SPECIES ABUNDANCE AND RICHNESS PATTERNS OF WINTERING WATERBIRDS IN SÉTIF WETLANDS COMPLEX (ALGERIA)

Hadjer GOUGA *, *Ettayib BENSACI* ** and *Zouhir BOULGUERAGUER* *

* University of Sétif 1, Faculty of Natural and Life Sciences, Campus El Bez, Sétif, Algeria, DZ-19000, gouga.hadjer@gmail.com, ORCID: 0009- 0000-7319-4035, boulgueraguer@yahoo.fr, ORCID: 0009-0007-7884-3170.

** University of M'sila, Department of Natural and Life Sciences, Route Principale RP 76, M'sila, Algeria, DZ-28000, tayeb.bensaci@univ-msila.dz, ORCID: 0000-0003-2549-4871.

DOI: 10.2478/trser-2025-0007

KEYWORDS: wintering waterbirds, wetlands, richness, abundance, Sétif region.

ABSTRACT

Surveys of wintering waterbirds were conducted in 17 wetland areas along the wetland complex of the Sétif region, with the aim to determine the variability of waterbird populations and the ornithological value of these wetlands for further strengthening of their management and conservation. Our survey revealed a total species richness of 47 waterbird species. The total regional population averages 31921 individuals per year recorded from 2014 to 2021. Among these species, 12 are dominant representing 94%. Based on the calculated occurrence index for each species, the population consists of two common species, 10 frequent species, and 35 rare species. The Kruskal-Wallis test (also referred to as one-way ANOVA) was utilized to compare the distribution of data series related to species richness, average abundance, and values of Shannon diversity and evenness among the different studied sites, showing highly significant differences between the wetlands.

RÉSUMÉ: Modèle d'abondance et de richesse des espèces d'oiseaux d'eau hivernants dans le complexe des zones humides de Sétif (Algérie).

Les études des oiseaux d'eau hivernant sont faites dans 17 sites le long du complexe de zones humides de la région de Sétif, dans le but de déterminer la variabilité des populations d'oiseaux d'eau et la valeur ornithologique de ces zones humides pour renforcer davantage leur conservation et leur gestion. Notre enquête révèle une richesse spécifique totale de 47 espèces d'oiseaux d'eau. La population régionale totale représente une moyenne de 31921 individus par an recensés de 2014 à 2021. Parmi ces espèces, 12 sont dominantes avec un taux de 94%. Sur la base de l'indice d'occurrence calculé pour chaque espèce, la population est répartie avec deux espèces communes, 10 espèces fréquentes et 35 espèces rares. L'application du test de Kruskal-Wallis (aussi appelée ANOVA unidirectionnelle), pour la comparaison de la distribution des séries de données liées à la richesse en espèces, à l'abondance moyenne et aux valeurs de diversité et d'uniformité de Shannon entre les différents sites étudiés, montre des différences très significatives entre ces zones humides.

REZUMAT: Modele de abundență și bogăție ale speciilor de păsări de apă care iernează în complexul de zone umede Sétif (Algeria).

Studiul păsărilor de apă iernante din 17 situri de-a lungul complexului de zone umede din regiunea Sétif, cu scopul de a determina variabilitatea populațiilor de păsări de apă și valoarea ornitologică a acestor zone umede pentru a consolida managementul și conservarea lor. Studiul nostru dezvăluie o bogăție specifică totală de 47 de specii de păsări de apă. Populația totală regională reprezintă o medie de 31921 indivizi pe an, înregistrate din 2014 până în 2021. Dintre acestea 12 sunt dominante cu 94%. Pe baza indicelui de apariție calculat pentru fiecare specie, populația are două specii comune, 10 frecvente și 35 rare. Aplicarea testului Kruskal-Wallis (ANOVA unidirecțional), pentru compararea distribuției seriei de date referitoare la bogăția speciilor, abundența medie și valorile diversității și uniformității Shannon între diferitele situri studiate, arată diferențe foarte semnificative între aceste zone umede.

INTRODUCTION

Wetlands are some of the most valuable ecosystems of our planet, offering a wide range of ecological and socio-economic services (Vie et al., 2009; Euliss et al., 2008; Zedler and Kercher, 2005).

These specific ecosystems tightly related with water have been impacted by human activities, including agriculture, urban development, nutrient pollution, climate change, etc. (Bănăduc et al., 2024, Fluet-Chouinard et al., 2023; Reis et al., 2017; Vie et al., 2009).

The decline in biodiversity is a pressing global issue (Johnson et al., 2017), diverse waterbird communities with high interspecific variation are supported by these wetlands, providing functional habitats for a variety of their seasonal needs (Ali, 1979). Due to their congregational behavior, these species have long served as excellent bioindicators for assessing the value and health of wetlands.

Due to the fragmentation, degradation and loss of wetlands, global waterbird populations have significantly declined over the past century (Wang et al., 2018; Niu et al., 2012).

Wetlands of Algeria due to their richness, diversity, geographical location and diverse climate play a key role in biodiversity conservation (Boumezbeur, 2002). Many of them are classified as wetlands of international importance under the Ramsar Convention and as Important Bird Areas (IBA) (Fishpool and Evans, 2001).

Waterbirds in Algeria were the subject of several studies due to their significant diversity, but they remained only moderately well known, due to limited collected data during the past century by some ornithologists (Samraoui et al., 2011; Isenmann and Moali, 2000). These early works are based on dispatched observations recorded intermittently in a few wetlands. Ongoing assessment, monitoring and understanding of the spatial distribution of species are essential for preserving biodiversity.

The wetland complex of the Sétif region in the Hauts Plateaux of Eastern Algeria serves as a vital stopover for many wintering waterbirds from the Sahara or returning to their usual nesting sites (Zoubiri et al., 2018; Baaziz et al., 2012). Previous surveys have been predominantly conducted separately in a limited number of sites of this region, which remains insufficient for fully understanding its real spatio-temporal richness and abundance variations.

Establishing baseline information on the distribution and abundance of waterbirds is a fundamental step for furtherthering deeper research and developing management and conservation strategies and policies (Lancelotti et al., 2009). Through our rpesent scientific contribution, we tried to gather and analyze information and data over an extended period of time to:

i) Assess the richness, abundance, and occurrence of waterbirds species throughout the wetlands complex of the Sétif region;
ii) Determine the ornithological value of these wetlands through analysis of the aquatic bird population structure over eight wintering seasons to characterize them, considering the spatial variability of waterbird populations;
iii) Inventory internationally important wintering quarters for the hosting and conservation of the counted avifauna.

MATERIAL AND METHODS

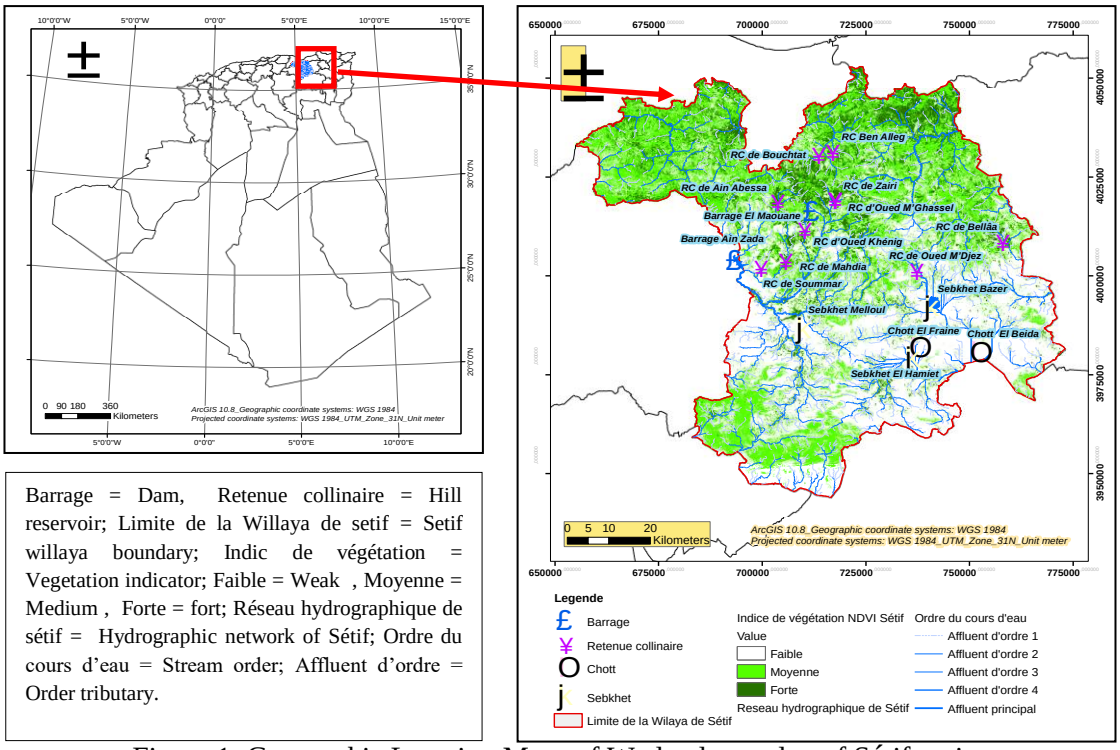
Study site

During the winter periods from 2014 to 2021, a total of 17 sites were surveyed across the wetland complex of the Sétif region (Fig. 1). These areas are among the largest and most diverse wetlands in the eastern part of Algeria, with a latitude extending to 1200 meters (Baaziz et al., 2012). They are characterized by a Mediterranean climate, with a semi-arid continental type, experiencing harsh, wet winters, and hot, dry summers with highly irregular annual precipitation (Keria, 2023).

This wetland complex encompasses a wide typological diversity of natural and artificial aquatic ecosystems (chotts, sebkhas, dams, hill reservoirs, etc.), including both shallow and deep, fresh and brackish waters. The majority of these aquatic ecosystems are highly dependent on rainfall for their water levels.

The aquatic vegetation consists of a few clumps of *Typha angustifolia*, *Phragmites australis*, and *Scirpus lacustris* in the estuaries of the wadis draining wastewater from the municipalities of the region (Baaziz, 2012).

The water supply is primarily from floodwaters, supplemented by spring water and wastewater. The reservoirs in the sub-watershed of Boussellam are primarily intended for irrigation of medium and small agricultural areas and livestock watering. There are a total of six reservoirs, mobilizing a total volume of 5.29 m^3/year of surface water. The spring-fed reservoirs are primarily constructed for the protection of cities and for fish farming (e.g., Zairi reservoir) (C.G.G., 1973).



Barrage = Dam, Retenue collinaire = Hill reservoir; Limite de la Willaya de setif = Setif willaya boundary; Indic de végétation = Vegetation indicator; Faible = Weak , Moyenne = Medium , Forte = fort; Réseau hydrographique de sétif = Hydrographic network of Sétif; Ordre du cours d'eau = Stream order; Affluent d'ordre = Order tributary.

Figure 1: Geographic Location Maps of Wetland complex of Sétif region.

Data collection

To estimate the structure of the wintering avian community in the wetlands of the Sétif region, we conducted an annual census over eight years (2014 to 2021). A total of 17 wetlands distributed throughout this complex were surveyed (Fig. 1). The monitoring of birds was carried out during the winter period. For the census both absolute and relative methods were utilized. When the population size of the birds to be counted was less than 200 individuals and located within 200 meters of the observer direct observation of the birds, involving individual counts (one by one) was used. For larger populations we conducted estimations by dividing the field of view into several strips, counting the number of birds in an average strip, and multiplying by the number of strips. This method presents an estimated margin of error of 5 to 10% (Legendre and Legendre, 1979; Blondel, 1975).

The richness is known as the number of species counted in each site for each year, whereas the abundance is the sum of individuals of met species.

For each species, the average population per site was calculated by dividing the sum of the annual populations recorded by the number of years (between 2014 and 2021). The recorded waterbirds were subdivided according to their feeding behavior and use of the aquatic environment into six guilds: the Anatids, the Rallids, the Larids, the Wading, the Shorebirds, and the Cormorants.

Data ecological analysis

The Shannon-Weaver Index H' (Shannon and Weaver, 1963) quantifies the heterogeneity of biodiversity in an environment and tracks its temporal evolution. It considers both the species richness and the relative abundance of each species, thus characterizing the equilibrium of a population within an ecosystem. It is expressed as: $H' = -\sum (ni/N) \times \text{Log } 2 (ni/N)$**.** Where N is the total number of individuals of all species, and ni is the number of individuals of species i (Blondel, 1975).

Pielou's evenness index (E): $E = H'/H \max$, where $H \max = \text{Log2 } (S)$, allows for the assessment of imbalances that the diversity index alone cannot detect. The closer its value is to 1, the more it indicates a well-balanced community structure in the ecosystem; S represents the number of studied species composing the community (Legendre and Legendre, 1979).

Statistical analyses

To compare the distribution of specific richness, abundance, and diversity indices across the different wetland sites studied, we employed the non-parametric global test ANOVA (One way ANOVA) Kruskall-Wallis (Scherrer, 1984). P values < 0.05 were considered significant. All statistical analyses were conducted using IBM SPSS software version 29.0.1.0(171).

RESULTS AND DISCUSSION

Specific composition of avian population

The monitoring of waterbird populations during the period 2014-2021 allowed us to assess a total of 47 species, equivalent to 48.45% of the total richness of birds recorded in Algeria (Samraoui et al., 2011). In order to provide an overview of the numerical importance of each recorded bird species, we chose to calculate the occurrence index for the entire study period. According to this, the current population is distributed among two common species, 10 frequent species, and 35 rare species (Tab. 1). The findings were compared to other similar studies in various wetland areas of the country, such as

the wetland complex of Souk Ahras province where 32 wintering species were reported by Guellati et al. (2014), the Oued Righ complex with 26 species (Bensaci et al., 2013), and the wetlands of the High Plateaus of central Algeria with 23 species (Zoubiri et al., 2018). The comparison revealed that all regularly wintering species were inventoried during the present study. Only a few species, such as the Eurasian Spoonbill, Water Rail, Collared Pratincole, and others, could have escaped observations, as well as the identification of passage birds such as Sandpipers and Plovers. Harsh winter weather conditions could also be a probable cause for confusion between species.

Table 1: Quantitative characterization of the wintering waterbird population in the wetland complex of the Sétif region during the 2014-2021 period; EM: Average headcount in the study area calculated over the 2014-2021 period; EPRO: effective of original regional population; %ENM/EPRO: Proportion of effective in relation to the original regional population; NZH: number of sites where the species is present; NT: Total number of sites equal to 17; IOR = (NZH/NT) x 100 relative occurrence index; R: Rare; F: Frequent; C: common. The overall species richness of the wintering waterbird population recorded in the study area is quite significant.

Waterbird species recorded	EM	EPRO	EM/EPRO%	NZH	IOR	Status
Anatidae						
Mallard duck (*Anas platyrhynchos*)	2,756	15,000	18.37	12	71%	C
Northern shoveler (*Anas clypeata)*	3,984	2,800	142.28	7	41%	F
Eurasian wigeon (*Anas penelope*)	1,925	4,400	43.75	5	29%	F
Gadwall duck (*Anas strepera*)	11	1,900	0.57	2	12%	R
Northern pintail (*Anas acuta*)	3	2,800	0.1	1	6%	R
Common teal (*Anas crecca*)	1,621	10,000	16.21	5	29%	F
Marbled duck (*Marmaronetta angustirostri*s)	1	65	1.53	1	6%	R
Tufted duck (Aythya fuligula)	4	3,000	0.13	1	6%	R
Common pochard (Aythya ferina)	76	6,000	1.26	2	12%	R
Ferruginous duck (Aythya fuligula)	45	60	75	2	12%	R
Common shelduck (Tadorna tadorna)	11,134	2,600	428.23	6	35%	F
Ruddy shelduck (Casca ferruginca)	7	100	7	1	6%	R
White-headed duck (Oxyura leucocéphala)	180	25	720	3	18%	R

Table 1 (continued): Quantitative characterization of the wintering waterbird population in the wetland complex of the Sétif region during the 2014-2021 period; EM: Average headcount in the study area calculated over the 2014-2021 period; EPRO: effective of original regional population; %ENM/EPRO: Proportion of effective in relation to the original regional population; NZH: number of sites where the species is present; NT: Total number of sites equal to 17; IOR = (NZH/NT) x 100 relative occurrence index; R: Rare; F: Frequent; C: common. The overall species richness of the wintering waterbird population recorded in the study area is quite significant.

Waterbird species recorded	EM	EPRO	EM/EPRO%	NZH	IOR	Status
Rallidae						
Eurasian coot (*Fulica atra*)	5,172	25,000	20.68	10	59%	C
Greylag goose (*Anser anser*)	1	770	0.13	1	6%	R
Common moorhen (*Gallinula chloropus*)	52	37,100	0.14	2	12%	R
Wading						
Greater flamingo (*Phoenicopterus ruber*)	1,029	1,500	68.6	3	18%	R
White stork (*Ciconia ciconia*)	58	1,600	3.62	2	12%	R
Common crane (*Grus grus*)	3	1,300	0.23	1	6%	R
Grey Heron (*Ardea cinerea*)	36	1,700	1.35	4	24%	F
Western cattle egret (*Ardeola ibis*)	103	1,200	8.58	3	18%	R
Little egret (*Egretta garzetta*)	3	1,100	0.27	1	6%	R
Black-winged stilt (*Himantopus himantopus*)	110	1,200	9.16	3	18%	R
Avocet (*Recurvirostra avosetta*)	13	940	1.38	2	12%	R

Table 1 (continued): Quantitative characterization of the wintering waterbird population in the wetland complex of the Sétif region during the 2014-2021 period; EM: Average headcount in the study area calculated over the 2014-2021 period; EPRO: effective of original regional population; %ENM/EPRO: Proportion of effective in relation to the original regional population; NZH: number of sites where the species is present; NT: Total number of sites equal to 17; IOR = (NZH/NT) x 100 relative occurrence index; R: Rare; F: Frequent; C: common. The overall species richness of the wintering waterbird population recorded in the study area is quite significant.

Waterbird species recorded	EM	EPRO	EM/EPRO%	NZH	IOR	Status
Larids						
Great crested grebe (*Podiceps cristatus*)	286	5,800	4.93	4	24%	F
Eared grebe (*Podiceps nigricollis*)	105	1,800	5.83	3	18%	R
Little grebe (*Tachybaptus ruficollis*)	202	4,700	4.29	6	35%	F
Yellow-legged gull (*Larus michahiellis*)	922	13,900	6.63	7	41%	F
Slender-billed gull (*Larus genei*)	1	1,700	0.058	1	6%	R
Black-headed gull (*Larus ridibundus*)	15	31,000	0.048	1	6%	R
Shorebirds						
Northern lapwing (*Vanellus vanellus*)	340	72,300	0.47	5	29%	F
Common ringed plover (*Charadrius hiaticula*)	47	540	8.70	2	12%	R
Little ringed plove (*Charadrius dubius*)	89	3,100	2.87	1	6%	R
Kentish plover (*Charadrius alexandrinus*)	34	660	5.15	1	6%	R
Golden plover (*Pluvialis apricaria*)	63	9,400	0.67	1	6%	R
Common greenshank (*Tringa nebularia*)	130	3,300	3.93	1	6%	R
Dunlin (*Calidris alpina*)	35	13,300	0.26	2	12%	R
Spotted redshank (*Philomachus pugnax*)	1	1,000	0.1	1	6%	R
Common snipe (*Gallinago gallinago*)	10	100,000	0.01	1	6%	R
Little stint (*Calidris minuta*)	64	3,000	2.13	1	6%	R
Eurasian curlew (*Numeus arquata*)	6	7,600	0.078	1	6%	R
Black-tailed godwit (*Limosa limosa*)	10	790	1.26	1	6%	R
Temminck’s stint (*Calidris temminckii*)	492	350	140.57	2	12%	R

Table 1 (continued): Quantitative characterization of the wintering waterbird population in the wetland complex of the Sétif region during the 2014-2021 period; EM: Average headcount in the study area calculated over the 2014-2021 period; EPRO: effective of original regional population; %ENM/EPRO: Proportion of effective in relation to the original regional population; NZH: number of sites where the species is present; NT: Total number of sites equal to 17; IOR = (NZH/NT) x 100 relative occurrence index; R: Rare; F: Frequent; C: common. The overall species richness of the wintering waterbird population recorded in the study area is quite significant.

Waterbird species recorded	EM	EPRO	EM/EPRO%	NZH	IOR	Status
Cormorans						
Western Marsh Harrier (*Circus aeruginosus*)	25	?	?	2	12%	R
Great Cormorant (*Phalacrocorax carbo*)	714	5,000	14.28	4	24%	F
Eurasian Kestrel (*Falco tinunculus*)	1	?	?	1	6%	R
Western Swamphen (*Porphyrio porphyrio*)	2	?	?	1	6%	R
Number of wintering individuals	31,921					

Structure and spatial organization of avian population

The results of the Kurskal-Wallis test of One-way ANOVA indicate that the species richness data series during the study period varied significantly among the different studied wetlands ($F(1,6) = 11.43$, $p = 0.001$). The maximum species richness was observed at Ain Zada Dam (16.25 ± 2.31), followed by Sebkhet Bazer (16 ± 3.29) and hill reservoirs of Soummar (11.87 ± 1.35) (Fig. 2; Tab.2). These relatively high values compared to all other sites in our study area demonstrate the importance of these wetlands as wintering areas for many species and indicate that these environments are characterized by a wide diversity of habitats (*Phragmites, Tamarix*, open water, etc.) (Zoubiri et al., 2018), good water level, high visibility, and better availability and variety of food (entomological richness) as well as a good surface area indicating the total carrying capacity of the site (Hamel, 2011).

The highest abundance was observed at Sebkhet Bazer and then at Ain Zada Dam (Fig. 3). This can be explained by the location of Sebkhet Bazer at the mouths of wadis, which provides a suitable biotope for avifauna and also contributes to the diversity of habitats and the increase in it carrying capacity. In the dam of Ain Zada the abundance of piscivorous species is due to its ichthyofaunal richness (Fig. 6). The same factor may explain the highest mean values of the Shannon diversity index and evenness at this site, followed by hill reservoirs of Soummar, Sebkhet Bazer, and Cott El Beida are the most diverse and balanced sites, showing fluctuations during the study period between (0.17 – 0.96 bits) and (0.13 – 0.89) (Figs. 4, 5). The difference between the data series of these two indices is highly significant ($F(14) = 34.95$, $p = 0.001$), ($F(14) = 35.16$, $p = 0.001$).

The values of the Shannon and evenness indices obtained in this study are very low, indicating an unequal distribution of the number of individuals among species. Sebkhet Bazer and Chott El Baida are dominated by dabbling ducks (Common shelduck) and birds requiring shallow feeding areas, like most waders and shorebirds. The hill reservoir of Soummar is dominated by diving ducks.

However, the capacity of other temporary wetlands that dry up completely during low rainfall years decreases considerably, such as the case of Chott El Fraine, Sebkhet Melloul, and other hill reservoirs that are mainly fed by floodwaters, in addition to spring and wastewater. Consequently, their flow rates are very irregular. Abusive use by farmers, which sometimes leads to the drying up of water bodies, causes species to flee and forces them to gather in permanent wetlands. These findings are consistent with those reported by Guellati et al. (2014) and Saifouni (2009) which stated that hill reservoirs are the least frequented by waterbirds.

Table 2: Average richness in the different study sites.

Sites	Average richness	Standard deviation
Chott El Beida	10.25	2.49
Sabkhet Bazer	16	3.29
Sabkhet El Hamiet	4.62	2.32
Dam de Ain Zada	16.25	2.31
Dam de El Maouane	6.5	1.92
R of Soummar	11.87	1.35
R of Zairi	5.87	1.12
R of ’Oued M’Ghassel	3.62	0.74
R of Ain Abessa	3	1.51
R of Oued M’Djez	6.87	2.58
R of Bellâa	1.37	2.87
R of Bouchtat	4.75	1.03
R of Mahdia	7.5	3.85
R of ’Ouèd Khénig	0.25	0.46
R of Ben Alleg	2.14	1.86

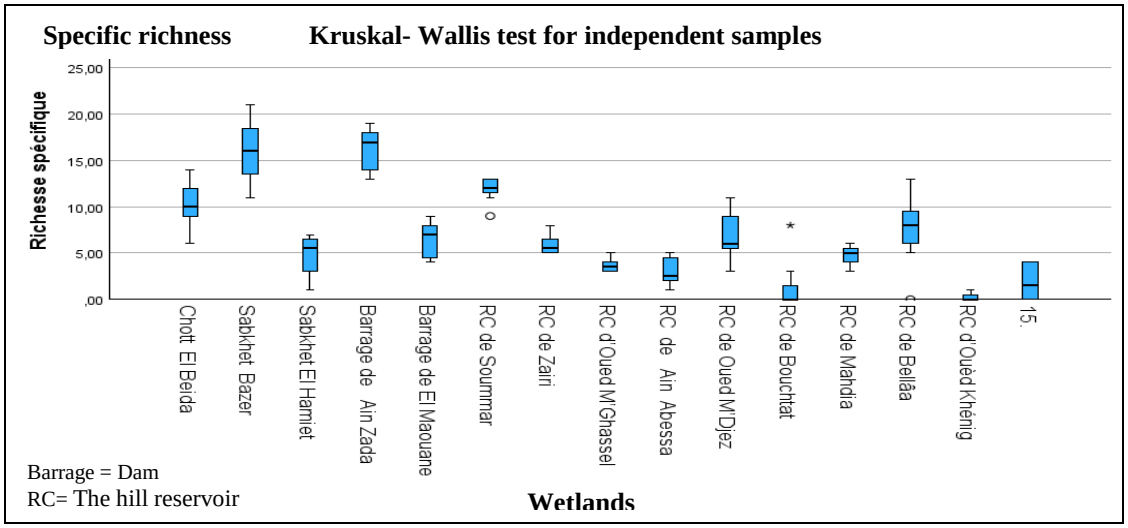


Figure 2: Variation in species richness among different study sites.

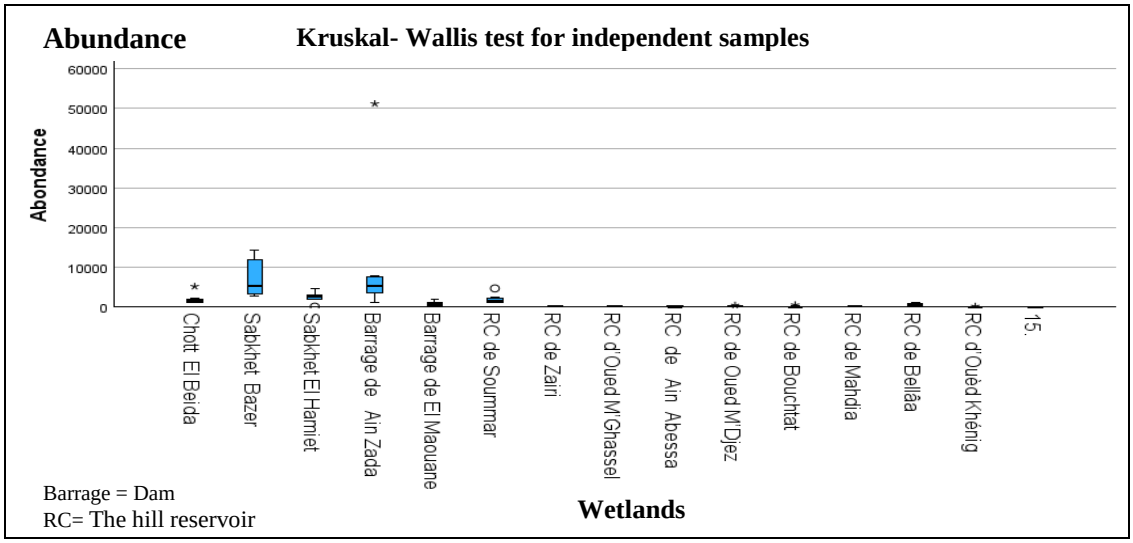


Figure 3: Variation in abundance among different study sites.

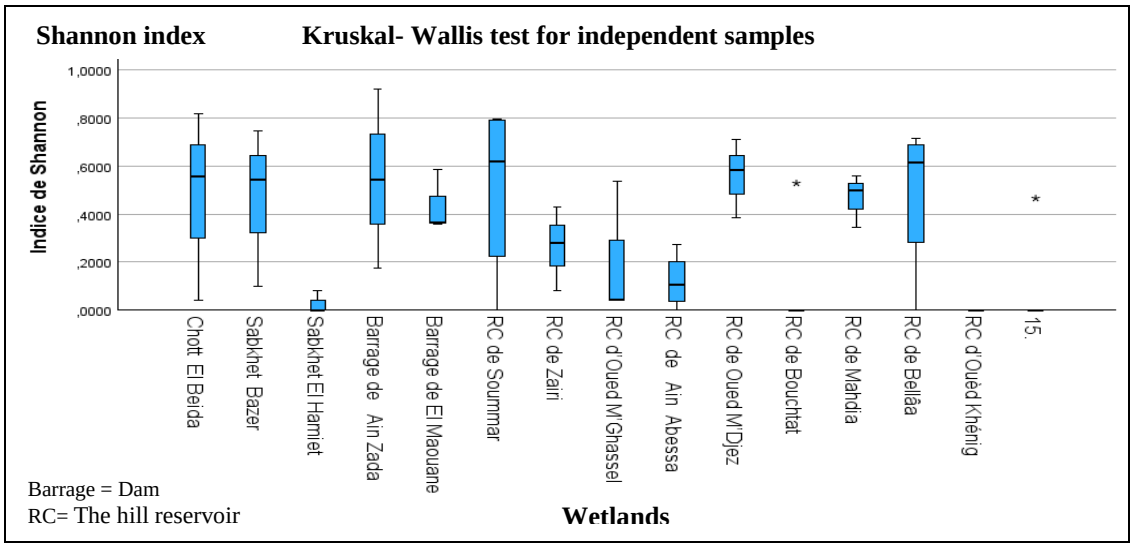


Figure 4: Variation in Shannon and Weaver diversity index among different study sites.

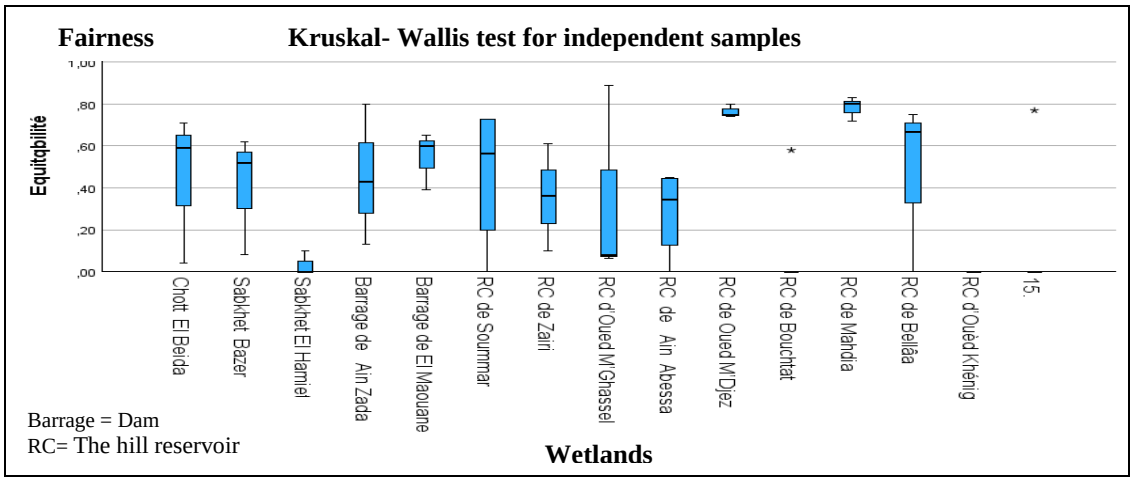


Figure 5: Variation in evenness index among different study sites.

Ornithological value of wetlands complex for waterbirds population

In terms of population, the dominant species, with a relative frequency exceeding 1% of the average population, are as follows in decreasing order of importance: Common shelduck (34.87%), Eurasian coot (16.20%), Northern shoveler (12.48%), Mallard (8.63%), Common teal (5.07%), Greater flamingo (3.22%), Yellow-legged gull (2.88%), Great cormorant (2.23%), Temminck's Stint (1.54%), Northern lapwing (1.06%) and Great crested grebe (0.89%). Together, they represent a cumulative value of approximately 89.07%. The mean method reveals the average population of the entire wintering population to be close to 31921 individuals.

Finally, birds are efficient indicators because they are sensitive to gradual or abrupt changes in their environment. They are also important in applications such as environmental quality, ecosystem integrity, and restoration, as they are used as early warning signs for environmental changes and for assessing climate changes (Mekonen, 2017).

CONCLUSIONS

There is a relative lack of quantitative studies on wintering aquatic bird species and their wintering habitats in the wetland complex of the Sétif region, particularly artificial wetlands (dams and hill reservoirs). This study, conducted over eight winter seasons (2014-2021), aims to provide initial insights into these wildlife populations' diversity, structure, and distribution patterns, to partially address the lack of information and contribute to establishing an ornithological database. The study also aims to gather the necessary assessment elements for the design of wetland management plans.

It is important to note that studying birds and their habitat associations is also cost-effective; a simple and standardized methodology provides information on the ecological conditions associated with them. This should prompt natural resource managers to quickly take appropriate preventive measures to address various threats and preserve avian diversity. For this purpose, certain species, especially those indicative of these types of wetland zones, should be taken into consideration in subsequent monitoring.

REFERENCES

1. Ali S., 1979 – The Book of Indian Birds, 11th edition, The Bombay Natural History Society, India, 187.
2. Baaziz N., Mayache B., Saheb M., Bensaci E., Ounissi M., Metallaoui S. and Houhamdi M., 2012 – Statut phénologique et reproduction des peuplements d'oiseaux d'eau dans l'éco-complexe de zones humides de Sétif (Hauts plateaux, Est de l'Algérie), *Bulletin de l'Institut Scientifique de Rabat*, 3, 77-87. (in French)
3. Bănăduc D., Curtean-Bănăduc A., Barinova S., Lozano V. L., Afanasyev S., Leite T., Branco P., Gomez Isaza D. F., Geist J., Tegos A., Simić S. B., Olosutean H. and Cianfaglione K., 2024 – Multi-interacting natural and anthropogenic stressors on freshwater ecosystems: their current status and future prospects for 21st century, *Water*, 16, 1483, 1-46, DOI: 10.3390/w16111483.
4. Bensaci E., Saheb M., Nouidjem Y., Bouzegag A. and Houhamdi M., 2013 – Biodiversité de l'avifaune aquatique des zones humides sahariennes: cas de la dépression d'Oued Righ (Algérie), *Physio-Géo-Géographie Physique et Environnement*, VII, 211-222, DOI: 10.4000/physio-geo.3198. (in French)
5. Blondel J., 1975 – L'analyse des peuplements d'oiseaux, éléments d'un diagnostic écologique, I, La méthode des échantillonnages fréquentiels progressifs (E. F. P.), *Revue d'Écologie (La Terre et La Vie)*, 29, 4, 533-589, DOI: 10.3406/revec.1975.4903. (in French)
6. Boumezbeur A., 2002 – Atlas de la zone humide algérienne d'importance international, 89.
7. Compagnie Générale de Géophysique, 1973 – Étude par prospection géophysique sur les hautes plaines de Sétif, Ministère de l'Hydraulique, DHW de Sétif, Algérie, 53. (in French)
8. Fishpool L. D. C. and Evans M. I. (eds), 2001 – Important bird areas in Africa and associated islands: priority sites for conservation, 51-70, *BirdLife Conservation Series*, 11.
9. Euliss N. H., Smith L. M., Wilcox D. A. and Browne B. A., 2008 – Linking ecosystem processes with wetland management goals: Chartering a course for a sustainable future, *Wetlands*, 28, 553-562, DOI: 10.1007/s10980-024-01942-9.
10. Fluet-Chouinard E., Stocker B. D., Zhang Z., Malhotra A., Melton J. R., Poulter B., Kaplan J. O., Goldewijk K. K., Siebert S., Minayeva T. and Hugelius G. 2023 – Extensive global wetland loss over the past three centuries, *Nature*, 614, 7947, 281-286, DOI: 10.1038/s41586-022-05572-6.
11. Guellati K., Maazi M. C., Benradia M. and Houhamdi M., 2014 – Le peuplement d'oiseaux d'eau du complexe des zones humides de la wilaya de Souk-Ahras: état actuel et intérêt patrimonial, *Bulletin Societe Zoologique de France*, 139, 263-277, DOI: 10.15470/vwujvf. (in French)
12. Hamel J., 2011 – Utilisation des oiseaux aquatiques comme bioindicateurs de l'intégrité des lacs de Montagne Marocains, Essai présenté en vue de l'obtention des grades de maître en environnement (M. Env.) et de maître en écologie internationale (M. E. I.). Sous la codirection de Réjean De Ladurantaye et Fanie Pelletier Université de Sherbrooke, Québec, Canada, 45-59. (in French)
13. Isenmann P. and Moali A., 2000 – Oiseaux d'Algérie, Société d'Études Ornithologiques de France, M. N. H. N., Paris, 336. (in French)
14. Johnson A. R., 1997 – Long-term studies and conservation of Greater flamingos in the Camargue and Mediterranean, *Colonial Waterbirds*, 20, 306-315.
15. Johnson C. N., Balmford A., Brook B. W., Buettel J. C., Galetti M., Guangchun L. and Wilmshurst J. M., 2017 – Biodiversity losses and conservation responses in the Anthropocene, *Science*, 356, 6335, 270-275, DOI: 10.1126/science.aam9317.
16. Keria H., Bensaci E. and Zoubiri A. 2023 – Monitoring the effect of droughts and extreme climate variables for various time periods on vegetation density in the Reghaia catchment, Algeria, *Sustainable Development*, 13, 1, DOI: 10.31924/nrsd.v13il.122.

17. Lancelotti J. L., Pozzi L. M., Yorio P. M., Diéguez M. C. and Pascual M. A. 2009 – Fishless shallow lakes of Southern Patagonia as habitat for waterbirds at the onset of trout aquaculture, *Aquatic Conservation: Marine and Freshwater Ecosystems*, 19, 5, 497-505, DOI: org/10.1002/aqc.1018.
18. Legendre L. and Legendre P., 1979 – Ecologie numérique, 1, Le traitement multiple des données écologiques, XIV, Paris, Masson et Montréal, Presses de l'Université du Québec, *Collection d'Ecologie*, 12. (in French)
19. Mekonen S., 2017 – Birds as biodiversity and environmental indicator, *Journal of Natural Sciences Research*, 7, 21.
20. Niu Z., Zhang H. and Wang X., 2012 – Mapping wetland changes in China between 1978 and 2008, *Chinese Science Bulletin*, 57, 2813-2823, DOI: 10.1007/S11434-012-5093-3.
21. Reis V., Hermoso V., Hamilton S. K., Ward D., Fluet-Chouinard E., Lehner B. and Linke S., 2017 – A global assessment of inland wetland conservation status, *Bioscience*, 67, 6, 523-533, DOI: org/10.1093/biosci/bix045.
22. Saifouni A., 2009 – État des lieux des zones humides et des oiseaux d'eau en Algérie, These de Magister en sciences agronomiques, Option: Gestion des Écosystèmes Forestiers, Ecole Nationale Supérieure Agronomique (E. N. S. A.)., El Harrach, Alger, 66-75. (in French)
23. Samraoui F., Alfarhan A. H., Al-Rasheid K. A. S and Samraoui B., 2011 – An appraisal of the status and distribution of waterbirds of Algeria: indicators of global changes? *Ardeola*, 58, 1, 137-163, DOI: 10.13157/arla.58.1.2011.137.
25. Vie J.-C., Hilton-Taylor C. and Stuart S. N., 2009 – Wildlife in a changing world – an analysis of the 2008 IUCN red list of threatened species, IUCN, Gland, 15.
26. Zedler J. B. and Kercher S., 2005 – Wetland resources: status trends ecosystem services and restorability, *Annual Review of Environment and Resources*, 15, 39-74, DOI: 10.1146/annurev.energy.30.050504.144248.
27. Zoubiri A., Bensaci E., Nouidjem Y., Saheb M. and Gasmi B., 2018 – Species composition and distribution pattern of waterbirds in Algerian Central Hauts Plateaux wetlands, *World Journal of Environmental Biosciences*, 7, 2, 26-30.
28. Wang X. D., Kuang F., Tan K. and Ma Z. J., 2018 – Population trends, threats, and conservation recommendations for waterbirds in China, *Avian Research*, 9, 14, DOI: 10.1186/S40657-018-0106-9.
29. *, www.ramsar.org