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Breeding biology of the red-backed shrike, *Lanius collurio*, in the Kızılırmak Delta in the north of Turkey

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Abstract: The population trend of the red-backed shrike, *Lanius collurio*, is declining in its range. We studied the breeding biology of this species in the 2011 and 2012 breeding seasons in the north of Turkey. Our study site was an area of approximately 650 ha in the Kızılırmak Delta. Population density was 2.4 breeding pairs (bp)/10 ha and 2.7 bp/10 ha in 2011 and 2012, respectively. Blackberry bushes were used most frequently as nest sites (66%). The mean height of the nests from the ground was 125 ± 39 cm. The mean height of nest plants was 224 cm ± 76 cm. Nest height and nest plant height were positively correlated. We present an inequality of breeding parameters in the two successive breeding seasons. In 2011, the red-backed shrikes arrived at their breeding sites later, began to breed later, laid smaller clutches, and were less productive than in 2012. The main factor of the nest failures was nest predation in the study area. We detected normal second broods (six pairs) and it seems that this case was not exceptional. The Kızılırmak Delta is an important breeding area of the red-backed shrike population and more comprehensive studies are required.

Key words: Red-backed shrike, breeding biology, Kızılırmak Delta, Turkey

1. Introduction

The red-backed shrike, *Lanius collurio*, is a medium-sized, long-distance migratory passerine bird (Harris and Franklin, 2000). It has a wide breeding range across the Western Palearctic (Lefranc and Worfolk, 1997). Due to the severe decline of some shrike species, it has attracted significant attention from conservation biologists (Van Nieuwenhuyse, 1999). Although the main reason for the decline is controversial, habitat loss is the most common explanation (Carlson, 1995). Land-use changes, intensive agricultural activities, and monoculture have contributed to the habitat loss of shrikes (Yosef, 1994).

The red-backed shrikes prefer to breed in bushy pastures and woodlands and at forest edges (Moskát and Fuisz, 2002). They are also regarded as farmland birds (Pärt and Söderström, 1999; Tryjanowski et al., 2002; Roos, 2006; Voříšek et al., 2010). They also breed in forest clearcuttings, especially in northern Europe (Hollander et al., 2011; Söderström and Karlsson, 2011; Lislevand, 2012). The males arrive at their breeding grounds 3–10 days before the females, and pair bonding occurs on the breeding ground (Carlson, 1989; Tryjanowski and Yosef, 2002). The male and the female build an open cup-shaped nest together, usually in the shrubs (Nikolov, 2000). While the female incubates the eggs, the male feeds the incubating female. Both parents look after the nestlings. Red-backed shrikes are single-brooded, but when their nesting attempt fails, they commonly build a new nest and breed again (Horváth et al., 2000).

Although the red-backed shrike breeds almost everywhere in Turkey (Kirwan et al., 1999; Perktaş, 2004), we only have limited information that was obtained from a study on a small population in central Turkey (Şahin, 2007), as well as individual records in various parts of Turkey about the breeding biology of this species (Kirwan et al., 2008). We have no knowledge about the reproductive success of this species in other parts of Turkey.

We aimed to contribute to the current literature by investigating the breeding biology and nest site selection of the red-backed shrike in the Kızılırmak Delta in northern Turkey.

2. Materials and methods

2.1. Study area

The Kızılırmak Delta is on the coastland of the Black Sea region in northern Turkey. It consists of different habitat

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types and hosts populations of a large number of bird species (Hustings and Van Dijk, 1994). The Kızılırmak Delta was identified by BirdLife International (2015) as an Important Bird and Biodiversity Area (IBA). The study area is located at the eastern part of the delta (41°39′N, 36°04′E).

The main study plot was a grassland area of approximately 650 ha with bushes between Cernek Lake and the shoreline. There were some small marshes and water channels, which shrank or dried up in the summer. Dominant perennial plants were blackberry bushes (*Rubus sanctus*), common hawthorn bushes (*Crataegus monogyna*), rushes (*Juncus sp.*), and common sea-buckthorn (*Hippophae rhamnoides*). There were also daphne (*Laurus nobilis*) and narrow-leafed ash (*Fraxinus angustifolia*) trees in the study area (Sarısoy et al., 2007). In this study plot, human activities were very limited. Field studies were also carried out in a second study plot on a 10-km unpaved road that passed through villages, arable fields, and grasslands. The vegetation was the same as in the main study plot. Water buffalos had been released from neighboring villages for grazing throughout the breeding period of the red-backed shrikes in the study area. Our study area is shown in Figure 1.

2.2. Method

The study was conducted during the 2011 and 2012 breeding seasons. We visited the study area once every 5 or 6 days, and we were in the field for a total of 26 days in 2011 and 24 days in 2012. We searched for the breeding pairs and nests between the beginning of May and the end of July. Population density was calculated as the number of breeding pairs per 10 ha (bp/10 ha). The distribution pattern of the breeding pairs in 2012 was determined with nearest neighbor analysis (Clark and Evans, 1954) using ArcGIS software.

We monitored the pairs that we located. We marked 9 males and 3 females and 5 males and 3 females with colored or alphanumeric rings in 2011 and 2012, respectively. We recorded nest plant species and the orientation of the nests. We measured nest plant height (NPH) and nest height (NH) above the ground with a tape ruler (±1 cm). The females lay an egg per day during the laying period, and the incubation period begins with the penultimate egg and lasts 14 days (Snow and Perrins, 1998). Initiation of the laying period and hatching time for the nests located during the nestling period were determined by counting backwards. We estimated the age of the nestlings by using the photographs of Olsson (1995), as well as the photographs of the nests that we had monitored from the beginning. The clutches that initiated after 10 June were considered late clutches, and these had experienced replacement and delayed clutches (Kuźniak, 1991). We calculated the clutch size of the nests at the egg stage by assuming that there was no individual egg loss in the broods. Nests that contained eggs but were only seen once, as well as nests where the female did not sit on the eggs, were excluded from the calculation. Hatching success was given as the percentage of eggs that hatched (Yosef,

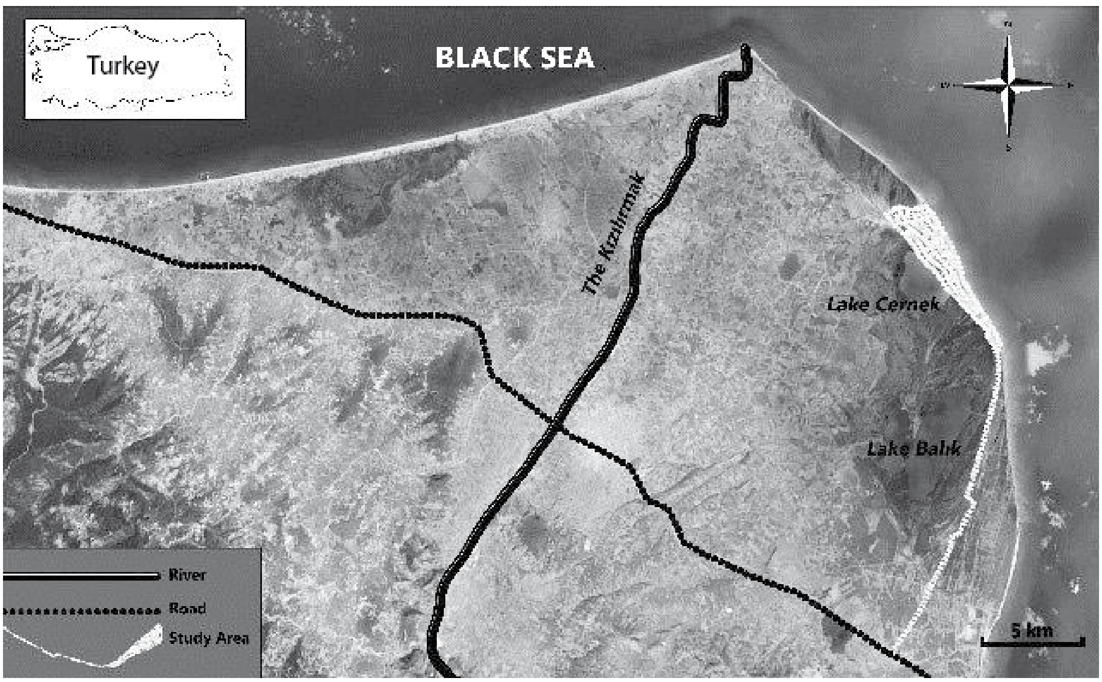

Figure 1. Study area (shaded part).

2000). If a pair produced at least one fledgling in any of its breeding attempts, it was regarded as 'successful', and breeding success was calculated as the ratio of successful pairs (Diehl, 1995). We assumed that the nests where at least one chick fledged were successful. When we calculated nest success, namely the ratio of successful nests, we used the nests that we had monitored since the building stage. To make use of the data from the nests that had been found at the incubation or nestling stage, we also calculated nest success according to the Mayfield method. Daily survival rates of the nests were calculated for the incubation and the nestling period (Mayfield, 1961, 1975). It was assumed that the incubation and nestling periods were 14 days each (Snow and Perrins, 1998).

The causes of nest failure were grouped into 5 categories: predation (nests with broken eggs or missing eggs/nestlings), unsuccessful incubation (the female incubated the eggs, but hatching did not occur), desertion (intact but cold eggs in the nest), human impact (nest ruined by local people), and unknown.

According to the Turkish State Meteorological Service, in April and May 2012 the study area was remarkably drier and 3–4 °C warmer than in 2011.

2.3. Statistical analysis

All the quantitative results were presented as mean values ± standard deviations. Statistical analyses were carried out using Minitab 16. We tested the normality of the data with the Anderson–Darling test. When the data were normally distributed, we performed parametric tests; otherwise we used nonparametric tests. To investigate the relationship between NH and NPH, we used Pearson correlation analysis and simple linear regression analysis. In the regression analysis, we assumed that NH was the dependent variable. The relationship between clutch size and laying time was tested using Spearman rank correlation analysis. We tested whether the clutch sizes and laying times were different in the two study years by using the Mann–Whitney U test. We used the Z test to test whether the hatching success, nest success, breeding success, and frequency of nest plant species were different in the two study years. The relationship between nest plant and nest success was tested using the chi-square test.

3. Results

The first individual was seen on 11 May 2011 and 2 May 2012 in each breeding season in the study area, respectively. Population density was 2.4 bp/10 ha and 2.7 bp/10 ha in 2011 and 2012, respectively. Breeding territories were distributed in clusters (Z = –1.69, P = 0.09) in 2012.

In 2011, we monitored 38 breeding pairs and found 55 of their nests. In 2012, we monitored 46 breeding pairs and found 53 of their nests.

3.1. Nest site

The nests were built on 7 plant species (n = 108). These supporting plants and their usage frequencies are shown in Figure 2. Blackberry (*Rubus sanctus*) was the nest plant that was used most often by the shrikes (66%). Most nests were oriented toward the south (28%), southeast (25%), and southwest (13%). A total of 19% of the nests were in the center of the supporting plants, whereas the others were orientated toward the east, west, or north (n = 53). The distribution of the locations of the nests is shown in Figure 3.

The average height of the nest plants was 224 ± 76 cm (range: 100–649 cm, n = 108). The average height of the nests above the ground was 125 ± 39 cm (range: 56–230 cm, n = 108). There was a strong linear relationship between NPH and NH (r: 0.818, P = 0.000). (Figure 4). According to the regression model, 67% of the NH variation was explained by NPH (F = 212.9, P = 0.000).

3.2. Breeding biology

3.2.1. Laying time

According to the data obtained from 33 nests, the first egg of the 2011 breeding season was laid on 24 May. The laying period started before 10 June in 76% of the nests. According to data obtained from 40 nests, the first egg of the 2012 breeding season was laid on 13 May. The laying period started before 10 June in 73% of the nests. Laying times of the red-backed shrikes are shown in Figure 5. When we investigated only early clutches, laying time in 2011 (median = 28 May, n = 29) was significantly later than in 2012 (median = 21 May, n = 25) (Mann–Whitney U test, U = 148.0, P = 0.000).

3.2.2. Clutch size

Clutch size was 4.41 ± 1.3 (range: 1–6, n = 27) and 5.57 ± 1.03 (range: 2–7, n = 28) in 2011 and 2012, respectively. The

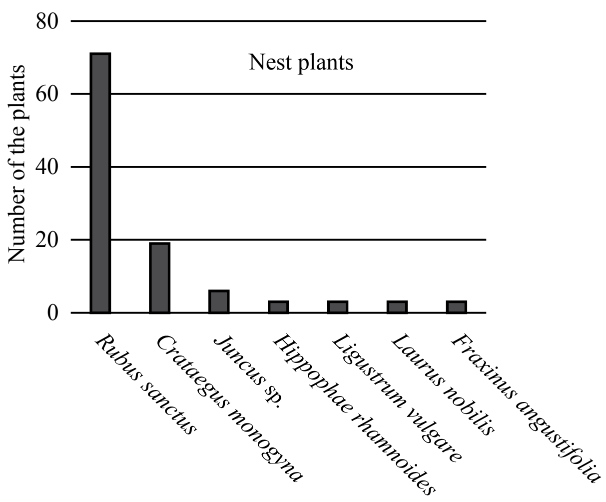

Figure 2. Nest plants of the red-backed shrikes (n = 108) in the Kızılırmak Delta during 2011–2012.

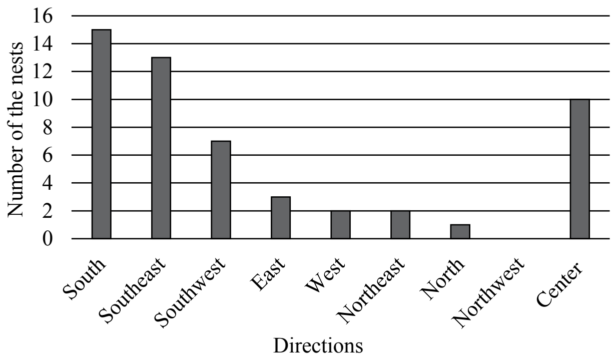

Figure 3. Distribution of the orientations of the red-backed shrike nests in the supporting plants.

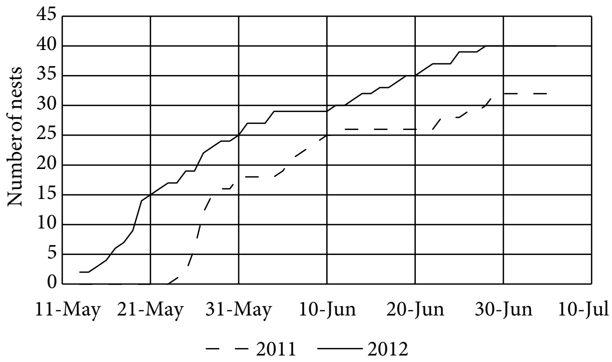

Figure 5. Laying time of the red-backed shrikes.

difference was statistically significant (Mann–Whitney U test, U = 169.5, P = 0.000). The clutch size distributions in the 2011 and 2012 breeding seasons are shown in Figure 6.

In the 2011 breeding season, clutch size was 4.8 ± 1.17 (n = 18) in early clutches, whereas in late clutches, clutch size was 4.0 ± 0.93 (n = 8). Although the difference was not statistically significant (Mann–Whitney U test, U = 38.5, P = 0.055), it was remarkable.

In the 2012 breeding season, in early clutches, clutch size was 5.8 ± 0.81 (n = 22); in late clutches, clutch size was 4.7 ± 1.86 (n = 6). Similar to 2011, the difference was not statistically significant (Mann–Whitney U test, U = 37.0, P = 0.080).

In 2011, as the breeding season progressed, clutch size became smaller (Spearman rank R = 0.601, P = 0.001). However, when late clutches were excluded from the analysis, there was no correlation between laying time and clutch size (Spearman rank R = 0.405, P = 0.107).

In 2012, there was no relationship between laying time and clutch size (Spearman rank R = 0.194, P = 0.342).

3.2.3. Hatching success

In the 2011 breeding season, at least one egg hatched in 70% of the nests (n = 37 nests) and hatching success was 36% (n = 74 eggs). In the 2012 breeding season, at least one egg hatched in 89% of the nests (n = 44 nests) and hatching success was 69% (n = 114 eggs). Hatching success was higher in the 2012 breeding season than in the 2011 breeding season (Z = –4.70, P = 0.00).

3.2.4. Breeding success

Breeding success was 39% (n = 38 bp) and 69% (n = 46 bp) in the 2011 and 2012 breeding seasons, respectively. The difference between the years was statistically significant (Z = –2.80, P = 0.005).

We detected 20 replacement clutches, which belonged to 18 pairs in the two study years. Two pairs built their third nests after two failures. Apart from these, we observed that six breeding pairs (three breeding pairs per study year) bred after a successful breeding attempt, and five of them produced fledglings. In one case, the male of one of these pairs was an individual that we had ringed before. We found a second nest very close to his previous nest in his territory. Although the rest of the pairs were not ringed, there were strong signs that they had a second brood. All of these pairs built the nests of their second broods very close to their first nests (less than 20 m). For example, one pair built their second nest in the same shrub where the first nest had been built. In another two cases, we observed that the males visited their nests immediately after feeding

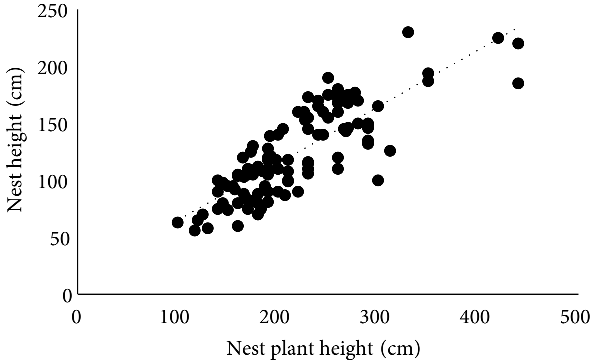

Figure 4. Scatter plot of nest height and nest plant height.

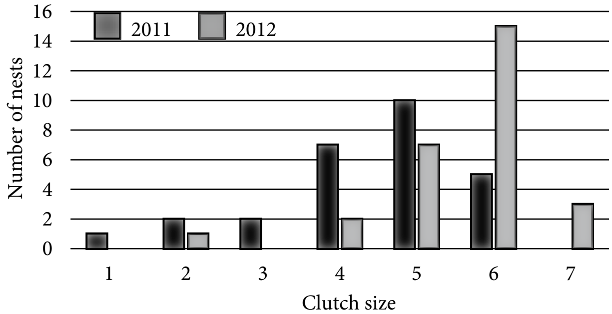

Figure 6. Clutch size distribution of the red-backed shrikes.

fledglings from their first attempts, while the females were sitting on the new eggs or nestlings in their territories.

3.2.5. Nest success

According to the Mayfield method, nest success was 32% (n = 33) and 76% (n = 40) in the 2011 and 2012 breeding seasons, respectively. During the incubation period, the daily mortality rate was significantly higher in 2011 than in 2012 (Z = 2.3, P = 0.021). During the nestling period, the daily mortality rate was also significantly higher in 2011 than in 2012 (Z = 2.13, P = 0.033).

In either study year, nest success in the incubation and nestling periods was not significantly different (2011: Z = −1.12, P = 0.262; 2012: Z = −1.49, P = 0.137).

According to the classical method, nest success was 12% (n = 25) and 38% (n = 13) in the 2011 and 2012 breeding seasons, respectively. The difference between the 2 years was not statistically significant (Z = −1.77, P = 0.077).

3.2.6. Nest failures

Nest predation was the most important factor causing nest failures (55%). The causes of the failures are shown in Table 1.

Despite the high predation rate, we did not witness any predation events, but we did observe potential predators in the study area. These were *Felis silvestris*, *Rattus rattus*, *Corvus corone cornix*, *Natrix tessellata*, and *Natrix natrix*.

In the study area, 28% of nest failures could not be explained. During the nest controls, we did not find any eggs in 11 of 16 nests that we had monitored during the nest building period.

The females produced undersized eggs in two cases. A female incubated only one tiny egg in 2011. The other incubated two tiny eggs in 2012. They sat on the eggs for a time longer than the incubation period.

There was no significant difference between successful and unsuccessful pairs in terms of NPH or NH from the ground in the two study years (Table 2).

Table 1. Causes of nest failure in the red-backed shrike population in the Kızılırmak Delta.

Causes of nest failures	Rate
Nest predation	55%
Unsuccessful incubation	10%
Desertion	2%
Human impact	5%
Unknown	28%

4. Discussion

The population density of the red-backed shrikes in our study area was relatively higher than that of certain other European populations (Lebedeva and Butiev, 1995; Kuźniak and Tryjanowski, 2000; Morelli, 2011; Ceresa et al., 2012). However, there are denser population records from Hungary and Slovakia (Farkas et al., 1997; Baláž, 2007). Breeding territories were distributed in clusters. Kuźniak and Tryjanowski (2000) reported a population in which breeding territories were nearly randomly distributed in a farmland in Poland. This difference may be associated with population size (Van Nieuwenhuyse, 2000).

The red-backed shrikes mostly used sheltering thorny blackberry bushes as their nest plant in the Kızılırmak Delta. This was expected, because this species was the most common plant shrub in our study area, and using thorny shrubs is advantageous for shrikes (Tryjanowski et al., 2000). The red-backed shrikes breed in different types of habitats, and nest plants vary with habitat types (Morelli, 2012). Average NH from the ground (125 ± 39 cm) was higher than that of certain other European populations (Nikolov, 2000; Tryjanowski and Sparks, 2001), lower than some (Tryjanowski et al., 2000), and similar to others (Väli, 2005) in our study area. NH variability in different populations may be due to habitat type differences in breeding areas. The results indicated that there was a positive correlation between NH and NPH. Our study supports the results of Väli (2005) and Lislevand (2012) about the relationship between NH and NPH. Birds build their nests in safe and concealed places (Ferguson-Lees et al., 2011). The safest nesting point in a plant may depend on its height. In other words, the safety of nests built at the same height from the ground but in plants of different height may be different.

Important differences existed between the two study years in terms of breeding phenology and reproduction success of the red-backed shrike in the Kızılırmak Delta. In 2012, they arrived and laid earlier than in 2011. According to the data obtained from the Cernek ringing station, the first individuals were caught between 25 April and 11 May in 2002–2012. The red-backed shrikes were late (11 May) in 2011 in comparison to the other years. Although the Kızılırmak Delta could be a stopover area for some of the individuals that were caught at the ringing station, our observation records coincided with the records of the ringing station.

Similar to some other farmland species, the first arrival dates of the red-backed shrike have shown a trend towards earliness in recent years (Tryjanowski et al., 2002; Cotton, 2003; Jonzén et al.; 2006). Therefore, the delayed arrival in 2011 was interesting. Delayed arrival could be caused by negative conditions in the wintering sites (Marra, 1998) or on the migration route of the migratory birds. Tøttrup et al. (2012) claimed that the 2011 drought in the Horn of Africa, an important stopover area for the red-backed shrikes, was the cause of the delay.

Table 2. The comparison of nest height and nest plant height of the successful and unsuccessful nests using Mann–Whitney U test.

Year		n	NH mean (cm)	SD	U	P	n	NPH mean (cm)	SD	U	P
2011	Successful nests	16	134	39.66	264.5	0.384	16	236	70.6	250.5	0.258
	Unsuccessful nests	39	122	38.25			39	216	62.4		
2012	Successful nests	33	128	40.09	278	0.506	33	222	67.3	313.5	1.000
	Unsuccessful nests	19	119	39.54			19	232	115.8		

Breeding time depends on arrival time (Nikolov, 2000; Smith and Moore, 2004; Söderström and Karlsson, 2011), and the red-backed shrikes have shifted their timing of breeding toward earlier dates (Matyjasiak, 1995; Hušek and Adamík, 2008). Time seems to be a restricting factor for migratory songbird populations. Early breeding is very important for increasing the breeding success of the birds (Newton, 2004; Antczak et al., 2009).

Although the clutch size of the red-backed shrike was similar to that of other European populations (Kuźniak, 1991; Horváth et al., 2000; Nikolov, 2004; Tryjanowski et al., 2006; Baláž, 2007), there was a significant difference between the two study years. In 2011, clutch size was significantly smaller than in 2012. Various factors affect clutch size (Perrins, 1965; Haymes and Blokpoel, 1980; Erikstad et al., 1993, Soler and Soler, 1996; Badyaev and Ghalambor, 2001). Ambient temperature is one such factor (Haywood, 1993). The average ambient temperature in April–June was significantly higher in 2012 than in 2011. We speculated that spring and summer temperature and other associated factors, such as food abundance, could explain at least part of the clutch size difference in our study area.

Clutch size declines throughout the season in red-backed shrikes (Kuźniak, 1991; Olsson, 1995; Antczak et al., 2009). The shrike population showed this trend in the first study year, but not in the second. This may be because of the high clutch replacement rate in 2011. It is known that birds lay smaller clutches in their second nests (Rooneem and Robertson, 1997; Amat et al., 1999; Antczak et al., 2009). Although the size difference between the early and late clutches was not significant, it was notable, particularly in the 2011 breeding season. In addition, when late clutches were excluded from the analyses, there was no relationship between laying time and clutch size in the 2011 breeding season.

Similar to the annual clutch size difference, there was a significant hatching success difference in terms of the ratio of the hatched eggs.

According to the classical method, nest success was higher in 2012 than in 2011; however, the result of the statistical test was not significant. This case probably resulted from being able to watch only a limited number of nests from the beginning, and so we had a small sample size in these calculations.

Mortality rates in the incubation and nestling periods were significantly higher in 2011 than in 2012. This means that, according to the Mayfield method, the second study year was better than the first year in terms of reproductive success of red-backed shrikes.

Although the mortality rate in the incubation period was similar to that of populations in Hungary, Bulgaria, and Poland, mortality in the nestling period was higher in the Kızılırmak Delta in the 2011 breeding season. As for 2012, the successful year, although the mortality rate in the incubation period was lower than in those populations, mortality in the nestling period was not lower (Matyjasiak, 1995; Horváth et al., 2000; Nikolov, 2004). Annual nest success differences are common in red-backed shrikes (Schaub et al., 2011). Nevertheless, our results could be a sign of threats to the nestlings. Especially in the 2012 breeding season, nest success was higher in the Kızılırmak Delta than in some other populations (Horváth et al., 2000; Baláž, 2007).

The most important cause of nest failure was nest predation (55%). When we took into account unexplained nest failures (28% of all cases), we thought that predation pressure could be underestimated. The nest predation rate seemed to be high at the early stage of the breeding cycle (egg-laying period), for which we did not use the Mayfield method calculations because of the small sample size. Moreover, the relatively low nesting success values that we calculated using the classical method are also likely associated with high nest predation in the early stage of the breeding cycle. The high predation rate might be related to high breeding density in the area (Roos, 2002).

Although we observed several potential predators and nest defense behavior against them by the shrikes, we did not observe any predation events directly. The high breeding density and closeness of some nests (e.g., less than 20 m) made us consider the possibility of intraspecies predation (Müller et al., 2005).

We detected three undersized eggs in two nests in the study area. Ash (1970) reported an egg that was 2/3 the size of a normal-sized egg, yet nevertheless experienced hatching. We did not come across any records in other publications of undersized eggs for red-backed shrikes. If long-lasting incubation on infertile eggs (such as tiny eggs) is more common than we observed, its influence on nest success should be examined in future studies.

Breeding success, i.e. the ratio of successful pairs, was higher in the 2012 breeding season than in 2011. If the first breeding attempt failed, a replacement clutch was done. It is known that the red-backed shrike is a single-brooded passerine (Horváth et al., 2000; Goławski, 2006). Double brooding is a rare case in this species (Lefranc and Worfolk, 1997; Müller et al., 2005; Hollander et al., 2011). We recorded normal second broods in the study area in both years. It seems that the normal second brood is not an exceptional case. There is a clear need for marking the shrikes individually to define the exact second brood rate.

In 2011, the year in which delayed arrival and delayed laying occurred, the clutch size, hatching success, nest success, and breeding success were lower than in 2012. The relationship between laying time and reproductive success was emphasized in some publications (Hušek and Adamík, 2008; Verhulst et al., 1995). These annual disparities could be connected to the climatic difference between the study years (Schaub et al., 2011; Søgaard Jørgensen et al., 2013).

The Kızılırmak Delta is an important breeding area for red-backed shrikes. Unlike some other red-backed shrike populations, the size of all the nestlings in the nests was similar and they had a healthy appearance (Müller et al., 2005; Şahin, 2007). Moreover, an increasing food source results in a rise in the second brood rate (Nagy and Holmes, 2005). It seems that the delta provides prey with rich foraging habitats and suitable nest sites for the breeding shrikes. Foraging water buffalos could be supporting the shrike population through preventing the grass from growing longer in our study area. Thus, hunting efficiency of the birds could increase (Yosef and Grubb, 1993). In addition, this area is attractive in the context of the high population density and occurrence of the normal second broods of the red-backed shrikes.

In conclusion, there is a clear need for future research of the red-backed shrikes in this area. These studies would make a significant contribution to the knowledge of population dynamics and life history traits of this species.

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