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THE RED-BACKED SHRIKE (*LANIUS COLLURIO*) IN THE CENTRAL SYSTEM OF THE IBERIAN PENINSULA

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Abstract.

The recent colonization of new breeding territories in Central Spain by the Red-backed Shrike (Lanius collurio) at the end of the 20th century is of significant biogeographical and ecological interest. This geographical expansion is paradoxical given the declining trend of the species across much of its global range. This paper presents findings on the biogeographical patterns and distribution range of the Red-backed Shrike in the Iberian Central system, as well as its habitat preferences, altitudinal shifts, potential distribution, and estimated population during the breeding period in the Community of Madrid (Spain), based on field work conducted between 2018 and 2020. The breeding population in the study area is consistently composed of approximately 500 pairs, with a preference for cool, open areas such as pastures or mosaics of meadows with thorny shrubs, situated above 1,000 m above sea level. These characteristics differentiate this population from those in the Spanish Eurosiberian region. Additionally, the anthropic and socio-economic peculiarities of the study area should be considered when establishing appropriate conservation measures to prevent local extinction in our changing world.

Keywords: *Biogeography, habitat selection, altitudinal shift, distribution, density, population*

Introduction

In the Iberian Peninsula the Red-backed Shrike (*Lanius collurio*) is present across a wide range of its northern half, from the Pyrenees to the Cantabrian Mountains, Galicia, northern Portugal, and the septentrional Iberian system (Tellería, 2018a; Tellería *et al.*, 2020). In recent years, it has notably expanded its distribution in the Soria province, also colonizing parts of the southern Iberian system in Teruel, Cuenca, Tarragona, and Castellón (Prades *et al.*, 2016). The colonization of the Central system is a more recent phenomenon, as the species was not known to breed there until the end of the 20th century. Currently, it has a population considered regular and apparently stable in Madrid, Segovia, Guadalajara, Avila, Salamanca, and Cáceres (Hidalgo *et al.*, 2020).

The ecological requirements of the Red-backed Shrike during the breeding season link it to the typical habitats of the Eurosiberian region. Its expansion towards the Central system is of significant biogeographical interest, as it highlights the role of mountain massifs as pathways for northern avifauna to penetrate the centre of the Peninsula. This expansion occurs through mountain ranges such as Ayllón, Rincón, Somosierra, and Guadarrama Mountains, which are relatively close to the northern Iberian system and serve as a connection to the Eurosiberian region. This region hosts a variety of typically northern passerines, such as the Common Bullfinch (*Pyrrhula pyrrhula*), Yellowhammer (*Embenza citrinella*), and Marsh Tit (*Poecile palustris*). Additionally, the marked altitudinal gradient of these mountains facilitates the habitat diversification, which benefits numerous bird species (Tellería, 1987). The presence of the Red-backed Shrike in the northern Iberian system has been known since ancient times.

Despite this wide diversity of bird species in mountain habitats, their populations are often sparse, sometimes consisting of only a few individuals. In the case of the Central system, this sparsity is enhanced by the peripheral nature of this Mediterranean mountain range in relation to the Eurosiberian region, further compounded by the geographical isolation of the Iberian Peninsula within the European continent. The distance from centres of abundance results in a decrease in the density and frequency of occurrence of various species towards the edges of their continental distribution, where environmental conditions are likely to be less favourable (Brown, 1984; Sagarin and Gaines, 2002).

Other environmental factors at a more local scale, along with their temporal variations, can also influence species abundance and hinder the recovery of populations after local extinctions. In these peripheral areas, new individuals are expected to arrive only from the edge of their distribution range, where recruitment rates are lower due to the high energetic cost of immigration from the central areas of their range.

Furthermore, understanding the spatiotemporal patterns of occurrences and abundance is more complex for migratory birds, as the ecological requirements of their habitats can change throughout their annual cycle (breeding, wintering, and migration). In this context, the study of habitats used during the breeding season is crucial (Morrison *et al.*, 2021), with habitat selection primarily influenced by factors such as predation risk , parasitism, competition, the availability of suitable nesting substrates, and food abundance (Alerstam, 1993; Newton, 2024).

These three factors- climate, distribution limits, and the peninsular isthmus effect - should be considered together when interpreting population changes in northern

Figure 1. The study area in the Iberian Peninsula.

bird species within the Central system of the Iberian Peninsula. Understanding the environmental parameters that determine the presence and distribution of these species, as well as conducting long-term monitoring to track their spatiotemporal dynamics, is essential for adopting effective conservation measures. This is particularly important in the context of climate change, which could directly or indirectly alter available resources, and consequently impact population abundance, distribution, and the likelihood of local extinctions (Sanz, 2002; Morelli, 2012).

Material and Methods

To assess the connectivity of the Red-backed Shrike population in the Central system (Figure 1) of the Iberian Peninsula with peripherical populations, we hypothesized from an exploratory approach, a progressive colonization of the species from the northern Iberian system. This hypothesis is based on the premise of the existence of potential and homogeneous breeding areas along the Central system, extending to its westernmost limit in Serra da Estrela (Portugal).

We collected 524 occurrences of the Red-backed Shrike in the Central system from 1987 to 2020 during the breeding period (June 1st to August15th) using Citizen Science records (eBird Data Set), ringing records, and bibliographic sources. These data were analysed using GIS, and a table was created to record the time versus the maximum distance (in km) from the breeding site for each year to the closest point of the Central system to the northern Iberian system (Pico Rivilla: 41.30, -3.21). The distances were calculated using the Haversine formula. A regression analysis using a polynomial function was then performed to determine the relationship between these variables.

The study of the Red-backed Shrike's distribution and habitat use in the Community of Madrid (Spain) was conducted over three years: 2018, 2019, and 2020. We designed a sampling protocol using mapping methods to locate and census all known breeding territories from late April to mid-September. A total of 150 visits (35 in 2018, 59 in 2019, and 56 in 2020) were carried out across 30 study areas. The occurrence data collected during fieldwork were processed using GIS to analyze altitudinal distribution and habitat selection.

The geographical distribution and potential population of the species in the Community of Madrid was estimated using a Species Distribution Model (SDM; Maxent v3.4.1). The highest predictive quality, based on the Area Under Curve (AUC) of the model, was achieved using environmental layers such as the hottest quarter temperature, driest quarter precipitation, vegetation structure, vegetation patch surface, and the ecotone index. Optimal habitat was estimated for AUC values greater than 0.9, which was then used to create a potential distribution map for the species.

The potential population was estimated by combining potential distribution, pair density, and a detectability index. This index was obtained by comparing regular censuses and marking all breeding pairs at three breeding sites (Figure 2).

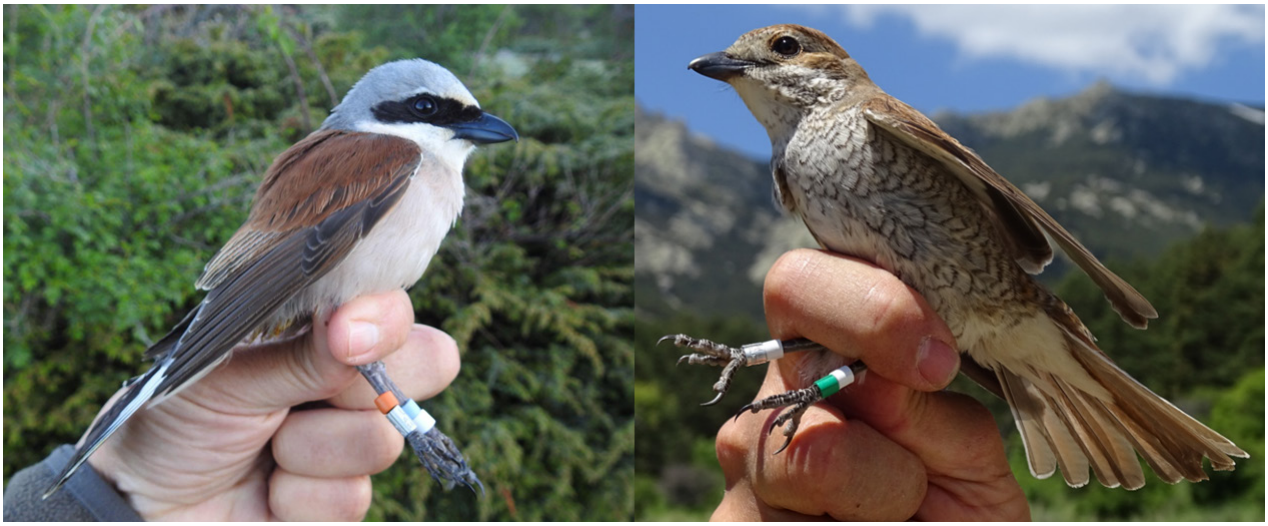

Figure 2. Red-backed Shrike male (left) and female (right) marked with colour rings.

Results

A relationship between the east-to-west distances and the year of observation indicates a westward colonization of the Red-backed Shrike in the Central system, likely originating from the Septentrional Iberian system. The analysis showed a strong positive correlation (r=0.8045, P=<0.0001, n=27 years) between the maximum distance of breeding records from the northern Iberian system each year and the time of records in the Central system (Figure 3). These data suggest that colonization occurred approximately from 1987, the year of the first record, until 2008, when regular sightings were documented throughout the entire Central system (Figure 4; Hidalgo *et al.*, 2020).

The Red-backed Shrike in the central system of the Iberian Peninsula has an altitudinal distribution during the breeding season ranging from 1,040 to 1,722 m a.s.l., with a mean value of 1,368 ± 146 m (n = 289) and a median of 1,356 m with an interquartile range of 217 m. The species' optimal habitat primarily consists of meadows, grasslands, and pastures, featuring small trees and thorny bushes used for nesting and as hunting perches. No breeding territories were found within forests or woods, although they were located in forest ecotones. The presence of the Red-backed Shrike was also not detected in human habitated areas or artificial infrastructures, although this does not appear to be a limiting factor, as breeding territories were identified on the outskirts of small towns.

The SDM obtained (Figure 5) revealed an extremely limited potential distribution range for the Red-backed Shrike in the study area (1,316 km^2), with just 0.7% of this area classified as optimal habitat. The environmental variables that most significantly influenced the SDM were the temperature of the hottest quarter, which had a positive effect for values below 20ºC, followed by vegetation structure, particularly the presence of pastures and bushes. The precipitation of the driest quarter was a limiting factor for values below 53.4 mm.

The census detectability index of 0.71 ± 0.08 was obtained. Across the 30 sites visited, a total of 116 territories occupied by pairs during the reproductive period were identified, with an average density of 4.59 ± 1.54 pairs/10ha. Based on the SDM, the Red-backed Shrike population in the Community of Madrid was estimated at 578 pairs (range 340 - 900; Hidalgo and Baonza 2023).

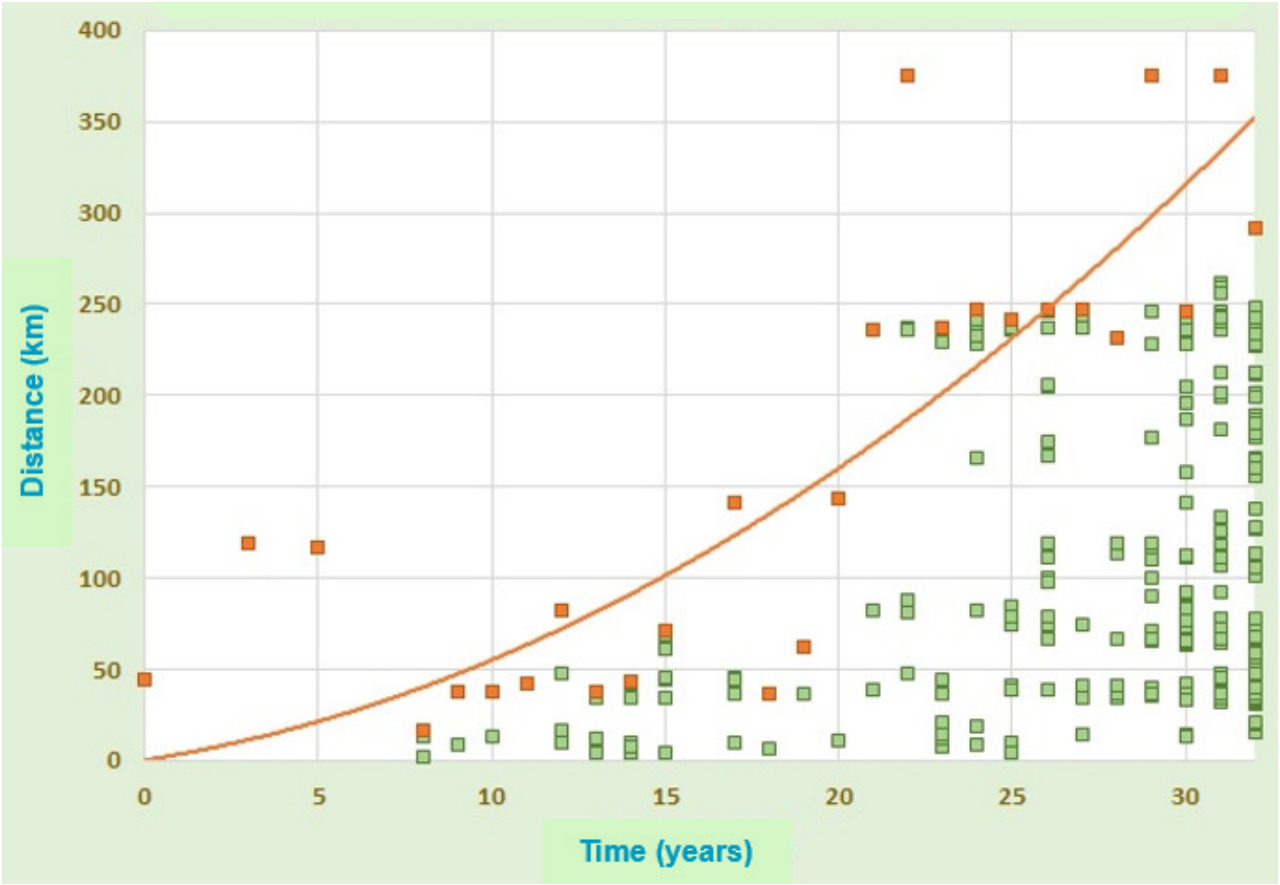

Figure 3. Distance from the septentrional Iberian system to the Red-backed Shrike breeding areas in the Central system of the Iberian Peninsula.

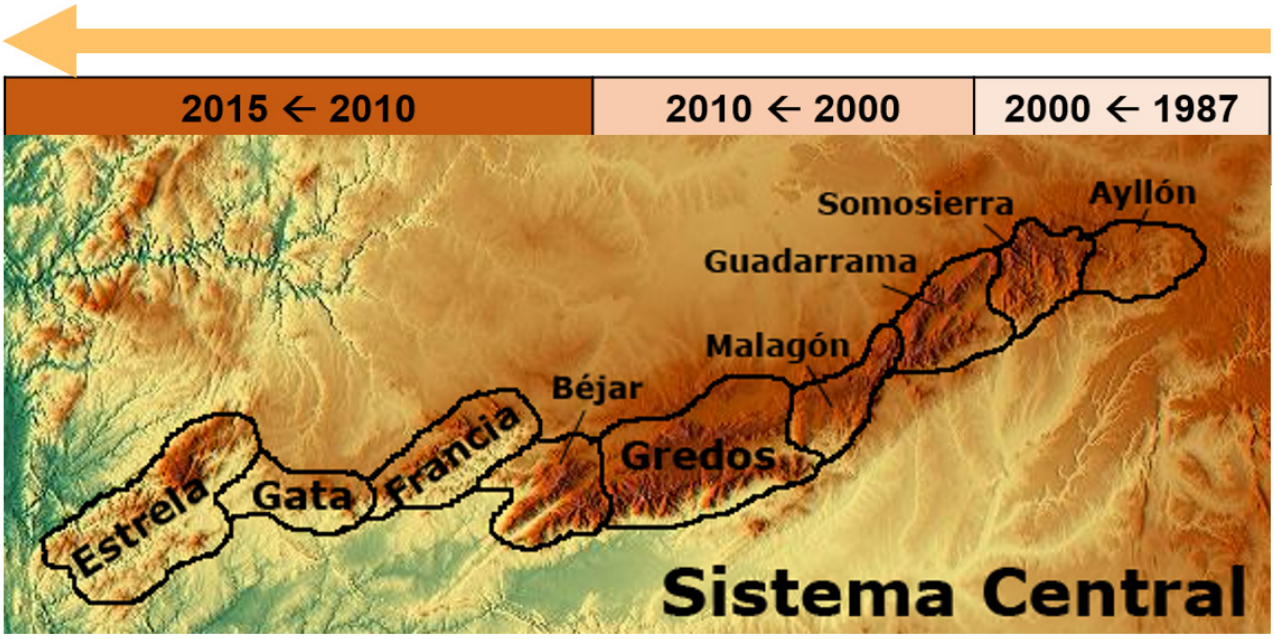

Figure 4. Red-backed Shrike colonization chronology of the Iberian Peninsula Central system.

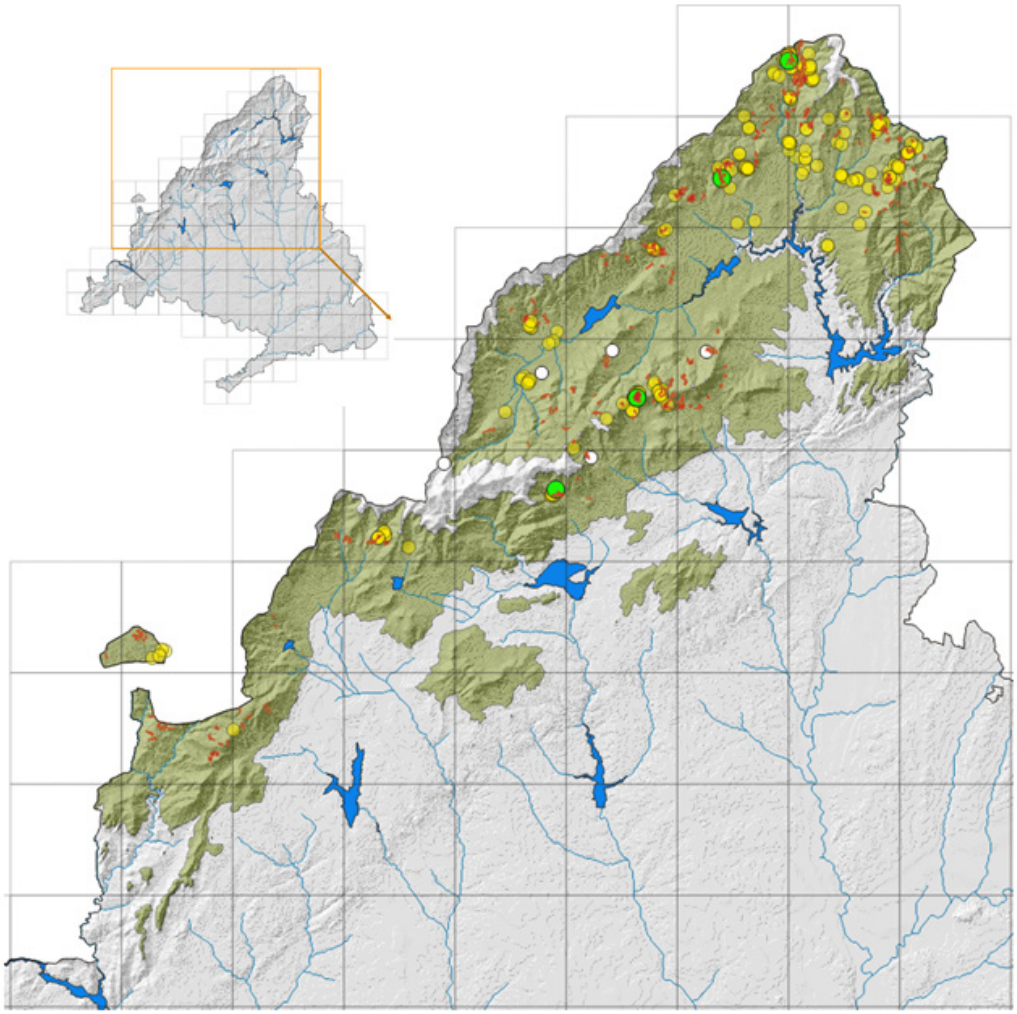

Figure 5. Red-backed Shrike Species Distribution Model in the Community of Madrid, Spain. Areas between 1,000 and 1,800 m a.s.l. (dark green); Potential distribution (red); Circles represent sampling sites –negative presence (white), positive presence (yellow) and positive presence with intensive effort for detectability estimation (light green).

Discussion

In the Community of Madrid, the Red-backed Shrike exhibits a higher altitudinal distribution during the breeding season compared to its range in the Eurosiberian region in the north of the Iberian Peninsula. This distribution is very similar to that observed in other European countries within the Mediterranean region (Inbar, 1995; Moskát and Fuisz, 2002; Tsiakiris *et al.*, 2009; Morelli 2012). The availability of suitable habitat in the study area is quite limited due to the extensive coverage of forest and woods. The species' ecological requirements within the Mediterranean region are met by the altitude and the subtle orographic differences between slopes.

The Red-backed Shrike population in Spain has experienced a significant decline over the past three decades (-54%), particularly in northern Spain and Portugal (Reino *et al.,* 2006; Escandell, 2017; Tellería *et al.*, 2020). However, this decline should not overshadow recent changes in its distribution area. Similar to the relatively recent colonisation of the central Iberian Peninsula by other species with a marked Eurosiberian character, such as the Tree Pipit (*Anthus trivialis*), the Red-backed Shrike has expanded from the septentrional Iberian system into new favourable areas within the Central and southern Iberian Systems, located in the Mediterranean region.

The colonization is partly attributed to the loss of optimal habitat and the accelerated decline of insect abundance across much of its range within the Eurosiberian region (Tryjanowski *et al.*, 2006), including northern Iberian (Tellería, 2018a, 2018b; Tellería *et al.*, 2020). These impacts appear to be linked to the EU's Common Agricultural Policy and its effects on landscape management (Camina and Yosef 2012), such as habitat fragmentation due to land consolidation for intensified agriculture, the loss of traditional extensive grazing that leads to excessive scrubland, and the use of pesticides contributing to arthropod population declines (cf. Yosef and Deyrup 1998).

As with other long-distance migratory species, these threats must be considered throughout the entire annual cycle, which complicates the task of understanding the species' challenges and developing appropriate management measures for conservation at breeding, wintering, and migration sites.

Other global factors, such as climate change, may be altering productivity cycles in breeding areas within the Eurosiberian region, potentially causing a retraction of populations towards mountain ranges, as observed in central Iberia. This trend requires further confirmation in other regions. In the Mediterranean region, climate models predict an increase in temperature that will exacerbate drought and lead to water stress on vegetation and a decline in arthropod productivity (Sanz, 2002; Araújo *et al.*, 2011), which could accelerate the local extinction of certain species populations.

For mountain birds and those within Eurosiberian ecosystems, these effects may push their breeding areas to more northern regions, or higher altitudes (Pearce-Higgins and Martin, 2023), with greater respond for forest clearings or upper the treeline species (Lehikoinen *et al.*, 2019), a pattern already reported for other animals in the Mediterranean region (Wilson, 2005; Flores *et al*. 2018), However, these altitudinal trends can be buffered by other environmental changes at local scale, like the scrubland and woodland encroachment after the land abandonment or the loss of traditional extensive grazing, that are interacting with climate to drive future changes as suggested in long term studies in the Guadarrama Mountains (Tellería, 2019; Caro-Miralles and Gutiérrez, 2023; Tena and Tellería, 2024). Some authors suggest that the combined effects of habitat transformation and climate change will progressively reduce and fragment the breeding populations of Red-backed Shrikes in the Iberian Peninsula, leading to the extinction in regions where recruitment rates do not offset population losses due to the species being at the edge of its Palearctic distribution range (Tellería, 2018a).

The Central system should be regarded as a field-laboratory for observing these changes, with the Red-backed Shrike serving as an excellent bioindicator of the environmental health of mountain agricultural areas. To prevent local extinctions, it is essential to conduct detailed studies of the dynamics of different Iberian populations of this species through long-term monitoring programs. These studies will help to understand the underlying causes and establish appropriate conservation measures.

In conclusion, it is urgent to implement conservation policies for the Red-backed Shrike that include actions to promote traditional extensive livestock farming, prevent land consolidation, and discourage other intensive agricultural practices. Restoration of degraded habitats, controlling excessive scrubland, and installing artificial perches in areas lacking natural ones (Yosef 1993; Van Nieuwenhuyse, 1999) could facilitate the local settlement of Red-backed Shrike populations in valleys and mountain passes with suitable habitats. Raising awareness about the Red-backed Shrike as an indicator of good conservation status in the countryside and other habitats should involve local communities that coexist with the species, encouraging them to conserve and enhance their natural surroundings.

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