

DISTRIBUTION OF THE ENDEMIC AND ENDANGERED ALGERIAN NUTHATCH (*SITTA LEDANTI*): CASE OF THE LARBAA FOREST

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Abstract

Description of the subject: The Algerian Nuthatch is an endemic bird species in Algeria. It is classified as an endangered species by I.U.C.N. and it figures in the list of Algerian protected wild species. Despite its status, not many types of research have been done on it, especially concerning the study of its effective.

Objective : We propose to give an overview of the number of Algerian Nuthatch's individuals, their densities, frequencies, their altitudinal and cartographic distribution in the Larbaâ forest, one of the locations of the species.

Methods : We have carried out our fieldwork during the 2019 breeding period. Thus, we have described the habitats (or dominant plant species) in the Larbaâ forest. The methods we have used to study the Algerian Nuthatch's population, are that of the Echantillonnage Fréquentiel et Progressif (E.F.P.) and that of the Point counts.

Results : The total number of Algerian Nuthatch's individuals is 40 for an area of 700 ha in the Larbaâ forest. Their densities are 0.57 individuals per 10 hectares, and 0.19 pairs per 10 hectares. Also, we have found that they are most abundant in the habitat of afares oak species (*Quercus afares*) from 1007 to 1059 meters above sea level.

Conclusion : The Larbaâ forest is home to the endemic Algerian Nuthatch. This endangered species is only known to occur in few forests located in the Kabylia of Babors (north-eastern Algeria). Nevertheless, the Larbaâ forest is subject to human activities that threaten the populations of the Algerian Nuthatch. Therefore, the protection of the Algerian Nuthatch is a priority nowadays.

Keywords : Distribution, endemic species, Algerian Nuthatch, forest, Algeria.

DISTRIBUTION DE LA SITTELE ALGÉRIENNE (*SITTA LEDANTI*), ENDÉMIQUE ET MENACÉE : CAS DE LA FORÊT DE LARBAA

Résumé

Description du sujet : La Sittelle Kabyle est un oiseau endémique d'Algérie. Elle est classée comme étant une espèce « En Danger » par l'U.I.C.N. et elle figure dans la liste des espèces sauvages protégées en Algérie. Malgré son statut, peu de recherches lui ont été consacrées, notamment en ce qui concerne l'étude de ses effectifs.

Objectifs : Nous nous proposons de donner un aperçu du nombre d'individus de la Sittelle Kabyle, de leurs densités, de leurs fréquences, de leur répartition altitudinale et cartographique dans la forêt de Larbaâ, un des lieux de localisation de l'espèce.

Méthodes : Nous avons effectué notre travail de terrain pendant la période de reproduction de 2019. Ainsi, nous avons décrit les habitats (ou les espèces végétales dominantes) de la forêt de Larbaâ. Les méthodes que nous avons utilisées pour étudier la population de la Sittelle Kabyle, sont celle de l'Echantillonnage Fréquentiel et Progressif (E.F.P.) et celle des points d'écoute.

Résultats : Le nombre total d'individus de la Sittelle Kabyle est de 40 pour une superficie de 700 ha, dans la forêt de Larbaâ. Leurs densités sont de 0,57 individus par 10 hectares, et de 0,19 couples par 10 hectares. De plus, nous avons constaté qu'ils sont plus abondants dans l'habitat de l'espèce du chêne afares (*Quercus afares*), de 1007 à 1059 mètres d'altitude.

Conclusion : La forêt de Larbaâ abrite l'endémique Sittelle Kabyle. Cette espèce, en danger, n'est rencontrée que dans quelques forêts situées en Kabylie des Babors (nord-est de l'Algérie). Néanmoins, la forêt de Larbaâ est sujette à des activités humaines, qui menacent les populations de la Sittelle Kabyle. La protection de la Sittelle Kabyle est donc devenue, aujourd'hui, une priorité.

Mots clés: Distribution ; espèce endémique ; Sittelle Kabyle ; forêt ; Algérie.

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INTRODUCTION

The Algerian Nuthatch (*Sitta ledanti* Vielliard, 1976) is an endemic and endangered bird species to Algeria [1, 2]. It belongs to the genera *Sitta* which contains other species and whose relationship is depicted by [3]. It has been put in the group of « Sittelles mésogéennes » including the Algerian, the Corsican *Sitta whiteheadi* and the Krüper's *Sitta krueperi* nuthatches. These three nuthatches live in the Mediterranean region and have been considered to be related to each other for a long time [4, 5, 6, 7]. Though, mitochondrial DNA analyses have indicated that the Algerian Nuthatch is at long last comparative with the Krüper's Nuthatch [8, 9, 10].

The Algerian Nuthatch is the sole endemic bird species to Algeria [2]. It was discovered on 5 October 1975, by Jean-Paul Ledant, at the top of Mount Babor [5]. Independently, Eric Burnier observed the species at the same spot and during that same year [4]. The name *Sitta ledanti* was given to it in 1976 by [11] as a tribute to the researcher who firstly observed and reported it. The Algerian Nuthatch is classified as an endangered species (EN) by the International Union for the Conservation of Nature (IUCN) [2]. Likewise, it has been on the list of non-domestic species protected by Algerian law since 1983 [12].

This Nuthatch was associated with the oak-fir forest of the Babor Massif at the time of its discovery [13, 1]. In 1989, however, it was seen in the zeen and afares oaks national forest of Guerrouche in the Taza National Park [14, 13]. Subsequently, it was observed in the zeen and afares oaks forests of Tamentout and Djimla, respectively in June and July 1990 [14]. Finally, in April 2018, it was observed in the Larbaâ forest [15]. These five forests are all located in the bio-geographical sub-sector of the Kabylie of Babors in North-Eastern Algeria [1].

The exhaustive inventory of Algerian Nuthatch's populations in its distribution range has so far only been carried out for the Djimla forest [16]. The aim of the present paper is thus to determine the number of individuals, solitary and breeding pairs of the Algerian Nuthatch's population, and to characterize its distribution in the Larbaâ forest.

MATERIAL AND METHODS

1. Study area

We have performed our study in the Larbaâ forest of the Beni Affeur estate. This forest is located in the wilaya of Jijel, straddling the Chahna and the Oudjana communes, in the Daïra of Taher (Fig. 1). Its geographical location is 36°38'00.0" N 005°53'00.0" E (North-Eastern Algeria). Its surface area is estimated at 700 hectares. It represents the fifth biotope recently discovered of the Algerian Nuthatch [15].

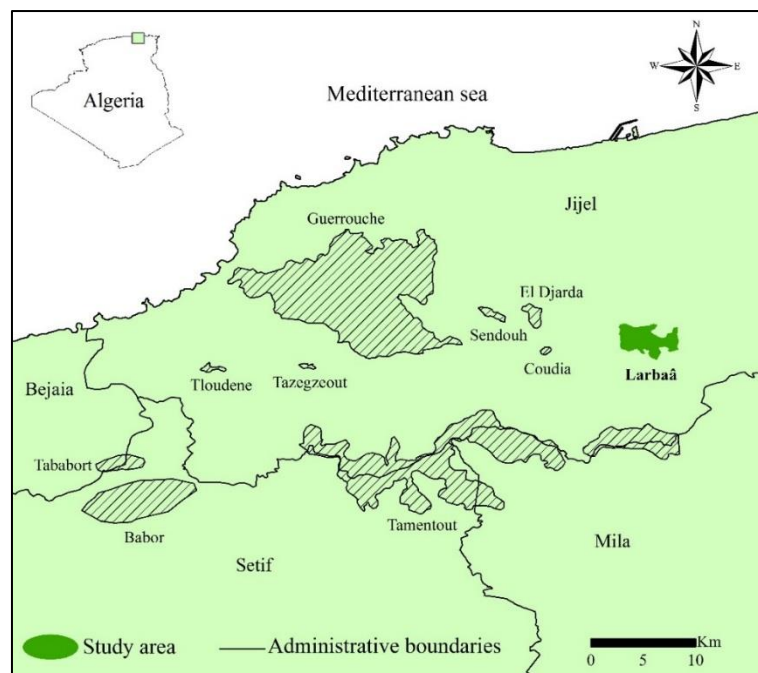


Figure 1: Algerian Nuthatch's distribution range and highlighting of the Larbaâ forest

The Larbâa forest culminates at 1264 meters, with an average altitude of 1029 ± 72 meters, and a minimum altitude of 903 meters (Fig. 2).

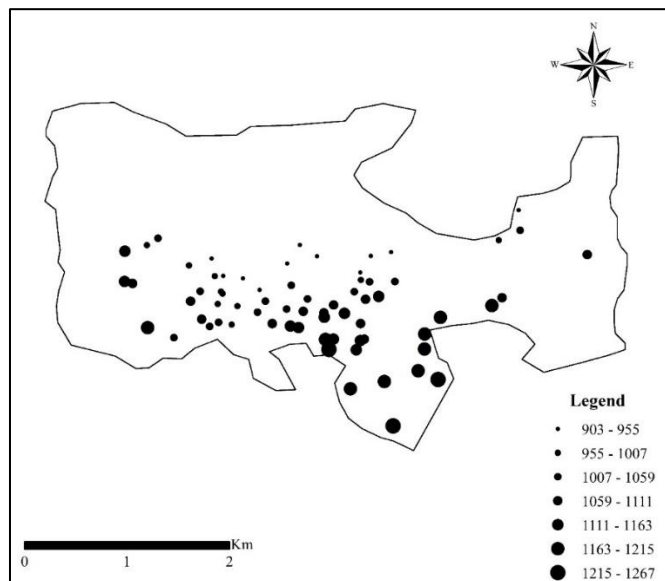


Figure 2: Map of the altitude classes according to the point counts carried out in the Larbâa forest.

The Larbâa forest is characterized by annual average temperatures and precipitations of the order of 12°C and 1520 mm, respectively. It is therefore located in the humid bioclimatic stage in cool winter. This forest is made up of stony and dry soils, and the geology of the Kabylie of Babors is relatively homogeneous. The soils of the Larbâa forest are acidic with a typical forest vocation [Boudy 1955 in 17]. Its vegetation is very thick, giving rise to three strata (trees, shrubs, and the grass) installation. The tree stratum is dominated by the afares oak (*Quercus afares*) noted in 80% of the total number of point counts made. This plant essence is followed by mixtures of afares and cork (*Quercus suber*) oaks noted in 13% of the total number of point counts made, and of afares and zeen (*Quercus canariensis*) oaks noted in 6% of

the total number of point counts made. The zeen oak alone, represents only 1% of the total number of point counts made (Fig. 3). Nevertheless, these plant formations are accompanied by other trees which are not dominant, notably maple trees (*Acer campestre*) and (*Acer obtusatum*), and bird (or cherry) trees (*Prunus avium*). The shrub stratum consists mainly of the thorny broom (*Calicotome spinosa*), the hairy broom (*Cytisus villosus*), and the tree heather (*Erica arborea*). Finally, the herbaceous stratum (or the ground) is less diversified; it is composed in particular of the *Plathantera bifolia*, *Cyclamen africanum*, *Osmunda regalis*, *Polystichum setiferum*, *Pteridium aquilinum*, and the *Urtica membranacea*.

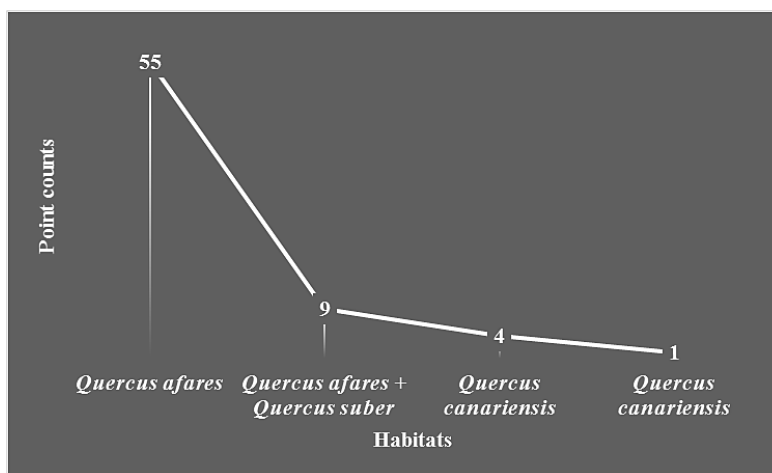


Figure 3: Graph of the number of point counts made in each habitat (or dominant plant species) in the Larbâa forest

2. Inventory and cartography of Algerian Nuthatch's individuals

The census of the Algerian Nuthatch was made from 30 March until 28 April 2019. This period corresponds to the breeding interval of this species [18, 19, 16]. We have used two methods to make our survey: (i) a qualitative method; Echantillonnage Fréquentiel et Progressif (EFP), that allowed us to determine the presence and

absence of the studied species [20], (ii) a quantitative method; point-counts, that permitted us to count the number of the species' individuals [21, 22, 16, 23]. To sample the entire Larbaâ forest, we have established 69 point counts (Fig. 4) on line transects; paths along which ones we have recorded and counted Algerian Nuthatch's individuals [24].

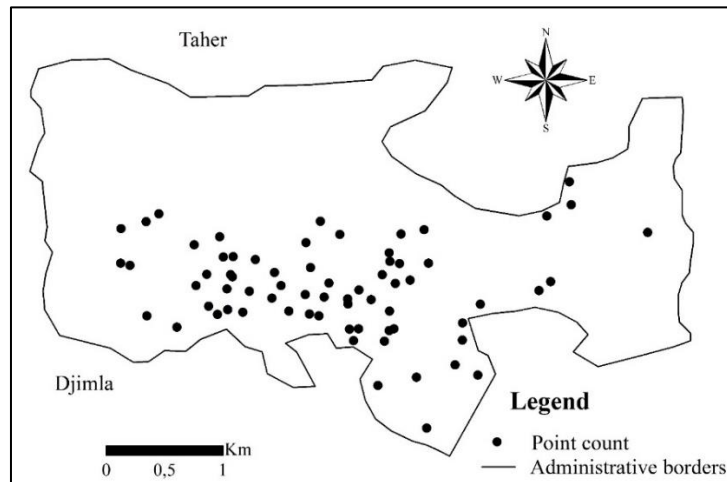


Figure 4: Algerian Nuthatch's point counts carried out in the Larbaâ forest.

We have counted all birds contacted within 30 m radius from us [25]. Also, we spaced the point counts about 100 meters apart to prevent sampling bias and to count twice the same birds [26]. We have avoided Larbaâ forest edges because these are subject to construction (houses, hen houses, etc.) we hence could not access them. The inventory of Algerian Nuthatch's individuals was made through the technique of auditory and visual identifications, and it is based on the singing and screeching of the species of our study [5, 6, 14, 27, 19, 16]. Distinction between Algerian Nuthatch's pairs and solitary individuals was insured as following: (i) « a pair » is noted by observing a pair of individuals, an occupied nest, a singing male defending and/or visiting his nest and a warning call (or harsh call) (ii) « a solitary individual » is noted as observing a solitary male that doesn't sing or make a warning call, and a male which is calling out for a female to construct a nest together but which are not yet a pair [28, 16, 25].

The cartographic work has done using the ArcGIS [GIS software]. Version 10.5.1. Redlands, CA : Environmental System Research Institute, Inc., 2016 [29, 30]. We have also used the (<https://gadm.org/>) site to draw the administrative boundaries.

2.1. Field measurements

We have completed our fieldwork in favourable weather conditions (absence of rain and strong winds). Firstly, we have recorded GPS coordinates and average altitudes using the model GPS receiver « Garmin map 76 CSx » at each point count made. Secondly, we have visually identified the plant strata by indicating trees species, shrubs, and the ground. Subsequently, we have noted the dominant vegetation types for the tree stratum named "habitats". Then we have calculated the dominance of each habitat using the rule of three [31]. To do so, we have divided the number of point counts established at each habitat to the total number of all point-counts made up in the whole Larbaâ forest, and we have multiplied the result per 100 to obtain the percentage of dominance. Thirdly, we have calculated the number of Algerian Nuthatch's individuals according to habitats of Larbaâ forest and to altitude classes in each point count. The number of individuals in each habitat was made with the Sturge's rule by calculating the number of classes with the formula $1+3.33 \log(n)$ where n is the sample size, which is the number of point counts in our study ($n=69$). After that, we have found the classes interval using the formula (Value max-value min)/number of classes), where value design altitude's values [32].

Finally, we have made the ANOVA test running with R software [33] to show the variability in altitudinal distribution between the habitats of the Larbaâ forest. After getting the results, we have run the Post Hoc test which the aim is to know which studied group is different from others [34].

2.2. Ecological calculations

We have made two kinds of ecological calculations to provide a description of characteristics of the Algerian Nuthatch's population in the Larbaâ forest ; the densities (or absolute abundances) and the frequencies (or relative abundances) of Algerian Nuthatch's individuals [35].

We have calculated the relative abundances in our case, based on the formula (F) provided by [36] that is structured as follows: $F(\%) = (\text{Number of individuals of the studied species} / \text{number of all individuals of all studied species}) \times 100$

Therefore, we have adapted this formula to our data (F') which consist to work on only one species, not on all species of the studied forest. The aim of this modification is to highlight the number of individuals accurate in each habitat (or dominant plant species) in the Larbaâ forest. We have, then, came up with this formulation: $F'(\%) = (\text{Number of individuals of the Algerian Nuthatch in each studied habitat} / \text{number of all individuals in all habitats of the Larbaâ forest}) \times 100$

The densities were calculated per 10 hectares following the rule uttered by [36]. To run them, we used the ratio between the total number of individuals multiplied by 10 and the surface area of the Larbaâ forest which is 700 ha [15]. This calculation was also applied to the number of Algerian Nuthatch's pairs, multiplying it by 10 and dividing the result obtained over the Larbaâ forest's surface area. Likewise, we have calculated the total number of Algerian Nuthatch's individuals in the Djebel Babor that we have wanted to compare our results to. To do so, we have used the number of pairs provided by [37] to obtain the number of individuals and we have multiplied it by 2, knowing that a pair is composed of two individuals, because there is any whole inventory in this area at this time.

RESULTS

1. Population characteristics and habitat of the Algerian Nuthatch

The Algerian Nuthatch's population size in the Larbaâ forest is 40 individuals. Indeed, it consists of 13 breeding pairs and 14 solitary individuals (Tab. 1). A pair is composed by 2 individuals. The largest number of Algerian Nuthatch's individuals of 27 is found in habitat of afares oak species. The lowest number of individuals of 2 is found in habitat the zeen oak species.

Table 1: Number of Algerian Nuthatch's individuals in the Larbaâ forest

Variables	Habitats (or dominant plant species)			
	<i>Quercus afares</i>	<i>Quercus afares + Quercus suber</i>	<i>Quercus afares + Quercus canariensis</i>	<i>Quercus canariensis</i>
Point counts	55	9	4	1
Breeding pairs	8	2	2	1
Solitary individuals	11	2	1	0
Total number of individuals	27	6	5	2

The highest relative frequency obtained is at 67% (Fig. 5). It was scored in the habitat of afares oak species. The lowest one is registered in the habitat of zeen oak species.

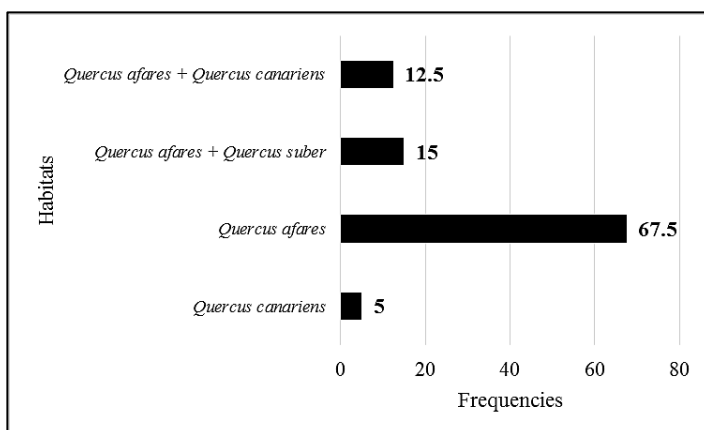


Figure 5: Frequencies of the Algerian Nuthatch in the Larbaâ forest.

The densities of the Algerian Nuthatch, in other hand, are 0.57 individuals /10 hectares (ha) and 0.19 pairs/10 hectares (Tab. 2). We have summarised, in the following table, the densities of other populations of this same species in other forests of its distribution range. The Babor forest, however, doesn't reflect the real densities of its population, because it hasn't been subject to a complete sampling (see methods section).

Table 2: Densities of the Algerian Nuthatch in some forests of its distribution range

Forests	Densities		Authors
	Individuals/10 ha	Pairs/10 ha	
Babor	1.29	0.65	[37]
Djimla	0.6	0.27	[16]
Tamentout	0.19	0.08	[23]
Larbaâ	0.57	0.19	Current study

ha: hectares

2. Algerian Nuthatch's altitudinal and geographical distribution.

The Larbaâ forest culminates at 1264 meters of altitude. The distribution of the Algerian Nuthatch's population in this forest follows an apparent altitudinal gradient, illustrated in Fig. 6, where the values of interest are highlighted in

bold. The number of individuals decreases with altitude, with a preference for low and medium altitudes between 903 and 1111 meters. The largest number of individuals, estimated at 14 is recorded in the class from 1007 to 1059 meters above sea level.

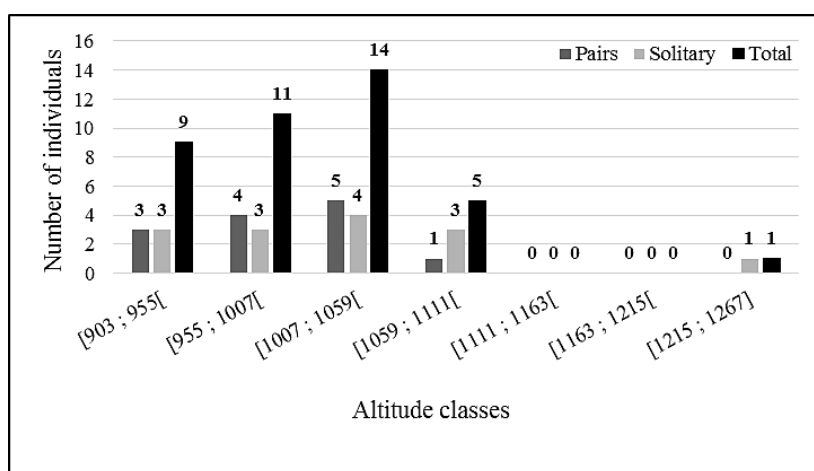


Figure 6: Altitudinal distribution of Algerian Nuthatch's individuals.

There is a significant difference in the altitudinal distribution between the habitats (or dominant plant species) of the Larbaâ forest (Tab. 3). Therefore, the habitat of afares oak species is distributed in the highest altitudes on average 1044 meters. The mixture of afares and cork oaks are dispersed in the lowest altitudes on average 952 meters. This result is confirmed by the Post Hoc test which showed that are these two groups (afares oak and mixture of afares

and cork oaks) which differ and which give the significant difference in the Species plants' altitudinal distribution ($p=0.0014$, $p<0.05$).

Concerning the cartographic distribution of Algerian Nuthatch's individuals, they are mainly distributed in the heart of the Larbaâ forest. This result is illustrated in (Fig. 7) which highlights the presence and absence of these individuals.

Table 3: Altitudinal distribution of pant species in the Larbaâ forest

Variable	Plant species (habitats)				Results
	<i>Quercus afares</i>	<i>Quercus canariensis</i>	<i>Quercus afares</i> + <i>Quercus canariensis</i>	<i>Quercus afares</i> + <i>Quercus suber</i>	
Altitude	1044±71 (n=55)	100 (n=1)	997±36 (n=4)	952±32 (n=9)	F=5.3 $p=0.002^*$

Average altitude ± standard deviation, n: number of point counts made, P: probability. *: level of significance at the threshold $\alpha=0.05$, where $p<0.05$.

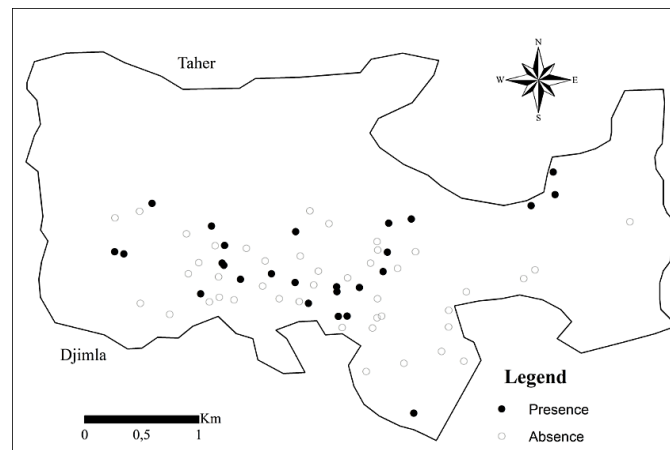


Figure 7: Algerian Nuthatch's presence-absence distribution in the Larbaâ forest

DISCUSSION

1. Algerian Nuthatch's population size and densities

The Algerian Nuthatch's population in the Larbaâ forest is the lowest of the forests surveyed so far. Indeed, we have found 40 individuals in the Larbaâ forest for an area of 700 ha. In another side, [37] have found about 164 individuals in the Djebel Babor for an area of 1268 ha, [16] have found 60 individuals in the Djimla forest for an area of 1000 ha, and [23] have found 187 individuals in the Tamentout forest for an area of 9688 ha. The difference between our result and others is probably be linked to the surface areas of the concerned forests ; that of the Larbaâ forest is smaller than that of others, so, there is less individuals than in other forests. Concerning the Corsican and the Krüper's nuthatches, their population sizes are so far away from that of the Algerian Nuthatch. In effect, the Krüper's Nuthatch's population is of 1014 individuals [38], and that of the Corsican Nuthatch is 1879 individuals [39]. We, therefore, deduce that the Algerian Nuthatch species is the weakest in its mesogeane group.

Moreover, the absolute abundances (or densities) of the Algerian Nuthatch's population is lower than those recorded for the Babor and Djimla forests [37, 16]. This statement confirms that the Algerian Nuthatch's population of the Larbaâ forest is the smallest one in its geographic range at this time of samplings.

2. Habitat selection of Algerian Nuthatch's individuals

Algerian Nuthatch's individuals prefer the afares oak species in the Larbaâ forest, as a habitat (dominant species) or mixed with other plant species. It is confirmed by their number and the percentage of their relative abundances.

Nevertheless, in the Babor, the Djimla, the Guerrouche and the Tamentout forests, Algerian Nuthatch's populations are observed in large numbers in zeen oak species, as a dominant species (habitat) or in a combination with other tree species (mixture). These other species may stand oaks, cedars (*Cedrus atlantica*), Numidian firs (*Abies numidica*), etc. [40, 14, 27, 16, 23]. There is also a disparity in habitat preferences between the Algerian Nuthatch and its relatives. Thus, the Corsican Nuthatch is breeding in Corsican pine species (*Pinus nigra laricio*) [41] and the Krüper's Nuthatch prefers red pine species (*Pinus brutia*) [42].

The divergence in habitat selection between Algerian Nuthatch's populations and between this species and its relatives, could be related to the dominant plant species mentioned in the forests where nuthatches are living. In fact, we are willing to think that the Algerian Nuthatch gets used to the plant species in the forests where it lives. This theory has to be confirmed with ulterior studies.

3. Algerian Nuthatch's altitudinal and geographic distributions

The Algerian Nuthatch is distributed from the low at medium altitudes (903-1111 meters) and it is most abundant at 1007-1059 meters in the Larbaâ forest, knowing that this forest culminates at 1264 m. This result is consistent with that found by [27] in the Guerrouche forest (on 800-hectare plot sampled), where the individuals of this same species are mainly distributed at low altitudes (600 - 800 meters). Also, the Corsican Nuthatch is known breeding from 900 meters upwards [43]. While, the populations of the Djimla, Babor and Tamentout forests prefer higher altitudes.

Indeed, the population of the Djimla forest, that culminates at 1349 m, is mainly distributed in 1101-1159 m and has not been registered at low altitudes [16]. The population of the Babor forest, which culminates at 2400 m, was recorded from 1050 to 1400 m [18]. Furthermore, the population of the Tamentout forest, that culminates at 1660 m, was noted at 1330–1413 m [23]. This observation is also established for the Krüper's Nuthatch [42]. The ANOVA test and plots of the plant species distribution according to the altitude show that the pattern of the Algerian Nuthatch's altitudinal distribution corresponds to the pattern of the *afares* oak species' distribution range. This confirms the fact that the Algerian Nuthatch prefers to breed in this type of habitat in the Larbaâ forest.

The preference of some nuthatches for high altitudes in a number of biotopes would probably coincide with the appearance of the plants formation, which are denser at high altitudes [37]. Doubtfully, the altitude on which each forest culminates drive the Algerian Nuthatch's altitudinal predilection in its geographic range.

Concerning the geographic distribution of the Algerian Nuthatch's individuals, they are mainly located in the heart of the Larbaâ forest, where the strata are abundant, avoiding the forest edges. Inhabitants of villages are set up in these forest parts. They cause, in that way, noises and animations that disturb Algerian Nuthatch's populations. This phenomenon is also observed for the same species in the Djimla and Tamentout forests [16, 23] and for the Corsican Nuthatch in Corsica [21].

CONCLUSION

The Larbaâ forest is dominated by the *afares* oak species (*Quercus afares*). It is home to an Algerian Nuthatch's population of forty individuals, distributed mainly in the heart of the forest. However, the extremities of the Larbaâ forest are frequented by residents, which reflecting a series of modifications and fragmentations into this forest.

The main human induced factors that threaten the populations of this species in all the forests of its distribution range are: (i) illegal logging (or cut trees) at the expense of dead trees, trunks and branches of which are used by the Algerian Nuthatch for nest building [18, 19] (ii) repeated forest fires that limit the availability of vegetation cover [44] (iii) overgrazing that prevents regeneration of the vegetation stand [37].

Consequently, the protection of the Algerian Nuthatch's distribution area must be a priority at this time. To succeed in this delicate mission, design forest and conservation management strategies and plans should be improved and public awareness need to be increased. Therefore, the authorities could create protected areas that encompass the Algerian Nuthatch's geographical range, as it has been recently done for the Babor forest [45]. Similarly, the conservation of all trees species in the Kabylie of Babors is a priority for the long-term survival of the Algerian Nuthatch for the reason that this endemic species uses all trees species for nesting and foraging [46].

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