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Long-distance Dispersal of the Afro-Eurasian Glossy Ibis From Ring Recoveries

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ABSTRACT

The Glossy Ibis is among the most widespread bird species in the world. However, the Glossy Ibis erratic occurrence and distribution makes it a difficult species to study, and we know little about its dispersal and metapopulation dynamics. This study summarises previously-scattered and unpublished information by collating, in a single database, the largest number of long-distance recoveries ever reached for this species (190 individuals). Our findings suggest that (i) according to old records (about 1910 - 1995) the dispersal from the breeding grounds in East Europe was directed towards the Sahelian floodplains, North-East Africa, the Middle East and India; (ii) West and East Europe populations are probably connected; (iii) the recently (about 1995 onwards) increasing and spreading populations in West Europe do not tend to migrate south and overwinter in Sub-Saharan Africa; and, (iv) the genetic distance between geographically distant populations might be low considering the records of long-distance flights with the most impressive, and unpublished, one being that of an individual moving from Spain to the Virgin Islands (> 6,000 Km). Overall, these findings highlight the need for a research network capable of dealing with the frequent changes in the distribution and dispersal dynamics of the Glossy Ibis and its fast responses to environmental changes.

Introduction

Of the 35 extant species of ibises and spoonbills (Aves: *Threskiornithidae*) in the world (Matheu and del Hoyo 2018), the Glossy Ibis *Plegadis falcinellus* is the most widely distributed, living and breeding on all continents except Antarctica (Hancock *et al.* 1992; del Hoyo *et al.* 1992). The species is often described as nomadic or semi-nomadic in some parts of its range, with established colonies dwindling and disappearing as new breeding colonies crop up elsewhere where the

species was previously absent or a rare non-breeder (Santoro *et al.* 2013; Santoro *et al.* 2016; Zwarts *et al.* 2009). The Glossy Ibis is also a migratory species, and it has been suggested it utilises different flyways between breeding sites in the Western Palearctic and wintering areas in tropical Africa (Schogolev 1996; Kirby *et al.* 2008; Zwarts *et al*. 2009). Several ringing programs were carried out in East Europe in the period between 1908 and 1982 (EURING database; Pigniczky and Vadász 2009; Zwarts *et al*. 2009). Overall, the ring recoveries from these areas suggest they mainly fly to the Sahel but also East Africa and the Middle East.

Over the past century, the Glossy Ibis has declined dramatically in its former breeding strongholds in eastern Europe and the Black and Caspian seas and, over a similar period of time, their numbers have remarkably decreased in their wintering areas in the Sahel (BirdLife International 2016; Hancock *et al.* 1992; del Hoyo *et al.* 1992; Schogolev 1996; Zwarts *et al*. 2009). Indeed, although counting data from local monitoring programmes have been collected intermittently and not always exhaustively, the overall impression is of decreasing numbers of breeding pairs in East Europe (Hungary, Serbia, Romania, Bulgaria, Ukraine, Russia, Azerbaijan, Turkey and Greece) over the 20th century, especially in the last 30-40 years (Zwarts *et al.* 2009). An analogous but, apparently more severe, situation seems that of the populations wintering in the Sahelian zone that, from 1980 onwards, have shown a sharp decline of about 90% in the Inner Niger Delta (Zwarts *et al.* 2009). Opposite to the declining pattern observed in the Eurasian-African region, over the last two decades the species has shown a remarkable increase in numbers and a regular presence during the breeding, but also the wintering, season in several sites of West Europe from where it had been locally extinct for decades as a breeder species (Santoro *et al.*, 2013; Champagnon *et al.* 2019; Santoro *et al.* 2010; Volponi 2019; Belhadj *et al.* 2007; Boucheker *et al.* 2009). The reasons why this has happened are still unclear and, as Zwarts *et al.* (2009) note, "*the recent increase in Spain is something of an enigma*". Interestingly, a considerable increase in populations' size and range expansion has been recorded in North America (150% increase per decade over the last 40 years, Butcher and Niven 2007; see also Patten and Lasley 2000). Similarly, in South Africa, the Glossy Ibis has increased in both range and abundance over the Western Cape in the period between 1987 and 2007 onwards (Underhill *et al.* 2016).

Although the population trend at the global scale is considered to be decreasing, the Glossy Ibis is regarded as a "Least Concern" species because of the vast population size (230,000-2,220,000 individuals, Wetlands International 2019) and the wide distribution range (BirdLife International 2019). The Glossy Ibis is also listed in Annex II of the Convention on Migratory Species (CMS) and protected by the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) (BirdLife International 2019). Within the AEWA area, according to data collated by Wetlands International and BirdLife International (2019), four different Glossy Ibis populations have been proposed based on a previous study by Kirby and colleagues (2008): (i) Sub-Saharan Africa, (ii) North Africa and Eastern and Southern Europe, (iii) South-west Asia, and (iv) Madagascar. This classification depends on a considerable amount of counts showing variable population size across the Important Bird Areas (IBA – BirdLife International) in Europe and Africa. We note that while these data provide information to envision the distribution of different populations and subpopulations in this vast area, this approach may be too simplistic as it does not contain any information on the individuals' movement and, therefore, on populations' connectivity. All the information currently available on the dispersal of the Eurasian African Glossy Ibises comes from ringing programs carried out in the breeding regions in the Eurasian zone. In contrast to the pioneering Glossy Ibis ringing programmes in eastern Europe (see e.g. Pigniczki and Vadász 2009) and the Black and Caspian sea areas, the ringing programs launched in western Europe and North Africa since 1996, when the species established in Doñana, use darvic rings, coloured and inscribed to allow for multiple resightings of the same individual, in addition or not to the traditional metal ring (Champagnon *et al.* 2019; Máñez *et al.* 2019;

Nedjah *et al.* 2019; Samraoui *et al.* 2012; Volponi 2019). Also, a ringing program was started by Dr Savas Kazantzidis in Greece in spring 2018 within the International Glossy Ibis Network, the research network on this species we launched in November 2017.

Overall, the literature based on ringing and count programs has so far provided details, often at a local scale, on the distribution and the potential migratory routes of the Eurasian-African Glossy Ibis. However, a comprehensive view of the metapopulation dynamics of this species is still almost unknown, mainly because it is challenging to study a species, such as the Glossy Ibis, so fluid in terms of site fidelity and dispersal habits. In this study, we aimed to take the first step in trying to understand the large-scale dispersal strategies of the Glossy Ibis in the Western Palearctic and Afro-Tropical. Therefore, we summarized and updated the existing information obtained from ringing recovery data (i.e. from dead individuals) in order to (i) propose a tentative sketch of the migratory flyways of the Glossy Ibises breeding in Europe, (ii) evaluate the potential connectivity between different Glossy Ibis populations (or subpopulations), and (iii) discuss whether and how our results match the four Glossy Ibis populations delineated by Kirby *et al.* (2008) for the AEWA area.

Study Area

The study area encompasses the region included in the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) where the Glossy Ibis is known to breed or winter. This region encompasses western, central, and Eastern Europe, the Black and Caspian Sea areas, Africa, and West Asia.

Methods

We obtained recovery data for the Glossy Ibis from the EURING database (n = 34) individuals). We collated these data with additional data provided by the SAFRING (in South Africa, n = 1), the Tour du Valat ringing database (n = 1), the Bird Ringing Centre of Russia (BRCR, n = 114) and by Zwarts and colleagues (ZDB, n = 40) which, in turn, obtained data from EURING and Wetlands International, Schogolev (1996), Sapetin (1978), Mullié *et al.* (1989) and Thonnerieux (1988). Given that our focus was on long-distance movements and because of visual clarity, we removed the records of < 200 Km far from the ringing area. Also, we did our best to remove any error and duplicate in the dataset. In particular, we eliminated several records from the EURING dataset because they appeared either in the ZDB or in the BRCR. We are confident that, if some error escaped to our control, it would not invalidate the overall pattern we describe.

Our data come from eleven Glossy Ibis breeding areas spanning western Eurasia, from the Caspian Sea to Spain, which we consider representative of the metapopulation and where ringing programs have been carried out. We cannot discard that the populations from the northern and southern Hemispheres are connected, so we also included recovery data from a ringing site in South Africa. In total, we used recovery records of 190 individuals proceeding from eleven ringing areas. Ringing programmes carried out between 1928 and 1982 (mostly from 1977-1982) are indicated as old ringing areas (ORA). In the ORA, only metal rings have been used. In the recent, still active, ringing areas (RRA; Doñana wetlands: since 1996; Ebro River Delta: since 1998; Camargue wetlands: since 2006), both metal and darvic rings with individual codes are used. For the sake of simplicity and homogeneity between ORAs and RRAs, in this study, we only used information proceeding from recovery data. At least four RRAs are not represented in our study because no recovery data that meet the > 200 Km criterion are available from these programs; they are located in: East and North-East Spain (Curcó and Brugnoli 2019; Vera *et al.* 2019), North Algeria (Nedjah *et al.* 2019), and North Italy (Volponi 2019) and Greece (Savas Kazantzidis).

Results

Most of the recovery records available for the Eurasian-African Glossy Ibis are of individuals marked in the ORAs (95.8 %). Eight out of nine ORAs are in the region comprised between

Hungary and the Caspian and Black Seas (Figure 1). One is in South Africa. The remaining recoveries (4.2 %) are from the RRAs which are located in Spain and France.
In the Eurasian region, from West to East, and then in South Africa, they are mainly from these areas (in brackets the country and the range of recoveries' years): 1) Espacio Natural de Doñana (Spain, 2000 – 2011), 2) Camargue wetlands (France, 2009 – 2015), 3) Kis Balaton (Hungary, 1913 – 1937), 4) Pusztaszer Landscape Protection Area (Hungary, 1991-1992), 5) Special Nature Reserve Obedeska Bara (Serbia, 1912-1940), 6) Dniestr River Delta (Ukraine, 1971 – 1982), 7) Kuban River (Russia, 1958 – 1966), 8) Volga River Delta (Russia, 1978 – 1980) , 9) Dagestan (Russia 1956 – 1995), 10) Kyzyl-Agach Nature Reserve (Azerbaijan, 1954 – 1960), 11) Benoni (South Africa, 1970 – 1988).

Recoveries from old ringing areas

The recoveries of Glossy Ibises ringed in Kis-Balaton (Hungary) suggest a scattered dispersal towards different directions which include Netherlands, Norway, Russia (west and north of Caspian Sea), Rumania, Egypt and South Italy. Those from the Black sea seem to fly to Italy and the Sahelian floodplains. The individuals ringed in the Southern Caspian Sea have been mainly recovered in the Middle East, Sudan and Arabian Peninsula whereas those ringed in the northern Caspian Sea in Sudan, Kazakhstan, Pakistan and India. Finally, a single long-distance record, from Zambia, has been detected from those ringed in South Africa.

Recoveries from recent ringing areas

Most of the dispersal data from the RRA monitoring programs come from the resighting of alive Glossy Ibises not represented in this study. The few RRA recoveries suggest that Glossy Ibises born in western Europe move towards North Africa (in the area comprised between Morocco and Tunisia) and the United Kingdom. An individual born in the Camargue wetlands was found dead in the Ebro Delta River (North-East Spain) and another one in Croatia. Finally, one individual born in Doñana wetlands (South Spain) has been recovered in the Virgin Islands (> 6,000 Km far from the natal site).

Discussion

Our study confirms that the Glossy Ibis is a bird species capable of impressive long-distance movements between the breeding and wintering areas. According to the recovery data we have gathered from different sources, the populations breeding in the eastern Eurasian region move to a area comprised between West and East Africa, with a large number of recoveries recorded in the Sahelian zone. Whereas the birds ringed in the Black Sea seem to prefer the Sahel and West Africa to winter, those ringed in the Caspian Sea have been found to move to East Africa, the Arabic peninsula and as far east as Pakistan and India. The majority of dispersal events from western Europe breeding sites is available in the form of recaptures (especially resightings) of alive individuals, a type of data we have not used in this study. However, the few recoveries from the new ringing areas suggest a similar pattern to that found in Santoro *et al.* (2016) with the resightings of Doñana-ringed Glossy Ibises during the breeding season. In both cases, the individuals breeding in West Europe seem to move preferentially to North Africa (from Morocco to Algeria) and Europe. The record of a Doñana-ringed individual recovered in the Virgin Islands that has been made in 2013 represents an unpublished data which adds to three other similar records made in Trinidad and Tobago (2008), Barbados (2010) and Bermudas (2013).
An enigma this study cannot solve is about the origin of the Glossy Ibises which settled in western Europe at the end of the 20th century and whose population is showing a sharp increase (Champagnon *et al.* 2019; Mañez *et al.* 2019; Santoro *et al.* 2013, 2016). The more plausible hypotheses seem to be either that they came directly from the declining eastern populations or that they came from the wintering grounds, more probably in West Africa. Interestingly, both the individuals ringed in the Black and Caspian Seas have been recovered in the Mediterranean, especially in Italy (Spina and Volponi 2008), suggesting they cross

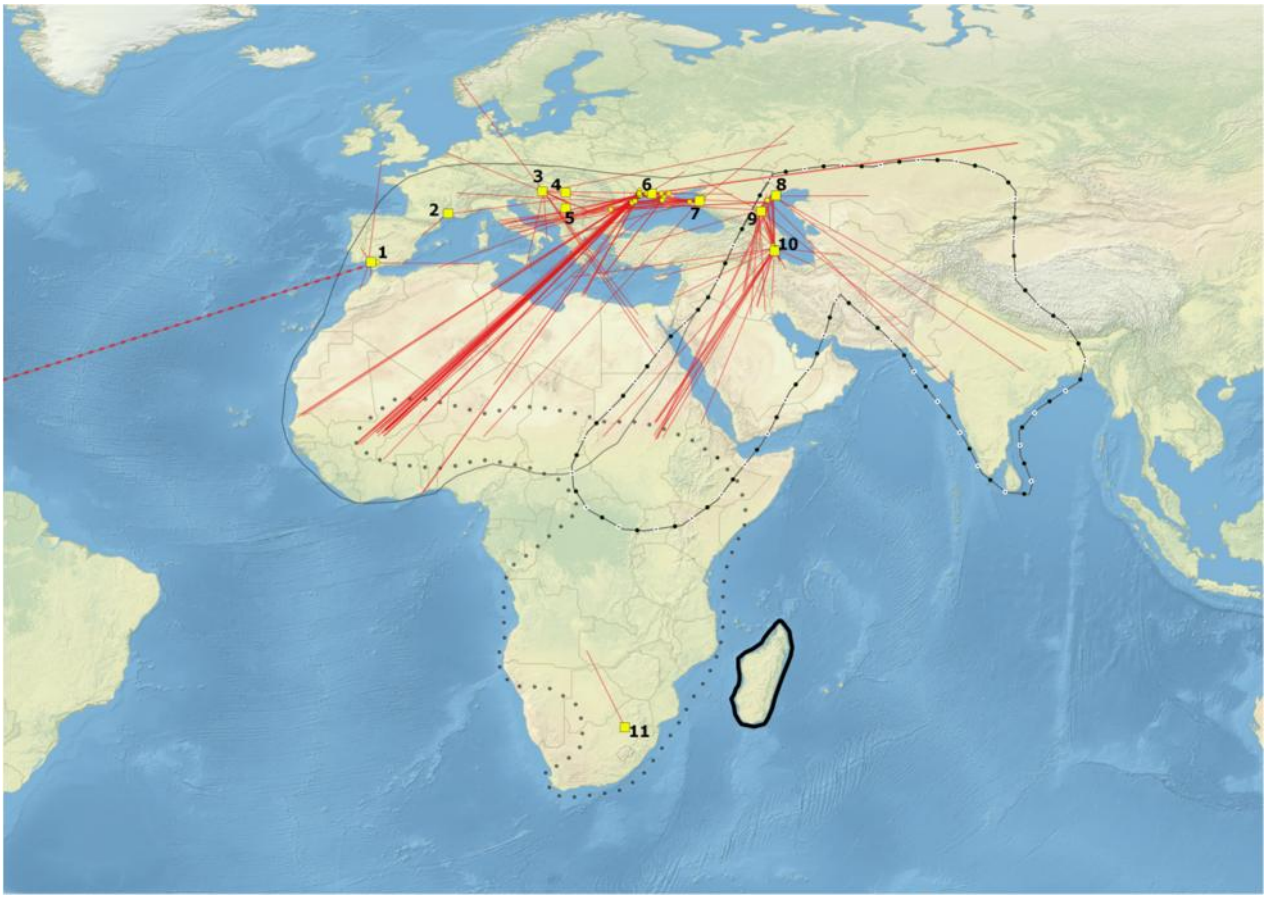
the central Mediterranean and enter Africa in particular through Tunisia and Algeria. However, the Doñana area is only a few hundred Km far from Morocco that is also a plausible gate of entry to Africa for the Eastern Glossy Ibises populations (Zwarts *et al.* 2009). Moreover, the resightings of individuals born in Doñana suggest connectivity at least with the Black Sea areas. On the other hand, unpublished data collated by the Estación Biológica de Doñana suggests that Doñana-born individuals may fly to West Africa too. There is a need to undertake monitoring studies of the species also in Eastern Europe. This is one of the priority objectives of the International Glossy Ibis Network (IGIN), and the recent start of a species banding program in Greece is encouraging.

A substantial limitation of our study is that data have not been collected over the same period. Thus, one might wonder whether the shown spatial variability is a consequence of spatial or of temporal dynamics. In other words, is the migration dynamic of the Glossy Ibises born in East Europe still the same? Are, for example, the old (1928 – 1952) recoveries from the Kis-Balaton in the nowadays deteriorated Nile Delta (Stanley and Warne 1998) informative of the current population dynamics? Most likely, they are not. The Glossy Ibis is a species that have demonstrated to be capable of adapting fast to environmental changes (e.g. Santoro *et al.* 2013) and to change its distribution range very quickly as it has been the case of West Europe, North America (Patten and Lasley 2000; Patten 2019) and South Africa (Underhill 2019). Therefore, we cannot be entirely sure that the data used in this study are informative of the current dispersal and migration dynamics of the species across the Eurasian-African region. The recoveries and resightings of the individuals ringed in the western populations suggest infrequent connectivity with West Africa and no movements to East Africa. A tentative explanation is that the distribution range of the species has shifted northward and this could be a consequence of the deteriorating conditions in their historical wintering zones in the Sahelian zone. This hypothesis is in line with the frequent observation, in winter, of large flocks of Glossy Ibises in Spain and other West Europe areas similar to what is being observed with other bird species. Many Holarctic bird species, like the White Storks *Ciconia ciconia*, are increasingly found in the last decades to overwinter at higher latitudes, closer to breeding grounds (Samraoui 1998; Rotics *et al.* 2017) because they rely on easy-to-access anthropogenic resources (landfills and agricultural areas). Also, dispersal is generally higher in juvenile than adults (Clobert *et al.* 2012) and, in this study, we did not access to the age of the recovered individuals. Dispersal of juveniles probably differs from the range of established populations and, therefore, the information presented in this study may not adequately reflect the exchanges among populations or their migration routes.

Finally, in the absence of any evidence of Glossy Ibises crossing the equator in Africa, birds that breed in southern Africa may be genetically distinct from those breeding in the Northern Hemisphere which would be in line with the classification made by Kirby and colleagues (2008). The few long-distance records coming from the South African ringing area might suggest this population is more sedentary compared to the others in the Eurasian region, although this could be an artefact due to detectability issues (i.e. lower probability of recovery). However, we think it is more probable that these birds form a panmictic population with little or no genetic structure. In support of this hypothesis, our results suggest that emigration to non-natal colonies and broad overlap in wintering areas provide ample opportunity for gene flow among Glossy Ibises that breed in western Eurasia and Mediterranean Africa. It has been suggested the Glossy Ibis has recently colonised America from the old world (Oswald *et al.* 2019) and that it started breeding in South Africa in the middle of the 20th century from Eurasian specimens (Underhill *et al.* 2016). A large-scale genetic study and the use of tracking devices (both among the IGIN goals) would undoubtedly help to disentangle the Glossy Ibis metapopulations' dynamics. The difficulty of studying the Glossy Ibis, which explains why there are so few studies on this species, lies in the sudden changes in its distribution and its changing dispersal habits. This plasticity, however, should be a priority research target in times, like these, when the global changes are threatening all ecosystems and living

organisms, and we urge others to understand the ecological processes driving the changes in distribution and abundance of species.

Figure 1. **European ringing locations of Glossy Ibis recovered in the Eurasian-African region. The red lines show the dispersal movements from the ringing areas that are yellow squares (main ringing sites) or circles (sporadic ringing sites). The main ringing sites are numbered clockwise starting from (1) Espacio Natural de Doñana (Spain), (2) Camargue wetlands (France), (3) Kis-Balaton (Hungary), (4) Pusztaszer Landscape Protection Area (Hungary), (5) Special Nature Reserve Obedeska Bara (Serbia), (6) Dniestr River Delta (Ukraine), (7) Kuban River (Russia), (8) Volga River Delta (Russia), (9) Dagestan (Russia), (10) Kyzyl-Agach Nature Reserve (Azerbaijan), (11) Benoni (South Africa). The ringing sites (1) and (2) are still active whereas all the others are old (between 1910s and 1990s) ringing programs. One dispersal movement signalled with a dashed red line departs from Doñana wetlands to Virgin Islands (not shown for visual clarity). The polygons delineate the four populations as suggested by Kirby et al. (2008). See the text for more details.**



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