BOLU ABANT IZZET BAYSAL UNIVERSITY
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

DETERMINING ECOLOGICAL FACTORS ON OSTRACODA SPECIES IN MALATYA (TURKEY)

MASTER OF SCIENCE

FİLİZ BATMAZ

BOLU, JULY 2018

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APPROVAL OF THE THESIS

DETERMINING ECOLOGICAL FACTORS ON OSTRACODA SPECIES IN MALATYA (TURKEY) submitted by **Filiz BATMAZ** in partial fulfillment of the requirements for the degree of **Master of Science** in **Department of Biology, The Graduate School of Natural and Applied Sciences of ABANT IZZET BAYSAL UNIVERSITY in 02/07/2018** by

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Graduation Date :

Doç. Dr. Ömer ÖZYURT ………………………………

Director of Graduate School of Natural and Applied Sciences

to my beloved family

and

supportive friends

DECLARATION

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Filiz BATMAZ

ABSTRACT

DETERMINING ECOLOGICAL FACTORS ON OSTRACODA SPECIES IN MALATYA (TURKEY)

MSC THESIS
FİLİZ BATMAZ
ABANT IZZET BAYSAL UNIVERSITY GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
DEPARTMENT OF BIOLOGY
(SUPERVISOR: PROF. DR. OKAN KÜLKÖYLÜOĞLU)

BOLU, JULY 2018

This study aimed to understand ecological effective on non-marine ostracod species in Malatya. Present study includes of 125 different water bodies randomly sampled from Malatya during 3-10 August 2015. Total of 25 living non-marine species (*Candona neglecta, Cyclocypris ovum, Cypria ophtalmica, Cypridopsis vidua, C. lusatica, Herpetocypris brevicaudata, H. intermedia, Heterocypris incongruens, H. rotundata, H. salina, Ilyocypris bradyi, I. brehmi, I. gibba, I. inermis, Isocypris beauchampi, Limnocythere inopinata, Potamocypris fulva, P. unicaudata, P. variegata, P. villosa, Prionocypris zenkeri, Pseudocandona albicans, Psychrodromus fontinalis, P. olivaceus, Trajancypris clavata*) were recorded and 24 of them were the new report for province. The most common species was *I. bradyi* and it collected from 24 sampling sites from all type of habitats. *C. lusatica* was found the first time in Turkey. Canonical corresponded Analyses (CCA) was applied to see correlation between species and ecological variables. The first two axes of CCA explained 66.1% relationship and most effective variables were salinity, water temperature and chloride on ostracods. C2 statistical analyses was applied to determine 15 species' (with 3 or more occurrences) tolerance/optimum value for 20 variables. UPGMA analyses showed 5 clustering group within 15 species. According to the results, ostracod species with relatively wide geographical ranges tend to show wide ecological tolerance ranges corresponding to a reduction to their optimum estimates.

KEYWORDS: Ostracoda, Ecology, Tolerance, Optimum, CCA, C2

ÖZET

MALATYA (TÜRKİYE) İLİNDEKİ OSTRAKODA TÜRLERİ ÜZERİNDE EKOLOJİK FAKTÖRLERİN BELİRLENMESİ

YÜKSEK LISANS TEZI
FİLİZ BATMAZ
ABANT İZZET BAYSAL ÜNİVERSİTESİ FEN BİLİMLERİ ENSTİTÜSÜ BIYOLOJI ANABILIM DALI
(TEZ DANIŞMANI: PROF. DR. OKAN KÜLKÖYLÜOĞLU)

BOLU, TEMMUZ - 2018

Bu çalışma Malatya'daki tatlısu ostrakodları üzerinde etkili olabilecek ekolojik faktörleri belirlemeyi amaçlamıştır. Çalışma sürecinde 3-10 Ağustos 2015 tarihleri arasında Malatya'dan 125 farklı su kütlesinden rastgele örnekleme yapılmıştır. Toplanan 25 tatlısu türünden (*Candona neglecta, Cyclocypris ovum, Cypria ophtalmica, Cypridopsis vidua, C. lusatica, Herpetocypris brevicaudata, H. intermedia, Heterocypris incongruens, H. rotundata, H. salina, Ilyocypris bradyi, I. brehmi, I. gibba, I. inermis, Isocypris beauchampi, Limnocythere inopinata, Potamocypris fulva, P. unicaudata, P. variegata, P. villosa, Prionocypris zenkeri, Pseudocandona albicans, Psychrodromus fontinalis, P. olivaceus, Trajancypris clavata*) 24 tanesi bölge için yeni kayıttır. *I. bradyi* 24 farklı istasyondan ve her tip habitattan toplanması dolayısıyla en yaygın türdür. *C. lusatica* Türkiye'de ilk kez bulunmuştur. Türlerin ekolojik veriler arasındaki ilişkiyi görmek için Kanonik İlişki Analizi (CCA) analizi yapılmıştı. CCA'nın ilk iki ekseni ilişkinin %66.1'ini açıklamış ve en etkili etmenler tuzluluk, su sıcaklığı ve klörür olarak bulunmuştur. 15 türün (3 ve daha fazla istasyonda bulunan) 20 veriye olan tolerans ve optimum değerlerini bulmak için C2 analizi yapılmıştır. UPGMA analizi sonucunda 15 tür 5 farklı gruba ayrılmıştır. Sonuçlara göre geniş ekolojik dağılıma sahip ostracod türleri, optimum değerleri indirgenirken tolerans aralıklarında genişleme eğilimi göstermektedir.

ANAHTAR KELİMELER: Ostrakoda, Ekoloji, Tolerans, Optimum, CCA, C2

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LIST OF ABBREVIATIONS AND SYMBOLS

A1	**:** First Antenna
A2	**:** Second Antenna
Md	: Mandibula
Mx	: Maxillula
T1	: First thoracopod
T2	: Second Thoracopod
T3	: Third Thoracopod
DO	**:** Dissolved Oxygen (mgL^{-})
EC	**:** Electrical Conductivity (μScm^{-})
TW	**:** Water Temperature (^{o}C)
ORP	**:** Oxidation Reduction Potential (mV)
ATM	**:** Athmospheric Pressure (mmHg)
EL	**:** Elevation (m a.s.l.)
SAL	**:** Salinity (ppt)
ToP	**:** Total Phosphate ($mg\ kg^{-}$)
InP	**:** Inorganic Phosphate ($mg\ kg^{-}$)
OrgP	**:** Organic Phosphate ($mg\ kg^{-}$)

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1. INTRODUCTION

1.1 Ostracoda

Ostracods are very tiny crustaceans which are mostly 0.3 - 5 mm long. They can be found in almost all kind of aquatic habitats from marine to non-marine (sometimes in semi-terrestrial and rarely terrestrial environments). There are more than 65 000 living and fossil ostracods described so far and more than 2 000 of them are non-marine ones (Ikeya et al., 2005).

The name Ostracoda comes from Greek word ‘ostrakon’ which means “shell” or “tile” (Meisch, 2000). Linne was the first to describe one of the Ostracoda in 1746 as *Monoculus conchapedata* (Ferguson, 1944). However the name of Ostracoda was firstly used in 1802 by P. A. Latreille .

Ostracods are the oldest known micro fauna due to their calcitic shell present. The oldest fossil presentative was reported from ca. Cambrian period (about 500 mya) marine sediments (Delorme, 1991).

The class of Ostracoda are subdivided into 2 subclasses (Podocopa and Myodocopa) and 5 orders. The Subclass Podocopa consists of Orders Podocopida, Platycopida and Paleocopida whereas the other subclass Myodocopa consist of 2 orders Myadocopida and Halocyprida (Horne et al., 2002; Horne, 2003). Living ostracods are subdivided into 3 main lineages as orders: Platycopida, Myodocopida and Podocopida while Platycopida and Myodocipida includes only marine species, the Podocopida includes marine, brackish and freshwater species (Meisch 2000). Since non-marine ostracods are involved in Order Podocopida, we will be only interested in this group (Figure 1.1).

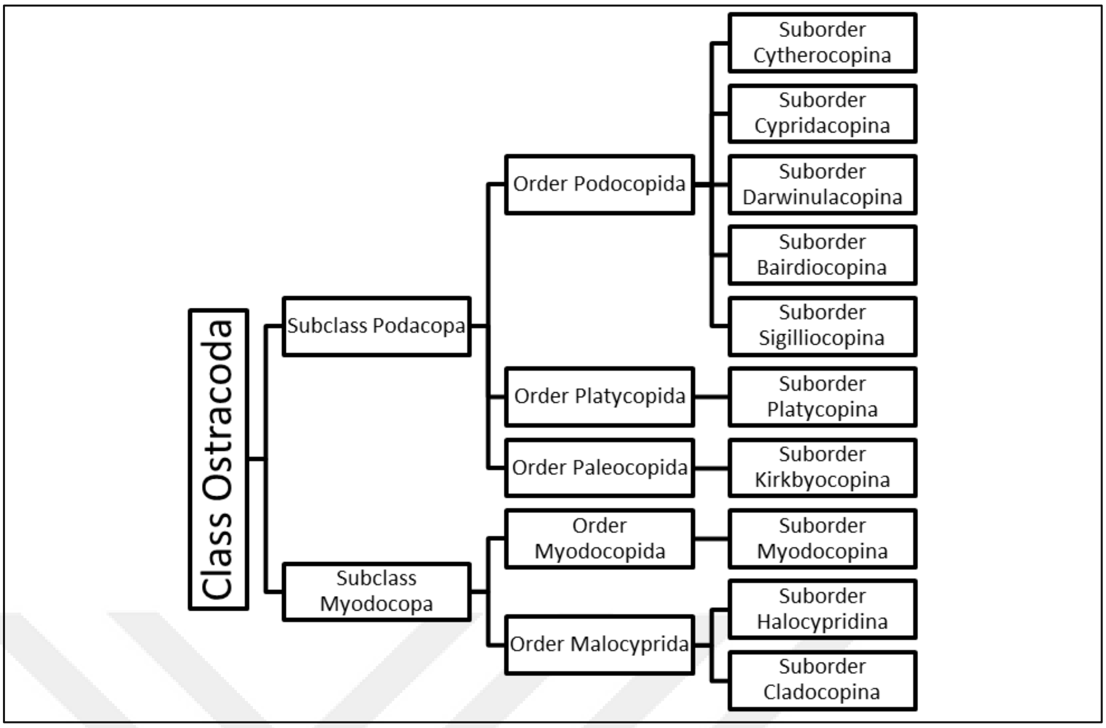

Figure 1.1. Class Ostracoda classification arranged from Meisch (2000).

1.1.1 Ostracod Morphology

Ostracod body enclosed within carapace which is commonly used diagnostic character. Carapace consists of two valves connected to each other at dorsal side with a structure called “hinge”. The closed carapace protects the body like armor from predation and habitat destructions (Meisch, 2000). Ostracod shell structure formed by chitinious and a low magnesium calcite. The outer side of shell may be different structures like tubercules, nodes, pores and spines which important for ostracod activities and taxonomic description (Delorme, 1991). Ostracod shells connect the body with adductor muscles which are provides the carapace movements (opening and closing). These muscles leave scars on the carapace and that scars also have a huge role for taxonomic description (e.g. like rosette in Darwinuloidea) (Meisch, 2000).

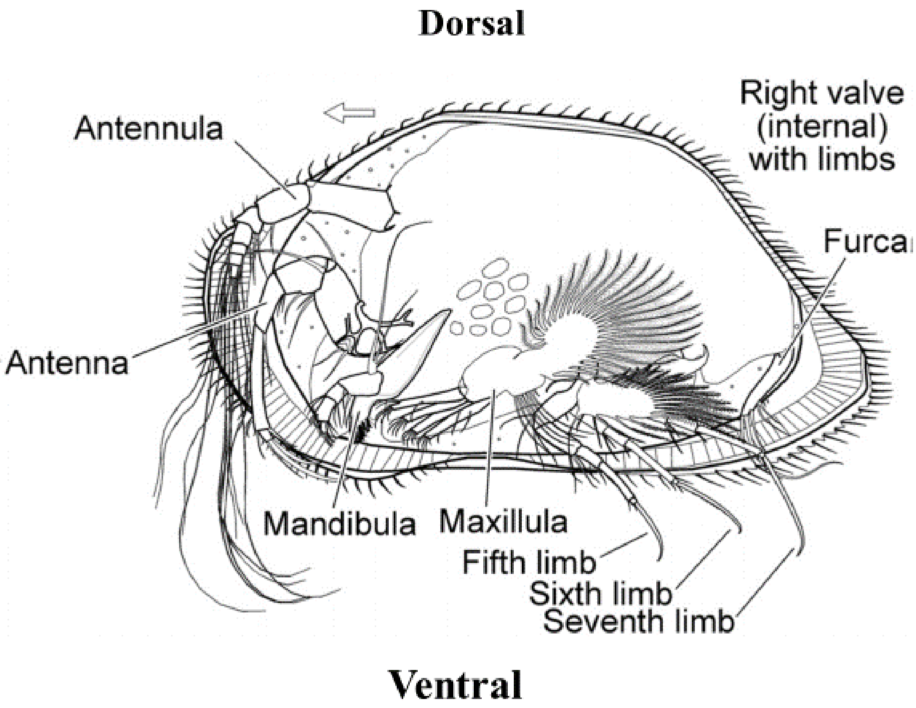

Figure 1.2 Ostracod morphology modified from Rodrigeuez-Lazzaro and Luiz Munoz (2012) (The arrow shows the anterior side).

When we look at on ostracod, we can see a closed carapace, some appendage pairs and a pair of median eyes. Inside the carapace, there is no clear segmentation on the ostracod body like the other Arthropods, but head and abdomen are obvious (Figure 1.2). Eight pairs of appendages (Table 1.1) are developed in an adult ostracod including Antennula (A1), Antenna (A2), Mandibula (Md), Maxillula (Mx1), First Thoracopod (T1 or L5), Second Thoracopod (T2 or L6), Third Thoracopod (T3 or L7) and Uropodal Ramus (furca) (Delorme, 1991, Meisch, 2000). Each appendage is important for taxonomic distinction of ostracod species.

Table 1.1 Ostracod appendages and their functions modified from Meisch (2000).

Member	Function
A1	swimming, crawling and sensory
A2	swimming, crawling and sensory, copulation and feeding
Md	feeding
Mx1	feeding and respiration
T1 or L5	feeding, copulation or walking
T2 or L6	walking
T3 or L7	cleaning, walking or climbing
Furca or Uropod	locomotion, copulation

Similar the other Crustaceans, ostracods are growing by moulting and this process called ecdysis. There are eight moult between egg and adult (A1, A2, A3, A4, A5, A6, A7, A8 and A). The last moulting (A) is the first sexually matured stage (Ozawa, 2013).

Freshwater ostracod eggs have some characteristics to allow it from desiccation and freezing, which are being double walled and a special fluid between in these walls. Some Ostracod species delay their hatching and spread over long period. This process calls 'resting eggs' and that for protect eggs from environmental threats. (Delorme, 1991)

Ostracods have bisexual and parthenogenetic (asexual) populations but some species are known to have mixed populations. According to Meisch (2000) four different reproductive modes can be seeing on ostracods. 1. Fully sexual reproductions. 2. Mixed reproduction which is includes a) bisexual populations with sexual reproduction, b) bisexual populations with mixed reproduction; they consist of diploid females and diploid males, diploid parthenogenetic females and triploid off-spring females. 3. Fully parthenogenetic reproduction. 4. Ancient asexuals with parthenogenesis.

1.1.2 Ecology and Distributions

Ostracods can be defined as the most abundant invertebrate taxon (Rosati et al. 2014). They are found in all kind aquatic habitat. Marine and non-marine waters, terrestrial and semi-terrestrial habitats (Külköylüoğlu and Vinyard, 2000), temporary and permanent ponds, lakes, streams, hot thermal waters (Laprida et al., 2006), ditches, canals, caves (Yavuzatmaca et al., 2012), fens and even moist organic mats of fens and in axial cups of certain plants such as bromeliads (Delorme, 1991, Meisch, 2000). They can be predators, herbivores, omnivores and dentritivores in aquatic ecosystem (Horne, 2003). They are considered as generalist since they can feed on various kind of food which are algae, organic detritus, living and dead plants, living and dead animals, fish food. Even some of organisms use ostracod as their host. Many ostracod species compete with oligochaetes and amphipods for food source in their habitat and many of them predated by fishes or gastropods (Ruiz et al. 2013)

Ostracoda has broad range of geographical distribution. They can be encountered on every zoogeographical zones and every layer of aquatic habitats. More than 200 years of research almost 65 000 living and fossil species have been recorded (Ikeya et al. 2005). According to Martens et al. (2008) 90% of ostracods regionally/locally endemic and the Palaearctic region has the highest ostracod diversity with 702 species (Figure 1.3).

There are pelagic ostracods too (swimming short distance) but most ostracods are benthic, crawling over or burrowing beneath the sediment (Delorme, 2001). Broad distribution of Ostracoda, because of their different transport ways. They can be transported by passive (wind, plants, insects, amphibians, fishes, birds, human activities) or active way (with their developed antenna (A2)) (Danielopol et al., 1994).

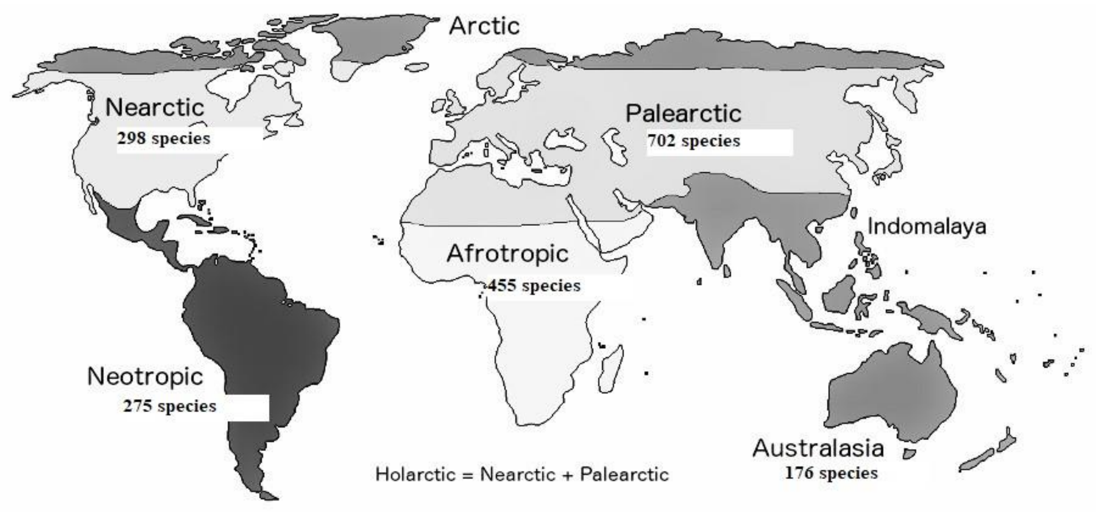

Figure 1.3 Zoogeographical distribution of freshwater ostracods, arranged from Martens et al. (2008).

Some scientist have propose to some factors to Ostracod distribution. Ruiz et al. (2013) had pointed that, salinity is the key factor of ostracod distribution. Heip (1976) put forward that positive correlation between temperature and ostracod population growt. Mesquita-Jones et al. (2012) had pointed that temperature is a main factor for ostracod growth and survival. Smith (1992) has indicated that ostracod diversity in lakes related to ion concentrations which are calcium, sulphate and bicarbonate.

Most of ostracod can be used as bioindicator species due to their sensitivity of environmental changes. Every ostracod species reacts differently to change of biotic and abiotic factors on their environment and each species prefers different ecological conditions or bring about some changes their assemblages (Frenzel and Boomer 2005). So, every species has their own tolerance range. Some of species has broad distribuyion on zoogeographical zones which call as cosmopolitan species, some of them has narrow distribution and they call as non-cosmopolitan species. Cosmopolitan species can recolonize easily to a new environment. Some species have wide tolerance to different environmental variables which can be called as euryoecious. As mentioned on Külköylüoğlu (2007) there are species the combination of two terms (cosmopolitan and euryoecious) that kind of species have broad tolerance range for environmental variables and have a large geographical distribution. He named this type species as cosmocious.

According to Külköylüoğlu (2004) cosmopolitan species can make artificial richness for aquatic habitats. When the water quality of habitat decreased cosmopolitan species tend to increase and native species occurrence getting lower. This phenomenon called as pseudorichness and it measured with ratio of cosmopolitan/non-cosmopolitan.

1.2 History of Freshwater Ostracod Studies in Turkey

Studies about Ostracoda in Turkey started with a German scientist. H.W. Schäfer was the first scientist who reported non-marine ostracods (*Ilyocypris brehmi, Cypris pubera, Eucypris pagasti, Heterocypris barbara, Stenocypris fischeri, Potamocypris arcuata* and *Zonocypris inconspicua*) in 1952. After him another German scientist G. Hartman (1964), studied about ostracods in Anatolia.

The first Turkish scientist who studied about non-marine ostracods was Dinçer Gülen (1975). He pioneered for Turkish Ostracodologists. His support of ostracod topic continued with his colleagues: Selçuk Altınsaçlı (1988), Cem Kubanç (1990), Oya Özuluğ (2001), Serpil Yaltalıer (2008).

Okan Külköylüoğlu started to work almost the same time with Altınsaçlı and he studied about Ostracod taxonomy, ecology and distribution. His studies not only about Turkey Ostracod but American's too. He has more than 70 published studies and is still working about ostracods. His colleagues contributed to topic. Important names he trained are: Derya Akdemir (2004), Necmettin Sarı (2007), Mehmet Yavuzatmaca (2009), Samet Uçak (2012).

Recently a checklist of ostracod fauna of Turkey was published by Külköylüoğlu et al. (2015) and 143 species belong to 49 genera were reported.

Most recently Özuluğ et al (2018) published a checklist of Quanternary and Recent Ostracod database and they reported 147 non-marine ostracod species in Turkey.

Paleontological studies have also made an important contribution to the Ostracoda database. Neriman DORUK, Nuran GÖKÇEN and Cemal TUNOĞLU were the first names to work about fossil ostracod in Turkey. Important names are after them are: A. Nazik, Ü. Şafak, A. Tuncer.

2. AIM AND SCOPE OF THIS STUDY

There are several studies about living and fossil ostracods in Malatya region. Despite of previous studies this study aims to collect more information about Malatya’s water bodies and ostracod distribution. Since collecting data about environmental and water chemistry can help us to predict ostracods ecological requirements.

The main aims of this study are, to :

i. Investigate ostracod diversity in Malatya.
ii. Obtain information about chemical and ecological characters of Malatya’s water bodies.
iii. Understand ostracods ecological tolerance/optimum values.
iv. Correlate sediment, water chemistry and ostracod distribution.

3. MATERIAL AND METHODS

3.1 Site Description

Malatya, the study area, is the most crowded city in the East Anatolian Region in Turkey. It has 14 counthy which are Merkez, Akçadağ, Arguvan, Arapgir, Battalgazi, Darende, Doğanşehir, Doğanyol, Hekimhan, Kale, Kuluncak, Pütürge, Yazıhan, Yeşilyurt (Figure 3.1). It covers 12 313 km^2 of surface area in between 35^{o}34’ and 39^{o}03’ in North and 38^{o}45’ and 39^{o}08’ in East. The city surrounded by Sivas, Erzincan, Elazığ, Diyarbakır, Adıyaman and Kahramanmaraş.

Malatya’s climate is typical continental climate, which is cold and rainy in winter, hot and arid in summer. Average air temperature is 13.3^{o}C in a year.

Malatya is a plain which surrounded by mountains (Nurhak mountains, Akçababa mountains, Yama mountain) and that mountains divided by rivers. There is no natural lake in Malatya but rich in rivers and flowing streams (Fırat nehri, Tohma çayı, Kuruçay, Sürgü çayı) (Governorship in Malatya, 2011).

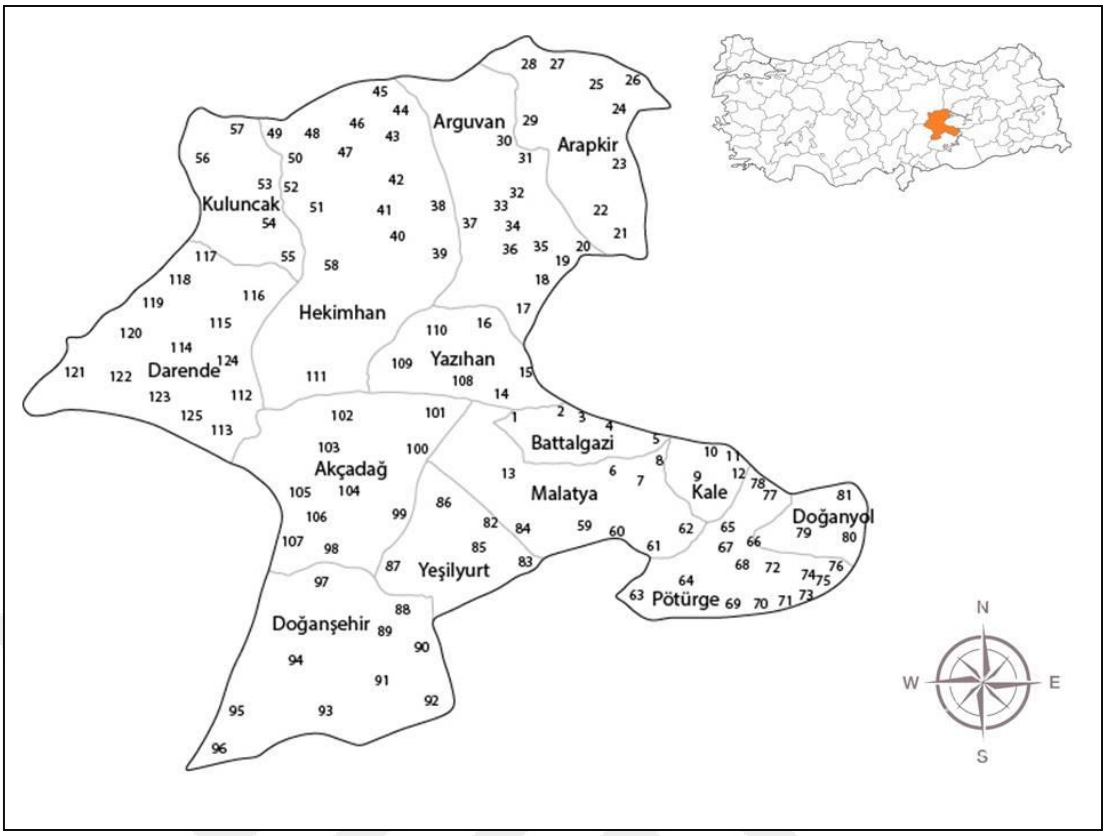

Figure 3.1 Distribution of randomly selected 125 sampling sites from 14 counties of Malatya, Turkey.

3.2 Sampling and Measurements

In Malatya city, total of 125 samples were collected from randomly selected different aquatic bodies during 03-10 August 2015. Sampling sites include 12 aquatic site types as reservoir, stream, water body, spring water, pool, trough, creek, lake, pond, river, canal and waterfall.

At each sampling sites, some of the environmental variables (dissolved oxygen concentration (DO, mgL^{-}), percent oxygen saturation (% sat.), water temperature (TW, ^{o}C), electrical conductivity (EC, μScm^{-1}), total dissolved solids (TDS, mgL^{-1}), salinity (SAL, ppt), pH, atmospheric pressure (ATM, mmHg), oxidation reduction potential (ORP)) were recorded before ostracods sampling to avoid possible results of 'Pseudoreplication' (Hurlbert, 1984) by a TSI-Professional Plus.

The air temperature (Ta, ^{o}C), wind speed (kmh^{-1}) and air moisture (%) were measured with a Testo 410-2 model of anemometer and also the basic geographical data (elevation, coordinates) were recorded with a geographical positioning system (GARMIN etrex Vista H GPS) *in situ*.

After that, 100 ml of water were taken from each sampling sites for anion-cation (sodium (Na), ammonium (NH_4), potassium (K), magnesium (Mg), lithium (Li), calcium (Ca), flüoride (F^-), chloride (Cl^-), nitrite (NO_2^-), bromide (Br^-), nitrate (NO_3), phosphate (PO_4) and sulphate (SO_4) analysis. The water samples were kept in plastic bottles, about $4^{o}C$ of container. Similar to water samples, sediment samples were taken from each sampling sites to analyses amount of organic-inorganic phosphate and total phosphate (mg kg^{-1}).

Ostracod samples were taken with the aid of standard hand-net (150 µm mesh size) by sweeping at bottom of water bodies from 0 to 100 cm intervals of their depth. Then, they were fixed in 250 ml plastic jars in %70 alcohol as soon as possible in situ. These samples were washed under tap water and again were stored in their jars in alcohol at the laboratory. To identify species, the soft body parts and carapace's structures of ostracods were used under a stereomicroscope (Olympus ACH 1X) and a light microscope (Olympus BX-51). During this process, taxonomic keys of Meisch (2000) and Karanovic (2012) were used. Both the soft body parts and carapaces were kept in slides with lactophenol solution and in micropaleontological slides, respectively. All of ostracods samples are saved at the Limnology Laboratory of Abant İzzet Baysal University.

In the laboratory, water samples were firstly filtered trough syringe-type membrane filter (0.45 µm) for anion-cation analysis that performed with the directions in the standard method no: 4110 using Ion Chromatography (Dionex 1100) in department of Environmental Engineering, Abant İzzet Baysal Universtiy (Bolu, Turkey). Dionex IonPac AS9-HC anion column (4x250 mm), Dionex IonPac AG9-SC (4X50 mm) pre-column and dionex ASRS-300 4 mm suppressor were used for anion analysis along with the application of 9 mm Na_2CO_3 solution as a carrier phase at a flow rate of 1 ml min-1. In cation analysis, Dionex IonPac CS12A cation column, Dionex IonPac CG12A (4x50 mm) pre-column and Dionex CSRS-300 4 mm suppressor was used. 10 ml of 1M meta sulfonic acid (MSA) were received as a carrier phase to prepare 1 L solution. Flow rate of prepared solution was 1 ml min-1 during analysis.

Sediment samples were firstly dried in drying oven at 40^{o}C (at least 24 hours), and then sequential extraction procedure provided in Ruban et al. (1999) was used for determination of phosphorus forms (inorganic, organic and total) in sediment. Sediment PO_4 analyses steps like this:

Initially, 200 mg dry sediment sample and 20 ml 1M HCl were mixed in a falcon tube and shaken for 16 hours. After shaked, samples were centrifuged on 2000 xg for 15 minutes (with Nüve HF 1200). Following these steps, samples were divided for two to analyses inorganic and organic phosphate types.

For analyze inorganic PO_4 amount in sediment; 2 ml supernatant were taken from centrifuged sample and 0.16 ml 12M NaOH added and filled up 10 ml with 7.84 ml deionize water. After that process, 2ml special reactive solution (prepared with 50 ml H_2SO_4, 15 ml $(NH_4)_6Mo_7O_{24}$, 30 ml $C_6H_8O_6$, 5 ml $C_8H_{10}K_2O_{15}Sb_2$) were added. The sample were analyzed after waited 15 minutes with LANGE DR 5000 spectrometer.

To analyse organic PO_4 amount in sediment, the centrifuged cake was taken. 12 ml deionize water were added on that cake and shaken for 5 minutes. After shake, the sample centrifuged on 2000 xg for 15 minutes (with Nüve HF 1200). Following the centrifuge, we spilled water from tube and repeated the process. After twice that procedure, we were put that remain cake on the oven and dry in 80^{o}C. The dry sample was burnt for 3 hours in 450^{o}C with ash oven. When the sample was dry, 20 ml 1M HCl were added and sample shaken for 16 hours. Following shake process, sample centrifuged on 2000 xg for 15 minutes. Finally, for analyses, 2 ml supernatant were taken from tube and 0.16 ml 12M NaOH were added and filled up to 10 ml with 7,84 ml deionize water. After 2 ml special reactive solution (prepared with 50 ml H_2SO_4, 15 ml $(NH_4)_6Mo_7O_{24}$, 30 ml $C_6H_8O_6$, 5 ml $C_8H_{10}K_2O_{15}Sb_2$) were added, the sample waited for 15 minutes and analyzed (by LANGE DR 5000 spectrometer).

3.3 Statistical Analyses

To examine the relationship between 15 species that occurred in 3 or more stations and the 10 environmental and chemical variables (pH, Salinity, Na, Mg, Inorganic Phosphate, Dissolved Oxygen, Water temperature, Ca, Cl^-, Organic Phosphate), a Canonical Correspondance analysis (CCA) was applied with Monte Carlo Tests (449 permutations). Before performing CCA, suitability of data for CCA was tested with Detrended Correspondance Analysis (DCA), if length of DCA is 3 or more the data is suitable to use for CCA (Birks et al., 1990; Ter Braak, 1987).

To estimate species tolerance (tk) and optimum (uk) levels with ecological and chemical variables (pH, dissolved oxygen, electric conductivity, water temperature, oxidation-reduction potential, atmospheric pressure, elevation, salinity, NH_4, NO_3, Na, K, Mg, Ca, F^-, Cl^-, SO_4, total phosphorus, inorganic phosphorus, organic phosphorus) C2 Software Program was used. C2 Analysis Program includes a transfer function of weighted averaging regression (Juggins, 2003).

Multivariate Statistical Package (MVSP) version 3.1 was used for applying Unweighted Pair Group Method with Arithmetic Mean (UPGMA) (Kovach, 1998) to analyzing clustering dendrogram between 15 ostracod species in Malatya UPGMA was applied based on percent similarity and data was log transformed.

Two-tailed t-tests with un/equal variance analyses was applied to compare the mean values of sites with and without species.

4. RESULTS

During this study 25 species were reported from 125 (43 of them were empty) different sampling sites in Malatya province (Table 4.1). The most frequent species were *I. bradyi* (in 24 sampling sites), *H. rotundata* (in 19 sampling sites) and *H. salina* (in 18 sampling sites) (Appendix A, B).

Table 4.1 Species diversity among different habitats and sampling sites in Malatya (*Candona neglecta* (CN), *Cyclocypris ovum* (COv), *Cypria ophtalmica* (Cop), *Cypridopsis vidua* (CV), *C. lusatica* (CYu), *Herpetocypris brevicaudata* (HB), *H. intermedia* (HIm), *Heterocypris incongruens* (HI), *H. rotundata* (HRo), *H. salina* (HSa), *Ilyocypris bradyi* (IBr), *I. brehmi* (IBe), *I. gibba* (IG), *I. inermis* (II), *Isocypris beauchamp*i (IBa), *Limnocythere inopinata* (LI), *Potamocypris fulva* (PFu), *P. unicaudata* (PU), *P. variegata* (PV), *P. villosa* (PVi), *Prionocypris zenkeri* (PZe), *Pseudocandona albicans* (PAl), *Psychrodromus fontinalis* (PFo), *P. olivaceus* (PO), *Trajancypris clavata* (TC).

Habitat type	**Sampling Site No**	**Species**	**Species/ Station**
lake	27, 47, 74, 75	COv, Cop, IBr	0.75
creek	11, 17, 25, 53, 62, 68, 76, 98, 100, 103, 111	CN, HI, HRo, HSa, IBr, IBe, II, PFu, PAI, PFo	0.9
through	9, 18, 19, 20, 21, 22, 23, 24, 28, 32, 33, 34, 35, 48, 57, 59, 64, 67, 70, 77, 79, 80, 81, 84, 92, 101, 105, 114, 117, 118, 119	CN, CV, Him, HI, HRo, HSa, IBr, II, PFu, PV, PVi, PZe, PAI, PFo, CYu	0.48
reservoir	1, 3, 8, 14, 15, 83, 86, 91, 99	CV, HI, HRo, IBr, II, LI	0.66
stream	2, 12, 30, 37, 40, 44, 46, 49, 50, 51, 61, 63, 65, 69, 72, 82, 93, 95, 97, 107, 110, 125	CV, HB, Him, HRo, HSa, IBr, II, IBa, LI, PV, PVi, PZe, PAI, PFo, PO	0.68
pond	31, 39, 42, 90	HSa, IBr, II, PU, PVi, PZe	1.5
river	54, 56, 66, 89, 113, 115, 120	IBr, II, PZe	0.42
spring water	5, 7, 10, 13, 26, 43, 45, 58, 94, 96, 116	CN, COv, CV, HI, HSa, IBr, II, PFo, PO	0.81
canal	108, 123, 124	IBr	0.33
water body	4, 16, 38, 55, 71, 73, 78, 106, 112	CN, HI, HRo, HSa, IBr, II, PVi, PZe	0.88
pool	6, 29, 36, 41, 52, 60, 85, 87, 88, 102, 104, 109, 122	HIm, HI, HRo, HSa, IBr, IG, PFu, PZe, TC	0.69
waterfall	121	IBr, PFu	2

Ostracod studies were started early in Malatya but recorded species were just 3 (*Psychrodromus olivaceus, Potamocypris fallax, Zonocypris costata*) on previous studies. In this study we found one common species (*P. olivaceus*) with earlier studies and the 24 species were the new record for the area (other three was missing). So, the number of recorded ostracod species has been 27 in the region and *C. lusatica* was found the first time in Turkey.

On the Figure 4.1. we can clearly see the distribution of ostracods in every sampling sites. As seen on the colored map, *P. fontinalis* found only south side of the province. *C. vidua* only found in 5 sampling sites and its distribution is vertical. Blue colour range (*H. incongruens*, *H. rotundata*, *I. bradyi*) has consistency on Figure 4.1 and it represents the most abundant species.

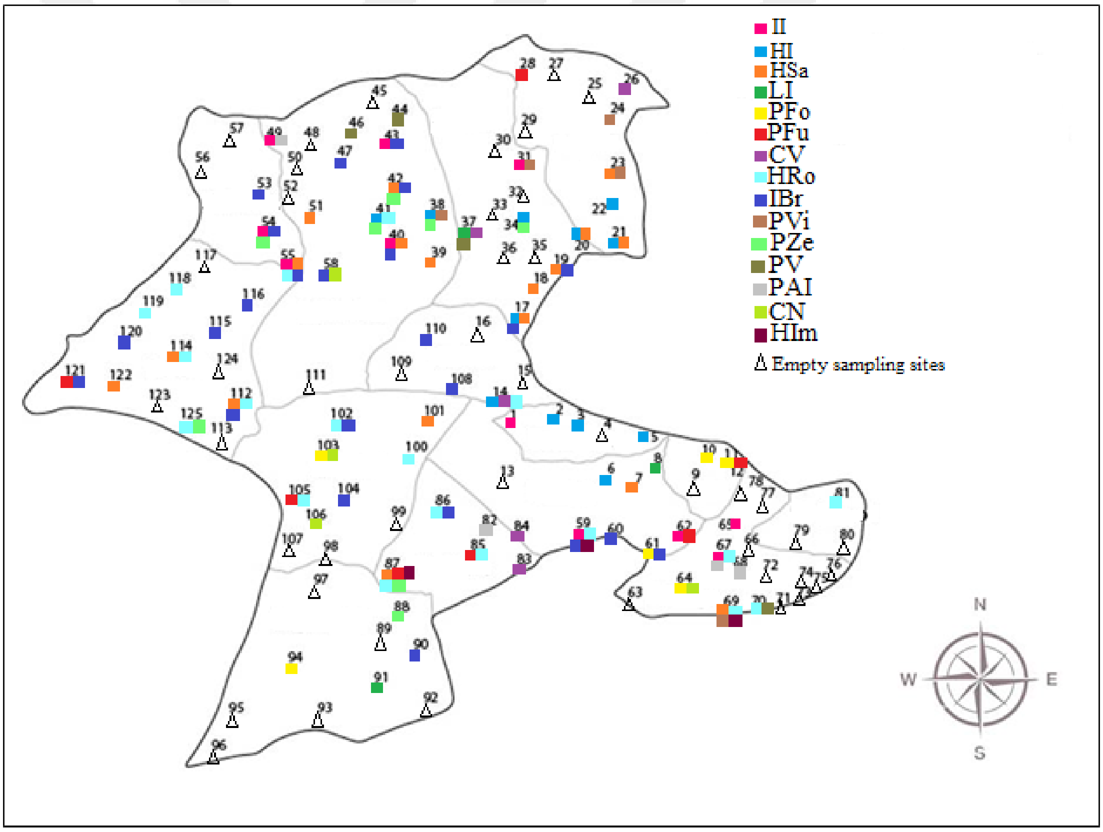

Figure 4.1 Distributions of of 15 ostracod (3 or more occurrence) species from 125 sampling sites in Malatya (*C. neglecta* (CN), *C vidua* (CV), *H. intermedia* (HIm), *H. incongruens* (HI), *H. rotundata* (HRo), *H. salina* (HSa), *I. bradyi* (IBr), *I. inermis*(II), *L. inopinata* (LI)), *P. fulva* (PFu), *P. variegata* (PV), *P. villosa* (PVi), *P. zenkeri* (PZe), *P. albicans* (PAl), *P.fontinalis* (PFo)).

4.1 Taxonomic Results

PHYLUM: ARTHROPODA

SUBPHYLUM: CRUSTACEA (Pennat, 1777)

CLASS: OSTRACODA (Latreille, 1802)

SUBCLASS: PODOCOPA (Müller, 1894)

ORDER: PODOCOPIDA (Sars, 1866)

Suborder Podocopina (Sars, 1866)

Superfamily Cypridoidea s. str. (Baird, 1845)

Family Candonidae (Kaufmann, 1900)

Subfamily Candoninae (Kaufmann, 1900)

Genus *Candona* s. str. (Baird, 1845)

Candona neglecta (Sars, 1887)

Genus *Pseudocandona* (Kaufmann, 1900)

Pseudocandona albicans (Brady, 1864)

Genus *Cypria* (Zenker, 1854)

Cypria ophtalmica (Jurine, 1820)

Genus *Cyclocypris* (Brady and Norman, 1889)

Cyclocypris ovum (Jurine, 1820)

Family Ilyocyprididae (Kaufmann, 1900)

Subfamily Ilyocypridinae (Kaufmann, 1900)

Genus *Ilyocypris* (Brady and Norman, 1889)

Ilyocypris bradyi (Sars, 1890)

Ilyocypris brehmi (Schafer, 1952)

Ilyocypris gibba (Ramdohr, 1808)

Ilyocypris inermis (Kaufmann, 1900)

Family Cyprididae (Baird, 1845)

Subfamily Eucypridinae (Bronshtein, 1947)

Genus *Prionocypris* (Brady and Norman, 1896)

Prionocypris zenkeri (Chyzer and Toth, 1858)

Genus *Trajancypris* (Martens, 1989)

Trajancypris clavata (Baird, 1838)

Subfamily Isocypridinae (Rome, 1965)

Genus *Isocypris* (G. W. Müller, 1908)

Isocypris beauchampi (Paris, 1920)

Subfamily Cypridopsinae (Kaufmann, 1900)

Genus *Cypridopsis* (Brady, 1867)

Cypridopsis vidua (O. F. Müller, 1776)

Cypridopsis lusatica (Schafer,1943)

Genus *Potamocypris* (Brady, 1870)

Potamocypris fulva (Bradyi, 1868)

Potamocypris unicaudata (Schäfer, 1943)

Potamocypris variegata (Brady and Norman, 1889)

Potamocypris villosa (Jurine, 1820)

Subfamily Herpetocypridinae (Kaufmann, 1900)

Genus *Herpetocypris* (Brady and Norman, 1889)

Herpetocypris brevicaudata (Kaufmann, 1900)

Herpetocypris intermedia (Kaufmann, 1900)

Genus *Psychrodromus* (Danielopol and McKenzie, 1977)

Psychrodromus fontinalis (Wolf, 1920)

Psychrodromus olivaceus (Bardy and Norman, 1889)

Subfamily Cyprinotinae (Bronshtein, 1947)

Genus *Heterocypris* (Claus, 1892)

Heterocypris incongruens (Ramdohr, 1808)

Heterocypris rotundata (Bronshtein, 1928)

Heterocypris salina (Brady, 1868)

Superfamily Cytheroidea (Baird, 1850)

Family Limnocytheridae (Klie, 1983)

Subfamily Limnocytherinae (Klie, 1938)

Genus *Limnocythere* s. str. (Brady, 1867)

Limnocythere inopinata (Braid, 1843)

4.2 Statistical Results

According to t-test unequal variance analyses (two-tailed p=0.05) results (Appendix D), the only statisticaly significant difference between the means of variables were found for Cl^- (p=0.005) and ORP (p=0.01) values of the sites with species (82) and without species (43). In contrast, there were no significant differences between the means of sites with and without species for DO, TW and SAL (p>0.05).

4.2.1 CCA Results

Canonical Corresponding Analyses (CCA) had been applied to define relationship between 5 ecological variables and 15 species, found from 3 or more sites.

According to Table 4.2 the first two axes of Canonical Correspondence Analyses (CCA) explained 66.1% of relationships between 5 variables (ORP, DO, Sal, TW, Cl^-) and 15 species (*C. neglecta*, *C vidua*, *H. intermedia*, *H. incongruens, H. rotundata, H. salina, I. bradyi*, *I. inermis*, *L. inopinata*, *P. fulva*, *P. variegata*, *P. villosa*, *P. zenkeri*, *P. albicans, P.fontinalis*)

Table 4.2 CCA summary table with 5 variables (ORP, DO, SAL, Tw, Cl^-) and 15 species (3 or more occurrence) from Malatya (*DCA Results).

Axes		1	2	3	4	Total inertia
Lengths of gradient*	:	7.768	4.457	4.133	8.639	
Eigenvalues	:	0.485	0.329	0.191	0.145	8.059
Species-environment correlations	:	0.809	0.649	0.511	0.483	
Cumulative percentage variance						
of species data	:	6.0	10.1	12.5	14.3	
of species-environment relation	:	39.3	66.1	81.6	93.4	
Sum of all eigenvalues						8.059
Sum of all canonical eigenvalues						1.232

CCA diagram (Figure 4.2) show that three variables; Water Temperature (TW) (F=4.197, P=0.02), Chloride (Cl^-) (F=3.544, P=0.02) and Salinity (SAL) (F=3.409, P=0.02) were the most affective parameters on species. The other two variables; Dissolved Oxygen (DO) (F=1.866, P=0.03) and Oxidation Reduction Potential (ORP) (F=2.177, P=0.01) did not show significant influence on species.

On Figure 4.2, *H. salina* showed positive relation and *H. intermedia* (HIm) showed negative relation with SAL. *I. inermis* (II) shows negative relation with DO. *P. fulva* (PFu) showed positive relation with ORP.

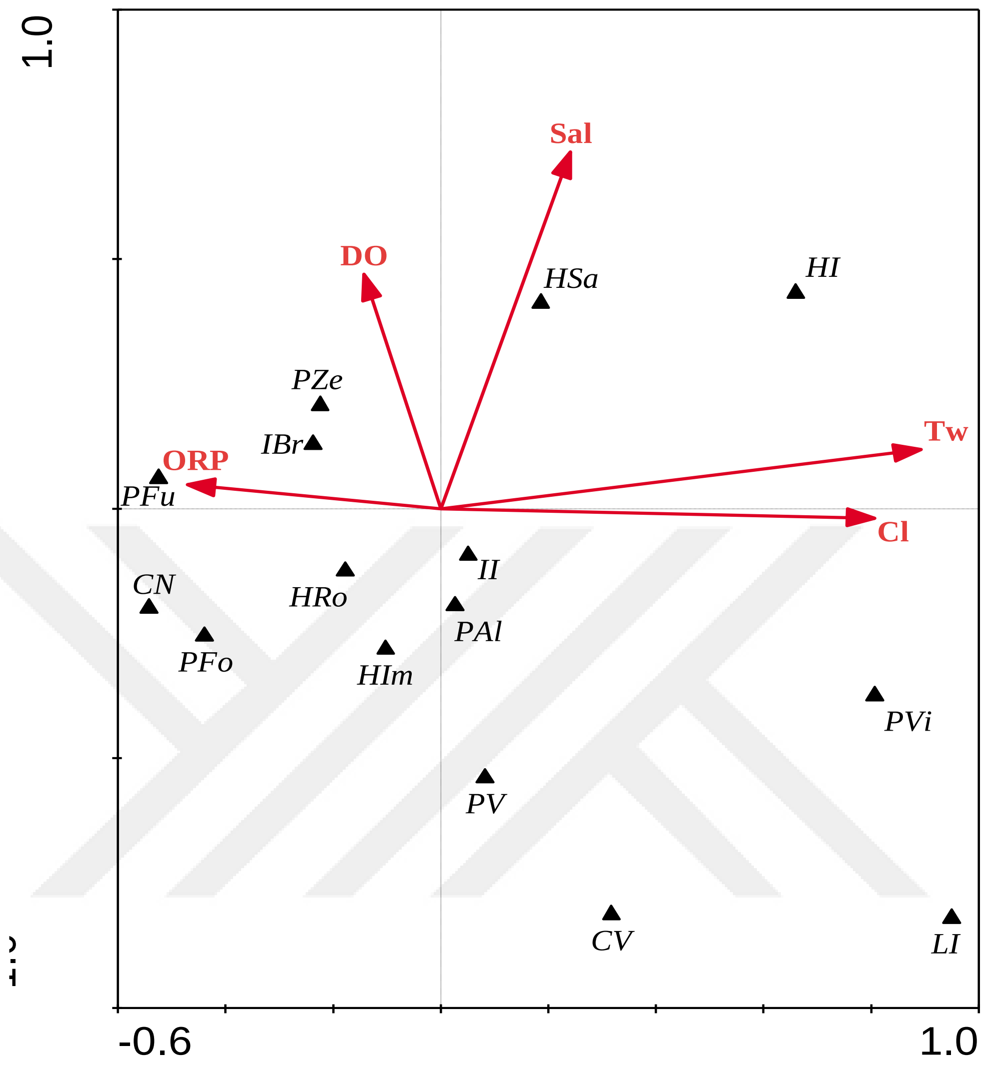

Figure 4.2 CCA diagram shows the effect of 5 variables (ORP, DO, SAL, Cl^-, TW) to 15 species (*C. neglecta* (CN), *C vidua* (CV), *H. intermedia* (HIm), *H. incongruens* (HI), *H. rotundata* (HRo), *H. salina* (HSa), *I. bradyi* (IBr), *I. inermis*(II), *L. inopinata* (LI)), *P. fulva* (PFu), *P. variegata* (PV), *P. villosa* (PVi), *P. zenkeri* (PZe), *P. albicans* (PAl), *P.fontinalis* (PFo)).

According to Figure 4.3, we see some variables showed correlation with specific sampling site. Of which, Chloride correlate with 18th site, TW correlated with sampling sites 2 and 19, ORP correlated with sampling sites 8, 44, 46, 72, 73 and 76.

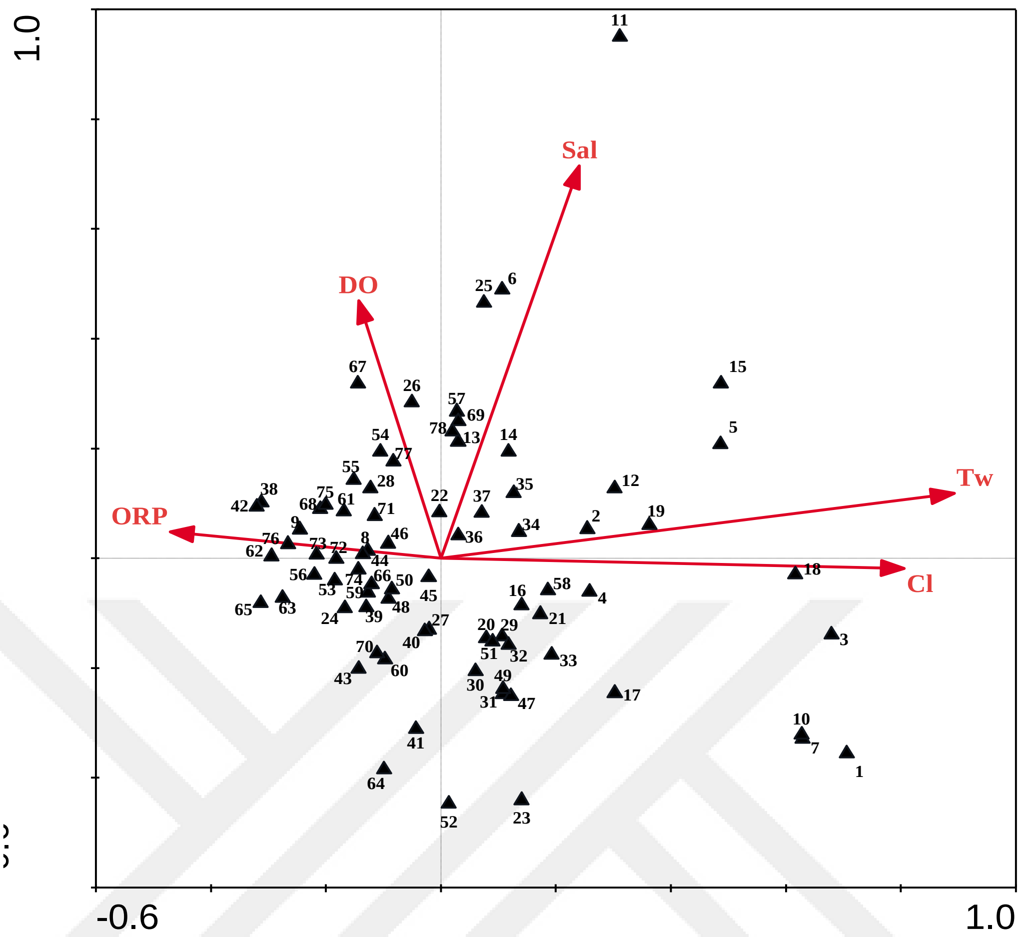

Figure 4.3 CCA diagram shows the effect of 5 variables (ORP, DO, SAL, TW, Cl^-) to 82 sampling sites.

4.2.2 C2 Results

C2 statistical analyses applied for 15 species and 20 ecological and chemical variables to determine that species tolerance and optimum values for Malatya province (Appendix C).

On the C2 result (Appendix C), *Candona neglecta* has minimum optimum value for Electric conductivity (EC), Salinity (SAL), Chloride (Cl^-), Organic

Phosphate (OrgP) and minimum tolerance point for Cl^- and Inorganic Phosphate (InP).

Cypridopsis vidua has maximum uoptimum point for Ammonium (NH_4), Fhloride (F^-), Total Phosphate (ToP) and Inorganic Phosphate (InP), minimum optimum point for pH, Dissolved Oxygen (DO), Oxidation Reduction Potential (ORP) and Sodium (Na), has maximum tolerance point for DO.

Herpetocypris intermedia has maximum tolerance range for SO_4 and InP, minimum tolerance for Na.

Heterocypris incongruens has maximum tolerance for EC, maximum optimum for DO but minimum tolerance for Organic Phosphate (OrgP).

Heterocypris rotundata has maximum tolerance range for Potassium (K), Magnessium (Mg) and Calcium (Ca).

Heterocypris salina has maximum optimum value for EC and SAL but minimum optimum for ToP, InP and OrgP. For tolerance level, it has maximum point for SAL and minimum point for Mg.

Ilyocypris inermis has maximum tolerance range for Elevation (EL) and minimum optimum for F^-.

Limnocythere inopinata has maximum optimum for pH,Water Temperature (TW) Athmosphere Pressure (ATM), Mg, Ca and minimum optimum for EL. For tolerance level, it has maximum tolerance for pH, TW, ORP, Nitrate (NO_3) and minimum tolerance for Ca, F^-, OrgP.

Potamocypris fulva has minimum tolerance for DO and ToP but maximum tolerance for F^-.

Potamocypris villosa has maximum optimum value for NO_3, Na, Cl^-, SO_4 and it has minimum tolerance for EC, ATM, EL, SAL but maximum tolerance range for Na and Cl^-.

Potamocypris variegata has minimum optimum point for K, Mg, Ca, TotP, OrgP. For tolerance level, it has maximum point for ATM but minimum point for K and SO_4.

Prionocypris zenkeri has minimum optimum value for NO_3 and NH_4. For tolerance level, it has minimum tolerance range for TW, ORP, NH4 and NO_3.

Psychrodromus fontinalis has maximum optimum point for ORP, EL, K but minimum optimum point for TW, ATM, SAL. For tolerance level, it has minimum tolerance for pH and ToP but maximum tolerance for NH_4.

Ilyocypris bradyi has minimum optimum value for SO_4.

Pseudocandona albicans has maximum tolerance level for OrgP.

4.2.3 UPGMA Results

According to UPGMA results (Figure 4.4) there are 5 main clustering groups in dendogram for 15 species. In first group there are 2 species (*C. neglecta, P. fontinalis*). Second group includes two species *(P. albicans, I. İnermis*), third group includes six species which are *P. fulva, I. bradyi*, *H. rotundata*, *H. salina*, *P. zenkeri*, *H. incongruens.* In fourth group there are 2 species (*P. villosa*, *H. intermedia*) and last group (5th) includes three species (*P. variegata, L. inopinata, C. vidua*). The species *I. bradyi*, *H. rotundata* and *H. salina* have high frequency and all in the same group (3rd).

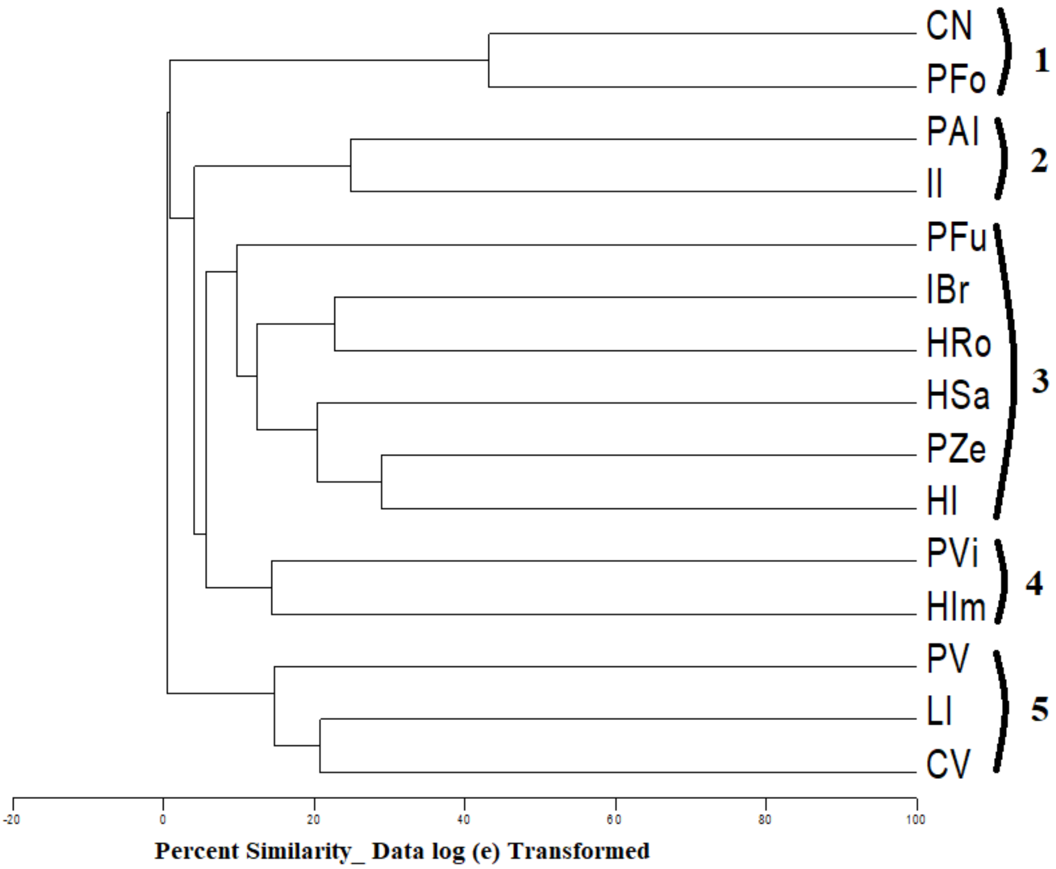

Figure 4.4 UPGMA results of 15 ostracod species.

5. DISCUSSION and CONCLUSION

Palaeological studies in Malatya had started with Nazik et al. (2008) and they reported 8 fossil taxa *(l. bradyi, I. gibba, Candona parallela pannonica, C. angulata, C. neglecta, H. salina, Cyprideis pannonica, C. anatolica)* from Upper Miocene deposits in the province. Recently Ercan et al. (2012) published a study and mentioned 11 taxa of fossil ostracods *(I. gibba, Ilyocypris angulate slavonica, Prionocypris zenkeri, Schellencandona sp. H. salina, Candona (candona) parallela pannonica, C. (C) xanthica, C. (C) burdurensis, C. (Neglecandona) decimai, C. (Typhlocypris) eremita, Pseudocandona compressa)* from Late Miosene period in Malatya. Thereby Malatya fossil ostracod database have 16 taxa in total. However as seen this list includes non-marine ostracods common with present study which are *I. bradyi, I. gibba, C. neglecta, H. salina*.

In earlier studies 3 living freshwater ostracod known in Malatya, which are *Zonocypris costata* (Hartman, 1964), *Psychrodromus olivaceus, Potamocypris fallax* (Gülen et al., 1994). In present study 25 species (*C. neglecta, C. ovum, C. ophtalmica, C. vidua, C. lusatica, H. brevicaudata, H. brevicaudata, H. incongruens, H. rotundata, H. salina, I. bradyi, I. brehmi, I. gibba, I. inermis, I. beauchampi, L. inopinata, P. fulva, P. unicaudata, P. variegata, P. villosa, P. zenkeri, P. albicans, P. fontinalis, P. olivaceus T. clavata*) were found from the area. Of the species *P. olivaceus* is common with the previous studies. Hereby, living non-marine ostracod in Malatya has raised 27 species with this study. On the Figure 4.1, ostracod distribution in the province can seen clearly.

Ilyocypris bradyi was the most abundant (24 sampling sites) species in present study. This bottom dependent species was found in every type of habitats (lake, creek, trough, reservoir, stream, pond, spring water, canal, water body, pool, waterfall) in Malatya. It is a cosmoecious species (Külköylüoğlu, 2013) and consider the most widespread ostracod (Meisch 2000; Mezquita et al.,1999a and b). This species is relatively close to ORP on the CCA diagram (Figure 4.2) and on previous studies this species showed positive correlation with ORP (Külköylüoğlu, 2005) that supported our results. *I. bradyi* examine as polythermophilic (Meisch, 2000) or oligothermophilic (Külköylüoğlu and Vinyard, 2000) on the previous studies and we found this species 10.9-30.2ºC range of temperature which is supported the previous studies. On the C2 results (Appendix C) *I. bradyi* has the minimum optimum point for SO_4.

Heterocypris rotundata was second most frequent (19 sampling sites) species in present study and found in 6 different habitat types (creek, trough, reservoir, stream, water body, pool). This species described as thermophilic summer form by Petkovski (1964). In present study this species found on 10.9-26.9ºC temperature range on August. According to C2 results (Appendix C) *H. rotundata* has maximum tolerance range for water kations K, Mg, Ca.

Heterocypris salina was third abundant species within 18 sampling sites and found creek, trough, stream, pond, spring water, water body, pool habitat types. This species prefers small, salty water bodies (Mesich, 2000). In CCA diagram (Figure 4.2) it showed strong relationship with salinity as expected. The results of C2 (Appendix C) also support this, it has maximum optimum and tolerance value for salinity. Ganning (1971) described this species as a summer form with optimum 5ºC temperature. In present study, we found it at 16.2-30.2ºC temperature range with 21.3ºC optimum value. According to C2 results, *H. salina* has minimum optimum value for total, organic and inorganic sediment phosphate.

One of the most common cosmoecious species *Heterocypris incongruens* was found in 12 sampling sites and five different habitat types which are creek, trough, reservoir, spring water, water body, pool. This species found almost all kind of habitats but according to Keyser and Nagorskaya (1998) prefers interspecific competitive habitats. On previous studies *H. incongruens* found in low DO levels (Fox and Taylor, 1955; Ganning, 1971; Meisch, 2000) but on present study it found as 5.7-12.26 mg/L^{-1} range and has maximum optimum value for DO. According to C2 results (Appendix C) it has maximum tolerance range for EC and minimum tolerance range for sediment organic phosphate concentration.

Ilyocypris inermis was collected from 11 sampling sites in creek, trough, reservoir, stream, pond, spring water, water body habitat types. This species reported from cold waters (Külköylüoğlu et al., 2010) and low salinity ranges (Meisch 2000).

It was found at 10.5-28.1°C range of temperature and salinity range was 0.2-0.76 mg/L on previous study. According to CCA result (Figure 4.2) it showed negative relationship with DO and its range was 5.26-9.93 mg/L^{-1}. On the C2 results (Appendix C) it has maximum tolerance for elevation (689-1611 m) and minimum optimum for water F^- ion (2.24-85.5 mg/L).

Prionocypris zenkeri was collected from eight sampling sites and six different habitat types that are trough, stream, pond, river, water body and pool. This bottom dweller cosmopolitan species prefers springs or habitats connected springs (Rosetti et al., 2005). Due to it has minimum tolerance and optimum (C2 results) for NH_4 and NO_3 we can say it has low toleration for pollution. According to C2 results (Appendix C) it has minimum tolerance for water temperature (14-24.6°C) and ORP (261.7-284.2). In previous studies this species showed significant positive relation with ORP (Külköylüoğlu and Sarı, 2012). Mischke et al. (2014) pointed its presence only in cold waters in the Jordan.

Potamocypris fulva was found in 7 sampling sites and creek, trough, pool, waterfall type of habitats. Külköylüoğlu et al. (2013) was pointed that species shows negative correlation with ORP and DO. In present study it has strong relationship with ORP on CCA results (Figure 4.2) and it has minimum tolerance range for DO on C2 results (Appendiz C). This species also has maximum tolerance range for water F^- ion and sediment total phosphate. In a previous study it was found in heavily polluted shallow lake (Külköylüoğlu et al., 2007) and our result support that, this species may have wide tolerance to pollution on water habitats.

Psychrodromus fontinalis was collected in six sampling sites and habitat types were creek, trough, stream and spring water. According to C2 results (Appendix C) it has minimum tolerance range for pH and sediment total phosphorus; maximum tolerance range for NH_4; minimum optimum value for TW, atmospheric pressure, salinity and maximum optimum value for ORP, water K ion. Mezquita et al. (2001) was pointed that *P. fontinalis* is a good indicator for clean waters. In parallel with this Dügel et al. (2008) indicate that species prefers cool and well oxygenated waters which support our results. In previous study it shows high tolerance for salinity (Külköylüoğlu et al., 2011) that contrast with present study.

Similar our study Külköylüoğlu and Sarı (2012) found the species with positive correlation to ORP.

Potamocypris villosa was found in 5 sampling sites and trough, stream, pond, water body habitat types. This species also known as cosmopolitan due to wide distribution. According to C2 results (Appendix C) this species has minimum tolerance for EC, atmospheric pressure, elevation, salinity. Similar to our study, Külköylüoğlu and Yılmaz (2006) pointed that the species negatively correlated with EC. These researchers also found that species from well oxygenated waters and pointed negative correlation with water temperature and pH. Continue from C2 results; it showed maximum optimum value for NO_3, SO_4 and also it has maximum tolerance and optimum value for Cl^- and Na . According to this results, *P. villosa* seems to be sensitive for water ion capacitiy changes.

One of the cosmoecious species *Cypridopsis vidua* was found in five sampling sites from trough, reservoir, stream, spring water habitat types. Delorme (1991) mentioned this species as saline tolerant but in present study it did not have broad range of salinity (0.15-0.39). This species one of the most common species in the faunal area (Meisch, 2000). Külköylüoğlu (2005) pointed that this species shows positive correlation with ORP and pH but in present study it has minimum optimum point for these variables. In an earlier study, it showed low tolerance to poorly oxygen levels (Danielopol, 1991) and present study support that with minimum DO levels. Other C2 results (Appendix C) for *C. vidua*; maximum optimum for NH_4, F^-, total and inorganic sediment phosphate and minimum optimum point for water Na ions.

Candona neglecta is another cosmopolitan species with wide distribution. It was found in four sampling sites and creek, trough, spring water, water body habitat types in this study. This species considered halophile (Meisch, 2000) and cold-loving species (Bronshtein, 1947, Ruiz et al., 2013; Rosati et al., 2014). In C2 results (Appendix C), it has minimum optimum for salinity and EC. Külköylüoğlu (2005) pointed its high tolerance for electrical conductivity changes. Other C2 results were minimum tolerance and optimum value for Cl^-, minimum tolerance for sediment inorganic phosphate and maximum optimum for sediment organic phosphate.

Bronshtein (1947) pinpointed that species only tolerate temperature above 20^{o}C and the range of water temperature was 10.9-18.7^{o}C in present study.

Potamocypris variegata was collected in four sampling sites and habitat types were trough and stream. This species called as polythermophilic (Hiller, 1972) and warm stenothermal (Nüchterlein, 1969). In present study it was found at 17.2-22.5^{o}C range of temperature so our results support the earlier studies. According to C2 results (Appendix C) it has maximum tolerance range for atmospheric pressure; minimum optimum value for water K, Mg, Ca ions and sediment total phosphate.

Pseudocandona albicans was found at four sampling sites and creek, trough, stream habitat types. According to Meisch (2000) this species lives in permanent, muddy and slow flowing waters and it prefers low salt content. In C2 results (Appendix C) this species has maximum tolerance level for sediment organic phosphate.

Herpetocypris intermedia was collected from three sampling sites and habitat types were trough, stream and pool. This species showed negative relationship with salinity in CCA results (Figure 4.2). According to Mezquita et al. (1999b) this species found in carbonated springs, relatively low water temperature and resist low oxygen concentration. In C2 results (Appendix C), *H. intermedia* has maximum tolerance range for SO_4 and sediment inorganic phosphate but minimum tolerance range for water Na ion.

Limnocythere inopinata was found at three sampling sites and habitat types were reservoir and stream. In present study it has maximum tolerance and optimum value for pH similar to the reports Meisch (2000) and Keyser and Nagorskaya (1998) pointed this species tolerate high alkali conditions. According to C2 results (Appendix C) it has maximum tolerance and optimum range for water temperature and Meisch (2000) reported it as polythermophilic species. Other C2 results showed that maximum tolerance for ORP, maximum optimum for atmosphere pressure, minimum optimum for elevation. In terms of water chemistry, it has maximum optimum for Mg, Ca; maximum tolerance for NO_3; minimum tolerance for F^-.

Other species are *Cyclocypris ovum, Herpetocypris brevicaudata, Psychrodromus olivaceus* was collected in 2 stations; *Cypria ophtalmica, Ilyocypris brehmi, Ilyocypris gibba, Isocypris beauchampi, Potamocypris unicaudata, Trajancypris clavata, Cypridopsis lusatica* was collected only one station. These species were not used on the analyses because they were statistically insignificant (occurred less than 3 times). Also *Ilyocypris brehmi* has recorded third times for Turkey in present study (Schafer, 1952: Yavuzatmaca et al. 2018).

Cypridopsis lusatica is the first record for Turkey. This species was collected from streams, pools, springs and aquatic habitats connected with springs on previous studies (Meisch, 2000; Mezquita et al. 1999b, 2005). Distribution of this species occacionally Europe (Meisch, 2000; Petkovski et al. 1999). There are limited information about this species ecology and distribution. According to Mezquita et al. (1999b) *C. lusatica* prefers warm waters. In a previous study this species was showed 7.83 optimum point for pH and 8.6 mg/L optimum point for DO (Mezquita et al., 2005). In present study we found this species 7.87 pH and 7.49 mg/L DO concentrations. *C. lusatica* was found in one station with 4 individuals and habitat type was trough. Other parameters we measured from sampling sites were: EC: 470.5 μScm^{-1}, TW: 25.1^{o}C, ORP: 200.8 mV, EL: 1317 m a.s.l., SAL: 0.22 ppt.

When we look at the UPGMA results (Figure 4.4), there are 5 group based on species occurence. Although the results are unsatisfactory, UPGMA results and CCA results (Figure 4.2) support each other. Species in the same group on UPGMA are distributed in the same regions on the CCA diagram.

As a result, this work has provided a wide range of information on the ostracod distribution, ecological characteristics, water and sediment chemistry of water bodies in Malatya. Collected samples and measured values can give us a lot of information about the characteristic of the region. Total of 25 ostracod species were collected from 125 sampling sites but only 15 species statistically meaningful (3 or more occurrence) for the analyses. In this study 24 species were new record for Malatya province and *Cypridopsis lusatica* was the first record for Turkey. The tolerance values of the species in this study were determined and compared with previous studies. The data obtained from this study suggest that ostracods can have different tolerance values in different habitats. Previous studies (Mezquita et al.

1999b) also support this assumption. Another consequence of this study is that the relationship between optimum and tolerance values. In some measurements it is seen that the tolerance range increases when the optimum value decreses. Also ecological variables, water chemistry and sediment phosphate values and ostracods tolerance to them important for using them as bioindicator for future studies. The t-test results show that ORP and Cl^- has important role for ostracod occurrence on the habitat. In previous studies (Mezquita et al., 1999a) mention that bicarbonate/chloride rate has major effect for ostracod distribution. Also Mesquita-Jones (2001) pointed Cl^- is one of the main factor for ostracod inhabiting in the Mediterranean brooks. This corresponding to our study.

Finally results of the present study contribute previous ostracod studies and the results of this study should support with new researches.

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APPENDICES

7. APPENDICES

Appendix A Ecological variables and taxa were reported from different aquatic bodies in Malatya. Abbreviations: St. no: site number, DO (dissolved oxygen concentration, mgL^{-1}), EC (electrical conductivity, μScm^{-1}), SAL (salinity, ppt), TW (water temperature, ºC), TDS (total dissolved solid, mgL^{-}), ORP (oxidation reduction potential, mV), ATM (atmospheric pressure, mmHg), EL (Elevation, m a.s.l), CN: *Candona neglecta*, COv: *Cyclocypris ovum*, COp: *Cypria ophtalmica*, CV: *Cypridopsis* vidua, CYu: *C. lusatica*, HB: *Herpetocypris brevicaudata*, HIm: *H. intermedia*, HI: *Heterocypris incongruens*, HRo: *H. rotundata*, HSa: *H. salina*, IB: *Ilyocypris bradyi*, IG: *I. gibba*, II: *I. inermis*, IBa: *Ilyocypris beauchampi*, LI: *Limnocythere inopinata*, PFu: *Potamocypris fulva*, PU: *P. unicaudata*, PV: *P. variegata*, PVi: *P. villosa*, PZe: *Prionocypris zenkeri*, PAl: *Pseudocandona albicans*, PFo: *Psychrodromus fontinalis*, PO: *P. olivaceus*. Habitat types (Ht type); 1: lake, 2: creek, 3: trough, 4: reservoir, 5: stream, 6: pond, 7: river, 8: spring water, 9: canal, 10: water body, 11: pool, 12: waterfall (empty cells show no sampling).

Appendix A (continued)

St No	Ht type	pH	DO	EC	TW	ATM	ORP	Moisture	EL	SAL	TDS	Coordinate	Date	Species
1	4	8.27	5.91	745	29.3	698.9	156.9	29.5	689	0.33	448.5	N 38° 28'.628" - E 038° 20'.663"	3.08.2015	II
2	5	8.79	8.64	625	30.8	698.9	200.7	35.8	691	0.27	370.5	N 38° 28'.462" - E 038° 25'.457"	3.08.2015	HI
3	4	8.89	7.87	676	34.5	698.7	186.1	52.8	681	0.27	370.5	N 38° 27'.158" - E 038° 28'.424"	3.08.2015	HI
4	10	8.93	6.84	856	26.4	696.8	216	30.5	703	0.42	552.2	N 38° 26'.714" - E 038° 29'.005"	3.08.2015	-
5	8	8.91	7.4	517	30.9	690.2	194.8	27.1	795	0.22	305.6	N 38° 26'.005" - E 038° 32'.756"	3.08.2015	HI
6	11	8.15	12.26	765	30.5	667.7	191.5	22.5	1081	0.33	448.5	N 38° 21'.887" - E 038° 29'.036"	3.08.2015	HI
7	8	6.7	2.08	3524	24.6	687.7	59.7	22.3	824	1.86	2301	N 38° 21'.081" - E 038° 34'.545"	3.08.2015	HSa
8	4	10.4	6.17	278.4	34.9	684.1	141.9	24.1	864	0.11	152.1	N 38° 11'.635" - E 038° 37'.434"	3.08.2015	LI
9	3	7.87	7.49	470.5	25.1	648.7	200.8	25.9	1317	0.22	305.5	N 38° 23'.251" - E 038° 47'.832"	3.08.2015	CYu
10	8	8.41	8.54	541	17.9	684.2	222.1	25.1	893	0.31	409.5	N 38° 24'.288" - E 038° 49'.633"	3.08.2015	PFo
11	2	8.3	10.5	310.8	13.5	666.5	250.8	23.2	1090	0.19	260	N 38° 22'.846" - E 038° 51'.787"	3.08.2015	PFu, PFo
12	5	8.15	9.17	231.4	14.4	647.3	246.9	35.1	1357	0.14	189.8	N 38° 20'.797"- E 038° 50'.437"	3.08.2015	-
13	8	7.33	6.55	662	13.6	685.7	248.6	53.8	876	0.42	552.5	N 38° 23'.351" - E 038° 13'.881"	4.08.2015	PO
14	4	8.29	5.78	838	26.9	699.7	206	44.1	718	0.39	526.5	N 38° 30'.410" - E 038° 15'.336"	4.08.2015	CV, HI, HRo
15	4	8.81	6.74	625	27.7	699.6	218.4	42.3	687	0.29	390	N 38° 33'.492" - E 038° 20'.649"	4.08.2015	-

Appendix A (Continued)

St No	Ht type	pH	DO	EC	TW	ATM	ORP	Moisture	EL	SAL	TDS	Coordinate	Date	Species
16	10	8.76	9.09	710	27.2	696.5	221.3	29.6	722	0.33	442	N 38° 35'.017" - E 038° 12'.826"	4.08.2015	-
17	2	8.52	7.31	4099	30.2	691.8	227.5	27.2	780	1.95	2424.5	N 38° 38'.181" - E 038° 16'.670"	4.08.2015	HI, HSa, IBr
18	3	8.41	9.06	1300	19.9	696.1	230.9	29.6	731	0.72	942.5	N 38° 41'.266" - E 038° 22'.760"	4.08.2015	HSa
19	3	8.32	3.62	2317	16.2	686	243.9	25.2	865	1.35	1696.5	N 38° 44'.857" - E 038° 25'.362"	4.08.2015	HSa, IBr
20	3	8.5	10.1	832	24.7	680.3	235.9	20.9	932	0.41	546	N 38° 49'.479" - E 038° 26'.899"	4.08.2015	HI, HSa
21	3	8.56	11.94	1232	29.6	680.1	227.3	16.3	929	0.56	741	N 38° 48'.348" - E 038° 31'.856"	4.08.2015	HI, HSa
22	3	8.32	5.17	938	26.8	661.5	234.6	14.2	1158	0.44	591.5	N 38° 50'.716" - E 038° 30'.460"	4.08.2015	HI
23	3	8.21	5.98	509	26	640.6	243.3	15.7	1444	0.24	325	N 38 53'.884" - E 038 30'.595"	4.08.2015	HSa, PVi
24	3	8.62	10.91	603	27.1	651.2	234.1	14.1	1298	0.28	377	N 38° 58'.152" - E 038° 32'.572"	4.08.2015	PVi
25	2	8.74	10.11	535	16	679.1	223.3	25.1	913	0.32	422.5	N 39° 04'.252" - E 038° 30'.672"	4.08.2015	-
26	8	10.92	10.71	436.1	28.8	658.5	234.1	12.5	1187	0.19	263.9	N 39° 04'.256" - E 038° 35'.381"	4.08.2015	COp, CV
27	1	8.85	11.66	104.8	11.3	632	237.7	18.9	1549	0.07	95.55	N 39° 01'.875" - E 038° 24'.141"	4.08.2015	-
28	3	7.96	6.24	695	19.8	651.9	271.6	17.5	1289	0.38	500.5	N 39° 03'.612" - E 038° 21'.688"	4.08.2015	PFu
29	11	8.55	8.59	342	19.2	643.9	263.3	32.1	1376	0.19	250.9	N 39° 00'.418" - E 038° 19'.240"	4.08.2015	-
30	5	7.63	3.93	457.2	20.2	645.4	260.1	35.4	1358	0.24	327.5	N 38° 59'.338" - E 038° 13'.356"	4.08.2015	-

Appendix A (Continued)

St No	Ht type	pH	DO	EC	TW	ATM	ORP	Moisture	EL	SAL	TDS	Coordinate	Date	Species
31	6	8.63	7.91	424.6	24.6	642	255	21.9	1408	0.2	278.2	N 38° 57'.564" - E 038° 15'.165"	4.08.2015	II, PU, PVi
32	3	8.87	8.42	365.3	26	647.2	247.1	29.3	1350	0.17	237.7	N 38° 54'.194" - E 038° 17'.196"	4.08.2015	-
33	3	7.84	6.64	396	16.9	657.7	265.4	40.6	1200	0.23	304.85	N 38° 50'.934" - E 038° 14'.070"	4.08.2015	-
34	3	7.72	9.47	612	19.9	656.4	283.5	21.2	1216	0.33	442	N 38° 48'.550" - E 038° 15'.206"	4.08.2015	HI, PZe
35	3	7.62	5.09	683	23.6	680.8	277.9	31.1	918	0.34	455	N 38° 45'.264" - E 038° 19'.613"	5.08.2015	-
36	11	7.41	7.56	1899	18.6	666.3	284.9	26.4	1085	1.12	1410.5	N 38° 44'.567" - E 038° 14'.999"	5.08.2015	-
37	5	7.94	1.91	654	22.3	660.5	266	30.9	1170	0.34	448.5	N 38° 49'.400" - E 038° 14'.072"	5.08.2015	CV, IBa, LI, PV
38	10	8.11	8.71	303.9	14	633.9	264.2	22.4	1527	0.19	252.2	N 38° 50'.619" - E 038° 08'.193"	5.08.2015	HI, PVi, PZe
39	6	7.69	6.6	2307	23.9	676.9	284.4	34.7	944	1.21	1527.5	N 38° 44'.810" - E 038° 05'.357"	5.08.2015	HSa
40	5	8.35	8.54	1327	18.8	664.9	281.9	36.3	1092	0.76	975	N 38° 48'.552" - E 038° 03'.842"	5.08.2015	HSa, IBr, II
41	11	7.78	5.34	796	19.3	634.3	272.8	26.9	1472	0.44	578.5	N 38° 51'.647" - E 037° 58'.947"	5.08.2015	HI, HRo, IG, PZe
42	6	8.3	10.76	404.3	18.2	633.9	279.6	23.6	1530	0.22	301.6	N 38° 55'.477" - E 038° 00'.480"	5.08.2015	HSa, IBr, PZe
43	8	7.69	6.18	423.1	26.6	636.6	263.4	24.5	1485	0.2	267.45	N 38° 57'.045" - E 038° 02'.227"	5.08.2015	IBr, II
44	5	7.96	7.03	281.9	20.7	627.8	273.4	21.3	1587	0.15	199.55	N 38° 59'.442" - E 038° 03'.640"	5.08.2015	PV
45	8	8.08	5.16	325.9	21.7	610.8	276.5	22.3	1813	0.17	226.85	N 39° 02'.091" - E 038° 01'.669"	5.08.2015	-

Appendix A (Continued)

St No	Ht type	pH	DO	EC	TW	ATM	ORP	Moisture	EL	SAL	TDS	Coordinate	Date	Species
46	5	8.56	7.07	127.6	22.5	616.1	267.6	31.3	1767	0.06	87.1	N 39° 00'.708" - E 037° 59'.122"	5.08.2015	PV
47	1	8.87	7.68	174	24.8	619.7	258.1	20.5	1729	0.08	113.1	N 38° 59'.343" - E 037° 57'.580"	5.08.2015	COv, COp, IBr
48	3	7.84	9.18	142.5	11.3	630.9	282.5	15.4	1583	0.09	125.45	N 39° 00'.904" - E 037° 54'.004"	5.08.2015	-
49	5	7.82	5.26	606	28.1	642.3	258.5	16.7	1439	0.27	370.5	N 39° 01'.612" - E 037° 49'.407"	5.08.2015	HB, II, PAl
50	5	7.7	4.91	1482	25	654.7	272.1	27.6	1224	0.74	962	N 38° 58'.175" - E 037° 51'.264"	5.08.2015	-
51	5	8.52	7.42	859	26.4	659.9	261.8	21.4	1161	0.41	546	N 38° 49'.158" - E 037° 52'.314"	5.08.2015	HSa
52	11	8.65	13.45	633	26	634.9	264	21.6	1475	0.3	403	N 38° 51.927" - E 037° 47.371"	5.08.2015	-
53	2	8.59	6.12	1359	25.9	650.1	279	26.3	1288	0.67	864.5	N 38° 52'.046" - E 037° 42'.916"	5.08.2015	IBr
54	7	8.53	8.36	718	20.8	655.4	284.2	32.6	1211	0.38	507	N 38° 49'.899" - E 037° 41'.061"	5.08.2015	IBr, II, PZe
55	10	8.51	7.12	1039	23.5	628.6	283.4	25.5	1590	0.53	695.5	N 38° 47'.264" - E 037° 42'.863"	5.08.2015	HRo, HSa, IBr, II
56	7	8.34	7.08	636	16.4	655.6	272.7	58.5	1247	0.37	494	N 38° 53'.454" - E 037° 38'.625"	6.08.2015	-
57	3	7.76	8.37	711	17.6	632.7	279.6		1537	0.4	533	N 38° 55'.797" - E 037° 45'.151"	6.08.2015	-
58	8	8.79	11.02	353.7	10.9	643.7	257.1	20.5	1386	0.24	315.9	N 38° 43'.667" - E 037° 53'.359"	6.08.2015	CN, IBr
59	3	8.1	8.07	410.9	16.8	626.7	189.3	21.4	1611	0.24	317.2	N 38° 15'.824" - E 038° 27'.823"	6.08.2015	HIm, HRo, IBr, II
60	11	8.26	6.45	566	21	621.7	217.7	25.2	1660	0.28	377	N 38° 14'.266" - E 038° 29'.665"	6.08.2015	IBr

Appendix A (Continued)

St No	Ht type	pH	DO	EC	TW	ATM	ORP	Moisture	EL	SAL	TDS	Coordinate	Date	Species
61	5	7.62	5.25	250	20.3	621.6	213.1	24.1	1673	0.13	178.1	N 38° 10'.803" - E 038° 28'.815"	6.08.2015	IBr, PFo
62	2	8.23	9.93	524	10.5	637.3	245	36.6	1444	0.36	468	N 38° 08'.363" - E 038° 32'.031"	6.08.2015	II, PFu
63	5	8.36	9.24	260.3	14.9	667.7	253.8	37.1	1041	0.16	209.95	N 38° 08'.589" - E 038° 34'.981"	6.08.2015	-
64	3	7.8	7.34	152.5	16.9	630.9	253	26.5	1551	0.09	117.65	N 38° 12'.177" - E 038° 33'.818"	6.08.2015	CN, PFo
65	5	8.52	8.63	474.6	17.1	681.2	299	63	926	0.27	363.35	N 38° 13'.941" - E 038° 46'.472"	7.08.2015	HB, II
66	7	7.79	6.99	635	16.5	688.2	290.6	56.8	807	0.37	494	N 38° 11'.286" - E 038° 44'.120"	7.08.2015	-
67	3	8.39	7.94	599	19.4	650.4	289.6	41.3	1159	0.3	396.5	N 38° 12'.256" - E 038° 39'.950"	7.08.2015	HRo, II, PAl
68	2	8.35	9.95	397	16	683.6	295.1	43.1	874	0.23	312	N 38° 09'.822" - E 038° 43'.195"	7.08.2015	PAl
69	5	8.29	6.64	348.6	20.1	652.9	285.9	30.5	1259	0.18	249.6	N 38° 05'.783" - E 038° 44'.335"	7.08.2015	HIm, HRo, HSa, PVi
70	3	8.24	8.96	245.9	17.2	669.5	282.3	33.2	1051	0.14	188.5	N 38° 01'.421" - E 038° 45'.680"	7.08.2015	HRo, PV
71	10	10.3		193.7	25.4	611.5	232.4	25.4	1779	0.09	124.8	N 38° 07'.505" - E 038° 53'.678"	7.08.2015	-
72	5	8.2	7.65	121.1	18.1	606.4	271.6	24.6	1896	0.07	90.35	N 38° 06'.893" - E 038° 55'.673"	7.08.2015	PO
73	10	8.77	6.63	382	34.7	635.3	252.1	22.3	1510	0.15	208	N 38° 07'.568" - E 039° 00'.757"	7.08.2015	-
74	1	9.37	8.7	303.2	28.9	653.4	222.8	22.6	1283	0.13	182.65	N 38° 10'.573" - E 039° 02'.389"	7.08.2015	-
75	1	9.16	9.09	301.5	36.4	653.7	197.6	24.8	1241	0.11	161.85	N 38° 10'.660" - E 039° 02'.526"	7.08.2015	-

Appendix A (Continued)

St No	Ht type	pH	DO	EC	TW	ATM	ORP	Moisture	EL	SAL	TDS	Coordinate	Date	Species
76	2	8.5	8.36	307.5	18.1	657.4	258.6	14.8	1233	0.17	230.1	N 38° 12'.553" - E 039° 02'.566"	7.08.2015	-
77	3	7.73	6.64	485.7	18.5	638.1	283.3	17.9	1415	0.27	361.4	N 38° 13'.558" - E 038° 55'.203"	7.08.2015	-
78	10	7.74	2.79	699	22.9	694	289.4	39.1	727	0.35	474.5	N 38° 15'.210"" - E 038° 51'.350"	7.08.2015	-
79	3	8.21	5.54	775	25.9	653.8	289.2	19.5	1224	0.37	494	N 38° 15'.767" - E 039° 00'.415"	7.08.2015	-
80	3	6.64	2.3	418.1	19.5	625.4	273.2	21.1	1538	0.23	303.55	N 38° 16'.567" - E 038° 16'.567"	7.08.2015	-
81	3	8.19	5.61	376.6	24.8	681.5	231.6	25.7	874	0.18	245.05	N 38° 18'.805" - E 039° 01'.858"	7.08.2015	HRo
82	5	8.32	8.24	311.2	19.5	649.3	299.4	36.4	1285	0.17	226.2	N 38° 13'.003" - E 038° 16'.685"	8.08.2015	PAl
83	4	8.63	6.87	314.9	25	644.7	258.2	27.4	1394	0.15	204.75	N 38° 04'.437" - E 038° 13'.792"	8.08.2015	CV
84	3	7.52	1.74	673	20.6	631.5	144.2	30.5	1592	0.36	481	N 38° 13'.190" - E 038° 18'.450"	8.08.2015	CV
85	11	8.15	8.96	370.2	14.7	641.2	244.3	23.6	1468	0.22	299	N 38° 13'.994" - E 038° 14'.939"	8.08.2015	HRo, PFu
86	4	7.92	11.48	468.1	18.6	679.2	263.7	30.7	996	0.26	349.05	N 38° 19'.360" - E 038° 09'.309"	8.08.2015	HRo, IBr
87	11	10.05	9.55	664	17.4	658.5	280.3	24.8	1207	0.38	507	N 38° 14'.670" - E 038° 03'.931"	8.08.2015	HIm, HRo, HSa, PFu, PZe
88	11	7.46	5.53	874	16.1	664	281.3	21.3	1177	0.52	682.5	N 38° 10'.989" - E 037° 57'.337"	8.08.2015	PZe
89	7	8.48	7.78	553	19.8	668	273.8	38.5	1126	0.3	396.5	N 38° 08'.830" - E 037° 56'.433"	8.08.2015	-
90	6	7.56	11.21	769	22.3	647.3	262.9	24.1	1363	0.4	526.5	N 38° 05'.209" - E 037° 56'.699"	8.08.2015	IBr

Appendix A (Continued)

St No	Ht type	pH	DO	EC	TW	ATM	ORP	Moisture	EL	SAL	TDS	Coordinate	Date	Species
91	4	8.83	8.05	325.8	28.4	651.1	264	21.2	1308	0.14	198.25	N 38° 01'.145" - E 037° 55'.328"	8.08.2015	LI
92	3	8.25	7.76	215	17.1	638.3	301.5	21	1470	0.12	164.45	N 37° 59'.270" - E 038° 07'.332"	8.08.2015	-
93	5	8.15	7.65	457.3	14.9	648.3	324.8	29.1	1331	0.28	368.55	N 37° 55'.605" - E 037° 55'.261"	8.08.2015	-
94	8	7.72	8.97	369.8	13.5	640.2	319.9	26.4	1424	0.23	308.75	N 38° 03'.712" - E 037° 45'.979"	8.08.2015	PFo
95	5	8.2	7.53	682	19.9	666.3	311.1	51.7	1097	0.37	494	N 38° 00'.693" - E 037° 41'.911"	8.08.2015	-
96	8	7.63	10.18	379.1	12.6	671.6	309.9	48.3	1027	0.24	322.4	N 37° 58'.617" - E 037° 39'.490"	8.08.2015	-
97	5	7.99	7.83	547	16.8	653.8	300.5	54.9	1245	0.32	422.5	N 38° 08'.409" - E 037° 50'.577"	8.08.2015	-
98	2	7.25	6.59	888	14	662.8	315.4	36.5	1137	0.56	728	N 38° 15'.901" - E 037° 55'.097"	9.08.2015	-
99	4	8.5	8.2	412.1	25.5	682.8	290.1	53.6	901	0.19	265.85	N 38° 18'.961" - E 038° 02'.276"	9.08.2015	-
100	2	8.03	5.54	482.8	19.1	684.8	297.9	45.5	881	0.26	353.6	N 38° 20'.980" - E 038° 03'.850"	9.08.2015	HRo, IBe
101	3	7.56	6.56	990	17.8	673.1	312.9	39.4	1006	0.57	747.5	N 38° 26'.021" - E 038° 01'.989"	9.08.2015	HSa
102	11	8.18	9.46	324.4	11.9	643.3	300.5	39.3	1381	0.21	282.75	N 38° 27'.592" - E 037° 54'.346"	9.08.2015	HRo, IBr
103	2	7.79	9.69	123.9	11.9	622.5	291.3	32.4	1653	0.08	107.25	N 38° 24'.889" - E 037° 51'.412"	9.08.2015	CN, PFo
104	11	7.62	1.37	693	19.8	636.6	262.9	33.2	1507	0.38	500.5	N 38° 21'.598" - E 037° 52'.489"	9.08.2015	IBr
105	3	7.59	9.36	171.9	10.9	617.6	274	38.3	1766	0.11	153.4	N 38° 23'.088" - E 037° 48'.051"	9.08.2015	HRo, PFu

Appendix A (Continued)

St No	Ht type	pH	DO	EC	TW	ATM	ORP	Moisture	EL	SAL	TDS	Coordinate	Date	Species
106	10	11.11	5.59	875	18.7	635.6	267	31.8	1541	0.49	650	N 38° 20'.563" - E 037° 44'.565"	9.08.2015	CN
107	5	7.72	5.64	638	18.6	632.9	260	28.4	1567	0.36	474.5	N 38° 19'.501" - E 037° 43'.827"	9.08.2015	-
108	9	7.97	7.35	1498	19.8	695.5	280.3	33.8	777	0.84	1079	N 38° 30'.485" - E 038° 10'.378"	9.08.2015	IBr
109	11	8.14	14.13	1032	19.2	680.2	297.2	22.9	899	0.59	754	N 38° 32'.713" - E 038° 04'.690"	9.08.2015	-
110	5	8.18	7.83	777	15.7	660.5	315.9	32.9	1139	0.47	617.5	N 38° 36'.938" - E 038° 01'.753"	9.08.2015	IBr
111	2	8.1	9.6	416.6	10.7	635.9	316.7	24.4	1462	0.28	372.45	N 38° 38'.028" - E 037° 51'.888"	9.08.2015	-
112	10	8.41	7.2	1447	25	676.5	295.7	32.3	941	0.71	923	N 38° 31'.409" - E 037° 49'.987"	9.08.2015	HRo, HSa, IBr
113	7	8.36	8.37	817	21.1	679	299.6	51.2	915	0.43	572	N 38° 29'.295" - E 037° 45'.570"	9.08.2015	-
114	3	7.96	5.54	560	17.3	641.8	307.9	38.2	1388	0.32	429	N 38° 39'.143" - E 037° 32'.251"	10.08.2015	HRo, HSa
115	7	8.48	8.44	690	18.2	666.9	294.5	41.6	1074	0.39	513.5	N 38° 39'.407" - E 037° 39'.343"	10.08.2015	IBr
116	8	7.7	5.9	877	17.4	654.7	296.4	35.5	1250	0.51	669.5	N 38° 42'.024" - E 037° 39'.755"	10.08.2015	IBr
117	3	8.51	8.82	398.5	14.8	639.9	297.4	32.8	1428	0.24	323.05	N 38° 43'.478" - E 037° 36'.206"	10.08.2015	-
118	3	7.89	8.35	495.9	15.1	627	296.3	34.4	1624	0.3	399.1	N 38° 42'.048" - E 037° 31'.167"	10.08.2015	HRo
119	3	8.25	8.82	350.2	17.2	644.6	286.2	33.1	1381	0.2	267.5	N 38° 40'.977" - E 037° 27'.822"	10.08.2015	HRo
120	7	8.51	8.97	641	15.7	662.6	286.3	40.5	1137	0.38	507	N 38° 38'.087" - E 037° 28'.102"	10.08.2015	IBr
121	12	8.47	9.58	345	13.5	654.1	291.6	38.2	1245	0.21	287.3	N 38° 33'.341" - E 037° 25'.389"	10.08.2015	IBr, PFu
122	11	8.07	6.61	1251	21.7	668.9	291.4	47.3	1081	0.67	871	N 38° 34'.621" - E 037° 29'.599"	10.08.2015	HSa
123	9	8.36	5.58	791	26.6	672.8	286.5	33.5	986	0.37	500.5	N 38° 31'.057" - E 037° 33'.626"	10.08.2015	-
124	9	8.46	11.9	653	25.2	674.5	288.1	31.7	991	0.31	422.5	N 38° 32'.057" - E 037° 35'.814"	10.08.2015	-
125	5	8.37	7.84	1252	24.6	660.2	261.7	29	1184	0.63	819	N 38° 26'.381" - E 037° 34'.889"	10.08.2015	HRo, PZe

Appendix B Water ion concentration and sediment Phosphate (PO_4^-) values in Malatya Abbreviations: St No (Sampling site), NH_4 (Ammonium (mg L^{-1})), NO_3 (Nitrate (mg L^{-1})), Na (Sodium (mg L^{-1})), K (Potasium (mg L^{-1})), Mg (Magnesium (mg L^{-1})), Ca (Calcium (mg L^{-1})), F^- (Floride (mg L^{-1})), Cl^- (Chloride (mg L^{-1})), SO_4 (Sulphate (mg L^{-1})), ToP (Total sediment Phosphate (mg kg^{-1})), InP (Sediment Inorganic Phosphate (mg kg^{-1})), OrgP (Sediment Organic Phosphate (mg kg^{-1})). CN: *Candona neglecta*, COv*: Cyclocypris ovum*, COp: *Cypria ophtalmica*, CV*: Cypridopsis vidua*, CYu: *C. lusatica*, HB: *Herpetocypris brevicaudata*, HIm: *H. intermedia*, HI*: Heterocypris incongruens*, HRo*: H. rotundata*, HSa: *H. salina*, IB: *Ilyocypris bradyi*, IG: *I. gibba*, II*: I. inermis*, IBa: *Ilyocypris beauchampi*, LI: *Limnocythere inopinata*, PFu: *Potamocypris fulva*, PU: *P. unicaudata*, PV: *P. variegata*, PVi: *P. villosa*, PZe: *Prionocypris zenkeri*, PAl: *Pseudocandona albicans*, PFo: *Psychrodromus fontinalis*, PO: *P. olivaceus* (empty cells show no sampling).

Appendix B (Continued)

St No	NH_4	NO_3	Na	K	Mg	Ca	F^-	Cl^-	SO_4	ToP	InP	OrgP	Species
1	19.23	2.74	67.98	13.56	35.17	76.46	0.198	85.5	85.32	0.83	0.77	0.19	II
2	51.4	25.3	42.23	12.87	32.46	83.38			43.21	0.2	0.18	0.01	HI
3	34.19	29	49.51		180.3	60.52	0.159	54.61	53.6	0.37	0.36	0.05	HI
4	40.37	20.8	48.94	1.386	71.14	34.67	0.742	51.21	12.35	0.25	0.2	0.01	-
5	94.38	64.7	12.25	5.112	14.02	62.62			26.3	0.42	0.4	0.07	HI
6	80.76	9.4	24.72	4.326	22.89	49.29	0.125	39.07	16.95	0.48	0.36	0.07	HI
7	81.49	0.23	19.06	6.31	43.02	32.94	0.109	24.51	23.61	0.36	0.25	0.04	HSa
8			22.5	3.788	44.6	102.8	0.123	40.06	65.24	0.45	0.34	0.02	LI
9			86.28	1.826	34.84	96.9	0.212	13.79	25.4				CYu
10										0.56	0.59	0.01	PFo
11			29.06	6.9	60.4	186.6	1.19		50.21	0.79	0.65	0.32	PFu, PFo
12			23.19	7.767	16.42	91.03	0.291	43.15	89.93	0.74	0.46	0.1	-
13	96.04	0.51	15.3	2.716	16.38	86.03	1.809	42.4	62.28	0.3	0.24	0.02	PO
14	124.1	16					0.688	87.96	51.56	0.23	0.28	0.03	CV, HI, HRo
15	161.8	71.1	60.41	4.584	68.78	72.78				0.53	0.52	0.02	-

Appendix B (Continued)

St No	NH_4	NO_3	Na	K	Mg	Ca	F^-	Cl^-	SO_4	ToP	InP	OrgP	Species
16	169.7	65.3	47.62		22.86	68.64	0.128	42.42	23.08	0.37	0.32	0.05	-
17	213.9	56	35.17		25.78	155.4	0.2	40.08	48.23				HI, HSa, IBr
18	73.78	7.48	19.43	6.236	22.22	80.44		70.41	61.25				HSa
19	111	9.49	28.21		1.988	64.42	0.274	55.95	67.08				HSa, IBr
20	126.1	22.7	42.44	3.15	20.92	75.4	0.1	9.747	16.13				HI, HSa
21	136.4	37.6	33.97	2.327	2.79	37.37	0.11	49.53	32.1	0.43	0.33	0.04	HI, HSa
22	113.2	15.9	71.57			52.01	0.026	7.351	6.058	0.55	0.55	0.03	HI
23	86.44	8.36	17.25	3.237	23.49	111.7	0.205	36.28	60.89				HSa, PVi
24	228.2	60.3	91.66	8.226	8.324	65.23	0.411	81.31	53.86	0.43	0.38	0.04	PVi
25			43.23	2.733	12.53	87.91		16.94	35.51	0.57	0.53	0.1	-
26			60.49	0.847	10.57	168.7		27.94	43.07				COp, CV
27			86.83	0.747	6.592	42.83		24.24	30.46	0.73	0.64	0.09	-
28			53.76	2.465	11.23	151.2		32.01	22.65	0.77	0.69	0.1	PFu
29			14.05	2.566	13.4	125.3	0.077	34.09	62.62	0.84	0.97	0.06	-
30			77.97	9.536	11.8	85.67	0.135	14.29	26.62	0.81	0.77	0.02	-

Appendix B (Continued)

St No	NH_4	NO_3	Na	K	Mg	Ca	F^-	Cl^-	SO_4	ToP	InP	OrgP	Species
31			18.7	2.661	12.87	106	0.047	19.56	39.15	0.75	0.96	0.03	II, PU, PVi
32			40.04	3.147	6.982	89.56		11.46	9.68	0.8	0.88	0.06	-
33			5.051	8.103	32.04	74.24		32.17	57.07				-
34			16.93	6.417	13.67	61.99		15.07	69.57				HI, PZe
35			23.79	1.602	15.42	83.88		51.16	85.96				-
36	282.7	2.64	50.46	2.362	41.92	96.73		13.01	12.51				-
37	173.2	7.8	35.8	1.697	65.23	98.5	0.121	32.6	31.65	0.75	0.76	0.07	CV, IBa, LI, PV
38			30.59	1.382	68.29	49.09	0.082	13.25	21.93	0.73	0.41	0.22	HI, PVi, PZe
39			16.12		69.87	102	0.119	23.78	17	0.34	0.29	0.03	HSa
40	233.2	19.5	10.2	1.65	20.01	49.67	0.302	19.14	34.39	0.34	0.32	0.03	HSa, IBr, II
41			15.9	7.36	93.01	235.6		19.03	37.59	0.47	0.35	0.08	HI, HRo, IG, PZe
42			11.29	6.646	17.22	103.4				0.51	0.33	0.05	HSa, IBr, PZe
43			13.33	1.257	86.32	80.4			18.95				IBr, II
44			5.746	0.9	30.81	90.64		20.54	13.57				PV
45			32.54	1.508	47.14	77.9		76.23	28.47	0.47	0.51	0.04	-

Appendix B (Continued)

St No	NH_4	NO_3	Na	K	Mg	Ca	F^-	Cl^-	SO_4	ToP	InP	OrgP	Species
46			13.11	0.267	30.9	8.558		18.14	23.24	0.5	0.59	0.01	PV
47			8.965	0.801	29.79	67.67		7.648	6.197	0.7	0.52	0.02	COv, COp, IBr
48			7.49	1	56.71	45.4			6.58	1.02	0.98	0.1	-
49			10.8	0.994	60.89	26.3		8.853	28.96				HB, II, PAl
50			15.63	4.121	14.59	78.31	0.193	23.34	63.2	0.3	0.3	0.02	-
51			25.36	1.874	14.61	41.82		8.137	9.491	0.2	0.16	0.03	HSa
52			14.49	3.05	15.26	92.52		18.98	20.91	0.6	0.58	0.05	-
53			14.48	3.441	27.86	76.78		14.94	7.926	0.37	0.35	0.04	IBr
54			8.999	1.075	32.3	75.4		17.96	13.11	0.42	0.38	0.06	IBr, II, PZe
55	141.5	23	74.12	2.836	21.56	96.94	0.051	14.63	24.82	0.4	0.28	0.1	HRo, HSa, IBr, II
56	72.05	4.92	19.18	4.646	12.3	45.04		15.37	18.23	0.28	0.29	0.05	-
57	80.98	1.58	16.65	6.314	52.6	42.11		15.32	26.8				-
58	110.2	12	16.52	7.191	48.78	26.07	0.435	2.104	4.499	0.39	0.35	0.09	CN, IBr
59	4	0.17	13.41	3.926	42.15	65.23	0.143	2.245	3.168				HIm, HRo, IBr, II
60	4.57	0.49	16.84	1.669	36.56	89.35	0.151	2.643	14.9	0.64	0.48	0.16	IBr

Appendix B (Continued)

St No	NH_4	NO_3	Na	K	Mg	Ca	F^-	Cl^-	SO_4	ToP	InP	OrgP	Species
61	5.49	0.08	11.71	2.125	23.86	118.2		1.866	3.309	0.45	0.25	0.14	IBr, PFo
62	1.38	0.05	17.97	2.081	27.04	146.2	0.059	4.459	8.271	0.7	0.78	0.18	II, PFu
63	1.54	0.1	15.92	1.795	63.25	60.78	0.069	3.487	13.4	0.76	0.83	0.08	-
64	1.41	0.02	11.47	2.554	48.21	91.82	0.083	1.82	18.7	0.69	0.41	0.54	CN, PFo
65	60.2	6.52	29.38	3.19	39.67	98.08		6.737	30.94	0.55	0.47	0.14	HB, II
66	38.48	0.7	21.26	2.32	40.13	74.3	0.071	7.175	22.5	0.73	0.77	0.12	-
67	22.97	2.21	90.57	4.164	50.16	103.3	0.101	15.45	12.09	0.84	0.62	0.29	HRo, II, PAl
68	163.8	12.4	60.23	0.235	51.53	60.51	0.241	17.91	72.71	0.73	0.64	0.3	PAl
69	99.08	7.92	9.302	3.829	48.2	119.1	0.386	35.71	48.96	0.78	0.74	0.3	HIm, HRo, HSa, PVi
70							0.256	10.66	28.18				HRo, PV
71			9.673	8.03	23.28	118				0.84	0.76	0.54	-
72	61..51	3.46	11.44	4.804	19.87	280.2	0.072	7.442	30.84	0.79	0.75	0.38	PO
73	170.2	139	5.233	5.099	19.53	188.2	0.073	4.444	28.91	0.81	0.75	0.23	-
74			4.884	8.45	23.41	74.6		10.29	13.68	0.76	0.71	0.22	-
75			2.11	3.781	33.29	97.57		35.3	91.8	0.7	0.43	0.31	-

Appendix B (Continued)

St No	NH_4	NO_3	Na	K	Mg	Ca	F^-	Cl^-	SO_4	ToP	InP	OrgP	Species
76	248.9	29.3	9.134	1.99	27.89	92.12		55.51	38.78	0.75	0.66	0.25	-
77	133.1	2.67	12.92	6.584	62.49	58.09		14.83	46.6				-
78			8.18	1.568	74.12	71.12		3.645	35.4	0.59	0.62	0.08	-
79			12.44	3.102	68.28	87.56		49.25	69.02				-
80			3.383	2.849	29.36	86.1		3.517	58.97				-
81	288.3	29.6	2.925	2.137	30.02	34.68		7.384	17.83	1.15	0.98	0.19	HRo
82	72.32	6.64	1.014	0.87	25.63	81.59	0.095	2.403	10.86	0.91	0.46	0.41	PAl
83	67.3	17.2	2.32	5.786	48.92	66.19	0.13	3.496	12.94	0.76	0.59	0.43	CV
84	219.5	2.52	1.694	6.63	47.56	96.52	0.447	11.86	15.74	0.71	0.61	0.19	CV
85			3.759	3.867	40.01	48.48		5.749	23.6				HRo, PFu
86			5.201	8.052	40.56	80.72				0.71	0.73	0.07	HRo, IBr
87			5.946	1.004	14.37	8.093	0.107	2.217	10.52	0.67	0.59	0.1	HIm, HRo, HSa, PFu, PZe
88			5.777	26.37	8.2	75.94	0.098	1.961	7.711	0.78	0.77	0.23	PZe
89			21.71	8.971	35.07	82.85	0.106	2.674	9.26	0.55	0.68	0.06	-
90			5.538	11.41	32.52	81.77	0.187	6.887	19.68	0.72	0.71	0.24	IBr

Appendix B (Continued)

St No	NH_4	NO_3	Na	K	Mg	Ca	F^-	Cl^-	SO_4	ToP	InP	OrgP	Species
91	266.1	131	6.82	12.64	28.1	96.95	0.162	2.618	8.316	0.53	0.58	0.07	LI
92			4.857	7.034	24.37	63.73	0.112	2.088	8.972	0.95	0.71	0.42	-
93	149.6	6.16	9.605	9.907	15.91	70.61				0.74	0.8	0.14	-
94			12.41	7.43	18.03	75.68	0.144	26.56	46.61	0.74	0.79	0.11	PFo
95			26.56	9.321	42.17	84.12	0.193	5.63	16.67	0.59	0.71	0.02	-
96			3.57	11.82	32.14	85.23	0.134	4.403	16.18	0.61	0.65	0.04	-
97			56.32	10.39	6.235	70.68	0.087	1.398	20.77				-
98	81.54	0.37	5.47	9.459	5.676	75.9	0.172	4.055	15.86	0.61	0.76	0.11	-
99	82.62	16.4	6.28	19.61	11.77	52.74	0.211	8.009	25.51	0.25	0.22	0.03	-
100	102.8	3.92	15.26	105	63.02	136.9	0.1	5.592	25.29	0.57	0.65	0.09	HRo, IBe
101	68.43	0.76	25	7.371	4.422	22.67	0.179	4.385	6.082				HSa
102	100.2	3.27	48.15	8.099	4.859	108.7	0.128	3.625	17.14	0.5	0.42	0.06	HRo, IBr
103	277.1	3.75	62.14	13	7.798	88.76	0.042	4.325	19.45	0.55	0.44	0.12	CN, PFo
104	193.7	3.24	50.15	15.07	9.041	72.76	0.128	4.491	8.287	0.24	0.22	0.03	IBr
105	292	1.95	20.15	23.29	13.97	80.39	0.119	2.285	12.65	1.58	1.68	0.45	HRo, PFu

Appendix B (Continued)

St No	NH_4	NO_3	Na	K	Mg	Ca	F^-	Cl^-	SO_4	ToP	InP	OrgP	Species
106			14	4.816	2.89	116.9	0.349	4.891	22.26	0.39	0.4	0.05	CN
107			23.46	2.449	1.469	124.7	0.073	5.126	17.68	0.71	0.76	0.02	-
108	72.33	2.86	36.89	6.805	4.083	75.06	0.33		29.59	0.54	0.46	0.15	IBr
109	76.64	2.64	61.35	6.062	3.637	126.1	0.126	10.05	26.88	0.41	0.32	0.13	-
110	93.07	4.04	3.56	8.736	5.241	97.87	0.135	5.458	30.49				IBr
111	156.5	4.11	4.59	3.342	2.005	118.9	0.069	21.61	48.32	0.67	0.56	0.39	-
112			6.38	8.922	5.353	48.87	0.078	3.558	21.8	0.16	0.21	0.03	HRo, HSa, IBr
113	199.8	19.7	8.89	6.462	3.877	120.1	0.108	3.13	7.548	0.39	0.35	0.06	-
114	55.36	1.52					0.134	13.66	21.44				HRo, HSa
115	64.23	6.82	15.62	7.443	4.466	97.06	0.051	6.459	7.383	0.4	0.34	0.05	IBr
116	74.87	1.26	45.23	15.92	9.549	66.02	0.198	2.649	7.561	0.22	0.15	0.07	IBr
117	78.19	7.98	36.24	8.605	5.163	96.49	0.44	2.859	36.92	0.72	0.55	0.15	-
118	159.1	1.2	23.78	10.18	25.62	79.06	0.112	3.231	10.13	1.04	0.81	0.13	HRo
119	119.8	6.84	22.46	4.277	15.23	68.81	0.025	2.915	12.83	0.58	0.44	0.1	HRo
120	205.8	19.7	35.41	7.249	35.2	34.21	0.053	3.062	40.09	0.37	0.31	0.06	IBr
121	215.5	17.2								0.12	0.1	0.02	IBr, PFu
122	225.7	12.1								0.18	0.17	0.03	HSa
123	102.8	15								0.31	0.29	0.03	-
124	90.63	15.5								0.32	0.28	0.05	-
125	93.95	12.3								0.84	0.93	0.12	HRo, PZe

Appendix C Tolerance (tk) and Optimum (uk) values of 15 species for 20 variables in Malatya Abbrevations:Code: Species' code, Cnt: Species' occurrence, Mx: Species' maximum occurrence, N2: Hill's coefficient, DO (dissolved oxygen concentration, mgL^{-1}), EC (electrical conductivity, μScm^{-1}), SAL (salinity, ppt), TW (water temperature, ºC), ORP (oxidation reduction potential, mV), ATM (atmospheric pressure, mmHg), EL (Elevation, m a.s.l.), NH_4 (Ammonium (mg L^{-1})), NO_3 (Nitrate (mg L^{-1})), Na (Sodium (mg L^{-1})), K (Potasium (mg L^{-1})), Mg (Magnesium (mg L^{-1})), Ca (Calcium (mg L^{-1})), F^- (Floride (mg L^{-1})), Cl^- (Chloride (mg L^{-1})), SO_4 (Sulphate (mg L^{-1})), ToP (Total sediment Phosphate (mg kg^{-1})), InP (Sediment Inorganic Phosphate (mg kg^{-1})), OrgP (Sediment Organic Phosphate (mg kg^{-1})). CN: *Candona neglecta*, CV: *Cypridopsis vidua*, HI: *Herpetocypris intermedia*, HI: *Heterocypris incongruens*, HRo: *H. rotundata*, HSa: *H. salina*, IB: *Ilyocypris bradyi*, II: *I. inermis*, LI: *Limnocythere inopinata*, PFu*: Potamocypris fulva*, PV: *P. variegata*, PVi: *P. villosa*, PZe: *Prionocypris zenkeri*, PAl: *Pseudocandona albicans*, PFo: *Psychrodromus fontinalis* (empty cells show no sampling).

Appendix C (Continued)

				pH		DO		EC		TW		ORP		ATM		EL	
Code	Cnt	Mx	N2	uk	tk	uk	tk	uk	tk	uk	tk	uk	tk	uk	tk	uk	tk
CV	5	52	1.52	7.74	0.93	2.58	3.43	626.9	194	21.44	3.18	166.19	76.14	635.93	18.99	1528	261
HIm	3	7	2.18	8.33	0.72	7.72	1.17	411.2	110.7	17.95	2.08	229.08	63.99	638.08	18.41	1460	243
HI	12	72	4.87	8.28	0.4	10.1	2.21	1144	995.4	25.97	4.87	240.14	31.89	673.18	16.01	1014	193
HRo	19	158	6.62	8.06	0.33	6.8	1.87	605.3	312.7	18.48	4.15	277.64	31.04	648.11	18.91	1315	237
HSa	18	190	3.86	8.39	0.31	8.28	3.28	1150	864.2	21.33	4.51	247.87	30.88	670.68	23.49	1055	300
IBr	24	138	6.95	8.12	0.4	7.75	2.27	626.8	420.5	18.52	4.4	271.91	35.42	639.08	16.41	1451	211
II	11	21	3.92	8.32	0.37	7.9	1.39	545.4	212	20.07	5.44	276.69	36.93	661.15	25.19	1167	314
LI	3	7	2.18	9.45	1.56	4.91	2.96	407.6	237.4	30.16	7.92	193.44	82.87	673.48	17.38	1003	229
PFu	7	75	3.29	8.88	1.14	9.36	0.69	487	195.5	15.16	2.83	261.94	20.85	648.14	14.69	1352	205
PV	4	175	1.75	8.25	0.24	8.12	2.8	259	174.9	18.47	3.32	278.66	9.567	659.17	30.24	1188	402
PVi	5	390	2.11	8.46	0.27	8.95	3.26	555.2	93.23	26.3	2.38	240.11	15.76	647.44	7.179	1349	99.8
PZe	8	208	2.65	9.05	1.24	9.88	1.13	568.1	170.1	18.07	1.23	280.23	2.725	648.87	14.93	1330	197
PAl	4	6	2.96	8.18	0.3	7.41	1.85	452.8	173.7	21.86	5.23	284.98	22.07	649.95	12.61	1281	185
PFo	6	66	2.52	7.79	0.15	9.06	1.26	199.5	148.9	13.35	2.73	288.55	32.76	629.82	15.43	1561	194
CN	4	66	1.65	7.99	0.78	8.06	2.24	188.6	164.9	15.62	3.83	256.86	16.52	632.19	8.525	1534	108

Appendix C (Continued)

				SAL		NH_4		NO_3		Na		K		Mg		Ca	
Code	Cnt	Mx	N2	uk	tk	uk	tk	uk	tk	uk	tk	uk	tk	uk	tk	uk	tk
CV	5	52	1.52	0.33	0.12	194	96.3	4.737	8.67	4.22	17.1	6.11	2.49	47.24	14.34	92.5	30.6
HIm	3	7	2.18	0.23	0.07	35.4	61.2	2.739	4.978	11.4	3.41	3.65	1.09	41.85	11.88	78.4	44.4
HI	12	72	4.87	0.55	0.47	96.4	74	22.46	20.02	30.3	13.8	3.58	2.59	16.27	22.14	66.7	48.8
HRo	19	158	6.62	0.33	0.15	70.5	92.4	4.846	9.171	13.6	17.5	7.43	19.4	34.32	42.12	94.7	103
HSa	18	190	3.86	0.62	0.51	100	64.8	13.94	11.18	29.3	16	3.03	2.62	16.26	10.78	76.4	25.1
IBr	24	138	6.95	0.34	0.21	67.7	62.7	6.532	10.23	35.5	27.2	6.72	5.13	18.58	12.92	92.6	26.2
II	11	21	3.92	0.29	0.12	41.3	53.4	4.668	6.395	28.1	23.2	2.83	2.19	44.3	22.3	89.1	27.3
LI	3	7	2.18	0.19	0.15	79.9	133	13.52	48.37	25.6	11.3	3.83	3.84	50.1	15.75	101	3.13
PFu	7	75	3.29	0.29	0.11	21.8	89.8	0.397	2.611	9.15	11.1	3.92	6.34	27.42	17.8	52.3	64.4
PV	4	175	1.75	0.14	0.09	11.7	66.4	0.527	2.992	4.56	14.6	0.2	0.7	10.4	29.18	12.8	47.2
PVi	5	390	2.11	0.26	0.04	170	97.7	38.91	35.38	60.9	51	6.2	3.36	15.85	14.91	84.3	32.2
PZe	8	208	2.65	0.32	0.1	0.43	8.06	0.057	1.057	9.5	5.14	3.97	4.04	16.65	13.04	53.8	62.7
PAl	4	6	2.96	0.23	0.07	49.5	56.4	4.356	4.579	22.4	40.3	1.37	1.48	42.25	19.45	66.3	35
PFo	6	66	2.52	0.12	0.09	157	176	2.12	2.387	40.1	32.4	9.53	5.55	16.9	19.18	85.3	23.3
CN	4	66	1.65	0.12	0.11	39.8	127	2.113	6.794	16.3	21.7	4.11	4.93	44.52	18.91	82	37.6

Appendix C (Continued)

				F^-		**Cl^-**		**SO_4**		**ToP**		**InP**		**OrgP**	
Code	Cnt	Mx	N2	uk	tk	uk	tk	uk	tk	uk	tk	uk	tk	uk	tk
CV	5	52	1.52	0.39	0.23	13.2	18.7	17.1	11.08	0.7	0.18	0.6	0.16	0.21	0.15
HIm	3	7	2.18	0.22	0.16	13.4	21.4	19.05	28.87	0.32	0.51	0.29	0.48	0.11	0.19
HI	12	72	4.87	0.1	0.13	30.3	21.9	38.16	22.9	0.21	0.25	0.17	0.2	0.02	0.03
HRo	19	158	6.62	0.08	0.1	10.8	9.31	22.58	13.12	0.45	0.41	0.4	0.39	0.08	0.08
HSa	18	190	3.86	0.13	0.12	22.5	25.9	29.53	28.97	0.12	0.24	0.08	0.17	0.01	0.03
IBr	24	138	6.95	0.09	0.11	5.21	6.57	11.53	10.97	0.39	0.15	0.28	0.14	0.08	0.04
II	11	21	3.92	0.03	0.07	9.76	14.7	26.32	14.79	0.43	0.31	0.39	0.3	0.1	0.09
LI	3	7	2.18	0.13	0.01	34.5	13.9	49.3	26.9	0.55	0.19	0.5	0.26	0.04	0.03
PFu	7	75	3.29	0.13	0.33	4	4.82	17.78	12.78	0.48	0.52	0.46	0.52	0.1	0.15
PV	4	175	1.75	0.2	0.16	13.7	9.2	26.92	5.789	0.12	0.37	0.13	0.4	0.01	0.03
PVi	5	390	2.11	0.33	0.14	62.6	31.1	55.81	6.288	0.3	0.32	0.27	0.3	0.04	0.09
PZe	8	208	2.65	0.05	0.07	3.39	6.6	14.71	27.89	0.52	0.27	0.42	0.26	0.07	0.05
PAl	4	6	2.96	0.08	0.08	7.59	6.8	21.37	20.73	0.6	0.5	0.36	0.3	0.26	0.22
PFo	6	66	2.52	0.08	0.14	8.88	12.5	25.09	16.31	0.61	0.11	0.52	0.2	0.18	0.2
CN	4	66	1.65	0.14	0.21	2.1	1.18	16.68	8.145	0.63	0.18	0.4	0.04	0.43	0.3

Appendix D t-test unequal variance analyses (two-tailed p=0.05) results Abbrevations: SAL (Salinity), TW (Water Temperature), DO (Dissolved oxygen), ORP (oxidation reduction potential), Cl^- (Chloride).

Appendix D (Continued)

SAL

t-Test: Two-Sample Assuming Unequal Variances

Mean	0.385679	0.315984
Variance	0.11082	0.049325
Observations	81	45
Hypothesized Mean Difference	0	
df	120	
t Stat	1.403962	
P(T<=t) one-tail	0.081456	
t Critical one-tail	1.657651	
P(T<=t) two-tail	0.162913	
t Critical two-tail	1.97993	

TW

t-Test: Two-Sample Assuming Unequal Variances

Mean	20.9321	20.55238
Variance	31.65171	35.22402
Observations	81	42
Hypothesized Mean Difference	0	
df	79	
t Stat	0.34246	
P(T<=t) one-tail	0.366457	
t Critical one-tail	1.664371	
P(T<=t) two-tail	0.732915	
t Critical two-tail	1.99045	

Appendix D (Continued)

DO

t-Test: Two-Sample Assuming Unequal Variances

Mean	7.613333	7.800488
Variance	4.979395	6.122565
Observations	81	41
Hypothesized Mean Difference	0	
df	73	
t Stat	-0.40762	
P(T<=t) one-tail	0.342371	
t Critical one-tail	1.665996	
P(T<=t) two-tail	0.684743	
t Critical two-tail	1.992997	

ORP

t-Test: Two-Sample Assuming Unequal Variances

Mean	255.3061	272.3093
Variance	1940.273	875.2504
Observations	82	43
Hypothesized Mean Difference	0	
df	115	
t Stat	-2.56285	
P(T<=t) one-tail	0.005836	
t Critical one-tail	1.658212	
P(T<=t) two-tail	0.011673	
t Critical two-tail	1.980808	

Appendix D (Continued)

Cl^-

t-Test: Two-Sample Assuming Unequal Variances

	85.504	43.1482
Mean	15.65731	7.993737
Variance	370.405	224.3632
Observations	81	81
Hypothesized Mean Difference	0	
df	151	
t Stat	2.828134	
P(T<=t) one-tail	0.002659	
t Critical one-tail	1.655007	
P(T<=t) two-tail	0.005318	
t Critical two-tail	1.975799	

Appendix E Various photos from sampling sites in study.

1. Sampling site 1 (03.08.2015)
2. Sampling site 23 (04.08.2015)
3. Sampling site 37 (05.08.2015)
4. Sampling site 60 (06.08.2015)
5. Sampling site 88 (08.08.2015)
6. Sampling site 94 (08.08.2015)
7. Sampling site 99 (09.08.2015)
8. Sampling site 123 (10.08.2015)


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2015/08/10