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Water Birds Adaptation and Monitoring in an Artificial Wetland in Northern Algeria

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ABSTRACT

We have, for the first time, provided data on the adaptation of water birds in an artificial wetland (Taksebt Dam, northern Algeria) based on a 4-years (2018-2021) study. A total of 17 species of water birds belonging to ten families and seven orders have been recorded. The number of water birds that frequented the study area varied from 1025 to 1396 individuals. The Anseriformes (Anatidae) were recorded as the most dominant, represented by five species: Mallard *Anas platyrhynchos*, Northern shoveler *Spatula clypeata*, Common shelduck *Tadorna tadorna*, Eurasian wigeon *Mareca penelope* and Eurasian teal *A. crecca*. The species that have adapted and became resident at the Taksebt Dam include: Mallard *A. platyrhynchos*, Common moorhen *Gallinula chloropus* and Great crested grebe *Podiceps cristatus*. The other species use the dam for feeding and/or resting.

INTRODUCTION

Wetlands are known for their attractiveness to birds, especially water birds. These serve as stopovers for migratory species and wintering sites for Palearctic species (Boulekhssaim *et al*., 2006). Wetlands contain a wide variety of habitats, recognized for their ecological, biological, hydrological and economic importance. These ecosystems are home to great biodiversity. Many species depend on wetlands and cannot survive elsewhere. The Mediterranean basin is among the most complex regions (Blondel *et al*., 2010), with a high rate of biodiversity and endemism (Myers *et al*., 2000). Natural environments are increasingly altered in the Mediterranean and this threatens biodiversity (Riservato *et al*., 2009).

Algeria has a total of fifty wetlands of international importance which include continental wetlands (marshes, wadis, lakes, garaets, floodplains, permanent and/or temporary ponds and plant hydromorphic zones) (Ramsar, 2012), coastal wetlands (dunes, estuaries, beaches, sea cliffs), agricultural and/or related urban areas and wooded areas (Samraoui and De Belair, 1997). The natural wetlands of Algeria have been the subject of several scientific studies in particular the eco-complexes of north-eastern Algeria which are classified among the richest ecosystems in the world (Metallaoui *et al*., 2014). However, artificial wetlands (dams, urban lakes, hill reservoirs) remain less studied and poorly documented (Belfethi, 2022). In Tizi-Ouzou region, the only artificial wetland that has been the subject of studies is the Djebla dam (Metna, 2014) dealing with the trophic ecology, ethology and reproductive biology of the Eurasian coot *Fulica atra*. However, despite being a larger artificial wetland in the same region, the Taksebt Dam has not been studied. We tried to fill the gap in ornithological information on the adaptation of water birds in response to this artificial wetland in northern Algeria. We aimed to establish an inventory and provide a baseline scale for the monitoring of the water birds associated with Taksebt Dam.

MATERIALS AND METHODS

Study area

The current study was conducted in Taksebt Dam

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which is an artificial in an artificial wetland located on the wadi Aissi, a tributary of the Sebaou River (Fig. 1). It is located approximately 10 km southeast of Tizi-Ouzou city, the dam has a flooded area of 550 ha and a total capacity of 181 million m^3. The embankment dam is 515 m long, with a maximum depth of 76 m. The Taksebt Dam impounds a reservoir that stretches approximately 11 km (MADRP, 2016).

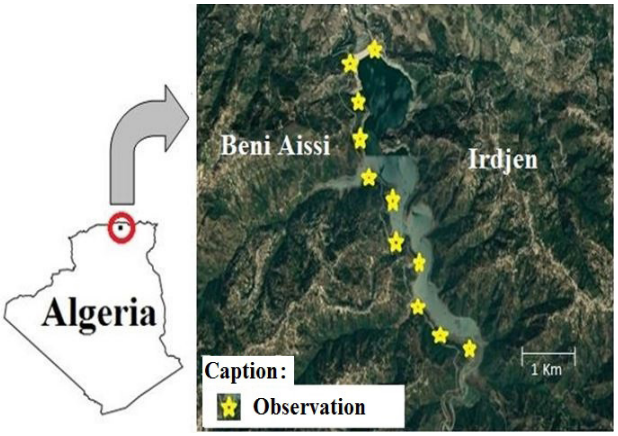

Fig. 1. Map showing location of the Taksebt Dam (Source: Google earth).

Survey design

During the four-years waterbird monitoring program (2018-2021, January-June each year) data were collected document winter visitors, summer visitors, and resident birds at Taksebt Dam.

For data collection techniques, two methods were used to count water birds: (i) direct counts from dam crest: Observers stationed on the dam crest visually counted individual birds arriving from downstream and landing on the water surface or banks. For flocks exceeding 200 individuals, visual estimates were used, especially before sunrise when visibility is limited. (ii) Vehicle-based surveys with spotting scope: To efficiently cover the entire water surface and accurately identify and count larger flocks, a vehicle-based survey method was employed. Observers used a 20x40 mm spotting scope to facilitate rapid and accurate counts. Collaboration with the regional forestry team provided access to vehicles and facilitated data collection.

Eleven observation points were established along the roadside perimeter of Taksebt Dam, following established protocols outlined in Blondel (1975). These selected locations aimed to provide comprehensive coverage of the dam area within a timeframe of approximately 1.5 to 2 hours, depending on observer experience.

Data analysis

Relative abundance is used to show the different population sizes and compared the population sizes of different species within the community (Chessel and Doledec, 1992).

Shannon index is used to analyze the species richness and evenness within the bird community. Additionally, Equitability index is used to assess the balance in species population abundances (Legendre and Legendre, 1979).

Principal component analysis (PCA) is a dimensionality reduction technique that is well-suited for analyzing datasets with multiple interrelated variables (Gotelli and Ellison, 2004). In our case, the data comprises three variables: population size, bird species, and years. It's likely that these variables exhibit some degree of correlation. It can be used to reveal potentially grouping species with similar population size trends, as PCA can be used in ecology for investigating species or community characteristics (Kitahara and Fujii, 2005).

RESULTS

A total of 17 species of water birds were recorded at the Taksebt Dam. The average water birds richness across the four years was 14 species. The species richness during the years 2018 and 2019 was 16 species which decreased to 13 species in 2020 and 2021 (Table I).

We observed a total of 17 water bird species (10 families and 7 orders) in Taksebt Dam, during the study period (2018-2021). The order Anseriformes is the most dominant with 5 species. It is followed by the Pelecaniformes (4 species), Charadriiformes (3 species), Podicipediformes (2 species) and the remaining orders (Gruiformes, Suliformes and Coraciiformes) were the least common. However, species composition varied across the study years. For instance, the Eurasian wigeon (*M. penelope*) and glossy ibis (*P. falcinellus*) were not recorded in 2018 and 2019, respectively; six species namely: *P. falcinellus,* Northern shoveler (*S. clypeata*), common shelduck (*T. tadorna*), *M. penelope*, Eurasian teal (*A. crecca*) and common kingfisher (*A. atthis*) in 2020 and four species namely: *P. falcinellus, T. tadorna, M. penelope* and *A. crecca* were not recorded in 2021. Resident species are great crested grebe (*P. cristatus*), mallard (*A. platyrhynchos*), and common moorhen (*G. chloropus*). They have established breeding populations at Taksebt Dam. The mallard and the common moorhen appear to favor the stilling basin located downstream of the dam spillway. This area offers a more stable water level and abundant aquatic vegetation compared to the upstream areas preferred by the great crested grebe. *P. falcinellus* was observed only once in late March 2018, likely as a

Table I. Water birds monitoring results at Taksebt Dam (2018-2021).

Orders/Families		Names of the species (abbreviations)	Status	2018	2019	2020	2021
				Count			
Pelecaniformes	Ardeidae	Little egret, *Egretta garzetta* (EG)	Summer visitor	8	10	13	3
		Grey heron, *Ardea cinerea* (AC)	Winter visitor	38	42	104	221
		Black-crowned night heron, *Nycticorax nycticorax* (NN)	Summer visitor	4	6	8	5
Threskiornithidae		Glossy ibis, *Plegadis falcinellus* (PF)	Passage migrant	43	0	0	0
Podicipediformes	Podicipedidae	Little grebe, *Tachybaptus ruficollis* (TR)	Winter visitor	13	10	11	2
		Great crested grebe, *Podiceps cristatus* (PC)	Resident	16	8	12	9
Anseriformes	Anatidae	Mallard, *Anas platyrhynchos* (AP)	Resident	125	127	109	46
		Northern shoveler, *Spatula clypeata* (SC)	Winter visitor	118	6	0	12
		Common shelduck, *Tadorna tadorna* (TT)	Winter visitor	2	2	0	0
		Eurasian wigeon, *Mareca penelope* (MP)	Winter visitor	0	15	0	0
		Eurasian teal, *Anas crecca* (ACR)	Winter visitor	41	32	11	0
Gruiformes	Rallidae	Common moorhen, *Gallinula chloropus* (GC)	Resident	17	20	23	27
Charadriiformes	Laridae	Yellow-legged gull, *Larus michahellis* (LM)	Winter visitor	450	591	753	896
Charadriidae		Little ringed plover, *Charadrius dubius* (CD)	Winter visitor	4	5	7	1
Scolopacidae		Common sandpiper, *Actitis hypoleucos* (AH)	Winter visitor	3	6	4	1
Suliformes	Phalacrocoracidae	Great cormorant, *Phalacrocorax carbo* (PCA)	Winter visitor	142	155	117	172
Coraciiformes Alcedinidae		Common kingfisher, *Alcedo atthis* (AA)	Winter visitor	1	2	0	1
		Total of the observed individuals		1025	1037	1172	1396

passage migrant. Similarly, *M. penelope* observed in winter 2019 represents a winter visitor.

Analyzing the abundance data derived from Table I, we can observe trends in avian species throughout the study period (2018-2021). *L. michahellis* emerged as the dominant species, reaching a peak relative abundance of 64.19%. *A. cinerea* held the second highest relative abundance at 15.83%. *P. carbo*, *A. platyrhynchos* and *S. clypeata* followed with abundances of 14.96%, 12.20% and 11.51%, respectively. The remaining species exhibited lower abundances, including *P. falcinellus* 4.20 %, *A. crecca* 4 %, *G. chloropus* 1.96 %, *P. cristatus* 1.56 %, *M. penelope* 1.45%, *T. ruficollis* 1.27%, *E. garzetta* 1.11%, *C. dubius* 0.60%, *N. nycticorax*, *A. hypoleucos* 0.58%, *T. tadorna* 0.20% and *A. atthis* 0.10%. Notably, *L. michahellis* and *A. cinerea* displayed a marked increase in relative abundance throughout the study period (2018-2021), while those of *A. platyrhynchos* and *A. crecca* declined. The decline for *A. platyrhynchos* was particularly noticeable in the last two years (2020 and 2021). A gradual increase in the total number of water birds utilizing the Taksebt Dam has been recorded. In 2018, the dam hosted 1025 individuals. The total water bird population size then increased slightly to 1036 individuals in 2019. This number increased further in 2020, reaching 1173 individuals, and peaked at 1396 individuals in 2021. This rise in total waterbird numbers is mainly driven by the population increase of two dominant species: *L. michahellis* and *A. cinerea*. However, the population rise of *L. michahellis* has been the key driver behind the overall increase water bird numbers. Figure 2 shows the trend in the population size of four species.

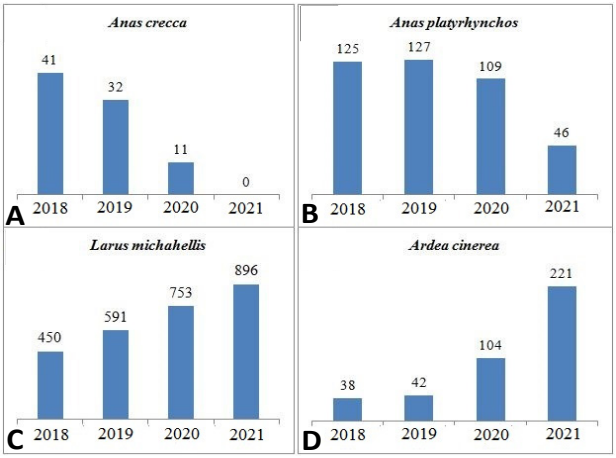

Fig. 2. Trend in the population size of *Anas crecca* (A), *Anas platyrhynchos* (B), *Larus michahellis* (C) and *Ardea cinerea* (D) during the study period 2018-2021s.

Figure 2A, B shows a gradual decline in population size of *A. crecca* and *A. platyrhynchos* over the four-years monitoring period (2018-2021) while Figure 2C, D shows a steady increase in populations of *L. michahellis* and *A. cinerea* during the same period.

The total number of recorded bird species (species richness) at the study site exhibited variation across the monitoring period. In 2018, 16 species were recorded. This number remained similar in 2019, with 16 species again being recorded. However, a decline was observed in 2020, with only 12 species recorded. Species richness then showed a slight recovery in 2021, with 13 species documented. While there was a decline compared to 2018 and 2019, species richness did show signs of recovery in the final year of the study.

The Shannon diversity index (H') exhibited a peak value of 2.64 bits in 2018, indicating the highest species diversity during that year. However, H' declined in subsequent years, reaching 2.17 bits in 2019, 1.88 bits in 2020, and a low of 1.67 bits in 2021. This trend suggests a decrease in overall species diversity at the study site. Similarly, the equitability index (E) reflects the distribution of abundances among species within the community. E values for 2018, 2019, and 2020 were 0.66, 0.54, and 0.51, respectively. Notably, the 2021 E value dropped to a minimum of 0.45, indicating the lowest level of species evenness observed throughout the study period. An equitability index approaching 0 suggests a strong dominance of a few species within the bird community, potentially leading to instability in the ecosystem.

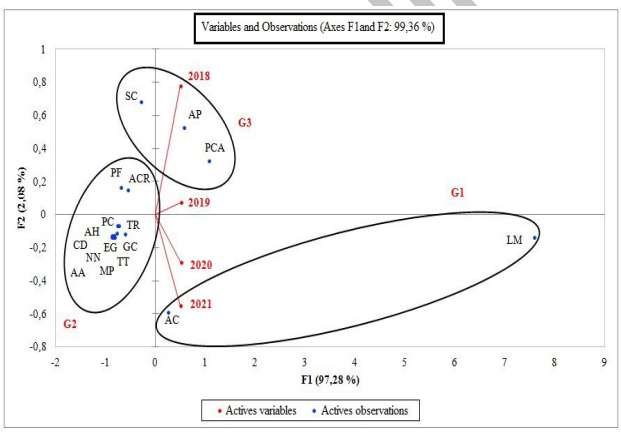

Fig. 3. Principal component analysis (PCA) of bird species population sizes during the study period (2018-2021).

The principal component analysis (PCA) in Figure 3 shows that 99.36% of information is recovered by the two axes (F1 and F2). However, the F1 axis (97.28%) carries more information than the F2 axis (2.08%). The species that contributes positively and strongly to the F1 axis is: *L. michahellis* (LM) with 86.81%. Species that contribute strongly to the F2 axis are: *S. clypeata* (SC) with 33.16%; *A. cinerea* (AC) with 24.54% and *A. platyrhynchos* (AP) with 19.94%. This is due to the high number of individuals in the population of these species.

Concerning the affinities between species according to their annual population size, we distinguish 3 groups: Group 1 (G1) is made up of species whose population size increased rapidly in the last two years (2020 and 2021) and reached maximum values (Table I). These are *L. michahellis* (LM) and *A. cinerea* (AC), and their numbers reached 896 and 221 individuals respectively in 2021. Group 2 (G2) is made up of species with low numbers of less than or equal to 43 individuals. The species concerned by this group are: *P. falcinellus* (PF), *A. crecca* (ACR), *P. cristatus* (PC), *T. ruficollis* (TR), *G. chloropus* (GC), *E. garzetta* (EG), *N. nycticorax* (NN), *T. tadorna* (TT), *A. hypoleucos* (AH), *C. dubius* (CD), *M. penelope* (MP) and *A. atthis* (AA). Group 3 (G3) is made up of species whose population sizesare irregular and unpredictable (Table I). The species concerned are: *S. clypeata* (SC), *A. platyrhynchos* (AP) and *P. carbo* (PCA).

In 2018, Group 3 (G3) species exhibited a relative narrow range in population sizes, varying from 118 to 142 individuals. This might seem a random event, because AP is a species that has seen its numbers increase due to the setting free of mallard ducks that took place (view the previous paragraphs) and the two other species, PCA and SC, are winter visitor species.

DISCUSSION

The results of the present study are important since it is the first ornithological study on this artificial reservoir, with a total of 17 species recorded. Very few works have been done on artificial water reservoirs and dams in Algeria. Among these works, we cite the study carried out in Jijel in Beni Haroun dam having a surface area of 3929 ha, and the result of the survey regarding water birds was 44 species (Chabou *et al*., 2020), but only 29 species were recorded by Belfethi (2022). It is the largest reservoir in Algeria and one of the largest in North Africa according to Bouhila *et al*. (2017). Our study site, with a surface area of 550 ha represents only 14% of the size of Beni Haroun dam but represents about 40% of its avifauna richness. In the Lake of Réghaïa (Algeria), 207 species of water birds are known (Bellatreche *et al*., 2002). In another artificial wetland at Kef Doukhane, Ghardaïa, 53 species were recorded (Chedad *et al*., 2020).

If we compare with natural wetlands such as the marsh of Redjla which is a natural wetland of 50 ha, which hosts

41 species of water birds (Chabou *et al*., 2020); a total of 53 avian species has been identified in the Boussedra marsh, a palustrine wetland, 55 ha in size (Boudraa *et al*., 2018); In a Saharan wetland, which is the depression of wadi Righ Ettayib, 53 species were recorded (Bensaci *et al*., 2013). In the wetland eco-complex of Setif, 79 species of water birds have been recorded (Baaziz *et al*., 2011). In the east of the country, Boucherit (2014) recorded 14 species of Anatidae in lake Tonga and 13 species in lake of birds during the years of 2013 and 2014, and only 10 species were recorded during 2016 in Blida in the wetland of wadi El Alleug (Ouarab *et al*., 2018). Figure 3 is a principal component analysis (PCA) showing the species assemblages with similar population size trends.

The resident breeding Mallard (*A. platyrhynchos*) population at Taksebt Dam appears to be influenced by restocking efforts. According to the general forestry directorate, DGF (2017), the Reghaïa hunting center, in collaboration with the DGF of Tizi-Ouzou, released 140 captive-raised Mallards into local wetlands in October 2018. This release likely explains the relatively high numbers observed during winter monitoring in 2018 (125 individuals) and 2019 (127 individuals), which are close to the number of released birds. However, the presence of mallards prior to restocking is also evident, as forestry archives indicate a count of approximately 70 individuals at Taksebt Dam in 2017.

The observed decline in Mallard (*A. platyrhynchos*) population after 2019 (109 individuals in 2020 and 46 individuals in 2021) suggests potential threats. Illegal hunting by local residents and egg collection are likely contributing factors. Furthermore, the released birds in 2018 may have been imprinted on humans due to captive rearing, making them easier to capture (Pers.Com., 2021). However, the successful breeding observed in summer 2018 (female with 7 ducklings) indicates the species' ability to adapt and reproduce in this artificial habitat.

The decline in population of Eurasian teal (*A. crecca*) likely relates to their dietary needs. Hayman and Hume (2008) report that *A. crecca* favors shallow wetlands rich in aquatic vegetation for foraging on seeds, roots, stems, and aquatic insects. The Taksebt Dam, with its deep water and limited vegetation, may not provide suitable foraging grounds. This is further supported by the absence of *A. crecca* observations in 2021. Therefore, their presence at Taksebt Dam appears to be opportunistic, utilizing the habitat during winters when more suitable wetlands might be unavailable.

The populations of both *L. michahellis* and *A. cinerea,* are expanding, particularly *L. michahellis* which is thriving in the north of Tizi-Ouzou region. Notably, these gulls exhibit a distinct behavior pattern. At sunset, they arrive and spend the night on the water's surface. Early morning at daybreak sees them depart in coordinated groups of 40-50 individuals, circling upwards to an altitude of about 60 meters before heading north together, presumably downstream. The initial groups were challenging to observe before sunrise, with only vocalizations audible. However, with increasing daylight, their behavior became clear. This departure process, involving multiple groups relaying in the sky, takes approximately 30 min. Additionally, co-author Talmat-Chaouchi's ongoing research suggests that *L. michahellis* has adapted to inland urban environments, successfully breeding on rooftops in Tizi-Ouzou city. This adaptation, coinciding with the construction of the Taksebt Dam, raises the possibility of a link between these developments and the observed population increase of *L. michahellis* at the dam. Her studies further suggest that the *L. michahellis* population was previously restricted to the coastal zone (Talmat-Chaouchi, unpublished data).

Two factors likely contributed to the population growth observed in this study: reduced hunting pressure and increased food availability:

Reduced hunting pressure

Due to their unpalatable flesh, both *L. michahellis* (yellow-legged gull) and *A. cinerea* (grey heron) are likely less targeted by hunters. This reduced pressure on their populations may be a contributing factor to their growth.

Increased food availability

Records from the national center for research and development of Fisheries and Aquaculture, MADRP (2016) indicate a possible link to increased food resources. The introduction of fish species in 2016, including 200,000 fry each of bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*), along with 500 fry and 28 adult pike-perch (*Sander lucioperca*), may have specifically benefitted *A. cinerea*, a known piscivorous (fish eater), and contributed to its population rise. The increased food availability. Likely explains the presence of the great cormorant (*P. carbo*), another piscivorous bird, in the reservoir. Recent drought induced water level drops (2020-2021) may have further enhanced prey fish visibility, potentially attracting additional piscivorous birds to the reservoir.

CONCLUSION

This study provides the first monitoring of water bird adaptation in a newly created artificial wetland in Tizi-Ouzou region. Our findings reveal that the most dominant order was Anseriformes (Anatidae) with 5 identified species: mallard (*A. platyrhynchos*), Northern shoveler

(*S. clypeata*), common shelduck (*T. tadorna*), Eurasian wigeon (*M. penelope*) and Eurasian teal (*A. crecca*). Several species, including mallard (*A. platyrhynchos*), common moorhen (*G. chloropus*), and great crested grebe (*P. cristatus*) appear to have adapted and became resident at this artificial wetland, suggesting they may be pioneer species in this new habitat. Other species likely utilized the dam for foraging and resting purposes. Notably, the yellow-legged gull (*L. michahellis*) and grey heron (*A. cinerea*) appear well-suited to this environment, while species like glossy ibis (*P. falcinellus*) and Eurasian wigeon (*M. Penelope*) struggled to adapt. Interestingly, mallard (*A. platyrhynchos*), despite initially adapting, experienced population decline likely due to hunting pressure.

DECLARATIONS

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IRB approval

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Statement of conflict of interest

The authors have declared no conflict of interest.

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