Ornis Hungarica 7: 27-37. 1997

Nesting success of the Red-backed Shrike (Lanius collurio) in a cultivated area

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Farkas, R., Horváth, R. and Pásztor, L. 1997. Nesting success of the Red-backed Shrike (*Lanius collurio*) in a cultivated area. – Ornis Hung. 7: 27-37.

We studied a stable population of Red-backed Shrikes in the Aggtelek National Park on an area which is a mosaic of arable lands with different degrees of cultivation. We analyzed the effect of cultivation on nesting success. We defined three types of land use: intensively cultivated plough-lands, extensively cultivated meadows or pastures, and uncultivated areas. Based on regular observations from several points on a transect, we made a map showing the location of the nests, the territories of the observed pairs and the land types. The observation period lasted 50-55 days a year between 1991 and 1996. We found that the decisive majority of nest failures were caused by predators. The nesting success was higher in the intensively cultivated and uncultivated lands than in the extensively cultivated areas. Bush size also affected nesting success, the risk of nest failure was lower in large groups of bushes than in lonely bushes. Human disturbance may have increased nest failures. We did not find any effect of bush type and distance from forest-edge on nesting success. We neither found any difference between the densities of pairs from different land-use types.

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1. Introduction

The breeding population of Red-backed Shrikes (*Lanius collurio*) have shown a marked decrease in some of its traditional habitats in Northern and Western Europe. Nowadays several projects try to reveal the possible causes of this trend all over Europe. According to the general view this population decline may be the result of the intensive, large-scale agricultural cultivation, especially the use of pesticides and the disappearance of breeding sites (Reuven & Lohrer 1995). We studied a stable population in an area cultivated by traditional agricultural methods. By analyzing the causes of nesting failure we would like to reveal the factors relevant to the maintenance of local Red-backed Shrike populations on cultivated areas.

2. Methods

The study was conducted in the Aggtelek National Park (Northern Hungary), in the valley of the Jósva-stream, between Jósvafő and Szinpetri (Visnyovszky & Márkus 1993). The 107 ha study area is surrounded by xerotherm oak forests (*Quercus pubescens, Quercus petrea*), hornbeam forests (*Carpinus betulus*), spruce plantation (*Picea abies*) and the two villages. A stable Red-backed Shrike

Tab. 1. Relationship between breeding density and nesting success in the Red-backed Shrike.

Years	number of pairs	breeding density (pairs / 10 ha)	intensively cultivated		extensively cultivated		uncultivated		nesting success (%)
			success	nest failure	success	nest failure	success	nest failure	
1991	41	3.83	11	3	10	7	7	3	68.2
1992	35	3.27	8	1	12	3	7	4	77.1
1993	34	3.18	8	4	6	7	8	1	64.6
1994*	40	3.74	8	7	5	11	5	4	45
1995*	46	4.3	9	6	10	11	8	2	58.6
1996	54	5.05	12	4	15	12	8	3	64.8
Total	250		56	25	58	51	43	17	

Years marked by * took part only in the analyzis of the densities of territories

population lives in the valley, with 35-54 territories per year (Tab. 1). Between 1991-1996 we collected data on 50-55 days a year (except 1994: 15 days), during the whole breeding season from the middle of May until the middle of August. From the beginning of June until mid July we made observations every day. Data on the amount of precipitation was measured at the local station of the Hungarian Meteorological Service.

We used a 5 kilometer long path for making observations and transect-counts in the valley. Boundary of a territory of a pair was established by synchronous observations of the neighbours. We defined three types of cultivation: intensively cultivated lands (plough-lands), extensively cultivated lands (meadows, pastures) and uncultivated or ruderal areas. We used a map with the scale of 1:5000. All observations, territories, found nests and land usage types were indicated on this map. To estimate the size of the area of each land type we cut around the areas from the map and weighed them on an electronic balance of 0.01 g accuracy. In the first two years nests were systematically searched and checked regularly.

All the statistical analyses were carried out by the software BIOM PC. All tests are 2-tailed except when it is stated otherwise.

3. Results

3.1. Habitat selection

The area of the different land types changed year to year depending on whether the local people started cultivation on new, previously uncultivated lands or they left the land uncultivated. We determined the number of pairs that seemed to have a territory in each land type in each year and calculated the population density. We did not find any significant difference between the population densities of different land types (One-way ANOVA $F_{(2,15)} = 1.714$, df = 2, $p > 0.05$).

3.2. Components of breeding success

We measured nesting success by the proportion of successful nests. We considered a nesting attempt successful if we recorded at least one juvenile bird on the parents' territory soon after the expected time of fledging. This study does not differentiate between first and second broods.

We did not find significant difference in nesting success between the years ($G = 3.284$, df = 4, $p < 0.5$) and we neither found any significant difference between any

Tab. 2. The most frequented plant species used for breeding

Species		Number of nests	% of total nests
blackthorn	*(Prunus spinosa)*	38	26.39
dogwood	*(Cornus sanguinea)*	19	13.19
willow	*(Salix sp.)*	18	12.51
wide rose	*(Rosa canina)*	17	11.81
elder	*(Sambucus nigra)*	14	9.72
hawthorn	*(Eunonymus sp.)*	10	6.94
others	*(10 species)*	28	19.44
sample size		144	100

combination of year groups. On average nesting success was 68.7%.

The average clutch size was 4.62, the size of clutches ranged from 2 to 7. Fifty-two percent of the clutches were destroyed entirely from the nests found in 1991 and 1992. Only 64.9% of the laid eggs hatched. The average hatching success/nests was 46.6%. Average hatching rates of eggs was 96.2% in the non-destroyed nests.

To find the effective factors we have to take a closer look at the causes of unsuccessful breeding attempts. We examined 42 destroyed nests found in four years (1991, 1992, 1993 and 1996).

Twenty-seven nests with eggs and 11 nests with nestlings were destructed. We could not identify the stage of destruction in 6 cases, when the content of the nest disappeared 1-2 days before or after the expected date of hatching. Although more clutches were destroyed in the egg-stage than with nestlings, we could not show a significant difference from the 1:1 ratio (Goodness of fit test, $G = 3.558$, $df = 2$, $p < 0.1$). It is not possible to reveal significant difference either between the nesting success of the two stages (test of independence, $G = 2.765$, $df = 1$, $p < 0.1$).

Thirty-four nests (80.9%) were destroyed by predators and 6 (14.3%) by rainfall. The cause was unknown in two other cases (4.8%), thus predators caused the decisive majority of clutch-destructions (Fig. 1). Jays (*Garrulus glandarius*) are suspected to be the most important nest-robbers but there are other species whose visibility is much lower, because they move on the ground hidden by the vegetation. We saw beech-martens (*Martes foina*), grass snakes (*Elaphe longissi-*

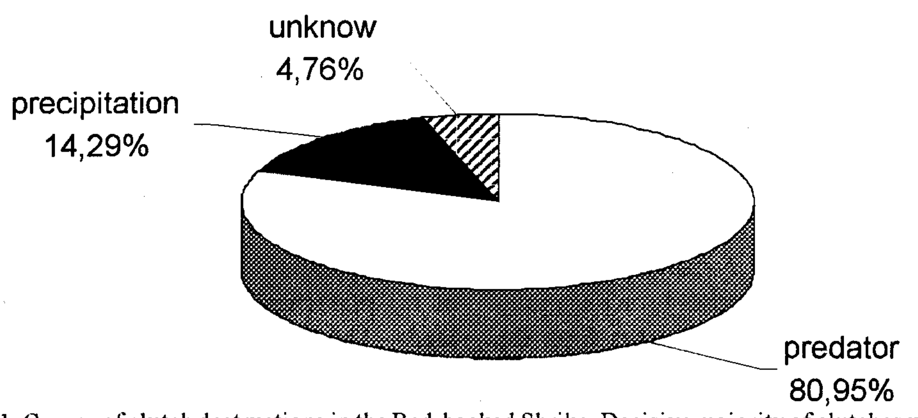

Fig. 1. Causes of clutch destructions in the Red-backed Shrike. Decisive majority of clutches were destructed by predators.

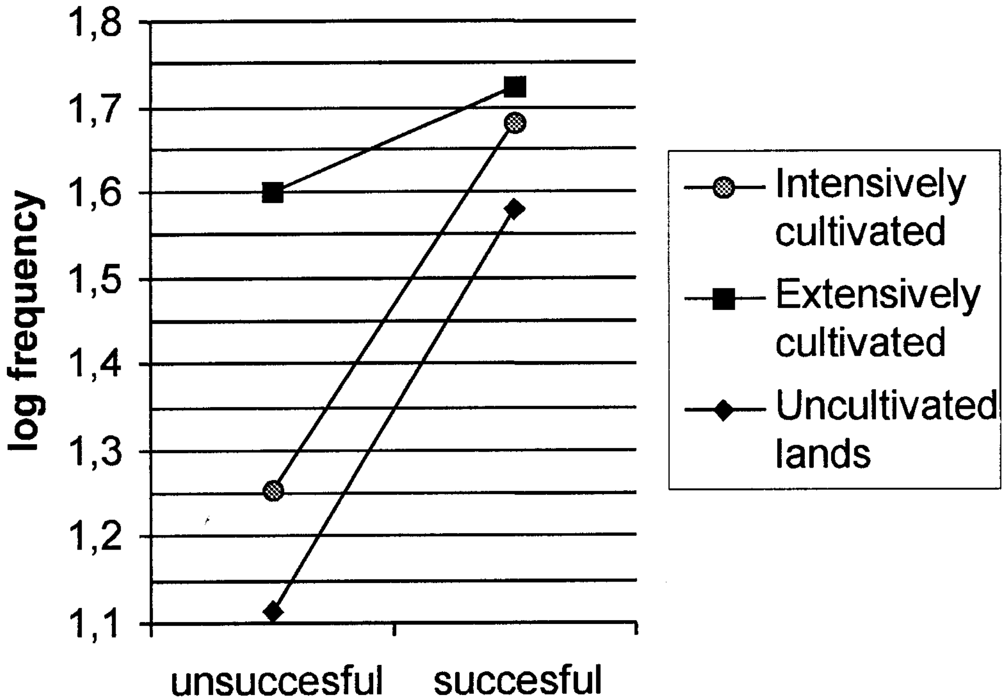

Fig. 2. Habitat-success interaction (interaction plot). The compared categories (unsuccessful and successfull nests) can be found on *x* axis, frequency of nests are shown on *y* axis. (See also the text.)

ma) and dormouses (*Glis* spp.) in the area. These are also potential nest predators.

3.3 Effects on nest failure

3.3.1. Habitat

We compared the nesting success of breeding pairs in the three land usage types. The proportion of successful nests was the lowest in the extensively cultivated areas (test of independence, $G = 6.351$, $df = 2$, $p < 0.05$).

The three types can be classified into two categories. The intensively cultivated and the uncultivated lands form one group and the extensively used areas form the other one. This classification is justified by the interaction plot (Fig. 2). The figure shows the natural logarithm of the number of nest failures and of the successful nests in the three different habitat types. Thus the parallel lines show that the proportion of unsuccessful and successful nests is nearly the same in the intensively cultivated and uncultivated areas. The level of significance increased by repeating the test with the two new groups ($G = 6.305$, $df = 1$, $p < 0.02$) (Fig. 3).

In order to give the magnitude of the effect we can express the difference in the proportional losses as odds ratios. We took the proportion of successful and unsuccessful nests in the extensively used lands and divided them by the same ratio of the intensively used and uncultivated lands. This odds ratio shows that how much times the first proportion is higher than the second. In our case the odds on success is 2.1 times better in intensively used and uncultivated regions than in extensively used regions (ω = 2.094).

3.3.2. Precipitation

We classified years according to the amount of precipitation measured in the local meteorological station. Years with less than 100 mm of rainfall during May and June were put into the first group whereas years with more than 100 mm were put into the second group. We did not get significant difference between the nesting success of the rainy and non-rainy years (test of independence, G = 2.376, df = 1, $p < 0.1$).

3.3.3. Nest sites

3.3.3.1. Bush size

We classified the potential breeding sites in the valley into two categories. Lonely bushes with small diameter got into the first group and groups of bushes with a larger extension got into the second group. We found a significant difference between the success of nests in these two bush size types (G = 4.521, df = 1, $p < 0.05$) (Fig. 4). The found bush size effect is strong as the odds on nesting success is four times better in the groups of bushes than in the lonely bushes (ω = 4.00). When we excluded the nests destructed by rainfall from the analysis, although the sample size decreased, the value of G increased (G = 5.333). The effect of land usage on success cannot be explained by the effect of bush size as there is no difference in the distribution of bush types in the 3 land usage types (G = 2.189, df = 1, $p < 0.2$) (Fig. 5). Obviously, the chosen type of cultivation does not depend on the size of the bushes in an area.

3.3.3.2. Bush type

We registered 16 plant species in the valley used by shrikes for nesting. These plants were usually shrubs or trees, there

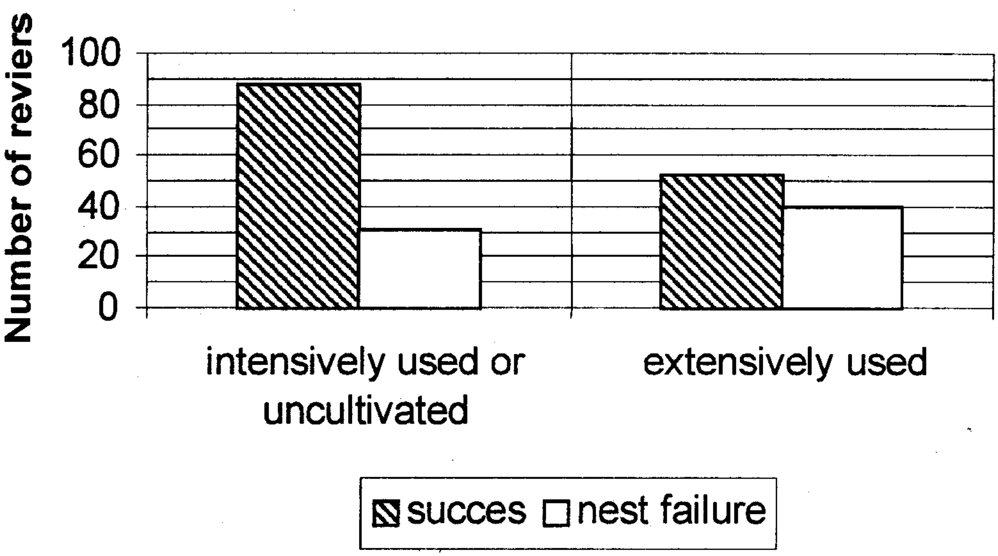

Fig. 3. The effect of habitat on nesting success of the Red-backed Shrike.

were only two occasions when we found a nest on soft-stalked plants. The most frequent plant species are shown in Tab. 2.

We studied whether the type of the nesting bush affect nesting success or not. Therefore we divided the 16 plant species into two classes. Open, thornless type was represented by such species like the willow (*Salix* spp.) and elder (*Sambucus nigra*), while closed, thorny bushes formed the second group among others with blackthorn (*Prunus spinosa*) and wide rose (*Rosa canina*). We could not show any difference between the success of these two groups of nests (G = 0.219, df = 1, $p < 0.7$). Repeating the calculation of the G statistics again only for the 6 most frequent plant species, its value increased but did not get significant (G = 2.020, df = 1, $p < 0.2$).

3.3.3.3. Location

The cross-section of the Jósva-valley can be easily divided in three sharply separated breeding areas. A nearly five kilometer long bushy stripe extends along the Jósva-stream. Another unbroken bush stripe runs at the edge of the bordering forest between the two villages. Between these two stripes a wider area can be found with different sized bushes. In the last class we separated nests on lonely bushes from groups of bushes. Comparing these four types there was no significant difference between the nesting success (G = 4.83, df = 3, $p < 0.2$).

3.3.4. Three-way interactions

Beside the series of tests of independence we also used log-linear models to reveal three-way interactions. First, we examined the interactions among nesting success (successful and unsuccessful), quantity of rainfall (under 100 mm and above 100 mm) and habitat types (intensively cultivated and uncultivated contrary to extensively cultivated areas), but only the success-habitat interaction proved to be significant (G = 1.845, df = 1, $p < 0.2$ for the 3-way interaction) (Fig. 6).

Three-way interaction could not be detected either among the size of bushes, nesting success and the two habitat types (in the latter case using the above defined categories) (G = 0.987, df = 1, $p < 0.5$).

3.3.5. Effect of observer's disturbance

In 1991 and 1992 we explored the valley for nests systematically and checked them regularly so they suffered from regular disturbance. In 1993 and 1996 we examined only the nests found by accident and checked them more rarely. There was a significant difference between the success of these two classes of nests (G = 2.064, df = 1, $p < 0.05$, one-tailed test).

However, we also compared the nesting success of checked nests and success of those non-disturbed breeding pairs whom we observed from a distance. First, we supposed that already the first breeding attempt of each pair was effective in the second group. In this case, the test of independence showed significant difference between the nesting success of disturbed and undisturbed pairs (G = 3.299, df = 1, $p < 0.05$, one-tailed test) (Fig. 7). The odds on success is 1.7 times better at the undisturbed pairs than at disturbed ones (ω = 1.726). However, when we

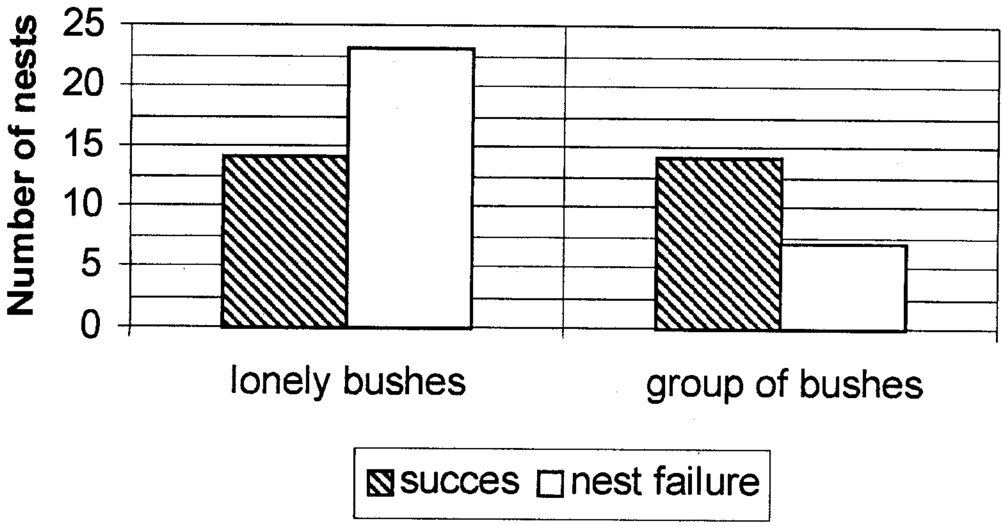

Fig. 4. The effect of bush size on nesting success of the Red-backed Shrike.

checked for the second attempts, we found at least 8 pairs whose fledglings came from a second nesting attempt with a high probability. Taking this into account, the difference between the disturbed and undisturbed groups disappeared ($G = 1.35$, $df = 1$, $p < 0.15$, one-tailed test)(Fig. 8).

4. Discussion

The density of breeding pairs did not differ considerably from densities in other Central European regions (Kuzniak 1991).

Nest failures are caused mainly by predators in the majority of open nesting Passerine species. Though the rainfall

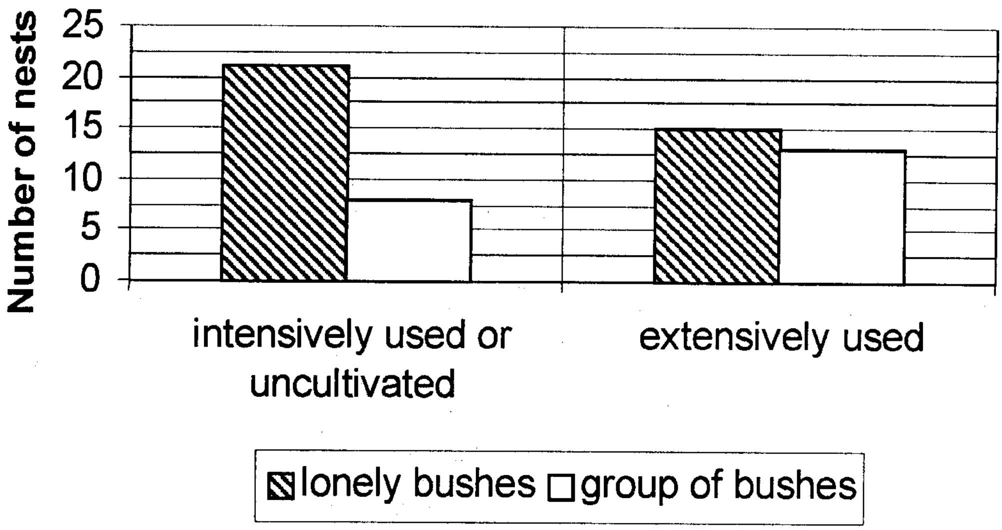

Fig. 5. Habitat is independent from bush types.

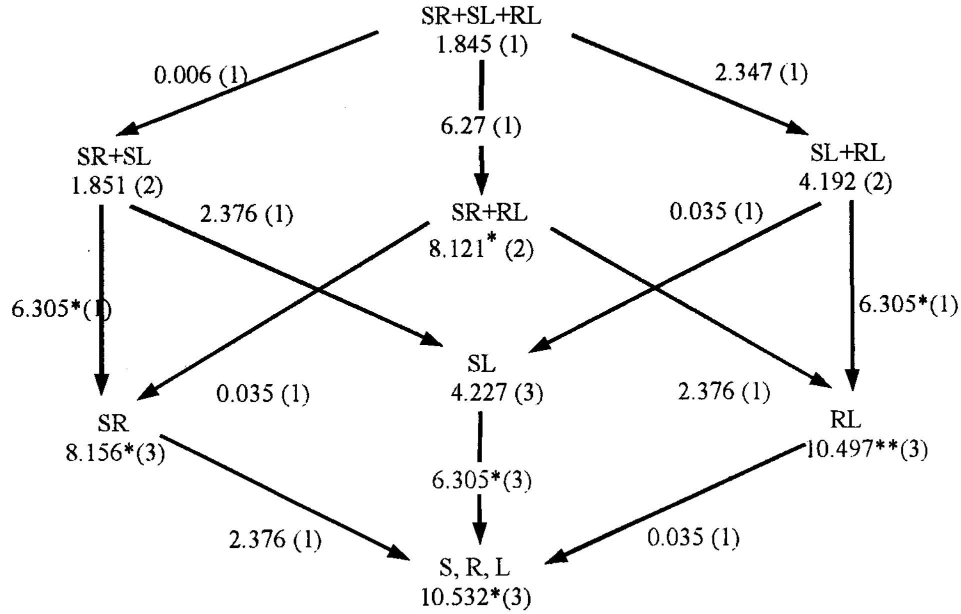

Fig 6. Success (S), rain (R) and land type (L) interaction. G values corresponding to model selection are given. The degrees of freedom are given in parentheses. The * shows the level of significance (*: $p < 0.05$; **: $p < 0.001$).

also causes nest failures, in our sample there are only a few drenched nests, therefore it is impossible to analyze the effect of rainfall. The amount of rainfall may have an indirect effect on the density of the resource populations and might decrease fledging success, but we do not have data to verify this assumption.

Similarly to others we did not find significant difference between the risk of predation in egg and nestling stages (Matyjasiak 1995). However, our sample size is small and we did not make comparison on daily predation rates. The nesting failure is rather high (52%). Fuisz *et al.* (1997) found that only 31.3% of nest failed, Kuzniak (1991) related that 40.4% of eggs and nestlings had lost and Rozgonyi (1993) also found nesting success higher.

Red-backed Shrikes in our population were less successful in the extensively used areas than in the intensively cultivated and uncultivated lands. Söderström *et al.* (1996) also found that nest predation rate was 2 times higher on grasslands than on other areas in a Swedish population. The reason of this effect may lay in the type of vegetation. As the result of regular mowing and grazing the vegetation is much shorter and scarcer in the extensively cultivated lands than in the intensively and uncultivated areas. This may increase the effectiveness of ground-predators. The predators moving on the ground may catch sight of the feeding male or female easier and find the bush where the nest can be found. Jays are important and well-visible predators but there are others like martens, grass snakes and dormouses. In the case of the Bull-headed Shrike (*Lanius bucephalus*) Takagi & Abe (1996) found that 46% of all nests was depredated by ground mam-

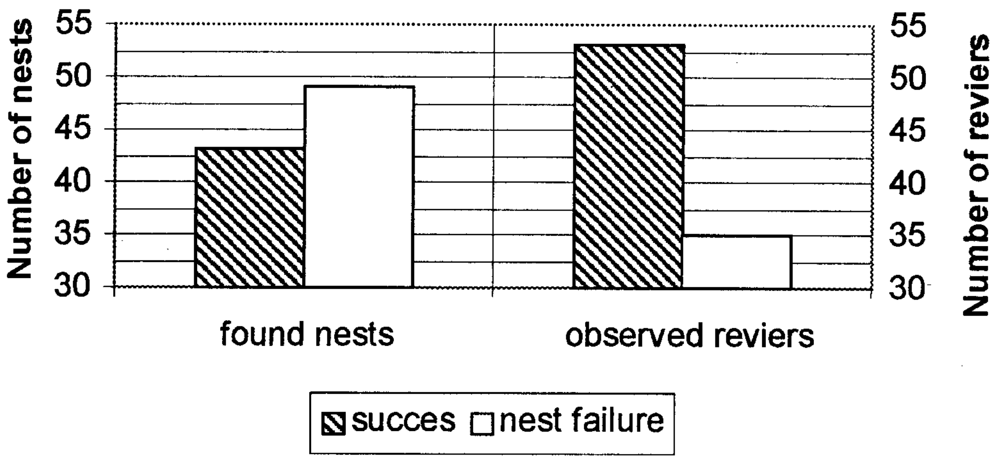

Fig. 7. Observer's inspections decrease success if we do not consider renestings. We did not disturbed nests when only reviers were studied.

mals. It would be important to study nest-predation itself and to identify the actual predators in order to understand the grassland-effect on nesting success found in two independent studies.

On the basis of the studied bush parameters, we can state that only the size of the bush affects nesting success. This effect is probably also due to predation as the interaction between nesting success and bush size was stronger among the predated nests. The bigger the bush is the more difficult it is to find the nest in it. According to Fuisz (1996) and Fuisz *et al.* (1997) Red-backed Shrikes select large, well developed bushes for nesting. Our result indicates that for the protection of the endangered populations it is very important to preserve the large, continuous bush groups in regions under agricultural cultivation.

The land types did not differ in bush size and the density of breeding pairs was the same in the three habitat types. It sug-

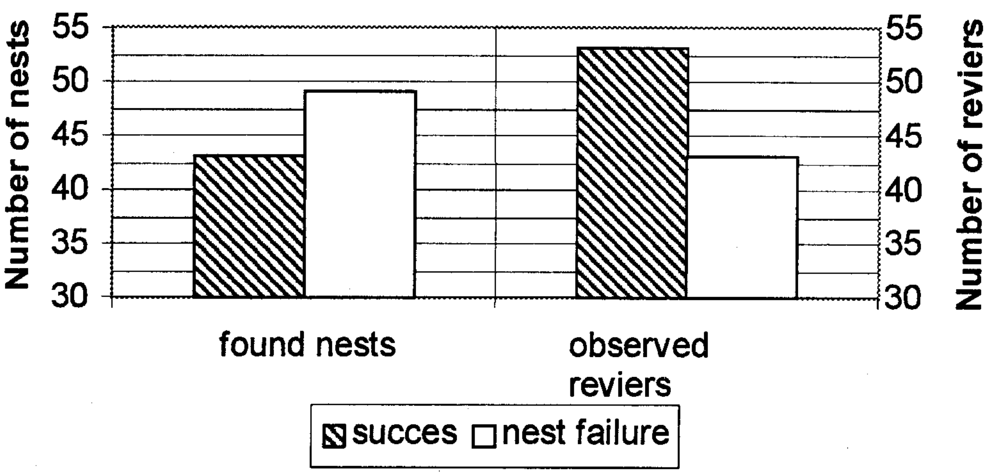

Fig. 8. Observer's inspections do not influence success if we consider renestings.

gests that habitat selection probably depends on the distribution of the bushes suitable for breeding (Diehl 1995).

Though we expected a bush-type effect which was found by Söderström *et al.* (1996), we did not find any difference between the success of nests in thorny and open bushes. Our study considers the whole breeding season, however Takagi & Abe (1996) revealed changing in nesting vegetation at Bull-headed Shrikes during the breeding season, and the nesting success increased as the result of this changing. According to Moskát (pers. comm.) a similar effect may also exist in the Red-backed Shrikes. We did not expect and did not find difference in success depending on the distance from the forests (edge-effect) since the valley is only 150-180 m wide. Others found edge-effects in other situations (Matyjasiak 1995, Söderström *et al.* 1996).

Biologists may also have an effect on the results of field studies. Kuzniak (1991) found that 26% of nest losses was the result of the frequent visits of the observer. According to our results there is no difference between the success of regularly disturbed and rarely disturbed nests. However, the results are not unanimous. It would be worth to do some further research to establish whether human disturbance increases the rate of nest predation or not.

Acknowledgments. This research project is a part of the complex nature status survey organized in the territory of the Aggtelek National Park. We are grateful to the administration of ANP for their generous support. We thank to Tamás Visnyovszky and Zoltán Márkus for taking part in the field work and their help in developing the methods of field observation. Csaba Moskát and Tibor Fuisz gave valuable advices in a former stage of data analysis. Éva Ludvig and Bálint Halpern gave useful comments on a former version of the manuscript.

Összefoglalás

A tövisszúró gébics (*Lanius collurio*) költési sikere művelt területen

A tövisszúró gébics európai állománya erős csökkenést mutatott az elmúlt évtizedekben, talán az egyre intenzívebb mezőgazdasági művelés miatt. Mi a faj egy stabil populációját tanulmányoztuk, egy különböző művelési fokozatú parcellákkal borított területen. A művelés lehetséges hatásait vizsgáltuk a költőpárok denzitására és költési sikerességükre. A 107 hektáros mintaterület a Jósva-patak völgyében (Aggteleki Nemzeti Park) fekszik. Háromféle területhasználati típust különítettünk el: intenzíven használt szántók, extenzíven használt kaszálók és legelők, valamint művelésbe nem vont területek. Megfigyeléseket 1991 és 1996 között, évi 50-55 terepnapon végeztünk. A territóriumok elkülönítését és a költési viselkedés megfigyelését egy 5 km-es transzekt mentén végeztük, az első két évben intenzíven kerestük a fészekeket és rendszeresen ellenőriztük a megtaláltakat. A párok territóriumait, a megtalált fészkeket és a területhasználat módját 1:5000 méretarányú térképen jelöltük.

Vizsgálataink szerint nincs szignifikáns különbség a fészkelőpárok denzitásában az egyes habitat-típusok között. A fészekaljak pusztulását döntő többségben a ragadozók okozzák. A fészkelési sikeresség lényegesen nagyobb az intenzíven művelt és a nem művelt területeken, mint az extenzíven műveltekben, talán azért, mert itt az alacsonyabb vegetációban a fészekrablók könnyebben megtalálják a fészkelőhelyet. Úgy találtuk, hogy a nagyobb bokorcsoportokban jóval kevesebb fészekalj semmisül meg, mint a magányos bokrokban. Ezért a veszélyeztetett gébics-populációk védelmének érdekében a nagy kiterjedésű bokrosokat meg kell óvni. A bokortípus és az erdőszéltől való távolság nem befolyásolta a fészekpusztulásokat. Az emberi zavaró hatásnak rendszeresen kitett fészkek és csak ritkábban zavartak sikeressége között nem találtunk különbséget.

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Received: Dec 10 1997, accepted: Mar 5 1998