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The consequences of pasture abandonment for the Ring Ouzel (*Turdus torquatus*) in the mountains of Slovakia

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Abstract

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Pasture abandonment plays important role in rapid changes of mountain alpine habitats in Europe. The Ring Ouzel (*Turdus torquatus alpestris* Brehm) is very sensitive to these changes. Its abundance is declining in western European mountains. However, there is little data from Slovakia. This study confirmed that old, abandoned pastures with high, dense vegetation, limit breeding of the Ring Ouzel due to decreased prey availability. In contrast, the pastures abandoned not long ago, may temporarily play a role of source of the Ring Ouzel population. The most suitable breeding sites were characterized by short green vegetation, patches of easily penetrable bare soil, and moss in green grass. The data predict fast decline in breeding populations of the Ring Ouzel in Slovakia.

Keywords

alpine birds, conservation, soil condition, upland

Introduction

Recent changes in the European mountain habitats have been very rapid. Forests are being afflicted by drought, pastures are abandoned, and warming in the mountains is twice the rate of the global average (Brunetti et al., 2009). Recent studies have shown that bird species breeding in mountain ecosystems, for long adapted to the cold, are the most vulnerable to climate and habitat change (Maggini et al., 2014; Scridel et al., 2018; de Gabriel Hernando, 2021, 2022). In most cases, adaptation to ensure survival and reproduction requires a much longer evolutionary time as showed large meta-analysis focussing on birds (Radchuk et al., 2019).

Several models and long-term studies, which were considered rare and extremely necessary for studies of changes in bird communities (Chamberlain et al., 2012; Scridel et al., 2018), predict a negative impact of climate and land use change on populations of mountain bird species and their rapid shift to higher elevations (Jetz et al., 2007; Ching Chen et al., 2011; Sim et al., 2011; Reif and Flousek, 2012; Flousek et al., 2015; Lehikoinen et al., 2019; Barras et al., 2021b; Fumy and Fartmann, 2021; Srinivasan and Wilcove, 2021).

One of the most frequently studied mountain bird species in view of these changes, is the Ring Ouzel (*Turdus torquatus*). The numbers of Ring Ouzel are falling rapidly in Great Britain (Wotton, 2016), Scotland (Sim et al., 2011), Germany (Fumy and Fartmann, 2021) and Switzerland (Barras et al., 2021b), but are stable in Norway (Keller et al., 2020). Modelling of the spatial distribution and altitudinal shift in the Ring Ouzel predict rapid decline in abundance and shift into higher elevations (von dem Busche et al., 2008; Barras et al., 2021b).

Studies on the Ring Ouzel, which come from the Western Carpathians, are sporadic. Ciach and Mrowiec

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(2013) studied habitat selection during breeding, Janiga and Višňovská (2021) examined breeding biology and Karaska et al. (2014) stated notes about decreasing population in the Orava region.

As the occurrence and reproduction of the Ring Ouzel influence, except of harsh weather and potential predation, mainly suitable habitat – mosaic of mountain forests and meadows with short grass and wet soil with availability of earthworms (Lumbricidae) (Barras et al., 2020, 2021c, 2022), the aims of this study were following: 1) to compare the Ring Ouzel abundance and habitat changes on the abandoned pasture around the mount Velký Brankov in 2023–2024, with data from 1985–1989 (Janiga and Višňovská, 2021), 2) to compare these data with the area around the Smrekovica mountain hotel, where grazing was discontinued recently, 3) to study preferences for foraging sites from the point of view of vegetation and soil characteristics and, 4) to discuss the influence of climate characteristics on the Ring Ouzel reproduction.

Materials and methods

Description of the study sites

The study was carried out in two study sites (Velký Brankov and Smrekovica) in 2023–2024. The sites have similar size (approximately 0.4 km^2, details in Bureš and Brecelj (2024)), limestone bedrock is the same, but pasture history is different. The first study site was Velký Brankov (1,134 m asl, 48°99'08.072"N, 19°31'24.450") in the western part of the Low Tatra mountains, where the breeding biology of the Ring Ouzel (*Turdus torquatus alpestris*) was studied from 1985–1989 (Janiga and Višňovská, 2021). The unforested ridge, oriented S-N was used for a long time as pasture in the past. During the succeeding years, the intensity of grazing rapidly declined, and as a result, the local habitat changed. The area of shrubs and forest increased, and the non-grazed meadows overgrew by dense high grass as is evident from pictures (Fig. 1). The site was used for comparison of the Ring Ouzel recent abundance with data from 1985–1989 (Janiga and Višňovská, 2021) and for comparison of habitat parameters and the Ring Ouzel abundance with newly established study site for long-term study around the Smrekovica mountain hotel in 2023 (Bureš and Brecelj, 2024).

The new study site Smrekovica (1,320 m asl, 48°99'20.595"N, 19°19'82.945"E) in the Velká Fatra mountains is an old pasture on an un-forested moderate slope, surrounded by spruce forest with a strip of spruce forest in the centre of the site, oriented S-N, where infrequent grazing was discontinued not long ago.

Description of habitat, soil and meteorological characteristics

For description of habitat and soil characteristics we used similar criteria to Barras et al. (2020). All measurements (soil moisture, soil penetrability and height of green grass) were done during nestling period of the Ring Ouzels at randomly chosen points across the study sites (Brankov and Smrekovica). Twenty-four measurements were taken at each site (details in Bureš and Brecelj (2024)). The centre of the randomly chosen point was bare ground and leaf litter as classified by Barras et al. (2020). The selected criteria were as follows: GPS coordinates, soil moisture, soil penetrability and height of green grass. A photo was taken at each point (approximately 1 m^2). The same criteria were used for comparison of foraging site and control site in its vicinity at the Smrekovica site in 2023–2024 (see below). We observed the Ring Ouzel as it was searching for prey using binoculars and registered the site where earthworms were successfully hunted (either directly, or by navigating a colleague to the site). The height of the vegetation was determined as average height of vegetation within a 10 cm diameter circle from the foraging site. The two control sites were then determined (1 m to the South, or North from the foraging site). The average of the measured criteria at each control site was used for statistical analyses. In total, 32 paired measurements (foraging and

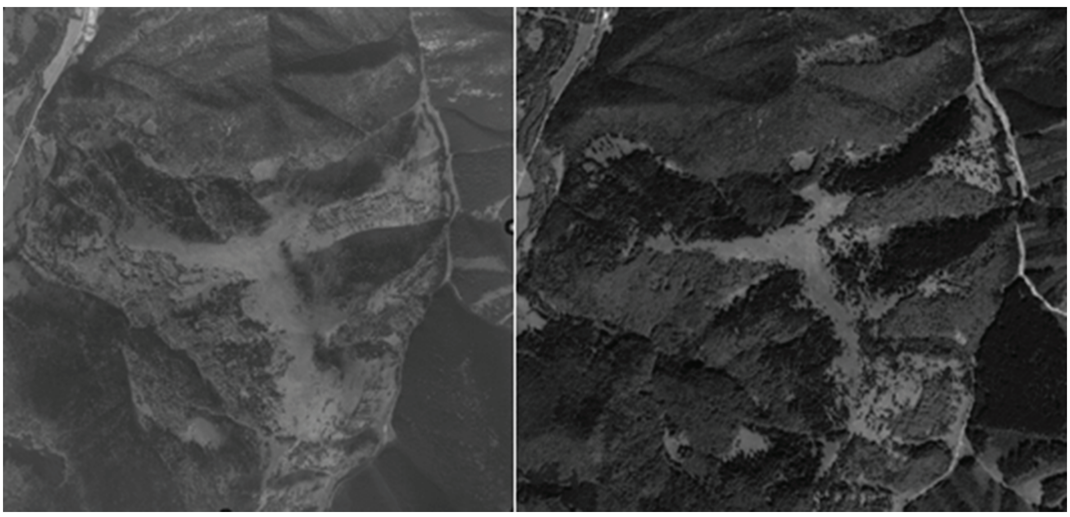

Fig. 1. Map of the study site in Brankov in 1988 (left: Google Earth) and in 2020 (right: Topographic institute Banská Bystrica).

control site) were taken.

The volumetric water content of the soil and soil temperature were measured by multi-parameter sensor type WET-2 (Delta-T Devices Ltd., Cambridge, England). Soil penetrability was measured with a penetrometer of our own construction. This indicates the force (kg cm^{-2}) needed to insert the tip into the soil to a depth of 6.35 mm, as described by Barras et al. (2020).

The percentage of fresh green vegetation, dry grass, soil, and stones, branches etc. in photos was recorded using a GIMP (GNU Image Manipulation Program) software to analyse the photographs. This free photo editing program offers a variety of tools for editing and retouching at a professional level. The analysis process was done by uploading an image into the GIMP interface, which then analysed the image and provided a description of the objects it identified in the image. If the photo analysis was not accurate, a drawing program on computer in the Photos app was used to make everything colour distinguishable.

Meteorological data (precipitations and temperature) shortly before and during the breeding period were taken at the closest mountain meteorological station on mount of Krížna (1,574 m asl, 15 km far from Smrekovica area). The data on average daily temperature and relative humidity were divided for statistical analyses into four periods: pre-laying (1–20 April), laying (21 April–10 May), incubating and hatching (11–25 May), nestling (26 May–10 June) in accordance with course of breeding season by Janiga and Višňovská (2021) and own data.

Abundance and breeding

The number of territories at the study sites was determined from territorial singing males after arrival at the locality (the first visit was on 20 April 2023 and on 25 April 2024). The nests were found by direct search for them in dense branches, close to the stem etc. Then, the nests were checked by mirror or with ladder, once during incubation of the eggs and twice during the nestling period in order to record basic data on breeding and to minimize the disturbance. The searching intensity was approximately twofold in 2024 at the Smrekovica site. The last check, for determining all successfully fledged nests in the site, was carried out after the predicted time of fledging (on 31 May 2023 and on 10 June 2024), when the number of found fledged nests, was corrected by searching for families with fed fledglings in the site (not all nests were found during study period and alarm calls of adults helped us to find fledglings).

Statistics

All analyses were conducted using the R program, version 4.1.1 (R Core Team 2021). We employed appropriate statistical two-sample tests (T-test, Wilcoxon test, and Kruskal-Wallis rank sum test) to compare soil and vegetation characteristics between the study sites of Brankov and Smrekovica. Normality was tested using the Shapiro-Wilk test. Similar tests were applied to compare soil and vegetation characteristics between foraging and control sites at Smrekovica, where appropriate paired test (T-test, Wilcoxon test, and Sign test) was chosen.

Differences in temperature and relative humidity between years (data from 1986–1989 were averaged), within each period: pre-laying (1–20 April), laying (21 April–10 May), incubation and hatching (11–25 May), and nestling (26 May–10 June) were analysed. For each period and variable, a multiple linear regression model was applied, where the dependent variable was either temperature or relative humidity, and the predictors were date and year (a categorical variable, with one level serving as the reference). These models allowed us to estimate how the expected value of the dependent variable changed both over time and between years. The assumption of equal slopes (i.e., no interaction between date and year) was based on the expectation that the general temporal trend (e.g., gradual spring warming) would be similar across years. This simplification enabled more stable parameter estimation within relatively short time intervals, given the limited data available per year. To ensure that this assumption did not distort the results, model diagnostics and visual inspections of time trends were conducted and revealed no major violations.

Each model provided insights into how the dependent variable changes with a unit increase in the date variable (i.e., a shift of one day) and allowed us to evaluate how the expected value changes, when years other than the reference year, are considered. From the parameter estimates, we interpreted whether the expected value increased or decreased when transitioning to a different year. The statistical significance of this difference was tested using a null hypothesis test on the parameter. Specifically, the null hypothesis in each model stated that the regression coefficient associated with a given year was equal to zero. This implies that, after controlling for the effect of date, the expected value of the dependent variable (temperature or relative humidity) in the given year did not differ from that in the reference year. The differences between years (periods) were considered statistically significant if the p-value was less than 0.05.

Results

Abundance and breeding

The abundance of singing territorial males was 1–2 at the Brankov site in 2023 and none in 2024. No nest was found in 2023–2024. The abundance of singing territorial males was 15 at the Smrekovica site in 2023 (16 in 2024), new nests found was 7 in 2023 and 16 in 2024. The abundance of registered families, feeding fledglings, was 11 in 2023 and 13 in 2024 at the Smrekovica site. The density at the Smrekovica site, at least 27.5 pairs km^{-2} in 2023 and 32.5 pairs km^{-2} in 2024, was very high.

Habitat characteristics

The abandoned pasture of Brankov is continuously over-

Table 1. Comparison of soil and vegetation characteristics between the study sites of Brankov and Smrekovica (n = 24, T-test (T), Wilcoxon test (W), Kruskal-Wallis rank sum test (KW)

Habitat parameters	Brankov		Smrekovica		P-value
	Mean	SD	Mean	SD	(Test)
Vegetation height (cm)	20.17	2.63	8.25	2.09	<0.001 (T)
Soil penetrability (kg cm^{-2})	2.47	0.79	2.20	1.14	0.342 (T)
Soil humidity (%)	39.15	7.17	46.08	15.07	0.051 (T)
Green vegetation (%)	58.71	14.05	62.99	15.18	0.278 (W)
Dry grass (%)	34.10	14.16	25.48	14.54	<0.001 (KW)
Soil (%) 5.85	5.22	9.65	4.64	<0.001 (KW)	
Stones etc. (%)	0.19	0.60	0.24	0.20	<0.001 (KW)

Table 2. Comparison of soil and vegetation characteristics between foraging and control sites at the Smrekovica site (n = 32, T-test (T), Wilcoxon test (W), Sign test (S))

Habitat parameters	Soil		Foraging		P-value
	Mean	SD	Mean	SD	(Test)
Vegetation height (cm)	7.31	2.44	5.65	2.05	0.007 (S)
Soil penetrability (kg cm^{-2})	2.55	1	1.5	0.81	<0.001 (S)
Soil humidity (%)	34.82	12.56	36.4	14.22	0.638 (T)
Green vegetation (%)	63.43	13.54	56.21	13.99	0.265 (S)
Dry grass (%)	21.48	10.23	20.35	11.15	0.349 (W)
Soil (%)	11.71	5.12	17	10	0.030 (W)
Stones etc. (%)	3.56	4.81	4.42	3.17	0.557 (S)

grown with tall grass which is significantly higher than that at the Smrekovica (Table 1). Other parameters, soil humidity and soil penetrability were comparable at the two sites. Photo analyses showed no difference in percentage of cover by fresh green vegetation between the two areas. But dry grass covered higher percentage of area at the Brankov and, on the contrary open soil and other material, mainly stones, covered significantly higher percentage at the Smrekovica (Table 1).

Preference of foraging sites

The soil hardness and vegetation height were lower at the foraging site, than at the control (Table 2). The soil humidity was the same. The picture analyses showed higher percentage of open soil at the foraging site, then at the control site (Table 2). Other analysed parameters, percentage of green vegetation, dry grass and other material (mainly stones) were not different (Table 2).

Table 3. Comparison of average daily temperature and relative humidity among years 2023, 2024 and 1986–1989 (old) during the breeding period (pre-laying – 1, laying – 2, incubating-hatching – 3, nestling – 4, data in 1986–1989 were averaged). Est. = estimated regression coefficient; t = t-statistic; p = p-value.

Temperature												
	1			2			3			4		
Period	Est.	t	p	Est.	t	p	Est.	t	p	Est.	t	p
old vs 2023	–1.84	–1.36	0.181	–0.75	–0.69	0.491	1.31	1.72	0.093	3.74	6.71	<0.001
old vs 2024	5.13	3.78	<0.001	1.74	1.61	0.112	2.00	2.63	0.012	4.45	7.97	<0.001
2023 vs 2024	6.97	5.13	<0.001	2.49	2.31	0.025	0.69	0.91	0.369	0.70	1.26	0.215

Relative humidity												
	1			2			3			4		
Period	Est.	t	p	Est.	t	P	Est.	t	p	Est.	t	P
old vs 2023	15.87	3.09	0.003	8.16	1.63	0.110	9.88	2.13	0.040	2.10	0.46	0.648
old vs 2024	–19.66	–3.83	<0.001	–18.27	–3.64	0.001	–18.61	–4.01	<0.001	–16.32	–3.57	0.001
2023 vs 2024	–35.53	–6.93	<0.001	–26.43	–5.27	<0.001	–28.49	–6.13	<0.001	–18.42	–4.03	<0.001

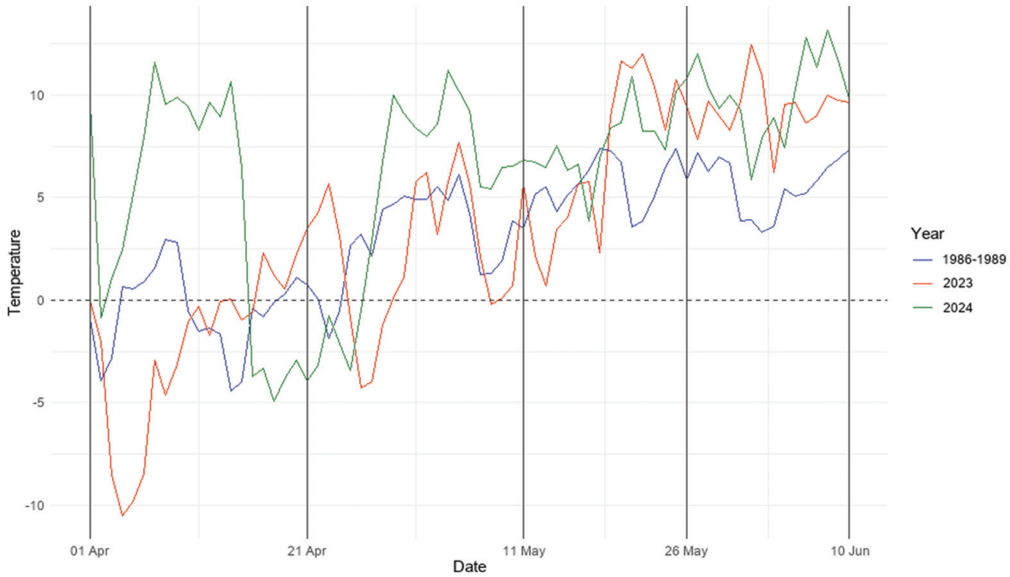

Fig. 2. Average daily temperature during the breeding periods (pre-laying, laying, incubating-hatching, nestling, data in 1986–1989 were averaged).

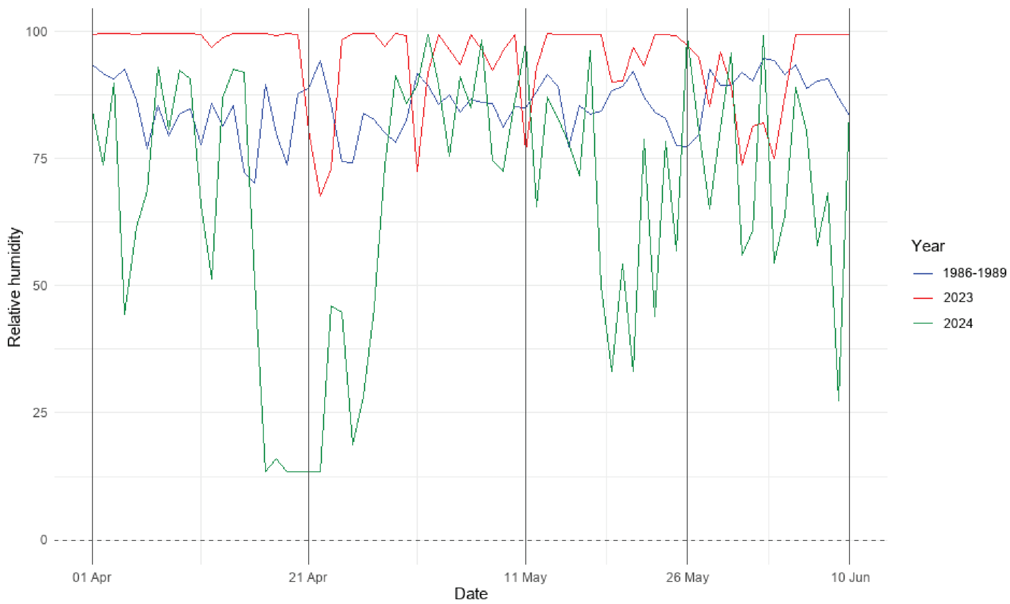

Fig. 3. Average daily relative humidity during the breeding periods (pre-laying, laying, incubating-hatching, nestling, data in 1986–1989 were averaged).

Temperature changes

The year 2023 was climatically similar as the period of 1986–1989, but the year 2024 was significantly drier and warmer (Table 3). In general, the temperature and relative humidity were extremely ambivalent during the breeding period in 2024 (Fig. 2 and Fig. 3). The dry and warm early spring in 2024 (February–half of April) caused rapid snow melt (75% of the Smrekovica site was covered by snow in 2023 on 24 April, but no snow cover on 25 April 2024). Recent warming in the study site is evident from Fig. 2 and Table 3, especially during the nestling period.

Discussion

Comparison of abundance of the Ring Ouzel during eighties (Janniga and Višňovská, 2021) with recent data confirmed fast decline of breeding pairs from, on average, 7 pairs year^{-1} (17.5 pairs km^{-2}) to none at the Brankov site. On the contrary, abundance of the Ring Ouzel at the Smrekovica site, where grazing was discontinued not long ago, is recently very high (about 30 pairs km^{-2}). As the main cause of the negative trend in abundance at the Brankov site was considered the habitat change. The old pasture is overgrown by dense high grass, but no such vegetation change is evident at the Smrekovica site. Declining grazing in Europe is widespread phenomenon (van den Pol-van Dasselaar et al., 2020) and the effects of grazing exclusion usually became apparent after 5 years (Kaufmann et al., 2021). Go hand in hand with this is usually increase in bryophyte abundance, which was evident at Smrekovica site, where grazing finished several years ago.

The role of habitat changes on the decline of Ring Ouzel populations has been documented by Ciach and Mrowiec (2013) in the Western Carpathians in Poland, by Barras et al. (2021b) in the Swiss Alps, and by Fumy and Fartmann (2021) in the Black Forest of Germany. The gradual abandonment of former mountain pastures, now overgrown with high grass, bushes and forests reduce breeding, mainly due to decreased availability of food. Preference for short vegetation in upland birds were reported in the White-winged Snowfinch (*Montifringilla nivalis*) in the Swiss Alps (Resano-Mayor et al., 2019), in the Water Pipit (*Anthus spinoletta*) in the Eastern Sudetes mountains (Bureš et al., 1999) and in the Ring Ouzel in the Swiss Alps (Barras et al., 2020). Chiffard et al. (2023) found that grazing intensity influences the diet of the Water Pipit and Wheatear (*Oenanthe oenanthe*) and Anger et al. (2024) consider restoration of extensive cattle grazing as key factor to increase populations of the Meadow pipit (*Anthus pratensis*).

Ciach and Mrowiec (2013) found that the Ring Ouzel in the Western Carpathians preferred higher altitudes and the proximity of clear-cuts and avoided small mountain meadows covered with a dense layer of vegetation on former mountain pastures. This is in accordance with our findings at Brankov. However, their conclusion that the presence of cultural landscape may have allowed the Ring Ouzel to colonize lower mountain areas is now questionable given the rapid warming during the decade after publishing their results. The shift to higher altitudes and decline in abundance in breeding areas is a recent phenomenon, rarely documented in Slovakia (Karaska et al., 2014).

Slovakia has lost nine-tenths of the number of sheep that were bred here before 1989. There were approximately three million sheep in Slovakia before political changes in 1989, but now, there are about three hundred thousand sheep only and sheep farming is on the decline (Zlatoš, 2017). Pastures on alpine meadows have only recently been rapidly abandoned in Slovakia. The sheep and cows only graze in meadows in valleys. Thus, the Ring Ouzel may suffer due to warming and low snow cover at lower altitudes and by overgrowing former pastures on alpine meadows. The unpleasant scenario we found at Brankov may be widespread over larger areas of the Slovakian mountains. Thus, altitudinal shifts of the bird to higher elevations, or more suitable refuges during the breeding are very probable. This means reduced breeding areas and decline in numbers. However, Barras et al. (2021a) documented variation in demography and life-history strategies across the range of the Ring Ouzel. Thus, there might be potential for adaptations of local populations.

The soil and vegetation characteristics are both valuable for comparison among studies and for estimating the suitability of an area for breeding. The main diet of the Ring Ouzel during breeding according to Barras et al. (2021c), is earthworms (Lumbricidae) (80% by abundance and 90% by biomass), but foraging behaviour is flexible (Bureš own unpublished data). Earthworm abundance depends mainly on ground vegetation cover and soil moisture and is highest during the nestling period (Barras et al., 2022). The penetrability of the soil is another key factor. The harder the soil, the less suitable it is for Ring Ouzel foraging for prey (Barras et al., 2020). Moreover, earthworms evacuate mostly under moss or on wet soft soil shaded by short vegetation where they are more easily detectable and available for the Ring Ouzel. Thus, prey availability for the Ring Ouzel decreases fast after pasture abandonment.

Warming in the mountains is significantly faster than the rate of the global average (Brunetti et al., 2009). Warming in the study area was confirmed as well, especially from the period of incubation and during the nestling period. However, in the case of the Ring Ouzel, higher relative soil humidity and precipitation can compensate for negative effect of warming, as the Ring Ouzel main diet is earthworm (Barras et al., 2021c). It was the case of the year 2023. On the contrary, the year 2024 was dry and warm, but without a noticeable negative effect on abundance and reproduction of the Ring Ouzel at the Smrekovica site. It could be caused by short vegetation (see above), by sufficient prey availability on natural alpine meadows and by flexible foraging behaviour of the Ring Ouzel as shown by data from wet (2023) and dry (2024) years (Bureš own unpublished data).

The results are in accordance with Barras et al. (2020) from the Alps. The data show that not only climate, but habitat changes as well may play a serious role in the decline in breeding populations of the Ring Ouzel in Slovakia. The fact that grazing has ceased is currently having a much more significant impact on habitats than climate change, and this is evident in the overgrowth of previously grazed areas (Wieser et al., 2019). In other words, some level of grazing is beneficial to maintain suitable habitat for the Ring Ouzel (Sim et al., 2013). Overall, recent and ongoing changes necessitate evaluation of the impact of both climate and habitat changes in any explanation for declining abundance of a mountain species in any area.

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Author contributions

S. Bureš initialized the study, collected samples in the field, interpreted the data, and wrote the manuscript. S.

Brecelj collected samples in the field and prepared data matrices. P. Jašková performed statistical analysis. All authors commented and approved the manuscript.

Availability of data and materials

Data matrices will be provided by corresponding author on reasonable request.

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