



Original article

Diversity of feeding habitats and diet composition in the turtle doves *Streptopelia turtur* to buffer loss and modification of natural habitats during breeding season

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ABSTRACT

The approach of the birds to use physical and alimentary resources in degraded and modified natural habitats is an important aspect of their adaptation. This study was undertaken during 2016–2017 at forty habitats in the Moulouya plain, Morocco to examine behavioral diet, habitat use and foraging ecology of turtle dove, *Streptopelia turtur*. We monitored turtle doves in four major plots namely cereal plots, lucerne farms, apple orchards, and stations in the Ansgmir River covering 40 habitats. Digestive tract contents were also identified and evaluated for 68 Turtle Doves shot by hunters during two consecutive years. The results showed that the turtle doves use a variability of feeding habitats. The cereal cultivation seemed to be more preferable habitat for feeding especially in the month of May, the first breeding phase of the year. But, during the months of August and July, the riverbanks were the preferred habitat for turtle doves. The diet of this species is polyphagous and diverse with a granivorous tendency. Diet analysis showed that soft wheat and barley seeds constituted 44.53% and 38.74% respectively followed by barley seeds with 38.74% and sand stones (9.16%) of the seeds eaten by Turtle Doves. However, moderate proportion of elements (7.32%) remained undefined. All these aspects, including the variability of feeding habitats and the wide diet seem to be an adaptive strategy followed by turtle dove to counter the degradation and the modification of its natural feeding habitats.

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1. Introduction

Turtle dove, *Streptopelia turtur* a migratory species coming from the Western Palearctic low altitude regions (Eraud et al., 2009; Lormee et al., 2016), is one of the Europe's fastest declining breeding bird species (Hayhow et al., 2017). It breeds in the northern part, especially North Africa, Europe and Asia (Browne et al., 2005; Bakaloudis et al., 2009). This bird is highly appreciated by the hunters (Alés, 1996), in Morocco more than 150,000 individu-

als are killed each hunting season. In the Médoc region of France, thousands of these birds are hunted every year during the breeding season (Dubois, 2002; Eraud et al., 2011).

Population decline of the Turtle Dove has been directly linked to the modification and reduction of its breeding habitat over the last few decades. This columbidae chooses its habitat in different ecosystems, including orchards, cultivated lands, forest edges, coppice trees, and hedgerow sceneries, where it finds most of its food (Kleemann and Quillfeldt, 2014; Kafi et al., 2015). These habitats play a very important role in the survival of the species. In fact, crops offer an important food resources, while the landscape fixed elements, such as trees, provide a capital support for nesting (Rocha and Quillfeldt, 2015; Hanane, 2016; Roshnath and Sinu, 2017). In wintering grounds, seeds are the main nutrients for turtle doves (Guy, 1991). But, low cereal productivity, due to drought and reduced cereal-growing surfaces, is one of the elements threatening the survival of this migratory specie, as well as its ability to

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adapt with difficult migratory trajectories (Eraud et al., 2013; Lormée et al., 2016). In particular, this species has a strictly granivorous diet and is mainly based on cultivated crops and their seeds (Guy, 1991; Roux et al., 2006). In addition to the hunting and predation, recent studies show that reduced food availability, destruction and modification of feeding habitats (Browne and Aebischer, 2003; Rocha and Quillfeldt, 2015), are among the main factors threatening the turtle dove population (Alés, 1996; Browne et al., 2005; Bakaloudis et al., 2009). This reveals how important is to study the trophic diet of the turtle dove (Lormée, 2001; Wells-Berlin et al., 2015).

In breeding zones, data on the turtle dove's diet is fragmentary and limited. Knowledge of the seeds that are ingested by Turtle Doves during the breeding period is necessary in order to carry out specific management actions which can increase the abundance of important dietary components (Boutin et al., 2007). Most of the investigations are focused mainly on breeding habitats, population size, and agricultural activity's effects on breeding (Eraud et al., 2009, 2011; Lormée et al., 2016). This work aimed to understand the Turtle dove's nutritive behavior and to identify the main seeds consumed by Turtle Doves in different habitats of the Middle Atlas region (Morocco). Knowledge of the main seeds included in the diet will help managers in planning grazing schemes that might increase the abundance of important seeding species in the breeding habitats. We are looking into how this game uses different cultivated fields and natural habitats to deal with degradation and loss of its original feeding habitats, during breeding season.

2. Material and methods

2.1. Study sites

The present study was carried out in the Ait Ayach valley, in the province of Midelt (32°41' North and 4°44' West), at the junction of

the Middle Atlas and the High Atlas, Morocco (Fig. 1). This mountainous region is dominated by agricultural activities including apple plantations. Also, these agro-ecosystems are characterized by a variety of agricultural practices that likely influence the turtle dove's nesting strategy and feeding behavior (Ousaaid et al., 2017). In the study zone, four habitats are distinguished, counting apple orchards, cereals (common wheat and barley), riverbanks, and lucerne cultivation.

2.2. Ethical note

This study was performed under the proper legislation of the Moroccan law and was approved by the Ethical Committee of both Moroccan Research Group for bird protection (Birdlife Morocco) and laboratory of Functional Ecology and Environment, Biology department, Faculty of science and Technology-Fez. Also, during study, all nest and birds were recorded with minimum disturbance. Digestive tract contents were identified and evaluated for 68 Turtle Doves shot by hunters during two consecutive years.

2.3. Methodology

After a preliminary survey and identification of the habitats visited by turtle dove in 2015, we conducted this work during the breeding season, from April 2016–September 2017. About 40 habitats in small plots (depending on the nature of agricultural fields) were monitored three times per month (separated by ten days). Ten cereal plots (3.45 ha), ten lucerne plots (1.39 ha), ten apple orchards (3.66 ha) and ten stations in the Insgmir river (2.63 ha) were monitored. In another part, the river banks were studied along a 5.7 km transect, from Tattéhante in the east to Bonhas in the Ouest. The observed turtle dove individuals, in each habitat, were counted (from 06:00 to 18:00 h) to analyze and follow the feeding behavior of this game.

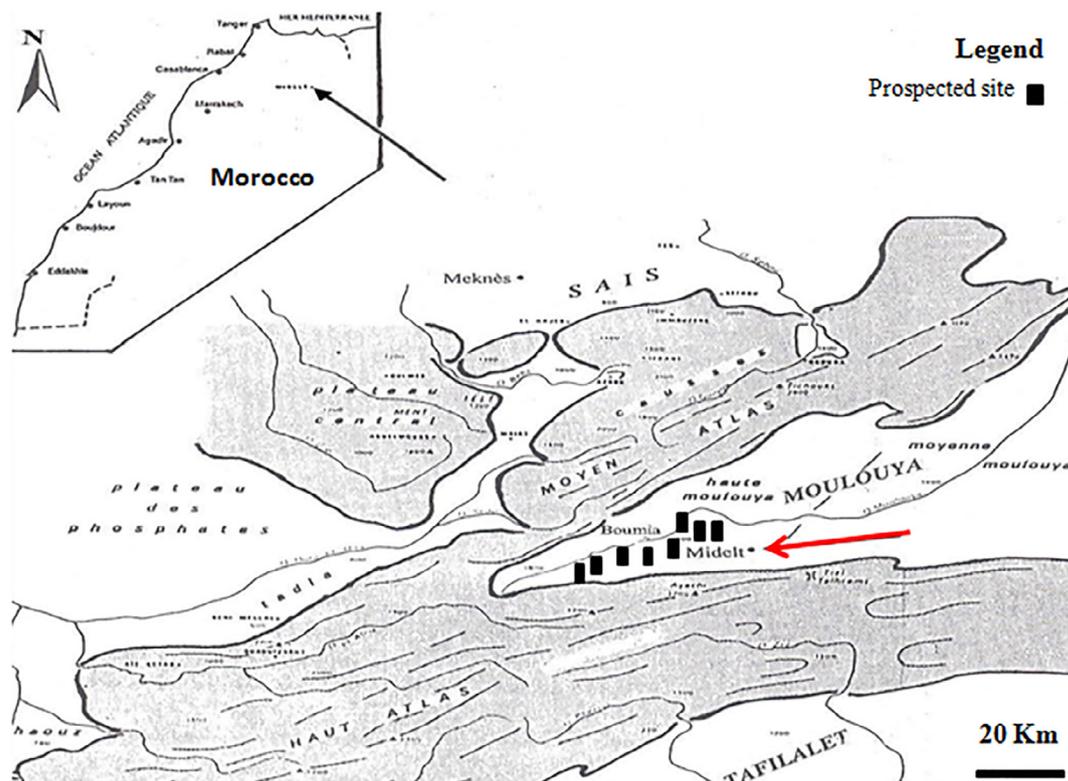


Fig. 1. Geographical localization of prospected habitats in Midelt province, Morocco.

2.4. Diet composition

To determine the turtle dove's trophic diet; a batch of 68 birds were analyzed. These individuals were collected in the studied region from the local hunters, between August and September 2016 and 2017. After determining the individual's sex via dissection, 38 males and 30 females were identified. The turtle dove's diet was determined by the analysis of the digestive tract contents. Seeds and debris consumed were compared with plant references collected from the studied zones.

2.5. Statistical analyses

Descriptive statistics were used to analyse data. Statistical tests were carried out by the SPSS software (version 18.00, IBM 2009) and STATGRAPHICS (Centurion XVI, 2010). After assessing normality and homoscedasticity of variances, parametric data, such as the comparison of seasonal feeding habitats, daily consultation of habitats and female-male diet were analysed using ANOVA one-way test and multiple range test (MRT). To describe variability of consulting habitats during breeding season (qualitative data), Detrended correspondence analysis (DCA) (For seasonal feeding gradient) and Factor analysis (potentially correlated habitats and periods) were conducted. Results reported as significant assume a false discovery rate of 0.05. Graphs are created by GraphPad Prism Mac 6.0 h software.

3. Result

3.1. Feeding habitats

The feeding habitat available and used by Turtle Doves are presented in Fig. 2. The graph showed that for feeding, the turtle doves use a variety of habitats. Cereal cultivation appeared to be the most favorable feeding agrosystems for this species ($F = 9.32$, $DF = 3$, $P < 0.001$). In fact, the turtle birds were highly concentrated in these plots (Table 1). Beside the cereal plots, riverbanks present a great interest for turtle doves feeding. This is very remarkable during the hot summer phase. On the contrary, lucerne plots and apple orchards were less preferred by the turtle dove during breeding season (Table 1).

Graphical representation ($F1 * F2$ and $F1 * F2 * F3$) of the results, using Detrended Correspondence Analysis (DCA) and Factor Analysis (FA), enabled us to identify four feeding habitats, variable depending on time (Figs. 3 and 4). During the month of April, turtle dove was observed more in the apple orchards (H2). Cereal plots (H1) were preferred massively by the turtle doves in May. But, during June the birds were located proportionally among the lucerne cultivation (H3), the apple orchards and the river banks. Between July and September, the turtle dove individuals were concentrated mainly on the Insgmir River banks (H4) before migration.

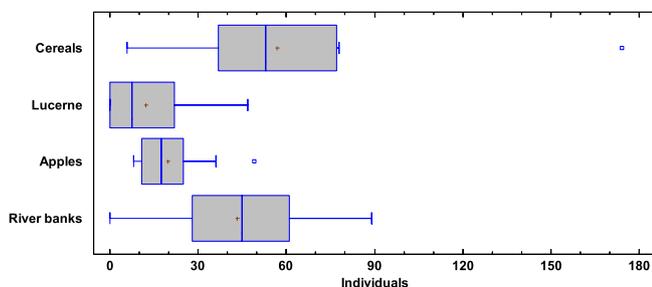


Fig. 2. Feeding habitats (Box and Whisker Plot) used by turtle doves during breeding season (2016–2017).

Table 1

Multiple comparison, determining which habitat is significantly important for turtle dove feeding.

Contrast	Sig.	Difference	+/- Limits
Cereals - Lucernes	*	44.7143	19.2936
Cereals - Apples	*	37.2857	19.2936
Cereals - River banks		13.5	19.2936
Lucernes - Apples		-7.42857	19.2936
Lucernes - River banks	*	-31.2143	19.2936
Apples - River banks	*	-23.7857	19.2936

* Significant difference ($P < 0.05$).

3.2. Feeding behavior

Turtle dove's feeding behavior was monitored in different feeding habitats during five months' period (from April to September). The observations were undertaken thrice a day; in the morning between 6:00–11:00 h, at Midday between 11:00–15:00 h and in the afternoon between 15:00–19:00 h. The results obtained are presented in Fig. 5.

The graphical presentation showed that the turtle doves visited feeding habitats throughout the day. However, the number of birds that visited these habitats was greater in the morning and afternoon ($DF = 1$; $F = 7.15$; $P = 0.009$). A fewer individuals fed during midday (Table 2). During the observations ($n = 23 * 40$ (habitats)), we also noticed that the turtle doves were feeding in groups, particularly in couple. In reality, an average of 19.59 ± 2.77 couples were observed every time in the field, compared with 9.09 ± 1.32 of solitary individuals. This difference was statistically significant ($DF = 1$, $F = 12.253$, $P = 0.001$).

3.3. Diet composition

Results obtained in the turtle's diet showed a wide diversification in the consumed elements (Fig. 6). Indeed, the digestive tract contents were very rich in seeds of different plant species and inert elements. Soft wheat dominates the trophic diet with 44.53%, followed by barley seeds with 38.74% and sand stones (9.16%). A small part of the content was occupied by the gastropod shells (0.24%) and grit stones (0.02%). However, a moderate proportion of elements (7.32%) remained undefined, because of their deteriorated forms and colors. The comparison between males and females of turtle doves revealed a qualitative difference; which was the presence of the gastropod shells only in females and the grit stones in males without any significant variance in weight (Table 3). For other elements, no significant difference was revealed between the two sexes.

These results showed a much diversified trophic diet in the turtle doves. However, most of consumed seeds were from cultivated plants, including soft wheat and barley. In addition, the presence of sand stones and gravel can be explained by their role in the physical digestion of food.

4. Discussion

In this study, we have shown that the turtle dove is visiting a variety of feeding habitats, including cereal plots, to fulfill its nutritional needs (Fig. 2). This is in consistent with the results reported by Dubois (2002) and Browne and Aebischer, (2003). In fact, the richness of cereal plots in edible seeds represents the main factor that attract the turtle doves to consult these habitats, as already mentioned by Lormée (2001), Roux et al. (2006) and Kafi et al. (2015). However, the consultation of lucerne cultivations, riverbanks and apple orchards may be due to the reduction in surfaces occupied by cereals, or under the pressure of human activities that

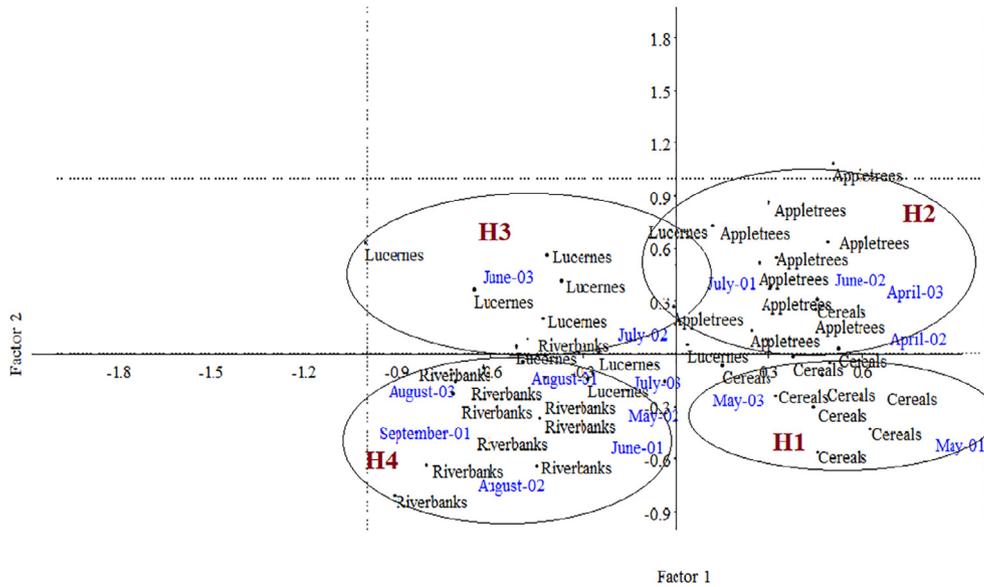


Fig. 3. Detrended Correspondence Analysis (DCA) (F1 (38.01%) * F2 (29.36%)) of feeding habitats visited by the turtle doves during breeding season (2016–2017).

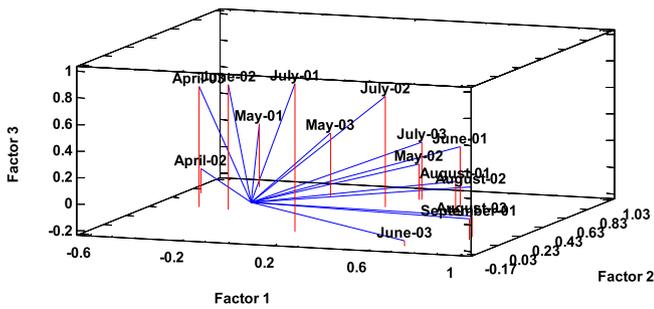


Fig. 4. Factor Analysis (FA) of feeding habitats used by turtle dove during breeding season (3D Loading plot, (F1 (38.01%) * F2 (29.36%) * F3(9.18%)).

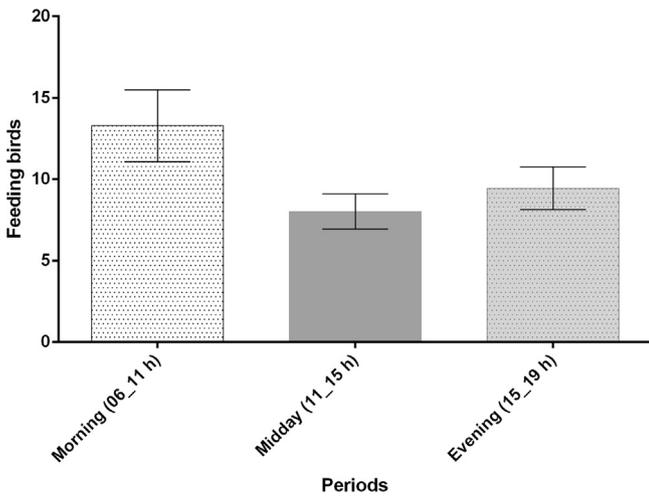


Fig. 5. Daily consultation of feeding habitats by the turtle doves during breeding season (2016–2017).

are modifying the natural habitats (Eraud et al., 2009; Hanane, 2014; Yuan et al., 2014). In reality, during recent years, cereal surfaces are in decline (Eyshi Rezaei et al., 2015; Marshall et al., 2015) because of the agricultural policies adopted in several countries and climate changes (Carpintero and Naredo, 2006; Marshall

Table 2

Multiple comparison, determining which period is suitable for turtle dove feeding.

Periods	Sig.	Difference	+/- Limits
Morning - Midday	*	5.27119	4.44456
Morning - Evening		3.84746	4.44456
Midday - Evening		-1.42373	4.44456

* Denotes a statistically significant difference.

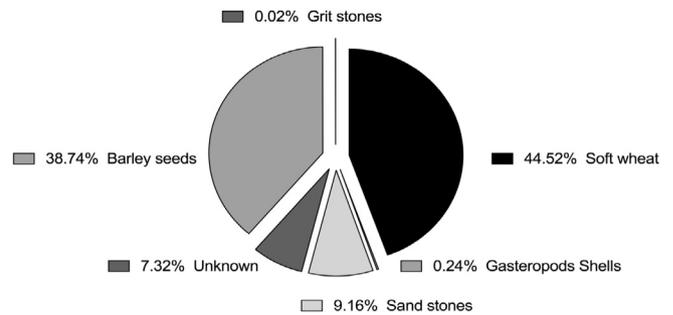


Fig. 6. Composition of turtle dove's diet.

Table 3

Comparison of digestive tract contents between males and females in turtle doves.

Digestive tract contents	Males (g)	Females (g)	F	p
Soft wheat	1.72 ± 0.69	2.45 ± 0.02	0.062	0.804
Barley seeds	1.54 ± 0.57	2.07 ± 0.80	0.153	0.698
Sand stones	0.22 ± 0.16	0.68 ± 0.05	0.665	0.421
Gastropods Shells	0.00 ± 0.00	0.026 ± 0.00	0.008	0.930
Grit stones	0.0018 ± 0.00	0.00 ± 0.00	0.879	0.356

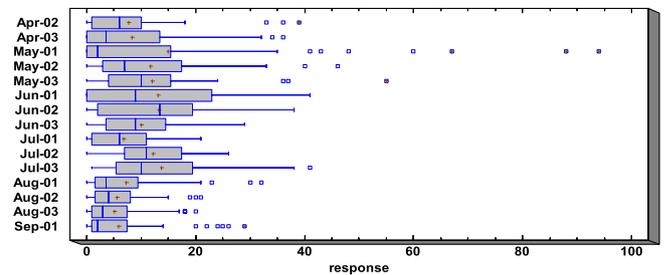


Fig. 7. Variation of turtle dove seasonal feeding behaviour (Box-and-Whisker Plot).

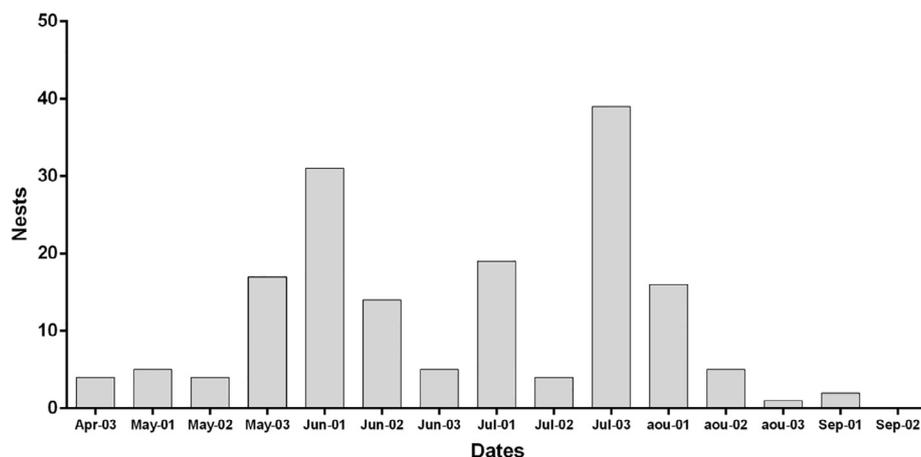


Fig. 8. Nesting phenology of turtle dove during breeding season (2016–2017).

et al., 2015). Therefore, river banks present a supplementary habitat rich in food and close to the water (Hanane, 2017; Kafi et al., 2015; Rocha and Quillfeldt, 2015), and these two elements (water and food) are fundamental for the any animal's life (Dubois, 2002; Mekonnen and Hoekstra, 2012; Paray et al., 2018).

The feeding activity of this game occurred essentially during the morning phase and before sunset (Fig. 5). This is consistent with the results reported by Dubois (2002). He showed that the increased diurnal temperatures, particularly in Midday, mean that the seed's metabolic water would become insufficient to cover the water requirements of this bird (Van Leeuwen et al., 2016; Jungklang et al., 2017; Abdu et al., 2018; Park et al., 2018). This fact pushes turtle doves to look for seeds early in the morning and late in the evening (Table 2), in order to minimize the water losses due to the displacement during the day's hottest periods (Dubois, 2002; Eyshi Rezaei et al., 2015). Turtle dove top feeding was observed during June and July (Fig. 7). These periods are synchronized with optimum breeding phases of this bird in the Mediterranean zone (Fig. 8). This coincidence indicated that the turtle doves look for food in order to rear their chicks. Furthermore, turtle doves feed in groups, especially in couple, this is in agreement with results revealed by Dubois (2002) and Ward and Enders (1985). Turtle dove feeds in couple or in a group, often with other bird species. In our case, turtle dove is associated with wood pigeon (*Columba palumbus*), the rock pigeon (*Columba livia*), the house sparrow (*Passer domesticus*) on cereal plots, blackbird (*Turdus merula*) on apple orchards and lucernes. This confirmed that this game shares the feeding habitats with other avian species. This group feeding behavior provides a possibility to obtain necessary information from other group members about the environment and the habitat's feeding quality (Lachmann et al., 2000; Serrano-Davies et al., 2017), then to decide whether to stay or leave their current foraging range (King and Cowlshaw, 2007).

As reported by many authors (Dubois, 2002; Roux et al., 2006; Gutiérrez-Galán and Alonso, 2016; Hanane, 2017), turtle dove is characterized by a wide trophic diet with affinity to cereal seeds. In our case, the digestive tract analysis showed that the turtle dove is characterized by a polyphagous trophic diet with a granivorous tendency (Fig. 6). However, according to Dubois (2002) this game occasionally consumes mollusks and inert materials. In the present study, besides gastropod shells, we found also sand and grit stones. These inert materials may play a role in physical digestion (Crompton and Nesheim, 2016; Vamanu, 2017).

Finally, our study suggested that the turtle dove is characterized by a diversity in several aspects of the diet. Feeding habitats are very diverse, depending on their nature (agricultural or natural)

and time. This diversity in feeding habitats is reflected in the digestive tract contents. Indeed, different cultivated and wild seeds are revealed in the trophic diet of hunted birds. In addition, the individuals of this game search their food in groups, associated with other species, in the coldest periods of the morning and evening to avoid all water losses. All these strategies would help turtle doves to deal with reduction of natural feeding habitats and unavailability of nutrients.

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