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## SPATIO-TEMPORAL VARIATION PATTERNS OF BIRD COMMUNITY IN THE OASIS ECOSYSTEM OF THE NORTH OF ALGERIAN SAHARA

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### ABSTRACT

The spatial and temporal variation patterns of birds were investigated in the Oasis ecosystem of the North of Algeria Sahara. This contribution aimed to investigate the poorly studied bird fauna of Bousaâda oasis. The direct observation method was used for bird counts, adopted only during the breeding period. A total of 53 species of birds from 29 families and 16 orders were assessed in the different habitats of the Oasis (palm, fruit trees and, cultivated crops). The Passeriformes order was the most abundant represented by 35 species and 16 families. The relative abundance and species richness were recorded during our study period over different seasons and thought that whole surveyed stations represent all the oasis habitats. The Bousaâda oasis holds 18 resident-breeder species and is a transit zone for many migratory birds 14 and 10 species for summer and winter migrants respectively) and 11 occasional visitor ones. These results confirmed the positive effects of stations and seasons on the richness and abundance of birds of Bousaâda oasis.

**Keywords:** Oasis, bird, spatio-temporal, Algeria.

### INTRODUCTION

Biodiversity studies attracted the world's attention to ensure several ecosystem services and its impacts on humans (Harrington et al., 2010). Declines in biological diversity during the 20th century have been directly attributed to the growing human activities (Heywood and Watson, 1995). The oasis is considered as a fragile ecosystem of the arid climate. Its landscape relies mainly on the structure of desert-oasis-river components (Yang et al., 2010). Over the centuries, oases have played a key role in the local socio-economic development and in the ensuring of ecological balance. Over the last century, the oasis ecosystem has been affected seriously due to multiple natural and human constraints: drought, salinity, urbanization, and layout programs (Botes and Zaid, 2002).

Oases constitute key habitats due to their ecological characteristics to survey biodiversity (Chenchouni, 2012). According to the Ramsar Convention, oases are considered a type of inland wetlands (Ramsar, 2007). However, the ecological characteristics of oases in Algeria varied between regions following their geographic location. Although, the ecosystems of arid and desert regions has very peculiar biodiversity related to locale biotope and climate (McGinley, 2007) particularly birds (Roshier et al., 2001; Mwaura, 2010; Chenchouni, 2012).

The avifauna of Algerian oases were reported by Heim de Balsac and Mayaud (1962) and Dupuy (1966) followed by updated data (Ledant et al., 1981; Isenmann and Moali, 2000; Samraoui, 2008). In southern Tunisia, many surveys were undertaken on the diversity and distribution of this avifauna (Selmi et al., 2002). Some studies were available on birds of oases in Algeria

(Boukhemza, 1990; Chenchouni, 2012; Bensaci et al., 2013) but these are insufficient and limited to some regions and/or occasional observations.

The present study was undertaken with the two basic objectives: i) to assess the bird diversity of the oasis located in arid climate differently to previous studies on Oases of Sahara Desert; and ii) to evaluate the spatio-temporal variation patterns of birds within Bousâada oasis.

## MATERIAL AND METHODS

### Study Area

Bousâada (35° 12' 36.97''N, 4° 10' 46.08''E) is a marvelous oasis, located in the centre of the northwardly located state of Algeria at an altitude of 602m above the sea level (Figure1). The oasis is delimited by three structural groups: high plains of the Algiers-Oran steppes to the north and east, Saharan desert to the south, and Saharan Atlas to the west (Kaabeche, 1990). The area has an arid climate (annual mean temperature 25°C, average annual precipitation <185.8 mm) with dry season extends all along the year.

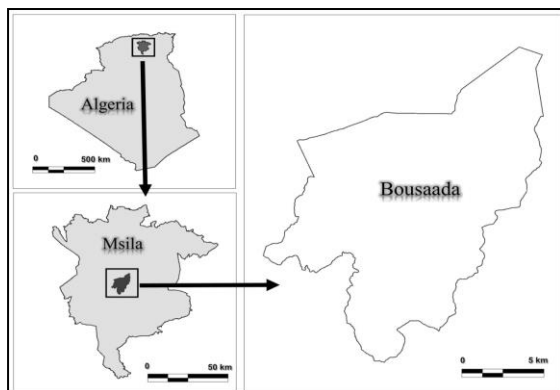


Figure 1: Study area location.

Bousâada oasis is the first one encountered while heading from the coastline to the Sahara Desert (Boutabba, 2013) Oasis is crossed by Oued Bousâada, flowing at the foot of a huge cliff used for irrigation. The landscape is dominated by

palm trees (*Phoenix dactylifera L.*) mixed with fruit trees and cultivated crops.

### Bird Surveys

Bird surveys were conducted from March 2019 to March 2020 which covered all seasons of the year, with three passes are performed in each station during each season, which normally can detect all wintering, visitor passage and breeding species (Blondel, 1975). The territory-mapping method is considered the most accurate and appropriate method for estimating species richness and then the abundance of avian communities, particularly in open habitats (Bibby et al., 1992).

This approach based on the assessment of all contacted birds and their abundances during a period of 15 minutes. A pair of binoculars (8×42) and a field guide book were also used to identify the species of birds observed. Counts were performed in calm weather, avoiding harsh weather, wind and bitter cold). A total set of 19 census points (station) was allocated non-randomly, based on accessibility and habitat type. Overall, these stations located in four (4) studied regions: Zakat El-Kib (ZEK), Loulaj (LLJ), JnanLebtom 1 (JB1) and, JnanLebtom 2 (JB2) (Table 1). These regions have different habitat characteristics. Depending on their location, the surveyed stations are the subject of varied urban pressure and human disturbance. Phenological types used were (1) resident breeder (RB) species present all year with breeding proof; (2) winter visitor (WV) species observed exclusively during the rainy season; (3) summer visitor (SV) migratory species in summer; (4) occasional visitor (OV) species that observed in the study region at least once (Isenmann and Moali, 2000).

Avian species richness was defined as the total number of species detected at each station during the study period. However, the species abundance

**Table 1: Characteristics of studied regions.**

Region	No. of stations	Vegetation Species Richness ( $\pm$ SD)	NDVI
<b>ZEK1</b>	4	47.00 $\pm$ 6.40	0.38 $\pm$ 0.03
<b>JB 2-1</b>	5	32.4 $\pm$ 7.68	0.23 $\pm$ 0.03
<b>JB 1-1</b>	5	37.00 $\pm$ 13.68	0.35 $\pm$ 0.04
<b>LLJ-1</b>	5	38.00 $\pm$ 6.80	0.29 $\pm$ 0.09

*NDVI: The normalized difference vegetation index*

corresponded to the highest number of birds counted by species indifferent point surveys.

### Data Analysis

Statistical tests were performed using SPSS 17.0 with a significance level of  $P \leq 0.05$ . All means are shown  $\pm$  standard error of mean unless stated otherwise.

We used parametric tests and ANOVA to test all variables, when the normality (Kolmogorov–Smirnov test) and homoscedasticity (Levene test), variables that did not conform to the requirements for parametric tests were transformed by logarithm or a square-root transformation before all analyses (Underwood, 1996).

A one-way multivariate analysis of variance (MANOVA) was performed to test the effect of stations and seasons on the richness and abundance of assessed birds.

The Shannon's diversity index ( $H' = -\sum pi \log pi$ ), where  $pi$ : is the proportion of individuals belonging to the  $i$ : the species) was used to identify the  $\alpha$ -diversity of bird species in different stations (Magurran, 2004). High values of  $H'$  and low values of  $H'$  indicate high species diversity (Krebs, 1999).

Equitability (Evenness), the distribution of abundances among species was computed as  $J' = H'/\ln S$ , whereas  $S$  is the number of species in each station (Magurran, 2004). Evenness ranges from 0 to 1 and as it approaches 1, individuals are

partitioned equally among species (Krebs, 1999).

## RESULTS

### Specific Richness

A total of 53 bird species, representing 40 genera, 29 families and 16 orders were recorded in the Oasis of Boussaâda from all surveyed stations (Table 1). Order Passeriformes was represented by the highest number of species (35; 16 families). Order Columbiformes was represented by 4 species while orders Accipitriformes, Pelecaniformes and Charadriiformes by two species each. Other orders (11) were represented by only a single species, (Table 2).

### Spatial Richness and Abundance Variation of Birds

The species mean richness varied significantly between surveyed stations (ANOVA:  $F_{1, 18} = 7.76$ ,  $P = 0.000$ ). The high mean richness value was recorded in the JB1-2 (13.18 $\pm$ 2.82) where the lower was marked in JB1-5 (5.18 $\pm$ 3.06) (Table 3).

The species mean abundance varied significantly between surveyed stations (ANOVA:  $F_{1, 18} = 6.79$ ,  $P = 0.000$ ). The high abundance was recorded in the JB2-1 (80.18 $\pm$ 41.91) where the lower was in JB1-5 (9.54 $\pm$ 6.50) (Table 3) one-way MANOVA confirmed the statistically significant difference in richness and abundance between stations,

**Table 2: Taxonomic list of the bird species recorded at all the different surveyed stations in the Bousaâda oasis during 2019 to 2020.**

Order	Family	Species	Common Name	Phenoloical Category
<b>Passeriformes</b>	Muscicapidae	<i>Phoenicurus moussieri</i>	Moussier's Redstart	OV
		<i>Phoenicurus ochruros</i>	Black Redstart	WV
		<i>Phoenicurus phoenicurus</i>	Redstart	OV
		<i>Oenanthe deserti</i>	Desert Wheatear	OV
		<i>Oenanthe leucura</i>	Black Wheatear	RB
		<i>Lusciniamе garhynchos</i>	Nightingale	SV
		<i>Erithacus rubecula</i>	Robin	WV
		<i>Ficedula hypoleuca</i>	Pied Flycatcher	SV
		<i>Muscicapas triata</i>	Spotted Flycatcher	SV
	Sylviidae	<i>Sylvia atricapilla</i>	Black cap	WV
		<i>Sylvia hortensis</i>	Western Orphean Warbler	SV
		<i>Sylvia melanocephala</i>	Sardinian Warbler	RB
	Phylloscopidae	<i>Phylloscopus collybita</i>	Chiff chaff	WV
		<i>Phylloscopus sibilatrix</i>	Wood Warbler	SV
		<i>Phylloscopus trochilus</i>	Willow Warbler	SV
	Fringillidae	<i>Chloris chloris</i>	Green finch	RB
		<i>Serinus serinus</i>	Serin	RB
		<i>Bucanetes githagineus</i>	Trumpeter Finch	OV
	Motacillidae	<i>Motacilla alba</i>	Pied Wagtail	WV
		<i>Motacilla cinerea</i>	Grey Wagtail	WV
		<i>Anthustrivialis</i>	Tree Pipit	OV
	Laniidae	<i>Lanius elegans</i>	Great Grey Shrike	WV
		<i>Lanius senator</i>	Woodchat Shrike	SV
	Passeridae	<i>Passer domesticus</i>	House Sparrow	RB
		<i>Passer montanus</i>	Tree Sparrow	RB
	Turdidae	<i>Turdus merula</i>	Black bird	RB
		<i>Turdus philomelos</i>	Song Thrush	WV

	Acrocephalidae	<i>Iduna opaca</i>	Western Olivaceous Warbler	SV
	Paridae	<i>Cyanistes teneriffae</i>	African Blue Tit	RB
	Alaudidae	<i>Galerida cristata</i>	Crested Lark	RB
	Emberizidae	<i>Emberiza striolata</i>	Striolated Bunting	RB
	Corvidae	<i>Corvus corax</i>	Raven	RB
	Hirundinidae	<i>Hirundo rustica</i>	Swallow	SV
	Sturnidae	<i>Sturnus vulgaris</i>	Starling	WV
	Cisticolidae	<i>Cisticola juncidis</i>	Zitting Cisticola	RB
<b>Columbiformes</b>	Columbidae	<i>Streptopeliade caocto</i>	Collared Dove	RB
		<i>Streptopelia senegalensis</i>	Laughing Dove	RB
		<i>Streptopelia turtur</i>	Turtle Dove	SV
		<i>Columba livia</i>	Rock Dove	RB
<b>Accipitriformes</b>	Accipitridae	<i>Neophronpercnopterus</i>	Egyptian Vulture	SV
		<i>Circus aeruginosus</i>	Western Marsh Harrier	OV
<b>Pelecaniformes</b>	Ardeidae	<i>Bubulcus ibis</i>	Cattle Egret	RB
		<i>Nycticorax nycticorax</i>	Black-crowned Night-heron	OV
<b>Charadriiformes</b>	Charadriidae	<i>Charadrius dubius</i>	Little Ringed Plover	SV
	Scolopacidae	<i>Tringa ochropus</i>	Green Sand piper	WV
<b>Ciconiiformes</b>	Ciconiidae	<i>Ciconia ciconia</i>	White Stork	SV
<b>Gruiformes</b>	Gruidae	<i>Grus grus</i>	Crane	OV
<b>Falconiformes</b>	Falconidae	<i>Falco tinnunculus</i>	Kestrel	RB
<b>Strigiformes</b>	Strigidae	<i>Athenenoctua</i>	Little Owl	OV
<b>Bucérotiformes</b>	Upupidae	<i>Upupaepops</i>	Hoopoe	RB
<b>Coraciiformes</b>	Meropidae	<i>Merops apiaster</i>	Bee-eater	SV
<b>Piciformes</b>	Picidae	<i>Jynxtor quilla</i>	Wryneck	OV
<b>Galliformes</b>	Phasianidae	<i>Alectoris barbara</i>	Barbary Partridge	OV

(RB=resident breeder, SV =summer visitor, OV: = occasional visitor, WV =winter visitor)

F (36, 378) = 6.37, p <.0005; Wilk's  $\Lambda$  = 0.378.

**Table 3: Spatial mean richness and abundance variations of assessed birds.**

Station	Richness (Mean $\pm$ SD)	Abundance (Mean $\pm$ SD)
JB1-1	5.82 $\pm$ 4.75	18.09 $\pm$ 11.84
JB1-2	13.18 $\pm$ 2.82	44.27 $\pm$ 40.90
JB1-3	8.45 $\pm$ 4.03	28.64 $\pm$ 18.40
JB1-4	6.45 $\pm$ 2.84	12.91 $\pm$ 5.28
JB1-5	5.18 $\pm$ 3.06	9.55 $\pm$ 6.50
JB2-1	12.82 $\pm$ 2.68	80.18 $\pm$ 41.91
JB2-2	8.00 $\pm$ 1.84	39.82 $\pm$ 18.62
JB2-3	6.73 $\pm$ 2.24	39.82 $\pm$ 23.37
JB2-4	7.18 $\pm$ 1.83	50.64 $\pm$ 30.02
JB2-5	7.09 $\pm$ 1.22	52.91 $\pm$ 30.33
LLJ1	11.00 $\pm$ 4.05	33.18 $\pm$ 44.27
LLJ2	7.45 $\pm$ 3.08	10.09 $\pm$ 8.29
LLJ3	8.36 $\pm$ 1.63	20.09 $\pm$ 32.33
LLJ4	9.36 $\pm$ 2.46	10.82 $\pm$ 5.56
LLJ5	7.18 $\pm$ 2.44	11.00 $\pm$ 5.80
ZEK1	11.91 $\pm$ 2.07	68.82 $\pm$ 32.53
ZEK2	10.55 $\pm$ 4.01	52.18 $\pm$ 40.37
ZEK3	10.55 $\pm$ 2.25	52.09 $\pm$ 24.62
ZEK4	10.73 $\pm$ 1.68	45.18 $\pm$ 24.41

**Seasonal Richness and Abundance Variation of Birds**

The species richness varied significantly between seasons (ANOVA:  $F_{1,3} = 3.65$ ,  $P = 0.013$ ). The high mean richness value was recorded during spring (9.82 $\pm$ 3.95) whereas the winter had the minimum richness (7.92 $\pm$ 3.30) (Table 4). However, no significant difference in abundance was found between seasons (ANOVA:  $F_{1,3} = 5.07$ ,  $P = 0.069$ ).

Similarly one-way MANOVA suggest a statistically significant differences in richness and abundance difference between seasons (F 36, 378 = 6.37, p <.0005; Wilk's  $\Lambda$  = 0.378).

**Table 4: Seasonal mean richness and abundance variations of assessed birds.**

Season	Richness (Mean $\pm$ SD)	Abundance (Mean $\pm$ SD)
Autumn	7.95 $\pm$ 2.87	27.92 $\pm$ 25.76
Spring	9.82 $\pm$ 3.95	31.72 $\pm$ 23.82
Summer	8.75 $\pm$ 3.38	34.70 $\pm$ 25.57
Winter	7.92 $\pm$ 3.30	53.50 $\pm$ 53.57

**Shannon-Weaver Diversity and Evenness (Equitability) Indexes**

The highest value of the Shannon diversity index was observed in the JB1-3 (3.64) and the lower of 2.34 was recorded in the JB1-4 station (Fig 2). The maximum value of the equitability index was recorded in the LLJ5 station (0.77), where the minimum value was noted in the JB1-4 (0.53) (Figure 3).

**Phenological Status of Birds**

The avifauna of Bousâada Oasis is dominated by resident breeder species (18 species), followed by summer visitor species (14 species), occasional visitor (11 species), and winter migrant (10 species) (Figure 4).

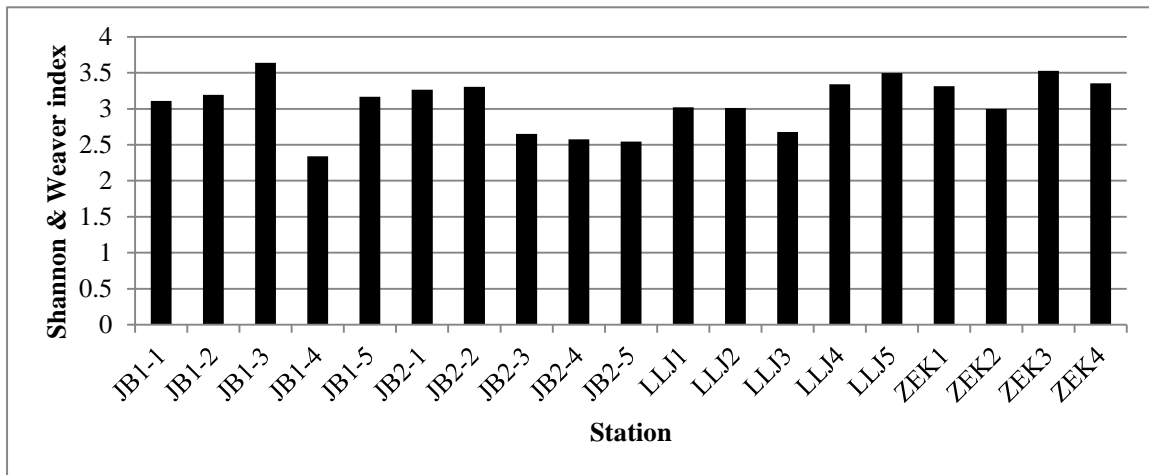


Figure 2: Shannon-Weaver diversity index variation of birds of Bousaâda Oasis.

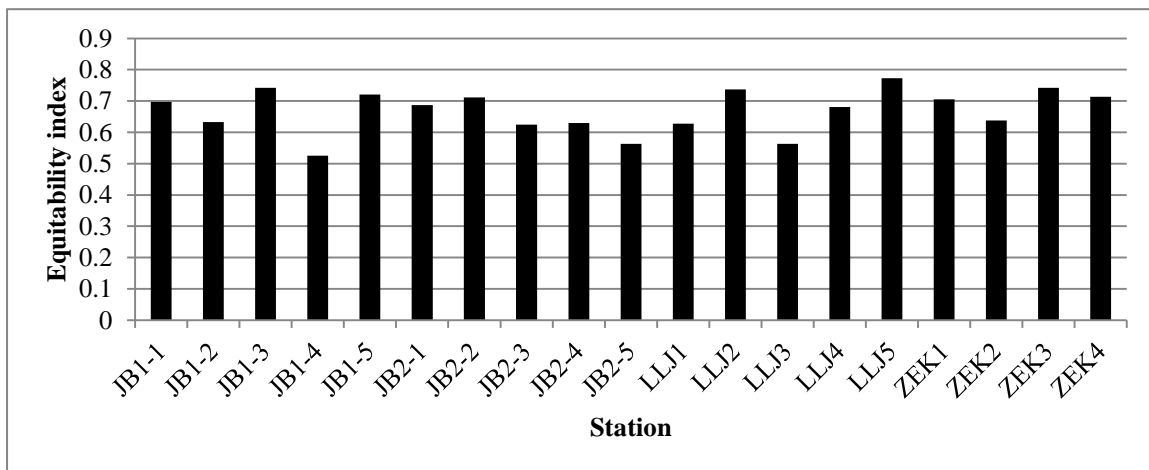


Figure 3: Evenness (Equitability) index variation of birds of Bousaâda Oasis.

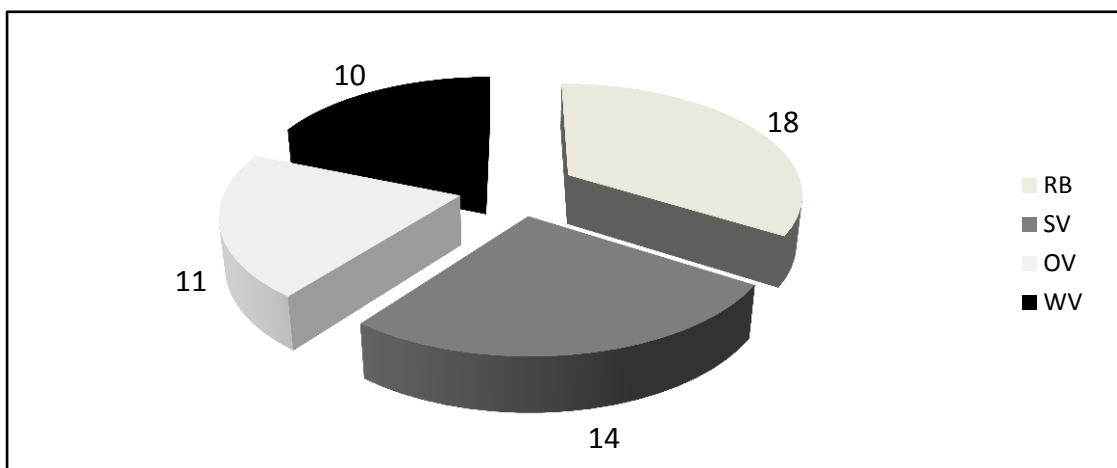


Figure 4: Phenological status of birds of Bousaâda Oasis.

RB: Resident breeder, SV: Summer visitor, OV: Occasional visitor, WV: Winter visitor



## DISCUSSION

The inventory of birds in Bousaâda oasis suggests that 53 bird species, representing 7.66% of the Algerian birds (Isenman and Moali, 2000). However, in the Ziban region (Biskra, Algeria) Farhi and Belhamra (2012) identified 136 species representing 18 orders and 42 families (including waterbirds), of which Passeriformes were represented by 58 species (12 families). Guezoul et al (2013) reported 59 species present over a larger area, covering three oases of the Northern Algerian Sahara.

The assessed richness in the study area is lower than that reported in south Tunisian oases, (Selmi, 2002: 86 species, 13 families, 4 orders). Species richness at Bousaâda oasis, was higher than that recorded by Guezoul et al. (2013) for different oases (Biskra: 47, Oued Souf: 33 and Ouargla: 44).

The highest richness of oases birds in Algeria was recorded in Timimoun region (SW Algeria), where 100 species (59 genera, 28 families and, 12 orders) were described. Large number of species can be attributed to varied habitat sampled, such as oases, salt lake, reeds, and suburban area (Boukhemza, 1990).

Order Passeriformes is prominently represented in all avian populations that are present in the oasis (66% of assessed species). This is in line with previous studies on oases birds of Algeria (Farhi and Belhamra, 2012; Guezoul et al., 2013). The presence of several bird species in the surveyed oases is closely linked to their phenology.

During the monitoring many species were presented in the most surveyed stations such as: Hybrid sparrow, Collared Dove, Laughing Dove, Turtle Dove, Rock Dove, Greenfinch and Blackbird), some of these are known to have an expansion of their distribution range over the Mediterranean basin (Bergier et al., 1999; Bendjoudi *et al.*,

2013) and worldwide (Bonter et al., 2010). These species are considered as the most abundant and the common birds in all oases of the Tunisian Sahara (Selmi., 2002).

Bousaâda oasis is known to have a high anthropogenic pressure (urbanization, high rate of ground water extraction, land encroachment) which led to the loss of many habitats, affecting bird's richness and abundance. Donnelly and Marzluff (2006) confirmed that bird species richness decreases with increasing urban land cover.

Assessed species represent different phenological status: 18 resident breeder species (34%), followed by 14 summer visitor species (26%), 11 occasional visitors (21%), and 10 winter migrant species (19%). The dominance of resident breeder species could be justified by the heterogeneity of the micro-habitats of oasis that contains palm and fruit trees and cultivated crops. Isenmann and Moali (2000) and Ledant et al., (1981), recorded that the species, like, *Phoenicurus ochruros*, *Erithacus rubecula*, *Sylvia atricapilla*, *Phylloscopus collybita*, *Motacilla alba*, *Motacilla cinerea*, *Lanius elegans*, *Turdus philomelos*, *Sturnus vulgaris*, and *Tringa ochropus*, as winter visitor to Algerao oasis. Other species, like, *Phoenicurus moussieri*, *Phoenicurus phoenicurus*, and *Bucanetes githagineus* are occasional visitors that use oasis as a stopover point during their trans-Saharan journey. These species stop on oases to supply energy to be able to reach their wintering or breeding site (Lavee et al., 1991, Bairlein, 1992; and Biebach et al., 2000).

Abundance of some species, such as feral pigeons, swallows, swifts, and a few other species that breed in walls indicated increased urbanization. Thus, landscape transformation of the oasis during last decade has been indicated previously (Botes and Zaid, 2002; Meddich et al., 2018). Significant special variation reveals the high quality of

habitats with high supply of seeds and productivity (Emlen, 1974).

The stations presented a high urban pressure and human disturbance were recorded a low species richness, which is in confirmation of Chace and Walsh (2006) and Sandström et al., (2006). Furthermore, variations in the composition of bird communities and abundances of species tend to be associated with the composition and structure of vegetation (Sewell and Catterall, 1998; White et al., 2005 and Daniels and Kirkpatrick, 2006).

Shannon and Weaver's index allow us to measure the complexity of a stand. A high value of this index indicates a settlement in many species for a small number of individuals. Conversely, a low value of the latter is either or a settlement characterized by a small number of species for many people, or to a settlement in which there is a dominant species. In other words, he studied the equilibrium of populations in an ecosystem.

Despite the rapid urbanization of Bousaâda region, this relevant diversity can be used to support the conservation of native bird populations, which is particularly important in biodiversity hotspots located in the arid region.

## CONCLUSION

Our results confirmed that Bousaâda oasis represents an important habitat exploited as wintering grounds, stopover site during trans-Saharan migration, and breeding sites for several species. Regarding the strategic geographic situation of this region as a key in the regional scale biodiversity and bird's dynamic this needs further investigations on habitat preferences of birds.

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