_2^--N, NO3-N, PO4-P, biological oxygen demand (BOD) were measured in the laboratory by following the standard methods (APHA, 1998). Faunal similarity between stations was determined by using Sørensen's similarity index (Krebs, 1989). Also, Shannon-Weaver (1949) and Simpson (1949) indices were applied to detect the species diversity of the stations. The relationships between Hydrachnidia fauna and physicochemical variables were analyzed by canonical correspondence analysis (CCA) in the CANOCO program (ter Braak, 1989).

RESULTS

As a result of the study, 276 individual species and 32 taxa belonging to 8 families and 11 genera were determined in Kargı Stream. Hydrachnidia species are belong to Hygrobatidae (9 taxa), Torrenticolidae (8), Sperchontidae (6), Lebertidae (3), Hydryphantidae (3), Aturidae (1), Hydrodromidae (1) ve Mideopsidae (1) families (Table 1). The most number of individuals was identified at the sixth station while there was no species at last station. The most representative genus of Kargı Stream was found as Atractides (6 species) and Sperchon (6 species) (Table 1).

Table 1. The distributions of water mite species and species diversity values at the stations in Kargı Stream

	St 1.	**St 2.**	**St 3.**	**St 4.**	**St 5.**	**St 6.**	**St 7.**
ARACHNIDA							
Hygrobatidae							
Atractides lunipes Lundblad, 1956	*	-	-	-	-	-	-
Atractides distans (Viets, 1914)	-	-	-	*	-	-	-
Atractides fluviatilis (Szalay, 1929)	-	-	-	*	-	-	-
Atractides nodipalpis (Thor, 1899)	-	*	-	-	-	-	-
Atractides walteri (Viets, 1925)	-	-	-	*	-	-	-
Atractides fissus (Walter, 1927)	-	-	*	-	-	-	-
Hygrobates fluviatilis (Strom, 1768)	-	*	*	*	*	*	-
Hygrobates decaporus (Koenike, 1895)	-	-	-	-	-	*	-
Hygrobates longipalpis (Hermann,1804)	-	-	-	-	-	*	-
Aturidae							
Aturus crinitus Thor, 1902	-	*	-	-	-	*	-
Hydrodromidae							
Hydrodroma despiciens (O.F.Müller,1776)	*	-	*	*	*	-	-
Lebertiidae							
Lebertia fimbriata Thor, 1899	*	-	*	*	*	-	-
Lebertia porosa Thor, 1900	*	*	-	-	-	-	-
Lebertia lineata Thor, 1906	-	*	-	*	*	*	-
Sperchontidae							
Sperchon brevirostris Koenike, 1895	-	-	-	*	*	-	-
Sperchon clupeifer Piersig, 1896	*	*	-	*	-	-	-
Sperchon plumifer Thor, 1902	-	*	-	-	-	-	-
Sperchon rostratus Koenike, 1900	-	-	-	-	*	-	-
Sperchon thori Koenike, 1900	-	-	-	*	-	-	-
Sperchon senguni Özkan, 1982	-	-	-	-	*	-	-
Mideopsidae							
Mideopsis orbicularis (O.F.Müller,1776)	-	-	*	*	*	-	-
Torrenticolidae							
Torrenticola anomala (C.L.Koch, 1837)	-	-	-	-	*	*	-
Torrenticola brevirostris (Halbert,1911)	-	*	*	*	-	-	-
Torrenticola barsica (Szalay, 1933)	-	*	-	*	-	*	-
Torrenticola disabatinola Pesic 2004	-	-	-	-	-	*	-
Torrenticola dudichi (Szalay, 1933)	-	-	-	*	*	*	-
Monatractides lusitanicus (Lundblad, 1941)	-	-	*	-	*	*	-
Monatractides stadleri (Walter, 1924)	-	-	-	*	-	-	-
Monatractides aberratus (Lundblad 1941)	-	*	-	-	-	-	-
Hydryphantidae							
Protzia rotunda Walter, 1908	*	-	-	-	-	-	-
Protzia eximia (Protz, 1896)	-	-	*	-	-	-	-
Thyas setipes (Viets, 1911)	*	*	-	-		-	-
SPECIES DIVERSITY INDICES							
Shannon-Weaver	2.09	3.05	2.43	**3.60**	3.13	2.92	-
Simpson	0.74	0.85	0.80	**0.91**	0.87	0.84	-

Shannon-Weaver (1949) and Simpson (1949) indices were applied for each station to determine diversity of Hydrachnidia species. According to both indices, the highest values were determined at fourth station, while the lowest values at first station (Table 1). According to Sørensen's similarity index, the highest value was detected between stations 4 and 5. The similarity value was found as zero because there was no common species of the first station with both third and sixth. The station 7 was dropped out from similarity calculations because of undetecting live material (Table 2).

Table 2. The similarity values between the stations based on Hydrachnidia fauna (%)

	Sta 1.	Sta 2.	Sta 3.	Sta 4.	Sta 5.	Sta 6.
Sta 1.	1					
Sta 2.	25	1				
Sta 3.	0	24	1			
Sta 4.	11	40	30	1		
Sta 5.	13	10	37	42	1	
Sta 6.	0	38	25	33	10	1

Minimum, average and maximum values of physicochemical variables at the stations were shown Table 3.

Table 3. Minimum, average and maximum values of physicochemical variables at the stations

		Sta 1.	**Sta 2.**	**Sta 3.**	**Sta 4.**	**Sta 5.**	**Sta 6.**	**Sta 7.**
Dissolved oxygen (mg/l)	Min	8.14	8.07	7.28	7.15	7.40	7.15	5.13
	Aver	8.95	8.99	8.41	8.37	8.46	7.83	7.19
	Max.	9.63	9.62	8.98	9.49	9.80	9.60	8.78
pH	Min	7,03	7,96	7,56	7,25	7,82	7,79	7,64
	Aver	7,87	8,15	8,13	8,12	8,22	8,07	8,26
	Max.	8,38	8,40	8,50	8,90	8,8	8,6	9,4
Temperature (°C)	Min	10.70	11.20	14.10	11.90	11.60	11.70	12.10
	Aver	12.58	12.95	15.25	14.63	15.20	17.95	18.78
	Max.	14.90	15.10	16.90	17.30	19.30	23.30	26.90
Electrical conductivity (µS/cm)	Min	301.20	299.50	350.30	304.40	318.80	370.30	457.20
	Aver	351.65	347.45	379.48	346.95	381.95	415.33	599.13
	Max.	396.70	392.90	412.00	393.40	411.50	430.70	916.00
NH_4-N (mg/l)	Min	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Aver	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Max.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
NO_2-N (mg/l)	Min	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Aver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Max.	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
NO_3-N (mg/l)	Min	0.16	0.21	0.15	0.23	0.25	0.25	0.15
	Aver	0.22	0.50	0.84	0.32	0.31	0.48	0.53
	Max.	0.28	1.26	1.26	0.40	0.36	0.70	1.00
PO_4-P (mg/l)	Min	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Aver	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Max.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cl^- (mg/l)	Min	2.39	2.78	3.03	3.55	4.24	5.96	15.33
	Aver	3.18	4.64	6.11	4.17	4.77	6.92	56.50
	Max.	3.72	8.01	8.03	4.56	5.10	8.40	132.21
BOD (mg/l)	Min	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Aver	1.50	1.00	1.75	2.00	1.25	2.00	1.25
	Max.	3.00	1.00	2.00	4.00	2.00	3.00	2.00

The CCA was applied to determine the relationships between identified species and physicochemical variables. According to this analysis, 24.6 % of the variance was described by the first axis of the relations species-environmental variables. Also, the first and second axis together explained 44.6 % of these relations (Table 4). And DO, EC, pH, °C, Cl, NO_3-N, BOD were found as affecting factors of the species distribution in this stream (Figure 2).

Table 4. Results of canonical correspondence analysis (CCA) from data collected during survey

Axes	1	2	3	4	Total inertia
Eigenvalues	0.685	0.559	0.504	0.419	4.291
Species-environment correlations	0.981	0.955	0.991	0.954	
Cumulative percentage variance					
of species data	16.0	29.0	40.7	50.5	
of species-environment relation	24.6	44.6	62.6	77.7	
Sum of all eigenvalues					4.291
Sum of all canonical eigenvalues					2.790

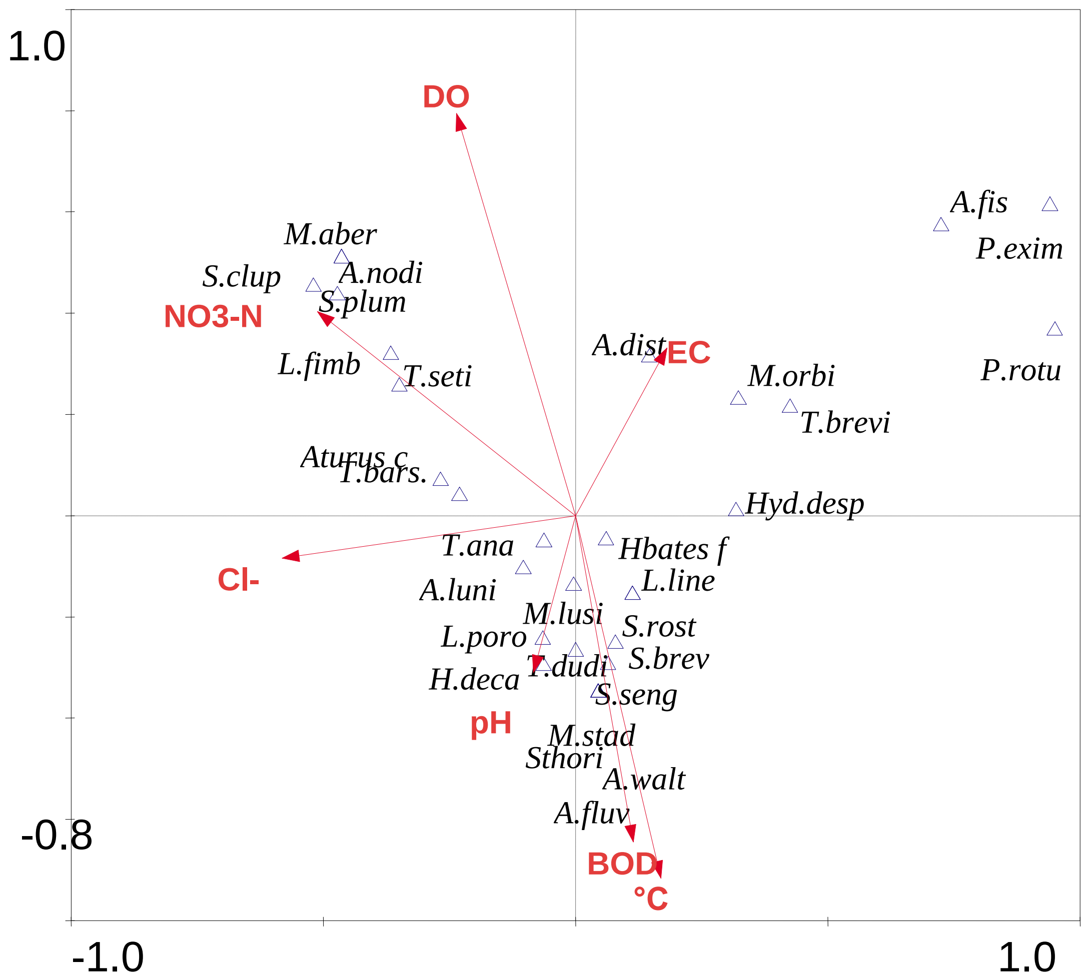

Figure 2. Diagram of CCA, The relationships between physicochemical variables and water mite species

DISCUSSION

It was found 32 species belonging to 8 families by conducting the current study at seven stations in Kargı Stream. Besides, some physicochemical variables were assessed to define ecological conditions of the stream.

According to the physicochemical features of Kargı Stream, it can be said that the stream has not polluted and has high water quality. For instance, it was found that dissolved oxygen values varied from 5,13 to 9,80 mg/l. The minimum dissolved oxygen values suggested to be not lower than 5,0 mg/l to sustain aquatic life in aerobic conditions in freshwaters (EPA, 1997). In this study, not only NH_4-N, NO_2-N and PO_4-P values were found to be under the analysis limits, but also NO_3-N was determined as quite low values. Therefore, the study introduces that the stream has a high quality of water based on this variables (TWPCR, 2012). As it was suggested in the literature that dramatic changes in pH values have several negative effects on aquatic organisms (Egemen and Sunlu, 1996); the Kargı Stream does not have these negative effects on its aquatic organisms since it did not come across any dramatic changes in pH values to the seven stations of the stream. Considering electrical conductivity, the highest values were detected to the seventh station at eustarine zone because of increasing both inorganic substance and marine effect; it is believed that conductivity values has increased at this station compared to the others (Kumbur et al., 2008; Çiçek and Ertan, 2012). Different electrical conductivities which differed significantly in their Hydrachnidia species (Bottger, 1980, Więcek et al., 2013). Almost all water mite species are very sensitive to high electrical conductivity and disappear at conductivity values above 1 mS/cm (Di Sabatino et al., 2000). The measured EC values are below this value in all stations of the current study. According to first and second axis in the CCA, EC showed a negative correlation with distribution of water mite species.

When the identified water mite assemblages during this study are reviewed in general, it can be seen that mostly species of high quality waters and some cosmopolitan species observed at the stations. Considering the stream as a whole, *Hygrobates fluviatilis, Lebertia fimbriata* and *Lebertia porosa* was represented by a maximum of individual species.

According to first axis, the most effective variable in the distribution of *Lebertia porosa* was determined as pH while EC showed negative correlation with species. Also, pH was a variable that had first degree effect in distribution of *Hygrobates decaparus, Monatractides lusitanicus* and had second degree effect in distribution of *Atractides lunipes Torrenticola anomala.* The best part of stream water mites have a wide pH tolerance though more species occur in circumneutral conditions (Angelier et al., 1985; Rundel and Hildrew, 1990).

Sperchon brevirostris, Hygrobates fluviatilis, Atractides nodipalpis are known to be tolerant species against organic pollution (Gerecke and Schwoerbel, 1991; Di Sabatino et al., 2000). *Hygrobates fluviatilis* is more common a water mite and can live quite a wide temperature range (Viets 1956: 1987). Water temperature values were ranged from 10.70 to 26.90 in this study and this species was found at five stations. CCA was showed that *Sperchon brevirostris, Sperchon rostratus, Sperchon senguni, Hygrobates fluviatilis, Monatractides stadleri* have positive relationship with temperature. This species was also affected by BOD. According to Di Sabatino *et al.* (2000), water temperature plays an essential role in the composition of water mite assemblages and influences the altitudinal and latitudinal distribution patterns of species.

There are several studies that investigated the physicochemical variables affecting the distribution of water mites. Smit and Van der Hammen (1992) investigated that influence of environmental variables on species composition of water mite fauna in coastal dune areas in the Netherlands and northwestern France. And they reported that the dimension, amount of water vegetation, pH and nutrient concentration as the most important environmental variables affecting species composition. Goldschmidt (2004) showed for various freshwater habitats in Costa Rica that chemical features of water exhibits less impact on the differentiation of water mite assemblages than habitat type, elevation, temperature and velocity. Nevertheless, he indicated the need for further comprehensive studies at the species level concentrating on microhabitats. Więcek *et al.* (2013) focused on a type of microhabitat in their study and they evaluated the water mites of peat land microhabitats in relation to water depth, temperature, electric conductivity, pH, dissolved oxygen, vegetation, and other invertebrates. They found strong correlations between the water mite fauna and both conductivity and pH gradient. Their results show that water conductivity is the most important of the examined factors, driving mite-species distribution in peat lands. However, biological oxygen demand, pH, and water temperature were found as the most effective factors in distribution of water mite assemblages in the current study.

Aquatic ecosystems should be evaluated not only from the economical point of view but also from biological perspective. Determination of species diversity and protection of natural balance in these ecosystems is considerably important in terms of sustainable environment management. As a result of study 32 species belonging to eight families were recorded. There aren't any studies based on determination of water mite fauna of Kargı Stream. Therefore, all taxa identified for the region have been recorded for the first time.

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