Zoology and Ecology, 2025, Volume 35, Number 1
Online ISSN: 2165-8013
https://doi.org/10.35513/21658005.2025.1.2

BREEDING ECOLOGY OF THE COMMON KESTREL *FALCO TINNUNCULUS* IN THE URBAN ENVIRONMENT OF THE BLIDA REGION, ALGERIA

Mustapha AROUDJ*[a], Samia OUARAB[b]

[a]Medicinal and Aromatic Plants Research Laboratory, Department of Biotechnology and Agro-Ecology, Faculty of Nature and Life Sciences, University of Blida 1, 09000, Blida, Algeria;
[b]Animal Eco-Biology Laboratory, Department of Biotechnology and Agro-Ecology, Faculty of Nature and Life Sciences, University of Blida 1, 09000, Blida, Algeria
*Corresponding author. Email: mustaphaaroudj@gmail.com / aroudj_mustapha@univ-blida.dz

Mustapha Aroudj: https://orcid.org/0009-0001-3631-7726

Aroudj, M., Ouarab, S. 2025. Breeding ecology of the Common Kestrel *Falco tinnunculus* in the urban environment of the Blida region, Algeria. *Zoology and Ecology* 35(1), 13–24. https://doi.org/10.35513/21658005.2025.1.2

Article history:
Received 20 July 2024;
accepted: 04 February 2025

Keywords:
Blida; Algeria; breeding ecology; breeding success; Common Kestrel (*Falco tinnunculus*); eggs; nests; urban environment

Abstract. The Common Kestrel (*Falco tinnunculus*), a diurnal bird of prey, is highly adaptable to urban environments. However, knowledge of its breeding ecology in Algeria is limited and focused on few localities. This study specifically examines Common Kestrel breeding in the urban environment of Blida (36°28'00" N, 2°49'00" E) over a five-year period, from 2019 to 2023. The results reveal that kestrel pairs adapt well and occupy a variety of nest types. The average area where a pair hunts and breeds is 1.99 ± 1.58 km². Clutch size varies between 2 and 6 eggs, with an average of 4.3 ± 1.5 eggs. Incubation lasts an average of 26 to 29 days (approx. 27.7 ± 1.3 days). The young leave the nest between 27 and 32 days after hatching (29.11 ± 1.91 days). Nevertheless, these falcons face competition from other birds and are impacted by human activities, notably the theft of eggs and chicks. In conclusion, this study highlights the Common kestrel's adaptation to the urban environment, while underlining the challenges posed by anthropogenic pressure.

INTRODUCTION

Gathering data on breeding biology and reproductive performance is a crucial aspect of numerous studies focused on the population ecology of birds. On a global scale, urbanized areas represent only a very small proportion of all environments exploitable by bird species (Lesaffre 2006). This fraction demonstrates a unique phenomenon worthy of interest in urban fauna studies. The Common Kestrel *Falco tinnunculus* (Linnaeus, 1758) has colonized urban environments and is highly adaptable to anthropogenic pressures (Cramp and Simmons 1980; Żmihorski and Rejt 2007; Riegert et al. 2009). This diurnal bird of prey is typically known for its hovering flight (Elphick and Woodward 2005; Cardozo et al. 2016; Sale 2020), and is systematically classified in the order Falconiformes and in the family Falconidae (Heim de Balsac and Mayaud 1962; Etchecopar and Hue 1964; Costantini and Dell'Omo 2020).

As all kestrel species, the Common Kestrel has a wide geographical distribution. However, in Algeria, it is primarily considered as sedentary (Heinzel et al. 1992), in which its breeding range extends over different types of habitats, from the coast to the heart of the Sahara, from open plains to mountains (Isenmann and Moali 2000).

The Common Kestrel is a predominantly monogamous raptor (Village 1990); however, divorce behaviour may occur, particularly following unsuccessful breeding attempts (Vasko et al. 2011). As all kestrels, this species is a secondary cavity nester (Village 1990; Costantini and Dell'Omo 2020). It starts nesting at the age of one year (Vergara and Fargallo 2011). The breeding season is well marked by the division of labour (Costantini and Dell'Omo 2020) and is characterized by courtship displays, where pairs announce their presence through loud calls and impressive territorial flights (Tinbergen 1940; Gensbol 2005).

According to the International Union for Conservation of Nature (IUCN), the Common Kestrel is classified as a species of Least Concern (LC) worldwide (Bird Life International 2024). This means that the species is at low risk of extinction. Furthermore, it enjoys legal protection in Algeria under Executive Decree No. 12-235 of 24 May 2012, which sets out the list of protected non-domestic animal species.

Several studies were devoted worldwide to the ecology of this species. They are well documented in Europe (Masman et al. 1986; Village 1990; Rejt 2004; Cardozo et al. 2016; Orihuela-Torres et al. 2017; Sale 2020), in Asia (Geng et al. 2009; Anushiravani and Sepehri

Roshan 2017; Kabeer et al. 2021: Chen et al. 2022), in Austria (Sumasgutner et al. 2013, 2014; Kreiderits et al. 2016; Huchler et al. 2020) and in Africa (Thiollay 2006; Laalou et al. 2017; Haroun and Taha 2022). In Algeria, several studies have been carried out on the diet in a suburban environment in El-Harrach (Baziz et al. 1999), in an agricultural environment in Dergana (Souttou 2002), in El-Harrach (Souttou et al. 2006, 2007, 2011), and in steppe environments in Djelfa (Souttou et al. 2015), but practically no studies have been carried out on the breeding biology of the Common Kestrel, except for those by Souttou et al. (2005), who monitored the breeding of a pair in a suburban environment in Algiers, and those by Kaf et al. (2015) in a semi-arid urban environment in Oum El Bouaghi.

In light of this shortcoming, the present work is designed to provide a more detailed information on the breeding ecology of Common Kestrel in an urban environment, by comparing some characteristics of breeding activities (nest and egg characteristics, choice of nesting site) over the years and in several sub-humid bioclimatic sites.

MATERIALS AND METHODS

Study area

This work was carried out in two communes in the Blida region of northern Algeria (36°28'N, 2°49'E; Figure 1). This region has a Mediterranean climate with hot summers. The Ouled Yaich commune boasts a major industrial zone, while Guerouaou has little industrialization.

As other animal species, Common Kestrels inhabit specific areas that are referred to as home ranges, where they carry out essential activities such as breeding and foraging (Village 1990; Costantini and Dell'Omo 2020). The species occupies diverse habitats, with each site displaying distinct landscape characteristics that impact home range usage and ecological behaviours. Specific details for each site are provided below (Table 1).

Monitoring Common Kestrel behaviour during breeding season

During the breeding season, we monitored the activities of four Common Kestrel breeding pairs and observed how they shared their tasks. Our method consisted of surveying different nesting areas on a daily basis, using a camera equipped with a powerful zoom lens, "Nikon Coolpix P1000", in order to minimize stress for the pair. The activities recorded generally included courtship, brooding, as well as feeding in and out of the nest. We also used direct visual observations to qualitatively assess the handling prey for kestrel chicks (Blasgosklonov 1987; Costantini and Dell'Omo 2020), as well as the analysis of nest remains after chick fledging (Riegert et al. 2007, 2009).

Monitoring Common Kestrel breeding phenology

The breeding biology of four Common Kestrel pairs nesting in different areas of the study region was being monitored over a 5-year period from 2019 to 2023. Once the nests of the nesting pairs had been identified, several field trips were made to the nesting areas. This enabled us to gather information on the characteristics of the breeding sites and to determine the laying date from the number of eggs in incomplete clutches. We were also able to take into account the laying of one egg each day (Alatalo et al. 1992) and clutch size, which represents the number of eggs a female can lay, the number of which present in the nest no longer varies between two consecutive visits to the nest after the end of the laying period (Ravussin et al. 2007; Telailia 2014). Bensouillah et al. (2014) state that a successful nest is the one where at least one chick fledged. Given that hatching success is calculated as the number of eggs hatched in relation to the total number of eggs laid, fledging success is the total number of fledged young in relation to the total number of eggs hatched, and breeding success represents the total number of fledged young in relation to the total number of eggs laid per nest.

Data analysis

Reproductive results are presented as mean ± standard deviation (SD) and were considered significant at a confidence level of $p < 0.05$. To estimate the home range of kestrels, we applied a simplified method based on GPS-derived nest distances (Gjershaug et al. 2004). Each distance was treated as the diameter of a circle, and the area was calculated using the formula $A = \pi \left(\frac{D}{2}\right)^2$, where D is the distance between two nests. The average of these areas estimates the home range, with variability indicated by standard deviation. The influence of weather on incubation and nestling periods was examined using scatter plot to explore the different reproductive parameters and assess the impact of climatic factors. However, monthly average rainfall (mm) and temperature (°C) data for the nestling and incubation periods were obtained from the Blida meteorological station for the study period between 2019 and 2023. All environmental factors (degree of anthropization, nest height, and orientation) were considered. The degree of anthropization was determined using a land-use map and population data, where a value of 1 was assigned to less anthropized areas and a value of 2 to highly anthropized environments (BNEDER Office. Pers. Com.). Nest height was measured from the ground using a meter tape, and nest orientation was determined based on the position of the nest entrance and how it was oriented

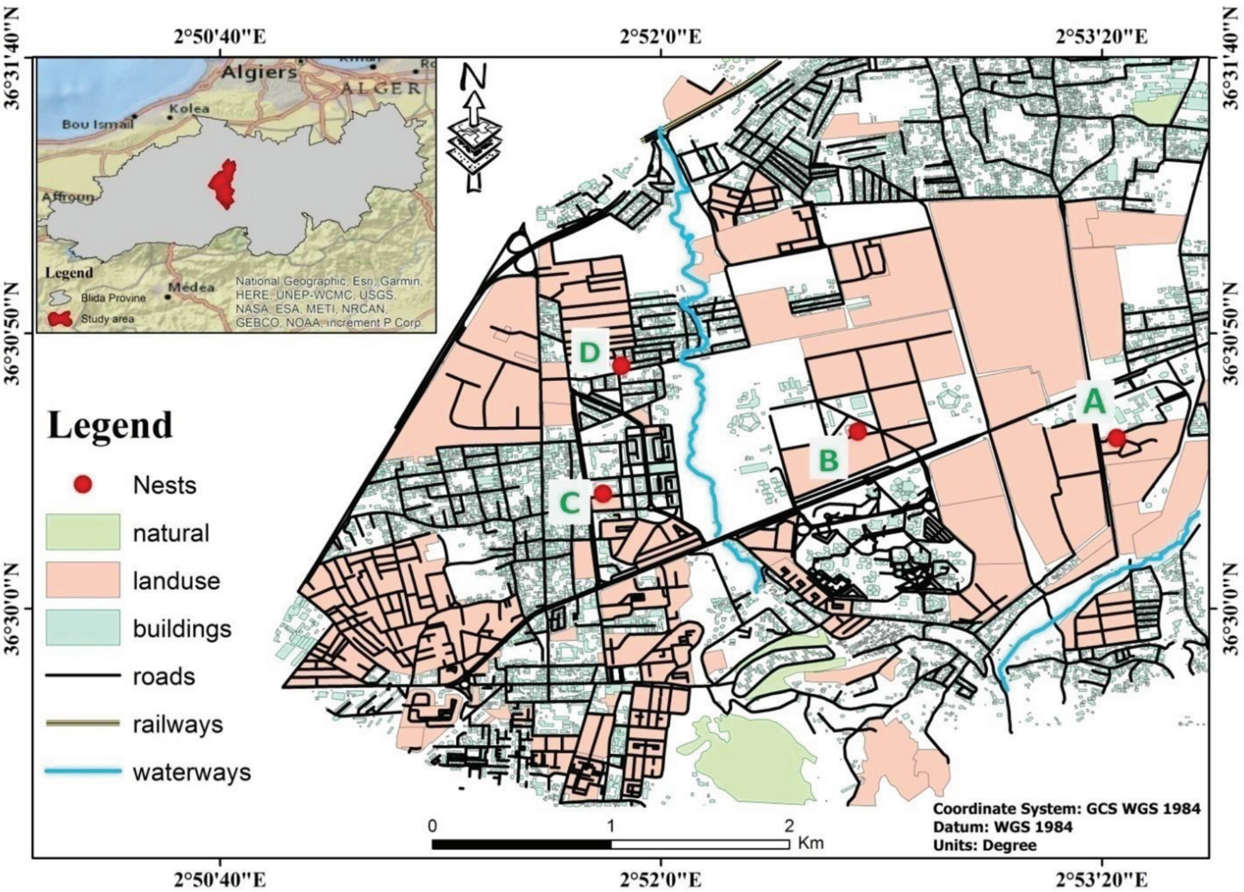

Figure 1. Location of the study area (Original, 2025).

Table 1. Parameters and description of different nests habitats.

Nests	A 36°30'31.0"N, 2°53'22.7"E	B 36°30'32.2"N, 2°52'35.7"E	C 36°30'20.9"N, 2°51'49.5"E	D 36°30'44.1"N, 2°51'52.8"E
Nest Location	Edge of a window	Air hole used by a pigeon	Pigeon nest associated with a ventilation pipe	Hole in a wall
Nest Height	15 m	7.6 m	7.5 m	7.9 m
Nest Orientation	North-east	North-east	North-west	South-west
Urban Area (ha)	~50 ha (mixed zone with low anthropization)	~30 ha (agro-ecological zone with less anthropization)	~100 ha (urban area with high anthropization)	~70 ha (urban area with high tanthropization)
Description of the Site	Residence blocks for female students, close to fruit and olive orchards, surrounded by agro-ecological nurseries	Block in agricultural plots with soft wheat, olive trees, and fruit trees (peach, orange)	Apartment complex close to intense human activity. Presence of Yellow-legged Gulls and a large pigeon population	A quieter residential area near a sewage discharge wadi (Oued Kef El Hmam).

relative to magnetic north using a compass (Ouarab et al. 2007). Both nest height and orientation were measured after the breeding season to avoid disturbing the nesting pairs. These three factors were correlated with reproductive success and hatching rate to study their influence on the bio-ecology of the species, using Principal Component Analysis (PCA) (Lê et al. 2008). Statistical analyses were performed using R, software version 4.2.2. (Core Team 2022).

RESULTS

Timing of breeding and nest placement

As with all diurnal birds of prey, the Common Kestrel breeds during the spring season. Over five years of observation, the same pairs demonstrated strong fidelity to their nesting sites, indicating that they are monogamous in this study area. The courtship phase was highly noticeable, marked by intense calls and spectacular aerial displays. The female signals her readiness to mate by leaning forward and calling to attract the male, who lands on her back. The male strengthens their bond by regularly offering prey to the female.

At sites B and C, pairs were content to occupy the nests of rock pigeons (*Columba livia* Gmelin, 1789). However, at site A, they laid their eggs directly on the ground after scraping a site next to a window, while at site D, they used a hole in a wall (Table 1). The home range area around the nest where a single common kestrel pair hunted and bred varied between 0.43 and 4.41 km², with an average of around 1.99 ± 1.58 km² (Table 2).

Clutch size

We observed that after mating the male Common Kestrels began provisioning the nest, while the females started egg-laying. The eggs were laid consecutively over several days, with an interval of around 24 hours between each laying. Average clutch size is 4.3 ± 1.5 eggs (e.g. number of breeding attempts = 10). Clutch size varied significantly from month to month, ranging from 2 to 6 eggs per clutch. Clutch sizes reached a maximum in May (5.3 ± 0.7; n = 3) and a minimum in March (2 ± 0.0; n = 2). It is important to note that egg-laying dates varied from one site to another. At sites C and D, egg-laying began as early as in mid-March, while at sites A and B, it started later, at the end of April (Figure 2).

Incubation period

According to our several observations at the nesting sites during the incubation period, we noted diverse activities. At sites A, C, and D, the females incubated alone as long as the last egg was laid, while at site B, a particular dynamic was observed where the male did not take part in incubation but actively defended the territory against other predators in the study site. The data collected reveal a significant variation in incubation duration, ranging from 26 to 29 days, with an average of around 27.7 ± 1.3 days. No missing data were observed, enhancing the precision of this parameter result. The median was 27.5 days, very close to the mean, indicating a symmetrical distribution. In contrast, the plot overview shows a consistent spread around the mean, emphasizing the stability of the measured values (Figure 3).

The scatters plots examining the effect of climatic factors on the incubation time of Common Kestrel eggs reveal some interesting information (Figure 4). The temperature does not appear to influence the incubation period of this kestrel species eggs ($R^2 = 0.02$) (Figure 4a). As for rainfall, a moderate correlation ($R^2 = 0.26$) suggests that higher levels of rainfall may be associated with longer incubation periods (Figure 4b).

Diet composition

The analysis of the diet of Common Kestrels (*Falco tinnunculus*) during the nestling period over the five years of this study reveals significant patterns in prey selection. Four distinct prey categories were identified within their diet. The dominant category in nests A and

Table 2. Distances between nests and home range area of Common Kestrel.

Distance between nests (km)			Home range area (km²)		
Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD
0.74	2.37	1.55 ± 0.69	0.43	4.41	1.99 ± 1.58

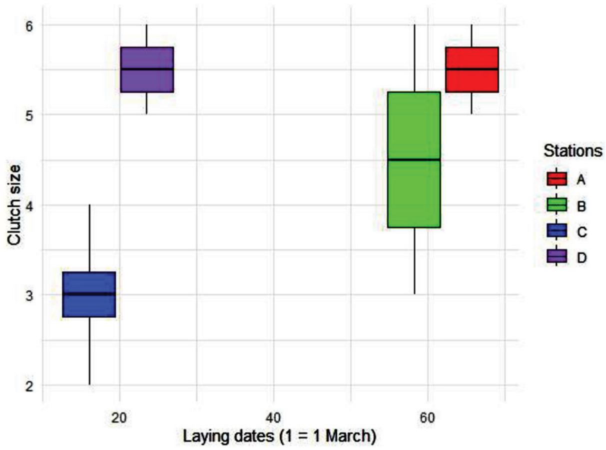

Figure 2. Clutch size variation in relation to average laying dates across different study sites.

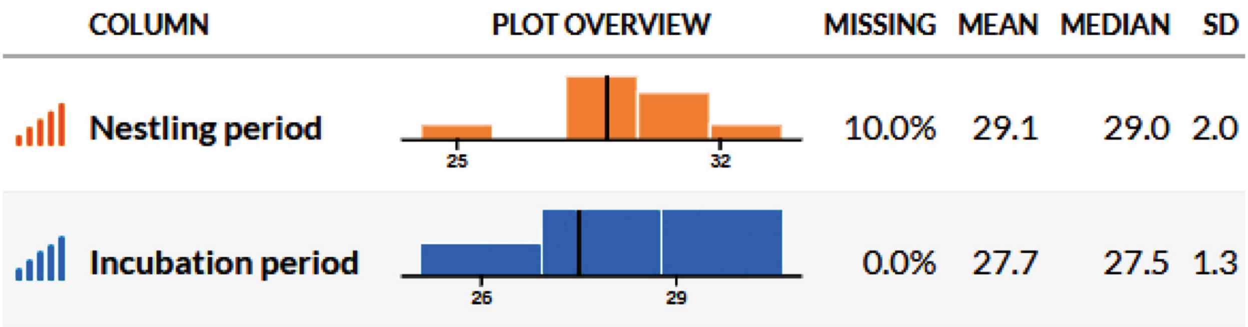

Figure 3. Statistical representation of Common Kestrel nestling and incubation periods in days.

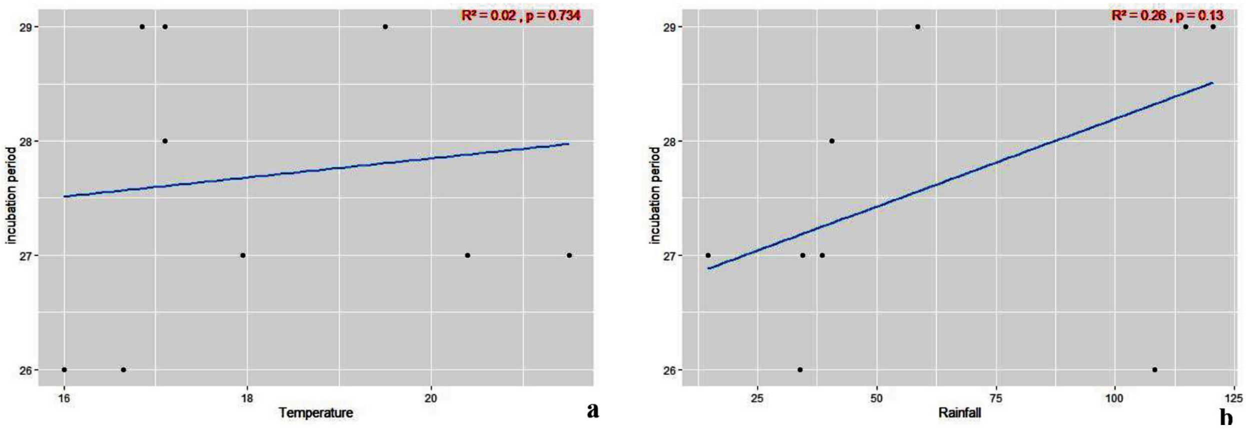

Figure 4. Relationship between Common Kestrel incubation period and regional climatic data: (a) temperatures, (b) rainfall.

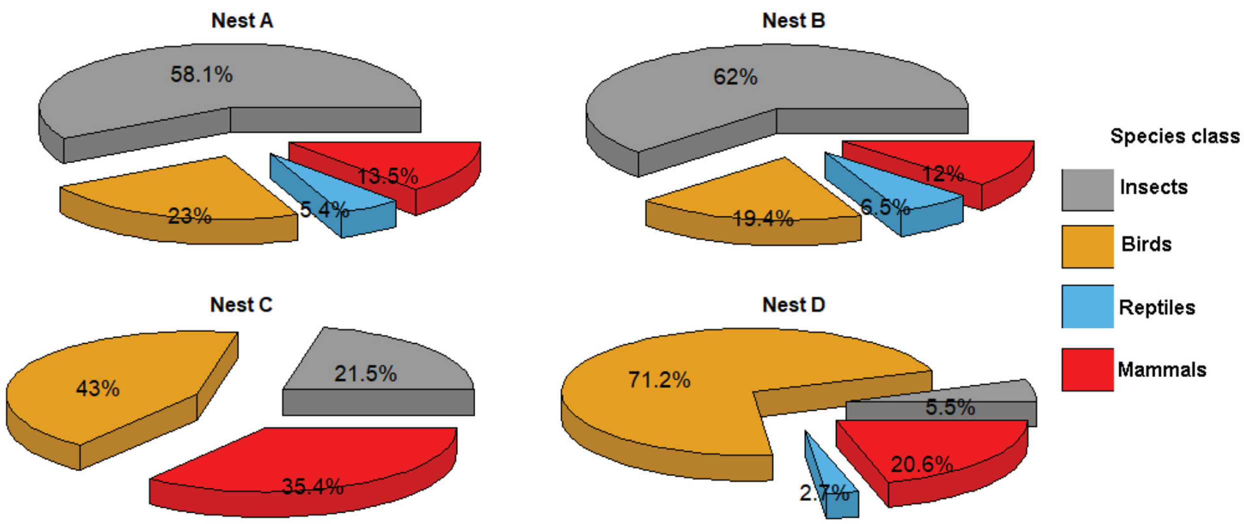

Figure 5. Distribution of diet composition by species class across different nests.

B was insects, comprising, respectively, 58.1% and 62% of the prey and represented by orthopterans and beetles. In contrast, birds like small passerines and pigeons were the most abundant prey in nests C and D, accounting for 43% and 71.2% of the total prey, correspondingly. Mammals were present in lower proportions, ranging from 12 % to 21.5%, while reptiles stood for 2.7% to 6.5% of the prey (Figure 5).

On the other hand, the results related to the nestling period revealed that chicks fledged 27 to 32 days after hatching, with an average duration of around 29.11 ± 1.91 days, which can vary according to the number of young found in the nest. Nevertheless, this period was marked in station B by predation, primarily due to human activities leading to the loss of 10% of the nestlings. As a result, the monitoring of the nestling period for these individuals could not be completed. The median is close to the average, suggesting a symmetrical distribution; however, the 10% missing data could introduce potential bias. The plot overview reveals a slight right skew, indicating that some individuals may have longer nestling periods (Figure 3).

A scatter plot analysis between temperature and nesting period revealed a slightly positive correlation ($R^2 = 0.06$) (Figure 6a). In contrast, a slightly negative relationship was observed between rainfall and nestling period, witch suggests that higher rainfall is associated with slightly shorter nesting periods. However, this relationship is also very weak, with a coefficient of determination $R^2 = 0.11$ and a p-value = 0.377 that is not statistically significant (Figure 6b).

Egg hatching and breeding success

The results of the Principal Component Analysis (PCA) performed on Common Kestrel breeding data revealed significant relationships between environmental factors and two breeding parameters (hatching rate and breeding success). The first two principal components together explained 69.2% of the total variance in the data, with the first dimension (Dim1) accounting for 49.1% and the second dimension (Dim2) for 20.1% (Figure 7).

With regard to variation in nest orientation, those fac-

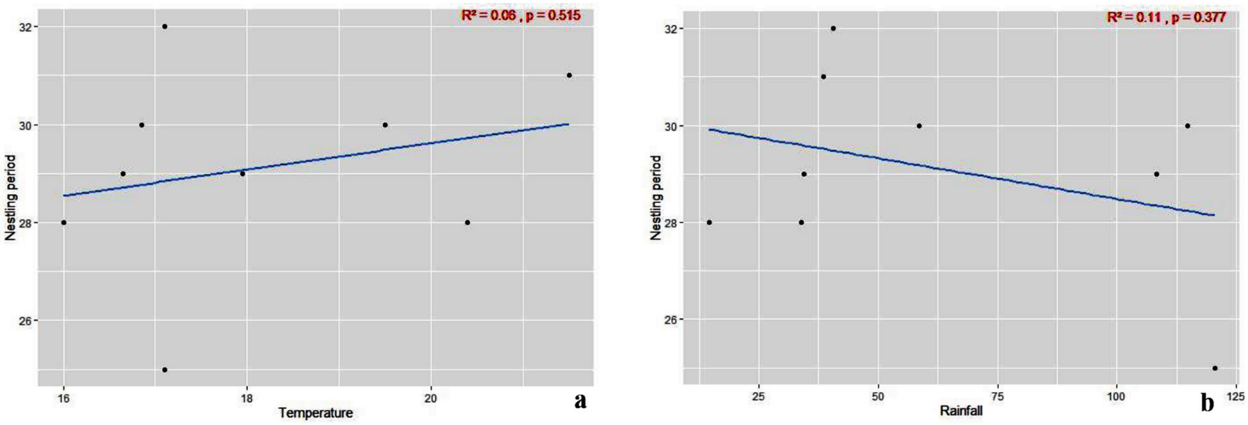

Figure 6. Relationship between Common Kestrel nesting period and regional climatic parameters: (a) temperatures, (b) rainfall.

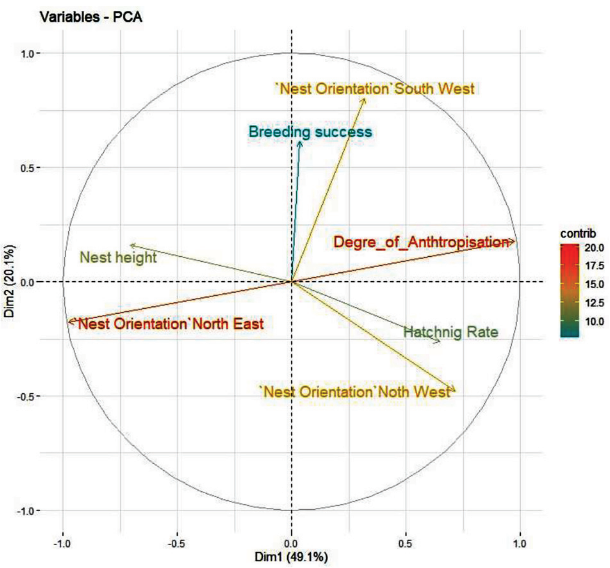

Figure 7. PCA correlation of environmental factors with hatching rate and reproductive success.

ing southwest showed a significant contribution to the Dim1 of the PCA. This explains why in 2022 and 2023 nests in site D were associated with high hatching rates (83.33% and 100%, respectively), as well as fairly high reproductive success. Similarly, northeast orientation played a different role at sites A and B. It is associated with a variation in hatching rates ranging from 33.33% to 100%, as well as 100% reproductive success in all years, with the exception of 2023 when there was a 0% decrease, attributed to the absence of chicks from their first days of feeding. The nest height variable shows some correlation with the Dim1 of the PCA, but is weakly related to reproductive success and hatching rates. This suggests that, although nest height may have an impact on micro-climate and protection from predators, it was not the main determinant of reproductive success in this study.

The degree of anthropization is strongly correlated with the Dim1 of the PCA. Nests located in areas of high anthropization are clearly distinguished from those in areas of low anthropization.

Two groups are identified: the first comprises nests with low anthropogenic impact (stations A in 2022 and 2023, and B in 2021 and 2023), which cluster together despite fluctuations in hatching rates and reproductive potential. The second group is comprised of nests that are strongly influenced by human activity, found at sites C (2019–2022) and D (2022 and 2023). These nests show a high degree of consistency, with high hatching rates and varied reproductive success (Figure 8).

DISCUSSION

The diversity of Common Kestrel nesting sites is well documented in scientific literature (Village 1990; Thévenot et al. 2003; Souttou et al. 2005; Laalou et al. 2017). This adaptability to different habitats is linked to its highly flexible trophic requirements (Navarro-López et al. 2014). Yet, in certain areas, Village (1990) observed that the most common nesting sites were not always used as expected. These choices may have a genetic component or be influenced by early life experiences (Costantini and Dell'Omo 2020). Common Kestrels possibly tend to prefer sites similar to those in which they were reared.

The ability to choose a variety of nesting sites enables Common Kestrels to make the most of available resources and optimize their chances of reproduction. On average, the hunting and breeding area for this species is around 1.99 ± 1.58 km². These values are consistent with other studies that have reported areas ranging from 0.059 to 3 km² (Geroudet 1984; Korpimäki et al. 1994; Kaf et al. 2015). This territorial dimension gives them ample space to search for prey and protect their breeding territory from other congeners.

In the study area, female Common Kestrels started

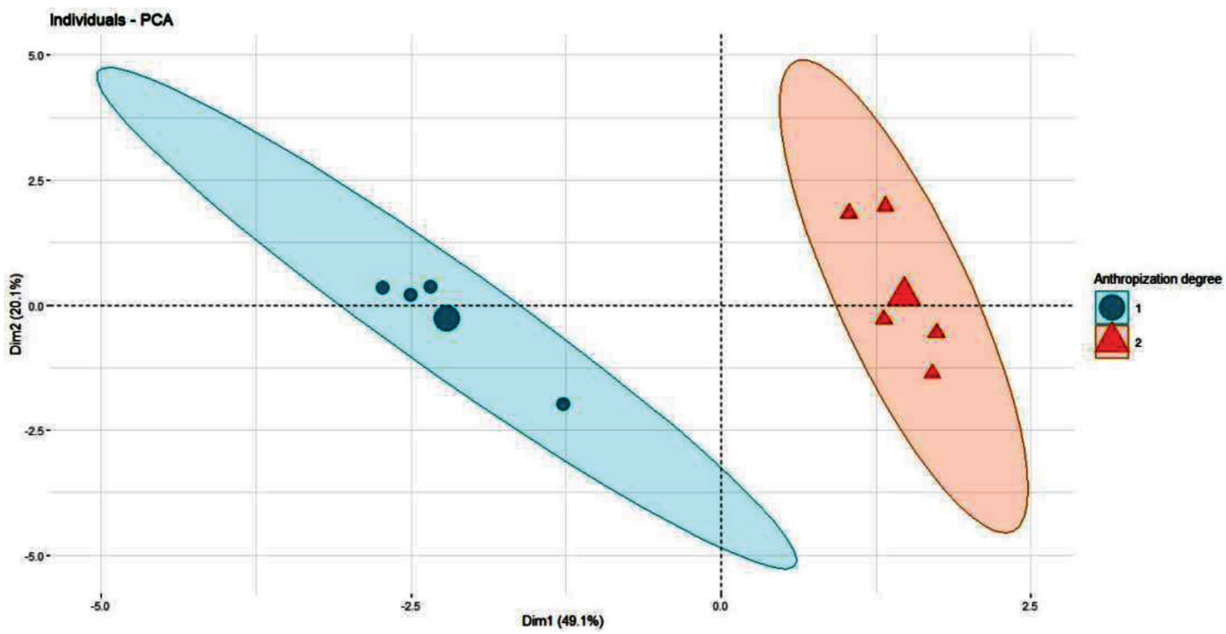

Figure 8. Principal Component Analysis of the degree of anthropization correlation.

laying 2–6 eggs from mid-March to the end of April. The average clutch size was 4.3 ± 1.5 eggs per nest. Our results are similar to those found in Italy by Salvati (2002), but differ from those observed in a highly urbanized environment in Oum El Bouaghi by Kaf et al. (2015), which show higher values of 5 to 6 eggs. This breeding parameter is least affected by weather condition (Kreiderits et al. 2016), but it attribute to increased food availability during the courtship, which enhances the physical condition of females (Huchler et al. 2020). Yet, we also recorded significant clutch sizes in agricultural habitats, so as to suggest that both urban and agricultural environments provide resources helpful to optimal clutch sizes in Common Kestrels.

Although Costantini et al. (2014) observed that the clutch size in kestrels is influenced by the laying date, other studies suggest that additional factors also play a role in this regulation. These observations reinforce the findings of Carrillo and González-Dávilla (2010), who noted that in a semi-arid region at Tenerife Island, egg-laying varies according to the climate, improving the importance of the environment on the reproductive cycle. However, Costantini and Dell'Omo (2020) shows that the decision on clutch size is under strong female control, even though it generally decreases later in the season. They also noted that kestrels lay larger clutches in northern regions, with no direct link to the laying date. Moreover, Village (1990) specifies that kestrels rarely lay a second clutch if the first one fails. These various studies emphasize that clutch size results from multiple factors including female control, climatic conditions, and the laying region, beyond just the laying date.

The Common Kestrel incubation period is characterized by cooperation between two partners in each pair. During this phase, the females incubate the eggs, while the males feed the nests and sometimes actively defend their territory against predators, particularly crows. This behaviour has previously been observed in southern Africa and Spain (Van Zyl 1999; Carrillo and Aparicio 2001). In our study, the incubation period varied from 26 to 29 days, with an average of 27.7 ± 1.3 days. These results are consistent with those of other researchers, notably in South Africa and Western Europe, where females incubate their eggs for around 26 to 27 days (Van Zyl 1999; Gensbol 2005). It should be noted that this period can be slightly extended in urban environments, as observed by Kaf et al. (2015).

In the present study, chicks fledged between 27 and 32 days after hatching, in line with previous research (Gensbol 1988; Harrisson and Greensmith 1994). This timing may be intrinsically linked to prey availability, which plays a critical role in the reproductive success of raptors. As highlighted in the literature, raptor productivity often fluctuates according to prey density and climatic conditions (Tornberg et al. 2005; Nielsen and Møller 2006; Lehikoinen et al. 2013). In our context, it is plausible that the observed fledging period coincides with a peak in food availability, enabling chicks to develop the necessary capabilities for flight. Indeed, a high density of prey during the nesting period could promote optimal growth in the young, ensuring adequate nutritional intake.

At all sites studied, the Common Kestrel (*Falco tinnunculus*) pairs frequently fed their chicks a variety of insects, such as orthopterans and beetles, in addition to small passerines and pigeons, in descending order. These results are consistent with those observed in Algeria by Baziz et al. (2001) and Kaf et al. (2015), as well as in Europe (Fattorini et al. 1999; Navarro-López and Fargallo 2015; Carrillo et al. 2017). In other regions, small mammals occupy a special place in the Common Kestrel's diet (Żmihorski and Rejt 2007; Geng et al. 2009; Malher and Magne 2010). However, birds, reptiles and chiropterans can also play an important role as replacement prey when rodents are scarce (Geroudet 1984; Kübler et al. 2005; Souttou et al. 2007). Hence, this analysis highlights the ecological diversity in feeding habits and potential adaptive behaviours of the species based on local prey availability and environmental conditions.

Weather conditions impact the breeding ecology of birds (Mainwaring et al. 2021). In the case of the Common Kestrel, Charter et al. (2007) noted that temperature and rainfall had a significant influence on reproductive success, depending on nest type. However, in our study, the temperature had no influence on the incubation or nesting period, aligning with findings in Italy by Salavati (2002) who noted a minimal effect in reproductive parameters of Common Kestrel. Conversely, studies of Lindström (1999) and Herfindal et al. (2015) have noted the importance of temperature during early life stages and its correlation with reproductive success. Nevertheless, in our result, rainfall was the critical factor affecting incubation dynamics of Common Kestrels. It is totally consistent with previous studies (Costantini et al. 2010; Kreiderits et al. 2016; Huchler et al. 2020). This effect may be attributed to decreased prey availability, as elevated rainfall typically reduced prey activity (Brown 1956), diminished hunting efficiency in kestrels and foraging success (Rijnsdorp et al. 1981; Öberg et al. 2015), affected the reproductive output (Skagen and Adams, 2012) as well as the timing and the location of bird breeding (Hidalgo et al. 2019; Fogarty et al. 2020).

Despite the importance of environmental factors, nest orientation plays a significant role in the reproductive success of the Common Kestrel (*Falco tinnunculus*). Southwest-facing nests have high hatching rates, although a few studies have specifically examined this variable where they show no significant selection of orientation (Sumasgutner et al. 2014). Moreover, Common Kestrels choose nesting sites at a variety of heights, as observed in different studies by Carrillo and Aparicio (2001), Souttou et al. (2005) and Malher and Magne (2010). This diversity of heights offers appropriate protection against predators such as gulls and ravens, which have proliferated in the region due to increase in uncontrolled landfills and the degradation of natural habitats.

Sorace and Gustin (2010) state that urban planning has no impact on the Common Kestrel. However, in some nests monitored during the present study, a significant negative impact of human influence on nest characteristics and, potentially, on their reproductive success rate appears to be a disturbing factor for the nesting of this raptor. Our results confirm those of Carrillo and Aparicio (2001) and Carrillo and González-Dávila (2005), who report that humans are among the predators of this species, its eggs and chicks. Moreover, Fargallo et al. (2001) noted additional cases of predation, which are generally attributed to rats and dormice preyed on eggs in building nests, while corvids, genets, and martens targeted eggs, chicks, and adults in tree nests. Yet, other studies show that nest characteristics significantly influence kestrel breeding phenology and success. For instance, Kreiderits et al. (2016) observed in Australia that kestrels nesting in building cavities lay eggs earlier than those nesting in planters. Additionally, breeding success is generally higher in closed nests compared to open nests (Fargallo et al. 2001; Charter et al. 2007; Kreidertis et al. 2016), likely due to a better protection from predators and extreme weather conditions (Costantini and Dell'Omo 2020).

CONCLUSION

Our study of the breeding ecology of the Common Kestrel over a five-year period demonstrates its vital role in urban biodiversity. Nests were located in a variety of anthropogenic structures, and breeding parameters varied from site to site according to environmental factors. Among these, rainfall showed a moderate influence on the incubation period, suggesting that higher levels may affect kestrel reproductive timing during this stage. The selection of nest orientation towards the southwest has proven to be an advantageous strategy, promoting high hatching rates. This choice of orientation could optimize the thermal regulation of the nests by minimizing exposure to extreme climatic variations. The adaptation of kestrels to nest at various heights is also a key factor in limiting predation, particularly by opportunistic species. This variation in nesting heights provides increased protection against predators and can positively contribute to reproductive success in anthropized environments. These results underline the importance of adapted urban management that takes into account the ecological requirements of this species, by integrating conservation practices that favour the creation of secure nesting niches and the limitation of disturbance factors. Taking these parameters into account could improve the resilience of kestrel populations in habitats increasingly dominated by humans, thereby contributing to their maintenance and adaptation in the face of rapid ecological changes. This calls for preservation actions, such as raising public awareness and habitat management practices. Finally, long-term monitoring of the impact of climate change and food availability merits further study to better understand the bio-ecology of this raptor species in urban environments.

ACKNOWLEDGMENTS

We express our sincere gratitude to the building owners, who generously allowed us access to their private properties for our research on this species' nesting behaviour. Additionally, we extend our thanks to the responsible of the Department of Biotechnology and Agro-Ecology for granting us permission to conduct our study. We are also appreciative of the cooperation from the Soumaa 7 university residence. Lastly, we acknowledge the invaluable assistance provided by Mr Benacherine M. who helped us with our findings.

REFERENCES

Alatalo, R., Höglund, V.J., Lundberg, A.,& Sutherland, W.J.1992. Evolution of black grouse leks: female preferences benefit males in larger leks. *Behavioral Ecology* 3(1), 53–59. https://doi.org/10.1093/beheco/3.1.53

Anushiravani, S., & Sepehri Roshan, Z. 2017. Breeding biology of the common kestrel, *Falco tinnunculus*, at natural nesting sites in the north of Iran (Aves: Falconiformes). *Zoology in the Middle East* 63(2), 176–177. https://doi.org/10.1080/09397140.2017.1299332

Baziz, B., Doumandji, S., & Souttou, K. 1999. Régime alimentaire du Faucon crécerelle *Falco tinnunculus* dans la banlieue d'El Harrach (Alger) [Diet of the common kestrel *Falco tinnunculus* in the banlieue of El Harrach (Algiers)]. *Alauda* 67(4), 342.

Baziz, B., Souttu, K., Doumandji, S.,& Denys, C.2001. Some aspects of the kestrel *Falco tinnunculus* diet in Algeria. *Alauda* 69, 413–418.

Bensouilah,T., Brahmia, H., Zeraoula, A., Bouslama, Z., & Houhamdi, M. 2014. Breeding biology of the European Green finch *Chloris chloris* in the loquat orchards of Algeria (North Africa). *Zoology and Ecology* 23, 199–207. https://doi.org/10.1080/21658005.2014.934514

Bird Life International. 2024. *Falco tinnunculus*. *The IUCN Red List of Threatened Species 2024*. 1:e. T22696362A206316110. https://dx.doi.org/10.2305/IUCN.UK.20213.RLTS.T22696362A206316110.en. Accessed on 16 October 2024.

Blasgosklonov, K., & Sokolov, I. 1987. Guide de la protection des oiseaux [Bird protection guide]. Moscou: Ed. Mir, 232 pp.

Brown, L.E. 1956. Field experiments on the activity of the small mammals, *Apodemus, Clethrionomys and Microtus. Proceedingsof Zoological Society of London* 126, 549–564. https://doi.org/10.1111/j.1096-3642.1956.tb00452.x

Cardozo, S.V., Berto, B.P., Caetano, I., Maniero, V.C., Fonseca, I.P.D., & Lopes, C.W.G. 2016. *Caryospora peneireiroi* n. sp. (Apicomplexa: Eimeriidae) in the common kestrel, *Falco tinnunculus* (Falconiformes: Falconidae), in mainland Portugal. *Revista Brasileira de Parasitologia Veterinária* 25, 202–206. https://doi.org/10.1590/S1984-29612016030

Carrillo, J., & Aparicio, J.M. 2001. Nest defencebehaviour of the Eurasian Kestrel (*Falco tinnunculus*) against human predators. *Ethology* 107, 865–875. https://doi.org/10.1046/j.1439-0310.2001.00718.x

Carrillo, J., & González-Dávilla, E. 2005. Breeding biology and nest characteristics of the Eurasian Kestrel in different environments on an Atlantic island. *Ornis Fennica* 82(2), 55–62.

Carrillo, J., & González-Dávilla, E. 2010. Impact of weather on breeding success of the Eurasian Kestrel *Falco tinnunculus* in a Semi-arid island habitat. *Ardea* 98, 51–58. https://doi.org/10.5253/078.098.0107

Carrillo, J., González-Dávila, E., & Ruiz, X. 2017. Breeding Diet of Eurasian Kestrels *Falco tinnunculus*on the Oceanic Island of Tenerife. *Ardea* 105(2), 99–111. https://doi.org/10.5253/arde.v105i2.a5

Charter, M., Izhaki, I., Bouskila, A., & Leshem, Y. 2007. The effect of different nest types on the breeding success of Eurasian kestrels (*Falco tinnunculus*) in a rural ecosystem. *Journal of Raptor Research* 41(2), 143–149. https://doi.org/10.3356/0892-1016-(2007)41[143:TEODNT]2.0.CO;2

Chen, K.H., Lin, W.L., & Lin, S.M. 2022. Competition between the black-winged kite and Eurasian kestrel led to population turnover at a subtropical sympatric site. *Journal of Avian Biology* 2022 (10), e03040. https://doi.org/10.1111/jav.03040

Core Team. R. 2022. R: A Language and Environment for Statistical Computing. *R Foundation for Statistical Computing*, version 4.2. 2. Vienna. Austria. https://www.R-project.org

Costantini, D., & Dell'Omo, G. 2020. *The Kestrel: Ecology, Behaviour and Conservation of an Open-Land Predator*. Cambridge University Press. https://doi.org/10.1017/9781108692120

Costantini, D., Carello, L., & Dell'Omo, G. 2010. Patterns of covariation among weather conditions, winter North Atlantic Oscillation index and reproductive traits in Mediterranean kestrels. *Journal of Zoology* 280, 177–184. https://doi.org/10.1111/j.1469-7998.2009.00649.x

Costantini, D., Dell'Omo, G., La Fata, I., & Casagrande, S. 2014. Reproductive performance of Eurasian Kestrel *Falco tinnunculus* in an agricultural landscape with a mosaic of land uses. *Ibis* 156(4), 768–776. https://doi.org/10.1111/ibi.12181

Cramp, S., & Simmons, K.E.L.1980. *Handbook of the Birds of Europe, the Middle East and North Africa*. Vol II. Ed. *Hawks to Bustards*. Oxford: Oxford University Press, 695 pp.

Elphick, J., & Woodward, J. 2005. *Oiseaux*. China: Editions Larousse Nature en poche, 224 pp.

Etchecopar, R.D., & Hue, F. 1964. *Les oiseaux du Nord de l'Afrique* [*The birds of North Africa*]. Paris: Ed. N. Boubée et Cie, 606 pp.

Fargallo, J.A., Blanco, G., Potti, J., & Viñuela, J. 2001. Nest box provisioning in a rural population of Eurasian Kestrels: breeding performance, nest predation and parasitism. *Bird Study* 48(2), 236–244. https://doi.org/10.1080/00063650109461223

Fattorini, S., Manganaro, A., Piattella, E., & Salvati, L.1999. Role of the Beetles in raptor diets from a Mediterranean urban area. *Fragmenta entomologica* 31, 57–69.

Fogarty, F.A., Cayan, D.R., DeHaan, L.L., & Fleishman, E. 2020. Associations of breeding-bird abundance with climate vary among species and trait-based groups in southern California. *PLoS ONE* 15, e0230614. https://doi.org/10.1371/journal.pone.0230614

Geng, R., Zhang, X., Ou, W., Sun, H., Lei, F., Gao, W., & Wang, H. 2009. Diet and prey consumption of breeding common kestrel (*Falco tinnunculus*) in Northeast China. *Progress in Natural Science* 19(11), 1501–1507. https://doi.org/10.1016/j.pnsc.2009.03.011

Gensbol, B. 1988. *Guide des rapaces diurnes d'Europe, d'Afrique du Nord et du Proche- Orient* [*Guide to the diurnal raptors of Europe, North Africa, and the Middle East*]. Neuchâtel: Ed. Delachaux et Niestlé, 383 pp.

Gensbol, B. 2005. *Guide des rapaces diurnes:Europe. Afrique du nord et Moyen-Orient* [*Guide to the diurnal raptors of Europe, North Africa, and the Middle East*]. Paris: Ed. Delachaux et Niestlé, 403 pp.

Geroudet, P. 1984. *Les rapaces diurnes et nocturnes d'Europe* [*The diurnal and nocturnal raptors of Europe*]. Lausanne: Ed. Delachaux et Niestlé, 426 pp.

Gjershaug, J.O., Rov, N., Nygard, T., Prawiradilaga, D.M., Afianto, M.Y., Hapsoro, & Suprianta, A. 2004. Home-range size of the Javan Hawk-Eagle (*Spizaetus bartelsi*) estimated from direct observations and radiotelemetry. *The Journal of Raptor Research* 38, 343–349.

Haroun, S.H., & Taha, R.G. 2022. First record and morphological contributions of *Procyrnea leptoptera* (Rudolphi, 1819) (Nematoda: Habronematidae) in the kestrel *Falco tinnunculus* Linnaeus (Falconiformes: Falconidae) from Egypt. *The Journal of Basic and Applied Zoology* 83(1), 35. https://doi.org/10.1186/s41936-022-00295-6

Harrison, C., & Greensmith, A. 1994. *Les oiseaux du monde* [*The birds of the world*]. Paris: Ed. Bordas, 416 pp.

Heim de Balsac, H., & Mayaud, N. 1962. *Les oiseaux du Nord-Ouest de l'Afrique* [*The birds of Northwest Africa*]. Paris: Ed. Le Chevalier P., 485 pp.

Heinzel, H., Fitter, R., & Parslow, J. 1992. *Oiseau d'Europe, d'Afrique du Nord et du Moyen-Orient* [*Birds of Europe, North Africa, and the Middle East*]. Paris: Ed. Delachaux et Niestlé, Neuchâtel, 319 pp.

Herfindal, I., Van De Pol, M., Nielsen, J.T., Sæther, B.E., & Møller, A.P. 2015. Climatic conditions cause complex patterns of covariation between demographic traits in a long-lived raptor. *Journal of Animal Ecology* 84, 702–711. https://doi.org/10.1111/1365-2656.12318

Hidalgo, A.N., Hall, M.L., Kingma, S.A., Van de Pol, M., & Peters, A. 2019. Rapid plastic breeding response to rain matches peak prey abundance in a tropical savanna bird. *Journal of Animal Ecology* 88, 1799–1811. https://doi.org/10.1111/1365-2656.13068

Huchler, K., Schulze, C.H., Gamauf, A., & Sumasgutner, P. 2020. Shifting breeding phenology in Eurasian kestrels *Falco tinnunculus*: Effects of weather and urbanization. *Frontiers in Ecology and Evolution* 8, 247. https://doi.org/10.3389/fevo.2020.00247

Isenmann, P., & Moali, A. 2000. *Oiseaux d'Algérie* [*Birds of Algeria*]. Paris: Ed. SEOP, 336 pp.

Kabeer, B., Bilal, S., Abid, S., Mehmood, A., Asadi, M.A., Jilani, M.J., & Hejcmanová, P. 2021. Determining population trend and breeding biology of common kestrel (*Falco tinnunculus*) at Sir Bani Yas Island of emirates. *JAPS: Journal of Animal and Plant Sciences* 31(2), 596–603. https://doi.org/10.36899/JAPS.2021.2.0247

Kaf, A., Saheb, M., & Bensaci, E. 2015. Preliminary data on breeding, habitat use and diet of common kestrel, *Falco tinnunculus*, in urban area in Algeria. *Zoology and Ecology* 25(3), 203–210. https://doi.org/10.1080/21658005.2015.1057989

Korpimäiki, E., Tolonen, P., & Valkama, J. 1994. Functional responses and load-size effect in central place foragers: data from the kestrel and some general comments. *Oikos* 69, 504–510. https://doi.org/10.2307/3545862

Kreiderits, A., Gamauf, A., Krenn, H.W., & Sumasgutner, P. 2016. Investigating the influence of local weather conditions and alternative prey composition on the breeding performance of urban Eurasian Kestrels *Falco tinnunculus*. *Bird Study* 63(3), 369–379. https://doi.org/10.1080/00063657.2016.1213791

Kübler, S., Kupko, S., & Zeller, U. 2005. The kestrel (*Falco tinnunculus* L.) in Berlin: investigation of breeding biology and feeding ecology. *Journal of Ornithology* 146(3), 271–278. https://doi.org/10.1007/s10336-005-0089-2

Laalou, A., Boulahia, A., Dakki, M.El, Agbani, M.A., & Qniba, A. 2017. Un nid de Faucon crécerelle *Falco tinnunculus* aménagé sur un nid de Cigogne blanche *Ciconia ciconia* délocalisé sur une plateforme artificielle à BirLahmer (Salé) [A kestrel nest *Falco tinnunculus* set up on a white stork nest *Ciconia ciconia* relocated to an artificial platform in BirLahmer (Salé)]. *Go-South Bulletin* 14, 111–112.

Lê, S., Josse, J., & Husson, F. 2008. FactoMineR: an R package for multivariate analysis. *Journal of statistical software* 25, 1–18. https://doi.org/10.18637/jss.v025.i0

Lehikoinen, A., Lindén, A., Byholm, P., Ranta, E., Saurola, P., Valkama, J., & Lindén, H. 2013. Impact of climate change and prey abundance on nesting success of a top predator, the goshawk. *Oecologia* 171, 283–293. https://doi.org/10.1007/s00442-012-2411-z

Lesaffre, G. 2006. *Nouveau précis d'Ornithologie*. Paris: Editions Vuibert, 216 pp.

Lindström, J. 1999. Early development and fitness in birds and mammals. *Trends in ecology and evolution* 14(9), 343–348. https://doi.org/10.1016/S0169-5347(99)01639-0

Mainwaring, M.C., Nord, A., & Sharp, S.P. 2021. The impact of weather on the behavior and ecology of birds. *Frontiers in Ecology and Evolution* 9, 777–478. https://doi.org/10.3389/fevo.2021.777478

Malher, F., & Magne, J.F. 2010. L'urbanité des oiseaux [The urbanity of birds]. *Ethnologie française* 40(4), 657–667. https://doi.org/10.3917/ethn.104.0657

Masman, D., Gordijn, M., Daan, S., & Dijkstra, C. 1986. Ecological energetics of the kestrel: field estimates of energy intake throughout the year. *Ardea* 74, 24–39.

Navarro-Lopez, J., & Fargallo, J.A. 2015. Trophic niche in a raptor species: the relationship between diet diversity, habitat diversity and territory quality. *PLoS One* 10(6), e0128855. https://doi.org/10.1371/journal.pone.0128855

Nielsen, J.T., & Møller, A.P. 2006. Effect of food abundance density and climate change on reproduction in the sparrowhawk *Accipiter nisus*. *Oecologia* 149, 505–518. https://doi.org/10.1007/s00442-006-0451-y

Öberg, M., Arlt, D., Pärt, T., Laugen, A.T., Eggers, S., & Low, M. 2015. Rainfall during parental care reduces reproductive and survival components of fitness in a passerine bird. *Ecology and Evolution* 5, 345–356. https://doi.org/10.1002/ece3.1345

Orihuela-Torres, A., Perales, P., Rosado, D., & Pérez-García, J.M. 2017. Feeding ecology of the Common kestrel *Falco tinnunculus* in the south of Alicante (SE Spain). *Revista Catalana d'Ornitologia* 33, 10–16.

Ouarab, S., Thevenot, M., & Doumandji, S. 2007. Reproduction du Serin cini*Serinusserinus* (Linné, 1766) dans le parc d'El Harrach et aux abords du marais de Réghaïa, Algérie (Aves, Fringillidae) [Breeding of the serin cini *Serinus serinus* (Linnaeus, 1766) in the El Harrach park and the Reserve of the Réghaïa marsh, Algeria (Aves, Fringillidae)]. *Bulletin de l'Institut Scientifique, Rabat* 29, 53–61.

Ravussin, P.A., Arrigo, D., Schaub, M., & Roulin, A. 2007. Succès de la reproduction et taux de survie du Gobemouche noir (*Ficedula hypoleuca)* dans l'ouest de la Suisse, en marge de son aire de répartition [Breeding success and survival rate of the pied flycatcher (*Ficedula hypoleuca*) in western Switzerland, at the edge of its range]. *Nos Oiseaux* 54, 29–40.

Rejt, L. 2004. Variability of the diet of Kestrel *Falco tinnunculus* in Warsaw. *Notatki Ornitologiczne* 45, 215–228.

Riegert, J., Dufek, A., Fainová, D., Mikeš, V., & Fuchs, R. 2007. Increased hunting effort buffers against vole scarcity in an urban Kestrel *Falco tinnunculus* population. *Bird Study* 54(3), 353–361. https://doi.org/10.1080/00063650709461495

Riegert, J., Lövy, M., & Fainov, D. 2009. Diet composition of common kestrels *Falco tinnunculus* and Long-eared Owls *Asiootus* coexisting in an urban environment. *Ornis Fennica* 86(4), 123–130. https://ornisfennica.journal.fi/article/view/133733

Rijnsdorp, A., Daan, S., & Dijkstra, C.1981. Hunting in the kestrel, *Falco tinnunculus*, and the adaptive significance of daily habits. *Oecologia* 50, 391–406. https://doi.org/10.1007/BF00344982

Sale, R. 2020. *The common kestrel*. UK: Ed. Snowfinch Publishing, 392 pp.

Salvati, L. 2002. Spring weather and breeding success of the Eurasian Kestrel (*Falco tinnunculus*) in urban Rome, Italy. *Journal of Raptor Research* 36(1), 15.

Skagen, S.K., & Adams, A.A.Y. 2012. Weather effects on avian breeding performance and implications of climate change. *Ecology and Applications* 22, 1131–1145. https://doi.org/10.1890/11-0291.1

Sorace, A., & Gustin, M. 2010. Bird species of conservation concern along urban gradients in Italy. *Biodiversity and Conservation* 19, 205–221. https://doi.org/10.1007/s10531-009-9716-1

Souttou, K. 2002. Reproduction et régime alimentaire du Faucon crécerelle *Falco tinnunculus* Linné, 1758 (Aves, Falconidae) dans deux milieux l'un suburbain près d'El Harrach et l'autre agricole à Dergana [Breeding and diet of the common kestrel *Falco tinnunculus* Linnaeus, 1758 (Aves, Falconidae) in two environments: one suburban near El Harrach and the other agricultural in Dergana]. Magister thesis, National institute of agronomy, El Harrach, Algeria, 251 pp.

Souttou, K., Baziz, B., Brahimi, R., Doumandji, S., & Denys, C. 2005. Biologie de la reproduction du Faucon crécerelle (*Falco tinnunculus*) dans un milieu sub-urbain à El Harrach (Alger, Algérie) [Breeding biology of the common kestrel (*Falco tinnunculus*) in a Suburban Environment in El Harrach (Algiers, Algeria)]. *Aves* 42(1), 3–21.

Souttou, K., Baziz, B., Doumandji, S., Denys, C., & Brahimi, R. 2006. Analysis of pellets from a suburban common kestrel *Falco tinnunculus* nest in El Harrach, Algiers, Algeria. *Ostrich* 77(3 & 4), 175–178. https://doi.org/10.2989/00306520609485530

Souttou, K., Bazziz, B., Doumandji, S., Denys, C., & Brahimi, R. 2007. Prey selection in the common kestrel, *Falco* *tinnunculus* (Aves, Falconidae) in the Algiers suburbs (Algeria). *Folia Zoologica-PRAHA* 56, 405–415.

Souttou, K., Manaa, A., Baziz-Neffah, F., Sekour, M., Doumandji, S., & Denys, C. 2011. Relations entre les disponibilités trophiques et le régime alimentaire du faucon crécerelle: application de l'indice de selection [Relations between trophic availabilities and the diet of the eurasian kestrel: application of the selection index]. *Sciences and Technologie C, Biotechnologies*, 62–70.

Souttou, K., Manaa, A., Sekour, M., Hamani, A., Denys, C., & Doumandji, S.2015. Importance de la prédation de trois rapaces sur la biodiversité dans des milieux steppiques à Djelfa (Algérie) [Importance of the predation of three raptors on biodiversity in steppe environments in Djelfa (Algeria)]. *Travaux de l'Institut Scientifique, Série Générale* 8, 97–103.

Sumasgutner, P., Krenn, H.W., Düesberg, J., Gaspar, T., & Gamauf, A. 2013. Diet specialisation and breeding success along an urban gradient: the kestrel (*Falco tinnunculus*) in Vienna, Austria. *Beiträgezur Jagd-und Wildforschung* 38, 385–397.

Sumasgutner, P., Schulze, C.H., Krenn, H.W., & Gamauf, A. 2014. Conservation related conflicts in nest-site selection of the Eurasian Kestrel (*Falco tinnunculus*) and the distribution of its avian prey. *Landscape and Urban Planning* 127, 94–103. https://doi.org/10.1016/j.landurbplan.2014.03.009

Telailia, S. 2014. Etude des oiseaux marins et côtiers du Nord Est Algérien :écologie et biologie de la reproduction et impact de l'environnement sur les espèces nicheuses [Study of marine and coastal birds in Northeast Algeria: ecology and breeding biology and the impact of the environment on nesting species]. PhD.Thesis, University Chadli Ben Jedid El-Tarf, Algeria, 210 pp.

Thévenot, M., Vernon, R., & Bergier, P. 2003. *The Birds of Morocco. British Ornithologists' Union, Checklist series* n°20. Tring, UK, 594 pp.

Thiollay, J.M. 2006. The decline of raptors in West Africa: long-term assessment and the role of protected areas. *Ibis* 148(2), 240–254. https://doi.org/10.1111/j.1474-919X.2006.00531.x

Tinbergen, L. 1940. Beobachtungenüber die arbeitsteilung des turmfalken (*Falco tinnunculus*) während der fortpflanzungsziet [Observations on the division of labor of the common kestrel (*Falco tinnunculus*) during the breeding season]. *Ardea* 29, 63–98.

Tornberg, R., Korpimaki, E., Jungell, S., & Reif, V. 2005. Delayed numerical response of goshawk to population fluctuation of forest grouse. *Oikos* 111, 408–415. https://doi.org/10.1111/j.0030-1299.2005.14066.x

VanZyl, A.J. 1999. Breeding biology of thecommon kestrel in southern Africa (32''s) compared to studies in Europe (53''). *Ostrich* 70(2), 127– 13. https://doi.org/10.1080/00306525.1999.9634527

Vasko, V., Laaksonen, T., Valkama, J., & Korpimäki, E. 2011. Breeding dispersal of Eurasian kestrels *Falco tinnunculus* under temporally fluctuating food abundance. *Journal of Avian Biology* 42, 552–63. https://doi.org/10.1111/j.1600-048X.2011.05351.x

Vergara, P., & Fargallo, J.A. 2011. Multiple coloured ornaments in male common kestrels: different mechanisms to convey quality. *Naturwissenschaften* 98, 289–98. https://doi.org/10.1007/s00114-011-0767-2

Village, A. 1990. *The Kestrel*. London: T & D Poyser.

Żmihorski, M., & Rejt, L. 2007. Weather-dependent Variation in the Cold-season Diet of Urban Kestrels *Falco tinnunculus. Acta Ornithologica* 42, 107–113. https://doi.org/10.3161/000164507781646861