Ornis Fennica 82:73–80. 2005

Brief report

Reproductive success of the Woodchat Shrike (*Lanius senator*) in Western Bulgaria

Boris P. Nikolov

Nikolov, B. P., Bulgarian Ornithological Centre, Institute of Zoology, Bulgarian Academy of Sciences; 1 Tsar Osvoboditel Blvd., 1000 Sofia, Bulgaria. bnikolov@poshta.net

Received 12 November 2004, accepted 28 February 2005

1. Introduction

The Woodchat Shrike (*Lanius senator*) is a passerine species, which is considered to have undergone a large decline throughout its breeding range in Europe. Its distribution has retracted towards the south and it was recently classified as "Vulnerable" (Tucker *et al.* 1994, Lefranc 1997). In spite of some local declines, southern Europe still holds the bulk of the European population of this species, Spain being the main stronghold (Hernández 1997a,b). Although some new thorough publications exist (Rehsteiner 2001), few profound studies are dedicated on the Woodchat Shrike and its breeding ecology remains insufficiently known (see compilations in Cramp & Perrins 1993, Lefranc & Worfolk, 1997, Harris & Franklin 2000). Most studies have been conducted in Central and Western Europe, some in Northern Africa (Moali *et al*. 1997, Brahimia *et al*. 2003) and Caucasus area (Gusev & Bednyi 1961, Adamyan 1964).

In spite of being widely distributed and locally numerous, still little is known about the Woodchat Shrike on the Balkans. Taking into account the species' slow and gradual range expansion to the north within Bulgaria (Simeonov 1970, pers. unpubl. data), at least moderately high nesting success was predicted, ensuring stable level or slight increase of the population. The present study was undertaken with the purpose to measure some of the Woodchat Shrike reproductive parameters in Western Bulgaria using the Mayfield method (Mayfield 1961, 1975). This would allow a comparison with the few other similar studies on this species (Bechet *et al*. 1998, Isenmann & Fradet 1998, Rehsteiner 2001), thus contributing to a consistency of methods proposed for shrike studies (Horvath *et al*. 2000).

2. Study area and Methods

Data were collected for five consecutive years (1999–2003) with different fieldwork effort, from May to August. The present study was conducted in two localities of Western Bulgaria:

1) Bezden – a village (233 inhabitants on 1 March 2001; Admin. Atlas Rep. Bulgaria 2002) at the foot of karst hills about 35 km NW of Sofia. The study area includes part of the stony slopes (600–750 m a.s.l.) with southern exposure. They are covered by scattered bushy – mainly *Crataegus monogyna* and less *Rosa* sp., and woody vegetation (chiefly *Prunus mahaleb* and *P. cerasifera*). This area is characterized by moderate-continental climate (Stanev *et al*.

1991). Preferred by the Woodchat Shrike plant species as nest-holders in that area (arranged in a descending series) were found *C. monogyna*, *P. mahaleb*, *Rosa* sp., and *P. cerasifera* (pers. unpubl. data).

2) Rupite area – located in the downstream valley of Struma River, about 200 km S of Sofia, just close to the Bulgarian-Greek border. The study area includes the volcanic ridge of Kozhuh (281 m), covered by diverse Mediterranean vegetation. Here, the Woodchat Shrikes use most often for nesting trees *Pyrus amygdaliformis* and *Quercus pubescens*, but also *Ulmus* sp. and *Paliurus spina-christi* (*pers. unpubl. data*). This protected area in climatic aspect falls into the Mediterranean continental-subtropical zone (Stanev *et al*. 1991).

The species appeared on the study sites usually in second or third week of April. About 4–6 days are needed for the pair to build a nest and usually 1–4 days after being constructed, the first egg is laid in it (*pers. unpubl. data*). Hence, I considered a clutch initiated after 1 June 1 as a replacement clutch. Replacement clutches were never laid in the same nests as the first clutches. As complete were considered those clutches, in which all eggs were laid.

Data from 30 nests (6 in 1999, 5 in 2000, 10 in 2001, 8 in 2002 and 1 in 2003) were considered for the present study. No between-year difference in nesting success and breeding success was found (Kruskal-Wallis One Way ANOVA on Ranks $H_4 = 4.00$, $P = 0.41$). Based on the pooled data, the Mayfield (1961, 1975) exposure-day method was used to estimate the probability of survival from the start of incubation to fledging. Except for the Woodchat Shrike (Bechet *et al*. 1998, Isenmann & Fradet 1998, Rehsteiner 2001), this method was recently applied to a number of other species of shrikes: Red-backed Shrike *Lanius collurio* (Payevsky 1985, Matyjasiak 1995, Horvath *et al*. 2000, Nikolov 2004), Loggerhead Shrike *L. ludovicianus* (Brooks & Temple 1990, Tyler 1992, Yosef 2000, 2001), Bull-headed Shrike *L. bucephalus* (Takagi 2001). In addition, different national nest record schemes use the Mayfield method as a tool for estimation of the breeding success of a number of bird species (Matyjasiak 1995, de Nobel *et al*. 2000).

For calculations of the daily survival rates of nests, the analyses adopted 14 days for the incubation period and 13 days for the nestling period (the latter does not include the hatching period of nearly 2 days, for which calculations were performed separately) (Table 1). The length of both periods is estimated on the basis of known data for each nest (date of first egg laid, hatching and fledging dates). The number of successfully hatched eggs is based on the number of nestlings present in the nest when visited for the first time during nestling stage (in most cases 0–5 days after hatching). The number of fledglings is based on the number of nestlings found in the nest during the last visit in its brood stage (usually 0–3 days before fledging), but in several cases it was achieved by their presence in the breeding territory after being already fledged. Hatching success (percent eggs laid that hatched) and fledging success (percent young hatched that fledged), as well as nesting success (number of nests with at least 1 young fledged/ number of nests with at least 1 egg laid x 100) and breeding success (number of all young fledged/ number of all eggs laid x 100) were also determined.

On average 3.4 ± 1.4 (SD) (range 2–7) visits per nest were performed, most nests being checked 3–4 times. All nest failures were registered, and following Yosef (2000) classified as depredated (by mammals – damaged nest structure, or by avian/reptilian predators – intact nest with missing contents) or deserted. In the case of deserted nests the pairs either stayed in the region (sometimes commencing second breeding attempt) or both male and female from a particular pair disappeared. Data are presented as means ± SD and $P < 0.05$ was adopted as the minimum acceptable level of statistical significance.

3. Results

Out of 16 nests found with complete clutches, 3 (18.8%) were replacement attempts after a previous clutch was lost. Clutch size ranged between 5 and 7 eggs (6.0 ± 0.73 eggs; Table 1). The median values of first and replacement clutches did not differ significantly (Mann-Whitney Rank Sum Test, $P > 0.05$). Most of the complete clutches found contained 6 eggs (n = 8, or 50%), followed

Table 1. Breeding parameters and reproductive success of the Woodchat Shrike in Western Bulgaria based on 30 nests (1999–2003) in relation to findings by other studies. The nestling period does not include the hatching period of nearly 2 days, for which calculations were performed separately. See text for further details on the overall probability of survival.

Variables	Studies on the Woodchat Shrike reproductive biology					
	Present study	Rehsteiner (2001)	Bechet *et al.* (1998); Isenmann & Fradet (1998)	Ullrich (1971)	Adamyan (1964)	Gusev & Bednyi (1961)
Average clutch size	6.00±0.73 (5–7; n=16)	5.21	5.14±0.82 (3–7)	5.38	6.03±0.86 (5–7)	6.21 (4–9; n=254)
First clutch size	6.15±0.69 (5–7; n=13)	5.47	5.35±0.71 (n=79 clutches)			
Replacement clutch size	5.33±0.58 (5–6; n=3)	4.70	4.68±0.85 (n=35 clutches)			
Incubation period	14.4±0.9 (n=10)	14	15	14.5–17	17–18	15–17
Nestling period	12.5±1.2* (n=9)	16	17	17 (16–18)	15–16	16–18
No. eggs laid	148	801		553	150	
No. eggs hatched	79			382	119	
No. nestlings fledged	61	309		297		
Daily mortality rate						
Nest-incubation	0.046	0.023	Overall daily mortality rate 0.031			
Nest-nestlings	0.022	0.034				
Per egg	0.002					
Per nestling	0.000					
Daily survival rate						
Nest-incubation	0.954	0.970–0.988	Overall daily survival rate 0.969			
Nest-nestlings	0.978	0.937–0.984				
Per egg	0.998					
Per nestling	1.000					
Survival estimate						
Nest-incubation	0.515					
Nest-nestlings	0.752					
Per egg	0.977					
Per nestling	1.000					
Probability of survival						
P_{egg}	0.503					
$P_{hatching}$	0.649					
$P_{nestling}$	0.752					
Overall probability of survival (%)	24.6	40.6	36.5			

Table 2. Number of nests lost during all stages of the Woodchat Shrike nesting attempts in Western Bulgaria due to predation, inclement weather and human interference (total sample n = 30 nests). As numerical values in parentheses data from Bezden (left side) and Rupite area (right side) are shown respectively.

Stage	Birds/ Reptiles	Mammals	Weather/Humans (deserted nests)	Total
Nest-construction	–	–	3 (3/0)	3 (3/0)
Egg-laying	2 (0/2)	2 (1/1)	–	4 (1/3)
Incubation	8 (5/3)	1 (0/1)	–	9 (5/4)
Nestlings	1 (1/0)	–	2 (2/0)	3 (3/0)
Total	11 (6/5)	3 (1/2)	5 (5/0)	19 (12/7)

by those with 5 and 7 eggs (n = 4, or 25% each).

A total of 148 eggs were laid, 79 (53.4%) of them hatched successfully, and 61 of the young hatched (77.2%) fledged successfully. Incubation period lasted between 12 and 15 days. The average probability of the nest surviving the initial stages was 0.515 and that of an egg surviving the incubation period to hatch was 0.503 (Table 1).

At least one egg hatched in 51.9% of clutches. The average nestling period was 13 days (range 11–14.5), the average probability of an egg hatching was 0.649 and the average probability of a nestling surviving to fledge was 0.752. The overall probability of survival of an egg at the onset of incubation that would result in a fledged young (*e.g.* laid eggs giving rise to fledged young) was 0.246, *i.e.* 24.6%.

Following the classical definitions of estimating the nesting success and breeding success, I found almost similar results – 40.7 and 41.2% respectively. When taken the number of all young fledged in relation to all successful nests (those produced at least 1 fledged young) and to all nests, the resulting picture of the brood size was 5.54 ± 1.37 (n = 11) and 2.03 ± 2.83 (n = 30) respectively.

Nineteen (63.3%) nests were lost, 14 due to depredation, and 5 were deserted because of inclement weather or human disturbance (Table 2). Avian or reptilian predators destroyed 11 (36.7%) of all nests, and mammals only 3 nests (10%). The majority (68.4%) of the nesting attempts failed during the egg-laying stage and incubation. During the stages of nest-construction and nestling period 6 nests were found deserted – 3 (or 15.8%) at each. The percentage of lost nests out of all found per study area varied from 54.5% (Bezden, 12 of 22 nests) to 87.5% (Rupite, 7 of 8 nests).

4. Discussion

In Western Bulgaria, as well as nation-wide, the Woodchat Shrike becomes less frequent from south (numerous) to the north (locally common) (*pers. unpubl. data*). Mirkov (1984) already discussed the breeding ecology of Woodchat Shrikes living in a village neighbouring to the village of Bezden studied here. The mean clutch size of 6.0 found in Western Bulgaria was among the highest throughout the Woodchat Shrike breeding range (Cramp & Perrins 1993, Schön 1994, Rehsteiner 2001). This is probably due to the fact that I only took full (established with certainty) clutches into account, whereas some studies involve clutches even of 2–3 eggs. If all clutches found included, the mean clutch size of the species for the present study would be 5.32 ± 1.39 (n = 22, range 2–7). Larger clutch size is known for the eastern race *L. senator niloticus* inhabiting Caucasus area – mean of 6.21 eggs for Georgia (n = 254 clutches) and in general (4) 5–7 (even 9) eggs in complete clutches from Georgia and Armenia (Gusev & Bednyi 1961, Adamyan 1964).

Although rarely statistically tested, the difference between the first and replacement clutches varies between "less than 1 egg" (Bonacorsi & Isenmann 1994) or "nearly 1 egg" (Isenmann & Fradet 1998) to "nearly 2 eggs" (Gusev & Bednyi 1961). According to Ullrich (1971) the mean clutch size "shrinks" from May (5.7), to June (5.2) and July (4.2). Negative correlation of clutch size with laying date was established also in Northern Africa (Brahimia *et al.* 2003). Half of the complete clutches found in both study sites contained 6 eggs. Almost similar results were achieved in Georgia – 50.5% (Gusev & Bednyi 1961) and Al-

geria – 44% (Moali *et al*. 1997). In contrast to that, Bonacorsi and Isenmann (1994) found that the 6-egg clutches of the Woodchat Shrike in Corsica are only 4.2% of all registered. The nests containing 6-egg clutches are most numerous in mid- and late May, and gradually disappear within first two decades of June (Stauber & Ullrich 1970). It was shown that the first clutches have the same breeding success as the replacement clutches (Bechet *et al*. 1998).

Similarly to other shrike species, it is known for the Woodchat Shrike that a number of replacement nesting attempts occur after failed initial nestings (see Cramp & Perrins 1993). In southern France, 46–47% of unsuccessful pairs were found to renest in two consecutive years (Isenmann and Fradet 1998). The authors considered this percentage of renesting pairs as a minimum value.

The established hatching success in Western Bulgaria (53.4%) is lower compared to that in Armenia – 80.5% (Adamyan 1964). In Northwestern Spain, the percentage of egg hatchability of the Woodchat Shrike (species associated with cultivated areas) was lower than that of the Red-backed Shrike, which inhabits forest edges and countryside (Hernández 1993). The fledging success, recalculated as proportion of eggs produced fledglings was 41.2%, thus being very similar to the respective value of 25.6–46.7% in Spain (Rehsteiner 2001) and slightly lower compared to 60% in Algeria (Moali *et al*. 1997). Nesting success of the Woodchat Shrikes studied here was very similar to that established in Spain (43% mean for three years, Rehsteiner 2001).

For the Red-backed Shrike, Holáň (1993) suggested that the lower number of nestlings in the second (or even third) breeding attempts compensate the losses that occur during the first breeding attempts. It is very likely the same to be valid for the Woodchat Shrike too. Two broods per season have been described for this species, mainly for North Africa and Israel (Cramp & Perrins 1993, Lefranc 1993).

The overall probability of survival was found to be 24.6%. Sometimes the calculations for the hatchling-stage are skipped and only the mean daily survival rate or this parameter separately for the two main – for eggs and nestlings, stages are used (see Isenmann & Fradet 1998, Rehsteiner 2001). The above-mentioned authors got results 36.5 and 40.6% respectively. Making the calculations by this way, I raised the mean daily survival rate of 0.965 (established for the species in Western Bulgaria) to the power of 32 (sum of the egg and nestling period), and the result was 32.5%. When using the more detailed formula, taking into account 19 days for the egg (clutch-size + incubation-time – 1) and 13 days for the nestling period, with daily survival probabilities 0.954 and 0.978 respectively, a result of 30.1% was achieved. Apparently, the final result (24.6, 30.1 or 32.5%) depends very much on the way of calculation of all parameters. To compare the results obtained by the Mayfield method between different studies is difficult without knowing the exact procedure of all calculations.

Quite high rate (63.3%) of nests were lost as a result of predation, inclement weather and human disturbance. Much lower value (30.3%) of nest failures was established in Algeria (Moali *et al*. 1997). Different species of predators negatively influenced nearly half of all nests (46.7%). No predators were directly observed at the nest, but among birds it was most probably the European Jay (*Garrulus glandarius*), and among reptiles – possibly the Green Lizard (*Lacerta viridis*) and, in the Rupite study area, the Four-lined Snake (*Elaphe quatuorlineata*). The first two species are among the potential predators of the Red-backed Shrike nests in Sofia region (Nikolov 2004). At both study sites the Jay is common and the Green Lizard is numerous (*pers. obs*.). The role of corvid birds as nest predators on open-nesting bird species, including shrikes, is widely known (Andrén 1992, Söderström *et al.* 1998, Söderström 2001, Roos 2002). Green Lizards often bask in the sun, lying on branches of bushes and trees, and a female Woodchat Shrike in Bezden area was observed to chase away two lizards in close proximity to the nest inside a bush. Although data about predation of snakes on shrike nests are scarce in Bulgaria to date (Nikolov 2004), the Four-lined Snake (together with other four species of snakes) is a well-expressed ornithophagous species in South-western Bulgaria (Beschkov & Nankinov 1979). The Magpie (*Pica pica*) and the Jay, together with the Green Lizard and several species of snakes, are mentioned by Bechet *et al*. (1998) among the predators exerting influence on the reproductive success of the Woodchat Shrike in Mediterranean

France. Chick predation by snakes (*Malpolon monspessulanus*, *Coluber jugularis*) is known for Israel (Shirihai 1996). In Armenia, only 6.1% of the nests were lost because of predators during the egg-stage (Adamyan 1964), which is very low compared to 43.3% for the same stage in Western Bulgaria.

Another important negative factors was found to be the inclement weather. In Central Europe, inclement weather (cool and rainy season) are considered the main cause for Woodchat Shrike breeding failures (Ullrich 1971, Schön 1994). Not far from the study area a female bird was found to brood already dead nestlings, as a result of bad weather spells (Mirkov 1984). Similarly, in 1999 two nests with dead nestlings (4 and 6 respectively) were found close to Bezden after such period of prolonged and heavy rainfalls. In Armenia 6.7% of the nests during the egg-stage were lost because of inclement weather (Adamyan 1964).

Direct human disturbance is considered not an important factor, negatively influencing the reproductive rates of the Woodchat Shrike in Western Bulgaria. The slopes around Bezden are visited by limited number of shepherds (and rarely mushroom-collectors), on the Kozhuh ridge the human presence is even more restricted. However, for some other shrike species, as in the case of the Red-backed Shrike, the human interference could often has detrimental effect on its breeding success (Knysh 1994, Tryjanowski & Kuźniak 1999).

The higher percent of lost nests in Rupite area (87.5%) in comparison to that in Bezden (54.5%) is probably due to the larger variety of predators (both avian/reptilian and mammalian), in spite of the differences in sample size. In this respect, the region of Rupite is quite similar to Mediterranean France, both of them with rich array of nest predators (Isenmann & Fradet 1998). Probably because of this the nests in Rupite area were placed higher above the ground (2.13 ± 0.89 m; n = 10) compared to those around Bezden (1.60 ± 0.32 m; n = 27); however, this difference was found to be not statistically significant (Mann-Whitney Rank Sum Test, $P > 0.05$). Other studies revealed either positive correlation between fledging success and height of nest location (Brahimia *et al.* 2003) or no relation between these variables (Bechet *et al.* 1998, Isenmann & Fradet 1998). It is known for the Red-backed Shrikes that avoid breeding in areas with high density of corvid predators (Roos 2002, Roos & Pärt 2004). The study area around Bezden is located at higher elevation and from climatic point of view it falls into the moderate-continental zone – very similar conditions to these in Central Europe, where the major negatively influencing breeding success factor is the inclement weather (Ullrich 1971, Schön 1994).

In conclusion, the reproductive rates of the Woodchat Shrike population inhabiting Western Bulgaria were found to be in concordance with most of the existing studies focused on its breeding biology. Compared to Spain, one of the European strongholds for this species, nesting and breeding success were found to be very similar, but the overall probability of survival (calculated using Mayfield method) appeared to be lower. However, the latter is much influenced by the way of calculations between different authors – whether hatching is taken into account as separate stage or the final result is achieved by using combined daily survival probabilities for egg and nestling stages only. Although comparatively high level of nest failures was found, the Woodchat Shrike population at both study sites appears stable. More widely-based future studies will contribute to the better understanding of different factors and their impact on the reproductive success not only of the Woodchat Shrike, but also of other shrikes and passerine species in general as well.

Acknowledgements: This study was partly supported by a grant N° B-MU-1103/ 01 of the National Science Fund at the Ministry of Education and Science (Republic of Bulgaria). Dr. Ueli Rehsteiner is thanked for the fruitful discussions on the Mayfield method. Valuable editorial comments for improving the manuscript were provided by Dr. Jukka Jokimäki and Dr. Stefan Karlsson.

References

Adamyan, M. S. 1964: The ecology of Lanius senator niloticus Bp. in Armenian SSR. — Zoologocheskiy Sbornik Zoologicheskogo Instituta Akademii Nauk Armenskoy SSR 13: 83–104. (In Russian)

Administrative Atlas of the Republic of Bulgaria. 2002: — Global Publ. House, Sofia. (In Bulgarian)

Andrén, H. 1992: Corvid density and nest predation in relation to forest fragmentation: a landscape perspective. — Ecology 73: 794–804.

Bechet, A., Isenmann, P. & Gaudin, R. 1998: Nest predation, temporal and spatial breeding strategy in the

Woodchat Shrike Lanius senator in Mediterranean France. — Acta Oecologica 19: 81–87.

Beschkov, W. & Nankinov, D. 1979: Materialen über die Ornithophagia der Schlangen im Gebirge "Maleschevska" (Südwestbulgarien) — Ekologiya 5: 55–63. (In Bulgarian with German summary)

Bonacorsi, G. & Isenmann, P. 1994: Biologie de la reproduction et nourriture de la Pie-grièche a tête rousse Lanius senator badius et de la Pie-grièche écorcheur Lanius collurio en Corse (France). — Alauda 62: 269–274. (In French)

Brahimia, Z., Dziri, H., Benyacoub, S., Chabi, Y. & Bańbura, J. 2003: Breeding ecology of Algerian woodchat shrikes Lanius senator: low breeding success. — Folia Zoologica 52: 309–316.

Brooks, B. L. & Temple, S. A. 1990: Dynamics of a Loggerhead Shrike population in Minnesota. — Wilson Bulletin 102: 441–450.

Cramp, S. & Perrins, C. M. (eds). 1993: The Birds of the Western Palearctic. Vol. 7. — Oxford Univ. Press, Oxford, New York.

de Nobel, P. W. T., Hagemeijer, W. E. J. M., Majoor, F. A., Teunissen, W. A. & van der Valk, R. 2000: Estimating nesting success of Dutch breeding birds. — Acta Ornithologica 35: 57–61.

Gusev, V. M. & Bednyi, S. N. 1961: [Materials on the ecology of the eastern race of the Woodchat Shrike (Lanius senator niloticus Bonaparte) in Eastern Georgia.] — Trudy Instituta Zoologii Akademii Nauk Gruzinskoy SSR 18: 41–51. (In Russian)

Harris, T., & Franklin, K. 2000: Shrikes & Bush-shrikes: Including wood-shrikes, helmet-shrikes, flycatcher-shrikes, philentomas, batises and wattle-eyes. — Christopher Helm, A & C Black. London.

Hernández, A. 1993: Estudio comparado sobre la biologia de la reproduccion de tres especies simpatricas de alcaudones (real Lanius excubitor, dorsirrojo Lanius collurio y común Lanius senator). — Doñana Acta Vertebrata 20: 179–250. (In Spanish).

Hernández, A. 1997a: Woodchat Shrike Lanius senator. — In The EBCC Atlas of European Breeding Birds: Their Distribution and Abundance (eds. Hagemeijer, W. J. M. & Blair, M. J.): 666–667. T & A D Poyser, London.

Hernández, A. 1997b: Acaudón Común Lanius senator. — In Atlas de las Aves de España (1975–1995) (ed. Purroy, F. J.): 472–473. Lynx Edicions, Barcelone. (In Spanish)

Holáň, V. 1993: Populačni hustota z hnízdní bionomie t`uhýka obecného (Lanius collurio) na Vsetínsku. — Sylvia 29: 3–11. (In Czech)

Horvath, R., Farkas, R. & Yosef, R. 2000: Nesting ecology of the Red-backed Shrike (Lanius collurio) in northeastern Hungary. — Ring 22: 127–132.

Isenmann, P. & Fradet, G. 1998: Nest site, laying period, and breeding success of the Woodchat Shrike (Lanius senator) in Mediterranean France. — Journal of Ornithology 139: 49–54.

Knysh, N. P. 1994: Influence of the disturbance factor and investigators press on the nest ruin of passerine birds (a case study of the Red-backed Shrike). — Berkut 3: 38–39. (In Russian with English summary)

Lefranc, N. 1993: Les Pies-gričches d`Europe, d`Afrique du Nord et du Moyen-Orient. — Delachaux et Niestlé, Lausanne and Paris. (In French)

Lefranc, N. 1997: Shrikes and the farmed landscape in France. — In Farming and birds in Europe (ed. Pain, D. J. & Pienkowski, M. W.): 236–268. Academic Press, London.

Lefranc, N. & Worfolk, T. 1997: Shrikes: A Guide to the Shrikes of the World. — Pica Press, London.

Matyjasiak, P. 1995: Breeding ecology of the Red-backed Shrike (Lanius collurio) in Poland. — In Shrikes (Laniidae) of the World: Biology and Conservation (ed. Yosef, R. & Lohrer, F.): 228–234. Proceedings of the Western Foundation of Vertebrate Zoology 6.

Mayfield, H. 1961: Nesting success calculated from exposure. — Wilson Bulletin 73: 255–261.

Mayfield, H. 1975: Suggestions for calculating nest success. — Wilson Bulletin 87: 456–466.

Mirkov, I. 1984: [Breeding of the Woodchat Shrike (Lanius senator L.) in the region of Sofia.] — Ornithological Information Bulletin 15/16: 70–74. (In Bulgarian)

Moali, A., Ait Sidhoum, D. & Isenmann, P. 1997: Quelques données sur la reproduction de la Pie-grièche à tête rousse Lanius senator en Algérie. — Alauda 65: 205–207.

Nikolov, B. P. 2004: Reproductive rates of the Red-backed Shrike (Lanius collurio L., 1758) (Aves: Laniidae) in Sofia region, Western Bulgaria. — Acta Zoologica Bulgarica 56: 75–82.

Payevsky, V. A. 1985: Nesting success of birds and methods of its estimation. — Ornitologiya 20: 161–169. (In Russian with English summary)

Rehsteiner, U. P. 2001: Breeding ecology of the Woodchat Shrike Lanius senator in one of its strongholds, southwestern Spain. Ph.D. thesis. Universtität Basel. — Verlag Schweizerische Vogelwarte, Sempach.

Roos, S. 2002: Functional response, seasonal decline and landscape differences in nest predation risk. — Oecologia 133: 608–615.

Roos, S. & Pärt, T. 2004: Nest predators affect spatial dynamics of breeding red-backed shrikes (Lanius collurio). — Journal of Animal Ecology 73: 117–127.

Schön, M. 1994: Zur Brutbiologie des Raubwürgers (Lanius e. excubitor): Gelege-, Brut-Grösse und Bruterfolg im Gebiet der Südwestlichen Schwäbischen Alb im Vergleich mit anderen Populationen. — Ökologie der Vögel 16: 173–217. (In German)

Shirihai, H. 1996: The Birds of Israel. Academic Press, London.

Simeonov, S. D. 1970: Über die Verbreitung mediterraner Vogelarten in Bulgarien. — Vogelwelt 91: 59–67.

Söderström, B. 2001: Seasonal change in Red-backed Shrike Lanius collurio territory quality – the role of

nest predation. — Ibis 143: 561–571.
Söderström, B, Pärt, T. & Rydén, J. 1998: Different nest predator faunas and nest predation risk on ground and shrub nests at forest ecotones: an experiment and a review. — Oecologia 117: 108–118.
Stanev, S., Kyuchukova, M. & Lingova, S. (eds.). 1991: The climate of Bulgaria. — BAS, Sofia. (In Bulgarian with English summary)
Stauber, W. & Ullrich, B. 1970: Der Einfluß des naßkalten Frühjahres 1969 auf eine Population des Rotrückenwürgers (Lanius collurio) und Rotkopfwürgers (Lanius senator) in Südwestdeutschland. — Vogelwelt 91: 213–222. (In German)
Takagi, M. 2001: Some effects of inclement weather conditions on the survival and condition of bull-headed shrike nestlings. — Ecological Research 16: 55–63.
Tryjanowski, P. & Kuźniak, S. 1999: Effect of research activity on the success of Red-backed Shrike Lanius collurio nests. — Ornis Fennica 76: 41–43.
Tucker, G. M., Heath, M. F., Tomialojc, L. & Grimmett, R. F. A. 1994: Birds in Europe: Their Conservation Status. — BirdLife International, Cambridge.
Tyler, J. D. 1992: Nesting ecology of the Loggerhead Shrike in southwestern Oklahoma. — Wilson Bulletin 104: 95–104.
Ullrich, B. 1971: Untersuchungen zur Ethologie und Ökologie des Rotkopfwürgers (Lanius senator) in Südwestdeutschland im Vergleich zu Raubwürger (L. excubitor), Schwarzstirnwürger (L. minor) und Neuntöter (L. collurio). — Vogelwarte 26: 1–77. (In German)
Yosef, R. 2000: The Mayfield method for standartisation of shrike breeding studies: the case of the Loggerhead Shrike (Lanius ludovicianus) in southcentral Florida. — Ring 22: 111–121.
Yosef, R. 2001: Nesting ecology of resident Loggerhead Shrikes in southcentral Florida. — Wilson Bulletin 113: 279–284.