# COMPARATIVE ANALYSIS OF OSTRACODA (CRUSTACEA) DIVERSITY AND DETERMINATION OF THEIR ECOLOGICAL CHARACTERISTICS IN DÜZCE AND KARABÜK (TURKEY) REGIONS

**By**

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# ABSTRACT


## COMPARATIVE ANALYSIS OF OSTRACODA (CRUSTACEA) DIVERSITY AND DETERMINATION OF THEIR ECOLOGICAL CHARACTERISTICS IN DÜZCE AND KARABÜK (TURKEY) REGIONS

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During this study, 36 ostracod taxa (22 living and 14 sub-recent) were randomly collected with 4155 individuals from 81 sites in Karabük region (4,145 km$^2$) in26 – 28 July 2012. All taxa are new reports for the region. First two axes of Canonical Correspondence Analysis (CCA) displayed 73.4% of the total inertia (6.245) of the relationship between species and environmental variables. Among the species, *Heterocypris incongruens*, *H. salina*, *Ilyocypris bradyi* and *Psychrodromus olivaceus* were found as the most frequently occurring species. When *H. incongruens* showed relatively higher optimum and tolerance values more than the mean values of 14 species analyzed, others showed species-specific tolerance and optimum levels. Majority of the species were mostly found from 50 troughs followed by stream, ditch, springs, ponds, lake and cave water. Results suggest that although troughs are artificial, they can provide suitable habitats for ostracods. However, converting natural water sources to troughs will eventually lower the species quality and diversity.

In contrast, total of 30 ostracod taxa (19 living and 11 sub-recent) with 2738 individuals were randomly collected from 81 sites in Düzce region (2573 $km^2$) in21-24 September, 2012. out of the individuals collected 16 species are new reports for Düzce region. First two axes of Canonical Correspondence Analysis (CCA) displayed 74% of the total inertia (5.488) for the relationship between species and environmental variables. Among the species *H.salina*, *I.bradyi*, *C.neglecta, P.olivaceus* were found as the most frequently occurring species when the last three species were also common in Karabük.

During comparative analyses, two critical hypotheses were tested which includes: (i) numbers of species are equally distributed at the same altitudinal ranges in Düzce and Karabük that altitude alone does not effect species distribution, and (ii) no difference found in the means numbers of species between the two regions. Results showed that there was no significant difference(means numbers of species between two region) in the diversity and change in the numbers of species within the corresponding altitudinal ranges.

**Keywords:** Ostracoda, distribution, tolerance, optimum, cosmopolitan, diversity, Karabük, Düzce.

## ÖZET


**DÜZCE VE KARABÜK (TÜRKİYE) BÖLGESİNDEKİ OSTRAKODA (CRUSTACEA) ÇEŞİTLİLİĞİNİN KARŞILAŞTIRMALI ANALİZİ VE EKOLOJİK ÖZELLİKLERİNİN BELİRLENMESİ**

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Karabük bölgesinde 36 takson toplanmıştır bunların 22 tanesi canlı form, 14'ü ise güncel kabuk formundadır. Toplam 81 istasyondan 4155 birey toplanmıştır, Karabük bölgesi 4,145 $km^2$ yüz ölçümüne sahiptir. Arazi çalışması 26-28 Temmuz 2012 tarihleri aralığında yapılmıştır. Türlerin hepsi Karabük bölgesi için yeni kayıttır. Çok Yönlü Bağlantılı Uyum Analizi (CCA) ndeilk iki eksende türler ve çevresel değişkenler arasındaki ilişkiyi %73.4, toplam varyans ise (6.245) olarak açıklamıştır. Tüm türler arasında *Heterocypris incongruens*, *H. salina*, *Ilyocypris bradyi* and *Psychrodromus olivaceus,* en sık görülen türlerdir. *H. incongruens*14 tür arasında en yüksek optimum ve tolerans seviyesine sahip olan türdür. Diğerleri ise sadece belli çevresel değişkenliklere karşı optimum ve tolerans seviyeleri değişmektedir. Yalaktan diğer değişik sucul ortamlarına gore daha çok örnekleme

yapılmıştır. Yalak sayısı 50 kadardır ve bunu dere, küçük su yolu, kaynak, su birikintisi, göl ve mağara suyu takip etmektedir.

Düzce'de 21-24 Eylül 2012 tarihleri arasında 81 istasyondan 2738 birey, 19 ü canlı 11 kabuk formu olmak üzere toplamda 30 takson kaydedilmiştir. Düzce ili 2573 km² yüz ölçümüne sahiptir. Daha once yapılmış olan çalışmalarda 7 takson ve 3 tür kaydedilmiştir. Bunlar *Candona* sp., *Ilyocypris* sp., *Pseudocandona* sp., *Candona neglecta*, *Psychrodromus* sp., *Ilyocypris bradyi, I.inermis.*Diğer 16 tür ise Düzce için yeni kayıttır. Çok Yönlü Bağlantılı Uyum Analizi (CCA) ndeilk iki eksende türler ve çevresel değişkenler arasındaki ilişkiyi %74.0, toplam varyans ise 5.488 olarak açıklamıştır.Türler arasında *Psychrodromus olivaceus*, *Heterocypris salina*, *Ilyocypris bradyi*, *Candona neglecta*olmak üzere en sık görülen türlerdir. Örneklemelerin yükseklikleri 7-1295 m arasındadır. Ancak, bizim görüşümüz yüksekliğin türlerin dağılımı üzerindeki etkisi ikinci planda yer almaktadır.

İki bölge için 2 hipotez bulunmaktadır.Bunlar; (i) türler aynı yükseklik aralıklarında dağılımları eşittir (ii) Karabük ve Düzce deki ortalama tür sayısı arasında farklılık yoktur.Sonuçlar iki bölge arasındaki çeşitlilik olarak birbirinden farklı olduklarını ortaya koymaktadır.Bu çalışma ilerdeki yapılacak çalışmalar için bir ön taslak niteliği taşımaktadır.

**Keywords:** Ostrakod, Dağılım, Optimum, tolerans, Çeşitlilik, Karabük, Düzce.

***To My Father and My Mother***

***Hasan YILMAZ and Nuray YILMAZ***

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# CHAPTER I

# INTRODUCTION

## Ostracoda

Ostracoda was first described by O.F. Müller in 1776. The name 'Ostracoda' comes from Greek word 'Ostrakon'which means'shell'. Ostracods are small (0.3-5mm) aquatic invertebrate crustaceans but some marine ostracods are about 30mm long (Meisch 2000). Ostracods can live in different aquatic bodies ranging from hot springs (Külköylüoğlu et al., 2003) to very cold waters (Delorme, 1991) in a widegeographical range (Külköylüoğlu et al., 2010). They have bivalved shell formed from calcium carbonate. They are known to be the oldest microfosil animals, and also are known as bioindicator species (Curry, 1999). Their carapace and valves have been used for paleolimnological and paleoclimatic studies in the aquatic ecosystem because ostracods help to understand past history of environment by means of using their carapace. They are also known as a popular model organisms for research on the evolution of reproductive modes (Martens, 1998a) and as proxies for climate and ecosystem changes (Holmes et al., 2002). If ostracods habitat preference and tolerance levels of individual species are known, their future habitat conditions can be estimated (Külköylüoğlu et al., 1998; Mezquita et al., 1999; Külköylüoğlu, 1999).

Ostracoda belongs to the Phylum Arthropoda and Subphylum Crustacea. They evolved from Cambrian age and were reported in the Devonian time. Ostracoda has two subclasses; Podocopa and Myodocopa (Horne et al., 2002). There are three orders of Ostracoda: Myodocopa, Platycopida and Podocopida (Meisch, 2000). Podocopa includes three orders as Podocopida, Platycopida and Palaecopida (Horne, 2003). Species while Podocopida include freshwater, brackish and some marine species. The freshwater ostracods have three subfamilies which are Cypridoidea, Cytheroidea and Darwinuloidea (Meisch, 2000).

**General Morphology of Ostracoda**

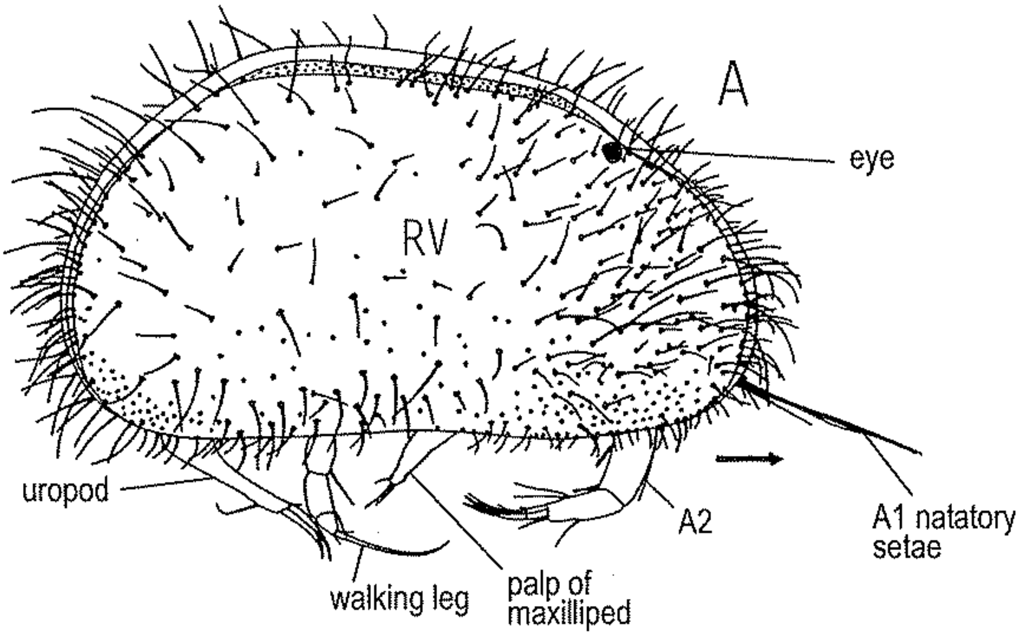


**Figure 1**.Ostracod example seen from lateral view of the right valve (RV) (Meisch 2000). (A1: first antenna, A2: second antenna).

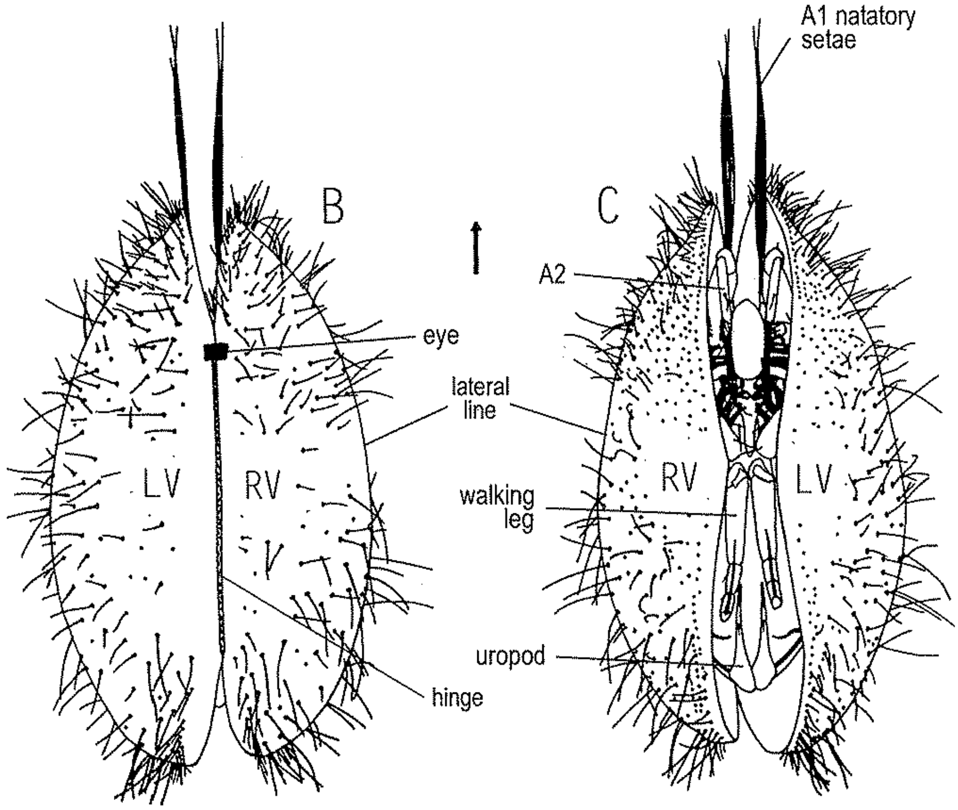


**Figure 2**.Ostracod example seen from dorsal and ventral view (Meisch 2000). (LV: Left walve, RV: Right walve, A1: first antenna, A2: Second antenna).

The ostracod body (Fig. 1) is enclosed between two calcified valves that are connected in the dorsal part with simple chitinous or complex calcite nonslip locking device (hinge) (Fig. 2). The carapace is an important part of the ostracod anatomy because it protects the animal from predators and provides stability for the benthic way of life. Ostracod's soft parts are protected within the valves, sometimes some parts can be out of valves such as the uropodal rami, walking and cleaning legs, first and second antenna. The valves are controlled by complex mechanisms of central adductor muscles that muscles scars are one of the tools to be used for species identification (Martens, 1998). Ostracod have two different eyes; one compound eyes situated in Myodocopida and 'nauplius' eyes are known in the Podocopida, Platycopida, Palaeocopida and Halocyprida (Kesling, 1951).

Some of the appendages found in ostracods are antennule (A1), antennae (A2), the mandibles (Md), Maxillule (Mx1), first thoracopod (T1), second thoracopod (T2), third thoracopod (T3), limbs and furca (uropod) (Meisch 2000; Martens 2003). However, both carapace and soft body parts are critically used during taxanomic description.

**Ecology**

Ostracods can live in nearly all aquatic habitats such as marine and non-marine habitats. Marine habitats included fluctuating salinities inwater, non-marine habitats include freshwater habitats, brackishwater habitats, and groundwater habitats. Freshwater habitats can be permanent or temporary, limnetic or with increased ionic content, epigean or hypogean, stagnant or flowing (Meisch, 2000). Thus, species are found variety of habitats such as lakes (pelagic and littoral zones bentic zones), lakelets, ponds, springs, creeks, streams, troughs, cave waters, ditches, irrigation canals, hot springs, waterfalls, dams. They arerarely found in semi-terrestrial environments such as the species *Scottia pseudobrownia* (Veugf, 1971).

Ostracods have different types of nutrition. Some are predators, herbivores, omnivores or detrivores. Some cytheroid ostracods are found to be symbionts, commensal or ectoparasites on the appendages of hypogean Isopoda, Decapoda (Hobbs and Peters, 1977).

Ostracod distrubution can be active by swimming or walking and/or passive (e.g., by human activities, natural events (rain, wind), animal activities (like birds, fishes, cows and others). Both types of movement provide their wide spread distribution all over the world.

**Hypotheses of the study**

**1) H1: There is no difference in the (alpha) species diversity of ostracods in particular habitats of Düzce and Karabük regions.**

**Rationality:** Some of the earlier studies (Külköylüoğlu et al. 2004) displayed similar ostracod species diversities at the local (alpha) diversity level. Such similarities may depend on several factors but can put insight into understanding of overall species diversity. Since Karabük and Düzce regions have geographical and ecological similarities, one may assume that species diversity would be similar. Although types of sampling sites are similar in both regions, comparision of species diversity in particular habitats (e.g., springs, troughs) will provide to see alpha values. Whatever the answer is it will bring out possibilities of comparision of these two regions.

**2) H2: There is no difference in the gamma species diversity of ostracod species between Düzce and Karabük.**

**Rationality:**Some of the earlier studies done at the higher e.g., regional gamma species diversity (Külköylüoğlu et al. 2012) levels displayed similar ostracod diversities. As known, gamma diversity, theoratically, includes bigger sampling sites. Therefore, I would like to make the first comparision of gamma diversities between these two regions (i.e. Karabük and Düzce). Finding gamma diversities can also help to understand beta diversity in two regions. Such conclusion can help to understand the levels of dis/similarities.

**Aims of this study**

The aims of this study are to (1) contribute to the knowledge on the Ostracoda fauna of Karabük and Düzce, (2) estimate ecological tolerance and optimum values of species to different ecological variables, (3) determine the most effective environmental variable(s) on species distribution and (4) compare three levels of (alpha,beta and gamma diversity) of species diversities between the sities.

# CHAPTER II

# MATERIALS AND METHODS

## Site Description

The fieldwork in the townsof the two regions (Akçakoca, Yığılca, Kaynaşlı, Gölyaka, Gümüşova, Cumayeri, Çilimli and Merkez) of Düzce (Figure 3) and (Eflani, Safranbolu, Ovacık, Eskipazar, Yenice and Merkez) of Karabük (Figure 4)).was done in randomly selected 162 different sites with 13 different aquatic bodies (lakes, lakelets, ponds, springs, creeks, streams, troughs, cave water, ditches, canals, hot springs, waterfall, dams).

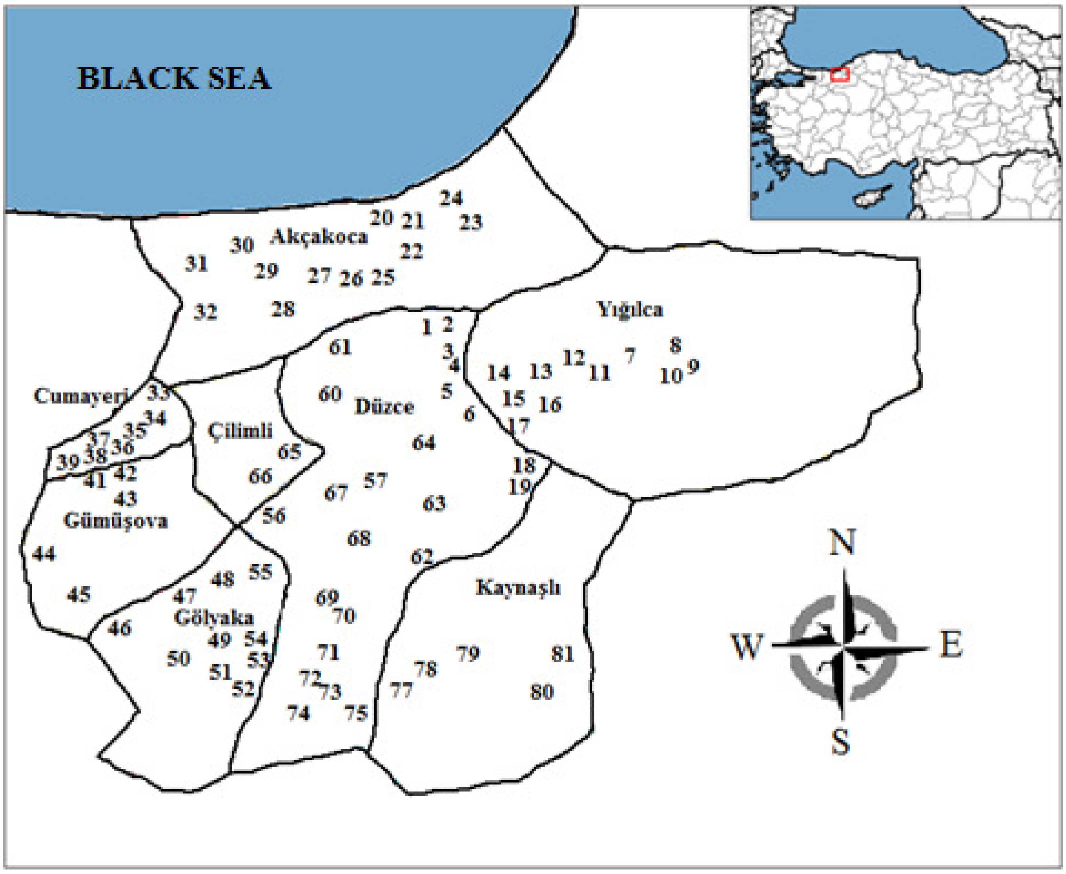


**Figure 3.** The map illustrates 81 stations in Düzce.

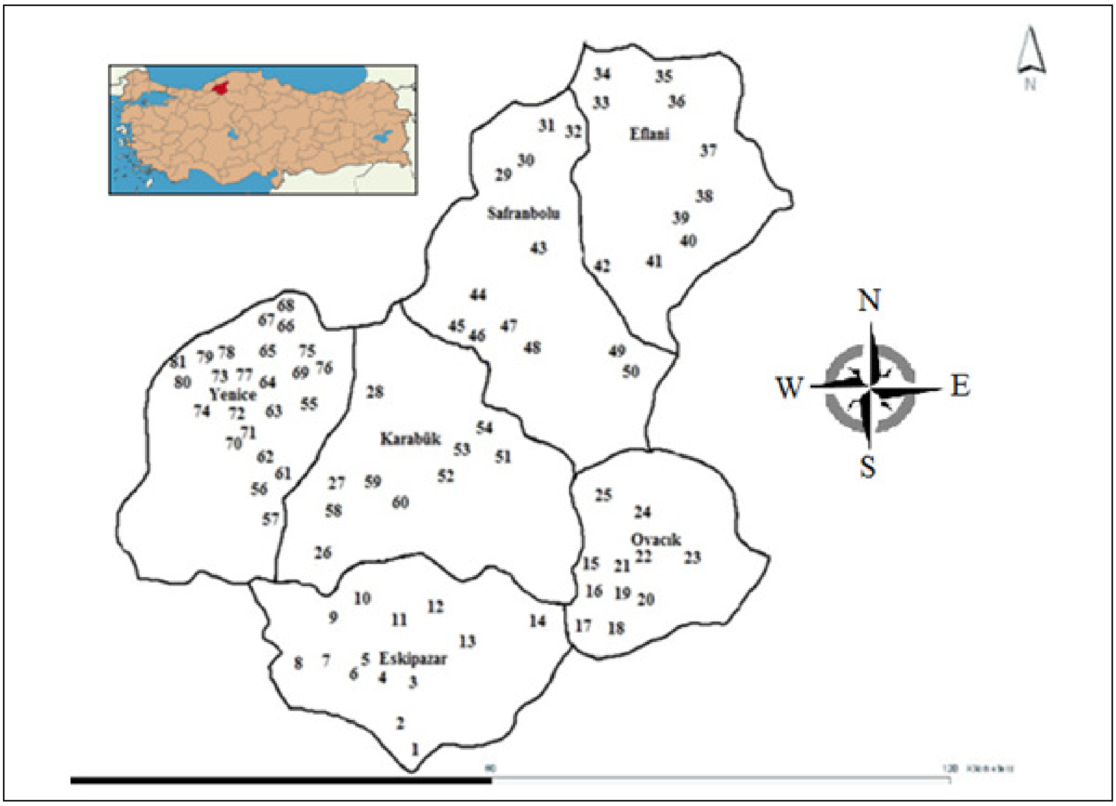


**Figure 4**. The map illustrates 81 stations in Karabük.

## Methodology

Samples were collected on 26th – 28th July 2012 and 21th-24th September 2012 from Karabük and Düzce, respectively. Elevan ecological variables (i.e. pH, water temperature (°C), air temperature (°C), altitude (m), electrical conductivity (µS/cm), specific conductivity (µS/cm), moisture (%), Atmospheric Pressure (mmHg), salinity (ppt), total dissolved solids (mg/l), dissolved oxygen (mg/l) were measured in each site. Moisture, air temperature and wind values were measured with Testo 410-2 model of anemometer. Geographical positioning system (Garmin GPS 45 XL) was used to record altitudes and coordinates. All other variables were measured in situ by YSI Professional Plus.

Ostracod samples were collected with a standard hand net and fixed in 70% ethanol and kept in 250ml plastic jars. In the laboratory,samples were separated with sieves of different mesh sizes of 0.25mm, 1.00mm, 1.50mm. All samples were washed again and fixed in 70% ethanol prior to futher analysis. Samples were separated under the Olympus ACH IX stereomicroscope and sorted into sample bottles and later fixed in 70% ethanol. Body parts and carapaces were used for taxonomic identification. Olympus BX – 51 was used for dissecting of body parts and slide preparation of each parts was preserved.Identification of ostracod into species was carried out by using taxonomic keysof Meisch (2000) and Karanovic (2012).

## Statistical Analyses

C2 program (Juggins 2003) was used to measure tolerance and optimum values of 12 species for the five most influential ecological variables (pH, water temperature, dissolved oxygen, specific conductivity, SHE) in Karabük and five variables (pH, disolved oxygen, electrical conductivity, water temparature and atmospheric pressure) for 11 species in Düzce.

Canonical Correspondence Analyses (CCA) (after DCA) with Monte Carlo Permutation (499) test (data was log (e) transformed and rare species were downloaded) to explain relationship between ecological variables and species (Ter Braak and Barendregt, 1986).

Species Diversity and Richness program version 4.2 (Seaby and Henderson 2006) was used to compare species richness and diversity between Karabük and Düzce.

**Alpha, Beta and Gamma Diversity**

There are three levels of species diversity measures (alpha, beta and gamma diversity). Alpha, beta and gamma diversity was defined by Whittaker in 1972. Alpha diversity or within habitat diversity, is known as by the number of species found in a certain area (Whittaker, 1972). Accordingly, habitat's size diversity could be change because there will be more space for more species (Külköylüoğlu, 2012).

Beta diversity (species turnover) between habitat diversity was used for comparison of diversity among ecosystem; and generally expressedas the differences between the areas compared.

Gamma diversity which is the total diversity according to (Hunter, 2002) was also used as the diversity of the entire landscape. It was considered as composite of both alpha and beta diversity (Peet, 1974). Although the application of these diversity types are not common in ostracods Külköylüoğlu et al., (2012) suggested good possibility of using the diversity indices to compare between Düzce and Karabük region.

Unweighted Pair Group Mean Averages (UPGMA) was used to show relationship among species of Karabük and Düzce area. The UPGMA analyses were formed with Multi - Variate Statistical Package (MVSP) version 3.1 (Kovach 1998).

Nonparametric method of Pearson Correlation Analyses was used to display correlations among ecological variables in both area Karabük and Düzce (SPSS version 11.0).

# CHAPTER III

# RESULTS

## Taxonomy

Total of 50 taxa from 41 genera were reported at 148 of 162 different sampling sites in both regions (Düzce and Karabük). All species belong to three families: Candonidae, Ilyocyprididae and Cyprididae.

Taxonomy:

PYHLUM: ARTHROPODA Latreille, 1806

SUBPHYLUM: CRUSTACEA Pennat, 1777

CLASS: OSTRACODA Latreille, 1806

SUBCLASS: PODOCOPA Müller, 1894

ORDER: PODOCOPIDA Sars, 1866

Suborder Podocopina Sars, 1866

Infraorder Cypridocopina Jones, 1901

**Düzce**

In Düzce, 30 taxa were reported from 73 of 81 different aquatic habitats, habitat types like (troughs, streams, cave water, springs, ponds, lakelets, lakes, creeks) (Table 1).

**Superfamily** Cypridoidea Baird, 1845

**Family** Candonidae Kaufmann, 1900

**Subfamily** Candoninae Kaufmann, 1900

**Genus** *Candona* Baird, 1845

*Candona neglecta* Sars, 1887

*Candona candida* (O.F. Müller, 1776)

**Genus** *Pseudocandona* Kaufmann, 1900

*Pseudocandona* sp.

**Subfamily** Cyclocypridinae Kaufmann, 1900

**Genus** *Cypria* Zenker, 1854

*Cypria ophtalmica* (Jurine, 1820)

*Cypria* sp.

**Genus** *Cyclocypris*Brady&Norman, 1889

*Cyclocypris leavis* (O.F. Müller, 1776)

**Family** Ilyocyprididae Kaufmann, 1900

**Subfamily** Ilyocypridinae Kaufmann, 1900

**Genus** *Ilyocypris* Brady&Norman, 1989

*Ilyocypris bradyi* Sars, 1890

*Ilyocypris decipiens* Masi, 1905

*Ilyocypris inermis* Kaufmann, 1900

*Ilyocypris monstrifica* (Norman, 1862)

*Ilyocypris* sp.

**<u>Family</u>** Cyprididae Baird, 1845

**<u>Subfamily</u>** Cypridinae Baird, 1845

**<u>Genus</u>** *Cypris* O.F. Müller, 1776

*Cypris pubera* O.F. Müller, 1776

*Cypris* sp.

**<u>Subfamily</u>** Eucypridinae Bronshtein, 1947

**<u>Genus</u>** *Tonnacypris* Diebel & Pietrzeniuk, 1975

*Tonnacypris lutaria* (Koch, 1838)

**<u>Subfamily</u>** Herpetocypridinae Kaufmann, 1900

**<u>Genus</u>** *Psychrodromus* Danielopol&Mc Kenzie, 1977

*Psychrodromus olivaceus* (Brady&Norman, 1899)

*Psychrodromus* sp.

**<u>Subfamily</u>** Cyprinotinae Bronshtein, 1947

**<u>Genus</u>** *Heterocypris* Claus, 1892

*Heterocypris incongruens* (Ramdohr, 1808)

*Heterocypris salina* (Brady, 1868)

*Heterocypris* sp.

**<u>Subfamily</u>** Cypridopsinae Kaufmann, 1900

**<u>Genus</u>** *Cypridopsis* Brady, 1867

*Cypridopsis vidua* (O.F. Müller, 1776)

*Cypridopsis* sp.

**<u>Genus</u>** *Potamocypris* Brady, 1870

*Potamocypris arcuata* (Sars, 1903)

*Potamocypris similis* O. F. Müller, 1912

*Potamocypris variegata* (Brady & Norman, 1889)

*Potamocypris* sp.

**Superfamily** Cytheroidea Baird, 1850

**Family** Limnocytheridae Klie, 1938

**Subfamily** Limnocytherinae Klie, 1938

**Genus** *Limnocythere* Brady, 1867

*Limnocythere* sp.

**Table 1.** Showsthe species diversity of 10 different aquatic bodies in Düzce. Abbreviations; Cc: *Candona candida*, Cn: *C. neglecta*, Cd: *Candona* sp.,Cv: *Cypridopsis vidua*, Cp: *Cypridopsis* sp., Co: *Cypria ophtalmica*, Cs: *C. sywulae*, Cp: *Cypris pubera*, Cy: *Cypris* sp., Cl: *Cyclocypris laevis*, Ds: *Dolerocypris sinensis,* Ib: *Ilyocypris bradyi*, Id: *I. decipiens*, Ii: *I.inermis*, Im: *I.monstrifica*, Ic: *Ilyocypris* sp., Lc: *Limnocythere* sp., Hi: *Heterocypris incongruens*, Hs: *H.salina*, Hc: *Heterocypris* sp., Pa: *Potamocypris arcuata*, Ps: *P.similis*, Pv: *P.variegata*, Po: *Psychrodromus olivaceus*, Py: *Psychrodromus* sp., Pc: *Pseudocandona* sp., Tl: *Tonnacypris lutaria*.

| Habitats | Numbers of Stations | Species |
|---|---|---|
| Trough | 17 | Po, Hs, Pa, Cv, Pv, Ps, Hi, Cn, Pc, Py, Cy, Pm |
| Stream | 26 | Po, Hs, Ps, Ib, Hi, Ii, Cn, Ic, Cd, Py, Pm, Cp |
| Puddle | 7 | Po, Pl, Hs, Id, Im, Ic, Hc, Py |
| Waterfall | 7 | Ps, Ic, Cd, Hc, Pm |
| Lake | 4 | Cv, Cc, Cp, Cs |
| Pond | 5 | Hi, Tl, Cl |
| Cave | 2 | - |
| Spring | 7 | Po, Ps, Ds, Ib, Hi, Cc, Cn, Pc, Hc, Py |
| Creek | 1 | - |
| Water canal | 4 | Cp |

The species diversity of streamsand troughs (12 speciesin each) were higher than spring (9 species) and puddles (8 species). While species diversity of waterfalls (5 species), lakes (4 species), ponds (3 species) and waterchannels (1 species) were relatively low respectively. (seeTable 1).

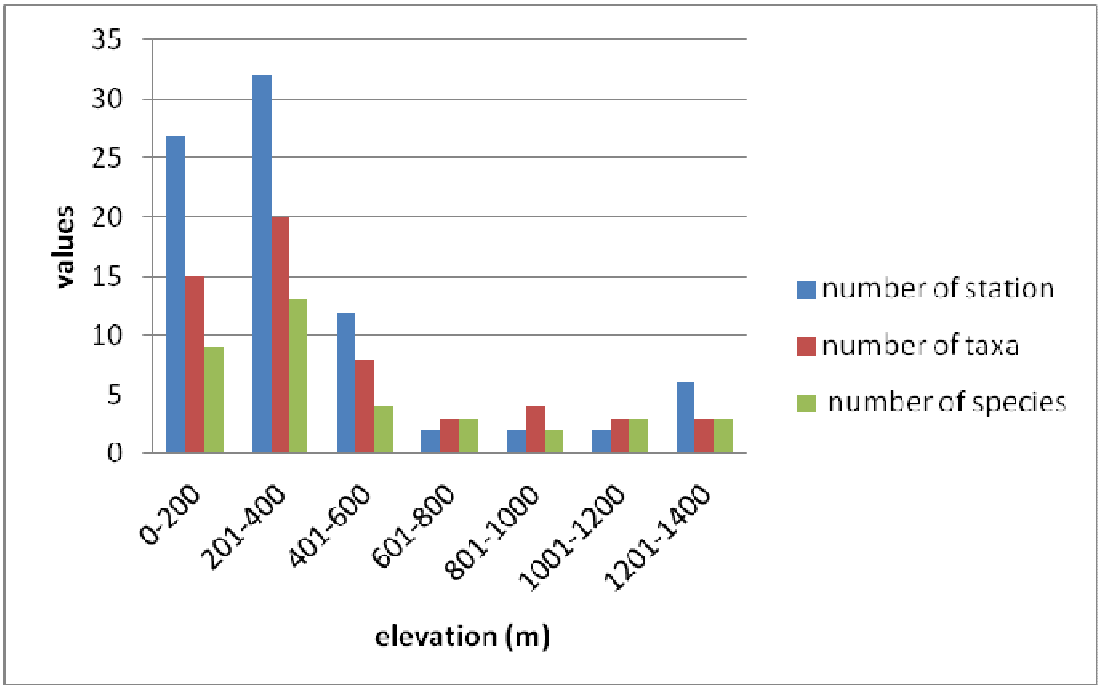


**Figure 5.** Number of species, taxa and stations within 200 m of altitudinal range.

The highest numbers of species (13 species) was found the range of 201-400 m.a.s.l with highest sampling sites than others such as 27 and 8 sites in 0-200m of range. The number of species between 401-1400 m a.s.l. was not statistically different from others (e.g.,3 species in 601-800 m a.s.l., 2 species in 801-1000 m, 3 species in 1201-1400 m) while number of sampling stations were different at the range of 401-600 m (12 sites) and 1201-1400 m a.s.l. (6 sites). The number of species and taxa recoreded between 401-1400 m.a.s.l were not significantly different. (Figure5).

**Table 2.** Optimum and tolerance values of 11 species to 5 different variables. Abbreviations; DO: Dissolved oxygen, EC: Electrical conductivity, Tw: water temperature, Alt: Altitude,PO:*Psychrodromus olivaceus,*HS: *Heterocypris salina,* HI: *H. incongruens,* CV: *Cypridopsis vidua***,** PS: *Potamocypris similis,* IB: *Ilyocypris bradyi,* II: *I. inermis,* CC*: Candona candida,* CN: *C. neglecta,* CL: *C. lactea,* CLA: *C. laevis.*

| | | | | pH | | DO | | EC | | Tw | | Alt | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name | Count | Max | N2 | Opt | Tol | Opt | Tol | Opt | Tol | Opt | Tol | Opt | Tol |
| PO | 13 | 155 | 4.02 | 7.94 | 0.18 | 7.62 | 1.16 | 505 | 132 | 16.5 | 1.87 | 252 | 311 |
| HS | 9 | 200 | 4.11 | 8 | 0.12 | 7.89 | 1.01 | 590 | 192 | 17.1 | 2.44 | 222 | 167 |
| CV | 2 | 82 | 1.02 | 7.95 | 0.08 | 7.06 | 0.64 | 649 | 5.44 | 20.8 | 1.34 | 344 | 68 |
| PS | 6 | 188 | 1.57 | 8.51 | 0.34 | 8.87 | 1.3 | 230 | 224 | 21.6 | 4.73 | 218 | 355 |
| IB | 5 | 110 | 2.93 | 8.23 | 0.23 | 9.6 | 1.67 | 496 | 214 | 13.6 | 1.98 | 291 | 378 |
| HI | 8 | 125 | 2.51 | 7.95 | 0.26 | 6.76 | 2.83 | 538 | 186 | 14 | 1.76 | 415 | 362 |
| II | 4 | 13 | 3.8 | 8.24 | 0.14 | 9.72 | 0.73 | 454 | 101 | 13.4 | 2.45 | 423 | 415 |
| CC | 2 | 81 | 1.68 | 8 | 0.62 | 7.22 | 6.51 | 359 | 177 | 14.5 | 2.9 | 533 | 413 |
| CN | 3 | 325 | 1.06 | 7.66 | 0.4 | 8.25 | 0.65 | 358 | 33.3 | 14.7 | 1.06 | 1101 | 332 |
| CL | 2 | 83 | 2 | 7.21 | 0.16 | 1.01 | 1.05 | 435 | 183 | 19.6 | 1.84 | 1270 | 311 |
| CLA | 2 | 100 | 1.35 | 7.13 | 0.16 | 0.51 | 1.05 | 523 | 183 | 20.5 | 1.84 | 1270 | 311 |
| | | | mean | 7.89 | 0.24 | 6.77 | 1.69 | 467 | 148.24 | 16.93 | 2.20 | 576.2 | 311.1 |
| | | | min | 7.13 | 0.08 | 0.51 | 0.64 | 230 | 5.44 | 13.4 | 1.06 | 218 | 68 |
| | | | max | 8.51 | 0.62 | 9.72 | 6.51 | 649 | 224 | 21.6 | 4.73 | 1270 | 415 |

The results of table 2 shows that all the five variables are important for the survivar of all the eleven species and each species have different tolerance level and optimum level for each parameters.

**Table 3.** The summary table of Canonical Correspondence Analysis (CCA).*Represents the results of Detrended Correspondence Analysis (DCA). 11 species with 5 variables from 33 sites.

| Axes | 1 | 2 | 3 | 4 | Total inertia |
|---|---|---|---|---|---|
| Eigenvalues : | 0.782 | 0.368 | 0.200 | 0.110 | 5.488 |
| Lengths of gradient* : | 9.452 | 3.199 | 2.520 | 2.371 | |
| Species-environment correlations : | 0.921 | 0.729 | 0.545 | 0.447 | |
| Cumulative percentage variance of species data : | 14.3 | 21.0 | 24.6 | 26.6 | |
| of species-environment relation: | 50.3 | 74.0 | 86.9 | 93.9 | |
| Sum of all eigenvalues | 5.488 | | | | |
| Sum of all canonical eigenvalues | 1.554 | | | | |



The value of 74.0 and variables of 5.488 in axes two recorded for the CCA diagram and table 3 shows a good species environmental relationship in 5 five variables in selected 33 sites.

The second axes of CCA explained 74% relationships between species and environmental variables (Table 3). The diagram of CCA shows that the most effective factor was water temperature (Tw) ($P=0.010$; $F=2.45$) on species followed by altitude (Alt) ($P=0.0020$; $F=3.58$), pH ($P=0.0020$; $F=3.55$), disolved oxygen ($P=0.0020$; $F=3.74$) and electrical conductivity (EC) ($P=0.2780$; $F=1.26$). The species *P. olivaceus*, *I.bradyi*, *I. inermis*, *H. incongruens*, *C. candida* and *C. neglecta* are located on the opposite site of water temperature while *C. vidua*, and*P.similis*and *H. salina,*are at the same site with disolved oxygen, water temparature, electrical conductivity and pH (Figure 6).

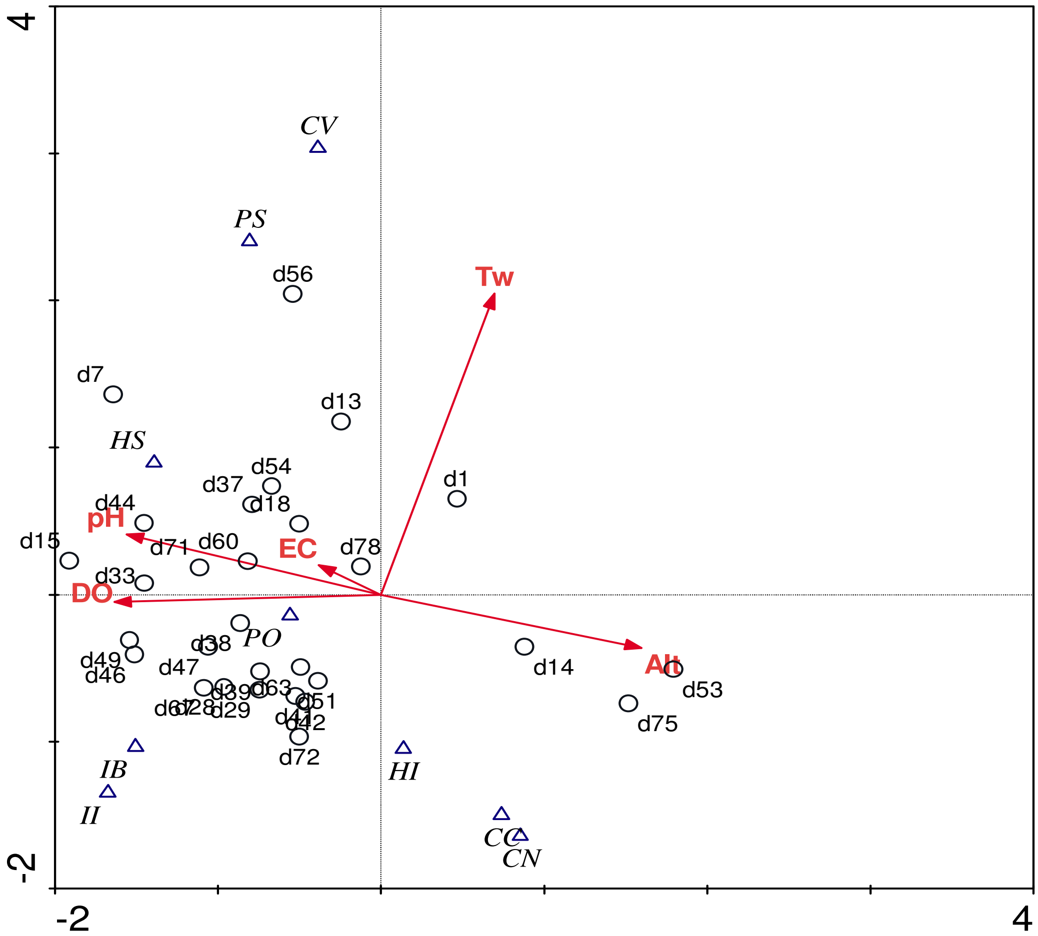


**Figure 6.** Canonical Correspondence Analysis (CCA) shows the relationship between 11 species and 5 environmental variables in Düzce. Abbreviations: CN: *Candona neglecta* CC: *C.candida* CV; *Cypridopsis vidua* HI: *Heterocypris incongruens,* HS: *Heterocypris salina,* IB: *Ilyocypris brady,* II: *I. inermis,* PS: *Potamocypris similis*.

**Karabük**

In Karabük, 36 taxa were reported from 75 of 81 different aquatic habitats, habitat types like (trough, stream, puddle, waterfall, lake, pond, cave, spring, creek, water canal) (Table 4).

**Superfamily** Cypridoidea Baird, 1845

**Family** Candonidae Kaufmann, 1900

**Subfamily** Candoninae Kaufmann, 1900

**Genus** *Candona* Baird, 1845

*Candona improvisa* Ostermeyer, 1937

*Candona neglecta* Sars, 1887

*Candona* sp.

**Genus** *Fabaeformiscandona* Krstic, 1972

*Fabaeformiscandona* sp.

**Genus** *Schellencandona* Meisch, 1996

*Schellencandona* sp.

**Genus** *Pseudocandona* Kaufmann, 1900

*Pseudocandona albicans* (Brady, 1864)

*Pseudocandona* sp.

**Family** Ilyocyprididae Kaufmann, 1900

**Subfamily** Ilyocypridinae Kaufmann, 1900

**Genus** *Ilyocypris* Brady&Norman, 1989

**Family** Ilyocyprididae Kaufmann, 1900

**Subfamily** Ilyocypridinae Kaufmann, 1900

**Genus** *Ilyocypris* Brady&Norman, 1989

*Ilyocypris bradyi* Sars, 1890

*Ilyocypris decipiens* Masi, 1905

*Ilyocypris inermis* Kaufmann, 1900

*Ilyocypris* sp.

**Family** Cyprididae Baird, 1845

**Subfamily** Cypridinae Baird, 1845

**Genus** *Cypris* O.F. Müller, 1776

*Cypris* sp.

**Subfamily** Eucypridinae Bronshtein, 1947

**Genus** *Eucypris* Vavra, 1891

*Eucypris pigra* (Fischer, 1851)

*Eucypris* sp.

**Genus** *Prionocypris* Brady&Norman, 1896

*Prionocypris* sp.

**Subfamily** Herpetocypridinae Kaufmann, 1900

**Genus** *Herpetocypris* Brady&Norman, 1889

*Herpetocypris brevicaudata* Kaufmann, 1900

*Herpetocypris chevreuxi* (Sars, 1896)

*Herpetocypris* sp.

**Genus** *Psychrodromus* Danielopol&Mc Kenzie, 1977

*Psychrodromus olivaceus*(Brady & Norman, 1889)

*Psychrodromus fontinalis*(Wolf, 1920)

*Psychrodromus* sp.

**Subfamily** Cyprinotinae Bronshtein, 1947

**Genus** *Heterocypris* Claus, 1982

*Heterocypris incongruens* (Ramdohr, 1808)

*Heterocypris reptans* (Kaufmann, 1900)

*Heterocypris salina*(Brady, 1868)

*Heterocypris* sp.

**Subfamily** Cypridopsinae Kaufmann, 1900

**Genus** *Cypridopsis* Brady, 1867

*Cypridopsis vidua*(O.F. Müller, 1776)

*Cypridopsis* sp.

**Genus** *Potamocypris* Brady, 1870

*Potamocypris fallax* Fox, 1967

*Potamocypris similis* G.W. Müller, 1912

*Potamocypris smaragdina* (Vávra, 1891)

*Potamocypris pallida* Alm, 1914

*Potamocypris variegata* (Brady & Norman, 1889)

*Potamocyprisvillosa* (Jurine, 1820)

*Potamocypris* sp.

**Superfamily** Cytheroidea Baird, 1850

**Family** Limnocytheridae Klie, 1938

**Subfamily** Limnocytherinae Klie, 1938

**Genus** *Limnocythere* Brady, 1867

*Limnocythere inopinata (Baird, 1843)*

*Limnocythere* sp.

**Table 4.** It shows species diversity of 8 different aquatic bodies in Karabük. Some abbreviations are used for species are given as Ci: *Candona improvisa*, Cn: *C. neglecta*, Cd: *Candona* sp.,Cv: *Cypridopsis vidua*, Cp: *Cypridopsis* sp., Cy: *Cypris* sp., Ec: *Eucypris* sp., Ep: *Eucyprispigra*, Fc: *Fabaeformiscandona* sp., .Ib: *Ilyocypris bradyi*, Id: *I. decipiens*, Ii: *I.inermis*, Ic: *Ilyocypris* sp., Li: *Limnocythere inopinata*, Lc: *Limnocythere* sp., Hc: *Herpetocyprischevreuxi*, Hc: *Herpetocypris* sp., Hb: *Herpetocypris brauicaudata,* Hi: *Heterocypris incongruens*, Hs: *H.salina*, Hr: *H. reptans*, Hc: *Heterocypris* sp., Ps: *Potamocypris similis*, Pfa: *P. fallax*, *Pp: P. pallida,* Ps: *P. smaragdina*, Pv: *P.variegata*, Pv: *Potamocypris villosa*,Pm: *Potamocypris* sp.,Pc: *Pseudocandona* sp.,*Psychrodromus olivaceus* (Po),*Psychrodromus fontinalis* (Pf), Py: *Psychrodromus* sp., Pa:*Pseudocandonaalbicans*, Pc: *Pseudocandona* sp., Pz: *Prionocypris zenkeri*, Sc: *Schellencandona* sp.

| Habitats | Numbers of stations | Species |
|---|---|---|
| Trough | 50 | Hi, Hs, Ib, Ic, Cd, Pf, Ii, Po, Ps, Hc, Pc, Ec, Pp, Sc, Pv, Pz, Hr, Pfa, Cn, Ep |
| Stream | 14 | Pa, Hi, Hs, Ib, Pm, Po, Ps, Pz, Pse, Pfa, Ps, Li |
| Cave water | 1 | - |
| spring | 3 | Ib, Pf, Hc, Fc, Hb |
| Pond | 7 | Hi, Hs, Ib, Ic, Pm, Po, Cd |
| Lakelet | 3 | Hi, Ic, Cd, Pm, Cy, Cv, Lc, Id |
| Lake | 1 | - |
| Creek | 2 | Hs, Ic |

The species diversity of trough (20 species) and stream (12 species) were higher than lakelet (8 species), pond (7 species), creek (2species), and spring (5 species) whereas, no species was found from lake and cave sampling sites.

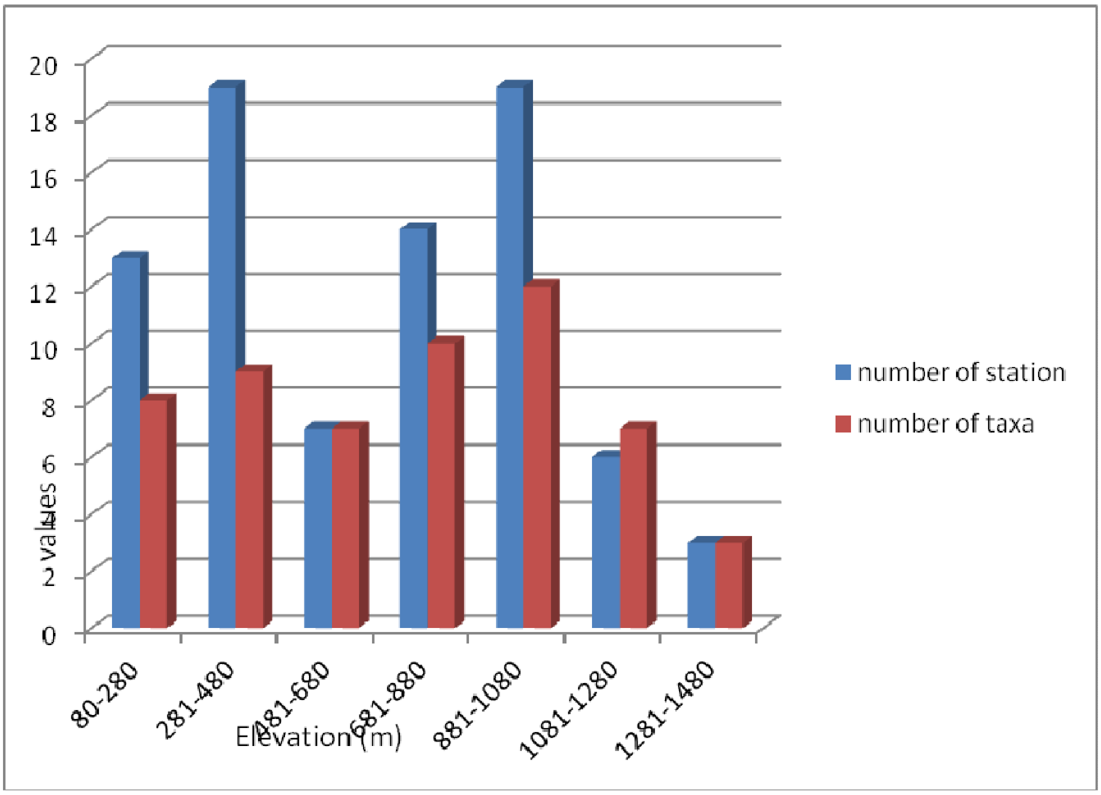


**Figure 7.** Number of taxa and stations at the range of 80-1480m in Karabük.

The highest number of species(12 taxa) (Fig. 7) was found at the range of 881-1080 masl. with highest sampling sites (19 sites) followed by range 681-880masl with 14 species and 8 sites. The number of species between 481-680 m were not statistically different from each other (e.g.,8 taxa in 80-280 m,; 9 taxa in 281-480 m) while thenumber of sampling stations were different at the range of 1281-1480m a.s.l. (3 species).

**Table 5.** This table show that optimum and tolerance value of 12 species (at least two occurences) to 5 ecological variables such as pH, Dissolved oxygen, Redox potential, electrical conductivity, water temperature, altitude and 12 species such as Po (*Psychrodromus olivaceus),* HS (*Heterocypris salina*)*,* PSI (*Potamocypris similis*)*,* IB *(Ilyocypris brady),* HI (*Heterocypris incongruens),* II(*Ilyocypris inermis*)*,* Cn(*Candona neglecta*)*, Psychrodromus fontinalis* (PFO), PP (*Potamocypris pallida*)*,* PZE (*Prionocypris zenkeri*)*,* PFA (*Potamocypris fallax*)*,* LI (*Limnocythere inopinata*)*.*

| | | | | | pH | | Tw | | DO | | SHE | | Ecs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Code | Count | Max | N2 | Opt | Tol | Opt | Tol | Opt | Tol | Opt | Tol | Opt | Tol |
| 1 | HI | 24 | 700 | 5.61 | 7.91 | 0.34 | 23.1 | 4.69 | 6.14 | 3.09 | 181 | 31.4 | 959 | 563 |
| 2 | HSA | 14 | 162 | 5.96 | 7.93 | 0.21 | 24.3 | 3.08 | 6.09 | 2.16 | 164 | 15.8 | 674 | 195 |
| 3 | IB | 12 | 32 | 7.73 | 7.85 | 0.34 | 22.7 | 3.87 | 7.36 | 1.45 | 172 | 23.8 | 722 | 426 |
| 4 | PFO | 5 | 145 | 2.14 | 7.5 | 0.14 | 13.9 | 3.47 | 7.82 | 1.18 | 197 | 10.8 | 620 | 49.7 |
| 5 | II | 4 | 19 | 2.32 | 7.64 | 0.31 | 16.6 | 8.81 | 7.41 | 2.22 | 185 | 23 | 581 | 55.2 |
| 6 | PO | 12 | 163 | 4.41 | 7.87 | 0.13 | 20.6 | 2.49 | 6.19 | 1.64 | 166 | 9.89 | 664 | 309 |
| 7 | PSI | 5 | 16 | 3.33 | 7.87 | 0.11 | 21.8 | 3.74 | 6.35 | 1.92 | 168 | 7.38 | 451 | 84.1 |
| 8 | PP | 3 | 103 | 1.34 | 7.89 | 0.4 | 19.5 | 2.69 | 6.13 | 2.41 | 165 | 27.1 | 673 | 262 |
| 9 | PZE | 2 | 44 | 1.14 | 7.91 | 0.07 | 22.5 | 1.27 | 8.92 | 2.48 | 164 | 6.84 | 615 | 48.6 |
| 10 | PF | 2 | 31 | 1.19 | 8.28 | 0.18 | 17.8 | 3.46 | 8.56 | 1.34 | 150 | 4.73 | 456 | 27.7 |
| 11 | CN | 2 | 17 | 1.12 | 7.21 | 0.37 | 17.4 | 1.41 | 4.63 | 1.28 | 214 | 23.1 | 1687 | 300 |
| 12 | LI | 2 | 160 | 1.03 | 8.69 | 0.82 | 24.3 | 2.83 | 7.59 | 2.67 | 115 | 48.2 | 1990 | 218 |
| | Mean | | | | 7.88 | 0.29 | 20.4 | 3.49 | 6.93 | 1.99 | 170 | 19.3 | 841 | 212 |
| | Max | | | | 8.69 | 0.82 | 24.3 | 8.81 | 8.92 | 3.09 | 214 | 48.2 | 1990 | 563 |
| | Min | | | | 7.21 | 0.07 | 13.9 | 1.27 | 4.63 | 1.18 | 115 | 4.73 | 451 | 27.7 |

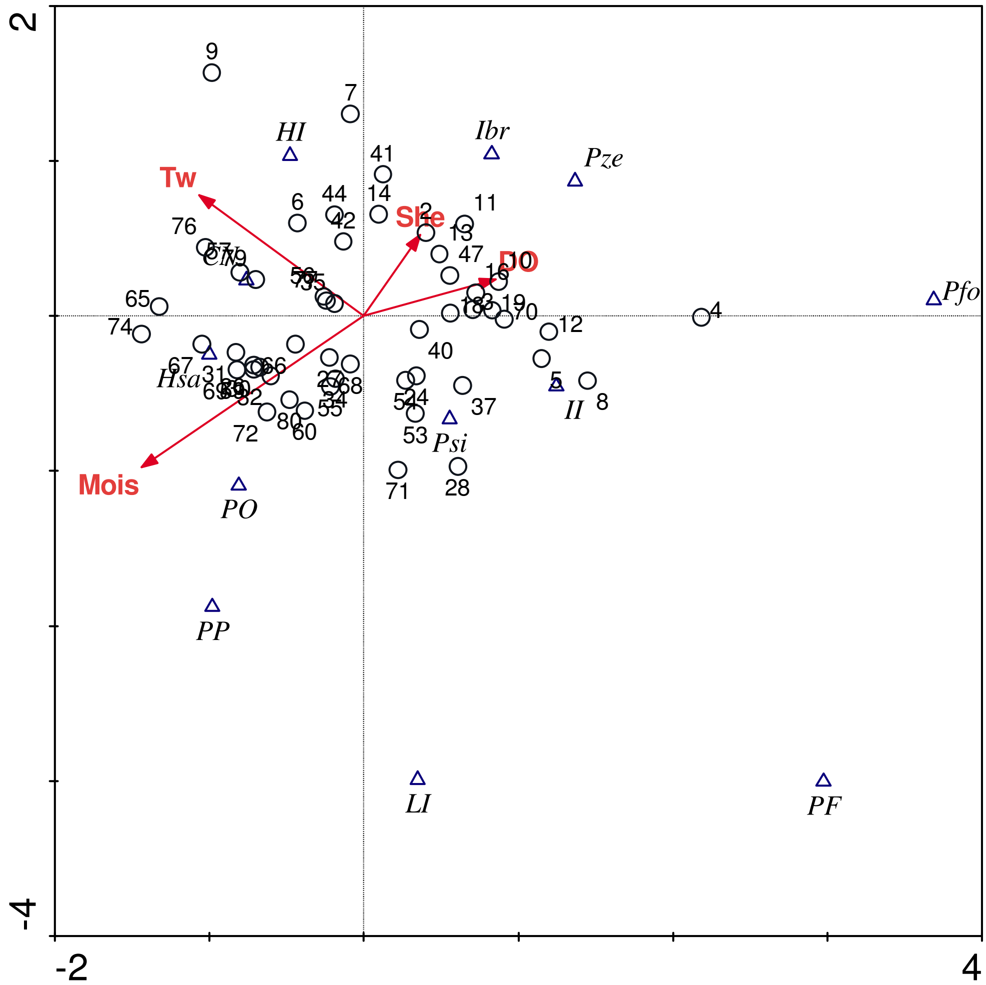


**Figure 8.** Canonical Correspondence Analysis (CCA) exhibits relationship between 12 species and four environmental variables.

**Table 6.** Summary table of CCA with four environmental variables and 12 species in Karabük.Lengths of gradient 6.832 (first two axes) moisture (P=0.008, F=2.317) and water temperature (P=0.014, F=1.976) were the most effective factors on species, followed by dissolved oxygen and redox potential.

| Axes | 1 | 2 | 3 | 4 | Total inertia |
|---|---|---|---|---|---|
| Eigenvalues: | 0.369 | 0.193 | 0.165 | 0.039 | 6.245 |
| Species-environment correlations: | 0.729 | 0.513 | 0.492 | 0.254 | |
| Cumulative percentage variance | | | | | |
| of species data: | 5.9 | 9 | 11.6 | 12.3 | |
| of species-environment relation: | 48.2 | 73.4 | 94.9 | 100 | |
| Sum of all eigenvalues: | | | | | 6.245 |
| Sum of all canonical eigenvalues: | | | | | 0.766 |

**Comparison of Düzce and Karabük**

In Düzce and Karabük, 10 recent and 8 subrecent forms of ostracods were found these includes*C. neglecta*, *Candona* sp., *Cypridopsis vidua, Cypridopsis*sp., *Cypris* sp., *Ilyocypris bradyi*, *I. decipiens*, *I. inermis, Ilyocypris* sp., *Limnocythere* sp., *Heterocypris incongruens, H. salina*, *Heterocypris* sp., *Potamocypris similis, P. variegata*, *Psychrodromus olivaceus*, *Psychrodromus* sp., *Pseudocandona* sp.

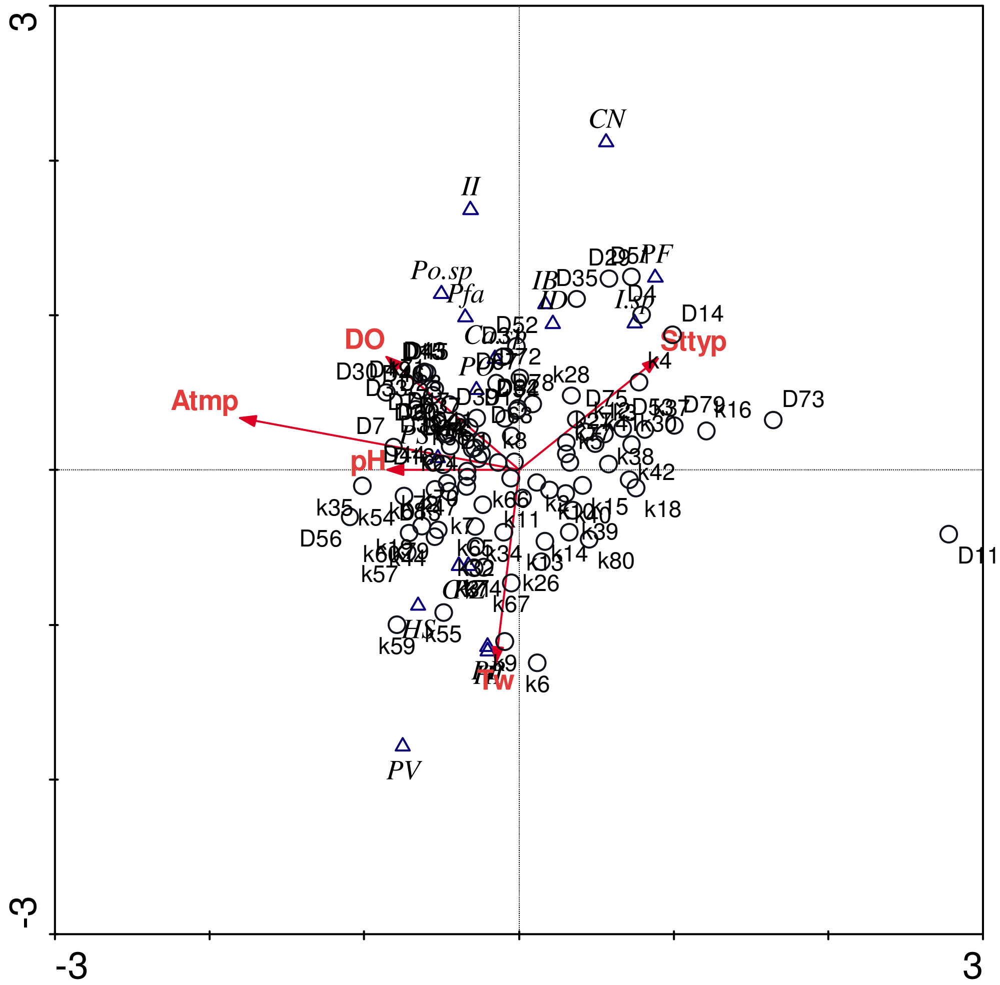


**Figure 9.** Canonical Correspondence Analysis (CCA) shows the relationships between 20 taxa and 5 environmental variables (water temperature, station type, dissolved oxygen, atmospheric pressure, pH in Düzce and Karabük). After manual selection moisture and altitude which were used in other diagram were not used during this analyses).

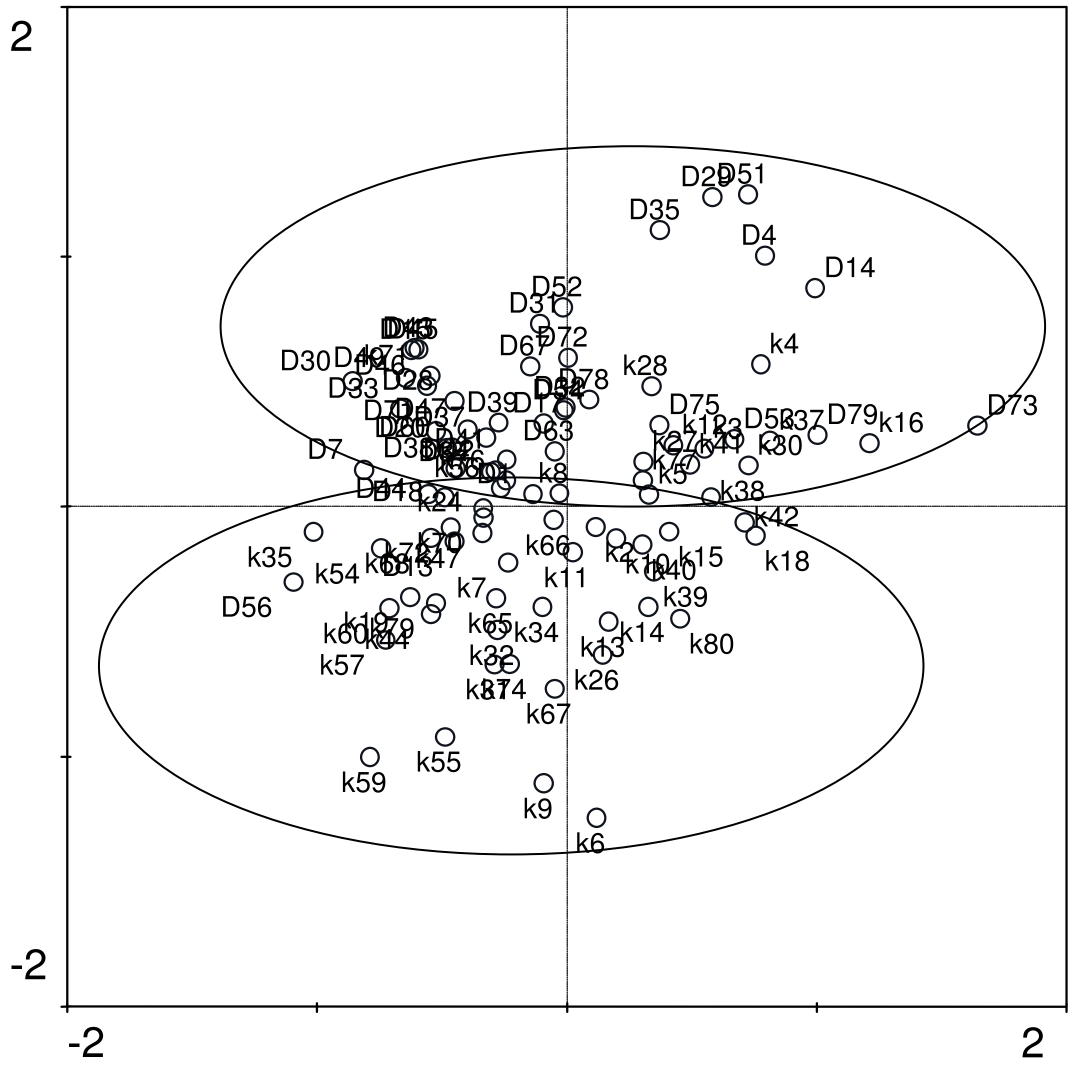


**Figure 10.** CCA diagram shows relationships numbers between of stations in Karabük and Düzce. Note that mostof the Düzce variables groupedin positive area (upper part of the axes) while Karabük variables accumulated in the negative area (lower part of the axes).

**Table 7.** Summary table of CCA with five environmental variables and 12 species. *DCA result.

| Axes | 1 | 2 | 3 | 4 | Total inertia |
|---|---|---|---|---|---|
| Lengths of gradient* : | 7.982 | 5.339 | 4.700 | 4.083 | |
| Eigenvalues : | 0.512 | 0.190 | 0.133 | 0.084 | 9.265 |
| Species-environment correlations : | 0.761 | 0.561 | 0.459 | 0.372 | |
| Cumulative percentage variance | | | | | |
| of species data : | 5.5 | 7.6 | 9.0 | 9.9 | |
| of species-environment relation: | 52.8 | 72.5 | 86.2 | 94.9 | |
| Sum of all eigenvalues : | | | | | 9.265 |
| Sum of all canonical eigenvalues: | | | | 0.969 | |

**Table 8.** Optimum (Opt) and tolerance (Tol) values of 20 species (at least two occurences) to seven variables.

| | | | | Stty | | pH | | DO | | Tw | | EC | | Atmp | | Alt | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | Co | Max | N2 | Opt | Tol | Opt | Tol | Opt | Tol | Opt | Tol | Opt | Tol | Opt | Tol | Opt | Tol |
| HI | 32 | 700 | 6.69 | 0.97 | 0.82 | 7.909 | 0.327 | 6.200 | 2.986 | 22.2 | 5.27 | 919.1 | 545.3 | 702.9 | 33.13 | 634.9 | 345.83 |
| HS | 23 | 200 | 9.39 | 0.99 | 0.68 | 7.967 | 0.160 | 7.064 | 1.832 | 20.3 | 4.598 | 628.6 | 187.5 | 728.7 | 12.56 | 311.3 | 191.22 |
| IB | 16 | 110 | 6.11 | 3.37 | 3.03 | 8.077 | 0.343 | 8.767 | 1.954 | 16.8 | 5.681 | 553.5 | 314.3 | 712.4 | 35.66 | 506.7 | 481.28 |
| I.sp | 17 | 3 | 14.2 | 3.72 | 2.88 | 8.105 | 0.314 | 7.118 | 2.129 | 19.4 | 4.539 | 479.2 | 179.7 | 671.1 | 132.8 | 484.1 | 343.66 |
| Ca.sp | 7 | 1 | 7 | 2.42 | 1.90 | 8.155 | 0.322 | 7.717 | 2.768 | 18.1 | 6.467 | 424.8 | 194.9 | 706.9 | 40.21 | 648.7 | 475.76 |
| PF | 5 | 145 | 2.13 | 1.01 | 0.45 | 7.499 | 0.140 | 7.816 | 1.179 | 13.8 | 3.470 | 619.9 | 48.78 | 657.8 | 23.25 | 548.4 | 686.95 |
| Po.sp | 7 | 8 | 2.8 | 2.35 | 1.46 | 8.219 | 0.207 | 8.508 | 1.597 | 18.9 | 4.975 | 733.6 | 474.0 | 717.8 | 24.85 | 476.0 | 280.71 |
| II | 8 | 19 | 6.07 | 1.58 | 0.53 | 7.985 | 0.374 | 8.748 | 1.798 | 14.7 | 5.314 | 507.0 | 103.6 | 710.60 | 41.25 | 611.5 | 444.30 |
| PO | 25 | 163 | 8.39 | 1.44 | 1.62 | 7.903 | 0.151 | 6.922 | 1.525 | 18.4 | 2.985 | 583.1 | 236.4 | 725.67 | 31.19 | 391.6 | 367.19 |
| PS | 11 | 188 | 2.13 | 1.32 | 1.75 | 8.417 | 0.408 | 8.491 | 1.797 | 21.6 | 3.963 | 263.0 | 195.5 | 734.92 | 41.01 | 319.0 | 465.86 |
| PP | 3 | 103 | 1.33 | 1 | 1.67 | 7.891 | 0.403 | 6.127 | 2.405 | 19.5 | 2.692 | 672.6 | 256.9 | 733.82 | 36.21 | 268.1 | 436.78 |
| PV | 2 | 16 | 1.65 | 1 | 1.67 | 7.960 | 0.028 | 6.210 | 2.227 | 21.8 | 2.616 | 672.4 | 50.13 | 729.58 | 6.788 | 357.3 | 26.870 |
| CV | 3 | 82 | 1.147 | 1.32 | 3.41 | 7.988 | 0.427 | 7.025 | 0.4714 | 21.1 | 4.444 | 622.6 | 139.5 | 729.36 | 35.740 | 378.05 | 367.945 |
| ID | 2 | 25 | 1.3120 | 3.41 | 2.12 | 7.816 | 0.6505 | 6.2789 | 0.148 | 18.1 | 7.778 | 424.5 | 123.6 | 736.27 | 47.800 | 308.69 | 516.188 |
| PZ | 2 | 44 | 1.1357 | 1.06 | 0.70 | 7.913 | 0.0707 | 8.9159 | 2.4819 | 22.4 | 1.272 | 615.4 | 47.73 | 702.79 | 15.556 | 610.31 | 185.137 |
| Pfa | 2 | 31 | 1.1917 | 1.91 | 0.70 | 8.277 | 0.1767 | 8.5576 | 1.3435 | 17.7 | 3.464 | 456.4 | 27.21 | 687.65 | 38.113 | 803.58 | 444.063 |
| CN | 5 | 325 | 1.1692 | 1.14 | 2.57 | 7.632 | 0.3548 | 8.0690 | 2.1466 | 14.8 | 1.718 | 426.0 | 388.8 | 671.68 | 36.864 | 1069.3 | 473.625 |
| CC | 2 | 81 | 1.6834 | 7.15 | 2.12 | 8.003 | 0.6151 | 7.2246 | 6.5053 | 14.4 | 2.899 | 359.2 | 147.6 | 717.93 | 34.789 | 532.61 | 412.95 |
| CL | 2 | 83 | 1.9993 | 6 | 1.67 | 7.207 | 0.1555 | 1.0063 | 1.0465 | 19.6 | 1.838 | 434.9 | 169.4 | 322.65 | 464.85 | 1270 | 385.909 |
| CLA | 2 | 100 | 1.3487 | 6 | 1.67 | 7.133 | 0.1555 | 0.5057 | 1.0465 | 20.5 | 1.838 | 522.5 | 121.8 | 100.28 | 464.85 | 1270 | 385.909 |
| | | | Mean | 2.46 | 1.67 | 7.903 | 0.289 | 6.863 | 1.969 | 18.7 | 3.891 | 545.9 | 197.6 | 660.06 | 79.879 | 590.03 | 385.909 |

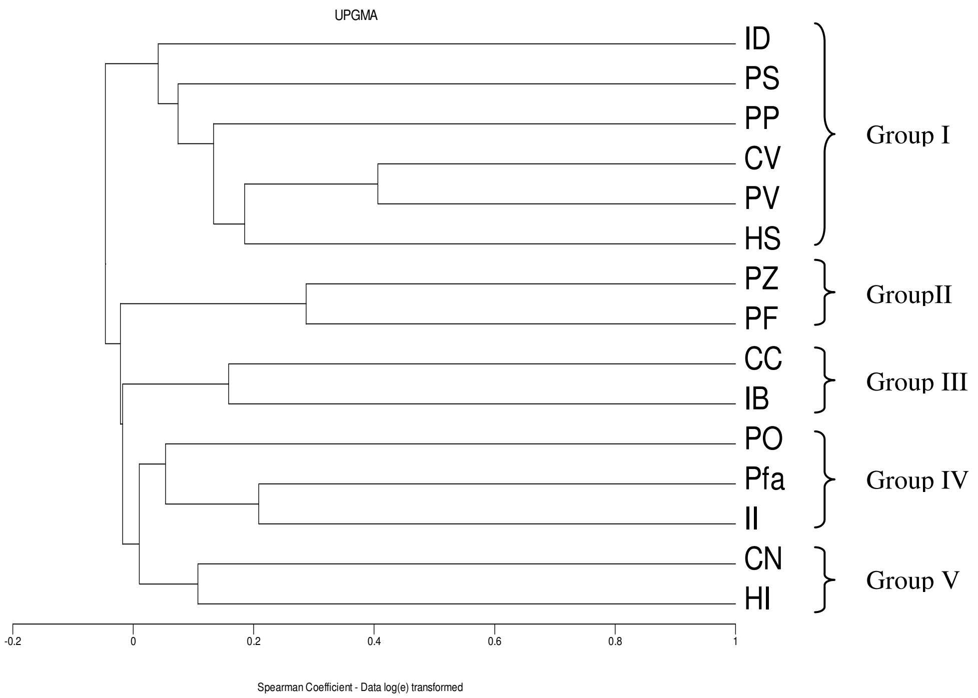


**Figure 11.** Shows the diagram of Unweighted Pair Group Mean Averages (UPGMA) shows clustering relationship of 15 species with 96 stations in Karabük and Düzce. Abbreviations were illustrated in Table 5.

**Table 9.** Pearson Correlation analyses shows relationship between five environmental variables. Abbreviations: Station type: STTYP, Disolved oxygen: DO, water temparature: Tw, atmospheric pressure: ATMP, altitude: ALT.

| | | STTYP | pH | DO | Tw | ATMP | ALT |
|---|---|---|---|---|---|---|---|
| STTYP | Pearson Correlation | 1 | .201* | -0.118 | -0.007 | -0.106 | 0 |
| | Sig. (2-tailed) | . | 0.49 | 0.254 | 0.948 | 0.305 | 0.999 |
| | N | 96 | 96 | 96 | 96 | 96 | 96 |
| Ph | Pearson Correlation | .201* | 1 | .487* | 0.15 | .202* | |
| | Sig. (2-tailed) | 0.049 | . | 0 | 0.145 | 0.048 | 0.32 |
| | N | 96 | 96 | 96 | 96 | 96 | 96 |
| DO | Pearson Correlation | -0.118 | .487** | 1 | -0.187 | .226* | -0.148 |
| | Sig. (2-tailed) | 0.254 | 0 | . | 0.068 | 0.027 | 0.151 |
| | N | 96 | 96 | 96 | 96 | 96 | 96 |
| Tw | Pearson Correlation | -0.007 | 0.15 | -0.187 | 1 | -0.81 | .228* |
| | Sig. (2-tailed) | 0.948 | 0.145 | 0.068 | . | 0.432 | 0.026 |
| | N | 96 | 96 | 96 | 96 | 96 | 96 |
| ATMP | Pearson Correlation | -0.106 | .202* | .226* | -0.081 | 1 | -.466** |
| | Sig. (2-tailed) | 0.305 | 0.048 | 0.027 | 0.432 | . | 0 |
| | N | 96 | 96 | 96 | 96 | 96 | 96 |
| ALT | Pearson Correlation | 0 | -.219* | -0.148 | .228* | -.466** | 1 |
| | Sig. (2-tailed) | 0.999 | 0.032 | 0.151 | 0.026 | 0 | . |
| | N | 96 | 96 | 96 | 96 | 96 | 96 |

Table 9 shows the pearson correlation between parameters properties pH and station type have positive relation pH, dissolved oxygen were found to have more positive correlation with station type than temperature atmospheric pressure and altitude. * 0.05, ** 0.01.

**Table 10.** Shannon-Wiener Diversity used to compare more than one ecosystem and explain all and each ecosystem.

| | | |
|---|---|---|
| Comparison Düzce and Karabük | All Sample Index: | 3.676 |
| | JackknifeStdError: | 0.1975 |
| Karabük Shannon (14 species) | All Sample Index: | 3.084 |
| | JackknifeStdError: | 0.2089 |
| Düzce Shannon (13 species) | All Sample Index: | 2.875 |
| | JackknifeStdError: | 0.1636 |
| Karabük Simpson (14 species) | All Sample Index: | 13.95 |
| | JackknifeStdError: | 3.286 |
| Düzce Simpson (14 species) | All Sample Index: | 13.96 |
| | JackknifeStdError: | 2.61 |
| Karabük Beta Diversity | WhittakerBw: | 7.84 |
| Düzce Beta Diversity | WhittakerBw: | 8.263 |

The results on table 10 revealed the diversity index calculated for all the sites studied. Alpha diversity of Karabük and Düzce based on the number of all living species are 24 and 19, respectively. This exhibits higher that alpha diversity of Karabük than Düzce. Indeed, Shannon Diversity index values were 3.084 and 2.87 for Karabük and Düzce, respectively.

# CHAPTER IV

# DISCUSSION AND CONCLUSION

## Species assemblages in Düzce

Total of 81 stations were visited in Düzce province. No ostracod was found in eight stations (6, 17, 24, 69, 70, 80, 81, 79). While a total of 30 taxa including 19 living species and 11 subrecent forms were found in other sites. Cosmopolitans showed dominancy in their abundance and occurrence as it was the result for *H. salina* with 9 times occurrencewith 641 indiviuals; *Ps. olivaceus* occurred13 times with 450 individuals; *C. neglecta* encountered3 times with 334 indiviuals; *I. bradyi* 5 times occurrencewith 240 indiviuals; *P. similis* found 6 times with 238 indiviuals.

*Candona candida* was found in two different aquatic bodies (lake and spring) located at 114m and 698m, respectively. it is regarded as cosmopolitan due to its widespread occurrence and high tolerance levels to different environmental variables (Külköylüoğlu 2004). The species was actually reported from Lake Efteni (Düzce) by Altınsaçlı and colleagues (1983). Table 2 shows the mean tolerance and optimum values for the species. Accordingly, optimum values of pH and disolved oxygen were higher than the mean of the other species. CCA diagram (Figure 8) illustrates a negative relationship of the species with water temperature. Sarı (2007) found the species closer to the center of CCA diagram but in this case *C. candida* was located outside of the center in the opposite side of temperature.

Two species of the genus *Cyclocypris* (*C. leavis, C.sywulae*) were found froma pond located at about 1270 m. Both species (*C. laevis and C. sywulae*) were found in Torkul pond at the same elevation ranges. Table 2 shows the mean tolerance and optimum values for the species. Until now, there is not much ecological knowledge for this species.

Other than the species discussed so far, the following five species (*Cypris pubera*, *Doleracypris sinensis* was found in spring, *Ilyocypris monstrifica*) was found from puddle in 208m. *Tonnocypris lutaria* was found from puddle and elevation in 510m. *Potamocypris arcuata* was found from trough at 331m) are encountered only one time during this study.

**Species assemblages in Karabük**

Total of 81 sites were visited in Karabük province. No living ostracods was found in 6 stations (stations 63, 36, 49, 20, 45, 81). While total of 36 taxa including 22 living and 14 subrecent species were found in province. In general, cosmopolitan species occurred more frequently than the other species forexample, *H. incongruens* was found 24times with 2097 indiviuals, *H. salina* encountered14times with 546 indiviuals, *P. olivaceus* occured12 times with 433 indiviuals, and *I. bradyi* 11times with 127 indiviuals.

*Limnocythere inopinata* was found in trough (station no 53) and stream (station no 69) between 354-659m. Yu Yin et al. (1999) found this species in waters where temperature was changed in 15–20°C as similar to our result. In contrast to the study of Külköylüoğlu et al. (2014) -except redox potential- The ecological optimum levels for the variables (pH, water temperature, dissolved oxygen, electrical conductivity) of the species were higher. Besides, this species was reported from waters with relatively high salinity (Cohen et al., 1983) which is also the case in the present study where the species exhibited high optimum levels for pH and electrical conductivity. According to CCA diagram, *L. inopinata* was located around and closer to the center. This may imply wide tolerance ranges of the species to different environmental variables. Earlier studies (Geiger, 1994; Meisch, 2000) reported that this species would prefer highly alkaline water bodies supported by the present study. The species was found along with another species *Paralimnocythere* sp. Considering the habitat (trough) and water types (pH=8.7, redox potential=114.45, dissolved oxygen=7.64, electricalconductivity=1980, salinity=1.02, water temperature=24.3), it was interesting to find both species from this trough. Although the identification of this species is not yet known, occurrence of both species together may suggest two possibilities: 1) either species are adapted to the relatively freshwater conditions (pH=7.54, redox potential=182.65, dissolved oxygen=3.86, electrical conductivity=476.7, salinity=0.25, water temperature=20.3), or 2) water is of brackish (or saline) type that is what the species usually prefer. Further studies should continue.

*Psychrodromus fontinalis* was found in trough and spring between 589-1189m altitude which was the highest point in Karabük that no other species was found at this altitude Külköylüoğlu et al. (2012) pinpointed that *P. fontinalis* could have wide ranges of distribution with the highest optimum estimate for altitude. According to Table 8, optimum levels of dissolved oxygen and redox potential of the species was higher than the mean of total but pH, electrical conductivity and water temperature were lower than that of the mean. In CCA diagram, *P. fontinalis*was located far away the center, suggesting that the species' tolerance levels to different variables may be much broader than what is known previously. Comparing to the results of Külköylüoğlu et al., (2012), electrical conductivity, redox potential and water temperature were higher but pH and dissolved  oxygen values were lower than our results. Overall, although there are not enough ecological information about the species, the findings suggest that *P. fontinalis* (like its conspecific cosmopolitan *P. olivaceus*) appears to have relatively high tolerances. Since nothing much is known, further studies are required to clarify the issue.

*Prionocypris zenkeri* was from trough and stream between 592-879m altitude. This species has high tolerances to dissolved oxygenbecause of its occurences in two different habitat. The optimum level is higher than the findings of Külköylüoğlu et al.(2012). According to CCA diagram *P. zenkeri* relationship with SHE and dissolved oxygen and not relationship with moisture. In CCA diagram, this species have positive relationship with dissolved oxygen and and SHE but it has negative relationship with moisture. Uçak (2012) reported this species with a positive relationship to moisture but our results showed a negative relationship.

*Potamocypris fallax* was found from trough and stream between 231-859m. Pieri et al.,(2009) found in stream and spring. Disolved oxygen and pH optimum levels higher than mean but water temperature and SHE optimum levels lower than mean. According to CCA, we can say this species so far from ecologic parameters and center.

*Potamocypris pallida* was found from a trough between 191-981m. of altitude. Generally, all optimum and tolerance levels so close to eachother and falls between the same range in the means. In CCA this species has positive relationship with moisture both negative relationship and dissolved oxygen negative relationship with SHE and dissolved oxygen. Altough its relatively common occurrence, ecological knowledge is not weel known about it.

Other than the species discussed so far, the following five species *P. albicans*, *C. improvisa*, *P. villosa*,*H. chevreuxi*, *H. brevicaudata*, *E. pigra*, *H. reptans*, *P. smaragdina )* are encountered only one time during this study.

**Comparison results of species assemblages**

*Candona neglecta* was found from Düzce and Karabük at the ranges of 204-1121 m and 470-530 m a.s.l., respectively. As seen, the species was found in relatively wide altitudinal ranges, suggesting a broad geographical distribution. Accordingly, distributional range of this species in Karabük is limited within about 60 m of altitudinal range and is overlapped in Düzce. Table 8 shows the mean tolerance and optimum values for species. In CCA, this species is located on the opposite site of the water temparature. Also, tolerance and optimum values of the species for temperature were found lower than the mean of total while dissolved oxygen value was higher but pH value was equal with the mean (Table 7). This agrees with the findings of Yılmaz (2005) in springs.

*Cypridopsis vidua*acosmoecious species (Külköylüoğlu, 2013) was found from a trough and a lake sample of Düzce in 125-347 m of altitude. In contrast, it was found from lakelet in Karabük at about 938m a.s.l. However the species can also be seem in different habitatas such as springs (Külköylüoğlu, 2006). Table 8 shows the mean tolerance and optimum values for the species. Generally all ecological tolerance levels are higher than the meanand this is supported by Placios-Fest (2001). If found this species to have highsalinity tolerance, and and high level of electrical conductivity the studies. Positive relationship with water temperature, was also found on the species located on the save diratum.

*Ilyocypris bradyi* was found from trough, spring and stream habitats in Düzce. In Karabük, additionally, it was also encountered from ditch and puddle.

Xiangzhong (2010) reported the abundance of this species and in rivers, springs, and puddles. Külköylüoğlu et al.,(2007) found the species also from many different aquatic bodies of Turkey, even in aneutrophic lake, Lake Yeniçağa. Similar results were also documented from the aquatic habitats of Spain (Mezquita et al. 1999). Acoording the CCA results,this species has negative relationship with water temperature but showed a positive relationship with station type. Supporting findings come from the tolerance values of the species (Table 7) where tolerance of the species to water temparature and electrical conductivity were lower than the mean of total but higher for pH and dissolved oxygen values.

*Ilyocypris decipiens* was found from a puddle in Düzce but a lakelet in Karabük.It was reported from ricefield in Italy (Rossi et al. 2003). Although habitats displayed some levels of similarities, altitudinal differences are evident between these two studies. One may consider that altitudinal range of the species is much wider than what we know previously. In CCA, this species has negative relationship with water temperature, interpreting that species may prefer cold to warm waters (Table 8). Scharf et al., (2005) found from the species lake in Germany and they did not find living from they found just valves in 70cm of depth.

*Ilyocypris inermis* was only found from a stream in Düzce between 137 and 960m but it was found in a trough in Karabük at the range of 231-1135m. Külköylüoğlu et al. (2010) reported the species from several different types of aquatic habitats such as creek, stream and irregation canal. Tolerance values of the species both in Düzce and Karabük seem to be relatively high where it was located on the opposite site of the temperature (Table 8, Figure 9). Also,findings of Külköylüoğlu and Yılmaz (2006) and Meisch (2000) support the results that the species has negative relationship with water temparature and conductivity.

*Heterocypris incongruens* was found from trough, stream, pond and spring in Düzce between 124-1270m. In Karabük, it was found from trough, stream, ditch, pond and spring between 171-1390m. Both altitudinal ranges overlap each other, suggesting a wide geographical distribution of the species. Besides, this cosmopolitan species is also known to tolerate wide changes in the values of water variables. Thus, as it was suggested, *H. incongruens* can be called as "cosmoecious" species (Külköylüoğlu 2013). Thismay imply that this species has wide tolerance for altitude and habitat preference. Table 8 shows the mean tolerance and optimum values of the species where it showed higher optimum and tolerance values for pH, DO, EC, and Tw than the mean of total. According to CCA, this species has positiverelationship with water temparature. Xiangzhong et al. (2010) reported this species tolerating low oxygen values that supports our resultsince the species optimum values for disolved oxygen lower than mean.

*Heterocypris salina* was found from trough, stream and puddle in Düzce between 196 and 372m of elevation. This species was also found from trough, stream, pond and creek between 118 and 1015min Karabük. Similarly, Uçak (2012) found the species from trough, stream and dam in Ankara region.Generaly, this species seems to be widely distributed as is the case for many cosmopolitan species. In contrast to *H. incongruens*, *H. salina* showed low tolerance ranges to the oxygen values. This is probably because of its habitat preferences where increasing temperature and salinity values eventually reduces dissolved oxygen values. In CCA diagram, the species was placed in the opposite site of thestation type, implying habitat preferences of the species. *H. salina*positive displayed relationship with electrical conductivity referring preference in saline water. According to

Külköylüoğlu and Vinyard (2000) *H.salina* is ahalobiont species in high saline waters.

*Potamocypris similis* was found from trough, stream, waterfall and spring in Düzce between 124-817m. while it was found from trough, creek and pond in Karabük between the elevation of 445-1252m. Accordingly, thisspecies seems to have wide occurrences in variety of habitats. Most recently, Külköylüoğlu and Sarı (2012) showed a positive relationship of the species with disolved oxygen implying species habitat preference with high oxygenated (and relatively low temperature) waters. This is supported in the present study that the species exhibited relatively higher optimum value for disolved oxygen than the total mean (Table 8). This, however, does not indicate any positive or negative relationship since this study did not do such analysis for the species. Unfortunately, there is not much information known about the ecology of the species. Further studies are suggested.

*Potamocypris variegata* was found from troughs in both Düzce and Karabük at about at 347m and 385m, respectively. However, the distribution of the species is not limited to troughs (Meisch, 1985, Külköylüoğlu et al. 1995, Mezquita et al., 1999).

*Psychrodromus olivaceus* was found from trough, stream, puddle and spring in Düzce between 141-1121m. In Karabük, it was found from trough, spring and a ditch. The species is one of the most frequently occurring one among the others in Turkey that it seemsto show a cosmopolitan distribution (Külköylüoğlu et al., 2012). According to CCA, the species was located near the center of diagramsupporting the idea above. As shown in Table 8, dissolved oxygen was the only variable with higher value than the mean of others.

According to Pearson correlation analysis, possible relationships among some of those environment variables and species (and both) were shown. In Table 9, there was a negative relationship between altitude and atmospheric pressure altitudinal ranges.

In this study UPGMA with 15 species in 96 sites from Düzce and Karabük.Accordingly,there are fiveclustering groups based on species occurrence (Figure 11).

UPGMA in first group includes six species (*I. decipiens*,*P.similis*,*P.pallida*, *C. vidua*, *P. variegata*, *H. salina*) reported fromtrough,creek and streams, except *I. decipiens* and *C. Vidua* which were found in lakelet. Generally, they prefer well oxygenated waters buttwo of them (*P. pallida* and *P. variegata*) were found in poor-oxygenated water bodies. All six species were encountered in waters with relatively high water temperature (≥20°C) in a large altitudinal ranges.

Second groupof UPGMA dendrogram has two species (*P. zenkeri* and *Ps. fontinalis*). Of which, *P. zenkeri* is known with its cosmopolitan distribution (Külköylüoğlu 2013) while *Ps. fontinalis* appears to have limited distribution as was the case in some previous studies (Karakaş-Sarı 2006, Sarı 2007, Uçak, 2012). Although studies revealed that *P. zenkeri* was usually acompanied by I. inermis (or *I. bradyi*) from springs and waters related to springs (Rossetti et al. 2005, Külköylüoğlu and Sarı 2012), we found them from non-flowing or slow water bodies of Karabük and Düzce during this study.

Third group covers twocosmopolitan species *C. candida* and *I. bradyi*which were generally found in trough and spring. Occurrence of both species togather from the sampling sites has already been revealed in previous studies (e.g., see Külköylüoğlu and Sarı 2012). Both species are called as “cosmoecious” species when they show high levels of tolerances to different values in a wide geographical ranges (Külköylüoğlu 2013). Such similarity was found in their ecology when they exhibited similar pH levels (7.9) andelectrical conductivity (341- 613 mS/cm) values.

Fourth groupof UPGMA wasthree species *P. olivaceus*, *P. fallax*, and *I. inermi*s. They werefound in well-oxygenated alkaline (mean pH 8) waters of trough, stream and springs. All these three species can be found in a relativley high temperature ranges from 13 to 21°C.

Fifth clusteringgroup has also two cosmoecious species, *C. neglecta* and *H. incongruens*. During this study,they were found from trough, stream and spring. Both species do have swimming ability which provides them to move actively away water bodies.

The small difference between the cities low (0.214) suggest variation between the areas. In comparison, alpha diversity values were found 23, 46, and 40 in Diyarbakır (Akdemir, 2011), Kahramanmaraş (Külköylüoğlu 2012), and Bolu (Sarı, 2007). Accordingly, our values were similar to the results of Diyarbakır results. Similar to the Shannon diversities, there are no significant difference in the abundance (dominancy) of the two area with 13.95 and 13.96 of the Simpson dominancy values found in Karabük and Düzce, respectively.

Based on the similarities in types of habitats, numbers of sampling sites and numbers of species shared in both areas, Gamma diversity can be evaluated for these two areas. Thus, combination of the numbers of species found in both area refers Gamma diversity, where 10 of 33 were common species (*C.* neglecta, *I. bradyi*, *I. decipiens*, *I. inermis*, *C.vidua*, *P. olivaceus*, *H. incongruens*, *H. salina P. similis*, *P. variegate*) Of which, 14 and 9 living species were found from Karabük and Düzce, respectively. It can, however, be unrealistic to make such combination for other areas (cities that mentioned above) since these are of certain kinds of variations among them. Besides, there are no specific works on Gamma diversity of the areas to make comparison in Turkey.

As seen in Table 9, Beta diversity value within each regions studied was higher (8.263) in Düzce than the Karabük (7.84) regions. Implication of this result is based on the differences in the numbers of different habitat types and species per habitat types. For example, while 50 of 81 sites were troughs in Karabük (where scarcity of water was apparent), 17 troughs of 81 sites were (out of 81 sites) in Düzce. Thus, we may suggest that increasing types of suitable habitats can increase numbers of species among the sites within the areas.

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# APPENDICES

**Appendix 1.** Karabük's ecological variables.

| St. No | Station name | St. type | pH | She | DO | %S (DO) | EC | Spec. EC | Sal | T w | TDS | Atmp | Coordinates | Alt | Mois |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | İ.pasa stream | 2 | 7.57 | 207.84 | 0.75 | 8.9 | 739 | 758 | 0.37 | 23.7 | 0.494 | 674.6 | 40°152'165"N, 32°37'960"E | 1004 | 19.5 |
| 2 | Bayındır trough | 1 | 7.97 | 211.03 | 7.45 | 80.6 | 1016 | 1152 | 0.57 | 18.8 | 0.7475 | 672.5 | 40°52'449"N, 32°36'038"E | 1015 | 24.6 |
| 3 | Tasman trough | 1 | 7.43 | 213.69 | 6.05 | 60.1 | 548 | 681 | 0.33 | 14.7 | 0.442 | 672.5 | 40°54'977"N, 32°33'346"E | 1005 | 29 |
| 4 | Tefen trough | 1 | 7.42 | 203.08 | 8.68 | 80.2 | 468.6 | 626.6 | 0.31 | 11.8 | 0.4075 | 639.7 | 40°54'867"N, 32°912'1036" | | |
| 5 | Railroad trough | 1 | 7.44 | 199.95 | 4.79 | 47.3 | 710 | 895 | 0.44 | 14.3 | 0.5785 | 688.9 | 40°56'188"N, 32°31'955"E | 781 | 21.9 |
| 6 | Dry trough | 1 | 7.59 | 176.05 | 0.89 | 11.9 | 696 | 633 | 0.3 | 30.3 | 0.4095 | 686.7 | 40°56'093"N, 32°30'252"E | 807 | 18.6 |
| 7 | A.Özkan trough | 1 | 7.43 | 193.79 | 104.1 | 8.86 | 617 | 597 | 0.29 | 26.7 | 0.39 | 684.1 | 40°55'908"N, 32°29'934"E | 844 | 18 |
| 8 | Goksu stream | 2 | 8.3 | 149.72 | 83.9 | 83.9 | 391 | 450 | 0.22 | 18.2 | 0.2819 | 682.9 | 40°55'666"N, 32°28'256"E | 859 | 19.2 |
| 9 | İsmail bey trough | 1 | 7.78 | 167.29 | 6.93 | 79.5 | 462.2 | 503.5 | 0.24 | 36.7 | 0.3276 | 662.2 | 40°55'683"N, 32°26'535"E | 1135 | 17.3 |
| 10 | Nameless trough | 1 | 7.71 | 180.24 | 8.27 | 89.4 | 385 | 427.5 | 0.21 | 19.7 | 0.2782 | 653.6 | 40°55'256"N, 32°24'492"E | 1252 | 19.2 |
| 11 | Adiller trough | 1 | 8.06 | 164.15 | 10.84 | 128.6 | 513 | 525 | 0.25 | 24 | 0.338 | 643.5 | 40°53'907"N, 32°23'073"E | 1390 | **17.2** |
| 12 | 1994 trough | 1 | 7.55 | 193.37 | 7.11 | 71.1 | 495.5 | 609.6 | 0.3 | 15.2 | 0.3959 | 672 | 40°55'900"N, 32°37'244"E | 1012 | 20.5 |
| 13 | Nameless trough | 1 | 7.9 | 166.23 | 6.99 | 83.2 | 388.2 | 388.9 | 0.19 | 24.8 | 0.2536 | 657.9 | 40°55'965"N, 32°40'771"E | 1178 | 17 |
| 14 | Limnocrene spring | 4 | 8.14 | 147.05 | 7.85 | 103.7 | 512 | 468 | 0.22 | 30 | 0.3055 | 657.9 | 40°55'984"N, 32°40'804"E | 1189 | 17.4 |
| 15 | 5li trough | 1 | 7.88 | 171.37 | 7.61 | 83.6 | 463.6 | 514.8 | 0.25 | 19.2 | 0.3347 | 643.2 | 40°58'369"N, 32°50'483"E | 1436 | 22.5 |
| 16 | Limnocrene spring | 4 | 7.48 | 195.63 | 5.37 | 58 | 499.4 | 568.2 | 0.28 | 18.8 | 0.3705 | 640.2 | 40°58'581"N, 32°51'247"E | 1436 | 20.1 |
| 17 | Pelitçik trough | 1 | 7.42 | 193.68 | 4.03 | 52 | 877 | 832 | 0.4 | 27.8 | 0.5395 | 659.9 | 41°00'075"N, 32°51'264"E | 1189 | 25.9 |
| 18 | Pöyrek trough | 1 | 7.22 | 210.34 | 2.7 | 28.5 | 1129 | 1316 | 0.66 | 17.4 | 0.858 | 675 | 41°00'761"N, 32°53'608"E | 981 | 23.6 |
| 19 | Nameless trough | 1 | 8.66 | 136.38 | 10.32 | 23.5 | 582 | 595 | 0.29 | 23.8 | 0.3835 | 686.6 | 41°02'298"N, 32°58'040"E | 833 | 23 |
| 20 | Çamaşırhane trough | 1 | 7.49 | 197.25 | 6.4 | 74.1 | 117.9 | 1253 | 0.62 | 22 | 0.8125 | 680.2 | 41°02'505"N, 32°55'867"E | 913 | 30 |
| 21 | Long trough | 1 | 7.36 | 199.35 | 5.51 | 63.5 | 905 | 960 | 0.47 | 22 | 0.624 | 670.3 | 41°02'264"N, 32°53'484"E | 1036 | 30.5 |
| 22 | Alıncak torugh | 1 | 7.46 | 193 | 7.24 | 83.2 | 693 | 746 | 0.36 | 21.3 | 0.4875 | 661.7 | 41°03'718"N, 32°52'979"E | 1153 | 34 |
| 23 | Small pond | 5 | 7.65 | 178.23 | 0.78 | 10.1 | 1051 | 1015 | 0.5 | 26.8 | 0.663 | 688.5 | 41°30'79"N, 32°50'920"E | 826 | 42.1 |
| 24 | Bagirsak 1 stream | 2 | 8.18 | 148.26 | 8.28 | 92.4 | 963 | 1052 | 0.52 | 20.6 | 0.6825 | 716.8 | 41°06'101"N, 32°48'438"E | 456 | 44.3 |
| 25 | Tek trough | 1 | 7.54 | 191.62 | 7.28 | 72.6 | 527 | 601 | 0.29 | 18.5 | 0.39 | 671.2 | 41°21'104"N, 32°42'012"E | 999 | 48 |
| 26 | Gogoren trough | 1 | 7.85 | 166.75 | 4.71 | 54.1 | 597 | 628 | 0.3 | 22.3 | 0.4095 | 667.5 | 41°20'831"N, 32°41'494"E | 1047 | 61.5 |
| 27 | Feride goncuoglu trough | 1 | 7.63 | 179.97 | 8.37 | 88.5 | 548 | 640 | 0.31 | 17.5 | 0.416 | 667.2 | 41°21'540"N, 32°41'938"E | 1068 | 60.5 |
| 28 | Gövören creek | 2 | 8.03 | 161.16 | 9 | 85.7 | 280 | 364.2 | 0.18 | 12.9 | 0.2366 | 666.8 | 41°22'450"N, 32°42'291"E | 963 | 59.8 |
| 29 | YSE trough | 1 | 8.05 | 156.64 | 4.11 | 45.1 | 367.5 | 408.4 | 0.2 | 19.7 | 0.2652 | 698.6 | 41°23'735"N, 32°43'667"E | 692 | 65.6 |
| 30 | Roadside ditch | 5 | 7.69 | 179.09 | 3.94 | 44.3 | 1400 | 1527 | 0.77 | 20.7 | 0.9945 | 701.9 | 41°21'399"N, 32°43'368"E | 659 | 61.2 |
| 31 | Eflani foucet trough | 1 | 7.99 | 161.42 | 3.92 | 47.4 | 728 | 735 | 0.36 | 24.5 | 0.481 | 722.6 | 41°27'558"N, 32°46'617"E | 385 | 58.7 |
| 32 | Creek pond | 5 | 7.85 | 169.7 | 4.38 | 50.1 | 487.8 | 525 | 0.25 | 21.3 | 0.3412 | 717.9 | 41°28'347"N, 32°48'893"E | 445 | 60.6 |
| 33 | Small pond | 2 | 8.05 | 159.66 | 6.69 | 75.2 | 469.9 | 514.2 | 0.25 | 20.6 | 0.3441 | 704.8 | 41°30'900"N, 32°53'363"E | 606 | 51.3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34 | Ulupınar trough | 1 | 8.12 | 152.55 | 6.17 | 71.9 | 555 | 589 | 0.29 | 22 | 0.3835 | 687.5 | 41°31'441"N, 32°55'201"E | 822 | 52.6 |
| 35 | Çamlık Haslemoğlu trough | 1 | 7.89 | 169.22 | 7.54 | 87.6 | 476.4 | 500.7 | 0.24 | 22.5 | 0.3256 | 789.4 | 41°32'257"N, 32°57'491"E | 796 | 45 |
| 36 | 7/7/2008 trough | 1 | 7.85 | 169.45 | 5.19 | 60.5 | 450.4 | 474.4 | 0.23 | 22.3 | 0.3081 | 680.8 | 41°31'330"N, 32°57'501"E | 903 | 48.3 |
| 37 | Kavaloğlu trough | 1 | 7.25 | 211.79 | 4 | 38.3 | 453.4 | 589.1 | 0.29 | 12.4 | 0.39 | 671.9 | 41°29'204"N, 32°57'339" | 1015 | 39.5 |
| 38 | Bostancılar  lake led | 6 | 8.14 | 152.28 | 7.06 | 80.5 | 283.3 | 278 | 0.13 | 26.1 | 0.1807 | 677.8 | 41°27'371"N, 32°56'976"E | 945 | 30.6 |
| 39 | Ortakcilar lake led | 6 | 8.61 | 123.41 | 6.46 | 82.1 | 197.2 | 188.3 | 0.09 | 27.6 | 0.1222 | 678 | 41°25'646"N, 33°00'603"E | 938 | 40 |
| 40 | Tabaklar stream | 2 | 7.82 | 173.23 | 5.63 | 63.2 | 437.5 | 475.8 | 0.23 | 20.8 | 0.3087 | 682.2 | 41°23'982"N, 32°58'472"E | 879 | 32.5 |
| 41 | 30June1990 trough | 5 | 7.74 | 178.92 | 8.78 | 92.3 | 468 | 549.2 | 0.27 | 26.5 | 0.3539 | 680 | 41°24'790"N, 32°55'781" | 900 | 17.5 |
| 42 | Big ditch | 5 | 7.74 | 179.21 | 5.2 | 64.9 | 573 | 556 | 0.27 | 25.6 | 0.364 | 680.6 | 41°23'461"N, 32°49'189"E | 915 | 27.2 |
| 43 | Foucet trough | 1 | 7.99 | 163.51 | 6.85 | 44.2 | 414.5 | 422.9 | 0.2 | 23.9 | 0.275 | 678 | 41°22'705"N, 32°46'508"E | 933 | 32.5 |
| 44 | Ceviz trough | 1 | 7.99 | 160.24 | 8.96 | 114.2 | 743 | 707 | 0.34 | 27.7 | 0.4615 | 711 | 41°15'130"N, 32°41'710"E | 551 | 29.8 |
| 45 | Mencilis magarası stream | 2 | 7.81 | 185.23 | 10.81 | 95 | 302.4 | 434.5 | 0.21 | 9.1 | 0.2821 | 696 | 41°16'425"N, 32°37'526"E | 685 | 38.8 |
| 46 | Mencilis magara ici | 3 | 7.6 | 189.82 | 4.86 | 47.1 | 411.2 | 540.2 | 0.26 | 12.5 | 0.351 | 689.4 | | | 45.4 |
| 47 | Aslanlar trough | 1 | 7.92 | 163.56 | 9.14 | 106.2 | 598 | 625 | 0.3 | 22.6 | 0.4095 | 704.2 | 41°15'536"N, 32°40'335"E | 592 | 24.8 |
| 48 | Konarı lake | 7 | 7.1 | 191.85 | 5 | 61.9 | 755 | 740 | 0.36 | 26 | 0.481 | 717.5 | 41°13'217"N, 32°47'031"E | 437 | 33 |
| 49 | Araç creek | 8 | 7.67 | 182.06 | 8.51 | 99.7 | 737 | 769 | 0.38 | 22.9 | 0.5005 | 718.3 | 41°11'984"N, 32°54'624"E | 411 | 28.9 |
| 50 | Toprakcuma trough | 1 | 7.89 | 160.17 | 9.59 | 135 | 901 | 779 | 0.37 | 33.2 | 0.507 | 717.4 | 41°12'325"N, 32°54'207"E | 413 | 30 |
| 51 | Ovacık river | 2 | 8.25 | 141.98 | 7.38 | 93.8 | 703 | 668 | 0.32 | 27.8 | 0.4355 | 726.2 | 41°07'850"N, 32°40'632"E | 312 | 44.4 |
| 52 | Abdi bag trough | | 8.83 | 106.81 | 6.75 | 84.6 | 1792 | 1709 | 0.86 | 27.6 | 0.1115 | 697.4 | 41°10'372"N, 32°41'292"E | 646 | 46 |
| 53 | Oluk trough | 1 | 8.7 | 114.45 | 7.64 | 92 | 1980 | 2008 | 1.02 | 24.3 | 1.3065 | 697.5 | 41°10'474"N, 32°41'360"E | 659 | 43.7 |
| 54 | Yello pond | 6 | 9.59 | 62.89 | 13.63 | 186.3 | 6610 | 5992 | 3.23 | 30.4 | 3.9 | 694 | 41°10'810"N, 32°41'985"E | 704 | 45.1 |
| 55 | Camli trough | 1 | 8.67 | 119.53 | 5.67 | 75.5 | 954 | 917 | 0.45 | 27.1 | 0.598 | 691.1 | 41°11'218"N, 32°41'774"E | 747 | 47.4 |
| 56 | Belenkoy trough | 1 | 7.69 | 185.55 | 8.23 | 91 | 1143 | 1265 | 0.63 | 20 | 0.819 | 720.5 | 41°09'887"N, 32°36'626"E | 393 | 50.2 |
| 57 | 11/03/1989 trough | 1 | 8.17 | 144.35 | 8.71 | 112.7 | 1057 | 995 | 0.49 | 28.3 | 0.65 | 721.2 | 41°09'870"N, 32°36'894"E | 382 | 52.1 |
| 58 | Odemis trough | 1 | 8.1 | 155.96 | 6.72 | 81.9 | 525 | 526 | 0.25 | 24.9 | 0.3445 | 718.5 | 41°09'443"N, 32°35'700"E | 417 | 53.7 |
| 59 | Yangın deposu trough | 1 | 8.64 | 116.6 | 5.66 | 75.5 | 2154 | 1088 | 1 | 29.3 | 1.2935 | 719.8 | 41°09'534"N, 32°35'591"E | 408 | 55.4 |
| 60 | Pirinçlik stream | 2 | 8.72 | 138.42 | 6.71 | 77.7 | 612 | 643 | 0.31 | 22.5 | 0.416 | 734.2 | | 251 | 62.4 |
| 61 | Soguk su trough | 1 | 7.92 | 173.96 | 10.88 | 88 | 346.5 | 473.6 | 0.23 | 10.9 | 0.318 | 715.4 | 41°09'466"N, 32°27'919"E | 231 | 66.5 |
| 62 | Soğuksu leaking | 2 | 7.91 | 132.32 | 10.51 | 97.2 | 311.7 | 417.8 | 0.2 | 70.2 | 0.2717 | 735.2 | 41°09'466"N, 32°27'919"E | 231 | |
| 63 | Hes şantiye stream | 2 | 8.14 | 153.39 | 6.12 | 68.8 | 332.3 | 362.2 | 0.17 | 20.7 | 0.2353 | 740.5 | 41°11'453"N, 32°26'426"E | 172 | 67.6 |
| 64 | Balıkısık stream | 2 | 7.89 | 173.08 | 7.29 | 86.5 | 538 | 551 | 0.27 | 23.8 | 0.3575 | 740.3 | 41°12'538"N, 32°25'124"E | 181 | 69.2 |
| 65 | Çamlıköy trough | 1 | 7.69 | 179.15 | 5.48 | 65.6 | 669 | 681 | 0.33 | 24 | 0.442 | 729.2 | 41°13'823"N, 32°25'905"E | 307 | 69.2 |
| 66 | Aziziye Oren trough | 1 | 7.7 | 183.6 | 6.34 | 69.1 | 677 | 760 | 0.37 | 19.3 | 0.494 | 710.4 | 41°13'030"N, 32°26'681"E | 530 | 58.5 |
| 67 | Mezarlik trough | 1 | 7.78 | 172.99 | 2.01 | 24.6 | 401.1 | 404.3 | 0.19 | 24.7 | 0.2626 | 718.7 | 41°12'673"N, 32°25'934"E | 443 | 59.5 |
| 68 | Mezarlık spring | 4 | 7.93 | 158.62 | 8.49 | 94 | 94.9 | 435.5 | 0.21 | 20.2 | 0.2827 | 720 | 41°12'605"N, 32°25'885"E | 428 | 54.8 |
| 69 | İncebacak stream | 2 | 7.54 | 182.65 | 3.86 | 43.1 | 476.7 | 524.5 | 0.25 | 20.3 | 0.3406 | 726.5 | 41°10'112"N, 32°21'050"E | 354 | 65.7 |
| 70 | İncebacak köy girişi trough | 1 | 7.77 | 166.79 | 7.24 | 79.9 | 519 | 569 | 0.28 | 20.4 | 0.3705 | 729 | 41°10'463"N, 37°21'111"E | 317 | 20.4 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 71 | Nizam Hayratı | 1 | 8.05 | 156.4 | 10.29 | 99.3 | 406.7 | 523.3 | 0.25 | 13.3 | 0.34 | 736.8 | 41°11'576"N, 32°71'671"E | 231 | 72.3 |
| 72 | Kadir Hayratı 1/8/2005 | 1 | 7.95 | 160.94 | 6.61 | 72.5 | 542 | 606 | 0.29 | 19.4 | 0.3965 | 740.3 | 41°11'782"N, 32°21'869"E | 191 | 72.5 |
| 73 | Şeker Pınar Kanyonu | 2 | 8.29 | 148.77 | 9.87 | 98.9 | 360.8 | 440.6 | 0.21 | 15.5 | 0.286 | 740.9 | 41°11'938"N, 32°21'737"E | 185 | 70.1 |
| 74 | Hacıosman trough | 1 | 7.7 | 176.36 | 2.75 | 33.2 | 593 | 594 | 0.29 | 24.9 | 0.3835 | 737.2 | 41°13'888"N, 32°21'744"E | 228 | 69.5 |
| 75 | Yortan trough | 1 | 7.71 | 176.27 | 6.92 | 90.8 | 802 | 742 | 0.36 | 29.2 | 0.481 | 733.1 | 41°15'463"N, 32°21'058"E | 264 | 57.1 |
| 76 | Demir yolu üstü leaking | 5 | 8 | 157.18 | 9.01 | 115.4 | 626 | 594 | 0.29 | 27.8 | 0.3835 | 741.7 | 41°12'095"N, 32°22'935"E | 171 | 55.9 |
| 77 | Derebasi trough | 1 | 7.18 | 216.3 | 4.53 | 47.5 | 1484 | 1741 | 0.89 | 17.3 | 1.131 | 715 | 41°14'558"N, 32°17'976"E | 470 | 46.5 |
| 78 | Köy içi trough | 1 | 7.61 | 182.82 | 9.3 | 97.2 | 571 | 656 | 0.32 | 18.2 | 0.429 | 727.2 | 41°14'081"N, 32°18'274"E | 333 | 54.2 |
| 79 | Derebacı trough | 1 | 7.9 | 161.98 | 7.46 | 92.5 | 627 | 618 | 0.3 | 25.8 | 0.403 | 727.6 | 41°14'036"N, 32°18'337"E | 323 | 51 |
| 80 | Filyos creek | 8 | 8.43 | 129.36 | | 79.2 | 642 | 599 | 0.29 | 28.9 | 0.39 | 744.8 | 41°12'949"N, 32°14'041"E | 118 | 43 |
| 81 | İl sınırı leaking | 5 | 7.58 | 194.59 | 8.68 | 94.2 | 585 | 638 | 0.31 | 20.7 | 0.416 | 747 | 41°16'144"N, 32°09'737"E | 82 | 44.7 |

**Appendix 2.** Düzce's Ecologic variables.

| St. no | St. name | St. type | pH | She | DO | %S(DO) | EC | s.EC | Sal | T w | T air | TDS | Atmp | Coordinates | Alt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Kurtsuyu village | 3 | 8.47 | 124.875 | 6.46 | 68.2 | 200 | 233.2 | 0.11 | 17.5 | 18.3 | 0.1514 | 715.3 | 40°59'412"N, 31°12'164"E | 510 |
| 2 | Kurtsuyu cave | 7 | 7.65 | 163.845 | 9.47 | 80.3 | 330 | 461.4 | 0.23 | 11.7 | 16.3 | 0.3023 | 725.6 | 40°57'968"N, 31°13'419"E | 387 |
| 3 | | 3 | 7.91 | 133.93 | 9.04 | 82.9 | 334.7 | 452 | 0.22 | 20.8 | 11.4 | 0.2938 | 725.6 | 40°57'968"N, 31°13'419"E | 387 |
| 4 | Kurtsuyu spring | 8 | 8.05 | 150.565 | 6.76 | 67.7 | 396.2 | 491.1 | 0.24 | 14.9 | 26.1 | 0.3192 | 721.9 | 40°58'589"N, 31°13'425"E | 429 |
| 5 | Subatak spring | 8 | 7.74 | 135.88 | 7.51 | 72.9 | 313.7 | 399.3 | 0.19 | 13.8 | 23.5 | 0.2593 | 723.1 | 40°58'399"N, 31°13'358"E | 433 |
| 6 | | 1 | 7.76 | 150.99 | 92.1 | 94.6 | 371.3 | 444.9 | 0.22 | 16.4 | 25.2 | 0.2892 | 370 | 40°58'014"N, 31°10'240"E | 370 |
| 7 | | 1 | 8.18 | 112.895 | 11.59 | 131.4 | 519 | 566 | 0.27 | 20.7 | 29 | 0.3705 | 731.8 | 40°57'656"N, 31°10'406"E | 331 |
| 8 | Saklıkent waterfall | 4 | 8.29 | 136.84 | 8 | 80.5 | 346.1 | 425.3 | 0.21 | 15.4 | 28.4 | 0.2763 | 709.8 | 40°56'433"N, 31°29'415"E | 582 |
| 9 | Saklıkent cave? | 7 | 8.33 | 126.18 | 10.54 | 93 | 301.9 | 426.2 | 0.21 | 9.8 | | 0.2769 | 702.5 | 40°56'429"N, 31°29'416"E | 656 |
| 10 | | 3 | 8.23 | 115.82 | 6.88 | 76.4 | 360.6 | 396.6 | 0.19 | 20.2 | 19.7 | 0.2581 | 475 | 40°57'003"N, 31°29'213"E | 475 |
| 11 | | 2 | 8.62 | 96.545 | 90.8 | 95.7 | 351.6 | 409.2 | 0.2 | 17.7 | 20.9 | 0.2659 | 358 | 40°58'058"N, 31°27'862"E | 358 |
| 12 | Serenaltı village | 2 | 8.12 | 114.1 | 7.13 | 77.2 | 511 | 577 | 0.28 | 19 | 21.4 | 0.377 | 734.8 | 40°56'952"N, 31°23'257"E | 320 |
| 13 | Hacı Ahmet trough | 1 | 7.95 | 123.73 | 7.07 | 80.6 | 597 | 649 | 0.32 | 20.8 | 21.1 | 0.4225 | 732.2 | 40°57'124"N, 31°23'226"E | 347 |
| 14 | | 8 | 7.55 | 145.5 | 4.25 | 44.5 | 458.7 | 542.3 | 0.26 | 17 | 21.1 | 0.3523 | 736.3 | 40°56'692"N, 31°20'408"E | 300 |
| 15 | Dutlar village | 1 | 7.58 | 146.83 | 13.54 | 49.2 | 538 | 614 | 0.3 | 18.8 | 20.8 | 0.3965 | 735.6 | 40°56'379"N, 31°20'286"E | 290 |
| 16 | | | 7.95 | 132.365 | 5.07 | 56.4 | 402.1 | 455.6 | 0.22 | 18.9 | 20.4 | 0.2958 | 735.9 | 40°55'809", 31°18'362"E | 304 |
| 17 | Hasanlar barajı | 5 | 8.22 | 115.63 | 7.78 | 85.5 | 308.5 | 335.1 | 0.16 | 20.8 | 18.8 | 0.2178 | 739.4 | 40°55'673"N, 31°18'294"E | 251 |
| 18 | | 1 | 8.04 | 125.285 | 7.66 | 82.3 | 459.4 | 528.9 | 0.26 | 18.1 | 20.1 | 0.3438 | 735 | 40°55'941"N, 31°17'196"E | 312 |
| 19 | | 2 | 8.01 | 127.065 | 7.56 | 82.6 | 387.3 | 438.7 | 0.21 | 18.9 | 20.7 | 0.2854 | 744.6 | 40°54'394"N, 31°15'388"E | 197 |
| 20 | Altunçay village | 1 | 7.94 | 108.69 | 8.39 | 88.1 | 165.8 | 191.4 | 0.09 | 16.4 | 18 | 0.1241 | 739.1 | 41°01'266"N, 31°12'723"E | 279 |
| 21 | Dereköy stream | 2 | 7.8 | 139.39 | 7.88 | 80.7 | 318.1 | 380.2 | 0.18 | 16.4 | 17.2 | 0.247 | 753.9 | 41°00'717"N, 31°13'738"E | 123 |
| 22 | Dadallı stream | 2 | 7.85 | 130.655 | 6.82 | 69.9 | 301.2 | 361.5 | 0.17 | 16.3 | 20.6 | 0.2346 | 760.9 | 41°03'709"N, 31°12'117"E | 44 |
| 23 | Akkaya stream | 2 | 7.99 | 121.415 | 9.26 | 94.7 | 190.5 | 230.7 | 0.11 | 15.9 | 19.6 | 0.1502 | 763.2 | 41°06'135"N, 31°15'107"E | 7 |
| 24 | Doğancılar village | 3 | 8.23 | 103.6 | 7.05 | 78.8 | 105 | 113.6 | 0.05 | 21 | 21.3 | 0.0741 | 750.9 | 41°03'571"N, 31°88'839"E | 143 |
| 25 | Belören spring | 8 | 7.95 | 117.13 | 5.82 | 60.1 | 74.7 | 88.5 | 0.04 | 16.8 | 20.5 | 0.0579 | 752.7 | 41°03'483"N, 31°08'843"E | 122 |
| 26 | 1985 trough | 1 | 8.16 | 109.46 | 6.93 | 74.2 | 101.8 | 116 | 0.05 | 18.6 | 20.5 | 0.0754 | 753.5 | 41°02'595"N, 31°09'105"E | 110 |
| 27 | Yeşilköy stream | 2 | 8.2 | 126.01 | 8.53 | 86.5 | 329.9 | 402.2 | 0.19 | 15.6 | 24.2 | 2613 | 753.7 | 41°01'672"N, 31°06'617"E | 108 |
| 28 | Sarıyayla trough | 1 | 8.19 | 119.74 | 9.98 | 97.1 | 287.6 | 369.4 | 0.18 | 13.4 | 22 | 0.2398 | 720.6 | 41°00'908"N, 31°04'786"E | 494 |
| 29 | Yaylacık spring | 8 | 8.21 | 122.64 | 9.23 | 89.6 | 255.6 | 328.2 | 0.16 | 13.4 | 22 | 0.2132 | 725.1 | 41°00'282"N, 31°04'114"E | 452 |
| 30 | Arabacı stream | 2 | 8.4 | 107.845 | 11.38 | 115 | 338.5 | 411.2 | 0.2 | 15.7 | 20.5 | 0.2671 | 755.6 | 41°02'626"N, 31°05'085"E | 104 |
| 31 | Aktaş waterfall | 4 | 8.17 | 117.55 | 9.23 | 89.9 | 281.9 | 356.4 | 0.17 | 14 | 23 | | 736 | 41°00'797"N, 31°02'534"E | 319 |
| 32 | Hemsin village | 3 | 7.69 | 129.36 | 6.25 | 64.3 | 387.7 | 462.3 | 0.22 | 16.6 | 23.2 | 0.3003 | 745.6 | 41°01'537"N, 31°01'480"E | 208 |
| 33 | Esmahanım stream | 2 | 8.2 | 116.99 | 9.67 | 99.4 | 329.6 | 394.5 | 0.19 | 16.4 | 23 | 0.2561 | 754.1 | 40°59'856"N, 30°59'249"E | 114 |
| 34 | Akpınar stream | 2 | 7.96 | 122.34 | 6.35 | 67.1 | 487.3 | 569.5 | 0.28 | 17.4 | 24.5 | 0.3698 | 745.1 | 40°55'863"N, 30°57'930"E | 198 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | Melen creek | 9 | 8.28 | 112.205 | 8.67 | 90.3 | 437.2 | 512.9 | 0.25 | 17.3 | 22 | 0.3325 | 753.8 | 40°54'436"N, 30°56'969"E | 113 |
| 36 | Harmankaya waterfall | 4 | 8.08 | 122.385 | 8.51 | 94.9 | 550 | 606 | 0.29 | 20.1 | 21.4 | 0.3965 | 757 | 40°56'625"N, 30°56'182"E | 76 |
| 37 | Çelikdere village | 3 | 8.32 | 112.475 | 8.37 | 87.9 | 401.1 | 468.1 | 0.23 | 17.5 | 20 | 0.3042 | 731.8 | 40°55'622"N, 30°53'916"E | 372 |
| 38 | | 1 | 8.04 | 122.055 | 7.84 | 73.2 | 291.7 | 349.9 | 0.17 | 16.3 | 20.8 | 0.2275 | 733.8 | 40°54'988"N, 30°53'596"E | |
| 39 | Üveyzbeli trough | 1 | 7.68 | 144.64 | 7.87 | 78.7 | 548 | 673 | 0.33 | 15.4 | 20 | 0.4365 | 736 | 40°53'902"N, 30°53'322"E | 319 |
| 40 | Hacıkadirler stream | 2 | 8.12 | 124.54 | 6.11 | 66.8 | 448.6 | 500.3 | 0.24 | 19.4 | 22.2 | 0.3256 | 753.6 | 40°50'794"N, 31°00'636"E | 115 |
| 41 | Sırtpınar trough | 1 | 8.04 | 113.405 | 6.17 | 59.2 | 484.3 | 624.2 | 0.31 | 13.3 | 17.8 | 0.4056 | 729.5 | 40°53'374"N, 30°56'093"E | 401 |
| 42 | Recep muhtar trough | 1 | 7.93 | 141.345 | 5.18 | 50.3 | 514 | 657 | 0.32 | 13.7 | 19.6 | 0.429 | 745.3 | 40°52'584"N, 30°55'577"E | 250 |
| 43 | Kıyıköy stream | 2 | 8.23 | 121.63 | 10.29 | 97.5 | 441.6 | 575.5 | 0.28 | 12.8 | 18.8 | 0.3744 | 751.8 | 40°52'584"N, 30°55'577"E | 250 |
| 44 | Soguksu trough | 1 | 8.14 | 117.1 | 7.35 | 76.5 | 698 | 823 | 0.41 | 17 | 18.5 | 0.533 | 741.6 | 40°51'331"N, 30°53'898"E | 261 |
| 45 | Halilbey stream | 2 | 8.34 | 118.29 | 10.53 | 99 | 403.4 | 531.1 | 0.26 | 12.4 | 19.7 | 0.3452 | 743.8 | 40°51'331"N, 30°53'898"E | |
| 46 | Yesilyayla stream | 2 | 8.11 | 118.295 | 9.21 | 90.8 | 380.7 | 473.7 | 0.23 | 14.7 | 21.5 | 0.3081 | 754.3 | 40°47'366"N, 30°51'186"E | 137 |
| 47 | Dereköy trough | 1 | 7.88 | 137.17 | 8.22 | 82.6 | 502 | 667 | 0.3 | 15.2 | 21.6 | 0.403 | 737.4 | 40°48'769"N, 30°53'847"E | 319 |
| 48 | Kıyıdüzü pond | 6 | 7.97 | 125.095 | 4.19 | 46.8 | 193.2 | 210.4 | 0.1 | 20.7 | 24.4 | 0.1365 | 728.7 | 40°47'720"N, 30°58'227"E | 423 |
| 49 | Aksu stream | 2 | 8.32 | 118.525 | 10.5 | 103.5 | 247.7 | 310.5 | 0.15 | 14.5 | 27.4 | 0.2015 | 745.3 | 40°45'056"N, 30°54'286"E | 228 |
| 50 | cay village stream | 2 | 8.36 | 202.33 | 10.27 | 104.5 | 279.6 | 337.5 | 0.16 | 16 | 26.2 | 0.2197 | 749.9 | 40°45'349"N, 30°56'431"E | 174 |
| 51 | Sacmalipinar spring | 8 | 8.25 | 120.305 | 9.83 | 93.7 | 223.2 | 288.3 | 0.14 | 13.3 | 26 | 0.1482 | 704 | 40°43'620"N, 30°57'401"E | 698 |
| 52 | Guzeldere waterfall | 4 | 8.32 | 133.36 | 10.02 | 94.5 | 118.2 | 155.2 | 0.07 | 12.6 | 24.5 | 0.1008 | 717 | 40°43'344"N, 31°02'632"E | 538 |
| 53 | Efteni lake 1 | 5 | 7.38 | 154.04 | 0.63 | 6.7 | 459.2 | 538.7 | 0.26 | 17.4 | 24.6 | 0.3497 | 753.2 | 40°45'254"N, 31°03'624"E | 114 |
| 54 | Efteni lake 2 | 5 | 8.07 | 124.665 | 6.16 | 67 | 562 | 636 | 0.31 | 18.9 | 26 | 0.416 | 753.4 | 40°45'480"N, 31°02'211"E | 125 |
| 55 | İcmeler village melen | 2 | 7.66 | 142.965 | 29.2 | 2.71 | 496.1 | 561.7 | 0.27 | 18.9 | 23.9 | 0.3653 | 753.2 | 40°49'311"N, 31°01'524"E | 105 |
| 56 | Saziye village trough | 1 | 8.58 | 96.665 | 8.96 | 105.8 | 162.8 | 169.8 | 0.08 | 22.9 | 26.6 | 0.1105 | 752.2 | 40°50'676"N, 31°02'836"E | 124 |
| 57 | Serefiye water channel | 10 | 8.62 | 92.995 | 14.59 | 176 | 168.3 | 176.2 | 0.89 | 22.7 | 26.5 | 0.144 | 748.9 | 40°53'093"N, 31°01'987"E | 165 |
| 58 | Hızar stream | 2 | 8.27 | 141.1 | 9.49 | 94.1 | 215.8 | 267 | 0.13 | 15 | 26 | 0.1735 | 730.1 | 40°55'733"N, 31°04'023"E | 389 |
| 59 | Yenivakık stream 2 | 2 | 8.2 | 118.765 | 8.99 | 93 | 409.6 | 484.5 | 0.23 | 16.9 | 25.1 | 0.3146 | 746.7 | 40°54'118"N, 31°05'359"E | 209 |
| 60 | Yaka village stream | 2 | 8.07 | 127.07 | 7.86 | 81.7 | 423.5 | 498.2 | 0.24 | 17.2 | 24.3 | 0.3327 | 747.5 | 40°54'877"N, 31°08'086"E | 196 |
| 61 | Bogazici stream | 2 | 8.11 | 122.34 | 7.62 | 71.5 | 421.4 | 512.6 | 0.25 | 15.4 | 22.3 | 0.3335 | 741.3 | 40°57'483"N, 31°17'077"E | 264 |
| 62 | Muncur stream | 2 | 8.17 | 126.985 | 9.1 | 87.7 | 378.5 | 476.8 | 0.23 | 14.1 | 17.2 | 0.36 | 742.6 | 40°48'894"N, 31°15'407"E | 239 |
| 63 | Sallar stream | 2 | 7.69 | 158.17 | 4.55 | 45.4 | 690 | 849 | 0.42 | 15.2 | 18 | 0.5525 | 748.2 | 40°50'928"N, 31°13'850"E | 193 |
| 64 | Akyazı water channel | 10 | 8.09 | 136.285 | 8.92 | 94.7 | 849 | 977 | 0.49 | 18.1 | 21.4 | 0.637 | 748 | 40°53'977"N, 31°10'929"E | 194 |
| 65 | Esenler water channel | 10 | 8.26 | 120.855 | 9.93 | 96.6 | 407.4 | 512.3 | 0.25 | 14.3 | 22.8 | 0.3328 | 749.7 | 40°54'118"N, 31°05'359"E | 209 |
| 66 | Mamure water channel | 10 | 8.02 | 125.39 | 9.57 | 98.1 | 325.6 | 389.6 | 0.19 | 16.4 | 23.2 | 0.2535 | 751.7 | 40°50'577"N, 31°06'743"E | 138 |
| 67 | Turaplar | 3 | 7.84 | 136.26 | 7.42 | 73.1 | 503 | 628 | 0.31 | 14.6 | 26.8 | 0.4095 | 751 | 40°48'715"N, 31°07'453"E | 141 |
| 68 | | 1 | 7.76 | 138.2 | 3.84 | 38.2 | 514 | 635 | 0.31 | 15 | 24.9 | 0.416 | 751.6 | 40°48'343"N, 31°06'016"E | 134 |
| 69 | Aydınpınar waterfall 1 | 4 | 8.59 | 109.975 | 10.28 | 99.9 | 137.9 | 117.2 | 0.08 | 13.5 | 22.5 | 0.1151 | 731.7 | 40°44'675"N, 31°06'264"E | 352 |
| 70 | Aydınpınar waterfall 2 | 4 | 8.23 | 123.78 | 8.82 | 84.5 | 135 | 73.8 | 0.08 | 13.8 | | 0.1131 | 731.5 | 40°44'675"N, 31°06'264"E | 352 |
| 71 | Bey village stream | 2 | 8.17 | 128.095 | 8.79 | 90.4 | 382.8 | 455.2 | 0.22 | 16.7 | 27.2 | 0.2958 | 744.9 | 40°46'279"N, 31°09'832"E | 204 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 72 | Torkul stream | 2 | 8.4 | 115.73 | 10.28 | 92.9 | 248.1 | 340.1 | 0.16 | 10.8 | 28.5 | 0.221 | 681.2 | 40°41'465"N, 31°08'205"E | 960 |
| 73 | Torkul pond 1 | 6 | 7.32 | 151.155 | 1.76 | 18.7 | 267.8 | 303.1 | 0.14 | 18.3 | 27.7 | 0.1976 | 657.4 | 40°40'764"N, 31°10'383"E | 1270 |
| 74 | Torkul pond 2 | 6 | 7.1 | 209.665 | 0.28 | 3.3 | 518 | 562 | 0.27 | 20.9 | | 0.364 | | 40°40'764"N, 31°10'383"E | 1270 |
| 75 | | 1 | 7.64 | 142.395 | 8.23 | 81.1 | 287.6 | 358.2 | 0.17 | 14.7 | 23.5 | 0.2327 | 667.7 | 40°41'086"N, 31°08'979"E | 1121 |
| 76 | | 2 | 8.37 | 115.835 | 9.54 | 94.5 | 328.3 | 404.9 | 0.2 | 15.1 | 26 | 0.2652 | 725.2 | 40°43'188"N, 31°14'415"E | 439 |
| 77 | Derdin Hot spring | 8 | 6.62 | 201.415 | 0.63 | 8.3 | 9702 | 8824 | 4.9 | 29.9 | 24.1 | 5.746 | 725.6 | 40°43'271"N, 31°14'482"E | 472 |
| 78 | Samandere waterfall | 4 | 8.59 | 106.26 | 8.37 | 82.3 | 272.2 | 340.7 | 0.16 | 14.6 | 24.3 | 0.2203 | 696.4 | 40°41'457"N, 31°15'635"E | 817 |
| 79 | Topuk village pond 1 | 6 | 8.27 | 110.92 | 5.4 | 57.3 | 148.5 | 170.6 | 0.08 | 18.2 | 22.2 | 0.1112 | 655.1 | 40°41'489"N, 31°21'690"E | 1295 |
| 80 | Topuk village pond 2 | 6 | 8.73 | 89.435 | 8.09 | 91.3 | 148.2 | 160.2 | 0.08 | 21.1 | | 0.104 | 654.9 | 40°41'489"N, 31°21'690"E | 1295 |
| 81 | Dipsiz lake | 5 | 8.41 | 95.485 | 6.31 | 70.6 | 85.6 | 54.5 | 0.04 | 20.1 | 20.8 | 0.0611 | 676.6 | 40°43'289"N, 31°23'031"E | 1009 |

**Appendix 3.** Karabük’s species. Abbreviation in Table 6.

| St. No | Pa | Pz | Hi | Hs | Ib | I.sp | Cd | Pf | Ci | Hc | Pm | Pv | Ii | Po | H. sp. | Ps | Hcs | Py | Fc | Hb | Ec | Pp | Sc | Ep | Pv | Cy | Cv | Lc | Id | Pz | Cp | Hr | Pc | Pf | Ps | Cn | Li |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | | | 700 | 15 | 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | | | | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | 128 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | 9 | | | 1 | | 4 | 56 | 15 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | 192 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | 45 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 31 | | | |
| 9 | | | 4 | | | | | | | | | | 3 | 2 | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | 1 | | | 1 | 6 | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | 145 | | | | | 19 | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | | | 4 | | 32 | | | | | | | | | | | 16 | 3 | | | | | | | | | | | | | | | | | | | | |
| 14 | | | | | 10 | | | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | | | | | 13 | | | | | | | | | | | | 3 | | 1 | 3 | | | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | | | | | | | | 10 | | | | | | | | | | | | | | | |
| 19 | | | | | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | | | | | | | | | | | | 2 | | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24 | | | | | 23 | | | | | | 8 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | 104 | | | | | | | | | | 94 | | | | | | | | | | | | | |
| 27 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | | | 3 | | | | | | | | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30 | | | 1 | 6 | | | | | | | 152 | | | 37 | | | | | | | | | | | | | | | | | | | | | | | |
| 31 | | | | 91 | | | | | | | | | | | | | | | | | | 7 | | | 6 | | | | | | | | | | | | |
| 32 | | | | 86 | | | | | | | | | | | | 15 | | | | | | | | | | | | | | | | | | | | | |
| 33 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 34 | | | | 16 | | | | | | | | | | | | 2 | | | | | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | | | 1 | | | 1 | | | | | | | | 25 | | | | | | | | | | | | | | | | | | | | | | | |
| 36 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 37 | | | | | | | | | | | | | 3 | 7 | | | | | | | | | | | | | | | | | | | | | | | |
| 38 | | | | | | 2 | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| 39 | | | | | | | 1 | | | | 1 | | | | | | | | | | | | | | | | 5 | 1 | 4 | | | | | | | | |
| 40 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3 | | | | | | | |
| 41 | | | 10 | | 25 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 42 | | | | | 1 | 1 | | | | | | | | 4 | | | | | | | | | | | | | | | | | 7 | | | | | | |
| 43 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 94 | | | | | |
| 44 | | | | 63 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 45 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 46 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 47 | | | 45 | | | | | 3 | | | | | | | | | | 1 | | | | | | | | | | | | 44 | | | | | | | |
| 48 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 49 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 51 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 52 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 53 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 160 |
| 54 | | | 15 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 55 | | | 136 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 56 | | | 253 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 57 | | | 203 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 58 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 59 | | | | 21 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 60 | | | | 1 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 61 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 62 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 | | 5 | | |
| 63 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 64 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | |
| 65 | | | | | | | | | | | | | | 7 | | | | | | | | | | | | | | | | | | | | | | | |
| 66 | | | 1 | | | 2 | | | | | | | | 7 | | | | | | | | | | | | | | | | | | | | | | 1 | |
| 67 | | | 63 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 68 | | | 19 | | 7 | | | | | | | | | 49 | | | | | | | | | | | | | | | | | | | | | | | |
| 69 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 |
| 70 | | | 35 | 51 | 13 | | | | | | | | | 23 | | | | | | | | | | | | | | | | | | | | | | | |
| 71 | | | | | | | | | | | | | 6 | 5 | | | | | | | | | | | | | | | | | | | | 3 | | | |

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| 72 | | | | | | | 1 | | | | | | | 163 | | | | | | | | 103 | | | | | | | | | | | | | | | |
| 73 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 74 | | | 350 | 23 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 76 | | | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 77 | | | 4 | 2 | 13 | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | 17 | |
| 78 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 79 | | | | 162 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 80 | | | | 6 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 81 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Appendix 4.** Düzce’s species. Abbreviation in Table 2.

| St. no | Po | I. sp | Pl | Cy | Ly | Hs | Pa | Pc | Cd | Hc | Py | Cv | Pv | Ps | Cp | Ds | Ib | Hi | Cp | Pm | Id | Im | Ii | Cc | Cp | Co | Cy | Cn | Cl | Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | 5 | | | | | 24 | 24 | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | 3 | | | | | | | | 3 | 1 | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | 6 | | | | | 122 | | 1 | | | | 82 | 16 | 15 | 1 | | | | | | | | | | | | | | | |
| 14 | 17 | | | | | | | 1 | | | | | | | | 8 | 5 | 9 | | | | | | | | | | | | |
| 15 | 3 | | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | | |
| 16 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | 155 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | |
| 21 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | | | | | 56 | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | 7 | | |
| 30 | | 1 | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | |
| 31 | | | | | | | | | | 3 | | | | | | | | | | | | | | | | | | | | |
| 32 | | | | | | | | | | | | | | | | | | | | | 25 | 18 | | | | | | | | |
| 33 | | 1 | | | | | | | | | | | | 2 | | | | | | | | | | | | | | | | |
| 34 | | 1 | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | |

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| 35 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 37 | | 1 | | | | 2 | | | | | | | | | | | | | | | | | | | | | | | | |
| 38 | 104 | | | | | 185 | | | | | | | | | | | | | | | | | | | | | | | | |
| 39 | | | | | | | | | | | 1 | | | | | | 15 | | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 41 | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | |
| 42 | | | | | | | | | | | | | | | | | | 125 | | | | | | | | | | | | |
| 43 | | | | | | | | | 1 | | | | | | | | | | | | | | 10 | | | | | | | |
| 44 | | | | | | 101 | | | | | | | | | | | 30 | | | | | | | | | | | | | |
| 45 | | | | | | 3 | | | | | 1 | | | | | | 110 | | | | | | | | | | | | | |
| 46 | | | | | | | | | | | | | | | | | | 1 | | | | | 13 | | | | | | | |
| 47 | 2 | | | | | 200 | | | | | | | | | | | | | | | | | | | | | | | | |
| 48 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 49 | 2 | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| 50 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 51 | 2 | | | | | | | | | | | | | | | | 80 | | | | | | | 81 | | | | | | |
| 52 | | | | | | | | | 1 | | | | | | | | | | | 1 | | | | | | | | | | |
| 53 | | | | | | | | | | | | | | | | | | | | | | | | 32 | 2 | | | | | |
| 54 | | | | | | | | | | | | 1 | | | | | | | | | | | | | | 7 | | | | |
| 55 | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | |
| 56 | | | | | | | | | | | | | | 188 | | | | 3 | | | | | | | | | | | | |
| 57 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 58 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 59 | | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 60 | | | | | | 3 | | | | | | | | | | | | | | | | | | | | | | | | |
| 61 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 62 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 63 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 64 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 65 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 66 | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| 67 | 119 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 68 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 69 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 71 | | | | | | | | | | | | | | | | | | | | | | | 7 | | | | | 28 | | |

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| 72 | | | | | | | | | 1 | | | | | | | | | | | 1 | | | 13 | | | | | | | |
| 73 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 80 | 18 |
| 74 | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | 83 | 100 |
| 75 | 31 | | | | | | | | | | | | | | | | | 25 | | | | | | | | | | 325 | | |
| 76 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 77 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 78 | | 1 | | | | | | | | | | | | | 24 | | | | | | | | | | | | | | | |
| 79 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 81 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**PHOTOS**

**Photo 1.** Station 15. Ovacık in Karabük.

**Photo 2.** Station 17. Hasanlar Dam in Düzce.

**Photo 3.** Station 33.Eflani in Karabük.

**Photo 4.** Station 48. Hot spring in Karabük.

**Photo 5.** Station 48. Kıyıdüzü pond in Düzce.

**Photo 6**. Station 73.Torkul pond in Düzce.

**Photo 7.** Station 23. Düzce Akkaya stream.

**Photo 8**. Station 42. Natural environmental in Karabük.

**Photo 9.** Station  39. Ortakçılar pond in Karabük.