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Friends in high places: Nest site selection and habitat use of Turtle Doves in an olive grove

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Abstract

Habitat suitability and food availability are important factors in the reproductive success of wildlife. Similarly, knowledge of nest site selection has important implications for wild bird conservation and management. We conducted a systematic study to quantify nest site choice by Turtle Doves *Streptopelia turtur* nesting in an olive grove. The analyses showed that both small-scale and large-scale habitat features are important. Turtle Doves chose a greater distance above the ground for nesting and a greater distance from tree trunks in unmanaged agrosystems. In addition, the analysis of landscape composition underlined the importance of the proximity of open fields used for foraging. Another finding from this study is that White Storks *Ciconia ciconia* and Turtle Doves nest in a closed proximity. The results are consistent with the hypothesis that Turtle Doves use the olive grove to protect their nest from predators and, at the same time, reduce energy costs due to the long distances involved in foraging.

Keywords *Streptopelia turtur*, Foraging, predation, nest site selection, Algeria, North-Africa.

Des amis bien placés : sélection du site de nidification et utilisation de l'habitat par les tourterelles des bois dans une oliveraie

Résumé

L'adéquation de l'habitat et la disponibilité de la nourriture sont des facteurs importants pour le succès reproductif de la faune. De même, la connaissance de la sélection du site de nidification a des implications importantes pour la conservation et la gestion des oiseaux sauvages. Nous avons mené une étude systématique pour définir le choix du site de nidification chez les tourterelles des bois (*Streptopelia turtur*) nichant dans une oliveraie.
L'étude a été menée entre avril et juillet 2018. Les nids ont été observés et enregistrés après l'installation des oiseaux nicheurs. Les coordonnées de chaque arbre-nid ont été collectées à l'aide d'un GPS. Quatre groupes de placements de nids ont été identifiés. Diverses variables de microhabitat et les caractéristiques des arbres-nids ont été mesurées. Les distances entre les nids des tourterelles des bois et différents éléments ont été calculées à l'aide d'un logiciel spécialisé.

Les analyses ont montré que les caractéristiques de l'habitat à petite et grande échelle sont toutes deux importantes. Les tourterelles des bois choisissent une plus grande hauteur par rapport au sol pour nicher et une plus grande distance par rapport aux troncs d'arbres dans les agrosystèmes non gérés. De plus, l'analyse de la composition du paysage a souligné l'importance de la proximité des champs ouverts utilisés pour se nourrir. Une autre découverte de cette étude est que les cigognes blanches (*Ciconia ciconia*) et les tourterelles des bois nichent à proximité les unes des autres. Les résultats sont cohérents avec l'hypothèse selon laquelle les tourterelles des bois utilisent l'oliveraie pour protéger leur nid des prédateurs et, en même temps, réduire les coûts énergétiques liés aux longues distances parcourues pour se nourrir.

Mots-clés *Streptopelia turtur*, Alimentation, prédation, sélection du site de nidification, Algérie, Afrique du Nord.

Introduction

The European Turtle Dove, *Streptopelia turtur*, is a long-distance migrant whose population has declined rapidly in the western part of its range in recent decades, despite being protected by international and national laws (ERAUD *et al*., 2013). This decline is expected to continue over the next three generations. As a result, the conservation status of the species has been classified as "vulnerable" on the IUCN Red List (IUCN Red List for Birds 2023).

Used by humanity as a symbol of love, the species is ceaselessly victimised by unsustainable poaching and hunting (LORMÉE *et al*., 2019). Recently, however, habitat loss appears to be the main cause of decline in both breeding and wintering grounds (BROWNE *et al*., 2004; BROWNE & AEBISCHER, 2005; DUNN & MORRIS, 2012; FISHER *et al*., 2018). Furthermore, in the context of climate change and as a trans-Saharan migratory bird (LORMÉE *et al*., 2016), the survivorship of Turtle Doves is strongly influenced by the environmental conditions of the areas where they rest during migration and the places where they spend the winter (NEWTON, 2004; WILSON & CRESSWELL, 2006; ERAUD *et al*. 2013; VICKERY *et al*., 2014). During their stay in the Sahel, birds of this species feed mainly on wild and cultivated seeds such as rice *Oriza* spp, millet *Panicum laetum,* and sorghum *Sorghum* spp. (MOREL, 1987), while during the breeding season, it relies on olive groves, orchards, lightly grazed pastures, semi-natural grasslands and fallows (HANANE, 2012; DUNN *et al*., 2020).

Natural selection shapes bird behaviour to select nest sites based on habitat features that maximize reproductive success (MARTIN, 1995). The ecological niche of many bird species, especially migratory birds such as the Turtle Dove, is shaped by these critical nesting habitat features (SQUALLI *et al*., 2021). Nesting sites, for example, need to be close to a food source and also need to be safe from predators. These features can operate at different spatial and temporal scales (BOND *et al*., 2005). Knowledge of these important processes can help managers and conservationists. Due to the threatened status of the Turtle Dove and in order to halt ongoing population decline, there is an urgent need to identify key features of Turtle Dove breeding habitats and to develop an action plan for this species in the region (FISHER *et al*., 2018). Despite previous research efforts that have investigated the nesting site preferences of this species (HANANE, 2014; DUNN *et al*., 2020; HANANE *et al*., 2023), further understanding of Turtle Dove settlement patterns is needed.

The objectives of this study are twofold. Firstly, to provide detailed quantitative information on the characteristics of Turtle Dove nesting sites. Secondly, to identify the factors that influence nest site selection.

Methods

Study area

The study was conducted in Dréan (Fig. 1), a small coastal town in north-eastern Algeria (36°41.170'N 7°41.520'E). Dréan is a rural village where large fields are cultivated with various crops, including cereals and vegetables. The climate of the region is of temperate Mediterranean type with an average annual temperature of 18°C and an average annual rainfall of 684 mm. Data were collected in an olive grove (*Olea europea*) used by a breeding colony of the White Stork *Ciconia ciconia* (ATHAMNIA *et al*., 2022). Olive groves are semi-natural Mediterranean ecosystems and the predominant agro-ecosystem in the Mediterranean region, especially in rural areas (LOUMOU & GIOURGA, 2003). Turtle Doves and several other species (Spanish Sparrow *Passer hispaniolensis*, Eurasian Hoopoe *Upupa epops*, Little Owl *Athene noctua*, and White Stork *Ciconia ciconia*) use different parts of olive trees as nesting sites.

Data collection

The study was conducted between the beginning of April and the end of July 2018. In order not to disturb the establishment of the nests of breeding birds, we preferred to wait until they had settled before we started sampling. The coordinates of each nest tree were recorded with a Garmin GPS and plotted on a map. The outcome of the survey in this study consisted of 4 groups of nest placements: (1) both White Stork and Turtle Dove nests on the tree, (2) no nests on the tree, (3) only White Stork nest on the tree, (4) only Turtle Dove nest on the tree. Microhabitat variables were measured for each tree, including tree height (TH), canopy height (CH), canopy volume (CV), canopy

diameter (CD) and height of lowest canopy boundary (HGC).

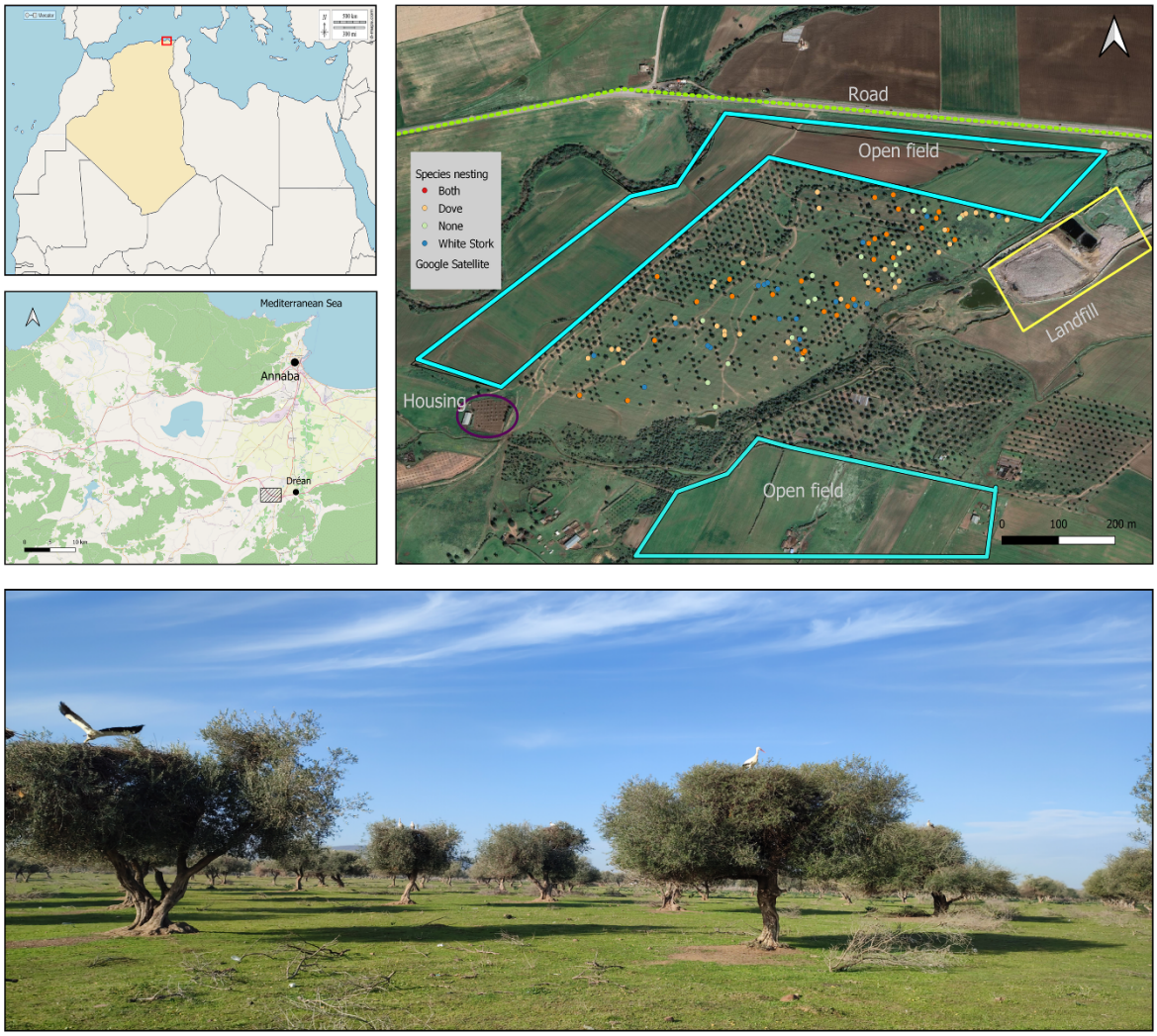

Figure 1. Location map of the study site in northeastern Algeria and view of the olive grove with nesting White Storks.
Carte de localisation du site d'étude dans le nord-est de l'Algérie et vue de l'oliveraie avec les cigognes blanches qui nichent.

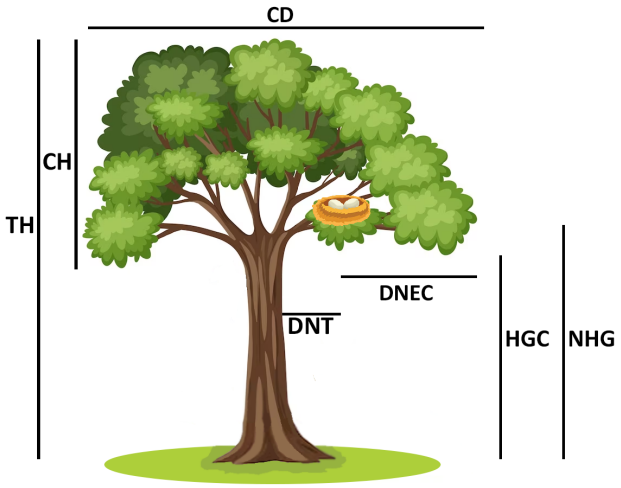

Figure 2. Measured tree and nest characteristics.
Mesures des caractéristiques des arbres et des nids.

In addition, a Bosch digital clinometer (0.05) with a tape measure of (0.01 m) was used to measure a number of nest tree characteristics, including nest height from ground (NHG), distance from nest to trunk (DNT) and distance from nest to outer part of canopy (DNEC) (Fig. 2). In addition, the distance of Turtle Dove nests to roads, human settlements, rubbish dumps and open fields was calculated using the dist2Line function from the 'geosphere' package (HIJMANS, 2019).

Data analyses

Descriptive statistics were used to analyze the characteristics of the Turtle Dove nests and the tree characteristics of the four groups of occupants (Turtle Dove only, White Stork only, both White Stork and Turtle Dove and no nest). The Shapiro-Wilk test, which was used to test the normality assumption, showed that all tree characteristics had a distribution that deviated significantly from a normal distribution. In view of this, the non-parametric Kruskal-Wallis test, followed by a post-hoc Tukey test, was performed to examine the significant differences in the medians between the subgroups with respect to the tree characteristics. We performed the non-parametric Wilcoxon signed-rank test to determine whether the nesting heights of the studied

Turtle Dove population differed from those reported in previous studies.

To identify factors associated with the presence or absence of nests, two multinomial logistic regressions were run with small-scale (tree height, height of the lowest boundary of the tree canopy, diameter of the tree canopy, and volume of the tree canopy) and large-scale variables (distance to human settlements, distance to landfill, distance to roads, distance to open fields), respectively. The stepwise procedure with the backward method to select the best model was used to control for the possible exclusion of predictors involved in suppressor effects that can occur with stepwise methods (Field, 2013). Considering that in this case, the true model is unknown, so AIC is preferable (SHAO, 1997; VRIEZE, 2012). Therefore, the final model selection was based on the lowest value of AIC. Then, the predicted values were estimated using the final multinomial model.

We then ran a generalized additive model (GAM) with a binomial error distribution to test whether or not the presence of Turtle Dove nests was related to distance from roads, human settlements, landfills and open fields. All statistical analyses were performed using R software (R Core Development Team, 2023).

Results

A total of 106 trees were examined. All trees were divided into four categories based on the presence of nests in the canopy. Both White Stork and Turtle Dove nests were found on 32 trees, only White Stork nests were found on 20 trees, only Turtle Dove nests were found on 32 trees, and no nests were found on 23 trees. The overall spatial distribution of the examined trees does not support the spatial distribution between core and periphery of trees with nests and trees without nests and therefore does not offer a way to clearly identify "core" and "periphery". This suggests that the evidence for a core-periphery effect in the current study is weak or absent.

Tree characteristics

Descriptive statistics for nest height (NH), distance from trunk (DNT) and distance from canopy edge (DNEC) are given in (Table 1). On a finer scale, canopy volume and canopy diameter had no significant impact on the probability of finding: nests with both species, only a Dove nest, or only a White Stork nest. In addition, the classification error of multinomial regression is (1-24/84)*100% = 71.4%, suggesting that species of tree occupants depend on important factors other than small-scale tree characteristics. It is possible that the olive trees studied did not show enough variation to prove the importance of small-scale traits such as canopy volume and tree height. Alternatively, other critical factors could also have a significant impact, but were not considered in this study. Multinomial regression with large-scale variables showed that all three distances (to open fields, residential areas, and garbage dumps) were significant for the occurrence of both species or just the Turtle Dove. In the case of the White Stork, only the distance to the landfill was significant (Table 2).

Table 1. Turtle Doves' nest characteristics at Dréan, north-eastern Algeria
Caractéristiques des nids de tourterelles des bois à Dréan, dans le nord-est de l'Algérie.

Nest characteristics	Mean	sd	Min	Max	N
Tree height (m)	5.73	0.57	3.70	7.13	207
Nest height (m)	3.98	0.77	2.53	7.70	69
Distance nest-tree trunk (m)	1.43	0.57	0.00	3.32	68
Distance nest-edge of canopy (m)	1.91	0.51	0.82	3.15	68

Table 2. Final multinomial model (stepwise backward method model selection) estimates (p-values are reported in the parentheses, reference group "None")
Estimations du modèle multinomial final (sélection du modèle par méthode de régression pas à pas en sens inverse) (les valeurs p sont indiquées entre parenthèses, groupe de référence "Aucun").

	Both species	Dove	White Stork
Intercept	12.57 (0.0)	22.71 (0.0)	-3.15 (0.0)
Distance to open fields	-0.01 (0.02)	-0.02 (0.00)	0.00 (0.99)
Distance to housing	-0.01 (0.0)	-0.02 (0.0)	0.00 (2.68)
Distance to landfill	-0.01 (0.01)	-0.02 ($1.25e^{-7}$)	0.00 ($8.1e^{-3}$)

Nest characteristics

Kruskal-Wallis results showed no statistically significant differences between the groups in terms of canopy height (p-value = 0.69), canopy diameter and volume (p-value = 0.76), tree height (p-value = 0 .61) and tree canopy height lowest limit (p-value = 0.94). Nest heights in Dréan were significantly higher than in Moroccan orchards and riparian habitats (MANSOURI *et al*., 2021): Wilcoxon signed rank test, V = 2415, p = 5.31 e^{-13}, respectively. Similarly, nest heights were significantly higher (Wilcoxon signed rank test, V = 2415, p = 5.31 e^{-13}) and further from the trunk than in Algerian orange groves (V = 2142, p = 3.8 e^{-10}) (KAFI *et al*., 2015). Furthermore, Turtle Doves nested at a greater height above the ground (V = 2415, p = 5.31 e^{-13}) and farther from the trunk (V = 1984, p = 7.32 e^{-7}) in the unmanaged olive grove in Dréan than in managed Moroccan olive groves (SQUALLI *et al*., 2022).

Generalized Additive Model

According to the results of the Generalized Additive Model (GAM), only the distance to the open field has a significant positive effect on the occupancy of the Turtle Dove (Table 3, Fig. 3), while the same model shows no significant effect of the distance to roads, human settlements and garbage dumps about the presence/absence of Turtle Dove nests.

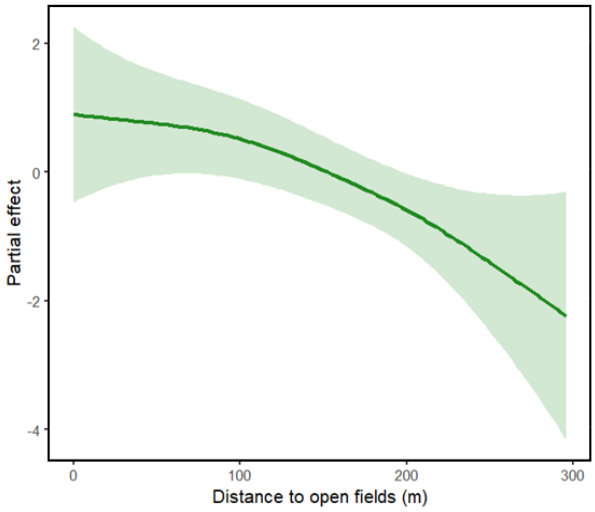

Figure 3. Generalized Additive Model (GAM) fit with 95% confidence intervals (shaded) depicting the relationship between distance nest-open fields and the presence/absence of dove nests.
Ajustement du Modèle Additif Généralisé (GAM) avec intervalles de confiance à 95% (ombragés) représentant la relation entre la distance entre les nids et les champs ouverts et la présence/absence des nids de tourterelles

Table 3. Parameter estimations for the GAM model for the presence/absence of dove nests.
Estimations des paramètres pour le modèle GAM concernant la présence/absence des nids de tourterelles.

Parameters	Estimate	se	z-value	p
Intercept	0.58	0.22	2.68	0.007
Open field	1.76	2.2	9.11	0.014

Discussion

Nest-site selection depends mainly on a number of factors that influence breeding success of Turtle Doves, such as availability of food resources, protection from predators and human disturbance (BROWNE & AEBISCHER, 2003; DUNN *et al*., 2020). Therefore, to determine habitat selection of breeding birds, it is essential to consider the environmental aspects of nest choice at many spatial scales, including nest placement, nest tree characteristics and landscape features, to understand the ecological requirements and habitat characteristics of the Turtle Dove (HANANE, 2017). Our study suggests that the selection of a suitable nest site by Turtle Doves may depend on a hierarchy of features distributed across different spatial scales (CHALFOUN & SCHMIDT, 2012).

Microhabitat features

For breeding birds, predation is an important constraint (RICKLEFS, 1969; MAJOR & KENDAL, 2008). Therefore, the selection of a safe nesting site is crucial for reproductive success (COLLIAS & COLLIAS, 1984; MARTIN, 1995; MACDONALD *et al*., 2016). The dense canopy and bushy branches of olive trees provide effective camouflage from aerial nest predators, as the dense foliage impedes the transmission of visual, acoustic and chemical signals (MARTIN, 1993). Camouflage of nests and avoidance of predators are therefore likely to influence the species' nesting in dense canopies and tall, overgrown thorn bushes (MASON & MACDONALD, 2000).

Nesting heights in olive groves (BOUKHEMZA-ZEMMOURI *et al*., 2008, this study) are much higher than those in orange orchards (KAFI *et al*., 2015; MANSOURI *et al*., 2021). This fact may reflect the greater pressure from ground predators that exists in unmanaged agricultural systems where human disturbance is low (HANANE, 2016). The distance between nest and tree trunk is also greater in olive groves than in orange orchards (KAFI *et al*., 2015). The fact that *Streptopelia*

turtur chose a larger canopy to hide the nest supports the hypothesis (it also did not build nests on leafless or dead trees), suggesting predator pressure in Dréan (CRESSWELL, 1997; LI & MARTIN, 1991). Incidentally, greater nest height and foliage volume can also lead to lower nest temperature, as nest microclimate and heat stress can determine breeding success of birds (WIEBE, 2001; WELMAN & PICHEGRU, 2023).

Similar to nest height, distance to the tree trunk, canopy cover and nest distance from the canopy edge could also be under strong selection pressure. A longer DNEC may facilitate camouflage, but also make detection by predators more difficult. As the flight of Turtle Doves from the nest is mainly horizontal, a shorter DNEC might facilitate the escape of adults from intruders. In a study on the reproductive ecology of Turtle Doves in an Algerian orange plantation, nest height and distance from the trunk were found to influence breeding success (KAFI *et al*., 2015).

Social interactions

Social factors are important habitat components (PODOLSKY, 1990), and the proximity of a conspecific's nest seemed to contribute to the occurrence of a Turtle Dove nest, which could underline the influence of such factors or the heterogeneous composition of favourable microhabitat features. Undoubtedly, predator avoidance and better food yield can promote flocks (PULLIAM, 1973). Flocks of grassland birds can find concentrated food resources more efficiently (CROOK, 1965) and gain time for foraging by spending less time searching for predators (CARACO, 1979; LAZARUS, 1979).

The white stork as "protector"

The branching trunks and horizontal branches of olive trees can make nests easily accessible and vulnerable to ground-dwelling predators such as reptiles. For example, the Montpellier snake *Malpolon monspessulanus* and the Pearled lizard *Timon pater* are relatively common in the area. The presence of nesting White Storks, which actively hunt reptiles, can deter these predators from raiding Turtle Dove nests. In addition to this protective nesting community, White Storks may also reduce predation pressure on Turtle Dove nests by acting as "protectors" to drive predatory birds such as crows out of the air (GÖTMAK & ANDERSSON, 1980; BURGER, 1984; HAEMIG, 2001). However, more research is needed to improve our understanding of the ecological dynamics associated with this protective nesting community.

Large-scale characteristics

Throughout North Africa, orange orchards and olive groves are among the most important nesting habitats for Turtle Doves (BOUKHEMZA-ZEMMOURI *et al*., 2008; HANANE & BAÂMAL, 2011; HANANE & BESNARD, 2014). Food is an important factor for reproductive success (MARTIN, 1987). As granivores, Turtle Doves rely mainly on cereal fields for food. As shown by the species' sensitivity to agricultural changes in their wintering grounds (MANSOURI *et al*., 2022). Therefore, it is necessary to better understand the nesting requirements of the Turtle Dove.

The presence of Turtle Dove nests was significantly and negatively related to the distance from nest-open fields; a result consistent with that found in southern Spain (GUTIERREZ-GALAN *et al*., 2019) and Morocco (MOUNIR *et al*., 2023). In this way, parental efforts are optimized as a function of individual and habitat quality, and time spent foraging is minimized, as predicted by life history theory (ROFF, 1992; STEARNS, 1992). Foraging is influenced by the availability, abundance and predictability of food sources. During the breeding season, many animals exhibit foraging behaviour consistent with central place foraging (ORIANS & PEARSON, 1979). This is a useful framework for describing foraging behaviour in birds, especially during periods of high energy demand and high predation risk (HEGNER, 1982; BOERSMA & REBSTOCK, 2009; BURKE & MONTEVECCHI, 2009). Central place foraging is a strategy that allows birds or other animals to maximize their foraging efficiency by minimizing travel time between the central location (nest) and food sources when load mass has no influence on travel and/or search time (SCHOENER, 1979; KACELNIK, 1984).

In the region, irrigated cropping systems and agricultural practices are the main drivers of species dynamics (HANANE, 2016). In Europe, agricultural intensification is blamed for the loss or modification of nesting and foraging habitats (BROWNE & AEBISCHER, 2005; MORENO-ZARATE *et al*., 2020). In Dréan, human encroachment (agricultural expansion) and fire are the main threats to breeding habitats. Knowledge of habitat use will help formulate effective conservation measures to mitigate negative impacts and support population recovery. We call for continuous monitoring of the status, habitat use and population dynamics of this threatened species.

Conclusion

By understanding habitat preferences and requirements, researchers can devise effective strategies to protect and restore vital habitats, enabling the

preservation of biodiversity and supporting the population dynamics of threatened species. Investigation of nest site choice by Turtle Doves *Streptopelia turtur* nesting in an olive grove showed the importance of large-scale features such as the proximity of open fields used for foraging. Other small-scales features and biotic interactions seem also to play a key role in nest selection, but these factors deserve further investigation. With increasing human activities, securing a sustainable future for both Turtle Doves and people in North Africa, remains a challenge.

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