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An Evaluation of the Water Quality of Yuvarlakçay Stream, in the Köyceğiz-Dalyan Protected Area, SW Turkey

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Abstract: The longitudinal and seasonal distribution of macroinvertebrates and the physical and chemical variables of Yuvarlak Stream in the Köyceğiz-Dalyan Protected Area in South-Western Turkey were studied between April 1992 and April 1993. The diversity, frequency, dominance, abundance and similarity of macroinvertebrates through the year were recorded. In addition, the Belgian Biotic Index was used as a biological criterion for the assessment of water quality for the first time in Turkey. According to the physico-chemical variables and the distribution of benthic macroinvertebrates, continuous slight and moderate organic pollution exists in the stream. The monitoring of the water quality of Yuvarlakçay Stream is also necessary for the protection of water quality in meromictic Lake Köyceğiz.

Key Words: South-Western Turkey, natural protected area, Yuvarlakçay Stream, benthic macroinvertebrates, water quality

Köyceğiz-Dalyan Özel Çevre Koruma Bölgesinde Bulunan Yuvarlakçay'ın Su Kalitesinin Değerlendirilmesi

Özet: Türkiye'nin güneybatısında bulunan Köyceğiz-Dalyan Özel Çevre Koruma Bölgesi'nde bulunan Yuvarlakçay'ın, taban büyük omurgasızlarının dağılımı ve fiziksel-kimyasal değişkenleri, Nisan 1992-Nisan 1993 tarihleri arasında çalışılmıştır. Bir yıl boyunca taban büyük omurgasızlarının çeşitlilik, sıklık, baskınlık, yoğunluk ve istasyonlar arası benzerlikleri tespit edilmiştir. Belçika Biyotik İndeksi bu sayısal analizlerle birlikte su kalitesini değerlendirmede Türkiye'de ilk defa biyolojik kriter olarak kullanılmıştır. Fiziko-kimyasal değişkenlerin sonuçlarına ve taban büyük omurgasızlarının dağılımına göre akarsuda sürekli, hafif ve orta derecede organik kirlilik saptanmıştır. Yuvarlakçay'ın su kalitesinin izlenmesi, meromiktik bir göl olan Köyceğiz Gölü'nün su kalitesinin korunabilmesi için de gereklidir.

Anahtar Sözcükler: Güneybatı Türkiye, doğal koruma alanı, Yuvarlakçay, taban büyük omurgasızları, su kalitesi

Introduction

In Turkey, running waters have received much less attention from limnologists than lakes, and the assessment of water quality is based mainly on physico-chemical variables. However, an ecosystem analysis using macroinvertebrates together with physical and chemical variables has recently been conducted in Turkey (1,2,3,4). In this study, a year-round ecological study of Yuvarlakçay Stream was undertaken with the emphasis on longitudinal and seasonal changes in the diversity, frequency, dominance, abundance, similarity and community structure of macroinvertebrates. In addition, the Belgian Biotic index (5) was used as a biological criterion for the rapid assessment of water quality.

Site description

A Mediterranean climate with hot, dry summers and mild, wet winters prevails in the area. Based on long-term average data, the mean annual precipitation over the basin is 1202 mm. The mean annual temperature is about 18°C. Yuvarlak Stream is one of the major surface waters in the basin, draining various geologic units into the meromictic Lake Köyceğiz, which in turn discharges to the Mediterranean Sea via a 14-km-long, meandering channel. Structural features of the stations are given in Table 1.

There are five hydrochemically different types of water in the study area: cold karstic or associated water, thermal, lake and sea water. Yuvarlak Stream has cold karstic water, located around Köyceğiz Lake, fed by karstic aquifers. Its chemical composition indicates a rock-water interaction typical of that observed in carbonate aquifers (6). Yuvarlak Stream discharges from limestone, dolomite and along the contact between limestone and ophiolite or alluvium.

Table 1. Structural features of the stations

Stations	Structure	Flow rate
1. Source of Yuvarlakçay	Boulder, trees (*Pinus brutia, Platanus orientalis*) around the shore.	rapid
2. Yuvarlakçay Before Fish Farm	Stony partial small boulder, trees (*Pinus brutia, Platanus orientalis*) around the shore.	slow
4. Yuvarlakçay After Fish Farm	Small boulder, partial large cobble, trees (*Pinus brutia, Platanus orientalis*) around the shore.	rapid
5. Yuvarlakçay Before Nasıfdede	Large cobble, sandy, trees (*Alnus* sp.) around the shore	slow
6. Nasıfdede tributary	sandy, marshy along the shore	slow
7. Yuvarlakçay After Nasıfdede	gravelly, sandy, trees (*Alnus* sp.) around the shore	slow
8. Mouth of Yuvarlakçay	sandy, partly silty, trees (*Alnus* sp.) around the shore	slow

Stream rocks can be classified according to the following scheme:

Boulder (>125 cm)
Small Boulder (25-124 cm)
Large Cobble (15-24 cm)
Cobble (5-14 cm)
Gravel (2-5 cm)
Small Gravel (0.1-2 cm)
Sand (<0.1 cm and grainy)
Silt (<0.1 cm and floury)

Materials and Methods

This study was conducted from April 1992 to April 1993 in 7 sampling periods.

Physical and Chemical Factors

Sampling was carried out at 8 sites along the stream. At each site, samples for chemical analysis were taken at the same time as collections of macroinvertebrates. Water samples for chemical analysis were collected from the middle of the water column using prewashed polyethylene bottles. All samples were analysed within 48 hours after collection.

Water temperature, dissolved oxygen, pH, and specific conductivity were measured in the field with portable instruments (WTW Wissenschaftlich-Technishe Werksttatten). NO_3, NO_2, PO_4, NH_4, Cl, Ca, Mg and total hardness were measured inthe laboratory according to the methods described below.

Ammonia was determined according to the method of Solorzano 1969 (7), nitrite according to the method of Snel and Snel 1957 (8), nitrate according to the Braun Systematik (Methodenblatt N 60), phosphate with Vanadate-Molybdate-Reagent (see Merck Wasseruntersuchung), and chloride according to the method of Mohr 1856 (10). For each measurement, analytical grade chemicals were used. All spectrophotometric measurements were carried out using a Hach DR 2000 spectrophotometer.

Macroinvertebrates

Benthic macroinvertebrates were collected by kicking for 5 minutes with 3 replications at 8 sampling sites with a handnet (1 mm mesh size; frame, 20 cm high and 30 cm wide). The collected material was sieved through two sieves with mesh sizes of 0.5 mm and 0.05 mm. The organisms were preserved in 80% alcohol. Taxa were determined to genus level. The Shannon-Weaver Diversity Index, frequency, dominance and similarity index was used for the numerical analysis of macroinvertebrates. The Belgian Biotic Index (5) provided an indication of the biological water quality assessment, as described by Kazancı et al (2).

Community diversity index

The Shannon-Weaver Index was used to calculate the diversity of the benthic macroinvertebrates at each site on the tributaries of Yuvarlak Stream.

$$H' = \sum_{i=1}^{s} Pi \text{ loge } Pi$$

H' : Shannon-Weaver Diversity Index

Pi : Ni/N

Ni : the number of individuals per taxon

N : the total number of individuals

When the diversity value is over 3, there is stability and balance in a community (10). If the value is less than 1, it indicates a heavily polluted system. Values between 1-3 are characteristic of moderately polluted conditions.

Quotient of Community similarity

The Sorensen Similarity Index was used. The degree of similarity between the samples was evaluated for each pair of sites using the quotient of similarity.

$$QS = \frac{2c}{a + b}$$

c: the number of taxa in both samples

a: the number of taxa in the first sample

b: the number of different taxa of second sample from the first sample

The values of this index can vary between 0 and 1.

Dominance

Dominance was calculated using the number of individuals of one taxon and the individuals of all taxa at one site.

$$D = \frac{N_A}{N_n} \times 100$$

D = Dominance value

N_A = Number of individuals of taxon A

N_n = Number of individuals of all taxa

Frequency

Frequency was calculated by using sampling number including each taxon and total sampling number.

$$F = \frac{Na}{N} X\ 100$$

F: Frequency

Na: Sampling number including taxon a

N: Total sampling number

Results

Physical-Chemical Characteristics

At the 8 sites along the stream, the water quality varies between class I and class III according to The Book of Instruction for Water Pollution Management issued by the Council of the Environment (11).

The temperature values increased along the stream from the source to the mouth (Table 2.).

Dissolved oxygen values were near or above saturation at all times at all sites except for the first site, which was very near the source of the stream. If we take into account that Yuvarlakçay Stream is fed by karstic aquifers, the lower value of dissolved oxygen saturation (min 56%, mean 76.4%) was an expected result in first site (Table 1).

The EC values were between 0.2 mS/cm and 0.57 mS/cm. The EC values for sites 6-7 near the mouth were higher (min 0.3 mS/cm, mean 0.4-0.46 mS/cm, max 0.51-0.63 mS/cm) than those for the other sites. But the EC value decreased due to fresh water addition from the karstic sources at collecting site 8 (Table 2).

pH was lower at the first site due to the karstic water (min 5.34). Waste water from local salmon fisheries increased the pH to 8.9.

The amount of $N\text{-}NO_2$ ranged from 0 to 0.1 mg/l, the amount of $N\text{-}NO_3$ ranged from 0 to 0.412 mg/l, the amount of $N\text{-}NH_4$ ranged from 0 to 0.32 mg/l and $P\text{-}PO_4$ ranged from 0 to 0.01 mg/l between Apri 1992 and April 1993.

The maximum content of $N\text{-}NO_2$ was 0.009 mg/l at the source of the stream. It increased after the salmon fishery site (0.1 mg/l) in the upstream region. The low concentrations recorded in the upstream sites are not suprising since the $N\text{-}NO_2$ is probably rapidly oxidized to nitrate under aerobic conditions. The high concentration of $N\text{-}NO_2$ was noted in Yuvarlakçay Stream especially at the polluted downstream sites (0.1-0.6 mg/l), which indicates continuous organic pollution along the stream except for the area at the source.

Considerable amounts of $N\text{-}NO_3$ were measured at the upstream sites and this could have been a result of the discharge of waste water of aquaculture sites. The considerably higher concentrations of $N\text{-}NO_3$ at downstream sites may have been due to organic waste waters.

The presence of appreciable amounts of $N\text{-}NH_4$ (0.32 mg/l) and even the smallest trace of nitrite in the running water indicates organic pollution. The change in the concentrations of ammonia, nitrite and nitrate may be used to characterise the self-purifying capacity of the running waters.

Table 2. The lowest, mean and highest values of measured physico-chemical parameters at the sites

NO	SITE		EC mScm-1	Temp. •C	pH	DO mg/l	DO %	$N-NO_3$ mg/l	$N-NO_2$ mg/l	$P-PO_4$ mg/l	$N-NH_4$ mg/l	Ca mg/l	Mg mg/l	Hardness meq/l
	Source of	Min	0.2	13.1	5.34	5.5	56	0	0	0	0	120,3	4,86	8
1	Yuvarlakçay	Max	0.5	14	8.24	13	128	0,06	0,009	0	0,22	160,3	58,34	12
		Mean	0.32	13.6	7.44	7.6	76.4	0.02	0,002	0	0,04	144,3	37,3	10,3
	Yuvarlakçay	Min	0.27	12.3	8.1	7.4	77	0.01	0	0	0	64,1	19,45	7
2	Before Fish	Max	0.47	19.1	8.5	10.1	113	0,08	0,009	0	0,18	192,4	87,52	15
	Farm	Mean	0.34	16.1	8.26	8.77	96	0,04	0,002	0	0,04	134	49,3	10,7
		Min	0.21	11.4	7.1	7	75	0	0	0	0	120,2	9,72	7
3	Fish Farm	Max	0.44	18.4	8.9	14.2	132	0,11	0,1	0,001	0,32	176,4	53,5	12
		Mean	0.32	16	8.1	9.1	91.3	0,04	0,004	0,0002	0,09	145,4	34,7	10,1
	Yuvarlakçay	Min	0.23	12	7.98	7.4	78	0	0	0	0	120,2	19,45	8
4	After Fish	Max	0.43	18	8.31	11.6	110	0,096	0,009	0,002	0,2	160,3	58,34	12
	Farm	Mean	0.32	15.6	8.07	9.5	97.1	0,04	0,006	0,0004	0,06	138,5	41	10,3
	Yuvarlakçay	Min	0.3	12.7	8.16	8.25	102	0,054	0,002	0	0	128,3	19,45	10
5	Before	Max	0.44	29.9	8.96	14.5	174	0,25	0,032	0,001	0,192	176,4	77,8	14
	Nasıfdede	Mean	0.36	22	8.41	11.3	136.1	0,12	0,015	0,0002	0,04	157,6	53,5	12,1
		Min	0.33	15.5	7.75	6.3	74	0,025	0	0	0	152,3	53,5	12
6	Nasıfdede	Max	0.63	22.2	8.3	11.1	115	0,412	0,01	0	0,25	320,6	525,1	60
		Mean	0.46	19.1	7.9	8.6	92.6	0,16	0,005	0	0,05	191	142	22,3
	Yuvarlakçay	Min	0.3	15.1	7.81	6.6	78	0,12	0,002	0	0	128,3	34,03	11
7	After Nasıfdede	Max	0.57	22.2	8.8	11.2	112	0,39	0,03	0,01	0,24	192,4	213,9	32
		Mean	0.4	19.3	8.1	8.5	92.7	0,23	0,01	0,001	0,03	175,2	116	18,1
	Mouth of	Min	0.31	13.8	8.13	8.6	95	0,14	0,004	0	0	136,3	19,45	10
8	Yuvarlakçay	Max	0.51	25.1	8.64	14.4	172	0,31	0,06	0	0,27	192,4	87,52	16
		Mean	0.4	20	8.32	12.1	114	0,2	0,02	0	0,04	159,2	59	12,7

The $P-PO_4$ values were generally very low (less than 0.01 mg/l) at all sites.

The higher levels of total hardness at all sites is a reflection of the geology of the study area. Much higher levels of hardness were measured at downstream sites, especially at Nasıfdede Branch, during all the sampling periods.

Macroinvertebrates

Table 3 provides the taxonomic lists of benthic macroinvertebrates in Yuvarlak Stream. The community consisted of 48920 individuals belonging to 92 genera of Platyhelminthes, Mollusca, Annelida and Arthropoda.

Frequency

Table 4 provides the frequency of these macroinvertebrates.

The frequency of *Dugesia* was 28.6% at site 1 and 14.3% at site 8. That of *Theodoxus, Gammarus, Baetis, Protonemura* was 100%. The frequency of *Perla* was 57.1%, and *Agapetus*, 85.7% at site 1 (source of the stream). *Melanopsis* (100%), *Aphelocherius* (71.4%), and *Onychogomphus* (71.4%) had higher frequencies at site 8 (mouth of the stream). The frequency of *Onychogomphus* was 100% at site 2. The frequency of *Rhyacophyla, Hydropsyche*, and *Diplectrona* was 85.7% and that of *Sericostoma* was 100% at site 4. Chironomidae (gen. sp.) had an 85.7% frequency at sites 4 and 7. The frequency of *Atherix* was 100% at site 2.

Dominance

Tables 5-11 show the dominance of macroinvertebrates. *Baetis* was dominant at site 1, reaching its highest value in May 1992 (43.1%). *Protonemura* (28.6% in May 1992), *Theodoxus* (25.7%

Table 3. Distribution of benthic macroinvertebrates

	SITES						
TAXA	1	2	4	5	6	7	8
Dugesia	*				*	*	*
Theodoxus	*	*	*		*	*	*
Valvata				*	*	*	*
Bithynia		*	*	*	*	*	*
Melanopsis					*	*	*
Lymnaeidae gen. sp.		*					
Radix				*	*	*	*
Gyraulus	*	*	*	*	*	*	*
Ancylus	*	*	*				*
Acroloxus						*	
Pisidium			*		*	*	*
Sphaerium		*	*				*
Hirudinea gen. sp.			*	*			*
Haementeria							*
Erpobdella			*	*		*	
Trocheta			*				
Oligochaeta gen. sp.	*	*	*		*	*	
Naididae gen. sp.			*			*	
Hydracarina				*	*	*	
Ostracoda			*	*	*		*
Palaemonetes					*		*
Gammarus	*		*	*	*	*	*
Baetis	*	*	*	*	*	*	*
Iron	*	*					
Rhithrogena	*	*	*				
Ephemerella		*	*	*	*	*	*
Caenis			*	*	*	*	*
Ephemera					*		
Protonemura	*	*					
Leuctra		*					
Perla	*	*	*				
Calopteryx					*	*	
Platycnemis					*		
Coenagrion					*		*
Aeschna		*	*				
Gomphus		*					
Onychogomphus		*	*	*	*	*	*
Ophiogomphus				*			
Orthetrum				*			
Corixa							*
Aphelocheirus					*	*	*
Gerris	*						
Hydrometra	*						
Mesovelia	*						
Velia	*						
Gyrinus		*					*
Orectochilus			*				
Peltodytes							*
Dytiscus							*
Hydrobius				*			
Hydrophilus		*		*			
Hydrous						*	
Dryops	*						
Elmidae gen. sp. 1		*	*	*		*	*
Elmidae gen. sp. 2	*	*	*				*
Elmis	*	*	*	*		*	*
Limnius	*	*	*	*	*	*	*
Donacia				*			
Rhyacophila	*	*	*			*	
Agapetus	*	*	*				
Hydroptilidae gen. sp.					*		
Oxyethira				*		*	
Hydroptila		*		*	*	*	
Diplectrona	*	*	*	*			
Hydropsyche	*	*	*	*	*	*	*
Cheumatopsyche					*	*	
Polycentropus		*				*	
Cyrnus				*			
Tinodes		*					
Limnephilus					*		
Lepidostoma							*
Leptocerus		*	*				
Sericostoma	*	*	*				*
Liponeura	*	*					
Tipula	*	*	*				*
Pedicia	*	*					*
Dicranota	*	*					
Helius					*		
Psychoda			*	*		*	
Dixa				*			
Simulium	*	*	*	*	*	*	*
Chironomidae gen. sp.	*	*	*	*	*	*	*
Culicoides		*	*		*	*	*
Empididae gen. sp.	*	*	*		*	*	*
Hemerodromia			*				
Chelifera				*			
Tabanidae gen. sp.		*		*		*	
Chrysops				*		*	
Haemotopota			*	*		*	
Tabanus		*		*		*	*
Atherix	*	*	*		*	*	*
Hydrellia					*		*

Table 4. Frequency values of benthic macroinvertebrates at each site.

	FREQUENCY %						
TAXA SITE NO.	1	2	4	5	6	7	8
Dugesia	28,6				16,6	14,3	14,3
Theodoxus	100	14,3	28,6		83,3	42,8	100
Valvata				60	83,3	57,1	100
Bithynia		14,3	28,6	40	83,3	57,1	85,7
Melanopsis					50	42,8	100
Radix				60	50	71,4	85,7
Gyraulus	28,6	42,8	85,7	80	66,6	85,7	85,7
Ancylus	57,1	14,3	57,1				42,8
Acroloxus						14,3	
Pisidium			57,1		33,3	28,6	100
Sphaerium		14,3	14,3				14,3
Hirudinea gen. sp.			28,6	20			42,8
Haementeria							14,3
Erpobdella			28,6	20		14,2	
Trocheta			14,3				
Oligochaeta gen. sp.	28,6	57,1	42,8		16,6	14,2	
Naididae gen. sp.			14,3			14,2	
Hydracarina				20	33,3	28,6	
Ostracoda			14,3	60	33,3		28,6
Palaemonetes					100		42,8
Gammarus	100		71,4	60	83,3	85,7	100
Baetis	100	100	85,7	60	66,6	71,4	71,4
Iron	100	14,3					
Rhithrogena	100	57,1	14,3				
Ephemerella		100	14,3	40	16,6	42,8	42,8
Caenis			14,3	40	66,6	71,4	57,1
Ephemera					16,6		
Protonemura	100	14,3					
Leuctra		14,3					
Perla	57,1	100	85,7				
Calopteryx					66,6	14,3	
Platycnemis					33,3		
Coenagrion					16,6		14,3
Aeschna		42,8	14,3				
Onychogomphus		100	85,7	40	33,3	28,6	71,4
Ophiogomphus				20			
Orthetrum				20			
Corixa							14,3
Aphelocheirus					33,3	28,6	71,4
Gerris	14,3						
Hydrometra	14,3						
Mesovelia	14,3						
Velia	14,3						
Gyrinus		14,3					14,3
Orectochilus			14,3				
Peltodytes							14,3
Dytiscus							14,3
Hydrobius				20			
Hydrophilus		14,3		20			
Hydrous						14,3	
Dryops	14,3						
Elmidae gen. sp. 1		28,6	85,7	20		42,8	57,1
Elmidae gen. sp. 2	42,8	14,3	14,3				28,6
Elmis	42,8	57,1	71,4	40		57,1	57,1
Limnius	57,1	57,1	57,1	20	25	14,3	57,1
Donacia				20			
Rhyacophila	42,8	42,8	85,7			28,6	
Agapetus	85,7	28,6	14,3				
Hydroptilidae gen. sp.					25		
Oxyethira				40		14,3	
Hydroptila		42,8		60	25	28,6	
Diplectrona	14,3	28,6	28,6	40			
Hydropsyche	57,1	85,7	85,7	40	50	85,7	28,6
Cheumatopsyche					25	14,3	
Polycentropus		57,1				28,6	
Cyrnus				20			
Tinodes		28,6					
Limnephilus					25		
Lepidostoma							14,3
Leptocerus		28,6	28,6				
Sericostoma	28,6	42,8	100				28,6
Liponeura	85,7	14,3					
Tipula	28,6	14,3	42,8				28,6
Pedicia	28,6	28,6					14,3
Dicranota	28,6	42,8					
Helius					25		
Psychoda			14,3	20		14,3	
Dixa				20			
Simulium	14,3	14,3	71,4	20	25	42,8	57,1
Chironomidae gen. sp.	57,1	57,1	85,7	60	75	85,7	57,1
Culicoides		14,3	14,3		25	14,3	14,3
Empididae gen. sp.	28,6	14,3	57,1		25	14,3	14,3
Hemerodromia			14,3				
Chelifera				20			
Tabanidae gen. sp.		14,3		20		42,8	
Chrysops				20		14,3	
Haemotopota			14,3	40		14,3	
Tabanus		28,6		40		14,3	14,3
Atherix	57,1	100	85,7		25	42,8	28,6
Hydrellia					25		14,3

Table 5. Dominance values of Benthic macroinvertebrates in April 1992

	DOMINANCE (%)						
TAXA SITE NO	1	2	4	5	6	7	8
Theodoxus	3						7
Valvata							0,2
Melanopsis							32
Radix							0,2
Gyraulus							2,6
Pisidium	0,3						0,6
Hirudinea gen. sp.							0,07
Erpobdella			17,7				
Oligochaeta gen. sp.	0,3	1,6	0,2				
Palaemonetes				8,3	57		
Gammarus	20,4			8,3		88	55,2
Baetis	30,7	5,8	31,2	25,3		0,3	0,5
Iron	22						
Rhithrogena	2,5	0,9	4,9				
Ephemerella		1,9	3,3	8,3		3,2	0,4
Caenis						0,9	0,2
Protonemura	11,4						
Perla	2,7	51	3,3				
Calopteryx					14,4		
Platycnemis					28,6		
Aeschna	0,3	1,6					
Gomphus							
Onychogomphus		0,9		8,3		0,6	0,3
Aphelocheirus						0,2	0,4
Elmidae gen. sp. 1			0,2				0,1
Elmis						0,3	0,1
Rhyacophila	1,3						
Diplectrona			22,8				
Hydropsyche	2,3	13,6				0,2	
Polycentropus		0,3				0,3	
Lepidostoma						0,3	
Sericostoma	0,3	21	15,8				
Liponeura	0,6		0,4				
Tipula	0,3	0,8					0,04
Simulium							0,04
Chironomidae gen. sp.				16,6		2,2	0,01
Tabanidae gen. sp.						3	
Haemotopota				16,6		0,3	
Tabanus							0,04
Atherix	2	0,6	0,2	8,3		0,2	

in July) and *Agapetus* (30% in September 1992) were other dominant genera at site 1. *Perla* was dominant at site 2 in 5 sampling periods and *Baetis* was dominant at site 2 in 2 sampling periods. *Perla* had a maximum value of 60.7% in August 1992 and *Baetis* had a maximum value of 33.1% in February 1993. Other dominant genera were *Sericostoma* with 21% and *Hydropsyhe* with 13.6% at site 2 in April 1992.

The various taxa had different levels of dominance at site 4 in various sampling periods. These taxa were: *Erpobdella* (17.7%), *Diplectrona* (22.8%), and *Sericostoma* (15.8%) in April 1992; Empididae (11.9%) in July 1992; Hydropsyche (39.6%) in August 1992; and *Agapetus* (11.6%) and *Sericostoma* (10%) in April 1993. But *Baetis* (max 33,1% in February 1993), *Simulium*

Table 6. Dominance values of Benthic macroinvertebrates in May 1992

	DOMINANCE (%)						
TAXA SITE NO	1	2	4	5	6	7	8
Theodoxus	6,7		0,1			0,04	2,7
Valvata						0,1	4,6
Bithynia		0,2	0,3			0,1	0,5
Melanopsis						0,1	22,5
Radix						0,1	1,3
Gyraulus			6,5			2,6	
Acroloxus	1		2,3			0,04	
Pisidium			0,4			0,1	2,2
Hirudinea gen. sp.							0,1
Oligochaeta gen. sp.		0,2					
Palaemonetes							0,1
Gammarus	8,2		2,4			94,63	60
Baetis	43,1	18,4	33,57			0,2	0,4
Iron	2						
Rhithrogena	2,5	10,7					
Ephemerella	1,6	4,5				0,45	0,4
Caenis		0,2				0,2	0,7
Protonemura	28,6						
Perla	1,5	47					
Calopteryx							0,1
Aeschna	0,5						
Onychogomphus		1,4	1,4			0,1	0,3
Corixa							1,1
Aphelocheirus						0,04	
Peltodytes							0,1
Dytiscus							0,1
Elmidae gen. sp. 1			0,7			0,04	0,1
Elmidae gen. sp. 2	0,5		1,5				0,1
Elmis	1,1		0,5			0,04	
Limnius	0,3	5,1					
Rhyacophila		1	2,8			0,1	
Agapetus	1						
Hydroptilidae gen. sp.						0,5	
Hydropsyche	0,2	4,3	1,3			0,2	
Lepidostoma							0,1
Sericostoma			4,3				
Liponeura	0,7		0,13				
Tipula			0,3				
Psychoda						0,03	
Simulium	0,2		30,3			0,2	0,1
Chironomidae gen. sp.			8,9				2,4
Empididae gen. sp.			1,8				
Chrysops						0,03	
Haemotopota			0,1				
Tabanus		1,2				0,03	
Atherix	0,3	5,8	0,4			0,03	

(max 30.3% in May 1992), Chironomidae (41.6% in February 1993) had differing dominance values in almost every sampling period.

Gyraulus (90% in August 1992) and Chironomidae gen. sp. (89,4% in February 1993) were the most dominant taxa at site 5.

The various taxa had different dominance values at site 6 in various sampling periods. These taxa were: *Theodoxus* (20.7% in September 1992); *Gammarus* (32 in September 1992); *Melanopsis* (33% in February 1993); *Caenis* (13.3% in February 1993); *Palaemonetes* (57%),

Table 7. Dominance values of Benthic macroinvertebrates in July 1992

TAXA SITE NO	DOMINANCE (%) 1	2	4	5	6	7	8
Dugesia	1,2						
Theodoxus	25,7				1	0,02	24,3
Valvata				0,44	17,4	0,4	3,3
Bithynia				0,9	33	0,23	0,8
Melanopsis						0,02	23,7
Radix				1,2	2,6	1,5	2,2
Gyraulus		0,6	8,1	56,1	27,8	5,4	17,7
Ancylus	0,8		2,9				
Pisidium			0,5			0,2	0,4
Hirudinea gen. sp.							0,1
Hydracarina				3,16			
Ostracoda			0,29	2,8			0,1
Palaemonetes					5,2		
Gammarus	15,7		3,8	0,7	7,8	89,4	26
Baetis	10,4	11,5	17,2		3,5	0,23	
Iron	5,4						
Rhithrogena	0,4						
Heptagenia		1,2					
Ephemerella		5,7		0,1			
Caenis				10,6		1,1	
Protonemura	6,5						
Perla		44,3	1,91				
Platycnemis					1,7		
Onychogomphus		2,3	0,2				
Aphelocheirus							0,8
Gerris	0,8						
Mesovelia	0,8						
Velia	8,8						
Hydrobius				0,9			
Hydrous						0,02	
Elmidae gen. sp. 1						0,12	
Elmis		0,6	0,2	0,1		0,02	0,1
Limnius	0,8	1,7	3,5	1,2			0,5
Rhyacophila			5,5				
Agapetus	21,1						
Oxyethira				0,2			
Hydroptila		1,7		16,8		0,2	
Diplectrona		1,7					
Hydropsyche	0,8	20,1	9,8	2			
Polycentropus		1,7					
Cyrnus				0,7			
Tinodes		1,7					
Sericostoma			9,1				
Liponeura	0,4						
Tipula	0,4			0,1		0,02	
Dicranota		2,9					
Simulium			15,8				
Chironomidae gen. sp.			9,3	1,3		1,1	
Empididae gen. sp.			11,9	0,2			
Chrysops				0,1			
Haemotopota				0,3			
Tabanus				0,1		0,02	
Atherix		2,3					

Calopteryx (14.4%), and *Platycnemis* (28.6%) in April 1992; and Chironomidae gen. sp. (11% in April 1993).

The dominant genus was *Gammarus* (max %92) at site 7 in almost every sampling period. Another dominant taxa was Chironomidae gen. sp. (max 89%) in February 1993. Naididae gen. sp. had a 46% dominance value in April 1993.

Table 8. Dominance values of Benthic macroinvertebrates in August 1992

TAXA SITE NO	DOMINANCE (%) 1	2	4	5	6	7	8
Theodoxus	15,2				13		22,5
Valvata				5,6	9,4	1,7	11
Bithynia				0,3	6,8	1,7	1,3
Melanopsis					17,1		11,1
Radix				3,1	0,8	3,1	3,3
Gyraulus			11,3	90	11,3	12,2	44,4
Ancylus	2,6						0,1
Pisidium							0,4
Hirudinea gen. sp.			10	0,1			
Oligochaeta gen. sp.		0,2					0,1
Hydracarina					0,6	0,3	0,3
Ostracoda				0,1			
Palaemonetes					3,8		0,1
Gammarus	21		0,3	0,1	23	52	4,8
Baetis	39,1	11	19		1,5	0,3	
Iron	0,2						
Rhithrogena	0,7						
Ephemerella	0,5	2,7					
Caenis		0,4			0,5	0,7	
Protonemura	8,7						
Perla		60,7	0,8				
Calopteryx					0,2		
Coenagrion					0,2		
Gomphus		0,2					
Onychogomphus		0,4	0,5	0,5	0,2		
Aphelocheirus					0,3		0,4
Gyrinus			0,3				
Elmidae gen. sp. 1			4,2				
Elmis	0,5				0,3		
Limnius	0,9	1,6				0,1	0,1
Rhyacophila	0,2		6,6				
Agapetus	5,1	0,2					
Hydroptilidae gen. sp.				0,1	0,8		
Hydroptila	0,9	1,7		0,1			0,1
Diplectrona							
Hydropsyche		7	39,6		9,5	0,4	
Cheumatopsyche					0,2		
Polycentropus		0,2					
Leptocerus		0,2					
Sericostoma	0,2	3,1	2,9				
Liponeura	1,2						
Pedicia	0,2	0,8					
Dicranota		0,8					
Chironomidae gen. sp.	2,6	8,4	2,1		0,5	27,5	
Empididae gen. sp.	0,2						
Atherix		0,4	2,4				

The various taxa had different dominance value at site 8 in various sampling periods. These taxa were *Dugesia* (15% in September 1992), *Valvata* (11% in August 1992), *Theodoxus* (24.3% in July 1992), *Melanopsis* (32% in April 1992), *Gyraulus* (44.4% in August 1992), *Gammarus* (60% in May 1992), and Chironomidae (77.2% in February 1993).

Diversity and Similarity

The highest diversity was calculated as 2.06 at site 1 in July 1992. The lowest diversity value was 1.48 in February 1993. The highest diversity value for site 2 was

Table 9. Dominance values of Benthic macroinvertebrates in September 1992

	DOMINANCE (%)						
TAXA SITE NO	1	2	4	5	6	7	8
Dugesia	0,8				0,8	2,4	15
Theodoxus	13				20,7	1,2	16,7
Valvata				14,6	6,5	2	10,8
Bithynia			0,1		8,9	0,1	2,2
Melanopsis					7,7	1,1	13,5
Radix				22,7	0,8	5,2	3,5
Gyraulus	0,2	0,8	12,3	58,7	5	4,2	13
Ancylus	4,3		0,9				0,1
Pisidium			0,4				1,6
Sphaerium							0,04
Hirudinea gen. sp.			4				
Haementeria							0,04
Oligochaeta gen. sp.	0,7						0,04
Ostracoda				0,3			
Palaemonetes					14		0,5
Gammarus	16		1,1		32	82	21,52
Siphlonurus					1,2		
Baetis	19,8	12,5	16,5	0,3			0,5
Iron	0,2						
Rhithrogena	5,9						0,04
Heptagenia		0,5					
Ephemerella	0,2	4,1					
Caenis		1	0,2	0,6	0,4		0,3
Protonemura	4,3						
Leuctra		2,6					
Perla	0,6	46	0,1				
Calopteryx					0,4	0,1	
Coenagrion							0,04
Aeschna	0,8	2,1					
Onychogomphus		2,6	0,04				
Ophiogomphus				1			
Orthetrum				1,3			
Aphelocheirus					0,4	0,6	0,1
Gerris		0,5					
Hydrophilus		0,5					
Elmidae gen. sp. 1		12	2,5	0,1			
Elmidae gen. sp. 2	0,2						
Elmis		1	2,2			0,1	0,1
Limnius	0,2	0,5	0,04		0,4		0,3
Helodidae gen. sp.							
Rhyacophila	0,2	0,5	0,4				
Agapetus	30						
Oxyethira				0,3		0,1	
Hydroptila		1				0,2	
Hydropsyche		2,6	13		0,4	0,1	0,04
Polycentropus		1,5					
Limnephilus					0,4		
Sericostoma			0,1				
Liponeura	0,6						
Tipula						0,1	
Pedicia		4,2					0,04
Dicranota	0,2						
Simulium			22,78				
Chironomidae gen. sp.	1,8	1	22			0,5	
Culicoides			0,2				
Empididae gen. sp.			1,1				
Tabanus		1		0,1			
Atherix		1,5	0,04				

Table 10. Dominance values of Benthic macroinvertebrates in February 1993

	DOMINANCE (%)						
TAXA SITE NO	1	2	4	5	6	7	8
Theodoxus	0,5		0,2		19		0,5
Valvata					0,4		1,1
Bithynia					0,8		0,2
Melanopsis					33		1,5
Radix				0,1		0,2	0,2
Gyraulus			9,4	1		0,5	1,3
Ancylus	2,4		0,4	0,1			
Pisidium					0,4		0,2
Sphaerium			0,4				
Erpobdella				0,2			
Trocheta			1,9				
Oligochaeta gen. sp.			1,1				
Naididae gen. sp.							0,5
Palaemonetes					7,9		
Gammarus	3,3		0,2		20,7	2,2	4,6
Baetis	41	33,1	33	5,3	1,8	2,5	4,6
Iron	39	0,6					
Rhithrogena	5,7	5,3					
Ephemerella	0,9	5,3				0,5	2,6
Caenis				0,2	13,3	1,7	
Ephemera					0,2		
Protonemura	0,5	0,6					
Perla		16,5	0,8				
Calopteryx					0,2		
Aeschna		0,6					
Onychogomphus		1,2	0,4				
Gyrinus		1,2					0,2
Orectochilus			0,2				
Elmidae gen. sp.			0,2				0,2
Elmis		0,6	0,6	0,6			0,2
Limnius			0,2				0,2
Donacia				0,1			
Rhyacophila		0,6	1,5				
Agapetus	1,4	0,6					
Hydroptila				0,1			0,4
Diplectrona	0,5	1,2		0,2			
Hydropsyche	0,5	4,7	2,4	0,5		0,2	0,7
Cheumatopsyche						0,2	0,2
Tinodes		1,2					
Leptocerus		0,6	0,2				
Sericostoma		5,9	2,2				0,4
Liponeura	3,3	1,2					
Tipula			0,2				
Dicranota		1,8					
Helius					0,2		
Psychoda				0,1		0,6	
Dixa				0,1			
Simulium		1,8	1,9	7,3		1,7	2,6
Chironomidae gen. sp.	0,5	14,2	41,6	83	2,1	89	77,2
Culicoides		0,6					
Hemerodromia			0,4				
Chelifera				0,1			
Tabanidae gen. sp.				1		0,5	
Atherix	0,5	0,6	0,6			0,2	0,4

Table 11. Dominance values of Benthic macroinvertebrates in April 1993

TAXA SITE NO	DOMINANCE (%) 1	2	4	5	6	7	8
Theodoxus	0,5	4,7			11		0,7
Valvata					2,6		3,3
Bithynia					3,4		0,4
Melanopsis					22		7,6
Lymnaeidae gen. sp.		4,7					
Gyraulus	0,5	0,7	6,5		1,6	1,6	2,7
Ancylus			0,8				0,2
Pisidium			0,6		1,6		2
Sphaerium		0,7					
Erpobdella			2,6			0,8	0,2
Oligochaeta gen. sp.		1,3	1,7		1,3	1,6	1,6
Naididae gen. sp.			6,9			46	4,3
Hydracarina					0,2		
Ostracoda							0,4
Palaemonetes					5		
Gammarus	4,4				15,3		19,2
Baetis	3,3	1,3	1,5		2,9		1,1
Iron	54,6						
Rhithrogena	1,1	0,7					
Ephemerella		4,7	3,3		0,3		1,1
Caenis					13,3		0,7
Protonemura	4,9						
Perla	0,5	51,7	3,5				
Aeschna			0,2				
Onychogomphus		9,4	3,7		0,3		0,2
Aphelocheirus							0,4
Dryops	0,5						
Elmidae gen. sp. 1		12	1,7			0,4	0,4
Elmidae gen. sp. 2		2			0,3		
Elmis	0,5	1,3	1		0,5		
Limnius			1,7				
Rhyacophila			1,3			0,8	
Agapetus	15,5		11,6				
Hydroptila					1,3		
Diplectrona			0,2				
Hydropsyche			3,5			0,8	
Cheumatopsyche							0,4
Polycentropus						0,4	
Leptocerus			15				
Sericostoma			10				0,2
Liponeura	6,1						
Tipula			0,6				0,2
Pedicia	0,5						
Dicranota	2,7						
Psychoda			0,2				
Simulium			3,9		2,6	0,4	1,1
Chironomidae gen. sp.	2,2	0,7	15,2		11	38,6	49,6
Culicoides		0,7			0,3	0,4	0,2
Empididae gen. sp.		0,7	2,2		0,3	4,1	1,6
Tabanidae gen. sp.		0,7				4,1	
Atherix	2,2	2	0,6		0,5		0,2
Hydrellia					2,4		

2.5 in April 1993. The lowest value was 1.51 in April 1992. The highest diversity at site 4 was 2.69 in April 1993 and the lowest diversity was 1.61 in August 1992. The highest diversity was 2 at site 5 in April 1992 and the lowest diversity was 0.75 in February 1993. The highest diversity at site 6 was 2.35 in April 1993 and the lowest diversity was 0.96 in April 1992. The highest value for site 7 was 1.47 in April 1993 and the lowest value was 0.49 in May 1992. The highest diversity was calculated as 2.1 at site 8 and the lowest diversity was calculated as 1.1 in February 1993. The diversity values was indicated slight and moderate pollution in all sites.

The similarity between sampling sites was calculated by using the data of April 1993. The highest similarity between sites 4 and 8 was 0.63. The highest similarity of site 2 with site 6 was 0.56. The similarity value between site 7 and 8 was 0.5 (Table 13, Figure 1)

Table 13. Similarity of collecting sites.

Site	1	2	4	6	7	8
1	1	0,46	0,37	0,36	0,14	0,24
2		1	0,5	0,56	0,48	0,5
4			1	0,45	0,51	0,63
6				1	0,33	0,68
7					1	0,5
8						1

Biotic index

The biotic index (De Pauw and Vanhooren 1983) (5) was applied for the first time to a running water in Turkey (2,3) (Table 12). The results of the biotic index and the physico-chemical characteristics of sites were concordant.

Table 12. Biotic index values for each site.

Station No	SITE	April 1992	May 1992	July 1992	August 1992	Sept. 1992	Feb. 1993	April 1993
1	Source of Yuvarlakçay	9	9	9	10	10	9	9
2	Yuvarlakçay Before Fish Farm	9	9	9	9	10	10	9
4	Yuvarlakçay After Fish Farm	8	8	8	8	9	9	9
5	Yuvarlakçay Before Nasıfdede	5	-	8	6	7	7	-
6	Nasıfdede	4	-	5	7	7	6	8
7	Yuvarlakçay After Nasıfdede	7	8	7	6	7	6	6
8	Mouth of Yuvarlakçay	8	8	6	7	9	9	8

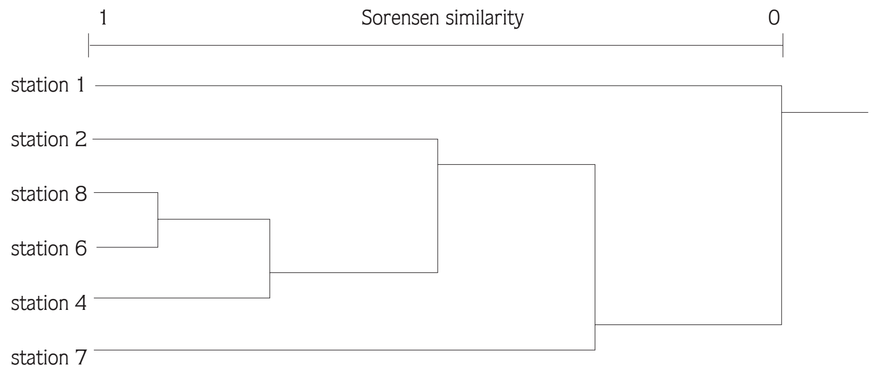

Figure 1. Dendogram prepared by the Sorensen similarity quotient.

Class	Biotic index	Significance
I	10-9	lightly or unpolluted
II	8-7	slightly polluted
III	6-5	moderately polluted critical situation
IV	4-3	heavily polluted
V	2-0	very heavily polluted

The biotic index values for sites 1 and 2 were 9-10, which indicate lightly or unpolluted water. These sites are near the source of the stream and their water quality was high. The biotic index values for site 4 were 8-9. The value 8 represents slightly polluted water, class II. The reason for this slight pollution was waste water from a salmon aquaculture site. The biotic index values for site 5 were between 5 and 8. These values denote class II and III water quality. Class II is slightly polluted and class III indicates moderately polluted water and a critical situation. The water quality of this site was affected by domestic waste water discharges from villages, polluted water from agricultural areas and waste water from a salmon aquaculture site. The biotic index values for site 6 were between 4 and 8, classes IV-II. Class IV indicates heavily polluted water. This site was affected by domestic waste water discharges from villages. The biotic index value showed that organic pollution stress affected the benthic macroinvertebrate composition continuously at this site. The biotic index values for site 7 (after the Nasıfdede Branch which was the most polluted site) were between 6 and 7, which denotes class II and class III. The water quality of site 7 decreased due to the discharge of Nasıfdede Branch. The biotic index values for site 8 were between I and III. The water quality of this site at the mouth was higher than at site 7 due to the effect of groundwater sources.

Discussion

Eight sampling sites were selected, from the source to the mouth of Yuvarlakçay stream, including 2 sites on lateral branches. The water quality of the downstream sites was lower than that of the upstream sites due to the effect of mixohaline water from Lake Köyceğiz, waste water from a salmon aquaculture site, domestic waste water discharge from villages and polluted water from agricultural areas. However, the pollution was not at a high level according to physico-chemical data (11). Site 1 was located at the source of Yuvarlakçay Stream and the species diversity was generally lower than at the downstream sites. The explanation for the low species diversity at the source is the absence of transportation of detritus from the upper reaches, limiting the diversity and quantity of available food. In general, stoneflies, mayflies, and caddisflies are intolerant of organic pollution (12). However, not all genera of caddisflies are intolerant to pollution. The caddisflies *Cheumatopsyche* and *Hydropsyche* have been found in organically polluted water (12). Genera which are indicators of high water quality, like *Iron, Rihthrogena, Protonemura, Perla, Limnius,* and *Liponeura* existed at site 1 with high frequency. The biotic index value at this site was also high (class I). The second site had the highest diversity value of all the sites. The reason for the high diversity value was the high water quality. The biotic index value was class I. The population density of collectors like Baetidae, Heptageniidae, and Hydropsychidae, and of predators like

Perla, Aeschna, and *Onychogomphus* increased at this site. Site 3 was the waste water of the salmon aquaculture site discharged into Yuvarlakçay Stream. The water quality at site 3 was low due to the high values of N-NO_2 (max 0.1 mg/l), N-NH_4 (max 0.32 mg/l) and pH (max 8.9). The water quality at site 4 was lower after this waste water discharge for every month. The population density of Hirudinea and Mollusca genera were high at this site, but these genera were absent at site 2 before the waste water discharge with rich organic materials. According to Hynes (12), the taxa commonly remaining in organically polluted zones are *Tubifex,* Tendipedidade, *Asellus* and *Erpobdella, Glossiphonia,* and *Helobdella* from Hirudinea. The biotic index value was lower than site 1 and was class II.

Gyraulus was the most frequent genus at site 5. This genus was the dominat (90%) species, especially when the level of water decreased and filamentous algae increased. Chironomidae was the dominant group when the water level increased in February 1993. The biotic index values was between class II and class III. According to Glazier (13), Molluscs and Triclads dominate in hard water limestone springs and more generally in hard permanent waters. N-NO_2 was determined at site 6 in every collecting period. The abundant species was *Palaemonetes antennarius,* which was resistant to the organic pollution and high salinity. The biotic index value for site 6 was the lowest, between II and IV. *Melanopsis* and *Theodoxus* were the abundant Mollusca species. *Calopteryx* had a frequency value of 66% and this genus existed only at sites 6 and 7. The total hardness was high (max 64 meq/l) at site 6 and so the Mollusca species and *Gammarus* were dominant. The biotic index values for all sites were in accordance with the changes in physico-chemical findings.

The water quality was higher at site 8 due to freshwater groundwater sources at this mouth site. This was reflected in the biotic index values, between I and II, except for July 1992 (class III).

Conclusions

The Köyceğiz-Dalyan region is an important, specially protected area due to the high biological diversity in the eastern Mediterranean region (14). The complex aquatic ecosystem in this region has special value (2,3,6,15,16). The center of the aquatic ecosystem is the meromictic Lake Köyceğiz, comprising of waters of both thermal and cold-karstic origin. The lake is principally fed by surface flow and groundwater recharge. Cold karstic waters include streams and springs. Yuvarlakçay is the most important cold-karstic water source for the lake, especially for the mixolimnion layer. Therefore, determination of water quality and monitoring with physico-chemical and biological methods is necessary for the protection of meromictic Lake Köyceğiz. A monitoring programme for Yuvarlakçay Stream based on the results of this study would be a guide for future protection activities.

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References

1. Girgin, S. & Kazancı, N., Researches on inland waters of Turkey I. Evaluation of water quality of Ankara Stream using physico-chemical and biological parameters. 1994 Özyurt Printing House, 184 pp. Ankara (in Turkish with English summary)
2. Kazancı, N, Girgin, S., Dügel, M.,& Gökçe, D. Researches on inland waters of Turkey II. Biotic index method for assesment of environmental quality of running waters. 1997 Özyurt Printing House, 100 pp Ankara (in Turkish with English summary).
3. Kazancı, N. & Dügel, M. Aquatic insects of the Köyceğiz-Dalyan nature reserve area with their usage for evaluation of environmental quality of running waters. 1996 XX. Int. Congress of Entomology Floransa, Italy.
4. Kazancı, N. Protection of Environment and Nature in Köyceğiz-Dalyan. Final Report of Hydrobiology Subproject (GTZ). Darmstadt, 1993 229 pp.
5. De Pauw, N. & Vanhooren, G. Method for biological quality assessment of watercourses in Belgium. Hydrobiologia. 100: 153-168, 1983.
6. Bayarı, S., Kazancı, N., Koyuncu, H., Çağlar, S. S., & Gökçe, D. Determination of the origin of the waters of Köyceğiz Lake, Turkey. J. Hydrology. 166: 171-191, 1994.
7. Solorzano, L., M. J. McGreery, Determination of ammonium in neutral waters by the phenylhypochlorite method. Journal of Limnology and Oceanography, 14: 799-801, 1969.

8. Snel, F.D., C.T. Snel, Colorimetric methods of analysis, Vol II 3rd ed., D. Van Nostrand Company Inc., New Jersey, Toronto, New York, London, 1957.

9. Mohr, F. R. Die Bestimmung der Halogenidionen in neutralen Lösungen löslicher Halogenide. In: G. Jander, H. J. Jahr,, H.Knoll (Eds.), Ma analyse, Ed. 221/221a 1969: 224-226. Berlin, 1856.

10. Krebs, C. J. Ecological methodology, 1989 Harper and Raw Publishers, N.Y., 654 pp.

11. Council of Environment The Book of Instruction of Water Pollution. 1988, Ankara, Turkey.

12. Hynes, H. B. N The biology of polluted waters. Liverpool Univ.Press, Liverpool. 202 p., 1960.

13. Glazier D. S. The fauna of North American temperate cold springs: patterns and hypotheses. Freshwater. Biol. 24: 527-542, 1991.

14. Kazancı, N. Odonata of the Köyceğiz-Dalyan Nature Reserve area in South Western Turkey, with *Lindenia tetraphylla* (Vander L.) New to the Turkish fauna (Anisoptera: Gomphidae). Notul Odonatol. 4: 105-106, 1995.

15. Kazancı, N., Plasa, R., Neubert, E. & Izbırak, A. On the limnology of Lake Köyceğiz (SW Anatolia). Zoology in the Middle East 6:109-126, 1992.

16. Kazancı, N., Izbırak, A., Çağlar, S. S. & Gökçe, D. A Hydrobiological research on Köyceğiz-Dalyan Specially Protected Area, 1992 Özyurt Printing House, Ankara. 160 pp. (in Turkish with English summary).