

Foraging efforts and behaviour of the European Turtle doves (*Streptopelia turtur*) during the breeding season



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Abstract During the breeding season, many avian species face spatial and seasonal variation in the availability of food resources required to rear chicks. Reduction of food abundance is often identified as the most important factor determining population trends and breeding success in bird species, such as the vulnerable European Turtle dove *Streptopelia turtur*. During the breeding periods, the increase of food requirements in chicks should increase foraging effort to maintain the amount of food required for optimal chick growth. To investigate the feeding effort of Turtle doves during the breeding season, we monitored foraging and drinking rates, in different wild habitats and farmlands, from March to September 2016-2017 in Midelt, Morocco. Similarly, breeding chronology, including nesting, laying, and chicks' fledging, were monitored in the same habitats to evaluate the correlation between breeding efforts and foraging rates. We found that Turtle doves feed actively from the arrival to departure dates. Foraging activities were intense during breeding phases, mainly laying and chicks' growth periods. Equally, Doves feed intensively during the end of the breeding season before migration departures. Besides, Doves feed actively during the morning and evening to avoid the hottest periods as a strategy to save metabolic water.

Keywords breeding season, feeding rates, Morocco, Turtle dove

1. Introduction

Many factors influence the structure of avian species, including habitat quality, competition, and species requirements (Sol et al 2011; Thornton et al 2011). One of the most critical factors in regulating all animal populations is food resource availability (Ferber et al 2004; Sol et al 2011). Bird species have access to food resources derived from human activities and wild resources during breeding and non-breeding seasons (Dias et al 2013; Mansouri et al 2019; Tremblay et al 2005). The availability of food resources permits the breeding success and survival of these species (Salleh Hudin et al 2017). Adults and their nestlings use food resources during breeding periods. However, reduced food provisioning of both adults and nestlings may influence survival rates and breeding success in bird species (White 2008).

The European Turtle dove (*Streptopelia turtur*) is a long-distance Afro-Palaearctic migrant bird that travels thousands of kilometers between breeding zones in North Africa and Europe and wintering grounds in sub-Saharan Africa (Lormee et al 2016). The population of Turtle doves has declined by 70 % in its European ranges. As in most other

avian species, European Turtle doves face considerable temporal and spatial variation in food availability (Dunn and Morris 2012). Turtle doves preferred nesting sites close to feeding habitats where food resources are abundant (Gutiérrez-Galán and Alonso 2016). Food resources influence many traits of this threatened game related to reproduction, such as breeding success, nestling growth, to wintering ecology, and migration capacities (Dunn et al 2018; Eraud et al 2009). Despite this axial role of feeding resources, few studies have interested foraging features in Turtle doves. Diet composition (Rocha and Quillfeldt 2015), foraging habitats (Gutiérrez-Galan et al 2019; Mansouri et al 2019), and the impact of resource availability on survival (Eraud et al 2009) are the only analysed issues. However, the study of feeding ecology of Turtle dove is required, since the consideration of food shortage as one of the main factors behind Dove's decline at both breeding and wintering quarters (Gutiérrez-Galan et al 2019). Further, the assessment of the feeding aspects will allow to evaluate recent feeding strategies of this game, particularly with loss and degradation of foraging habitats.

In this study, our objective was to examine the feeding behaviour and strategies of Turtle doves during the breeding season. We aimed to analyse, in the field, the evolution of feeding rates in correlation to breeding activities, including nesting, laying, and hatching. However, many studies reported that with the growth of chicks, avian species accelerate foraging rates to satisfy the food requirements of nestlings (Tremblay et al 2005). Therefore, we have based our study during the breeding season in Midelt province where Doves were reported as a breeder (Mansouri et al 2020), intending to quantify the feeding rates in correlation with breeding chronology easily.

2. Materials and Methods

2.1. Study area

The present study was carried out in the Ait Ayach valley, Midelt province Morocco. The study zone was located at the high plain of Moulouya at the Middle Atlas and the High Atlas chain (figure 1). The Midelt is located at 1300 to 1600 m above sea level. A steppe climate is present in Midelt. The annual average temperature in Midelt is 14.7 ° C and the average rainfall per year is 263 mm. This mountainous region is dominated by agricultural activities, including apples, cereals, Lucerne, and other cultivated plantations (Mansouri et al 2019, 2020). The study sites were selected at Okhaja rural centre. Four habitats are distinguished, counting apple

orchards, cereals (common wheat and barley), riverbanks, and lucerne cultivation.

2.2. Sample design

The monitoring of the feeding activities of Turtle dove was carried out in different kinds of wild and agricultural habitats, during one breeding season, from March to September 2016-2017. The selected sites, including ten cereal plots (3.45 ha), ten lucerne plots (1.39 ha), ten apple orchards (3.66 ha) and ten stations in the Ansguemir river (2.63 ha), were topographically high for better visibility (better and easy feeding birds counting). Equally, the habitats were camouflaged (apple trees and other riparian vegetation) to avoid any disturbance for feeding birds. Feeding rates were recorded as the number of feeding Doves observed at each site every two hours from 06:00 to 18:00. The observations were done by binoculars (in case of good visibility conditions). In parallel, drinking rates were recorded in the nearest water point, in Ansguemir River, to the feeding site. Turtle dove's displacement from foraging site to water point was considered as drinking attempt. On the other hand, breeding activities, including nesting (construction of nests), laying (number of eggs), and hatching (fledged chicks), were monitored in the surrounding apple orchards. Temperatures were extracted from the Midelt weather biometeorology station during the 2016-2017 season.

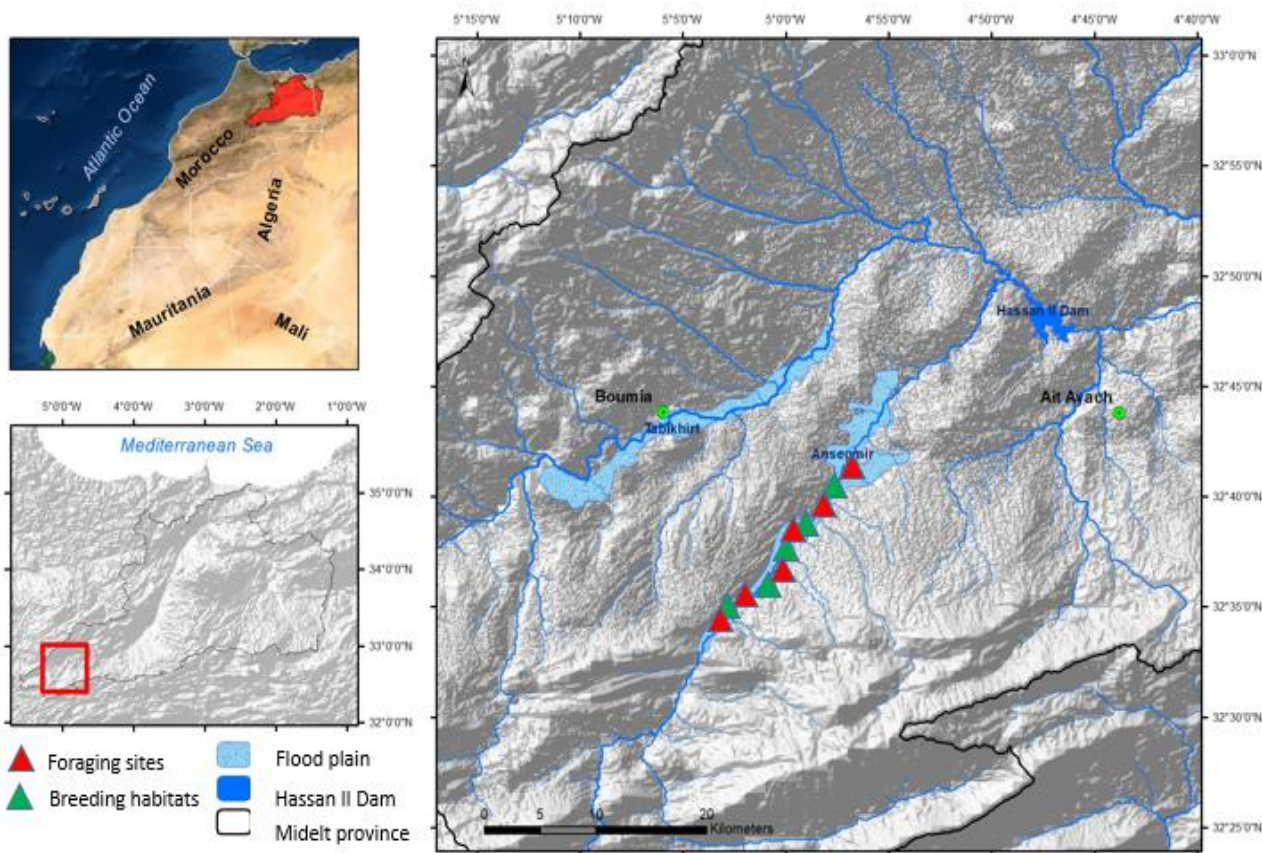


Figure 1 Foraging and breeding habitats of Turtle doves at Oukhaja, in Midelt Province (Morocco) during breeding season 2016-2017.

2.3. Data analysis

Statistical analyses were done in STATGRAPHICS Centurion software, version XVI.I. Before running the statistical tests, we checked for normality and homogeneity of variance for all variables with the Kolmogorov–Smirnov test. The relation between foraging and drinking rates was tested with Pearson's correlation coefficient, considering seasonal and diurnal rates as variables. We analysed the relationship among breeding activities, including nesting (nest construction) separately, laying (eggs), hatching (fledged chicks), and foraging rates by Simple Regression (linear model) and the lack of fit test to determine whether the selected model is adequate to describe the observed data (foraging), considering feeding activities as dependent variables and breeding parameters as factors. Similarly, the relationship between drinking activities (dependent variable) and diurnal temperatures (factor) was analysed by Simple Regression and the lack of fit test. ANOVA one-way test was conducted to compare seasonal and diurnal feeding and drinking rates. All variables with a *P*-Value greater than 0.5 were eliminated. Results were given as mean \pm SD, and Graphs were created by GraphPad Prism Mac 6.0h software.

3. Results

3.1. Feeding behaviour

We recorded 1220 unique feeder visits over 153 days (Feeding = 964 and drinking = 256). During the breeding season, breeding Turtle doves feed actively. Generally, individuals feeding rates increased throughout the season with two maximum feeding rates from May to July and August (Figure 2). On the other hand, feeding activities and drinking rates were distributed throughout the day. While daily activities were intense between 06:00 and 10:00 h and between 16:00 and 18:00h. Moreover, foraging rates were uncorrelated with drinking activities during day ($n = 12$, Correlation Coefficient = 0.802561, $P = 0.7811$), while seasonally these two activities were correlated ($n = 14$, Correlation Coefficient = 0.541861, $P = 0.0453$). In term of comparison, feeding rates were dominant during breeding season ($n = 14$ (decades; 10 days), $F = 8.26198$, $P < 0.05$) and daily ($n = 12$ (hours), $F = 18.4221$, $P < 0.05$) in comparison with drinking water.

3.2. Foraging rates and breeding chronology

Feeding activities started after the arrival of migrant Turtle doves to study sites (Figure 3). Feeder visits to foraging sites were observed since their first days in the breeding area during April. On the contrary, breeding chronology, mainly nesting activities, started lately during the first week of May. Foraging rates were intense in coincidence with the intensity of breeding activities, mainly the hatching of chicks between the last week of May and the first week of August. Another reprise of foraging intensity was observed during the last week of August before autumnal migration.

Foraging rates were controlled by breeding activities of Turtle doves (Figure 4). Feeding rates were correlated mainly to breeding chronology, largely laying eggs and hatching chicks. While nesting activities were less correlated with foraging degrees. On the other hand, no relation was recorded between feeding activities and the breeding phase during the day.

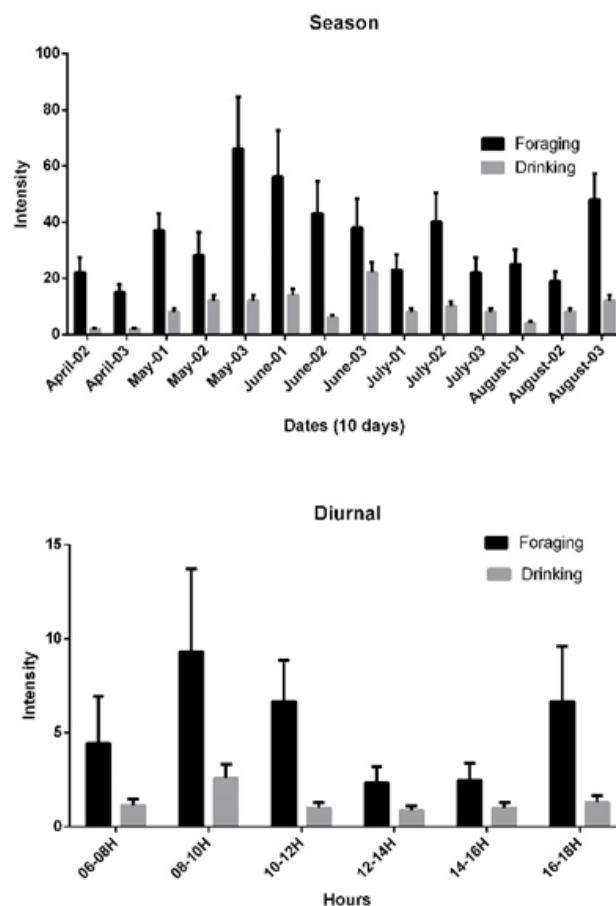


Figure 2 Seasonal and diurnal feeding activities of Turtle doves in Midelt during breeding season 2016-2017.

4. Discussion

Loss of foraging sites was mentioned as one of the main factors affecting Turtle dove *Streptopelia turtur* population trends in breeding and wintering grounds (Dunn et al 2018; Moreno-Zarate et al 2020). In this study, we have monitored the foraging behaviour of the vulnerable Doves during the breeding season from the arrival to departure dates.

Research of foraging resources started immediately after the arrival of the first migrant Turtle doves to breeding habitats during the second week of April. Feeding rates were intense during the morning between 06:00 and 10:00 h, and evening between 16:00 h and 18:00 h. This is in agreement with the results reported in Turtle doves by Mansouri et al (2019). These authors mentioned intense foraging rates in Turtle doves during the morning and evening. As a possible

explanation, this feeding behaviour during the coldest periods of the morning and evening permits to avoid the summer hottest temperatures of the midday. Because the research for foraging resources in hot temperatures accelerate the loss of physiologic waters (Bonter et al 2010; Savory 1980), and this is confirmed by the close correlation recorded between drinking rates of Doves and the evolution

of summer temperatures (figure 5). On the other hand, foraging activities were distributed from the arrival to migration departures in autumn, which is in agreement with results mentioned by Mansouri et al (2019) in the same zone, and supporting the actively feeding rates from the arrival to departure of this threatened species.

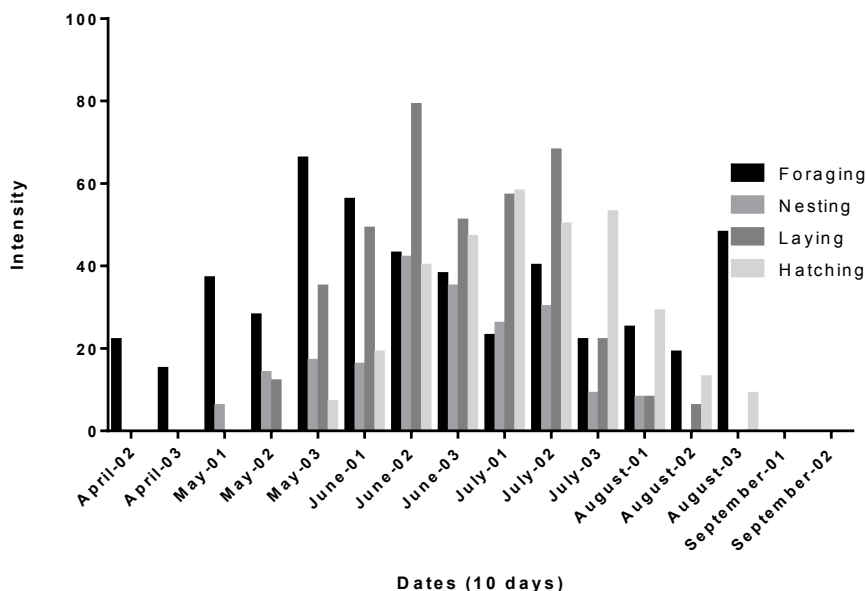


Figure 3 Feeding rates and breeding chronology of Turtle doves in Midelt during breeding season 2016-2017.

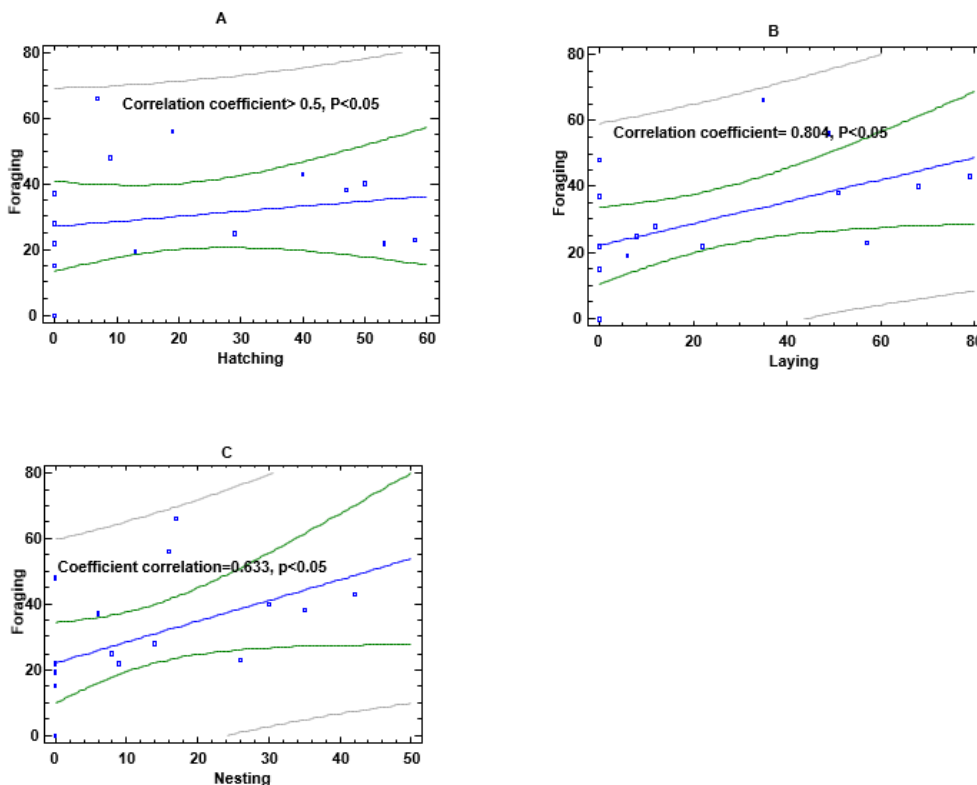


Figure 4 Relationship among, A) foraging and hatching, B) foraging and laying, and C) foraging and nesting, tested with Simple Regression and Analysis of Variance with Lack-of-Fit.

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During the breeding season, foraging rates were correlated to the breeding activities, mainly laying and hatching. The intensity of feeding rates increased with the increasing number of laid eggs and hatched chicks between the last week of May and the first week of August. These increasing foraging rates, particularly during hatching periods, are supposed to be induced by the food supply required by new nestling as recorded in many avian species (Gill and Hatch 2002; Robb et al 2008). For example, during the breeding season, the food supply required by chicks of carrion crows, *Corvus corone corone*, increased significantly with their growth (Canestrari et al 2007). All avian nestlings require more food supply following their growth ((Maziarz and Wesolowski 2010), and this forces their parents to increase foraging rates to satisfy the requirements of chicks (Boland et al 1997; Caffrey 1999; Roehe et al 2016). This

explains the coincidence between high-intensity rates of foraging activities and the occurrence of laid eggs and hatched chicks of Turtle doves during breeding seasons. Other intense feeding rates were recorded after the breeding phase (nesting, laying, and fledging) in the last week of August. The high foraging rates observed in the last periods before migration departures, in autumn, are possibly due to the attempts of Turtle doves to accumulate the satisfying reserves that are enough to cross the harsh Saharan desert to wintering grounds. At this point, many long-distance migrant birds were documented to accumulate fuel reserves before starting their migration journeys (Eikennar 2017; Goymann et al 2010; Schaub et al 2008), and these reserves are used as fuel to accomplish their long flying flights (Howard et al 2018; Sjöberg et al 2015).

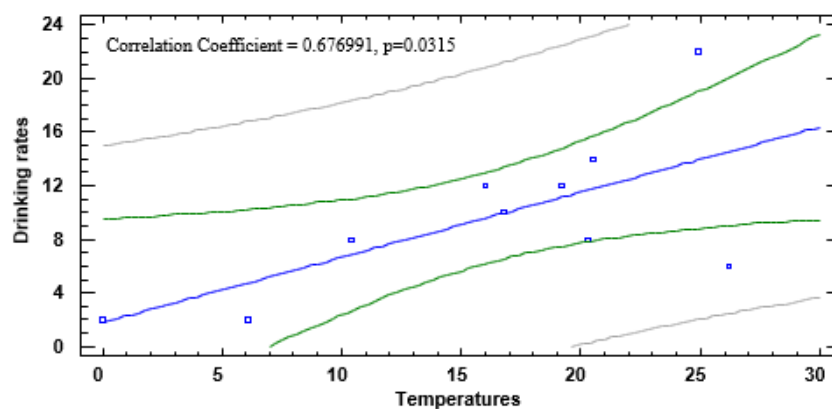


Figure 5 Correlation between drinking rates of Turtle doves and diurnal temperatures in breeding zone.

5. Conclusions

In summary, our study demonstrates that feeding rates of migrant Turtle doves started from the first day in the breeding zone. Diurnally, Turtle doves feed actively during the coldest periods of the morning and evening. Moreover, foraging activities were intense during the rearing of nestlings to satisfy the food requirements of Dove's chicks. While drinking rates were intense during the hottest temperatures of the summer. Besides, feeding activities were recovered just before migration departures to accumulate sufficient reserves for long migration journeys. Additional studies of feeding behaviour and ecology of Turtle doves are required to explore further the relationship between feeding sorties realised by parents and nestling growth. Similarly, the relationship between feeding efforts and success rates will be an essential feature to understand foraging strategies of doves.

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Conflict of Interest

The authors declare that there are no conflict of interest with this work.

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