Pakistan J. Zool., vol. 51(2), pp 433-447, 2019. DOI: http://dx.doi.org/10.17582/journal.pjz/2019.51.2.433.447

Effect of Habitat Types on Breeding Bird Assemblages in the Sidi Reghis Forests (Oum El Bouaghi, North-Eastern Algeria)

Abderraouf Chouaib Rebbah[1], Mohcen Menaa[2,*], Salah Telailia[3], Menouar Saheb[1] and Mohamed Cherif Maazi[2]

[1]*Department of Natural and Life Sciences, Faculty of Sciences, University of Oum El Bouaghi, Constantine Road, Oum El Bouaghi, Algeria*
[2]*LEAT Laboratory, Department of Biology, Faculty of Natural and Life Sciences, University of Souk-Ahras, Annaba Road, Souk-Ahras, Algeria*
[3]*Faculty of Sciences, University of El Tarf, El Tarf, Algeria*

ABSTRACT

This study was set in three forest habitats of Sidi Reghis Mountain within the province of Oum El Bouaghi (north-eastern Algeria). We conducted the first bird survey in this area using the point count method to describe the composition of woodland breeding avifauna and to analyze the spatial distribution among habitat types (oak woodlands, pine woodlands and oak-pine mixed woodlands). A total of 69 species were observed. One species was recorded only in mixed oak-pine forests, six were found exclusively in oak woodlands and 17 species were found only in pine woodlands. We noted 20 protected species, only one endangered species, and five endemic species to the Maghreb and/or to North Africa. The presence of these species with patrimonial value reinforces the importance of the conservation of Sidi Reghis avifauna. Bird abundance, species richness and species diversity were significantly higher in pure pine woodlands than in mixed oak-pine and oak forests. According to PERMANOVA and ANOSIM tests, and the NMDS plot, the avian assemblages of Sidi Reghis Mountain varied significantly between different habitats. Further, SIMPER test indicated that six of the seven species were responsible for the mean of 50% of dissimilarity between sampled habitats. The dissimilarity between pine woodlands and mixed oak-pine forests was about 50%, in general, and produced by differences in abundance of Common Chaffinch *Fringilla coelebs,* European Serin *Serinus serinus,* House Sparrow *Passer domesticus,* European Greenfinch *Chloris chloris,* Spotted Flycatcher *Muscicapa striata,* and Common Blackbird *Turdus merula*. The differences between pine woodlands and oak woodlands (about 60%) and oak-pine mixed woodlands and oak woodlands (about 50%) were mainly produced by species that were present in just one sampled area, most with preference for pine woodlands. The differences related to pine woodlands are the results from Moussier's Redstart *Phoenicurus moussieri* and European Turtle Dove *Streptopelia turtur* presence.

Article Information
Received 12 March 2018
Revised 23 May 2018
Accepted 13 June 2018
Available online 29 January 2019

Authors' Contribution
ACR and MM did bird survey, analyzed the data and wrote the article. ST, MS and MCM helped in bird surveys and in writing of the manuscript.

Key words
Sidi Reghis forests, Point count, Avian assemblages, Habitat types, Community parameters.

INTRODUCTION

Birds are one of the most attractive life forms on Earth, with their ability to fly and wonderful coloration. They are found in different habitat types across the globe and provide numerous ecosystem services for the suite of species that live alongside them (Sekercioglu, 2006; Whelan *et al*., 2008). Birds are often used as a wildlife tool for a variety of purposes that facilitate the development of management strategies in avian protection and their effective implementation in nature conservation practices (Titeux, 2006).

Avian scientists have long been interested in the role that environmental characteristics play in avian-habitat relationships. Habitat features have been shown to greatly influence the structure and composition of bird assemblages, as well as the range and occurrence of bird species (MacArthur and MacArthur, 1961; MacArthur, 1964; Cody, 1985; Wiens, 1989). Research indicates that distribution patterns of forest bird assemblages are related to the availability of resources such as food, and niche space, which are in turn affected by habitat diversity and composition (MacArthur and MacArthur, 1961; MacArthur, 1964; Cody, 1985; Wiens, 1989). Also, many biologists have considered floral composition as the secondary determinant factor affecting bird community assemblages (Holmes and Robinson, 1981; Wiens and Rotenberry, 1981; Robinson and Holms, 1984; Rotenberry, 1985; Benyakoub, 1993; Bellatreche, 1994). Other factors such as foliage volume (Buchanan *et al*., 1999), tree age

* Corresponding author: m.menaa@univ-soukahras.dz
0030-9923/2019/0002-0433 $ 9.00/0

(Sallabanks *et al*., 2006), plant productivity (Cody, 1981), structure of the shrub stratum (Reid *et al*., 2004; Díaz, 2006), plant succession and stand management (Sweeney *et al*., 2010), size and configuration of patchy habitats, connectivity (Henderson *et al*., 1985) and edge effects (McGarigal and McComb, 1995; Turner *et al*., 2001) have also been revealed to impact avian assemblages.

Multiple studies on Algerian water birds in aquatic environments have produced species lists that are useful descriptors for distributional patterns (Houhamdi and Samraoui, 2002; Samraoui and Samraoui, 2008), but there are only a few avian studies associated with Algerian forest environments that have analyzed how bird community composition varies with habitat characteristics across ecological gradients (Benyacoub, 1993; Bellatreche, 1994; Mostefai, 2011; Menaa *et al*., 2016). These and other descriptive studies (Bensizerara *et al*., 2013) have dealt with the breeding ecology of bird communities in forested habitats (Bensouilah *et al*., 2014; Boudeffa *et al*., 2015).

The mountain of Sidi Reghis is located in a mountainous region of Algeria. Due to the size of its land surface area and altitude, which varies between 800 m and 1635 m above sea level (a.s.l.), the mountain is characterized by higher rainfall and a unique vegetation cover, both of which differ vastly from the climatic conditions and plant assemblages that occur in the semi-arid lowlands that surround it (Mosbah, 2007). These contrasting bioclimatic zones are clearly mirrored in the variance of the vegetation structure, which boasts diverse plant species, and consequently habitats. Natural processes, such as soil erosion from water and wind, as well as temporal changes affect plant succession on Sidi Reghis. Floral assemblages are additionally impacted by anthropogenic disturbance factors (FAO, 2012), due to the proximal location of well-developed human settlements at the base of the mountain. Anthropological impacts through the exploitation of wood, over-grazing, fires, reforestation, and the uncontrolled dumping of garbage (Mosbah, 2007), all affect the biodiversity of forested patches.

In this study, the aim is to inventory the forest avifauna of Sidi Reghis**,** and to explore the effects of habitat types on avian assemblages by studying community parameters (abundance, species richness and occurrence frequency); to determine the intensity of habitat selection by each species. In addition, this study also aimed to providing management recommendations that encourage forest avifauna to live and breed in different forest types of the Sidi Reghis Mountain.

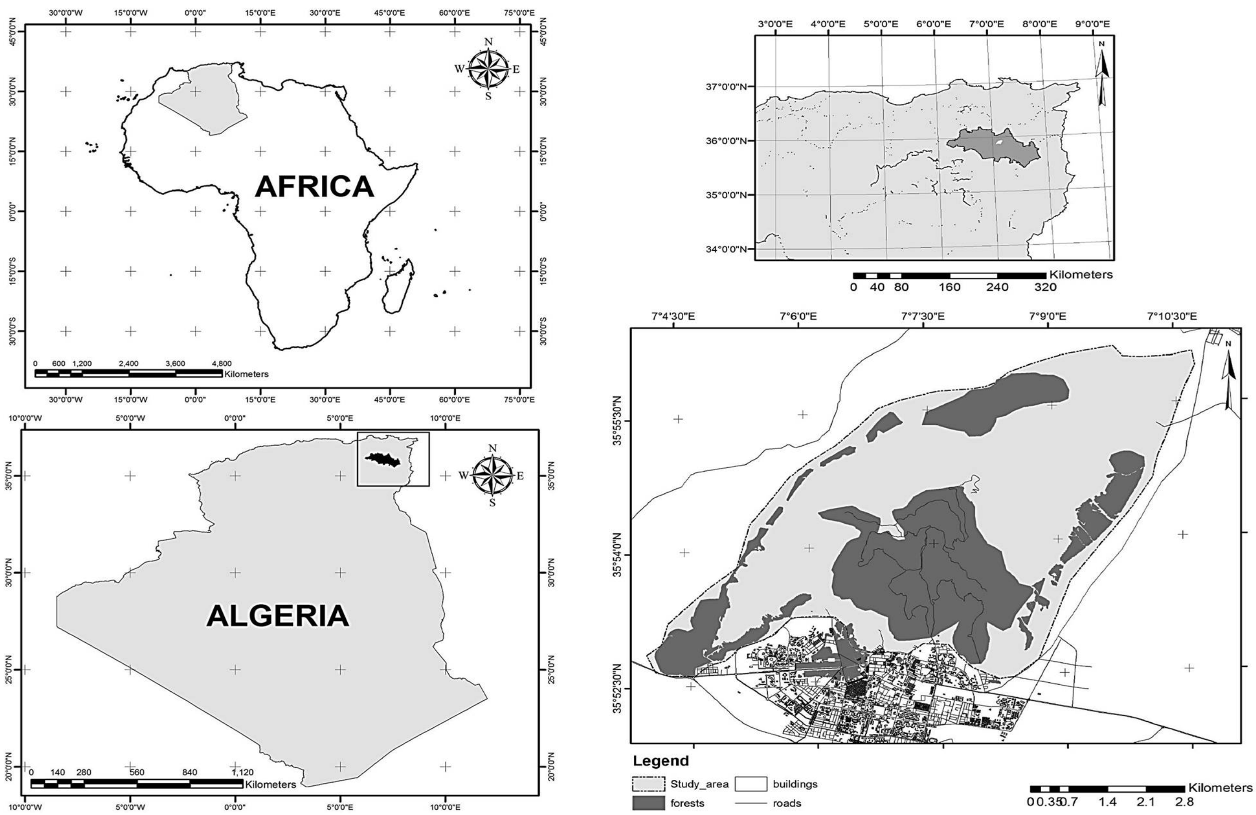

Fig. 1. Geographic location of the mountain of Sidi Reghis.

MATERIALS AND METHODS

Study site

This study was carried out in the mountain of Sidi Reghis in Northeastern Algeria near the town of Oum El Bouaghi. The study area covers approximately 4106 ha and forms a part of the Hracta forest (Fig. 1), which belongs to the forest zone of the Algerian-Tunisian border and extends over more than 26,000 ha (Boudy, 1955). The central locality of the Sidi Reghis Mountain is located at 35° 54' 10.27" N and 7° 7' 26.58" E. The main soil types are clay, calcareous-clay, and ferruginous soils, of which calcareous-clay soil dominates (BNEDER, 1997). The climate is semi-arid, with a seven-month dry season from May to November, and a rainy season from December to April. Mean annual precipitation ranges from 267.91 mm to 435.88 mm, and average monthly temperatures are 4.8°C in December and 34.33 °C in July (ONM, 2016).

According to Mosbah's (2007) description, there are two main parts in the Sidi Reghis forest; native (indigenous) tree species (*Quercus ilex*) and reforested (non-native) tree species (*Pinus halepensis*). The forest includes three major habitat types that are classified according to the dominant tree species: holm oak (*Quercus ilex*) forests, Aleppo pine (*Pinus halepensis*) stands and mixed oak and pine stands.

Bird surveys

Birds were surveyed using a point count or IPA method (Indices Ponctuels d'Abondance; see Blondel *et al*., 1970; Bibby *et al*., 1992), with two bird surveys undertaken over the breeding season in 2014, 2015 and 2016 (Drapeau *et al*., 1999). One survey took place from mid-March to mid-April for early breeders and the second from mid-May to mid-June for species that arrived later.

The census technique involved a count of all birds seen or heard inside or outside a 100 m radius circular plot during a 15 min period. Birds that flew over and did not land in trees or on the ground were recorded but not included in the data analysis because point counts were not considered a suitable method for these taxa (Bibby *et al*., 2000). Surveys were restricted to good weather conditions (no rain and wind speed lower than 20 km/h) and occurred within the four hours of sunrise, when vocal activities of diurnal birds began (Frochot and Roché, 1990). We established 126 point count stations that were distributed systematically across the entire study area. Each point count was separated by at least 250 m from all other points to minimize the probability of sampling the same bird more than once because, in forested areas, the loudest song can be heard at a maximum distance of approximately 250 m (Foucès, 1995). We used the maximum abundance of each bird species per survey point from the replicate counts, because these counts are closer to the real number of individuals and species present in each plot (Sánchez *et al*., 2012).

Data analyses

Bird species composition

To compare diversity between habitat types, a variety of community parameters were used. The Shannon-Wiener index (diversity: H') was calculated with the parameters that affect this index, such as species richness (S), relative abundance (A), and frequency of occurrence (F%) (Anjos *et al*., 2010). Observed distribution of these community parameters was tested for normality using Shapiro-Wilk test (Shapiro and Wilk, 1965) and the Fligner-Killeen test (Fligner and Killeen, 1976) for homogeneity of variance among habitats. Then, one-way analysis of variance (ANOVA) tests were used to test for differences in species richness, relative abundance, and species diversity among the three main surveyed habitats (oak stands, pine stands, oak-pine mixed forests). When a significant difference was detected, Tukey's Honestly Significant Difference *post-hoc* tests (Kramer, 1956; Keselman and Rogan, 1977) were used to determine individual mean differences ($\alpha=0.05$).

Comparison of bird assemblages among habitat types

We used non-metric multi-dimensional scaling (NMDS) to test for differences between avian assemblages and habitat types. The NMDS was constructed using a matrix of ecological dissimilarity among habitat types (Legendre and Legendre, 1998), and a probability value that was calculated based on 10,000 Monte Carlo simulations. An advantage of using NMDS is that it is based on ranked distances, which tends to linearize the relationship between environmental distance and biological distance (Legendre and Legendre, 1998). The amount of stress can be used for judging the goodness of fit of NMDS. Kruskal (1964) provided an interpretation of the stress value with respect to the goodness of fit of NMDS, indicating that a small stress value highlights a good fit (lower than 0.2). Whereas; a high value points towards a weak fit (higher than 0.2). Although, the amount of stress is informative, it has been generally accepted that stress levels only offer a vague indication of goodness of fit (Oksanen, 2013).

To analyze the differences in bird assemblage composition between habitats a Permutational Multivariate Analysis of Variance procedure (PERMANOVA) was used (Anderson, 2001). This procedure acts as a matrix-based non-parametric analysis of variance. PERMANOVA analyses and segments sums of squares using semi-metric and metric distance matrices using permutation methods (Anderson, 2005). When differences were detected, a one-way Analysis of Similarity (ANOSIM) was used to further investigate whether bird community structure (a single data matrix composed of the relative abundance of all species detected at each point count) differed among the possible pairwise combinations in the three sampled habitats (Minchin, 1987). This was done because ANOSIM tests whether the dissimilarities identified in the assembly composition are larger between groups than within groups or not; this also produces an estimated p-value based on 10,000 Monte Carlo simulations (Clarke, 1993). In addition, a Similarity Percentage (SIMPER) test was conducted to estimate overall dissimilarity among habitat types. The SIMPER test also allows to assess the relative contribution of each species to the assembly composition, both in respect of contribution to the average similarity within a group (*i.e.* which species at what abundance tends to characterize groups); and average dissimilarity between groups (*i.e.* which species at what abundance tends to separate groups) (Clarke, 1993). A Bray-Curtis pairwise distance coefficient was used in all cases to express similarities as it is less sensitive to differences among rare species, and 10,000 Monte Carlo permutations were conducted to generate the random test statistics (Bray and Curtis, 1957).

All analyses were undertaken in R (R Development Core Team, 2014) with the Community Ecology Package 'vegan' (Oksanen *et al*., 2010).

RESULTS

Bird species composition

During the breeding periods of 2014, 2015 and 2016, we conducted 252 visits (252 partials IPA). A total of 1276 pairs of birds in 53 genera and 69 species were recorded. Fifty three species were Passeriformes and the remainder (16) were non-Passeriformes. Sixty one bird species were found in pine woodlands, fifty one in oak woodlands and 34 in mixed oak-pine forests (Table I).

Table I.- Bird species/families/orders and avian distribution recorded in the mountain of Sidi Reghis during the breeding period of 2014, 2015 and 2016.

No.	Scientific name/ Common English name	Habitat	Abundance	F (%)	IUCN red list status 2015	National protection status 2012
Order: Ciconiiformes						
Family: Ciconiidae						
1.	*Ciconia ciconia*/ White stork	Pine	6.5	4.76	LC	P
Order: Pelecaniformes						
Family: Ardeidae						
2.	*Bubulcus ibis*/ Western cattle egret	Pine	11.5	4.76	LC	UP
Order: Accipitriformes						
Family: Accipitridae						
3.	*Neophron percnopterus*/ Egyptian vulture	Oak/Pine	6.5	6.35	EN *	UP
4.	*Gyps fulvus*/ Griffon vulture	Oak	0.5	0.79	LC	P
5.	*Hieraaetus pennatus*/ Booted eagle	Oak/Mix	3.5	5.56	LC	P
6.	*Milvus migrans*/ Black kite	Oak/Mix	8.5	9.52	LC	P
7.	*Buteo rufinus cirtensis*/ Long-legged buzzard	Oak/Mix	5.5	7.14	LC	P
Order: Columbiformes						
Family: Columbidae						
8.	*Columba livia*/ Rock dove	Pine	20.5	9.52	LC	UP
9.	*Streptopelia turtur*/European turtle dove	Mix/Oak/Pine	45.5	33.33	LC	UP
10.	*Streptopelia decaocto*/Eurasian collared dove	Pine	19	14.29	LC	UP
Order: Strigiformes						
Family: Strigidae						
11.	*Bubo ascalaphus*/ Pharaoh eagle-owl	Oak	0.5	0.79	LC	P
12.	*Athene noctua*/ Little owl	Pine	1	1.59	LC	P
Order: Apodiformes						
Family: Apodidae						
13.	*Apus apus*/ Common owift	Pine	49	5.56	LC	UP
Order: Coraciiformes						
Family: Meropidae						
14.	*Merops apiaster*/ European bee-eater	Pine	2.5	2.38	LC	P

No.	Scientific name/ Common English name	Habitat	Abundance	F (%)	IUCN red list status 2015	National protection status 2012
Order: Bucerotiformes						
Family: Upupidae						
15.	*Upupa epops/* Eurasian hoopoe	Mix/Oak/Pine	15.5	15.87	LC	P
Order: Falconiformes						
Family: Falconidae						
16.	*Falco tinnunculus/* Common kestrel	Oak/Mix	6	7.94	LC	P
Order: Passeriformes						
Family: Laniidae						
17.	*Lanius meridionalis/* Southern grey shrike	Oak/Pine	2	2.38	NE *	UP
18.	*Lanius senator/* Woodchat shrike	Mix/Oak/Pine	13.5	15.87	LC	UP
Family: Corvidae						
19.	*Corvus corax/* Northern raven	Mix/Oak/Pine	20.5	25.4	LC	UP
Family: Paridae						
20.	*Periparus ater/* Coal tit	Mix/Oak/Pine	4	3.97	LC	UP
21.	*Cyanistes teneriffae/* African blue tit	Mix/Oak/Pine	17.5	16.67	LC	UP
22.	*Parus major/* Great tit	Mix/Oak/Pine	18	13.49	LC	UP
Family: Alaudidae						
23.	*Lullula arborea/* Woodlark	Oak/Pine	5.5	4.76	LC	UP
24.	*Alauda arvensis/* Eurasian skylark	Pine	8.5	3.17	LC	UP
25.	*Galerida macrorhyncha/* Maghreb lark	Oak/Pine	10.5	10.32	LC	UP
26.	*Melanocorypha calandra/* Calandra lark	Pine	8	5.56	LC	UP
Family: Pycnonotidae						
27.	*Pycnonotus barbatus/* Common bulbul	Pine	0.5	0.79	LC	UP
Family:Hirundinidae						
28.	*Hirundo rustica/* Barn swallow	Oak/Pine	9.5	3.97	LC	UP
29.	*Ptyonoprogne rupestris/* Eurasian crag martin	Oak/Pine	4.5	2.38	LC	UP
30.	*Delichon urbicum/* Common house martin	Pine	6	3.17	LC	UP
Family: Phylloscopidae						
31.	*Phylloscopus trochilus/* Willow warbler	Mix/Oak/Pine	6	7.14	LC	UP
32.	*Phylloscopus collybita/* Common chiffchaff	Mix/Oak/Pine	18.5	16.67	LC	UP
33.	*Phylloscopus bonelli/* Western Bonelli's warble	Mix/Oak/Pine	7	7.14	LC	UP
Family: Sylviidae						
34.	*Sylvia atricapilla/* Eurasian blackcap	Mix/Oak/Pine	2	2.38	LC	UP
35.	*Sylvia borin/* Garden warbler	Mix/Oak/Pine	9.5	8,73	LC	UP
36.	*Sylvia hortensis/* Western orphean warbler	Mix/Oak/Pine	11.5	13.49	LC	UP
37.	*Sylvia deserticola deserticola /* Tristram's warbler	Oak/Pine	6	3.97	LC	UP
38.	*Sylvia cantillans/* Subalpine warbler	Mix/Oak/Pine	11	8.73	LC	UP
39.	*Sylvia melanocephala/* Sardinian warbler	Mix/Oak/Pine	13	13.49	LC	UP
Family: Regulidae						
40.	*Regulus ignicapilla/* Common firecrest	Oak/Pine	3	3.17	LC	P
Family: Troglodytidae						
41.	*Troglodytes troglodytes/* Eurasian wren	Oak/Pine	1.5	2.38	LC	UP
Family: Certhiidae						
42.	*Certhia brachydactyla/* Short-toed treecreep	Pine	1.5	2.38	LC	UP
Family: Sturnidae						
43.	*Sturnus vulgaris/* Common starling	Pine	5	1.59	LC	UP
Family: Turdidae						
44.	*Turdus merula/* Common blackbird	Mix/Oak/Pine	116	76.19	LC	UP
45.	*Turdus viscivorus/* Mistle thrush	Oak/Pine	1	0.79	LC	UP

No.	Scientific name/ Common English name	Habitat	Abundance	F (%)	IUCN red list status 2015	National protection status 2012
Family: Muscicapidae						
46.	*Cercotrichas galactotes/* Rufous-tailed scrub robin	Pine	1	0.79	LC	UP
47.	*Muscicapa striata/* Spotted flycatcher	Mix/Oak/Pine	91.5	52.38	LC	P
48.	*Erithacus rubecula/* European robin	Mix/Oak/Pine	17.5	12.7	LC	UP
49.	*Luscinia megarhynchos/* Common nightingale	Pine	2	2.38	LC	UP
50.	*Ficedula speculigera/* Atlas pied flycatcher	Oak/Pine	2	3.17	LC	P
51.	*Ficedula albicollis/* Collared flycatcher	Pine	2.5	3.97	LC	P
52.	*Phoenicurus ochruros/* Black redstart	Mix/Oak/Pine	2.5	2.38	LC	P
53.	*Phoenicurus moussieri/* Moussier's redstart	Mix/Oak/Pine	39	30.95	LC	P
54.	*Monticola saxatilis/* Common rock thrush	Mix/Oak/Pine	7.5	5.56	LC	P
55.	*Monticola solitarius/* Blue rock thrush	Mix/Oak/Pine	11.5	11.11	LC	UP
56.	*Oenanthe oenanthe/* Northern wheatear	Mix/Oak/Pine	3.5	3.17	LC	UP
57.	*Oenanthe hispanica/* Black-eared wheatear	Mix/Oak/Pine	4.5	4.76	LC	UP
58.	*Oenanthe leucura/* Black wheatear	Oak/Pine	9	8.73	LC	UP
Family: Passeridae						
59.	*Passer domesticus/* House sparrow	Pine	74.5	14.29	LC	UP
Family: Motacillidae						
60.	*Motacilla alba/* White wagtail	Mix/Oak/Pine	13	9.52	LC	UP
Family: Fringillidae						
61.	*Fringilla coelebs/* Common chaffinch	Mix/Oak/Pine	155.5	73.81	LC	UP
62.	*Chloris chloris/* European greenfinch	Mix/Oak/Pine	111.5	65.87	LC	UP
63.	*Linaria cannabina/* Common linnet	Mix/Oak/Pine	13	14.29	LC	UP
64.	*Loxia curvirostra/* Red Crossbill	Mix/Oak/Pine	13.5	11.9	LC	P
65.	*Carduelis carduelis/* European goldfinch	Oak/Pine	1	0.79	LC	P
66.	*Serinus serinus/* European serin	Mix/Oak/Pine	151.5	80.16	LC	P
67.	*Spinus spinus/* Eurasian siskin	Mix	0.5	0.79	LC	UP
Family: Emberizidae						
68.	*Emberiza cia/* Rock bunting	Oak/Pine	4	3.97	LC	UP
69.	*Emberiza cirlus/* Cirl bunting	Oak/Pine	1	0.79	LC	UP

Oak, oak woodlands; Mix, mixed oak-pine forests; Pine, pine woodlands. P, protected; UP, unprotected (according to the National Protection status 2012); NE, not evaluated; LC, least concern; EN, endangered (according to the IUCN Red List status 2015).

One species was recorded only in mixed oak-pine forests (Eurasian Siskin *Spinus spinus*; at one point count), six species were found only in oak woodlands and 17 species were found only in pine woodlands (Table I). The six most commonly detected species in the mountain of Sidi Reghis were Common Chaffinch (155.5 pairs), European Serin (151.5 pairs), Common Blackbird (116 pairs), European Greenfinch (111.5 pairs), Spotted Flycatcher (91.5 pairs), and European Turtle Dove (45.5 pairs). These six species accounted for over half (52.62%) of all detections (Table I).

The family with the highest species richness was Muscicapidae (13 species), followed by Fringillidae (seven species), Sylviidae (six species), Accipitridae (five species) and Alaudidae (four species). These five families alone represented more than 50% of the total species richness of the community. The family that dominated the population in number of pairs was Fringillidae (446.5 pairs), followed by Muscicapidae (194 pairs), Turdidae (117 pairs), Columbidae (85 pairs), and Passeridae (74.5 pairs). They represented more than 70% of the total abundance of the entire population (Table II).

Results from the *one-way* ANOVA analysis for the effect of forest type on bird species richness (S), abundance (A) and diversity (H') indicated that forest bird abundance and species richness significantly differed among the three forest types (abundance: $F_{2.123} = 6.205$, $p < 0.01$, adjusted $R^2 = 0.076$; species richness: $F_{2.123} = 6.059$, $p < 0.01$, adjusted $R^2 = 0.074$). Abundance and species richness were significantly higher in pure pine woodlands than in mixed oak-pine forests and oak woodlands (Tukey's HSD *post-hoc* test: $p < 0.01$) (Fig. 2A, B; Table III).

Species diversity also differed significantly among the three forest types ($F_{2.123} = 5.108$; $p < 0.01$, adjusted $R^2 = 0.063$), with significantly higher species diversity in pure pine woodlands than in mixed oak-pine forests and oak woodlands (Tukey's HSD *post-hoc* test: $p < 0.01$) (Fig. 2C; Table III).

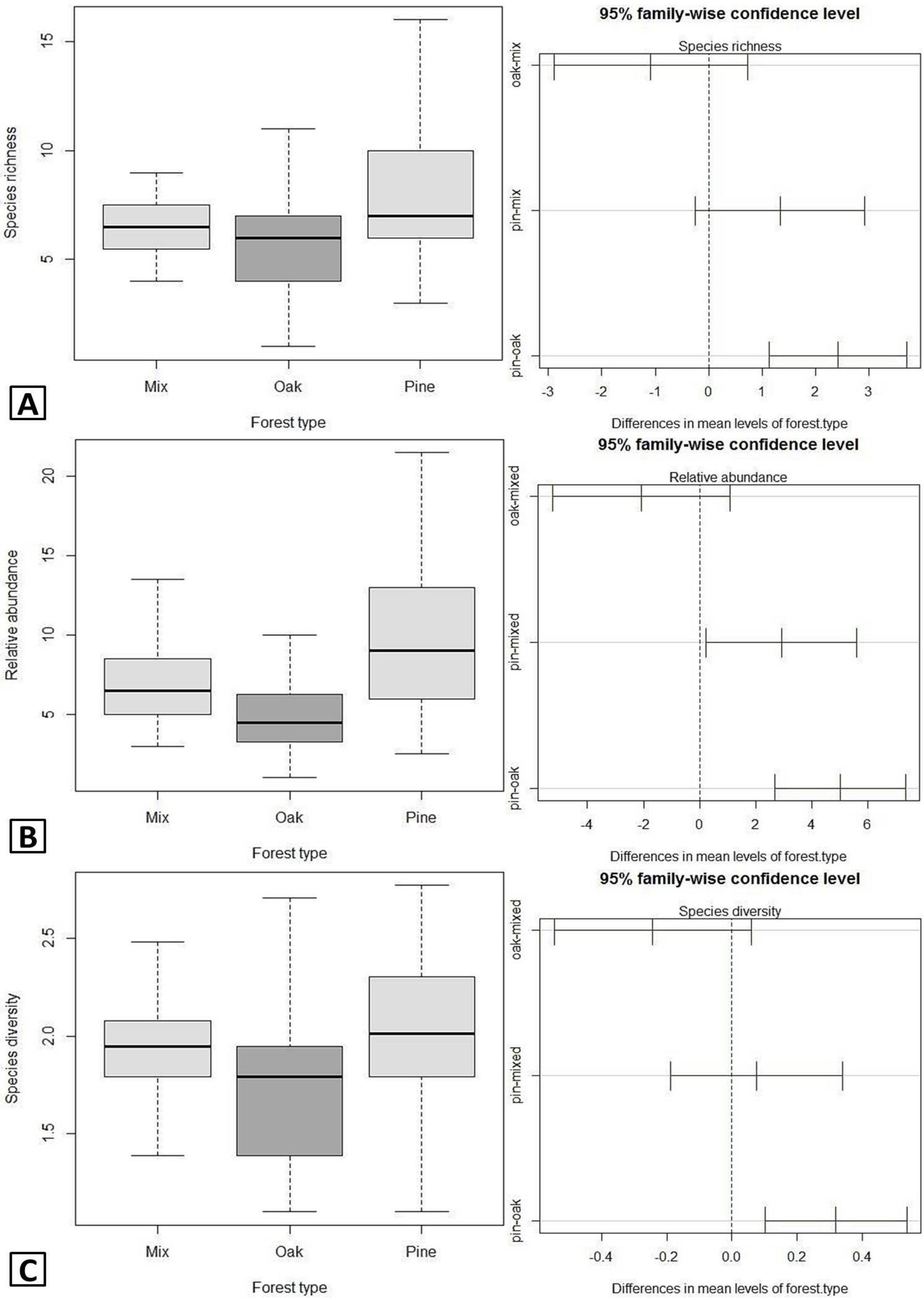

Fig. 2. The relative abundance (A), species richness (B), and species diversity of forest birds in mixed oak-pine forests (Mix), oak woodlands (Oak), and pine woodlands (Pine) (C). Left graphic represent significant ($p < 0.05$) pairwise differences between forest types for each community parameters.

Table II.- The composition of avian families according to their species number and their relative abundance.

No.	Family	Species	P (%)	Abundance	P (%)
1.	Ciconiidae	1	1.45	6.5	0.51
2.	Ardeidae	1	1.45	11.5	0.90
3.	Accipitridae	5	7.25	24.5	1.92
4.	Falconidae	1	1.45	6	0.47
5.	Columbidae	3	4.35	85	6.66
6.	Strigidae	2	2.90	1.5	0.12
7.	Apodidae	1	1.45	49	3.84
8.	Meropidae	1	1.45	2.5	0.20
9.	Upupidae	1	1.45	15.5	1.21
10.	Alaudidae	4	5.80	32.5	2.55
11.	Hirundinidae	3	4.35	20	1.57
12.	Motacillidae	1	1.45	13	1.02
13.	Pycnonotidae	1	1.45	0.5	0.04
14.	Troglodytidae	1	1.45	1.5	0.12
15.	Muscicapidae	13	18.84	194	15.20
16.	Turdidae	2	2.90	117	9.17
17.	Sylviidae	6	8.70	53	4.15
18.	Phylloscopidae	3	4.35	31.5	2.47
19.	Regulidae	1	1.45	3	0.24
20.	Paridae	3	4.35	39.5	3.10
21.	Certhiidae	1	1.45	1.5	0.12
22.	Laniidae	2	2.90	15.5	1.21
23.	Corvidae	1	1.45	20.5	1.61
24.	Passeridae	1	1.45	74.5	5.84
25.	Fringillidae	7	10.14	446.5	34.99
26.	Emberizidae	2	2.90	5	0.39
27.	Sturnidae	1	1.45	5	0.39
Total		69	100%	1276	100%

Table III.- Summary of statistics (*p*-values of Tukey's HSD *post-hoc* test) for the effects of forest type on bird indices richness (S), abundance (A) and diversity (H').

	p adjusted		
	Oak-Mix	Pine-Mix	Pine-Oak
Abundance (A)	0.5319272	0.045359*	0.0024044**
Species richness (S)	0.1397081	0.7761908	0.0019996**
Species diversity (H')	0.5509712	0.3508092	0.0065755**

Oak, oak woodlands; Mix, mixed oak-pine forests; Pine, pine woodlands; *, p<0.05; **, p<0.01; ***, p<0.001.

Comparison of bird assemblages among habitat types

Avian assemblages in Sidi Reghis Mountain varied significantly between the different habitats (PERMANOVA: $F_{2,58}$ = 5.572, p < 0.001). Further, differences in bird species composition among the possible pairwise combinations in the three sampled habitat types were confirmed by the ANOSIM test (Table IV). These results were supported by the nonmetric multidimensional scaling (NMDS) analysis, which produced a good fit (0.185 stress) with a clear positive linear relationship between the observed dissimilarity and the ordination distances (for linear fit: r^2 = 0.835; Fig. 3).

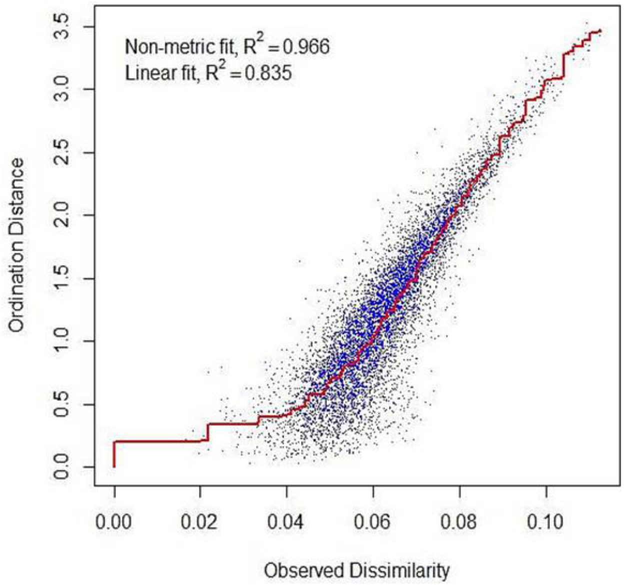

Fig. 3. Shepard plot for nonmetric multidimensional scaling (NMDS) results. Dashed line signifies a perfect linear relationship between calculated and ordination distances.

Table IV.- ANOSIM (Analysis of Similarities, R value) for bird assemblages among the possible pair wise combinations in the three sampled habitats: Pine woodlands (Pine), oak woodlands (Oak) and mixed oak-pine forests (Mix).

	R	p
Oak-Mix	0.1616	0.005**
Pine-Mix	0.1879	0.001***
Pine-Oak	0.2958	0.001***

p = significance based on 1,000 randomizations.

The NMDS plot revealed that some species were entirely restricted to a given habitat type, which shared different complements of its avifauna with other habitat types (Table V; Fig. 4). The most marked contrast in species composition was between oak woodlands and pine woodlands, with only 14 species in common (Table V; Fig. 4). They diverged considerably in their bird assemblage composition, being distinctly separated at opposite ends of the ordination diagram. The mixed oak-pine sites were similarly different, with 30 species in common with oak woodlands and/or pine woodlands (Table V), appearing to cluster between oak woodlands and pine woodlands (Fig. 4). Considering the overlapping of oak woodlands and oak-pine forests, pine woodlands hosted the most dissimilar community (Table V).

Table V.- Cumulative contributions of most influential species in the mean dissimilarity among the possible pair wise combinations in the three sampled habitats: Pine woodlands (Pine), oak woodlands (Oak) and mixed oak-pine forests (Mix). Av. a and av. b, average abundances per group (habitat types).

Species	Contribution	av. a	av. b	Contribution %	Cumulative contribution %
Pine-Mix					
Fringilla coelebs	0.0710478	1.35897	1.11111	9.968095	9.968095
Serinus serinus	0.0607794	1.19872	1.05556	8.527431	18.495526
Passer domesticus	0.0571555	0.40385	0.97222	8.018988	26.514514
Chloris chloris	0.0539133	0.86538	0.88889	7.564105	34.078619
Muscicapa striata	0.0524917	0.76282	0.77778	7.364657	41.443276
Turdus merula	0.0507155	0.79487	0.94444	7.115447	48.558723
Streptopelia turtur	0.0334066	0.37179	0.41667	4.686992	53.245715
Phoenicurus moussieri	0.0234303	0.28846	0.27778	3.287297	56.533012
Columba livia	0.0189194	0.04487	0.41667	2.654414	59.187426
Parus major	0.0168982	0.10256	0.30556	2.370835	61.558261
Corvus corax	0.0158162	0.13462	0.19444	2.219036	63.777297
Sylvia hortensis	0.0153507	0.04487	0.19444	2.153721	65.931018
Melanocorypha calandra	0.0152900	0.05769	0.13889	2.145212	68.07623
Sylvia melanocephala	0.0132557	0.08333	0.19444	1.859785	69.936015
Phylloscopus collybita	0.0131953	0.15385	0.11111	1.851323	71.787338
Pine-Oak					
Fringilla coelebs	0.0727977	1.35897	0.98333	10.25581	10.25581
Serinus serinus	0.0657735	1.19872	1.30000	9.26622	19.52203
Chloris chloris	0.0568835	0.86538	0.93333	8.01379	27.53582
Turdus merula	0.0551641	0.79487	1.23333	7.77157	35.30739
Muscicapa striata	0.0505925	0.76282	0.60000	7.12751	42.4349
Passer domesticus	0.0471794	0.40385	0.85000	6.64667	49.08157
Phoenicurus moussieri	0.0321247	0.28846	0.38333	4.52575	53.60732
Streptopelia turtur	0.0286978	0.37179	0.30000	4.04297	57.65029
Erithacus rubecula	0.0220475	0.05769	0.35000	3.10607	60.75636
Corvus corax	0.0170339	0.13462	0.21667	2.39975	63.15611
Streptopelia decaocto	0.0154303	0.08333	0.35000	2.17384	65.32995
Motacilla alba	0.0154296	0.03846	0.31667	2.17373	67.50368
Phylloscopus collybita	0.0134489	0.15385	0.15000	1.8947	69.39838
Columba livia	0.0134167	0.04487	0.31667	1.89015	71.28853
Mix-Oak					
Passer domesticus	0.0627180	0.97222	0.85000	8.376758	8.376758
Serinus serinus	0.0619996	1.05556	1.30000	8.280806	16.657564
Fringilla coelebs	0.0573192	1.11111	0.98333	7.655677	24.313241
Chloris chloris	0.0502815	0.88889	0.93333	6.715706	31.028947
Turdus merula	0.0501594	0.94444	1.23333	6.699395	37.728342
Muscicapa striata	0.0421844	0.77778	0.60000	5.634244	43.362586
Streptopelia turtur	0.0285359	0.41667	0.30000	3.81132	47.173906
Phoenicurus moussieri	0.0274056	0.27778	0.38333	3.660355	50.834261
Columba livia	0.0249577	0.41667	0.31667	3.333402	54.167663
Erithacus rubecula	0.0221259	0.13889	0.35000	2.955184	57.122847
Corvus corax	0.0170531	0.19444	0.21667	2.277655	59.400502
Streptopelia decaocto	0.0162399	0.11111	0.35000	2.169037	61.569539
Sylvia hortensis	0.0158538	0.19444	0.15000	2.117466	63.687005
Parus major	0.0158203	0.30556	0.15000	2.112991	65.799996
Sylvia borin	0.0156559	0.19444	0.13333	2.091041	67.891037
Motacilla alba	0.0139006	0.02778	0.31667	1.856602	69.747639
Melanocorypha calandra	0.0134747	0.13889	0.03333	1.79971	71.547349

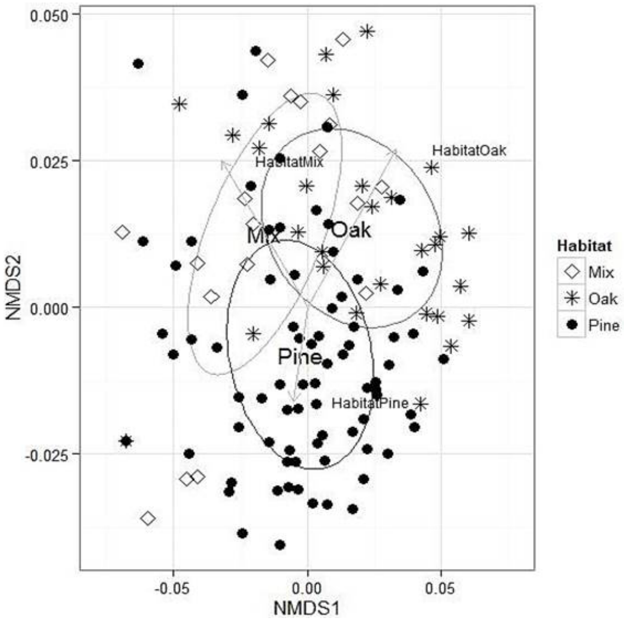

Fig. 4. Nonmetric multidimensional scaling (NMDS) analysis ordination biplot based on Bray-Curtis coefficient of similarities between avian assemblages and habitat types in the mountain of Sidi Reghis (stress=0.185). Oak, oak woodlands; Mix, mixed oak-pine forests; Pine, pine woodlands.

Six of the seven species were responsible for the mean of 50% of dissimilarity between sampled habitats (Table V). The dissimilarity between pine woodlands and mixed oak-pine forests was about 50%, in general, and produced by differences in abundance of common chaffinch, European serin, house sparrow, European greenfinch, spotted flycatcher and common blackbird. The differences between pine woodlands and oak forests (about 60%) and between oak-pine mixed and oak woodlands (about 50%) were mainly produced by species that were present in just one sampled area, most with preference for pine woodlands.

The differences related to pine woodlands are the results from Moussier's redstart and European turtle dove presence.

DISCUSSION

Bird species composition

According to Isenmann and Moali (2000), 406 species of birds are found in Algeria, thus the species recorded at the mountain of Sidi Reghis correspond to 17% of the Algerian avifauna.

In addition, about 25% of birds occurring in the mountain of Sidi Reghis are "protected" (JORDAP, 2012): white stork *Ciconia ciconia*, Griffon vulture *Gyps fulvus*, booted eagle *Hieraaetus pennatus*, black kite *Milvus migrans*, long-legged buzzard *Buteo rufinus cirtensis*, Pharaoh eagle-owl *Bubo ascalaphus*, little owl *Athene noctua*, European bee-eater *Merops apiaster*, Eurasian boopoe *Upupa epops*, common kestrel *Falco tinnunculus*, common firecrest *Regulus ignicapilla*, spotted Flycatcher, Atlas Pied Flycatcher *Ficedula speculigera*, collared flycatcher *Ficedula albicollis*, flack redstart *Phoenicurus ochruros,* Moussier's redstart, common rock thrush *Monticola saxatilis*, red crossbill *Loxia curvirostra,* European goldfinch *Carduelis carduelis* and European serin. Nonetheless, among the 69 species recorded in this study, only one is considered as "endangered" (IUCN, 2016): Egyptian vulture, and another "not evaluated": southern grey shrike. Five species are endemic to the Maghreb and/or to North Africa (Balsac and Mayaud, 1962; Etchecopar and Hüe, 1964; Howard and Moore, 1991): Maghreb lark, Atlas pied hlycatcher, African blue tit, Tristram's warbler, long-legged wuzzard.

The presence of numerous protected, endangered and endemic species confirms the importance of the mountain of Sidi Reghis as a key habitat for the conservation of rare and endemic avifauna. Black kite *Milvus migrans*, Egyptian vulture *Neophron percnopterus*, common kestrel *falco tinnunculus*, booted eagle *Hieraaetus pennatus*, long-legged buzzard, on the other hand, have been taken into account because some of the pairs nest in the heart of the mountain of Sidi Reghis and feed there.

The most abundant species at the Mountain of Sidi Reghis is common chaffinch, which is a typical forest bird in North Africa and temperate Europe (Cherkaoui *et al*., 2007; Dronneau, 2007; Mostefai, 2011; Menaa, 2016). Muller (1985) demonstrated that this sparrow occupies the first place in all types of forests, whether hardwoods, conifers or mixed stands.

Interestingly, several species nesting in Sidi Reghis forests are mainly subservient to open areas (Calandra lark *Melanocorypha calandra*, Maghreb lark, Wood lark *Lullula arborea*, Eurasian skylark *Alauda arvensis,* Cirl bunting *Emberiza cirlus* and rock bunting *Emberiza cia*) and urban land (white stork *Ciconia ciconia*, rock dove *Columba livia*, European turtle dove barn swallow *Hirundo rustica*, common house hartin *Delichon urbicum* and house sparrow). This is easily explained because the Sidi Reghis Mountain contains forest edges influenced by anthropological impacts and the proximal location of well-developed human settlements at the base of the mountain (around the mountain there is a large urban agglomeration, especially in the south).

Our results also support the conclusions of Camprodon and Brotons (2006). We have suggested that the presence of species of grassland and open areas beside purely forest species is due to the mosaic structure of the Sidi Reghis forests (presence of clearings and scrubland) and the clearing in agro-forestry habitats that also support grassland species (because the grasslands are located adjacent to the mountain).

Comparison of bird assemblages among habitat types

Using diversity indices is one of the most important challenges in ecological studies aiming at understanding patterns of biodiversity and their underlying causes (Colwell and Coddington, 1994).

Increases in vegetation structure complexity and floristic composition are quite often related to enrichment of bird communities (Wiens, 1989; Hobson and Bayne, 2000a, b; Shochat *et al*., 2001; Laiolo, 2002; Machtans and Latour, 2003). However, relative abundance, species richness and species diversity of forest birds in the mountain of Sidi Reghis were on average higher in pine woodlands than oak woodlands and mixed oak-pine forests, contrary to our expectation.

On the other hand, several authors found lower species richness in coniferous compared to broadleaved forests (James and Wamer, 1982; Barbaro *et al*., 2005; Gil-Tena *et al*., 2007) or a greater association of bird communities with the latter (Berg, 1997). Nonetheless, results from previous studies are often contradictory and dependent on the scales and study areas.

Similarly, Hobson and Bayne (2000a) could not associate higher species richness to coniferous or deciduous forests. Studies conducted in the Iberian Peninsula regarding the environmental patterns associated with the distribution of forest avian communities have also pointed out this uncertainty (Tellería and Santos, 1994; Carrascal and Díaz, 2003).

Consequently, the significant increase in bird species richness in pine forests is likely to be the result of the assemblage of bird species from urban land and open area. In contrast, the significant decrease in bird species richness in mixed oak-pine forests is likely to be the result of the loss and degradation of native vegetation by land management practices in Sidi Reghis Mountain, where the native holm oak have been replaced by the introduced Aleppo pine. Because native vegetation is important for many species, numerous authors have equated 'habitat' with 'native vegetation' (Andrén, 1994). Hence, the loss of native vegetation at landscape and regional scales has been linked to the loss of native species around the world (Andrén, 1994; Kerr and Deguise, 2004). Similarly, the loss of native vegetation at the local scale tends to reduce native species richness, which is in accordance with our results.

Our study revealed some resemblance of bird communities among habitat types. These three habitats are geographically close to each other, while the whole of this mountain allows a sparse evolution of the vegetation. Each elevation stage has its own type of flora. The lower elevation is composed of an Aleppo pine plantation (introduced for reforestation during the last two centuries) which develops to the detriment of other species. The intermediate elevation is composed of mixed woodlands of Aleppo pine and holm oak. Finally, the higher elevation consists of holm oak, the autochthonous species which is typical of the Mediterranean region (Djema and Messoudène, 2009).

In contrast, strong dissimilarity between bird communities among habitats was found in Sidi Reghis Mountain. This is probably due to the geographical (altitude) and ecological characteristics. Most of the differences are found between the lower mountain altitude part (pine woodlands) and the higher mountain altitude part (oak woodlands). In the lower altitude part, the pine woodlands connect with open areas (grasslands) and urban lands, allowing a wider range for species movement. In higher altitude, bird community of oak woodlands has its own forest characteristics which are specific to altitudes above 1500 m. The hostility of the climate and the poverty of the soil yield poor vegetation cover in this part of the mountain: the holm oak only occupies rocky spaces providing shelter from the wind (Mosbah, 2007).

CONCLUSION

The results obtained in this study significantly contribute to knowledge of breeding birds in the Sidi Reghis Mountain; help further assessing the effects of habitat types on the integrity of bird communities. This information will help also in planning future conservation activities to maintain the biodiversity in this forest ecosystem by providing a short list of some management recommendations, according to Fischer and Lindenmayer (2007): 1) Forest landscape management should focus on maintaining forest heterogeneity in order to provide a diversity of habitat types that are useful to a range of different bird species; 2) Especially for bird species which depend on native vegetation, it is very important to restore large and structurally complex patches of native vegetation in order to provide core habitat for these species and 3) Provide habitat for many species throughout the woodstands, by maintaining and/or restoring a matrix that is structurally similar to native vegetation.

ACKNOWLEDGEMENTS

We are extremely grateful to Mr. Youcef Khoudja Nazih (Forest Conservation District of Oum El Bouaghi) for providing us stock maps and other information. We would like to thank all the staff of Tour du Valat research institute, and particularly to Dr. Patrick Grillas, Ms. Roberta Fausti, Dr. Thomas Galewski, Mr. Anis Guelmami and Mr. Antoine Arnaud, for their help and support. We would like to acknowledge the valuable comments and suggestions of Dr. Paul Acker, which have improved the quality of this paper. We also thank all the members of the Algerian National Association of Ornithology (ANAO).

Statement of conflict of interest

Authors have declared no conflict of interest.

REFERENCES

Anderson, M.J., 2001. A new method for non-parametric multivariate analysis of variance. *Austral. Ecol.*, **26**: 32-46. https://doi.org/10.1046/j.1442-9993.2001.01070.x

Anderson, M.J., 2005. *Permutational multivariate analysis of variance*. Department of Statistics, University of Auckland, Auckland, pp. 32-46.

Andrén, H., 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat - A review. *Oikos*, **71**: 355-366. https://doi.org/10.2307/3545823

Anjos, L., Holt, R.D. and Robinson, S., 2010. Position in the distributional range and sensitivity to forest fragmentation in birds: A case history from the Atlantic forest Brazil. *Bird Conserv. Int.*, **20**: 392-399. https://doi.org/10.1017/S0959270909990256

Barbaro, L., Pontcharraud, F.V., Vetillard, F., Guyon, D.A. and Jactel, H., 2005. Comparative responses of bird, carabid, and spider assemblages to stand and landscape diversity in maritime pine plantation forests. *Ecoscience*, **12**: 110-121. https://doi.org/10.2980/i1195-6860-12-1-110.1

Bellatreche, M., 1994. *Écologie et biogéographie de l'avifaune forestière nicheuse de la Kabylie des Babors*. Thèse de Doctorat, Université de Dijon, France.

Bensizerara, D., Chenchouni, H., Si Bachir, A. and Houhamdi, M., 2013. Ecological status interactions for assessing bird diversity in relation to a heterogeneous landscape structure. *Avian Biol. Res.*, **6**: 67-77. https://doi.org/10.3184/175815513X13577344603957

Bensouilah, T., Brahmia, H., Zeraoula, A., Bouslama, Z. and Houhamdi, M., 2014. Breeding biology of the European Greenfinch *Chloris chloris* in the loquat orchards of Algeria (North Africa). *Zool. Ecol.*, **24**: 199-207. https://doi.org/10.1080/21658005.2014.934514

Benyacoub, S., 1993. *Écologie de l'avifaune forestière nicheuse de la région d'El-Kala (Nord-Est algérien)*. Thèse de Doctorat, Université de Bourgogne, France.

Berg, A., 1997. Diversity and abundance of birds in relation to forest fragmentation, habitat quality and heterogeneity. *Bird Stud.*, **44**: 355-366. https://doi.org/10.1080/00063659709461071

Bibby, C.J., Burgess, N.D., Hill, D.A. and Mustoe, S.H., 2000. *Bird census techniques*, 2nd ed. Academic Press, London, UK.

Bibby, C.J., Collar, N.J., Crosby, M.J., Heath, M.F., Imboden, C., Johnson, T.H. and Thirgood, S.J., 1992. *Putting biodiversity on the map: Priority areas for global conservation*. International Council for Bird Preservation, Cambridge, UK.

Blondel, J., Ferry, C. and Frochot, B., 1970. La méthode des indices ponctuels d'abondance (IPA) ou des relevés d'avifaune par "stations d'écoute". *Alauda*, **38**: 55-71.

BNEDER, 1997. *Etude agro-pédologique sur 334 000 ha de la wilaya d'Oum El Bouaghi, zone sud, Algérie*. Bureau National des Etudes de Développement, Algérie.

Boudeffa, K., Brahmia, Z. and Benyacoub, S., 2014. Breeding ecology of the Atlas Pied Flycatcher *Ficedula speculigera* in an old oak *Quercus suber* forest in northeastern Algeria. *Bird Stud.*, **61**: 73-81. https://doi.org/10.1080/00063657.2013.876971

Boudy, P., 1955. *Economie forestière Nord-Africaine*, Vol. 1. Déscription Forestière de l'Algérie et de la Tunisie, Larose, Paris, France.

Bray, J.R. and Curtis, J.T., 1957. An ordination of the upland forest communities of southern Wisconsin. *Ecol. Monogr.*, **27**: 325-349. https://doi.org/10.2307/1942268

Buchanan, J.B., Forsman, E.D., Pierce, D.J., Lewis, J.C. and Biswell, B.L., 1999. Characteristics of young forests used by spotted owls on the western Olympic Peninsula Washington. *Northw. Sci.*, **73**: 255-263.

Camprodon, J. and Brotons, L., 2006. Effects of undergrowth clearing on the bird communities of the Northwestern Mediterranean Coppice Holm oak forests. *Forest Ecol. Manage.*, **221**: 72-82. https://doi.org/10.1016/j.foreco.2005.10.044

Carrascal, L.M. and Díaz, L., 2003. Asociación entre distribución continental y regional. Análisis con la avifauna forestal y de medios arbolados de la Península Ibérica. *Graellsia*, **59**: 179-207.

Cherkaoui, S.I., Dakki, M., Selmi, S., Rguibi Idrissi,

H. and Thévenot, M., 2007. Les oiseaux de la subéraie de la Ma'amora (Maroc): Phénologie du peuplement, statut des espèces nicheuses et évolution depuis le début du vingtième siècle. *Alauda*, **75**: 15-32.

Clarke, K.R., 1993. Non-parametric multivariate analyses of changes in community structure. *Austral. Ecol*., **18**: 117-143. https://doi.org/10.1111/j.1442-9993.1993.tb00438.x

Cody, M.L., 1981. Habitat selection in birds: the roles of vegetation structure, competitors, and productivity. *Bioscience*, **31**: 107-113. https://doi.org/10.2307/1308252

Cody, M.L., 1985. *Habitat selection in birds*. Academic Press, London, UK.

Colwell, R.K. and Coddington, J.A., 1994. Estimating terrestrial biodiversity through extrapolation. *Phil. Trans. R. Soc. Lond. B*, **345**: 101-118. https://doi.org/10.1098/rstb.1994.0091

de Balsac, H.H. and Mayaud, N.,1962. *The birds of North-West Africa: Geographical distribution, ecology, migrations, reproduction*. Encyclopédie ornithologique, 10.

Díaz, L., 2006. Influences of forest type and forest structure on bird communities in oak and pine woodlands in Spain. *Forest Ecol. Manage*., **223**: 54-65. https://doi.org/10.1016/j.foreco.2005.10.061

Djema, A. and Messaoudene, M., 2009. The Algerian forest: Current situation and prospects. In: Modeling, valuing and managing Mediterranean forest ecosystems for non-timber goods and services. *Eur. Forest Inst. EFI Proc. Finland*, **57**: 17-28.

Drapeau, P., Leduc, A. and McNeil, R., 1999. Refining the use of point counts at the scale of individual points in studies of bird-habitat relationships. *J. Avian Biol*., **30**: 367-382. https://doi.org/10.2307/3677009

Dronneau, C., 2007. Peuplement d'oiseaux nicheurs d'une forêt alluviale du Rhin (suite et Fin). *Alauda*, **75**: 373-388.

Etchecopar, R. and Hue, F., 1964. *Les oiseaux de l'Afrique du Nord*. Boubée, Paris, France.

FAO, 2012. *The state of food insecurity in the world*. IFAD.

Fischer, J. and Lindenmayer, D.B., 2007. Landscape modification and habitat fragmentation: A synthesis. *Glob. Ecol. Biogeogr*., **16**: 265-280. https://doi.org/10.1111/j.1466-8238.2007.00287.x

Fligner, M.A. and Killeen, T.J., 1976. Distribution-free two-sample tests for scale. *J. Am. Stat. Assoc*., **71**: 210-213. https://doi.org/10.1080/01621459.1976.10481517

Foucès, V., 1995. *Les comunitats d'helòfits i el poblament d'espècies de Passeriformes associat a l'illa de Buda. Departament de Medi Ambient (Generalitat de Catalunya), Barcelona, Spain*. Unpublished Report.

Frochot, B. and Roché, J., 1990. Suivi de populations d'oiseaux nicheurs par la méthode des indices ponctuels d'abondance (IPA). *Alauda*, **58**: 29-35.

Gil-Tena, A., Saura, S. and Brotons, L., 2007. Effects of forest composition and structure on bird species richness in a Mediterranean context: Implications for forest ecosystem management. *Forest Ecol. Manage*., **242**: 470-476. https://doi.org/10.1016/j.foreco.2007.01.080

Heim de Balsac, H. and Mayaud, N., 1962. *Les oiseaux du Nord-Ouest de l'Afrique*. Lechevalier, Paris, France.

Henderson, M.T., Merriam, G. and Wegner, J., 1985. Patchy environments and species survival: Chipmunks in an agricultural mosaic. *Biol. Conserv*., **31**: 95-105. https://doi.org/10.1016/0006-3207(85)90043-6

Hobson, K.A. and Bayne, E., 2000a. Breeding bird communities in boreal forest of western Canada: consequences of "unmixing" the mixedwoods. *Condor*, **102**: 759-769. https://doi.org/10.1650/0010-5422(2000)102[0759:BBCIBF]2.0.CO;2

Hobson, K.A. and Bayne, E., 2000b. The effects of stand age on avian communities in aspen-dominated forests of central Saskatchewan Canada. *For. Ecol. Manage*., **136**: 121-134. https://doi.org/10.1016/S0378-1127(99)00287-X

Holmes, R.T. and Robinson, S.K., 1981. Tree species preferences of foraging insectivorous birds in a northern hardwoods forest. *Oecologia*, **48**: 31-35. https://doi.org/10.1007/BF00346985

Houhamdi, M. and Samraoui, B., 2002. Occupation spatio-temporelle du Lac des Oiseaux par l'avifaune aquatique. *Alauda*, **70**: 301-310.

Howard, R. and Moore, A., 1991. *A complete checklist of the birds of the world*, 2nd ed. Academic Press Ltd.

Isenmann, P. and Moali, A., 2000. *Birds of Algeria*. SEOF, France.

James, F.C. and Wamer, N.O., 1982. Relationships between temperate forest bird communities and vegetation structure. *Ecology*, **63**: 159-171. https://doi.org/10.2307/1937041

IUCN, 2016. *The IUCN red list of threatened species TM*. http://www.iucnredlist.org/ (Accessed 21

December 2016).

JORADP, 2012. Décret exécutif n° 12-235 du 24 mai 2012, fixant la liste des espèces animales non domestiques protégées. *J. Off. Répub. Algér. Démoc. Popul*., **35**: 5-11.

Kerr, J.T. and Deguise, I., 2004. Habitat loss and the limits to endangered species recovery. *Ecol. Lett*., **7**: 1163-1169. https://doi.org/10.1111/j.1461-0248.2004.00676.x

Keselman, H.J. and Rogan, J.C., 1977. The Tukey multiple comparison test: 1953–1976. *Psychol. Bull*., **84**: 1050. https://doi.org/10.1037/0033-2909.84.5.1050

Kramer, C.Y., 1956. Extension of multiple range tests to group means with unequal numbers of replications. *Biometrics*, **12**: 307-310. https://doi.org/10.2307/3001469

Kruskal, J.B., 1964. Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. *Psychometrika*, **29**: 1-27. https://doi.org/10.1007/BF02289565

Laiolo, P., 2002. Effects of habitat structure, floral composition and diversity on a forest bird community in north-western Italy. *Folia Zool*., **51**: 121-128.

Legendre, P. and Legendre, L., 1998. *Numerical ecology*. Developments in Environmental Modeling 20. Elsevier, Amsterdam, Netherlands.

MacArthur, R.H., 1964. Environmental factors affecting bird species diversity. *Am. Natural*., **98**: 387-397. https://doi.org/10.1086/282334

MacArthur, R.H. and MacArthur, J.W., 1961. On bird species diversity. *Ecology*, **42**: 594-598. https://doi.org/10.2307/1932254

Machtans, C.S. and Latour, P.B., 2003. Boreal forest songbird communities of the Liard Valley, northwest territories Canada. *Condor*, **105**: 27-44. https://doi.org/10.1650/0010-5422(2003)105[27:BFSCOT]2.0.CO;2

McGarigal, K., McComb, W.C., 1995. Relationships between landscape structure and breeding birds in the Oregon Coast Range. *Ecol. Monogr*., **65**: 235-260. https://doi.org/10.2307/2937059

Menaa, M., 2016. *Structure and dynamics of the nesting bird of the Boumezrane forest Ain Zana, Souk-Ahras*. PhD Thesis, University of Oum El Gouaghi, Algeria.

Menaa, M., Maazi, M.C., Telailia, S., Saheb, M., Boutabia, L., Chefrour, A. and Houhamdi, M., 2016. Richness and habitat relationships of forest birds in the Zeen Oak woodland (Forest of Boumezrane, Souk-Ahras), Northeastern Algeria. *Pakistan J. Zool*., **48**: 1059-1069.

Minchin, P.R., 1987. Simulation of multidimensional community patterns: towards a comprehensive model. *Pl. Ecol*., **71**: 145-156.

Mosbah, B., 2007. *Etude comparative de la dynamique de la flore lichénique corticole sur* Quercus ilex *L, et* Pistacia atlantica *Desf au niveau du Djebel Sidi Reghis (Oum El Bouaghi)*. Mém. Ingén. Ecol. Univ. Oum El Bouaghi, Algérie.

Mostefai, N., 2011. L'avifaune nicheuse de la suberaie de Hafir (Tlemcen-Algérie). *Alauda*, **79**: 207-213.

Muller, Y., 1985. *L'avifaune forestière nicheuse des Vosges du Nord: sa place dans le contexte médio-européen*. Thèse de Doctorat, Université de Dijon, France.

Oksanen, J., 2013. *Vegan ecological diversity-vegan*. 2.0-7 in R version 2.15.2 (2013-03-19).

Oksanen, J., Blanchet, F.G., Kindt, R., Legendre, P., O'Hara, R.B., Simpson, G.L. and Wagner, H., 2010. *Vegan: Community ecology package*. R Package Version 1.17–11, 2011.

ONM, 2016. *Données météorologiques de la station d'Oum El Bouaghi (2006-2016)*. Office Nationale de Météorologie.

R Development Core Team, 2014. *R: A language and environment for statistical computing R Foundation for Statistical Computing*. Vienna, Austria. http://www.R-project.org/

Reid, S., Díaz, I.A., Armesto, J.J. and Willson, M.F., 2004. Importance of native bamboo for understory birds in Chilean temperate forests. *Auk*, **121**: 515-525. https://doi.org/10.1642/0004-8038(2004)121[0515:IONBFU]2.0.CO;2

Robinson, S.K. and Holmes, R.T., 1984. Effects of plant species and foliage structure on the foraging behavior of forest birds. *Auk*, **101**: 672-684. https://doi.org/10.2307/4086894

Rotenberry, J.T., 1985. The role of habitat in avian community composition: Physiognomy or floristics? *Oceologia*, **67**: 213-217. https://doi.org/10.1007/BF00384286

Sallabanks, R., Haufler, J.B. and Mehl, C.A., 2006. Influence of forest vegetation structure on avian community composition in west-central Idaho. *Wildl. Soc. Bull*., **34**: 1079-1093. https://doi.org/10.2193/0091-7648(2006)34[1079:IOFVSO]2.0.CO;2

Samraoui, B. and Samraoui, F., 2008. An ornithological survey of the wetlands of Algeria: Important bird areas, Ramsar sites and threatened species. *Wildfowl*, **58**: 71-98.

Sánchez, S., Javier Cuervo, J. and Moreno, E., 2012.

Vegetation structure in beech-fir forests: Effects on the avian community. *Rev. Ecol*., **67**: 213-222.

Sekercioglu, C.H., 2006. Increasing awareness of avian ecological function. *Trends Ecol. Evol*., **21**: 464-471. https://doi.org/10.1016/j.tree.2006.05.007

Shapiro, S.S. and Wilk, M.B., 1965. An analysis of variance test for normality (complete samples). *Biometrika*, **52**: 591-611. https://doi.org/10.1093/biomet/52.3-4.591

Shochat, E., Abramsky, Z. and Pinshow, B., 2001. Breeding bird species diversity in the Negev: effects of scrub fragmentation by planted forests. *J. appl. Ecol*., **38**: 1135-1147. https://doi.org/10.1046/j.1365-2664.2001.00667.x

Sweeney, O.F.M., Wilson, M.W., Irwin, S., Kelly, T.C. and O'Halloran, J., 2010. Breeding bird communities of second rotation plantations at different stages of the forest cycle. *Bird Stud*., **57**: 301-314. https://doi.org/10.1080/00063651003801713

Tellería, J.L. and Santos, T., 1994. Factors involved in the distribution of forest birds in the Iberian Peninsula. *Bird Stud*., **41**: 161-169. https://doi.org/10.1080/00063659409477216

Titeux, N., 2006. *Modelling species distribution when habitat occupancy departs from suitability*. Dissertation, Catholic University of Leuven, Belgium.

Turner, M.G., Gardner, R.H. and O'neill, R.V., 2001. *Landscape ecology in theory and practice*. Springer, New York.

Whelan, C.J., Wenny, D.G. and Marquis, R.J., 2008. Ecosystem services provided by birds. *Annls. N.Y. Acad. Sci*., **1134**: 25-60. https://doi.org/10.1196/annals.1439.003

Wiens, J., 1989. *The ecology of bird community: Foundations and patterns*, Vol. 1. University Press, Cambridge. https://doi.org/10.1017/CBO9780511608568

Wiens, J.A. and Rotenberry, J.T., 1981. Habitat associations and community structure of birds in shrubsteppe environments. *Ecol. Monogr*., **51**: 21-42. https://doi.org/10.2307/2937305