J. BIOL. ENVIRON. SCI.,
2020, 14(40), 5-15

Original Research Article

Traditional Orchards and Drivers of Reproductive Performance in a Northern Algerian Population of Laughing Doves (*Spilopelia senegalensis*)

Khayreddine Boucherit[1,4], Ali Elafri [2,4*], Hafid Brahmia[3], Ismahen Halassi[2,4], Mohamed Cherif Maazi[1] and Moussa Houhamdi[4]

[1]Faculté des Sciences de la Nature et de la Vie, Université de Souk Ahras, ALGERIA
[2]Faculté des Sciences de la Nature et de la Vie, Université Abbes Laghrour, Khenchela ALGERIA
[3]Faculté des Sciences de la Nature et de la Vie, Université Abdel Hafid Boussof, Mila, ALGERIA
[4]Laboratoire Biologie Eau et Environnement (LBEE). Faculté des Sciences de la Nature et de la Vie et des Sciences de la Terre et de l'Univers. Université 8 Mai 1945 Guelma. BP. 401 24000 Guelma, ALGERIA

Received: 17.02.2020; Accepted: 22.05.2020; Published Online: 25.06.2020

ABSTRACT

As a good example of species which have adapted in specific anthropogenic habitats as traditional orchards, we studied the breeding ecology of a northern Algerian population of Laughing Doves. We built multifactorial models for three components of Laughing Dove reproductive performance *clutch size, number of hatchlings, and number of fledglings* using generalized linear models (GLM). None of the studied factors: orchard type, laying period, nest location or nest size was affecting clutch size. Number of chicks hatched per nest was affected by orchards type and laying period. Based on model averaged estimates, the hatching success of Laughing Dove was negatively related to "olive orchards and early timing of breeding" ($\beta = -0.53$; $z = -2.16$; $p = 0.3$). Whereas the number of chicks fledged per nest only differed with orchard type, and model averaged estimates showed a negative relation to olive orchards ($\beta = -0.30 \pm 0.17$; $z = -1.72$, $p = 0.28$). No other variables, horizontal and vertical location or nest size, were related to the variation in breeding performance. So, we suggest that the main drivers of nest failures and reproductive performance of Laughing Doves were egg predation and other variables which are not investigated.

Keywords: Breeding outcome, GLM, nest location, olive and orange orchards

INTRODUCTION

Traditional orchards are inhabited by an exceptionally large number of arthropod and bird species (Herzog 1998,Bailey et al. 2010), because they combine two absolutely different habitats in one place: grasslands in the understorey and open canopy broadleaved woodland in the overstorey (Horak et al. 2013).This type of tree crop can be considered as an alternative Mediterranean forest due to its high rate of spatial expansion in many hilly areas, a fact that has increased the number of different avifauna species adapted to this specific anthropogenic habitat (Cooper et al. 2007, Poirazisis et al. 2011). Because evergrowing demands for natural resources pushed by the growing population and the economic development, traditional orchards have been widely abandoned in favour of larger monocultures, and orchards became dominated by large and intensively managed orchards aimed at maximizing fruit production (Benton et al. 2003, Myczko et al. 2013). An increasing intensity of orchards management is known to be a threat for several birds (Kajtoch 2017). Therefore, it is important and necessary to understand the ways in which bird and other organism communities react with these new landscapes, in order to provide effective conservation strategies capable of mitigating global biodiversity declines. Identifying factors influencing a species' ecological niche and demography is a prerequisite for species conservation. Even though authorities in North Africa (Morocco, Tunisia, and Algeria) considered nature conservation as a secondary priority in comparison to other, more pressing issues, like poverty, health and education, scientific researchers of these countries still attempt to provide several studies and investigate the effects of natural system modification on many bird species conservation such as Hanane and Baamal (2011) ; Hanane (2012, 2014, 2015, 2016)when they investigated the effect of orchards characteristics and several environmental and socio-biological variables on the breeding performances of Turtle Doves (*Streptopelia turtur*) in Moroccan agroecosystems. Also, Boukhriss and Selmi (2009, 2019) investigated the ecological factors and processes shaping nest survival to assess the breeding success of Laughing Dove (*Spilopelia senegalensis*) and understanding their spatio-temporal dynamics. Accordingly, we conducted this scientific research to complete

* Corresponding author: alielafri@gmail.com

what our colleagues in Morocco and Tunisia did, regarding the factors influencing the breeding performance of Doves in this kind of area, under a constant agricultural intensification and farming practice changes in the Mediterranean North Africa sub-region. Here, the question is addressed for the ecological drivers of reproductive performance in a northern Algerian population of Laughing Doves. Reproductive performance of this Columbidae can be sub-divided into different components, such as clutch size, number of hatchlings, number of fledglings or nest survival. Examining these three components of reproductive performance in relation to potentially influential environmental and socio-biological factors, may provide important information on an animal's life-history (Hatchwell 1996, Schaub et al. 2012) and should help in creating management plans for species of conservation concern. Given this context, we aim in this study to investigate the role of several environmental and socio-biological factors like timing of breeding, nest size and nest location among orchards and within tree as a potential drivers of breeding success in Laughing Doves during two consecutive years.

MATERIALS AND METHODS

Study area

The current study was carried out in an agricultural area of Guelma province (36° 46′ N, 7° 28′ E), north-eastern Algeria. The climate of the region is subhumid, mild, and rainy in winter and hot in summer, and the annual average temperature is about 17.3 °C varying between 4 °C in winter and 35.4 °C in summer. The annual mean rainfall is 654 mm (Bensouilah et al. 2014). The main ecological characteristics of the area is that it is crossed by the most important and mighty river of north-eastern Algeria (Seybouse River). Each side of the river is highly productive agricultural lands, and much intensive fruit farming has been recently established (Zeraoula et al. 2015). Data were collected from three orange orchards and three olive orchards (28 ha in total), chosen at random. The mean distances of the chosen orchards from the Seybouse River were respectively (4000.88 m± 3000.4) and (214.33 m ± 83.33) for olive and orange orchards (Figur 1).

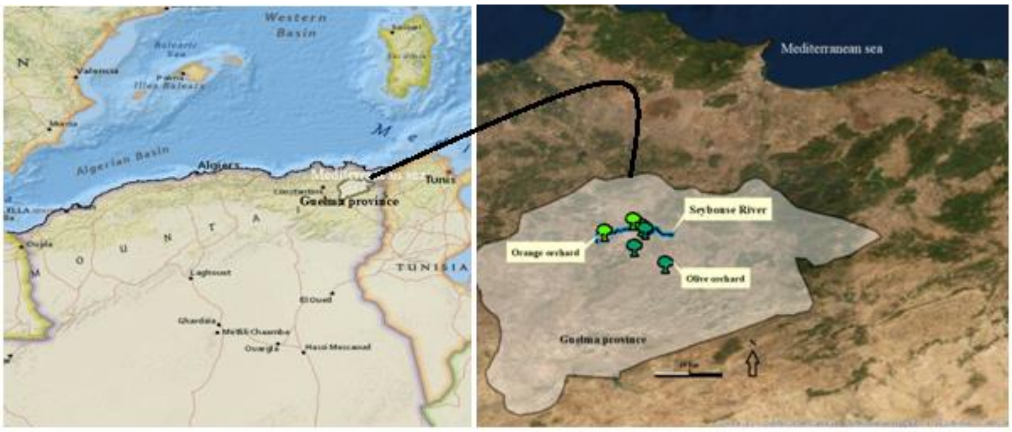

Figure 1. Location of the study area and the investigated orchards.

Fieldwork

From early March to late August (2015–2016), nests were searched for by checking potential nest sites available in the area, while using parental behavioural cues that can sometimes inform about the location of the nest. When an active nest was found, we immediately checked its content and tried to determine laying dates, clutch size, and the number of nestlings hatched and fledged. Each nest was visited every 2–4 days until it failed or young fledged (Martin and Geupel 1993, Hanane and Baâmal 2011).

The laying date was determined either based on the knowledge about it or by backdating from the known hatching date, assuming that incubation lasts 14 days for both species (Cramp and Perrins 1994). The number of chicks hatched was known by the presence of chicks in nests. The number of chicks fledged was determinate by (1) direct observation of chicks fledged, (2) their presence around the nest-tree and (3) observing the chicks just before fledging [minimum age of 12 days, when they start fledging from the nest (Hanane and Baâmal 2011, Hanane 2016)]. After the nest was inactive (i.e., fledging or failure), the following variables concerning nest position were measured for each nest: nest external diameter, nest tree height, nest height above the ground, distance from the nest to the lowest part of the canopy, distance from the nest to the trunk, distance from the nest to the external part of the canopy.

Statistical procedures

General statistics

All data were checked for normality (Shapiro–Wilks), homogeneity of Variances (Levene Test), and outliers. Chi-Square Test was used to evaluate: (1) variations in nest placement (horizontal and vertical position) within the tree, (2) significant differences in nest preferences for the nesting orchard type, and (3) variations in nest diameter. G-tests (Zar 2010) were used to compare proportions of clutches, hatchlings, and fledglings between: (1) orchards type, (2) timing of breeding, (3) vertical zones, (4) horizontal zones, and (5) nest size.

Predictive modelling

In order to reduce the dimensionality of the aforementioned measurements to a smaller number of representative variables, they were transformed on a set of categorical variables (TableI). After this, we built multifactorial models for three components of Laughing dove reproductive performance *clutch size, number of hatchlings, and number of fledglings* using generalized linear models (GLM)with a Poisson distribution and a log link function (Seavy et al. 2005), in order to evaluate how breeding success is predicted by the recorded habitat and social factors. For hatching and fledging success, the logarithm of the number of eggs in each clutch was included as an offset. Explanatory variables significantly correlated were not included in the same models.

Model Fit

The best-fit model is found by maximum likelihood techniques. The maximum likelihood estimators (MLEs) for ($\beta 0$, $\beta 1$ … etc.) are obtained by finding the values that maximizes log-likelihood (Agresti andKateri 2011), so a goodness-of-fit (GOF) test was performed. By default models were adjusting when dispersion is equal to 1. This will perform the adjustment. It will not change the estimated coefficients βj, but it will adjust the standard errors (McCullagh andNelder 1989).Information criteria, such as Akaike Information Criterion (AIC), are usually presented as model comparison tools for GLMs. The AIC were calculated from the general formula AIC = −2 (log likelihood) + 2 K, where K is the number of parameters. The model with the lowest AIC was selected as the best-fitting model. I corrected AIC for a small sample size using AICc (Hanane 2016). We checked residuals from the models. In all cases, residuals showed a normal distribution, for which the use of GLMs was suitable. All statistical analyses were performed in R-3.6.1 software, and results were considered significant at $p < 0.05$.

Table 1. Variables used in the modelling of components of reproductive performance in the Laughing dove.

Hypothesis	Variable	Description
Timing of breeding	Start of egg-laying	Back calculating based on age and nr. of fledglings for nests found after clutch completion assuming one egg laid per day #, 14 days incubation
Nest location	Vertical position	Categorical variable with five levels *(see results)*
	Horizontal position	Categorical variable with Three levels *(see results)*
	Orchards type	Categorical variable with two levels *(see results)*
Nest size	External diameter of nests	Categorical variable Two levels *(see results)*

RESULTS

General findings

Nesting ecology

During the two years of study, we located 134 nests (70 in olive orchards and 64 in orange orchards). Nest were not uniformly distributed within the tree, three horizontal zones were distinguished (Chi =29.87, df= 2, $p < 0.05$) (Figure 2, 3): zone A, nests were located up to 200 cm from the trunk (33% of nests); in the zone B, nests were located > 200 cm and up to 300 cm(53% of nests); and in zone C nests were located > 400 cm (14%). In all analysed trees nests of doves were also vertically stratified (Chi =60.65, df= 4, $p < 0.05$), five vertical placement were described (Figure 2, 3): The top part of the tree canopy (Category I), and the lower part of the tree canopy (Category V) have a lower number of nests (6% and 4% respectively). So, all most al of nests (90%) were located in the middle zones (II, III, and IV) (scale between zones was 100cm). Concerning the nests size, the various measurements we conducted showed a significant difference in nest size (Chi =45.26, df = 1, $p < 0.05$), were two levels have been distinguished: small nests up to 15 cm of external diameter (represent 21% of all nests), and medium nest > 15 cm that represent 79% of all nests (Figure 3). Finally, we did not found any differences (Chi =0.61, df = 1, p = 0.43) in nest preferences for the nesting orchards type

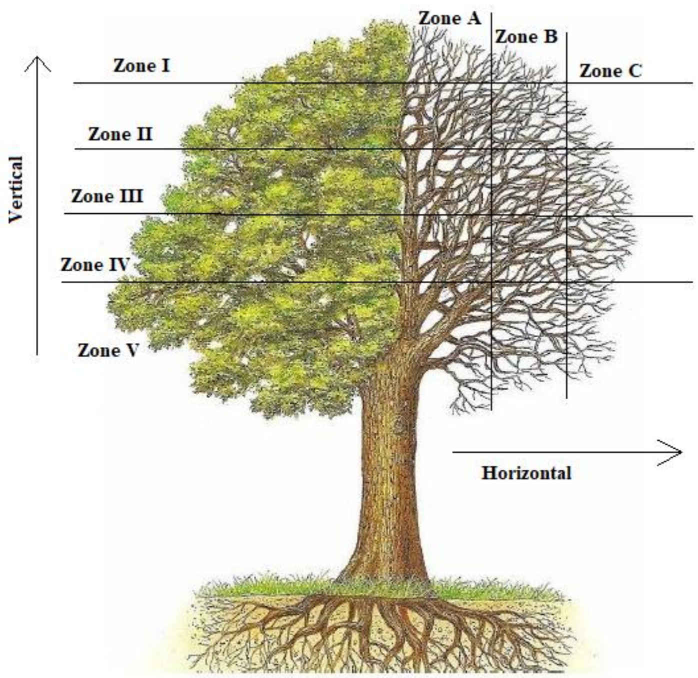

Figure 2. Definitions of the three horizontal zones (A, B and C) and the five vertical categories (I, II, III, IV and V) of nest location in the tree canopy.

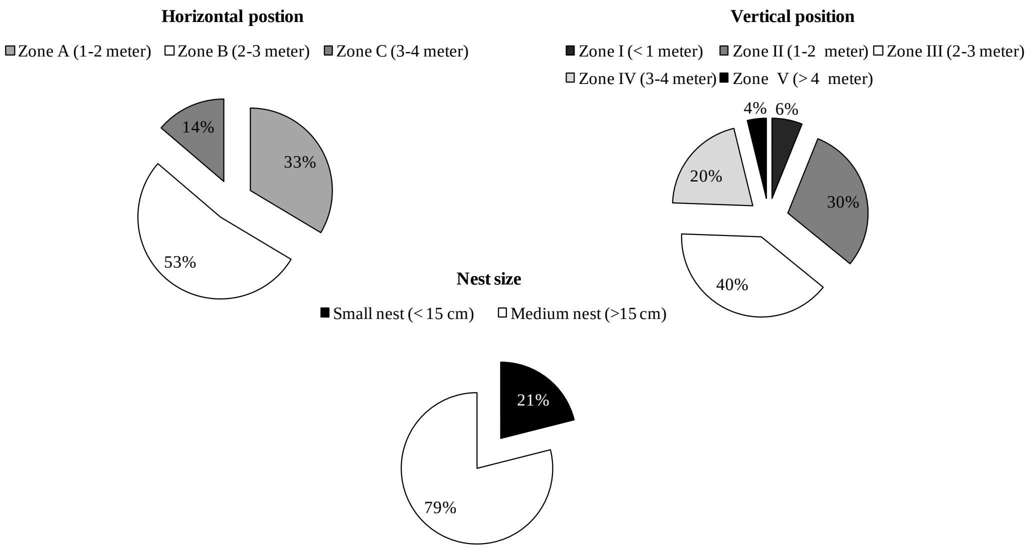

Figure 3. Variations in nest diameter and spatial distribution of nests within the tree.

Reproductive performance

During the two-year study, the number of eggs varied from one to two in all the examined nests, and the average clutch size was 1.83 eggs (SE = 0.03, N = 134). Among the 134 clutches monitored, 64. 17 % were successful (proportion of fledged nests among the monitored nest sample). Average fledging success was 1.00 (±0.07) fledglings per nest, ranging from 0 to 2 fledglings (Table 2). However, according to the Mayfield method, our sample of 134 Laughing Dove nests, where there were 48 failed and there were 143.25 exposure days, the daily survival probability would be 0.98. Using a nesting period of 32 days (4 laying, 14 incubating, and 14 nestling), the total survival probability would be 0.57. So, in this study, there is a 57% chance that a nest will fledge at least one young.

Across 2 years, nest survival (± SE) over an average nesting period of 29.48 ±0.27 per nest (Table 2). The whole nesting period is emphasized on an average laying period of (116 days ± 1.08, n= 134), an average of 15. 07 (± 0.07, n = 108) days of incubation and an average of 14.68 (± 0.16, n = 91) days of rearing (Table 3).

Table 2. Reproductive performance of Laughing dove in 2015-2016 (Mean ± SE).

Year	Clutch size	Number of fledglings (overall nests)	Naïve nest success
2015	1.81 (±0.04) (71)	0.92 (±0.1) (71)	47.37 % (71)
2016	1.84 (±0.04) (63)	1.12 (±0.1) (63)	54.78 % (63)
2015-2016	1.83 (±0.03) (134)	1(±0.07) (134)	51.07 % (134)

Table 3 Nest survival of Laughing dove in 2015-2016 (mean number of days ± SE).

Year	Egg laying	Incubation	Rearing	Whole nesting period
		per nest	per nest	per nest
2015	119.5 (±2.43) (71)	14.92 (±0.05) (61)	14.71 (±0.18) 55	29.14 (±0.41)
2016	112.5 (±0.08) (63)	15.3 (±0.15) (47)	14.63 (±0.31) (36)	(30.1) (±0.28)
2015-2016	116 (±1.08) (134)	15.07 (±0.07) (108)	14.68 (±0.16) (91)	29.48 (±0.27)

Variables affecting the breeding output (Model selection)

Clutch size

According to the G-test analysis (Table 4)of the proportion of eggs in the nest in relation to orchards type, the timing of breeding, nest location, and nest size, the number of eggs depends only on the horizontal position of the nest within the tree (p<0.05 under G-test). Among the three positions, apparently, zone C chance of having two eggs more than zone A and B. In the analyses of all thematic hypotheses groups (Table 5), the null model was ranked highest, and therefore no other variables were related to variation in clutch-size, orchard type (*z* =0.29, p=0.77), the timing of breeding (z=0.14, p=0.88), vertical location (z=-0.01, p= 0.98), horizontal location (z=0.25, p=0.79), and nest size (z=0.07, p=0.94).

Table 4. Proportion of eggs in the nest in relation to orchards type, timing of breeding, nest location, and nest size.

		Number of eggs in nest					
Variables		1 (%)	2 (%)		G-test	df	p-value
Orchards type	Olive	20	80	Olive/Orange	1.121	1	0.290
	Orange	13.10	86.90				
Timing of breeding	Early	18.5	81.5	Early/Late	0.25	1	0.61
	Late	15.2	84.8				
Vertical location	Zone I	12.5	87.5	I/II/III/IV/V	3.57	4	0.46
	Zone II	22.5	77.5	/	/	/	
	Zone III	9.8	90.2	/	/	/	
	Zone IV	22.2	77.8	/	/	/	
	Zone V	20	80	/	/	/	
Horizontal location	Zone A	15.9	84.1	A/B	0.59	1	0.44
	Zone B	21.7	78.3	**B/C**	**7.73**	**1**	**0.005**
	Zone C	0	100	**C/A**	**5.15**	**1**	**0.02**
Nest size	Small	18.5	81.5	Small/Medium	0.07	1	0.79
	Medium	16.3	83.7				

Hatching success

The difference was statistically significant between the orange orchard and olive orchard (**G-test = 6.77, df = 2, p = 0.03**) in terms of percentages of chicks hatched per nests. We may conclude that orange orchards seem to positively influence the number of chicks hatched per nest, where the proportion of hatchlings was higher (60% of nests have 2 chicks per nest) if compared to olive orchards (Figure 4). Model selection yielded two models with a ΔAICc < 2 to the top ranked model (ΔAICc of null model = 12.97). These models contained the variables “orchards type” and “orchards*timing of breeding”. Both indicate a significant goodness-of-fit (p=0.3). Moreover, according to the AICc weight, orchards and their interaction (*) with timing of breeding showed weights exceeding 70%, leading it to be the best model that has estimated effects on hatching success (Table 5). The model explained 12 % of the deviance in the hatching success and 17 % of their variance. Based on model averaged estimates and SE, the hatching success of Laughing Dove was negatively related to “olive orchards and early timing of breeding” (β = −0.53 ± 0.16; 95 % CI −0.61 to 0.016, z = −2.16, p = 0.3).

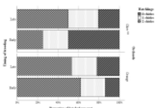

Figure 4. Percentage of chicks hatched per nests in the two orchards type. Difference was statistically significant between orange orchard and olive orchard (**G-test = 6.77, df = 2, p = 0.03**).

Fledgling success

The number of chicks fledged per nest differed significantly (G-test = 3.77, df = 2, p =0.28) between orchard types; they were greater in orange orchards than in olive ones. Approximately fifteen percent (50%) of nests that produced two checks fledgling, and low proportion of nests that failed, were recorded in orange orchards (Figure 5). Model selection yielded one model with a ΔAICc < 2 to the top ranked model (ΔAICc of null model = 13.57). The top ranked model contained the variables "orchards type". The model indicates a significant goodness-of-fit (p=0.04), and explained 12 % of the deviance in the hatching success and 11.91 % of their variance. Based on model averaged estimates and SE, fledging success was negatively related to olive orchards (β = −0.30 ± 0.17; 95 % CI −0.64 to 0.04, z = −1.72, p = 0.048). Therefore, the number of fledglings of laughing doves seems to be higher in orange orchards more than olive ones.

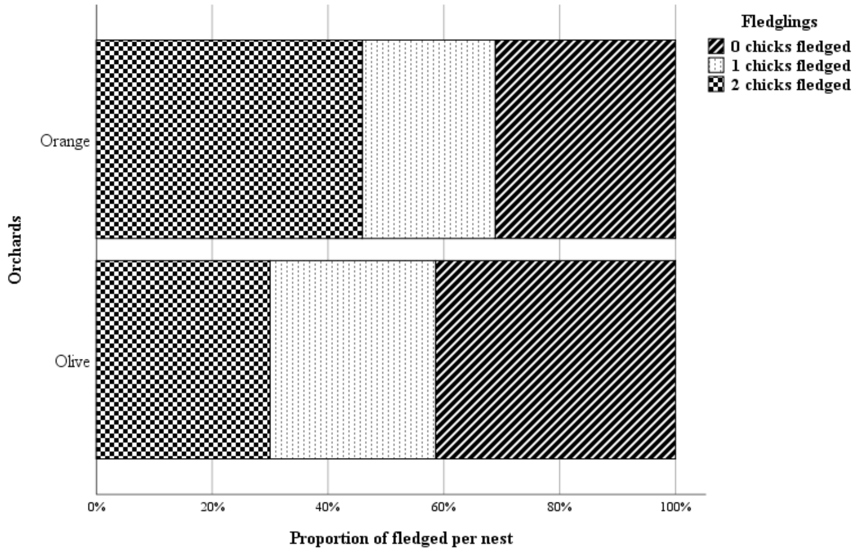

Figure 5. Percentage of chicks fledged per nests in the two orchards type. Difference was statistically significant between orange orchard and olive orchard (**G-test = 3.77, df = 2, p = 0.04**).

Table 5. Model selection results for the analysis of breeding performance of Laughing doves in relation to environmental and social factors.

Reproductive performance	Models	k	AICc	ΔAICc	Wi	AICcwi	GOF (P)
Clutch size	Null	1	342.52	0.00	0.41	0.41	
	Or	1	344.5	1.98	0.15	0.56	
	Tim	1	344.56	2.04	0.14	0.71	
	NS	1	344.58	2.06	0.14	0.86	
	HL	2	346.31	3.79	0.06	0.92	
	Or*Tim	3	348.6	6.08	0.02	0.94	
	Or*NS	3	348.66	6.14	0.019	0.96	
	Tim*NS	3	348.68	6.16	0.02	0.98	
	VL	4	350.71	8.19	0.00	0.99	
	HL*NS	5	352.66	10.14	0.00	0.99	
	Tim*HL	5	352.75	10.23	0.00	0.99	
	…						
Number of checks hatched	Or*Tim	3	331.13	0	0.42		**0.30**
	Or	1	331.76	0.63	0.30	0.72	**0.36**
	Tim	1	333.96	2.83	0.10	0.83	
	NS	1	334.59	3.46	0.074	0.90	
	Or*NS	3	335.54	4.41	0.04	0.95	
	HL	2	335.77	4.64	0.04	0.99	
	VL	4	339.75	8.62	0.00	1	

	Null	1	344.1	12.97	0.00	1	
	…						
Number of checks fledged	Or	1	336.91	0.0000	0.99	0.990	**0.28**
	Tim	1	348.65	11.74	0.002	0.992	
	HL	2	348.38	11.47	0.003	0.996	
	NS	1	348.95	11.04	0.002	0.998	
	VL	4	350.89	11.98	0.000	1.00	
	Null		350.48	13.57	0.001	0.999	
	…						

Models with a ΔAICc ≤ 11 to the highest ranked model as well as null models are presented. K = number of parameters in the model. Wi = Akaike'sweight; ". . ." refers to additional models examined, but not listed in detail to avoid overlong table, as they were little informative. N = 134.

DISCUSSION

Olive and orange orchards as a source of novel conditions offer possibilities for species that are able to cope with the challenges of changing environments and human disturbance. Laughing Doves are good examples of species which have adapted since they still nest successfully in this kind of man-made habitats, such as other doves around the Mediterranean North African countries (Morocco and Tunisia) (Hanane et al. 2011, Hanane 2014, Boukhriss and Selmi 2019). Laughing Doves and other similar species, especially the Turtle Doves continue to show a strong population decline in their northern range of distribution (Dunn and Morris 2012), which leads us to give more attention to this group of species if we want to provide effective conservation strategies capable of mitigating global biodiversity declines. Therefore, our study underlines with this purpose, mainly by identifying ecological drivers of reproductive performance in a northern Algerian population of Laughing Doves.

In orchards forms of Guelma farmlands (Northern Algeria), the choice of olive and orange trees by the studied breeding population of Laughing Doves did not indicate a particular attraction. But in a population from Tadla lowland (Central Morocco), Laughing Doves have occupied only olive groves (Hanane et al. 2011, Hanane, 2014). Such dissimilarly should be related to the availability and the suitability of these two orchards category in the study area, it is the best factor that promotes distribution patterns of nest substrate selection in Doves species and other similar canopy-birds (Browne et al. 2005; Hanane and Baâmal 2011).

Within the tree, nests were not uniformly distributed. The behaviour of nest placement may be a response to the height of trees available for nesting, which is an important factor affecting nest placement within the tree, as in the case of many bird species (Boukhemza-Zemmouri et al. 2008, Boukhriss andSelmi 2009; Taberner et al. 2012). In concordance with (Boukhriss andSelmi 2009; Hanane et al. 2011, Brahmia et al. 2015), our results also confirmed that Laughing Doves preferentially consider the central part of the canopy and the median part of branches when selecting for nesting placement in olive and orange orchards (either horizontally or vertically, all most all of nests were located in the middle zones within the tree). Vulnerability to predation, brood parasitism, the suitability of microclimate for nestlings, and resource acquisition are the main variables driving nest placement of many canopy birds (Siepielski et al. 2001).

Regarding the reproductive performance of Laughing Doves, our results showed that the estimated daily survival rate using Mayfield's method and data on productivity was similar to those previously estimated for the same Dove species by Brahmia et al. (2015) in an agricultural landscape in Northern Algeria, and by Boukhriss and Selmi (2019) in a southern oasis of Tunisia. It was also identical to that reported for analogous Dove species nest at a similar agricultural landscape in Morocco by Hanane et al. (2011) and Hanane (2016).

The previous study that has been published about Laughting Dove in the same region (Brahmia et al. 2015), did not investigate the relationship between the reproductive performance of this species and environmental and socio-biological factors. Thus, this proposed research is intended to fill this research gap, by examining three components of reproductive performance (clutch size, hatching success, and fledgling success) in relation to potentially influential environmental and socio-biological factors, such as timing of breeding, nest size, and nest location among orchards and within the tree.

Firstly, variation in clutch size is an important factor related to the fitness of individuals, it gives information about how much a female can allocate to the reproduction, which may be influenced by several ecological factors (Jetz et al. 2008). Our results showed that none of the study factors: orchard type, laying period, nest location, or nest size affecting clutch size in the Laughting Doves. We may conclude that clutch size was mediated through factors pertaining to either the aforementioned factors, such as female body condition, perceived predation risk, inter- and intra-specific competition, natural and anthropogenic disturbance, food availability, habitat suitability and interactions among these aspects (Grendelmeier et al. 2015). This fact is consistent with the typical pattern shown by similar Dove species both in Europe (Peiro, 1990, Browne et al. 2005) and North Africa (Hanane andBaamal 2011, Kafi et al. 2015).

Secondly, the Number of hatchling and fledglings provides a reproductive performance value per individual, breeding pair, or population (Siriwardena et al. 2000). In our study, we found that numbers of chicks hatched and fledged per nest are greater in orange orchards than olive orchards. The negative relation to olive orchards highlighted by our predictive modelling concerning hatchling and fledglings success was contrasted with Hanane's (2016) findings (about Turtle Doves), when he predict a negative relation to orange orchards, and he relates this fact to biotic disturbances, where orange orchards are under continuous human management if compared to olive orchards. We are not puzzled, especially when many researchers confirmed that bird species richness and abundance in orchards may depend not only on the management of the orchard but also on the surrounding landscape composition (Benton et al. 2003; Bailey et al. 2010, Myczko et al., 2013). In our study, orange orchards are much closed to the Seybouse River and (214.33 m ± 83.33) if compared to olive orchards (4000.88 m± 3000.4) (Fig. 1). On each side of the River, intensive fruit farming has been recently established (Zeraoula et al. 2015). It is well known that species richness and abundance were enhanced by an increase in the area covered by orchards in the surrounding landscape (Horak et al. 2013). According to these suggestions, we may conclude that suitable habitats in terms of food diversity and tepid microclimate that were made by this mighty river on the nearby landscape of orange orchards contribute positively in the hatchling and fledglings success of Laughing Doves. In addition, mature olives had branched trunks and large horizontal branches, granting access for ground-dwelling predators such as reptiles and snakes (pers.obs of *Lizard* spp. on the Laughing Dove's nest), to some nests in the canopy (Khoury et al. 2009). Therefore, we should also consider this risk as an additional factor that may affect nesting outcomes in olive more than orange orchards.

In addition to the effect of orchard type, the timing of breeding was also identified as a significant predictor of the number of chicks hatched per nest, with more chicks hatching in the late period than in the early period, exclusively for olive orchards. We hypothesize that the observed increase in hatchlings as the breeding period progress could be at least partly due to:

First, most nest failures were due to egg predation for the Laughing Dove in the studied olive orchards (Brahmia et al. 2015). Similar results were obtained in an oasis habitat of southern Tunisia when predators seemed to more frequently consume bird eggs than nestlings (Boukhriss et al. 2009, Boukhriss andSelmi 2018). Second, the possible increase in parental defense behaviour with the progress in the nesting attempt, when birds are known to take higher risk against predators and to defend more intensely their nests as the breeding attempt progresses and its reproductive value increases (Brunton 1990, Boukhriss andSelmi 2010). Lastly, Boukhriss andSelmi (2019) in their recent study on drivers of nest survival rate in Laughing Doves conclude that the last nests would necessarily have a high probability of survival.

Unlike olive orchards, orange forms have not shown any effect of laying period on the reproductive success of Laughing Doves, which does, however, not come in line with the findings of Hanane (2016). In his study, the researcher was identified the lying period as a significant predictor of the number of chicks fledged per nest in orange orchards (more chicks fledging in the early period than in the late period). This result has been explained by the hunting activity, and the continuous presence of children, who continually look for nests during the summer holidays. If we look at the situation under the investigation zones, I would suggest only this that it was absolutely not the case. A little more, we can be argued that orange orchards of north-eastern Algeria are less disturbed (hunting activity or intensive agriculture) if compared with Hanane's (2016) finding. The main reason is that Algeria is an oil-producing country it does not depend so much on such farming activities, unlike its neighbour Morocco.

CONCLUSION

Our results complete the information obtained on the subject of the breeding ecology of North African Doves. We conclude that the main drivers of nest failures and reproductive performance in a northern Algerian population of Laughing Doves were egg predation and events pertaining to either the investigated factors (nest size, horizontal and vertical location of nests). We could also argue that anthropogenic conditions and the surrounding landscape composition (fruit farming, water source, and cereal crop) are undeniably the main guarantors of a bright future for this North African population in the investigated area. Supporting this landscape diversity would be necessary not only for the Laughing Doves but also for all the seed-eating birds if we want to provide effective conservation strategies capable of mitigating global biodiversity declines. Finally, further studies are needed to improve our understanding of the effects of predatory activity, especially ecology and feeding behavior of the suspected nest predators. This will allow us to quantify the actual effect of the major part of the potentially influential environmental and socio-biological factors on the productivity of this Columbid species.

ACKNOWLEDGMENTS

We thank the agricultural managers of orchards for their help.

REFERENCES

Agresti A, and Kateri M (2011). Categorical data analysis. Springer Berlin Heidelberg.206-208.

Bailey D, Schmidt-Entling MH, EberhartP, Herrmann JD, Hofer G, Kormann U, and Herzog F (2010). Effects of habitat amount and isolation on biodiversity in fragmented traditional orchards. J Appl Ecol 47:1003-1013.

Bensouilah T, Brahmia H, Zeraoula A, Bouslama Z, and Houhamdi M (2014).Breeding biology of the European Greenfinch *Chloris chloris* in the Loquat orchards of Algeria (North Africa).Zoology and Ecology 24(3):199-207.

Benton TG, Vickery JA, and Wilson JD (2003). Farmland biodiversity: is habitat heterogeneity the key? Trends Ecol Evol18 :182-188

Boukhemza-Zemmouri N, Belhamra M, Boukemza M, Doumandji S, and Voisin JF (2008).Biologie de reproduction de la Tourterelle des bois Streptopelia turtur arenicola dans le Nord de l'Algérie.[Breeding Biology of the Turtle Dove in the North of Algeria.] Alauda 76 : 207-222.

Boukhriss J, andSelmi S (2009). Nidification et succès reproducteur de la tourterelle maillé *Streptopelia senegalensis* dans une oasis du sud Tunisien.[Nesting habits and reproductive success of the Laughing Dove *Streptopelia senegalensis* in the Oases of Southern Tunisia.] Alauda 77:187-192.

Brahmia H, Zeraoula A, Bensouilah T, Bouslama Z, and Houhamdi M (2015). Breeding biology of sympatric Laughing *Streptopelia senegalensis* and Turtle *Streptopelia turtur* Dove: a comparative study in northeast Algeria. Zool Ecol 25:220-6.

Browne SJ, Aebischer N, and Crick H (2005). Breeding ecology of Turtle Doves *Streptopelia turtur*in Britain during the period 1941–2000: an analysis of BTO nest records cards. Bird Study 52:1-9.

Brunton D.H (1990). The effects of nesting stage, sex, and type of predator on parental defense by killdeer (*Charadrius vociferous*): testing models of avian parental defence. Behav Ecol Sociobiol 26:181-90.

Cooper T, Arblaster K, Baldock D, Farmer M, Beaufoy G, Jones G, Poux X, McCracken D, Bignal E, Elbersen B, Washer D, Angelstam P, Roberge JM, Pointereau P, Seffer J,and Galvanek D (2007).Final report for the study on HNV indicators for evaluation. Institute for European Environmental Policy, London.

Dunn JC, and Morris AJ (2012). Which features of UK farmland are important in retaining territories of the rapidly declining Turtle Dove *Streptopelia turtur*?. Bird Study59(4): 394-402.

Grendelmeier A, Arlettaz R, Gerber M, and Pasinelli G (2015). Reproductive performance of a declining forest passerine in relation to environmental and social factors: implications for species conservation. PLoS One. doi.org/10.1371/journal.pone.0130954.

Hanane S, and Baâmal L (2011). Are Moroccan fruit orchards suitable breeding habitats for Turtle Doves Streptopelia turtur? Bird Study 58(1) : 57-67.

Hanane S, Bergier P, and Thevenot M. (2011). La reproduction de la tourterelle maillée Streptopelia senegalensis dans la plaine du Tadla (Maroc central): analyse comparée avec la tourterelle des bois Streptopelia turtur. Alauda (Dijon) 79(1): 17-28.

Hanane S (2012). Do age and type of plantings affect turtle dove Streptopelia turtur nest placement in olive agro-ecosystems?. Ethology Ecology & Evolution 24(3): 284-293.

Hanane S (2014). Plasticity in nest placement of the Turtle Dove (Streptopelia turtur): experimental evidence from Moroccan agro-ecosystems. Avian Biology Research 7(2): 65-73.

Hanane S (2015). Nest-niche differentiation in two sympatric Streptopelia species from a North African agricultural area: the role of human presence. Ecological Research 30(4): 573-580.

Hanane S (2016). Effects of location, orchard type, laying period and nest position on the reproductive performance of Turtle Doves (Streptopelia turtur) on intensively cultivated farmland. Avian Research 7:4.

Hatchwell BJ, Chamberlain DE,and Perrins CM (1996).The reproductive success of blackbirds Turdus merula in relation to habitat structure and choice of nest site. Ibis 138: 256-262.

Herzog F (1998).Streuobst: a traditional agroforestry system as a model for agroforestry development in temperate Europe. Agrofor Syst42:61-80.

Horak J, Peltanova A, Podavkova A, Safarova L, Bogusch P, Romportl D,and Zasadil P (2013). Biodiversity responses to land use in traditional fruit orchards of a rural agricultural landscape. Agriculture, ecosystems & environment178:71-77.

Jetz W, Sekercioglu CH, and Bohning-Gaese K (2008). The worldwide variation in avian clutch size across species and space. doi.org/10.1371/journal.pbio.0060303.

Kafi F, HananeS, Bensouilah T, Zeraoula A, Brahmia H, and Houhamdi M (215).Les facteurs déterminants le succès de reproduction de la Tourterelle des bois (*Streptopelia turtur*) dans un milieu agricole Nord-Africain. Revue d'Écologie (Terre Vie) 70(3):271-9.

Kajtoch Ł (2017).The importance of traditional orchards for breeding birds: the preliminary study on Central European example. Acta Oecologica.78: 53-60.

Khoury F, Janaydeh M, andAl-Hmoud A.R (2009). Nest placement and nesting success in two finch species colonizing a recently established plantation in an arid region. Journal of Ornithology150(1):29-37.

Martin TE, andGeupel GR (1993). Nest-monitoring Plots: Methods for locating nests and monitoring success. Journal of Field Ornithology64:507-519.

McCullagh P, and Nelder JA (1989). Generalized linear models., 2nd edn.(Chapman and Hall: London). Standard book on generalized linear models.

Myczko Ł, Rosin Z.M, Skórka P, Wylegała P, Tobolka M, FliszkiewiczM, and Tryjanowski P (2013). Effects of management intensity and orchard features on bird communities in winter. Ecological research28(3) :503-512.

Peiro V. (1990). Aspectos de la reproduccion de la Tortola común (*Streptopelia turtur*) en Madrid. Mediterr Ser Biol 12 :89-96.

Poirazisis K, Karris G, and Martinis A (2011). Birds in organic olive grove: the case from Zakynthos island. Internationalconference for organic agriculture and agro-eco tourism in the Mediterranean at: Zakynthos Island, Greece.Volume: ISBN: 978-960-85961-7-7

Schaub M, Reichlin TS, Abadi F, Kéry M, Jenni L, and Arlettaz R (2012). The demographic drivers of local population dynamics in two rare migratory birds. Oecologia 168:97-108.

Schilling J, Freier KP, Hertig E, and Scheffran J (2012). Climate change, vulnerability and adaptation in North Africa with focus on Morocco. Agriculture, Ecosystems & Environment 156: 12-26.

Seavy NE, Quader S, Alexander JD and Ralph CJ (2005). Generalized linear models and point count data: statistical considerations for the design and analysis of monitoring studies. USDA Forest Service Gen Tech Rep 191:744-753.

Siepielski AM, Rodewald AD, andYahnerRH (2013).Nest site selection and nesting success of the Red-eyed Vireo in central Pennsylvania. The Wilson Bulletin02-307.

Siriwardena GM, Baillie SR, Crick HQ, andWilson JD (2000). The importance of variation in the breeding performance of seed-eating birds in determining their population trends on farmland. Journal of Applied Ecology 37(1):128-148.

Taberner A, Tamarit R,and Gil-Delgado JA (2012). Position of Blackbird (*Turdus merula*) nests in orange trees.Avian Biology Research 5: 193-197.

Zar JH (2010).Biostatistical analysis, 5th edn. Prentice Hall, Upper Saddle River.

Zeraoula A, Bensouilah T, Brahmia H, Bouslama Z, Houhamdi M,and Kerfouf, A. (2016). Breeding biology of the European Blackbird *Turdus merula* in orange orchards. Journal of King Saud University-Science 28(4):300-307.