Zoodiversity, **57**(5):469–476, 2023
DOI 10.15407/zoo2023.05.469

Ornithology

UDC 598.2(261.48:1-18:65)

AN OVERVIEW OF THE ECOLOGICAL VALUES OF SOUMAR WETLAND ON WATERBIRDS DIVERSITY

S. Laroug[1], M. Houhamdi[2] & M. Bara[2*]

[1]*Laboratoire de Gestion et Valorisation des Ressources Naturelles et Assurance Qualité. Faculté SNVST, Université de Bouira, 10000 Bouira, Algeria*
[2]*Laboratoire Biologie, Eau et Environnement, Université8 Mai 1945 Guelma BP 401 Guelma 24000, Algérie*
**Corresponding author*
E-mail: mouslim.bara@gmail.com

M. Bara (https://orcid.org/0000-0003-3818-424X)

urn:lsid:zoobank.org:pub:01D80221-EDAD-42E3-A6D8-3AB6EEFED9E0

An Overview of the Ecological Values of Soumar Wetland on Waterbirds Diversity. Laroug, S., Houhamdi, M. & Bara, M. — The diversity and richness of the waterbird community is the main criterion used to classify wetlands as Ramsar and/or IBA sites. This study was carried out in the Soumar wetland (Setif province — northeastукт Algeria) from September 2019 to September 2020. Our aim was to study the ecological values of this wetland and the status of waterbirds. We recorded a total of 23 species belonging to 11 families. June was the most diverse month of the year (Shannon–Weaver and Simpson indices reached the maximum). October was the most equitable month (equitability reached maximum). We noted four key species according to IUCN status: Ferruginous Duck, *Aythya nyroca* (Near Threatened), Common Pochard, *Aythya ferina* (Vulnerable), White-headed Duck, *Oxyura leucocephala* (Endangered) and Northern Lapwing, *Vanellus vanellus* (Near Threatened). The main phenological status of waterbirds in Soumar was breeding or sedentary (26 % and 21 % respectively). The geographical location of the Soumar wetland and its diversity profile require a local management plan (depending on the waterbirds and their conservation), allowing the Soumar wetland to join the Ramsar network.
Key words: wetland, waterbirds, richness, conservation, Soumar.

Introduction

In an ecological framework, 'diversity' is a concept based on the variety of animals in a delineated study area (Gattone & Di Battista, 2009).

North African wetlands provide a wide variability of wetlands used for wintering and stopover by Palearctic migratory birds (Fishpool & Evans, 2001). The number of anthropogenic landscapes has increased steadily. Wang et al. (2021) stated that the anthropogenic landscapes (such as farmland, fish ponds, dams and artificial wetlands) can be extensively used by waterbirds.

In North Africa, the inadequate infrastructure and poor data on wetland surveys may bias conservation efforts. Classification of wetlands as Ramsar or IBA sites requires equal survey effort (Fishpool & Evans, 2001). Also, Wauchope et al. (2022) reported the necessity of using Before/After or Control/Intervention study designs. However, each species responds differently to these conservation efforts depending on its life history characteristics, habitat requirements and response to human activities (Jackson et al., 2020).

Many data report that Ramsar is now an underused conservation tool in North Africa (Gaget et al., 2020). This is despite the fact that waterbirds are considered 'flagship' taxa for tracking changes in wetlands and are included as a criterion in the classification of wetlands as Ramsar or IBA sites (Kingsford et al., 2020).

The objectives of this study were: 1) to provide an overview of the abundance, richness and diversity of the waterbird community in the Soumar wetland (Setif); 2) to model the effect of temperature and rainfall on waterbird abundance; 3) to list the phenology and conservation status of all waterbirds recorded. We used an intensive monthly data set to investigate the relationship between site selection and waterbird trends. Our hypothesis is related to the geographical location of the Soumar wetlands (in the flyway of waterbirds from Europe to southern and central Africa and vice versa).

Study area

The Soumar wetland (36°09′20″ 36°15′N 5°15′45″ 5°19′45″ E) is a small artificial dam located 10 km to the west of the province of Setif (north-east Algeria). Officially, this dam is under the supervision of the Aïn Arnat district, near the A1 motorway (east-west road) (fig. 1). The main characteristics of the site are 42 ha, a length of 5 km, a height of 13 m, a depth of 2 m, a capacity of 1.2 Hm3 and an altitude of 960 m (measurements provided by the ANBT — National Agency for Dams and Transfers). This wetland is flooded by the Oued Boussellam stream (see map).

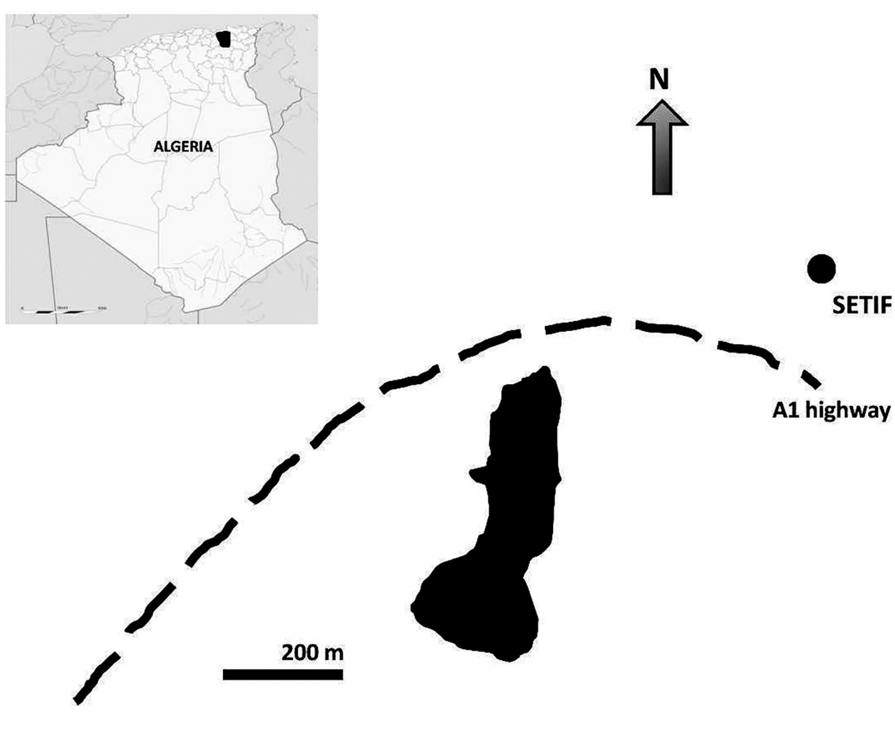

Fig. 1. Geographical location of the Soumar wetland (Setif, Northeast Algeria).

Material and Methods

This study was carried out from September 2019 to September 2020 in Soumar wetland. A bimonthly waterbirds' counting was done during twilight period of the day. We use an ornithological binocular 60 × 80 type "Bushnell Legend Ultra HD 20". During the sampling, we selected an individual counts (I.C) or a group visual estimation (G.V.E) depending on distance and number of waterbirds (Blondel, 1975). An error estimated between 5 and 10 %. The software PAST 4.11 was used for data analysis (Hammer et al., 2001). The Kruskal–Wallis test was used in order to compare between monthly abundance.

We calculating 09 ecological indices (richness S, Abundance, Dominance-D, Simpson 1/D, Shannon–Weaver H', Berger–Parker, Margalef, equitability) (See Shannon and Weaver, 1949; Pielou, 1975; Magurran, 1988; Dustan and Fox, 1996) then we calculated a Rényi diversity profile (β diversity) for each month. This Rényi series allowing the comparison between ecological indices according to α value (α = 0 richness; α = 1 Shannon index; α = 2 inverse Simpson index (1/D); and α = a higher values approximates to Berger–Parker index). Equitability is slightly influenced by alpha value, it decreasing along "y axis" in the case of rare and/or dominant species (Andrade et al., 2015).

The ranking position of each month is depending on diversity indices model (Tóthmérész, 1995). CAB-FAC analysis was done using two climatic factors (temperature and rainfall). Varimax rotation was applied to simplify the assemblage of waterbirds. We accepted only the data that contributing > 4 % of the assemblages.

Results

Abundance and richness of waterbirds

During the study we recorded 23 species of waterbirds belonging to 11 families. The Anatidae is the most dominant family with 7 species, followed by the Charadriidae and Podicipedidae with 3 species, then the Rallidae and Ardeidae with 2 species, the Ciconidae, Phoenicopteridae, Acciptiridae, Scolopacidae, Recurvirostridae, Laridae with only one species (fig. 2).

The maximum number of waterbirds was recorded in September 2019 (2208 individuals) and June 2020 (2234 individuals). There was no significant difference between the monthly abundances (H-chi^2 = 17.17, p-value = 0.0797). Richness reached its maximum in May 2020 (17 species) and the maximum values of dominance were recorded in October 2019 (0.37) and September 2020 (0.34) (fig. 2). Figure 3 shows the dominance of the waterbird community in the Soumar wetland (Sertif). We found that in October and September, the dominance reached maximum values of 0.37 and 0.34 respectively. The linear trend line of dominance showed that all values were scattered during the months (R^2 = 0.02).

Referring to the IUCN Red List of Threatened Species (see www.iucnredlist.org), we identified four species as critically endangered. These are the Ferruginous Duck, *Aythya nyroca* (listed as Near Threatened), the Common Pochard, *Aythya ferina* (listed as Vulnerable), the White-headed Duck, *Oxyura leucocephala* (listed as Endangered) and the Northern Lapwing, *Vanellus vanellus* (listed as Near Threatened).

Table 1. Monthly trending of Simpson, Shannon, Evenness, Margalef and Berger–Parker indices in the Soumar wetland (Setif, Algeria)

Indices	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Aprl	May	Jun	Jul	Aug	Sep
Simpson	0.80	0.62	0.77	0.74	0.76	0.71	0.75	0.8	0.78	0.82	0.80	0.78	0.65
Shannon	1.89	1.12	1.69	1.50	1.65	1.40	1.71	1.91	1.84	2.04	1.94	1.80	1.28
Equitability	0.74	0.7	0.7	0.65	0.75	0.67	0.61	0.70	0.65	0.75	0.71	0.75	0.62
Margalef	1.55	0.56	1.34	1.22	1.07	0.94	1.98	1.84	2.10	1.81	1.85	1.33	0.96
Berger-Parker	0.30	0.48	0.32	0.35	0.33	0.38	0.36	0.3	0.31	0.29	0.30	0.32	0.41

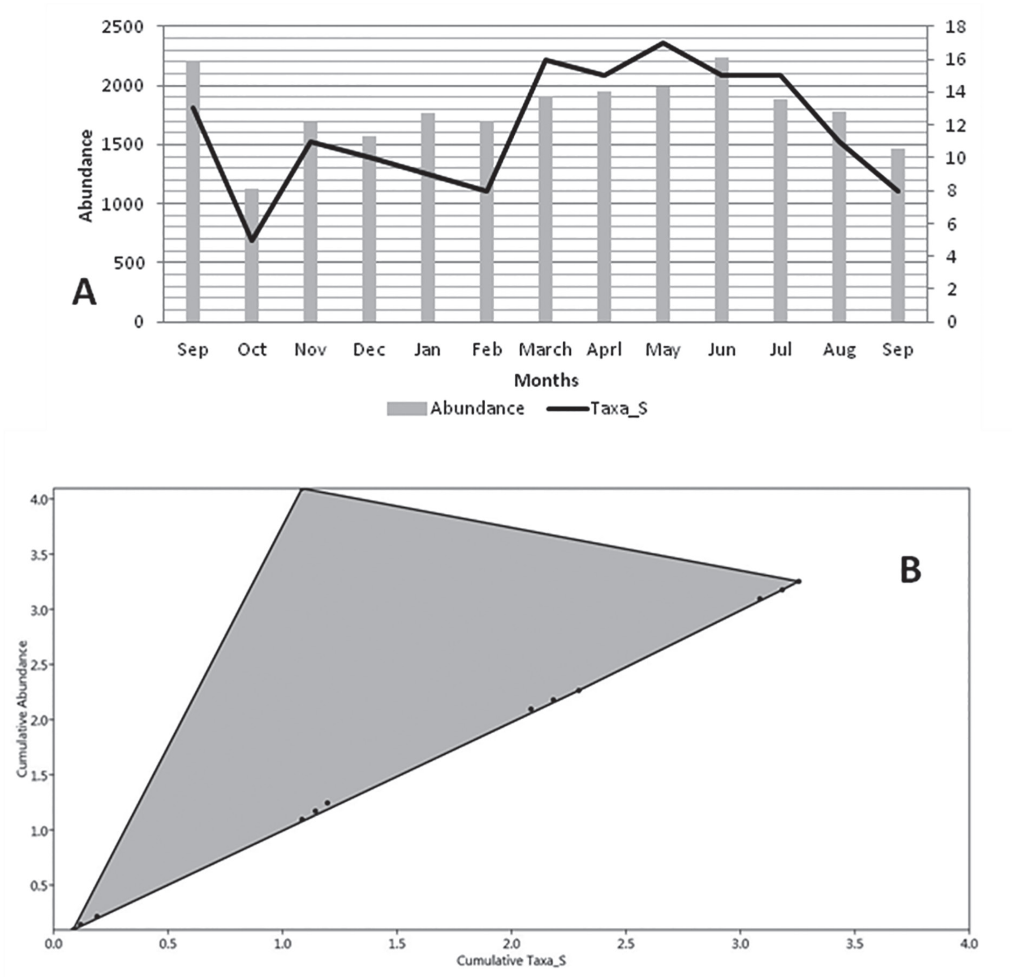

Fig. 2, A — monthly trend of abundance and richness of waterbirds in the Soumar wetland (Setif, Algeria). Abundance = number of individuals and Taxa_S = number of species. B — cumulative effect between abundance and richness using the Gini measure of evenness (G').

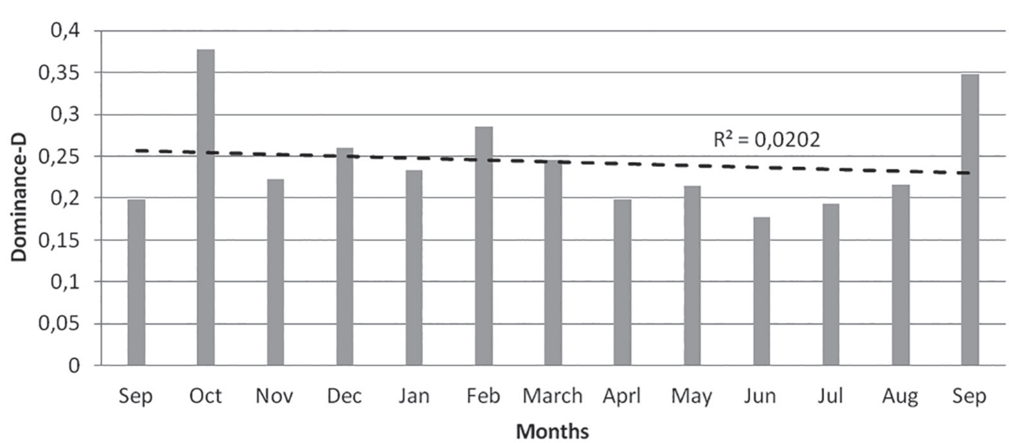

Fig. 3. Monthly trend of waterbird dominance in the Soumar wetland (Setif, Algeria).

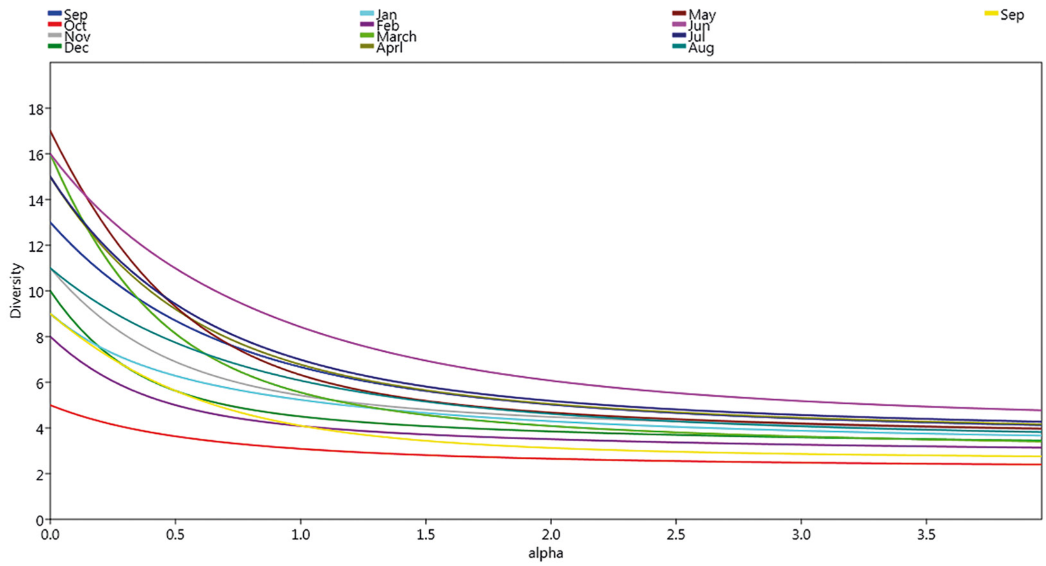

Fig. 4. Diversity profile of waterbirds alpha diversity for each month in the Soumar wetland (Setif, Algeria). α = 0 richness; α = 1 Shannon–Weaver index; α = 2 inverse Simpson index (1/D); and α = a high value approximates the Berger–Parker index.

Diversity profiles

The monthly variations of ecological indices (summarized in table 1) were: the maximum value of Simpson, Shanon–Weaver and Equitability were recorded in June (0.82 / 2.04 / 0.75 respectively), the maximum value of Berger–Parker was recorded in October (0.48), and the maximum value of Margalef was recorded in May (2.1) (table 1). Figure 4 exposed the template of alpha diversity according to months in Soumar wetland (Setif). May, June and March showed a higher number of species in the diversity profile (higher values when alpha = 0) (fig. 4). Indeed, in May we recorded the high value of richness (17 species), regardless of the diversity index evaluated. However, we noted that in June the Shannon index (H'= 2.04) increasing, indicating that although there is an equitability between richness and abundance (equitability index = 0.75). October was the least diverse independently of the diversity index evaluated (low richness and abundance). The curve representing December, February and September 2020 were smoother along the profile, which indicates low equitability (0.65, 0.67 and 0.62 respectively). Except for October (D-Simpson = 0.62 and Margalef = 0.56), all months were ranked differently depending on the weight given to rare or dominant species (fig. 4).

Conservation and phenology status

Between September 2019 and September 2020, we recorded nine sedentary species (39.12 %), six breeding species (26.08 %), and four wintering species (17.39 %). Other species were registered as crossing or passenger species (8.69 % / two species), rare or permanent (4.34 % / with only one species respectively).

During this study, we noted 4 IUCN conservation's status. The least concern LC species dominate (19 species). Two species had a near threatened NT status and one species was VU and one species as endangered EN.

Environmental factors effect

Table 2 presented the effect of temperature and rainfall on waterbirds abundance in the Soumar wetland using Varimax rotation. We performed a factors analysis, which resulted

Table 2. Data from CABFAC analysis with Varimax rotation applied on waterbirds species that contributing > 4 % to the assemblages

PC	Eigenvalue	Variance, %
1	8.8318	67.94
2	1.2369	9.51
3	0.90274	6.94
4	0.60032	4.62

Table 3. The Varimax scores for factors 1–4. The bold numbers indicate waterbirds abundance with high (> 1) absolute values of factor scores

Species	Factor 1	Factor 2	Factor 3	Factor 4
Fulica atra	8.29E−08	−3.48E−07	−3.72E−07	3.45E−07
Gallinula chloropus	0.55275	−2.2121	−0.084848	−1.4164
Tadorna tadorna	0.45184	−0.002058	0.35498	−0.093349
Spatula clypeata	0.25723	−1.6107	**1.2283**	**1.8792**
Anas platyrhynchos	8.98E−08	−2.82E−07	−2.69E−07	3.06E−07
Aythya nyroca	**1.9187**	0.21022	0.60611	−0.42166
Aythya ferina	**1.837**	0.35162	0.80491	−0.16509
Spatula querquedula	0.70851	−0.88309	−0.18887	**2.0491**
Oxyura leucocephala	−5.00E−08	−2.38E−07	−7.37E−08	1.75E−07
Himantopus himantopus	**1.6436**	0.78313	0.041697	−0.002773
Charadrius alexandrinus	0.41045	−1.8896	0.50183	−0.54525
Charadrius dubius	**1.7751**	0.6059	0.63147	**1.6871**
Vanellus vanellus	0.033933	−1.4864	−1.0329	**1.2644**
Actitis hypoleucos	**1.238**	−0.42616	−1.1116	−1.5945
Larus michahellis	**1.3083**	−0.37924	**1.0143**	−0.0062466
Podiceps cristatus	0.1543	−0.50756	−1.5722	**1.6033**
Tachybaptus ruficollis	**1.6436**	0.78313	0.041697	−0.002773
Podiceps nigricollis	0.34147	0.010427	0.20735	−0.034524
Bubulcus ibis	0.89828	0.97379	−1.4855	0.40606
Ardea cinerea	0.11476	−1.0345	−1.6678	**1.0036**
Ciconia ciconia	**1.2052**	−0.045992	−1.5724	−0.5097
Phoenicopterus roseus	0.18031	0.75756	−2.4855	−0.24001
Circus aeruginosus	0.67298	−2.0032	−0.41032	−1.3051

in 4 factors holding 89.01% of variance (table 2). We noted that the factor 1 explained the large proportion of the information (67.94 % see table 2) corresponded to *Aythya nyroca, Aythya ferina, Himantopus himantopus, Charadrius dubius, Actitis hypoleucos, Larus michahellis, Tachybaptus ruficollis* and *Ciconia ciconia* (table 3). Factor 2 accounted for 9.51 % of variance but did not included species. The Factor 3 accounted for 6.94 % of variance corresponded to *Spatula clypeata* and *Larus michahellis*. The Factor 4 accounted for 4.62 % of variance and corresponded to *Spatula clypeata, Spatula querquedula, Charadrius dubius Vanellus vanellus, Podiceps cristatus* and *Ardea cinerea* (table 3).

Discussion

This paper revealed the significant part of the Soumar wetland (Setif province, north-eastern Algeria) for waterbirds during the migration. This wetland occupies a key position in the waterbirds flyway (Palearctic-trans-Saharan migrant flyway). It can also be a stopover wetland for many waterbirds (coming from central Europe). We supposed that, flamingos, ibises and gulls crossing this area during migratory period. SOUMAR was go around by four (04) key species that listed as threatened species in the IUCN Red List (ferruginous duck "NT", common pochard "Vu", white-headed duck "EN" and northern lapwing "NT").

We recorded 23 species (belonging to 11 families), noting that the Soumar wetland covers only 42 ha. In the neighbouring eco-complex, Lake Tonga (2400 ha, El Taref province, northeast Algeria) Loucif et al. (2020) reported 35 waterbird species belonging to 11 families and Guerbes-Sanhadja (100 ha, Skikda province, northeast Algeria) Bara et al. (2020) reported 35 waterbird species belonging to 13 families. In 40 important wetlands on the Azov-Black Sea coast of Ukraine, Chernichko et al. (2023) reported 106 waterbird species.

The Soumar wetland is neither a Ramsar nor an IBA site. Nevertheless, the conservation values that provide food availability and site selection for four waterbird species (see Results section). The wetlands revealed high and significant values for many waterbirds that use it as a stopover, breeding or wintering site. Also, many waterbirds had changed their phenological status becoming sedentary birds in the region. Our data showed that we recorded the highest diversity profiles in the Soumar wetland in June. In fact, this month of the year the wetland reached its maximum ecological values with a substantial Shanon–Weaver, Simpson and equitability indices.

We recorded three taxa (coots, ducks and grebes) that dominate the wetland in September and October. These three taxa were recorded go around SOUMAR as a sedentary or wintering population. Coots were divided on two Meta populations (sedentary versus wintering). Grebes and ducks leaving the wetland in June (during the end of spring and early summer), indeed Berger–Parker index recorded its minimum value). The diversity profiles can be explained through a process that is described in a functional approach (Gattone & Di Battista, 2009). We noted that in June the dominant species (coots' Meta population, wintering ducks and grebes) leaving the wetland.

The adjusted values of diversity are obtained among environmental factors. Rousseau et al. (1999) reported that the Gini measure of evenness (G') reveals well the measures of diversity by showing the cumulative relationship between abundance and richness. In this case, the number of individuals (abundance) and the number of species (richness) tended as a linear curve (fig. 1). However, it is important to note that linearity may be too restrictive for modelling diversity (Gattone & Di Battista, 2009).

We found that the phenological status (breeding, wintering, sedentary, passenger) of waterbirds can control a specific pattern of diversity in the Soumar wetland. The relationship between environmental factors (such as temperature and rainfall) and the abundance of waterbirds was significantly related to their requirements. The artificial wetlands can carry out the migration of waterbirds by providing opportunities as stopover sites. Vickery et al. (2014) found a drastic decline in long-distance migrating waterbirds due to habitat loss at stopover sites. Between 2019 and 2020, climate stations in Skikda and Oum El Bouaghi reported low rainfall (mainly in the Guerbes-Sanhadja wetlands and the Hauts Plateaux wetlands) (see climate data). Many long-distance migratory waterbirds used Soumar during their stopover (e. g. the greater flamingo breeding in southern Algeria — El Golea colony) (Boucheker et al., 2011).

We strongly recommend that policymakers fund more conservation projects in the Soumar. This can maintain the abundance and richness of waterbirds (diversity profiles) and also to allow the classification of this wetland as a Ramsar and IBA site.

Acknowledgments

The authors are very grateful to all volunteers for their help during the sampling. We thank the reviewers for their helpful comments. This study is funded by "Ministere de l'enseignement superieur et la recherché scientifique" and "DGRSDT". There is no conflict of interest.

Author's contribution

Selma Laroug: data sampling and manuscript editing. Moussa Houhamdi: manuscript reviewing. Mouslim Bara: study conception, data analysis and manuscript editing.

References

Andrade, E. R., Jardim, J. G., Santos, B. A., Melo, F. P. L., Talora, D. C., Faria, D. & Cazetta, E. 2015. Effects of habitat loss on taxonomic and phylogenetic diversity of understory Rubiaceae in Atlantic forest landscapes. *Forest Ecology and Management*, 349, 73–84.

Bara, M. & Segura, L. N. 2019. Effect of Air Temperature and Water Depth on Bird Abundance: A Case Study of Rallidae and Anatidae in the Northeastern Algerian Garaet Hadj Tahar. *Pakistan J. Zool.*, **51** (1), 211–217.

Bara, Y., Bara, M., Bensouilah, M., Saheb, M., Atoussi, S. & Houhamdi, M. 2020. Assessments of physicochemical parameters of Garaet Hadj Tahar wetland and their effect on waterbirds settlement. *Ukrainian Journal of Ecology*, **10** (2), 33–39.

Blondel, J. 1975. Analyse des peuplements d"oiseaux d"eau. Élément d"un diagnostic écologique. I : La méthode des échantillonnages fréquentiels progressifs (E.F.P). *Terre et Vie*, 29, 533–589.

Boucheker, A., Samraoui, B., Prodon, R., Amat, J. A., Rendón-Martos, M., Baccetti, N., Esquerre, F. V., Nissardi, S., Balkiz, Ö., Germain, C., Boulkhssaim, M. & Béchet, A. 2011. Connectivity between the Algerian population of Greater Flamingo Phoenicopterus roseus and those of the Mediterranean basin. *Ostrich*, **82** (3), 167–174.

Chernichko, J. I, Kostiushyn, V. A., & Vinokurova, S. V. 2023. The red data book waterbirds in the coastal wetlands of the Azov-Black sea region of Ukraine — the results of the august counts 2018 and 2021. *Zoodiversity*, **57** (2), 181–190.

Dustan, C. E. & Fox, B. J. 1996. The effects of fragmentation and disturbance of rainforests on ground dwelling small mammals on the Robertson Plateau New south Wales Australia. *J. Biogeogr*, 23, 187–201.

Fishpool, L. D. & Evans, M. I., eds. 2001. *Important Bird Areas in Africa and associated islands: Priority sites for conservation*. BirdLife International, Cambridge.

Gaget, E., Le Viol, I., Pavón-Jordán, D., Cazalis, V., Kerbiriou, C., Jiguet, F., Popoff, N., Dami, L., Mondain-Monval, J. Y., Defos du Rau, P., Abdou, W. A. I., Bozic, L., Dakki, M., Encarnação, V. M. F., Erciyas Yavuz, K., Etayeb, K. S., Molina, B., Petkov, N., Uzunova, D., Zenatello, M. & Galewski, T. 2020. Assessing the effectiveness of the Ramsar Convention in preserving wintering waterbirds in the Mediterranean. *Biological Conservation*, 243, 108485.

Gattone, S. A. & Battista, T. D. 2009. A functional approach to diversity profiles. *Journal of the Royal Statistical Society: Series C (Applied Statistics)*, **58** (2), 267–284.

Hammer, ø, Harper, D. A. T. & Ryan, P. D. 2001. PAST: paleontological statistics software package for education and data analysis. *Palaeontologia Electronica*, **4** (1), 9.

Jackson, M. V., Choi, C.-Y., Amano, T., Estrella, S. M., Lei, W., Moores, N., Mundkur, T., Rogers, D. I. & Fuller, R. A. 2020. Navigating coasts of concrete: Pervasive use of artificial habitats by shorebirds in the Asia-Pacific. *Biological Conservation*, 247, 108591.

Kingsford, R. T., Porter, J. L., Brandis, K. J. & Ryall, S. 2020. Aerial surveys of waterbirds in Australia. *Scientific data*, **7** (1), 172.

Loucif, K., Bara, M., Grira, A., Maazi, M. C., Hamli, A. & Houhamdi, M. 2020. Ecology of avian settlements in lake Tonga (Northeast Algeria). *Zoodiversity*, **54** (4), 275–284.

Magurran, A. E. 1988. *Ecological diversity and its measurement*. Princeton University Press, Princeton, NJ.

Pielou, E. C. 1975. *Ecological Diversity*. Wiley, New York.

Rousseau, R., Van Hecke, P., NIjssen, D. & Bogaert, J. 1999. The relationship between diversity profiles, evenness and species richness based on partial ordering. *Environmental and Ecological Statistics*, **6** (2), 211.

Shannon, C. E. & Weaver, W. 1949. *The mathematical theory of communication*. University of Illinois Press, Urbana, IL

Tóthmérész, B. 1995. Comparison of different methods for diversity ordering. *J. Veg. Sci.*, 6, 283–290.

Vickery, J. A., Ewing, S. R., Smith, K. W., Pain, D. J., Bairlein, F., Skorpilova, J. & Gregory, R. D. 2014. The decline of Afro-Palaearctic migrants and an assessment of potential causes. *Ibis*, 156, 1–22.

Wang, X., Li, X., Ren, X., Jackson, M. V., Fuller, R. A., Melville, D. S., Amano, T. & Ma, Z. 2021. Effects of anthropogenic landscapes on population maintenance of waterbirds. *Conservation Biology*, **36** (2), e13808.

Wauchope, H. S., Jones, J. P., Geldmann, J., Simmons, B. I., Amano, T., Blanco, D. E., Fuller, R. A., Johnston, A., Langendoen, T., Mundkur T., Nagy, S. & Sutherland, W. J. 2022. Protected areas have a mixed impact on waterbirds, but management helps. *Nature*, **605** (7908), 103–107.

Received 3 May 2023
Accepted 5 September 2023