

Importance and Winter Ornithological Value of Lake El-Golea (Ghardaïa, Algerian Sahara)

Biad Radhia

Biology, Water and Environment Laboratory (LBEE), Department of Ecology and Environmental Engineering, Faculty SNV-STU, University 8 May 1945 Guelma, BP 401 2400 Guelma, Algeria, biad.radhia@univ-guelma.dz

Bounab Choayb

Department of Biology, Faculty SNV-ST, University of Ghardaïa, Algeria

Guergueb El Yamine

Department of Biology, Faculty SNV-ST, University of Ghardaïa, Algeria

Biad Mohamed Fetheddine

Department of Biology, Faculty SNV-ST, University of Ghardaïa, Algeria

Houhamdi Moussa

Laboratoire Biologie, Eau et Environnement (LBEE), Faculté SNV-STU, Université 8 Mai 1945 Guelma. BP. 401 24000 Guelma (Algérie).

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Cover Page Footnote

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IMPORTANCE AND WINTER ORNITHOLOGICAL VALUE OF LAKE EL-GOLEA (GHARDAÏA, ALGERIAN SAHARA)

BIAD RADHIA^{1,2}, BOUNAB CHOAYB^{1,3}, GUERGUEB EL YAMINE^{1,3}, BIAD MOHAMED
FETHEDDINE³, AND HOUHAMDI MOUSSA¹

1* *Biology, Water and Environment Laboratory (LBEE), Department of Ecology and Environmental
Engineering, Faculty SNV-STU, University 8 May 1945 Guelma, BP 401 2400 Guelma, Algeria*

2 * *Department of Ecology and Environmental Engineering, Faculty SNV-STU, University 8 May 1945 Guelma,
Algeria*

3. *Department of Biology, Faculty SNV-ST, University of Ghardaïa, Algeria*

Corresponding author's e-mail: biad.radhia@univ-guelma.dz / biad.radia@gmail.com

ABSTARCT

This study is carried out on two winter period (2018-2019 and 2019-2020) in Lake El-Golea (Ghardaïa, northern Sahara of Algeria). Its objective is to determine the ornithological value of this lake and to in ferits importance in maintaining aquatic avifauna during the winter season. This inventory shows a diversity equivalent to forty-one species belonging to thirteen families and nine orders of which eighteen are protected by various Algerian and international laws. The most represented family is that of the Anatidae with twelve species while the family with the highest number is that of the Phenicopteridae represented only by one species, the Greater Flamingo (*Phenicopterus roseus*). These waterbirds occupy the lake in different ways: the insectivores are distributed on the banks and in the shallow areas of the lake while, the herbivores, polyphages and piscivores are concentrated in the deepest areas and in the centre of the lake. It is important to note, however, the presence of two vulnerable species, the Common Pochard (*Aythya ferina*) and the Marbled Duck (*Marmaronetta angustirostris*) and anear-threatened species, the Greater Ring- Ferruginous Duck (*Aythya nyroca*).

Keywords: Species richness, wintering, wetlands, waterbirds, Lake El-Golea, Algerian Sahara.

INTRODUCTION

North Africa's wide diversity of wetlands provides wintering and staging areas for many Western Palearctic waterbirds (Bensaci et al., 2012, Beghdadi et al., 2016). Algeria, by its geographical position and its immense coastline of 1600 km represents the most important contact area of the southern shore of the Mediterranean (Houhamdi 2002). It is placed in the system of migrations within the Palearctic zone and in that of trans-Saharan migrations between Eurasia and tropical Africa. It also occupies a pivotal position in this migration system as it is located on the two main migration routes

(Flyway) of the Eastern Atlantic (Bendahmane, 2015). Its importance, as a mandatory crossing zone for a large part of the fauna, between the Palearctic and Afro-tropical regions, gives it a particular interest for faunistic, ecological and biogeographic studies (Metallaoui and Houhamdi, 2008, 2010). The wetlands of the highlands and Sahara of Algeria considered as reservoirs of faunistic and floristic diversity represent at the same time particular ecosystems hosting dozens of species of waterbirds, whether sedentary or migratory (Saheb et al., 2006 ; Boulekhssaim et al., 2006 ; Houhamdi et al., 2008, 2009 ; Baaziz et al., 2011, Boukrouma et al., 2011; Bensizrara et al., 2013, Hafid et al., 2013, Bensaci et al.,

2012, Bouzid, 2017). The El-Golea Lake, also known as Sebket El-Melah, is a body of natural salt water of 18,947 ha, located in the middle of the Sahara, like all the Saharan wetlands represents a very great ornithological importance mainly during the season of wintering and trans-Saharan transit during the period of reproduction (Bouzid et al., 2009; Sadaoui, 2015; Meddour et al., 2015; Bouzid, 2017; Guergueb et al., 2014). This work was done to demonstrate the role of this wetland in two winter period from September 2018 to April 2019 and from September 2019 to April 2020) in maintaining the aquatic avifauna and increasing the true value of this wetland for the overwintering of aquatic avifauna

MATERIAL AND METHODS

Study Area

Lake El-Golea (30°30'20"N 02°55'34"E) is a Ramsar site N° 1429 classified since 12 December 2004 and is located 280 km southwest of the city of Ghardaïa. The site is located at an altitude of 397m (Dubief, 1963); It is a continental depression of 18950ha (D.P.S.B, 2012) consisting of two bodies of water; an upper basin with moderate salinity, very rich from a biodiversity point of view, similar to a pond, and a Sebkhia or Salt Lake devoid of all vegetation (Figure1). Lake El-Golea plays a key role in maintaining the biodiversity of the Mediterranean and central Sahara because it is on one of the migration paths of waterfowl, connecting the Western Palearctic and the Afro-tropical region, especially that connecting the coastal lakes and those of the Sahel region. However, it supports three populations of nesting water birds: the Ferruginous Duck (*Aythya nyroca*) (Boumezbeur et al., 2005), the Greater Flamingo (*Phoenicopterus roseus*) and Ruddy Shelduck (*Tadorna ferruginea*) (Mesbah et al., 2014).

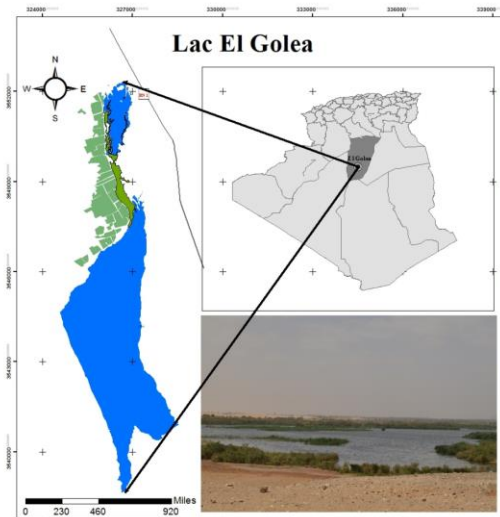


Figure 1: Geographical location of Lake El-Golea.

Methodology

This work was carried out in order to inventory and determine the status of the aquatic avifauna frequenting the wetland of Lake El Golea (Ghardaïa province). Bi-monthly monitoring and observation campaigns were conducted from September 2018 to April 2019 and September 2019 to August 2020, winter period; Counts were conducted from 8h to 17h using a Spotting Scope KONUS Spot 20x60. In general, individual counts were conducted when the group of birds is near (less than 200 m) and the population is less than 200 and if not, where the group is remote and/or has a population in excess of 200 individuals, we made visual estimates of the group (Bibby et al., 1998, Houhamdi and Samraoui 2002). This technique is most commonly used for winter counts and counts of waterbird populations. However, it has a margin of error depending on the observer's experience and the accuracy of the optical equipment used, often estimated between 5 and 10 % (Lamotte & Bourliere. 1969, Blondel 1975, Tamisier et Dehorter, 1999).

The ecological study of this avifauna was addressed by determining the ecological indexes related to the balance of this stand: Total abundance, Relative abundance (RA %), Specific richness,

Frequency of occurrence (Fi %) and the determination of guilds and conservation status. The results of the study are presented graphically as monthly averages, then a multivariate statistical analysis (Correspondence Factor Analysis) was applied using the ADE-4 software (Chessel and Doledec, 1992).

In ecological studies, biological diversity appears to be a direct concept that can be assessed in a quick and easily understandable manner. Measures of this diversity are good indicators of ecosystem health (Magurran, 1988; Si Bachir, 2005). The total wealth of a stand is the number of species contracted at least once at the end of (N) surveys (Blondel, 1975). This is the total number (S) of species present in a biotope (Ramade 1984).

Relative abundance (RA %) is a concept that allows an assessment of a species, category, class or order (OR) in relation to all animal populations present together (N) in an inventory (Faurie et al., 2003). It is calculated according to the following formula:

$$RA\% = \frac{ni}{N} \times 100$$

Frequency of occurrence (Fi %) is the ratio expressed as a percentage of the number of surveys containing the species (i) taken into account in the total number of surveys conducted (P) (DAJOZ, 1982). It is calculated using the following formula:

$$Fi\% = \frac{pi}{P} \times 100$$

The aquatic birds surveyed were subdivided according to their Feeding Habits and diet and their use of environments into four main guilds: Grebes and Cormorants, Ducks and Coots, Laro-shorebirds and raptors. The conservation status was also assessed in accordance with the list of protected species in Decree N°. 83-509 on protected

non-domestic animal species. The Decree of 17 January 1995 supplementing the same list and Executive Decree N°. 12. - 235 of 24 May 2012 establishing the list of protected products in non-domestic animal species (Joradp, 2018). At the international level, we referred to the IUCN Red List (Vie et al., 2009; IUCN, 2020).

RESULTS AND DISCUSSION

Results

Forty-one species of waterfowl belonging to thirteen families and nine orders have been recorded in Lake El-Golea (Table 1), the equivalent of 10.10 % of the total wealth of birds recorded in Algeria (Isenmann and Moali, 2000). The most abundant are the Charadriiformes with seventeen species belonging to four families, followed by the Anseriformes represented by eleven species belonging to a single family, the Anatidae then the Pelecaniformes with six species belonging to two families. The other orders (Podicipediformes, Suliformes, Ciconiiformes, Phœnicopteryforms and Accipitriformes) are represented by a single family (Figure 2).

It should be noted that the Greater Flamingo (*Phoenicopterus roseus*), the Northern Shoveler (*Spatula clypeata*), the Eurasian Coot (*Fulica atra*), the Black-winged Stilt (*Himantopus himantopus*), the Ferruginous Duck (*Aythya nyroca*), Ruddy Shelduck (*Tadorna ferruginea*) and Common Moorhen (*Gallinula chloropus*) were observed during both wintering seasons.

The avian stand encountered during the study period (forty-one species) belonging to thirteen families in which, the richest species family is that of Anatidae, eleven species (26.83 %), followed by Scolopacidae, nine species (21.95 %). Ardeidae are represented by four species (9.76 %) followed by Laridae and Charadriidae by three species (7.32 %). Recurvirostridae, Threskiornithidae

and Rallidae are represented by two species (4.88%). The families represented by a single species are: Podicipedidae, Phalacrocoracidae, Ciconiidae, Phoenicopteridae, Accipitridae. The twenty-four species recorded during the 2019 wintering season are spread over eleven families in which the richest species family is Anatidae by ten species (41.67 %) followed by Ardeidae by three species

(12.50 %). Rallidae and Recurvirostridae are represented by two species (8.33 %) each, seven families are represented by one species (4.17 %): Podicipedidae, Phalacrocoracidae, Ciconiidae, Threskiornithidae, Phoenicopteridae, Accipitridae, Charadriidae with the absence of both the Scolopacidae and Laridae families.

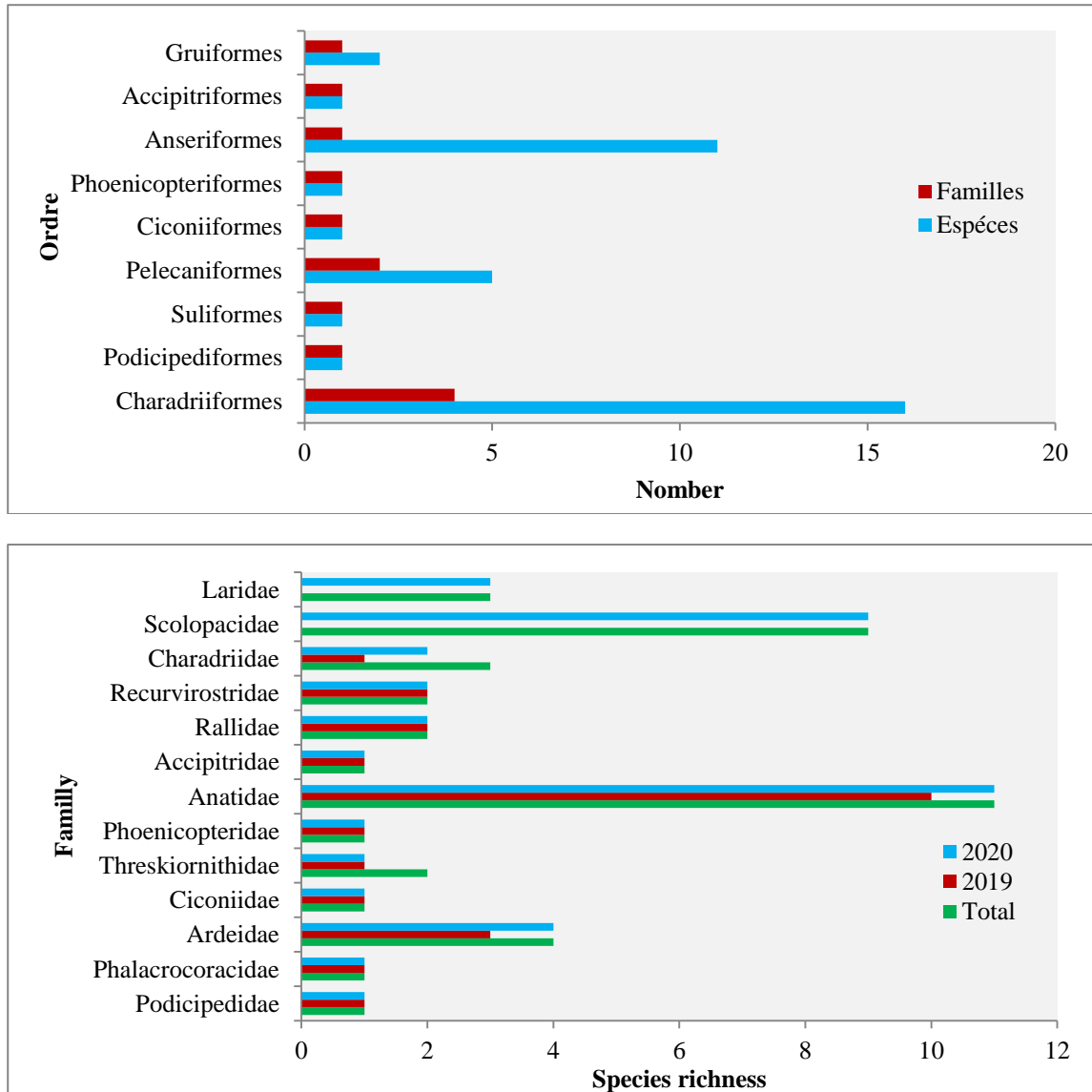


Figure .2: Species richness of the aquatic avifauna of Lake El-Golea. (A).

Table 1: Taxonomic list of birds of the El Golea wetland.

Ordre	Famille	Nom scientifique	Ab%		Fi%		UICN	DZ
			2019	2020	2019	2020		
Podicipediformes	Podicipedidae							
LittleGrebe		<i>Tachybaptus ruficollis</i>	0,17	0,15	3,64	36,36	LC	NP
Suliformes	Phalacrocoracidae							
Great Cormorant		<i>Phalacrocorax carbo</i>	0,14	0,08	81,82	27,27	LC	P
Pelecaniformes	Ardeidae							
Grey Heron		<i>Ardea cinerea</i>	0,45	0,19	72,73	72,73	LC	NP
Great Egret		<i>Ardea alba</i>	2,24	0,11	36,36	36,36	LC	P
SquaccoHeron		<i>Ardeola ralloides</i>	0,00	0,03	0,00	9,09	LC	P
LittleEgret		<i>Egretta garzetta</i>	0,22	0,09	27,27	27,27	LC	P
Ciconiiformes	Ciconiidae							
White Stork		<i>Ciconia ciconia</i>	0,79	0,11	45,45	27,27	LC	P
Pelecaniformes	Threskiornithidae							
EurasianSpoonbill		<i>Platalea leucorodia</i>	0,09	0	54,55	0,00	LC	P
Glossy Ibis		<i>Plegadis falcinellus</i>	0,00	0,11	0,00	36,36	LC	P
Phoenicopteriformes	Phoenicopteridae							
GreaterFlamingo		<i>Phaenicopterus roseus</i>	28,64	62,85	100,00	100,00	LC	P
Anseriformes	Anatidae							
NorthernPintail		<i>Anas acuta</i>	4,98	0,06	90,91	9,09	LC	NP
EurasianTeal		<i>Anas crecca</i>	0,10	2,08	45,45	9,09	LC	NP
Mallard		<i>Anas platyrhynchos</i>	1,81	0,48	72,73	81,82	LC	NP
Common Pochard		<i>Aythya ferina</i>	0,00	0,90	0,00	72,73	VU	NP
FerruginousDuck		<i>Aythya nyroca</i>	16,62	1,81	81,82	100,00	NT	P
EurasianWigeon		<i>Mareca penelope</i>	0,46	0,00	72,73	9,09	LC	NP
Gadwall		<i>Mareca strepera</i>	7,55	0,10	72,73	27,27	LC	NP
MarbledDuck		<i>Marmaronetta angustirostris</i>	6,19	2,33	27,27	81,82	VU	P
NorthernShoveler		<i>Spatula clypeata</i>	12,94	5,35	100,00	100,00	LC	NP
RuddyShelduck		<i>Tadorna ferruginea</i>	0,34	1,92	72,73	100,00	LC	P
Common Shelduck		<i>Tadorna tadorna</i>	0,22	2,07	54,55	81,82	LC	P
Accipitriformes	Accipitridae							

Western Marsh Harrier		<i>Circus aeruginosus</i>	0,08	0,01	54,55	9,09	LC	P
Gruiformes	Rallidae							
EurasianCoot		<i>Fulica atra</i>	8,42	11,79	100,00	100,00	LC	NP
Common Moorhen		<i>Gallinula chloropus</i>	2,32	0,33	100,00	81,82	LC	NP
Charadriiformes	Recurvirostridae							
Black-wingedStilt		<i>Himantopus himantopus</i>	2,56	3,55	100,00	100,00	LC	P
Pied Avocet		<i>Recurvirostra avosetta</i>	2,51	0,40	90,91	45,45	LC	P
Charadriiformes	Charadriidae							
LittleRingedPlover		<i>Charadrius dubius</i>	0,00	1,54	0,00	54,55	LC	NP
Common RingedPlover		<i>Charadrius hiaticula</i>	0,00	0,69	27,27	45,45	LC	P
KentishPlover		<i>Charadrius alexandrinus</i>	0,15	0	0,00	0,00	LC	NP
Charadriiformes	Scolopacidae							
Common Sandpiper		<i>Actitis hypoleucos</i>	0,00	0,06	0,00	18,18	LC	NP
LittleStint		<i>Calidris minuta</i>	0,00	0,09	0,00	27,27	LC	NP
Ruff		<i>Philomachus pugnax</i>	0,00	0,20	0,00	27,27	LC	NP
SpottedRedshank		<i>Tringa erythropus</i>	0,00	0,02	0,00	9,09	LC	NP
Green Sandpiper		<i>Tringa ochropus</i>	0,00	0,32	0,00	27,27	LC	P
Common Snipe		<i>Gallinago gallinago</i>	0,00	0,03	0,00	9,09	LC	NP
SpottedRedshank		<i>Tringa erythropus</i>	0,00	0,02	0,00	9,09	LC	NP
Wood Sandpiper		<i>Tringa glareola</i>	0,00	0,02	0,00	9,09	LC	NP
Temminck'sStint		<i>Calidris temminckii</i>	0,00	0,02	0,00	9,09	LC	NP
Charadriiformes	Laridae							
Gull-billedTern		<i>Gelochelidon nilotica</i>	0,00	0,01	0,00	9,09	LC	P
Black-headed Gull		<i>Chroicocephalus ridibundus</i>	0,00	0,01	0,00	27,27	LC	NP
Black Tern		<i>Chlidonias niger</i>	0,00	0,07	0,00	9,09	LC	NP

On the other hand, the 2020 winter season marks the presence of thirty nine species distributed over thirteen families, the richest of which is that of the Anatidae by eleven species (28.21 %) followed by the Scolopacidae by nine species (23.28 %), Ardeidae by four species (10.26 %), and the Laridae which is represented by three species (7.69%). Rallidae, Recurvirostridae and Charadriidae are represented by two species (5.13 %). The six families: Podicipedidae, Phalacrocoracidae, Ciconiidae, Threskiornithidae, Phoenicopteridae and Accipitridae are represented by a single species.

In the 2019-2020 season, the most abundant species over the two wintering seasons is the Greater Flamingo (*Phoenicopterus roseus*) (28.64 % and 62.85 %), followed by the Ferruginous Duck (*Aythya nyroca*) (16.62 %), then

Northern Shoveler (*Spatula clypeata*) (12.94 %) and in the 2020-2021 wintering season the Greater Flamingo (*Phoenicopterus roseus*) followed by the Eurasian Coot (*Fulica atra*) (11.79 %) and the Northern Shoveler (*Spatula clypeata*) (5.35 %).

Species of Least Concern status (LC) are the most represented in this wetland (38 species or 92.68 %), followed by the vulnerable (VU) class with 4.88% which is represented by two species of Anatidae (the Common Pochard (*Aythya ferina*) and Marbled Duck (*Marmaronetta angustirostris*)). However, Ferruginous Duck (*Aythya nyroca*) is the only recorded bird with a Near Threatened IUCN (NT) conservation status (Fig.3). This species regularly nests in this lake (Boumezbeur et al., 2005 and regular personal observation).

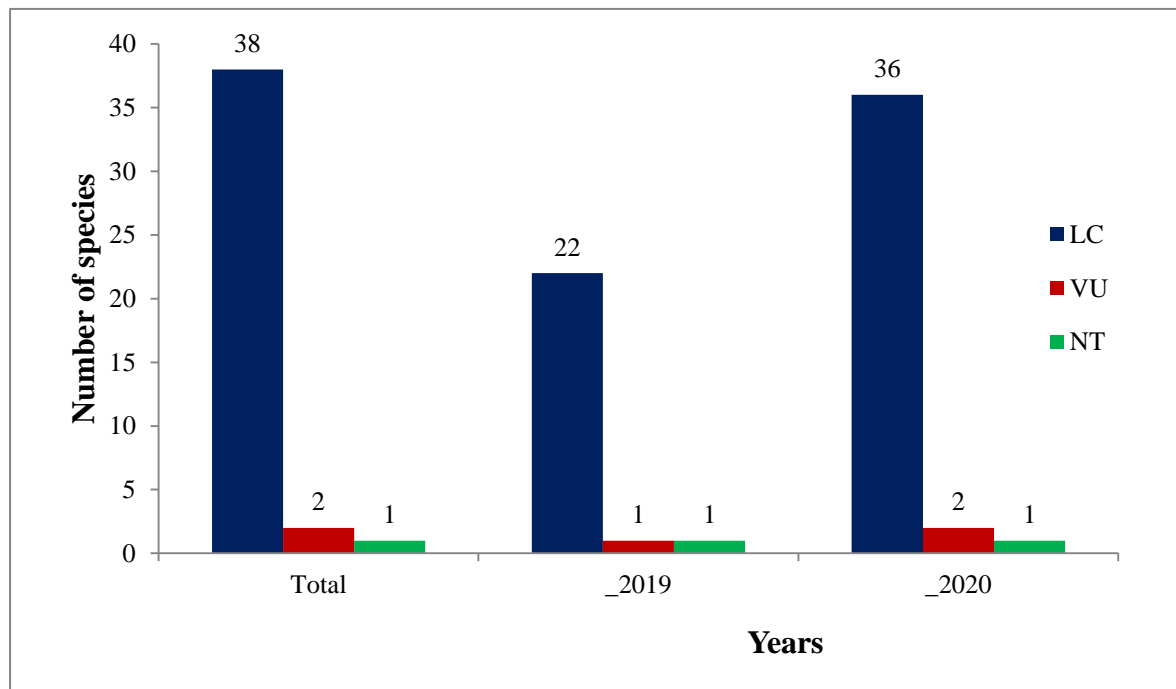


Figure 3: IUCN conservation status of the aquatic birdlife of Lake El-Golea.

According to the Decree of the Official Journal of the Algerian Republic (JORADP, 2018) where Algeria has listed several fauna and floristic species of national ecological importance. The

avifauna encountered during our study at Lake El-Golea is subdivided into two groups: unprotected species and protected species, twenty-three species (56.10 %) and eighteen species (43.90 %)

respectively (Figure 4). They are represented by: the Grey Heron (*Ardea cinerea*), the Great Egret (*Ardea alba*), the Little Egret (*Egretta garzetta*), Eurasian Spoonbill (*Platalea leucorodia*), Glossy Ibis (*Plegadis falcinellus*), White Stork (*Ciconia ciconia*), Greater Flamingo (*Phoenicopterus roseus*), Mallard (*Anas platyrhynchos*), Ferruginous Duck (*Aythya nyroca*), Marbled Duck (*Marmaronetta angustirostris*), Ruddy Shelduck (*Tadorna ferruginea*), Common Shelduck (*Tadorna tadorna*), Western Marsh Harrier (*Circus aeruginosus*), Black-winged Stilt (*Himantopus himantopus*), Pied Avocet (*Recurvirostra avosetta*), Common Ringed Plover (*Charadrius hiaticula*), Wood Sandpiper (*Tringa ochropus*), Spotted Redshank (*Gelochelidon nilotica*).

It should be noted that during the second wintering season (2019-2020), the lake was more diverse and therefore had more protected species (Figure 4). Eighteen species (58.33 %) compared to fourteen (44.15 %). Regarding the non-protected species, it hosted twenty-one species.

birds are in first place with twenty species (48.78 %). They are mainly recorded during the second wintering season (2019-2020) and are followed by polyphagous birds (34.15 %) fourteen species, then by piscivorous birds with (14.63 %) six species and finally by carnivorous birds with 2.44 % represented by a single species (Figure 5). During the first season (2018-2019), insectivores are poorly represented. They occupy the same rank as piscivores with five representatives (20.83 %). Polyphagous species are the most abundant (54.17 %) with thirteen In terms of trophic status, insectivorous.

Four main guilds were observed in this lake. Laro-Limicoles occupy the first position with twenty-six species (63.41 %) (Figure 6) followed by Ducks and Coots (29.27 %) twelve species, then Grebes and Cormorants (4.88 %) two species and finally by Raptors with only one species (2.44 %). This evolution is noted in the same way during the two seasons of study but with unequal representation (Figure 6).

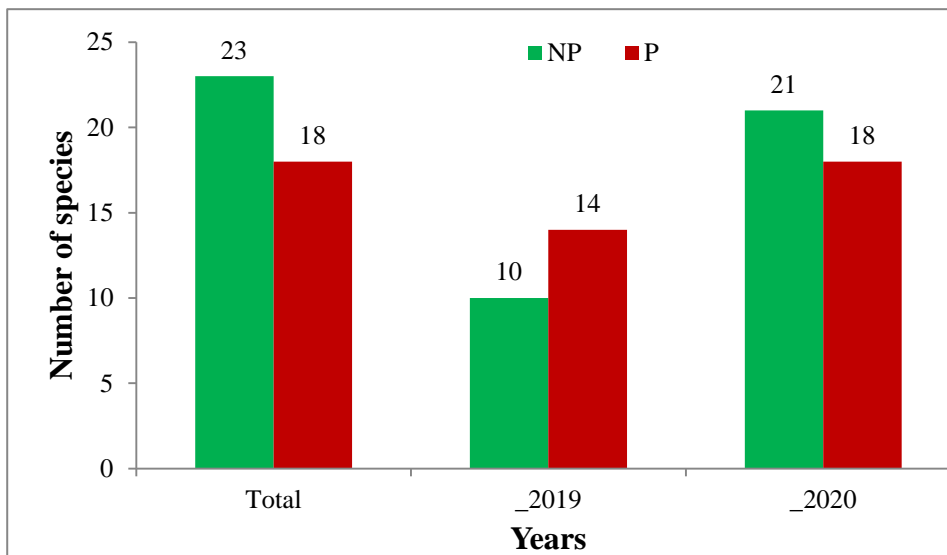


Figure 4: Protection status of the aquatic avifauna of Lake El-Golea under Algeria law.

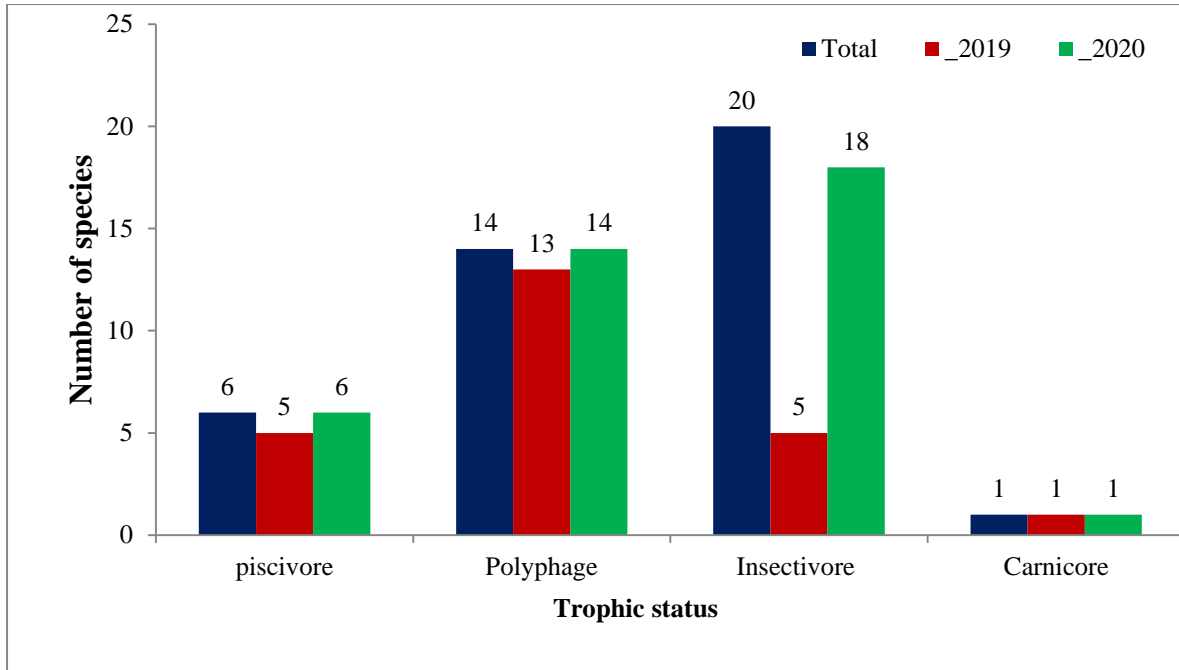


Figure 5: Trophic status of the aquatic avifauna of Lake El-Golea.

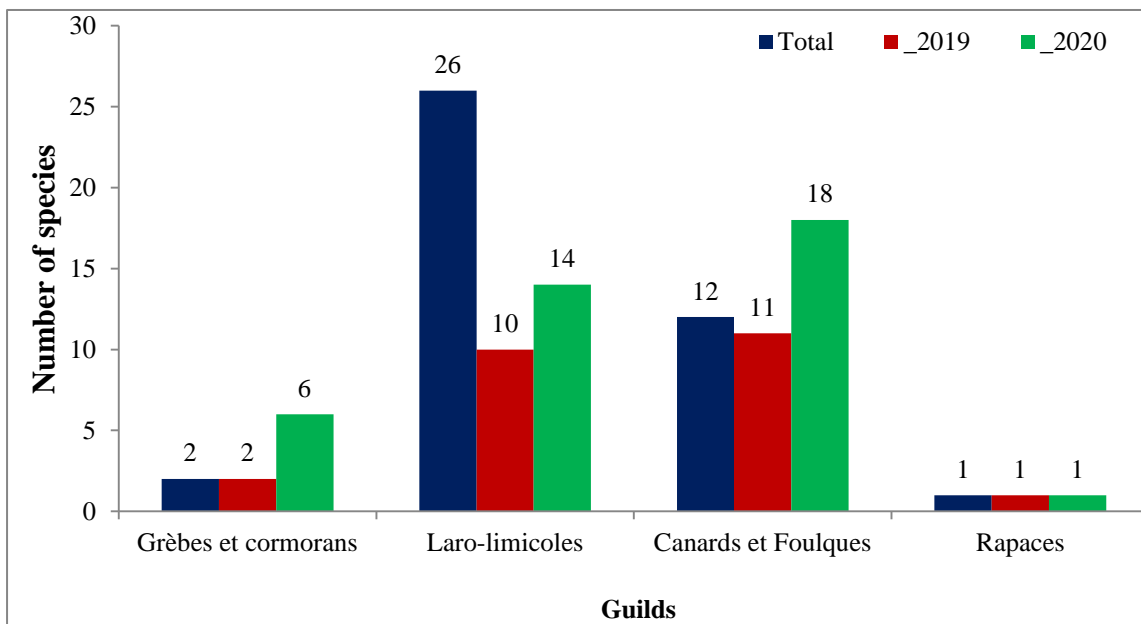


Figure 6: Guilds of aquatic birds of Lake El-Golea.

DISCUSSION

41 waterfowl species from thirteen families and nine orders were registered in Lake El-Golea, the equivalent of 10.10% of the total richness of Algerian birds. (Isenmann and Moali, 2000). The situation of Lake El-Golea, also known as Sebkheth

El-Melah, in the middle of the Sahara in southern Algeria, is of prime importance

for bird diversity and for its retention throughout the wintering season. Indeed, this Saharan wetland hosted, during the two seasons concerned by the study (2018-2019 and 2019-2020), forty-one species of waterbirds belonging to thirteen families

and nine orders. This can match the large wintering areas of the Oued Righ, located further north in this Saharan region of 2011, Beghdadi et al., 2016, Bouzid, 2017).

All these studies show on one hand that the specific richness of these environments varies between thirteen and seventeen species and that the families of Anatidae and Scolopacidae are the most diversified. On the other hand, these wetlands also host key or flagship species of aquatic environments throughout the Western Palearctic: the Ferruginous Duck (*Aythya nyroca*), the Marbled Duck (*Marmaronetta angustirostris*), the Common Pochard (*Aythya ferina*), the Greater Flamingo (*Phoenicopterus roseus*), etc., which often breed in this region (Bensaci et al., 2013, Mesbah et al., 2014) In general, these wetlands have hosted between nine and eleven species of waterbirds (Seddik et al., 2010, 2012, Maazi et al., 2010, Bensaci et al., 2011, 2013, Nouidjem et al., 2012). During these two consecutive seasons, Lake El-Golea has thus sheltered a specific richness that can compete with the large wetlands of the Algerian coast and highlands (Baaziz et al., 2011, Lardjane-Hamiti et al., 2012, 2013, Bouzegag et al., 2013)

On the same site, previous studies carried out during the 2008-2009 season showed an avian richness of thirty-four species belonging to twenty-one families and eight orders (Sadaoui, 2015). In 2014-2015, another study showed a richness of thirty-six species belonging to thirteen families and nine orders where the Anatidae are the most represented with twelve species. The Scolopacidae and Ardeidae come second with four species each (Meddour et al., 2015). Finally, during a more consequent study carried out over four consecutive years (2005-2009), with ChottAin El-Beida (Ouargla province located north of Ghardaïa province) an avian diversity of seventy-one species of birds were recorded, including forty-eight species of water-birds (Bouzid, 2017). The

Algeria (Bensaci et al., 2011, Nouidjem 2008, Bouzegag 2008,

most important species on the site are Common Shelduck (*Tadorna tadorna*), Ruddy Shelduck (*Tadorna ferruginea*), Mallard (*Anas platyrhynchos*), Gadwall (*Mareca strepera*), Eurasian Wigeon (*Mareca penelope*), Eurasian Teal (*Anas crecca*), Northern Pintail (*Anas acuta*), Northern Shoveler (*Spatula clypeata*), Marbled Duck (*Marmaronetta angustirostris*), Marbled Duck (*Aythya ferina*), Ferruginous Duck (*Aythya nyroca*). Garganey (*Spatula querquedula*) and Tufted Duck (*Aythya fuligula*) appear irregularly and sporadically (Sadaoui, 2015, Bouzid, 2017).

The numbers of the key species frequenting Lake El-Golea are quite high. The Ferruginous Duck (*Aythya nyroca*) reaches over 650 individuals, the Ruddy Shelduck (*Tadorna ferruginea*) fluctuates between 80 and 380 birds and the Greater Flamingo (*Phoenicopterus roseus*) reaches over 2500 individuals.

Generally speaking, Lake El-Golea has hosted numerous species of national and international importance during our study period, (43.90%) or eighteen species, are protected by the Algerian law (Ledant et al, 1981, Isenmann and Moali 2000). (4.88%) are classified as vulnerable by the IUCN these are Common Pochard (*Aythya ferina*) and the Marbled Duck (*Marmaronetta angustirostris*) and one has a Near Threatened conservation status, the Ferruginous Duck (*Aythya nyroca*)(2.44 %).

These waterbirds are distributed in different ways in the wetland. This occupation is often affected by different factors, the most important of which are the requirements and biology of the species and anthropogenic factors. The majority of avian species, mainly piscivores and polyphagous species, occupy the centre of the wetland and areas of greater depth, while waders and insectivores are distributed along the banks

and in areas of swaying water in search of food.

CONCLUSION

Lake El-Golea, by its geographical position in the heart of the Algerian Sahara, is a preferred place for the maintaining of the biodiversity of fauna and flora. It is an ideal and obligatory stopping place for birds during their pre- and post-nuptial migrations. During the two seasons of the study, it played an important role for many avian species wintering and/or transiting in the Algerian Sahara. An estimated forty-one species belonging to eighteen families were recorded in this wetland during the two wintering seasons. The majority of these species is observed in most of the wetlands of Algeria and North Africa and is therefore habituated winterers by excellence on these southern shores of the Mediterranean. These waterbirds are composed of insectivores, polyphagous, piscivores and carnivores which find in this waterbody a favorable place during the whole period of their presence, which sometimes exceeds the winter period. The avian composition of this site is dominated by the Anatidae which, like the majority of Algerian wetlands, are the most represented in terms of richness and numbers. Among the two species, the Ferruginous Duck (*Aythya nyroca*) and the Greater Flamingo (*Phoenicopterus roseus*), are wintering in large numbers and often remain during the breeding season to nest, the former in the Heliophytes of the northern sector and the latter in a colony in the centre of the wetland, which is an added value to the site.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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