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Water Birds as Indicators of Ecological Conditions in a Ramsar Wetland (Sebkhet Bazer, East of Algeria)

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ABSTRACT

Background: Wetlands are the highly complex ecosystems due to various interactions between the components, where, the most iconic of ecological changes are the water birds. The current study was aimed to examine the interactions between the water birds diversity, abundance and the abiotic factors in Sebkhet Bazer.

Methods: The investigation was conducted between March 2013 and December 2014 in Sebkhet Bazer (Sétif, Algeria, 36°05′N and 5°45′E), by monitoring water birds abundance (grouped into 4: Anatidae, Rallidae, Phoenicopteridae and Shorebirds) and measuring the physico-chemical water parameters (depth, temperature, pH, salinity and vegetation cover). All statistical analysis was performed using the InfoStat software (2017), it was carried out in two steps, by testing of fixed linear models; first of the seasonal differences in water body variables and second of the seasonal differences in bird abundance for the 4 water bird groups.

Result: The results showed that the physico-chemical parameters of water varied considerably from season to season. The four groups of birds reached their lowest abundance in summer, with Rallidae and Phonicopteridae being more abundant in spring, Anatidae in winter and Shorebirds in autumn, suggesting that this variation is attributed to changes in water body characteristics between the four seasons. Therefore, the abundance of the different water bird group could be used as an ecological indicator of this wetland's characteristics. If these features are altered by climate change, the water bird community would be also affected.

Key words: Abiotic parameters, Climate change, Sebkhet Bazer, Water birds.

INTRODUCTION

Wetlands are complex ecosystems due to various interactions between their biotic and abiotic components (Ramamurthy and Rajakumar, 2014), being critical global sources, sinks and transformers of various elements in their biogeochemical cycles (Greb *et al*. 2006). Hence, the response of wetlands to environmental changes such as climate change and hydrology have recently received remarkable attention (Zhang *et al.* 2016), where changes in wetlands components can cause complex interaction between ecological processes (Lagos *et al.* 2008).

More specifically, water birds that are among the most important wetland icons (Mistry *et al.* 2008; Reid *et al*. 2013; Zhang *et al*. 2016), including a large group of species whose distribution is related to the availability and quality of water bodies. In addition, seasonal conditions depend on local resources (Lagos *et al,* 2008), either short (months) or long (years) time scales; and at species and group levels (Almaraz and Amat, 2004).

These species play a crucial role in many food webs of aquatic ecosystem and they are known as good 'bio-indicators' as they are very sensitive to minor environmental changes (Debnath *et al*. 2018).

Furthermore, climate conditions can influence bird distribution and density by changing temperatures and precipitation (Zhang *et al.* 2015). Water bird density and diversity are also associated with vegetation structure and composition (Cunningham *et al,* 2008; Nawaz-Rajpar and Zakaria, 2014).

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Algerian wetlands are located in one of the most vulnerable Mediterranean areas, where the drying up of sites in spring is a major constraint on water birds distribution (Saifouni, 2008).

Moreover, climate changes are likely to have the greatest impact on Mediterranean wetlands through alterations in hydrological regimes: specifically, the nature and variability of the hydroperiod (Erwin, 2009), thus affecting animal's health and biodiversity (Kuraz *et al.* 2021). Given their biogeographical and geomorphological context, this study focuses on one Algerian wetland, which represents a refuge and breeding site for several water bird species, thus highlighting its ecological and ornithological importance, hence several recent studies published over the past few years (Samraoui *et al*. 2011, 2013; Baaziz *et al.* 2011; Bensaci *et al*. 2011; Charchar *et al*. 2016; Djelailia *et al*.

2017). It has become one of the important research projetcs in wetlands, but no scientific research has reported the water bird distribution according to water quality. Consequently, further research in Algeria is needed on the above area as well as the world.

Therefore, this study aims to determine the avian abundance and diversity of Sebkhet Bazera Ramsar wetland, over the four seasons and to make a comprehensive analysis of seasonal variations in water birds according to the water body properties (temperature, pH, salinity, vegetation cover and depth). The present study is one of the first in Algeria to explicitly address how environmental conditions vary with the seasons, which can modify water bird communities.

MATERIALS AND METHODS

This study investigation was conducted between March 2013 and December 2014 in the Salt Lake (Sebkhet) of Bazer, also called Sebkhet Bazer (36°05′N and 5°45′E, 917 m), which covers 4,379 ha and is located in the eco-wetland complex of the Sétif region (northeastern Algeria) (Fig 1). This wetland has been classified as a Ramsar site since 2004 under criteria 2 and 6, including its importance for the wintering of Greater Flamingo *(Phoenicopterus roseus)* and Common Shelduck *(Tadorna tadorna*).

This Sebkhet is a labile lake whose water level depends on climatic conditions. The site is characterized by the presence of halophilic groups represented by *Salicornia fruticosa*, *Suaeda fruticosa* and *Atriplex glauca* that support high levels of salinity and agricultural land groups represented by several species such as *Papaver rhoeas*. The presence of nitratophilic aquatic vegetation such as *Typha angustifolia* and *Phragmites sp* is increasingly important biologically for the maintenance of breeding water birds, mainly Anatidae and Rallidae.

Sebkhet Bazer is part of the semi-arid bioclimatic region with a cold winter. According to data recorded at the Ain Sfiha weather station over the last fourteen years, the annual average temperature of Sebkhet Bazer was 15.1°C. The coldest month was January when the monthly average temperature was 5°C and the warmest month was August with an average temperature of 26.6°C. Annual precipitation was 318.26 mm, with spring being considered the rainy season, particularly in March, when the highest precipitation value (83.3 mm) was recorded. The minimum precipitation value is recorded in summer (23.88 mm) during the dry season.

Water body properties

To measure the physico-chemical parameters of the water, seasonal surveys in the 4 cardinal directions were carried out, taking 3 samples per season in the immediate vicinity of the waterbody, about 1 to 2 metres from the border and less than 50 cm deep. Temperature (°C) was measured in situ thermometer by directly introducing a thermometer at the sampling point. pH measurement was made using the electrometric method by a pH meter.

The measurement of Electrical Conductivity (EC) was performed by using a conductivity meter.

The salinity measurement is made possible from the Conductivity Meter (direct reading). To measure the water depth, we selected the flat area where the height of the water was near or equal. The water depth was measured in centimetres (± 1 cm) using a degraded rule. At each sampling point, the rule was pressed vertically to allow us to take the correct measurements. In both cases, four climatic seasons are considered; winter (December to February), spring (March to May), summer (June to August) and autumn (September to November).

Vegetation cover

The vegetation cover study concerns the proportion of covered surface area by visual estimation. It is the vertical projection of aerial organs of plant species, in which scrub cover (%) was estimated visually in circular plots with a 25 m radius every 100 m in each trampled transect. Eight transects from 2 m to 4 m have been established in the 4 cardinal directions of Sebkhet Bazer. The proportions are therefore recorded in season; these values vary between 0 and 100%, for example the average vegetation cover of 70% covers 7/10 of the total area.

Bird surveys

Bimonthly counts were conducted from March 2013 to December 2014. Early in the morning until the afternoon, the counting was performed in the 4 cardinal points of the Sebkhet by choosing high altitudes to allow us to have a global view of the area, using a pair of binoculars (8 × zoom 30) and an Optolyth telescope (20 × 80). A digital camera of 5 megapixels resolution and the bird identification guide of Heinzel (Heinzel *et al.* 2011) were used for species identification.

Water bird counting is very attractive for its absolute method and an individual count was generally carried out when the group of birds was close to the survey unit (except 200 m) and less than 200 individuals. In the opposite case, when the group was remote and/or larger than 200 individuals, visual estimates were made (Houhamdi and Samraoui, 2002) and average values were noted. To ensure the application of this method, the work was done with the help of the conservators of the forests of El Eulma, SETIF.

Data exploitation and statistical analysis

The recorded water birds were grouped into 4 main groups (Anatidae, Phoenicopteridae, Rallidae and Shorebirds (including: Charadriidae family, Scolopacidae family), using the (Heinzel *et al.* 2011) grouping method. The bird's abundance, which represents the monthly number of species present on the site, was noted. The Shannon diversity index (H) (Shannon and Weaver, 1949) was calculated for each bird group, month and season as follow:

$$H' = \sum_{i=1}^{s} p_i \log 2 (p_i)$$

$$p_i = \frac{n_i}{N}$$

The statistical analysis was carried out in two steps. First, the seasonal differences in water body variables (temperature, pH, salinity, depth and vegetation cover) were tested using mixed linear models (models 1, 2, 3, 4 and 5). The four variables were used as response variables, while the season was included as an independent variable and the year as a random factor. In all cases, the experimental unit was the data recorded each month and finally post hoc tests (LSD de Fisher) were performed to verify the differences between the seasons. In these four models, the normality of the residuals was confirmed.

In the second step, the seasonal differences in bird abundance were tested for the 4 water bird groups (Anatidae, Phoenicopteridae, Rallidae and Shorebirds) using generalised mixed linear models (models 6, 7, 8 and 9), which adapted a Poisson distribution with a log function. The Shannon diversity index (H') of Anatidae and Shorebirds was also analysed by mixed liner models (model 10 and 11). Season was included as a fixed factor and year as a random factor in all models. The experimental unit considered was the recorded data for each month (three months per season) and post hoc tests (LSD de Fisher) were performed to verify seasonal differences. All statistical analysis was performed using the 2017 version of the InfoStatsoftware.

RESULTS AND DISCUSSION

Waterbird diversity

The monitoring of Sebkhet Bazer by the water bird allowed to inventory a total of 54 species belonging to 30 genera, 14 families and 7 orders. These species are grouped into 4 groups, including 22 shorebird species, Anatidae represented by 13 species, Rallidae with 2 species and Phoenicopteridae with 1 species (Table 1).

This remarkable avifauna richness were presented during our study, being these values greater compared to other sites as in Sebkhet Djendli (Bensizerara *et al.* 2013), despite its larger surface. This means the existence of favorable conditions for water bird to survive. The species present in the site have different periods of attendance, depending on their feeding needs, their reproduction and also their adaptation to climatic conditions.

Seasonal variation of environmental parameters

The precipitations of site presents seasonal fluctuations, spring is the most rainy month, 83.3mm is recorded in the month of March, on the other hand in the summer we recorded 0mm in the month of August. The water quality of Sebkhet Bazer varies from neutral to slightly alkaline, the pH varying from 6.91 to 8.6. The water temperature varies from 15.9 to 24°C, the salinity varies from 15% to 35%. Sebkhet Bazer area is characterized by its drought in summer, with a measured depth of 0 cm in some areas, reaching a maximum of 35 cm in May (spring). The percentage of vegetation cover is high in spring (May) with 80% coverage, but decreases in late summer (August) (Fig 2).

In models 1, 2, 3, 3, 4 and 5, seasonal variation in pH, salinity, water depth and vegetation cover is statistically significant (Table 2; Fig 2) According to post hoc tests, the temperature was higher in spring and summer than in winter and fall; pH was higher in summer than in other seasons; salinity was higher in summer and fall with lower values in winter; depth and vegetation cover were greater in spring and intermediate values in summer and winter (Fig 2).

Seasonal variation of water birds abundance and diversity

The Anatidae species reached 3,472 individuals during the winter, when the diversity index value was (2.15), the Rallidae species was represented by 542 individuals in the spring, while H' = 1,988. The Phonicoterideae species counted 2850 individuals. *Shorebirds* were very abundant in the fall with 2,865 individuals, or the H' index 1.488.

Statistical analysis using the abundance of Anatidae, Phoenicopteridae, Rallidae and Shorebird (models 6, 7, 8 and 9 respectively) also showed a significant effect of the seasonal variable (Table 3), which means that the abundance

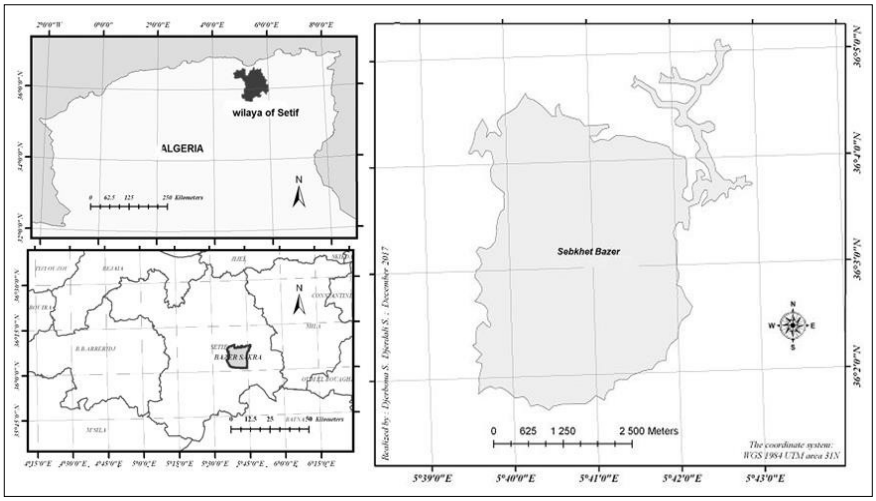

Fig 1: Geographical location of the Ramsar site of SebkhetBazer (North Eastern Algeria).

Table 1: Systematic list of waterbirds of Sebkhet Bazer (North Eastern Algeria).

Family	Species	Scientific name
Anatidae	Mallard	*Anas platyrhynchos*
	Eurasian Wigeon	*Anas penelope*
	Northern Shoveler	*Anas clypeata*
	Common Shelduck	*Tadorna tadorna*
	Ruddy Shelduck	*Tadorna ferruginea*
	EurasianTeal	*Anas crecca*
	Marbled Duck	*Marmaronetta angustirostris*
	Garganey	*Anas querquedula*
	Ferruginous Duck	*Aythya nyroca*
	Tufted Duck	*Aythya fuligula*
	Common Pochard	*Aythya ferina*
	White-headed Duck	*Oxyura leucocephala*
	Greylag Goose	*Anser anser*
Rallidae	Common Moorhen	*Gallinula chloropus*
	Eurasian Coot	*Fulica atra*
Ardeidae	Western Cattle Egret	*Bubulcus ibis*
	Grey Heron	*Ardea cinerea*
	Great Wihte Heron	*Egretta alba*
	Little Egret	*Egretta garzetta*
Phoenicopteridae	Greater Flamingo	*Phoenicopterus ruberroseus*
Ciconiidae	White Stork	*Ciconia ciconia*
Laridae	Yellow-legged Gull	*Larus michahellis*
	Slender-billed Gull	*Chroicoce phalusgenei*
	Black Tern	*Chlidoni asniger*
	Whiskered Tern	*Chlidonias hybrida*
	White-winged Tern	*Chlidonias leucopterus*
	Black-headed Gull	*Chroicoce phalusridibundus*
Podicipedidae	LittleGrebe	*Tachybaptus ruficollis*
Accipitridae	Long-legged Buzzard	*Buteo rufinus*
Accipitridae	Western Marsh Harrier	*Circusa eruginosus*
Recurvirostridae	Pied Avocet	*Recurvirostra avosetta*
	Black-winged Stilt	*Himantopus himantopus*
Haematopodidae	Eurasian Oystercatcher	*Haematopus ostralegus*
Charadriidae	Northern Lapwing	*Vanellus vanellus*
	Kentish Plover	*Charadrius alexandrinus*
	Little Ringed Plover	*Charadrius dubius*
	Common Ringed Plover	*Charadrius hiaticula*
	European Golden Plover	*Pluvialis apricaria*
	Grey Plover	*Pluvialis squatarola*
Scolopacidae	Common Snipe	*Gallinago gallinago*
	EurasianCurlew	*Numenius arquata*
	Spotted Redshank	*Tringa erythropus*
	Common Redshank	*Tringa totanus*
	Common Greenshank	*Tringa nebularia*
	Common Sandpiper	*Actitis hypoleucos*
	Ruff	*Philomachus pugnax*
	Wood Sandpiper	*Tringa glareola*
	Marsh Sandpiper	*Tringa stagnatilis*
	Green Sandpiper	*Tringa ochropus*
	Little Stint	*Calidris minuta*
	Dunlin	*Calidris alpina*
	Curlew Sandpiper	Calidris ferruginea
Threskiornithidae	Glossy ibis	*Plegadis falcinellus*
Gruidae	Common Crane	*Grus grus*

of these bird groups varies with the season (Fig 3). Thus, post hoc tests showed that Anatidae abundance was higher in winter; Rallidae and Phoenicopteridae were more abundant in spring, while *Shorebirds* reached a higher number in autumn (Fig 3). For all four groups, the lowest abundance was reached in summer, what could be attributed to the lack of rainy days during summer (Malavasi *et al.* 2009).Furthermore, the migratory populations leave the area in summer (Deshkar *et al.* 2010).

With respect to bird diversity represented by the Shannon Diversity Index, the two groups considered (Anatidae and *Shorebirds*) showed significant seasonal

Table 2: Fixed effects of the linear mixed models using the different environmental factors as response variables (physicochemical parameters, water depth and cover vegetation) in SebkhetBazer (North East Algeria).

Dependent variables	Independent variables	numDF	denDF	F-value	p-value
Model 1 - Temperature (°C)	(Intercept)	1	17	2964.94	<0.0001
	Season	3	17	23.84	<0.0001
Model 2 - pH	(Intercept)	1	17	4540.99	<0.0001
	Season	3	17	5.76	0.0066
Model 3 - Salinity (%)	(Intercept)	1	17	270.34	<0.0001
	Season	3	17	7.16	0.0026
Model 4 - Water depth (cm)	(Intercept)	1	17	127.61	<0.0001
	Season	3	17	34.31	<0.0001
Model 5 - Vegetation cover (%)	(Intercept)	1	17	167.05	<0.0001
	Season	3	17	12.84	0.0001

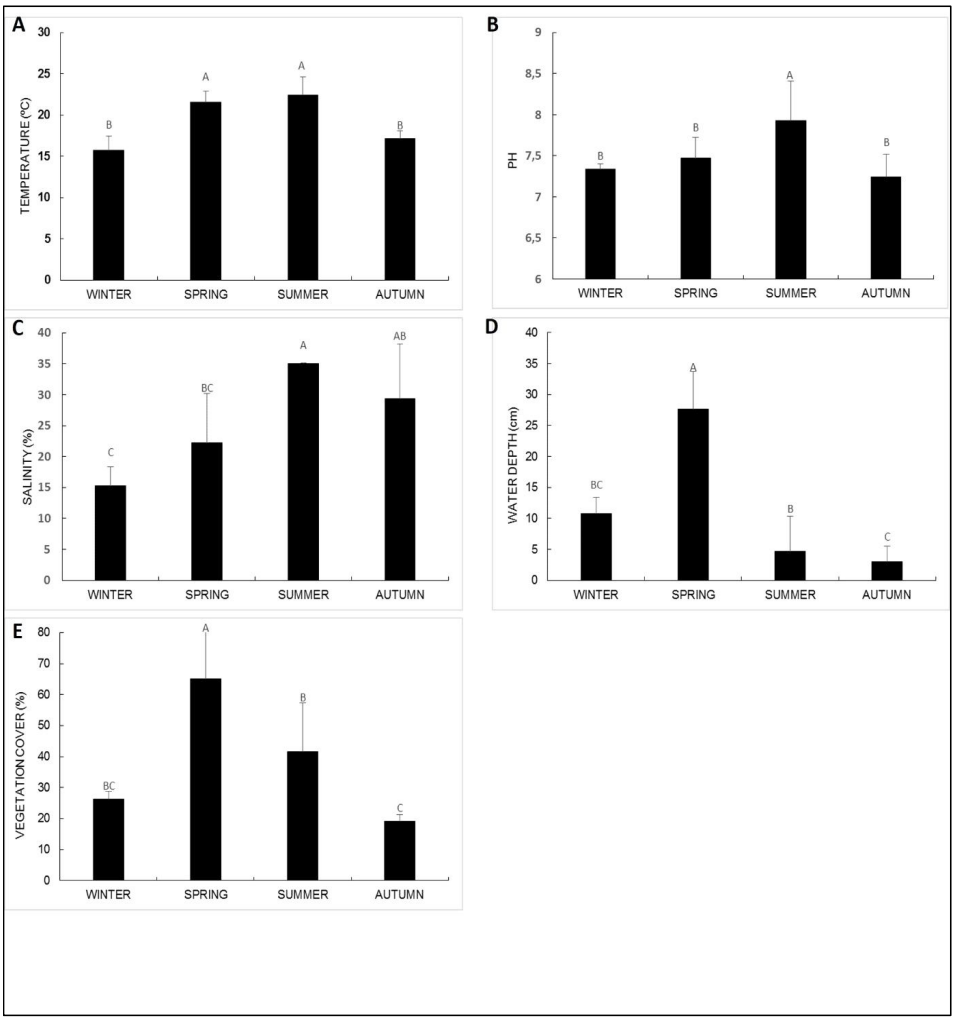

Fig 2: Mean values of the environmental variables in the four seasons in Sebkhet Bazer (North East Algeria). Capital letters show significant differences among seasons within each bird's group according to the post hoc test. The error bars show the standard error.

Table 3: Fixed effects of the generalized linear mixed models using the abundance of the different water bird's groups of Sebkhet Bazer (North East Algeria) as dependent variable.

Dependent variable	Independent variable	Chi-square	df	p-value
Model 6 - Anatidae	Season	9801.38	3	<0.0001
Model 7 - Rallidae	Season	1364.55	3	<0.0001
Model 8- Phoenicopteridae	Season	12022.14	3	<0.0001
Model 9 - Shorebirds	Season	11719.98	3	<0.0001

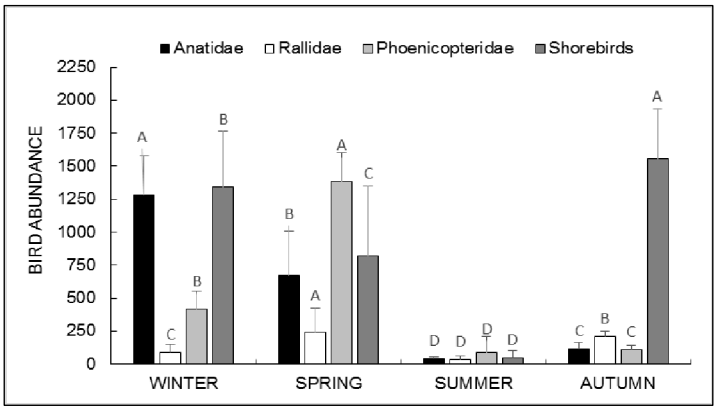

Fig 3: The mean abundance of the different groups of water birds in Sebkhet Bazer (North East Algeria). Capital letters show significant differences among seasons within each bird's group according to the post hoc test. The error bars show the standard error.

differences (models 10 and 11; Fig 4; Table 4). The diversity of Anatidae showed significant differences only between summer and autumn, while for *Shorebirds* only between spring and autumn (Fig 4).

Our results show different groups distribution of water birds among seasons, which could be related to environmental variables such as water depth, vegetation cover and consequently food availability. In fact, several studies have demonstrated that water birds composition, diversity and abundance are exposed to seasonal changes (Nirmal Kumar *et al*. 2007; Malavasi *et al*. 2009), reliant on factors as precipitation and hydrological regime also macroclimatic events (Romano *et al.* 2005).

Thus, wetlands being integrated systems are affected by the changes in the key physical as well as chemical parameters of hydrosphere (Sonal *et al.* 2010). The physicochemical parameter of water is influencing the distribution of water birds in Sebkhet Bazer by determination of the foraging behavior (Collazo *et al.* 2002; Darnell and Smith, 2004) and by the availability and abundance of the birds' prey (Manikannan *et al.* 2012).Vegetation cover has also an important effect on water birds especially in spring, when the highest cover was observed in our site, the area vegetation can create different micro-habitats (Nawaz-Rajpar and Zakaria, 2014).

Environmental prerequisites of the Anatidae species

The high abundance of the Anatidae species is observed in winter, we speak of wintering, in which the wintering of species and in particular of Anatidae corresponds to their more or less prolonged stay during the winter months away from their breeding grounds (El Agbani, 1997), Anatidea's wintering at Sebkhet Bazer could be explained by Sebkhet Bazer's position in several flyways (Krapu *et al*. 2006; Rizzo and Battisti, 2009), where waterfowl gather mainly in Anatidea in its winter quarters (between January) in the Western Palearctic (Rüger *et al*. 1986) and has a very particular sociability in the Mediterranean (Charchar *et al*. 2016).

Several studies confirm that Anatidae spend their winter in North Africa, particularly in Algeria (Houhamdi and Samraoui 2001, 2003; Metallaoui *et al*. 2014) and Morocco (El Agbani,1997); the high percentages observed during this period seem to be closely linked to the search for food for many Anatidae species (Houhamdi and Samraoui 2001, 2003; Metallaoui *et al*. 2014) and to parade activities (Tamisier and Dehorter, 1999).

Water levels control the availability and accessibility of food for ducks and other water birds (Therkildsen and Bregnballe, 2006; Dalby *et al*. 2013), this group can generally feed at depths up to 40 cm (Andrews, 1995) which is the case in this area.

On the other hand, the exploitation of resources in time and space during the wintering period depends largely on temperature (Maclean *et al*. 2008; Sauter *et al*. 2010). In Sebkhet Bazer, the lowest temperatures recorded during the winter are 5.10°C, which explains the favourable climate of Anatidae and its abundance, especially the mallards. Under very extreme conditions, this species is sensitive to winter temperatures (Sauter *et al*. 2010), the extreme cold further north during winter (*e.g*. with icing over of wetlands) can lead to cold-weather movements of some ducks to milder regions, such as North Africa.

Table 4: Fixed effects of the linear mixed models using the diversity of birds as response variables.

Dependent variable	Independent variable	numDF	denDF	F-value	p-value
Model 10 - Anatidae	(Intercept)	1	17	178.79	<0.0001
	Season	3	17	4.04	0.0245
Model 11 - Shorebirds	(Intercept)	1	17	87.62	<0.0001
	Season	3	17	3.91	0.0272

numDF = degree of freedom of numerator; denDF = degree of freedom of denominator.

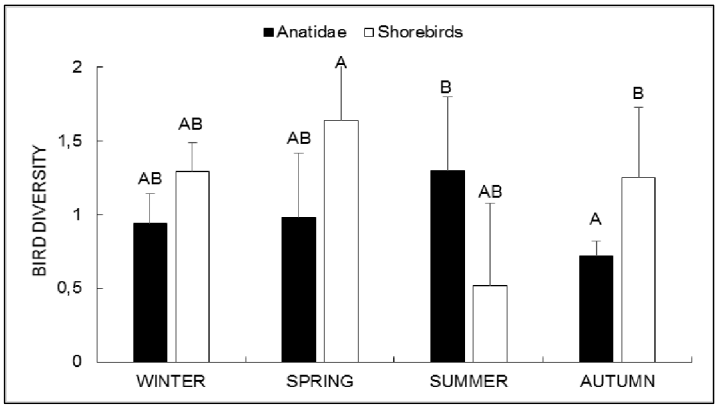

Fig 4: Mean diversity of Anatidae and Shorebirds of Sebkhet Bazer (north east Algeria) in the four seasons. Capital letters show significant differences among seasons within each bird's group according to the post hoc test. The error bars show the standard error.

Environmental prerequisites of the Phoenicopteridae species

The greater flamingo (*Phoenocopteridae* species) was more abundant in spring during its breeding season, which could be explained by the position of Sebkhet Bazer in North Africa as a critical breeding ground for the greater flamingo (Saheb *et al.* 2006; Bensaci *et al.* 2011).

According to the classification adopted by Ramsar, this site is classified on the basis of its importance in the reproduction of flamingo. Its abundance depends on food, climate and water levels (Tuite, 2000). In this study site, in spring, the average water depth was 27 cm, which could be considered an appropriate depth for this species, since pink flamingos prefer to feed from a few millimetres to 80 cm depth (Johnson and Cézilly, 2007), hence the importance of the Sebkhet for the great flamingo (Béchet and Johnson, 2008) which specifies the impact of the water level on Phonicopteridea.

In addition, the greater flamingo prefers the salt zone, as is the case of the Bazer Sebkhet, where high salinity values were reported in the spring. The results indicate that the salt zone has absolutely contributed to the increase in the population of flamingo, it uses this salt habitat in spring when its main prey "*Branchinectella media*" (Samraoui *et al*. 2006) is abundant (Bechet *et al*. 2009; Lee *et al*. 2011) as reported in this case study site by Gouga (2014).

Environmental prerequisites of the Rallidae species

This study concluded that Rallidae abundance was higher in spring, coinciding with the breeding season. During this season, deep water and vegetation cover had the highest values, which could provide habitat for nesting and foraging. As in this site, this group over winters and nests in the large saline waters of the Algerian highlands, including Setif (Djerdali, 1995; Baaziz *et al*. 2011) and in the Sahara (Samraoui and Samraoui, 2007; Samraoui *et al*. 2013) where vegetation density and depth are considered essential factors affecting their distribution and abundance (De Kroon, 2004). Hence, the Rallidae prefer muddy bottoms well recovered by emergent, floating or submerged vegetation (Fortunati and Battisti, 2011 ; Thevenot *et al.* 2003, Brambilla *et al*. 2012) report that this group prefers to nest in rivers bordered by a vegetation belt composed of bulrushes, as *Phragmites typha* and rushes (*Juncus autus* and *J. maritimus*), unpolluted and little affected by chemical pollution, where they can be better protected from floods or strong winds typical of the area (Boukrouma *et al*. 2016). This is the case for the spring biotope, where these species cover a large part of the study area. The water depth at Sebkhet Bazer in spring is also higher and can reach 35 cm, allowing Rallidae to nest (Brambilla *et al*. 2012) and where food is abundant (Zitouni *et al*. 2014).

Environmental prerequisites of the Shorebirds species

Shorebirds were most abundant in the fall, corresponding to the period before migration, when water depth reached its lowest value. During this migration period, Shorebirds adapt to seasonal (Sala *et al*. 2000) and annual climates, they can also adapt to climate by changing their behaviour or diet or by changing their migration routes (Stutzman and Fontaine, 2015).

The average precipitation has a negative impact on the abundance of several coastal waders (Rehfisch *et al*. 2004), which explains the Shore birds preference for mudflats (Cunningham *et al*. 2016; Philippe *et al*. 2016).The shallowest water depth for feeding (Zhenming *et al*. 2006) must be less than ten cm (Bellio and Kingsford, 2013) as in this site whose average value is 3 cm in autumn. In addition, the physico-chemical quality of water directly and indirectly affects their food accessibility (Manikannan *et al*. 2012; Pandiyan *et al*. 2014; Pandiyan and Asokan, 2016).

CONCLUSION

This case study highlighted interactions between the water bird diversity and abundance and the abiotic factors in Sebkhet Bazer, northeastern Algeria. On the basis of the promising findings presented in this paper, the abundance of the different water bird groups could be used as an ecological indicator of this wetland's characteristics. Sebkhet Bazer's abiotic variability gives it a particular capacity for the hosting and conservation of water birds, in which the distribution of these sensitive elements is influenced by seasonal environmental variables and also by other threats such as pollution, poaching, egg collection and drying of the area, which sometimes lasts for several months (June to November), due to climate change. Despite the international importance of this heritage site (Ramsar site), it nevertheless requires a genuine conservation strategy applicable by local authorities and residents.

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