EUROPEAN-ASIAN POPULATION OF GREAT WHITE PELICAN *PELECANUS ONOCROTALUS*, FROM BREEDING TO WINTERING: A REVIEW

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ABSTRACT

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Great White Pelican *Pelecanus onocrotalus* (hereafter: GWP) is an IUCN Near Threatened species having two distinct populations. The first population is a migratory European-Asian population that has an extensive Palearctic breeding range from eastern Europe to western Asia and has exhibited a sharp decline during the last couple of decades. The second population, on the other hand, is a sedentary but stable population that breeds mostly in Kenya, South Africa, and Namibia. Herein, we review the literature available on the occurrence patterns of these populations. Many studies on the migratory population show that conditions during winter have substantial impacts on survival, with food availability and predator avoidance being important and affected by location. For both the migratory and sedentary GWP populations, results showed that an increase in human activities, especially poaching, has been the main cause of decline. Furthermore, climate change appears to be important as well. We recommend three areas of research to better understand GWP trends: 1) investigation of migratory routes, 2) within-group patterns of movement and habitat use as winter approaches, and 3) identification of likely migratory stopover sites. Poaching should be banned strictly at GWP wintering sites, and appropriate management decisions need to be made to ensure GWP protection.

Key words: breeding sites, Great White Pelican, migratory bird, Near Threatened, water birds, wintering sites

INTRODUCTION

The aim of this study was to review the literature for the Great White Pelican (*Pelecanus onocrotalus*, GWP), especially the European-Asian population, from the breeding to the wintering stage. We addressed the population status of GWP and gaps in understanding its wintering and stopover periods, and we recommend research areas needing further attention. Migratory waterbirds often cover thousands of kilometers to find suitable habitat, which means crossing many international borders (Jones *et al.* 2008). The distribution and abundance of food are two of the important drivers of bird nesting location (Urfi 2003). Waterbirds enhance feeding efficiency according to their energy budget and varying foraging strategies (Geary *et al.* 2020). They select breeding sites to maximize reproduction probability, which includes shielding from nest predators (Liebezeit & George 2002, Gjerdrum *et al.* 2005). The non-breeding period is also important in a migratory birds' annual cycle, as it promotes energy saving; when they have a suitable wintering period, their next breeding period is more optimal (Blackburn & Cresswell 2016). However, these mechanisms are not understood well yet. The migration ecology of northern breeding birds is influenced by multiple factors (Gupte *et al.* 2019), including the phenology of spring migration and ecological conditions on the wintering grounds (Robson & Barriocanal 2011). Much of the non-breeding period is devoted to migration (Sillett & Holmes 2002). Migration is assumed to be hazardous and may result in mortalities more than during other life periods (Åkesson & Hedenström 2007). A large proportion of migratory birds do so to mitigate the likely risks of harsh temperature conditions (Umar *et al.* 2018). Altering of habitats due to a number of factors, such as land development, may negatively affect populations of long-distance migrants in terms of adult survival or breeding success as well (Patchett *et al.* 2018). Thus, it is important to identify these long-term factors along migratory routes to implement helpful conservation measures (Palm *et al.* 2015). Included among the important issues regarding migration is wintering site fidelity, which is believed to reinforce adaptive behavioural features and genetic integrity (Guillemain *et al.* 2009). Habitat quality affects subsequent reproduction, survival, and population size. Past studies have focused on how to quantify the effective occupation patterns by season (Probst & Hayes 1987,

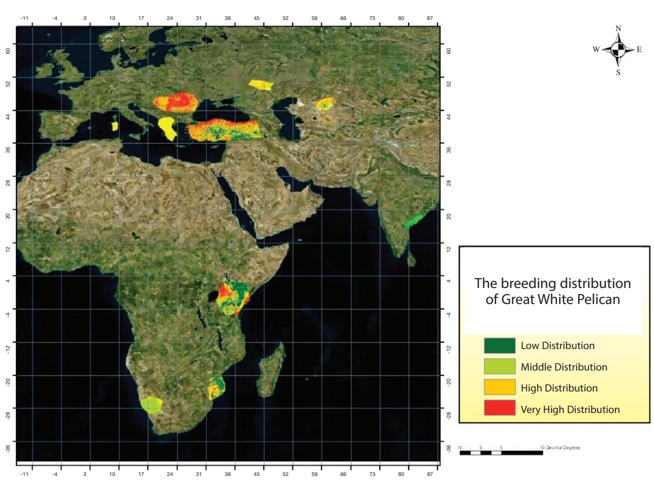

Fig. 1. Distribution of breeding habitats for the European-Asian (migratory) and African (sedentary) populations of Great White Pelicans *Pelecanus onocrotalus*

TABLE 1
A summary of the breeding populations of Great White Pelicans *Pelecanus onocrotalus*

Location	Estimated breeding population size	Trends	Time period	Reference
Romania	3 000–3 500 pairs	Increasing	2000s	Munteanu 2008; Catsadorakis *et al.* 2015
Ukraine (south of the country)	Rare visitors in spring and summer	No trends	1950s, 1960s, 1970s, 1980s	Catsadorakis *et al.* 2015
Ukraine (Orlov Island)	50–150 pairs	Unknown	2001–2006	Catsadorakis *et al.* 2015
Turkey (different wetlands in central, eastern regions)	8–13 pairs	Unknown	1960s	Kumerloeve 1963, 1964; Ertan *et al.* 1989; Yarar & Magnin 1997
Turkey (different wetlands in central, eastern regions)	300–420 pairs	Increasing	1970s, 1980s, 1990s	Ertan *et al.* 1989; Yarar & Magnin 1997
Turkey (total)	250–400 pairs	Increasing	1990–2000	Crivelli *et al.* 2000
Greece (total)	50–100 pairs	Increasing	1990–2000	Catsadorakis *et al.* 2015
Greece (Lake Mikri Prespa)	258–806 pairs	Increasing	2000–2010	A.J. Crivelli unpubl. data from the Society for the Protection of Prespa
Russia (Rostovsky Reserve)	Infrequent breeder	No trends	1995–2020	Malinovskaya *et al.* 2021
Uzbekistan (Sudochye Lake system)	96 individuals	Unknown	2014–2015	Idrisovich *et al.* 2018
Black Sea (northern coast)	500–600 individuals	Unknown	1980s, 1990s	Catsadorakis *et al.* 2015
Black Sea (Tendra Bay)	3–41 pairs	Unknown	1995–1998	Catsadorakis *et al.* 2015
Coastal regions of the Black Sea	14 800 pairs	Increasing	1963–1993	Nankinov 1996
Danube Delta (Merheiu Lake)	3 000–3 500 pairs	Unknown	1990	Crivelli *et al.* 1991
Danube Delta (Merheiu Lake)	6 900 pairs	Increasing	2001	Schogolev *et al.* 2005
Danube Delta (Merheiu Lake)	3 590–4 160 pairs	Increasing	2001–2002	Platteeuw *et al.* 2004
Danube Delta (whole)	17 000 individuals	Increasing	2016	Marinov *et al.* 2016
Italy (southern Sardinia)	15 individuals	Decreasing	2008	Grussu & Atzeni 2012
Italy (Muravera)	6 individuals	Decreasing	2008	Grussu & Atzeni 2012
India (Kolleru Wildlife Sanctuary)	Infrequent breeder	No trends	2008	Taher & Mani 2008
Kenya (Lake Elmenteita)	2 600 pairs	Unknown	1970s	Brown *et al.* 1973
Kenya (Lake Elmenteita)	8 000 individuals	Unknown	1968–1971	Brown *et al.* 1973
South Africa (KwaZulu-Natal)	6 000 to 9 000 individuals	Increasing	1950–2005	Bowker *et al.* 2010
Namibia (Fish River Canyon National Park)	Infrequent breeder	No trends	2010	Trimble *et al.* 2011

Norris & Marra 2007). Due to poor knowledge of the flyways and stopover sites selected by GWPs, satellite tracking has been applied in recent decades to map occurrence in some European-Asian and African regions (Izhaki *et al.* 2002).

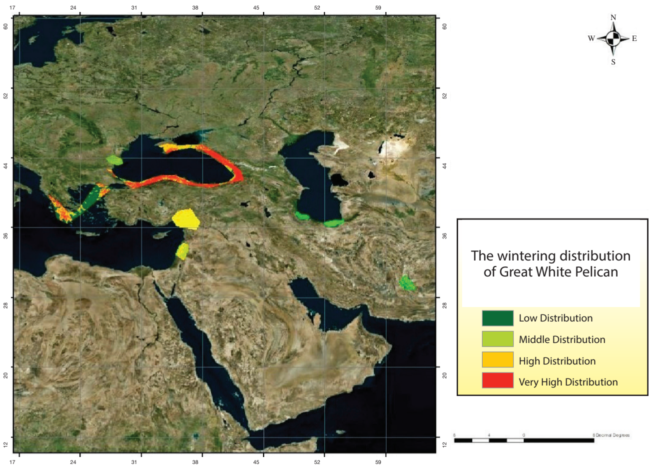

Fig. 2. Distribution map of wintering habitats for the European-Asian population of Great White Pelicans *Pelecanus onocrotalus*

The GWP is a distinct species of the Pelecanidae family with a Near Threatened conservation status according to IUCN (Crivelli *et al.* 2000, Megaze & Bekele 2013). It is extensively distributed in the Palearctic region including Eastern Europe, Asia, and Africa (Fig. 1). Two distinct populations are recognized, one in Eastern Europe and Asia and the other in Africa (Table 1) (Crivelli *et al.* 1991). The European-Asian population began fragmenting at the beginning of the twentieth century, possibly due to factors such as hunting, land use change, and habitat loss. The African population, on the other hand, is non-migratory (Crivelli & Schreiber 1984, Handrinos & Catsadorakis 2020). Overall, there is little information on the migratory routes of GWP, and only a few studies have investigated the population size of wintering populations (Fig. 2, Table 2).

METHODS

Published papers were reviewed after using journal search engines such as Google Scholar, Semantic Scholar, Research Gate, Academia Edu, JSTOR, Bio-One, and PubMed. Also included were Wiley Online Library, SpringerLink, Elsevier, Science Direct, and Taylor & Francis Online. Key words used in the search were: "Great White Pelican", "migratory bird", "water birds", "wintering sites", "near-threatened", and "breeding sites". These

TABLE 2
A summary of the wintering populations of Great White Pelicans *Pelecanus onocrotalus*

Location	Estimated population size (individuals)	Trends	Time period	Reference
Israel (Huleh Nature Reserve)	16 000	Unknown	Spring 1972	Paz 1972 as cited in Crivelli *et al*. 1991
Israel (Huleh Nature Reserve)	30 000	Unknown	Autumn migration 1971	Paz 1972 as cited in Crivelli *et al*. 1991
Israel (Huleh Nature Reserve)	40 000	Increasing	2000s	Michev *et al.* 2011
Turkey (Belen Pass)	7 300	Unknown	September 1976	Sutherland & Brooks 1981
Turkey (Çukurova Delta)	7 700	Unknown	1980s	Van der Have *et al.* 1988
Coastal regions of Black Sea	10	Decreasing	1963–1993	Nankinov 1996
African populations	No migration movement	No trends	1977–1978	Guillet & Crowe 1983
Iran (Kiashahr, Alagol wetlands)	Initial migrant (the number is unspecified)	No trends	2002–2003	Khalilipour *et al.* 2007
Iran (Bujagh wetland)	11	Unknown	Winter 2007	Mansoori 2009
Iran (Miankaleh wetland)	38	Unknown	Winter 2007	Mansoori 2009
Iran (Fereidoon-Kenar wetland)	190	Unknown	Winter 2007	Mansoori 2009
Iran (Anzali wetland)	54	Unknown	Winter 2007	Mansoori 2009
Iran (Hamoun wetland)	1	Decreasing	April 2007	Behrouzi-Rad 2009
Greece	Fewer than 20	Decreasing	Up to 2015	Catsadorakis *et al.* 2015
Bulgaria (Bourgas Bay)	61 700	Increasing	Autumn 2011	Michev *et al.* 2011

key words were used in combination with other terms to search efficiently. Additionally, we performed some of the searches using the names of well-known authors in the field of GWP research. The publication year of the reviewed papers ranged from 1951 to 2021. The search process was restricted mainly to the breeding and wintering phases of GWP.

RESULTS AND DISCUSSION

Our results, including relevant citations, are summarized in Figs. 1 and 2 and in Tables 1 and 2. Overall, the migratory flyways of GWP, though briefly studied in several papers, remain poorly understood. Our review showed a lack of new data during the last 10 years for the wintering period of GWP on a global scale. The spacing and frequency of stopovers between breeding and wintering is another area of research that requires more investigation.

Despite many factors that might influence the breeding phase of GWP, reviewed studies indicated that the availability of food seems to be the primary driver of breeding, followed by nesting habitat that facilitates reproduction and predator avoidance. Numerous factors may affect the demographic condition of GWP in their annual cycle but high on the list is nesting habitat in which GWP best survive.

The coastal region of the Black Sea contained the most frequently used breeding sites for migratory GWP, at least until the end of the twentieth century. However, there are too few recent studies by which to estimate the current number of breeding pairs in the Black Sea region. Until the beginning of the twentieth century, the Danube Delta was the second most frequently used region for GWP breeding. The Rostovsky Reserve in Russia and the Kolleru Wildlife Sanctuary in India were also important. For the sedentary population, Lake Elmenteita in Kenya had the highest number of GWP breeding pairs until the 1970s, and until 2010, the KwaZulu-Natal province in South Africa was the second most populated breeding region. Fish River Canyon National Park in Namibia was noted as attracting breeders, but infrequently.

Migratory GWP were affected differently during wintering than during breeding. The timing of spring migration shifted and changes in food abundance and quality affected GWP likelihood of returning to a wintering ground. These may carry on to affect reproduction and survival. In a study by Greenberg (1986), the prominent criteria for bird site selection were discussed. Regardless, the dispersion patterns of GWP at the start of wintering requires more empirical research.

In Eurasia, Israel has been a very important spot for wintering GWPs. Turkey also has important wintering spots including the Belan Pass and Çukurova Delta. In addition, Iran has had prominent wintering sites for the GWP at various wetlands in recent decades, but it is currently much less. Among the European countries, studies on the GWP's wintering population in Greece are still ongoing. It is clear that there is still a long path toward the understanding of the migratory flyways of GWP. The coastal regions of the Black Sea, despite frequent breeding, attract few GWP for wintering, as identified in studies until 2015.

With the increasing level of human interference, development of farming practices, and industrialization, there has been a big drop in the population trend of GWP worldwide. Currently, only ~50% of their nesting sites are under protection. In addition, disturbances to breeding colonies, habitat loss, hunting, entanglement in power lines, pesticide biomagnification, and conflict with humans for fish were also substantial factors for the GWP's population decline.

Recommendations

It is imperative that more studies be conducted during the breeding period of GWP throughout their range. Monitoring of GWP's breeding populations will provide data from which more effective management strategies can be designed. It is also necessary for GWP wintering populations to be studied more closely on a large scale. The stopover period of GWP is ambiguous, and thus requires further investigation. However, investigating the flyways of GWP may require the use of modern technologies. Finally, understanding of dispersion patterns of GWPs when they are looking for wintering sites also requires study.

We recommend that poaching be banned, especially in the countries in which the wintering sites of GWP exist. We also recommend that agricultural practices, especially in central Asia, become more sustainable and compatible with species like GWP. Included would be studies that investigate how power lines, changes in water levels (e.g., river influx into wetlands), and natural changes in vegetation cover (e.g., fire, drying wetlands) can influence GWP populations. The restoration of wintering sites on the Ramsar list (especially those on the Montreux Record) can also be considered as a practical measure to help preserve GWP aquatic habitats. The process must incorporate local people who live in proximity to wintering sites in order for conservation plans to be successful.

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