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Orjinal Article

The Effect of Climatic Factors of Karamık and Acıgöl Lakes on the Distribution of the Species of Water Mites (*Acari, Hydrochnida*)

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Abstract

The purpose of this study was to assess water mites (*Acari, Hydrochnida*), which are biological indicator organisms of water fauna, in Acıgöl (Denizli province) which is a salt water lake situated in a prevalently semi-arid climate and Karamık Lake, which is a freshwater lake located in a subhumid climate. Specifically the lake waters being either salty or fresh are among the main dominant factors determining the number of water mite species. While the number of species in the salty waters with playa characteristics of Acıgöl were limited, it was observed that although the freshwater Karamık Lake had started to dry up because of global warming, the number of species was more plentiful. Both lakes were particularly studied from the perspective of climate characteristics and it was determined that both had entered the exsiccation process related to global climate change. While the climatic drought tendency has an effect on the low water level, it also reduces the habitats of the water mites. The study also includes the dissemination areas of watermites determined in the Republic of Turkey.

Key words*: Climate, Lake, Indicator organism, Turkey, Watermite*

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INTRODUCTION

In this study, ecological risks brought on by draught, have been studied by comparing the reactions of indicator organisms from two lakes from the Lakes Region in Turkey, one of them being Acıgöl which is located in an area with dominantly semiarid climate conditions and the other one, Karamık Lake, which is located in an area where subhumid climate conditions prevail (Figure 1). Acıgöl has been studied by various researchers, arid and semiarid areas have been noted for providing good examples of playa, shot, sebha, salar and Salinas (Erinç 1967).

As can be understood from its name, the waters of Acıgöl (Bitter Lake) are salty. Just like Karamık Lake, Acıgöl Lake is a tectonically formed lake in the Lakes Region. In his doctoral dissertation regarding the Sultandağları and its environs, Atalay (1977) pointed out that Karamık Lake was a rather shallow tectonic lake located on the western edge of Sultandagları and highly affected by seasonal level changes (Atalay 1977).

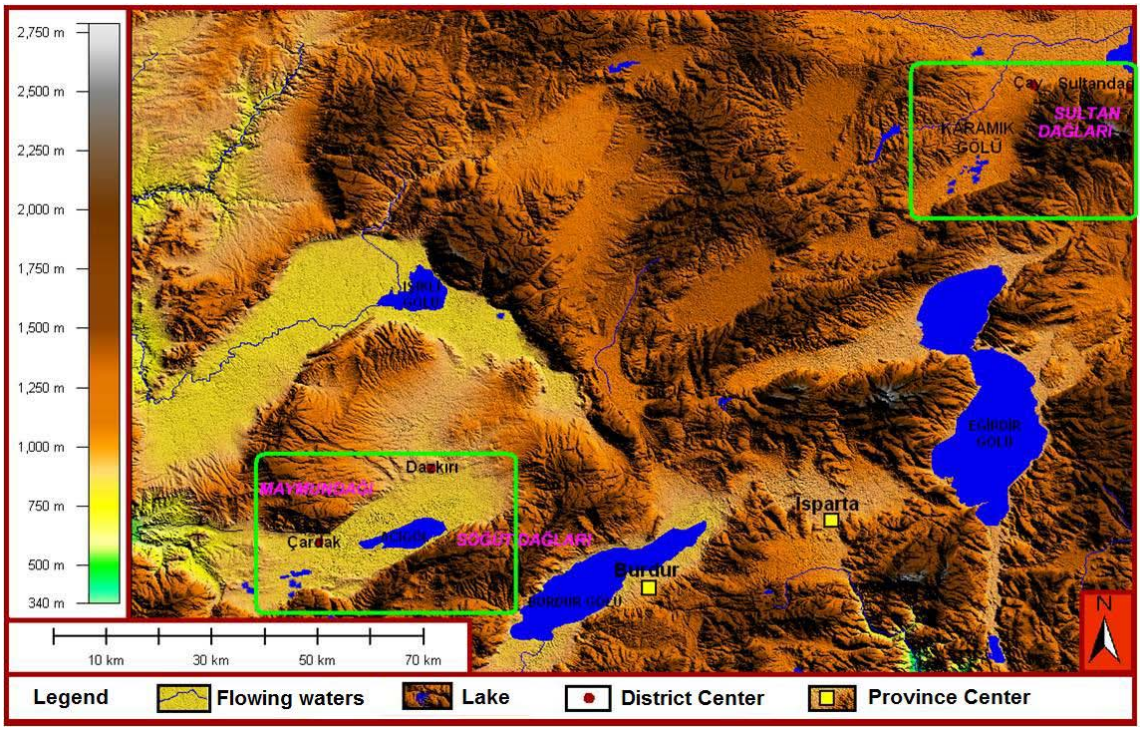

Figure 1 A three dimensional site location map of Acıgöl and Karamık Lakes.

This study concentrated on emphasizing the richness of the biological indicator organism species formed in accordance with the hydro-climatic characteristics of lake Acıgöl which is one of the salt water lakes and the freshwater lake Karamık which are located in the Lakes Region of Turkey. Acıgöl is situated within the borders of Denizli and Afyonkarahisar provinces. The precipitation area of Acıgöl is 1292.0 km^2. The lake is supplemented by its own catchment area as well as faulting and karstic sources. Karamık Lake, on the other hand, is located within the boundaries of Çay district in Afyonkarahisar province on the northwest section of Sultandağları. Both lakes have a tectonic origin.

Acıgöl is situated on the west wing of the Batı Toroslar (Western Toros Mountains) within an area where block faulting tectonics is quite prevalent (Yağmurlu and Şentürk 2006). The deepest point of this NE-SW striking depression, which is associated with the faults playing a part in the formation of the lake, is occupied by Acıgöl (Erinç 1967; Sungur 1974). While limestone forms the main lithology in the southern part of the lake, conglomerates and lake limestone are widespread in the northern part. Quarternary sediments with a lacustrine and fluvial origin can be found on the bottom parts of the lake.

Karamık Lake, on the other hand, has been formed as a result of faulting movements caused by alpine tectonic movements. The paroxysm phase of the tectonic movements in the area occurred in Upper Oligocene, the area was broken and shattered and a depression was formed along the faults bordering west, north, northeast of Sultandağları and south and southwest parts of Emirdağları. Karamık Lake was formed at the southwest part of this depression (Atalay 1977).

Maymundağı (1600 m) is situated north of Acıgöl, whereas its south and east sides are occupied by Yandağ, which is a part of Söğüt Dağları. The peaks of Yandağ, Çığrı hill and Fazıllar hill reach (1710 m) and (1810 m.) respectively. Yandağ has a rugged topography which includes karstic shapes.

Karamık Watershed is occupied by Miocene lakes, materials coming from Emir and Sultandağları have settled in the watershed and while mountainous areas lose elevation, lake limestones, marn and clays have formed in central parts of lake watersheds. Deposits consisting of gravel, sand and partly clays have formed on the northern skirts of Sultandağları which is located south of the watershed (Atalay 1977).

Acıgöl Watershed is a closed watershed so it is unable to discharge its water. The watershed is not supplemented by any tributary on a year round basis. That is why there are very few live organisms in the saline waters of Acıgöl. Water analysis carried out has revealed that 1 liter of water contains

29,3 gr Na (Sodium), 3,2 gr Mg (Magnesium), 26,6 gr SO_4 (Sodium Sulphate) and 41,7 gr CI (Chloride)(Acıgöl Watershed Underground water Reserve Report 1965)(Figure 2). An analysis of these results clearly shows that the waters of Acıgöl are extremely saline. The rich sodium and chloride percentage in the lake water does not allow living organisms an opportunity to survive.

Acıgöl is not a deep lake, its deepest place does not exceed 2-3 m even during pluvial periods. Dependent upon the draught tendency of each passing day, while the areal precipitation in 1975 was 160 km^2, today the areal amount has receded to half of that. Especially during the summer the areal figure can recede as low as 50 km^2.

Karamık Lake, on the other hand, is situated on the southern part of the watershed with a tectonic origin extending in a north-south direction east of Sultandağları and west of Kükürt Mountain. The NE-SW directional length of the lake is 16 km, the widest spot of the east-west directional is 7.8 km while its height is around 1002 m. The surface area of the lake is around 56 km^2 (Figure 3). The depth of the lake is 1-2 m and it has the quality of an extremely shallow and eutrophic lake.

The lakeside consists of wide marsh areas. The lake water seeps through the underground water reservoirs in the vicinity of Armutlu Village into Eğirdir Lake, from which it continues to Kovada and finally discharges into the Mediterranean Sea. This process makes the water sweet. Thus, compared to Acıgöl, the lake is much richer regarding species. Elevation of the water surface especially during winter and spring seasons while declination in water level almost amounting to exsiccation can be observed in the summer.

Systematically water mites are also known as Arhropoda sub-phylum Chelicerata of the phylum Arachnida class within Hydracarina, also known as Hydrachnidia or Hydrachnellae. Today, over 5000 species belonging to over 40 genera have been reported (Smith and Cook 1991).

Free living water mites survive in underground waters, pools, marshes, ponds, lakes and seas while parasitic ones live in mantle cavities of mollusks and reptiles. All the larva exist in aquatic invertebrates or in the gills of fish as external parasites (Bader 1975).

As a result of research carried out on the water mite fauna of Karamık Lake, a total of 22 water mite species belonging to 8 genera were discovered (Uysal 2005). Additionally, 5 species belonging to 4 genera were discovered in the research carried out for Acıgöl. Especially major differences were determined regarding the number of species which is dependent on the water characteristics and environmental factors of both two lakes; also the other distribution areas in Turkey for the determined species were given.

It has been indicated that water mites can be used as indicators in determining healthy water sources and in ecological works carried out for high mountain waters and underground waters (Bader 1975).

Figure 2 A view from Acıgöl Lake.

Figure 3 A view from Karamık Lake

The objective of the study was to examine the ecological risks to lakes situated in a semiarid region of our country ensuing from global warming and the ambient interaction of live organisms. Acıgöl and Karamık Lakes were selected for this study because one of them has salty water and the other one fresh and at the same time both have entered an exsiccation phase. The distance between these lakes which are situated within the tectonic extention of the West Toros Mountains in sequence is approximately 90-100 km. The objective of the work was to resolve the issues regarding the change of water mites in the unit area, manifesting the amount and change ratios with the changes in the natural

environment, studying the effect of ecological conditions on water mites and the ensuing results.

It is important for future generations and the sustainability of natural habitats that ecological risks caused by the deterioration of natural environments and the extinction of species is analyzed for the number of species and changes in ratios which are affected by exsiccation trends in semiarid areas.

MATERIAL AND METHODS

The exsiccation process which started as a result of the global warming in the 21st century has also resulted in starting an exsiccation process in the effected marshlands located in areas of Turkey in which semiarid climate conditions prevail, which is a major problem. The deterioration of the natural environment and ecological balance is deeply felt by organisms.

This is why the reactions of biological organisms regarding climate changes and the habitat have gained prominence. In this study, first the climate characteristics of Acıgöl and Karamık lakes were established and the climate oscillations were determined. The ecological characteristics of both lakes were determined and their interaction with the water mites was studied.

In addition between the years 2002-2005, water mite collecting activities were carried out (Figure 4). Water mite specimens were collected from among those actively swimming in the pelagic region, from random aquatic plants in the lake and picked out of the mud of the lake bed. The species of the water mites picked out of the lake were determined in a laboratory environment and registered. By this means the biological indicator organism potentials were determined for both lakes and their relevant relationships with the climate were discussed.

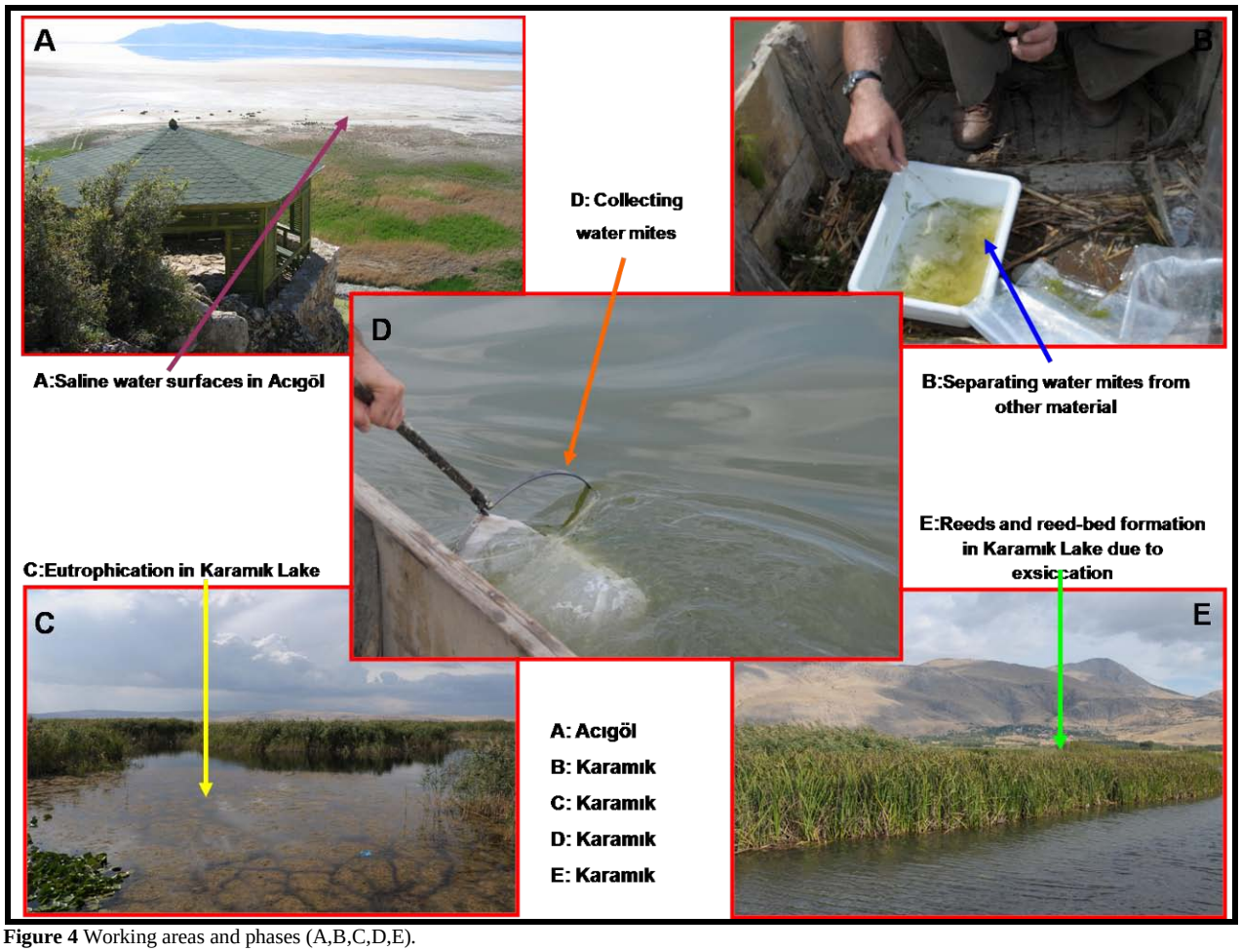

Figure 4 Working areas and phases (A,B,C,D,E).

Data Analysis

The altered form of the Mediterranean Climate subjected to continentality can be observed in Acıgöl Watershed. The annual precipitation in the region averages between 350–400 mm. The precipitation figures for meteorology stations within the Watershed are 368,4 mm for Çardak and 392,5 mm for Dazkırı. Precipitation is particularly heavy during winter and spring. The spring periods in the region are rather short (35–40 days). On the other hand, the summer months are plagued by draught. Although the Mediterranean Climate mostly prevails in the region, factors such as its elevation, distance from the sea and cleavage degree, winter temperatures are much lower than in the Mediterranean Region (-4,-16^{0}C). This characteristic has a similarity with the Central Anatolian Continental Climate.

The summer temperatures in the Watershed are neither as high as those of the Mediterranean Region nor as low as those of the Central Anatolian Region. The average temperature in the Watershed varies around (13–13,4^{0}C) (Çardak; 13,4^{0}C, Dazkırı;13^{0}C). Evaporation starts in April-May and continues rigorously until October. Annual evaporation amounts are around 1100 mm. The prevailing wind direction in the watershed area is southerly.

On the other hand, because of the continentality of macroclimate regions during summer months in Turkey, distance from the sea and elevation, the Karamık Lake and its environs have a continental climate (Figure 5). The mean temperatures in the Watershed vary around 10,9-11,5^{O}C (Sultandağı;10,9, Çay;11,5^{O}C). The annual total rainfall varies between 370-700 mm (Sultandağı; 371, Çay;580, Sultandağları; 700 mm). Local conditions reveal the climatic differences in the watershed. As a matter of fact, while the northern slopes of Sultandağları reveal subhumid characteristics, the environs surrounding the Eber and Akşehir lakes show characteristics typical to a semiarid climate. The northern slopes of Sultandağları receive approximately 200 mm more rainfall than the watershed basin. The natural vegetation has the characteristics of a park-like forest. On the other hand, a steppe vegetation cover prevails in the watershed basin and its vicinity.

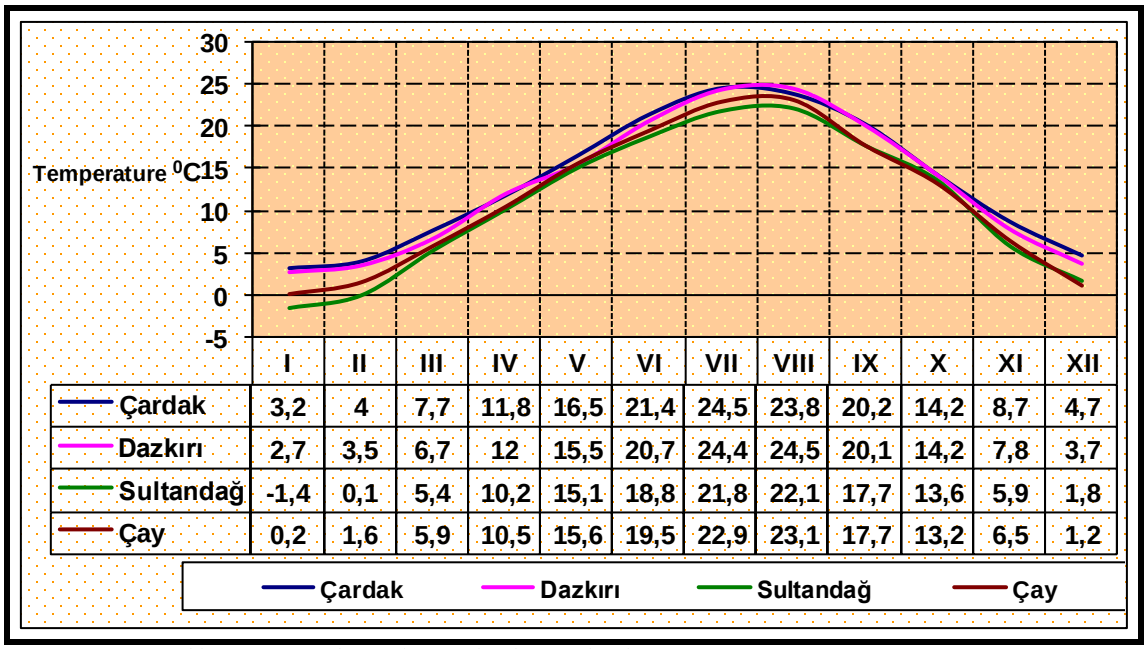

Figure 5 Mean monthly temperature changes in Acıgöl and Karamık Lake areas.

This situation transpires from the fact that in the western part of Central Anatolia the Sultandağları rise like a wall which causes orographic rainfall. So much so that while Çay, which is situated on the northern skirts of Sultandağları receives 580 mm of rainfall, Bolvadin which is 14 km further north receives only 403 mm. Especially the damp winds blowing from N and NE directions hit the mountain and rise and the ascending air mass cools adiabatically and generates orographic rainfall which causes the northern slopes to receive more rain.

In comparison with Karamık Watershed, while the Acıgöl Watershed is warmer with a more intense evaporation process and stronger maritime features, the effects of exsiccation are also relatively stronger. Mean annual temperatures of Acıgöl are higher, while total annual rainfall is less (Numbers for Acıgöl Watershed: Mean Temperature

13-13.4 ^{O}C, Annual Total Rainfall varies between 350-400 mm). Summer months in the Karamık Watershed are slightly cooler; because of the continentality, distance from the sea and elevation, mean annual temperatures are lower (11,8-12 ^{O}C), while rain is more abundant due to the orographic impact (Sultandağı; 371, Çay; 580 mm)(Figure 6).

The cumulative deviation method was used to determine the arid and humid seasons in the watershed. The method in question is based on taking the annual total rainfall amount which deviates from the long term annual mean rainfall amount and adds it to the sum for the next year. Thus the rainfall excess is transferred as a plus over to the next year while the rainfall deficit is shown as a minus. Periods with recurrent excess rainfall are indicative of humid periods while periods with deficient rainfall indicate arid periods.

A study of the cumulative deviation graph prepared for Acıgöl Watershed reveals a humid period from 1997 to 1981 whereas the period from 1981 to 1984 indicates an unstable period. The exsiccation tendency in the research area started in 1984 progressing rigorously until 1993. From 1994 to 2003 humidity increased until an exsiccation period which continues to date interceded in 2003 (Figure 7). Similarly since 1990 to date, the general tendency of the Karamık Watershed has been a prevalence of exsiccation and the lake area particularly started to exsiccate and has been reduced to half its size between the years 1990 to 2009.

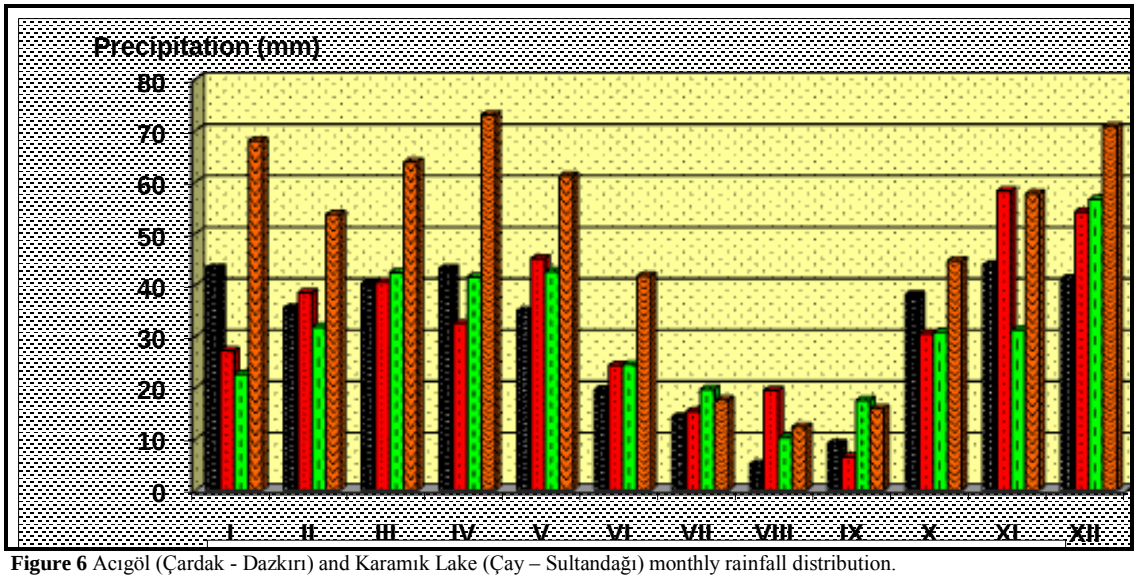

Figure 6 Acıgöl (Çardak - Dazkırı) and Karamık Lake (Çay – Sultandağı) monthly rainfall distribution.

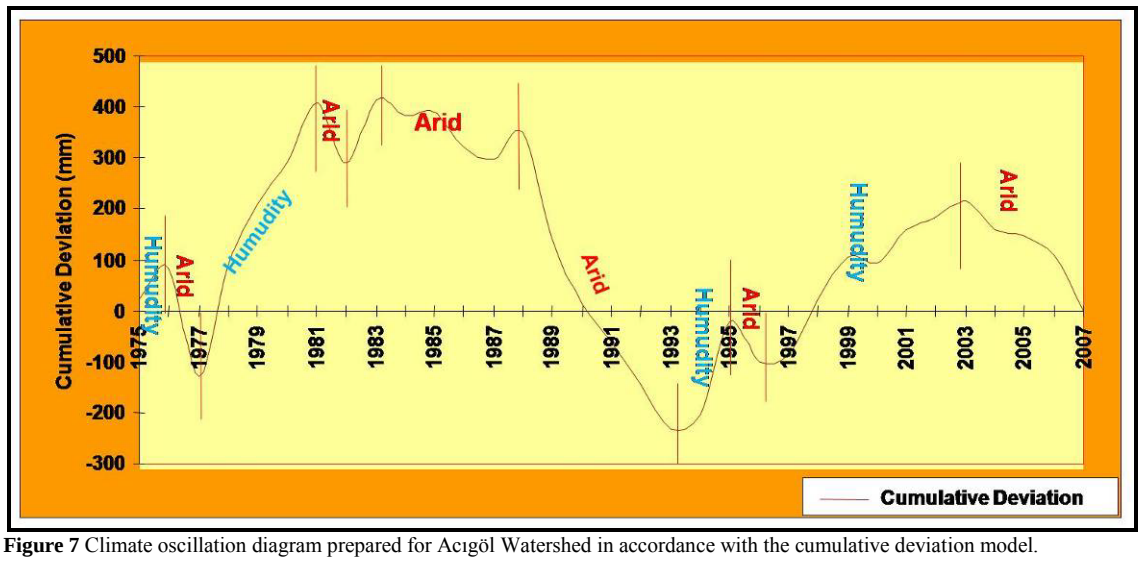

Figure 7 Climate oscillation diagram prepared for Acıgöl Watershed in accordance with the cumulative deviation model.

Findings for Karamık Lake Water Mites

Hydrachnidae Leach, 1815;
Hydrachna s.str. *skorikowi* (Piersig, 1900): 27.07.2003, 2♀♀, Karamık Lake, Afyonkarahisar. Recorded in Turkey in Bitlis, Hakkari, Muş, Van, Kayseri, Elazığ, Erzurum, Tokat (Özkan 1982b; Erman 1990; Özkan et al. 1993; Sezek 1998; Küçüköner 2001; Bursalı 2002).
Hydrachna Diplohydrachna globosa (Geer 1778): 06.08.2003, 1♀, 2♂♂, Karamık Lake, Afyonkarahisar. Recorded in Turkey in Erzurum, Tokat, Samsun, Bitlis, Van, Kayseri, Elazığ and Tokat. (Özkan 1982b; Erman 1990; Boyacı 1995; Özkan et al. 1993; Sezek 1998; Bursalı 2002).
Hydrachna Rhabdohydrachna processifera (Koenike 1903): 27.07.2003, 2♀♀, Karamık Lake, Afyonkarahisar. Recorded in Bitlis, Turkey (Özkan 1982b).
Eylaidae Leach, 1815;
Eylais setosa (Koenike 1897): 06.08.2003, 3♀♀, Karamık Lake, Afyonkarahisar. Recorded in Elazığ, Erzurum and Ardahan in Turkey (Erman 1990; Sezek 1998; Erman and Özkan 2000; Aşçı 2002).
Eylais extendens (Müller 1776): 06.08.2003, 2♀♀, Karamık Lake, Afyonkarahisar. Recorded in Erzurum, Muş, Bitlis, Van, Hakkari, Konya, Elazığ, Kayseri, Ardahan and Tokat in Turkey. (Özkan 1982a; Erman 1990; Özkan et al. 1993; Boyacı 1995; Sezek 1998; Erman and Özkan 2000; Aşçı 2002; Bursalı 2002).
Hydryphantidae Thor, 1900;
Hydryphantes (*s.str.*) *dispar* (Schaub 1888): 21.07.2003, 3♀♀, Karamık Lake, Afyonkarahisar. Recorded in Erzurum, Muş, Van, Bitlis, Elazığ, Hakkari Ardahan and Tokat in Turkey. (Özkan 1982b; Erman 1990; Küçüköner 2001; Erman and Özkan 2000; Aşçı 2002; Bursalı 2002).
Hydryphantes (*Polyhydryphantes*) *flexuosus* (Koenike 1885): 19.07.2003, 8♀♀, 2 nimf, Karamık Lake, Afyonkarahisar. Captured in Van, Elazığ, Kayseri, Kars in Turkey (Özkan 1982b; Erman 1990; Özkan et al. 1993; Erman and Özkan 2000; Küçüköner 2001; Aşçı 2002).
Georgella helvetica (Haller 1882): 06.08.2003, 9♀♀, 2 nimf, Karamık Lake, Afyonkarahisar. Recorded in Van, Elazığ, Konya, Kayseri and Kars provinces in Turkey. (Özkan 1981b; Erman 1990; Boyacı 1995; Özkan et al. 1993; 1995; Erman and Özkan 2000; Aşçı 2002).
Hydrodromidae Viets, 1936;
Hydrodroma despiciens (Müller 1776): 06.08.2003, 8♂♂, 7♀♀ Karamık Lake, Afyonkarahisar. Captured in Van, Bitlis, Hakkari, Elazığ, Kayseri, Tokat and Ardahan provinces in Turkey (Özkan 1981a; Erman 1990; Özkan et al. 1993; Erman and Özkan 2000; Aşçı 2002; Bursalı 2002).
Limnesiidae Thor, 1900;
Limnesia fulgida (Koch, 1836): 21.07.2003, 2♂♂, 06.03.2003, 2♀♀, Karamık Lake, Afyonkarahisar. Recognized in Erzurum, Bitlis, Van, Bingöl and Kars provinces in Turkey (Özkan 1982a; Erman and Özkan 1997; Aşçı 2002).
Unionicolidae Oudermans, 1842;
Unionicola crassipes (Müller 1776): 06.03.2003, 2♂♂ , Karamık Lake, Afyonkarahisar. Recorded in Kayseri and Konya provinces in Turkey (Özkan et al. 1993, Boyacı 1995).
Unionicola minor (Soar, 1900) : 06.08.2003, 2♀♀, Karamık Lake, Afyonkarahisar. Recognized in Konya province in Turkey (Özkan et al. 1993; Boyacı 1995).
Pionidae Thor, 1900;
Piona alpicola contraversiosa (Neumann, 1880): 15.06.2004, 5♀♀, Karamık Lake, Afyonkarahisar. Recorded in Kayseri, Van, Tokat provinces in Turkey (Özkan et al. 1993; Küçüköner 2001; Bursalı 2002).
Arrenuridae Thor, 1900;
Arrenurus (*s.str.*) *rodrigensis* (Lundblad 1954): 16.10.2003, 2♂♂, Karamık Lake, Afyonkarahisar. Recorded in Elazığ, Konya, Van, Rize provinces in Turkey (Erman 1990; 1992; Boyacı 1995; Küçüköner 2001; Aşçı 2002).
Arrenurus (*s.str.*) *affinis* (Koenike 1887): 06.8.2003, 1♂, Karamık lake, Afyonkarahisar. Recognized in Elazığ, Kayseri, Adıyaman, Yozgat, Erzurum, Van and Kars provinces in Turkey. (Erman and Özkan 1997; Küçüköner 2001; Aşçı 2002).
Arrenurus (*s.str.*) *bruzelii* (Koenike 1885): : 06.8.2003, 5♂♂, Karamık lake, Afyonkarahisar. Recorded in Erzurum, Elazığ, Kayseri, Ardahan and Tokat provinces in Turkey (Erman 1990; Erman and Özkan 1997; 2000; Aşçı 2002; Bursalı 2002).
Arrenurus (*s. str.*) *maculator* (Müller 1776): 21.07.2003, 2♂♂, Karamık Lake, Afyonkarahisar. Recorded in Elazığ and Kars provinces in Turkey (Erman 1990; Özkan and Erman 1991; Erman and Özkan 2000; Aşçı 2002).
Arrenurus (*s.str.*) *cuspidator* (Müller 1776): 04.10.2004, 2♂♂, Karamık Lake, Afyonkarahisar. Recognized in Elazığ, Adıyaman, Erzurum, Ardahan and Tokat provinces in Turkey. (Erman and Özkan 1997; 2000; Aşçı 2002; Bursalı 2002).
Arrenurus (*s. str.*) *cuspidifer* (Piersig 1896): 16.10.2003, 5♂♂, Karamık Lake, Afyonkarahisar. Recognized in Elazığ, Adıyaman, Kayseri, Erzurum, Van, Kars and Tokat provinces in Turkey. (Erman and Özkan 1997; 2000; Küçüköner 2001; Aşçı 2002; Bursalı 2002).
Arrenunıs (*s. str.*) *suecius* (Lundblad, 1917): 16.10.2003, 1♂, Karamık Lake, Afyonkarahisar. Recorded in Kayseri province in Turkey (Özkan et al. 1993).
Arrenurus (*Megaluracarus*) *globator* (Müller, 1776): 16.10.2003, 1♂, Karamık Lake, Afyonkarahisar. Recorded in Kayseri, Konya, Van and Rize provinces in Turkey. (Özkan et al. 1993; 1995; Küçüköner 2001; Aşçı 2002).

Findings for Acıgöl Lake Water Mites;

Water mite species discovered as a result of the studies carried out in Acıgöl;

Hydryphantes (*Polyhydryphantes*) *octoporus* Koenike 1896: 01.06.2006 ♀, Acıgöl, Afyonkarahisar. Recorded in Erzurum, Konya, Hakkari and Tokat provinces in Turkey.

Diplodontus scapularis Duges, 1834: 01.06.2006, 2♀♀ 1 nymph, Acıgöl, Afyonkarahisar. Recorded in Kayseri, Kars and Tokat provinces in Turkey.

Limnesia fulgida Koch, 1836: 01.06.2006, 1♀♀, Acıgöl, Afyonkarahisar. Recognized in Erzurum, Bitlis, Van and Bingöl, Ardahan and Kars provinces in Turkey (Özkan 1982a; Erman and Özkan 1997; Aşçı 2002).

Axonopsis (*Hexaxonopsis*) *rotundifrons* (Viets 1922): 17.07.2006, 2♂♂ Acıgöl, Afyonkarahisar. A new registration for fauna of Turkey.

Arrenurus (*Arrenurus) tricuspidator* (Müller 1776): 29.08.2005 2♂♂, 19.06.2008 5♂♂, Acıgöl, Afyonkarahisar. Previous determined in Elazığ province in Turkey (Erman 1990).

DISCUSSION

The freshwater Karamık Lake is in possession of more favorable ecological conditions for the water mite. The high level of precipitation (658 mm), appropriate temperatures and particularly the fresh water makes it a more appropriate ecological environment for water mites. As a result 22 species of water mites belonging to 8 genera were determined in Karamık Lake.

Acıgöl, on the other hand, is a typical example of a saline lake bearing the playa characteristics of lakes in arid regions. The lake is faced with negative features such as saline water, shallowness and insufficient supplementary sources. The lake watershed as started an exsiccation process as a result of low precipitation (390 mm) and the effects of global warming. As a result of these facts, only 5 species of water mites belonging to 4 genera were discovered in Acıgöl.

The ecological conditions sustained by the lakes have a particularly determining role on the species of water mites. It is clear that in time, changing ecological conditions will result in a decrease in the number of species, their extinction, or relocation. As it is, both lakes have started exsiccation processes and their water levels are decreasing annually.

This study, which was carried out on indicator organisms, will provide the opportunity to compare the reflections of ecological change in the lakes on living organisms in the future.

Acıgöl and Karamık lakes which have been formed under semiarid climate conditions are loosing ground on a daily basis because of global warming which is one of the main problems of the 21st century. The study focused on analyzing the effects of climatic parameters on water mites which are a species of aquatic fauna. Changing ecological conditions have a negative effect on organisms. During the past 30 years Acıgöl has lost approximately 2/3rds of its domain. Similarily Karamık lake has undergone a major excissation and started to turn into a marsh. The two lakes are approximately 90-100 km apart. The ecological risks which have a emerged as a result of the excissation of the lakes, particularly in Acıgöl lake which has saline water, has resulted in a limited number of species while the increasing exsiccation shall further decrease the existing number of species and their ratios. It was determined the the water mites were affected in both lakes by the characteristics of the ecological environment and particular differences were observed depending on whether the lake waters were sweet or saline. Karamık Lake with the sweet water and a more humid environmental ecology also had more species to offer. That is why Karamık Lake was able to present 22 species of water mites belonging to 8 genera. On the other hand, Acıgöl lake which has a more arid environment, saline waters and playa characteristics could produce only 5 species of water mites belonging to 4 genera.

Particularly both lakes are under ecological risks and when considered through different parameters, for example abiotic factors, it is clear that the high salinity of Acıgöl lake has been a decisive factor in limiting the dissemination and habitats of water mite species. It is impossible to say that the changes which have incurred in time in the ecological balance of both lakes have resulted in appropriate environmental conditions favorable to water mite fauna. Particularly, in addition to such factors as having a semiarid climate and losing domain as a result of the exsiccation process which was incepted by global warming, pollution of lake waters is also a major factor contributing to the low numbers of water mite species.

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