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Thilelli Aitouakli
Department of Animal Biology, Faculty of Natural and Life Sciences, Ferhat ABBAS University - Setif1, Setif 19000, Algeria Laboratory of Improvement and Development of Plant and Animal Production, University of Ferhat Abbas, Setif1, Setif 19000, Algeria, aitouakli.thilelli@univ-setif.dz

Ettayib BENSACI
Department of Natural and Life Sciences, Faculty of Sciences, M'Sila University, M'Sila Algeria, tayeb.bensaci@univ-msila.dz

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Cover Page Footnote

We are grateful to the owners of the orchards for allowing us to work in their properties and the direction of agriculture services for their help. We thank also Mrs.Aitouakli Rachid, Aoudia Fazia and Derbal Djaber for their help in fieldwork and encouragements. We are also thankful to Mr. Mohammed Gana for preparing maps.

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BREEDING ECOLOGY AND NEST- SITE SELECTION OF TURTLE DOVES (*STREPTOPELIA TURTUR)* IN THREE NEW ORCHARD HABITATS

THILELLI AITOUAKLI[1,2], ETTAYIB BENSACI[3]*

[1]*Department of Animal Biology, Faculty of Natural and Life Sciences, Ferhat ABBAS University - Setif1, Setif 19000, Algeria*
[2]*Laboratory of Improvement and Development of Plant and Animal Production, University of Ferhat Abbas, Setif1, Setif 19000, Algeria*
[3]*Department of Natural and Life Sciences, Faculty of Sciences, M'Sila University, M'Sila Algeria*

Corresponding author's e-mail: tayeb.bensaci@univ-msila.dz

ABSTRACT

The main aim of our work was to investigate the breeding parameters in three orchard types in Algeria (apple, cherry and nectarine) for better conservation of existing species. A total of 149 active Turtle dove nests were monitored in these man–made agro-systems. Egg laying occurred from early May and continued until mid-August. Egg laying started later in cherry trees and stopped earlier in nectarines. Nest density was higher in apple orchards. Nests were located higher in nectarine. Clutch size was similar among orchard types. Northeast was the dominant orientation in all orchards. Breeding success was higher than that recorded in former studies. Desertion was the main cause of nest failure. The apple orchards are the preferred breeding area for turtle dove in this region.

Keywords: Turtle dove, breeding, nest-site, orchard habitat, Algeria.

INTRODUCTION

Turtle Dove (*Streptopelia turtur*) is a bird presented by two subspecies: *S. t. turtur* and *S. t. arenicola* in Europe and North Africa respectively as a summer visitor with breeding strongholds reported around the Mediterranean basin (Burfield & van Bommel 2004).

Among the serious questions of biological conservation, the animal population survey in decline, or even those in the process of extinction, appears to be increasingly important (Zemmouri 2008).Though it extends from Europe to Asia and North Africa(Fisher et al., 2018),this species is showing a distribution range with a rapid decline (Hanane 2018). Actually, these population declines are essentially due to the reduction or the destruction of nesting habitat (Browne et al., 2004), food availability (Browne & Aebischer 2003, Zolbaji & Science 2015), agricultural, and use and hunting (Boutin& Lutz 2007).

The breeding ecology of this species has been reported in many studies in Europe (Murton 1968, Peiro 1990, Dias et al., 2013, Aubineau & Boutin 1998, Rocha & Hidalgo 2002, Browne et al., 2004, Bakaloudis et al., 2009). As a regular migrant breeding birds in Africa (Thévenot et al., 2003, Isenmann et al., 2005, Hanane & Baamal 2011), Turtle Doves were a subject of some breeding monitoring in North African countries such as Morocco (Hanane et al., 2011) and Tunisia (Boukhriss & Selmi 2019). In Algeria, both population size and breeding ecology aspects remain poorly explored (Boukhemza-Zemmouri et al., 2008, Hanane2009, Yahiaoui et al., 2014, Kafi et al., 2015) despite the importance of such datato better understand the long-term dynamics of this species at different spatial scales. This lack of data availability is

probably due to the country's wideness and the diversity of breeding habitats.

In the Mediterranean region, turtle doves breed in a wide variety of habitats of agro-forestry landscapes such as forests (Browne & Aebischer 2005, Bakaloudis et al., 2009, Dias et al., 2013, Hanane&Yassin 2017) and scrubs (Browne et al., 2005). Besides,fruit orchards started to catch the researchers' attention recently, particularly olive and orange orchards (Boukhemza-Zemmouri et al., 2008, Hanane & Baamal 2011, Kafi et al., 2015, Hanane 2018), since they are recognizedto be more suitable for breedingcompared to other agro-systems' habitats (Thévenot et al., 2003, Pausas & Austin 2001, Hanane 2009, Absi et al., 2015, Kafi et al., 2015, Brahmia et al., 2015). Accordingly, enriching the data, leading to a better understanding of parameters influencing the occupation of habitats and breeding aspects by turtle doves is increasingly becoming a subject of interest.

In this study, we aimed to answer the following questions related to the Turtle dove's ecology and its conservation: Do Turtle doves breeding in these new orchard types have the same breeding parameters of usual habitats? Which habitat is most suitable for the breeding of Turtle dove? Is nesting success affected by orchard habitat selection? Also, to fill the knowledge gaps, particularly understanding which nest-site parameters influence the occupation of habitats and breeding aspects by turtle doves.

MATERIAL AND METHOD

Study Area

The present study has been carried out in Hamma Bouziane plain (constantinoise high plains of Algeria) near to Constantine metropolitan province. This plain is located between 36°22′41″N - 36°28′10″N latitudes and 06°28′34″E - 06°37′45″E longitudes (Fig.1), at an altitude ranging from 280 to 784 m above sea level, extended over 7335 hectares, The agricultural landscape consists mainly of small-scale agricultural systems dominated by Cereal crops, market gardens, and orchards

Hamma Bouziane has a sub-humid climate with hot and drysummers and moist and mild winters. The highest temperatures recorded in the period from June to August range from 27 to 33 °C. The period from December to February is considered a cool season, with an average temperature between 6 and 8°C. The area receives a mean annual rainfall ranging from 500 mm to 700 mm distributed from November to April. The study area is characterized by large surfaces of orchards. The most extensive orchards in the study area are Apple, Olive, Cherry and Nectarine orchards. The species breeding took place in three orchard habitatsspread over 13.37 ha and covered with Apple (5.45 ha), Cherry (6.34 ha), and Nectarine (1.58 ha) trees which represent 27.37 %, 31.84%, and 7.94 % respectively.

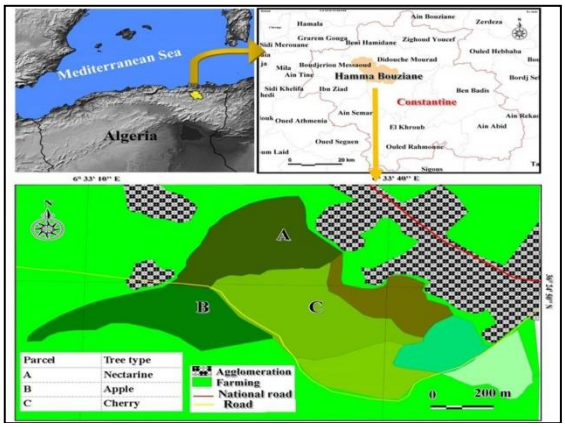

Figure1: Location of the study area (North-East Algeria).

Data Collection

The Fieldwork was carried out in the three orchard habitats: Apple, cherry, and nectarine for two consecutive breeding seasons (2017 and 2018). Nests location in allorchard trees was systematically determined with(5-6) days visits,

according to(Martin & Geupel 1993) protocol during the breeding seasons period from early March to mid-October each year to determine the first egg laying date. Most nests were found during nest building or egg laying periods. Each nest was marked using a number noted on the lower part of the tree accompanied by reported GPS coordinates to relocate and monitor the nests later.

A nest was considered as active when eggs, nestlings, or incubating adults were present (Hanane & Baamal 2011)**.** For each nest monitored, we noted clutch-size and determined laying-date. Clutch-size was determined for complete clutches only. Laying date was determined either by knowing the date when the first egg was laid or by backdating from the known hatching date, by assuming that the incubation period is 14 days (Browne et al., 2005), with a laying interval of one day between consecutive eggs in a clutch (Colwell 2006). A nest was considered successful if at least one hatched egg, otherwise it was considered as failed. When the same number of eggs remained in a nest after the expected date of hatching it was considered deserted. They were considered depredated, when eggs disappeared before the expected hatching date, they were considered as failed because of predation by observation of: (1) eggshell fragments or perforated eggs; (2) dead nestlings with damaged bodies; (3) lack of eggs or nestlings in the period during which they should have remained in the nests et al., 2015).

When nests were found, three position variables were measured: nest tree height (NTH) and nest height above ground (NHG) (Mezquida 2004), in addition to nest orientation, was determined using GPS direction tool.

Statistical Analysis

Statistical analysis was performed using SPSS 17.0 with a significance level of $P \leq 0.05$. All means are shown as ± standard error unless stated otherwise.

Firstly, the normality (Kolmogorov–Smirnov test) and homoscedasticity (Levene test) tests were tested for all variables. Variables that did not conform to the requirements for parametric tests were transformed by logarithm or a square-root transformation before to all analyses (Underwood 1996).

One way ANOVA test was used to assess, the possible effects of orchard type on nest placement parameters, nest characteristics, nest orientation, clutch size and egg-laying. Moreover, a two way multivariate analysis of variance (MANOVA) was performed to analyze the effect of habitat type and between years on breeding parameters.

The correlation among nest placement variables was tested by using Pearson's rank correlation (*r*).

Chi-squared test ($\chi 2$) was computed to determine the association between the proportion of successful and unsuccessful nests and orchard habitats

RESULTS

Breeding Season and Laying Period

In the entire study area, egg-laying was recorded between early May and mid-August. The difference in the first egg-laying between the three orchards was significant (ANOVA: $F_{2, 145} = 25.25$, $P < 0.001$). Moreover, breeding in nectarine habitat started from the first decade of May till the first decade of July, while breeding in apple trees started from the second decade of May till the second decade of August, followed by the cherry trees which was registered between the last decade of May and the first decade of August (Fig.6).

The laying period varied between different orchard habitats, where the longest turtle dove laying period was observed in apple (98 days), followed by cherry (78 days) and nectarine (69 days).

Habitat use and Nest Density

A total of 149 nests (93 in apple, 30 in cherry, and 26 in nectarine orchards) were located during our two consecutive study years, knowing that apple, cherry, and nectarine orchards are representing 27.37 %, 31.84%, and 7.94 % respectively, of the total surface of the study region.

The nest densities varied between the three orchard habitats, where the highest values were recorded in apple (17.06 nests/ ha) and in nectarine orchards (16.46 nests/ ha), and the lowest density was observed in cherry orchards (4.73 nests/ ha) (Fig.2).

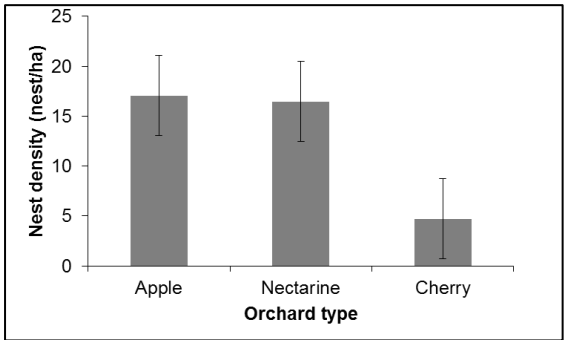

Figure 2: Turtle dove's densities in different orchard habitats.

Nest Placement

The Turtle Dove's nest placement differs significantly between orchard types (MANOVA: *Wilks'k= 0.983,* $F_{4, 288}$*= 1.27, P <0.001),* while no significance was observed between the first and second year (MANOVA: *Wilks'k= 0.828,* $F_{2, 144}$*= 3.14, P <0.001*).The nest height ranges were: (0.8 -4.1m) in apple, (1.2-2.77 m) in cherry and (1.26- 2.96m) in nectarine trees.

In term of the relative vertical position of nests, both nest height above ground (NHG) and nest tree height (NTH) were higher in nectarine trees than in apple and cherry trees (ANOVA : $F_{2,145}$*= 7.11, P = 0.01*) respectively (Table1).A significant positive correlation was also found between nest height above ground and nest tree height (*r = 0.852, p <0.001*) (*r = 0.99, p <0.001*) (*r =0.80, p <0.001*) in apple, cherry and nectarine trees respectively. Through our study, the canopy nest placement varied between the different types of trees. In nectarine plantations nests tended to be located in the highest part comparing to apple and cherry.

Nest Characteristics

A significant difference was found between the internal nests' diameter between orchards (ANOVA: $F_{2, 146}$= 16.95, *P <0.001*), where the mean internal diameter was the highest (13.79± 1.46cm) in cherry habitat. However, no difference was noted in the external diameter between the orchards (ANOVA: $F_{2, 146}$*= 2.54, P = 0.082*).

Nests Orientation

The results showed that the nest orientation was not uniformly distributed in general. It varied significantly between the three orchards (ANOVA: $F_{7, 16}$*= 2.97, P < 0.05*). The majority of nests in apple and Cherry trees were placed in the NE orientation with 24.7% and 33.3 % respectively, while most of the nests (34, 6%) in nectarine trees were located in the N orientation (Fig.3).

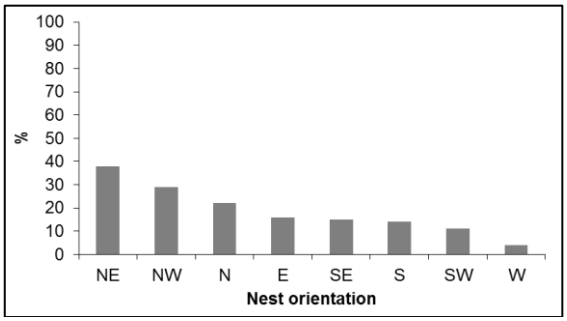

Figure 3: Distribution of nests orientation of breeding turtle dove in all orchards habitats.

There is no significant difference between clutch size of different nest orientation (ANOVA: $F_{8, 139}$*= 0. 928, P = 0. 495*).

Table 1: Nest placement variables of Turtle Dove in three breeding orchards.

	Habitat	Mean ± SD	Max	Min	N
Nest Height above Ground (NHG)(m)	Apple	1.89 ± 0.47	4.1	0.8	93.00
	Cherry	1.99 ± 0.46	2.77	1.2	30.00
	Nectarine	2.26 ± 0.30	2.96	1.26	26.00
Nest Tree Height (NTH)(m)	Apple	3.53 ± 0.58	7	1.9	93.00
	Cherry	3.60 ± 0.67	4.7	2.28	30.00
	Nectarine	3.92 ± 0.24	4.4	3,4	26.00

Table 2: Nest measurements of Turtle Dove in three breeding orchards.

	Habitat	Mean ± SD	Max	Min	N
Internal Nest Diameter (cm)	Apple	4.52 ± 1.45	9.1	2.00	93
	Cherry	6.47 ± 2.31	14.70	2.10	30
	Nectarine	5.25 ± 1.17	6.80	4.20	26
External Nest Diameter (cm)	Apple	13.05 ± 1.82	18.00	9.00	93
	Cherry	13.79 ± 1.46	10.90	17.00	30
	Nectarine	12.88 ± 1.64	15.00	10,00	26

Table 3: Nest placement variables of successful and unsuccessful nests of Turtle Dove in three orchard types.

Habitat	Variables	Mean ± se	N	Range	Successful	Un-Successful	P -values (ANOVA)
Apple	NHG	1.42 ± 0.08	93	1.26 -1.57	1.42 ± 0.59	1.08± 0.51	0.557
	NTH	3.14 ± 0.09	93	2.96 - 3.31	3.05 ± 0.69	3.25± 0.45	0.171
Cherry	NHG	1.32 ± 0.09	30	1.13 - 1.50	1.39 ± 0.50	1.25± 0.45	0.447
	NTH	3.21 ± 0.16	30	2.88 -3.53	3.17 ± 0.92	3.25± 0.75	0.797
Nectarine	NHG	1.89 ± 0.06	26	1.76 - 2.02	1.95 ± 0.22	1.83± 0.41	0.367
	NTH	3.43 ± 0.11	26	3.21 - 3.65	3.70 ± 0.47	3.17± 0.41	0.020

NTH: nest tree height; NHG: nest height above ground. a values are based on non-parametric Mann–Whitney U -test.

Table 4: Causes of failed nests of Turtle dove in different breeding habitats.

Failure cause	Egg desertion		Harvest		Predation		Natural factors	
Orchard type	N%		N%		N%		N%	
Apple	4	33.33	2	17.00	3	25.00	3	25.00
Cherry	7	63.64	2	18.18	2	18.18	0	0.00
Nectarine	6	75.00	2	25.00	0	0.00	0	0.00

In contrast, nest orientation varied significantly regarding nest tree height (NTH) (ANOVA*: $F_{8, 140}$= 2. 104, P = 0. 039*). There is no statistical significant association between breeding success and nest orientation of all orchard habitats ($\chi(7) = 4{,}402$, p = 0.733).

Clutch Size

The number of eggs varied from one to two in all orchards' trees. In the apple orchards, the frequencies of clutch sizes of one and two eggs were 48.65% and 51.35% (Fig.4), respectively. While in nectarine orchards they were 30.00% and 70.00% respectively.

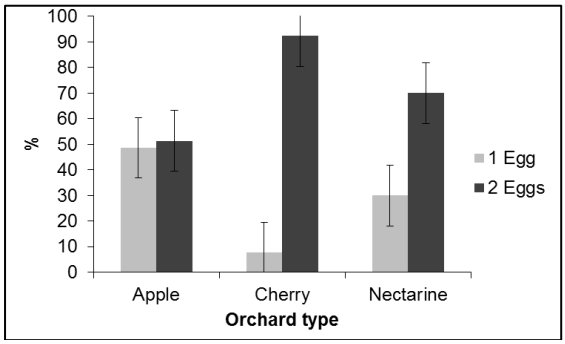

Figure 4: Frequencies of clutch sizes of breeding turtle dove in different orchards habitats.

Contrary to cherry trees, clutch sizes of two eggs were dominated (92.31%) one egg (7.69%). Besides this, the mean clutch size was not significantly different between the three orchards (*ANOVA: $F_{2,61}$= 1.158, P = 0.321*) (Fig.5).

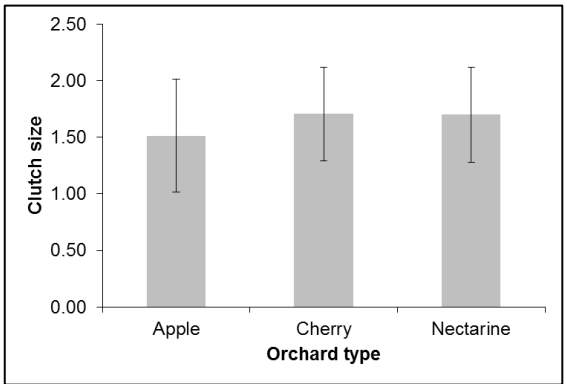

Figure 5: Mean clutch sizes of breeding Turtle dove in different orchards.

Nest-Site Selection and Breeding Success

The mean proportion of successful nests was 61.28 ± 6.3 % in all orchards breeding success in apple orchard nests was highest (70.73%) followed by Cherry (59.26%) and Nectarine (53.85%).There is no significant statistical association between nest success and orchard type (*$\chi(2) = 0.107$*, p = *0.692*).

Furthermore, theresults showed no effects of nest placement on breeding success in apple and cherry, however,a significant difference betweensuccessful and unsuccessful nests in nectarine was observed. Interestingly, a significant effect of internal nest diameter on breeding success in the whole orchards habitats was also observed (ANOVA: *$F_{1,147}$= 5.16, P = 0.024).*

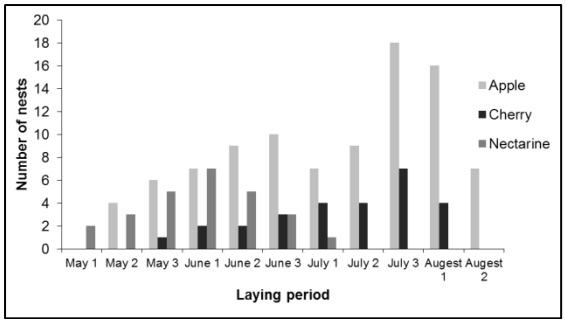

Figure 6: Nesting phenology of Turtle dove in different breeding habitats.

Failure Causes

No significant variation of failure rate was recorded between orchard types (*Wald* χ^3_4*= 6.59, P = 0. 159)*, despite the high failure percentage in Nectarine (46,15%). Egg desertion was the main factor mainly affected nest success during the incubation period in the nectarine (75.00%), cherry (63.64%), and apple (33.33%) ((Fig.7; Table 4).However, the harvest, predation and natural factors (hail, thunderstorm, and winds), have slightly contributed to nest failure in all orchard types.

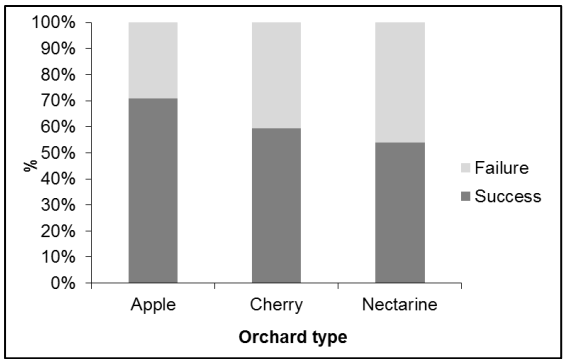

Figure 7: Percent of success and failure nests of Turtle dove in different breeding habitats.

DISCUSSION

Our results showed for the first time the breeding preferences of Turtle Dove in three new breeding habitats in Algeria and North Africa: apple, cherry, and nectarine orchards.

We reported nest densities of (17.06 nests/ ha) in apple, (16.46 nests/ ha) in nectarine and (4.73 nests/ ha) in cherry trees. The two former values were higher than the orange and olive orchard (6.56 nests/ha) values demonstrated by (Boukhemza-Zemmouri et al., 2008) works in Algeria. In contrast, our values were lower than those reported in olive and orange orchards (28.2 nests/ha), (45 nests/ha) respectively in (Hanane & Maghnouj 2005) studies in Morocco. Accordingly, (Browne et al., 2004) found that nest densities recorded in North Africa seem to be higher than those recorded in the European breeding areas. On the other hand, (Hanane & Baamal 2011) research suggest that the high values of nest density recorded could be justified by the specific attention received by man-made fruit orchards in this period (more protected) compared to olive orchards, woodlands and shrub habitats which may not be always controlled. This finding was confirmed by the studies of (Yahiaoui et al., 2014) in North Africa. The same author reported that the distribution of this species is directly related to the type of habitat, and habitat quality and not with the habitat size.

In North Africa, man-made plantations are among the most frequented nesting habitats for this species (Hanane 2009,Yahiaoui et al., 2014, Boukhriss & Selmi 2019). We suggest that the preference of apple and nectarine orchard by Turtle doves was related directly to the late harvesting period since it was delayed from last august to last October in apple and from early July to mid-September in nectarine. In contrast, the low nest density in cherry trees was due probably to the early harvesting period that started last May till last June. Similar to reported observations in the orange orchard, the harvesting period is characterized by the continuous presence of human disturbance which could directly affect the breeding parameters (Mitchell et al., 1996,Hanane & Baamal 2011).

Moreover, the nest height varies according to habitat (Fisher et al., 2018).

Our results showed that Turtle Doves breeding in nectarine orchards prefers vertical parts of the trees than in apple and cherry, despite any significant effect of nest placement on breeding success.

The NHG value was higher in nectarine trees (2.26±0.30m) which is similar to (Hanane & Maghnouj 2005, Boukhemza-Zemmouri et al., 2008, Sadoti 2008) results in orange and olive trees to provide protection from predation and to avoid inclement weather. Comparatively toother types of orchards, former studies reported in North Africa, showed higher values than ours(5.28± 1.15m) in palm date trees in Biskra (Algeria) (Absi et al., 2015), (2.61 ± 0.08m)in the orange orchard at Tadla region (Morocco) and (3.44 ± 0.11m) in the olive orchard (Hanane & Baamal 2011). Moreover, it is well-known that the habitat type is a key determining factor in nesting placement in several passerine species (Lomáscolo et al., 2010, Horie & Takagi 2012).The positive correlation between (NHG) and (NHT) in nectarine, apple, and cherry trees in our study confirmed the previous founding in olive and orange trees in Hanane (2016). However, the significant difference in NTH (Table 1) between successful and unsuccessful nests in nectarine orchards, revealed the importance of this microhabitat variable for failure or success. Accordingly, building a high nest placement is considered as a strategy to avoid man threat and climbing predators. Conversely in this study, the lowest nest heights in the orchards mentioned previously might be justified by the limited access of external people and predators in the agricultural plot (Barea 2008, Hanane 2009). Accordingly, our results showed no influence in nest placement between successful and unsuccessful breeding in apple and cherry orchards suggesting that other factors may interfere (Mezquida & Marone 2002, Rodríguez & Moreno 2008).

However, though nest orientation preferences have been demonstrated in many studies (Rauter et al., 2002, Norment & Green 2004). Most of the studied nests were found to have (NE) dominant orientation. Indeed, the east preferences of Doves may be explained obviously seeking out the rising rays of the sun, while trying to protect themselves from the hottest ones of the day. Also, they also seem to seek to protect themselves from the prevailing winds and the rain, which are west wind at this season. An east and south-east orientations of the nests have been observed in Spain (south-west of Madrid) by Peiro (2001), who considered that, among the factors that condition nest microhabitat which is in concordance with our findings.

This finding was also demonstrated by Boumekhmza-Zemmouri et al., (2008). Our results also reported that no association between nest orientation and clutch size of all orchard habitats was shown which is in an accordance with the reported pattern of Turtle Doves both in Europe (Peiro 1990, Browne et al., 2005) and North Africa (Hanane & Maghnouj 2005, Kafi et al., 2015).

Clutch size ranged between one to two eggs with means of (1.51±0.50), (1.71±0.47) and (1.70±0.48) for apple, cherry and nectarine respectively. However, our values for clutch size in different orchard types are lower than those reported in olive trees (2.96 ± 0.05) in Algeria and Morocco for orange orchards (1,91 ± 0,02) and olive orchards (Hanane& Baamal 2011). Plus, no effect of orchard habitat and different nest orientations on the clutch size of the Turtle Dove was proven. However, habitat quality and food availability shown to be critical factors affecting the population clutch size (von Haartman 1971, Bensouilah 2015).

The mean breeding success for all studied habitats(74.68 %) is higher than that found in natural habitat in Algeria (24.71 %) by (Yahiaoui et al., 2014), in fruit orchards in Morocco (48.8 %) (Hanane & Maghnouj 2005) and in Spain

(53 %) in Extremadura and (36-58 %) in Madrid (Rocha & Hidalgo, 20002). These differences due probably to their microhabitats factors that may affect nesting success (Wilson & Cooper 1998,Schmidt & Ostfeld 2003, et al., 2013). The highest value for breeding success was recorded in apple trees (86, 96%) for all the surveyed nests. Besides, we showed that the high breeding success in apple orchards is relatively linked to the high tree density in this plantation compared to other orchards. It has been demonstrated that the hatching success of some bird species is directly related to nests preferences (Vinuela & Sunyer 1992, Amar et al., 2006).In fact, in the Mediterranean region, many previous studies reported the breeding characteristics and nest-site selection of this species mainly in palm trees, orange and olive orchards (Boutin 2001**,**Thévenot et al., 2003, Munoz-Cobo & Montesino 2004, Boukhemza-Zemmouri et al., 2008**,** Hanane & Baamal 2011).As reported by (Hinsley et al., 1995) the turtle dove tends to be associated with woodland because they ensure a favorable microclimate protecting nest contents from adverse weather conditions and predators. From another part, the highest successful nesting in apple is due probably to the age of trees and reduced human disturbance by limited access to this plantation.

The nest failure percentage was higher in Nectarine (46, 15%).Egg desertion factor mainly affected nest success during the incubation period in the nectarine (75.00%), cherry (63.64%) and apple (33.33%) (Fig.7; Table 4).Similarly to previous breeding Turtle Doves studies in North Africa, the main nest failures causes were attributed to nest desertion (Hanane & Maghnouj 2005, Boukhemza-Zemmouri et al., 2008). On the contrary to Turtle Doves breeding in Europe, where predation was the main cause of nest failure (Murton 1968,Peiro 2001, Browne et al., 2004).However, in this habitat type, agricultural practices are related to the maintenance of trees (fruit harvest and herbicide applicators) were considered as the main factors that disturb Turtle Doves, as well as the natural factors (hail, thunderstorm and winds)

CONCLUSION

The results of this study show that, breeding success of studied habitats is higher than that found in natural and man-made habitat in North Africa. Indeed, according to (Hanane & Baamal 2011) it is currently accepted that the species is well adapted to the conditions of orchards and cereal crops as well as to the constraints due to the anthropogenic activities.

Interestingly, its essential to raise awareness among farmers to reduce disturbance to nesting Turtle Doves particularly during treatment and harvest periods. Additional studies are needed to improve our understanding of the effects of agro-system patterns, anthropogenic disturbances, agricultural periodic activities, on nest site selection and breeding success of Turtle Dove. Bird banding is an important approach to study the population size and habitat use of Turtle Dove in these environments.

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