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Range of the Greater Flamingo, *Phoenicopterus roseus*, metapopulation in the Mediterranean: new insights from Turkey

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Abstract Metapopulation conservation should rely on a flyway approach aiming at assessing the spatial range of metapopulations by estimating the level of exchanges among local populations. In the western Mediterranean, Greater Flamingos have been shown to constitute a metapopulation with natal and breeding dispersal among colonies. In this paper, we examine whether this metapopulation reaches Turkey using a band-resighting study. Our results are the first evidence of natal and breeding dispersal from the western Mediterranean to Turkey, and suggest that the Gediz Delta, one of the two Turkish breeding colonies, can play a significant role in the recruitment of flamingos from the western Mediterranean. In 2003 and 2004, breeders of western Mediterranean origin accounted for more than 1.2 and 1.9% of the estimated breeding population of the Gediz Delta, respectively. Our observations also indicate that the western Mediterranean and Southwest Asia may constitute two sets of populations, which overlap in Turkey. Finally, the resightings of flamingos banded in Turkey show that post-fledging dispersal from Turkey reaches both the eastern and western Mediterranean wetlands. Future data on the natal and breeding dispersal of flamingos born in Turkey could clarify further the connection between Turkey and the western Mediterranean metapopulation.

Keywords Capture-recapture · Colonial waterbirds · Conservation · Dispersal · Gediz Delta

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Introduction

Bird conservation has recently benefited from the implementation of the flyway approach in action plans (Boere and Taylor 2004). This approach is most often applied to migratory birds. However, the flyway concept should also be of critical importance for the conservation of metapopulations as it aims at addressing conservation issues over a geographical scale appropriate to the extent of the biological processes underlying population dynamics

(Amat et al. 2005). Metapopulation theory should thus be useful, for instance, in planning for the conservation of colonial waterbirds at an appropriate spatial scale, because the extinction of their colonies can be prevented or compensated by the demographic connections among colonies (Brown and Kodric-Brown 1977; Opdam 1991; Opdam et al. 1995; Stacey et al. 1997; Hanski 1999; Esler 2000). Mapping the range of a metapopulation and estimating the level of exchange among colonies are thus critical to understanding the dynamics of the species of concern and to establishing sound conservation measures.

The Greater Flamingo (*Phoenicopterus roseus*) is a partially migratory, dispersing and at times nomadic species, found widely distributed in the shallow brackish or saline lakes of the Mediterranean; West, East, and South Africa; and South and Southwest Asia (Kahl 1975; Johnson 1997b). The world population is >500,000 individuals (Wetlands International 2002). In the Mediterranean region, the presence of two populations is generally recognized (Kahl 1975; Johnson 1989). The western Mediterranean population probably numbers 100,000 individuals. The eastern Mediterranean population, which is suspected to include the Asian range of the species, is estimated at 290,000 individuals (Wetlands International 2002). This latter population is said to be stable (Wetlands International 2002), however, there is no recent count from Asia to support this claim. In contrast, the western Mediterranean population has been shown to have increased in recent years (Johnson 1997a); however, ≥90% of this population breeds in fewer than 10 sites (BirdLife International 2004). In addition, breeding is irregular at some of these sites due to the fluctuations in water levels that characterize saline lakes of many parts of the Mediterranean (Nager et al. 1996).

Resightings of flamingos banded in the western Mediterranean suggest that natal dispersal (movements from the birth site to the first breeding site; Greenwood 1980) and breeding dispersal (movements among successive breeding sites; Greenwood 1980) occur markedly at the western Mediterranean scale. Flamingos born in France, Spain, and Italy were observed to breed at other colonies in the western Mediterranean, and similarly, to switch from one colony to another afterward (Balkız et al., unpublished data). These colonies are connected in such a way that (1) the high levels of philopatry exhibited by individuals (Nager et al. 1996; Balkız et al., unpublished data) lead us to think that the demographies of colonies are sufficiently independent so that one colony may become extinct irrespective of the demographics of the others, and (2) natal and breeding dispersal among colonies is frequent enough (Nager et al. 1996; Balkız et al., unpublished data) that recolonization of extinct colonies can occur. These colonies can thus be considered as forming a metapopulation *sensu lato* (see Esler 2000), i.e., a population composed of several interconnected populations (Hanski and Gilpin 1991) covering the western Mediterranean region. Due to the lack of long-term research-oriented capture-recapture studies outside the western Mediterranean, the range of this metapopulation has been unknown to this point. In particular, the degree of connectivity with the eastern Mediterranean set has been unclear, while recent field surveys provided the first evidence that the western Mediterranean flamingos could reach the eastern Mediterranean region, in particular Turkey. This paper presents the results of both literature surveys and field surveys implemented in and around Turkey in order to establish the level and the nature of connectivity between the western and eastern Mediterranean populations of the Greater Flamingo.

Turkey hosts one of the largest flamingo populations of the Mediterranean region with up to 19,000 breeding pairs in 2005 in two colonies, the Gediz Delta and Tuz Lake (Fig. 1; Balkız et al., unpublished data). Surveys conducted between 1996 and 2002 in Turkey reported observation of 22 individuals banded in France and 4 in Spain (Johnson 1991, 1992; M. Sıkı, personal observation). Forty-seven percent of these bands were read near breeding colonies. However, the breeding status of these individuals remained uncertain. Therefore, it is not clear whether these movements were part of natal and/or breeding dispersal from the western Mediterranean or simply resulted from erratic movements. Band resighting efforts at the breeding colonies were initiated in 2003 in order to determine the nature of these movements.

In the Greater Flamingo, the distribution of individuals among colonies could be shaped according to an age-related despotism, resulting in differential dispersal (natal and breeding) with younger breeders displaced to lower quality colony sites (Nager et al. 1996; Rendón et al. 2001). The Camargue colony in France is a long-established, highly saturated and competitive breeding site (Cézilly and Johnson 1995; Cézilly et al. 1996; Nager et al. 1996; Johnson 1997a; Pradel et al. 1997). On the other hand, the Gediz Delta colony in Turkey is a site where breeding became regular only recently (Sıkı 1985; Balkız et al, unpublished data). We therefore made the hypothesis that the Gediz Delta colony could host a higher proportion of younger breeders than the Camargue.

Regarding movements from Asia, recoveries of dead flamingos from Iran and Kazakhstan colonies (hereafter Southwest Asian colonies) have been reported as far as both the eastern and western Mediterranean (Johnson 1989; Behrouzi-Rad 1992; Tavares, unpublished data), with lower intensities in the western Mediterranean (Kahl 1975; Johnson 1989). These two Asian populations are believed to have similar movement patterns (Scott 1975; Johnson 1989; Behrouzi-Rad 1992). Iranian flamingos,

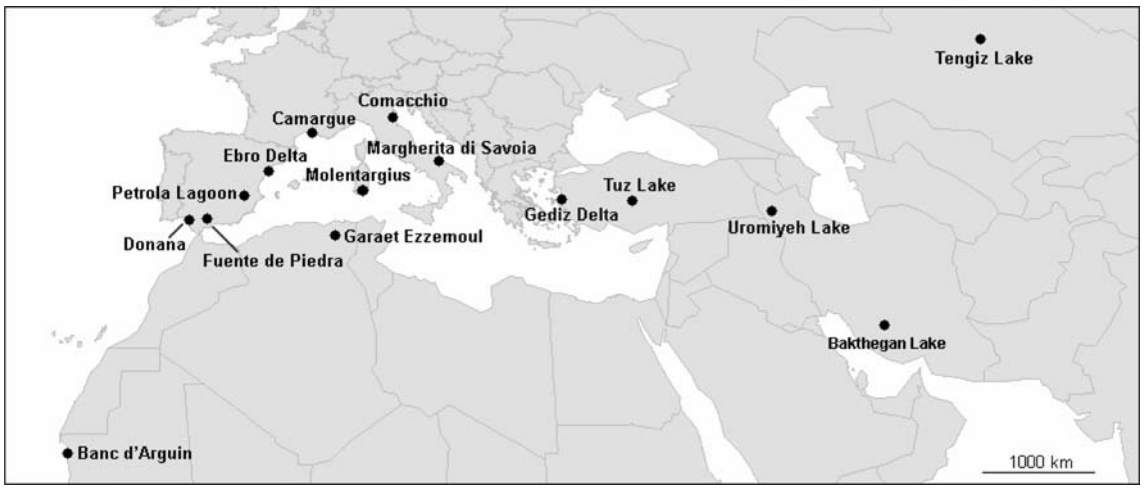

Fig. 1 Map of the successful breeding colonies of Greater Flamingos used at least once from 2000 to 2005 along the Mediterranean and in West Africa and Southwest Asia

which are better documented, were recovered at the farthest northwest in France and at the farthest southeast in Sri Lanka and India, with a large proportion of the recoveries made in Turkey (11.5%, the third highest rate after Iran and India; Behrouzi-Rad 1992). The nature of these movements, however, is not known (e.g., regular movements or incidental records). The possibility of regular movements from Southwest Asia to Turkey has been widely accepted; however this assumption was based mainly on sparse information coming from old recoveries (Scott 1975; Kasparek and van der Ven 1983; Johnson 1989; Behrouzi-Rad 1992). We explore here further evidence from a literature survey and from our field observations.

Finally, the extent of the movements of flamingos born in Turkey to other parts of the range of the species was unknown because of the absence of any banding scheme. We thus initiated a flamingo chick-banding scheme for the first time in Turkey in 2003 and repeated the operation until 2005. Resightings of these flamingos permitted the first map of the post-fledging dispersal of Turkish flamingos to be drawn (movements of individuals from the birth place and before their first breeding attempt; Barbraud et al. 2003).

The main objectives of our study were thus (1) to update our knowledge on the range of the western Mediterranean metapopulation of the Greater Flamingo, in particular to specify if it covers Turkey in the eastern Mediterranean, (2) to specify the role of Turkey in the population dynamics of breeders from the western Mediterranean colonies, (3) to bring new insights regarding the movements from Southwest Asia to Turkey, and finally (4) to map the post-fledging dispersal distribution of flamingos born in Turkey.

Methods

Resightings of banded birds at colonies

There are two known breeding colonies of Greater Flamingos in Turkey. The first one is located in an active salt pan within the Gediz Delta (N38°32′, E26°52′) and the second one in Tuz lake in Central Anatolia (N38°34′, E33°29′). The Tuz Lake colony is 17 km from the lakeshore, and no resightings could be made there. At the Gediz Delta colony, we carried out three field surveys from May to August in 2003 and 2004, each lasting at least 3 days, and six field surveys in the same period in 2005, each lasting 1 day. We spent a total of 33 days in the field during the three seasons, and made 163 h of observation at the breeding colony. Resightings were made with telescopes allowing accurate reading of the band code from up to 300 m (Johnson 2000). We considered a bird to be a breeder if it was observed incubating an egg, attending young, or if it was observed on the same nest for more than 24 h (this was assessed using landscape features to locate the incubating bird from one day to another).

The number of confirmed banded breeders in the Gediz Delta colony represents only a proportion of the total number of breeders that dispersed to the site because (1) not all chicks are banded in their natal colonies, so that unbanded dispersers may breed unnoticed at the Gediz Delta, and (2) the probability of resighting banded breeders is <1 due to field conditions and observer effort. Given that PVC band loss is rare in flamingos (A. R. Johnson, personal communication), we did not consider that it could influence the number of banded breeders observed in an area. Thus, to get a rough estimate of the actual number of

dispersers breeding at the Gediz Delta, we first calculated the average proportion of the chicks banded in the Camargue (France) since 1977 and in Fuente de Piedra (Spain) since 1986. Because recruitment starts at age 3 (Johnson et al. 1993), we set the limit of the last banding year 3 years before the year of observation in the Gediz Delta colony (up to 2000 for 2003 and 2001 for 2004 colony). We then used the resighting histories of banded flamingos (confirmed and unconfirmed breeders from France, Spain, and Sardinia) in the Gediz Delta colony during 2003 and 2004 breeding surveys to estimate the daily resighting probability (P_d) as:

$$P_d = \frac{n}{i \times (d-1)},$$

where n is the number of reobservations following the first observation summed over all individuals, i is the number of different individuals observed, and d is the number of days of survey ($d - 1$ is thus the maximum possible number of reobservations for each individual). We then calculated the probability of observing a banded bird present in the area during the whole study period (P_t) as:

$$P_t = 1 - (1 - P_d)^d.$$

The position of a nest on the breeding island might influence the probability of observing an incubating bird occupying it, i.e., breeders nesting at the periphery of the island might be easier to observe during successive days. This would in turn lead to the overestimation of daily resighting probabilities and underestimation of the number of immigrant breeders. However, we believe this bias is not strong, because we could observe breeders outside their nests (during incubation shifts) and in open water feeding their chicks after the incubation period. Using this formula, we thus tended to slightly underestimate the number of immigrant breeders at the Gediz Delta. Finally, in the absence of a priori information on the readability of various colored bands, we treated all observations equally regardless of the PVC band color.

Age structure of the western Mediterranean flamingos breeding at the Gediz Delta

We compared the age structure of individuals from France (Camargue) and Spain (Fuente de Piedra) that were confirmed breeding at the Gediz Delta with that at the Camargue colony. With few individuals at the Gediz Delta colony (8), we could consider only two age-classes. We decided to set the cut-off point between the two age-classes where recruitment ends because it is possible that the dominance of older flamingos established by Rendón et al. (2001) is related to the dominance of experienced breeders over first-time breeders. Recruitment in flamingos is possible at the age of 3, but it is known often to be delayed (Johnson et al. 1993; Cézilly et al. 1996; Pradel et al. 1997; Johnson 2000; Tavecchia et al. 2001), either due to environmental constraints or as an individual strategy (Nager et al. 1996; Pradel et al. 1997; Tavecchia et al. 2001). A previous study indicates that recruitment ends by the age of 10 (Pradel et al. 1997), i.e., the individuals over 9 years old observed breeding for the first time were most likely recruited initially in another colony from which they later dispersed or had previously bred unnoticed in the same colony (Green et al. 1989; Nager et al. 1996). Thus, we chose our first age class as individuals between 3 and 9 years old and the second age class as individuals 10 years old or older. After pooling the two age classes for the breeders of 2004, the only common year of data collection in the two colonies, we compared the age structures using a Fisher's exact test.

Banding in the Gediz Delta, Turkey

At the end of each breeding season, specifically on 17 August 2003, 1 August 2004 and 31 July 2005, we captured 200, 247, and 270 flamingo chicks born in the Gediz Delta, respectively. All chicks were measured and banded with both a metal ring and a plastic band bearing a unique alphanumeric code (Johnson 1989). The resightings and recoveries of these individuals from August 2003 to December 2005 in sites other than the Gediz Delta allowed mapping the post-fledging dispersal range of flamingos born in Turkey. We took into account the farthest observation of the individuals from their natal colony assuming the movements took place in a straight line (see Amat et al. 2005).

Results

Resightings of individuals from the western Mediterranean

We made a total of 183 resightings over 3 years (2003–2005), and observed 62 individuals born in France, 11 in Spain, 10 in Sardinia, and 3 in continental Italy during the breeding season near the Gediz Delta colony (Fig. 2).

In 2003 and 2004, respectively, nine and six individuals born in France (Camargue) were confirmed as breeders at the Gediz Delta colony. Two of them bred there successively for the 2 years. In 2004, another two flamingos born in Spain (Fuente de Piedra) were confirmed as breeders. Among the 15 confirmed breeders, only one 26-year-old

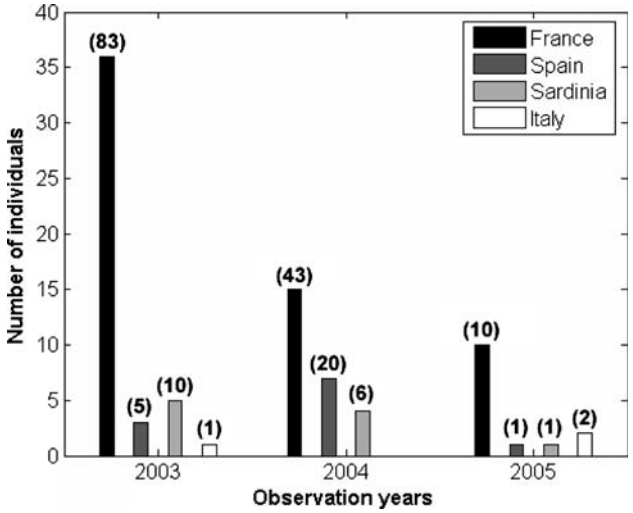

Fig. 2 Origin (site of birth) and numbers of western Mediterranean flamingos resighted during the breeding season in the Gediz Delta (2003–2005). The number of resightings is given *in parentheses* for each year and origin separately

individual born in France had been observed breeding elsewhere before. The others were observed breeding for the first time in the Gediz Delta (age range from 5 to 18). We estimated the total number of dispersers at the Gediz Delta only in 2003 and 2004 because in 2005 we could not assess the breeding status of any banded individual due to logistical constraints preventing sufficient resighting effort.

In the Camargue, from 1977 to 2000, 11.1% of the chicks were banded from a total of 17,118 chicks fledged. Therefore, the observation of nine banded breeders from the Camargue in 2003 could correspond to the presence of as many as 81 breeders (9/0.111) from France at the Gediz Delta colony. The estimated daily resighting probability (P_d) was 0.087 in the Gediz Delta colony, so that the probability of observing a banded bird during the whole study period (P_t) was 0.695. We can thus estimate that 117 breeders (81/0.695) from France were present in the Gediz Delta in 2003, which is more than 1.9% of the estimated breeding population that year, calculated as two times the estimated number of chicks: 6,200.

From 1977 to 2001, 11.1% of chicks were banded in the Camargue from a total of 17,918 chicks fledged. In Fuente de Piedra, from 1986 to 2001, 11.5% of the chicks were banded from a total of 11,003 chicks. Therefore, 6 banded breeders from the Camargue in 2004 could correspond to the presence of as many as 54 breeders (6/0.111) at the Gediz Delta colony. Similarly, 2 banded breeders from Fuente de Piedra could correspond to 17 breeders from Spain. The estimated daily resighting probability (P_d) was 0.138, so that the probability of observing a banded bird during the whole study period (P_t) was 0.855. We can thus estimate that 63 breeders (54/0.855) from France and 20 from Spain were present in the Gediz Delta colony in 2004, together comprising more than 1.2% of the estimated breeding population that year, calculated as two times the estimated number of breeding pairs: 7,238.

Comparison of the Gediz Delta and the Camargue colonies

As expected, younger breeders from the western Mediterranean colonies were proportionally more abundant in the Gediz Delta than in the Camargue (Fig. 3). This difference is not significant at the traditional 5% level, but significant at the less conservative 10% level, which is more appropriate to small sample sizes (two-tailed Fisher's Exact test, $P = 0.097$). Also, it is significant at the 5% level when we test whether the breeding flamingos from the western Mediterranean colonies were younger at the Gediz Delta rather than whether there was simply a difference in the age structure (one-tailed Fisher's exact test, $z = 3.892$, $df = 1$, $P = 0.0485$).

Resightings of individuals from Southwest Asia

In each of the 3 years of observations at the Gediz Delta, we observed one individual (or several) around the colony with a metal ring on its tarsus. The position of the ring prevented us from reading its code and from following the

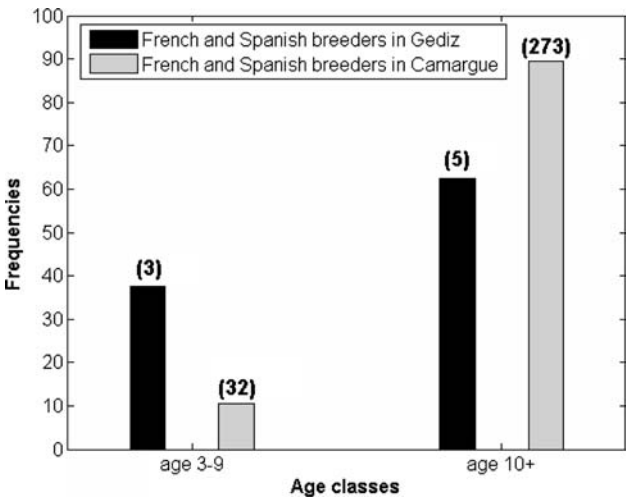

Fig. 3 Comparison of the age structures of flamingos born in two major colonies of the western Mediterranean (Camargue in France and Fuente de Piedra in Spain) confirmed breeding at the Gediz Delta and in the Camargue in 2004. The number of confirmed breeders in both colonies is mentioned *in parentheses*

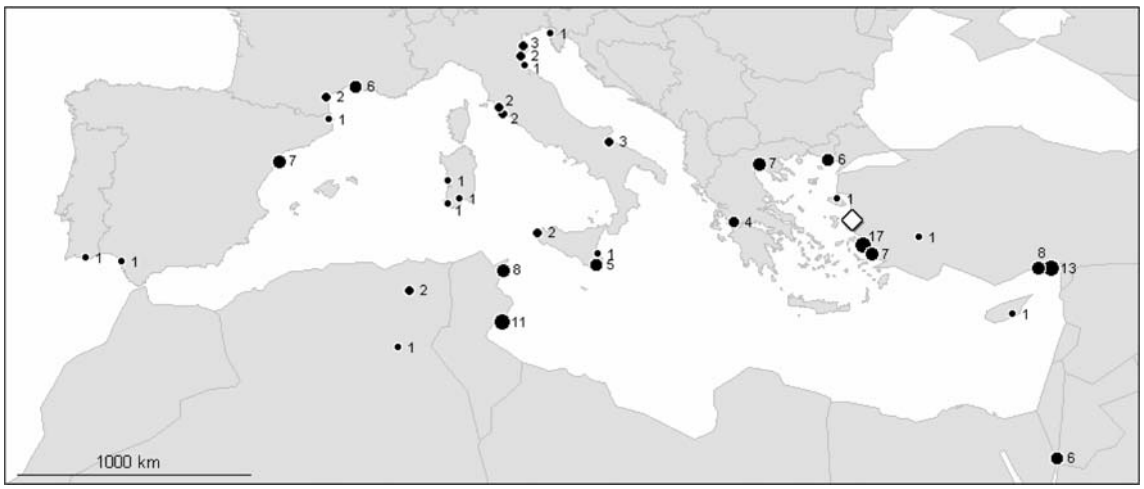

Fig. 4 Post-fledging dispersal distribution of flamingos born and banded in the Gediz Delta (*diamond*), Turkey (2003–2005). The number of individuals resighted and recovered is indicated for each site, and the sizes of the *circles* are proportional to these numbers

individual across the colony, so that the number of such individuals and their breeding status remained unknown. Only in Kazakhstan and Iran are flamingos ringed with a metal ring on the tarsus and no plastic band (Johnson 1990). We therefore suspected these birds to be Southwest Asian flamingos. For these birds to be of western Mediterranean origin, two unlikely events would have had to occur: the PVC band must have been lost and the metal ring would have to have shifted from the tibia to the tarsus. As mentioned previously, PVC band losses are rare in Greater Flamingos, and the shift of metal ring from the tibia to the tarsus seems very unlikely given the leg morphology of the species with no such record in the literature. Thus, the origin of such birds is most likely Southwest Asia.

Post-fledging dispersal of flamingos born in Turkey

Among the 717 flamingos banded as chicks in Turkey between 2003 and 2005, 136 different individuals were resighted from August 2003 to December 2005 for a total of 261 resightings outside the Gediz Delta (Fig. 4). Thirty-four percent of these individuals were resighted in Turkey (46 individuals) and 66% in nine other countries: Italy (24 individuals), Tunisia (19), Greece (18), Spain (9), France (8), Israel (6), Algeria (3), Portugal (1), and Slovenia (1). Also one individual never observed before was recovered in Cyprus, and one observed previously in Tunisia was later recovered in the same country. The resightings and recoveries done outside Turkey were mainly concentrated in Italy (26%), Tunisia (21%), and Greece (20%). The details of resightings and recoveries by banding year (cohort) are given in Table 1.

Table 1 Details of the post-fledging dispersal distribution of flamingos banded in Turkey and resighted/recovered from August 2003 to December 2005 by cohort

Site of observation	Number of individuals by cohort				% Post-fledging dispersal		
	2003	2004	2005	Total	2003	2004	2005
Cyprus	1[a]	0	0	1	1.8	0	0
Portugal	0	1	0	1	0	1.8	0
Slovenia	0	0	1	1	0	0	4.2
Algeria	1	1	1	3	1.8	1.8	4.2
Israel	2	4	0	6	3.6	7.1	0
France	2	5	1	8	3.6	8.9	4.2
Spain	3	2	4	9	5.3	3.6	16.7
Greece	5	7	6	18	8.9	12.5	25
Tunisia	6	9[b]	4	19	10.7	16.1	16.7
Italy	7	13	4	24	12.5	23.2	16.7
Turkey	29	14	3	46	51.8	25	12.5
Total	56	56	24	136			
% Resighted/banded	28	23	9	19			
Number of resightings	107	120	34	261			

[a] Recovery of an individual never observed before

[b] Recovery of an individual that had previously been observed at the same site (not included in the sum)

Discussion

The range of the western Mediterranean metapopulation

Our study established the first evidence that both natal and breeding dispersers from the western Mediterranean colo-

nies could reach Turkey. The number of immigrant breeders observed at the Gediz Delta colony was low. However, when correcting for the proportion that were banded and the resighting probabilities, we found that, respectively, more than 1.2 and 1.9% of the breeders in the colonies of 2003 and 2004 were from France or Spain. Although only statistically marginally significant, the age distribution of the 2004 breeders was skewed toward younger individuals, indicating that the Gediz Delta can be an important site for the recruitment of flamingos from the western Mediterranean colonies. This result thus supports the despotic distribution hypothesis at a large geographical scale.

When we looked at the life histories of the individuals belonging to the second age class, we found that with the exception of one individual aged 26, all six confirmed breeders in the Gediz Delta colony in 2003 and 2004 were observed breeding for the first time in those years regardless of their age (from 10 to 18 years of age). Following the results of Pradel et al. (1997), we suspect that some of them could have already bred unnoticed, including in the Gediz Delta, where breeding has occurred irregularly since 1982. There, banded birds from the western Mediterranean were observed in the colony without confirmation of their breeding status. This in turn strengthens the idea that this site may host mostly younger breeders, whose breeding attempts might have been missed due to the irregularity or absence of resighting efforts. More definitive results on this issue could be obtained by long-term resighting studies at the colony site.

Resightings made in Central Anatolia (Johnson 1992) suggest that the Gediz Delta may not be the only site where natal and breeding dispersal from the western Mediterranean occurs in Turkey. Thus, future studies should focus on finding methods to approach Tuz Lake (the other colony site in Turkey) from land to give insights into dispersal to Turkey.

Our study proves that the western Mediterranean metapopulation of the Greater Flamingo extends over the Gediz Delta colony with directional dispersal from west to east. However, to prove that Turkey is a part of this metapopulation, we still need data on the natal and breeding dispersal of flamingos born in Turkey to establish first the existence, and then the frequency, of exchange among the colonies.

Movements from Southwest Asia

In 1986, 371,000 individuals were observed during fall at only two wetlands of Central Anatolia (Johnson and de Boer 1988; Kirwan et al., unpublished data). According to Johnson (1995), this exceptional record was related to Indian outflows from the Rann of Kutch region, where such high population counts had been reported in the past. Earlier the same year in Iran, the wintering population was higher than ever (around 100,000 individuals; Behrouzi-Rad 1992). It is thus reasonable to suspect that the unusual record from Turkey stems from the same source as the one that affected Iran.

1999 was the second unusual year, with the highest wintering population ever reported in Turkey (51,000 individuals; DHKD 1999). It was a significantly high record for the Mediterranean with no similar change in the western Mediterranean (A. R. Johnson, personal communication). On the other hand, the same year, the breeding colony of flamingos in Uromiyeh Lake (Iran) was abandoned (YEKOM Consulting Engineers 2002). The causes that forced flamingos to abandon breeding (i.e., the shortage of the main food item, *Artemia salina*, in the lake; YEKOM Consulting Engineers 2002; Jalving and Vos 2003) might have also affected the winter carrying capacity of the lake; we can therefore speculate that the increase in Turkey resulted from an inflow from Iran.

These records, together with the resightings of Southwest Asian flamingos in the Gediz Delta colony and the recoveries, strengthen the possibility that movements from Southwest Asia to Turkey occur regularly. We thus speculate that the wintering and the breeding sites in Turkey may be used regularly by flamingos from Southwest Asian populations.

First data on the post-fledging dispersal from Turkey

In all the cohorts, the greatest number of individuals was always observed in Italy, Tunisia, and Greece. The high concentrations in Greece can be linked to its proximity to Turkey. However, this is not true for Italy and Tunisia. Flamingos flying on an east-to-west route from Turkey seem to have a high probability of being ''sampled'' in Italy and Tunisia. These two countries together provide a chain of wetlands that stretches across the entire width of the Mediterranean basin that might act like stepping stones on the way to or from the Turkish colonies.

All observations of banded flamingos in Israel were of Turkish and Southwest Asian origin: six flamingos banded in Turkey (two in 2003 and four in 2004) and three in Iran (Behrouzi-Rad 1992) were resighted and/or recovered in Israel. In contrast, no flamingos banded in France, Spain, Sardinia, and continental Italy have ever been observed in Israel. In other words, together with individuals from Iran, flamingos from Turkey have been proven to move outside the distribution range of the western Mediterranean flamingos.

The place of Turkey in the Greater Flamingo range

In conclusion, resightings and recoveries of flamingos in Turkey have proved that the country hosts individuals from both the western Mediterranean and Southwest Asia, while previous findings usually concluded there was a lack of strong interaction between these two regions (Kahl 1975; Johnson 1989). The observations of Turkish and Iranian flamingos in Israel, together with the lack of resightings of individuals of western Mediterranean origin in this country, strengthen the hypothesis that, even if rare exchanges occur, the western Mediterranean and Southwest Asia constitute two sets of populations. However, even a low rate of exchange between populations (1–10 efficient migrants per generation) might be enough to homogenize the gene pool at a larger geographical scale (Mills and Allendorf 1996). Therefore, the existence of two sets of populations in terms of the structure of movements may not necessarily correspond to an underlying genetic difference between Southwest Asian and western Mediterranean populations. The exchange rate between these regions could depend on distance.

Located in between these two regions, Turkey can host flamingos from both the Mediterranean region and Southwest Asia; similarly, flamingos born in Turkey may have a higher chance to disperse to both regions. This implies that, to conserve the Greater Flamingo in the western Mediterranean and Southwest Asia, international cooperation is needed along the whole flyway of the species, acknowledging the role of Turkish wetlands for both sets of populations. A reserve network designed along this flyway will serve not only to conserve the local populations but also the overlap between the western Mediterranean and Southwest Asian populations that may occur in the Turkish wetlands, because direct exchanges are limited. Future banding and resighting studies in Turkey can deepen our knowledge about the population dynamics of flamingos.

We believe that the methodology used in this study to estimate the total number of immigrant breeders from other colonies and to determine the importance of individual colonies at the flyway level is a promising tool that could be applied to conservation of other colonial waterbird species with similar population structures.

Zusammenfassung

Verbreitung der Metapopulation des Flamingos (*Phoenicopterus roseus*) im Mittelmeerraum: Neue Erkenntnisse aus der Türkei

Der Schutz von Vogelpopulationen sollte den Flyway berücksichtigen und das Verbreitungsgebiet einer Metapopulation durch Abschätzung des Austausches zwischen den lokalen Populationen bewerten. Im westlichen Mittelmeerraum bilden Flamingos eine Metapopulation, die durch Austausch von Jung- und Altvögeln zwischen Kolonien gekennzeichnet ist. In dieser Arbeit untersuchen wir an Hand von Sichtungen beringter Vögel, ob diese Metapopulation die Türkei erreicht. Wir erbringen den ersten Nachweis von Jung- und Altvogeldismigration vom westlichen Mittelmeer bis zur Türkei und legen nahe, dass das Gediz-Delta, eines von zwei Brutgebieten türkischer Kolonien, eine bedeutende Rolle für die Rekrutierung von Flamingos spielt, die aus dem westlichen Mittelmeer stammen. In den Jahren 2003 und 2004 machten Brutvögel aus dem westlichen Mittelmeer mehr als 1.2 bzw. 1.9% der Brutpopulation des Gediz-Deltas aus. Unsere Beobachtungen zeigen weiterhin, dass im westlichen Mittelmeer und in Südwest-Asien zwei Gruppen von Populationen leben, die auf türkischem Gebiet überlappen. Schließlich zeigen die Sichtungen von in der Türkei beringten Flamingos, dass die dismigrierenden Flügglinge aus der Türkei sowohl Feuchtgebiete im östlichen als im westlichen Mittelmeerraum erreichen. Erhoffte zukünftige Daten zur Dismigration von Flamingos könnten weitere Verbindungen zwischen Flamingos aus der Türkei und der Metapopulation des westlichen Mittelmeerraums klären.

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