Breeding ecology of Algerian woodchat shrikes *Lanius senator*: low breeding success

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A b s t r a c t . Breeding ecology of woodchat shrikes *Lanius senator* was investigated in the EL-Kala National Park in North-East Algeria (36°53'N; 8°30'E) in 1998–1999. *Quercus suber* was the tree species most frequently used as support for nests, which were constructed at a mean height of 5 m. First eggs in clutches were laid 7 May, and clutch size was 4.9. Approximately 42% eggs gave fledglings. Clutch size declined during the course of the breeding season but fledgling success did not. Fledging success was positively correlated with per clutch mean egg length and the height of the nest location above ground. We suggest that the major selective pressures that shape the life history of Algerian woodchat shrikes are relatively heavy predation and poor food availability.

Introduction

Over most of the Western Palearctic area, populations of the woodchat shrike *Lanius senator* are in decline, and the species is now considered threatened in many countries (S n o w & P e r r i n s 1998) but remains relatively common in the Mediterranean area, including North Africa (S n o w & P e r r i n s 1998, I s e n m a n n & F r a d e t 1998, B e n y a c o u b & C h a b i 2000). The breeding biology of this species remains poorly known and many aspects require further study.

Reproductive strategies of passerine birds show some consistent patterns, which most probably evolved under selection pressures generated by food and predation (M a r t i n 1995). Food of insectivorous birds is usually abundant and accessible for a rather short period during the breeding season (M a r t i n 1995). Predation on nests is an especially important factor of selection, and its rate is to a large extent associated with nesting sites and sometimes also with time during the breeding season (R i c k l e f s 1969, M a r t i n 1995). Open nests located in bushes or short trees experience particularly heavy predation (R i c k l e f s 1969). As such, a common pattern of decline in clutch size and breeding success has been observed over the course of the breeding season (P e r r i n s 1970, C r i c k et al. 1993), as has careful nest site selection by breeding pairs (M a r t i n 1995).

We aim in this paper to analyse some characteristics of the breeding ecology of the woodchat shrike in Algeria, an area for which detailed data have been so far lacking. The main objectives of this study were to: 1) obtain information on nest location and size, clutch size, egg sizes, nestling growth and fledging success; 2) characterize timing of egg laying and its relation with other life history traits; and 3) investigate whether fledging success is

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related to other life history traits and nest location. Our study raised the important question of whether failure or success of a brood is influenced by bird quality related variables. If so, then we can predict that fledging success of a particular clutch should be positively influenced by nest and nesting characteristics or egg size (c.f. G o o d b u r n 1991).

Material and Methods

The study was carried out in the EL-Kala National Park in North-East Algeria (36°53'N; 8°30'E) over a two-year period (1998–1999). Climatic conditions during April and May of the study were largely similar, with relatively high mean temperature 14–19 °C and rainfall 21–53 mm per month. The study area was extensively cultivated farmland, with non-intensive livestock systems influencing the character of vegetation (B e n y a c o u b & C h a b i 2000). The study site was located amongst the mosaic of degraded forest habitats with *Quercus suber* dominating and concurring with shrubs of *Myrtus comunis*, *Rubus ulmifolius*, *Pistacia lentiscus*, *Calycotome villosa*, *Daphne gnidum*, *Erica arborea*, *Genista tricuspidata*, *Lolium multiflorum*, *Lythrum hypossopifolia* and others.

Searching for nests started in February and was conducted at least once a week. Thirty-nine initiated clutches of the woodchat shrike were monitored during the course of nesting (23 nests in 1998 and 16 in 1999) every 1–5 days, more frequently during the expected time of hatching and the nestling period. As the search for nests within the forest patches studied was detailed, it is unlikely that any initiated woodchat shrike clutch could remain non-recorded in the study area. Consequently, we were able to consider a within-clutch proportion of eggs, which produced fledglings as a simple measure of fledging success.

The nesting tree/shrub species were determined in 1998 (n = 22 records, 1 record lost). In 1998–1999, tree height and the height of nest location were measured (with n = 37 records of nest location height), with n = 27 of the nests measured to the nearest mm (external diameter, nest cup diameter and depth). The sample sizes differ for different variables due to subsampling or incompleteness of records. All of the initiated clutches were controlled to record the date of the onset of egg laying, clutch size, the number of fledglings and losses at different stages. Egg dimensions were measured in a subsample of clutches to the nearest 0.1 mm with calipers: egg length (L) and breadth (B). These measurements were used to calculate egg volume (V) and egg shape (ES) according to the formulas: $V = 0.000507*L*B^2$ (H o y t 1979), and $ES = B/L*100\%$. All characteristics related to egg dimensions are presented as means per clutch to avoid the non-independence of egg traits within clutches (B a ń b u r a & Z i e l i ń s k i 1990, 1998, Z i e l i ń s k i & B a ń b u r a 1998). For descriptive purposes, we also studied the growth of nestling woodchat shrikes. In 16 broods, the growth of nestlings was monitored by weighing a random nestling from a brood, from the day 1 to 13 of the nestling life (3–7 nestlings from different broods per day).

The data were analysed by standard parametric and non-parametric methods (S o k a l & R o h l f 1995). In the analysis of the within-clutch proportion of eggs that produced fledglings (binomial error), the generalized linear model approach was applied (D o b s o n 1990). Original nest characteristics were used to calculate principal components for further analysis. Split-linear regression was conducted following K o v á č et al. (1999). All analyses and calculations were carried out using MS Excel and STATISTICA 5.5 (S t a t S o f t 1997).

Results

Sixteen or 69.57% ± 9.59 (SE), of the 22 nests analysed in 1998 were constructed on *Quercus suber*, 2 on *Fraxinus angustifolia*, 2 on *Crategus monogyna*, 1 on *Olea oleaster* and 1 on *Pyrus communis*. Woodchat shrikes tended to select trees rather than bushes on which to construct a nest; nest height varied greatly (Table 1).

Table 1. Nest site and nest characteristics of woodchat shrikes in 1998–1999 in Algeria.

Variable	n	Mean ± SD	Median	Min	Max
Nesting tree height (m)	35	6.4 ± 2.7	5.9	2.5	16.0
Nest site height (m)	37	5.1 ± 1.6	5.0	1.7	9.0
Nest external diameter (mm)	27	119.6 ± 15.3	119.7	91.8	160.0
Nest cup diameter (mm)	27	77.6 ± 5.7	78.0	50.0	90.0
Nest cup depth (mm)	27	54.4 ± 8.3	55.0	47.0	90.0

No significant difference in the distribution or mean value of the date of the onset of laying was recorded between 1998 and 1999 (Kolmogorov-Smirnov test: P > 0.1; Mann-Whitney test: P = 0.31). No between-year difference in clutch size, fledgling number or egg traits (length, breadth, volume, shape; 56 eggs in 11 clutches in 1998 and 40 eggs in 7 clutches in 1999; mean clutch size in the subsample: 5.3 ± 0.2 SE) was found (Hotelling T test: P = 0.60; individual t tests with separate variance estimation: 0.11 < P < 0.56). Consequently, pooled characteristics are presented hereafter (Tables 2 and 3). Incubation lasted 15–17 days, mean 15.7 ± 0.2 (SE), from the moment of having laid the last egg in the clutch.

Clutch size was negatively correlated with laying date (r = -0.62, n = 35, P < 0.0001) (Fig. 1). Successful and non-successful broods did not differ in the date of laying (Mann-

Table 2. The date of the onset of laying, clutch size and the number of fledglings in woodchat shrike broods in 1998–1999 (pooled) in Algeria.

Variable	n	Mean ± SD	Median	Min	Max
Laying date	39	7 May ± 11.37	4 May	13 April	11 June
Clutch size	35	4.91 ± 1.01	5.00	3	6
Fledgling number	35	2.14 ± 2.40	0	0	6
Fledgling number (non-0)	17	4.41 ± 1.28	4	2	6

Table 3. Characteristics of eggs of woodchat shrikes in 1998–1999. Per-clutch mean values for 17 complete clutches included.

Variable	Mean ± SD	Median	Min	Max
Egg length (mm)	22.9 ± 0.65	22.9	21.7	24.1
Egg breadth (mm)	16.7 ± 1.06	16.9	13.4	17.6
Egg volume (cm^3)	3.0 ± 0.40	3.1	1.8	3.5
Egg shape	72.9 ± 4.08	73.2	61.2	78.9

Whitney test: P = 0.46). A generalized linear model with laying date as the independent variable and fledging success (binomial error) as response variable showed no relation between these two variables (χ^2: P = 0.30).
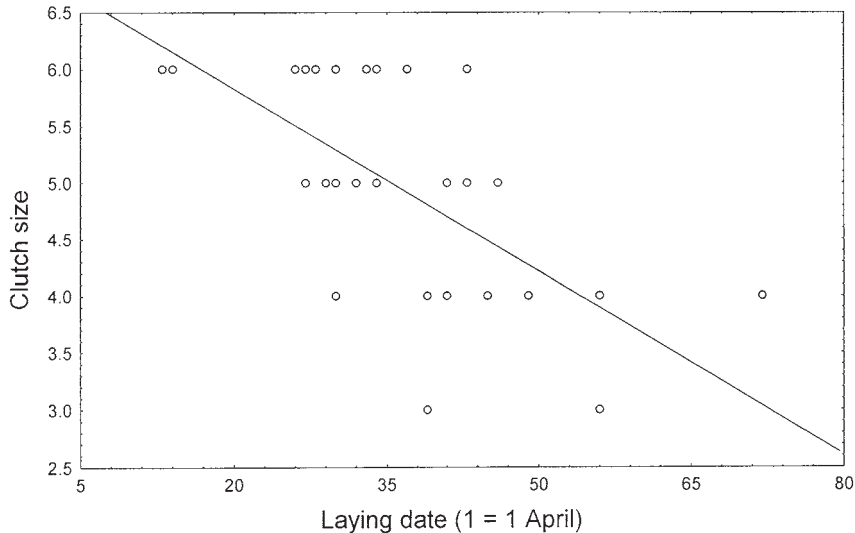

Fig. 1. Relationship between clutch size and the onset of egg laying in the woodchat shrikes studied in 1998–1999.

Seventy-five of 178 eggs gave fledglings (42.13% ± 3.71 SE), and 17 out of 39 clutches (43.59% ± 7.94 SE) gave at least 2 fledglings (Table 2). So, most breeding attempts failed (56.41 % ± 7.94 SE): 20.51% ± 6.46 (SE) of the 39 initiated clutches were abandoned at different stages of egg laying and incubation probably due to predation; 25.64% ± 6.99 (SE) of the clutches were completely destroyed by human or animal predators; 2.56% ± 2.53 (SE) were completely destroyed at the nestling stage; and 7.69% ± 4.27 (SE) were completely destroyed at the stage of nestlings after first having partially destroyed eggs (n = 39). Partial destruction occurred in 10.26% ± 4.86 (SE) at the stage of eggs and in 7.69% ± 4.27 (SE) at the stage of nestlings (n = 39). We found no breeding losses caused by bad weather.

Mean egg size positively influenced fledging success (generalized linear model: χ^2_1 = 39.34, P < 0.0001); mean egg length in successful clutches was 23.25 mm ± 0.21 (SE) as compared with 22.58 mm ± 0.18 (SE) for clutches that failed to produce any fledglings. A generalized linear model with nest and nest site characteristics as independent variables and fledging success as response variable showed that the height of the nest location above ground positively influenced fledging success (χ^2_1 = 14.77, P = 0.0001), whereas neither nest characteristics nor the height of the nesting tree were related to fledging success (NS). Nests that produced no fledglings were generally constructed at a lower height than successful nests: 4.73 m ± 0.40 (SE) v. 5.68 m ± 0.25 (SE).

Growth of nestlings was fast and roughly linear during the first 9 day period (slope = 2.83 ± 0.11 SE), then markedly slower reaching fledging mass (slope = 0.92 ± 0.38 SE), as shown by the split-linear regression (Fig. 2). Day 9 ± 0.59 SE is the breakpoint of the split-linear regression line. The split-linear regression accounted for more variation (R^2 = 0.95)

than a simple linear regression ($R^2 = 0.94$) or a quadratic regression ($R^2 = 0.92$) which were analysed for comparison (F tests: $P < 0.001$).
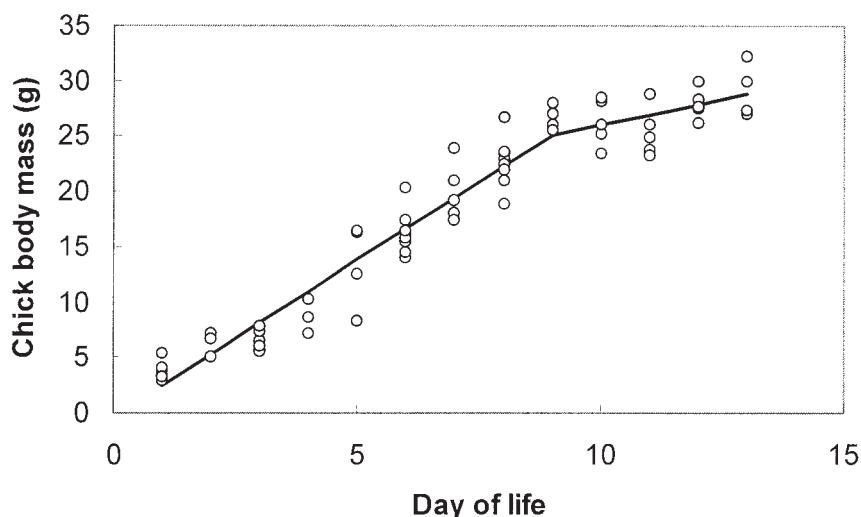

Fig. 2. Growth of woodchat shrike chick body mass with a split regression curve shown.

Discussion

Woodchat shrikes nested mostly on *Quercus suber* in our study area. This corroborates suggestions that open *Quercus* forests are the species' preferred habitats, where available, in the Mediterranean area (S n o w & P e r r i n s 1998). I s e n m a n n & F r a d e t (1998) suggest that woodchat shrikes generally use the most abundant tree or bush species, so that the selection of the nest site is rather opportunistic. The tree or shrub species that support shrike nests constrain the possible range of height at which the nests are constructed. As in most of the species' breeding area, woodchat shrikes constructed nests at a mean height of about 5 m (G u s e v & B e d n y i 1961, A d a m i a n 1964, U l l r i c h 1971, H u d e c et al. 1983, C r a m p & P e r r i n s 1993, B o n a c c o r s i & I s e n m a n n 1994). However, this mean value is much higher than that of another Algerian population studied near Tizi Ouzou, 2.62 m (M o a l i et al. 1997). Nest external diameter was relatively low in our study area, whereas the diameter and depth of nest cup were similar to the values reported in other studies (H u d e c et al. 1983, C r a m p & P e r r i n s 1993). Also, egg dimensions in our woodchat shrike population were within the range reported for different parts of the species' area (G u s e v & B e d n y i 1961, E t c h e c o p a r & H u e 1964, H u d e c et al. 1983, C r a m p & P e r r i n s 1993).

In many areas of woodchat shrike distribution, a mean clutch size is > 5 eggs, but a mean clutch size of 4.75 has also been reported (I s e n m a n n & F r a d e t 1998, G u e r r i e r i & C a s t a l d i 2000), so that the value of about 4.9 recorded in our study is within this range. Typical of single–brooded passerines (P e r r i n s 1970, C r i c k et al. 1993), Algerian woodchat shrikes showed a seasonal decline in clutch size. However, the timing of breeding did not have any effect on nest or fledging success. In our study area, laying eggs started at similar time as in the Tizi Ouzou (M o a l i et al. 1997), but earlier than in southern France (I s e n m a n n & F r a d e t 1998).

Nest predation is known to cause relatively low breeding success in different woodchat shrike populations (C r a m p & P e r r i n s 1993; B e c h e t et al. 1998). Predation by animals and humans was also a main factor of breeding failure in our study population in which weather-related causes, important in many shrike populations (e.g. S t a u b e r & U l l r i c h 1970; T a k a g i 2001), seem to play a non-significant role. In French populations, B e c h e t et al. (1998) recorded an even lower breeding success (36.5%) than we observed. Time of the season does not appear to affect nest predation (B e c h e t et al. 1998). A high level of nest loss due to predatory animals is characteristic of the passerines constructing open nests in shrubs (R i c k l e f s 1969, M a r t i n 1995). A similar phenomenon may also occur in species that nest in short trees. Our observation that fledging success is positively correlated with the height at which a nest is located suggests that there may exist a pressure of natural selection to nest higher up within a tree. On the other hand, I s e n m a n n & F r a d e t (1998) and B e c h e t et al. (1998) did not record any relation between breeding success and nest site, including the nest height. This suggests that the existence and direction of the selection pressure to nest higher may be highly site-specific.

Fledging success was also positively related to egg length, which is not reported very often (W i l l i a m s 1994). A possible explanation may be that woodchat shrike pairs of high quality, perhaps old ones, lay bigger eggs, are good at selecting a right location to nest and are better at nest defense against predators. Such effects were described in some avian species such as magpies *Pica pica* (G o o d b u r n 1991).

Comparative data for nestling growth in woodchat shrikes are scarce. G u s e v & B e d n y i ' s (1961) graph is similar to ours in general characteristics, but detailed comparison is not feasible. The shape of the woodchat shrike growth curve may be considered as a version of the typical curve of altricial passerines (c.f. O ' C o n n o r 1984). The curve has one significant break point that divides it into two component lines reflecting two stages of the nestling development (Fig. 2). At the beginning of the first stage nestlings develop their thermoregulatory abilities, which reduces energy loss and thus favours mass gain, which results in the high growth rate. At the second stage, there occurs a decrease in growth rate at about 9 days old, resulting from energy expenditure to plumage development (O ' C o n n o r 1984). The general pattern suggests that nestling shrikes grow as fast as possible to attain adult body mass (30–40 g, S n o w & P e r r i n s 1998). They do not show an excess weight before fledging, which combined with slow growth is very characteristic of many passerines nesting in safe places, such as hole-nesters, especially aerial insectivores (O ' C o n n o r 1984, R e m e ś & M a r t i n 2002).

In summary, the woodchat shrike population studied seems to be exposed to relatively high predation, resulting in low breeding success (B e n y a c o u b & C h a b i 2000). If this pressure were consistent over a longer time range, then some changes in breeding behaviour would be expected (M a r t i n 1995). In general, a tendency to make ontogeny as short as possible would be expected (R i c k l e f s 1969, M a r t i n 1995, R e m e ś & M a r t i n 2002). Nest site choice and nesting behaviour would be predicted to undergo a strong pressure of natural selection. The actual modifications of the breeding strategy, if the predation pressure continued to operate, would be constrained by some genetic and environmental factors. The major environmental constraint in the study area would be a lack of more suitable trees (accessibility and height). This may also explain some discrepancy between the results concerning nest site selection reported in this paper and those shown by I s e n m a n n & F r a d e t (1998) and B e c h e t et al. (1998). We would not predict the

occurrence of a selective predation pressure on the timing of breeding as long as the predation rate is not related to time during the season.

Food is probably also an important factor, influencing both clutch size and breeding success in Algerian woodchat shrikes. In many European areas, woodchat shrikes prey upon lizards and frogs (C r a m p & P e r r i n s 1993). These animals are rarely available in our study site, the diet being composed mostly of insects belonging to Orthoptera and Coleoptera, whose abundance increases seasonally prior to breeding (unpublished observation). This may negatively influence the quality of food preferred by woodchat shrikes. Consequently, we suggest that the major selective pressures that shape the life history of Algerian woodchat shrikes are relatively heavy predation and poor food availability and quality (c.f. M a r t i n 1995).

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