

STATUS AND POPULATION TRENDS OF THREE GLOBALLY THREATENED ANATIDS AT ONE OF THEIR KEY WINTERING AND NESTING SITES IN MOROCCO

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Abstract. The Merja de Fouwarate Ramsar site is home to the largest Moroccan population of the Ferruginous Duck (*Aythya nyroca*), a globally near-threatened species, and is also one of the best Moroccan sites for the wintering and nesting of two other species of Anatidae, the Marbled Teal (*Marmaronetta angustirostris*), a globally near-threatened species, and the Common Pochard (*Aythya ferina*), a vulnerable species. A 12-year-long monitoring of these three species was conducted at the Ramsar site of Fouwarate. The primary objective of this research was to establish the phenological status, conservation status, and population trends of these three species. Results revealed a positive population trend for the Common Pochard and Ferruginous Duck between 2011 and 2017, while the population trend of the Marbled Teal exhibited no significant directional change during this period. After 2019, the populations of all three species exhibited pronounced signs of decline. This trend is explained by local and regional circumstances, primarily attributed to climate change and the influence of local anthropogenic factors. Based on these results, it will be imperative to change the national protection status to the Common Pochard, which remains unprotected. Additionally, it is necessary to update the species' phenological status in Morocco from "Occasional Breeder" to "Resident Breeder" and establish an appropriate wetland management plan to preserve Fouwarate's significant ecological and socioeconomic role.

INTRODUCTION

Wetlands are of paramount importance for biodiversity and human well-being (Taylor et al. 2021). The wetlands of North Africa play a key role in the wintering and migratory stopover of birds from Eurasia (Samraoui et al. 2011). Morocco is a North African country located on two of the three Palearctic–African bird migration flyways (East Atlantic and the Mediterranean/Black Sea). Merja Fouwarate, one of the wetlands on the Moroccan North Atlantic coast, holds significant importance for water birds (FDR 2018). It encompasses a variety of natural habitats that provide necessary conditions for nesting, stopovers, and wintering for around sixty species of water birds (Lahrouz et al. 2013a). During the wintering and migration periods, the number of these birds can exceed 20,000 individuals (Lahrouz 2015). Among these are several rare or endangered species of ducks, herons and waders (Lahrouz et al. 2012, 2013b, c), which contribute to the site's high heritage value.

Thanks to its biological, ecological, and socio-economic assets, Merja Fouwarate was designated as a Ramsar site in 2018 (FDR 2018). Additionally, it was also selected as a Site of Biological and Ecological Interest (SIBE) within the framework of the Master Plan for Protected Areas (AEFCS 1996).

In view of the increasing heritage value of the Fouwarate wetland for key species of Moroccan avifauna (Maire et al. 2013), we have carried out a major study involving regular ornithological monitoring of the site over the last decade. It is in this context that we present the results of the analyses of the data collected. These results have enabled us to understand the status of three ducks with a globally unfavourable conservation status: Ferruginous Duck and Marbled Teal are classified as "Near Threatened", and Common Pochard is ranked "Vulnerable" (IUCN 2023) in this wetland, and to identify potential trends and demographic changes.

MATERIALS AND METHODS

Study site

The study site is situated in the far north-eastern region of the city of Kénitra which has a Mediterranean climate: average annual rainfall is around 650 mm, concentrated in three months (November to January), while average air temperatures do not exceed 15°C. The dry period is characterised by intense evaporation, with an average temperature of 35°C in August. Merja Fouwarate is an expansive freshwater marsh spanning approximately 620 hectares. Its precise geographical coordinates are 34.242494°N, 6.548408°W. The marsh is positioned along the left bank of the terminal section of the Sebou River, with an elevation ranging from 3 to 6 meters above sea level (Figure 1). The marsh receives its water supply from various sources, which include the emergence of the Maamora groundwater, a small hydrographic network comprising three streams named Oued Foui, Oued bled El Ghaba, and Oued Fouwarate, urban wastewater, and precipitation (Ababou, 2006, Ben Bouih et al. 2005). To facilitate water exchange, Merja Fouwarate directs its water into the Sebou River through a natural canal called Oued Swarat, which has been adapted for this specific purpose (Bourak et al. 2017).

The marsh is moderately eutrophic (Ait Messaoud 2005) and encompassed by a thick vegetation cover, primarily consisting of hydrophytes (*Typha angustifolia*, *Bolboschoenus maritimus*, *Juncus acutus*, *Phragmites australis* and *Nerium oleander*) (Karibi and Messous 2019). Additionally, there are small clusters of *Eucalyptus gomphocephala* and *Pinus pinaster* within the surroundings. In times of low water levels, a broad mudflat becomes visible along the periphery of the site (Slim et al. 2023).

The site harbours the largest population of White-headed Duck and Ferruginous Duck in Morocco (Lahrouz et al. 2018, 2023; Ouassou et al. 2018). The White-headed Duck (*Oxyura leucocephala*) is classified as “Endangered” on the IUCN Red List (BirdLife International 2017), while the Ferruginous Duck is categorized as “Near Threatened” (BirdLife International 2019). Similarly, the area is among the top four wintering sites for the Marbled Teal (Ouassou et al. 2021), a “Near Threatened” species (BirdLife International 2022). Additionally, it ranks among the twelve best wintering sites for Common Pochard (Ouassou 2020), “Vulnerable” species (BirdLife International 2021). In addition, the site includes several other groups of rare or threatened water birds belonging to rallids, herons and shorebirds (Lahrouz et al. 2012, 2013b, c).

Censuses

This article presents findings based on a comprehensive waterfowl monitoring initiative conducted at the Ramsar site Merja Fouwarate for a period of twelve years, spanning from 2011 to 2022. However, data for the year 2020 was unavailable due to COVID-19 related confinement measures, leading to a gap in the dataset, yet we judge that it will not affect our results much given the long duration of monitoring and the lack of change in parameters that could affect our results such as the climate or anthropic actions. The monitoring activities covered waterfowl’s wintering and breeding season, from January to July (Cherkaoui et al. 2013; Lahrouz et al. 2012). Over the last two years (from September 2021 to October 2023), the counting efforts were extended to cover all months of the year. The objective of this expansion was to assess the phenological status

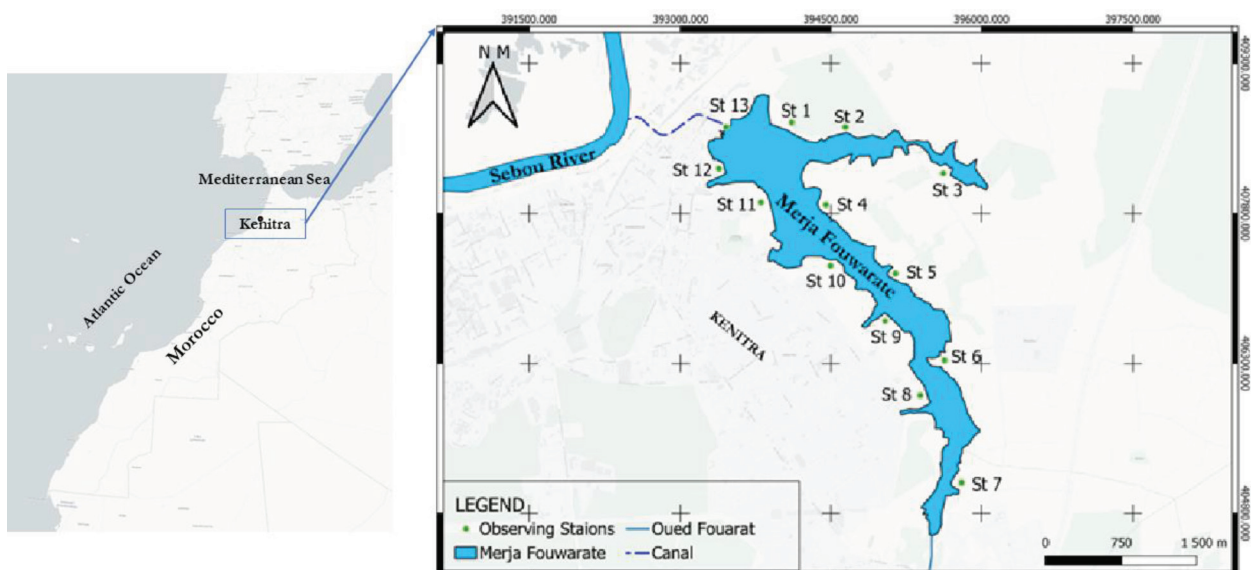


Figure 1. Location of the study sites Merja Fouwarate in relation to Kénitra city and the mouth of the Sebou River.

of the three targeted species within the site, providing a more comprehensive understanding of their presence and behaviour throughout the year.

To ensure a comprehensive bird census, the wetland Merja Fouwarate was divided into 13 observation stations. These stations were carefully positioned to cover the entire area effectively and the choice of stations, the angle of observation, the speed of counting and the speed of movement between observation stations made the counting more precise and avoided double counting of the same birds. Generally, a morning starting as soon as the sun rises is sufficient to explore the entire area. The counting was carried out using a pair of binoculars, a telescope and a digital SLR with a 600 mm objective lens. The counting process primarily focused on two key parameters: first, determining the number of individual birds present, and second, counting the total number of broods. The latter was measured by counting the number of females accompanied by young ducklings, each female followed by the ducklings is considered a brood.

Statistical analyses

The data collected was compiled to assign a single value to each species and for each year. This value corresponds to the annual average of all the workforce recorded during this year (seven months). These means are presented with their standard error (mean ± SE), using Excel software.

To compare the averages of these species and know the species of anatids that dominates this wetland, we used the ANOVA test. Statistical analysis was carried out in SPSS version 22.0 (IBM Corp. Released 2013).

To identify potential trends in numbers and nesting of these three species and possible correlations between

these two variables and time, we applied the classic non-linear regression model, with function adjustment using the least squares method (Nisbet et al. 2009). Reproductive success was estimated at each site by the evolution of the maximum number of females observed with ducklings per year (independent variable). These values, as for the numbers, are then considered dependent variables. The type of model (or adjustment) was determined based on both the significance ($p < 0.05$) and the Person's correlation coefficient R. The greater the latter value is, the better the model fits the data. When the same values of P and R are displayed for two or three models, the use of residual values (low values) makes it possible to determine the best model. Additionally, to understand the phenological cycle of seasonal changes in the abundances of each species, we described population data at different observation dates.

RESULTS

Phenology and abundances of the study species

The monthly monitoring carried out between September 2021 and October 2023 proves that the three species showed almost the same phenological behaviours (wintering, migratory and sedentary breeding) (Table 1) in the Ramsar site of Merja Fouwarate; in fact, they stayed on the site throughout the year, their numbers gradually increased during the fall and winter until a maximum recorded in January–February, then the numbers dropped at the beginning of March. From May onwards the numbers rose slightly again until the end of summer when we observed a decrease (Figure 2). Table 1 summarizes the phenological status of these three anatids at Merja de Fouwarate and at the national level and also shows the conservation status attributed to these species at the national level and by the IUCN and finally the state of protection by Moroccan laws.

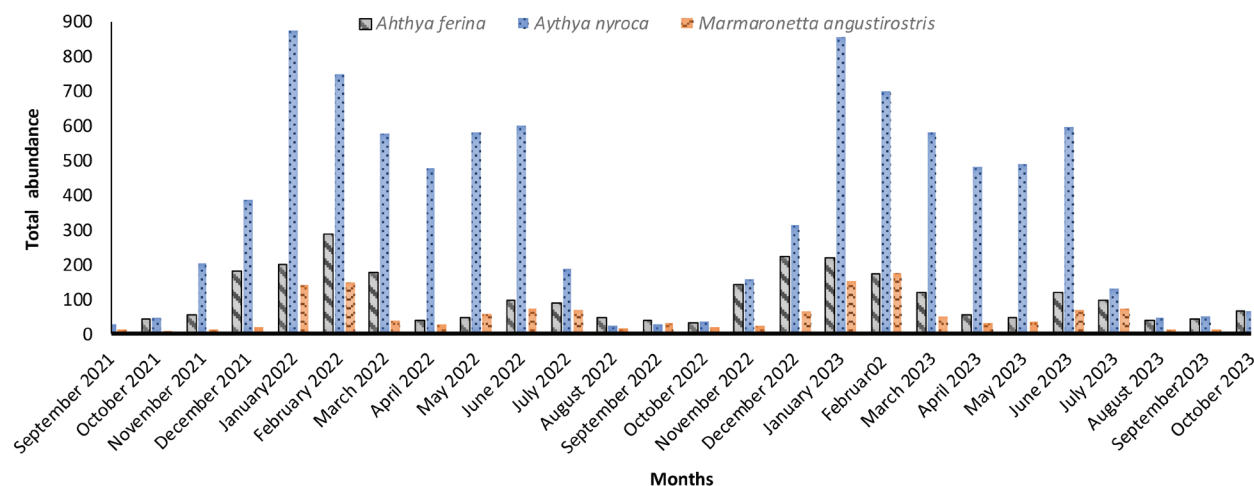


Figure 2. Monthly variations in abundance of the three studied anatid species in Merja Fouwarate between September 2021 and October 2023.

Table 1. Phenological and conservation status of the three threatened duck species in the Ramsar site Merja Fouwarate. (WV = winter visitor; OB = occasional breeder, PM = passage migrant; RB = resident breeder; VU = vulnerable; EN = endangered; NT = near threatened).

| Species | Phenological status in Merja Fouwarate | National phenological status (Bergier et al. 2017) | Conservation status in Morocco (El Agbani et al. 2011) | IUCN conservation status | Protected species according to the law 29-05 (CITES category 4) (B.O. 2011) |
|---|--|--|--|--------------------------|---|
| Common Pochard (<i>Aythya ferina</i>) | WV, RB | WV, PM, OB | VU | VU | No |
| Ferruginous Duck (<i>Aythya nyroca</i>) | WV, RB | WV, RB | ED | NT | Yes |
| Marbled Teal (<i>Marmaronetta angustirostris</i>) | WV, RB | WV, PM, RB | ED | NT | Yes |

Table 2. Species-specific average annual populations and maximum counts of females with ducklings over twelve years at the Ramsar site Merja Fouwarate (2011–2022).

| | Average annual populations | | Maximum counts of females with ducklings | |
|------------------------------------|----------------------------|----------------------------|--|----------------------------|
| | Average (ESM) | Min. (year) Max. (year) | Average(ESM) | Min. (year) Max. (year) |
| <i>Aythya nyroca</i> | 549 (± 49.48) | 236 (2011) 707 (2017) | 44 (± 2.26) | 22 (2011) 63 (2017) |
| <i>Aythya ferina</i> | 256.87 (± 34.66) | 82 (2011) 414 1 (2019) | 26 (± 4.36) | 3 (2011) 44 (2017) |
| <i>Marmaronetta angustirostris</i> | 95 (± 15.76) | 33 (2012) 179 (2018) | 14 (± 1) | 10 (2011) 22 (2018) |

Table 2 shows the average annual populations and maximum counts of females with ducklings for twelve years at the Merja Fouwarate Ramsar site (2011–2022).

The statistical analysis of the data using ANOVA indicates significant differences in the average abundance among these three species ($F = 56.25$, $df = 3.35$, $p < 0.001$). The most abundant species among these waterfowl is the Ferruginous Duck (*Aythya nyroca*), followed by the Common Pochard (*Aythya ferina*), and finally the Marbled Teal (*Marmaronetta angustirostris*).

Trends in population sizes of the study species

Ferruginous Duck *Aythya nyroca*

The Ferruginous Duck population follows a quadratic growth model (Figure 3a):

$y = -6.6199x^2 + 26737x - 3E + 07$; $R^2 = 0.9429$; $p < 0.001$. With an average annual increase of 46.7 individuals (± 26.99), two phases characterize this trend: the first, from 2011 to 2017, shows a relatively rapid growth, reaching a maximum of 707 individuals in 2017 (Table 2). The second phase exhibits a demographic stabilization from 2017 to 2022. Similarly, the number of females with ducklings also follows a quadratic model (Figure 3b):

$y = -0.753x^2 + 3039.1x - 3E + 06$; $R^2 = 0.9138$; $p < 0.001$. With a very slight average annual increase of 1.73 females (± 2.26), two phases are evident here as well, with a slight increase from 2011 to 2017, followed by a very small decrease or even stability around 50 females with ducklings between 2017 and 2022.

Common Pochard *Aythya ferina*

Over the entire study period, the population of the Common Pochard showed continuous growth from 2011 to 2022, following a quadratic model (Figure 4a):

$y = -3.8853x^2 + 15697x - 2E + 07$; $R^2 = 0.8994$; $p < 0.001$.

The average annual demographic growth is estimated to be 44 individuals (± 34.66) (Table 2). Figure 3 shows the presence of a threshold (starting in 2019) beyond which the population declines until 2022. The growth of the number of females with ducklings also followed a quadratic model (Figure 4b):

$y = -0.0531x^3 + 320.43x^2 - 644644x + 4E + 08$; $R^2 = 0.9076$; $p < 0.001$. This evolution was marked by two phases: the first one, from 2011 to 2017, witnessed rapid growth in numbers (53 broods in 2017). This was followed by a second phase, from 2017 to 2022, during which the number continuously declined.

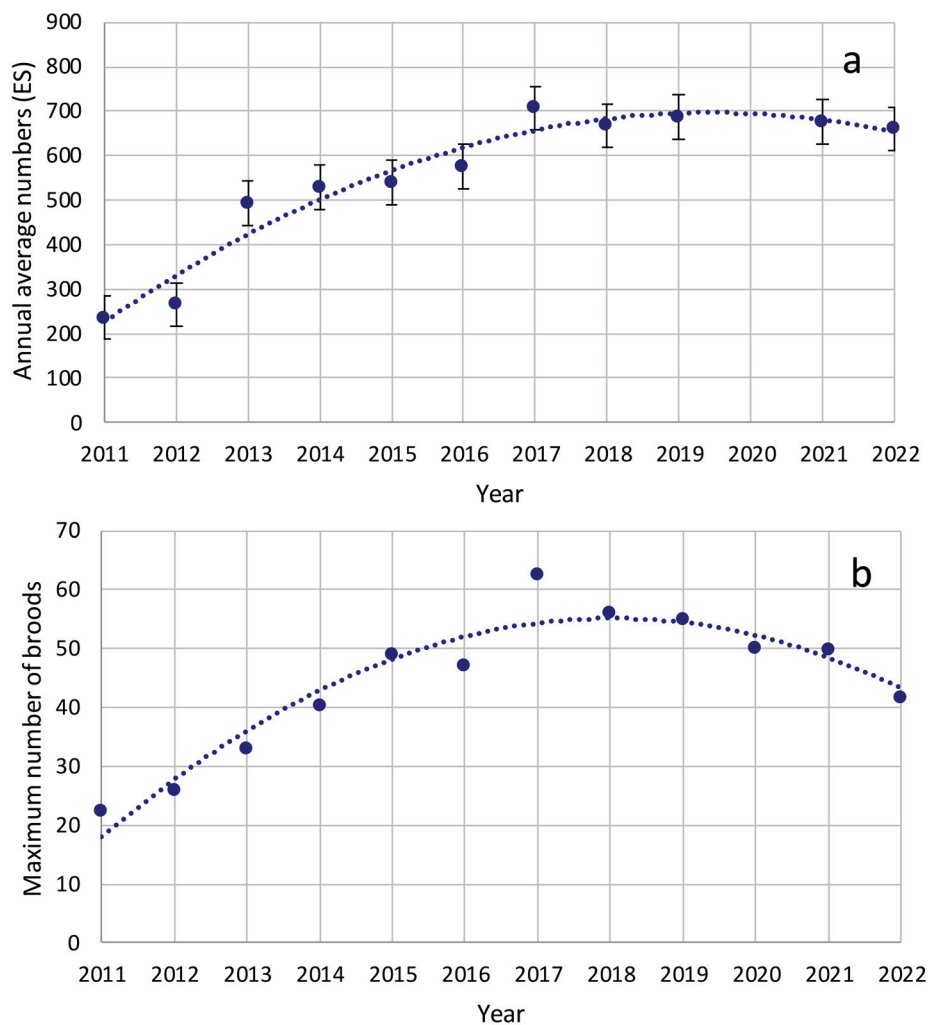


Figure 3. Evolution of annual average numbers (a) and the maximum number of broods (b) of the Ferruginous Duck at Merja Fouwarate between 2011 and 2022.

Marbled Teal *Marmaronetta angustirostris*

Over the past ten years, the species did not show a significant difference in its average annual populations ($R^2 = 0.3579$; $p = 0.21984$). Therefore, the population does not demonstrate a clear trend in evolution over time (Figure 5a). The same observation was made for the number of females with ducklings ($R^2 = 0.862$; $p = 0.020$) over the years (Figure 5b), despite a decrease recorded during the last four years.

DISCUSSION

The results of this study provide information on the populations change over the last decade of three globally threatened waterfowl species: Ferruginous Duck, Common Pochard and Marbled Teal.

The population of the Ferruginous Duck experienced a significant increase between 2011 and 2017, reaching

a maximum average population of 707 individuals in 2017, and a maximum of 63 breeding pairs in 2017 (Table 2). These figures have led to the recognition of the Merja Fouwarate Ramsar site as the best wintering and breeding site for this species in Morocco (Ouassou 2020). This expansion has also been observed in other sites in the northern part of the country (Samraoui and Samraoui 2008), which accommodate between 31% and 90 % of the wintering population in Morocco (Ouassou et al. 2018), particularly Lake Sidi Boughaba, located 10 km away as the bird flies (Cherkaoui et al. 2013; Thévenot and Qninba 2003), the Smir Wetlands Complex (El Agbani et al. 2009), and Barrage Hassar (Rihane and El Hamoumi 2017). This increase has also been observed in the regional context, as approximately 600 breeding pairs are noted in the complex of Al’Kala (Isenmann and Moali 2000; Vinicombe 2000) and approximately 80 breeding pairs of the Ferruginous Duck in Tunisia (Isenmann et al. 2005). However, between 2019 and 2023, a slight decrease in population and the number of breeding pairs was recorded. This regression

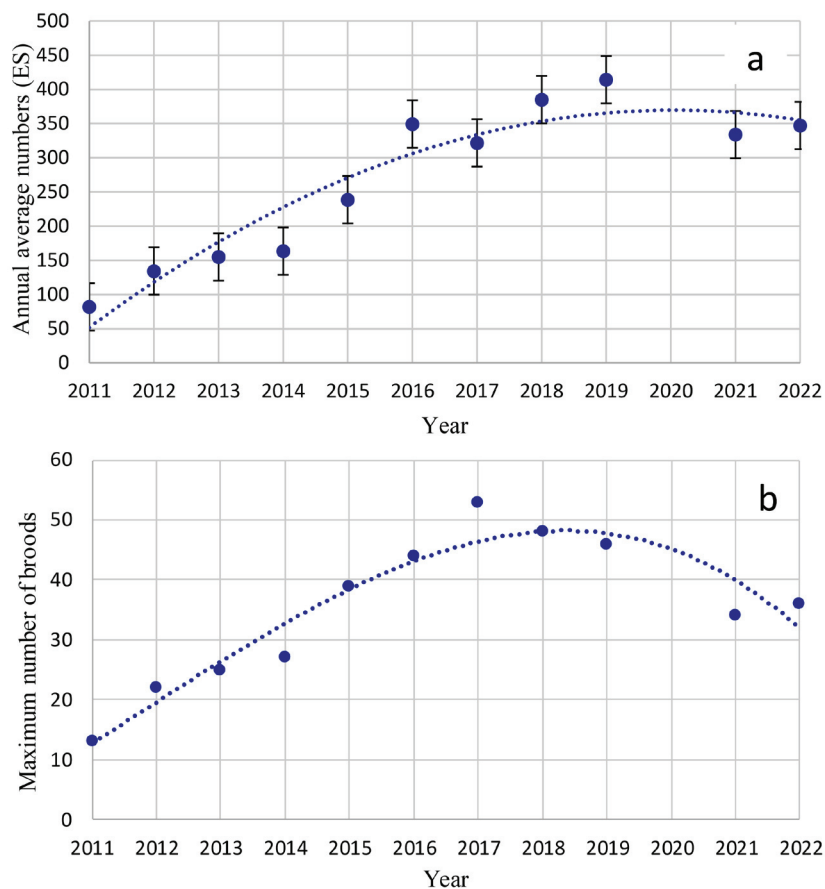


Figure 4. Evolution of annual average numbers (a) and the maximum number of broods (b) of the Common Pochard at Merja Fouwarate between 2011 and 2022.

could be indicative of the rapid decline in the global population of this species (BirdLife International 2019). The Common Pochard has shown a consistent and continuous increase in its population and its nesting has become regular since it first settled on the site in 2010 (Lahrouz et al. 2012). This increase can be attributed, like other waterfowl species, to the improved hydrological conditions of the site, leading to an increase in the flooded area and the abundance of aquatic vegetation required for nesting. This local dynamic also appears to be occurring in a limited number of wetland areas in Morocco, such as Merja of Sidi Boughaba (Cherkaoui et al. 2013), Merja Bargha Smir marshland, Douiyat water basin (Thévenot et al. 2003), some Middle Atlas lakes (Bergier et al. 2022) and later at Oued Martil (El Khattabi 2021). At the regional level, the species first nested in Algeria in 2009 after 49 years of absence (Lardjane-Hamiti et al. 2012), and it has since become a resident breeder (Bouali et al. 2021) in Tunisia as well (Hamdi and Charfi-Cheikhrouha 2011). However, the decrease observed from 2019 onwards can also be attributed to the global decline in its population, leading to its classification as “Vulnerable” in the IUCN Red List since 2015 (BirdLife International 2021).

The Marbled Teal mostly nests in only a few wetland

areas in Morocco, including Merja of Fouwarate, Merja of Sidi Boughaba, Oued Massa, and Douiyet (Qninba et al. 2017; Ouassou 2021), despite the country hosting 47% of the population of the western Mediterranean (Ouassou et al. 2021). The population of the Marbled Teal at Merja Fouwarate has shown fluctuations from year to year over the past decade, with a decline in the number of breeding pairs after 2018. The trend shows an uncertain short-term evolution, which has been similarly observed at the national level by Cherkaoui et al. (2013) and Ouassou et al. (2021). At the regional level, the species is resident and breeding in Algeria (Bouze-gag et al. 2013) and Tunisia (Isenmann et al. 2005), and the trend is also uncertain, with redistribution noted between Tunisia and Algeria (Wetlands International 2022). Globally, the population is declining (Wetlands International 2022; BirdLife International 2022).

In general, we have observed a regression in the overall population of the Ferruginous Duck and the Common Pochard after 2017. This can be attributed to the decline in the global population of these two species, on one hand, and to local anthropogenic factors, on the other hand. The rapid urbanization around the wetland, which has now become completely surrounded by urban areas, has led to intense disturbances from high visitor num-

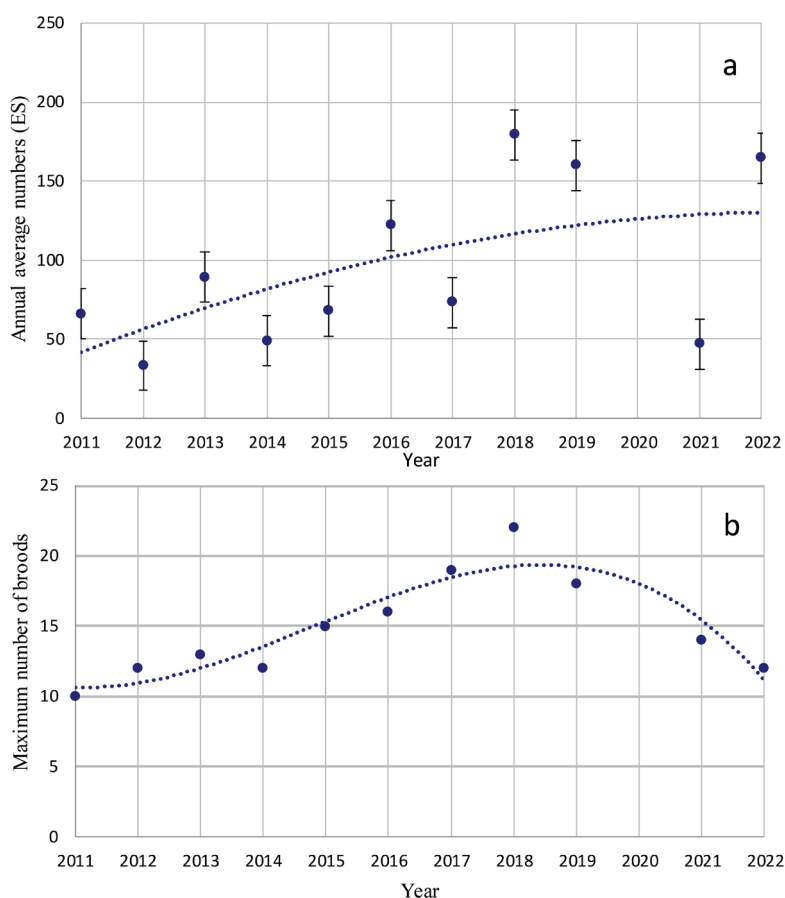


Figure 5. Evolution of annual average numbers (a) and the maximum number of broods (b) of the Marbled Teal at Merja Fouwarate between 2011 and 2022.

bers and their vehicles, resulting in noise and visual pollution.

The monthly monitoring of the population of these three species between September 2021 and October 2023 showed that the species have become sedentary and nest in Merja Fouwarate since they are observed throughout the year. Their numbers gradually increase during the fall and winter, this is undoubtedly due to the arrival of wintering migrants who come to reinforce the sedentary population, then the numbers decrease with the departure of the winterers at the beginning of March, leaving only nesting individuals. The increase in numbers in June and July is explained by the appearance of ducklings.

The grazing and cutting of vegetation, especially *Typha* and *Phragmites*, by the local population have contributed to the excessive shrinkage of the habitats required for the camouflage of the females during incubation. However, we cannot overlook the inhibitory effect of stray dogs, whose quasi-permanent presence in the site poses a real threat to the nesting water birds. These threats, which are generally due to a combination of climate change and anthropogenic pressures (Lahrouz et al 2011), are also noted in almost all Mediterranean wetlands (Taylor et al 2021).

CONCLUSIONS

Overall, a positive dynamic in the populations of threatened ducks and females with ducklings was observed at this Ramsar site between 2011 and 2017. This trend is likely linked to improvements in hydrology and habitat quality, such as the development and diversity of hydrophytes. However, beyond this date, the dynamics of these anatids are showing signs of regression. This regression is part of a regional and global context, but it is exacerbated by local anthropogenic factors, including urban development, disturbance, visual and noise pollution from unregulated visitors, high grazing pressure, unrestricted use of the area by the local population, and the lack of a specific conservation status apart from its classification as a Ramsar site in 2018.

Following the analysis of these results, we recommend that it will be imperative to assign a protection status to the Common Pochard, which is currently unprotected. Additionally, it is necessary to update its phenological status in Morocco from “Occasional Breeder” to “Resident Breeder”, since our study proved that it is present on the site all year round and nests regularly.

We also call on the relevant authorities to take swift actions to protect this site by designing and imple-

menting an appropriate development and management plan aimed at conserving the ecological assets of this Ramsar site.

Conflict of interests

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Data Availability

The data used to support the findings of this study are included in the article.

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