TAXONOMY, DISTRIBUTION, AND ECOLOGY OF ZOOPLANKTONS (CRUSTACEA) IN TROUGH WATERS OF ANKARA

By

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ABSTRACT

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Troughs are one of the main components of villages in Turkey. They are constructed by converting from springs. Until now, there is no extensive study investigating trough species composition and diversity. In order to contribute the knowledge on the zooplanktons in troughs, 142 troughs were randomly visited from 17 counties of Ankara between 22 June and 03 July 2011. Total of 11 Copepoda, (only Cyclopoida and Harapacticoida) and seven Cladocera species were determined. Out of 18 zooplankton species, 12 of them (*Paracyclops chiltoni*, *Paracylops*

fimbiratus, *Paracyclops imminutus*, *Tropocyclops prasinus*, *Diacyclops bisetosus*, *Acanthocyclops vernalis*, *Canthocamptus staphylinus*, *Attheyella crassa*, *Bryocamptus minutes*, *Macrothrix hirsuticornis*, *Ouxyurella tenucaudis*, *Moina macrocopa*) are new records for Ankara. *P. imminutus* was reported for the third time in Turkey after about 50 years. Unweighted Pair Group Mean Averages (UPGMA) illustrated four main clustering groups of zooplankton based on ecological characteristics. Poisson Distribution Analyses showed almost random distribution of species among the troughs (s^2 / μ = 1.04). With their cosmopolitan characteristics, three species (*M. hirsuticornis*, *E. serrulatus*, and *C. sphaericus*) are the most common species, and occurred from 63, 29, and 24 times, respectively. Comparing the other species, ecological tolerance and optimum values of these species were relatively higher than the mean tolerances for different environmental variables. Results support that troughs may provide suitable conditions for zooplankton species.

Keywords: Copepoda, Cladocera, trough, distribution, ecology, Poisson Distribution

ÖZET

ANKARA YALAKLARINDAKİ ZOOPLANKTON (CRUSTACEA) TAKSONOMİSİ, DAĞILIMI, VE EKOLOJİSİ

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Yalaklar Türkiye'deki köylerde bulunan başlıca elemanlardan biridir. Kaynak sularından dönüştürülerek inşa edilirler. Şimdiye kadar yalak tür kompozisyonunu ve çeşitliliğini geniş bir biçimde inceleyen bir çalışmaya rastlanılmamıştır. Yalaklardaki zooplankton bilgisine katkı sağlamak için 22 Haziran – 3 Temmuz 2011 tarihleri arasında, Ankara'nın 17 ilçesinden rastgele seçilmiş 142 yalak ziyaret edilmiştir. Toplamda 11 Copepoda (sadece Cyclopoida ve Harpacticoida) ve 7 Cladocera türü belirlenmiştir. 18 zooplankton türünden 12 tanesi (*Paracyclops chiltoni*, *Paracyclops*

fimbiratus, Paracyclops imminutus, Tropocyclops prasinus, Diacyclops bisetosus, Acanthocyclops vernalis, Canthocamptus staphylinus, Attheyella crassa, Bryocamptus minutus, Macrothrix hirsuticornis, Oxyurella tenuicaudis, Moina macrocopa) Ankara için yeni kayıttır. *P. imminitus* 50 yıl aradan sonra Türkiye'den 3. kere rapor edilmiştir. Ağırlıksız Çiftli Grup Ortalama Analizi türleri ekolojik karakterlerine göre dört ana gruba ayırmıştır. Poisson Dağılım Analizine göre türler yalaklar arasında rastgele bir dağılım göstermektedirler (s^2 / μ = 1.04). Kozmopolit karakterlerinden dolayı üç tür (*M. hirsitucornis*, *E. serrulatus*, ve *C. sphaericus*) en çok bulunan türlerdir ve sırasıyla 63, 29, ve 24 defa bulunmuşlardır. Diğer türler ile karşılaştırıldığında, bu türlerin ekolojik tolerans ve optimum değerleri, farklı çevresel değişkenlerin ortalama değerlerinden genelde yüksektir. Sonuçlar, yalakların zooplankton türleri için uygun ortam sağlayabileceği desteklenmektedir.

Anahtar Kelimeler: Copepoda, Cladocera, yalak, dağılım, ekoloji, Poisson Dağılımı

To My Mother and My Father

Mükerrem BAŞAK and Adnan Faruk BAŞAK

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ABBREVIATION

P1: First thoracic appendages

P2: Second thoracic appendages

P3: Third thoracic appendages

P4: Fourth thoracic appendages

P5: Fifth thoracic appendages

P6: Sixth thoracic appendages

Enp: Endopodite (Enp3: third segment of endopodite)

Exp: Exopodit

CHAPTER I

1. INTRODUCTION

The term 'plankton' used by Victor Hensen (1887) for the first time comes from Greek word 'planktos' to 'wanderer' or 'drifter'. According to his definition, plankton is an organism smaller than 2 cm and can remain suspended at water surface or floated in the water (Hensen 1887 in, Şahin and Akyurt, 2010). After that Ernst Haeckel (1890) (in, Şahin and Akyurt, 2010) renamed the term 'plankton' to include all drifting organisms. Plankton now can be described by their ecological niches as any drifting organisms that dwell in pelagic zones of oceans, seas and freshwater bodies. They are primarily divided into two groups, phytoplankton and zooplankton. Phytoplanktons are the autotrophic organisms. However, the group of zooplankton consists of heterotrophic organisms included phylum Rotifera and Copepoda and Cladocera which are belong to Crustacea subphylum. They have an important position in aquatic food chains, energy transmission from primary producers to the top trophic levels, predatory fishes and marine mammals. Phytoplankton also known as primary producers are feed by zooplankton which are eaten by planktivorous fishes (Sommer and Stibor, 2002; Akbulut 2004).

Zooplanktons are related to environmental conditions and can rapidly respond toenvironmental changes (Dodson and Frey, 2001; Williamson and Reid, 2001; Dodson et al., 2005). Most zooplankton species are found in a wide variety of water bodies. In this study only two zooplankton groups, Copepoda and Cladocera, will be investigated.

1.1. COPEPODA

The subclass Copepoda, H. Milne Edwards 1840, comprise small crustaceans that can be found in marine environments and almost all freshwater bodies. There are two infraclasses and nine orders. Infraclass Progymnoplea includes the order Platyeopioida, and other infraclass Neocopopoda contains other eight orders. These eight orders are organized in two suborders. Gymoplea suborder only contains Calanoida order, and Podoplea include other seven orders. Two of the nine orders, Poecilostomatoida and Siphonostomatoida, are primarily parasitic and mainly marine. Three other orders, Platycopioida, Misophrioida and, Mormonolloida, are primarily marine forms. Remaning four orders, Calanoida, Cyclopoida, Harpacticoida and Gelyelloida, are mainly freshwater species. The subclass Copepoda contain 11500 species includes all free-living, parasitic and associated forms (Humes, 1994 in, Dole-Oliver et al., 2000). Three orders, Calanoida, Cyclopoida, and Harpacticoida, nearly have 5500 species. The calanoids include about 2300 species, 550 of them are freshwater form; 800 species of freshwater cyclopoids, and there are 3600 harpaticoid species, of which 1120 can be found in inland, mostly in freshwaters (Williamson and Reid, 2001). The number of species identified so far in the Turkey is 106 (Ustaoğlu, 2004). Cyclopoid copepods are generally cosmopolitan.

1.1.1. Morphology

Freshwater copepods have segmented body, could be elongate, fusiform, or cylindrical, with an exoskeleton. Freshwater copepods are generally 0.5 - 2.0 mm long. Some species like *Macrocylops fuscus* and *Megacyclops gigas,* and several genera of calanoids could be 3.0 to 5.0 mm in length (Dussart and Defaye, 2001). Basically, they have 16 somites but six of them are fused into cephalosome and remaining 10 form the thoratic somites and urosome. The prosome, anterior part, consist of cephalosome and thoratic somites and urosome represents the posterior part of body. In females, by fusion of two somites, genital complex is formed. Copepods have 12 pairs of appendages: antennules, antennae, mandibles, maxillules, maxillae, maxillipeds, four natotary legs, the modified fifth leg, and so-called sixth leg (Figure 1). In calanoids, first antennae are long, often up to body length or longer. The first antenna of the cyclopoids has 6-21 segments and rarely reaches the length of cephalothorax. Harpacticoids have the shortest antenna with 6-9 segments. The body shape of calanoid, cyclopoid, and harpacticoid copepods different (Figure 2). Bisexual reproduction is the rule in copepods. However, three harpacticoid species, *Elaphoidella bidens*, *Epactophanes richardi*, and *Canthocamptus staphylinus* are reported as parthenogenetic species (Dole-Oliver et al, 2000).

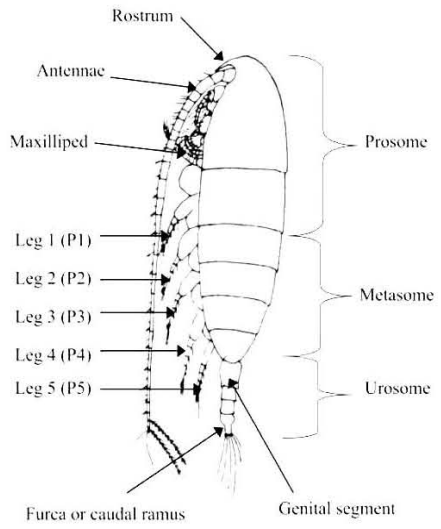


Figure 1. General body plan of a copepoda species (Anonymous 1).

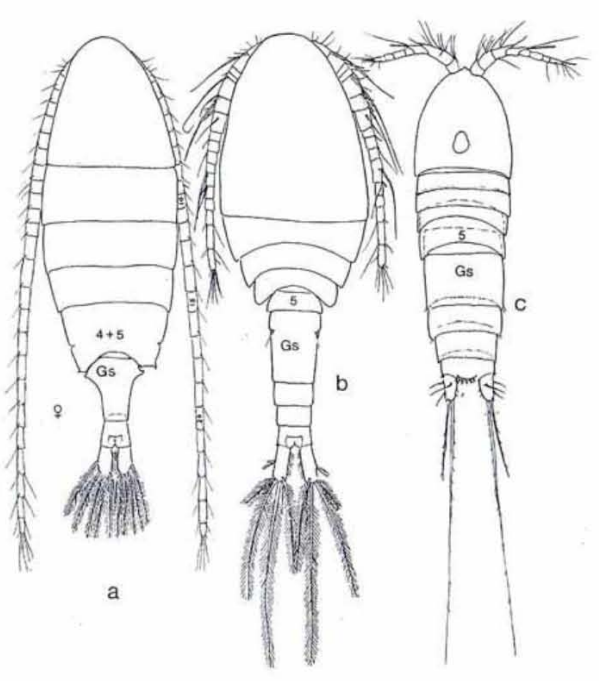


Figure 2. Three different body shape of copepoda. a, Calaniformes; b, Cyclopiformes; c, Harpactiformes. (after Dussart and Defaye, 2001).

1.1.2. Ecology

Copepods includes 10 orders, however, only four of which, Harpacticoida, Cyclopoida, Calanoida and Gelyelloida, represent free-living freshwater organisms. In our study, only Cyclopoida, Calanoida, and Harpacticoida orders were examined. Harpacticoid and cyclopoid copepod groups can be very abundant and rich in benthic environments. The swimming modes and diets of copepods are affected from their habitat preferences. Harpacticoids are typically crawlers, walkers and burrowers over substrates in the littoral, benthic, and interstitial habitats. They are detritivorous organisms consume microalgea, fungi, and protozoa and decompose plant and animal matter. Predation is rare around them but some of them take larger preys like nematodes. Cyclopoids are generally good swimmers but some species are bottom dependent. They are grasping feeders and consisted to be omnivorous. Several large cyclopoids are predatory. They have diverse diets include algae, rotifers, copepods and even larval fishes. Calanoid group of zooplanktons are planktonic organisms. Most calanoids are herbivorous and they glide slowly through the water. Their mouthparts are adapted for filtering. They also ingest particles ranging in size small algae to larger algae and microzooplankton. Copepods constitute an extensive portion of the biomass and productivity of freshwater systems (Brandorff, 2012) Copepods feed on a wide variety of food. Also, by being food to many freshwater predators, mainly planktivorous fish, they play an important role in aquatic food chain. They play an important role in freshwater aquaculture. Some of them are beneficial like serving food for small fishes, but some are may result in complete production losses such as they can be host or vector of human disease (Piasecki et al, 2004) , most important example is cholera. Although their exoskeleton consists of

chitin, they do not preserve well in sediment. However, Bennike (1998) found fossil egg sacs belong to Diaptomus genus from Denmark.

1.1.3. Distribution

Copepods are found in many kinds of aquatic environments, including deep, permanent, temporary waters, benthic lotic, littoral and pelagic water of lakes and oceans, large rivers, wetlands and even under the frozen surface of an Antarctic lake (Dussart and Defaye, 2001). Some species are also common in interstitial and subterranean systems. Cyclopidae family, well represented in freshwater habitats, has a great majority with including two freshwater subfamilies, Eucyclopinae and Cyclopinae. Other families inhabit different environmets, such as, Oithonidae family primarily include marine planktonic forms, Ergasilidae family known by their parasitic females, found in coastal margines, and Lernaeidae comprises all parasites of freshwater fishes. The Cyclopidae species are cosmopolitan in freshwaters. Only the family Oithonidae contains largely marine species. Most of the genera, belongs to the Eucyclopinae, like Eucyclops, Paracyclops, and Tropocyclops, and most genera of Cyclopinae, like Diacyclops, Acanthocyclops, Mesocyclops are cosmopolitan (Dussart and Defaye, 2001; Boxshall and Defaye, 2008). Contrarily, Dussart and Defaye (2001) underlined that the genus Afrocyclops was mainly restricted to the African continental and the genera Cochlacocyclops and Psammacyclops were found exclusively in Madagaskar. Harpacticoids inhabit the littoral benthic habitats of the lotic and lentic environments, also they could be found rarely in the plankton. Only three of them represent the freshwater species, which are, Ameiridae, Canthocamptidae, and Parastenocarididae. Harpacticoids are distributed widely. Canthocamptidae is the largest family that contains the most common species of

harpacticoids within the genera Attheyella, Bryocamptus and Canthocamptus. This cosmopolitan family is predominantly found in freshwater habitats. Freshwater species are distributed widely distributed across Europe, Asia, North America, and Africa (Dussart and Defaye, 2001; Boxshall and Defaye, 2008). The Calanoida are planktonic organisms, mainly found in benthic habitats of subteranean lakes. In calanoids, Diaptomidae is the dominant family in inland waters and distributed widely. Acartiidae and Pseudodiaptomidae families are also cosmopolitan (Boxshall and Defaye, 2008). Except the Antartic, cosmopolitan taxa occur in freshwater in all zoogeographic regions are the families Ameridae, Canthocamptidae, Cyclopidae, Diaptomidae, Ergasilidae, Harpacticidae, Laophontidae, Lernaeidae, Parastenocarididae.

1.2. CLADOCERA

The suborder Cladocera are found mostly in inland aquatic habitats, but rarely in oceans. They belong to the class Branchiopoda. Four orders belong to Cladocera; Ctenopoda, Onychopoda, Haplopoda, and Anomopoda. There are 11 families and more than 80 genera. Order Anomopoda contain 5 families; Daphniidae, Bosminidae, Macrothricidae, Ilyocryptidae, and Chydoridae. Sididae and Holopediidae families are belongs to Ctenopoda order. Predatory orders Onychopods, which contains Polyphemidae, Cercopagididae and Podonidae, and Haplopods contains only Leptodoridae family. The species number is still unclear but is estimated between 450 and 600 species (Dole-Oliver et al., 2000). Chydoridae family is the largest family by containing 39 genera. The subfamily Chydorinae contains 19 genera and 102 species, and Macrothricidae include 15 genera and 56 species. The number of species identified from Turkey is 92 (Ustaoğlu, 2004).

1.2.1. Morphology

Cladocerans are small transparent organisms and have a common name as water fleas because of their shape. They are about 0.2-3.0 mm long in general, but it can reach to 18.0 mm in a single case of *Leptora kindtii* (Forro et al, 2008). They do not have a clearly segmented body or appendages. Their body consists of head, thorax, and abdomen. The trunks and appendages are enclosed by a transparent shellike covering (carapace) in the orders Anomopoda and Ctenopoda. It is functionally bivalve and embares the trunk. The head is usually protected by a cephalic shield that may curve forming a beak like Daphnia. Thorax and abdomen are fused as a trunk. Except the Monospilus and Bryospilus species, all species head is marked by a single compound eye and additional anterior ocellus. Ocellus may be larger than the compound eyes like in some species of Chydoridae. Cladocerans like other crustaceans have five pairs of appendages on the head part of the body; two pairs of antennae, one pair of mandibles, and two pairs of maxillae. The first pair of antennae, called antennules, is usually small, one segmented. The second pair of antennae, called antennae, is long, segmented and branched. There are 4-6 pairs of unsegmented thoratic legs. The postabdomen, which is important in taxonomic identification, carries claws, spines and denticles. It is mobile and can reach out of the carapace. Appendages of a Cladocera are shown in Figure 3.

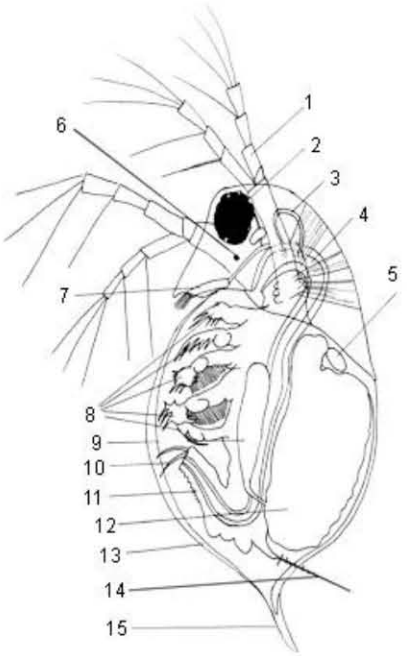


Figure 3. The anatomy of a Cladocera. Abbreviations : 1, Antenna; 2, Compound eye; 3, Enzyme Gland; 4, Esophagus; 5, Heart; 6, Nauplius eye; 7, Antennula; 8, Phyllopods; 9, Ovar; 10, Furca claws; 11, Postabdomen; 12, Brood; 13, Carapax shell; 14, Rudder bristle; 15, Spina. (Anonymus 2).

1.2.2. Ecology

Cladoceran species are mostly found in freshwater ecosystems, great majority with Anomopoda and Ctenopoda orders. Chydoridae, Macrothricidae, Illyocryptidae, and Sididae families contain the most benthic species (Forro et al, 2008). They have swimming appendages so they can swim or crawl (Fefilova et al., 2008). Some of them can live on macrophytes (e.g. *Alona rustica*) and some others prefer muddy bottoms like *Leydigia leydigi*. Great majority of benthic species, Ilyocryptidae, Macrothricidae, Chydoridae, are frequented in sand, mud, and in clay (Dole-Oliver et al., 2000). Their food choice is not so broad. Many, but not all are filter feeders.

Small particles like bacteria, algae or even ciliates, small rotifers and copepod nauplii are constituted as their diets. Predation among cladocera is not common. Nevertheless they are eaten by any freshwater predator. All kind of fishes, birds, some copepods are some examples of cladoceran predators (Dodson and Frey, 2001). Same as copepods, they are an important group in aquatic food web to transport energy. All species of cladocerans particularly reproduce by parthenogenesis. Females produce eggs which develop into more parthenogenesis females. These egg numbers may be only two, Chydoridae, or might be more than twenty as in Daphnidae (Brooks, 1959). However, sexual reproduction can be seen in unfavorable conditions. Some of parthenogenetic eggs develop into males. This occurs at different times of the year in different species. For example, *Oxyurella tenuicaudis* is monocyclic species while some chydoris like *L. leydigi*, *Chydorus sphaericus*, are dicyclic (Simirnov, 1974). Sarma et al. (2005) concluded that many aspects of cladoceran life history parameters differ in temperate and tropical species. Cladocerans also used in paleolimnological studies. Sub-fossil Cladocera species (generally Bosminidae, Chydoridae, and Daphniidae) appear in lake sediments mainly in separate body parts like head shields, carapaces and postabdomen or as epphipia, which protects diapausing eggs, (Eggermont and Martens, 2011). Sub-fossils of cladocerans can be used to track past changes, like climate, lake level, or zooplankton, fish abundance (Jeppesen et al., 2003).

1.2.3. Distribution

Cladocerans are widespread group occuring primarily in freshwaters. They are more abundant in lakes, ponds, slow moving rivers and streams (Dodson and Frey, 2001). According to Brooks (1959), because of shallow, weddy backwaters of

lake, there are much larger species in lakes and ponds than rivers. Order Anomopoda has worldwide distribution. Chydoridae and Macrothricidae families, belong to order Anomopoda, are the most widespread group (Forro et al., 2008). For this order, palaearctic region contains the more species, followed by Nearctic region. In Europe, *Moina micrura*, *Alona affinis*, *A. intermedia*, *A. guttata*, *Graptoleberis testudinaria*, *Alonella excise*, *Pleuroxus aduncus*, *P. laevis*, and *Chydorus sphaericus* are known as truly cosmopolitan. Ilyocryptus, Macrothrix, Alonella, Chydorus, and Alona genera are distributed worldwidely. However, Dumont and Negrea (2002) state that, cosmopolitanism of species is limited in number.

1.3. History of zooplankton studies from Turkey

Mann (1940)* reported many species from 25 different localities from Turkey. He reported 14 species from Ankara: Emir Lake: *Daphnia magna*, *Moina brachiata*, *Arctodiaptomus* (Rh.) *bacilifer*, Mogan Lake*: Daphnia magna*, *Moina brachiata*, *A. bacillife*r, *A.* s.str. *spectabilis* nov.spec. Çubuk Lake: Cyclops sp., *A.s* s.str. *spectabilis* nov.spec., *Eucyclops serrulatus*, *Cyclops strenuus*, *Cyclops* (Metacyclops) *amoenus* nov.spec, A puddle near Ankara: *C. strenuus*, *C. ankyrae* nov.spec.

Geldiay (1949)* made a study at Emir and Çubuk lakes. 13 species were reported in total: Çubuk Lake: *D. brachyurum, C. strenuus, Potamobius (Astacus) fluviatilis,* Emir Lake: *Alona affinis, B. longirostris* var. *cornuta, Chydorus sphaericus, Daphnia magna, D. longispina, D. pulex, Simocephalus exspinosus, S. vetulus, Cyclops strenuus, Diaptomus emiri.*

Muckle (1951)* made a study about freshwater cladocerans of Turkey.

Lindberg (1953) collect samples from many part of Turkey. Some of them from Yarım burgaz, *Paracyclops fimbriatus*, *Thermocyclops hyalinus*, and *Protocyclops kosswigi* n. g. et n. sp.; from İnkaya Village, *P. fimbriatus*, *Acanthocyclops longuidoides clandestinus*; from Ayva Villages, *Macrocyclops albidus, Eucyclops serrylatus, P. fimbriatus A. robustus, A. bicuspidatus*; from Ereğli (İnsırtı), *E. serrulatus, Tropocyclops prasinus, P. fimbriatus f. imminuta, A. robustus, A. bicuspidatus, A. languidoides*; from Çayırköy Cave (Çaycuma region), *E. serrulatus*, *T. prasinus*, *P. fimbriatus f. imminuta*, *A. robustus*, *A. languidus*, *A. languidoides*, Cyclopides copepodites; from enterance of Cave Ilıksu (Ereğli region), *E. serrulatus*, *T. prasinus*, *P. fimbriatus f. imminuta*, *A. languidus*, *A. languidoides clandestinus*; from Alayurt (Ereğli), *P. fimbriatus f. imminuta*, *A. robustus,* Cyclopides copepodites.

Lindberg (1957) reported Cyclopoid copepods from Anatolia region. *Eucyclops serrulatus*, *E. macruroides*, *Cyclops* sp., *Paracyclops fimbriatus* from Hatay; *P. fimbriatus imminutus*, *E. serrulatus* from Urfa; *Macrocyclops albidus*, E. *serrulatus*, *P. fimbriatus* from Elazığ region were reported.

Kiefer (1952)* reported calanoid copepods from 19 different locations of Turkey.

Gessner (1957)* reported Cladocera and Copepoda species from Lake. Van

Margoritora and Cottarelli (1970)* found some Cladocera and Copepoda species from Lake Abant.

Demirhindi (1972)* determine seasonal zooplanktonic organisims from Meriç, Gala, Bafa, Güllük, Köyceğiz, Apolyont, Manyas, Salda, and Yarışlı Lakes.

Geldiay and Tareen (1972)* published a study about planktons of Gölcük Lake.

Tokat (1972)* reported Cladocera and Copepoda species of Hazar Lake.

Ongan et al. (1972)* investigated Cladocera species from Burdur, Yarışlı, Karataş and Beyşehir lakes.

Fiers (1979)* reported nine species from Ankara; three Cladocera *Moina branchiata, Scapholeberis kingi, Ceriodaphnia reticulata,* and six Copepoda species *Chydorus sphaericus, Eucyclops serrulatus, Cyclops lacustris lacustris, Megacyclops viridis, Thermocyclops sp., Arctodiaptomus (Rh.) bacilifer.*

Ortak and Kırgız (1988)* determined the Cladocera and Copepoda fauna of Gala Lake.

Gündüz (1991a)* reported a taxonomic study about cyclopoida and calanoida groups of Bafra Balık Lake.

Gündüz (1991b)* reported a taxonomic study about Cladocera of Bafra Balık Lake.

Ustaoğlu and Akyürek (1994)* investigated the zooplankton fauna of Akşehir Lake.

Emir (1994b)* determined the zooplankton fauna of Çavuşçu and Eber Lakes.

("*" in Yağcı Apaydın, 2008)

Altındağ and Özkurt (1998) found five species of Cladocera, *Daphnia longispina, Daphnia cucullata, Ceriodaphnia quadrangula, Bosmina longirostris, Diaphanosoma birgei,* and two Copepoda, *Acanthodiaptomus denticornis, Cyclops vicinus,* and eight Rotifera species from the Kunduzlar and Çatören Dam Lakes.

Şevik and Kılıç (1998) reported three Cladocera species, *Daphnia magna, Simocephalus vetulus,* and *Leydigia leydigi* from Bozova 1 (Büyükgöl) and Bozova 2 (Küçükgöl) Lakes.

Güher (1999) reported 32 species of Cladocera and 19 species of Copepoda from Mert, Erikli, Hamam, and Pedina Lakes, at İğneada, Kırklareli.

Güher (2000) found 39 Cladocera species from Thrace region (Edirne, Tekirdağ, Kırklareli). *Simocephalus serrulatus, Moina salina, Moina macrocopa, Echinisca rosea, Disparalona rostrata, Dunhevedia crassa, Leydigia acanthoeercoides, Tertocephala ambigua, Oxyurella tenuicaudis and Diaphanosoma orghidani* species are new records for Thrace region in Turkey.

Akbulut (2000) worked on the community structure of zooplanktonic organisms in Lake Akşehir. In this study 36 Rotifera, 2 Copepoda and 6 Cladocera species had been recorded.

Ustaoğlu et al. (2001) identified the Cladocera and Copepoda fauna of İkizgöl (Bornova - İzmir). 12 cladocerans and 4 copepods species had been reported.

Tellioğlu and Şen (2001) reported two Cladocera and three Copepoda species from their study that seasonal distribution of the Copepoda and Cladocera fauna of Hazar Lake (Elazığ).

Altındağ and Yiğit (2002) found ten rotifers, five cladocerans, and two copepods species from Lake Burdur. Seven rotifers and one cladoceran *Diaphanosoma brachyurum,* are new records for Lake Burdur.

Güher (2002) worked on Lake Terkos and, 28 species of Cladocera and 13 species of copepods had been reported.

Bekleyen (2003) found 16 cladocerans, three copepods, and 28 rotifers from Göksü Dam Lake, Diyarbakır.

Ustaoğlu et al. (2003) determine the microcrustacean fauna of Lake Sazlıgöl (Menemen-İzmir). 21 cladocerans, eight copepods, and five ostracods had been found. Eucypris ornate (Ostracoda) was recorded for the first time in this study.

Toklu and Sarıhan (2003) investigated the Copepoda and Cladocera fauna along the Iskenderun Bay, Yumurtalık Botaş coastlines. 33 species belong to copepods and three species belongs to cladocerans were recorded.

Altındağ and Yiğit (2004) found two copepods, nine cladocerans, and 32 rotifers from Beyşehir Lake.

Güher and Kırgız (2004) recorded 28 Copepoda species. *Paracyclops affinis, Paracyclops fimbriatus, Cyclops scutifer, Cyclops kolensis, Megacyclops (Acanthocyclops) gigas* are new for the Thrace region of Turkey.

Bozkurt et al. (2004) worked on Yarseli Dam Lake and they found that seven Copepoda, 11 Cladocera, and 18 Rotifera species.

Bozkurt (2004) reported seven Copepoda, nine Cladocera, and 32 Rotifera species at his study named preliminary observation on the zooplankton fauna of some ponds and dam lakes in Eastern Mediterranean region.

Göksü et al. (2005) identified the Cladocera and Copepoda fauna of Asi River (Hatay). Seven Copepoda and 15 Cladocera species were recorded.

Aygen and Balık (2005) reported 16 Cladocera, 12 Copopoda, one Ostracoda, two Amphipoda, one Isopoda, one Mysidacea, and one Decapoda species from the study named Crustacea fauna of Işıklı Lake and springs (Çivril, Denizli).

Tellioğlu and Yılmaztürk (2005) found three copepods and four cladocerans species from Pertek region of Keban Dam Lake.

Ustaoğlu et al. (2006) found 10 copepoda and 18 cladocerans from Akgöl (Selçuk-İzmir). *Kurzia latissima* of Cladocera is new record for Turkish freshwater fauna.

Aladağ et al., (2006) studied at Çatalan Dam Lake (Adana) and they found eight Cladocera and two Copepod species.

Bekleyen (2006) found that there are five Copepoda and 12 Cladocera species in Devegeçidi Dam Lake (Diyarbakır).

Türkmen et al. (2006) reported two Cladocera, two Copepoda, and 23 Rotifera species from Gölbaşı Lake (Hatay).

Bozkurt (2006) determined four Copepoda, five Cladocera and 33 Rotifera from Yenişehir Lake (Hatay). *Lecane leontina* is firstly reported from Turkey.

Saler and Arslan (2007) investigated Copepoda and Cladocera fauna of TMI 12 Lake (Elazığ). Two species of Copepoda and five species of Cladocera were recorded.

Alper et al. (2007) determined the Cladocera and Copepoda fauna of İkizcetepeler Dam Lake and four copepods and eight cladocerans were recorded.

Yıldız et al. (2007) recorded four copepods, eight cladocerans, and 29 rotifers from the study named Seasonal Fluctuations in the Zooplankton Composition of a Eutrophic Lake: Lake Marmara (Manisa, Turkey).

Kaya and Altındağ (2007) studied from 11 different localities of Turkey and they found 13 Cladocera species from them.

Bekleyen and Taş (2008) reported 10 cladocerans, three copepods and 18 rotifers at their work named zooplankton fauna of Çernek Lake (Samsun). *Diaphanosoma lacustris, Daphnia longispina, Moina micrura, Pleuroxus aduncus, Alona rectangula, Leydigia leydigi, Acanthocyclops robustus* and all Rotifera species are new records for Çernek Lake.

Sönmez et al. (2008) found 12 Copepoda from Balıkesir province. *Megacyclops viridis, Macrocyclops albidus, Mesocyclops leuckarti, Paracyclops chiltoni, Bryocamptus (B.) minitus, B. (R.) pygmaeus* and B. *(B.) tarnogradskyi* were recorded for the first time from Balıkesir.

Bozkurt and Sagat (2008) determined the vertical distribution of Birecik Dam Lake zoopalnkton. Seven copepods, 11 cladocerans, and 21 rotifers were recorded from this study.

Dirican and Musul (2008) indicated one Copepoda, seven Cladocera, and 11 Rotifera from Çamlıgöze Dam Lake (Sivas).

Özen et al. (2008) reported four Copepoda, four Cladocera, and eight Rotifera species from their study named as an example of ecological devastation Eğirdir Lake.

Ustaoğlu et al. (2008) found five Copepoda, seven Cladocera, and 24 Rotifera species from glacier lakes and rivers on Uludağ (Bursa) Mountain.

Yalım and Çıplak (2008) identified three Cladocera and four Copepoda species from Yeşil Lake (Antalya).

Güher and Erdoğan (2008) reported 12 Copepoda, 15 Cladocera, and 60 Rotifera species from Alıç Lake.

Bozkurt et al. (2009) found four copepods and 14 cladocerans species from Aslantaş Dam Lake (Osmaniye). All species are new records for this lake since it is the first study carried out Aslantaş Dam Lake.

Aygen et al. (2009) reported 30 Rotifera, eight Cladocera, and three Copepoda from Lake Eğrigöl, high mountain lake, (Gündoğmuş-Antalya). All taxa were first records fort the lake.

Özdemir Mis and Ustaoğlu (2009) found six Copepoda, 10 Cladocera, and 17 Rotifera from Gölcük Lake (Ödemiş). Four Cladoceran species, *Daphnia hyalina, Leydigia leydigi, Alona rectangula, Pleuroxus uncinatus*, and two Copepoda species, *Macrocyclops albidus, Cyclops vicinus*, were firstly reported from this lake.

Özdemir Mis et al. (2009) identified eight copepods, 20 cladocerans, and 37 rotifers from Tahtalı Dam Lake (İzmir).

Özbay and Altındağ (2009) reported one copepod, four cladocerans, and 25 rotifers from River Kars.

Saler and İpek (2009) determined two species of copepods and four species of cladocerans from Seli Stream (Elazığ).

Bekleyen and İpek (2010) found two copepods, three cladocerans, and 29 rotifers from Lake Balıklıgöl (Şanlıurfa). *Lecane thienemanni* and *Notommata glyfura* are new records for Turkey. *Lecane thienemanni* was also new for Western Asia.

Gülle et al. (2010) identified three Copepoda and three Rotifera species from Lake Burdur.

Ertosun et al. (2010) recorded two Cladocera, two Copepoda, and 26 Rotifera species from Uçpınar Dam Lake (Uşak).

Özçakalp and Temel (2011) found two cladocerans, three copepods, and 13 rotifers from Lake Küçükçekmece (İstanbul).

Deveci et al. (2011) identified two Copepoda, three Copepoda, and 23 Rotifera species from Lake Sünnet.

Saygı et al. (2011) recorded two copepods, five cladocerans and 28 rotifers from Liman Lake in Kızılırmak Delta.

Özdemir Mis et al. (2011) found 11 taxa from Copepoda, 20 taxa from Cladocera, and 53 taxa from Rotifera from Yuvarlak Stream (Köyceğiz-Muğla).

Saler (2011) reported one copepod, two cladocerans, and eight species of rotifers from her study named zooplankton of Munzur River (Tunceli).

Saler and Haykır (2011) found two Cladocera, four Copepoda, and 15 Rotifera species from Pulumur Stream (Tunceli). All taxa were reported for the first time.

Kırkağaç et al. (2011) determined two species of Copepoda, three species of Cladocera, and 12 species of Rotifera from Porsuk River (Eskişehir).

Yağcı Apaydın and Ustaoğlu (2012) examine the zooplankton fauna of Lake İznik and they reported 35 Rotifera, 14 Cladocera, and 5 Copepoda species.

1.4. Previous works in Ankara

Akbulut (2004) identified 2 Copepoda, 3 Cladocera, and 25 Rotifera species in Ova Stream. *Daphnia longispina*, *Bosmina longirostris*, and *Chydorus sphaericus* are belong to cladocerans, and *Cycylops vicunus* and *Acanthodiaptomus denticornis* are belongs to the copepod groups.

Yiğit and Altındağ (2005) reported 4 Copepoda, 9 Cladocera, and 18 Rotifera species from Hirfanlı Dam Lake. *Daphnia galeata, D. longispina, D. manga, D. pulex Leydig, Diaphanosoma lacustris Korinek, Chydorus sphaericus, Bosmina longirostris, Eurycercus lamellatus, Macrothrix laticornis* are cladoceran species. *Arctodiaptomus acutilobatus, Acanthodiaptomus denticornis, Cyclops abyssorum, Megacyclops viridis* are reported as copepod species.

Demir (2005) determined 5 copepods, 7 cladocerans, and 21 rotifers in her study. As cladocerans *Daphnia longispina*, *Bosmina longirostris*, *Ceriodaphnia quadrangula*, *Chydorus sphaericus*, *D. cucullata*, *D. pulex* Leydig, *Diaphanosoma lacustris* Korinek, and as copepods *Acanthodiaptomus denticornis*, *Acanthocyclops robustus*, *Cyclops vicinus* Uljanin, and *Diacyclops bicuspidatus* were reported from Kurtboğazı Dam Lake. Except *D. longispina* and *D. bicuspidatus*, all species were reported from Çamlıdere Dam Lake.

Yiğit (2006) found 8 Copepoda, 9 Cladocera, and 11 Rotifera species in Kesikköprü Dam Lake. As copepods, *Cyclops vicinus*, *Diacyclops bicuspidatus*,

Megacyclops viridis, *C. abyssorum*, *Eucyclops serrulatus*, *Arctodiaptomus acutilobatus*, *Acanthodiaptomus denticornis*, and *Nitocra hibernica* were reported. *Diaphanosoma lacustris*, *Daphnia manga*, *D.pulex*, *D. longispina*, *Bosmina longirostris*, *Macrothrix laticornis*, *Disparalona rostrata*, *Chydorus sphaericus*, and *Monospilus dispar* were determined as cladocerans.

Altındağ et al. (2007) investigate the zooplankton community in Lake Mogan and they found 3 Copepoda, 10 Cladocera, and 59 Rotifera species. *Alona rectangula*, *Bosmina longirostris*, *Ceriodaphnia quadrangula*, *Chydorus sphaericus*, *Daphnia longispina*, *D. pulex*, *Diaphanosoma lacustris*, *Macrothrix laticornis*, *Pleuroxus aduncus*, *Simocephalus vetulus* were found as cladoceran species. *A. acutilobatus*, *A. bacillifer*, and *Eucyclops macruroides* were reported as copepod species from Lake Mogan.

Atıcı et al. (2008) determined 4 copepods, 9 cladocerans, and 24 rotifer species from Sarıyar Dam Reservoir. *Alona rectangula, Bosmina longirostris, Ceriodaphnia quadrangula, Chydorus sphaericus, Daphnia galeata, D. longispina, Diaphanosoma brachyurum, Leydigia leydigi, Macrothrix laticornis* were reported as cladoceran species. Copepoda species that were found are *Acanthocyclops robustus, Acanthodiaptomus denticornis, A. acutilobatus, A. bacillifer.*

Atıcı et al. (2010) investigate the accumulation of heavy metals (Cd, Pb, Hg, Cr) and their state in phytoplanktonic algae and zooplanktonic organisms in Beyşehir Lake and Mogan Lake, Turkey. From Beyşehir Lake they reported 2 Copepoda (*Eudiaptomus drieschi, Cyclops* sp.), 7 Cladocera (*Alona rectangula, A. guttata, Chydorus sphaericus, Daphnia longispina, Diaphanosoma brachyurum*, *Eurycercus lamellatus, Grabtoleberis testudinaria)*, and 19 Rotifera species and 3 Copepoda (*Acanthodiaptomus* sp., *Cyclops* sp., *Nauplius* sp.), 7 Cladocera (*A. rectangula,*

Ceriodaphnia quadrangula, D. longispina, D. brachyurum, Macrothrix laticornis, Pleuroxus aduncus, Simouphalus vetulus), and 55 Rotifera species from Mogan Lake.

Buyurgan et al. (2010) reported Copepoda with 2 taxa, Cladocera with 3 taxa, and Rotifera with 43 Rotifera. *Cyclops* sp., and *Arctodiaptomus* sp. were determined as copepods and *Bosmina longirostris, Chydorus sphaericus, Macrothrix laticornis* as cladocerans species.

Artificial habitats that have been increase in number since human activity begins are dramatically effect natural habitats. For example, they cause to loss in species composition (Külköylüoğlu, 2003). Troughs are one of the examples of artificial structures altering natural water bodies to artificial one. When we look at the meaning of trough we found that trough is a structure that animals drink water, made by cement or wood, and a long, narrow usually boxlike shape, used chiefly to hold water or food for animals (Urdang and Flexner, 1973; TDK, 2012).According to TODAIE (2011), there are 34.999 villages are found in Turkey. Each village contains at least one trough which is located in or nearby the village. They are built by converting springs or groundwater. Troughs are used to store water for animals and also drinking water for villagers or irrigation. They are usually made by cement, wood, metal, plastic or even automobile wheels. They are variable in shape and size also. Modification of water body by using artificial structure is a common method to increase biodiversity in fresh or marine waters (Bulleri and Chapman, 2004; Burt et al., 2009). Artificial reefs made from truck tires and concrete blocks (Lim et al., 1976), or made from sticks, poles, bundles of brushes (Polovina, 1991) to increase to fish diversity. Artificial beds constructed from plastics are lead to increase the growth of macro-algae (Godoy and Coutinho, 2002). However, there is no study

about the effect of troughs on freshwater aquatic biodiversity. If they support diversity for animals and plants, they could be called as "artificially natural habitats" (Külköylüoğlu, pers. comm.).

The aims of this study are 1) to determine the zooplankton fauna of troughs in Ankara region, 2) to contribute knowledge on zooplankton ecology and diversity, and 3) to emphasize the similarity between troughs and their species composition.

CHAPTER II

2. MATERIAL and METHODS

2.1. Site Description

The capital of Turkey, Ankara situated in the Central Anatolia region (N 39° 55' 15.0054" and E 32° 51' 14.8062", 938 m a.s.l.) is of about 25.207 km^2 surface area (Figure 4). It is located a little to the northwest of the center of the country with mountain forests to the north and dry plain at south, Konya plain, and surrounded by Kızılırmak and Sakarya basins. There are 14 natural lakes, 136 irrigation ponds and 11 dam lakes. The main rivers are Kızılırmak, Sakarya River, Ankara Stream, Kirmir Stream, Ova Stream and Balaban Stream. The main lakes are Tuz Gölü, Lake Mogan and Lake Eymir. The main dams are Sarıyar, Kesikköprü, Çubuk-1, Çubuk-2, Bayındır, Kurtboğazı, Çamlıdere and Asartepe. Ankara has a continental climate, hot and dry in summer, cold and snowing in winter. However, due to its location, climates in different characters can be seen. Northern parts of province has wetter climate than southern parts, where drier climate is effective. Livestock breeding is an important source of livelihood for villagers in Turkey, also in Ankara. For this reason troughs are essential for water supply to livestock and for human.

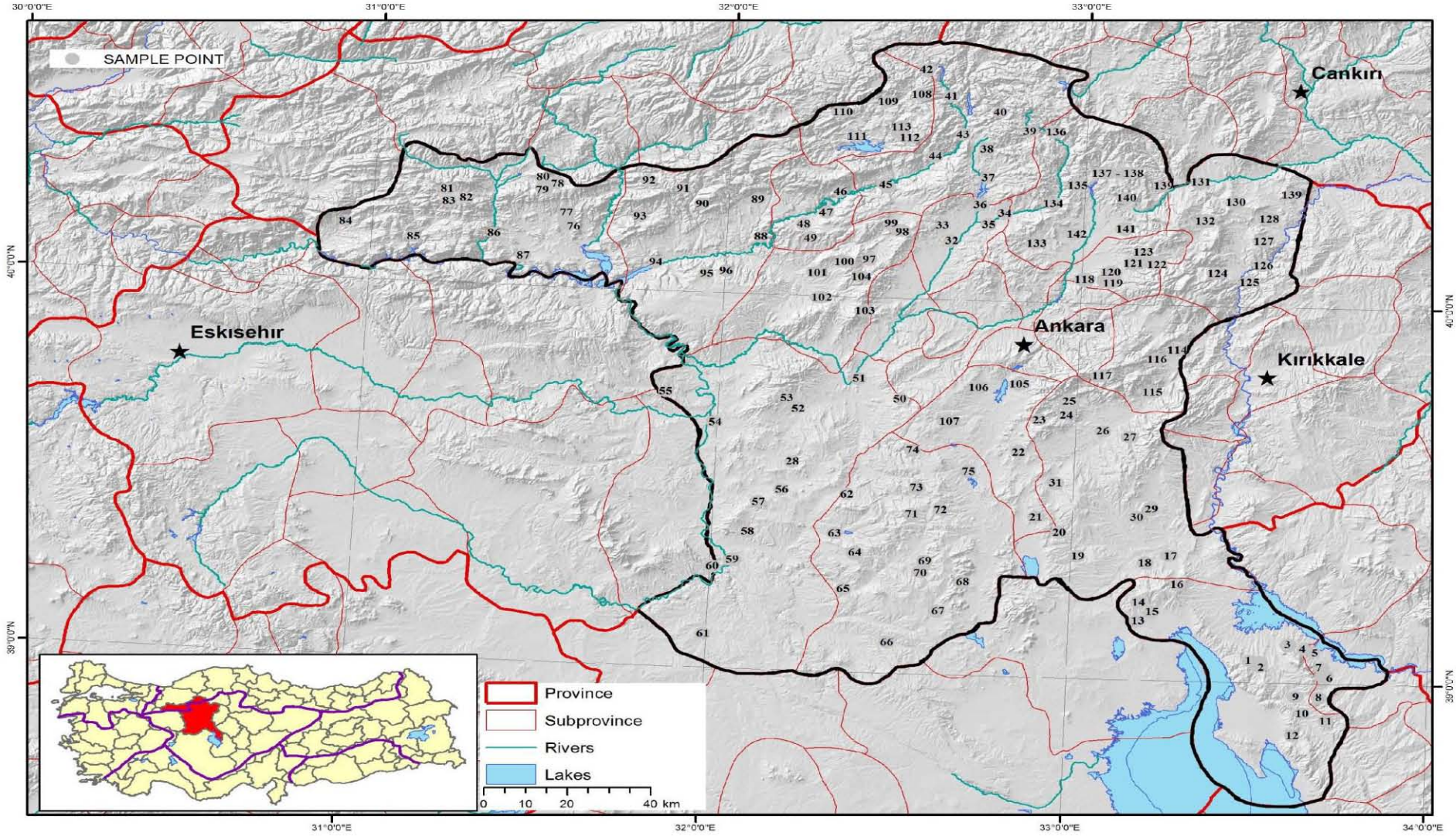


Figure 4. The map illustrates 142 trough sites sampled in Ankara.

2.2. Sampling Methods and Measurements

There are 25 counties in Ankara. Samples were collected from 17 of 25 counties, because the remaining eight counties are at the city center where there are no troughs found. These 17 counties are; Gölbaşı, Şereflikoçhisar, Evren, Bala, Kazan, Kızılcahamam, Güdül, Polatlı, Haymana, Nallıhan, Beypazarı, Ayaş, Çamlıdere, Elmadağ, Akyurt, Kalecik, and Çubuk. From these 17 counties, 142 troughs were randomly selected (Figure 5). Selection of troughs were based on the ratio of the surface area of each county that the bigger the area the higher the numbers of stations and troughs (e.g., area with the size of 0-1000 km^2 5 stations were selected when the area is about 1000-2000 km^2, 10 stations and the areaequal and/or more than 2000 km^2, 15 stations were selected). It was thought that there should be 20 km distance between two stations at least. The zooplankton samples were randomly collected from 142 troughs between 22 June and 3 July 2011. We used to collect samples using a plankton hand - net with 45 µm of mesh size and 20 cm in diameter. The samples were collected in 250 ml plastic jars and fixed with %70 alcohol, 150 ml sample from collector, 100 ml alcohol. Depth (D, m), width (W, m), and length (L, m), were measured by a standard meter. Water temperature (Tw, ºC), electrical conductivity (EC, µS/cm), salinity (Sal, ppt), pH, specific electrical conductivity (SPEC, µS/cm), dissolved oxygen (DO, mg/L), percent oxygen saturation (%DO, % mg/L), total dissolved solid (TDS, mg/L), and water atmospheric pressure (atm, mmHg) were measured by YSI Professional Plus Multiparameter. Geographical data (altitude (alt) and coordinates) were obtained by using Garmin GPS 12 XL. Because of invonveniency in GPS, we did not measure the coordinates and elevations for the last four stations. Anemometer (Testo 410-2 model) was used to measure air moisture (MOI), wind speed and air temperature

(Ta). In laboratory, samples were washed under water and filtered through 500 µm sized sieves to separate Rotifera. Cladocera and Copepoda samples were stored in 70% ethanol. Zooplankton samples were separated into two tubes, one contains cladocerans and one copepods, under stereomicroscope (Olympus ACH 1X) and fixed with 70% ethanol. Specimen dissection was made in glycerol and they mounted on a permanent slide. Taxonomic investigations were done under Olympus BX-51 microscope. Borutskii (1964), Dussart (1969), Einsle (1996), Karaytuğ (1999), Dussart and Defaye (2001), and Wells (2007) were used to identify copepods. Flösner (1972) was used for cladocerans as a taxonomic key. At macroscopic investigations, there were some frog larvae, amphipods, ostracods and mollusks were observed.

2.3. Statistical analyses

For statistical analyses, 12 species were used that occurred at least 3 times along with the 10 most important environmental variables (depth, width, length, altitude, moisture, water temperature, electrical conductivity, pH, dissolved oxygen, and atmospheric pressure). To obtain the normal distribution of variables, the raw data was log (e) transformed whenever necessary.

Unweighted Pair Group Mean Averages (UPGMA), applied by using MVSP version 3.1 (Kovach, 1998), was used to show a possible clustering relationship among the 12 zooplankton species (*Eucyclops serrulatus, Paracyclops chiltoni, P. fimbiratus, Acanthocyclops robustus, A. vernalis, Canthocamptus staphylinus, Attheyella crassa, Macrothrix hirsuticornis, Chydorus sphaericus, Pleuroxus aduncus, Ouxyurella tenucaudis, Leydigia leydigi*).

Non parametric Spearman correlation analyses, evaluated by SPSS program version 11.01, were used to understand the relationships between 10 physiochemical environmental variables and 12 species.

Species optimum estimates and tolerance ranges were calculated by using C2 program (Juggins, 2003), were progress with 10 environmental variables and eight zooplankton species.

To investigate the correlation between altitude and species, a graph was drawn by dividing altitudes 100 m intervals. The class interval was determined by selecting class width. Accordingly, class interval should be between 10 and 20 (the range should be at least 10 class intervals but not more than 20.) There are 142 stations and when class interval divided into 10, 14.2 is found which is suitable.

Poisson distribution model was used to determine the types of population dispersion.

Poisson probability can be calculated based on the formula below:

Where, x is the number of occurrences of an event, μ is the mean number of successes that occur in a specified region, and e is the constant value, equals to 2.71828. Values of Poisson probability were tested with Chi-square test. After that the distribution of species was determined based on the ratio between variance and mean (s^2/μ). Accordingly, if ($s^2 / \mu = 1$) random distribution; ($s^2 / \mu > 1$) clumped distribution; ($s^2 / \mu < 1$) uniform distribution (Ludwig and Reynolds, 1988).

CHAPTER III

3. RESULTS

In this study, 11 Copepoda species, eight Cyclopoid (*Eucyclops serrulatus, Paracyclops chiltoni, P. fimbiratus, P. imminutus, Tropocyclops prasinus, Diacyclops bisetosus, Acanthocyclops robustus, A. vernalis*) and three Harpacticoid (*Canthocamptus staphylinus, Attheyella crassa, Bryocamptus minutus*) and seven Cladocera species (*Macrothrix hirsuticornis, Chydorus sphaericus, Pleuroxus aduncus, Ouxyurella tenucaudis, Leydigia leydigi, Moina macrocopa, M.branchiata*) were reported. This is the third time that *P. imminutus* recorded for Turkey.

3.1.Systematic description for Copepoda

PHYLUM: ARTHROPODA Latreille, 1829

SUBPYHLUM: CRUSTACEA Brunnich, 1772

CLASS: MAXILLOPODA Dahl, 1956

SUBCLASS: COPEPODA, Milne-Edwards, 1840

ORDER: CYCLOPOIDA, Burmeister, 1834

FAMILY: CYCLOPIDAE Dana, 1846

SUBFAMILY: EUCYCLOPINAE

Genus: *Eucyclops* Claus, 1893

Eucyclops serrulatus (Fisher, 1851)

Genus: *Paracyclops* Claus, 1893

Paracyclops chiltoni (Thomson, 1882)

Paracyclops fimbiratus (Fisher, 1853)

Paracyclops imminutus Kiefer, 1929

Genus: *Tropocyclops* Kiefer, 1927

Tropocyclops prasinus (Fisher, 1860)

SUBFAMILY: CYCLOPINAE

Genus: *Diacyclops* Kiefer, 1927

Diacyclops bisetosus (Rehberg, 1880)

Genus: *Acanthocyclops* Kiefer, 1927

Acanthocyclops robustus (G. O. Sars, 1863)

Acanthocyclops vernalis (Fisher, 1853)

ORDER: HARPACTICOIDA G.O. Sars, 1903

SUBORDER: OLIGOARTHRA Lang, 1944

FAMILY: CANTHOCAMPTIDAE Brady, 1880

SUBFAMILY: CANTHOCAMPTINAE Brady, 1880

Genus: *Canthocamptus* Westwood, 1836

Canthocamptus staphylinus (Jurine, 1820)

Genus: *Bryocamptus* Brady, 1880

Subgenus: *Bryocamptus* Chappuis, 1928

Bryocamptus minutus (Claus, 1863)

Genus: *Attheyella* Brady, 1880

Attheyella crassa (Sars, 1862)

3.2.Systematic description for Cladocera

PHYLUM: ARTHROPODA Latreille, 1829

SUBPHYLUM: CRUSTACEA Brünnich, 1772

CLASS: BRANCHIOPODA Latreille, 1817

SUBCLASS: PHYLLOPODA Preuss, 1951

ORDER: DIPLOSTRACA Gerstaecker, 1866

SUBORDER: CLADOCERA Latreille, 1829

FAMILYA: MOINIDAE Goulden, 1968

Genus: *Moina* Baird, 1850

Moina branchiata (Jurine, 1820)

Moina macrocopa (Straus, 1820)

FAMILYA: MACROTHRICIDAE Norman and Brady, 1867

Genus: *Macrothrix* Baird, 1845

Macrothrix hirsuticornis Norman and Brady, 1867

SUBFAMILYA: CHYDORINAE Stebbing, 1902

Genus: *Pleuroxus* Baird, 1843

Pleuroxus aduncus (Jurine, 1820)

Genus: *Chydorus* Leach, 1816

Chydorus sphaericus (O.F.Müller, 1776)

SUBFAMILYA: ALONINAE Frey, 1967

Genus: *Leydigia* Kurz, 1875

Leydigia leydigi (Schoedler, 1863)

Genus: *Oxyurella* Dybowski and Grochowski, 1894

Oxyurella tenuicaudis (Sars, 1862)

3. 3. Taxonomic Description, Distribution and Ecology of Copepoda

Eucyclops serrulatus (Fisher 1851)

Female: Body is quite slender with anterior part is ovoid. Segments are distinctly separated. The antennules have 12 segments, the last 3 ones bears a hyaline lamella. Furcal branches are about 4-6 times as long as wide. The other margin of each branch has a dense row of small teeth. Terminal internal seta is only a little longer than the outer one, which is spiniform. First to fourth thoracic appendages (P1 to P4) biramous, each one has 3 segments. Third segment of endopodite (Enp3) of P4 ends with two terminal spines, in general the inner one slightly longer than the outer one.

Fifth thoracic appendage (P5) is only one segmented with 3 articles; an inner spine and 2 setae are almost equal in length.

Male: Body very slender. Furcal branches are about 3 – 4 times longer than wide and it does not contain external denticulation. Terminal inner seta is longer than the furca. Sixth thoracic appendage (P6) is contains an outer spine which is longer than the inner setae.

Length of female: 0.80 – 1.45 mm

Length of male: 0.68 – 0.80 mm

Distribution: Cosmopolitan, it was found throughout Europe, Africa, Asia in Malaysia and Japan as in Mexico, the Azores and the equator (Dussart, 1969).

Ecology: This species is very widespread. It can be found in the littoral zones. Found both in the temporary ponds produced by overflowing rivers in groundwater. Dussart (1969) stated that *E. serrulatus* had has wide tolerance to pH. Additionally, it is an indicator species in eutrophic lakes (Özdemir Mis and Ustaoğlu, 2009).

Tropocyclops prasinus (Fisher, 1860)

Female: Cephalothorax is oval. Abdomen contains fringes of lashes. The antennules are 12 segmented with long seta on first and the fourth segments and on the last 3 segments hyaline lamella can be seen. Furcal branches are 2.3 - 3 times longer than wide, without denticulation or lateral internal ciliation. Internal and external terminal setae of the furca are as long as the branches of the furca. P1 to P4 biramous, each ramus contain 3 segments. Enp3 of P4 ends with one inner seta and one outer spine, inner seta always longer then the length of the segment. P5 is one segmented and it bears an external and a terminal seta and an inner long spine.

Male: Antennae have 17 segments, but last two section sections are welded together. P6 composed of a thin inner spine and two plumose setae that are about equal in length.

Length of female: 0.67 – 0.95 mm

Length of male: 0.55 – 0.60 mm

Distribution: Cosmopolitan. It can be found throughout Europe, except in the far north, North Africa and to Japan (Dussart, 1969).

Ecology: It is a form of warm and brackish water, rarely planktonic. They live in the small collections of water and also found in the backwaters of the river, marshes, springs, lakes and caves (Dussart, 1969). Sönmez et al. (2008) found *T. prasinus* from different water bodies in Balıkesir.

Diacyclops bisetosus (Rehberg, 1880)

Female: Body slightly flattened and cuticle is usually finely punctuated. The antennules are seems short but they are composed of 17 segments. Furcal branches are 5 to 7 times longer than wide. Terminal internal seta of the furca is equal or slightly shorter than the terminal external seta. Besides, terminal median internal and external setae are very long and finely plumose. P1 to P4 biramous, each ramus contain 3 segments. Enp3 of P4 terminated with 2 spines, internal one is 1.5 times longer than the external one, and it is slightly longer than the Enp3. P5 is 2 segmented. The second segment contains a long outer seta and a short inner spine.

Male: P6 with an internal short spine and two setae whose outer one is about three times longer than the inner one.

Length of female: 0.81 – 1.50 mm

Length of male: 0.80 – 1.00 mm

Distribution: Cosmopolitan. It has been reported from Nova Zembla, New Zealand, Canada, Europe, and Asia (Dussart, 1969).

Ecology: This species prefers temporary waters, brackish water with high salinity (Frisch et al., 2006).

Acanthocyclops robustus (G. O. Sars, 1863)

Female: Anterior part is oval. The antennules are composed of 17 segments. Furcal branches are 4 – 5.5 times longer than wide. Terminal internal seta is as long as the branch of furca and it also more than twice as the terminal external seta. . P1 to P4 biramous, and each ramus contain 3 segments. Enp3 of P4 terminated with an inner spine, slightly longer than the outer or equal in length. Outer seta often forms as a strong spine. P5 is 2 segmented. The last segment bears an outer long seta and an inner short spine. *A. robustus* is often confused with *A. vernalis*.

Male: Body length is about ¾ as the female. Ventral seta of P6 is as twice as the median spine, and the dorsal seta is longer than the spine.

Length of female: 1.30 – 1.40 mm

Length of male: 1.00 – 1.10 mm

Distribution: Cosmopolitan. It is widespread throughout to Europe, North Africa, America, Asia, and New Zealand (Einsle, 1996).

Ecology: It can be found in the littoral zones of rivers, lakes, swamps, and small water bodies (Einsle, 1996; Bozkurt and Güven, 2010), and prefers mud layer. Besides, *A. robustus* is a eutrophic indicator species (Bekleyen and Taş, 2008).

Acanthocyclops vernalis (Fischer, 1853)

Female: Body is rather slender. The antennules are 17 segmented. Furcal branches are 5 – 6 times longer than wide. Terminal internal seta is longer than the half of furcal branches and longer than the terminal external seta, formed as a spine. P1 to P4 biramous, and each ramus are 3 segmented. Enp3 of P4 contain inner spine which is slightly shorter than the outer spine. P5 has 2 segments. There are a terminal seta and subterminal spine at the second segment.

Male: P6 with a medial spine which as long as the ventral spine or hardly longer than the dorsal seta.

Length of female: 1.00 – 1.80 mm

Length of male: 1.00 – 1.20 mm

Distribution: Cosmopolitan. It has been reported from Europe, Asia, North Africa, America (Dussart and Defaye, 2001).

Ecology: The species is found from high mountain waters, as well as semi permanent ponds, littoral zones of lakes, lowland ponds (Einsle, 1996).

Paracyclops fimbriatus (Fisher, 1853)

Female: Body is tapers in its posterior part. The antennules are short, and 8 segmented. There is no hyaline lamella in the last 2 segments. Furcal branches are finely divergent and 4 – 6 times longer than wide. Furcal branches are dorsally crossed by a row of small spines. P1 to P4 biramous, and each ramus are 3 segmented. Enp3 of P4 has an inner seta longer than the outer spine. P5 is one segmented with 3 articles; 2 outer setae and an inner spine. External seta is slightly longer than the internal spine.

Male: Furcal branches are 3 times longer than the wide. A row of spines are strong at the base. The antennules are 17 segmented P6 contains a strong outer spine and two setae internal one is shorter than the external one.

Length of female: 0.62 – 0.92 mm

Length of male: 0.55 – 0.81 mm

Distribution: Palaearctic, Nearctic. As known as, it is distributed in Europe, Asia, China, Japan, and India (Karaytuğ, 1999.)

Ecology: *P. fimbriatus* mostly prefer to burrow within the sediment (Sarvala, 1998), and it is known as a good swimmer (Dole – Oliver et al., 2000). Göksu et al., (2005) reported *P. fimbriatus* from Asi River between the 9.8°C – 29.1°C range. Similarly, Özdemir Mis et al., (2009) found the species between 7.8°C – 29.0°C temperature range from the Tahtalı Dam Lake.

Paracyclops chiltoni (Thomson, 1882)

Female: Second and third abdominal somites are ornamented with distinct pits dorsally and ventrally. Furcal branches are short, parallel and contain ornamentation of row of pits or cuticular depressions on ventral surface. The antennules are 8 segmented. P1 to P4 biramous, and each ramus are 3 segmented. P5 is one segmented and outer seta is equal in length with inner spine.

Male: Furcal branches are about 2.3 times longer than wide.

Length of female: 0.55 – 0.79 mm

Length of male: 0.58 – 0.65 mm

Distribution: Cosmopolitan (Karaytuğ, 1999).

Ecology: Found from littoral zones of water bodies (Peixoto et al., 2008).

Paracyclops imminutus (Kiefer, 1929)

Female: Dorsally, urosome ornamented with finer surface pits. Furcal branches are parallel and very close to each other. Also, furca branches are 3 to 4 times longer than wide. P1 to P4 biramous and 3 each one segmented. P5 is one segmented and inner spine slightly shorter than external seta.

Male: Furcal branches slightly curved inwards.

Length of female: 0.67 – 1.07 mm

Length of male: 0.67 – 0.96 mm

Distribution: Occurs from Europe, Russia, and Israel (Karaytuğ, 1999).

Ecology: As other Paracyclops species, *P. imminutus* found from benthic and littoral zones of water bodies (Karaytuğ, 1999). Also Lindberg (1953) reported as *P. fimbriatus f. imminuta* from many caves.

Canthocamptus staphylinus (Jurine, 1820)

Female: Posterior margins of body smooth. Rostrum is in the form of small triangular protuberance. The antennules are 8 segmented and antennal appendage is 2 segmented with 4 setae. Anal plate rounded with row of well developed spinules on posterior margin. Caudal branches are parallel and almost twice as long as the wide. Exopodite (exp) of P1 - P4 and Enp of P1 – P3 are 3 segmented. Enp of P4 is 2 segmented. Enp3 of P1 is slightly longer than the entire Exp. Basal segment of P5 contains 6 setae, unequal length, and there are 5 setae at the distal segment.

Male: From second to fourth abdominal segments bear ventrally continuous row of spinules. Caudal branches and anal plate are as in female. Enp of P2 2 segmented and Enp of P4 is in the form of elongate produced into spine at apex. Basal segment of P5 bears 2 spines, unequal length; distal segment is elongated with 5 setae and 1 spine.

Length of female: 0.60 – 0.90 mm

Length of male: 0.60 – 0.80 mm

Distribution: Widespread in Palearctic (Borutskii, 1964).

Ecology: It can be inhabit various water bodies, and characteristics of shallow ponds and the littoral zones of oligotrophic lakes (Sarvala, 1998). Also, this species known as like cold water (Borutskii, 1964).

Bryocamptus minitus (Claus, 1863)

Female: Body segments are not serrate at the posterior margin. The antennules are 8 segmented and antennal appendage is 2 segmented with 4 setae. Outer margin of anal plate bears bifurcate denticles, varying in number between 7 and 12. Caudal branches are square, as long as wide, and tapers backwardly. Exp of P1 to P4 and Enp of P1 to P3 are 3 segmented. Enp P4 is 2 jointed. Enp of P1 slightly longer than the Exp. Basal segment of P5 bears 6 pinnate setae and distal segment bears 5 setae.

Male: From second to fourth abdominal segments bears row of spinules on both sides. Anal plate contains 7 – 9 bifurcate denticles. Caudal branches are square, at ventral side of branches strong spinules found. P1 and Exp of P2 – P4 are as in the female. Enp of P2 is 2 segmented. P5 bears 2 spines on the basal segment and 6 setae on the distal one.

Length of female: 0.50 – 0.65 mm

Length of male: 0.50 mm

Distribution: Widely distributed in Europe and North America (Borutskii, 1964).

Ecology: Inhabits large water bodies and small ponds. This species encountered mostly in the littoral vegetation (Borutskii, 1964).

Attheyella crassa (G.O. Sars 1863)

Female: body segments are serrate at the posterior margin. Abdominal segments are equipped with long spines. Anal segment sets with 2 long and several short spines along ventral margin of cleft. Head segment is wide and rounded with small rostrum in front. The antennules are 8 segmented. Anal plate is rounded with short hairs. Bothe margins of caudal branches are arcuate and dorsal surface transverse row of hairs that extends onto ventral surface. Exp of P1 – P4 and Enp of P1 are 3 segmented, Enp of P2 – P4 are 2 segmented. Enp of P1 slightly longer than Exp. Basal segment of P5 is well developed and sets with 6 pinnate setae; distal segment is elongate or irregular in form and bears with 5 setae, both margins and sides of distal segment covered with rows of spinules.

Male: From sevond to fourth abdominal segments, there are continuous row of spinules. Caudal branches are cylindirical, almost twice as long as wide with transverse row of spinules, without inner margin. Enp of P3 is 3 segmented. Basal segment of P5 is sets with 2 unequal setae and distal segment is like in the female.

Length of female: 0.67 – 0.70 mm

Length of male: 0.50 mm

Distribution: Widespread in Europe, Central Asia, and North Africa (Borutskii, 1964).

Ecology: this species can inhabit in large water bodies like lakes and rivers, and also inhabit in brooks and ponds (Borutskii, 1964).

3.4. Taxonomic Description, Distribution and Ecology of Cladocera

Moina macropoda (Straus, 1820)

Female: In lateral view body is wide oval. Shell is slightly checkered. Ventral part of body is smoothly curved with bristles along the entire length. A large compound eye located near the front edge. Antennae are very strong. The postabdomen is very wide and long. The basal widened portion at the proximal side contains rows of long spines which spread to dorsal to the dorsal side. There are forked tooth on the distal part of postabdomen near the abdominal claw where there is no strong teeths. Ephippium is dark brown and contains 2 eggs.

Male: Smaller and more elongated than the female. From the side view, head is almost triangular, narrow, and long. Antennulae under the eye reaches almost as long as the hull. Distal part of postabdomen is slightly wider than the female.

Length of female: 1.0 - 1.8 mm

Length of male: 0.5 - 0.86mm

Disrtibution: Holarctic. Some species are known from Neoarctic region (Flössner, 1972).

Ecology: Small pond and pools, sometimes saline waters (Flössner, 1972).

Moina Brachiata (Jurine, 1820)

Female: Its head relatively large constituting about one fourth of its body. The large eye is located in the dorsal part of the head. Antenna is long and quite robust. The postabdomen is broad at the base but strongly tapers toward the end. There are 5 – 8 strong teeth at the base of the abdominal claw. Ephippium contains one egg.

Male: smaller and lower than the female. Dorsal margin of the shell is slightly concave. Compound eye is relatively larger than the female. Antennulae is almost half as long as the body. The postabdomen is the same in shape as the female.

Length of female: 1.0—1.5 mm

Length of male: 0.8 – 1.1 mm

Distribution: Palaearctic and Ethiopian. It is common in the southern and central part of the Palaearctic region (Flössner, 1972).

Ecology: It prefers planktonic zones of freshwater habitats. Being the hot water dwellers, it particularly found in the temporal ponds of the plains, like rain pools, ditches. Shallow eutrophic reservoirs and rivers are also preferred by the species (Flössner, 1972).

Macrothrix hirsuticornis *(*Norman and Brady, 1867)

Female: In the lateral side, it is broadly rounded, almost oval. The dorsal edge of *M. hirsuticornis* forms a very smooth curve, and there is no saw like tooth structure.Antennulae is weak, backward curved, widened distally. Exp of the antennae has 4, Enp has 3 segments. Postabdomen rather thick, in lateral slightly flattened, and distally narrows. Ephippium contain of 1 or 2 egg.

Male: Smaller than the female, nearly oval, although a little less rounded in shape. Head is rather large. Antennulae almost straight, hardly widened distally. Postabdomen is similar to female in shape.

Length of female: 0.55 – 2.0 mm

Length of male: 0.4 – 0.6 mm

Distribution: Palaearctic, Neotrophical, Australian. It is very widespread species known from South and North America, Greenland, Europe, Syria, Iran, Central and East Asia, North and Central Africa and Antarctic (Flössner, 1972).

Ecology: It can be inhabit very different waters like oligotrophic ponds, swamps, rice fields, highly saline inland waters, nutrient rich small bodies, and large lakes (Flössner, 1972). *M. hirsuticornis* has high density at low water temperatures (Einarsson and Örnolfsdottir, 2004; Margaritora and Usai, 2009).

Oxyurella tenuicaudis (Sars, 1862)

Female: The posterior margin of the carapace is more than half of the maximum length. Head is shorter. Antennulae are short and thick. Enp and Exp of antennulae are consists of 3 segments. Postabdomen is long and thin and its width is almost same throughout. The denticles at the posterior edge are very small, but their length increase towards the ventral corner. There is a fine spine at the base of the furcal claw.

Male: In the lateral view, upper and lower edges of the shell are nearly parallel. Rostrum is shorter and blunter than female. In postabdomen, there are no dorsal spine rows. Only 2 -5 bristle groups are located distally. Dorsal base of furcal claw carry a fine spine, smaller than female.

Length of female: 0.5 – 0.75 mm

Length of male: 0.4 – 0.5 mm

Distribution: Holarctic and Ethiopian. Spread all over the Europe, except with the arctic north. (Flössner, 1972).

Ecology: It prefers the shallow water with vegetation cover, floating and submerged vegetation cover. Ustaoğlu et al. (2006) also concluded that, *O. tenuicaudis* prefers vegetation zones of water bodies. It is also known as a warm waterspecies (Flössner, 1972).

Leydigia Leydigi (Schielder, 1863)

Female: In lateral view, body seems like a rectangular in shape. The eye is smaller than oscellus, in contrast to the majority of Cladoceran species. Antennae contain 3 segmented Exp and Enp. Postabdomen is spectacular in shape and always mount from the carapace. Dorsal side of postabdomen is curved. In lateral side, there are 9 – 12 bundles, each consist of 5 – 8 setae of varying sizes. Furcal claw is long and slender, with a basal fine spine.

Male: In lateral view, it seems more elongated than the female, with evenly rounded posterior margin of the shell. Postabdomen is very long and the furcal claw is the same as with the female.

Length of female: 0.7 – 1.0 mm

Length of male: 0.6 – 0.7 mm

Distribution: Holarctic and Neotrophic. It is widespread in Europe, except with the subarctic and arctic zones (Flössner, 1972).

Ecology: It is a littoral species (Gaiser and Lang, 2009), lives in the upper layer of the bottom sediment, mud vegetation substrate and nutrient rich waters (Duigan and Kovach, 1991). *L. leydigia* can be found in alkaline to slightly acidic waters, ponds, lakes, rivers and swamps. Population density is generally low (Flössner, 1972).

Pleuroxus aduncus (Jurine 1820)

Female: Dorsal margin of valve in posterior part slightly concave. In lateral, body is wide – oval, the posterior part is much lover then anterior part. Denticulation can be seen in the ventro - caudal part. Antennules are short. Postabdomen is short and dorsal margin is slightly convex. Also, dorsal part of the postabdomen contains row of spinules. Furcal claw contain 2 basal fine spines, the inner one is tiny, but sometimes nearly half as long as the outside.

Male: Dorsal part of the shell is slightly convex. Denticles on the ventro – caudal part are larger than females. Postabdomen is slender, tapers distally. Furcal claw contain only one basal spine.

Length of female: 0.4 – 0.7 mm

Length of male: 0.4 – mm

Distribution: The species has a cosmopolitan distribution (Flössner, 1972).

Ecology: *P. aduncus* can be found in macro vegetation part of water bodies (Özdemir Mis et al., 2009; Bozkurt and Güven, 2010) It can be found in eutrophic waters, strongly acidic bogs and heat pond, in saline water; in winter it is rarely found (Flössner, 1972). *P. aduncus* prefers productive waters that support macrophyte growt in littoral zones of water bodies (Duigan and Kovach, 1991; Nandini and Sarma, 2000).

Chydorus sphaericus (O.F. Müller, 1785)

Female: In lateral view, body is spherical to oval – rounded. Antennules are much shorter than tip of rostrum. Exp and Enp of annentules are 3 segmented. Postabdomen is short and wide. It has 7 to 10 relatively small denticles with little variance in size. Furcal claw has two basal spines.

Length of female: 0.3 – 0.5 mm

Length of male: 0.25 – 0.37 mm

Male: In lateral view, it is unevenly rounded – oval in shape. Postabdomen narrow in its postnatal part slightly expanded before base of claw. There is no basal spine on claw.

Distribution: Cosmopolitan (Flössner, 1972).

Ecology: It is very adaptable species to different kinds of water habitats like from large and deep lakes to source and the tiny water accumulation. Duigan and Kovach (1991), found *C. sphaericus* from saline condition Also, it is found at the littoral zones of oligotrophic and moderately eutrophic lakes (Vijverberg and Boersma, 1997) and vegetation regions (Bozkurt and Sagat, 2008). It is also successful at the pelagic zone (Hoffmann, 1998).

3.5. Evaluation of data

Total of 12 species were newly recorded for Ankara. Those are *Paracyclops chiltoni, P. fimbiratus, P. imminutus, Tropocyclops prasinus, Diacyclops bisetosus, Acanthocyclops vernalis, Canthocamptus staphylinus, Attheyella crassa, Bryocamptus minutus, Macrothrix hirsuticornis, Ouxyurella tenucaudis, Moina macrocopa.* At most 6 and at least 1 species were found in a trough. In 43 troughs no species were found. These stations are; 2, 5, 6, 13, 16, 17, 18, 23, 27, 31, 32, 35, 36,

42, 45, 51, 52, 54, 61, 62, 63, 64, 65, 70, 72, 77, 80, 82, 86, 88, 91, 95, 97, 99, 115, 117, 118, 120, 128, 132, 134, and 136. The average number of species in a trough is 1.79. The mean age of trough is 35.59. The most collected species was *Eucyclops serrulatus*, 63 times with 4914 individual. Secondly, *M. hirsuticornis* were collected 29 times with 1631 individual. Thirdly, *Chydorus sphaericus* were collected 24 times with 1425 individual. *T. prasinus*, *D. bisetosus*, *P. imminutus*, *B. minutes*, *M. macrocopa*, and *M. branchiate* are the least collected species, one time.

The numbers of species and the environmental variables measured for each trough were shown in Appendix 1 and Appendix 2, respectively. Some abbreviations are used for species are given below; *Eucyclops serrulatus* (EU), *Paracyclops chiltoni* (PC), *Tropocyclops prasinus* (TP), *Diacyclops bisetosus* (DB), *Acanthocyclops robustrus* (AR), *Paracyclops fimbiratus* (PF), *Acanthocyclops vernalis* (AV), *Paracyclops imminutus* (PI), *Canthocamptus staphylinus* (CAN), *Attheyella crassa* (ATT), *Bryocamptus minutus* (BR), *Macrothrix hirsuticornis* (MH), *Chydorus sphaericus* (CS), *Pleuroxus aduncus* (PA), *Oxyurella tenuicaudis* (OT), *Leydigia leydigi* (LL), *Moina macrocopa* (MM), *Moina branchiata* (MB). The distribution of station numbers, total species numbers, species, individual numbers and station numbers with no species per county are shown in Table 1.

Table 1. Table shows the distribution of station numbers (STAT. NO.), species, and the individual numbers of each species (INDV. NO.) across counties. EU: *Eucuclops serrulatus*, PC: *Paracyclops chiltoni*, PF: *P. fimbiratus*, PI: *P. imminutus*, AV: *Acanthocyclops vernalis*, AR: *A. robustrus*, TP: *Tropocyclops prasinus*, DB: *Diacyclops bisetosus*, CAN: *Canthocamptus staphylinus*, ATT: *Attheyella crassa*, BR: *Bryocamptus minutus*, MH: *Macrothrix hirsuticornis*, CS: *Chydorus sphaericus*, PA: *Pleuroxus aduncus*, OT: *Oxyurella tenuicaudis*, LL: *Leydigia leydigi*, MM: *Moina macrocopa*, MB: *Moina branchiata*. Also see Appendix 1 and Appendix 2 for detailed information.

COUNTIES	ST. NO.	SPECIES	INDV. NO.
Gölbaşı	5	MH, EU, PC, CS	371
Şereflikoçhisar	10	EU, CAN, MH, ATT, PF, BR, PC	418
Evren	6	EU, MH, CS, TP, PF, OT	129
Bala	13	PC, MH, PA, EU, MM, CS, OT, DB	597
Kazan	4	PC, EU	226
Kızılcahamam	10	EU, PC, PF, MH, CS, CAN, AR, PA	997
Güdül	4	EU, PC, CS, MH	598
Polatlı	12	EU, PF, OT, CS, PC	278
Haymana	14	EU, PF, MH, CS, AV	518
Nallıhan	12	EU, CS, PF, PC	219
Beypazarı	9	PC, PF, CS, EU	447
Ayaş	8	PF, EU, LL, MH	317
Çamlıdere	5	EU, CS, MH, CAN, ATT	1356
Elmadağ	5	EU, PF, PL, MH, CS	29
Akyurt	5	MB, EU, AV, CAN	11
Kalecik	10	MH, EU, PA, CS	1609
Çubuk	10	EU, PF, AR, LL, CAN, CS, MH	401
Total:	142		8521

3.6. Data analyses

Based on (UPGMA) dendrogram, 12 zooplankton species were clustered into four main groups (Figure 6). First group contains two species, *Oxyurella tenuicaudis* and *Paracyclops fimbiratus*. Four species were found in the second cluster, *Acanthocyclops vernalis*, *Leydigia leydigi*, *Canthocamptus staphylinus*, and *A. robustrus*, while third cluster represented by two species, *Chydorus sphaericus*, and *P. chiltoni*. The fourth group contains four species, *Pleuroxus aduncus*, *Macrothrix hirsuticornis*, *Attheyella crassa*, and *Eucyclops serrulatus*.

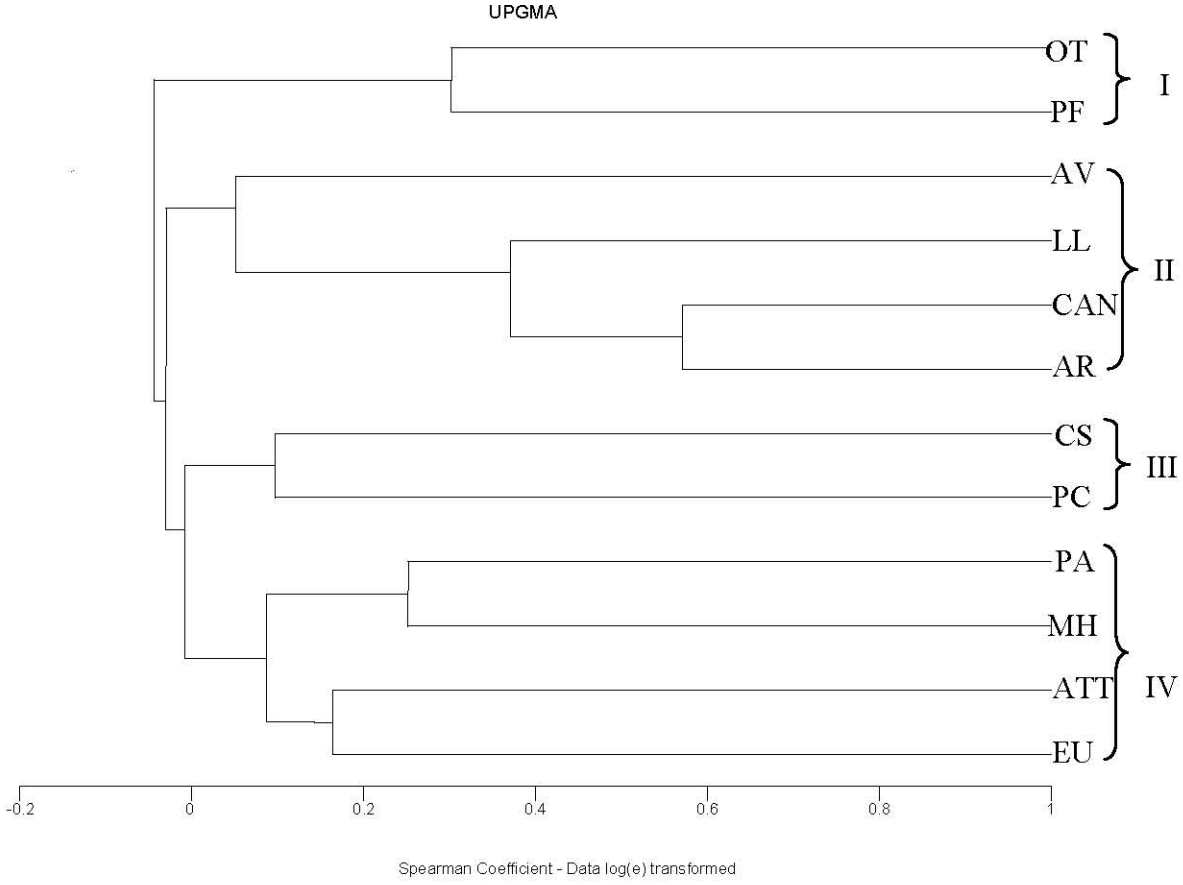


Figure 5. Unweighted Pair Group Mean Averages (UPGMA) illustrates the clustering relationships of 12 zooplankton species.

Spearman correlation analysis emphasizes the relationships between 10 environmental variables and 12 species (Table 2). *Eucyclops serrulatus* and *Paracyclops chiltoni* showed significant negative and positive correlation to pH ($P < 0.05$), respectively. Also, *P. chiltoni* revealed a significant negative and positive correlation to moisture ($P < 0.01$) and dissolved oxygen ($P < 0.05$), respectively. However, *Acanthocyclops vernalis* has negatively and positively correlation to dissolved oxygen ($P < 0.05$) and moisture ($P < 0.01$). The only positive correlation with water temperature was seen for *P. chiltoni* ($P < 0.01$). Additionally, *A. robustrus* ($P < 0.05$) and *Canthocamptus staphylinus* ($P < 0.01$) were negatively, *P. chiltoni* ($P < 0.01$) was positively correlated to atmospheric pressure. Besides, altitude has a positive significant correlation to *A. robustrus* ($P < 0.05$), *Macrothrix hirsuticornis* ($P < 0.05$), and *C. staphylinus* ($P < 0.01$). *C.staphylinus* has a positive correlation to *A. robustrus* ($P < 0.01$), *A. vernalis* ($P < 0.05$), and *Leydigia leydigi* ($P < 0.05$) (Table 2).

Table 2. Spearman correlation shows the relationships between environmental variables and species. n = 97, "(a)" marked where n = 93. "*" correlation is significant at the 0.05 level (2-tailed) and "**" correlation is significant at the 0.01 level (2-tailed). Depth and Length did not show any significant correlation between envrionmetal variables and species.

	W	ALT	MOI	TW	EC	pH	DO	ATM	EU	PC	AR	PF	AV	MH	CS	PA	OT	LL	CAN	ATT
W	1.000																			
ALT	.040[(a)]	1.000																		
MOI	-.098	.078[(a)]	1.000																	
TW	.059	-.316**[(a)]	-.424**	1.000																
EC	-.025	-.305**[(a)]	-.016	.092	1.000															
pH	-.100	-.406**[(a)]	-.297**	.540**	-.021	1.000														
DO	.014	-.025[(a)]	-.363**	.549**	-.072	.557**	1.000													
ATM	-.034	-.898**[(a)]	-.103	.387**	.356**	.345**	.059	1.000												
EU	.034	.095[(a)]	.120	-.117	-.110	-.239*	-.029	-.067	1.000											
PC	.127	-.185[(a)]	-.322**	.261**	.131	.219*	.212*	.266**	-.252*	1.000										
AR	.137	.228*[(a)]	-.150	-.140	.019	-.108	.017	-.224*	-.052	-.062	1.000									
PF	-.212*	.091[(a)]	.062	-.120	.053	-.150	-.076	-.089	.018	-.120	-.069	1.000								
AV	-.053	.168[(a)]	.267*	-.197	.166	-.116	-.222*	-.178	-.127	-.076	-.026	-.085	1.000							
MH	.060	.253*[(a)]	-.027	.010	-.138	-.126	.185	-.191	.092	.069	-.093	-.028	-.114	1.000						
CS	-.048	.137[(a)]	.012	.000	-.208*	.031	.060	-.198	.049	.097	-.082	-.096	.049	-.025	1.000					
PA	-.060	.001[(a)]	.061	.034	-.002	.066	.070	.019	.070	.065	-.030	-.098	-.037	.252*	.007	1.000				
OT	-.130	.056[(a)]	-.085	.17	.190	-.036	.089	.086	-.068	.043	.030	.302**	-.037	-.025	-.007	-.043	1.000			
LL	.188	.002[(a)]	-.088	-.119	.077	-.162	-.164	.003	-.054	-.062	.489**	-.069	-.025	-.093	-.082	-.030	-.030	1.000		
CAN	.058	.295**[(a)]	-.131	-.137	.006	-.177	.110	-.335*	.039	.012	.571**	.006	.204*	-.014	.052	-.053	-.053	.251*	1.000	
ATT	-.147	.054[(a)]	.123	-.014	-.003	-.151	.101	-.085	.164	-.062	-.021	-.069	-.026	.218*	.087	-.030	-.030	-.021	.251*	1.000

According to tolerance optimum values calculated (Table 3), ecological tolerance and optimum estimations for species are variable. Some species have a higher value for both tolerance and optimum estimates than the mean. *Canthocamptus staphylinus* had maximum optimum values and *Pleuroxus aduncus* had minimum optimum values for depth. In addition *Chydorus sphaericus* showed the highest tolerance level for depth. *Paracyclops chiltoni* showed the maximum, and *P. aduncus* showed the minimum optimum level for width. Also, *P. chiltoni* had the highest maximum tolerance level for width. *Ouxyurella tenucaudis* had the maximum optimum level and *C. staphylinus* had the minimum optimum level for length. Furthermore, *P. fimbiratus* had the highest tolerance value for length. For altitude, *C. staphylinus* had the maximum optimum value. *P. fimbiratus* showed minimum optimum value but highest tolerance level. *Eucyclops serrulatus* showed maximum optimum value and *O. tenucaudis* showed the minimum optimum value for moisture. *P. aduncus* had the highest tolerance level for moisture, also. *P. aduncus* had maximum optimum value and highest tolerance level to water temperature. Additionally *C. sphaericus* had the minimum optimum level to the water temperature. For electrical conductivity, *O. tenucaudis* showed the highest optimum and tolerance level. Also, *C. sphaericus* had the minimum tolerance level for electrical conductivity. *Macrothrix hirsuticornis* had the minimum optimum level but the highest tolerance level for pH. *P. aduncus*, however, had the maximum optimum level for pH. *C. staphylinus* showed the maximum optimum value and *P. fimbiratus* showed the minimum optimum value for dissolved oxygen. *M. hirsuticornis* had the highest tolerance level for DO. *C. staphylinus* had the maximum optimum value and *P. chiltoni* had the minimum optimum value for atmospheric pressure. In addition, *C. sphaericus* showed the highest tolerance level to it.

Table 3. Optima (uk) and tolerance (tk) values are calculated for the mean depth (D), altitude (ALT), water temperature (Tw), electrical conductivity (EC), pH, dissolved oxygen (DO), and atmospheric pressure (ATM). N2 shows Hill's coefficient (measure of effective number of occurrences). Count and Max represent numbers of species occurrence and numbers of individuals.

				D		ALT		MOI		Tw		EC		pH		DO		ATM	
Species	Count	Max	N2	u_k	t_k	u_k	t_k	u_k	t_k	u_k	t_k	u_k	t_k	u_k	t_k	u_k	t_k	u_k	t_k
E. serrulatus	63	1114	11.083	0.32	0.17	988.2	254.55	42.42	20.12	18.17	4.11	536.12	713.07	7.99	0.66	10.17	2.93	672.2	10.14
M. hirsuticornis	29	298	10.441	0.4	0.17	1028.7	264.51	37.48	16.71	18.24	2.84	634.44	542.7	7.13	2.24	11.26	3.45	669.5	5.74
P. chiltoni	15	21	8.802	0.35	0.19	952.38	224.09	26.18	7.56	19.71	2.78	633.33	574.57	7.93	0.34	10.63	3	680.1	16.61
P. fimbriatus	18	56	3.38	0.3	0.09	448.76	661.35	35.25	7.85	17.09	2.13	460.56	797.02	7.27	0.62	9.49	2.71	665.7	15.19
C. sphaericus	24	704	3.366	0.35	0.22	1048.3	278.16	40.46	9.36	16.65	3.03	194.89	240.73	8.17	0.72	10.6	2.67	670.3	22.38
C. staphylinus	6	12	2.9044	0.45	0.2	1388.4	126.69	25.53	21.82	16.2	3.22	451.3	155.58	7.68	0.32	11.31	1.5	645.4	7.49
P. aduncus	4	57	2.0746	0.16	0.16	1107.5	189.65	41.66	42.2	22.09	8.61	495.41	132.16	8.19	0.74	11.19	2.21	670.2	11.69
O. tenuicaudis	4	84	1.5686	0.29	0.05	1027.3	167.05	20.78	10.57	20.81	1.65	900.04	11877	8.03	0.42	10.78	1.83	672.6	8.7
Mean				0.33	0.16	998.72	270.76	33.72	17.02	16.62	3.55	538.26	629.07	7.8	0.76	10.68	2.54	668.2	12.27
Max.				0.45	0.22	1388.4	661.35	42.42	42.2	22.09	8.61	900.04	1876.7	8.19	2.24	11.31	3.45	680.1	22.38
Min.				0.16	0.05	448.76	126.69	20.78	7.56	16.2	1.65	194.89	132.16	7.13	0.32	9.49	1.5	645.4	5.74
St.dev.				0.085	0.056	259.84	166.13	8.383	11.594	2.085	2.17	200.9	563.7	0.41	0.621	0.619	0.649	10.08	5.488

The Poisson distribution ($P<0.05$, $N>30$) results showed that, species were almost randomly distributed among troughs ($s^2/\mu = 1.04$) (but see Discussion). The graph drawn according to the frequency distribution table (Figure 7) supports our results (See also Ludwig and Reynolds, 1988) (For Poisson distribution calculations, see Appendix 3).

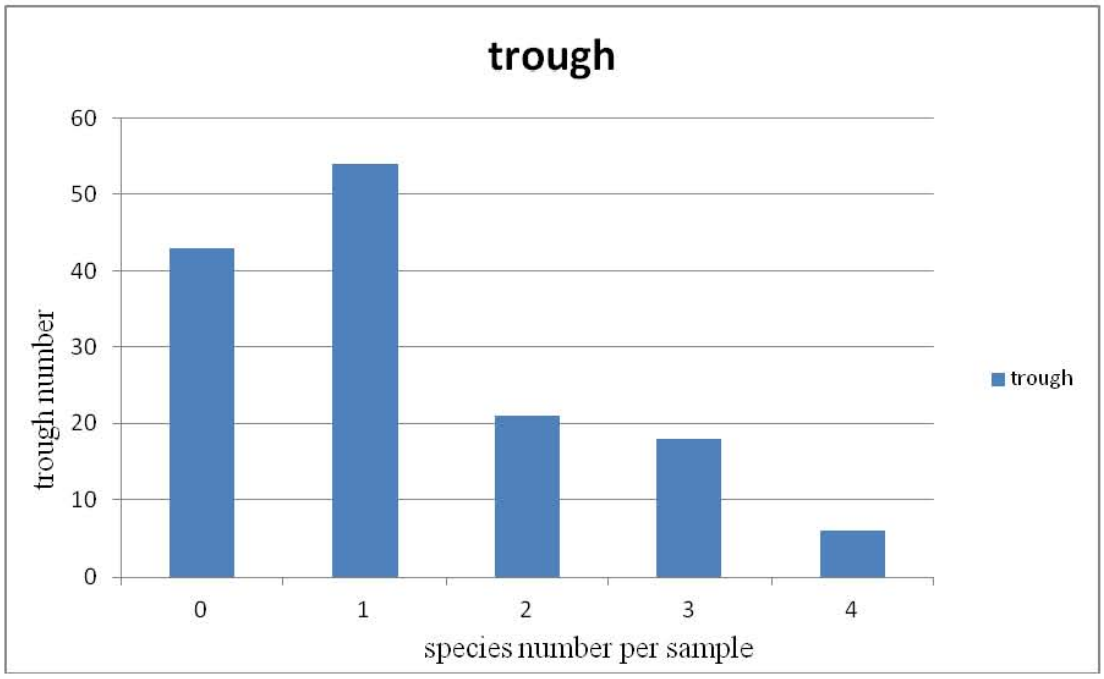


Figure 6. It shows relationships between the species number per sample and trough number.

Altitude was not play a significant role in the present study. We found 11 species from 14 troughs from the elevation range of 1201 – 1300 m, 10 species were found from the range 901 – 1000 m from 29 troughs, and there are nine species between the ranges of 1001 – 1100 m from the 33 troughs (Figure 8).

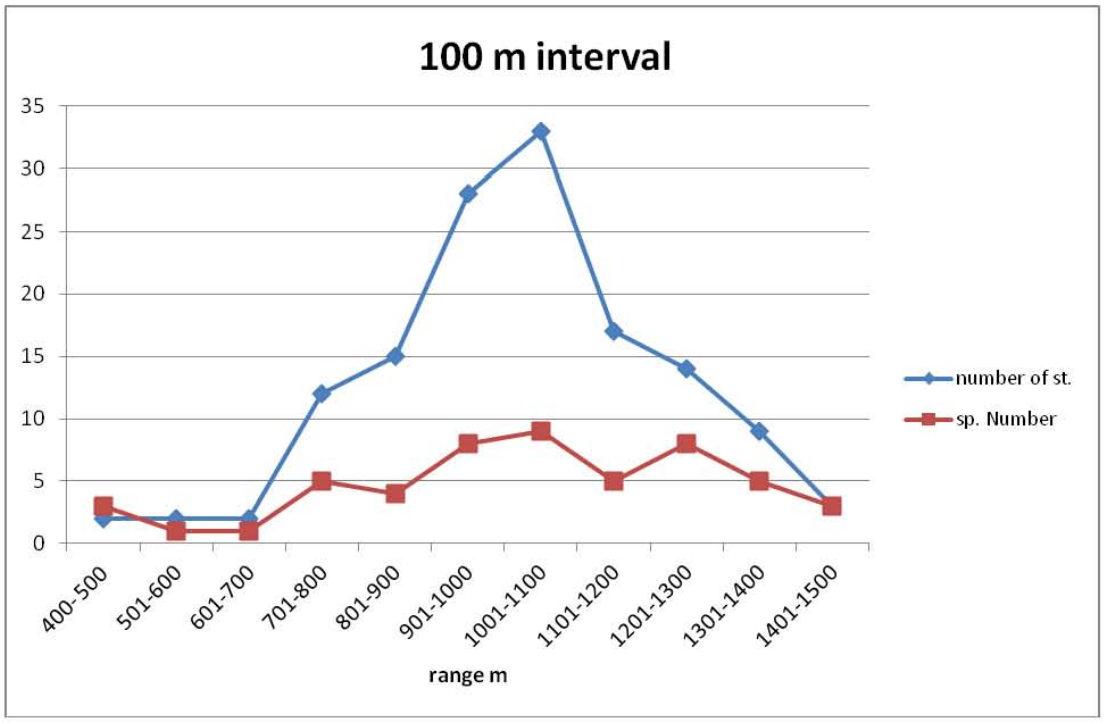


Figure 7. It shows the relationships between number of species and trough number at different altitudinal ranges.

CHAPTER IV

4. DISCUSSION and CONCLUSION

During this study 18 zooplankton species collected from 142 stations in 17 counties from Ankara. Among which, 12 are (*Paracyclops chiltoni*, *P. fimbiratus*, *P. imminutus*, *Tropocyclops prasinus*, *Diacyclops bisetosus*, *Acanthocyclops vernalis*, *Canthocamptus staphylinus*, *Attheyella crassa, Bryocamptus minutes*, *Macrothrix hirsuticornis*, *Ouxyurella tenucaudis*, *Moina macrocopa*) reported from Ankara for the first time. *Eucyclops serrulatus* was the most frequently occuring species, 63 times with 4914 individuals. Secondly, *M. hirsuticornis* was collected 29 times with 1631 individuals. *Chydorus sphaericus* is the third most common species, 24 times with 1425 individual. After Lindberg (1953 and 1957), *P. imminutus* were recorded for the third time in Turkey. While calculating maximum and minimum values of environmental variables, troughed numbered as 21th and 28th were eliminated because of unreliable values (Appendix 1).The dendrogram of UPGMA represents (Figure 6) four groups. In addition, some clustering groups of UPGMA dendrogram are supported by the Tolerance (*tk*)/Optimum (*uk*) values (Table 3) of some species and by the results of Spearman Correlation Analysis (Table 2). For example, the fourth group in UPGMA includes *Attheyella crassa*, *Macrothrix hirsuticornis*, *Pleuroxus aduncus*, and *Eucyclops serrulatus*. *M. hirsuticornis* displayed a positive

correlation with *A. crassa* and *P. aduncus* in Spearman analysis. Generally, *M. hirsuticornis* and *E. serrulatus* showed the highest tolerance values than mean among the environmental variables.

Oxyurella tenuicaudis and *Paracyclops fimbiratus* are seen within the first group in the UPGMA (Figure 6). In Spearman analyses, these two species are positively correlated with each other ($P < 0.01$) (Table 2).

Oxyurella tenuicaudis found from four troughs. In a previous study, Ustaoğlu et al. (2003) measured some environmental variables which are pH (7.42 – 8.84), dissolved oxygen (4.2 – 16.0 mg/l), and water temperature (11.0 – 32.5 °C). The measurements in this study show similarity with our results which are pH (7.31 – 8.12), water temperature (18.3 – 21.3 °C), dissolved oxygen (4.2 – 16.0 mg/l), electrical conductivity (424.3 – 4667.0 µS/cm) and altitude (785.0 – 1271.0 m). It also shows high tolerances to electrical conductivity (1876.73) (Table 3). Due to these results, we may suggest that *O. tenuicaudis* prefers warm waters.

Paracyclops fimbiratus were found from 18 troughs. It can inhabit many kinds of aquatic bodies like ponds moss, different benthic habitats of lakes, springs, regardless of temperature, current speed, sediment type, and organic matter; and also it can be found in groundwater (Galassi, 2001). According to the tolerance optimum values, *P. fimbiratus* has the highest tolerance to the altitude. This result is supported by Jersabek et al. (2001) who underlined that *P. fimbiratus* was one of the species that can be found both subalphine and/or alphine regions and lower altitudes. Robertson et al. (1997) concluded that *P. fimbiratus* has high density at low pH, but we did not find any correlation between them. According to tolerance optimum table (Table 3), it has high tolerance to altitude (661.35).

There are four species in the second group of UPGMA, *Acanthocyclops vernalis*, *Leydigia leydigi*, *Canthocamptus staphylinus*, and *A.robustrus* (Figure 6). According to Spearman analyses, *C. staphylinus* positively correlated with remaining three species (Table 2).

Acanthocyclops vernalis was found from only two troughs. This species is a common species which shows high tolerance to environmental variables (Dussart, 1969). Hann and Zrum (1997) found it between the pH ranges of 8.3 and 8.4, water temperature (18.5 – 18.9 °C), and dissolved oxygen (6.2 – 7.1 mg/l). The pH (7.33 – 7.74), water temperature (13.8 – 14.6 °C) and dissolved oxygen (1.33 – 8.02 mg/l) measurement of these two trough water are coincided with the results that we mentioned above. According to these results this species did not have wide ranges to environmental variables because of that further studies might be needed to figure out its exact tolerance levels. Besides, it shows negative correlation with dissolved oxygen. Nevertheless, Davidson et al. (1998) concluded that *A. vernalis* abundance positively associated with dissolved oxygen. Finally, it has been found between the 1048 – 1304 m altitudinal ranges, so that the species may have a tendency to be prefer high altitudes (Appendix 1).

We found *Leydigia leydigi* from only two troughs. In their seasonal study at Lake Gölcük, Özdemir Mis and Ustaoğlu (2009) found *L. leydigi* only in June, where pH were (8.43), dissolved oxygen were (9.5 mg/l), electrical conductivity were (202 µS/c), and water temperature (20.8 °C). Besides, Bozkurt et al. (2009) also found this species from Aslantaş Dam Lake only in two month, May and August, during their seasonal study, where pH were (8.1) in May and (7.81) in August, dissolved oxygen were (8.01 mg/l) in August, and water temperature were (19.77 °C) in May and (30.92 °C) in August. These are supported by Flössner (1972), who concluded that *L.*

leydigia generally had low population density. Some environmental variables that we found are pH (6.49 – 7.54), water temperature (14.7 – 15 °C), electrical conductivity (489.6 – 736.0 µS/c), and dissolved oxygen (5.40 – 7.99 mg/l). These results correspond with the results of Bekleyen (2003) as pH (7.56 – 8.65), water temperature (5.0 – 27.0 °C), and dissolved oxygen (6.0 – 13.0 mg/l).

Canthocamptus staphylinus is a cosmopolitan species (Apostolov and Pesce, 1989). It was found from only six troughs in this study. Ustaoğlu et al. (2001) found the species along with some environmental variables as pH (6.90 – 8.55), water temperature (2.0 – 25.1°C), electrical conductivity (201 – 407 µS/cm), and dissolved oxygen (4.08 – 11.52 mg/l). Our results are nearly coincide with Ustaoğlu et al (2001) measurement as pH (6.49 – 7.81), electrical conductivity (7.36 – 98.9 µS/cm), water temperature (13.8 – 19.4 °C), dissolved oxygen (7.99 – 12.1 mg/l), and altitude (972 – 1457 m), and differences probably caused by cosmopolitan characteristics of the species. Furthermore *C. staphylinus* shows positive correlation with altitude and atmospheric pressure ($P < 0.01$) (Table 2).

Acanthocyclops robustrus found from only two troughs, but it is a cosmopolitan species (Silva, 2008). Some environmental variables found in this study are pH (6.49 – 7.81), water temperature (14.0 – 15.0 °C), electrical conductivity (380 – 736 µS/c), and dissolved oxygen (7.99 – 11.48 mg/l). These results are consistant with the measurements of Bozkurt et al. (2009) as pH (7.81 – 8.97), water temperature (11.04 – 30.92 °C), and dissolved oxygen (7.81 – 9.48 mg/l). In the present study, altitudinal range of *A. robustrus* was between 1297 and 1404 m. It also shows positively significant correlation with altitude ($P < 0.05$) (Table 2) so we can say that *A. robustrus* can tolerate high altitudinal conditions in waters.

The third group of UPGMA consists of two species, *Chydorus sphaericus*, and *Paracyclops chiltoni* (Figure 6).

Chydorus sphaericus was found from 24 troughs. It is known as a cosmopolitan species (Miracle, 1982) and can adapt many kinds of waters (Adalsteinson, 1979). In this study, it shows wide tolerances to ecological variables such as, dissolved oxygen (1.33 – 18.84 mg/l), pH (7.22 – 9.27), water temperature (12.4 – 28 °C), altitude (442 – 1457 m) and electrical conductivity (75.8 – 1070 µS/cm). Our results cope with the results of Aygen and Balık (2005) whose measurements were water temperature (5.4 – 28.5 °C), pH (7.49 – 9.25), and electrical conductivity (174 – 623 µS/cm). Deveci et al. (2011) concluded that there is a negative correlation of *C. sphaericus* with dissolved oxygen in Lake Sünnet (Bolu). However, during the present work, we did not find any correlation between them. *C. sphaericus* has positive correlation with electrical conductivity ($P < 0.05$) (Table 2), and show high tolerance to depth (0.22) and atmospheric pressure (22.38) (Table 3).

Paracyclops chiltoni, found from 15 troughs, is a cosmopolitan species (Karaytuğ, 1999). The maximum and minimum values of *P. chiltoni* in this study were as pH (7.46 – 8.7), electrical conductivity (174 – 2775 µS/c), water temperature (16.5 – 26.9 °C), and dissolved oxygen (6.62 – 19.05 mg/l). According to Spearman Correlation Analyses, it shows positive correlation with water temperature ($P < 0.01$), pH and dissolved oxygen ($P < 0.05$) (Table 2).

According to the fourth group of UPGMA there were four species, *Pleuroxus aduncus*, *Macrothrix hirsuticornis*, *Attheyella crassa*, and *Eucyclops serrulatus* (Figure 6). *P. aduncus*, and *E. serrulatus* are cosmopolitan species and *M.*

hirsuticornis has wide distribution (Flössner, 1972; Miracle, 1982). *M. hirsuticornis* has positive significant corraltaion with *P. aduncus* and *A. crassa* ($P < 0.05$) (Table 2).

According to Flössner (1972), *Pleuroxus aduncus* is a cosmopolitan species. In this study, it was found only from four troughs. The ecological parameters of water we found this species are pH (7.47 – 8.61), electrical conductivity (358.4 – 563.0 µS/c), water temperature (13.6 – 26.9 °C), and dissolved oxygen (8.72 – 12.45 mg/l). Our measurements show similar results of Yalım et al. (2011) as pH (7.3 – 7.9), water temperature (17.3 – 22.8 °C), electrical conductivity (11.3 – 19.7 µS/c), and dissolved oxygen (7.0 – 9.6 mg/l). Although, *P. aduncus* had the highest tolerance value to moisture (42.20) and the water temperature (8.61) (Table 3), it did not show any correlation with these variables in Spearmen correlation analysis (Table 2).

Macrothrix hirsuticornis is the second most common species in this study. It was collected from 29 troughs. *M. hirsuticornis* known as a wide spread species (Flössner, 1972). Ustaoğlu et al. (2008) reported some result as pH (8.02 – 9.82), water temperature (4.8 – 23 °C), dissolved oxygen (5.30 – 8.0 mg/l), and electrical conductivity (70 – 102 µS/cm). The results of this study show similarity with our physico-chemical measurements as water temperature (12.7 – 26.9 °C), electrical conductivity (16.88 – 2690 µS/cm), pH (6.86 – 9.62), and dissolved oxygen (2.5 – 16.13 mg/l). Besides, Usai and Margaitora (1987) stated that *M. hirsuticornis* was widespread in many water environments both at low and high altitudes. According to our Spearman correlation analyses, it is positively correlated with altitude ($P < 0.05$) (Table 2). Lastly, it shows the highest tolerance to dissolved oxygen (3.45) and pH (2.24) (Table 3).

Attheyella crassa is one of the species that collected from only two troughs. Water temperature (16.2 – 18.7 °C), electrical conductivity (98.9 – 1159 µS/c), dissolved oxygen (10.76 – 10. 89 mg/l), and pH (7.33 – 7.48) are coincided with the results of Ustaoğlu et al. (2008) as pH (8.02 – 9.82), water temperature (4.8 -23.0 °C), electrical conductivity (70.0 – 102.0 µS/c), and dissolved oxygen (5.30 – 8.0). In addition, *A. crassa* collected from 1071 – 1193 m altitudinal ranges (Appendix 1). Yalım and Çıplak (2008) also colleced *A. crassa* samples from the Lake Yeşil located at 1600 m.

Collecting from 63 troughs, *E. serrulatus* was the most common species during the present. It is a well known cosmopolitan species (Alekseev et al., 2005; Boxhall and Defaye, 2008). In this study, ecological values were measured as pH (6.49 – 9.15), electrical conductivity (15.94 – 3866 µS/cm), dissolved oxygen (1.33 – 16.13 mg/l), altitude (705 – 1457 m) and water temperature (12 – 31.7 °C). Özdemir Mis and Ustaoğlu (2009) provided some water variables from Lake Gölcük including *E. serrulatus*. These are pH (7.83 – 9.46), dissolved oxygen (4.2- 14.0 mg/l), electrical conductivity (182- 283 µS/cm), and water temperature (4.2- 25.9 °C). Also, Bekleyen and İpek (2010) reported pH (5.7 – 7.5), water temperature (15.5 – 27 °C), and dissolved oxygen (2.4 – 6.2 mg/l). Additionally, pH (6.9 – 8.9), dissolved oxygen (5.6 – 12.3 mg/l), water temperature (11.1 – 28.6 °C), and electrical conductivity (375 – 8570 µS/cm) were measured by Özdemir Mis et al. (2011). Also according to tolerance optimum table (Table), it shows high tolerance to water temperature (4.11 °C), electrical conductivity (713.07 µS/cm), and dissolved oxygen (2.93 mg/l). All these reports support that *E. serrulatus* shows high tolerances to the ecological variables. Besides, *E. serrulatus* showed significant negative correlation

with pH ($P < 0.05$) (Table 2), also in the study of Rundle and Ramsay (1997), the CCA diagram *E. serrulatus* shows positive correlation with pH.

The most frequently occurring three species, *Eucyclops serrulatus*, *Macrthrix hirsuticornis*, and *Chydorus sphaericus* were also the most abundant and dominant species. These species have a broad geographical distribution in natural systems and wide ecological tolerances to the environmental variables (Miracle, 1982). In present study, we collect them from 63 (*E. serrulatus*), 29 (*M. hirsuticornis*), and 24 (*C. sphaericus*) different troughs. These three species were frequently found together in troughs. In contrast, in UPGMA dendrogram, only *E. serrulatus* and *M. hirsuticornis* were clustered in a single group. The reason of this probably relies on the difference in the tolerances of the individual species to the various environmental variables. Besides, among almost all of the variables, these three species tend to have greater tolerance levels than the mean value (Table 3). This probably gives an advantage them to exist in the wide range of conditions. On the other hand, none of these species shows significant correlations to those variables (Table 2). So, we may suggest that there is no need to show direct significant correlation to have high tolerance to environmental variables, and cosmopolitan character of species deals with that (Külköylüoğlu, pers. comm.).

The maximum number of species in a trough was 6, and the collected species from there, were cosmopolitan species. Similarly, Uçak (2012) reported at most 5 ostracod species in a trough, and also these were mostly cosmopolitan species, too.

Troughs are very useful structures for villagers and animals in many ways. They are cleaned by villagers and rehydrate again. Drenner et al. (2009) reported that zooplankton species are recolonize after lentic systems are filled by rainfalls. The

same thing happens for troughs; after rehydration zooplankton species are reappear after a while. This cleaning process may be one of the reasons that low number of different species in a trough, there might be not enough time to recolonize. Among zooplanktons, rotifers and copepods are fastly colonized in the new water habitats than cladocerans (Badosa et al., 2010). Frisch and Green (2007) also concluded that, cyclopoid copepods are firstly colonized especially Eucylops and Tropocyclops genera, by having the capacity to colonize the water column after rehydration. In present study, species numbers of copepods (mostly cyclopoid copepods) are higher than cladocerans, so colonization rate might have role on this. Additionally, we did not find any calanoid copepods. Not having enough time to colonize might be one possibility. On the other hand, the habitat preferences differences might be another reason. Calanoid copepods can be found in many kinds of water bodies, for example from temporary ponds in Iceland (Scher et al., 2000), from Antartica (Pugh et al., 2002), from caves (Brancelj, 2005, in Brancelj and Dumont, 2007), from lakes, rivers etc... (Bozkurt, 2004; Yiğit, 2006; Atici et al., 2008). However, calanoid copepods are planktonic organisms, while cyclopoid and carpacticoid copepods prefer substrates in littoral or benthic habitats (Galassi et al., 2009). Another difference between cyclopoid copepods and calanoid copepods is that, calanoid copepods are generally predominant in oligotrophic conditions, while cyclopoid copepods are suited and well adapted to eutrophic conditions (Gannon and Stremberger, 1978; Kaya and Altındağ, 2007; Aygen et al., 2009). Depends on this information, troughs can be considered as eutrophic habitatswhere some indicator species (e.g., *Chydorus sphaericus*, *Eucyclops serrulatus*, and *Acanthocyclops robustus*) are found in troughs (Bekleyen and Taş, 2008; Özdemir Mis and Ustaoğlu, 2009).

Stoch (2007) reported that in high altitudinal environments above 2700 m, copepods species richness is low. However, between the 1100 – 2700m species richness increases. According to the Figure 8, which is represents the relationships between number of species and trough number at different altitudinal ranges, it is clear that species number is increased with altitude. Nevertheless, numbers of troughs are also increased, so this might be reason the high numbers of species at high altitudes in this study, because altitude was not playing significant role on the species.

After calculating the variance and mean values, we defined the ratio of s^2 / μ=1.04 for Poisson distribution.According to Ludwing and Reynolds (1988), if this ratio equals to 1 distribution pattern is random, if it is smaller than 1 distribution pattern is uniform, and if ratio is greater than 1 distribution pattern is clumped. We decided that zooplankton distribution pattern among troughs is random because of the difference (0.04) was small enough to be neglected. Indeed, the graph that shows random because of the difference distribution pattern is overlapped with our distribution pattern graph (Figure 7) (for more information, see Ludwing and Reynolds, 1988).

Troughs are built by converting springs, because the usage of them is very important and useful for villagers. Despite the original species composition of spring habitat affected, by the converting, troughs may provide suitable conditions for some aquatic species, especially cosmopolitan species. To have better understanding of the importance of troughs on the biodiversity, further studies on different taxonomic groups are needed.

In conclusion;

- 1.79 was the average number of species in a trough, and the maximum number of species in a trough was 6. Most common species were *Eucyclops serrulatus*, *Macrothrix hirsuticornis, Chydorus sphaericus* occured from 63, 29 and 24 different troughs. These species have a broad geographical distribution in freshwater systems. *Paracyclops chiltoni, P. fimbiratus, P. imminutus, Tropocyclops prasinus, Diacyclops bisetosus, Acanthocyclops vernalis, Canthocamptus staphylinus, Attheyella crassa, Bryocamptus minutes, Macrothrix hirsuticornis, Ouxyurella tenucaudis, Moina macrocopa* are new records for Ankara. This is the third time that *P. imminutus* reported from Turkey.

- Ecological tolerances values of the cosmopolitan species were not always greater than the mean, however, these species had the greater tolerances among other species. This may be advantages to allow them to exist in broad range conditions

- Troughs provide better places for cosmopolitan species. By future studies trough structure and functions could be better understood.

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APPENDICES

Appendix 1. Measurements of 18 different variables and geographical data of 142 stations. Abbrevation: pH; DO (mg/L): dissolved oxygen; EC (µS/cm): electrical conductivity; TDS (mg/l): Total Dissolved Solids; %S: oxygen saturation; (T°Cw): water temperature; (T°Ca): air temperature; Sal (ppt): salinity; Alt: altitude: (m); volume of troughs: (m3); dep.: depth of troughs: (m); wid.: width of troughs: (m); heig: height of troughs: (m); MOI (%): moisture; ST. NO: station number; SP.CODE: species codes.

ST. NO	age	dep. (m)	wid. (m)	leng .(m)	VOL .(M3)	ALT. (m)	$T^{\circ}C_A$	MOI	$T^{\circ}C_W$	EC	SAL	pH	SPEC	DO	DO%	TDS	ATM	COORD.
1		0,2	3	2	1,2	1062	34,5	19	21	716	0,38	7,99	769	12,34	139,2	0,5005	676,2	N39°03'482" E33°31'545"
2		0,4	0,5	7	1,4	1062	35,4	21	20,2	915	0,5	7,82	999	13,9	154,3	0,65	688,9	N39°03'243" E33°31'545"
3	17	0,5	0,5	3	0,75	972	36,1	19	14,1	551	0,34	7,5	696	11,72	114	0,455	670	N39°06'236" E33°36'831"
4	23	0,1	1	10	1	996	33,3	22	31,7	615	0,26	8,94	544	15,24	209,6	0,351	669,9	N39°05'495" E33°39'618"
5	6	0,5	0,5	9	2,25	930	36,7	20	17	809	0,47	7,35	955	12,8	133,8	0,624	682,3	N39°05'092" E33°40'985"
6		0,3	0,75	3	0,68	1041	33,8	19	21,7	347,2	0,18	7,81	369,8	13,43	155,7	0,2405	671,1	N39°02'515" E33°42'382"
7		0,2	0,4	0,3	0,24	1039	30,8	26	23,9	274,9	0,13	8,33	280,6	14,4	174	0,182	672,8	N39°02'516" E33°42'372"

Appendix 1. continued

ST. NO	age	dep. (m)	wid. (m)	leng .(m)	VOL .(M3)	ALT. (m)	T°C$_A$	MOI	T°C$_W$	EC	SAL	pH	SPEC	DO	DO%	TDS	ATM	COORD.
8		0,4	0,4	8	1,28	1271	31,6	19	19,5	213,9	0,11	7,51	238,8	11,31	123	0,1547	673,3	N38°57'751" E33°42'257"
9		0,4	0,4	10	1,6	1271	24,2	34	20,8	768	0,41	7,4	836	9,04	102	0,546	675,4	N38°57'868" E33°38'297"
10		0,4	0,4	8	1,28	1042	24,1	30	21,1	369	0,19	8,02	299,1	14,72	165	0,2593	668,8	N38°55'306" E33°39'490"
11		0,2	0,6	3	0,36	1175	22,9	42	21,7	599	0,31	7	639	11,5	135,5	0,416	677,2	N38°54'176" E33°43'484"
12		0,4	0,3	6	0,72	1017	18,2	50	16,2	1155	0,7	7,48	1389	10,76	109,4	0,9035	672,1	N38°51'670" E33°37'904"
13		0,2	0,6	3	0,36	1019	16,6	53	14,7	1084	0,68	7,6	1350	13,06	100,6	0,8775	677,2	N39°09'478" E33°11'380"
14	72	0,5	1	18	9	1074	19,7	45	18,4	402,9	0,22	7,86	461	11,3	151	0,2996	673,1	N39°12'465" E33°11'620"
15	12	0,2	0,5	14	1,4	984	24,1	32	13,6	779	0,5	7,44	996	6,34	60,6	0,65	680,3	N39°10'972" E33°13'961"
16	26	0,2	0,5	18	1,8	1041	26,1	92	13,6	584	0,37	7,37	750	11,84	116,2	0,4875	676,4	N39°15'372" E33°18'089"
17	56	0,3	0,5	6	0,9	843	31,2	24	14	1965	1,29	7,31	2490	1,82	18,7	1,6185	691,1	N39°20'099" E33°16'412"
18	5	0,2	0,5	12	1,2	907	26,7	28	17,5	896	0,52	7,59	1065	8,04	83,4	0,676	685,9	N39°18'835" E33°12'500"

Appendix 1. continued

ST. NO	age	dep. (m)	wid. (m)	leng .(m)	VOL .(M3)	ALT. (m)	T°C$_A$	MOI	T°C$_W$	EC	SAL	pH	SPEC	DO	DO%	TDS	ATM	COORD.
19	8	0,1	0,5	3	0,15	1020	18,3	19	26,9	563	0,26	8,61	543	12,45	158	0,351	675,9	N39°19'642" E33°01'104"
20	14	0,2	0,4	13	1,04	1064	33,4	23	24,2	2690	1,41	8,6	2730	11,59	141	1,7745	671,9	N39°23'369" E32°57'936"
21	63	0,3	0,6	7	1,26	1183	37,3	19	17,2	486,3	0,28	7,8	574,1	7,28	76,6	0,3725	663	N39°25'688" E32°54'001"
22		0,5	0,6	21	6,3	1068	34,4	21	18,8	1782	1,04	7,46	2027	16,13	177,1	1,313	670,5	N39°36'252" E32°50'735"
23	43	0,5	0,7	6	2,1	1182	33,1	25	13,6	642	0,41	7,3	822	5,5	52,8	0,533	662	N39°41'341" E32°53'791"
24		0,4	0,4	6	0,96	1202	28,9	23	15,9	412	0,24	0,34	498,2	7,44	76,7	0,3244	660,1	N39°44'474" E32°59'133"
25		0,2	0,5	10	1	1212	23,8	35	19,6	778	0,43	8,1	869	13,54	148,5	0,5655	675,2	N39°44'472" E32°59'128"
26		0,2	0,5	7	0,7	959	24,3	45	19,7	752	0,41	8,64	836	15,85	175,5	0,5395	680	N39°39'727" E33°04'664"
27		0,3	0,5	12	1,8	1029	25,6	39	24,3	2141	1,11	7,97	2171	12,64	153,1	1,4105	674,4	N39°38'860" E33°09'233"
28	6	0,7	0,4	10	2,8	1049	24,1	30	19,9	478,1	0,26	0,5	529,6	6,9	76,4	0,3445	673,3	N39°33'435" E32°12'932"
29	13	0,4	0,5	8	1,6	926	21,3	37	15,3	4121	2,74	6,93	5070	7,54	79,5	3,2955	683	N39°27'744" E33°13'202"

Appendix 1. continued

ST. NO	age	dep. (m)	wid. (m)	leng .(m)	VOL .(M3)	ALT. (m)	T°C$_A$	MOI	T°C$_W$	EC	SAL	pH	SPEC	DO	DO%	TDS	ATM	COORD.
30		0,5	0,7	18	6,3	1001	21,3	36	19,3	410,6	0,22	7,56	459,6	8,18	89	0,297	677,4	N39°26'158" E33°10'946"
31		0,1	0,4	6	0,24	1032	20,7	47	15,4		0,79	7,45	1553	2,84	27,9	1,2075	674,7	N39°31'259" E32°57'174"
32		0,1	0,4	14	0,56	884	24,1	42	13,1	632	0,41	7,57	820	4,48	44	0,533	687,9	N40°09'349" E32°37'696"
33	40	0,2	0,3	11	0,66	992	26,4	29	16,5	279,1	0,16	7,87	334,5	9,05	94,2	0,2171	678,6	N40°11'866" E32°36'193"
34	61	0,3	0,6	4	0,72	925	25,3	30	17,8	309,7	0,17	7,92	359,7	8,35	89,5	0,2334	683	N40°13'997" E32°46'739"
35		0,5	0,3	9,6	1,44	923	31,2	25	16,5	433,9	0,25	7,66	522,5	9,13	95,8	0,3387	683,4	N40°12'320" E32°43'956"
36	59	0,2	0,4	6	0,48	922	35,2	27	19,3	435,2	0,24	7,46	490,2	8,71	95,5	0,3165	683,5	N40°15'404" E32°42'349"
37	31	0,3	0,5	2	0,3	976	32,9	26	14,7	452,6	0,28	7,56	576	7,93	80,1	0,3685	679	N40°19'646" E32°43'431"
38	19	0,3	0,4	3	0,36	1117	33,8	25	20,1	188,8	0,11	8,05	208,6	7,08	78,9	0,1352	667,2	N40°24'222" E32°43'059"
39		0,3	0,5	2	0,3	1457	37,7	18	19,4	479,8	0,26	7,71	543,3	12,1	132,8	0,3517	641,1	N40°27'363" E32°50'382"
40	74	0,6	0,5	6	1,8	1404	38,5	21	14	380,1	0,23	7,81	482,8	11,48	112,4	0,3133	644,7	N40°30'181" E32°45'127"

Appendix 1. continued

ST. NO	age	dep. (m)	wid. (m)	leng .(m)	VOL .(M3)	ALT. (m)	T°C$_A$	MOI	T°C$_W$	EC	SAL	pH	SPEC	DO	DO%	TDS	ATM	COORD.
41	62	0,2	0,3	6	0,36	1028	32,3	22	25,4	137,4	0,06	9,15	136,7	13,61	164,5	0,089	671,5	N40°32'548" E32°36'664"
42		0,3	0,7	0,3	0,63	1339	32,2	26	26,9	130,1	26,9	9,93	125,5	11,61	144,9	0,0813	648,5	N40°36'573" E32°32'422"
43	17	0,3	0,4	3	0,36	940	27,6	28	19,8	234,8	0,12	8,22	260,7	9,31	104,5	0,1697	679,2	N40°26'398" E32°38'982"
44	48	0,5	0,3	16	2,4	936	28,4	29	16,1	491,1	0,29	8,09	594,9	9,65	98,5	0,3861	678,4	N40°22'829" E32°34'457"
45		0,1	0,6	6	0,36	776	27,3	46	22,1	580	0,3	7,48	617	5,21	62,1	0,403	690,3	N40°18'253" E32°25'829"
46	5	0,6	0,6	18	6,48	869	27,2	33	17,6	174	0,1	7,72	202,4	8,17	85,8	0,1313	684,3	N40°16'738" E32°18'594"
47	60	0,5	0,4	12	2,4	806	25,5	31	27,2	484,9	0,22	8,79	464,5	11,88	152,4	0,3016	689,3	N40°13'419" E32°16'525"
48	60	0,7	0,5	14	4,9	880	26,1	30	18,3	664,9	0,26	7,77	535,2	8,62	93,3	0,3478	684,7	N40°11'362" E32°12'861"
49	100	0,4	0,6	12	2,88	1025	23,5	41	16,5	437,8	0,25	7,52	522,4	9,45	96,8	0,34	672,7	N40°09'281" E32°14'132"
50		0,32	0,5	10	1,6	1044	27,4	39	19,1	727	0,48	7,47	823	9,98	109,1	0,533	670,7	N39°44'000" E32°30'352"
51	58	0,45	0,85	11	4,21	779	30,4	33	17,9	936	0,54	7,61	1085	8,57	92	0,702	693,7	N39°46'970" E32°23'272"

Appendix 1. continued

ST. NO	age	dep. (m)	wid. (m)	leng. (m)	VOL .(M3)	ALT. (m)	T°C$_A$	MOI	T°C$_W$	EC	SAL	pH	SPEC	DO	DO%	TDS	ATM	COORD.
52		0,3	0,2	5	0,3	772	34,6	26	16,3	429,8	0,25	9,13	519,8	9,95	102,5	0,3387	683,8	N39°42'280" E32°13'301"
53		0,3	0,4	28	3,36	1032	38,1	18	21,3	424,3	0,22	8,12	439,3	10,7	121,9	0,2977	670,3	N39°43'666" E32°11'525"
54		0,32	0,6	13	2,5	689	39,1	17	15	5555	3,78	7,44	6873	4,25	436	4,459	696,5	N39°39'465" E31°59'473"
55	7	0,3	0,6	20	3,6	765	40,1	13	23,4	3205	1,74	8,7	3311	12,9	163,4	2,1515	689,8	N39°43'956" E31°51'136"
56	40	0,42	1,5	12	23,1	839	37,6	13	18,2	258,2	0,2	7,72	417,8	10,51	111,3	0,2695	679	N39°28'856" E32°11'370"
57	17	0,15	0,7	17	1,79	832	39,5	17	28	1070	0,5	7,82	1012	7,11	95	0,6565	683,6	N39°26'801" E32°07'537"
58		0,2	0,5	14	1,4	862	35	20	17,4	685	0,4	7,61	805	6,62	70,03	0,5265	684,3	N39°21'947" E32°05'972"
59	45	0,3	0,4	25	3	743	34,1	23	25,8	995	0,48	8,54	981	13,32	164,3	0,637	690,5	N39°17'392" E32°03'869"
60	4	0,3	0,25	35	2,63	785	34,4	30	18,3	4667	2,94	7,31	5422	8,82	94,2	3,523	687,4	N39°16'219" E32°00'279"
61		0,5	0,35	2	0,35	842	31,8	30	20,7	975	0,53	9,22	1061	10	112,3	0,689	681,7	N39°05'390" E31°59'649"
62		0,4	0,55	12	2,64	1053	25,4	40	12,5	483,7	0,31	7,4	635,3	6,9	64,8	0,6128	668,3	N39°28'538" E32°22'223"

Appendix 1. continued

ST. NO	age	dep. (m)	wid. (m)	leng .(m)	VOL .(M3)	ALT. (m)	T°C$_A$	MOI	T°C$_W$	EC	SAL	pH	SPEC	DO	DO%	TDS	ATM	COORD.
63	95	0,2	0,5	5	0,5	930	27,7	35	18,2	956	0,55	7,5	1497	7,09	76,7	0,715	678,2	N39°22'201" E32°20'654"
64	2	0,3	0,7	8	1,68	1152	28,6	34	20,7	641	0,34	7,75	699	7,86	89,1	0,455	660,3	N39°19'125" E32°24'287"
65		0,05	0,5	3	0,08	1057	23,4	40	21,1	392,2	0,2	8,53	423,1	7,27	83,8	0,275	667,8	N39°13'284" E32°22'425"
66		0,35	0,5	6	1,05	983	24,2	44	16,6	1921	1,18	7,43	2293	7,64	79,9	1,4885	674	N39°05'022" E32°30'091"
67	42	0,15	0,5	20	1,5	1132	25	39	17,6	424,1	0,24	7,77	496,5	10,9	115,1	0,3224	662	N39°10'149" E32°38'139"
68		0,3	0,5	45	6,75	1140	22	42	17,9	652	0,37	7,56	755	6,76	70,7	0,4875	661,8	N39°14'997" E32°42'048"
69		0,6	0,8	16	7,68	1110	23,3	42	13	889	0,58	7,43	1154	5,82	55,5	0,7475	664,1	N39°17'875" E32°35'671"
70	13	0,4	0,5	20	4	1064	20,4	43	18,7	1198	0,68	7,75	1362	9,21	102,4	0,884	668,2	N39°16'430" E32°35'031"
71	55	0,3	0,4	10	1,2	1335	18,5	45	12,4	431,5	0,28	7,37	568	8,59	80,1	0,3698	647	N39°25'669" E32°33'210"
72	50	0,2	0,7	5	0,7	1292	18,1	47	12,9	381,1	0,24	7,41	496,1	6,01	52	0,3224	651	N39°26'428" E32°38'084"

Appendix 1 continued

ST. NO	age	dep. (m)	wid. (m)	leng. (m)	VOL .(M3)	ALT. (m)	T°C$_A$	MOI	T°C$_W$	EC	SAL	pH	SPEC	DO	DO%	TDS	ATM	COORD.
73	13	0,2	0,5	1	0,1	1204	16	50	14	757	0,48	7,33	958	1,33	13,8	0,624	657,8	N39°29'903" E32°33'872"
74	32	0,3	0,5	0,8	1,2	1153	16,4	53	12,7	542	0,35	7,44	709	6,04	56,7	0,4615	661,9	N39°35'880" E32°32'989"
75		0,2	0,4	14	1,12	1048	15,8	53	14,6	656	0,4	7,74	819	6,38	61,4	0,533	670,6	N39°32'785" E32°42'381"
76		0,3	0,3	15	1,35	840	27,9	28	16,9	765	0,45	7,96	907	8,66	90	0,5915	687,2	N40°11'556" E31°32'461"
77		0,1	0,3	2	0,06	895	21,4	31	18,9	622	0,34	8,09	703	8,74	96,7	0,455	682,4	N40°11'875" E31°32'927"
78	35	0,4	0,64	0,5	1,3	902	17,6	42	14,4	376,2	0,23	7,92	471,6	8,66	84,8	0,3068	669	N40°16'451" E31°30'859"
79	60	0,3	0,45	5	0,68	895	16,4	65	15,7	373,8	0,22	8,11	654,5	10,27	104,4	0,2958	677,6	N40°17'102" E31°28'455"
80		0,5	0,7	2	0,7	960	16,4	56	15,3	481,5	0,29	7,89	590,7	8,57	84	0,3842	703,8	N40°17'102" E31°28'458"
81		0,2	0,15	2,5	0,08	1269	15,9	50	14	472,4	0,29	8,02	597,4	7,2	70,4	0,3881	654,2	N40°12'874" E31°12'611"
82	15	0,3	0,4	1,5	0,18	1269	15,9	50	13,8	467,3	0,29	7,36	595	8,28	80,8	0,3868	654,4	N40°12'874" E31°12'611"
83	13	0,2	0,28	14.5	0,48	1265	21,1	36	13,7	506	0,32	7,47	647	9,04	87,1	0,4225	669	N40°12'873" E31°12'632"

Appendix 1. continued

ST. NO	age	dep. (m)	wid. (m)	leng. (m)	VOL .(M3)	ALT. (m)	$T^{\circ}C_A$	MOI	$T^{\circ}C_W$	EC	SAL	pH	SPEC	DO	DO%	TDS	ATM	COORD.
84	52	0,45	0,45	6	1,22	442	20	42	20,9	597	0,32	8,16	648	9,31	111,1	0,4225	720,3	N40°08'994" E30°55'550"
85	45	0,4	0,5	3	0,6	751	23,4	39	16,7	952	0,57	7,88	1132	11,21	118,1	0,7345	696,5	N40°07'126" E31°07'037"
6	12	0,2	0,2	1,5	0,06	566	21,3	44	18,4	677	0,37	7,97	7,63	7,58	81,3	0,494	709,8	N40°08'135" E31°20'648"
87	3	0,5	0,35	3,8	1,28	482	19,7	43	17,2	832	0,49	8,12	977	8,85	91,6	0,637	717,4	N40°04'750" E31°25'736"
88	62	0,25	0,5	6	0,75	765	27,2	26	15,9	1066	0,65	7,57	1291	7,7	78,2	0,8385	692,7	N40°09'154" E32°05'744"
89	11	0,3	0,5	24	3,6	798	30,4	26	18,2	578	0,32	8,5	666	19,05	202,3	0,4355	689,1	N40°15'146" E32°05'078"
90		0,35	0,45	13	2,05	1316	27,7	27	17,3	300,4	0,17	9,02	353,5	18,84	196,3	0,2294	647,9	N40°14'144" E31°55'532"
91	10	0,4	0,5	14	2,8	1330	24,2	30	15,3	11,04	0,68	7,69	13,56	9,52	96	0,8775	645,3	N40°16'405" E31°52'164"
92	14	0,25	0,5	9	1,13	1235	26,9	25	22,1	253,7	0,13	9,27	268,4	18,4	211,2	0,1748	653	N40°17'434" E31°46'257"
93		0,1	0,35	8	0,28	840	25,1	28	15,1	417,5	0,25	8	516	10,63	106,6	0,3361	685,2	N40°11'845" E31°45'216"
94		0,3	0,4	40	4,8	519	26	26	24,8	2775	1,44	8,7	2786	12,13	148	1,8135	710,6	N40°04'435" E31°48'121"

Appendix 1. continued

ST. NO	age	dep. (m)	wid. (m)	leng .(m)	VOL .(M3)	ALT. (m)	T°C$_A$	MOI	T°C$_W$	EC	SAL	pH	SPEC	DO	DO%	TDS	ATM	COORD.
95	13	0,2	0,5	9	0,9	906	24,1	30	15,7	412	0,24	7,68	504,3	8,69	87,1	0,3276	678,9	N40°02'998" E31°56'816"
96	12	0,45	0,6	7	1,89	939	20,6	40	17,4	368,2	0,21	7,45	431,1	8,66	93,1	0,2802	676,4	N40°03'504" E32°00'246"
97	60	0,2	0,4	6	0,48	1060	22	42	15,8	275	0,16	7,4	334	7,24	74,4	0,2165	667,9	N40°05'998" E32°24'148"
98	40	0,4	0,4	20	3,2	1062	18,8	43	14,5	361,7	0,22	8,15	453	7,9	79,3	0,2931	668,7	N40°10'872" E32°28'527"
99	44	0,2	0,3	2	0,12	1039	22,4	43	16,5	1850	0,1	7,4	221,3	7,03	72,8	0,1437	672	N40°11'723" E32°27'420"
100	50	0,5	0,5	8	2	1079	21,8	39	18,3	175,1	0,1	7,67	201,4	9,08	93	0,1313	668	N40°05'568" E32°19'788"
101	30	0,2	0,4	18	1,44	726	24,4	40	20,8	536	0,28	7,89	582	6,93	78,2	0,377	696,5	N40°03'769" E32°15'600"
102		0,3	0,6	20	3,6	794	26	29	14,7	489,6	0,3	7,54	609,4	5,4	54,1	0,3965	691,1	N39°59'734" E32°16'123"
103		0,5	1	2	1	1166	23	28	19,1	294,3	0,16	9,62	329,6	16,02	176	0,2139	661,2	N39°57'826" E32°23'591"
104		0,2	0,25	30	1,5	1184	28	28	13,2	446,5	0,28	7,56	577,1	9,7	93	0,3751	659,8	N40°03'220" E32°22'774"

Appendix 1. continued

ST. NO	age	dep. (m)	wid. (m)	leng. (m)	VOL. (M3)	ALT. (m)	T°C$_A$	MOI	T°C$_W$	EC	SAL	pH	SPEC	DO	DO%	TDS	ATM	COORD.
105	55	0,3	0,6	10	1,8	1029	28,6	27	17,7	763	0,44	7,5	884	6,16	64,8	0,572	671,3	N39°46'914" E32°50'246"
106		0,1	0,6	2	0,12	1029	28,3	26	17,7	390,8	0,22	7,87	455,2	7,31	78,7	0,2958	666,6	N39°46'104" E32°43'413"
107	18	0,4	0,2	2	0,16	1157	25,9	25	13,2	424	0,27	7,46	540,4	6,65	64,9	0,3575	661,3	N39°40'589" E32°38'848"
108		0,4	0,6	25	6	1376	20,2	53	13,4	89,2	0,05	7,17	114,7	4,48	43,7	0,0748	645,9	N40°32'721" E32°31'633"
109	65	0,6	0,6	24	8,64	1297	24,9	47	18,1	89,9	0,05	7,22	104,5	10,03	110	0,0682	651,4	N40°31'425" E32°25'861"
110		0,2	0,4	4	0,32	1148	22,9	42	14,7	75,8	0,04	8,57	95	11,69	113	0,0618	662,5	N40°29'577" E32°18'045"
111		0,2	0,4	5	0,4	1025	23,8	44	12,8	538	0,35	7,43	70,2	8,15	79,3	0,455	672,3	N40°25'643" E32°21'027"
112		0,7	0,4	15	4,2	1193	25,3	38	18,7	98,9	0,05	7,33	112,5	10,89	117	0,0744	659	N40°27'502" E32°28'638"
113	48	0,1	0,6	20	1,2	1196	25,6	38	14,2	557	0,34	7,41	701	6,93	68,5	0,455	658,9	N40°27'503" E32°28'638"
114		0,2	0,4	3	0,24	994	31,3	28	19,9	344,8	0,18	8,58	382	10,74	117,8	0,2483	673,7	N39°52'972" E33°16'657"

Appendix 1. continued

ST NO	age	dep. (m)	wid. (m)	leng .(m)	VOL. (M3)	ALT. (m)	$T^{\circ}C_A$	MOI	$T^{\circ}C_W$	EC	SAL	pH	SPEC	DO	DO%	TDS	ATM	COORD.
115	10	0,2	0,4	5	0,4	932	29,1	34	15,2	574	0,35	7,67	708	3,92	38,7	0,4615	678,7	N39°46'111" E33°12'663"
116	33	0,2	0,4	10	0,8	926	26,5	32	18,7	588	0,33	8,11	670	10,9	117,1	0,4355	668,4	N39°51'343" E33°13'053"
117	52	0,2	0,3	8	0,48	1335	25,7	32	15,1	387,2	0,23	7,5	478,6	9,27	91,1	0,3107	646,6	N39°48'580" E33°03'820"
118		0,4	0,55	4	0,88	998	24,4	56	18,1	686	0,39	7,35	792	5,77	61,3	0,5135	673,8	N40°03'815" E33°00'443"
119		0,4	0,8	10	3,2	1118	28,3	45	14,8	586	0,36	7,75	728	7,5	74,3	0,4745	664,5	N40°05'003" E33°05'024"
120		0,4	0,3	20	2,4	1118	26	62	13,2	284,6	0,18	7,53	398	9,53	92	0,2392	663,4	N40°05'004" E33°05'024"
121		0,3	0,5	4	0,6	1309	21,1	58	12	484,5	0,32	7,3	647,2	6,1	57,2	0,42	629,7	N40°08'134" E33°10'160"
122	50	0,2	0,4	11	0,88	1304	20,2	86	13,8	720	0,46	7,55	919	8,02	60,9	0,598	649,2	N40°08'135" E33°10'141"
123	42	0,2	0,5	12	1,2	1304	19,1	85	13,6	358,4	0,22	7,47	458,2	9,23	88,6	0,2977	658	N40°08'135" E33°10'161"
124		0,5	0,4	3	0,6	990	19,7	73	16,5	430,7	0,25	7,78	512,7	8,67	88,1	0,3335	675,1	N40°05'288" E33°22'651"

Appendix 1. continued

ST. NO	age	dep. (m)	wid. (m)	leng .(m)	VOL .(M3)	ALT. (m)	T°C$_A$	MOI	T°C$_W$	EC	SAL	pH	SPEC	DO	DO%	TDS	ATM	COORD.
125	20	0,5	0,4	3	0,6	840	30,9	40	22,6	600	0,31	8,11	629	9,14	106,3	0,4095	683	N40°04'021" E33°28'006"
126		0,5	0,3	6	0,9	681	30,5	34	18,7	648	0,36	7,97	737	7,82	84,4	0,481	698,8	N40°06'724" E33°30'381"
127	9	0,4	0,8	6	1,92	980	31,1	39	13,7	3866	0,23	7,79	470,7	7,48	76,4	0,3055	674,6	N40°10'572" E33°30'256"
128	63	0,1	0,4	8	0,32	980	33,8	39	23,6	701	0,35	9,89	720	10,1	120,3	0,468	692,5	N40°14'160" E33°31'343"
129		0,4	0,5	8	1,6	705	28,8	43	23,4	15,94	0,83	8,22	16,43	9,89	114,8	1,766	696,3	N40°18'24" E33°34'961"
130		0,6	0,5	16	4,8	967	23,7	52	20,2	562	0,3	7,74	618	8,72	97,7	0,403	675,9	N40°16'75" E33°25'501"
131	11	0,4	0,2	10	0,8	815	23,6	56	19,8	899	0,49	7,96	999	7,57	83,3	0,65	689,1	N40°19'75" E33°19'428"
132	12	0,2	0,3	8	0,48	998	22,3	58	15,7	841	0,51	7,64	10,25	3,68	38,1	0,6695	673,7	N40°13'627" E33°20'359"
133		0,4	0,3	2	0,24	1066	29,8	40	13,8	582	0,36	7,62	742	8,16	77,7	0,481	670,1	N40°09'423" E32°51'871"
134		0,4	0,3	15	1,8	1048	29,9	60	20,8	700	0,37	7,9	761	14,48	165,4	0,494	678	N40°15'895" E32°54'555"

Appendix 1. continued

ST. NO	age	dep (m)	wid. (m)	leng .(m)	VOL .(M3)	ALT. (m)	T°C$_A$	MOI	T°C$_W$	EC	SAL	pH	SPEC	DO	DO%	TDS	ATM	COORD.
135	42	0,3	0,7	8	1,68	1297	33,4	27	15	736	0,04	6,49	90,8	7,99	79,5	0,0585	651,4	N40°19'120" E32°58'565"
136		0,4	0,6	3	0,72	1420	36,2	26	12,9	503	0,32	7,93	658	8,48	81,1	0,429	642,1	N40°27'288" E32°54'623"
137		0,4	0,5	15	3	1251	29,2	30	19,4	386,8	0,21	7,59	434,3	10,17	112,2	0,2821	654,6	N40°20'963" E33°03'858"
138		0,1	0,2	0,6	0,01	1251	29,2	30	19,4	386,8	0,21	7,59	434,3	10,17	112,2	0,2821	654,6	N40°20'963" E33°03'858"
139	62	0,5	0,4	7	1,4		28,7	38	15,2	506	0,3	7,58	624	6,05	59,9	0,403	680	
140		0,3	0,4	7	0,84		26,5	36	17,1	176,8	0,1	6,86	208,2	9,8	103,6	0,1352	661,8	
141	100	0,1	0,3	4	0,12		26,5	43	13,6	459	0,29	7,3	591,1	4,51	64,3	0,3842	657,7	
142	30	0,1	0,7	0,2	1,4		23,6	49	13,1	16,88	1,13	7,19	21,92	2,5	25,5	1,4235	673,7	

Appendix 2. Collection date and the number of species per trough. St. No: Station number.

DATE	St.No	EU	PC	TP	DB	AR	PF	AV	PI	MH	CS	PA	OT	LL	MM	MB	CAN	ATT	BR	Total	SP.CODE
22.06.2011	1		17																	1	PC
22.06.2011	2																			0	
22.06.2011	3	8															1			2	EU, CAN
22.06.2011	4	2																		1	EU
22.06.2011	5																			0	
22.06.2011	6																			0	
22.06.2011	7									1	3									2	MH, CS
22.06.2011	8	3		4						76										3	EU,TP,MH
22.06.2011	9	36					3						1							3	EU,PF,OT
22.06.2011	10									162										1	MH
22.06.2011	11	7																		1	EU
22.06.2011	12	98								89								2		3	EU,MH,ATT
23.06.2011	13																			0	
23.06.2011	14									1										1	MH
23.06.2011	15	51					2			4									2	4	EU,PF,MH,BR
23.06.2011	16																			0	
23.06.2011	17																			0	
23.06.2011	18																			0	
23.06.2011	19		7							51		57								3	PC,MH,PA
23.06.2011	20	1								3					2					3	EU,MH,MM
23.06.2011	21									2										1	MH

Appendix 2. continued

DATE	St.No	EU	PC	TP	DB	AR	PF	AV	PI	MH	CS	PA	OT	LL	MM	MB	CAN	ATT	BR	Total	SP.CODE
23.06.2011	22	62	10							228										3	EU,PC,MH
23.06.2011	23																			0	
23.06.2011	24	6								1	2									3	EU,MH,CS
23.06.2011	25	4	2							8	3		11							5	EU,PC,MH,CS,OT
23.06.2011	26	281																		1	EU
23.06.2011	27																			0	
23.06.2011	28									142										1	MH
23.06.2011	29				12															1	DB
23.06.2011	30	2									2									2	EU,CS
23.06.2011	31																			0	
24.06.2011	32																			0	
24.06.2011	33		5																	1	PC
24.06.2011	34	221																		1	EU
24.06.2011	35																			0	
24.06.2011	36																			0	
24.06.2011	37	6																		1	EU
24.06.2011	38	26																		1	EU
24.06.2011	39	153	6				6			1	8						10			6	EU,PC,PF,MH,CS,CAN
24.06.2011	40					10											12			2	AR, CAN
24.06.2011	41	646																		1	EU
24.06.2011	42																			0	

Appendix 2. continued

DATE	St.No	EU	PC	TP	DB	AR	PF	AV	PI	MH	CS	PA	OT	LL	MM	MB	CAN	ATT	BR	Total	SP.CODE
24.06.2011	43		11																	1	PC
24.06.2011	44	84									16	2								3	EU,CS,PA
24.06.2011	45																			0	
24.06.2011	46	3	21								234									3	EU,PC,CS
24.06.2011	47	35																		1	EU
24.06.2011	48		2							1										2	PC,MH
24.06.2011	49	4								298										2	EU,MH
25.06.2011	50	1																		1	EU
25.06.2011	51																			0	
25.06.2011	52																			0	
25.06.2011	53						3						84							2	PF,OT
25.06.2011	54																			0	
25.06.2011	55	12																		1	EU
25.06.2011	56	16																		1	EU
25.06.2011	57	129									13									2	EU, CS
25.06.2011	58		7																	1	PC
25.06.2011	59		1																	1	PC
25.06.2011	60						2						11							2	PF,OT
25.06.2011	61																			0	
26.06.2011	62																			0	
26.06.2011	63																			0	
26.06.2011	64																			0	

Appendix 2. continued

DATE	St. No	EU	PC	TP	DB	AR	PF	AV	PI	MH	CS	PA	OT	LL	MM	MB	CAN	ATT	BR	Total	SP. CODE
26.06.2011	65																			0	
26.06.2011	66	1					2													2	EU, PF
26.06.2011	67	290								119										2	EU, MH
26.06.2011	68	3					5													2	EU, PF
26.06.2011	69																			0	
26.06.2011	70																			0	
26.06.2011	71										10									1	CS
26.06.2011	72																			0	
26.06.2011	73	4						64			16									3	EU, AV,CS
26.06.2011	74									1										1	MH
26.06.2011	75							3												1	AV
27.06.2011	76	5																		1	EU
27.06.2011	77																			0	
27.06.2011	78										1									1	CS
27.06.2011	79	3																		1	EU
27.06.2011	80																			0	
27.06.2011	81	3																		1	EU
27.06.2011	82																			0	
27.06.2011	83	63					2													2	EU, PF
27.06.2011	84		7								127									2	PC, CS
27.06.2011	85						7													1	PF

Appendix 2. continued

DATE	St.No	EU	PC	TP	DB	AR	PF	AV	PI	MH	CS	PA	OT	LL	MM	MB	CAN	ATT	BR	Total	SP.CODE
27.06.2011	86																			0	
27.06.2011	87						1													1	PF
28.06.2011	88																			0	
28.06.2011	89		1																	1	PC
28.06.2011	90						2				4									2	PF, CS
28.06.2011	91																			0	
28.06.2011	92										40									1	CS
28.06.2011	93	304																		1	EU
28.06.2011	94		2																	1	PC
28.06.2011	95																			0	
28.06.2011	96	94																		1	EU
30.06.2011	97																			0	
30.06.2011	98						2													1	PF
30.06.2011	99																			0	
30.06.2011	100	104																		1	EU
30.06.2011	101	3																		1	EU
30.06.2011	102													32						1	LL
30.06.2011	103									94										1	MH
30.06.2011	104	74								8										2	EU,MH
30.06.2011	105	60																		1	EU
30.06.2011	106	2	3							1	1									4	EU,PC,MH,CS

Appendix 2. continued

DATE	St.No	EU	PC	TP	DB	AR	PF	AV	PI	MH	CS	PA	OT	LL	MM	MB	CAN	ATT	BR	Total	SP. CODE
30.06.2011	107										2									1	CS
01.07.2011	108	3																		1	EU
01.07.2011	109	113									155									2	EU, CS
01.07.2011	110	239								25	704									3	EU, MH,CS
01.07.2011	111	44								11	2									3	EU, MH,CS
01.07.2011	112	45								2	11						1	1		5	EU, MH,CS,CAN,ATT
01.07.2011	113	1																		1	EU
01.07.2011	114						2		1	2										3	PF,PI,MH
01.07.2011	115																			0	
01.07.2011	116										23									1	CS
01.07.2011	117																			0	
02.07.2011	118																			0	
02.07.2011	119															1				1	MB
02.07.2011	120																			0	
02.07.2011	121	1																		1	EU
02.07.2011	122							7									2			2	AV, CAN
02.07.2011	123	26								104		30								3	EU, MH,PA
02.07.2011	124	1114									34									2	EU, CS
02.07.2011	125	2																		1	EU
02.07.2011	126										1									1	CS
02.07.2011	127	154																		1	EU

Appendix 2. continued

DATE	St.No	EU	PC	TP	DB	AR	PF	AV	PI	MH	CS	PA	OT	LL	MM	MB	CAN	ATT	BR	Total	SP.CODE
02.07.2011	128																			0	
02.07.2011	129	11																		1	EU
02.07.2011	130	12								115		4								3	EU,MH,PA
02.07.2011	131	2																		1	EU
02.07.2011	132																			0	
03.07.2011	133	12					3													2	EU,PF
03.07.2011	134																			0	
03.07.2011	135	8				11								1			1			4	EU,AR,LL,CAN
03.07.2011	136																			0	
03.07.2011	137	5																		1	EU
03.07.2011	138	11					2				3									3	EU,PF,CS
03.07.2011	139	25																		1	EU
03.07.2011	140	21					56			46										3	EU,PF,MH
03.07.2011	141	30					3													2	EU,PF
03.07.2011	142	125					3			35										3	EU,PF,MH
	Total	4914	102	4	12	21	106	74	1	1631	1415	93	107	33	2	1	27	3	2	178	

Appendix 3. Poisson distribution calculations

species number per through	0	1	2	3	4
through	43	54	21	18	6

Mean=((0*43)+(1*54)+(2*21)+(3*18)+(4*6)) / 142 so mean is almost equal to 1.22.

μ^x	$e^{-\mu}$	x	x!	$e^{-\mu}*\mu^x/x!$
1	0.295268	0	1	0.295267514
1.22	0.295268	1	1	0.360226368
1.4884	0.295268	2	2	0.219738084
1.815848	0.295268	3	6	0.089360154
2.215335	0.295268	4	24	0.027254847

Poisson Probabilities;

class	x	f(obs.freq.)	f(x)	$f(x^2)$	pois. Prob	expec.prob
1	0	43	0	0	0.295267514	41.92799
2	1	54	54	54	0.360226368	51.15214
3	2	21	42	84	0.219738084	31.20281
4	3	18	54	162	0.089360154	12.68914
5	4	6	24	96	0.027254847	3.870188

class	x	f(obs.freq)	exp prob	O-E	$(O-E)^2$	$(O-E)^2/E$
1	0	43	41.92799	1.072013	1.149211785	0.027409
2	1	54	51.15214	2.847856	8.110282717	0.158552
3	2	21	31.20281	-102028	104.0972902	3.336151
4	3	18	12.68914	5.310858	28.20521374	2.222783
5	4	6	3.870188	2.129812	4.536097962	1.172061

df = n -2, df=3

Calculated chi square is 6.916957, p = 0.05, table chi square is 7.815. While calculated chi square is smaller than the table chi square, we accept null hypothesis.

$s^2 = \sum f(x2)-N(m2)/N-1 = 1.309555$

$s^2/\mu = 1.04764$, nearly 1.04

PHOTOS



Photo 1. Station 6, Solokuşağı Village, Evren



Photo 2. Station 12, Yöreli Village, Bala



Photo 3. Station 21, Çimşit Village, Gölbaşı



Photo 4. Station 27, Ergin Village, Bala



Photo 5. Station 55, Ömerli Village, Polatlı



Photo 6. Station 61, Uzunbey Village, Polatlı



Photo 7. Station 87 Hıdırlar Village, Nallıhan



Photo 8. Station 108, Avdan Village, Çamlıdere



Photo 9. Station 132, Değirmenköy, Kalecik



Photo 10. Station 135, SaraycıkVillage, Çubuk