World Journal of Environmental Biosciences

Available Online at: **www.environmentaljournals.org**

Volume7, Issue 1: 40-47

ISSN 2277- 8047

Structure and Diversity Pattern of Urban Birds in Semi-Arid Region of Algeria

Samira Benchabane[1], Ettayib Bensaci[2], Yassine Nouidjem[2*], Sabrina Bougoudjil[1], Menouar Saheb[1]

[1]Department of Natural and Life Sciences, University of Oum El-Bouaghi, Algeria.
[2]Department of Natural and Life Sciences, University of M'Sila, Algeria.

ABSTRACT

With the aim to evaluate the urban birds' diversity, this study was conducted in a semi-arid region of Algeria in an old city characterized by homogeneous habitats. The monitoring was carried out during two consecutive years, from January 2013 to December 2014, allowed assessing 32 species, representing 09 orders and 20 families. Passeriformes were the most, represented by 20 species. The families most represented were Fringillidae, Muscicapidae and Colombidae by 5, 4 and 3 species, respectively. Resident breeders were the most dominant by 20 species (63 %), whereas 08 species (25 %) are summer migrants. Only 2 species were wintering and passage migrants; where, 24 passerines and 8 non passerines species were assessed. However, opportunistic and tolerant species are the most abundant. Overall, the socio-economic activities of the study area and urbanization landscape are the main factors in species structure and abundance in this city. These findings are important to estimate the effect of urbanization pressure on biodiversity, especially urban birds, and relevant to future urban management by offering various habitat types.

Keywords: *Richness, Birds, Urban Ecosystem, Semi-Arid, Algeria.*

Corresponding author: Nouidjem Yassine
e-mail✉ nouidjemyacine@yahoo.fr
Received: 03 October 2017
Accepted: 17 January 2018

1. INTRODUCTION

The modification of natural habitats into agricultural and urbanized areas produce a mosaic of land types ranging from highly built urban to natural or semi-natural areas (McDonnell et al., 1993). Increasing urbanization is a major threat to biodiversity (John et al., 2009).

Birds are excellent indicators to survey the effects of urbanization since they respond rapidly to changes in landscape configuration and modification (Marzluff et al., 1998). Overall, urban development is one of the main reasons of the greatest local extinction, and frequently eliminates the large majority of native species (Kowarik, 1995; Marzluff, 2001).

Nonetheless, it is encouraging to see this evolution in research interest in urban biodiversity, and particularly urban bird ecology, in recent years (John et al., 2009). Assessment of species' richness and diversity is particularly useful in monitoring biodiversity because it depends on the habitats' characteristics (Breininger et al., 2002). In Europe, urban birds have been particularly well studied in Germany since 1989 (Otto and Witt, 2002). England follow-ups were made from 1988 to 1994 in Greater London (Hewlett, 2002), France, (Clergeau et al., 1998), Italy (Dinetti, 1994), Brussels (Weiserbs and Jacob, 2007). In Algeria, except for limited studies on some bird species in urban ecosystems (Moali et al., 2003; Mesbahi, 2011; Mestari et al., 2013; Brahmia et al., 2015; and Kaf et al., 2015), very few studies have been conducted on urban birds' diversity and their distribution patterns.

In this study, we aimed to assess the richness, abundance and diversity pattern of an urban area located in semi-arid climate, particularly to, (i) assess and compare avian diversity (species richness, Shannon–Wiener index and evenness) along the year (i.e. between different phonological periods), and also, (ii) find out the tendency of these ecosystems for invasive species. This contribution can be served as a tool for planners and urban managers.

2. MATERIELS AND METHODS

Study area

Our research was conducted over two years 2013 and 2014, in Ain Beida city (Oum El Bouaghi, Algeria - 35°47'47'' N, 7°23'34'' E) (Figure 1). This city is located in semi-arid climate with annual mean rainfall average less than 400mm / year, it is characterized by cold winters with snowfall and very hot summers. It covers over 52 km^2, and has a population of almost 120218 inhabitants with an average density of 2312 inhabitants /Km^2.

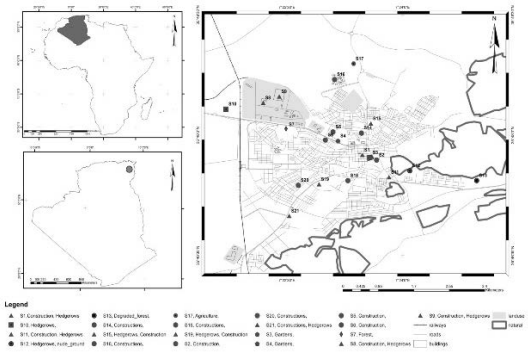

Figure 1: Location of the study area

The urban structure of the study area

Ain Beida city was created in 1939 as a colonial center, as well as the majority of Algerian cities during the colonial period. This city had been recognized as having significant urban growth. Three urban structures of the city were determined: The former colonial buildings, Informal constructions, and Dominant tissues for later urbanization.

Bird monitoring

With the aim to study the bird diversity at Ain Beida city, point counts were carried out in different habitat types and locations within the city. To reach our goal, we adopted the punctual indices of abundance method (Blondel et al., 1970), which remains the most appropriate for these habitats. This approach is based on the assessment of all contacted birds and their abundances during a period of 15 minutes, where all birds seen or heard are listed without distance limit. Outside the breeding season, we applied the direct observation method (Bibby et al., 2000). Also, this technique estimates species' richness regardless of species' abundances provided it is applied under favorable weather conditions (Bibby et al., 2000).

Monthly counts are performed on each station, this survey frequency allowed to determine the phonological status (Resident breeder, summer migrant, wintering and migrant passage) of all the assessed bird species.

A pair of 8×42 resolution binoculars (Olympus mark) and a field bird guide were also used to identify observed bird species. A total of 152 samplings were undertaken, representing all habitat types that varied in their building density to incorporate all levels of urbanization (Figure 1). Several sampling points were recorded in each habitat. Avian species' richness was defined as the total number of species detected at each site during the study. However, the species abundance corresponded to the highest number of birds counted by species in different point surveys.

Data analysis

Furthermore, the richness and relative abundance, as two complementary indices were calculated; Shannon–Wiener index (H′) and evenness index, along the study period and at each count station.

The Shannon–Wiener index (H′) was estimated as $H' = -\Sigma (n_i/N \log_2 n_i/N)$, where n_i and N are the number of individuals of each species and the total number of individuals, respectively (MacArthur, 1955). Mean (± SD), species richness (S), Abundance, Shannon—Wiener (H′) indices and Evenness were subsequently calculated for each month.

Finally, an evenness index, as suggested by Pielou (1966), was estimated for each point E= H′ tot/ H′max, where H′ tot is the Shannon–Wiener index calculated for all points pooled, and where H′max = log2 Stot, with S tot representing the total number of species recorded. Statistical tests were performed using SPSS 17.0 with a significance level of P ≤0.05. The main aim was to investigate the possible monthly and yearly differences of bird richness, relative abundance, and calculated indices (one simple t-test and independent simples t-test). A Factorial correspondence analysis (FCA) between species and sampling dates (months) was developed (Palm, 1993).

3. RESULTS AND DISCUSSION

Specific richness and abundance of birds

The inventory of urban birds at Ain Beida city during two consecutive years, from January 2013 to December 2014, allowed assessing 32 species, representing 09 orders, and 20 families that represent 30.3% of families counted in Algeria.

Passeriformes were the most represented by11 families and 20 species (62.5% of species richness). The families mostly represented were Fringillidae, Muscicapidae and Colombidae by 5, 4 and 3 species, respectively (Table 01; Figure 2).

Specific richness

Mean monthly richness during the study period was 23.38 ± 5.8. This richness displayed a temporal variation through the study period. Where mean monthly richness was significantly different ($t = 19.74$, $df = 23$, $P = 0.000$). Although, no significant difference was found between years ($t(22) = 0.103$, $P = 0.919$) (Figure 3). The peak was observed during June with 31 species, however, the less richness (16 species) was noted during January and December for both years. In fact, the breeding period from March to September showed the highest specific richness. The diversity index of Shannon displayed two peaks during May and August (Figure 3).

Abundance

The urban ecosystem showed important bird abundance varied between (2704 and 6856 individuals), with mean monthly abundance of 4572.38 ± 317.16. A significant different was found between months ($t = 14.41$, $df = 23$, $P = 0.000$). However, no significant difference was found between 2013 and 2014 ($t(22) = 1.16$, $P = 0.26$). It was dominated by the rock dove pigeon, House sparrow, Common Starling, Eurasian Collared Dove and Common Swift. Overall, the abundance was relatively high from April to September of each year. These months coincide the breeding period. However, the wintering period (from November to January) showed the lowest bird abundance (Figure 4). The swallows and swifts arriving from their wintering quarters marked their presence

during this season. In summer 2013, the abundance was maximal (8100 individuals) over four seasons of two years. House sparrow recorded the largest abundance with more than 2400 individuals comparatively to other species.

Nevertheless, the rock dove pigeon and Eurasian collared dove remained as abundant especially in summer. Storks, swallows and swifts remained as present with very large numbers.

Table 1. Species assessment and their status

Family	Common name	Scientific name	Phenological Status
Passeridae	House sparrow	Passer domesticus	RB
Sturnidae	Common Starling	Sturnus vulgaris	W
Turdidae	Common Blackbird	Turdus merula	RB
Paridae	Eurasian Blue Tit	Cyanistes caeruleus	RB
	Great Tit	Parus major	RB
Fringillidae	European Greenfinch	Carduelis chloris	RB
	European Serin	Serinus serinus	RB
	Common Chaffinch	Fringilla coelebs	RB
	Common Linnet	Linaria cannabina	RB
	Red Crossbill	Loxia curvirostra	RB
Muscicapidae	European Robin	Erithacus rubecula	W
	Spotted Flycatcher	Muscicapa striata	SM
	European Pied Flycatcher	Ficedula hypoleuca	SM
	Black Wheatear	Oenanthe leucura	SM
Laniidae	Woodchat Shrike	Lanius senator	SM
Corvidae	Northen Raven	Corvus corax	RB
Hirundinidae	Barn Swallow	Hirundo rustica	SM
	Common House Martin	Delichon urbicum	SM
Sylviidae	Garden Warbler	Sylvia borin	MP
Alaudidae	Eurasian Skylark	Alauda arvensis	RB
Colombidae	Rock Dove	Columba livia	RB
	Eurasian Collared Dove	Streptopelia decaocto	RB
	European Turtle Dove	Streptopelia turtur	RB
Ciconiidae	White Stork	Ciconia ciconia	SM
Falconidae	Common Kestrel	Falco tinnunculus	RB
Upupidae	Eurasian Hoopoe	Upupa epops	RB
Strigidae	Little Owl	Athene noctua	RB
Tytonidae	Western Barn Owl	Tyto alba	RB
Apodidae	Common Swift	Apus apus	SM
Ardéidae	Western Cattle Egret	Bubulcus ibis	RB
Accipitridae	Black Kite	Milvus migrans	RB
	Egyptian Vulture	Neophron percnopterus	MP

Ecological indices

Ecological indices were used for a better understanding and analysis of changes of urban birds' structure during the study period across the year periods in the city.

Shannon-Weaver index and evenness

Shannon-Weaver diversity index allowed us to measure the complexity of diversity of the community. The high value of this index indicated that the community is very diversified. Conversely, a low value of this index signified the weak diversity and a small number of species.

The Figure (5) shows two important peaks 3.17 and 3.05, during May and August, respectively. However, the lowest value was noted during the month of December (1.81). Mean monthly Shannon-Weaver index was relatively low (2.44± 0.54), where monthly values were significantly different between months ($t = 2.44$, $df = 23$, $P = 0.000$). While, no significant difference was found between study years ($t(22) = 0.316$, $P = 0.755$). This index displayed a slight stability during the breeding season.

The evenness (equitability) index is related directly to the distribution of abundances on the species richness. Similarly, considering Shannon index, the evenness displayed a relative stability from April to September. The maximum of 0.65 and 0.63 were observed during the months of May and August, respectively, in two study years. Whereas, the minimum value of 0.44 was noted during January (Figure 6). Mean monthly evenness value was (0.54± 0.08), however, a significant motherly difference was reported ($t = 32.82$, $df = 23$, $P = 0.000$), but no inter-years difference was found ($t(22) = 0.335$, $P = 0.741$).

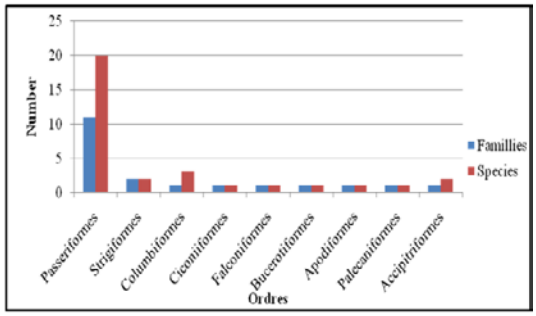

Figure 2: Distribution of families and species following the orders

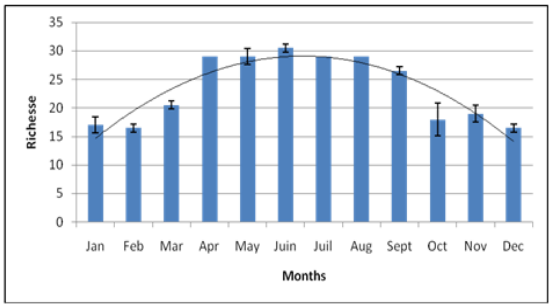

Figure 3: Bird species richness at Ain Beida city during the study period

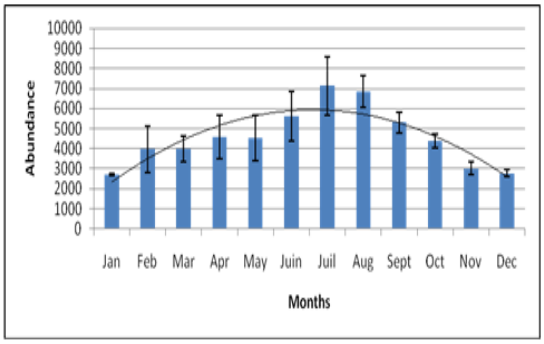

Figure 4: Bird species abundance at Ain Beida city during the study period

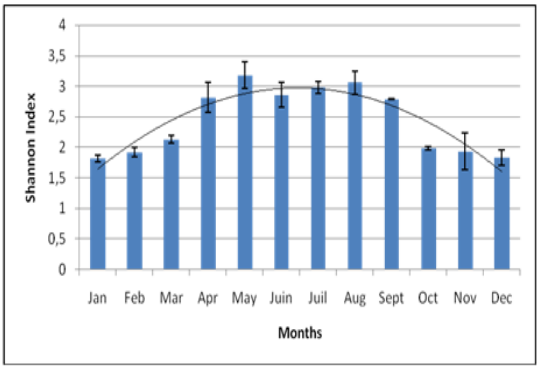

Figure 5: Variation of Shannon-Weaver index of bird community at Ain Beida during the study period

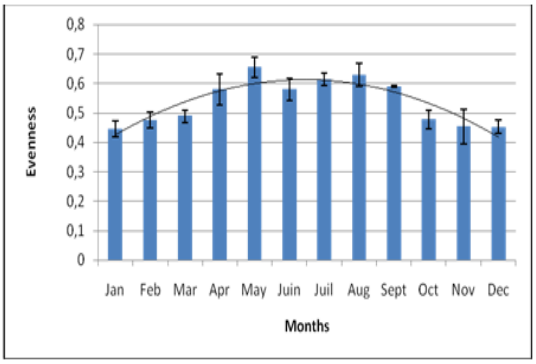

Figure 6: Variation of Evenness of bird community at Ain Beida during the study period

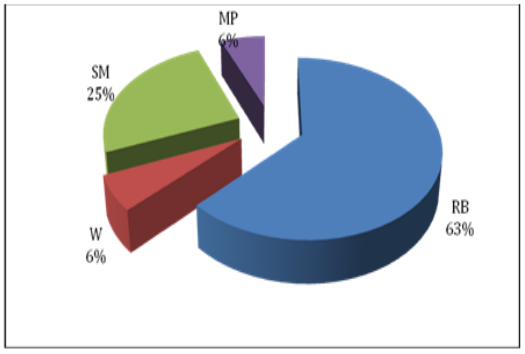

Figure 7: Phenological status of urban birds at Ain Beida city

Phenological status of birds at Ain Beida city

Most of the assessed birds have the resident breeder status (63 % -20 species). Whereas, 25 % (08 species) are summer migrants, most of these species are: swallows, storks, swifts, etc. Only 2 species are wintering and passage migrants, respectively.

Overall, 25 species are passerines birds and 7 are non passerines species (Table 1; Figure 7)

Table 2: Phenology of bird species in Ain Beida City (2013-2014)

Months	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Columba livia	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Streptopelia turtur	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Streptopelia decaocto	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			■
Passer domesticus	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Sturnus vulgaris	■	■	■	■	■	■					■	■	■	■	■	■	■	■					■	■
Ciconia ciconia	■	■	■	■	■	■	■	■				■	■	■	■	■	■	■	■	■	■		■	■
Turdus merula	■	■	■	■	■	■	■	■	■					■	■	■	■	■	■	■	■		■	■
Cyanistes caeruleus	■		■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■
Parus major	■		■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■		■	■
Serinus serinus			■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■
Chloris chloris	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Erithacus rubecula				■	■											■			■				■	
Fringilla coelebs	■			■	■	■	■	■	■	■	■					■	■	■	■	■	■	■	■	■
Loxia curvirostra	■			■	■							■				■							■	
Upupa epops	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Hirundo rustica				■	■	■	■	■	■							■	■	■	■	■	■			
Delichon urbicum				■	■	■	■	■	■							■	■	■	■	■	■			
Corvus corax	■	■	■	■	■	■	■	■	■	■	■			■	■	■	■	■	■	■	■		■	
Falco tinnunculus	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Bubulcus ibis	■	■	■	■	■	■	■	■	■	■			■	■	■	■	■		■	■	■	■	■	■
Milvus migrans	■				■		■	■	■		■		■	■	■	■		■	■	■		■		
Sylvia borin				■	■	■	■	■	■							■	■	■	■	■	■			
Athene noctua		■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■		■
Tyto alba	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■			■		
Apus apus					■	■	■	■	■								■	■	■	■	■			
Linaria cannabina				■	■	■	■	■	■							■	■	■	■	■	■			
Lanius senator					■	■	■	■	■								■	■	■	■	■			
Muscicapa striata				■	■	■	■	■	■	■	■					■	■	■	■	■	■	■	■	■
Ficedula hypoleuca					■	■	■	■	■								■	■	■	■	■			
Neophron percnopterus			■	■		■	■	■	■		■			■	■	■		■	■	■	■	■		
Oenanthe leucura		■	■	■	■	■	■	■	■	■				■	■	■	■	■	■	■	■	■		
Alauda arvensis	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			

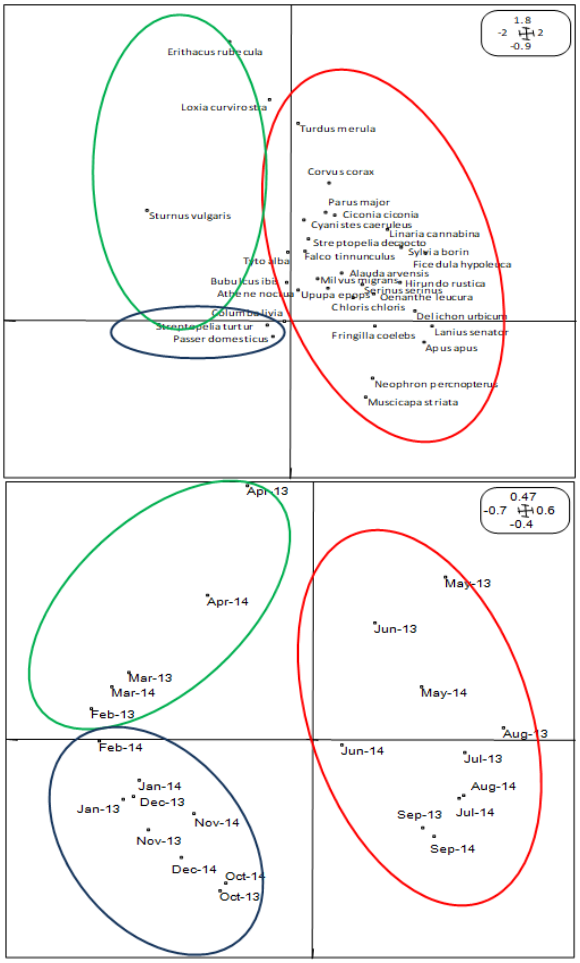

Figure 8. Graphical presentation of factorial correspondence analysis (FCA) showing the distribution of bird species throughout different months of the study period. Factorial plan 1x2 indicates around 76 % of the total variation (Axe 1: 57.94%; Axe 2: 18.27%)

The distribution of 32 species in 24 months is represented in a two-axis coordinate system (Figure 8), which altogether explains >76% of the total variance. Three distinct periods are apparent:

The first period was from October to February. It represented the winter period that was characterized by the presence of the common and resident species such as: Streptopelia turtur and Passer domesticus. These species occupied different types of urban habitats throughout the year with high numbers during this period in the two years of study.

The second period was spread over the months of March and April. It was characterized by the presence of the species that arrived there for nesting (early breeders) or for a first egg-laying, these species are: Erithacus rubecula, Loxia curvirostra, Tyto alba, Sturnus vulgaris, Athene noctua, Bubulcus ibis.

Finally, the third period stretched from May to September for the two study years. This period was characterized by a high number of species, some of them are breeding and others are passage visitors, which coincide at the end of August and the month of September. However, several breeding species among them lay twice a year. The abundant species during this period are: Columba livia, Streptopelia decaocto, Ciconia ciconia, Turdus merula, Parus major, Chloris chloris, Fringilla coelebs, Hirundo rustica, Delichon urbicum, Falco tinnunculus, Apus apus and Muscicapa striata.

4. DISCUSSION

This study examined trends in richness and abundance of urban birds across a range of sampled habitats implanted in an Algerian semi arid city. The most recurrent pattern described for urban avifaunal distribution was a negative relationship between species richness and urbanization (Blair, 1996; Chiari et al., 2010).

Overall, assessed bird species in the study area represented 7.88% of all Algerian bird species (Isenmann and Moali, 2000). However, the species richness was low in our survey comparing to former results reported in Mediterranean cites, 42 species in Rennes (France), 43 species in Donges-Est (France), 60 species nest in central of Paris (Malher and Magne, 2010).

As well, in Europe, the richness is very higher than our study area, which identified only 32 species. There were 86 breeding species which have been identified in Florence (Italy) (Dinetti, 2009), 103 species regularly nest on the Land of Berlin (Otto and Witt, 2002) and 126 species were identified from 1988 to 1994 in Greater London (Hewlett, 2002).

Chace and Walsh (2006), reported that species richness declines as a result of the loss of the natural habitat and the reduction of resource availability. In the study area the urban density varied between 65 -90% in the centre, where it is lower in the peri-urban (35-60 %). Bird species richness decreases with increasing urban land cover (Donnelly and Marzluff, 2006; Pennington et al., 2008), similar to what happened in Ain Beida city, where large natural lands were urbanized in the last twenty years with an annual urban evolution of 2.74 % between 1998 and 2008 (R.G.P.H, 2008). This speed in urban growth is expressed by the high population density (2595 hab/Km2) in 2016 (Mazouz and Adad, 2018). The recorded temporal patterns of richness and abundance along the study period over the years may reflect the combined effect of phenological status of species that occupied the study area, and the quality of habitats represented by food availability (Bolger, 2001; Marzluff, 2001). The dominance of urban ecosystems by passerines species illustrates an image of their importance in global level. Our results confirmed the previous studies found in other urban areas in the world, that the passerines are mostly represented by more than 60% of bird species (Blondel and Mourer-Chauvier, 1998; Aliabadian et al., 2005). In our study area, the most found species are resident breeders (63%), in agreement with what reported by Garaffa et al., (2009), that urbanization favors both synanthropic non-migratory species and exotic species, while excluding many species sensitive to human disturbance (Rottenborn, 1999; Allen

and O"Conner, 2000; Whited et al., 2000). The dominance of resident breeder species could be explained by the heterogeneity of urban habitats of the study area (Gardens, Const+ Hedgerows, Agriculture, Degraded Forest, Hedgerows…) that offer breeding conditions and a variety of food resources. However, only 10 species are migratory nesting. This can be explained by the competition from sedentary species well acclimatized to the difficult conditions of this area especially during winter.

Despite the fact that their natural habitats are woodlands, forests or open areas, many non-native species were determined in the study area as residents with considerable numbers, such as: Streptopelia decaocto, Falco tinnunculus, Loxia curvirostra, Tyto alba, Bubulcus ibis. One of the great conservation challenges of urban extension is that it replaces the native species that are lost with widespread "weedy" nonnative species (Michael and McKinney, 2002). Shochat et al. (2010), found that the urbanization increases total bird densities, where only a few species contribute to this increase, in fact, urbanization increases the abundance of feral pigeons, swallows, swifts, and a few other species that breed in walls. Birds in urban ecosystems are usually opportunistic species with general guild, where specialized diets disappear from urban assemblages as urbanization increases (McKinney and Lockwood, 1999), these last authors, indicated that, the urbanization process decreased the taxonomic characteristics of avian communities by the loss of rare and specialist species, and by the increase of generalist urban birds.

Our results indicated that urbanization affect bird species' richness, both by decreasing native species' diversity and addition of widely distributed synanthropic species, such as: Rock Dove, Western Cattle Egret and House Sparrow.

The remarkable abundance observed of limited species (Columba livia, Streptopelia turtur, Passer domesticus and Chloris chloris) especially those opportunistic species in the study area could be explained by the urban growth which is in conversion of natural habitats into managed urbanized systems on hand, and socioeconomic patterns of the region. This dominance was directly reflected on evenness values. However, the business and agriculture are the main activities in the study area, which produce a high amount of waste, that attract many opportunistic species, where waste tips constitute important food sources widely utilized particularly by opportunistic species (Pomeroy, 1975; Belant, 1997). Also, the location of grain storage silos in this city, favored a high number of pigeons (Columba livia). The main assessed bird species in the study area are granivores, omnivores, and areal insectivores, according to (Allen and O"Conner, 2000; Chace and Walsh, 2006), where these guilds are the most tolerant to urban environments. The vegetation species of the study area are dominated by non-native flora that may justify the low species richness. White et al, (2005), reported that the higher proportion of exotic vegetation supports the lower richness and abundance of bird species, where, a native flora may support more diverse bird communities.

Overall, our findings are similar to general patterns described for urban birds in many regions of the world, however the species richness and abundance are strongly related to socioeconomic pattern, the high urbanization structure, and the birds' guilds.

Considering species richness, our study city is less diversified than most cities in the Mediterranean region, especially in the northern shore. The reduced number of the urban garden and lower vegetation rate in this city could be one of the main causes of this poorness.

Our results provide essential information for urban planners and conservationists on the importance of urban ecosystems, but a huge effort is needed to improve the situation by planning gardens and encouraging native trees plantation. In future urban development plans, it's recommended to pay attention to: 1) green spaces, where the habitat quality for birds can be improved by variation of vegetation structure, 2) preferring native and adaptive vegetation species for planting, and 3) avoiding wild dump of domestic waste particularly into urban agglomerations.

5. ACKNOWLEDGEMENTS

We thank Youcef-khoudjaNazih for his help in preparing the Map and also, we also thank the members of Association NationaleAlgériend'Ornithologie (A.N.A.O), and the PhD students of University of Oum El Bouaghi: HedjabRamzi, for their invaluable field assistance.

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