

The spatial and temporal distributions of waterbirds in Lakes Akşehir-Eber and Lake Köyceğiz in western Anatolia, Turkey - a comparative analysis

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Abstract: The waterbirds at 2 wetlands (Lakes Akşehir-Eber and Köyceğiz) in western Turkey were compared to determine their spatial and temporal distributions along with their habitat characteristics. The waterbirds were evaluated according to whether they were residents, winter migrants, summer migrants, or transit migrants and were assigned to foraging behavior groups. At Lakes Akşehir-Eber, 67 waterbird species belonging to 17 families and 9 orders were observed, while at Lake Köyceğiz 42 species belonging to 14 families and 9 orders were recorded. The waterbird fauna in both lake systems is composed of the following bird groups in the same order of occurrence: diving birds > wading birds > ducks > marsh birds. According to the qualitative comparison of waterbirds in the wetlands, the compositions of winter and summer migrant communities showed significant differences that could suggest that the vegetation composition, the size, the eutrophication level, and the seasonal climatic conditions of these wetlands play a role.

Key words: Waterbirds, distribution, wetlands, Lakes Akşehir-Eber, Lake Köyceğiz, western Anatolia

Batı Anadolu'daki (Türkiye) Akşehir-Eber Gölleri ve Köyceğiz Gölü'ndeki sukuşlarının alansal ve zamansal dağılımları – karşılaştırmalı bir analiz

Özet: Türkiye'nin batısındaki 2 sulak alandaki (Akşehir-Eber ve Köyceğiz Gölleri) sukuşları, habitat özellikleri ile birlikte alansal ve zamansal dağılımlarını belirlemek için karşılaştırıldı. Sukuşları yerli, kış göçmeni, yaz göçmeni veya geçit ziyaretçisi olmalarına göre değerlendirildi ve beslenme davranışlarına göre gruplara ayrıldı. Akşehir-Eber Göllerinde 17 familya ve 9 takıma dahil olan 67 sukuşu türü gözlenirken Köyceğiz Gölünde 14 familya ve 9 takıma ait 42 tür kaydedildi. Her 2 göl sisteminde de sukuşu faunası benzer şekilde şu kuş gruplarından oluşmuştur: dalıcı kuşlar, sığ su ve çamurda yürüyen kuşlar, ördekler ve bataklık kuşları. Bu sulak alanlardaki sukuşlarının niteliksel karşılaştırmasına göre, kış ve yaz göçmenleri topluluklarının bu sulak alanların vejetasyon yapısı, büyüklüğü, ötrofiklik seviyesi ve mevsimsel iklim koşulları nedeniyle önemli farklılıklar gösterdiği söylenebilmektedir.

Anahtar sözcükler: Su kuşları, dağılım, sulak alanlar, Akşehir-Eber Gölleri, Köyceğiz Gölü, Batı Anadolu

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Introduction

Similar to tropical forests, wetland ecosystems contain rich biodiversity and are sites of conservation concern due to the extensive food chain. Birds are important consumers in aquatic systems and are indicators of both water quality and biodiversity. The presence of waterbird species in wetlands depends on certain conditions such as habitat types, climatic conditions, and resource stability. Wetland habitats are used by bird species for nesting, breeding, feeding, sheltering, migration stopovers, and wintering in the different parts of their annual life cycle and are especially important habitats for long-distance migratory bird species (Weller, 1999; Getzner, 2002). Waterbird communities have been examined in many studies for annual variations in abundance and species composition. The composition indicates the biogeography of the region (DuBow, 1988; Weller, 1999; Guadagnin et al., 2005; Romano et al., 2005; Junk et al., 2006; Iriondo et al., 2007).

Turkey, where Asia, Europe, and the Middle East meet, is located on the main bird migration routes, namely the Bosphorus in the northwest, the Artvin-Borçka pass in the northeast, and the Hatay-Belen pass in the south, and contains living areas suitable for a variety of bird species. Turkey has more than 200 wetlands with different ecological characteristics and the total marshy area exceeds 1,000,000 ha. During the autumn and spring migration periods, some wetlands in central Anatolia are intensively used by different migrant bird species (Sutherland and Brooks, 1981; Bilgin and Akçakaya, 1987; Van der Have et al., 1989; Kok and Ongeane, 1995; Mrlik et al., 1995; Roselaar, 1995; Beaman, 1997; Kirwan et al., 1998; Kaya et al., 1999; MEF, 2004; Eken et al., 2006; Perktas et al., 2006). Most of the 128 Important Bird Areas (IBA) are wetlands in Turkey, and 12 internationally important wetlands have been determined according to Ramsar's fish and waterfowl criteria (BirdLife International, 2001; Ramsar Convention, 2008). The number of studies on birds has been increasing recently, but the majority of these studies have focused on determining the avifauna in wetlands (Sıki et al., 1998; Çobanoğlu Görgün, 2000; Richardson, 2003; Nergiz and Tabur, 2007; Uzun et al., 2008). In addition, the relationship between avifauna and environmental pollution has been assessed (Ayaş et al., 1997; Ayaş, 2007).

In general, wetlands are being subjected to an increasing degree of human pressure through water loss, changes in the natural flood regime, farmland reclamation, pollution, over-utilization of natural water resources, and poaching (Junk et al., 2006; Battisti et al., 2008). Similarly, increasing urban, industrial, agricultural, and other human activities are having a negative effect on water resources in Turkey. The wetlands of Turkey, such as Eşmekaya Marshes, Hotamış Marshes, Meke Lake (Ramsar site), and Seyfe Lake (Ramsar site), are also subjected to these harmful effects and are drying up. Thus, climatic changes and drought obviously influence the wetlands in central Anatolia much more than those in other areas. Therefore, our objectives in this study were as follows: to determine the composition of the bird communities of Lakes Akşehir-Eber and Lake Köyceğiz, to compare the spatial and temporal patterns of waterbird species of these areas to those of other wetlands in western Anatolia, to establish a relationship between habitat type and foraging groups, and to emphasize the significance of Lakes Akşehir-Eber and Lake Köyceğiz for waterbirds.

Materials and methods

Study area: The avifauna of Lakes Akşehir-Eber and Lake Köyceğiz was seasonally studied in 2006 and 2007 and was compared with the waterbird fauna of 2 other lakes. The avifauna of Lake Beyşehir (Tabur and Ayyaz, 2005) and Nallıhan Bird Sanctuary (Perktas and Ayaş, 2005) were previously studied and were used to compare the spatial and temporal patterns of waterbird species. The locations of these wetlands are shown in Figure 1 and detailed information regarding the wetlands is given in Table 1. Lakes Akşehir-Eber (38°34'N, 31°19'E) are 2 connected lakes located in the Akarçay closed basin in central Anatolia and are potential Ramsar Sites. Lake Akşehir (maximum lake area 35,300 ha, maximum water depth 7 m) is a tectonic lake, fed by streams; Lake Eber (maximum lake area 16,800 ha, maximum water depth 6 m) is fed by the Akarçay stream (Munsuz and Ünver, 1983; Yazar and Magnin, 1997; Altınışlı et al., 2000; Kılıç and Güven, 2005; BirdLife International, 2008). Lake Eber is a shallow lake surrounded by reed beds. It has slightly salty and alkaline water, and its water depth changes throughout the year (Elmacı, 1995). Lake

Table 1. Comparison between wetlands in area and waterbird species number.

Wetlands	Study Period	Area (ha)	All Waterbirds	Winter Migrants	Summer Migrants	Study
Akşehir-Eber Lakes	2006-2007	212,500	67	21	23	Our study
Köyceğiz Lake	2006-2007	14,000	42	18	4	Our study
Beyşehir Lake	2000-2002	65,600	55	26	9	Tabur and Ayvaz (2005)
Nallıhan Bird Sanctuary	2000-2001	900	40	11	6	Perktaş and Ayaş (2005)

Köyceğiz (36°52'N, 28°38'E) is located in the coastal zone of western Anatolia. This lake is included in the Köyceğiz–Dalyan Special Environmental Protection Area (SPA; 1 of 14 SPAs in Turkey) (MEF-EPASA, 1988). This lake (14,000 ha; maximum water depth of 30 m) is fed by springs and several streams, and it has brackish water (BirdLife International, 2008). This area has numerous natural and man-made water channels.

We studied the vegetation of these lakes and classified the habitat types in accordance with the European Nature Information System (EUNIS). EUNIS Habitat Classification comprises explanatory documents and a database by Davies et al. (2004). EUNIS Habitat Classification is a system that allows for the description of habitat types and is supported by the European Environment Agency (EEA).

Lake Beyşehir (37°46'N, 31°31'E) is the largest freshwater lake in Turkey (maximum water depth of 10 m) and is 75 km west of Konya. The lake is fed by mountain streams and several springs. According to a study of the ornithofauna of Lake Beyşehir, 181 bird species were recorded. There are 33 islands of different sizes in the lake. The dominant plant species were recorded as *Phragmites australis* and *Typha angustifolia* (Tabur and Ayvaz, 2005). Nallıhan Bird Sanctuary (40°06'N, 31°36'E) is located north of Sarıyar Dam Lake. This area is a seasonal wetland (approximately 900 ha). According to Perktaş and Ayaş (2005), 130 bird species were recorded in this aquatic ecosystem. This area contains seasonal mudflats, standing ponds, streams, grasslands, wet grasslands, rocky areas, farmlands, and settlements, which are important habitats. This wetland contains numerous aquatic plants, such as *Typha latifolia*, *T. angustifolia*, and *P. australis*.

Bird surveys: Waterbird surveys were conducted from January 2006 to February 2007 at Lakes Akşehir-

Eber and Lake Köyceğiz. Birds were identified by sight using binoculars, field telescopes, and mist nets. During field studies, guidebooks were used to identify the birds (Heinzel et al., 1995; Mullarney et al., 1999). We selected waterbirds from the avian fauna that are obligate wetland users (Weller, 1999) and all other species were excluded from the analysis. The selected species belong to 9 orders: Podicipediformes, Pelecaniformes, Ciconiiformes, Anseriformes, Phoenicopteriformes, Falconiformes, Gruiformes, Charadriiformes, and Coraciiformes. The waterbirds were grouped based on foraging behavior and habitat use. Therefore, the analysis groups and the waterbird families were grouped as follows: 1) surface and aerial diving birds (Podicipedidae, Phalacrocoracidae, Pelecanidae, Accipitridae, Laridae, Sternidae, Alcedinidae), 2) wading birds (Ardeidae, Ciconiidae, Threskiornithidae, Phoenicopteridae, Haematopodidae, Recurvirostridae, Charadriidae, Scolopacidae, Glareolidae), 3) ducks (Anatidae), and 4) marsh birds (Rallidae) (Traut and Hostetler, 2004). Species were also divided into trophic groups based on their food type: F = phytoplankton (filter feeders), P = plants, V = vertebrates (amphibians, fish, reptiles, birds, rodents), and I = invertebrates (insects, mollusks, crustaceans, etc.) (Romano et al., 2005; Iriondo et al., 2007), and some species were included in P/I (feed on both plants and invertebrates) and I/V (feed on both invertebrates and vertebrates) groups. In field studies, birds were monitored seasonally and these lakes were visited at least twice in each season. The species were assigned to the following groups: 1) residents (R), 2) winter migrants (WM), 3) summer migrants (SM), and 4) transit migrants (TM). These classifications and IUCN (International Union for Conservation of Nature) criteria were considered for waterbird species in all lakes (Table 2) (IUCN Red List of Threatened Species 2001 ver. 3.1).

The spatial and temporal distributions of waterbirds in Lakes Akşehir-Eber and Lake Köyceğiz in western Anatolia, Turkey - a comparative analysis

Table 2. Waterbird species occurrence among 4 wetlands during the study periods, with birds ranked by family.

Family	Species	Status				Trophic Group
		Akşehir-Eber*	Köyceğiz*	Beyşehir	Nallıhan	
Podicipedidae	<i>Tachybaptus ruficollis</i>	R	R	R	WM	I/V
	<i>Podiceps cristatus</i>	R	WM	R	WM	I/V
	<i>Podiceps nigricollis</i>	R	WM	WM		I/V
	<i>Podiceps griseigena</i>	R		WM		I/V
Phalacrocoracidae	<i>Phalacrocorax carbo</i>		R		WM	V
	<i>Phalacrocorax aristotelis</i>		R			V
	<i>Phalacrocorax pygmeus</i>	WM	R	WM		V
Pelecanidae	<i>Pelecanus onocrotalus</i>	SM			TM	V
	<i>Pelecanus crispus</i>			SM		V
Ardeidae	<i>Ixobrychus minutus</i>	SM	TM	SM		I/V
	<i>Nycticorax nycticorax</i>	SM			SM	I/V
	<i>Ardeola ralloides</i>	SM	SM	SM	SM	I/V
	<i>Bubulcus ibis</i>	TM				I/V
	<i>Egretta garzetta</i>	R	R	TM	SM	I/V
	<i>Casmerodius albus</i>	WM	WM	R	WM	I/V
	<i>Ardea cinerea</i>	WM	R	R	R	I/V
	<i>Ardea purpurea</i>	SM	SM	SM	TM	I/V
	<i>Botaurus stellaris</i>	SM		WM		I/V
	Ciconiidae	<i>Ciconia nigra</i>	TM			SM
<i>Ciconia ciconia</i>		SM	SM	SM	SM	I/V
Threskiornithidae	<i>Plegadis falcinellus</i>	SM	TM	TM		I/V
	<i>Platalea leucorodia</i>	SM	TM		TM	F
Phoenicopteridae	<i>Phoenicopterus ruber</i>	SM	TM			F
Anatidae	<i>Cygnus olor</i>			WM		P/I
	<i>Anser albifrons</i>	TM		WM		P
	<i>Anser anser</i>			WM		P
	<i>Tadorna ferruginea</i>	R		WM	R	P/I
	<i>Tadorna tadorna</i>	WM	WM	WM		P/I
	<i>Anas penelope</i>	WM	WM	WM	WM	P
	<i>Anas strepera</i>		WM	WM	TM	P
	<i>Anas crecca</i>	WM	WM	WM	WM	P/I
	<i>Anas platyrhynchos</i>	R	R	R	R	P/I
	<i>Anas acuta</i>	WM		WM	TM	P/I
	<i>Anas querquedula</i>	WM		WM	WM	P/I
	<i>Anas clypeata</i>	WM		WM	WM	P/I
	<i>Netta rufina</i>	WM		WM		P
	<i>Aythya ferina</i>	WM	WM	R	WM	P/I
	<i>Aythya nyroca</i>	WM	WM	WM		P/I
	<i>Aythya fuligula</i>	WM	WM	WM	TM	P/I
	<i>Aythya marila</i>	WM				P/I
	<i>Oxyura leucocephala</i>	WM				P/I
	Accipitridae	<i>Circus aeruginosus</i>	R	R	R	TM
<i>Circus cyaneus</i>		WM		WM	TM	I/V
<i>Circus macrourus</i>					TM	I/V
<i>Circus pygargus</i>		SM				I/V
<i>Haliaeetus albicilla</i>				TM		V
<i>Pandion haliaetus</i>				TM		V

Table 2. (Continued).

Family	Species	Status				Trophic Group
		Akşehir-Eber*	Köyceğiz*	Beyşehir	Nallıhan	
Rallidae	<i>Rallus aquaticus</i>	TM		WM		P/I
	<i>Porzana parva</i>	WM				P/I
	<i>Porzana pusilla</i>	SM				P/I
	<i>Gallinula chloropus</i>	R	R	R	TM	P/I
	<i>Fulica atra</i>	R	R	R	WM	P/I
Haematopodidae	<i>Haematopus ostralegus</i>				TM	I
Recurvirostridae	<i>Himantopus himantopus</i>	SM		SM	TM	I
	<i>Recurvirostra avosetta</i>	SM			TM	I
Charadriidae	<i>Charadrius dubius</i>	TM		SM	SM	I
	<i>Charadrius hiaticula</i>				TM	I
	<i>Charadrius alexandrinus</i>	TM				I
	<i>Vanellus spinosus</i>	SM		TM		I
	<i>Vanellus vanellus</i>	SM	WM	TM		I
Scolopacidae	<i>Calidris alpina</i>	SM	WM			I
	<i>Calidris minuta</i>	TM	WM	TM		I
	<i>Calidris alba</i>			TM		I
	<i>Calidris temminckii</i>	SM				I
	<i>Philomachus pugnax</i>	WM			TM	P/I
	<i>Gallinago gallinago</i>	TM	WM			I
	<i>Tringa erythropus</i>				TM	I
	<i>Tringa totanus</i>	WM	WM	WM	TM	I
	<i>Tringa nebularia</i>	WM				I
	<i>Tringa stagnatilis</i>			TM		I
	<i>Tringa ochropus</i>		WM	WM	WM	I
	<i>Tringa glareola</i>	TM	TM			I
	<i>Actitis hypoleucos</i>	WM	TM	WM	TM	I
	Glareolidae	<i>Glareola pratincola</i>	TM			
Laridae	<i>Larus melanocephalus</i>			SM		I/V
	<i>Larus minutus</i>		WM			I/V
	<i>Larus ridibundus</i>	R	R	WM	R	I/V
	<i>Larus genei</i>	SM	WM			I/V
	<i>Larus argentatus</i>			R		I/V
	<i>Larus cachinnans</i>	R	R		TM	I/V
	<i>Larus canus</i>			WM		I/V
Sternidae	<i>Larus fuscus</i>			WM		I/V
	<i>Sterna hirundo</i>	SM	SM			I/V
	<i>Sterna albifrons</i>	SM				I/V
	<i>Sterna nilotica</i>			TM		I/V
	<i>Chlidonias niger</i>	SM				I/V
Alcedinidae	<i>Chlidonias leucopterus</i>	SM				I/V
	<i>Alcedo atthis</i>	R	R	SM		V
	<i>Halycon smyrnensis</i>		R			V
Total	67	42	55	40		

*Our study

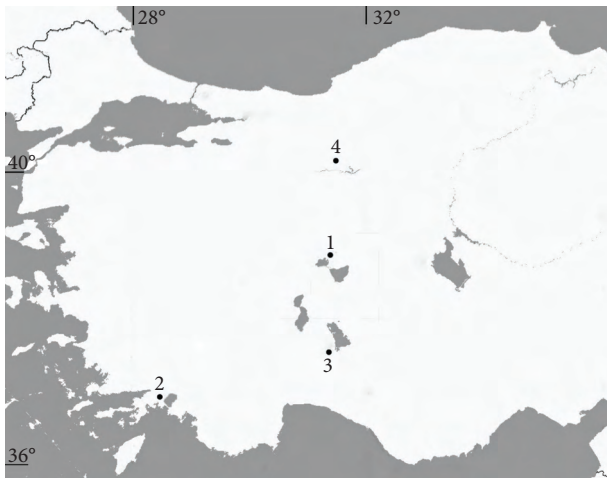


Figure 1. Map of the study areas (1: Akşehir and Eber Lakes, 2: Köyceğiz Lake, 3: Beyşehir Lake, 4: Nallıhan Bird Sanctuary).

Analysis: The survey results were statistically analyzed to compare the waterbirds of the 4 wetlands. The similarities between these lakes were determined based on the number of winter and summer migrants and assessed using a cluster analysis procedure. Bird data (0/1 integers indicating absence/presence) were used in the analysis. The similarity matrix of the Jaccard coefficient was used to produce UPGMA (unweighted pair-group method) by the PC program NTSYS-pc 2.1 (©2000 by Applied Biostatistics, Inc.) (Rohlf, 1996).

Results

In the field survey performed around Lakes Akşehir-Eber, 4 major EUNIS habitat types were determined: permanent eutrophic lakes (PEL), rooted submerged vegetation of eutrophic water bodies (RSVEW), flooded *Phragmites australis* beds (FPAB), and iris beds (IB). These habitat types are all in some way occupied by waterbirds. PEL is open water, was usually used by waterbirds for feeding, and was preferred mainly by surface and aerial diving birds, ducks, and some marsh birds (moorhens [*Gallinula chloropus*] and coots [*Fulica atra*]). Apart from these, most of the waterbirds used RSVEW, FPAB, and IB habitats for feeding, nesting, resting, and hiding. In particular, wading birds stayed near vegetation and the edge of the lake. FPAB constituted the common

habitat type in Lake Eber and was surrounded by the IB habitat type in this lake. In contrast, the floristic structure of Lake Akşehir has changed recently due to drought, so IB, which was characterized by grasslands, has become the dominant vegetation type all around Lake Akşehir. The FPAB habitat type was only occasionally seen in a small percentage of other habitat types. The water level in Lake Akşehir fluctuates seasonally and the lake is almost dry in summer.

Although Lakes Akşehir-Eber are connected to each other via a small water passage, the waterbird communities were markedly different in these lakes. Lake Akşehir is wide and shallow and suffers from drought, while Lake Eber has a large reed bed and small islands and is surrounded by grassland. In Lake Akşehir, the reed bed covers only a few small parts of the lake. Therefore, Lake Eber is rich in bird species while Lake Akşehir is rich in bird abundance (e.g. flamingo [*Phoenicopterus ruber*], Ruddy Shelduck [*Tadorna ferruginea*], and avocet [*Recurvirostra avosetta*] flocks). *Phoenicopterus ruber*, *Recurvirostra avosetta*, and *Anas penelope* were only observed at Lake Akşehir. Hunting is common throughout the year in Lakes Akşehir-Eber, but especially in winter when the duck species are abundant. Lake Eber is popular for hunters because it has numerous islets and appropriate places like cottages for hiding. These cottages were built by villagers who use them when cutting reeds and fishing. Hunting is not regulated at Lake Eber and we determined that herons and egrets are also sometimes hunted. In winter, the surveys were conducted by walking on the frozen lake. Villagers make holes in the ice for fishing, and some winter migrant birds often feed at the holes; we frequently observed that grey herons would wait near a hole to catch fish. Furthermore, waterbirds such as grebes, ducks, and coots used the small ponds with chilly water in the reed bed clearings of the lake for feeding. In May 2006, Lake Eber's water level was normal, but Lake Akşehir became nearly dry and looked like a large marshy area with sparse reed beds.

Lake Köyceğiz covers boggy and marshy ground, reed beds, water channels, and arable and cultivated areas. According to the EUNIS Habitat Classification, this lake and its environs fit the following classifications: permanent eutrophic lakes

(PEL), rooted submerged vegetation of eutrophic water bodies (RSVEW), flooded *Phragmites australis* beds (FPAB), Anatolian *Typha domingensis* beds (ATDB), and *Schoenus littoralis* beds (SLB). RSVEW was very intensive around the mouths of the Yuvarlak and Namnam rivers, located at the northeast and northwest of this lake. FPAB commonly surrounded the whole lake and was extremely dense in channels at the south of the lake. ATDB was distributed throughout the north and northwest of the lake. SLB was common at the north of the lake where the Namnam River enters.

Although the reed beds are important habitats for birds, these areas are sometimes destroyed by burning and cutting to gain farmland, and this is a major threat for some waterbirds that prefer these habitats. Lake Köyceğiz was declared to be a Special Protection Area in 1988, and since then hunting has been strictly forbidden around the lake. In spring and winter, the cultivated areas flooded and were used by numerous waterbird species, not only herons and egrets but also snipes (*Gallinago gallinago*), ducks (*Tadorna tadorna*), and lapwings (*Vanellus vanellus*). Cormorants (*Phalacrocorax* sp.) swam with gulls (*Larus* sp.), grebes (*Tachybaptus* sp. and *Podiceps* sp.), and coots (*Fulica atra*) for feeding in open water, but mostly preferred the small islands in the lake. To avoid the dense boat traffic in this lake, the waterbirds mostly preferred narrow channels, since the wide ones were usually used for tours, and the waterbirds were also observed in open water near the side of the lake.

During the bird surveys, 17 families with 67 species and 14 families with 42 species were recorded in Lakes Akşehir-Eber and Lake Köyceğiz, respectively. Thus, a total of 17 families with 73 species were recorded during the study periods in these wetlands. The number of species per family were as follows: Podicipedidae (4), Phalacrocoracidae (3), Pelecanidae (1), Ardeidae (9), Ciconiidae (2), Threskiornithidae (2), Phoenicopteridae (1), Anatidae (15), Accipitridae (3), Rallidae (5), Recurvirostridae (2), Charadriidae (4), Scolopacidae (10), Glareolidae (1), Laridae (4), Sternidae (4), and Alcedinidae (2) (Tables 1 and 2). Three families (Pelecanidae, Recurvirostridae, and Glareolidae) were not observed at Lake Köyceğiz. Significant differences in foraging behavior groups

were observed at the different wetlands. At Lakes Akşehir-Eber, 17 surface and aerial diving bird species were observed, and 13 were observed at Lake Köyceğiz. Wading birds, the richest group, were represented by 30 species at Lakes Akşehir-Eber and by 18 at Lake Köyceğiz. Ducks were represented by 1 family (Anatidae), which had the largest number of species, and 15 of these species were identified at Lakes Akşehir-Eber and 8 at Lake Köyceğiz. Marsh birds were the smallest group and were represented by 1 family; 5 species were recorded at Lakes Akşehir-Eber and 2 at Lake Köyceğiz (Figure 2). Across all the wetlands, waterbirds per trophic group were recorded as follows: F = 2, P = 4, V = 6, I = 16, P/I = 18, and I/V = 27. It is clear that the I, P/I, and I/V trophic groups were predominant in these wetlands (Figure 3). Among the waterbird families, Scolopacidae was the most prevalent in the I group; similarly, the P/I group was largely composed of Anatidae and the I/V group mostly of Ardeidae (Table 2). At Lakes Akşehir-Eber, 13 species of all waterbirds were residents, 21 were winter migrants, and 23 were summer migrants. At Lake Köyceğiz, 14 species were residents, 18 were winter migrants, and 4 were summer migrants. Therefore, seasonal species made up 66% of all waterbirds at Lakes Akşehir-Eber and 52% at Lake Köyceğiz (Table 2). During our surveys, 2 species were determined as threatened according to IUCN criteria. *Oxyura leucocephala* is an Endangered (EN) species only observed at Lake Eber and *Aythya nyroca* is a Near Threatened (NT) species observed at both Lake Eber and Lake Köyceğiz. Other birds were considered to be Least Concern (LC) (Table 2).

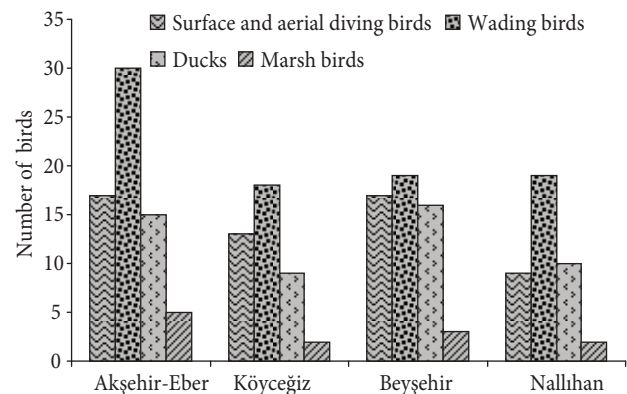


Figure 2. Distribution of waterbirds according to foraging behavior.

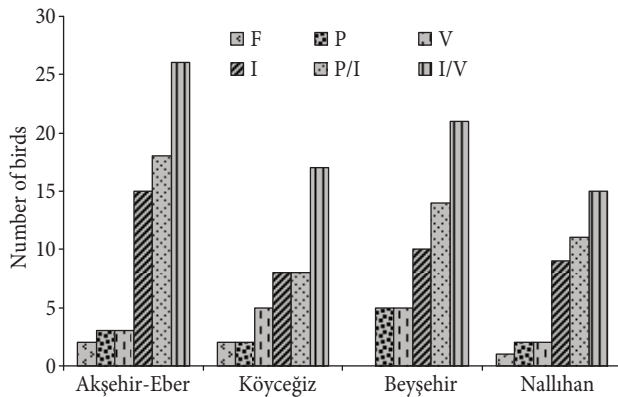


Figure 3. Distribution of waterbird trophic groups at the wetlands (F = phytoplankton, P = plants, V = vertebrates, I = invertebrates, P/I = plants and invertebrates, I/V = invertebrates and vertebrates).

Waterbird species composition was found to differ in all wetlands between seasons. There were temporal variations due to changing seasonal species composition. Similarities of waterbirds in these wetlands were generated from the data given in Table 2; transit migrant species were excluded. According to the cluster for winter birds, Lakes Akşehir-Eber and Lake Beyşehir, which are the closest geographically, were the most similar, as expected, and Lake Köyceğiz and Nallıhan Bird Sanctuary formed a separate subcluster (Figure 4). Although Lake Köyceğiz and Nallıhan Bird Sanctuary are far from each other, the establishing of a subcluster might have originated

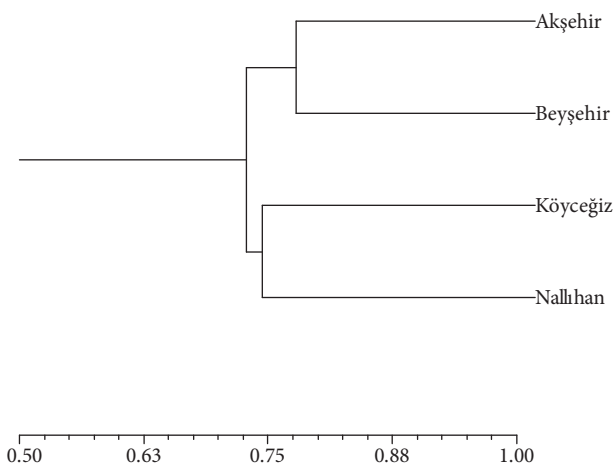


Figure 4. UPGM dendrogram summarizing the similarity of waterbird fauna of the wetlands in winter (NTSYS-pc options: Coefficient: SM (SimQual - similarity for qualitative data), clustering method: UPGMA).

from the small size of Nallıhan Bird Sanctuary and the coastal location of Lake Köyceğiz. In the cluster for summer birds, Lake Köyceğiz and Nallıhan Bird Sanctuary were the closest to each other again, with Lake Beyşehir also connected to this branch. According to this cluster, the most diverse location was Lakes Akşehir-Eber, since the richness of summer migrants was highest at this wetland while it was lower at Lake Köyceğiz (Figure 5).

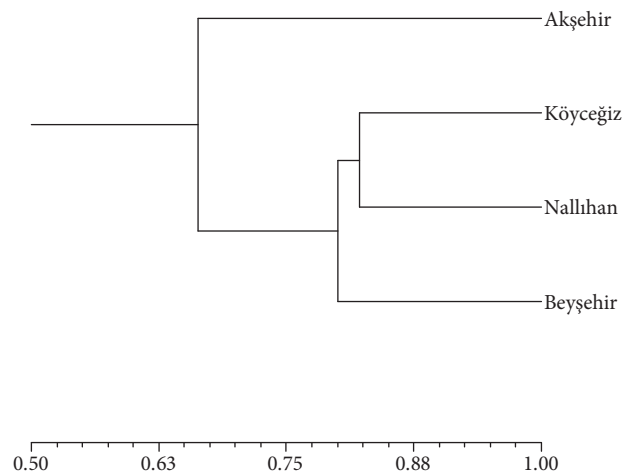


Figure 5. UPGM dendrogram summarizing the similarity of waterbird fauna of the wetlands in summer (NTSYS-pc options: Coefficient: SM (SimQual - similarity for qualitative data), clustering method: UPGMA).

Discussion

In our study, 73 waterbird species were identified at both wetlands, whereas the waterbird community compositions of the other 2 wetlands, Lake Beyşehir and Nallıhan Bird Sanctuary, located in western Anatolia, were reported to be 55 and 40, respectively (see Figure 1; Perктаş and Ayaş, 2005; Tabur and Ayyaz, 2005). Therefore, the total number of waterbird species was 89 for the 4 compared wetlands. Proportions of waterbird species were found to differ among the 4 wetlands; Lakes Akşehir-Eber and Lake Köyceğiz had the highest proportions of waterbirds, 48.5% and 37.8%, respectively. The lowest proportions were recorded at Lake Beyşehir (30.4%) and Nallıhan Bird Sanctuary (30.8%). Wetland preferences and richness of waterbirds also differed between the wetlands. In the 4 wetlands, 15 waterbirds (*Tachybaptus ruficollis*,

Ardeola ralloides, *Egretta garzetta*, *Casmerodius albus*, *Ardea cinerea*, *Ardea purpurea*, *Ciconia ciconia*, *Anas penelope*, *Anas platyrhynchos*, *Anas crecca*, *Aythya ferina*, *Circus aeruginosus*, *Gallinula chloropus*, *Fulica atra*, and *Tringa totanus*) were common. However, 30 of the waterbirds were present in only 1 wetland. These were as follows: at Lakes Akşehir–Eber, *Bubulcus ibis*, *Aythya marila*, *Oxyura leucocephala*, *Circus pygargus*, *Porzana parva*, *Porzana pusilla*, *Charadrius alexandrinus*, *Calidris temminckii*, *Glareola pratincola*, *Sterna albifrons*, *Chlidonias niger*, and *Chlidonias leucopterus*; at Lake Köyceğiz, *Phalacrocorax aristotelis*, *Larus minutus*, and *Halycon smyrnensis*; at Lake Beyşehir, *Pelecanus crispus*, *Cygnus olor*, *Anser anser*, *Haliaeetus albicilla*, *Pandion haliaetus*, *Calidris alba*, *Tringa stagnatilis*, *Larus melanocephalus*, *Larus argentatus*, *Larus canus*, *Larus fuscus*, and *Sterna nilotica*; and at Nallıhan Bird Sanctuary, *Circus macrourus*, *Haematopus ostralegus*, and *Charadrius hiaticula*. A Vulnerable (VU) species, *Pelecanus crispus*, was only reported at Lake Beyşehir by Tabur and Ayvaz (2005). *Circus macrourus* is a NT species and was recorded only at Nallıhan Bird Sanctuary by Perktaş and Ayaş (2005). Thus, 4 species in the 4 wetlands were assigned to the IUCN threatened category, and this reflects the importance of the western Anatolian wetlands for migratory waterbirds (Table 2).

Pelecanus crispus, *Netta rufina*, and *Chlidonias hybrida* were recorded at Lakes Akşehir-Eber by Eken et al. (2006) and *Sterna nilotica* was reported in the list of BirdLife International (2008), but these species were not observed during our study period. In previous studies at Lake Köyceğiz, a total of 206 bird species were recorded between 1946 and 1991 (Kılıç and Kasperek, 1989; Eppler et al., 1991). Of these birds, 39 waterbird species were not observed during our study period; these species are as follows: *Podiceps grisegena*, *Pelecanus crispus*, *Nycticorax nycticorax*, *Anas acuta*, *Anas querquedula*, *Anas clypeata*, *Netta rufina*, *Circus cyaneus*, *Circus pygargus*, *Haliaeetus albicilla*, *Pandion haliaetus*, *Rallus aquaticus*, *Porzana parva*, *Himantopus himantopus*, *Recurvirostra avosetta*, *Burhinus oedicephalus*, *Glareola pratincola*, *Charadrius dubius*, *Charadrius hiaticula*, *Charadrius alexandrinus*, *Pluvialis squatarola*, *Vanellus spinosus*, *Calidris alba*, *Calidris temminckii*, *Philomachus pugnax*, *Lymnocyptes minimus*,

Limosa limosa (NT), *Numenius arquata*, *Tringa nebularia*, *Tringa stagnatilis*, *Larus melanocephalus*, *Larus fuscus*, *Gelochelidon nilotica*, *Sterna albifrons*, *Sterna sandvicensis*, *Chlidonias niger*, *Chlidonias leucopterus*, *Chlidonias hybrida*, and *Ceryle rudis*. In contrast, 5 waterbird species from Lake Köyceğiz were first recorded in our study: *Phalacrocorax carbo*, *Phoenicopiterus ruber*, *Tadorna tadorna*, *Anas strepera*, and *Larus genei*.

Forage groups were also found to vary between wetlands; the proportion of diving birds at Lake Köyceğiz (33%) was nearly the same as that at Lake Beyşehir (31%), while it was 25% at Lakes Akşehir-Eber and 23% at Nallıhan Bird Sanctuary. Wading birds were sighted in similar proportions at 3 wetlands: 48% at Nallıhan Bird Sanctuary, 45% at Lakes Akşehir-Eber, and 43% at Lake Köyceğiz, while the lowest percentage (35%) occurred at Lake Beyşehir. The highest percentage of ducks (29%) was observed at Lake Beyşehir and the lowest was at Lake Köyceğiz (19%); the percentages of these birds were similar between Lakes Akşehir-Eber (23%) and Nallıhan Bird Sanctuary (25%). The highest number of marsh birds was observed at Lakes Akşehir-Eber (7%), while at the other 3 wetlands the proportion was the same (5%) (Figure 2). Ma et al. (2007) stated that the difference in bird composition was related to habitat preferences. Our findings are consistent with this assumption. At Lake Köyceğiz, more residents were observed than at the other lakes, but in general the resident birds constituted the smallest group in all these wetlands. Residents were composed of mostly diving birds, which need larger areas of water for foraging and use perching areas near the water. Many of the winter migrants were ducks, while the summer migrants were wading birds. Thus, these waterbirds that use the same habitats (shoreline, basin substrate, etc.) replaced each other each season. Therefore, the wetland preferences of these groups were significantly different among seasons. The I/V group differed from the other groups in numbers, and the percentages of this group were similar (38%-40%) among the wetlands (Figure 3). This group included mostly surface and aerial diving birds, which use the water column, mudflats, and shoreline areas in wetlands. In contrast, the P/I group was mostly composed of ducks that especially need the water surface, water column, basin substrate, and

mudflats. Herremans (1999) suggested that there were ecological associations between trophic groups and wetland types and also noted that eutrophic waters were more appropriate for herbivorous species rather than piscivorous/carnivorous ones. Moreover, piscivorous/carnivorous species were mostly associated with oligo- and mesotrophic waters, but species feeding on invertebrates were present everywhere. Lakes Akşehir-Eber are a eutrophic wetland and, in total, species of the P and P/I groups (feeding on plants) were predominant in this area.

The similarities of the wetlands in clusters, given in Figures 4 and 5, may be associated with their areas and bird species richness, irrespective of the other factors. According to the MacArthur-Wilson model, species richness is affected by distance and area (MacArthur and Wilson, 1963). Furthermore, Weller (1999) stated that large wetlands tend to have more species than smaller ones. Thus Lakes Akşehir-Eber, which are larger than Lake Beyşehir, had far more waterbirds. However, among all the wetlands, Nallıhan Bird Sanctuary is the smallest, but it had nearly the same waterbird species richness as Lake Köyceğiz. Additionally, Lakes Akşehir-Eber and Lake Köyceğiz shared 36 waterbird species. Lakes Akşehir-Eber shared 41 species with Lake Beyşehir and 33 with Nallıhan Bird Sanctuary, while 29 waterbirds were found at both Lake Köyceğiz and Lake Beyşehir, 24 at both Lake Köyceğiz and Nallıhan Bird Sanctuary, and 28 at both Lake Beyşehir and Nallıhan Bird Sanctuary.

According to Türkeş (2000) and Kutiel et al. (2001), Turkey has been divided into 7 regions based on similarities in rainfall regime. Lakes Akşehir-Eber and Nallıhan Bird Sanctuary are within the Continental Central Anatolia region, which is characterized by cool rainy springs, cold rainy winters, and warm and lightly rainy summers, and has a semiarid and dry semihumid steppe climate. Only Lake Beyşehir is located in the Mediterranean to Central Anatolia Transition region, which is characterized by moderately rainy winters and springs. Lake Köyceğiz is in the Mediterranean region, which is markedly seasonal with cool and very rainy winters and hot dry summers, and has a humid and semihumid subtropical climate. According to these data, the precipitation patterns of Lakes Akşehir-Eber and Nallıhan Bird Sanctuary are similar. These

wetlands could be considered as having similar climatic characteristics, but Lake Köyceğiz is quite different. Despite the climatic differences between Lake Köyceğiz and the other wetlands, their winter migrant waterbird composition was quite similar. This might have originated from the eurythermal tolerance of winter migrants; our postulation was similarly reported by Weller (1999) and Newton (2008). However, the summer composition of waterbirds was not similar between Lakes Akşehir-Eber and Lake Beyşehir. The difference might have originated from the climatic characteristics of these wetlands and the foraging preferences of the waterbirds. Perктаş et al. (2006) recorded that some waterfowl species present in both wintering and breeding seasons in 5 wetlands and the migratory statuses of these birds in Turkey were different from those in the rest of Europe.

In winter and summer, the species composition showed variations due to seasonal species. Among the 4 wetlands, the numbers of winter and summer migrants showed small variations only at Lakes Akşehir-Eber. According to Romano et al. (2005), replacement of these seasonal species between seasons was considered to be related to latitude. In our study, the lakes at the same latitudes varied in terms of waterbird richness; summer migrants mostly preferred Lakes Akşehir-Eber, while Lake Beyşehir was preferred by winter migrants. Nallıhan Bird Sanctuary, located far from the other wetlands, was preferred by transit migrants. Lake Köyceğiz and Nallıhan Bird Sanctuary are the wetlands farthest apart, but their waterbird species compositions were similar (Figure 6). Including all of the wetlands, 8 of the waterbird families contained resident species, 9 families contained winter migrants, and 13 contained

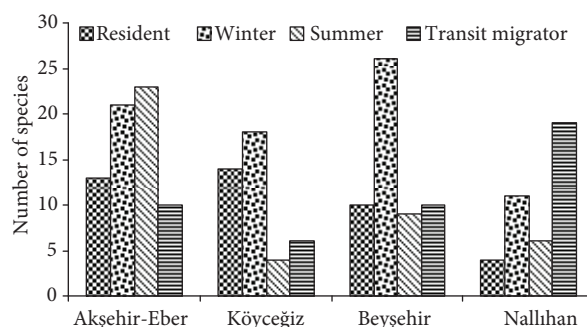


Figure 6. Distribution of waterbirds by season in the 4 wetlands.

summer migrants. Phalacrocoracidae were resident only at Lake Köyceğiz, while Ardeidae, Anatidae, and Accipitridae were common at all the wetlands (Figure 7). Podicipedidae were resident at Lakes Akşehir-Eber, whereas they were winter migrants at the other wetlands. In contrast, Phalacrocoracidae, Accipitridae, and Rallidae were resident at Lake Köyceğiz, but they were winter migrants at the other wetlands. Charadriidae were observed only at Lake Köyceğiz as winter migrants (Figure 8). Except for Alcedinidae, all families of summer migrants were found at Lakes Akşehir-Eber, but only 3 families were recorded at Lake Köyceğiz, 7 at Lake Beyşehir, and 3 at Nallıhan Bird Sanctuary (Figure 9).

Perktaş and Ayaş (2005) suggested that Nallıhan Bird Sanctuary was not preferred by birds as much as in previous years due to the aridity and poor vegetation composition caused by climatic conditions. In general, wetlands suffer from pollution and global drought in Turkey, as well as in the rest of the world (Kılıç and Güven, 2005; Tabur and Ayyaz, 2005; Junk et al., 2006; BirdLife International, 2008). It is well known that Lakes Akşehir-Eber have been contaminated by urban and industrial sewage, and these lakes are also under pressure due to intensive illegal hunting and reed burning. Kılıç and Güven (2005) reported that these lakes almost dried up in 2001 because of dam construction and

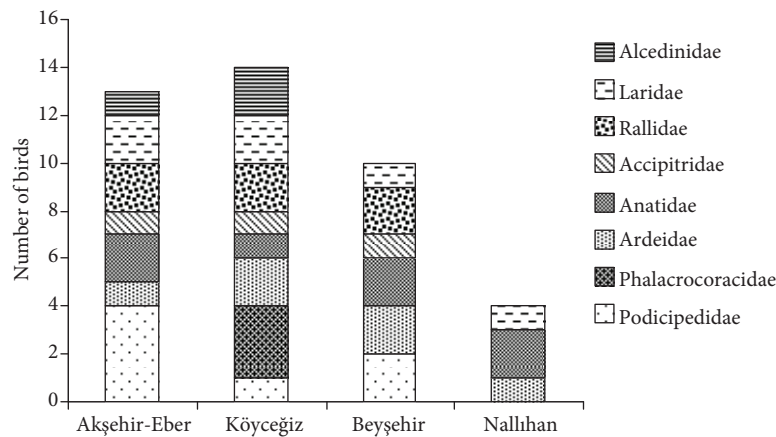


Figure 7. Resident species richness of waterbirds in the 4 wetlands, by family.

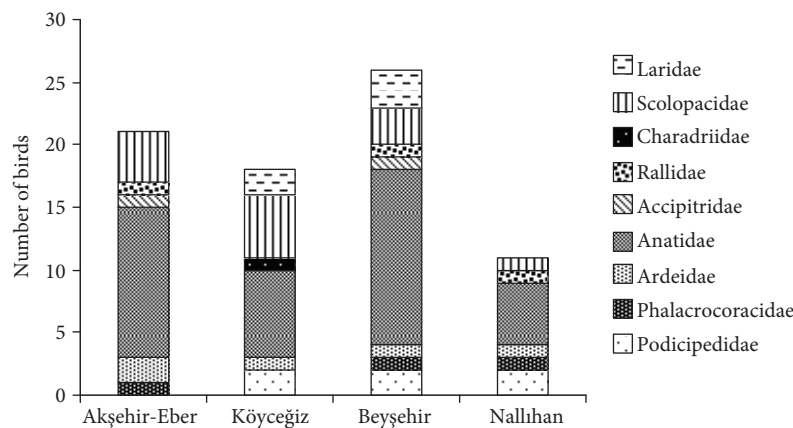


Figure 8. Winter migrant species richness of waterbirds in the 4 wetlands, by family.

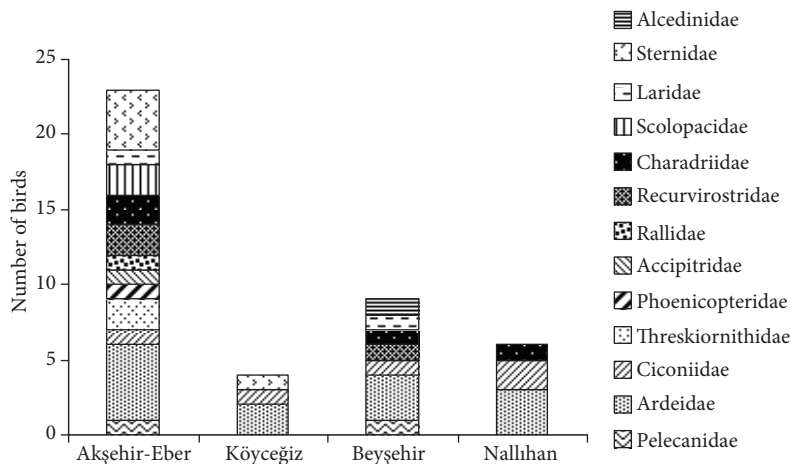


Figure 9. Summer migrant species richness of waterbirds in the 4 wetlands, by family.

underwent eutrophication due to pollution. At Lake Beyşehir especially, the birds suffered due to hunting, pollution, use of chemicals, reed cutting, and construction (Tabur and Ayvaz, 2005). At Lake Köyceğiz there were interesting conflicts between fishermen and cormorants, and beekeepers and bee-eaters. Kirby et al. (2008) stated that the main threats to the threatened and near-threatened migratory waterbird species are predominantly agriculture (and aquaculture), biological resource use, natural system modifications, and pollution, in spite of the climatic changes. Similarly, Green et al. (1996) determined that Lake Burdur was the most important wintering site for *Oxyura leucocephala*, a globally threatened species, and that this lake was threatened by construction, decreasing water levels, pollution, and illegal hunting. Therefore, we believe that the concepts of conservation biology and ecosystem management should be applied to these wetlands based on the conservation concern revealed in this study. The conflicts between birds and humans, land use for agriculture, illegal hunting, and global threats such as drought should be assessed together, and the

wetlands in Turkey need a new review process in line with these concepts.

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