International Journal of Earth, Energy and Environmental Sciences
ISSN: 2517-942X
Vol:10, No:7, 2016

Plecoptera Fauna of Alara and Karpuz Streams and Determination of their Relationships with Water Quality

Hasan Kalyoncu, Ayşe Güneş

***Abstract*—**This study was carried on 12 determined stations, on Alara and Karpuz Streams, between January and November 2014. Seasonal samples were taken from the stations to analyze physicochemical parameters and Plecoptera Fauna in the water. The correlation between identified taxa and physicochemical data were tried to determine. As the result of the study, 2088 individuals from Plecoptera fauna were examined, 3 genera and 13 species were identified. The taxa of *Brachyptera risi*, *Capnia bifrons*, *Dinocras cephalotes*, *Diura bicaudata*, *Isogenus nebecula*, *Isogenus* sp., *Isoperla grammatica*, *Leuctra hippopus*, *Leuctra inermis*, *Leuctra moselyi*, *Leuctra* sp., *Nemoura* sp., *Perla bipunctata*, *Perla marginata*, *Protonemura meyeri* and *Rhabdiopteryx acuminata* were determined. In Alara Stream, the dominant species were; *Isogenus nebecula* at stations I and IV, *Leuctra moselyi* at station II, *Leuctra hippopus* at stations III, V and VI. In Karpuz Stream, *Brachyptera risi* was the dominant species in all stations. While *Leuctra hippopus* was the dominant taxon in Alara Stream, in Karpuz Stream it was *Brachyptera risi*. The highest diversity value was at station III and the lowest was at station VI in Alara Stream and the lowest diversity value was at station VI, while the highest was at station I in Karpuz Stream. In Alara Stream, the most similar stations were I and III, while in Karpuz Stream the highest similarity was determined between stations I and II. As for the evaluation result, the water quality of Alara and Karpuz Streams were determined as at oligosaprobic level.

***Keywords*—**Alara Stream, Karpuz Stream, Plecoptera, water quality.

I. Introduction

STREAMS are much less studied habitats than others because measurements of ecological agents like inflow ratio, temperature, supporting salts etc. show variations. Flora and fauna of streams change very rapidly since there is a complicated interaction among ecological agents. Habitat types of streams should be ecologically determined before the determination of flora and fauna of streams [1].

Macrozoobenthic organisms require special physical and chemical conditions. The presence or absence of these organisms, their amounts, morphology, physiology and behaviors varies with the change of physical and chemical conditions [2].

Physicochemical features of water are in a permanent change in course flow of natural streams even there is no pollution. This situation is due to environmental factors. These factors are generally expressed as geomorphologic, anthropologic, biologic and seasonal. Macrozoobenthic organisms, living in streams, show different response to these factors and these responses, results with exchanges [3].

Macroinvertebrates are the most used communities in streams to determine the water quality. Indicator organisms show similarities and differences in unpolluted and polluted waters. Plecoptera are indicator organisms of unpolluted water bodies [4].

The order Plecoptara is represented by 2000 species and offer important data to researchers who are studying in applied studies in aquatic environments and to theoretical branches like zoogeography. Present day Plecoptera members are representatives of the oldest insects since Carboniferous era (approximately 300 years). The order Plecoptera is one of the most important aquatic insect order in order to evaluate water quality level of streams [5].

The fauna of Aquatic Plecoptera is generally used in studies of macrozoobenthic fauna as well as in evaluation of water quality indices or in faunistic studies [4], [6]-[11]-[20] but there is no study encounterd about physicochemical structure of the fauna of aquatic Plecoptera. Even there are such studies in Europa and the World [21]-[25], the fauna of aquatic Plecoptera studies [26] are also present.

II. Material and Methods

Alara and Karpuz Streams are two of important streams of Antalya basin. Alara Stream provides drinking water to many of villages of Manavgat and Okurcalar and Avsallar town of Alanya as well as irrigationTrout aquaculture is an important activity in springs of these streams. [27]. Karpuz stream is located on east of Antalya Gulf and far 12 km to Manavgat and 15 km to Side [28].

A. Collection and Preservation of Samples

1 L capacity dark colored polyethylene sample collection pots were used in order to collect water samples. 6 stations were determined on Karpuz and Alara Streams and water samples were collected between January 2014 and November 2014 in seasonal periods from total 12 stations and collection timings were also considered to be same at each time. chloride ion (Cl^-), ammonium nitrogen (NH_4^+-N), nitrite nitrogen (NO_2^--N), nitrate nitrogen (NO_3-N), orthophosphate ion (PO_4-P), Biological Oxygen Demand (BOD) values (mg/l) from collected samples were measured in Süleyman Demirel University of Geothermal Energy, Underground Water and Mineral Resources Research and Application Center. Water

Hasan Kalyoncu is with the Department of Biological Sciences, Süleyman Demirel University, Turkey (e-mail: hasankalyoncu@sdu.edu.tr).

temperature (^{0}C), pH, electricity Conductivity (µS/cm), dissolved oxygen (mgO_2/L) values were measured in the field.

Plecoptera samples were collected from the rocks, stones and gravels which were found in the basement streams and among the aquatic plants by benthic shovel which were made by 50x30 sized iron and having 500 µm pored pile fabric for approximately 20 minutes and scanned in a diameter of 100 m around the sampling area [29]. Collected samples were fixed by 70% alcohol in field and then taken to laboratory in where Plecoptera samples were separated from others and then identified samples were put in 70% ethyl alcohol containing glass made sampling bottles and were kept in dark medium. Illies [30], Hynes [31], Nilson [32], and Zwick [33] were used for identification of Plecoptera samples, at family, genus and species levels.

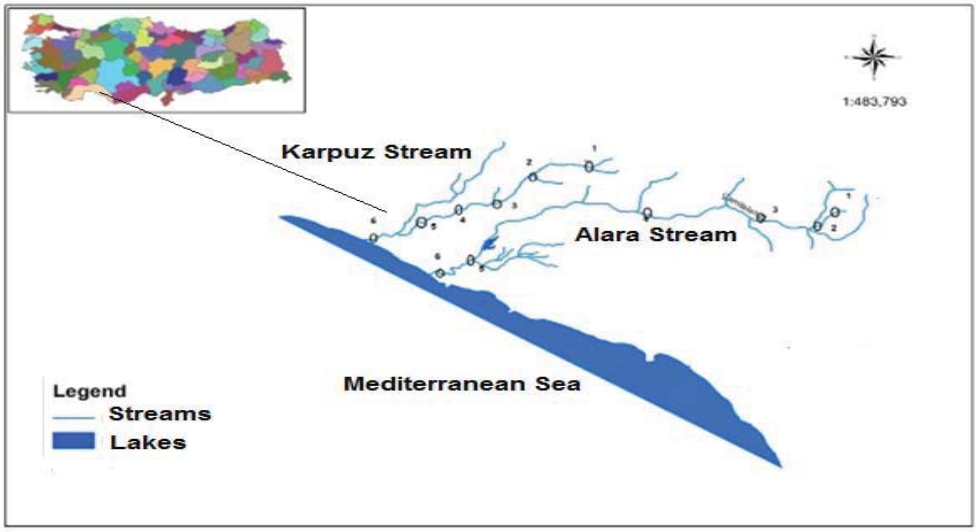

Fig. 1 Alara and Karpuz Stream

TABLE I
DISTRIBUTIONS, COORDINATES AND ALTITUDES OF 12 STATIONS

Karpuz Stream			Alara Stream		
	Coordinates	**Altitude**		**Coordinates**	**Altitude**
1	N 36º 45.425' E031º 39.176'	59 m	**1**	N 36° 45.447' E 32° 09.195'	443 m
2	N 36º 45.352' E031º 38.855'	125 m	**2**	N 36° 45.608' E 32° 08.696'	440 m
3	N 36º 45.192' E 031º 38.374'	11 m	**3**	N 36° 45.378' E 32° 01.673'	260 m
4	N 36º 44.266' E 031º 37.219'	12 m	**4**	N 36° 45.669' E 32° 00.387'	240 m
5	N 36º 43.773' E 031º 35.709'	3 m	**5**	N 36° 41.465' E 31° 43.354'	21 m
6	N 36º 43.150' E 031º 33.616'	0 m	**6**	N 36° 39.958' E 31° 39.095'	**0,5 m**

III. PHYSICAL AND CHEMICAL FINDINGS

A. Physical Findings

Physicochemical variables were analyzed in 12 sampling points on karpuz and Alara streams seasonally and maximum, average and minimum values of stations were given in Table IV. According to seasonal measurements which obtained from Karpuz Stream, the lowest pH value is in station V as 7.91 and the highest pH value is in station I found as 8.29. As to the measurements which obtained from Alara Stream, the lowest pH value is in station III as 8.10 and the highest is found in station IV as 8.29. Both Karpuz and Alara Streams have high dissolved oxygen value. The average dissolved oxygen values of Karpuz Stream were showed changes between 6.6 and 7.49 and as to Alara Stream, the average dissolved oxygen values were showed changes between 8.49 and 10.28. The highest average water temperature is found in station VI as 18.3 ^{0}C and the least average water temperature is found in station I as 10.4 ^{0}C in Alara Stream during the field study.

The highest average water temperature is found in station V as 20.18 ^{0}C and the least average water temperature is found in station I as 16.05 ^{0}C in Karpuz Stream during the field study. The highest average electrical conductivity is found in station VI as 584.5 µS/cm and the lowest average electrical conductivity is found in station III as 393.75 µS/cm in Karpuz Stream. The highest average electrical conductivity is found in station III as 406 µS/cm and the lowest average electrical conductivity is found in station IV as 272 µS/cm in Alara Stream. In Karpuz Stream, the highest average chloride ion is found in station VI as 44.27 mg/L and the lowest average chloride ion is found in station II as 6.85 mg/L. In Alara Stream, the highest average chloride ion is found in station VI as 7.3 mg/L and the lowest average chloride ion is found in station IV as 2.06 mg/L. The highest average ammonium nitrogen is found in station IV as 0.16 mg/L and the lowest average ammonium nitrogen is found in both stations II and III as 0.06 mg/L in Karpuz Stream. In Alara Stream, the highest average ammonium nitrogen is found in station VI as 0.15 mg/L and the lowest average ammonium nitrogen is found in station I as 0.03 mg/L. The highest average nitrate

nitrogen is found in station VI as 0.34 mg/L and the lowest average nitrate nitrogen is found in station I as 0.10 mg/L in Karpuz Stream. The highest average nitrate nitrogen is found in both stations I and VI as 0.42 and the lowest average nitrate nitrogen is found in station III as 0.24, in Alara Stream.

TABLE II
MINIMUM, AVERAGE AND MAXIMUM VALUES OF STATIONS ACCORDING TO PHYSICOCHEMICAL PARAMETERS OF KARPUZ STREAM

STATIONS		O_2 (mg/l)	pH	ºC	E.C (µS/cm)	Cl^- (mg/l)	NO_2^--N (mg/l)	NO_3-N (mg/l)	NH_4^+-N (mg/l)	PO_4-P (mg/l)	BOD (mg/l)
	Min.	6,75	8,00	13,00	356	4,24	BDL	0,05	BDL	BDL	0,44
I	**Avr**	7,49	8,29	16,05	475,5	16,60	BDL	0,10	0,07	BDL	0,93
	Max.	8,30	8,84	23,3	631	42,07	BDL	0,21	0,10	BDL	1,58
	Min.	6,31	8,06	13,2	356	4,34	BDL	BDL	BDL	BDL	0,42
II	**Avr**	7,24	8,12	16,9	402,25	6,85	BDL	0,11	0,06	BDL	0,96
	Max.	8,15	8,19	26,9	470	10,05	BDL	0,28	0,09	BDL	1,72
	Min.	6,22	8,08	12,9	361	4,46	BDL	BDL	BDL	BDL	0,20
III	**Avr**	6,91	8,15	18,65	393,75	7,51	BDL	0,14	0,06	BDL	0,60
	Max.	7,44	8,29	30,9	463	10,69	BDL	0,44	0,08	BDL	1,12
	Min.	6,18	7,65	14,2	358	5,10	BDL	0,05	BDL	BDL	0,42
IV	**Avr**	6,91	8,05	18,43	419,75	9,88	BDL	0,11	0,16	BDL	0,68
	Max.	7,45	8,22	27,0	455	12,21	BDL	0,21	0,41	BDL	1,74
	Min.	6,23	7,60	14,7	385	5,54	BDL	0,14	BDL	BDL	0,14
V	**Avr**	6,66	7,91	20,18	439,5	23,02	BDL	0,28	0,10	BDL	0,85
	Max.	7,30	8,12	29,8	478	59,90	BDL	0,40	0,18	BDL	2,01
	Min.	6,24	7,76	15,1	427	7,65	BDL	0,02	BDL	BDL	0,41
VI	**Avr**	7,09	7,94	19,23	584,5	44,27	BDL	0,34	0,12	BDL	0,98
	Max.	8,05	8,07	28,1	668	86,21		0,58	0,12		2,29

TABLE III
MINIMUM, AVERAGE AND MAXIMUM VALUES OF STATIONS ACCORDING TO PHYSICOCHEMICAL PARAMETERS OF ALARA STREAM

STATIONS		O_2 (mg/l)	pH	ºC	E.C (µS/cm)	Cl^- (mg/l)	NO_2^--N (mg/l)	NO_3-N (mg/l)	NH_4^+-N (mg/l)	PO_4-P (mg/l)	BOD (mg/l)
	Min	9,18	8,01	10,1	240,5	1,43	BDL	0,16	BDL	BDL	0,65
I	Avr	10,28	8,11	10,4	282,62	2,66	BDL	0,42	0,03	BDL	1,49
	Max	10,9	8,31	13,9	330	5,23	BDL	0,82	0,09	BDL	1,86
	Min.	9,1	7,94	9,6	309	2,21	BDL	0,08	BDL	BDL	0,61
II	Avr	9,46	8,13	13,3	377	2,92	BDL	0,39	0,07	BDL	1,65
	Max.	9,98	8,45	21,1	484	3,49	BDL	1,12	0,11	BDL	2,44
	Min.	8,23	7,86	10,7	375	2,65	BDL	0,03	0,06	BDL	0,43
III	Avr	8,61	8,10	14,3	406	3,39	BDL	0,24	0,06	BDL	1,14
	Max.	8,99	8,36	21	447	4,58	BDL	0,52	0,09	BDL	1,57
	Min.	8,66	8,17	9,6	249	1,56	BDL	0,24	BDL	BDL	0,38
IV	Avr	9,32	8,29	12,65	272	2,06	BDL	0,3	0,06	BDL	1,82
	Max.	9,8	8,49	19	326	2,92	BDL	0,33	0,09	BDL	3,84
	Min.	9,25	7,92	12,7	279,7	2,13	BDL	0,2	BDL	BDL	0,94
V	Avr	9,58	8,12	15,6	324,42	3,07	BDL	0,28	0,06	BDL	1,23
	Max.	9,87	8,33	22,9	374	3,43	BDL	0,38	0,11	BDL	1,55
	Min.	8,33	7,94	13,3	245,5	3,13	BDL	0,3	0,06	BDL	0,44
VI	Avr	8,49	8,11	18,3	352,37	7,3	BDL	0,42	0,15	0,14	1,02
	Max.	8,68	8,20	26	414	11,65	BDL	0,6	0,33	0,45	2,08

***BDL:** Below detection limit

The measured orthophosphate and nitrite nitrogen values were found under analysis limits in both Karpuz and Alara Streams.

The highest average BOD is found in station VI as 0.98 mg/L and the least average BODs is found in station III as 0.6 mg/L in Karpuz Stream and the highest average BOD is found in both station IV as 1.82 mg/L and the least average BOD is found in station VI as 1.02 in Alara Stream.

B. Biological Findings

Seasonal sample collection is achieved from predetermined 12 stations which 6 stations from Karpuz Stream and 6 stations from Alara Stream during January 2014 and November 2014 from Karpuz and Alara Streams. 11 species and 3 genera were identified in Alara Stream and 8 species were identified in Karpuz Stream at the end of the study (Table IV). Belonging to the Order Plecoptera there have been 132 samples in station I, 234 samples in station II, 153 samples in station III, 199 samples in station IV, 169 samples

in station V and 53 samples in station VI identified from Alara Stream. There have been 132 samples of 4 species in station I, 59 samples of 5 species in station II, 39 samples of 4 species in station III, 326 samples of 3 species in station IV, 581 samples of 5 species in station V and 10 samples of 2 species in station VI identified from Karpuz Stream.

Isogenus nebecula has been found 38.64% dominant in station I and 35.15% dominant in station IV, *Leuctra moselyi* has been found 48.29% dominant in station II, *Leuctra hippopus* has been found 26.80% dominant in station III, 68.05% dominant in station V and 60.38% dominant in station VI if organisms were examined according to their dominancy in Alara Stream. *Brachyptera risi* has been found 54.14% dominant in station I, 66.1% dominant in station II, 64.1% dominant in station III, 96,93% dominant in station IV and 92.6% dominant in station V while *B. risi* and *L. hippopus* have been found dominant species when organisms were examined according to their dominancy in Karpuz Stream.

B. risi is the most frequent species in station I, station III, station IV, station V and station VI while *L. hippopus* is the most frequent species in station II when identified organisms were examined according to their frequency in Karpuz Stream. *L. moselyi* is the most frequent species in station II, *L. nebecula* is the most frequent species in station III and *L. hippopus* is the most frequent species in station VI and *D. bicaudata* is the most frequent species in station V (Table V) when identified organisms were examined according to their frequency in Alara Stream.

In Alara Stream, the highest diversity value was determined as 1.87 in station III and the lowest was 0.75 in station VI. The highest diversity value in Karpuz Stream was determined as 1.28 in station I, followed by station II by 1.11, station III by 1.01, station VI by 0.69, stations V and VI by 0.32 and by value of 0.15, the lowest diversity value was determined in station IV. The highest diversity value in Alara Stream was followed by station IV by 1.81, station II by 1.59, station I by 1.55, station V by 1.16 and finally station VI by 0.75 (Table VI).

When similarity values of sampling points of Alara Stream were examined, maximum similarity values have been found in stations I and III by a value of 0.88 and in stations III and IV by the exact same value. Maximum similarity values have been found in stations I and II by a value of 0.9 when similarity values of sampling points of Karpuz Stream were examined. Similarity value of stations II and IV were determined as 0.85, stations III and IV as 0.9 and they were identified as the most similar stations. These stations are also similar according to water quality levels and ground structure (Table VII).

TABLE IV
INDIVIDUAL TOTAL DOMINANCY VALUES OF SPECIES OF THE ORDER PLECOPTERA AND THEIR STATION-WISE DISTRIBUTION

ALARA STREAM			**STATIONS**			
TAXA LIST	**I**	**II**	**III**	**IV**	**V**	**VI**
Brachyptera risi	0,76	-	0,65	-	-	-
Dinocras cephalotes	-	0,85	-	1,01	-	-
Diura bicaudata	3,79	4,27	9,8	4,52	2,37	-
Isogenus nebecula	38,64	13,25	18,3	35,18	7,1	-
Isogenus sp.	-	0,85	-	0,5	-	-
Isoperla grammatica	2,27	0,85	2,61	9,05	5,92	-
Leuctra hippopus	23,48	20,94	26,8	22,11	68,05	60,38
Leuctra inermis	11,36	2,14	11,11	5,53	7,73	-
Leuctra moselyi	18,94	48,29	22,22	15,58	10,6	37,74
Leuctra sp.	-	4,27	6,54	-	0,59	-
Nemoura sp.	-	-	-	0,5	-	-
Perla bipunctata	0,76	2,99	1,31	4,52	1,18	1,89
Perla marginata	-	0,43	0,65	1,51	-	-
Protonemura meyeri	-	0,85	-	-	-	-
KARPUZ STREAM			**STATIONS**			
TAXA LIST	**I**	**II**	**III**	**IV**	**V**	**VI**
Brachyptera risi	54,14	66,1	64,1	96,93	92,6	50
Capnia bifrons	0,75	-	-	-	-	-
Diura bicaudata	-	-	-	-	0,17	-
Isogenus nebecula	20,3	8,47	-	-	0,34	-
Isoperla grammatica	-	-	5,13	0,61	1,2	-
Leuctra hippopus	3,76	6,78	17,95	-	5,68	50
Leuctra moselyi	7,52	10,17	-	-	-	-
Rhabdiopteryx acuminata	13,53	8,47	12,82	2,45	-	-

TABLE V

INDIVIDUAL TOTAL FREQUENCY VALUES OF SPECIES OF THE ORDER PLECOPTERA

ALARA STREAM			**STATIONS**			
TAXA LIST	**I**	**II**	**III**	**IV**	**V**	**VI**
Brachyptera risi	25	-	25	-	-	-
Dinocras cephalotes	-	50	-	25	-	-
Diura bicaudata	50	50	50	75	50	-
Isogenus nebecula	50	75	50	75	50	-
Isogenus sp.	-	25	-	25	-	-
Isoperla grammatica	50	25	25	50	25	-
Leuctra hippopus	50	50	100	50	50	50
Leuctra inermis	50	50	75	50	50	-
Leuctra moselyi	75	50	50	75	75	25
Leuctra sp.	-	25	25	-	25	-
Nemoura sp.	-	-	-	25	-	-
Perla bipunctata	25	75	25	75	50	25
Perla marginata	-	25	25	75	-	-
Protonemura meyeri	-	25	-	-	-	-
KARPUZ STREAM			**STATIONS**			
TAXA LİST	**I**	**II**	**III**	**IV**	**V**	**VI**
Brachyptera risi	75	50	50	50	50	50
Capnia bifrons	25	-	-	-	-	-
Diura bicaudata	-	-	-	-	25	-
Isogenus nebecula	25	25	-	-	25	-
Isoperla grammatica	-	-	25	25	50	-
Leuctra hippopus	25	75	25	-	25	25
Leuctra moselyi	50	25	-	-	-	-
Rhabdiopteryx acuminata	50	50	50	50	-	-

TABLE VI
SHANNON-WIENER DIVERSITY INDEX VALUES OF SPECIES OF THE ORDER PLECOPTERA

	Stations					
Diversity	**I**	**II**	**III**	**IV**	**V**	**VI**
Alara Stream	1,55	1,59	**1,87**	1,81	1,16	0,75
Karpuz Stream	**1,28**	1,11	1,01	0,15	0,32	0,69

TABLE VII
SIMILARITY VALUES OF STATIONS OF SPECIES OF THE ORDER PLECOPTERA

ALARA STREAM						
STATIONS	**I**	**II**	**III**	**IV**	**V**	**VI**
I	1					
II	0,7	1				
III	**0,88**	0,81	1			
IV	0,73	0,69	0,76	1		
V	0,87	0,8	**0,88**	0,73	1	
VI	0,6	0,4	0,46	0,42	0,54	1
KARPUZ STREAM						
STATIONS	**I**	**II**	**III**	**IV**	**V**	**VI**
I	1					
II	**0,9**	1				
III	0,6	0,66	1			
IV	0,44	0,5	0,85	1		
V	0,54	0,6	0,66	0,5	1	
VI	0,5	0,85	0,66	0,8	0,57	1

IV. DISCUSSION AND RESULTS

All stations of both streams were on the oligosaprobic level according to results of physicochemical analysis. All stations of both streams have water quality level I according to systematic of Klee [34]. Alara Stream shows substantially richer structure than Karpuz Stream.

3 genera and 13 species of the Order Plecoptera have been identified from collected samples of both Karpuz and Alara Streams. There have been found 8 species in Karpuz Stream and 3 genera and 11 species in Alara Stream. *Brachyptera risi*

has been found only in station I and station III during winter season and there has been no any taxon found in other stations of Alara Stream but it has been found in all stations of Karpuz Stream. It has been mostly found during winter and autumn seasons. This study showed that mentioned species could be distributed from 0m altitude to 443m altitude and temperature interval could be from 30.9 ^{0}C to 10.1 ^{0}C. Average temperature variation has been seen in between 10.4 ^{0}C and 20.18 ^{0}C. It has been seen hypocrenal, eprihitral, metarhitral and hyporhitral sections of streams and above 150 m altitudes according to [35]. High individual numbers have been observed in cold, lukewarm and warm waters of streams with high course flow. The results and literature knowledge were compatible to each other except altitude. Kalyoncu [36] has found genus *Brachyptera* in 8.98 ^{0}C average temperature in the source section station of Aksu Stream. Additionally, Dökümcü [37] has found this species in Istranca Brook of İstanbul.

Capnia bifrons is only seen in station I of Karpuz Stream and during autumn season. Course flow has been normal, temperature value has been found 9.2 ^{0}C and on 59 m altitude. It has been seen hypocrenal, eprihitral, metarhitral and hyporhitral sections of streams and above 150 m altitudes according to [35]. This taxon is well distributed between 9 and 18 ^{0}C and generally prefers still sections of streams.

Dinocras cephalotes is only seen in station II during spring and autumn season and in station IV during winter season. Distribution of this taxon is changing from 240 m to 440 m altitudes. The observed temperature values of this species were 9.6 ^{0}C and 21.1 ^{0}C and average temperature is between 12.65 and 13.3 ^{0}C. It has been seen in hypocrenal, eprihitral, metarhitral, hyporhitral and epipotomal sections of streams and above 150 m altitudes according to [35]. High individual numbers have been observed in cold, lukewarm and warm waters of streams with high course flow. Zeybek [38] has found this species in Çukurca Brook during autumn and winter seasons and Yorulmaz [9] has found it in between 191 m and 673 m altitudes in Eşen Stream.

Diura bicaudata is found in first 5 stations of Alara Stream. It is found in station I and station III during winter and autumn seasons, in station II and station V during spring and autumn seasons, in station IV during winter, autumn and spring seasons of Alara Stream. It is found only in station V of Karpuz Stream during the spring season. Distribution of this taxon is changing from 3 m to 443 m altitudes. The observed temperature values of this species were 9.6 ^{0}C and 22.9 ^{0}C and average temperature is between 10.4 and 15.6^{0}C. It has been seen in eucrenal, hypocrenal and eprihitral sections of streams and above 150 m altitudes according to [35]. High individual numbers have been observed in cold, lukewarm and warm waters of streams with slow course flow.

Isogenus nebecula is found in first 5 stations of Alara Stream. It is found in station I and station III during winter and autumn seasons, in station II and station IV winter, spring and autumn seasons, in station V during autumn and spring seasons of Alara Stream. It is found in station I, station II and station V of Karpuz Stream during spring season. Distribution of this taxon is changing from 3 m to 443 m altitudes. The observed temperature values of this species are 9.6 ^{0}C and 22.9 ^{0}C and average temperature is between 10.4 and 15.6 ^{0}C. It has been seen in eucrenal, hypocrenal and eprihitral sections of streams and above 150 m altitudes according to [35]. High individual numbers have been observed in cold, lukewarm and warm waters of streams with high course flow.

Isogenus sp. is observed in station II and station IV of Alara Stream during autumn season. Distribution of this species is changing from 12 m to 240 m altitudes. The observed temperature values of this species are between 19^{0}C and 21.1 ^{0}C.

Isoperla grammatica is found in first 5 stations of Alara Stream. It is found in station I of Alara Stream during winter and autumn season, in station II during autumn season, in station III during winter season, in station IV during winter and spring seasons and in station V during spring season. It is observed in station III and station IV of Karpuz Stream during spring season and in station V during spring and winter seasons. Distribution of this taxon is changing from 3 m to 443 m altitudes. The observed temperature values of this species were 9.6 ^{0}C and 21.1 ^{0}C and average temperature is between 10.4 and 20.18 ^{0}C. It has been seen in epirhitral, metarhitral, hyporhitral and epipotomal sections of streams and above 150 m altitudes according to [35]. High individual numbers have been observed in streams with high course flow. This species has no certain temperature preference which is known as eurythermic. Reference [9] has found it in between 60 m and 673 m altitudes in Eşen Stream.

Leuctra hippopus is found in all stations of Alara Stream. It is found in station I, station II, station V and station VI of Alara Stream during summer and autumn seasons and in station III during all seasons and in station IV during spring and summer seasons. It is not only seen in station IV of Karpuz Stream. It is observed in station I, station III, station V and station VI only during spring season and in station III during winter, spring and autumn seasons. Distribution of this taxon is changing from 0 m to 443 m altitudes. The observed temperature values of this species were 10.3 ^{0}C and 26.9 ^{0}C and average temperature is between 10.4 and 20.18^{0}C. It has been seen in eucrenal, hypocrenal, epirhitral, metarhitral and hyporhitral sections of streams and above 150 m altitudes according to [35]. High individual numbers have been observed in lukewarm waters of streams with high course flow. Yorulmaz [9] has found it in between 191 m and 673 m altitudes in Eşen Stream. Kalyoncu and Zeybek [39] have found these species in average temperature between 11.47 ^{0}C and 14.71 ^{0}C in Ağlasun and Isparta Streams.

Leuctra inermis is found in first 5 stations of Alara Stream. It is found in station I and station IV of Alara Stream during spring and summer seasons, in station II and station V during winter and summer seasons and in station III during winter, spring and autumn seasons. Distribution of this taxon is changing from 21 m to 443 m altitudes. The observed temperature values of this species were 9.6 ^{0}C and 13.9 ^{0}C and average temperature is between 10.4 and 15.6 ^{0}C. It has been seen in epirhitral, metarhitral and hyporhitral sections of

streams and above 150 m altitudes according to [35]. High individual numbers have been observed in lukewarm and cold waters of streams with high course flow.

Leuctra moselyi is found in all stations of Alara Stream. It is found in station I, station IV and station V of Alara Stream during winter, summer and autumn seasons, in station II and station III during winter and autumn seasons and in station VI during autumn season. It is found in station I and station II of Karpuz Stream. It is observed in station I during winter and autumn seasons and in station II during autumn season. Distribution of this taxon is changing from 0 m to 443 m altitudes. The observed temperature values of this species were 9.6 ^{0}C and 26 ^{0}C and average temperature is between 10.4 and 18.3^{0}C. It has been seen in epirhitral, metarhitral and hyporhitral sections of streams and above 150 m altitudes according to [35]. High individual numbers have been observed in very cold and cold waters of streams with high course flow. Yorulmaz [9] has found this species in average temperature between 10.75 ^{0}C and 14.71 ^{0}C. Birol [40] has found this species in average temperature between 8.1 ^{0}C and 22.1 ^{0}C in Dipsiz-Çine Stream.

Leuctra sp. is observed in station II, station III and station V of Alara Stream during autumn season. This study shows the distribution of this species change from 21 m to 440 m altitudes. This species is determined in temperatures between 21 ^{0}C and 22.9 ^{0}C.

Nemoura sp. is only observed in station IV of Alara Stream during autumn season. This study shows the distribution of this species is 240 m altitudes. This species is determined in 19 ^{0}C. Kalyoncu et al. [4] has found this species in average 11.7 ^{0}C temperature in Aksu Stream.

Perla bipunctata is found in all stations of Alara Stream. It is found in station I of Alara Stream during winter season, in station II during spring, summer and autumn seasons, in station III during winter season, in station IV during winter, spring and summer seasons, in station V during spring and summer seasons and in station VI during winter season. This study shows the distribution of this species is changing between 0 m and 443 m altitudes. The observed temperature values of this species are 9.6 ^{0}C and 26 ^{0}C and average temperature is between 10.4 and 18.3 ^{0}C. It has been seen in metapotamal, epipotomal, hyporhitral, epirhitral, metarhitral, hypocrenal and eucrenal sections of streams and above 150 m altitudes according to [35]. High individual numbers have been observed in every temperature with high and medium course flow. Kalyoncu and Zeybek [39] have found these species in average temperature between 12.06 ^{0}C and 14.71 ^{0}C in Ağlasun and Isparta Streams.

Perla marginata is found in station II of Alara Stream during spring season, in station III during summer season and in station IV during winter, spring and autumn seasons. This study shows the distribution of this species is changing between 240 m and 440 m altitudes. The observed temperature values of this species is 9.6 ^{0}C and 19 ^{0}C and average temperature is between 12.65^{0}C and 14.3 changing. It has been seen in epirhitral, metarhitral and hypocrenal sections of streams and above 150 m altitudes according to [35]. High individual numbers have been observed in lukewarm and cold waters of streams with high and medium course flow. Yorulmaz [9] has identified this species in between 191 m and 673 m altitudes in Eşen Stream.

Protonemura meyeri is only seen in station II of Alara Stream during spring season. This study shows the distribution of this species is 440 m altitudes. This species is determined in 10.9 ^{0}C temperature and average temperature is found as 13.3 ^{0}C. It has been seen in epirhitral, metarhitral and hypocrenal sections of streams and above 150 m altitudes according to [35]. High individual numbers have been observed in very cold, col and lukewarm waters of streams with high and medium course flow. Kalyoncu and Zeybek [39] have found this species in average temperature between 11.47 ^{0}C and 14.71 ^{0}C in Ağlasun and Isparta Streams.

Rhabdiopteryx acuminate is found in first four stations of Karpuz Stream during winter and spring seasons. This study shows the distribution of this species is changing between 11 m and 125 m altitudes. The observed temperature values of this species is 12.9 ^{0}C and 30.9 ^{0}C and average temperature is between 16.05^{0}C and 18.65^{0}C. It has been seen epirhitral, metarhitral, hyporhitral and epipotomal sections of streams and between 100 m – 150 m altitudes according to [35]. High individual numbers have been observed in lukewarm and cold waters of streams with high and medium course flow.

ACKNOWLEDGMENT

This research has been supported by Unit of Scientific Research Projects, Süleyman Demirel University (Project No: 3772-YL1-13). We are deeply grateful to them for their financial support.

REFERENCES

[1] Kalyoncu, H., 2002. Aksu Çayı'nın Fiziksel Kimyasal ve Biyolojik Olarak İncelenmesi. Süleyman Demirel Üniversitesi, Fen Bilimleri Enstitüsü, Doktora Tezi, 171s, Isparta.

[2] Hynes, K.E., 1998. Bentic Macroinvertebrate Diversity and Biotic İndices for Monitoring of 5 Urban and Urbanising Lakes within the Halifax Regional Municipality (HRM), Nova Scotia, Canada. Soil & Water Conservation Society of Metro Halifax. xiv,114 p.

[3] Barlas, M., 1995. Akarsu Kirlenmesinin Biyolojik ve Kimyasal yönden Değerlendirilmesi ve Kriterleri. Doğu Anadolu Bölgesi I. ve II. Su Ürünleri Sempozyumu, 465-479, Erzurum.

[4] Kalyoncu, H., Yorulmaz B., Barlas M., Yıldırım, M.Z. ve Zeybek M. 2008. Aksu Çayı'nın su Kalitesi ve Fizikokimyasal Parametrelerinin Makroomurgasız Çeşitliliği Üzerine Etkisi. Fırat ünv. Fen ve Müh. Bil. Dergisi 20 (1), 23-33.

[5] Kazancı, N., 2008. Türkiye Plecoptera (Insecta) Faunası Plecoptera (Insecta) Fauna of Turkey Türkiye İç Suları Araştırmaları Dizisi Ix. İmaj Yayıncılık. Pp. 56

[6] Kalyoncu, H., Çiçek, N. L., Akköz, C and Yorulmaz, B. 2009. Comparative performance of diatom indices in aquatic pollution assesment. African Journal of Agricultural Research, Vol. 4 (10), pp. 1032-1040.

[7] Kalyoncu H., Gülboy H. 2009. Benthic Macroinvertebrates from Darıören and Isparta Streams (Isparta/Turkey) - Biotic Indices and Multivariate Analysis. Journal of Applied Biological Sciences, 3(1):100-107

[8] Duran M., 2006, Monitoring Water Quality Using Benthic Macroinvertebrates and Physicochemical Parameters of Behzat Stream İn Turkey, Polish Journal Of Environmental Studies, 15(5), 709-717

[9] Yorulmaz, B., 2006. Eşen Çayı (Kocaçay) Su Kalitesinin Fiziksel, Kimyasal ve Biyolojik Açıdan İncelenmesi. Ege Üniversitesi, Fen Bilimleri Enstitüsü, Doktora Tezi, 195 s, İzmir.

[10] Duran M., Akyıldız Kıvanç G., Özdemir A., 2007, Gökpınar Çayı'nın Büyük Omurgasız Faunası ve Su Kalitesinin Değerlendirilmesi, Türk Sucul Yaşam Dergisi, 5(8), 577-583.
[11] Öz, B. 2007. Batı Karadeniz Bölgesi Akarsularında Bentik Makroinvertebrat Faunası Üzerine Bir Arastırma. Hacettepe Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi. 105s, Ankara.
[12] Zeybek, M., Kalyoncu, H. 2012. Köprüçay Nehri'nde Biyotik İndeksler ile Çeşitlilik İndekslerinin Karşılaştırılmalı olarak incelenmesi, 5. Ulusal Limnoloji Sempozyumu, 27-29 Ağustos 2012, S. 52, Isparta.
[13] Kalyoncu H., Akyıldırım G.H., Yorulmaz B. 2009. The Comparison of the Diversity and Biotic Indices with Physical-Chemical Analyses Applied to Macroinvertebrate Community to Determine The Water Quality. International Conference on Lakes and Nutrient Loads-Pocrades, Agricultural University of Tirana, Albania, 24-26 April 2009, 22 p.
[14] Kalyoncu H., Barlas M., Ertan Ö.O. 2009b. Aksu Çayı'nın Su Kalitesinin Biotik İndekslere (Diyatomlara ve Omurgasızlara Göre) ve Fizikokimyasal Parametrelere Göre İncelenmesi, Organizmaların Su Kalitesi ile İlişkileri. Türk Bilim Dergisi, 2(1): 46-57.
[15] Zeybek, M., Kalyoncu, H., 2010. Köprüçay Nehri Bentik Omurgasız Faunasının Belirlenmesine Yönelik Bir Araştırma. Batı Akdeniz Doğa Bilimleri Sempozyumu, 4-6 Kasım, Burdur, 8s.
[16] Zeybek, M., Kalyoncu H., 2012a. Köprüçay Nehri'nde Biyotik İndeksler İle Çeşitlilik İndekslerinin Karşılaştırmalı Olarak İncelenmesi. Eğirdir Su Ürünleri Fakültesi Dergisi, 8(1), 42-50.
[17] Zeybek, M., Kalyoncu H., Ertan, O. Ö., Çiçek, L. N. 2012b. Köprüçay Irmağı (Antalya) Bentik Omurgasız Faunası, Süleyman Demirel Üniversitesi, Fen Bilimleri Enstitüsü Dergisi, 16(2), 146-153.
[18] Kazancı N., 2012a. Türkiye'den Plecoptera (Insecta) Kayıtları, 5,2: 85-95
[19] Kazancı N., Türkmen G., Bolat H. A., 2012b, Nesli tehlikede olan *Marthamea vitripennis* (Burmeister 1839)' in (Insecta, Plecoptera) habitat özellileri, 5,1:1-18
[20] Yorulmaz B., Sukatar A., 2012, Water Quality and Manegement Strategies of Esen River (Muğla-Turkey), 12th International Multidisciplinary Scientific GeoConference, 5, 1061-1066
[21] Kovács T., Juhász P., Turcsányi I., 2001, Ephemeroptera, Odonata and Plecoptera larvae from the River Tisza (1997-1999), 25: 135-143
[22] Sharma M. P., Sharma S., Gael V., Sharma P., Kumar A., 2006, Water Quality Assessment of Behta River Using Benthic Macroinvertebrates, Life Science Journal, 68-74 pp.
[23] Ganie, A. M., Pal, A. K., Pandit A. K. 2014." Water Quality Assessment of Lar Stream, Kashmir Using Macroinvertebrates as Variable Tolerants to Diverse Levels of Pollution", Pakistan Entomologist, 36(1), 73-78.
[24] Stoyanova, T., Vidinova, Y., Yaneva, I., Tyufekchieva, V., Parvanov, D., Traykov, I., Bogoev, V. 2014. "Ephemeroptera, Plecoptera and Trichoptera as Indicators for Ecological Quality of the Luda Reka River, Southwest Bulgaria, Acta Zoologıca Bulgarıca, 66 (2), 255-260.
[25] Nairian, H. 2014. "Evaluation of water quality and organic pollution of Shadegan and Hawr Al Azim wetlands by biological indices using insects", Journal of Entomology and Zoology Studies, 2 (5), 193-200.
[26] Tyufekchieva, V., Kalcheva, H., Vidinova, Y., Yaneva, I., Stoyanova, T., Ljubomirov, T., 2013. Distribution and Ecology of Taeniopterygidae (Insecta: Plecoptera) in Bulgaria, Acta Zoologica Bulgarica, 65(1), 89-100.
[27] Özdoğan, İ., 2010. Akarsularda Taşkın Öteleme Modelleri: Alara Çayı Uygulaması. Süleyman Demirel Üniversitesi, Fen Bilimleri Enstitüsü, Doktora Tezi. 126s, Isparta
[28] Çiçek, İ., Türkoğlu N., Gürgen G., 2009. Karpuz Çay Deltasının (Antalya Doğusu) Paleojeomorfolojisi. Coğrafi Bilimler Dergisi, 6(1), 21-38.
[29] Plafkin, J. L., Barbour, K. D., Gross, S. K., Hughes, R. M., 1989. Rapid Bioassesment Protocols for use in Streams and Rivers, Benthic Macroinvertebrates and Fish, EPA/444/4-89-001, Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, D.C.
[30] Illies, J., 1955. Die Tierwelt Deutschlands Plecoptera, 150 p. Germany.
[31] Hynes, H. B. N., 1977. A Key to the Adults and Nymps of British Stoneflies, Freshwater Biological Association Scientific Publication No: 17, 90 p. Ontario.
[32] Nilsson, A., 1996. Aquatic Insects of North Europe (A Taxonomic Handbook) I. Apollo Books, 274p. Stensrup, Denmark.
[33] Zwick, P., 2004. Key to The West Palaearctic Genera of Stoneflies (Plecoptera) İn The Larval Stage, Limnologica, 34, 314-348.
[34] Klee, O., 1991. Angewandte Hydrobiologie. G. Theieme Verlag, 2. Neubearbeitete und erweiterte Auflage, 272 p. Stuttgart-New York.
[35] Kloiber, S. A., Hering, D. 2009. Distribution and Ecological Preferences of European Freshwater Organisms Plecoptera, Pensoft Publishers, 262p, Sofy-Moskova.
[36] Kalyoncu H., Barlas M., Yorulmaz B. 2008. Aksu Çayı'nda (Isparta-Antalya) Epilitik alg Çeşitliliği ve Akarsuyun Fizikokimyasal Yapısı Arasındaki İlişki. Ekoloji, 17, 66, 15-22
[37] Dökümcü, N., 2013. Istranca Deresi (Durusu-İstanbul) Bentik Makroomurgasız Faunasının Tespiti, İstanbul Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, 79s, İstanbul.
[38] Zeybek, M., 2007. Çukurca Dere Ve Isparta Deresi' Nin Su Kalitesinin Makrozoobentik Organizmalara Göre Belirlenmesi, Süleyman Demirel Üniversitesi. Fen Bilimleri, Yülsek Lisans Tezi, 100 S, Isparta.
[39] Kalyoncu H., Zeybek M. 2009. Ağlasun ve Isparta Derelerinin Bentik Faunası ve Su Kalitesinin Fizikokimyasal Parametrelere ve Belçika Biyotik İndeksine Göre Belirlenmesi. Biyoloji Bilimleri Araştırma Dergisi, 1(3): 41-48.
[40] Birol, N., 2007. Dipsiz-Çine Çayı (Muğla-Aydın)'Nın Bentik Makroomurgasızlarının Belirlenmesi, Muğla Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, 134s, Muğla.