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Richness and Habitat Relationships of Forest Birds in the Zeen Oak Woodland (Forest of Boumezrane, Souk-Ahras), Northeastern Algeria

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A B S T R A C T

Boumezrane's forest is a significant center for biodiversity. Since last year the forest is facing destruction and degradation. Although the forest is recognized as an important area for avian diversity, it has never received ornithological attention. Many studies have been conducted on the relationship of birds with habitat features, however their associations are not completely understood. Hence we need information on the relationship between occurrence of birds and structural components of zeen oak habitats. We examined relative bird abundance by using the point count method and its relationship to environmental descriptors. A total of 68 visits of 39 bird species were recorded in the zeen oak stands. Avian species richness at each point count ranged between four and 14 species. The most dominant families in number of pairs are *Paridae* (121 pairs), *Turdidae* (115.5 pairs), *Sylviidae* (57.5 pairs), *Picidae* (55.5 pairs), and *Fringillidae* (43.5 pairs). They cater for more than 70% of the total abundance of the entire community. Using principal component analysis and canonical correspondence analysis methods, we determined that the size of trees with the height of shrub layer is an important criterion for differentiation of the avifauna of Boumezrane. The second criterion is the volume of tree stratum.

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Authors' Contribution

MM and MCM conceived and designed the study were involved in bird surveys, analyzed the data and wrote the article. ST and LB helped in bird surveys. MS, AC and MH helped in collecting habitat measurement data and in writing of the manuscript.

Key words

Zeen oak, point count method, the size of trees, the height of shrub layer, the volume of tree stratum.

INTRODUCTION

Birds are one of the most popular life forms on the planet, and that biodiversity leads to a richness of life and beauty (Joshi and Shrivastava, 2013). Birds are ideal bio-indicators and useful models for a variety of purposes. They are valuable tools in ecology and biogeography and are increasingly used to underpin the implementation of effective protection or management strategies for nature conservation (Titeux, 2006).

Habitat structure is an important determinant of species diversity and richness and is also an important factor contributing to the habitat selection of individual species (Gould, 2000; Watson *et al*., 2004; Giles, 2004; Yu and Guo, 2013). The association of whole avian communities and individual species with specific habitat structural attributes is influenced by many factors including the provision of adequate resources for foraging and breeding, and shelter from weather, predators and parasites (Hildén, 1965).

The relationship between bird species distribution and vegetation was first investigated by Bond (1957) who found that bird species distribution followed an individualistic pattern in a vegetation gradient in North America.

Many studies have been conducted on association of birds with habitats along environmental gradients (Bond, 1957; James, 1971; Smith, 1977; Bibby *et al*., 1985; Newton, 1995). Most of these studies have shown strong correlations between bird species and habitat features, especially vegetation structure (MacArthur and MacArthur, 1961; James, 1971; James and Warner, 1982; Denis, 2009; Delahaye, 2006). Although most of these studies determined some of the habitat requirements of avian species and the effects of habitat alteration, their interrelationships are not completely understood. Hence information on the relationship between occurrence of birds and structural components of zeen oak *Quercus canariensis* habitats are needed.

Boumezrane's forest is a significant center for biodiversity. However, it is subject to a variety of threats and more particularly those related to human activities.

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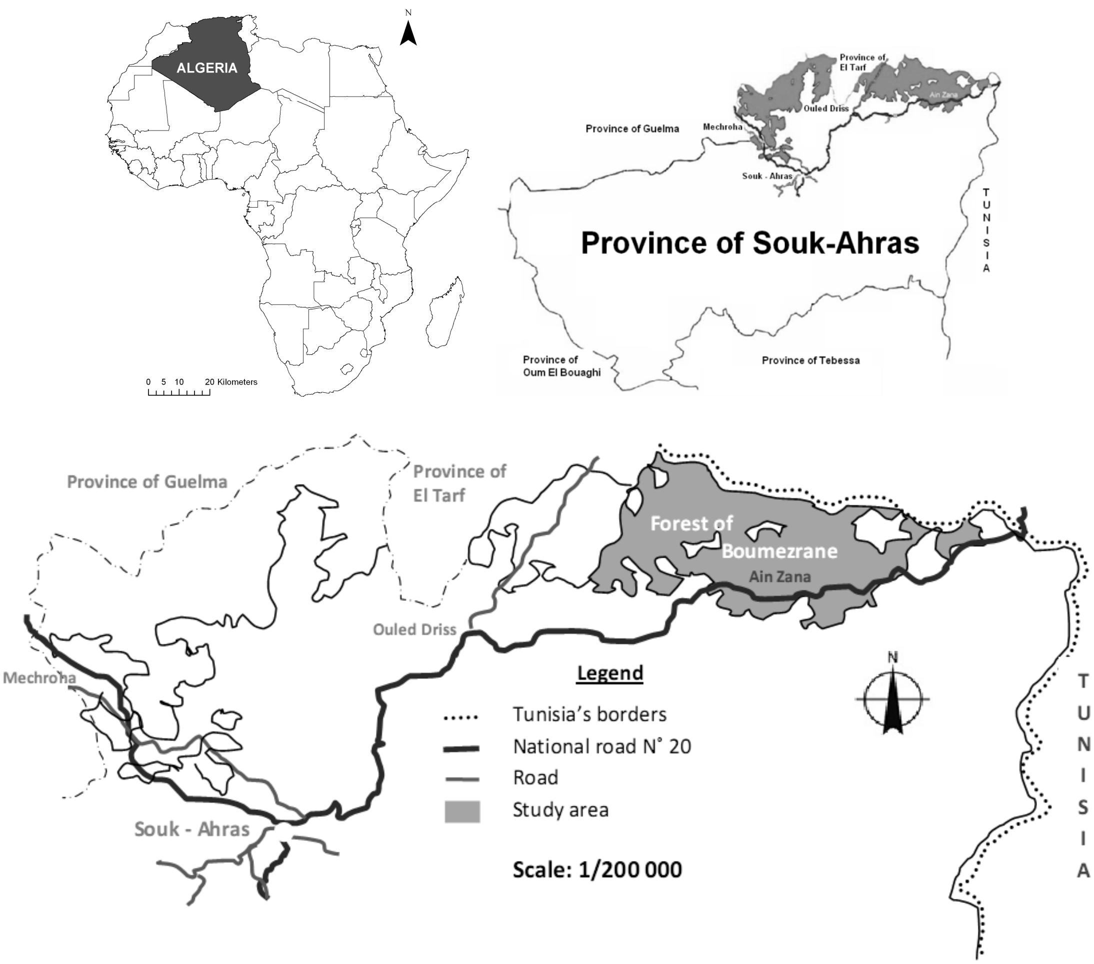

Fig. 1. Geographic location of the forest of Boumezrane

Extensive fires are the main cause of current biodiversity decline (Djama and Messaoudene, 2009). Although this productive forest is recognized as an important area for avian diversity, it has never received ornithological attention.

The objective of this study was to prepare the inventory of forest avifauna, to investigate bird-habitat relationships and to identify environmental characteristics that influence the distribution of birds in the forest of Boumezrane.

MATERIALS AND METHODS

Study site

The study was conducted in the forest of Boumezrane (36˚ 24' N, 8˚ 12' E). The forest is located in Northeastern Algeria about 40 km east of the town of Souk Ahras, and within Northeast of Ain Zana commune, bordering Tunisia. It covers 7428.8 ha (3900 ha of cork oak *Quercus suber*, 2400 ha of zeen oak *Quercus canariensis*, 400 ha of olive *Olea europaea* and secondary essences, and 700 ha of scrubland.

Climate is sub-humid with annual precipitation ranging between 600 and 900 mm and average monthly temperatures of 3°C in January to 33°C in August (Anonymous, 2013).

Bird surveys

To identify breeding birds on the study site, point count or IPA method (Indices Ponctuels d'Abondance) was applied. It was developed in France by Ferry and Frochot (1970), subsequently it has been standardized by the International Bird Census Committee (International Bird Census Committee, 1977). The point count method was employed because it seems to be the most suitable method for forest birds in dense and homogeneous areas and for developing relative indices of abundance and inferences about bird-habitat relationship (Blondel *et al.*, 1970; Bibby *et al*., 2000; Gibbons and Gregory, 2006). The observer stood at the centre of a 100 m radius circular plot and recorded all birds detected in all directions by visual observation, song or call note for 20 minutes. Overflying birds that did not land on trees or on the ground were recorded but not included in the statistical analysis. The twenty minutes were enough to record all the birds in a plot and brief enough to avoid or reduce double counting (Sánchez *et al*., 2012).

All surveys were conducted between one and four hours after sunrise on clear and calm mornings (when bird activity is important) (Frochot and Roché, 1990), since the morning period yields the best results (Lynch, 1995).

In order to count both early and late nesting species (to ensure that the entire nesting period of all species was sampled) (Drapeau *et al*., 1999), sampling stations were visited twice during the breeding season. The first round of sampling was conducted from 15 March to 26 April 2013 and the second in exactly the same order, from 15 May to 25 June 2013. Overall, 34 survey plots or 68 partial surveys were distributed through a wide range of environmental conditions within the zeen oak forest. The higher of the two counts of pair numbers is used as an index of abundance for each species at each station. Each singing male, occupying the nest, or family of birds out of the nest was counted as one pair, whereas a bird merely seen or heard calling was counted as a half pair.

Habitat measurements

At each bird sampling station habitat measurements were taken. The habitat characteristics were recorded after each session of point counts.

The structure of vegetation was quantified by measuring: i) the height of mean tree stratum (H) and ii) shrub layer (h); (H) and (h) were measured directly with a hypsometer, iii) the diameter of the largest timber (dmax) d at breast height (1.3m, a tape measure was used) and iv) the total basal area (Gm^2). Gm^2 is usually a measurement taken at the diameter at breast height (1.3m) of a tree above ground and includes the bark. We also visually estimated v) density of tree stratum (A) and vi) density of shrub layer (a).

Data analyses

Bird species richness, species diversity index (Shannon's index, H') and equitability (evenness index, J') were calculated at each individual point. Principal Components Analysis (PCA) was used to reduce the original set of structural variables and to detect structure in the relationship between birds and habitat characteristics (Legendre and Legendre, 1998).

To identify which habitat variables were important for determining bird species composition and abundance in zeen oak stands, we used Canonical Correspondence Analysis (CCA) (ter Braak, 1995). This ordination technique was designed to detect patterns of variation in a set of response variables (bird species abundance) that could be explained by patterns of variation in a set of predictor variables (habitat data). The resulting ordination expresses not only the pattern of variation in species composition, but also the main relations between bird species and each environmental variable (Jongman *et al*., 1987).

All analyses were performed using the computer language R, version 3.0.1 (R Development Core Team, 2013) and multivariate analysis on ade4 package available in R (Chessel *et al*., 2004; Dray *et al*., 2007).

RESULTS

Bird species abundance and composition

Thirty nine bird species (Table I) were recorded in 68 visits (68 IPA partials) at the 34 sites of zeen oak stands. Avian species richness at each point count ranged between four and 14 species (10±1).

The eight most common forest bird species were Levaillant's green woodpecker *Picus vaillantii* (26 pairs), European Robin *Erithacus rubecula* (41 pairs), Common Blackbird *Turdus merula* (50.5 pairs), Great Tit *Parus major* (76 pairs), (Ultramarine) Blue Tit *Parus caeruleus (ultramarinus)* (29.5 pairs), Short-toed Tree creeper *Certhia brachydactyla* (32 pairs), Eurasian Jay *Garrulus glandarius* (21 pairs), and Common Chaffinch *Fringilla coelebs* (43.5 pairs). Other species were represented only by 1–2 pairs (*e.g.* Common Whitethroat *Sylvia communis*, Collared Flycatcher *Ficedula albicollis* and Hoopoe *Merops apiaster*).

The diversity of bird communities remained strong (H'= 2.10) as well as the evenness index (J'= 0.93), which indicates a good distribution of individuals among species.

Moreover, the concept of frequency F (%), allowed to easily discriminate the species characteristics of an habitat (low density, but acceptable frequency) of those, whose presence is irregular (Muller, 1985). Thus, the number of regular, constant or ubiquitous species, whose frequency is greater than or equal to 50%, are eight; with five, two and one species for each of the category respectively. However, we noticed 26 rare or accidental species with a frequency of less than 25% and five by incidental species with a frequency between 25 and 50 % (Table I). The most dominant families in number of species are Sylviidae (eight), Turdidae (four), and Picidae (three) (Table II). These three families alone represent more than 40% of the total species richness of the

Table I.- Bird species/families/orders recorded in Zeen Oak forest during the breeding period of 2013.

Sr. No.	Common/English name (Scientific name)	Code	Abundance	F (%)	IUCN Red List status 2015.1
Order: Accipitriformes					
Family: Accipitridae					
1.	Bonelli's eagle *(Hieraaetus fasciatus)*	HIFA	1	2.94	LC
2.	Eurasian griffon vulture *(Gyps fulvus)*	GYFU	6	2.94	LC
Order: Bucerotiformes					
Family: Upupidae					
3.	Hoopoe *(Upupa epops)*	UPEP	1	2.94	LC
Order: Columbiformes					
Family: Columbidae					
4.	Common wood pigeon *(Columba palumbus)*	COPA	14	20.59	LC
5.	European turtle dove *(Streptopelia turtur)*	STTU	5	11.76	LC
Order: Coraciiformes					
Family: Meropidae					
6.	European bee-eater *(Merops apiaster*	MEAP	2.5	8.82	LC
Order: Cuculiformes					
Family: Cuculidae					
7.	Common Cuckoo *(Cuculus canorus)*	CUCA	3.5	11.76	LC
Order: Falconiformes					
Family: Flconidae					
8.	Common kestrel *(Falco tinnunculus)*	FATI	1.5	5.88	LC
Order: Galliformes					
Family: Phasianidae					
9.	Common Quail *(Coturnix coturnix)*	COCO	1	2.94	LC
Order: Passiformes					
Family: Alaudidae					
10.	Wood lark *(Lullula arborea)*	LUAR	4	11.76	LC
Family: Certhidae					
11	Short-toed Treecreeper *(Certhia brachydactyla)*	CEBR	32	58.82	LC
Family: Corvidae					
12	Common raven *(Corvus corax)*	COCO	3.5	5.88	LC
	Eurasian jay *(Garrulus glandarius)*	GAGL	21	58.82	LC
Family: Fringillidae					
13.	Common chaffinch *(Fringilla coelebs)*	FRCO	43.5	79.41	LC
	Family: Hirundinidae				
14.	Barn swallow *(Hirundo rustica)*	HIRU	0.5	2.94	LC
Family: Muscicapidae					
15.	Spotted flycatcher *(Muscicapa striata)*	MUST	2.5	2.94	LC
16.	Collared flycatcher *(Ficedula albicollis)*	FIAL	2	5.88	
17.	Pied flycatcher *(Ficedula hypoleuca)*	FIHY	8	20.59	LC

Continued

Sr. No.	Common/English name (Scientific name)	Code	Abundance	F (%)	IUCN Red List status 2015.1
Family: Oriolidae					
18.	Eurasian golden oriole *(Oriolus oriolus)*	OROR	12	5.88	LC
Family: Paridae					
19.	Great tit *(Parus major)*	PAMA	76	100	LC
20.	(Ultramarine) blue tit *(Parus caeruleus)*	PACA	29.5	61.76	LC
21.	Coal tit *(Parus ater)*	PAAT	15.5	35.29	LC
Family: Sylviidae					
22.	Melodious warbler *(Hippolais polyglotta)*	HIPO	0.5	2.94	LC
23.	Common whitethroat *(Sylvia communis)*	SYCO	1	5.88	LC
24.	Blackcap *(Sylvia atricapilla)*	SYAT	10	17.65	LC
25.	Sardinian warbler *(Sylvia melanocephala)*	SYME	5	14.71	LC
26.	Orphean warbler *(Sylvia hortensis)*	SYHO	1.5	2.94	LC
27.	Subalpine warbler *(Sylvia cantillans)*	SYCA	3	5.88	LC
28.	Western bonelli's warbler *(Phylloscopus bonelli)*	PHBO	20	38.24	LC
29.	Firecrest *(Regulus ignicapillus)*	REIG	16.5	32.35	LC
Family: Troglodytidae					
30.	Winter wren *(Troglodytes troglodytes)*	TRTR	11	29.41	LC
Family: Turdidae					
31.	European robin *(Erithacus rubecula)*	ERRU	41	70.59	LC
32.	Moussier's redstart *(Phoenicurus moussieri)*	PHMO	6	14.71	LC
33.	Common blackbird *(Turdus merula)*	TUME	50.5	82.35	LC
34.	Mistle thrush *(Turdus viscivorus)*	TUVI	18	32.35	LC
Order: Piciformes					
Family: Picidae					
35.	Levaillant's green woodpecker *(Picus vaillantii)*	PIVA	26	64.71	LC
36.	Great spotted woodpecker *(Dendrocopos major)*	DEMA	24	5.88	LC
37.	Lesser spotted woodpecker *(Dendrocopos minor)*	DEMI	4	8.82	LC
38.	Eurasian wryneck *(Jynx torquilla)*	JYTO	1.5	5.88	LC

community. Families that dominate the population in number of pairs are Paridae (121 pairs), Turdidae (115.5 pairs), Sylviidae (57.5 pairs), Picidae (55.5 pairs), and Fringillidae (43.5 pairs). They represent more than 70% of the total abundance of the entire population.

The classification of species into bird communities at the study site according to their feeding behaviour was: 64.10 % of bird species were insectivores followed by omnivores (12.82% of species) and birds of prey (10.26% of species). Granivores and frugivores were poorly represented (7.96% and 5.13% of species, respectively). The avian population of the zeen oak forest consisted of four guilds: 17 species (43.6%) of arboreal birds, six species (15.38%) of land birds, nine species (23.08%) found in the bushes, and seven (17.95%) were recorded while hovering in the sky.

Principal component analysis of habitat variables

A strong correlation between the total basal area and the density of tree stratum (Pearson correlation coefficient = 0.72, t-test: $t = 5.862$, $df = 32$, $p = 0.000$) was shown. Strong correlation was also shown between the height and the density of shrub layer (Pearson correlation coefficient = 0.63, t-test: $t = 4.564$, $df = 32$, $p = 0.000$) and between the diameter of the largest timber and the height of tree stratum (Pearson correlation coefficient = 0.61, t-test: $t = 4.397$, $df = 32$, $p = 0.000$).

The first three axes of the PCA (Fig. 2) represent almost 86% of the total variation in the habitat structure matrix (PCA1, 39.64 %; PCA2, 28.09%; PCA3, 18.21%).

The first factor is the variability of the volume of vegetation: total basal area, density, tree cover and the largest diameter of timber measured on the plot. The

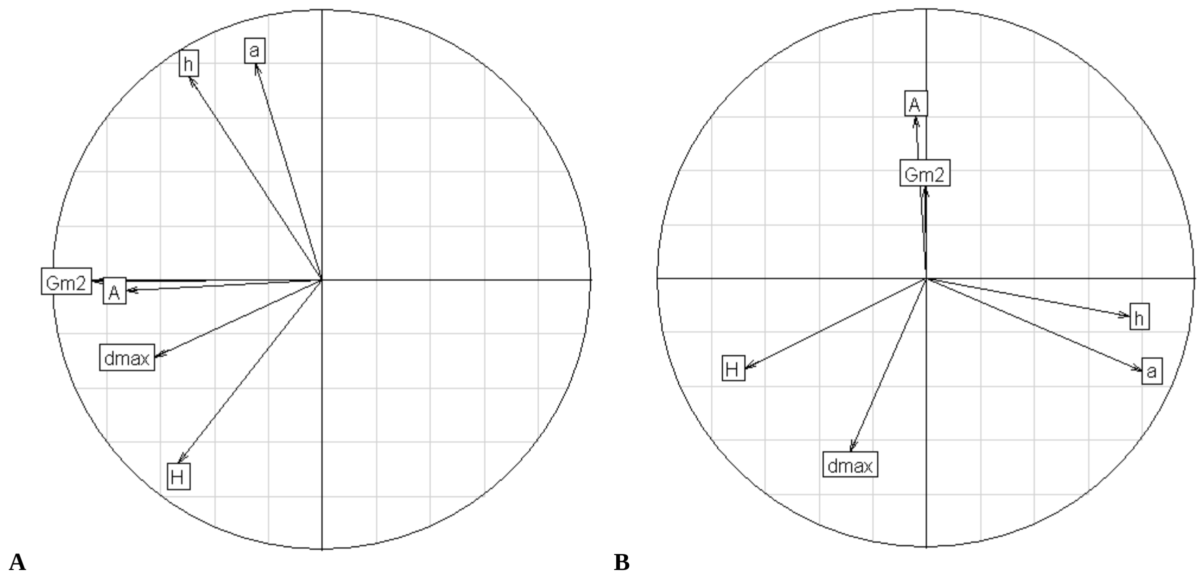

Fig. 2. Correlation circle from PCA of environmental descriptors. Factor plan F1 F2 (A) and factor plan F1 F3 (B).

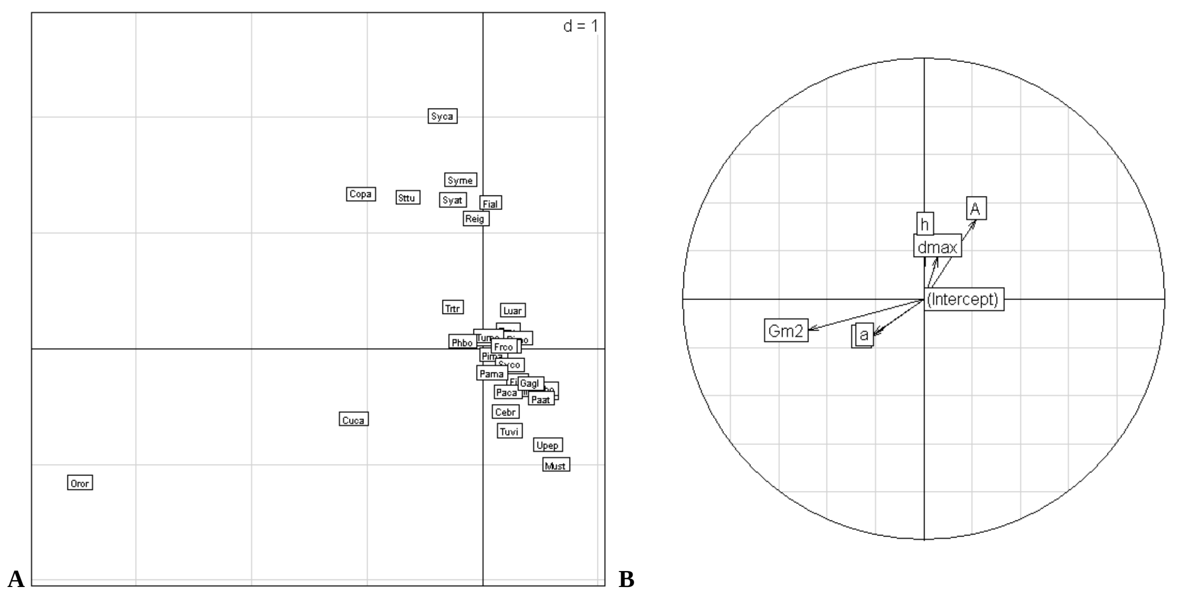

Fig. 3. Ordination biplot depicting the first two axes of the CCA ordination. Continuous explanatory variables are represented by correlation circle (B) and species positions (A) are indicated by their acronyms (See Table I for species codes).

second factor reflects the size of the trees stand height. The third axis represents the occupation of the shrub: height and density of shrub layer.

General patterns from CCA ordination

Associations of the environmental gradients described by CCA with bird community parameters are shown in Figures 3 and 4. The first three CCA axes represent almost 79% of the variability in the data (CA1: 36.04 %, CA2: 27.18%, CA3: 15.75%).

The species ordination indicated that axis 1 (negative loading) was a gradient of total basal area with height of tree stratum. Western Bonelli's warbler (*Phbo*), common wood pigeon (*Cuca*), and Eurasian golden oriole

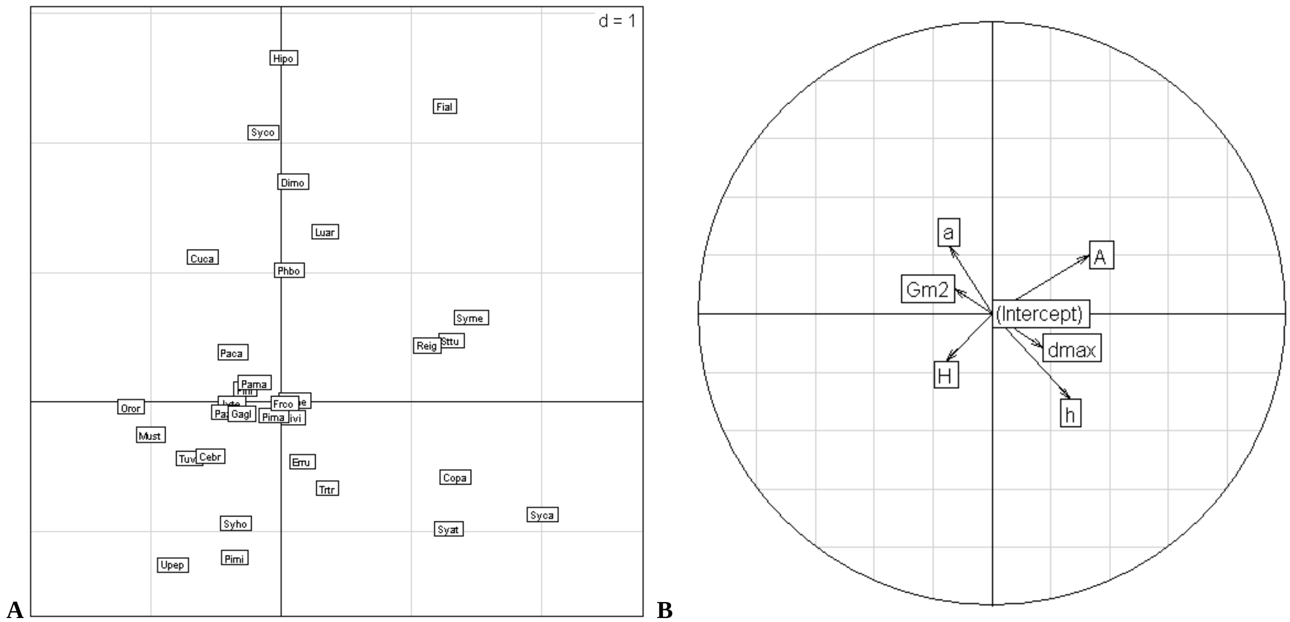

Fig. 4. Ordination biplot depicting the factor plan F1 x F3 of the CCA ordination. Continuous explanatory variables are represented by correlation circle (B) and species positions (A) are indicated by their acronyms (See Table I for species codes)

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

S. No.	Family	Species	P%	Abund-ance	P%
01	*Accipitridae*	2	5.13	7	1.33
02	*Alaudidae*	1	2.56	4	0.76
03	*Certhidae*	1	2.56	32	6.1
04	*Columbidae*	2	5.13	19	3.62
05	*Corvidae*	2	5.13	24.5	4.67
06	*Cuculidae*	1	2.56	3.5	0.67
07	*Falconidae*	1	2.56	1.5	0.29
08	*Fringillidae*	1	2.56	43.5	8.29
09	*Phasianidae*	1	2.56	1	0.19
10	*Hirundinidae*	1	2.56	0.5	0.1
11	*Meropidae*	1	2.56	2.5	0.48
12	*Muscicapidae*	3	7.69	12.5	2.38
13	*Paridae*	3	7.69	121	23.05
14	*Picidae*	4	10.26	55.5	10.57
15	*Oriolidae*	1	2.56	12	2.29
16	*Sylviidae*	8	20.51	57.5	10.95
17	*Troglodytidae*	1	2.56	11	2.1
18	*Turdidae*	4	10.26	115.5	22
19	*Upupidae*	1	2.56	1	0.19
	Total	**39**	**100**	**525**	**100**

(*Oror*) were oriented close to these with a high proportion of Eurasian golden oriole (*Oror*) (*i.e.* a strong correlation between Eurasian golden oriole and the gradient of total basal area with height of tree stratum). In contrast, axis 2 (positive loading) was a gradient of density of tree stratum and diameter of the largest timber with the height of shrub layer and included wood lark (*Luar*), Firecrest (*Reig*), Collared Flycatcher (*Fial*), blackcap (*Syat*), sardinian warbler (*Syme*), and subalpine warbler (*Syca*).

For axis 3, species oriented close to vectors for density of shrub layer (positive loading) are great tit (*Pama*) and (ultramarine) blue tit (*Paca*).

The results indicate that the first factor of differentiation of the zeen oak woodland of Boumezrane forest avifauna is the size of trees (total basal area and height of tree stratum) with the height of shrub layer; those variables most influencing bird species, followed by the volume of tree stratum (density of tree stratum and diameter of the largest timber) and finally, density and height of shrub layer.

DISCUSSION

Our study presents the data concerning the structure and dynamics of the forest birds zeen oak woodland of Boumezrane forest in Souk Ahras (Northeastern Algeria).

Species richness and composition

The patterns of species richness and the composition of avifauna within oak stands in zeen oak woodland of Boumezrane forest were approximately similar to Europe, Morocco, and Algeria (Blondel and Farré, 1988; Benyakoub, 1993; Bellatreche, 1994; Cherkaoui *et al.*, 2007).

Blondel and Farré (1988) found 39 species in close habitats of holm oak in Corsica, while, Cherkaoui *et al.* (2007) identified 46 species in the cork oak stands of Ma'amora in Morocco. In Algeria, Benyakoub (1993) found 42 species in the zeen oak forests in El-Kala region, Bellatreche (1994) found 34 species in the zeen oak habitat of Babors in Kabylie, and Mostefai (2011) found 40 species of nesting birds in the cork oak forest of Hafir in Tlemcen.

Based on the number of bird species breeding in the zeen oak forest of Boumezrane, it is mostly the same as that of breeding birds elsewhere in the Western Palaearctic (Blondel and Mourer-Chauviré, 1998) and confirms the inclusion of the Algerian forest in the same European biogeographic realm.

Levaillant's green woodpecker *Picus vaillantii* with great values abundance (26 pairs), great spotted woodpeckers *Dendrocopos major,* and lesser spotted woodpecker *Dendrocopos minor* those characterize the Algerian oak (Mostefai, 2011). Other birds like pied flycatcher *Ficedula hypoleuca* is restricted to mount cedar of Central and Eastern North of Algeria (Mostefai, 2011). However, it was recorded from the zeen oak forest. Collared flycatcher *Ficedula albicollis* whose migration routes pass through eastern Algeria, hence rarely observed during autumn migration, and yet it is more regular in spring particularly in the east, although in low numbers (only two pairs were recorded in the study area) (Isenmann and Moali, 2000).

European bee-eater *Merops apiaster* and barn swallow *Hirundo rustica* were found in the forest because the forest of Boumezrane contains forest edges and habitats influenced by human beings (presence of habitation in the forest).

The 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 clear and the mosaic structure of zeen oak stands (presence of clearings and fields), the clearing of the open oak forests to create agro-forestry habitat that also supports grassland species, as the grasslands are located adjacent to the forest.

Habitat relationships with species richness

Several studies have shown that natural factors, such as plant diversity and habitat structure affect the composition and richness of bird communities (Cody, 1981; Diaz, 2006; Reid *et al*., 2004; Robinson and Holms, 1984). The vast majority of these studies cover areas of American or European boreal forests and U.S. forests in general (Hobson and Bayne, 2000; Thompson *et al*., 1999; Denis, 2009; Delahaye, 2006).

In African deciduous forests only a few studies have been conducted *e.g.* Ghana (Wiafe *et al*., 2010) and Algeria (Benyakoub, 1993; Bellatreche, 1994).

Our results are consistent with the notion that bird communities respond in complex ways to a variety of structural and floristic elements within woodland habitats (Donald *et al*., 1998). The relationships determined for species richness were broadly consistent with many previous studies and were to some extent expected (Hewson *et al*., 2011).

The results are, however, not surprising because our study was conducted in a limited range of composition, *i.e*. zeen oak stands and structure variables include variables dimensions of wood that are the basis of greater variability of forest stands.

According to our results of the canonical correspondence analysis (Figs. 3, 4), the predictor variables which are best correlated with the variance of bird communities are the size of trees with the height of shrub layer and the volume of tree stratum. In the open area, the gradient of the density of shrub layer appeared to be more related to bird assemblages structuring.

Whereas, the relationship between the tree height (tree size) and the breeding occurrence of the birds may be related to the selection of safe nesting places, nests situated in the lower parts of trees may suffer from higher levels of predation or disturbance than nests situated in the higher parts of trees (Jokimäki, 2000).

The results highlight the importance of shrub layer development in explaining bird community parameters. Shrubs promote structural heterogeneity, increasing the diversity of different breeding sites and refuges, and increase food diversity and availability during the breeding season through the associated arthropod fauna (Golet *et al*., 2001; Bonham *et al*., 2002 ; Johnson and Freedman, 2002; Sánchez and Parmenter, 2002).

Most of the studies that have focused on the effect of shrub layer on birds focused on structural characteristics such as cover (Golet *et al*., 2001; Kirk and Hobson, 2001; Ross *et al*., 2001; Herrando and Brotons, 2002; Liebezeit and George, 2002; Bombay *et al*., 2003; Díaz, 2006), height (Kirk and Hobson, 2001; Fernandez-Juricic *et al*., 2002; Díaz, 2006), or frequently disregarding floristic composition (Holmes and Robinson, 1981; Robinson and Holmes, 1984; Gillespie and Walter, 2001).

In this study, structural characteristics of shrub layer, such as cover or height, were also important determinants of abundance and richness.

In addition, the mean tree diameter is positively correlated with tree volume and in turn it affects the productivity of vegetation that can have a very significant effect on bird communities (Jokimäki and Huhta, 1996). Large trees also have a large surface of bark and greater structural complexity (Nilsson, 1979; Schieck *et al*., 1995). Arboreal birds of prey are more abundant in older stands where invertebrates or dead wood and rotting branches are more abundant than in young stands (Laiolo, 2002).

CONCLUSIONS

Overall, we can conclude that the results obtained in this study significantly contribute to greater knowledge of breeding birds in the zeen oak woodland of Boumezrane forest, helping to further understand how the structure of these bird assemblages can vary significantly at the local and/or regional level within structural configuration of the habitat and to assess the effects of habitat change on the integrity of these communities. This information will help also in planning future conservation activities and maintain the biodiversity in these forest ecosystem.

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Statement of conflict of interest

Authors have declared no conflict of interest.

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