

ASSESSMENT OF BIODIVERSITY DIFFERENCES BETWEEN NATURAL AND ARTIFICIAL WETLANDS IN CYPRUS

SALIH GUCEL^{1,*}, COSTAS KADIS², OZGE OZDEN^{3,4}, IRIS CHARALAMBIDOU⁵, CONOR LINSTAD⁶, WAYNE FULLER^{4,7}, CONSTANTINOS KOUNNAMAS² AND MUNIR OZTURK⁸

¹Near East University, Environmental Sciences Institute, Nicosia, Cyprus

²Frederick University, Nature Conservation Unit, Nicosia, Cyprus

³Department of Landscape Architecture, Faculty of Architecture, Near East University

⁴Centre for Ecology and Conservation, Cornwall Campus, Exeter University, UK.

⁵Department of Life and Health Sciences, Environmental Management Programme, University of Nicosia, Cyprus

⁶WWF-UK

⁷Faculty of Agricultural Sciences and Technologies, Lefke, Cyprus.

⁸Ege University, Botany Department, Science Faculty, Bornova-Izmir, Turkey

*Corresponding author's email: sgucel@hotmail.com

Abstract

Despite being a dry country, historically, Cyprus had many wetlands, both freshwater and saline. However, pollution, mosquito management, increased use of water and drainage of wetland areas for agriculture and building, led to the loss of many of the original wetlands. On the other hand, persistent water shortages have led to the construction of more than 100 dams on the island. In this study, the biodiversity of two natural wetlands, Ronnas River and Oroklini Lake, was compared to that of two man-made wetlands, Geçitköy (Panagra) Reservoir and Achna Dam. Baseline ecological surveys of plants, invertebrates and birds were carried out at bi-monthly intervals from February to June 2006. In total, 495 plant species, out of which 22 were endemic, were recorded with Gecitkoy (Panagra) Dam showing the highest plant diversity and Oroklini Lake the lowest. A total of 13 invertebrate orders were recorded, however, no statistical difference was found between the number of orders in artificial and natural wetlands. Furthermore, 18 butterfly species were recorded, with the highest diversity found at Ronnas River on *Centaurea* sp., *Onopordum cyprum*, *Pistachia* sp. and *Cistus creticus*. Less diversity found at Oroklini Lake and Achna Dam was due to an absence of maquis vegetation in these areas. Moreover, the highest butterfly diversity in all wetlands was observed in February and April, following winter rainfall in February, and increasing temperatures in April. Lower insect numbers and diversity in May were due to windy conditions. A total of 83 bird species were identified, with 32 recorded at Ronnas River, 29 at Oroklini Lake, 25 at Geçitköy (Panagra) Reservoir and 35 at Achna Dam. Most individuals were counted at Achna Dam (1493) and the least at Ronnas River (217). At Oroklini, Geçitköy and Achna, the most abundant species was the Common Coot while most species recorded at Ronnas were terrestrial, with the Common Wood-pigeon being the most abundant species. However the outcome so far is that there is little difference between these two wetlands types in terms of biodiversity richness. This study has demonstrated that artificial wetlands do provide important habitats for flora and fauna and these sites should be managed with biodiversity as well as water resources.

Introduction

Water resources in Cyprus are scarce, with the climate becoming increasingly arid (Iliadis & Maris 2007). This scenario is predicted to continue in the face of temperature rises and reduced precipitation within the Mediterranean region (Anon., 2007), including Cyprus (Giannakopoulos *et al.*, 2010, Hadjinicolaou *et al.*, 2010). One of the solutions to this shortage over the past two decades has been the construction of dam reservoirs which store water and extend its availability throughout the year (Evangelidou, 2011). There are currently more than 100 dams and water storage ponds in Cyprus and new are under construction (Naukkarinen, 2006), with Cyprus being the first country in Europe in terms of the number of dams per square kilometre (Anon., 2011).

Although it has become apparent that these artificial wetland sites have become key areas for improving and maintaining existing levels of biodiversity in Cyprus (Gucel, 2010), dam construction is controversial (Naukkarinen, 2006). Environmental impacts associated with dams typically include issues related to loss and disturbances in local ecosystems, in terms of both flora and fauna (Monosowski, 1985). Studies comparing man-made wetland function and ecological value to that of natural wetlands have been conducted using indicators such as hydrology, soils, and biological communities (Webb &

Newling, 1985, Kentula *et al.*, 1992, Havens *et al.*, 2002). There is debate as to whether created systems are similar in function to the natural systems that have been altered or lost (Whigham, 1999), while Malakoff (1998) concluded that created wetlands were at best less than 60% equivalent to a natural marsh 13 years after their establishment. In general, there is considerable interest in designing methods that assess the ecological condition or integrity of wetlands in order to document their extent of degradation, to provide early warning of ecosystem stress or degradation, to determine the effectiveness of management actions, and to track wetland condition for regulatory programs charged with wetland management, restoration and mitigation (Fennessy *et al.*, 2007).

To date, little attempt has been made in Cyprus either for determining biodiversity of wetland ecosystems or for identifying the biodiversity differences between natural and artificial wetlands. There is little baseline ecological data on these sites (Flint & Stewart, 1992, Anon., 1998, Charalambidou *et al.*, 2008, Goçmen *et al.*, 2008, Baier *et al.*, 2009, Kassinis *et al.*, 2010) while the value of land is better understood in economic terms than from ecological aspects (Fennessy *et al.*, 2007). Thus the long-term roles of wetlands in ecological sustainability are rarely considered.

The aim of this research was to compare biodiversity between natural and artificial wetlands, and to improve

the understanding of the role of artificial wetlands in the protection of biodiversity in a context of increasing pressures on water resources and to promote the value of infrastructure designed for water resource management in the protection of biodiversity.

Materials and Methods

Study sites: Ecological surveys of plants, invertebrates and birds were carried out at bi-monthly intervals from

February 2006 until June 2006. Two natural and two artificial wetlands were selected for this study (Fig. 1). Ronnas River is a natural wetland located at the south-west region of Karpaz village. Oroklini Lake is a natural, brackish marsh/lake between Larnaca and Nicosia Districts. The man-made Geçitköy (Panagra) Reservoir is located on the west of Kyrenia Mountain range. The man-made Achna Dam is situated in Famagusta District, near Dasaki Achnas village.

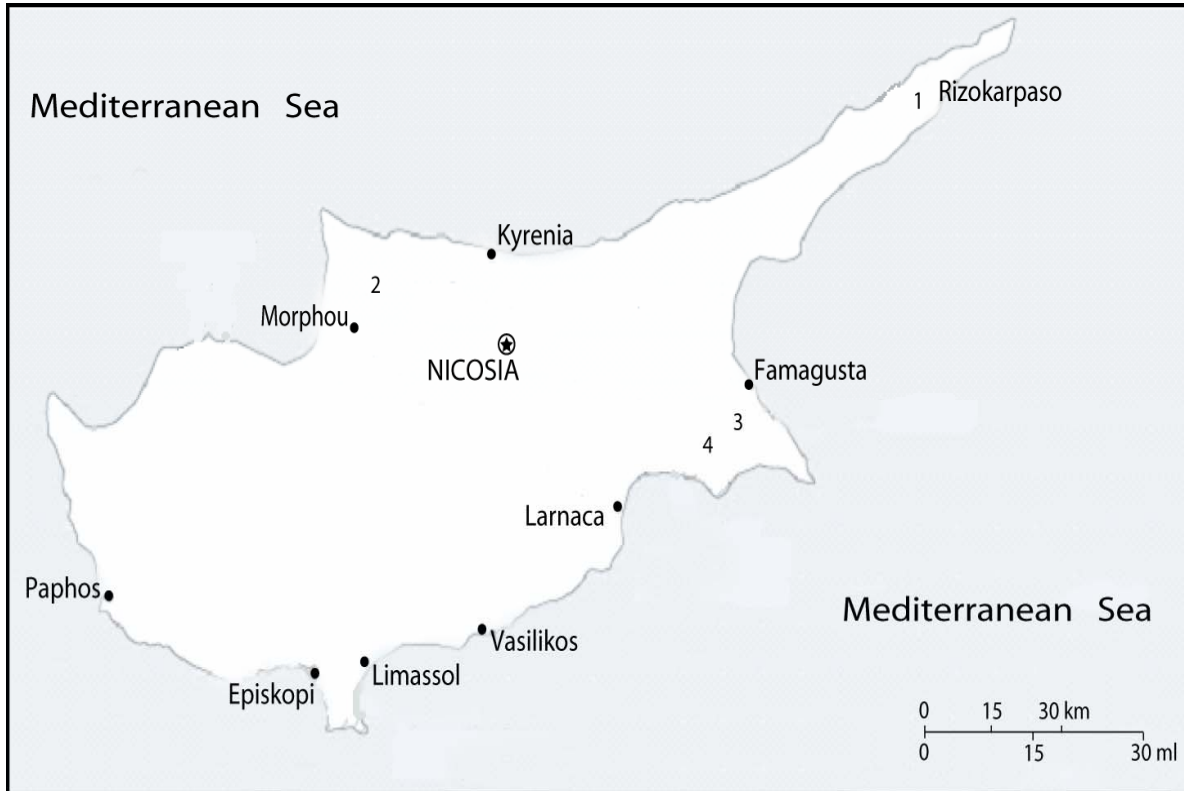


Fig. 1. A map of Cyprus showing the four study Sites: 1. Ronnas River; 2. Gecitkoy (Panagra) Dam; 3. Achna Dam; 4. Oroklini Lake.

Ronnas River has been defined as a biodiversity rich wetland habitat supporting rare plant species, such as *Mentha aquatica* and *Nigella ciliaris* (Ozden & Sarpten, 2007). Part of the site towards Ronnas Bay lies within the Karpaz Special Environmentally Protected Area (SEPA), due to the presence of important habitats and species (Fuller *et al.*, 2010).

Gecitkoy (Panagra) Reservoir was created by damming the Egri stream, which flows from the Kyrenia mountain range. This water is used for the irrigation of agricultural crops grown by the village of Gecitkoy. However, migrating birds also use the area for wintering, breeding and as a stop-over site during spring and autumn migration (Flint & Stewart, 1992). The endemic Cyprus Tulip *Tulipa cypria* is found around the reservoir, along with many species of fungi (Momany & Gucel, 2009). The Cyprus Tulip is listed in Annex II of the EU Habitats Directive (92/43/EEC) and is classified as “Endangered” by Tsintides *et al.*, (2007). It is locally common around Geçitköy village and is protected under the “Ordinance” (21/97 “Environment Law” 10 (2)).

Achna Dam is an irrigation dam (379 ha) supplied with water mostly by a pipeline from the Kourris Dam in Limassol District. There is also an intermittent river that provides some water during rainy winters. Water is used to irrigate the orchards that surround most of the area around the dam. There are also extensive areas of barley fields along the NE side of the dam. The native wetland vegetation is primarily composed of *Tamarix* sp. and some *Phragmites* sp. all growing along the shores of the dam. There are also extensive stands of the exotic *Acacia saligna* along the dam shores (Iezekiel *et al.*, 2004). Due to its importance as a breeding area for Black-winged Stilt (*Himantopus himantopus*) and Spur-winged Lapwing (*Vanellus spinosus*), the wetland has been identified as an Important Bird Area (IBA; Iezekiel *et al.*, 2004).

Oroklini Marsh is a natural, small (91 ha) and shallow brackish marsh/lake, which usually holds water during wet winters. In recent times water levels have been maintained through the supply of water from the waste water treatment plant of Larnaca. There is a drainage canal that connects to the nearby sea and, when water levels are high, grey mullet

(*Mugil* sp.) enter the marsh and remain there. There is waterside vegetation in the form of *Phragmites australis* reeds and open areas with halophytic vegetation (*Suaeda vera*, *Salicornia* sp.) (Iezekiel *et al.*, 2004). Due to its importance as a breeding area for Black-winged Stilt and Spur-winged Lapwing, the wetland has been identified as an IBA (Iezekiel *et al.*, 2004).

Sampling and identification of plants: Plants were collected following the random quadrat sampling (40 x 40 m) and the species were identified using Meikle (1977, 1985) and Viney (1994).

Sampling and identification of invertebrates: The invertebrate surveys included butterfly surveys with identification to the species level and general insect surveys with species differentiated, but identified only to the order level. The procedure used was 'transect recording' or the Pollard Walk, as described by Pollard (1977). Transects of a known length (between one and two kilometers in length in each wetland) were walked without stops by a recorder. Using the insect net from each direction of the wetland (North, East, South and West), 20 insect net samples were taken (80 samples in total from each wetland). The collected insect specimens were taken to the laboratory and identified to insect orders.

Bird counts and identification of birds: Birds were monitored using point counts and the 'look-see' methodology (Bibby *et al.*, 1992) whereby the observer surveyed a predefined area with a telescope and binoculars. The species and numbers of birds were recorded.

Results

Plants: A total of 495 plant species were identified (Table 1). Oroklini Lake had the smallest plant diversity among the studied areas, while Geçitköy (Panagra) Reservoir had the highest. The most abundant species in Oroklini Lake was the *Phragmites australis* (Reed) along with halophytic vegetation (*Suaeda vera*, *Salicornia* sp.). At Achna Dam, the most abundant species were *Tamarix* sp., *Phragmites* sp. and *Acacia siliqua*. At Gecitkoy (Panagra) Reservoir and Ronnas River, these were *Arunda donax* and *Phragmites australis*.

Invertebrates: The invertebrate orders identified during the surveys were: Mollusca, Siphonaptera, Coleoptera, Diptera, Homoptera, Hemiptera, Thysanura, Thysanoptera, Hymenoptera, Orthoptera, Odonata, Lepidoptera and Neuroptera. The butterfly species identified at each site for all surveys are shown in Table 2. The highest butterfly diversity was found in the Ronnas Wetland. This is thought to be because the butterflies usually feed and rest on flowers, which are most abundant at the Ronnas wetland site. They prefer to feed on nectar of flowers, especially on the Mediterranean native plants (Maquis). There is no maquis in Oroklini and Achna,

therefore their diversity was lower. During the survey in Ronnas, the butterflies were recorded on *Centaurea* sp., *Onopordum cyprium*, *Pistachia* sp. and *Cistus creticus*.

The highest species diversity in all wetlands was observed in February and April (Fig. 2). February is the peak extent of the wetland area following winter rainfall, while in April the temperature starts to increase towards the summer maximum. The results for May were affected by windy conditions when the survey was conducted, which is expected to result in lower insect numbers and diversity.

Gecitkoy has the highest order diversity (9 out of the 10 observed), followed by Oroklini and Ronnas (8 out of 10) and Achna (7 out of 10). There is no difference between the number of orders identified in artificial and natural wetlands. The areas studied are influenced by human activities (Oroklini lake in particular is surrounded by houses and the building in the area is to be continued), and this is why these surveys have to be repeated for more years.

Birds: A total of 83 bird species were identified (Table 3), with similar numbers of species recorded at all wetlands: 32 at Ronnas River, 29 at Oroklini Lake, 25 at Geçitköy (Panagra) Reservoir and 35 at Achna Dam. The total number of individual birds counted was 217 at Ronnas River, 1442 at Oroklini Lake, 486 at Geçitköy (Panagra) Reservoir and 1493 at Achna Dam. At three of the wetlands (Oroklini, Geçitköy and Achna) the most abundant species was the Common Coot (*Fulica atra*) with numbers reaching more than 250 birds in a single count (Achna Dam). Most of the species recorded at Ronnas were terrestrial; as it is the smallest wetland of the four, and the most abundant bird was the Common Wood-pigeon (*Columba palumbus*).

The larger number of individuals for some bird species (e.g. Common Coot) at Achna and Oroklini wetlands may be because they are larger than Ronnas and Geçitköy, and provide a wider variety of niches for feeding and nesting.

Discussion

The results show that there is no consistent pattern in the biodiversity differences between natural and artificial wetland sites. Many workers are still debating on the fact whether these created systems are similar in function to the natural systems that have been lost (Whigham, 1999). However, Hartzell *et al.*, (2007), also found similar results, where created wetlands and water bodies with wetland characteristics (old farm ponds) provided many of the habitat attributes of natural systems. The two sites with the highest diversity of plant and bird species were natural wetland - Ronnas and artificial wetland - Geçitköy Panagra. The natural and created sites may have different vegetation assemblages, because soil has a significant influence on the composition of the wetland plant assemblage. Confer & Niering (1992) and Fennessy *et al.*, (2004) found that plant species richness was similar between natural and created palustrine, emergent wetlands.

Table 1. Plant species (scientific names) recorded at two natural wetlands, Ronnas River and Oroklini Lake, and two man-made wetlands, Geçitköy (Panagra) Reservoir and Achna Dam, in Cyprus, from February to June 2006. Where an asterisk (*) denotes an endemic species.

Gecitkoy	56. <i>Cynodon dactylon</i>	112. <i>Onobrychis venosa*</i>
1. <i>Adonis annua</i>	57. <i>Cytinus hypocistis</i>	113. <i>Ononis reclinata</i>
2. <i>Aegilops triuncualis</i>	58. <i>Dactylis glomerata</i>	114. <i>Ononis viscosa</i>
3. <i>Alkanna leihmanii</i>	59. <i>Daucus carota</i>	115. <i>Onopordum cyprium*</i>
4. <i>Allium orientale</i>	60. <i>Dittrichia graveolens</i>	116. <i>Onosma fruticosum*</i>
5. <i>Allium ampeloprasum</i>	61. <i>Dittrichia viscosa</i>	117. <i>Onosma giganteum</i> var. <i>hispidum</i>
6. <i>Allium neopolitanum</i>	62. <i>Echinops ramosissimus</i>	118. <i>Ophrys kotschyii*</i>
7. <i>Allium nigrum</i>	63. <i>Echinops spinosissimus</i>	119. <i>Ophrys levantina</i>
8. <i>Allium trifoliatum</i>	64. <i>Echium angustifolium</i>	120. <i>Ophrys lutea</i> ssp. <i>galilee</i>
9. <i>Ammi majus</i>	65. <i>Ephedra fragilis</i>	121. <i>Ophrys sphagodes</i> ssp. <i>Mammosa</i>
10. <i>Anthemis palaestina</i>	66. <i>Erodium laciniatum</i>	122. <i>Ophrys umblicata</i> ssp. <i>Attica</i>
11. <i>Antirrhinum majus</i>	67. <i>Eryngium creticum</i>	123. <i>Ophrys umblicata</i> ssp. <i>Umblicata</i>
12. <i>Arisarum vulgare</i>	68. <i>Eucalyptus camaldulensis</i>	124. <i>Opopanax hispidulus</i>
13. <i>Arum dioscoridis</i>	69. <i>Euphorbia chamaepeplus</i>	125. <i>Orchis morio</i> subsp. <i>syriaca</i>
14. <i>Arundo donax</i>	70. <i>Euphorbia dimorphocaulon</i>	126. <i>Ornithogalum narbonense</i>
15. <i>Asparagus acutifolius</i>	71. <i>Ferula communis</i>	127. <i>Oxalis pes-caprae</i>
16. <i>Asperula cypria*</i>	72. <i>Filago gallica</i>	128. <i>Pallenis spinosa</i>
17. <i>Asphodelus aestivus</i>	73. <i>Foeniculum vulgare</i>	129. <i>Papaver rhoeas</i>
18. <i>Astragalus caprinus</i>	74. <i>Fumana arabica</i>	130. <i>Parkinsonia aculeata</i>
19. <i>Astragalus cyprius*</i>	75. <i>Fumaria kralikii</i>	131. <i>Phagnolon rupestre</i>
20. <i>Atractylis cancellatus</i>	76. <i>Gagea juliae*</i>	132. <i>Phalaris aquatica</i>
21. <i>Avena barbata</i>	77. <i>Gagea graeca</i>	133. <i>Phalaris minor</i>
22. <i>Barlia robertiana</i>	78. <i>Galium murale</i>	134. <i>Phleum subulatum</i>
23. <i>Bellardia trixago</i>	79. <i>Genista sphacelata</i>	135. <i>Phragmites australis</i>
24. <i>Bellevalia trifoliata</i>	80. <i>Geranium tuberosum</i>	136. <i>Pinus brutia</i>
25. <i>Biscutella didyma</i>	81. <i>Geropogon hybridus</i>	137. <i>Pinus halepensis</i>
26. <i>Bromus lanceolatus</i>	82. <i>Gladiolus italicus</i>	138. <i>Pinus pinea</i>
27. <i>Bryonia cretica</i>	83. <i>Gynandrisis sisyrrinchium</i>	139. <i>Pistacia lentiscus</i> var. <i>lentiscus</i>
28. <i>Bunium ferulaceum</i>	84. <i>Helianthemum obtusifolium*</i>	140. <i>Pistacia terebinthus</i>
29. <i>Calendula arvensis</i>	85. <i>Helichrysum conglobatum</i>	141. <i>Polygonum aviculare</i>
30. <i>Calicotome villosa</i>	86. <i>Hipperhania hirta</i>	142. <i>Polygonum equistiforme</i>
31. <i>Calystegia sepium</i>	87. <i>Hippocrepis unisiliquosa</i>	143. <i>Prasium majus</i>
32. <i>Capparis spinosa</i>	88. <i>Hyacinthella millingenii</i>	144. <i>Prosopis farcta</i>
33. <i>Cardaria draba</i>	89. <i>Hyosyamus aureus</i>	145. <i>Ptilostemon chamaepeuce*</i>
34. <i>Cardopatum corymbosum</i>	90. <i>Hypericum triquetrifolium</i>	146. <i>Pyrus syriaca</i>
35. <i>Carduus argentatus</i>	91. <i>Juncus fontanesii</i>	147. <i>Quercus coccifera</i>
36. <i>Carduus pycnocephalus</i>	92. <i>Juncus hybridus</i>	148. <i>Ranunculus asiaticus</i>
37. <i>Carlina involucrata</i> ssp. <i>cypria*</i>	93. <i>Juniperus phoenicea</i>	149. <i>Ranunculus bullatus</i>
38. <i>Carthamus tenuis</i>	94. <i>Lagoecia cuminoides</i>	150. <i>Ranunculus ficaria</i>
39. <i>Casuarina equisetifolia</i>	95. <i>Lathyrus aphaca</i>	151. <i>Raphanus raphanistrum</i>
40. <i>Centaurea aegilophila</i>	96. <i>Lathyrus blepharicarpus</i>	152. <i>Rapistrum rugosum</i>
41. <i>Centaurea hyalolepis</i>	97. <i>Leontice leontopetalum</i>	153. <i>Reseda orientalis</i>
42. <i>Ceratonia siliqua</i>	98. <i>Leontodon tuberosus</i>	154. <i>Rhagadiolus stellatus</i>
43. <i>Chrysanthemum coronarium</i>	99. <i>Lithodora hispidula</i>	155. <i>Rhamnus oleoides</i>
44. <i>Cistus creticus</i>	100. <i>Malva parviflora</i>	156. <i>Romulea tempskyana</i>
45. <i>Cistus parviflorus</i>	101. <i>Matricaria recutita</i>	157. <i>Rubia tenuifolia</i>
46. <i>Cistus salviifolius</i>	102. <i>Medicago praecox</i>	158. <i>Rubia tinctorum</i>
47. <i>Clematis cirrhosa</i>	103. <i>Mercurialis annua</i>	159. <i>Rubus sancta</i>
48. <i>Convolvulus oleifolius</i> var. <i>desertii</i>	104. <i>Micromeria myrtifolia</i>	160. <i>Rumex pulcher</i>
49. <i>Convolvulus siculus</i>	105. <i>Micromeria nervosa</i>	161. <i>Salvia fruticosa</i>
50. <i>Crataegus azarolus</i>	106. <i>Myrtus communis</i>	162. <i>Salvia verbenaca</i>
51. <i>Crataegus monogyna</i>	107. <i>Neotinea maculate</i>	163. <i>Sarcopoterium spinosum</i>
52. <i>Crucianella latifolia</i>	108. <i>Nerium oleander</i>	164. <i>Scabiosa prolifera</i>
53. <i>Crupina crupinastrum</i>	109. <i>Notobasis syriaca</i>	165. <i>Scandix pecten-veneris</i>
54. <i>Cupressus sempervirens</i>	110. <i>Olea europaea</i>	166. <i>Scolymus hispanicus</i>
55. <i>Cynara cardunculus</i>	111. <i>Onobrychis caput-galli</i>	

Table 1. (Cont'd.).

167. <i>Scutellaria sibthorpii</i> *	26. <i>Centaurea calcitrapa</i>	86. <i>Narcissus tazetta</i>
168. <i>Serratula cerinthifolia</i>	27. <i>Centaureum erythraea</i>	87. <i>Nigella fumariifolia</i>
169. <i>Sherardia arvensis</i>	28. <i>Centaureum pulchellum</i>	88. <i>Nonea philistea</i>
170. <i>Silene nocturna</i>	29. <i>Centaureum spicatum</i>	89. <i>Odondites cypria</i> *
171. <i>Sinapis alba</i>	30. <i>Centaureum tenuiflorum</i>	90. <i>Onobrychis venosa</i> *
172. <i>Smilax aspera</i>	31. <i>Chenopodium album</i>	91. <i>Onopordum cyprium</i> *
173. <i>Solanum nigrum</i>	32. <i>Chenopodium murale</i>	92. <i>Origanum majorana</i>
174. <i>Sonchus oleraceus</i>	33. <i>Chrozophora tinctoria</i>	93. <i>Origanum syriacum</i> *
175. <i>Stellaria media</i>	34. <i>Convolvulus arvensis</i>	94. <i>Orlaya daucoides</i>
176. <i>Zanichella palustris</i>	35. <i>Convolvulus betonicifolius</i>	95. <i>Oryzopsis miliacea</i> var. <i>pumilis</i>
177. <i>Tamarix tetragyna</i>	36. <i>Convolvulus oleifolius</i> var. <i>pumilis</i>	96. <i>Otanthus maritimus</i>
178. <i>Tamus officinalis</i>	37. <i>Cordia myxa</i>	97. <i>Papaver hybridum</i>
179. <i>Tetragonolobus purpureus</i>	38. <i>Cyclamen persicum</i>	98. <i>Papaver rhoeas</i>
180. <i>Teucrium creticum</i>	39. <i>Cynoglossum creticum</i>	99. <i>Parentucellia latifolia</i>
181. <i>Teucrium micropoidoides</i> *	40. <i>Daucus aureus</i>	100. <i>Paronychia argentea</i>
182. <i>Thymus capitatus</i>	41. <i>Daucus broteri</i>	101. <i>Paronychia macrosepala</i>
183. <i>Tordylium syriacum</i>	42. <i>Ecballium elaterium</i>	102. <i>Phalaris brachystachys</i>
184. <i>Torilis tenella</i>	43. <i>Eryngium creticum</i>	103. <i>Phyla filiformis</i>
185. <i>Tragopogon sinuatus</i>	44. <i>Eryngium maritimum</i>	104. <i>Physanthyllis tetraphylla</i>
186. <i>Trifolium angustifolium</i>	45. <i>Euphorbia helioscopia</i>	105. <i>Picris altissima</i>
187. <i>Trifolium leucanthum</i>	46. <i>Euphorbia peplis</i>	106. <i>Pistacia atlantica</i>
188. <i>Tulipa cypria</i> *	47. <i>Euphorbia sintenisii</i>	107. <i>Plantago amplexicaulis</i>
189. <i>Typha domingensis</i>	48. <i>Evax eriosphaera</i>	108. <i>Plantago lagopus</i>
190. <i>Umbilicus rupestris</i>	49. <i>Ferula communis</i>	109. <i>Plantago lanceolata</i>
191. <i>Urgenia maritima</i>	50. <i>Ferulago syriaca</i>	110. <i>Plantago maritima</i>
192. <i>Valantia hispida</i>	51. <i>Filago pyramidata</i>	111. <i>Plantago ovata</i>
193. <i>Valeriana officinalis</i>	52. <i>Ficus carica</i>	112. <i>Poterium verrucosum</i>
194. <i>Velezia rigida</i>	53. <i>Frankenia hirsuta</i>	113. <i>Pseudorlaya pumila</i>
195. <i>Verbascum sinuatum</i>	54. <i>Fumana thymifolia</i>	114. <i>Pulicaria dysenterica</i>
196. <i>Veronica cymbalaria</i>	55. <i>Fumaria parviflora</i>	115. <i>Rhagadiolus stellatus</i>
197. <i>Vicia hybrida</i>	56. <i>Galium canum</i>	116. <i>Rosmarinus officinalis</i>
198. <i>Vicia villosa</i>	57. <i>Galium verrucosum</i>	117. <i>Rostraria amblyantha</i>
199. <i>Ziziphus lotus</i>	58. <i>Genista sphacelata</i>	118. <i>Rostraria cristata</i>
200. <i>Zosima absinthifolia</i>	59. <i>Gladiolus triphyllus</i> *	119. <i>Salvia fruticosa</i>
Ronnas	60. <i>Glycyrrhiza glabra</i>	120. <i>Scaligeria cretica</i>
1. <i>Acer obtusifolium</i>	61. <i>Hedysarum spinosissimum</i>	121. <i>Scandix australis</i>
2. <i>Aegilops biuncialis</i>	62. <i>Heliotropium hirsutissimum</i>	122. <i>Scirpoides holoschoenus</i>
3. <i>Aleopecurus myosuroides</i>	63. <i>Hipperhania hirta</i>	123. <i>Scolymus maculatus</i>
4. <i>Allium rubrovittatum</i>	64. <i>Hypochoeris glabra</i>	124. <i>Sedum sediforme</i>
5. <i>Anchusa strigosa</i>	65. <i>Ipomoea sagittata</i>	125. <i>Sideritis curvidens</i>
6. <i>Andrachne telephiodes</i>	66. <i>Ipomoea stolonifera</i>	126. <i>Silene fuscata</i>
7. <i>Anemone coronaria</i>	67. <i>Kohlerauchia velutina</i>	127. <i>Silene vulgaris</i>
8. <i>Apium graveolens</i>	68. <i>Lathyrus annuus</i>	128. <i>Sorghum halepense</i>
9. <i>Aristolochia sempervirens</i>	69. <i>Limonium albidum</i> ssp. <i>cyprium</i> *	129. <i>Styrax officinalis</i>
10. <i>Atriplex halimus</i>	70. <i>Limonium echioides</i>	130. <i>Taraxacum cyprium</i>
11. <i>Ballota nigra</i> *	71. <i>Limonium meyeri</i>	131. <i>Telmissa microcarpa</i>
12. <i>Bellis perennis</i>	72. <i>Limonium sinuatum</i>	132. <i>Teucrium divaricatum</i>
13. <i>Beta vulgaris</i> ssp. <i>maritima</i>	73. <i>Limonium virgatum</i>	133. <i>Teucrium micropodioides</i> *
14. <i>Borago officinalis</i>	74. <i>Linum strictum</i> ssp. <i>spicatum</i>	134. <i>Tordylium aegyptiacum</i>
15. <i>Bosea cypria</i> *	75. <i>Lolium perenne</i>	135. <i>Trachymia distachya</i>
16. <i>Briza maxima</i>	76. <i>Lolium rigidum</i>	136. <i>Trifolium campestre</i>
17. <i>Bromus madritensis</i>	77. <i>Mandragora officinarum</i>	137. <i>Trifolium cherleri</i>
18. <i>Bromus rubens</i>	78. <i>Medicago disciformis</i>	138. <i>Trifolium clypeatum</i>
19. <i>Bupleurum sintenisii</i>	79. <i>Medicago littoralis</i>	139. <i>Trifolium globosum</i>
20. <i>Bupleurum subovatum</i>	80. <i>Medicago marina</i>	140. <i>Trifolium pampylicum</i>
21. <i>Cakila maritima</i>	81. <i>Medicago polymorpha</i>	141. <i>Trifolium stellatum</i>
22. <i>Calamintha incana</i>	82. <i>Medicago rotata</i>	142. <i>Trigonella spinosa</i>
23. <i>Calicotome villosa</i>	83. <i>Medicago rugosa</i>	143. <i>Urtica urens</i>
24. <i>Carex flacca</i>	84. <i>Mentha longifolia</i>	
25. <i>Carthamus lanatus</i>	85. <i>Myrtus commonis</i>	

Table 1. (Cont'd.).

Achna	51. <i>Galium setaceum</i>	105. <i>Sisymbrium irio</i>
1. <i>Acacia cyanophylla</i>	52. <i>Glinus lotoides</i>	106. <i>Solanum villosum</i>
2. <i>Ainsworthia trachycarpa</i>	53. <i>Hedynois rhagadioloides</i>	107. <i>Spergularia marina</i>
3. <i>Ajugaiwa</i>	54. <i>Helianthemum salicifolium</i>	108. <i>Sisymbrium irio</i>
4. <i>Allium cupani</i> ssp. <i>cyprium</i>	55. <i>Heliotropium dolosum</i>	109. <i>Tamarix smyrnensis</i>
5. <i>Allium curtum</i>	56. <i>Heliotropium europaeum</i>	110. <i>Thesium humile</i>
6. <i>Allium paniculatum</i> ssp. <i>pallens</i>	57. <i>Herniaria cinerea</i>	111. <i>Tragopogon sinuatus</i>
7. <i>Alyssum strigosum</i>	58. <i>Hirschfeldia incana</i>	112. <i>Tribulus terrestris</i>
8. <i>Amaranthus graecizans</i> ssp. <i>Graecizans</i>	59. <i>Hypecoum imberbe</i>	113. <i>Trifolium pamphylicum</i> var. <i>pamphylicum</i>
9. <i>Amaranthus hybridus</i> ssp. <i>Hybridus</i>	60. <i>Hypochaeris echinophorus</i>	114. <i>Urospermum picroides</i>
10. <i>Anagallis arvensis</i> ssp. <i>arvensis</i> var. <i>arvensis</i>	61. <i>Hypochaeris unisiliquosa</i>	115. <i>Valerianella vesicaria</i>
11. <i>Anagallis arvensis</i> ssp. <i>arvensis</i> var. <i>caerulea</i>	62. <i>Kickxia elatine</i> ssp. <i>sieberi</i>	116. <i>Verbena officinalis</i>
12. <i>Anchusa aegyptiaca</i>	63. <i>Lagoecia cuminoides</i>	117. <i>Verbena supina</i>
13. <i>Anchusa undulata</i> ssp. <i>hybrida</i>	64. <i>Lamium amplexicaule</i>	Oroklini
14. <i>Andrachne telephiodides</i>	65. <i>Lathyrus cicrea</i>	1. <i>Acacia saligna</i>
15. <i>Anthemis parvifolia</i>	66. <i>Leontodon tuperosus</i>	2. <i>Amaranthus graecizans</i> ssp. <i>graecizans</i>
16. <i>Anthemis tricolor</i> *	67. <i>Linum bienne</i>	3. <i>Anagallis arvensis</i> var. <i>cerulean</i>
17. <i>Asparagus stipularis</i>	68. <i>Lotus ornithopodioides</i>	4. <i>Arthrocnemum macrostachyum</i>
18. <i>Aster squamatus</i>	69. <i>Lythrum tribracteatum</i>	5. <i>Atriplex rosea</i>
19. <i>Asteriscus aquaticus</i>	70. <i>Malva aegyptiaca</i>	6. <i>Atriplex semibaccata</i>
20. <i>Beta vulgaris</i>	71. <i>Malva sylvestris</i>	7. <i>Avena sativa</i>
21. <i>Bolboschoenus nigricans</i>	72. <i>Medicago orbicularis</i>	8. <i>Bassia indica</i>
22. <i>Bupleurum laucifolium</i>	73. <i>Melilotus sulcatus</i>	9. <i>Cakile maritima</i>
23. <i>Capsella bursa-pastoris</i>	74. <i>Mercurialis annua</i>	10. <i>Carlina involucrata</i> ssp. <i>cypria</i> *
24. <i>Carduus argentatum</i> ssp. <i>aciculata</i>	75. <i>Misopates orontium</i>	11. <i>Chenopodium opulifolium</i>
25. <i>Carlina involucrata</i> ssp. <i>cyprica</i> *	76. <i>Muscari parviflorum</i>	12. <i>Cichorium intybus</i>
26. <i>Carlina lanata</i>	77. <i>Narcissus seretinus</i>	13. <i>Cressa cretica</i>
27. <i>Carlina pygmaea</i> *	78. <i>Nicotiana glauca</i>	14. <i>Dittrichia viscosa</i>
28. <i>Cheilanthes pteridioides</i>	79. <i>Nigella nigellastrum</i>	15. <i>Echinops spinosissimus</i>
29. <i>Chenopodium vulvaria</i>	80. <i>Nigella unguicularis</i>	16. <i>Frankenia pulverulenta</i>
30. <i>Chrozophora nigrum</i>	81. <i>Noaea mucronata</i>	17. <i>Halopeplis amplexicaulis</i>
31. <i>Chrozophora tinctoria</i>	82. <i>Onobrychis crista-galli</i>	18. <i>Helianthemum salicifolium</i>
32. <i>Cnicus benedictus</i>	83. <i>Opuntia ficus indica</i>	19. <i>Helianthus tuberosus</i>
33. <i>Colchicum pusillum</i>	84. <i>Phagnalon rupestre</i> ssp. <i>rupestre</i>	20. <i>Hordeum marinum</i>
34. <i>Convolvulus althaeoides</i>	85. <i>Phyla nodiflora</i>	21. <i>Juncus maritimus</i>
35. <i>Convolvulus dorycnium</i>	86. <i>Pimpinella cretica</i>	22. <i>Lactuca serriola</i>
36. <i>Conyza bonariensis</i>	87. <i>Plantago afra</i>	23. <i>Lavatera cretica</i>
37. <i>Coronilla scorpioides</i>	88. <i>Plantago coronopus</i> ssp. <i>commutata</i>	24. <i>Lycium ferocissimum</i>
38. <i>Crepis tortida</i>	89. <i>Plantago cretica</i>	25. <i>Lythrum hissopifolia</i>
39. <i>Crucianella aegyptiaca</i>	90. <i>Plantago squarosa</i>	26. <i>Melilotus indicus</i>
40. <i>Cynara cornicera</i>	91. <i>Polycarpon tetraphyllum</i>	27. <i>Mesembryanthemum nodiflorum</i>
41. <i>Delphinium peregrinum</i> var. <i>eriocarpum</i>	92. <i>Polygonum angustifolium</i>	28. <i>Onopordum cyprium</i> *
42. <i>Dianthus strictus</i> var. <i>troodi</i> *	93. <i>Polygonum equisetiforme</i>	29. <i>Parapholis incurva</i>
43. <i>Rumex conglomeratum</i>	94. <i>Portulaca oleraceae</i>	30. <i>Phragmites australis</i>
44. <i>Emex spinosa</i>	95. <i>Pterocephalus brevis</i>	31. <i>Polypogon maritimus</i>
45. <i>Erodium ciconium</i>	96. <i>Salosa verbenaca</i>	32. <i>Salicornia europaea</i>
46. <i>Erucaria hispanica</i>	97. <i>Salsola kali</i>	33. <i>Spergularia marina</i>
47. <i>Euphorbia chamaesyce</i>	98. <i>Salvia viridis</i>	34. <i>Sphenopus divaricatus</i>
48. <i>Filago eriocephala</i>	99. <i>Schoenus nigricans</i>	35. <i>Stipa capensis</i>
49. <i>Fumaria officinalis</i>	100. <i>Scilla autumnalis</i>	36. <i>Suaeda aegyptiaca</i>
50. <i>Galium aparine</i>	101. <i>Scorpiurus muricatus</i> ssp. <i>sabvillosus</i>	37. <i>Suaeda vera</i>
	102. <i>Sideritis curvidens</i>	38. <i>Tamarix smyrnensis</i>
	103. <i>Silene macrodonta</i>	39. <i>Triticum aestivu</i>
	104. <i>Sinapis arvensis</i>	

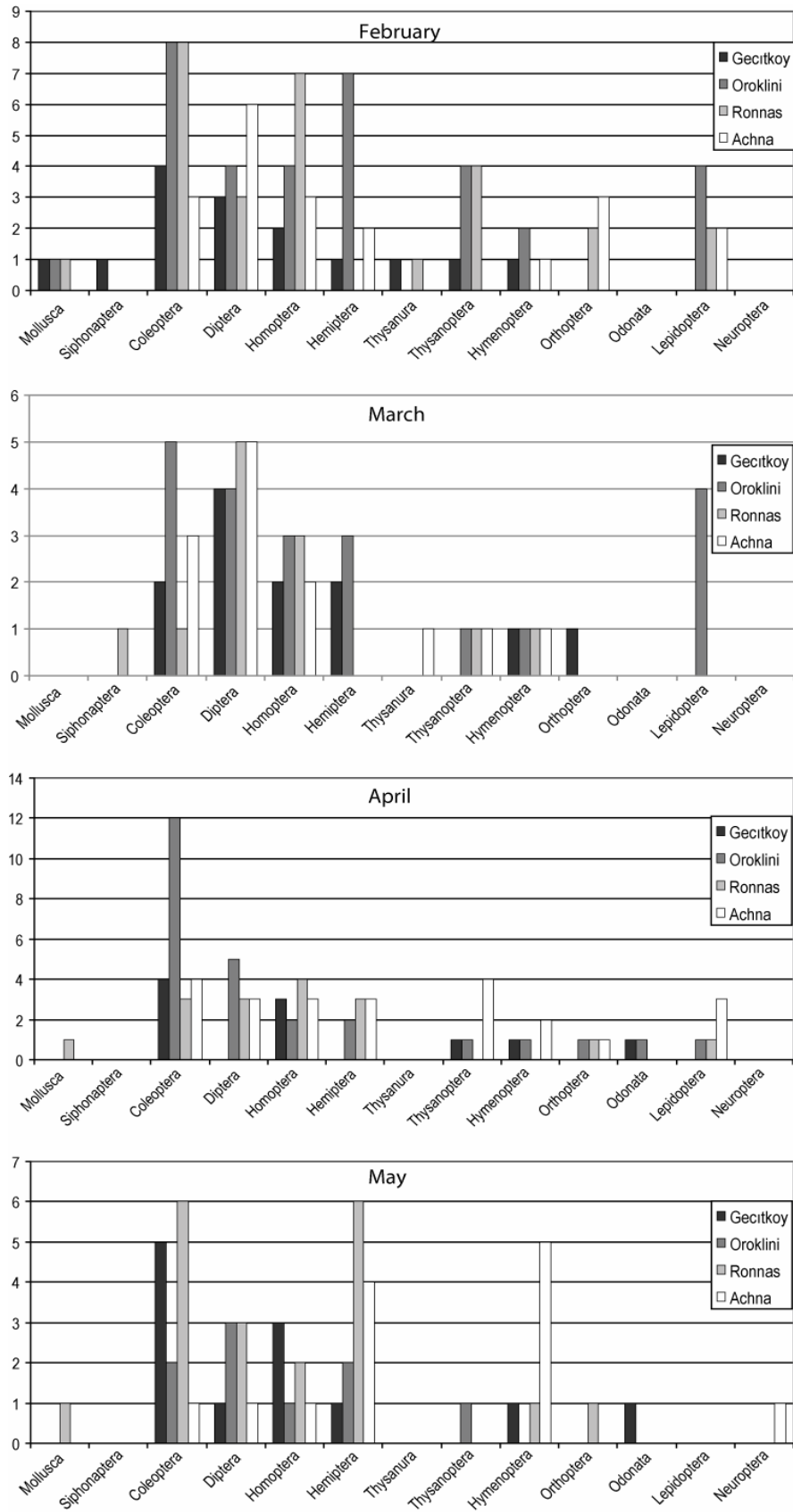


Fig. 2. Number of insect species identified by order in the four wetlands.

Table 2. Butterfly species identified in each wetland from all surveys (*endemics).

Gecitkoy (artificial)	<i>Anthocharis cardamines</i> (Orange Tip)
<i>Pieris brassicae</i> (Cabbage White)	<i>Papilio machaon</i> (Swallow Tail)
<i>Artogeia rapae</i> (Small White)	<i>Zerynthia cerisyi</i> (Eastern Festoon)
<i>Gonepteryx cleopatra</i> (Cleopatra)	<i>Maniola cypricola</i> (Cyprus Meadow Brown) *
<i>Venessa atalanta</i> (Red Admiral)	<i>Glaucopsyche paphos</i> (Paphos Blue)*
<i>Anthocharis cardamines</i> (Orange Tip)	<i>Colias crocea</i> (Clouded Yellow)
<i>Papilio machaon</i> (Swallow Tail)	<i>Thymelicus acteon</i> (Lulworth Skipper)
<i>Venessa cardui</i> (Painted Lady)	<i>Gegenes pumilio</i> (Pygmy Skipper) (Relatively Rare Butterfly)
<i>Maniola cypricola</i> (Cyprus Meadow Brown) *	Achna (artificial)
<i>Glaucopsyche paphos</i> (Paphos Blue) *	<i>Pieris brassicae</i> (Cabbage White)
<i>Colias crocea</i> (Clouded Yellow)	<i>Glaucopsyche paphos</i> (Paphos Blue) *
<i>Thymelicus acteon</i> (Lulworth Skipper)	<i>Pontia edusa</i> (Eastern Bath White)
Ronnas (natural)	<i>Colias crocea</i> (Clouded Yellow)
<i>Pieris brassicae</i> (Cabbage White)	<i>Carcharodus alceae</i> (Mallow Skipper)
<i>Artogeia rapae</i> (Small White)	Oroklini (natural)
<i>Gonepteryx cleopatra</i> (Cleopatra)	<i>Pieris brassicae</i> (Cabbage White)
<i>Venessa cardui</i> (Painted Lady)	<i>Glaucopsyche paphos</i> (Paphos Blue) *

The differences in vegetation between systems may lead to differences in other assemblages because plants provide both food and habitat for both invertebrates and vertebrates (Danielson, 1998, Zimmer *et al.*, 2000). Similar avian species richness (Brown & Smith, 1998, Brown & Batzer, 2001, Juni & Berry, 2001, Ratti *et al.*, 2001, Balcombe *et al.*, 2005) and diversity (Juni & Berry, 2001, Ratti *et al.*, 2001) between natural and created depressional wetlands has been reported. For example, Wissinger *et al.*, (2001) found the composition of the macroinvertebrate assemblage to be similar between the natural and created emergent wetlands. It was also observed that there was no difference in the number of orders of invertebrates identified in natural and artificial wetlands. Given the short survey period and the wide variation in the sizes of the sites, however, it cannot be concluded that artificial wetlands can replace the biodiversity lost by the disturbance of natural wetlands in Cyprus. Indeed, the use of artificial wetlands for public water supply and irrigation results in the water levels being highly variable and, in periods of water shortage, these wetlands can be drained completely, making the ecosystem more vulnerable than natural wetlands not managed for water supply.

This study has demonstrated that artificial wetlands do provide important habitats for flora and fauna and these sites should be managed with biodiversity as well as water resources objectives. Caliskan (2008) also mentions that the protection of natural wetlands should be maintained as a high priority as the particular communities and functions provided by these wetlands may not be replaced by artificial wetlands. Only where natural wetland loss is unavoidable artificial wetland should be considered as a replacement for these valuable ecosystems.

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Table 3. Bird species recorded at two natural wetlands, Ronnas River and Oroklini Lake, and two man-made wetlands, Geçitköy (Panagra) Reservoir and Achna Dam, in Cyprus, from February to June 2006.

	Common name	Scientific name	Ronnas	Oroklini	Gecitkoy	Achna
1.	Little grebe	<i>Tachybaptus ruficollis</i>		+	+	+
2.	Great Crested Grebe	<i>Podiceps cristatus</i>				+
3.	Black-necked Grebe	<i>Podiceps nigricollis</i>				+
4.	Great Cormorant	<i>Phalacrocorax carbo</i>			+	+
5.	Mediterranean Shag	<i>Phalacrocorax aristotelis desmaresti</i>	+			
6.	Black-crowned Night-heron	<i>Nycticorax nycticorax</i>				+
7.	Cattle Egret	<i>Bubulcus ibis</i>		+		
8.	Little Egret	<i>Egretta garzetta</i>		+	+	+
9.	Great (White) Egret	<i>Casmerodius albus</i>				+
10.	Grey Heron	<i>Ardea cinerea</i>			+	+
11.	Purple Heron	<i>Ardea purpurea</i>		+		+
12.	Glossy Ibis	<i>Plegadis falcinellus</i>		+		+
13.	Eurasian Wigeon	<i>Anas penelope</i>				
14.	Gadwall	<i>Anas strepera</i>				
15.	Eurasian Teal	<i>Anas crecca</i>		+		+
16.	Mallard	<i>Anas platyrhynchos</i>		+	+	+
17.	Garganey	<i>Anas querquedula</i>		+		+
18.	Northern Shoveler	<i>Anas clypeata</i>		+		+
19.	Common Pochard	<i>Aythya ferina</i>		+	+	
20.	Western Marsh-harrier	<i>Circus aeruginosus</i>		+		+
21.	Common Buzzard	<i>Buteo buteo</i>	+			
22.	Common Kestrel	<i>Falco tinnunculus</i>	+		+	
23.	Chukar	<i>Alectoris chukar</i>	+		+	
24.	Black Francolin	<i>Francolinus francolinus</i>	+		+	
25.	Little Crake	<i>Porzana parva</i>		+		
26.	Common Moorhen	<i>Gallinula chloropus</i>		+	+	+
27.	Common Coot	<i>Fulica atra</i>		+	+	+
28.	Black-winged Stilt	<i>Himantopus himantopus</i>		+		+
29.	Eurasian Thick-knee	<i>Burhinus oedicephalus</i>				+
30.	Collared Pratincole	<i>Glareola pratincola</i>				+
31.	Little Ringed Plover	<i>Charadrius dubius</i>		+		+
32.	Common Ringed Plover	<i>Charadrius hiaticula</i>				
33.	Kentish Plover	<i>Charadrius alexandrinus</i>				
34.	Spur-winged Lapwing	<i>Vanellus spinosus</i>		+		+
35.	Little Stint	<i>Calidris minuta</i>		+		
36.	Ruff	<i>Philomachus pugnax</i>		+		+
37.	Common Snipe	<i>Gallinago gallinago</i>	+	+		+
38.	Great Snipe	<i>Gallinago media</i>				+
39.	Black-tailed Godwit	<i>Limosa limosa</i>		+		+
40.	Spotted Redshank	<i>Tringa erythropus</i>				+
41.	Common Redshank	<i>Tringa totanus</i>		+		+

Table 3. (Cont'd.).

	Common name	Scientific name	Ronnas	Oroklini	Gecitkoy	Achna
42.	Marsh Sandpiper	<i>Tringa stagnatilis</i>		+		+
43.	Common Greenshank	<i>Tringa nebularia</i>		+		
44.	Green Sandpiper	<i>Tringa ochropus</i>		+		+
45.	Wood Sandpiper	<i>Tringa glareola</i>		+		+
46.	Common Sandpiper	<i>Actitis hypoleucos</i>		+		+
47.	Common Black-headed Gull	<i>Larus ridibundus</i>		+		+
48.	Slender-billed Gull	<i>Larus genei</i>		+		
49.	Audouin's Gull	<i>Larus audouinii</i>	+			
50.	Yellow-legged Gull	<i>Larus michahellis michahellis</i>			+	
51.	Caspian Gull	<i>Larus (argentatus) cachinnans</i>				+
52.	White-winged (Black) Tern	<i>Chlidonias leucopterus</i>				+
53.	Common Wood-pigeon	<i>Columba palumbus</i>	+			
54.	Common Cuckoo	<i>Cuculus canorus</i>	+			
55.	European Bee-eater	<i>Merops apiaster</i>	+			
56.	Crested Lark	<i>Galerida cristata</i>	+			
57.	Barn Swallow	<i>Hirundo rustica</i>	+		+	
58.	Red-rumped Swallow	<i>Hirundo daurica</i>	+			
59.	Northern House Martin	<i>Delichon urbicum</i>			+	
60.	European Robin	<i>Erithacus rubecula</i>	+		+	
61.	Black Redstart	<i>Phoenicurus ochruros</i>			+	
62.	Common Stonechat	<i>Saxicola torquata</i>	+		+	
63.	Cyprus Wheatear	<i>Oenanthe cyprica</i>	+			
64.	Eurasian Blackbird	<i>Turdus merula</i>	+			
65.	Song Thrush	<i>Turdus philomelos</i>	+			
66.	Cetti's Warbler	<i>Cettia cetti</i>	+			
67.	Zitting Cisticola	<i>Cisticola juncidis</i>			+	
68.	Olivaceous Warbler	<i>Hippolais pallida</i>	+			
69.	Spectacled Warbler	<i>Sylvia conspicillata</i>	+			
70.	Cyprus Warbler	<i>Sylvia melanothorax</i>	+		+	
71.	Blackcap	<i>Sylvia atricapilla</i>	+			
72.	Great Tit	<i>Parus major</i>	+			
73.	Woodchat Shrike	<i>Lanius senator</i>	+			
74.	Black-billed Magpie	<i>Pica pica</i>	+			
75.	Eurasian Jackdaw	<i>Corvus monedula</i>			+	
76.	Hooded Crow	<i>Corvus corone</i>	+		+	
77.	House Sparrow	<i>Passer domesticus</i>	+			
78.	Spanish Sparrow	<i>Passer hispaniolensis</i>	+			
79.	Chaffinch	<i>Fringilla coelebs</i>			+	
80.	European Greenfinch	<i>Carduelis chloris</i>	+			
81.	European Goldfinch	<i>Carduelis carduelis</i>	+		+	
82.	Eurasian Linnet	<i>Carduelis cannabina</i>			+	
83.	Corn Bunting	<i>Miliaria calandra</i>	+		+	

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