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Wintering Water Birds in Lac Ayata (Oued Righ Valley, Algerian Sahara)

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ABSTRACT

Bi-monthly field trips were conducted from September 2022 to mid-April 2023 to inventory and study the ecology of aquatic birds wintering at Lac Ayata, an unclassified wetland in the Oued Righ Valley (Eastern Sahara, Algeria). During these surveys, 22 species belonging to nine families were recorded. The family Anatidae was strongly represented, with eight species and high overall abundance (1,170–1,164 individuals recorded during February and March 2023). Notably, two of these species are listed on the IUCN Red List: the Ferruginous Duck (*Aythya nyroca*) and the Marbled Teal (*Marmaronetta angustirostris*). The families Scolopacidae and Recurvirostridae followed, with three species each. Of the total species recorded, seven used this wetland only as a stopover during migration, while 15 species remained throughout the wintering season. The most densely populated months were February and March, whereas the highest species richness (14 species) was observed in December 2022, January, and late March 2023. A balanced distribution of bird populations was particularly noticeable at both the beginning and end of the wintering season (September 2022 and March 2023). Furthermore, statistical analysis using Correspondence Factor Analysis (CFA) revealed that the wintering season can be subdivided into three distinct phases: the early wintering season (September–October), the mid-wintering season (November–January), and the late wintering season (February–early April).

INTRODUCTION

The wetland eco-complex of the Oued Righ Valley in Algeria's eastern Sahara serves as an essential stopover during critical periods for many waterbirds, either wintering in the Sahara or returning to their usual breeding sites **(Bouzegag, 2008; Nouidjem, 2008; Bensaci *et al.*, 2011, 2013, 2015; Houhamdi *et al.*, 2025)**. The diversity of aquatic habitats, particularly the vegetative belts, attracts numerous breeding bird populations. In the Algerian context, few studies have focused on describing the ecological role of wetlands and their close relationships with the migratory waterbirds

that frequent them **(Houhamdi & Samraoui, 2001, 2002, 2003, 2008; Houhamdi, 2002; Mayache *et al.*, 2008; Metallaoui & Houhamdi, 2008; Metallaoui *et al.*, 2009)**. Moreover, these studies concern only the regions bordering the northern coastline of the country and the Algerian High Plains **(Maazi, 2005, 2009; Seddik, 2005, 2011; Boulekhssaim *et al.*, 2006, 2009; Saheb *et al.*, 2006; Samraoui *et al.*, 2006; Houhamdi *et al.*, 2008)**.

Therefore, biomonitoring, reproduction, and wintering strategies of aquatic birds, particularly within Saharan continental hydrosystems, remain underexplored and insufficiently documented. Since the vast aquatic ecosystems of the Oued Righ Valley are often inaccessible and difficult to reach, they have been the subject of very few scientific studies. Located at the foothills of the Saharan Atlas, the region features a wetland eco-complex composed of about a dozen shallow brackish to saline water bodies, some of which dry up completely during the summer months **(Nouidjem, 2008; Bouzegag, 2015)**. Nonetheless, Chott Melghir (551,500 ha), Chott Merouane (337,700 ha), Lac Oued Khrouf (1,200 ha), and Lac Ayata (40 ha) are the only water bodies that retain water year-round **(Nouidjem, 2008; Bensaci *et al.*, 2011, 2013, 2015; Nouidjem *et al.*, 2012, 2014, 2015, 2016; Bouzegag *et al.*, 2013; Bouzegag, 2015)**.

In the present work, we reported preliminary results from censuses of waterbirds frequenting Lac Ayata (Oued Righ Valley, Algerian Sahara) during the 2022/2023 wintering season, while also determining their specific statuses within this wetland. We emphasized the urgent need to protect this ecosystem by clarifying the role it plays for aquatic birds. Accordingly, our objectives were to identify the key characteristics of this habitat and to highlight its national and international significance in sustaining waterbird populations. This approach enables us to present the current state of the avian population in the region and to assess its conservation value and carrying capacity, thereby preparing the ground for effective management and conservation planning.

MATERIALS AND METHODS

Study area

Located at 33°29.867′ N and 5°59.403′ E, Lac Ayata is a wetland ecosystem formed by the overflow of water from the Oued Righ Canal. This artificial watercourse originates in the palm groves of Touggourt in the south and flows northward into Chott Merouane, covering a total distance of 155km **(Bouzegag, 2008, 2015; Megrerouche *et al.*, 2025)**. The latter discharges its excess water along its banks, which led to the emergence of this water body. This small Saharan lake expands over an area of approximately 40 hectares during the flood season **(Nouidjem, 2008)** (Fig. 1, Photo 1).

Lac Ayata, which has existed for about 35 years, is a freshwater wetland located in a strategic area at the entrance of the city between two main routes: the RN3, which connects Biskra to Ouargla and Hassi Messaoud, and the railway line linking Biskra to

Touggourt. The wetland is divided into two parts, each covering an area of 20 hectares. The northern section constitutes a shallow water body (maximum depth of 60cm) and is devoid of vegetation, while the southern section is dominated by *Phragmites australis*, along with several endemic species such as *Tamarix articulata*, *Atriplex halimus*, *Retama retam*, *Anabasis articulata*, *Salsola fruticosa*, and *Juncus acutus* **(Bouzegag, 2008)**.

This mosaic of habitats provides an ideal refuge for numerous animal species, including *Sus scrofa*, *Lepus capensis*, *Canis lupus*, and *Vulpes zerda* **(Bouzegag, 2015)**. The waterbird community is primarily represented by *Phœnicopterus roseus* (Greater Flamingo), *Spatula clypeata* (Northern Shoveler), *Anas platyrhynchos* (Mallard), *Ciconia ciconia* (White Stork), as well as several species of shorebirds **(Bouzegag, 2015)**.

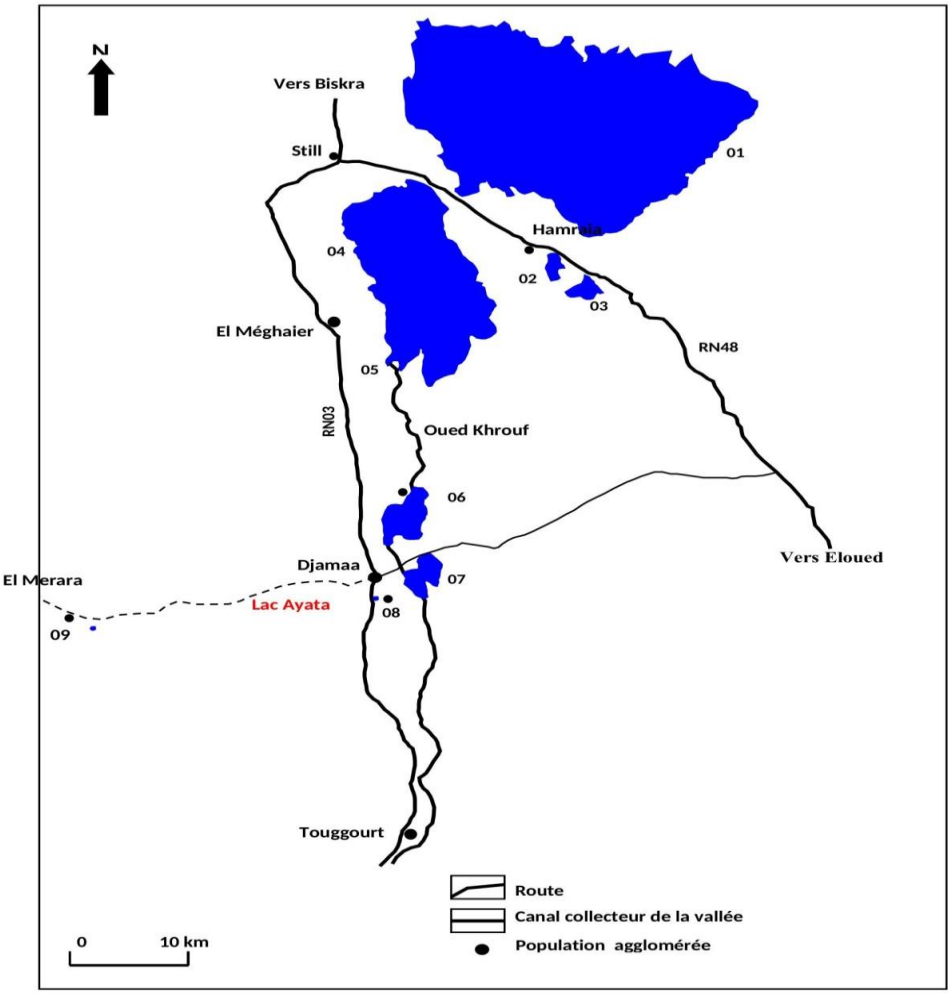

Fig. 1. Geographical location of Lac Ayata

Photo 1. General view of Lake Ayata (taken by Ines Houhamdi on 14 January 2023)

Sampling

This project forms part of the preparation for a doctoral thesis on the importance and ecological role of wetlands in the Oued Righ Valley, with a particular focus on Lac Ayata and its significance for waterbirds. The research is fundamentally based on a comprehensive census of all waterbird species that frequented and used this wetland throughout the 2022/2023 wintering season, spanning September to mid-April. The study further aimed to determine the conservation status of these species and to analyze their ecological characteristics.

To achieve these objectives, bi-monthly field surveys were conducted from September 2022 to April 2023, generally between 8:00 a.m. and 5:00 p.m. For bird counts and population monitoring, we used a KONUS 20×60 spotting scope and applied the following protocol: individual counting was carried out when the group contained fewer than 200 individuals and was located within 200 meters; in cases where groups were more distant and comprised larger numbers, visual estimations were made instead **(Blondel, 1975; Tamisier & Dehorter, 1999; Houhamdi, 2002)**. This approach is among the most widely used in winter censuses of aquatic birds, though it carries a margin of error—largely dependent on observer experience and habitat characteristics—that can reach up to 10% **(Lamotte & Bourlière, 1969)**.

Following the counts, we calculated and monitored several ecological indices to describe the balance of the wintering population. These included total abundance per survey (number of birds per outing), species richness, and population equilibrium indices (Shannon–Weaver Index and Equitability Index) **(Houhamdi, 2002)**. Finally, a multivariate statistical analysis—Correspondence Factor Analysis (CFA)—was applied to

characterize the seasonal dynamics of wintering birds in this wetland **(Chessel & Doledec, 1992)**.

RESULTS AND DISCUSSION

During the entire wintering season (September 2022–mid-April 2023), 22 species of waterbirds belonging to nine families were recorded at Lac Ayata (Table 1). This avifauna was largely dominated by ducks (Anatidae), which were mostly observed in the deeper areas of the waterbody. The Northern Shoveler (*Spatula clypeata*) and the Eurasian Teal (*Anas crecca crecca*) were by far the most numerous species, occurring throughout the entire wintering season. Shorebird and wader populations were primarily concentrated along the banks, wet meadows, and areas influenced by water level fluctuations. The Western Marsh Harrier (*Circus aeruginosus*) was regularly observed flying over both the open areas and reedbeds of the lake.

Anatidae. This was the most common family in Lac Ayata, represented by eight species (Table 1, Fig. 2). The Eurasian Teal (*Anas crecca crecca*), Northern Shoveler (*Spatula clypeata*), and Mallard (*Anas platyrhynchos*) were the three most regularly observed species throughout the wintering season. In contrast, the Ferruginous Duck (*Aythya nyroca*), Marbled Teal (*Marmaronetta angustirostris*), Ruddy Shelduck (*Tadorna ferruginea*), and Common Shelduck (*Tadorna tadorna*) were rare, recorded only in small numbers (generally fewer than 15 individuals) and for short periods. The two shelduck species (*T. tadorna* and *T. ferruginea*) comprise a regular breeding subpopulation within the valley **(Nouidjem, 2008; Nouidjem *et al*., 2012, 2014, 2015, 2016)**. Notably, the Marbled Teal and Ferruginous Duck are of significant ecological importance as both species have an unfavorable global conservation status and are listed as threatened in Algeria **(Isenmann & Moali, 2000; Houhamdi, 2002; Houhamdi & Samraoui, 2008; Aberkane *et al*., 2013, 2014; Bouzegag *et al*., 2013; Aberkane, 2014; Abdi *et al*., 2015; Charchar *et al*., 2015; Lardjane-Hamitti *et al*., 2015; Merzoug *et al*., 2015; Narsis *et al*., 2019, 2022; Loucif *et al*., 2021)**.

Phoenicopteridae. This family was represented by a single species, the Greater Flamingo (*Phoenicopterus roseus*), which rarely frequented this relatively small waterbody and is considered a passage species (Fig. 2). The maximum count was nine individuals in December 2022 (Table 1). This species is known to breed in the region's largest wetland, Chott Merouane (337,700 ha), and in the High Plains north of the valley **(Boulekhssaim *et al*., 2006; Saheb *et al*., 2006; Samraoui *et al*., 2006; Houhamdi *et al*., 2008; Bensaci *et al*., 2011, 2013, 2015; Bouaguel *et al*., 2013; Houhamdi *et al*., 2025)**.

Ardeidae. Three species were recorded: Grey Heron (*Ardea cinerea*), Great Egret (*Ardea alba*), and Little Egret (*Egretta garzetta*) (Table 1 & Fig. 2). The first two were

observed only at the beginning of the wintering season, whereas the Little Egret was recorded during all surveys. Its abundance was highest at the start of the season but declined steadily thereafter, corroborating earlier findings **(Bouzegag, 2008, 2015)**. These species were frequently seen in *Phragmites australis* reedbeds bordering the southern sector of the wetland **(Thévenot *et al*., 2003; Seddik *et al*., 2010, 2012)**.

Ciconiidae. Represented by a single species, the White Stork (*Ciconia ciconia*), which, although abundant and a regular breeder along the Algerian coastline and High Plains **(Ledant *et al*., 1981; Isenmann & Moali, 2000)**, was observed only once at Lac Ayata in October 2022 (Table 1 & Fig. 2). Two individuals were recorded occupying muddy areas of the lake. They exhibited shy behavior, taking flight at the slightest disturbance and being the last to return to settle.

Recurvirostridae. Two species were documented: the Black-Winged Stilt (*Himantopus himantopus*) and the Pied Avocet (*Recurvirostra avosetta*) (Table 1 & Fig. 2). The Black-Winged Stilt occurred throughout the season in high numbers, especially toward the end, reflecting pre-nuptial migratory gatherings **(Maazi *et al*., 2010)**. This species breeds widely in the valley. The Pied Avocet, which also breeds in the region, was observed only from December 2022, with numbers never exceeding 20 individuals.

Scolopacidae. Three species were recorded: the Common Redshank (*Tringa totanus*), Spotted Redshank (*Tringa erythropus*), and Common Snipe (*Gallinago gallinago*) (Table 1). All exhibited wintering status at Lac Ayata and across North Africa (Fig. 3) **(Thévenot *et al*., 2003)**. They were usually observed alone or in small groups along the banks and in water-level fluctuation zones.

Charadriidae. Represented by a single species, the Kentish Plover (*Anarhynchus alexandrinus*) (Table 1). This species breeds in the Oued Righ Valley **(Nouidjem, 2008; Bensaci *et al*., 2013; Bouzegag *et al*., 2013; Bouzegag, 2015)** and the High Plateaus **(Baaziz *et al*., 2011)**. It was recorded during all field visits and was classified as a wintering species, with numbers exceeding 30 individuals.

Rallidae. Two species were observed: the Common Moorhen (*Gallinula chloropus*) and the Water Rail (*Rallus aquaticus*) (Table 1 & Fig. 2). The Moorhen was present throughout the study period, while the elusive Water Rail was detected only once, with four individuals in stands of *Phragmites australis*.

Accipitridae. Represented by the Western Marsh Harrier (*Circus aeruginosus*), a species also reported in other wetlands **(Seddik, 2005, 2011; Baaziz, 2012)**. This diurnal raptor frequently patrolled over Lac Ayata and attempted to nest in the *Phragmites* stands of the southern sector.

Overall, 22 species were documented during the wintering season, of which 15 were identified as permanent winter residents at Lac Ayata, while seven were considered rare (Fig. 3). These rarer species were generally recorded during post- and pre-nuptial migration periods, reinforcing the vital ecological role of Lac Ayata in supporting waterbirds along their north–south migratory routes **(Ledant *et al*., 1981; Isenmann &**

Moali, 2000; Houhamdi *et al*., 2008; Bensaci *et al*., 2013; Bouzegag, 2015). In general, Anatidae occupied the central zones of the lake, whereas waders and shorebirds were mainly distributed in shallow and muddy areas subject to water fluctuations.

Table 1. Cheklist and phenology of waterbirds in Lac Ayata (wintering season 2022/2023)

		Sep_1	Oct_1	Oct_2	Nov_1	Nov_2	Dec_1	Dec_2	Jan_1	Jan_2	Feb_1	Feb_2	Mar_1	Mar_2	Apr_1	Phenological status
Anatidae	*Aans plathyrhychos*	55	69	28	67	71	68	35	23	27	19	19	19	19	19	Winternig
	Spatula clypeata	75	130	148	81	87	73	177	163	331	631	748	786	96	47	Winternig
	Anas acuta	0	0	0	0	0	0	5	8	8	12	17	19	2	0	Winternig
	Anas crecca crecca	0	0	83	309	219	174	325	299	335	455	380	271	39	0	Winternig
	Marmaronetta angustorostris	0	6	0	0	0	0	0	0	0	0	0	0	0	0	Postnuptial passage
	Tadorne Casarca	0	0	0	0	0	0	0	0	0	0	0	0	2	0	Prenuptial passage
	Tadorna tadorna	0	0	0	0	0	2	2	2	2	0	0	0	0	0	Hivernant
	Aythya nyroca	0	0	0	0	0	0	0	0	0	0	0	0	15	11	Prenuptial passage
Phoenicopteridae	*Phoenicopterus roseus*	0	2	0	0	0	9	0	6	6	0	0	0	0	0	de passage
Ardeidae	*Ardea cinerea*	25	30	2	3	2	1	2	0	0	0	0	1	0	6	Winternig
	Ardea alba	0	2	0	0	0	0	0	0	0	0	0	0	0	0	Postnuptial passage
	Egretta garzetta	20	20	6	1	1	1	2	1	1	1	1	1	2	3	Winternig
Ciconiidae	*Ciconia ciconia*	0	0	2	0	0	0	0	0	0	0	0	0	0	2	passage
Recurvirostridae	*Himantopus himantopus*	35	36	22	15	18	18	19	21	17	23	32	29	76	73	Winternig
	Recurvirostra avosetta	0	0	0	0	0	0	18	8	4	4	4	4	4	4	Winternig
Scolopacidae	*Tringa totanus*	18	22	16	11	19	10	13	13	0	0	0	12	14	11	Winternig
	Tringa erythropus	22	16	24	10	28	16	14	18	11	17	15	19	17	21	Winternig
	Gallinago gallinago	0	0	0	16	22	12	23	17	15	22	25	11	11	17	Winternig
Charadridae	*Anarhynchus alexandrinus*	0	22	27	28	29	23	23	26	22	36	42	33	22	19	Winternig
Rallidae	*Gallinula chloropus*	28	18	18	24	16	24	21	22	32	40	36	27	27	24	Winternig
	Rallus aquaticus	0	0	0	0	0	4	0	0	0	0	0	0	0	0	Passage
Accipitridae	*Circus aeruginosus*	0	0	1	0	0	0	2	0	3	2	0	0	0	0	Winternig

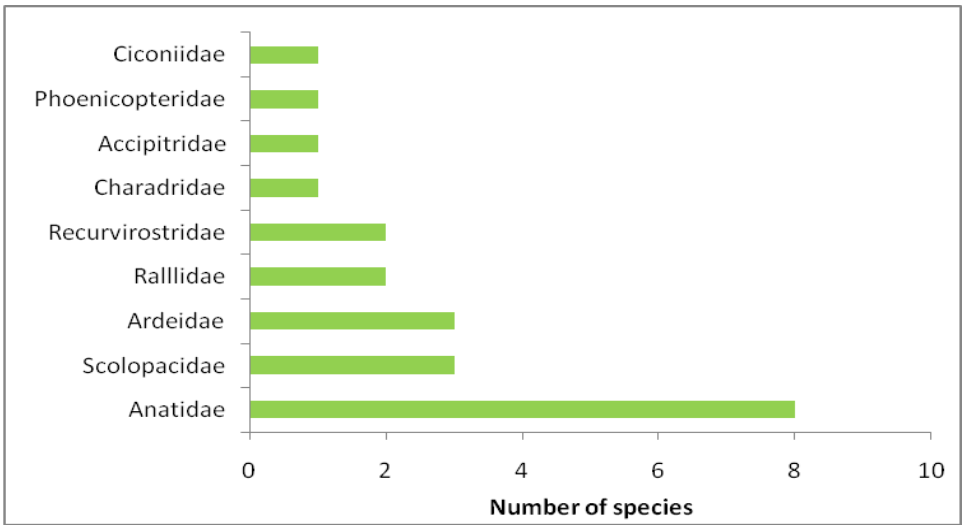

Fig. 2. Number of species observed per family

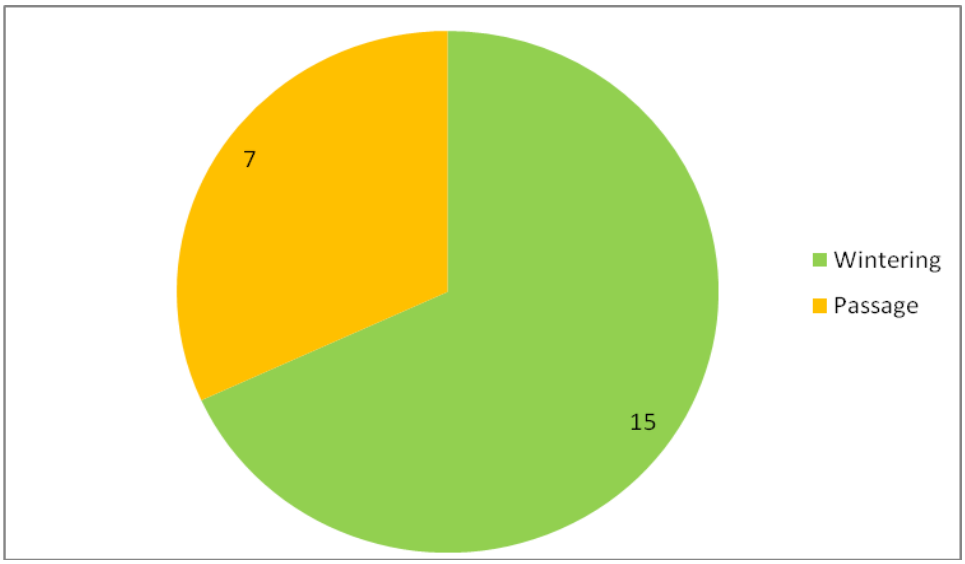

Fig. 3. Phenological status of species during the wintering season

Study of ecological indicators

Abundance

Since the beginning of September 2022, marking the onset of the wintering season, Lac Ayata hosted 278 waterbirds. Numbers gradually increased until February 2023, when the population peaked at 1,315 individuals (Fig. 4). This peak corresponded to the massive arrivals of wintering birds and/or individuals temporarily using the wetland during the transit and post-breeding passage months (October and November).

From March through April, population numbers declined steadily, reflecting the end of the wintering season, as birds progressively departed the site to return to their breeding grounds. These patterns highlight the crucial role of Lac Ayata as a Saharan wetland, sustaining avian diversity during wintering periods. Its importance is comparable to that of other key waterbodies along the southern Mediterranean shore **(Houhamdi & Samraoui, 2001, 2002, 2003, 2008; Houhamdi, 2002; Houhamdi *et al.*, 2008; Metallaoui & Houhamdi, 2008, 2010; Seddik *et al.*, 2010, 2012; Boukrouma *et al.*, 2011)**.

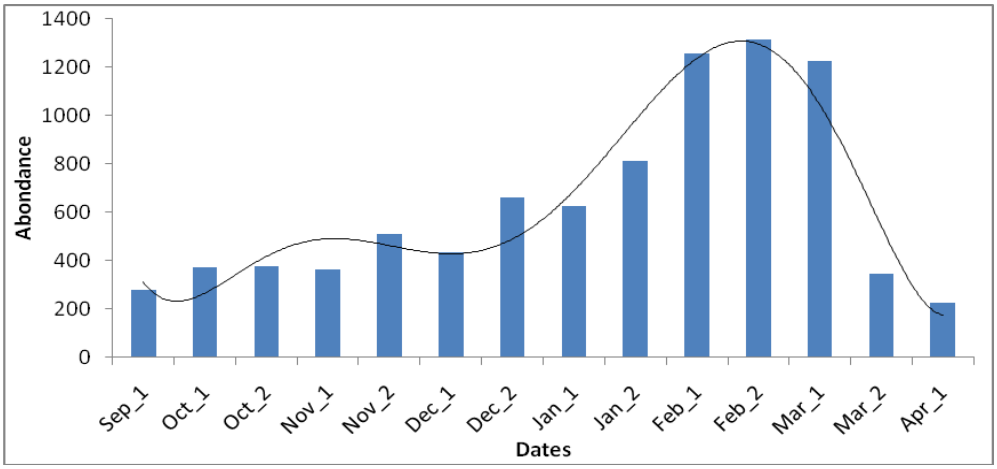

Fig. 4. Evolution of abundance during wintering saison (2022/2023)

Species richness

The graph illustrating the evolution of species richness in aquatic birds revealed a sawtooth pattern, characterized by three distinct peaks (Fig. 5). The first peak, with 13 species, was recorded in October, coinciding with the arrival of the first wintering species (*Anas crecca crecca*, *Spatula clypeata*, *Anas platyrhynchos*, sandpipers, and *Gallinula chloropus*), as well as migratory species such as the Greater Flamingo (*Phoenicopterus roseus*), Garganey (*Spatula querquedula*), and Western Marsh Harrier (*Circus aeruginosus*).

The second peak occurred in December 2022 and January 2023, reaching a maximum of 14 species. This period was marked by the additional presence of the Common Shelduck (*Tadorna tadorna*) and the Water Rail (*Rallus aquaticus*).

The third and final peak appeared at the end of March, signaling the conclusion of the wintering season. During this phase, pre-nuptial migrants such as the Ruddy Shelduck (*Tadorna ferruginea*) and the Ferruginous Duck (*Aythya nyroca*) were observed, before departing toward their breeding grounds.

In summary, Lac Ayata hosted 22 waterbird species over the course of the 2022/2023 wintering season, with species richness peaking at 14 during December, January, and March. These findings are consistent with previous reports from similar

wetlands in Algeria **(Isenmann & Moali, 2000; Bensaci *et al.*, 2013; Bouzegag *et al.*, 2013; Bouzegag, 2015)**.

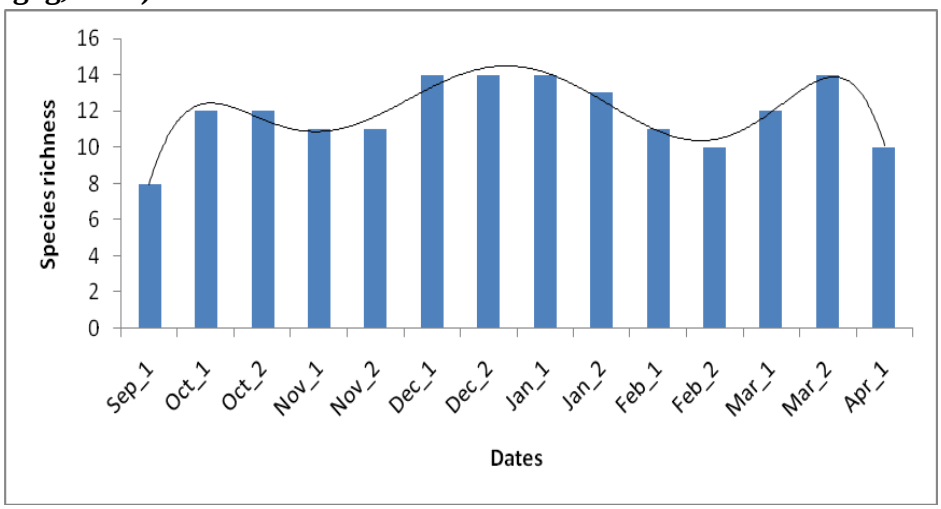

Fig. 5. Evolution of species richness during wintering saison (2022/2023)

Diversity index

The graphical representations of the two population equilibrium indices revealed broadly similar patterns, with the highest Shannon–Weaver and equitability values recorded at both the beginning and the end of the wintering season (Figs. 6 & 7). Specifically, these peaks occurred in September–October 2022 and again in March 2023, although both indices generally showed limited fluctuations throughout the study period. The Shannon–Weaver index ranged from 1.074 to 3.077 (March) (Fig. 6), while the equitability index ranged from 0.475 (March) to 0.938 (September) (Fig. 7).

Overall, the highest values of both indices were recorded during months when Lac Ayata was only sparsely frequented by waterbirds—that is, when both species richness and individual abundance were low. Conversely, the lowest index values were observed in January and February, when three wintering Anatidae species—the Eurasian Teal (*Anas crecca crecca*), Mallard (*Anas platyrhynchos*), and Northern Shoveler (*Spatula clypeata*)—dominated the lake.

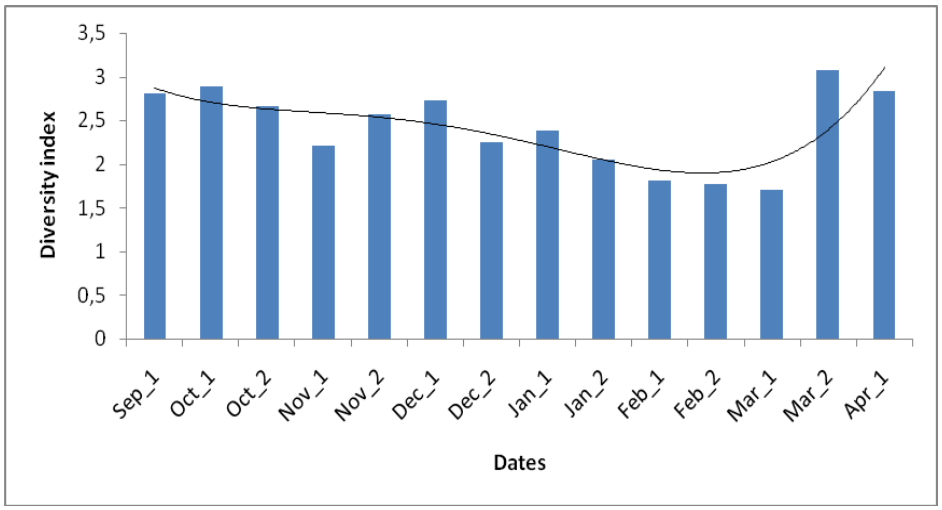

Fig. 6. Evolution of Shannon and Weaver diversity index during wintering season (2022/2023)

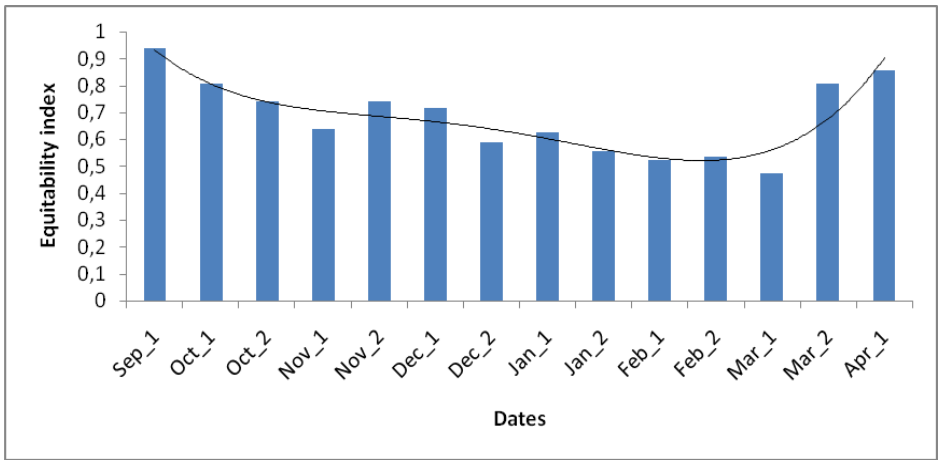

Fig. 7. Evolution of equitability index during wintering season (2022/2023)

Multivariate statistical analysis

The multivariate analysis of the bimonthly counts, expressed on the 1×2 factorial plan of the AFC (Fig. 8), explained 67% of the total inertia and revealed a clear temporal structuring in the occupation of Lac Ayata by aquatic birds. This analysis subdivided the wintering season into three distinct sub-phases:

- **First sub-phase (September–October):** This phase marked the onset of the wintering season, during which species such as the Marbled Teal (*Marmaronetta angustirostris*), Ferruginous Duck (*Aythya nyroca*), Little Egret (*Egretta garzetta*), Great Egret (*Ardea alba*), Shelducks (*Tadorna ferruginea*, *Tadorna tadorna*), White Stork (*Ciconia ciconia*), and Black-winged Stilt (*Himantopus himantopus*) were observed. This period resembled the end of the wintering

season (late March–early April), when flocks of Black-winged Stilts and passing White Storks were again recorded. Water levels during these periods were relatively low.

- **Second sub-phase (November–mid-December):** This stage was characterized by the presence of Mallards (*Anas platyrhynchos*), Sandpipers (*Tringa* spp.), Kentish Plover (*Anarhynchus alexandrinus*), and Moorhen (*Gallinula chloropus*), along with migratory species such as the Greater Flamingo (*Phoenicopterus roseus*) and the Water Rail (*Rallus aquaticus*). During this phase, water levels were at their highest, as Lac Ayata received excess irrigation water from surrounding palm groves.
- **Third sub-phase (late December–January):** This final stage was marked by the arrival of late wintering species, including the Eurasian Teal (*Anas crecca crecca*), as well as delayed transient species such as the Common Shelduck (*Tadorna tadorna*) and the Pied Avocet (*Recurvirostra avosetta*). At this time, water levels began to decline and temperatures gradually rose.

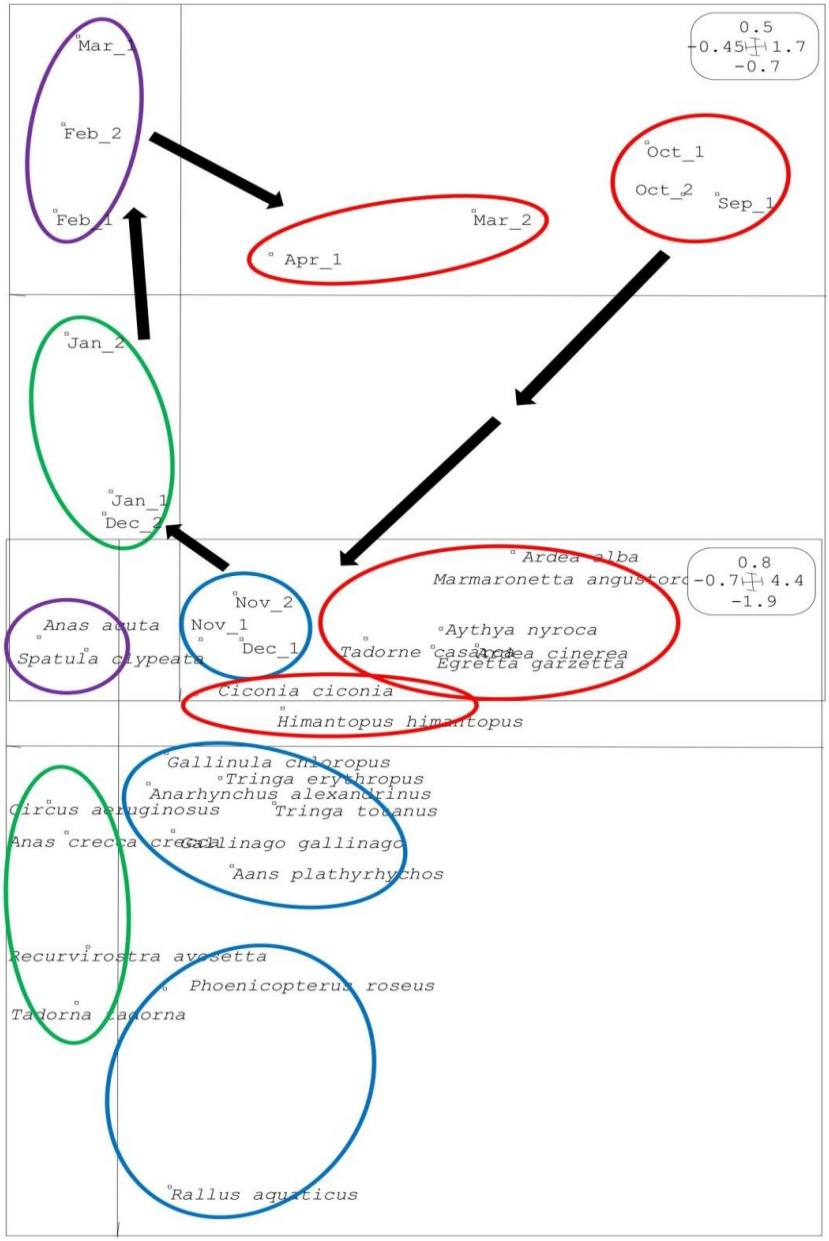

Fig. 8. Factorial plan (1x2) of the AFC of wintering waterbird counts. Axes of inertia F1: 0.46 & F2: 0.21

CONCLUSION

Over the 2022–2023 wintering season, waterbird numbers at Lac Ayata (Oued Righ Valley, Algerian Sahara) fluctuated between 227 and 1,315 individuals. These inter-monthly variations were strongly influenced by the birds' biological cycles and the fluctuating water levels of the lake. Overall, Lac Ayata proved to be a highly diverse

wetland, supporting 22 species from nine families. Of these, 15 were regular winter visitors, while seven appeared only during migratory stopovers.

As in most Algerian and North African wetlands, the family Anatidae was the most represented, with eight species recorded. Notably, two species of international concern were documented: the Ferruginous Duck (*Aythya nyroca*), a regular wintering bird in southern Mediterranean wetlands often observed in numbers exceeding Ramsar Convention thresholds, and the Marbled Teal (*Marmaronetta angustirostris*), which used Lac Ayata as a stopover during migration. Both species are listed on the IUCN Red List and are of particular importance given their global conservation status.

The need to conserve and protect this wetland is therefore of growing urgency. We strongly suggest that designating Lac Ayata as a Ramsar site would significantly enhance its protection, reinforce the conservation of Saharan wetlands more broadly, and ensure that numerous waterbird species can continue to use them as critical sites for wintering, migration, and breeding.

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