Breeding Biology, Chronology, and Reproductive Success of the European Serin (Serinus serinus) at Moulouya High Plain (Morocco)

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The European serin (Serinus serinus) is one of the best examples of a species in the western Palaearctic that has expanded its distribution ranges in current periods. However, the breeding features of serin are not well known and were restricted for some localities, as well as there have not been any deep and comparable studies on its mortality and menacing factors. This study investigates breeding biology, including breeding chronology, nesting strategies, and reproductive success of the European serin in farmland and woodland habitats at Moulouya high plain (Morocco), during 2016. Results showed that, at high-altitude breeding habitats, the European serin started breeding activity lately by 25 April (construction of the first nest) and continued until 19 July (last fledging date). Moreover, most nests (96.42%) were found in farmlands, mainly in apple orchards. Two broods were recorded between April-May and June-July, and the clutch size was an average of 3.04 ± 0.13 eggs/nest. For reproductive success, among the 65 examined nests, 73.84% were active during the nest construction phase and 87.42% of eggs have succeeded during the incubation phase. Reproductive success was higher (93.83%) during fledging. Clutches were failed due to predation (15.9%), nest desertion (14.35%), and destruction of nests (8.88%). Finally, our study highlights that the European serin breeds in high-altitude zones with late and shorter breeding seasons, which might allow this bird to avoid high lands’ vigorous climate conditions and their effect on breeding success.

1. Introduction

Information on breeding biology and reproductive performances of avian species constitutes a central part in the understanding of their population bio-ecology and adaptation, as it permits the academics and wild defenders to identify problems [1, 2]. Equally, it has direct implications in conservation procedures [3]. On the other hand, the study of breeding biology allows to estimate breeding success and productivity, which are likely useful in population dynamics.

The serin (Serinus serinus) is a small, socially monogamous finch [4, 5], common in southern Europe, North Africa, and some western parts of Asia, which sings intensively throughout the breeding period. The serin is one of
the best examples of a species in the western Palaearctic that has expanded its distribution ranges in recent times [6]. The breeding biology, chronology, and success of the serin are not well known and were limited for some localities, and there have not been any comparable studies on its mortality and failure factors mainly in the south of the Mediterranean Basin [7].

In North Africa, the European serin is reported as resident and breeding species [8]. In Algeria, the species is well studied in terms of distribution ranges, habitat use, and breeding seasons [8–10]. While in Morocco, the bird is less studied, and most observations were fragmented in time and space [11, 12]. However, with the recent changes in climatic conditions, intensification of agricultural activities, and illegal capture and trade of wildlife species [13, 14], the knowledge of the features that could impact the breeding performance and survival of this small Fringillidae is urgently required.

In this study, we used field prospects to uncover breeding performances of the European serin in different ecosystems. We analysed the patterns of breeding biology, breeding chronology, and nesting strategies inside farmlands and woodlands. More specifically, we studied nesting trees, nest location, breeding chronology (nest construction dates, laying dates, and hatching dates), and breeding success in orchards and woody vegetation. These aspects are suggested to fill the gap of lacking data about this tiny bird in Morocco and North Africa.

2. Materials and Methods

2.1. Study Area. Fieldwork was conducted in the northwest Moulouya high plain, situated at Midelt Province, Daraa-Tafilalet region, between the High Atlas mountains in the North and Middle Atlas in the Northeast (Figure 1). Geographically, the study zone was at a high altitude ranging between 1300 and 1600 m upon sea level [13]. The Moulouya zone is characterized by a cold arid climate with a mountainous tendency, and the rainfall regime is marked by a monsoonal tendency, and the rainfall regime is marked by a variable and irregular low rainfall; stormy precipitation brings eroded products upstream, the annual average temperature and precipitations being about 29°C and 89 mm successively. Two sites were selected: farmlands including 16 apple orchards and woodlands counting riparian habitats and forest plantation (small islets’ vegetation around agricultural areas) (Table 1).

2.2. Data Collection. Based on results mentioned in [9] and preliminary field prospections during 2015, we searched for nests from early March to late August 2016 by means of parental behavioral cues (mainly, the courtship of the mating birds) and Common Birds Census (CBC) methodology [15], based on both the acoustic calls and the observation of birds during the breeding season. Inside farmlands, nests or breeding pairs were researched line by line based on apple orchards’ tree-lines [12, 15] (Figure 2). In woodlands, nests and breeding birds were searched with a walked transect of five (two to three transects for visit in Tamarix, poplar and wild rose due to their small surfaces) to seven km (~9 transects for visit in Salix dominating the area), from 06.00 to 18.00 hours, based on the surface of each habitat.

We recorded the nest placement (five descriptors: nest height above the ground, nest distance to the central trunk, nest inside or in the periphery of orchard, and nesting-tree) and nest dimension (three descriptors: big diameter, small diameter, and depth). Similarly, breeding chronology (three descriptors: nest construction date (initiation of the first nest per season), laying date of the first egg, and hatching date of the first chick per season), nest status (three descriptors: new-empty, egg incubation, hatching and chick rearing), and failure factors (four descriptors: predation, desertion, destruction (natural and/or human impacts), or death of the clutch) were recorded. However, for nests discovered during the incubation or chick rearing stages, laying date could not be determined with precision. We thus relied on the aspect of eggs or chicks (feathers of nestlings), and we used descriptive accounts from known-aged nests in the same population and area to determine the nest laying date approximately. Similarly, the nature of predators was searched via shell, meat fragments, feathers, fresh animals, and human traces inside or in the vicinity of nests. For example, rats typically leave eggshell fragments, while snakes feed on nests without leaving a trace [16]. To reduce the impact of our investigations on the monitored nests, we used an endoscopic camera to check nest contents, and measurements (nest dimensions) were realised via vernier calipers, during the morning when birds look for food out of the nest. In parallel, climatic conditions (diurnal temperatures and rainfall) were accessed from the Midelt Weather Station during 2016, to assess their impact on breeding chronology.

2.3. Statistics. Statistics were done in STATGRAPHICS Centurion software, version XVI.1, and results were given as sample size and mean ± SD. Moreover, breeding success rates were evaluated by the calculation of success nests (active nests/built nests), hatching eggs (hatched eggs/laid eggs), survived chicks (chicks leaving their nests/fledged chicks) [15–17]. Clutch size was calculated as the number of eggs/total active nests. Preferences toward nesting trees were calculated by percentage (number of nest per supporting tree/all nests).

We checked for normality and homogeneity of variance for all variables via Kolmogorov–Smirnov test. Correlations among breeding chronology parameters (nest construction period (from first nest to the last nest), laying period (from first egg to the last egg), and hatching period (from first chick to the last chick) were tested with Pearson correlation coefficient. To assess differences in breeding success among breeding phases (nest construction, laying, hatching) and among failure factors (predation, desertion, destruction), the ANOVA One way test was used, considering the 16 breeding habitats inside farmlands (for breeding success). We analysed separately the relationship between breeding chronology (depending variables), including nest construction period, laying period, hatching period, temperature, and rainfall (factors) by General linear Model, and all variables with P
values lesser than 0.5 were considered as predicting factors. To investigate the relevance of failure factors to impact the breeding success of the serin, during breeding phases, predation, desertion, destruction, death and unhatched nests were considered as predictors of success (response variables: with 0 (no fledglings produced for nest, no hatching of eggs, no occupation of nest) and 1 (at least one fledgling produced for nest, at least one egg has hatched and at least the nest was occupied for once), then a model with a binomial error structure and logit link function was applied.

3. Results

3.1. Nesting Strategies. At the end of the breeding season, 96.42% of nests \((n = 54)\) were recorded on orchards (50% on Golden delicious \((n = 28)\) nests) and 46.42% Starkrimson delicious \((n = 26)\) nests) and 3.52% woodlands (1.78% on poplar and 1.78% on wild rose) (Figure 3(a)). Moreover, in apple orchards, 81.35% of nests were located in the center of groves, while only 18.64% of nests were located in the periphery \((n = 16\) orchards, \(t = 2.75357\) \(P\) value = 0.013) (Figure 3(b)).

Generally, the Serin’s nests were cup-shaped, with an external diameter of \(8.30 \pm 0.29\) cm \((n = 65\) nests), an internal diameter of \(7.03 \pm 0.29\) cm, and a cup depth of \(5.82 \pm 0.35\) cm. Nest height above the ground was \(214.15 \pm 0.09\) cm and \(95.4 \pm 0.09\) cm \((n = 65\) nests) far from the tree center trunk.

3.2. Breeding Chronology. The breeding chronology of the European serin, including nesting, laying, and hatching dates at Moulouya, is summarized in Figure 4. After the formation of breeding pairs (based on acoustic courtship and visual mating), initiation of nest construction began during the last week of April at Midelt (the first nest was recorded on 25 April), and the nesting period dated from 25 April to 5 July (last new-built nest of the season). In parallel, laying activity was observed on 28 April (the first egg), only three days after the construction of the first nest. The last laying date was on 15 July and the laying period was 78 days. On the other hand, the first observed chick was on 9 May, and eggs’ hatching continues to 19 July. High correlations were revealed among breeding periods (Table 2). However, breeding periods were not influenced by temperatures and rainfall (Table 3). At the end of breeding season, two broods were observed; the first between April and May, and the second between June and July.
3.3. Clutch Size and Breeding Success. In summary, the European serin’s clutch size ranged between three and five eggs with a medium size of 3.04 ± 0.13 eggs. On the other hand, among the 65 recorded nests (Table 4), 73.84% were succeeded (were active during all breeding phases) at Moulouya high plain. During the incubation period, the fledging success rate was more significant, with 87.42% hatched eggs. Equally, during the rearing phase, 93.83% of chicks have survived. In total, success rates were higher during chicks rearing ($n = 15$, $F = 699.14$, $DF = 2$, $P < 0.001$) (Figure 5).

Failure factors were variable (Table 5). In summary, 15.9% of clutches were failed due to predation attacks (7.69% of nests, 4.79% of eggs, 3.42% of chicks), 14.35% of clutches were failed due to nest desertion by parents (10.76% of nests, 3.59% of eggs) and 8.88% of clutch due to destruction of nests (7.69% of nests, 1.19% of eggs) ($n = 15$ orchards, $F = 1.08$, $DF = 2$, $P = 0.349$).
4. Discussion

The study highlights the European Serin’s reproductive biology at Moulouya high plain Morocco, occupying farmlands and woodlands. Though a common species, the study parameters were poorly studied in the area.

To date, it is known that the European serin is a resident-breeding species in Morocco and Algeria [11, 18], since this bird was recorded in forest areas and farmlands, mainly oases [8, 19]. Similarly, in our case, nests of the European serin were found inside orchards and woodlands. However, the higher portion of nests was placed inside apple orchards.
in comparison with woody habitats. The high incidence of Serin inside apple orchards (on Golden delicious and Starkrimson delicious) is related to their abundance in the study area [15, 20]. Additionally, [13] have reported the breeding of Serin in apple orchards in Midelt province. On the other hand, nests were cup-shaped, with small

| Phase   | Parameter     | Number | %    |
|---------|---------------|--------|------|
| Nests   | Total         | 65     | 100  |
|         | Succeeded     | 48     | 73.84|
|         | Predated      | 5      | 7.69 |
|         | Deserted      | 7      | 10.76|
|         | Destructed    | 5      | 7.69 |
| Eggs    | Total         | 167    | 100  |
|         | Succeeded     | 146    | 87.42|
|         | Predated      | 8      | 4.79 |
|         | Deserted      | 6      | 3.59 |
|         | Destructed    | 2      | 1.19 |
|         | Unhatched     | 5      | 2.99 |
| Chicks  | Total         | 146    | 100  |
|         | Succeeded     | 137    | 93.83|
|         | Predated      | 5      | 3.42 |
|         | Died          | 4      | 2.73 |
|         | Deserted      | 0      | 0    |

**Table 4: Breeding success of the European Serin and failure factors at Moulouya high plain.**

**Figure 5:** Comparison (graphical ANOVA) of reproductive success among breeding phases (nest construction, laying of eggs, and hatching of chicks) at Moulouya.

**Table 5:** Failure factors reducing the breeding success (success of chicks = emancipation of chicks, success of eggs = hatching of chicks, success of nests = occupied by the breeders) of the European serin.

| Phase          | Estimate | Standard error | Wald test | P    |
|----------------|----------|----------------|-----------|------|
| Nest construction | Intercept | -0.075        | 0.334     | 2.253| 0.007|
|                | Predation | -0.236        | 0.039     | 6.452| 0.032|
|                | Desertion | -1.043        | 0.057     | 9.765| 0.004|
|                | Destruction | -0.061        | 0.022     | 6.452| 0.047|
|                | Unhatched | -0.021        | 0.028     | 0.243| 0.653|
|                | Scale     | 1.000          | 0.013     |      |      |
| Hatching of eggs | Intercept | -1.164        | 0.432     | 3.321| 0.034|
|                | Predation | -1.522        | 0.027     | 10.634| 0.001|
|                | Desertion | 0.037         | 0.042     | 6.876| 0.030|
|                | Destruction | -0.011        | 0.012     | 0.735| 0.621|
|                | Unhatched | -1.832        | 0.037     | 10.536| 0.001|
|                | Scale     | 1.000          | 0.043     |      |      |
| Emancipation of chicks | Intercept | -1.232        | 0.154     | 2.136| 0.034|
|                | Predation | -2.417        | 0.014     | 9.342| 0.022|
|                | Desertion | -0.052        | 0.041     | 0.152| 0.714|
|                | Died      | -1.062        | 0.003     | 10.016| 0.026|
|                | Scale     | 1.000          | 0.043     |      |      |
dimensions, and were placed at an important height above
the ground to avoid ground stressors [21–23].

Breeding activities of the European serin started during
the last week of April (construction of first nests) at
Moulouya high plain and continued till the second week of
July (the hatching of last chicks). Our results are similar to
those cited in Europe, while they are different from those
cited in North Africa. In Morocco (Marrakech, only 280 km
to Moulouya) and in Algeria (Reghaïa in North), serin
started breeding activities from February and March [8, 11],
which is earlier by two months. On the contrary, in Europe,
mainly France and Spain, the breeding activities of the serin
were between April and May [7, 8, 24], and these are close to
our results. However, the authors of [15, 16] have reported
late breeding dates in other passerines, including the Eu-

5. Conclusion

Our findings highlight four key messages: (1) data indicate
that serin selected farmland habitats for breeding in high-
altitude zones; (2) breeding chronology was late in Moul-
ouya high plain; (3) breeding success was higher in the
studied zone; (4) predation, nest desertion, and destruction
were the most threatening factors to European serin in
Moulouya high plain. Given that European serin is widely
distributed in the Mediterranean zone and western Palear-
tic, more studies on the population size, foraging ecology,
and population trends are needed to establish proper manage-
ment strategies [30].

Data Availability

The data used to support the findings of this study are in-
cluded within the article.

Conflicts of Interest

The authors declare they have no conflicts of interest.

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