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Original Article

Seasonal variation of the Malascostraca (Crustacea) fauna and their relationship with physicochemical parameters in Seyhan Basin, Türkiye

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Abstract: This study aimed to investigate the seasonal distribution of the Malacostraca fauna in the Seyhan Basin by examining their relationship with some physicochemical parameters. Field studies were done in the spring, summer, and autumn of 2019 at 23 stations. As a result, 4302 individuals were examined, and 5 families (Niphargidae, Gammaridae, Palemonidae ve Potamidae) and 10 species belonging to the orders Amphipoda and Decapoda were recorded. *Echinogammarus ischnus, Gammarus mladeni* and *G. pseudanatoliensis* are the first records for this basin. According to the results of the Shannon-Wiener diversity (H) index, the highest diversity was calculated at station 11 in the spring (0.72), at station 22 (0.66) in the summer and autumn, the lowest diversity was recorded at station 3 in the spring (0.22) and autumn (0.05), and at station 1 in the summer (0.17). According to Shannon Evenness (E), the most balanced distribution was found at station 22 in the spring and summer (0.97), and at station 1 in the autumn (0.96). The stations with the lowest homogeneity were determined as at station 3 in the spring (0.22) and autumn (0.53), and at station 1 in the summer (0.59). According to the results of the clustering analysis, the highest similarity was observed between the 3rd and 5th stations (89%), while the 2nd station was determined to be the station with the lowest similarity, separating from all other stations. According to the Pearson correlation analysis, a significant negative correlation was observed between DO and temperature and total nitrogen, while a significant positive correlation was found between temperature and EC (P<0.01). When the water quality classes of the stations are examined according to the criteria of the Water Quality Regulation, stations have 1st (very clean) or 2nd (moderately polluted) class water quality.

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Introduction

The Malacostraca, an important component of aquatic ecosystems, includes large groups such as Decapods, Isopods, and Amphipods, with over 40,000 species worldwide (İpek and Özbek, 2022). Species of this class are used as indicator organisms in some biotic indices (Trend Biotic Index) because they are found in marine and inland water, easily collected, and are in direct contact with the benthic zone (De-La-Ossa-Carretero et al., 2011). Species in this class are typically preferred in ecotoxicological studies because they are indicator species of moderately polluted waters (Rainbow et al., 1989; Rainbow and White, 1990; Baytaşolu and Gözler, 2018; İpek and Özbek, 2022), e.g. the *Gammarus-Asellus* ratio is used to determine organic pollution.

The class Malacostraca was first recorded in Türkiye in the early twentieth century (Geldiay and Kocataş 1970; İpek and Özbek, 2022). Özbek and Ustaolu (2006) provided a Malacostraca checklist for Türkiye inland waters, which included 126 species, in 37 genera. Recently, taxonomic and ecological studies on the Malacostraca fauna of Türkiye have increased, and the findings showed that their distribution in Türkiye consists of the super-ordos Peracarida (except Cumacea) and Eucarida (except Euphausiacea) (Özbek and Ustaoğlu, 2006; Özbek, 2011; Özbek et al., 2016; Harlıoğlu and Farhadi, 2018; Baytaşoğlu, 2018; İpek and Özbek, 2022). According to the latest checklist, a total of 201 taxa in the Malacostraca are

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Table 1. General information about Seyhan Basin sampling stations.

No	Station name	Province	Agriculture	Farming	Latitude	Longitude	Altitude
1	Meşelik Stream	Kayseri	Unavailable	Available	38.6811	36.5499	1710 m
2	Sal Stream	Kayseri	Unavailable	Available	38.6517	36.5659	1801 m
3	Soğuksu Stream	Kayseri	Unavailable	Available	38.6236	36.4487	1679 m
4	Kömün Stream	Kayseri	Unavailable	Unavailable	38.4631	36.3572	1816 m
5	Hamamgözü Stream	Kahramanmaraş	Available	Available	37.8757	36.3906	1450 m
6	Daru Stream	Kahramanmaraş	Unavailable	Unavailable	37.8377	36.3488	1400 m
7	Sazak Stream	Adana	Unavailable	Unavailable	38.0441	35.911	1250 m
8	Sarnaz Stream	Kayseri	Unavailable	Available	38.0692	35.7611	1680 m
9	Terece Stream	Kayseri	Available	Available	38.0862	35.6907	1530 m
10	Bahçecik Stream	Adana	Unavailable	Unavailable	37.9228	35.7713	1120 m
11	Gürlean Stream	Adana	Unavailable	Available	37.7582	35.8298	643 m
12	Söğüt Stream	Adana	Unavailable	Unavailable	37.6378	35.4882	1280 m
13	Simidin Stream	Adana	Unavailable	Available	37.4389	35.3964	650 m
14	Ayıotu Stream	Adana	Unavailable	Available	37.5950	35.1287	1040 m
15	Cin Stream	Adana	Unavailable	Unavailable	37.5396	35.0115	1234 m
16	Haliminharmanyeri Stream	Niğde	Unavailable	Unavailable	37.6840	34.7792	1400 m
17	Derin Stream	Niğde	Unavailable	Unavailable	37.6746	34.7955	1574 m
18	Taşpınar Stream	Niğde	Unavailable	Unavailable	37.6022	34.602	1500 m
19	Ardıçlı Stream	Niğde	Unavailable	Available	37.5321	34.8243	940 m
20	Kuru Stream	Kayseri	Unavailable	Unavailable	38.6549	36.5682	1796 m
21	Acar Stream	Kahramanmaraş	Unavailable	Unavailable	37.8529	36.3549	1330 m
22	Gümüşören Dam Lake	Kayseri	Available	Available	38.2181	35.717722	1290 m
23	Dölekli Pond	Adana	Unavailable	Available	37.5994	35.28766	832 m

found in Türkiye, including 121 species of Amphipoda (16 families, 31 genera), 27 species of Isopoda (9 families, 13 genera), 40 species of Decapoda (16 families, 18 genera), 9 mysids (1 family, 5 genera) and 4 tanaids (3 families, 4 genera) (İpek and Özbek, 2022).

Seyhan Basin, one of the 25 inland water basins of Türkiye, covers 2.82% of the country with an area of 22,042 km^2, mostly located in the Eastern Mediterranean region. The Seyhan River starts with the emerging Göksu, Kürtün, Eğlence, and Çakıt rivers and their tributaries after crossing the Taurus Mountains with the rivers joining the Zamanti River originating in Central Anatolia and flows into the Mediterranean Sea by forming the Adana-Mersin border. The Seyhan River is 560 km long with all its tributaries, especially the Zamanti and Göksu rivers. The average annual precipitation of the basin is 624 mm, and the average annual flow of 211.07 m^3/s (SYGM, 2017; 2018; Altın and Barak, 2012). Based on the above-mentioned background, this study aimed to investigate the seasonal distribution of Malacostraca fauna in the Seyhan Basin, as well as the relationship between physicochemical parameters and Malacostraca fauna distribution.

Materials and Methods

Samplings were done at 23 stations during the spring, summer, and autumn of 2019 (Table 1). At each station, temperature, salinity, dissolved oxygen, electrical conductivity, and pH were measured in the middle part of the river using a HachLange Hq 40 D multi-parameter meter and recorded on site. Water samples were taken in 1-liter polyethylene containers and they were brought to the laboratory with a cold chain following TS EN ISO 5667-3 and TS ISO 5667-6 standards for analysing other water parameters. TS EN 12260 standard was followed for total nitrogen analysis.

Sampling of macrobenthos was performed by following the multihabitat sampling method using a 500 µm diameter bottom grab. The collected macrobenthos were preserved in plastic bottles containing 4% buffered formaldehyde solution and transported to the Nevşehir Hacı Bektaş Veli University Hydrobiology Laboratory. The samples were identified under stereo microscope (LEICA EZ-4D) and a light microscope (LEICA DM-500) using keys of Karaman and Pinkster (1977a, b, 1987), Barnard and Barnard (1983), Mateus and Mateus (1990), Özbek (2003), Fišer et al. (2009) and İpek and Özbek (2022) for Amphipoda and Brandis et al. (2000) for Decapoda.

To examine the community structure, dominance, and frequency values were calculated based on the number of individuals (Bellan-Santinim 1969). Shannon-Wiener diversity (H) and Shannon evenness (E) indices were used to determine the population density relationships among species (Shannon and Weaner, 1949). Cluster analysis based on the Bray-Curtis similarity index was applied to reveal similarities and differences between the stations. The relationships between the physicochemical parameters were evaluated by Pearson correlation analysis, and the relationships between the identified taxa and physicochemical parameters were examined by applying Canonical Correspondence Analysis (CCA). Past-3 and CANOCO-4.5 software were used for the statistical analysis.

Results and Discussions

The physicochemical variables of water in the studied stations are shown in Table 2. A multicollinearity test was performed to eliminate the multicollinearity problem among the physicochemical variables evaluated within the scope of the study. R^2 and variance inflation factors (VIF) of the test results are given in Table 3, and a high correlation was found between salinity and electrical conductivity variables (VIF > 10). For this reason, the salinity variable was eliminated from further analysis. According to the results, a significant negative correlation was observed between DO and temperature and total nitrogen, while a significant positive correlation was found between temperature and EC ($P<0.01$) (Table 4).

The water quality classes of the stations in terms of some parameters (WQR, 2021) were evaluated based on the average values of all the studied stations, it was determined that the stations had first-class water quality in terms of temperature, pH, and total nitrogen. In terms of EC, except for 3 stations (stations 13, 15, and 23) with class II water quality, the other stations were in class I water quality. According to DO, 11 stations (stations 1, 8, 10, 12, 13, 16, 17, 18, 19, 22, and 23) had class II water quality while the others had class I water quality. According to the results, the water quality was high at all stations where the study was carried out regarding physicochemical parameters. In addition, there were no serious impacts that would threaten the water quality at the studied stations.

As a result of the sampling studies done at 23 stations, individuals belonging to the Malacostraca class were encountered at 12 stations with a total of 4302 individuals. As a result, 10 species belonging to the families Niphargidae, Gammaridae, Palemonidae, and Potamidae of the orders Amphipoda and Decapoda were identified (Table 5). Although there is no study of the Malacostraca class in the Seyhan basin, some records have been found in the literature (Pretzmann, 1963; Karaman and Pinkster, 1977a; Karaman, 2003; Özbek et al., 2007; Fišer et al., 2009; Özcan and Ergüden, 2013; İpek and Özbek, 2022). In this study, 12 species were recorded, and *E. ischnus G. mladeni*, and *G. pseudanatoliensis* were recorded for the first time in this basin. On station basis, the highest diversity was found at station 11, with three species in the spring. While some species were found at more than one station. Some species were found at only one station. From the family Gammaridae, *Echinogammarus ischnus* Stebbing, 1899, *G. agrarius* Karaman, 1973, *G. balcanicus* Schaferna, 1922, *G. goedmakersae* Karaman and Pinkster, 1977, *G. mladeni* Karaman & Pinkster, 1977, *G. osellai* Karaman & Pinkster, 1977, and *G. pseudanatoliensis* Karaman & Pinkster, 1987; from the family Niphargidae, *Niphargus kirgizi* Fišer, Çamur-Elipek & Özbek, 2009; from the family Potamidae, *Potamon potamios* (Olivier, 1804), and from the family Palaemonidae, *Palaemon antennarius* H. Milne Edwards, 1837 were recorded in this study.

Looking at the seasonal species diversity, nine species were found in the autumn and summer and

Table 2. Physicochemical variables of the stations in Seyhan Basin (EC: electrical conductivity, DO: dissolved oxygen, TN: total nitrogen).

Water Quality Classes	Seasons	Temperature (°C)	pH	EC (µS/cm)	DO (mg/L)	TN (mg/L)
I	-	≤ 25	6.5-8.5	<400	>8	<3.5
II	-	≤ 25	6.5-8.5	400-1000	6-8	11.5
III	-	≤ 30	6.0-9.0	1000-3000	3-6	25
IV	-	>30	6.0-9.0	>3000	<3	>25
1	Spring	15.1	8.27	291	8.3	0.65
	Summer	17.8	8.24	312	7.1	1.10
	Autumn	12.1	8.47	324	7.96	1.65
	Mean	**15**	**8.33**	**309**	**7.79**	**1.13**
2	Spring	13.2	8.14	282	7.79	0.57
	Summer	20.4	8.37	249	7.1	1.08
	Autumn	10.4	8.66	244	10	1.34
	Mean	**14.67**	**8.39**	**258.33**	**8.3**	**1**
3	Spring	13.2	7.66	298	8.65	0.53
	Summer	13.4	8.06	256	8.23	1.12
	Autumn	13.1	8.58	296	9.15	1.76
	Mean	**13.23**	**8.1**	**283.33**	**8.68**	**1.14**
4	Spring	17.3	8.16	306	8.34	0.69
	Summer	18.4	7.82	369	8.08	1.32
	Autumn	-	-	-	-	-
	Mean	**17.85**	**7.99**	**337.5**	**8.21**	**1**
5	Spring	12.4	7.84	368	8.5	0.10
	Summer	14	7.9	400	8.06	1.07
	Autumn	12.6	8.48	350	9.74	1.31
	Mean	**13**	**8.07**	**372.67**	**8.77**	**0.83**
6	Spring	14.2	8.06	242	9.18	0.14
	Summer	15.1	8.07	276	7.87	0.93
	Autumn	-	-	-	-	-
	Mean	**14.65**	**8.07**	**259**	**8.53**	**0.53**
7	Spring	12.5	8.04	313	9.14	0.18
	Summer	17	7.84	393	8.05	1.53
	Autumn	16	8.63	408	8.44	1.02
	Mean	**15.17**	**8.17**	**371.33**	**8.54**	**0.91**
8	Spring	11.8	7.67	222	8.39	0.43
	Summer	15.5	8	291	6.88	0.98
	Autumn	-	-	-	-	-
	Mean	**13.65**	**7.84**	**256.5**	**7.64**	**0.71**
9	Spring	10.5	7.62	104	8.81	0.22
	Summer	18.7	8.13	212	7.18	1.02
	Autumn	15.1	8.44	218	8.6	0.38
	Mean	**14.77**	**8.06**	**178**	**8.2**	**0.54**
10	Spring	18.3	8.15	193	7.84	0.10
	Summer	17.6	7.99	279	7.81	1.38
	Autumn	16.1	8.61	299	8.15	0.63
	Mean	**17.33**	**8.25**	**257**	**7.93**	**0.70**
11	Spring	17.6	8.06	349	8.77	0.39
	Summer	19.1	8.1	378	8	1.28
	Autumn	16.6	8.5	349	7.96	0.98
	Mean	**17.77**	**8.22**	**358.67**	**8.24**	**0.88**

Table 2. To be continued.

Water Quality Classes	Seasons	Temperature (°C)	pH	EC (μS/cm)	DO (mg/L)	TN (mg/L)
12	Spring	14.6	8.28	277	8.22	0.15
	Summer	19.5	8.27	410	6.75	0.56
	Autumn	15.8	8.55	401	7.75	0.45
	Mean	**16.63**	**8.37**	**362.67**	**7.57**	**0.39**
13	Spring	18.7	7.89	456	8.35	0.35
	Summer	23.4	7.83	453	6.96	1.28
	Autumn	21.4	8.28	435	7.84	0.63
	Mean	**21.17**	**8**	**448**	**7.72**	**0.75**
14	Spring	9.2	7.59	167	9.65	0.36
	Summer	14.1	7.94	225	8.27	1.92
	Autumn	12.8	8.6	219	8.42	1.69
	Mean	**12.03**	**8.04**	**203.67**	**8.78**	**1.32**
15	Spring	17.5	8.78	469	7.96	0.32
	Summer	17.1	8.47	481	7.7	1.41
	Autumn	14.1	8.91	467	9.15	0.94
	Mean	**16.23**	**8.72**	**472.33**	**8.27**	**0.89**
16	Spring	20.5	7.15	173	7.56	0.24
	Summer	30	8.7	223	7.18	0.87
	Autumn	21.9	9.21	205	8.15	0.76
	Mean	**24.13**	**8.35**	**200.33**	**7.63**	**0.62**
17	Spring	22.6	7.57	151	7.23	0.27
	Summer	20.1	8.21	218	6.98	0.80
	Autumn	20.3	8.98	201	8.2	0.57
	Mean	**21**	**8.25**	**190**	**7.47**	**0.55**
18	Spring	18.5	8.15	331	7.64	0.21
	Summer	23.2	8.42	396	6.73	0.10
	Autumn	20.2	8.52	413	7.8	0.10
	Mean	**20.63**	**8.36**	**380**	**7.39**	**0.14**
19	Spring	22.6	7.25	373	7.94	0.26
	Summer	24.1	8.4	391	7.67	1.37
	Autumn	19.6	8.61	417	7.6	0.84
	Mean	**22.1**	**8.09**	**393.67**	**7.74**	**0.82**
20	Spring	12.4	8.12	252	8.98	0.53
	Summer	13.4	8.26	228	8.74	0.89
	Autumn	10.3	8.74	214	7.44	1.47
	Mean	**12.03**	**8.37**	**231.33**	**8.39**	**0.96**
21	Spring	13.3	8.1	298	9.41	0.10
	Summer	15.9	7.95	315	8.43	1.65
	Autumn	13.3	8.23	290	10	2.03
	Mean	**14.17**	**8.09**	**301**	**9.28**	**1.26**
22	Spring	20.8	8.21	380	7.88	0.87
	Summer	27.6	8.52	357	7.9	1.45
	Autumn	17.2	9.73	269	5.8	1.62
	Mean	**21.9**	**8.82**	**335**	**7.19**	**1.31**
23	Spring	18.5	8.04	542	9.08	0.13
	Summer	25.5	8.2	544	6.99	0.90
	Autumn	22.3	8.36	503	7.15	1.14
	Mean	**22.1**	**8.2**	**530**	**7.74**	**0.73**

Table 3. Multicollinearty analysis of physicochemical parameters in Seyhan Basin (EC: Electrical conductivity, DO: Dissolved oxygen, TA: Total nitrogen).

Dependent variable	**R^2**	**VIF**
Temperature (°C)	0.520	1.921
pH	0.876	1.141
EC (µS/cm)	0.003	**37.64**
DO (mg/L)	0.612	1.634
Salinity	0.003	**34.51**
TA (mg/L)	0.121	8.287

Table 4. Pearson correlation analysis of physicochemical parameters in Seyhan Basin (EC: Electrical conductivity, DO: Dissolved oxygen, TA: Total nitrogen).

	Temperature (°C)	**pH**	**EC (µS/cm)**	**DO (mg/L)**	**TA (mg/L)**
Temperature (°C)	1				
pH	0.092	1			
EC (µS/cm)	**0.329**	0.111	1		
DO (mg/L)	**-0.605**	-0.154	-0.136	1	
TA (mg/L)	-0.051	0.294	0.042	**-0.57**	1

Table 5. Distribution of Malacostraca taxa in Seyhan Basin according to stations (I: Spring, Y: Summer, S: Autumn, *: Rare, **: Infrequent, ***: Usually, ****: Mostly, and *****: Continuous).

Species	**1**	**2**	**3**	**4**	**5**	**9**	**10**	**11**	**18**	**20**	**22**	**23**
Echinogammarus ischnus											✓	
Gammarus agrarius												
Gammarus balcanicus			✓					✓				
Gammarus goedmakersae	✓		✓		✓	✓						
Gammarus mladeni		✓										
Gammarus osellai				✓						✓		
Gammarus pseudanatoliensis	✓									✓		
Niphargus kirgizi								✓				
Potamon potamios							✓	✓	✓			
Palaemon antennarius											✓	✓

Table 6. Distribution of Seyhan Basin Malacostraca taxa according to seasons (+: Rare, ++: Infrequent, ++++: Usually, ++++: Mostly, and +++++: Continuous).

Species	**Spring**	**Summer**	**Autumn**
Echinogammarus ischnus	+	+	+
Gammarus agrarius	+	+	-
Gammarus balcanicus	+	+	+
Gammarus goedmakersae	+++	++	+++
Gammarus mladeni	-	+	+
Gammarus osellai	-	+	+
Gammarus pseudanatoliensis	+	++	++
Niphargus kirgizi	+	-	+
Potamon potamios	++	++	+
Palaemon antennarius	++	++	+

eight species in the spring (Table 6). Most of the recorded species were encountered in all seasons, while *G. agrarius* was not encountered in the autumn, *G. mladeni* and *G. osellai* in the spring, and *N. kirgizi* in the summer. Looking at the abundance values at the stations, *G. goedmakersae* was the most dominant species with 2039 individuals, followed by *G. pseudanatoliensis* with 1325 individuals (Table 7). The lowest numbers of individuals were found in *P. potamios* (11 individuals) and *N. kirgizi* (16

Table 7. Abundance values of Seyhan Basin Malacostraca taxa according to seasons.

	Spring			Summer			Autumn			Total	
Species	N/m2	%D	%F	N/m2	%D	%F	N/m2	%D	%F	N/m2	%F
Echinogammarus ischnus	15	1,15	8,33	30	2,84	8,33	10	0,52	8,33	55	1,28
Gammarus agrarius	36	2,75	8,33	100	9,47	8,33	0			136	3,16
Gammarus balcanicus	12	0,92	8,33	75	7,10	8,33	3	0,15	8,33	90	2,09
Gammarus goedmakersae	849	64,86	33,33	397	37,59	25,00	793	40,94	33,33	2039	47,40
Gammarus mladeni	0			60	5,68	8,33	28	1,45	8,33	88	2,05
Gammarus osellai	0			34	3,22	8,33	156	8,05	8,33	190	4,42
Gammarus pseudanatoliensis	274	20,93	8,33	157	14,87	16,67	894	46,15	16,67	1325	30.80
Niphargus kirgizi	13	0,99	8,33	0			3	0,15	8,33	16	0.37
Potamon potamios	103	7,87	16,67	200	18,94	16,67	49	2,53	8,33	352	8.18
Palaemon antennarius	7	0,53	25,00	3	0,28	16,67	1	0,05	8,33	11	0.26
Total	1309			1056			1937			4302	

Table 8. Diversity and density index values calculated at stations according to seasons (S: number of species, N: individuals).

Station	Season	S	N	H	E
1	Spring	1	346	0.000	1.000
1	Summer	2	174	0.168	0.591
1	Autumn	2	968	0.678	0.985
2	Summer	1	60	0.000	1.000
2	Autumn	1	28	0.000	1.000
3	Spring	2	210	0.219	0.622
3	Summer	1	75	0.000	1.000
3	Autumn	2	329	0.051	0.526
4	Summer	1	34	0.000	1.000
5	Spring	1	290	0.000	1.000
5	Summer	1	198	0.000	1.000
5	Autumn	1	8	0.000	1.000
9	Spring	1	15	0.000	1.000
9	Summer	1	32	0.000	1.000
9	Autumn	1	59	0.000	1.000
10	Spring	1	2	0.000	1.000
10	Summer	1	1	0.000	1.000
11	Spring	3	51	0.721	0.685
11	Summer	1	100	0.000	1.000
11	Autumn	2	4	0.562	0.877
18	Spring	1	3	0.000	1.000
18	Summer	1	2	0.000	1.000
20	Spring	1	274	0.000	1.000
20	Summer	1	150	0.000	1.000
20	Autumn	2	482	0.629	0.938
22	Spring	2	39	0.666	0.973
22	Summer	2	80	0.661	0.968
23	Spring	1	79	0.000	1.000
23	Summer	1	150	0.000	1.000
23	Autumn	1	49	0.000	1.000

individuals). Seasonally, 1937 individuals were detected in the autumn, 1309 in the spring, and 1056 in the summer.

Shannon-Wiener diversity (H) and Shannon Evenness (E) indices were calculated using the species and their numbers (Table 8). According to the results, the highest diversity (H) was found at stations 11 (0.72) and 22 (0.67), and the lowest diversity at station 3 (0.22) in the spring. The E-value, which expresses stability, was highest at station 22 (0.97) and lowest at station 3 (0.22). In summer, the highest diversity (H) was found at station 22 (0.66) and the lowest at station 1 (0.17), while the most balanced distribution was found at station 22 (0.97) and the least balanced distribution at station 1 (0.59).

In the autumn, the highest diversity (H) was found at station 22 (0.66) and the lowest at station 3 (0.05), while the most balanced distribution was found at stations 1 (0.96) and 20 (0.94) and the least balanced distribution was found at station 3 (0.53). No

Table 9. Bray-Curtis index similarity ratios of Seyhan Basin sampling stations.

	1	2	3	4	5	9	10	11	18	20	22	23
1	1											
2	0.00	1										
3	0.50	0.00	1									
4	0.00	0.00	0.00	1								
5	0.50	0.00	0.89	0.00	1							
9	0.13	0.00	0.29	0.00	0.35	1						
10	0.00	0.00	0.00	0.00	0.00	0.00	1					
11	0.00	0.00	0.00	0.00	0.00	0.00	0.04	1				
18	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.04	1			
20	0.48	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	1		
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	1

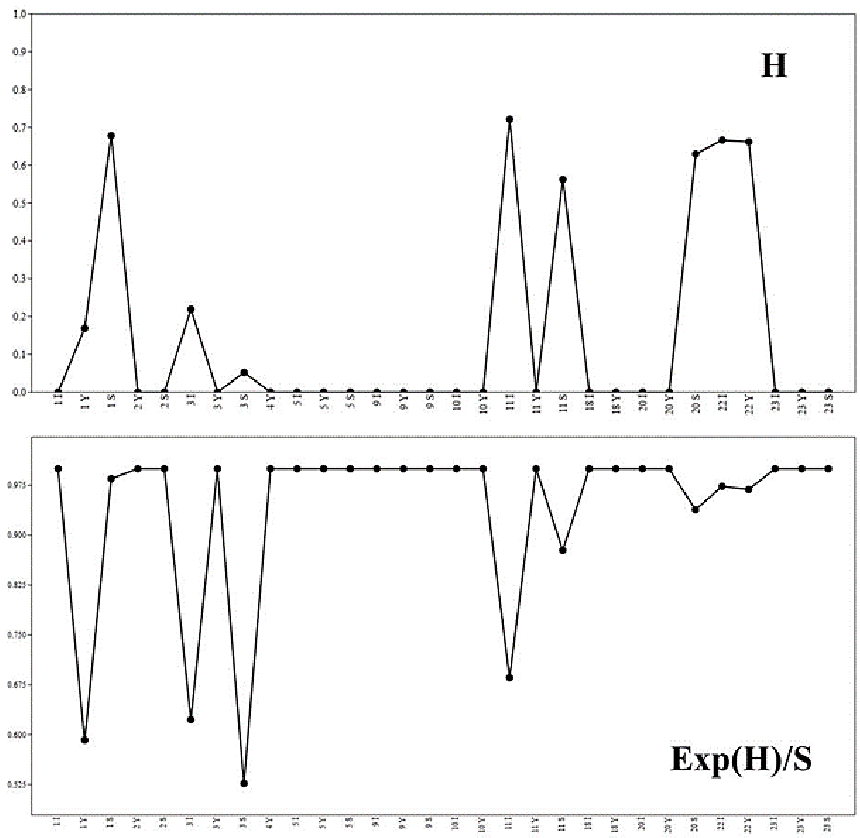

Figure 1. Diversity indexes at stations belonging to the Seyhan Basin (H: Shannon-Wiener diversity index, EH: Shannon-Evenness).

significant results were obtained at the stations represented by one species in all seasons, and H and E values were calculated as 0 and 1, respectively (Fig. 1, Table 8). The H-value calculated at all stations and periods examined ranged between 0.05-0.72 and was below 1. According to Wilhm and Dorris (1968), a value greater than 3 indicates high-quality water, between 1-3 indicates moderately polluted water, and less than 1 indicates polluted water. Although the results showed a polluted water class, this can be explained by the fact that there is no homogeneous distribution in the stations. The dominant species were observed in small numbers and with low population rates, and the other taxa detected do not form dense populations. Therefore, according to the Shannon-Wiener Malacostraca class, the water quality in the stations has a moderately polluted water class rather than a polluted water class. This is supported by the fact that Amphipoda contains indicator species of moderately polluted waters, and the physicochemical variables measured represent very clean and moderately polluted water classes in all stations

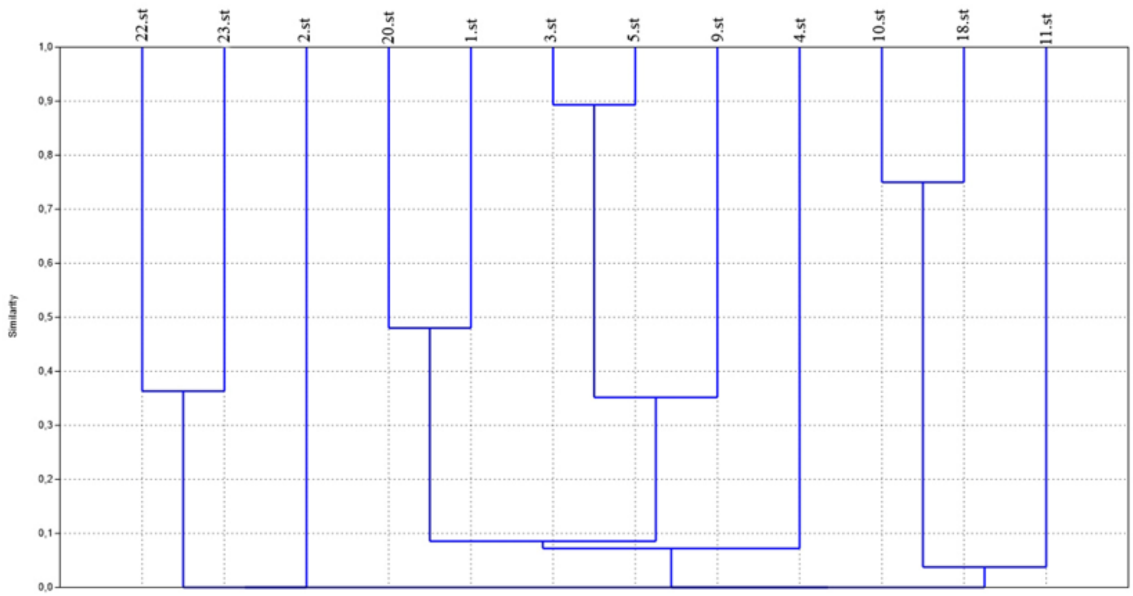

Figure 2. Cluster clustering analysis graph of similarities of Seyhan Basin stations (Bray-Curtis).

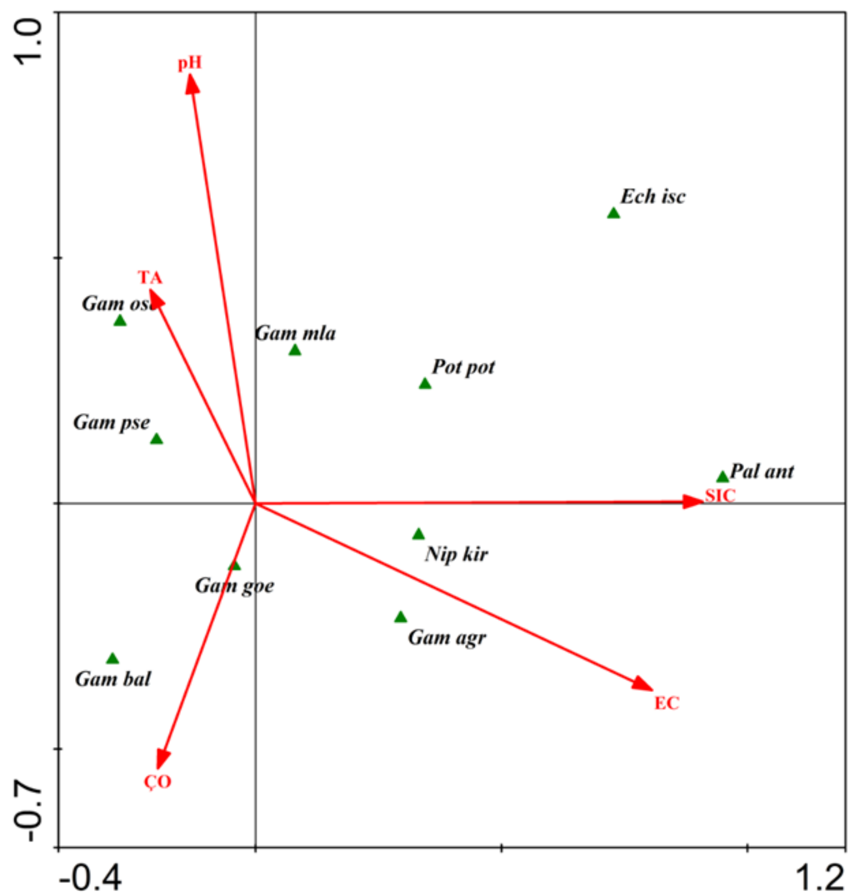

Figure 3. Canonical correspondence analysis between Malacostraca species and physicochemical variables [Esc isc: *Echinogammarus ischnus*, Gam. agr: *Gammarus agrarius*, Gam. bal: *Gammarus balcanicus*, Gam goe: *Gammarus goedmakersae*, Gam mla: *Gammarus mladeni*, Gam pse: *Gammarus pseudanatoliensis*, Gam ose: *Gammarus osellai*, Nip prairie: *Niphargus kirgizi*, Pal ant: *Palaemon antennarius*, Pot pot: *Potamon potamios*]

(Table 2).

According to the distribution of the taxa detected in the stations, the similarity between the stations is shown in Figure 2 and Table 9. The highest similarity was observed between the 3rd and 5th stations, with a rate of 89%, followed by the 10th and 18th stations, with a rate of 75%, and the 2nd station was not similar to any other station.

Based on CCA results, Do, total nitrogen, pH, temperature, and electrical conductivity variables were found to be located on opposite axes (Fig. 3). The most determinant variables for species distribution were pH, electrical conductivity, and temperature. When the distribution of species according to their ecological requirements was evaluated, *G. agrarius*, *G. balcanicus*, *G. osellai*, and *P. antennarius* were located in the same direction as total nitrogen, temperature, dissolved oxygen, and electrical conductivity variables in the CCA graph.

The distribution of *G. balcanicus* was positively correlated with DO and negatively correlated with pH, temperature, and total nitrogen. In previous studies, Parvulescu and Hamchevici (2010) reported that DO, COD, NO_2-N, and PO_4-P were effective factors in the distribution of the species. There is a strong correlation between *G. balcanicus* distribution and DO in the Çoruh basin (Baytaşoğlu, 2018). Despite its high tolerance to organic pollution, *G. balcanicus* is found in oxygen-rich and cold spring waters (Özbek, 2003).

Gammarus agrarius is found in the coastal areas of rivers and lakes with abundant vegetation. This species, which is highly resistant to organic pollution, has been found in waters with high ion concentrations (Özbek, 2003). In this study, *G. agrarius* species had a positive relationship with EC and were located in the same direction as the temperature. The EC of water increases proportionately to the concentration of ions in the water, water movement, and temperature (Anonymous, 2014). The fact that *G. goedmakersae*, which was determined to be the dominant species during the spring and summer seasons, was found near the center of the CCA dendogram and can be interpreted as the species' high ecological tolerance.

Gammarus pseudanatoliensis is located in the same direction as total nitrogen and pH. In addition, this species was found to be the most dominant species in the autumn. As a result, this species may have a high level of ecological tolerance. *Echinogammarus ischnus* is located far from other taxa and physicochemical variables in the CCA diagram.

Conclusion

According to the stations evaluated within the scope of the study, despite agricultural activities, this situation does not threaten the physicochemical properties of the stations. In the basin, although some values are seen to be high periodically, they have generally good quality and the stations had 1st (very clean) or 2nd (moderately polluted) class water quality. There is no detailed study on determining the Malacostraca class in the Seyhan basin, but seven of the 12 species reported in the literature were detected. In addition to these species, *Gammarus pseudanatoliensis*, *Echinogammarus ischnus,* and *G. mladeni* are new records for the basin. As a result of the study, *G. osellai*, *G. pseudanatoliensis,* and *G. goedmakersa* were the most tolerant species against organic pollution, while *Potamon potamios* was the least tolerant species. In this study, the stations evaluated were reference points, and the low number of individuals caused the relationship between physicochemical parameters and species to be close to each other.

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