Breeding ecology of the Cream-coloured courser Cursorius cursor on a pastureland in the Souss-Massa National Park (West-central Marocco)

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Abstract

This study presents the first data on the breeding ecology of Cream-coloured Courser *Cursorius cursor* in a grazed steppe in West-central Morocco. The egg-laying occurred between early May and July, with most nests found between May and June. The observed mean clutch size (1.86 ± 0.36 SD, n = 21 nests) and mean egg volume index (11.59 ± 1.03 cm^3, n = 39 eggs) were comparable to those recorded in *C. c. exsul* in Cape Verde. Nest survival recorded over the whole incubation period was relatively high.

Introduction

The Cream-coloured Courser *Cursorius cursor* (Latham, 1787) (Charadriiformes, Glareolidae), is the most northerly representative of Cursoriinae and it is adapted to semi-desert and desert environments. The global range of this species extends from Cape Verde, to the Canary Islands, to North Africa, and continues eastward, along the Sahel area to the Middle East, the Arabian Peninsula and northwestern India (Maclean 1996). Despite the lack of comprehensive population size estimates across its geographic range, the species is categorized as Least Concern, although it is presumed that the overall population trend is declining (BirdLife International, 2023). The species is polytypic with three subspecies identified based on morphological differences. The nominate subspecies *C, c, cursor* breeds from Canary Islands to North Africa and through the Middle East (Gutiérrez, 2001; Maclean and Kirwan, 2016). More recently, breeding has been reported for Southern Spain (Cabrera 2022).

In Morocco, the Cream-coloured Courser is known as sedentary or migratory breeding (Thévenot et al. 2003). The core of the population is mainly distributed over large areas of the eastern and southwestern Morocco, including the Atlantic Sahara (Thévenot et al. 2003; Bergier et al. 2022). An estimated population size of 5000 – 15000 pairs was reported in the early 1980s (Bergier et al 2022); however, these estimates was not based on the results of a systematic survey. The species is not considered a target of bird hunters, but rare cases of poaching may occur locally.

Knowledge pertaining to the general ecology of this poorly studied wader (Thomas et al. 2003) is limited to habitat preferences in Canary Islands (Palomino et al 2008) and in arid areas of Morocco (Traba et al. 2013). With the exception of detailed information on the breeding ecology of the endemic subspecies

C. c. *exsul* from Cape Verde (Rice et al. 2020), our understanding of the breeding ecology of this species remains poorly documented (Cramp and Reynolds 1972; Yom-Tov 1989; Thévenot et al., 2003). Therefore, the objective of this study is to provide preliminary investigation on the breeding parameters (clutch size, egg size, egg volume index and hatching success) of the nominate subspecies in semi-arid environment within the Souss-Massa National Park (west-central Morocco). Our results can serve as a fundamental basis for supporting conservation measures.

Materials and methods

Study area

The fieldwork was conducted on a delimited steppe land area of c. 680 ha in the Souss-Massa National Park (SMNP) (30° 05' N, 9° 40' W), located on the Atlantic coast of west central Morocco (Fig. 1). The climate is Mediterranean semi-arid, with an average annual temperature ranging from 14 to 25 °C and a variable mean rainfall rarely exceeding 200 mm/year, concentrated in autumn and spring (Malki et al. 2017). The effects of direct Saharan influence on climate result in a dominance of scarcely vegetated steppe, grazed by sheep, goats and camels.

Data collection

The fieldwork was conducted between the 18th of April and 28th of July in 2018 and from 10th of April to 23th of August in 2021. Potential nesting pairs (spotting broods, birds constantly moving through a plot, adult staying without feeding activity, adults back to the nest, or alarming bird) were searched, during the midday (11h00 -15h00) when parents usually incubate, using binoculars and a telescope Leica Televid (20–60 × 80). During each visit, two observers walking simultaneously travelled at low speed (1-2 km/ day), different routes not fixed in advance, with frequent stops at vantage points to look carefully for pairs. For each located potential nesting plot, we intensively searched for a nest or chicks. In 2021 breading season, we were helped by local shepherds, who provided localization of pairs or nests due to their daily presence in almost all the study area. For each nest found, the date, clutch size and geographic coordinates were recorded, utilizing a GPS device (Garmin Dakota 20). After the clutch was completed, we measured the width and length of all eggs with a digital caliper (to the nearest 0.1 mm). We estimated egg volume index using the formula: $V\ (cm^3) = K_v \times L \times W^2$, where L = length (cm), W = maximum width (cm) and $K_v = 0.5236 - [0.5236 \times 2 \times (L/W)] \times (1/100)$ (Douglas 1990).

For nests with known laying dates i.e. nests found before the second egg was laid, they were checked, from a distance, at least once a day. The incubation duration was determined for nests with known laying dates, or by back-dating with a reference to the incubation duration (19 days; see results). We only recorded clutch size if it remained the same between visits, therefore did not taking into account eggs lost due to predation prior to the first visit or during egg-laying.

Nests were monitored every 1- 3 days and the fate of the nests was evaluated based on the following parameters: “hatched” if at least one egg hatched, “depredated” when fragments of eggshells were found around an empty nest, “abandoned” if no eggs hatched after 20 days and the parents deserted the nest and “unknown” when eggs disappeared, but predation was not confirmed. Trampling was assumed to have happened where crushed eggs and yolk were found in the nest, with footprints of livestock at the nest.

Statistical analyses

The frequency distributions of clutch size in the two years and in two laying periods (May vs June-July) were compared using the Pearson's χ^2 test with simulated p-value based on Monte Carlo simulation with 4999 replicates. We tested the effect of year and laying date on egg volume using a Linear Mixed Model including nest ID as random intercept. The analysis was performed using the R-package *lme4* 1.1.27.1 (Bates et al. 2015). Type II ANOVA with Satterthwaite approximation of the degrees of freedom was used to test the significance of the fixed factors using the R-package *lmerTest* 3.1-3 (Kuznetsova et al. 2017). Model assumptions were visually checked using the R-package *performance* 0.8.0 and 95% confidence intervals were estimated using the R-package *parameters* 0.15.0 (Lüdecke et al. 2020). Marginal and conditional R^2 was calculated according to Nakagawa et al. (2017) using the package *performance*. Predictor effect plots were made using the R-package *sjPlot* 2.8.9 (Lüdecke 2021). Daily survival probabilities of clutches during incubation were estimated using the Generalized Linear Model approach (Rotella et al. 2004) implemented in the program MARK 9.0 (White and Burnham 1999) using the R-package *Rmark* 2.2.7 (Laake 2013). As the sample size was very small, we did not included any covariate in the model. Nest survival over the whole incubation period was estimated by raising the daily survival rate to the power of 19 (i.e. the estimated duration of incubation in days in our population). All statistical analysis were performed in R 4.1.2 (R Development Core Team 2021).

Results

Nesting habitat

Nesting sites were largely confined to relatively flat and barren stony and sandy areas among sparse Yellow restharrow *Ononis natrix* and Strauch-dornlattich *Launaea arborescens,* heavily grazed by sheep and goats. No nests were found either in cultivated or in fenced areas withing the Park. Nests consisted of a small scratch in the ground, without nesting material, but often with some pebbles and small shell fragments around it (Fig. 2).

Egg-laying dates and incubation period

We recorded a total of seven nests in 2018 and 14 in 2021. Egg-laying occurred from the beginning of May (earliest laying date = 1 May (2021) till late July (latest laying date = 18 July 2021). Most eggs were laid between May and June (Fig. 3). The average incubation period was 19.3 ± 0.7 days (Min.: 18 ; Max.: 21 ; n = 9 nests). During the fieldwork, we found parents protecting two recently hatched chicks on 17 May 2021 and two other chicks approximately a week old (age estimated based on their plumage) on 23 August 2021. Therefore, based on the estimated age of chicks, laying may start as early as late April, and it may last until late July.

Clutch size and egg dimensions

The most frequent clutch size was two eggs (mean ± SD 1.86 ± 0.36, range 1-2, n = 21). The frequency of one-egg clutches was very low (1 out of 7 in 2018, 2 out of 14 in 2021) and not significantly different between years ($\chi^2 = 0.00$, df = 1, p = 1) nor between laying periods (May *vs* June–July: $\chi^2 = 0.51$, df = 1, p = 0.59). The mean egg volume index was 11.59 ± 1.03 cm^3. The mean egg length and width were 33.82 ± 1.54 and 26.16 ± 0.89 mm (n = 39 eggs) (Table 1). Egg size tended to be smaller in 2021, even though the difference between years was not significant ($\beta_{Year2021} \pm SE = -1.24 \pm 0.62$, $F_{1,10.972} = 4.09$, p = 0.068). On the other hand, egg volume index significantly declined during the breeding season ($\beta_{Laying\ date} \pm SE = -0.03 \pm 0.01$, $F_{1,11.074} = 6.01$, p = 0.03) on average by about 0.9 cm^3/month (Fig. 4).

Nest survival

Information on nest fate was available for a total of 21 nests. 67% of the monitored nests (2018: 5 out of 7, 2021: 9 out of 14) hatched successfully, three nests were abandoned, two nests were trampled and the fate was unknown for two nests (disappeared) . Estimated daily nest survival over the entire monitoring period was 0.97 (95% CI: 0.91-0.99) which translates in a survival rate over the 19 days of incubation of 0.54 (95% CI: 0.16–0.82).

Discussion

This study reports the first detailed, albeit preliminary, data on the reproductive season, breeding parameters and nest survival of Cream-coloured courser in Morocco.

According to Bergier et al. (2022), the populations of the *cursor* subspecies in south-eastern Morocco are partly migratory. In the study area, birds that have wintered elsewhere arrive in the nesting area in March-April and leave in groups from the end of September (M. Aourir & Y. Teyar, pers. obs.). Laying activity occurs between early May and July, with most nests found between May and June. In the Atlantic Sahara (southern Morocco), the species breeds during autumn and winter, in response to heavy rainfall

(Qninba et al 2011; Amezian et al 2014). Based on the spring-early summer nesting activity established both in this study and in north-western Morocco (Rihane et al 2018) and during autumn-winter in the Saharan area (southern Morocco), it is likely that some birds, after breeding in autumn-winter in the south, move to the north of the Sahara to breed again, as suggested by Bergier et al. (2022). In other parts of its breeding range, the *cursor* subspecies breeds mainly from February to June (Cramp and Reynolds 1972; Cramp & Simmons, 1983; Yom-Tov 1989).

The mean clutch size recorded (1.86) was comparable to that recorded in *C. c. exsul* (2, n = 51 nests) in Cape Verde (Rice et al. 2020). The consistent two-eggs clutch trait seems to be an invariant breeding character of the species, uncommon among shorebirds that usually lay four eggs (Maclean 1972; Arnold 1999). The tropical origin of coursers can be a non-exclusive explanation for two-egg clutches, in agreement with Maclean (1972), who reported that of the five families of Charadrii whose clutch size is typically less than four eggs, three are of tropical origin (Glareolidae, Burhinidae and Dromadidae).

While clutch size was similar, the incubation period was consistently shorter than that reported by Rice et al. (2020) in the *exsul* subspecies (18 to 21 versus 21 to 26 day). This reproductive flexibility, already observed in other shorebirds (Amat et al. 2001; Wallander and Andersson 2003), could be explained as an adaptation strategy to cope with the different environmental condition found in the semidesertic habitats of Morocco and the tropical environment of Maio (Cape Verde).

The mean clutch volume (23.64 ± 2.02 cm^3) of the studied population in Morocco was comparable to that reported for *C. c. exsul* populations (24.25 ± 0.32 cm^3) in Cape Verde (Rice et al. 2020). We observed a significant decrease of the egg volume index during the breeding season, averaging at 0.9 cm^3/month, which is consistent with observations in other shorebirds (Kubelka et al. 2019; Teyar et al. 2021). In the Souss-Massa plain, which includes our study area, the abundance of insects significantly declines during the dry and hot season (Ajerrar et al. 2023). Therefore, we strongly suspect that the decline in egg size be related to the decrease in their major food resources (insects) during summer dray season.

The Cream-coloured courser population in SMNP showed a slightly higher nest survival rates (54%) than that reported by Rice et al. (2020) in the *exsul* subspecies (48.1%) in Cape Verde. As the main cause of nesting failure was predation, this finding suggests that courser nests faced a lower risk of predation in our study area. The second leading cause of nest loss was trampling by livestock. Although trampling can affect nest success, grazing can be beneficial to coursers as it reduces vegetation cover, thus facilitating foraging and possibly allowing efficient surveillance for incubating birds (Walters 1984; Palomino et al 2008).

This present investigation represents a first step towards understanding the breeding ecology of the Cream-coloured courser in west-central Morocco. Our data has to be considered preliminary, due to the small sample of nest detected and the lack of standardization of survey methods, which do not make data on, for example, the distribution of laying dates fully comparable between years. Further research is therefore necessary to investigate in particular the effect of habitat characteristics and livestock grazing on the distribution of nests and the breeding success of the species. These data must be considered fundamental for the conservation of the species.

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Figures

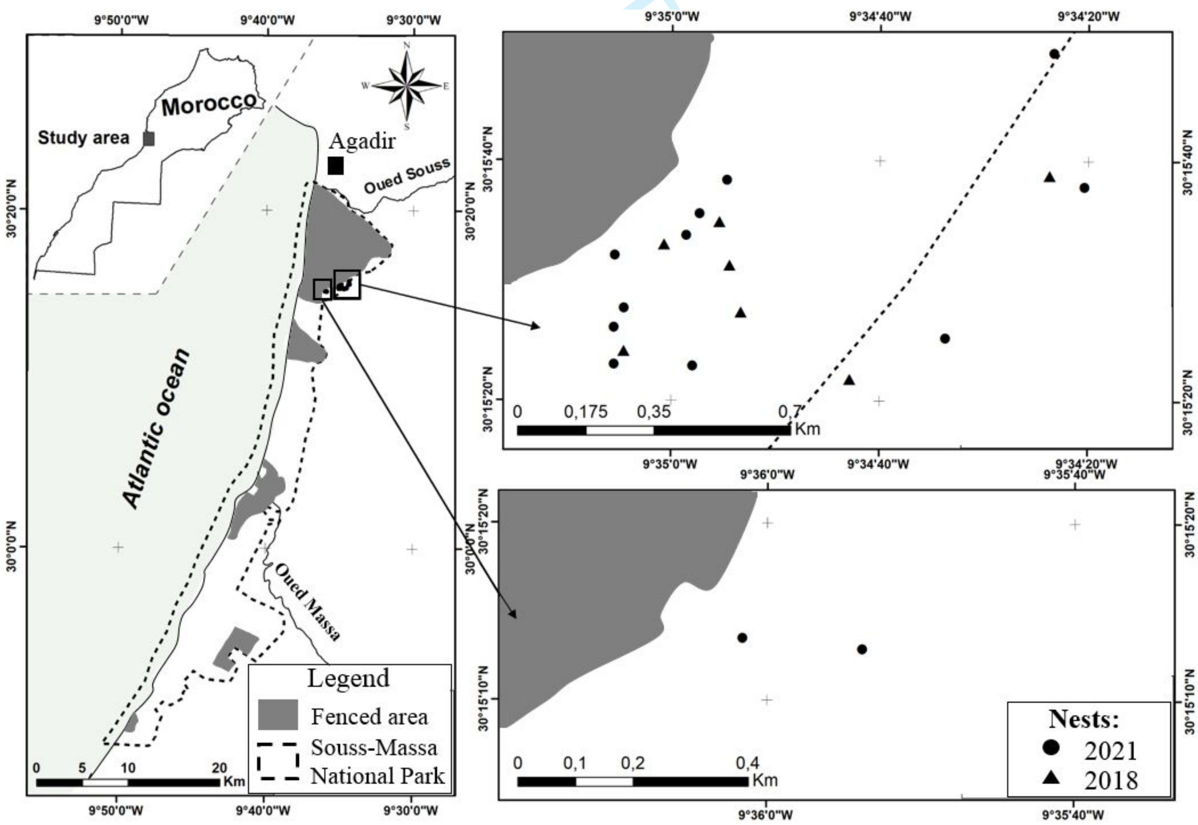

Figure 1. Map of the study area and distribution of Cream-coloured coursers nests found in the two year of monitoring.

Figure 2. Cream-coloured courser nest

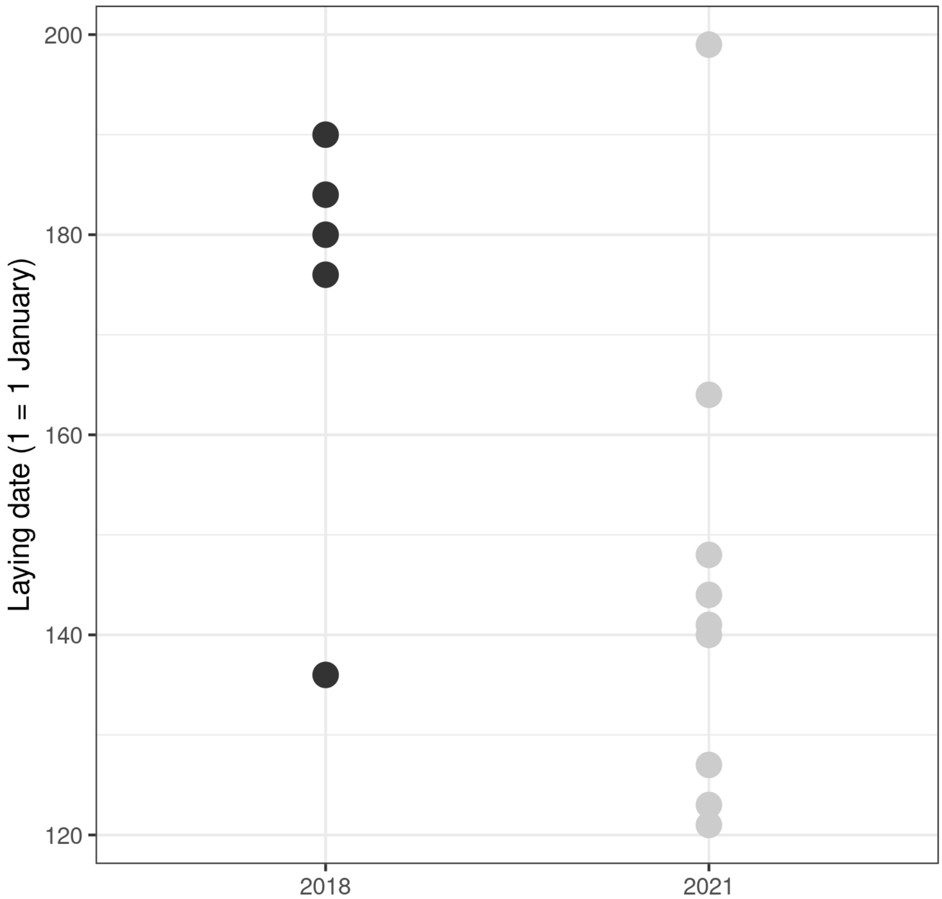

Figure 3. Distribution of egg-laying dates of a sample of Cream-colored coursor nests with known laying and/or hatching dates (5 in 2018 and 9 in 2019) recorded in the Souss-Massa national Park.

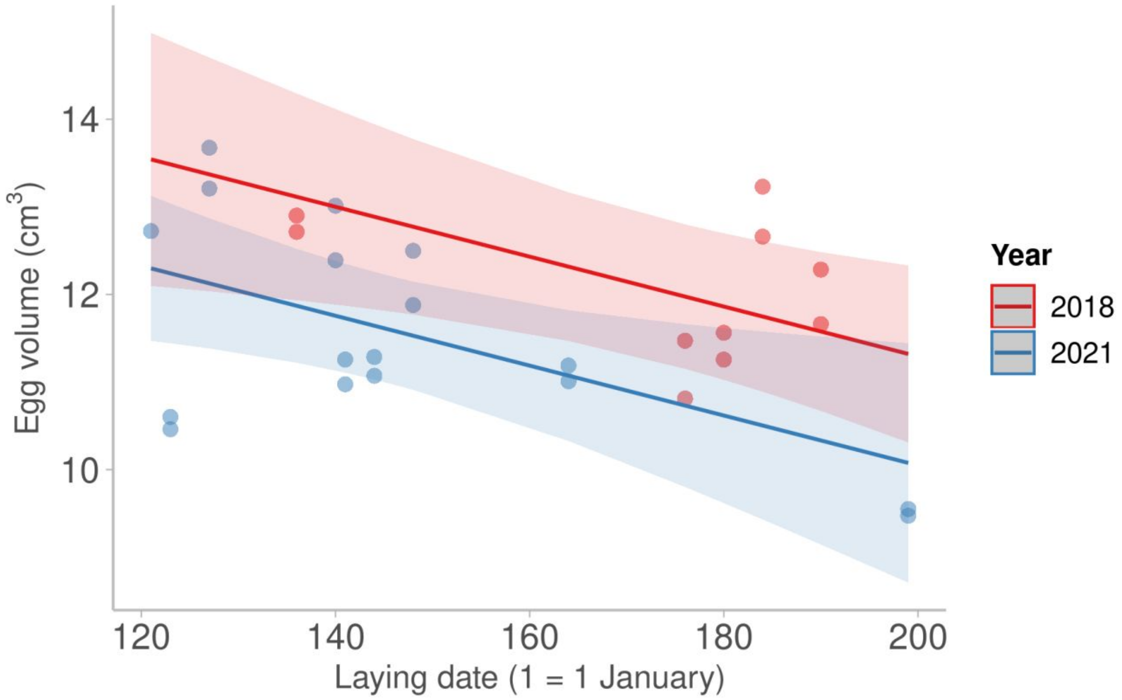

Fig. 4. Relationship between egg volume and laying date estimated from the Linear Mixed Model Egg Volume Index ~ Year + Laying date + (1|NestID). The model was significantly different from the null model (χ^2 = 6.70, df = 1, p = 0.035; conditional R^2 = 0.93, marginal R^2 = 0.33). Shaded area, 95% confidence intervals.

Table 1. Summary statistics (mean ± SD) of egg measurements of the Cream-colored courser recorded in Morocco in two breeding seasons.

Egg trait	2018 (n = 13)	2021 (n = 26)	Total (n = 39)
Length (mm)	33.7 ± 1.29	33.9 ± 1.67	33.8 ± 1.54
Width (mm)	26.5 ± 0.64	26.0 ± 0.97	26.2 ± 0.90
Volume index (cm^3)	12.1 ± 0.76	11.7 ± 1.17	11.8 ± 1.06