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Original Article

Coexistence between primary and secondary cavity-nesting birds in Chelia-Ouled Yagoub National Park of Algeria

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ABSTRACT

In forest ecosystems, the cavity-nesting community is strongly dependent on the availability of tree cavities in which the breeding season takes place. This work aims to investigate links between two ecological groups as primary and secondary cavity-nesting species. The investigations carried out using the count point method, during two breeding seasons from Mars to July 2018 and 2019, made it possible to distinguish eight species of cavity-nesting birds; only the Levaillant's Woodpecker *Picus vaillantii* constitutes a primary cavity able to dig its cavities. In the Chelia-Ouled Yagoub National Park, the modeling of the occurrence data highlights a significant coexistence between the latest species and only three secondary cavity-nesting species, namely the Atlas Pied Flycatcher *Ficedula speculigera*, the Eurasian Hoopoe *Upupa epops*, and the Short-toed Treecreeper *Certhia brachydactyla*. This result supports the consideration of woodpeckers as keystone species for biodiversity, whose protection leads to the conservation of forest balance in general.

1. Introduction

Tree microhabitats are small substrates created by animals or by mechanical damage affecting the tree because of high winds or extreme heat [1]. Among these micro-habitats, tree cavities constitute excellent ecological niches for many plants, fungi [2], invertebrates such as insects [3], and vertebrates including birds and mammals [4, 5, 6]. These taxa are called cavity-nesting species [7].

Worldwide, cavity-nesting birds represent an important group of avian fauna [8]. Between 4 and 11% of birds are obligate cavity nesters that require cavities for their reproductive success, while 9 to 18% of birds use cavities for food, to reproduce, or as a shelter to limit the risk of predation [9]. In general, this group constitutes 30-45% of the total individuals of forest birds [10].

There are two groups of cavity-nesting birds according to the way they obtain their habitat as cavities. The primary cavity-nesting birds excavating their cavities on trees such as woodpeckers, represent this ecological group's dominant species. Secondary cavity nesters occupy tree holes that were dug by excavators or generated by the natural aging or decay of the tree [11, 12, 13]. They are unable to dig their cavities. For the two groups, the cavities represent a vital habitat around which they interact with their biotic and abiotic environments [14]. In forest ecosystems, the unavailability of cavities constitutes a limiting factor for

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the growth rate of the local cavity-nesting populations [9, 15, 16].

Woodpeckers are key species that contribute to the functioning of the entire forest ecosystem [17, 18]. Indeed, they are the only species able to create nesting cavities. For example, in the closed forests of Poland, the total number of bird species is positively correlated to the number of woodpecker species [19]. In the deciduous forests of northern Europe, the occurrence of birds is regularly associated with the European Green woodpecker *Picus viridis* [20]. In addition, in the Mediterranean forests of Italy, the Great Spotted Woodpecker *Dendrocopos major* has a positive effect on the distribution of all secondary cavity-nesting species [21]. Consequently, the abundance and richness of avifauna in a forest ecosystem can be favorably influenced by the presence of woodpeckers [22]. The woodpecker populations are considered umbrella species because their presence in an area indicates the presence of other species. Therefore, the conservation of woodpeckers helps protect other components of forest fauna.

In Algerian forests, three woodpecker species are found, the Great Spotted Woodpecker *Dendrocopos major*, the Lesser Spotted Woodpecker *Dryobates minor*, and the Levaillant's Woodpecker *Picus vaillantii*, an endemic species to North Africa [23]. The latter has been the subject of studies on its habitat, diet, and reproduction [24, 25, 26, 27, 28]. This fieldwork has been developed to analyze the ecological and spatial links between the primary and secondary cavity-nesting species frequenting the National Park of Chelia-Ouled Yagoub in the Aurès Mountains, of northeastern Algeria.

2. Materials and Methods

2.1. Study area

This work was carried out in the forest massifs of Ouled Yagoub (35°19′ N, 6°06′ E) which covers a total surface area of 30 000 ha (Figure 1), belonging to the National Park of Chelia-Ouled Yagoub in northeastern Algeria, with an altitude range from 1100 m to 2328 m asl [29] (Figure 2). These ecosystems which are home to the most xeric and southernmost Atlas cedar forests, were designed as a National Park in 2021; following Law No. 11 - 02 of 02/17/2011 relating to the country's protected areas. The massif forests span four bioclimatic levels: cold humid, cold subhumid, cool subhumid, and cool semi-arid levels. The average monthly rainfall values are very fluctuating and range between 0 and 128 mm with an average annual accumulation of 522.6 mm [30].

Fig 1. Ouled Yagoub cedar forests – Khenchela – Algeria.

2.3. Data collection

Ornithological surveys took place during two successive breeding seasons (mid-March – early July), using the count point method commonly used in ornithology [31, 32]. A total of 120 count points with passes were surveyed to detect the different cavity-nesting species likely to frequent the study area [33]. To avoid double counting, the points were separated by at least 300 meters and were chosen randomly. The total prospected area was about 1 500 ha, it covered all types of habitats that characterize the National Park Chelia-Ouled Yagoub: pure cedar forests (1 950 – 2 173 m asl), holm oak–cedar forest (1 700 – 1 950 m asl), mixed cedar forests (1 450 – 1 700 m asl), pine forests, oak forests, and agricultural lands (1 100 – 1 450 m asl). These formations are dominated by Atlas cedar *Cedrus atlantica*, holm oak *Quercus ilex*, and Aleppo pine *Pinus halepensis* [29].

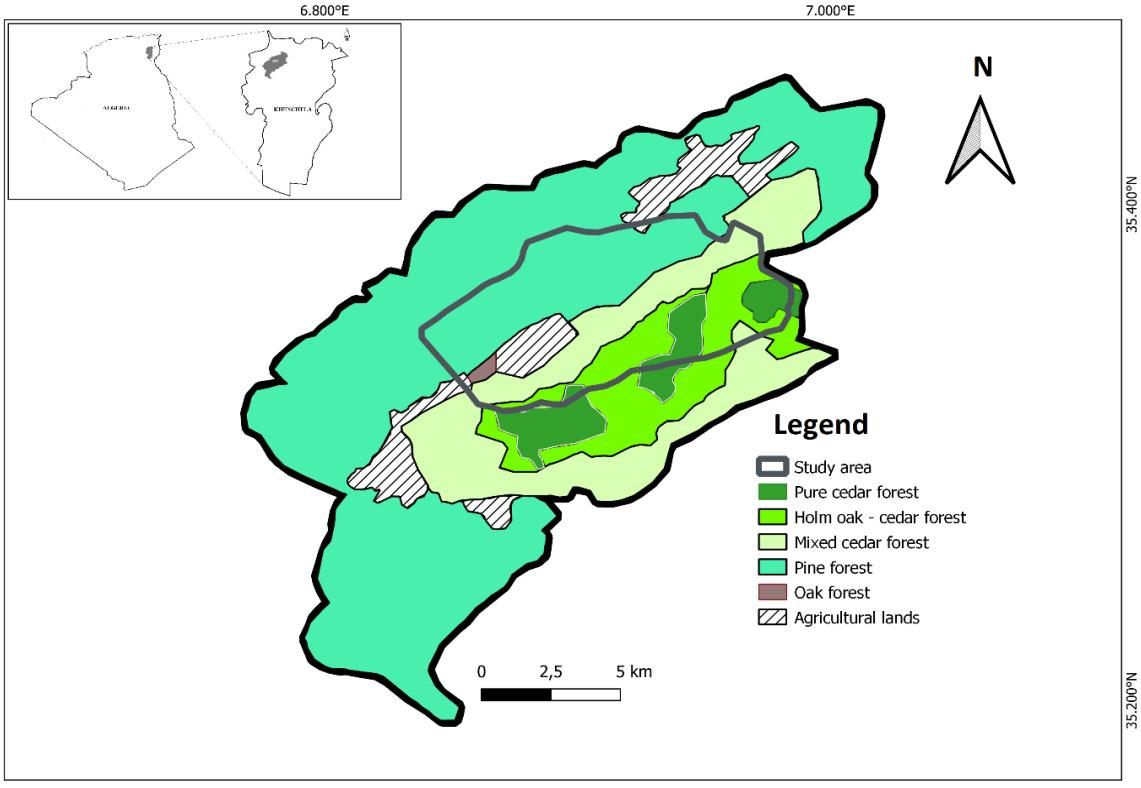

Fig 2. Location of Ouled Yagoub forests – Khenchela - Algeria.

2.3. Statistical analysis

The coexistence analysis of two ecological groups was carried out using a general linear model with a logit link function and binary distribution, in which the variables treated were the presence-absence of secondary cavity-nesting species. The binary response variable was the presence or absence of woodpeckers. Significance levels were set at $p < 0.05$. This analysis was performed in IBM SPSS 23 [34].

3. Results and Discussion

3.1. Ornithological findings

At the level of National Park Chelia-Ouled Yagoub, the observations carried out at 120 count points during two breeding seasons (2018 and 2019) allowed the detection of eight cavity-nesting birds, three orders, and six families (Table 1). They include a single primary cavity-nesting species, Levaillant's Woodpecker *Picus vaillantii*, which is present in 46 count points and was completely absent on the agricultural lands. This latest excavator represents the only excavator resident in the forest massif of Ouled Yagoub. Seven secondary cavity-nesting species were detected too: the North African Blue Tit *Cyanistes teneriffae*; Atlas Pied Flycatcher *Ficedula speculigera*; Moussier's Redstart *Phoenicurus moussieri*; Black Wheatear *Oenanthe leucura*; Tristram's Warbler *Curruca deserticola*; Eurasian Hoopoe *Upupa epops* and Short-toed Treecreeper *Certhia brachydactyla*. Five endemic taxa to North Africa were identified as Levaillant's Woodpecker, North African Blue Tit, Atlas Pied Flycatcher, Moussier's Redstart and Atlas Warbler. This high rate of endemism reflects the genetic diversity in the National Park, which promotes ecological balance within these forest massifs.

Table 1: Cavity-nesting species detected in Chelia-Ouled Yagoub National Park, Algeria [35].

Order	Family	Species	A	B	North African endemism
Piciformes	Picidae	*Picus vaillantii*	LC	Yes	Yes
Passeriformes	Paridae	*Cyanistes teneriffae*	LC	No	Yes
	Muscicapidae	*Ficedula speculigera*	LC	No	Yes
		Phoenicurus moussieri	LC	Yes	Yes
		Oenanthe leucura	LC	No	Yes
	Sylviidae	*Curruca deserticola*	LC	No	Yes
	Certhiidae	*Certhia brachydactyla*	LC	No	No
Bucerotiformes	Upupidae	*Upupa epops*	LC	Yes	No

A: IUCN (LC: Least Concern);

B: Executive Decree n° 12–235 of 24 May, 2012.

The African Blue Tit is the most common, species and it was present in 68 count points (56.66% of the total count points), followed by the Tristram's Warbler with 51 count points (42.5%), the Moussier's Redstart (43 count points and 35.83%), the Short-toed Treecreeper (40 count points and 33.33%), the Atlas Pied Flycatcher (29 count points and 24.16 %), and the Black Wheatear (12 count points and 10%). However, Eurasian Hoopoe was poorly detected (7 points and less than 10%).

At the scale of forest type, pine forests attract mostly populations of North African Blue Tit (41.18% of total records), Tristram's Warbler (39.21%), and Atlas Pied Flycatcher (51.73%). Moussier's Redstart and Black Wheatear are mostly present in the mixed cedar forests of about 30.23% and 33.34%, respectively. While the holm oak cedar forests of high altitudes and the pure cedar forests of the summits are dominated by the populations of Levaillant's Woodpecker (45.34%) and Short-toed Treecreeper (52.5%). These habitats also host the majority of records related to Eurasian Hoopoe (57.4%) (Figure 3). At the level of agricultural systems, only three species (North African Blue Tit, Atlas Warbler, and Black Wheatear) were detected with poor percentages (< 10%).

Habitat and nesting support selection by forest birds in general [36] and cavity-nesting avian species in particular [37] are strongly related to vegetation composition and physiography. In the Mediterranean rim, many cavity-nesting species use cedar-dominated old-growth forests [38, 39, 26]. The results of this study, combined with those carried out in North Africa [40, 41, 26, 27, 28] show the importance of these forest habitats for woodpeckers and numerous secondary cavity-nesting species. In our case, Levaillant's Woodpecker constitutes the only excavator of cavities in the entire forest massif of Ouled Yagoub, as indicated by [42].

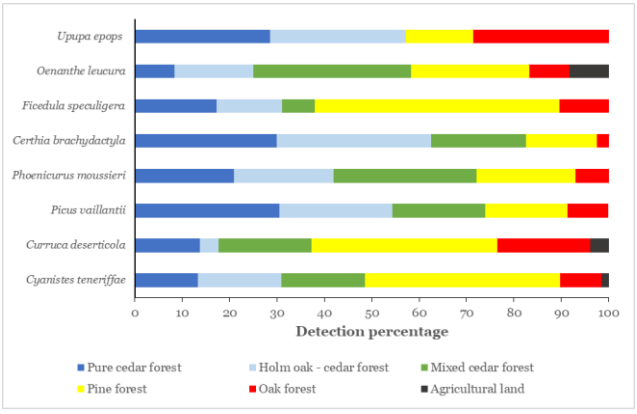

Fig 3. Cavity-nesting species detected in each forest type.

3.2. Coexistence between primary and secondary cavity-nesting species

The statistical analysis of the coexistence indicated that three cavity-nesting species depended on the presence of Levaillant's Woodpecker as the Atlas Pied Flycatcher, Short-toed Treecreeper, and Eurasian Hoopoe (Table 2). The other secondary cavity-nesting species do not show any significant coexistence with the excavator.

Table 2: Results of the General Linear Model (GLM) of the coexistence between secondary cavity-nesting birds and Levaillant's Woodpecker (Response variable = Presence or Absence of the Levaillant's Woodpecker).

Species	Count points	Optimal value	Standard error	Wald test	*P-value*
North African Blue Tit	68	-0.616	0.488	1.597	0.206
AtlasPied Flycatcher	24	-1.614	0.616	6..872	0..009*
Moussier's Redstart	43	0.985	0.545	3.268	0.071
Tristram's Warbler	51	0.184	0.471	0.153	0.695
Black Wheatear	12	0.298	0.790	0.142	0.706
Eurasian Hoopoe	7	2.849	1.356	4.416	0.036*
Short-toed Treecreeper	40	1.205	0.477	6.398	0.011*

The coexistence between secondary cavity-nesting species and the Levaillant's Woodpecker highlights the importance of the latest breeding population for the presence of three secondary cavity-nesting associations. These results support the hypothesis supposing that high relationships exist between primary and secondary cavity-nesting species.

Fig 4. Cavity excavated by Levaillant's Woodpecker *Picus vaillantii* on an Atlas cedar tree.

The reproductive success of certain populations of secondary cavity-nesting species requires a sufficient number of exploitable cavities already excavated by the primary cavity-nesting species (Figure 4), in particular the Levaillant's Woodpecker. The spatial association and coexistence between these two ecological groups of birds seems obligatory especially since they have the same ecological requirements. These findings suggest the umbrella function of excavators in the functioning of the forest system.

For the other species that did not show significant coexistence with Levaillant's Woodpecker, it seems that they are non-obligate cavity-nesting species. So that they do not require a cavity to reproduce.

4. Conclusion

In conclusion, our results confirm that woodpeckers are keystone taxa for forest biodiversity. Indeed, the preservation of the habitats of these umbrella species improves their ecological performance, which contributes to the conservation of cavity-nesting communities. Other studies in the same context are recommended to better understand the functioning of this procession of species and forest biodiversity in general.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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