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ORIGINAL ARTICLE

The turtle dove (*Streptopelia turtur*) in Midelt plain, Morocco: nesting preferences and breeding success *versus* the impact of predation and agricultural practices

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Abstract Breeding success plays a crucial role in the dynamics of bird populations and yet is the least-studied avian life-stage. Habitat quality during breeding phase may have important implications for survival and conservation, particularly for declining populations in landscapes that have undergone wide-scale human modification. The European Turtle dove is a widespread but fast declining species both in breeding and wintering zones. Reduced food availability is thought to influence breeding success of this game species, but it is not known how agriculture practices could influence breeding Doves, in its high altitude breeding zones. Here, we monitored Turtle dove nests in apple orchards from early Marsh to the end of October 2015. Nest-tree support, breeding success, and predation were determined and analysed depending on agricultural practices. Compared to prune, cherry and other plantation, apple orchards had the highest overall Turtle doves' nests (85%). However, 60% of recorded nests were located on *Golden delicious*, where are noted the highest nesting success rates (respectively 77.6% and 57.9% for eggs and chicks). However, Turtle dove showed high rate of nesting failure in the Midelt region, more especially in apple orchards, and this is mainly due to predation attacks, which caused a loss of 77.8% of broods, both among eggs and chicks. In addition, several farming practices in apple orchards influenced significantly nesting success of this species. In fact, this game bird does not breed in the orchards covered by hail-nets. Similarly, tree pruning disturb doves nesting on apples.

Keywords: apple orchards, breeding success, farming activities, European turtle doves

Introduction

Numbers of both farmland and migratory birds have been decreasing since the 1970s (Heath et al 2000; Burfield and Van Bommel 2004; Eaton et al 2011), and knowing the cause of these regressions is essential in determining approaches to aid population recovery. This is the case of European Turtle dove (*Streptopelia turtur*), which is a migratory and breeding species in North Africa (Thévenot et al 2000; Dakki and Sehhar 2004), Europe and Russia (Browne and Aebischer 2004; Lormee et al 2016). North African and Western European populations this threatened species overwintering in sub-Saharan Africa and Sahelian savannah (Eraud et al 2009; Lormee et al 2016), and migratory flyways include southern France, Spain and Morocco (Browne and Aebischer 2004; Eraud et al 2009). Conservation of this species is therefore of international concern.

In bird species, population declines can typically be attributed to a combination of reductions in breeding habitat and food availability (Wiehn and Korpimäki 1997; Dombrowski and Golawski 2002; Gutiérrez-Galán and Alonso 2016), which have effects on survival and breeding productivity. In the case of the Turtle doves, an analysis of CBC data between 1965 and 1995 concluded that breeding site availability on farmland was controlling Doves distribution (Browne et al 2004; Dunn and Morris 2012; Hanane 2016). Cereal production in Africa, strongly influences overwinter survival of Turtle doves, suggesting that conditions on wintering lands are also vital for this species (Eraud et al 2009; Mansouri et al 2019). Although, the effects of climate change, droughts and food supply in both breeding and wintering zones (Browne and Aebischer 2001), hunting (Jarry 1999;

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Rocha and Hidalgo 2002; Boutin and Lutz 2007) and competition with the collared dove (*Streptopelia decaocto*) remain poorly acknowledged or require advance evaluations (Rocha and Hidalgo 2002; Browne and Aebischer 2003; Hanane 2017). Farmland diversity has decreased around world (Pain and Pienkowski 1997; Dombrowski and Golawski 2002; Zwarts et al 2009), leading to hedgerow and woodland removal and total loss of nesting sites (Pain and Pienkowski 1997; Jarry 1999). The overuse of pesticides, suppression of woodland within farmland and the reduced range of cereal cultivation have been suggested as human-related factors putting pressure on bird populations (Best and Stauffer 1980). Habitat degradation may have also taken place, with a reduction in breeding sites quality, such as tall, suppression of wild plants for nesting or farmlands with mono-culture (Best and Stauffer 1980; Hanane and Baâmal 2011; Gutiérrez-Galán and Alonso 2016), resulting in longer distances travelled between nesting and feeding sites (Dunn and Morris 2012).

In such context, detailed knowledge of the species' habitat requirements across its home ranges is directly necessary to comprehend the role of certain habitat features in favouring higher Turtle dove breeding rate, and to develop targeted and effective management measures (Pain and Pienkowski 1997; Hanane 2017). However, few studies have addressed these questions in North Africa (Hanane et al 2011; Hanane 2014), and these works were mainly focused on the breeding aspects at low altitude habitats (300-700 m). This study aimed to investigate the breeding ecology of Turtle doves in its high altitude farmlands. In addition, this paper is particularly focused on the impact of particular agricultural practices on the Turtle dove nesting preferences and the predation rate in high altitude habitats.

Materials and Methods

Study area and sites

The present study was carried out in Ait Ayach valley (32°41'N, 4°44'W), Midelt province (Morocco), which located at the Northern foot of Jbel Ayyachi, in the Central High Atlas chain. The prospected habitats (orchards) were at altitudes of 1450-1650 m, belonged to the upper Moulouya plain. This plain was dominated by farmlands, including apple plantations, and a semi-arid climate, with dry and relatively cold winter. The annual average temperature being about 29 °C. Precipitations were low (annual average of 89 mm), with about 21 cm of snow (2015-2017). The Ansgmir River and Hassan II reservoir constitute the major sources of water in this semi-arid area. They permitted to create an irrigated perimeter of 4.200 ha, occupied by both cereals and fruit trees, which would play a major role in the bio-ecology of the Turtle dove (Table 1). These agro-ecosystems were characterized by agricultural activities relatively diversified (pruning, irrigation, grass mowing, installation of protection nets, use of chemical pesticides, etc.), and with high potential impact on nesting strategy and behaviour of the Turtle dove (Table 2).

Methods

The study was conducted between early April and the end of October 2015, taking into account the breeding season of turtle dove in North African zones (Hanane 2014). Data was collected in three distinct apple orchards: representing differences in farming activities: (i) hail-net-covered orchards, (ii) Tree-pruned orchards, (iii) non-covered and non-pruned apple orchards. Censuses were performed from the early mornings to the end of the day, including days of unsuitable weather conditions (wind, rain).

Preferences toward nesting support was studied in nine non-covered and non-pruned apple orchards, and their surrounding hedges, formed by poplar and wild rose trees (Figure 1). In addition, other farmlands were prospected (Table 3), including two plum orchards (240 trees), two cherry orchards (218 trees), two islets of tamaris (800 trees), two islets of cypress (140 trees) and one patch of walnut (50 trees).

To investigate the effect of hail-nets on breeding preferences of Turtle doves, ten unpruned apple orchards (five covered with hail-net (1200 trees) and five uncovered (1200 trees)) were monitored. In parallel, the pruning impact on nesting was studied in nine additional non-covered apple orchards (3300 trees), where nests were recorded on cut and uncut trees of the two apple varieties, cultivated in the study site. Nests were investigated by a qualified observers with line prospection (the observer search nests line by line in apple orchards). The location of each nest tree was marked on a map of the study plot, and monitored (visited once per day). Moreover, other nesting parameters (Figure 2), including nest dimensions, incubated eggs and chicks, predation rate, agricultural practices and their interaction with nesting parameters, were monitored and measured.

Statistical analysis

Descriptive statistics were used to analyse data. Statistical tests were done in R software, version R2.12.2 (R Core Development Team, 2009) and graphs were created by GraphPad Prism 6.01. After assessing normality of variances, all data were non-parametric. Therefore, comparison of breeding success, including eggs hatching and chick fledging rates, between two apple varieties in all orchards, was tested with chi-square test. Additionally, the correlations between egg's abundance, chick's hatching and predation rates were analysed with Spearman's Correlation. On the other hand, the density of nests (number of nests per 100 trees) was calculated in each nesting support to precise Dove preferences toward tree-support for breeding.

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Table 1 Principal agricultural plantations in Midelt Province.

Plantation	Species	Surfaces (Ha)
Cereals	Durum wheat	2330
	Soft wheat	217
	Barley	172
	Maize	200
Farming	Alfalfa	548
	Bean	10
Fruit Trees	Apple tree	1 503
	Peach tree	13
	Pear tree	54

Table 2 Major agricultural practices in apple orchards in Midelt region.

Practices	Period	Frequency	Methods
Tree trimming	Dec.-Feb.	Once a year	Use of secateurs and saws
Irrigation	Whole year	1-2 times/month (depending on whether)	Traditional systems
Treatments	Mar.-Sept.	1-3 times/month (depending on the degree of infestation)	70% with tractor and boom sprayer 30% with mobile trolley sprayers
Mowing grass	Mar.-Oct.	3-4 times/year	6% traditional (sickles) and 94% with back engines (brush cutters)
Netting	Apr.-Sept.	Permanent	Covering of some orchards with hail nets, that are installed for long periods

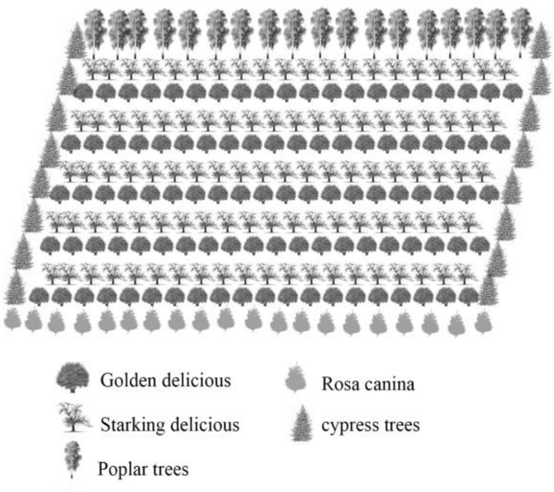

Figure 1 Distribution model of trees in the prospected apple orchard (10 rows x 20 lines).

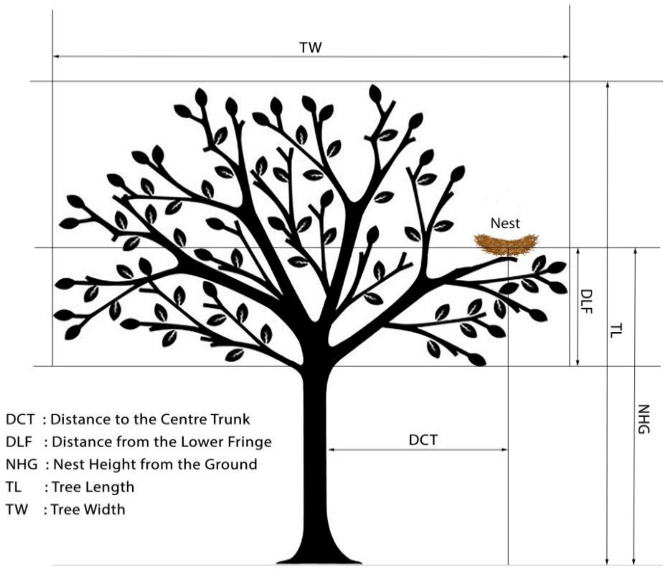

Figure 2 Parameters of nest location on the apple trees.

Results

Impact of agricultural activities on nesting activities

Nest-support utilization

Turtle doves started singing and flight displays (courtship) almost as soon as they arrived on the monitored sites in mid-April and birds were observed in all studied orchards. Nest construction began few weekends after their installation in breeding orchards. At the end of breeding season, 84.69% of nests were recorded on apples, 9.18% on wild rose, 5.10% on Tamaris, and 1.02% on poplar. Plum, cherry, cypress and walnut trees, remain inhabited by turtle doves. This confirms firstly that the Turtle dove do not use some trees as a nesting supports. To precise Doves preferences toward support trees, the density of nests in each orchards (number of nests per 100 trees) was calculated (Table 3). The highest values were recorded in wild rose (15.3) and apple trees (4.6), while lowest values were recorded in the Tamaris (0.6) and poplars (0.5). Despite wild rose supporting a high density nests, apple trees play a major role as nesting supports for the species due to their abundance in the study area.

Effect of hail nets

In ten monitored apple orchards, nesting activities were limited to uncovered trees. Thirty nests were recorded in uncovered 1200 apple trees. Hail-nets covered-apples were inhabited by Turtle doves (Figure 3). Hail-nets might formed a physical obstacle to Dove's nesting activity. Therefore, the overuse of hail-net could threat nesting and breeding success of Doves and other bird populations.

Effect of tree pruning

A total of 83 nests were recorded throughout the study habitats (nine non-covered apple orchards). However, the majority of nests (97.6%) were noted in unpruned apple trees. Only 2.4% of nest were located on pruned trees (Figure 4). Despite the similarity in number of pruned and unpruned apples, nesting activity of the turtle dove were favourable in pruned trees. Concerning the breeding success (Table 4), pruned trees appeared to be favourable for the turtle doves, with a success of 77.6% for eggs and 57.9% for chicks in golden variety. Pruning trees may reduce nesting quality of trimmed trees. In addition, pruning activity might provide small twigs locally used for nest construction.

Table 3 Size of study samples and nest densities in four different nesting trees used by Turtle doves.

Shaft Type	Apple tree	Tamaris	Wild rose tree	Poplar tree	Total
Number of trees	1800	800	60	200	3260
Number of nests (%)	84.69	5.10	9.18	1.02	100
Density (nests/tree)	0.046	0.006	0.150	0.005	0,207

Figure 3 Hail Nets installed on apples (Midelt orchards).

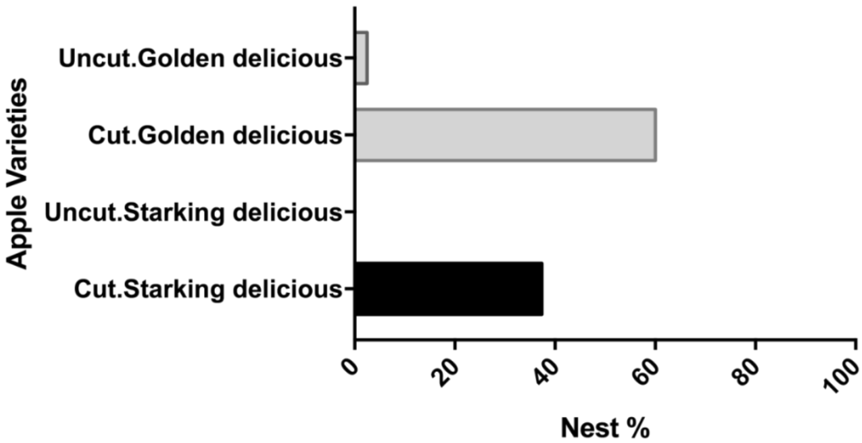

Figure 4 Effect of turtle doves cutting trees on the nesting at the apple.

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Table 4 Success of nests on two varieties of apple trees.

Tree variety*	C. SD		C. GD		UC. SD		UC. GD	
	Number	%	Number	%	Number	%	Number	%
Number of eggs	61		98		0		4	
Successful eggs	20	32.78	76	77.55	0	0	4	100
Chicks hatched	20		76		0		4	
Successful chicks	8	40	44	57.89	0	0	0	0

*SD: starking delicious, GD: golden delicious, C: cutted, UC: uncutted.

Impact of agricultural activities on the breeding success

Influence of nesting supports on egg hatching

Breeding success was monitored in different nesting trees throughout nine non-covered and non-pruned apple orchards and their surrounding hedges (Table 5), and revealed high variation of hatching rates depending on tree species. Hatching rate was 100% on both wild roses and poplar trees, followed by 80% on tamaris trees. Trees of these three species ensure better egg's protection from predators, due to significant height of poplar trees, thorny structure of wild rose, beside bushy branches and foliage of tamaris. On the other hand, hatching rate in apples was medium (about 58%), eggs were predated in their nests.

Effect of apple's variety on breeding success

Turtle doves breeding success on two varieties of apples (*Golden* and *Starking delicious*) was studied in nine uncovered apple orchards. As result, 60.2% of nests were built on the golden variety (Figure 4), against 39.8% on the *Starking delicious*. Similarly, breeding success reached 77.6% for eggs and 57.9% for chicks on golden variety, counter 22.4% for eggs and 42.1% for chicks on *Starking delicious* (Test for eggs success: $Chi^2 = 7.93$, df = 2, $P = 0.019$; and for Chicks: $Chi^2 = 9.946$, df = 2, $P = 0.0069$). *Golden delicious* seemed to provide better protection to spawning birds.

Effect of Predation

Predation of eggs was observed throughout study orchards. Almost, during all the laying period, with highest attacks during July (Figure 5). First eggs were attacked during the second week-end of May. Moreover, the highest predation rates were observed during June and July. In parallel, first attacks on chicks were recorded in the primer decade of June (3^{th} June) and continued until early September, with two picks, respectively during the second decade of June and the second decade of August. The frequency of egg predation seems to be slightly proportional to the abundance of eggs (R = 0.635, P=0.011), while this correlation is not clear for predation of chicks (R = 0.43, $P = 0.101$).

Table 5 Hatching success in the different trees.

Nesting parameters\Trees =>	Apple		Tamaris		Wild rose		Poplar	
	Number	%	Number	%	Number	%	Number	%
Number of eggs	166		10		18		2	
Number of predated eggs	54	32.53	2	20	0	0	0	0
Number of eggs lost by fallen fruit	6	3.61	0	0	0	0	0	0
Number of abandoned eggs	2	1.20	0	0	0	0	0	0
Number of unhatched eggs	8	4.81	0	0	0	0	0	0
Number of successful eggs	96	57,83	8	80	18	100	2	100

Discussion

Despite that olive and orange trees are the most important nest-trees used for breeding by Turtle doves (Hanane 2012; Hanane and Baâmal 2012; Hanane 2014; Hanane 2017), this study provides first evidence on breeding doves inside apple orchards, and therefore these habitats might play a similar role in high altitude zones, especially, with their placement next to extent of cereals and water availability (Mansouri et al 2019). In the study site, the majority of nests (84.69%) were recorded in apple orchards compared to five other tree species. The choice of apple trees indicated a high quality of these varieties as nesting support and their availability in the study area, which is in agreement with previous study in Britain that showed this species requires a good quality habitat features with suitable nesting and feeding areas in close proximity (Browne et al 2004; Dunn and Morris 2012; Gutiérrez-Galán and Alonso 2016). Apple trees, organized in dense orchards, provide for Turtle doves both safety (relatively dense trees and foliage forming a good camouflage) and favourable nesting structures (i.e. forks made with horizontal or sub-horizontal branches) and abundant twigs to build their nests. Moreover, these orchards, as well as other fruit trees, are generally associated or close to cereal and irrigated lands, as food sources (Mansouri et al 2019).

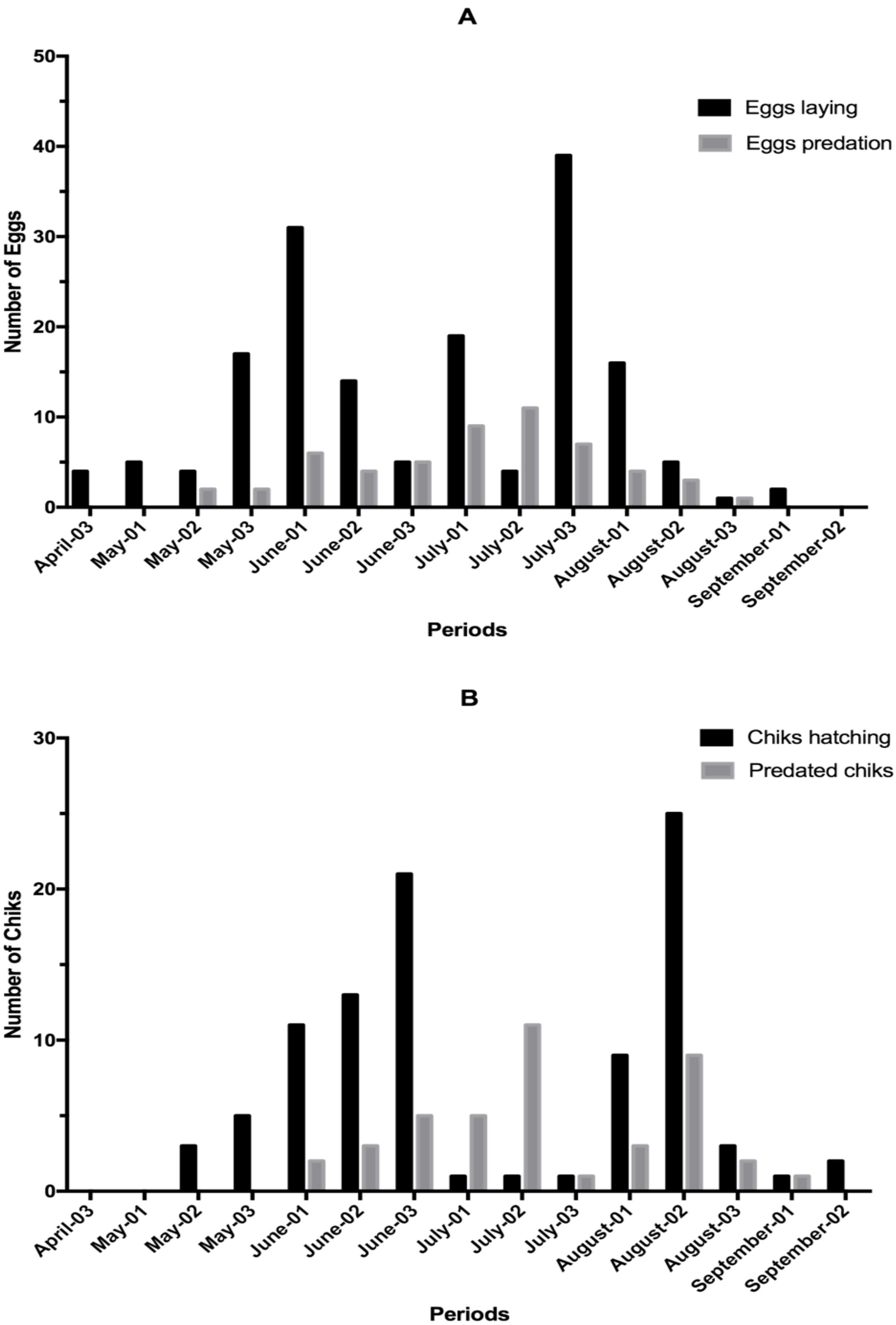

Figure 5 Phenology of turtle doves nest predation. (**A**): Predation of eggs; (**B**): Predation of chicks.

Turtle doves have placed their nests on *Golden delicious* and *Starking delicious* with a preferences toward golden delicious (60.2% of nests). Despite this supporting role played by apples, farming technics and practices cause a serious problem to this threatened species. Covered orchards (with hail nets) and pruning technics limited nesting activity, which is in agreement with results reported by (Blanke and Weidenfeld 1997; Tasin et al 2008), and support that the Turtle doves suffer from agricultural practices in Mediterranean farmlands (Rocha and Hidalgo 2002; Hanane and Baâmal 2011; Hanane 2012). In this work, hail nets form a physical obstacle against birds, and lead Doves to avoid these covered orchards (Blanke and Weidenfeld 1997; Tasin et al 2008). Similarly, the pruned apple trees were unsuitable for turtle dove's nesting. The pruned twigs lead to a destruction of suitable horizontal forks, which facilitate nesting. On the contrary trimmed twigs may serve as small twigs locally used for nest construction, as other species, like Pied Flycatchers (*Ficedula hypoleuca*) which profit from local twigs and plants to build their nest (Briggs and Deeming 2016).

The Breeding success of Turtle doves was also differed within different nest-tree supports. Wild rose and poplar were the safest support for nesting with 100% of success for eggs. Nesting success on apple trees was medium, with 58% of hatching. The protection of nests on Wild rose and poplar, is due to the significant height of poplar trees, thorny structure of wild rose and bushy branches and foliage. These elements camouflage nests from predators. On the contrary, despite the availability of apples, 42% of nest had been lost, the majority of them (77% of egg) were predated (Figure 6). However, in term of the breeding success, obtained result are similar to those cited in agro-ecosystems, such as olives, oranges (55.5%) and forests, as woodland and coniferous trees (53%) (Marraha 1992; Hanane and Baâmal 2011). But, in term of failure factors, our results indicate that the predation of eggs was the major threat to nesting success (Figure 5, 6, 7), which is differed from the reduction of nesting sites reported in Britain and Spain (Browne 2004; Rocha and Quillfeldt 2015; Gutiérrez-Galán and Alonso 2016), and nest desertion cited in olives and oranges in Morocco (Hanane and Baâmal 2011; Hanane 2016). The habitat features and characteristics could interfere in this case (Chamberlain and Fuller 2000; Baker et al 2012). The abundance of cats and reptiles, especially snakes (Figure 8), in the study sites could be the most relevant in the predation factor. In addition, predation attacks were observed almost during all the incubation and nestling periods, with highest frequencies during June, July and August.

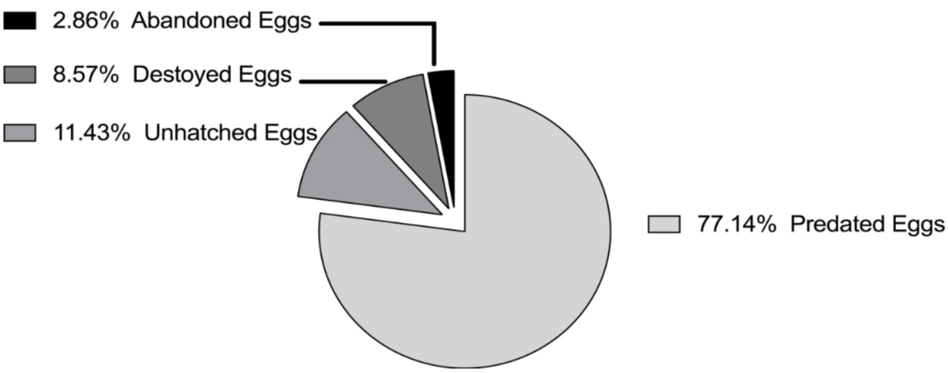

Figure 6 Hatching failure factors of turtle doves.

Figure 7 Predated nests of turtle doves in the apple trees. (**A**) Predated nests with chicks; (**B**) Predated nests with eggs.

Figure 8 Horseshoe snake on apple tree.

The results of this work show that, in the studied apple orchards, Turtle doves face different threats from those cited in other agricultural habitats in North Africa (Marraha 1992; Hanane 2017) and southern Europe (Browne et al 2004; Rocha and Quillfeldt 2015; Gutiérrez-Galán and Alonso 2016). This game species looks, however, to be well-adapted to apple orchard conditions (Mansouri et al 2020). Indeed, although they are highly frequented, the nesting success (47%) confirm the importance and the suitability of such habitats for breeding Turtle doves.

Conclusions

In conclusion, the findings obtained from this study indicate that Turtle doves breed in apple orchards located in high altitude zones and have an adequate potential to support this threatened species. However, further, more depth studies on the effects of predators on the survival of Turtle Dove nests are needed. Investigation on how this species behaves in more natural and artificial Mediterranean habitats are also required to determine whether Turtle doves change their behaviour depending on habitat type.

Conflict of Interest

The authors declare no conflict of interest.

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