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RESULTS OF LARGE MAMMAL MONITORING IN THE ROZTOCHYA NATURE RESERVE OVER 40 YEARS OF OBSERVATIONS, 1984–2025

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Background. Long-term wildlife monitoring is crucial for understanding population dynamics and informing conservation strategies. This study presents a 40-year analysis of large mammal communities in the Roztochya Nature Reserve (Western Ukraine). The study period covers two distinct methodological approaches: traditional surveys (1984–2019), which yielded data with significant limitations for quantitative analysis, and modern camera trap monitoring initiated in 2020 to overcome these shortcomings and provide objective, verifiable data on the region's fauna.

Materials and Methods. Historical data from 1984–2019, collected via transect counts and track surveys, were critically reviewed. From 2020 to mid-2025, a systematic camera trap survey was implemented, with the network expanding from 4 to 20 devices. Analysis focused on species composition, detection frequencies, and seasonal activity patterns. We calculated a relative abundance index to assess recent population trends and compared the effectiveness of the two monitoring approaches.

Results. The camera trap monitoring yielded over 2000 detection days for 13 mammal species. The European roe deer (*Capreolus capreolus*) was the most frequent species (~53.4 %), followed by the red fox (*Vulpes vulpes*, ~18 %) and the wild boar (*Sus scrofa*, ~10 %). A significant increase in detections was observed for roe deer and wild boar in 2023–2024. A key finding was the confirmation of the European wildcat's (*Felis silvestris*) regular presence since 2024, changing its status from extremely rare to a permanent resident. The transient status of the grey wolf (*Canis lupus*) was also confirmed.

Conclusions. The transition to camera trapping provides a more accurate assessment of the mammal community, proving highly effective for detecting rare and elusive species. These results allow for a critical revision of the conservation status of several key species, most notably the European wildcat. The study underscores the importance of the Roztochya Nature Reserve as a key refugium and ecological corridor, with population dynamics likely influenced by recent nationwide changes in hunting management.

Keywords: camera traps, mammals, monitoring, Roztochya Nature Reserve, population dynamics

INTRODUCTION

Roztochya is a hilly region in Eastern Europe, extending through southeastern Poland and the Lviv Oblast of Ukraine, and forming part of the main European watershed. Geographically, it is a low ridge with an average altitude of 320–370 m (Marynych, 1993). The Ukrainian part of Roztochya is located in Lviv Oblast, covering approximately 1,700 km². The landscape is dominated by forests (50 %), agricultural and urban areas (30 %), ponds, meadows, and marshes. The region's protected area network is extensive, with over 20 % of the territory under formal protection. The reserve borders the Yavorivskyi National Nature Park, forming a continuous ecological complex crucial for regional biodiversity. However, systematic monitoring of large mammals using camera traps has not yet been fully put into operation in the neighboring park, limiting the availability of comparable quantitative data for a broader transboundary analysis in this study.

Systematic studies of the mammal fauna in the Roztochya Nature Reserve have been conducted since 1984, with some historical data dating back to the 19th–20th centuries (Tatarinov, 1973). Until 2020, monitoring relied primarily on traditional methods such as visual sightings, track recording, and snow-track transects. This approach had inherent limitations, stemming from its reliance on subjective assessments and the varying qualifications of observers, which compromised data consistency and comparability over time (Zwerts *et al*., 2021).

To enhance the accuracy and objectivity of monitoring, camera traps were implemented as the primary data collection method starting from 2020. Camera traps provide continuous, non-invasive monitoring with objective photographic evidence, making them a powerful tool for studying species composition, abundance, behavior, and seasonal activity (Rovero & Zimmermann, 2016). They are particularly effective for documenting rare and elusive species (Carbone *et al*., 2001) and enable robust statistical analysis (Kays *et al*., 2020). The implementation of this modern methodology in the Roztochya Nature Reserve was a necessary step to achieve a new qualitative level of research.

Therefore, the aims of this study were to: (1) critically assess the long-term historical dataset on large mammals in the reserve collected from 1984 to 2019 (2) present the first comprehensive results from the newly established camera trap monitoring program (2020–2025), (3) provide an updated assessment of the species composition, relative abundance, and activity patterns of the large mammal community, and (4) re-evaluate the conservation status of key and rare species based on the new, objective data.

MATERIALS AND METHODS

Historical monitoring (1984–2019). From 1984 to 2019, the monitoring of large mammals (Artiodactyla, Carnivora, Lagomorpha, and select Rodentia) in the Roztochya Nature Reserve relied on traditional field methods (**Table 1**), following the standard recommendations for the Chronicles of Nature (Litopys pryrody) in Ukrainian protected areas (summarized in Andriienko *et al*., 2002). The research included route-based counts to record animals and their tracks, conducted at different times of the year along designated transects. Particular attention was paid to snow-track surveys during the winter, when stable snow cover enabled mapping daily routes and activity of mammals, which was crucial for assessing the abundance and distribution of predators and ungulates. For some species, such as the grey wolf (*Canis lupus*) or the European badger (*Meles meles*), additional efforts were made to locate and map dens, lairs, and territory boundaries. Throughout the year, both incidental and targeted visual encounters were also recorded. It is important to note that the effectiveness and regularity of these surveys, especially winter ones, were highly dependent on weather conditions – namely, the presence, duration, and quality of snow cover. This led to a certain irregularity in data collection and potential seasonal bias, as conducting comprehensive track counts was hampered in years with little or unstable snow. Therefore, fieldwork was planned during the most favorable periods of each season to mitigate these limitations.

Camera trap survey (2020–2025). Starting from autumn 2020, camera traps were deployed for monitoring. In 2020-2021, 4 to 9 camera traps were installed at locations selected to ensure maximum biotope diversity and device security against theft (**Fig. 1**). During this period, a single camera model was used: UOVision UV-557. All cameras operated continuously (24/7) in motion detection mode with medium sensitivity settings and an active infrared (940 nm) flash at night. The cameras were set to capture three consecutive photos upon motion detection.

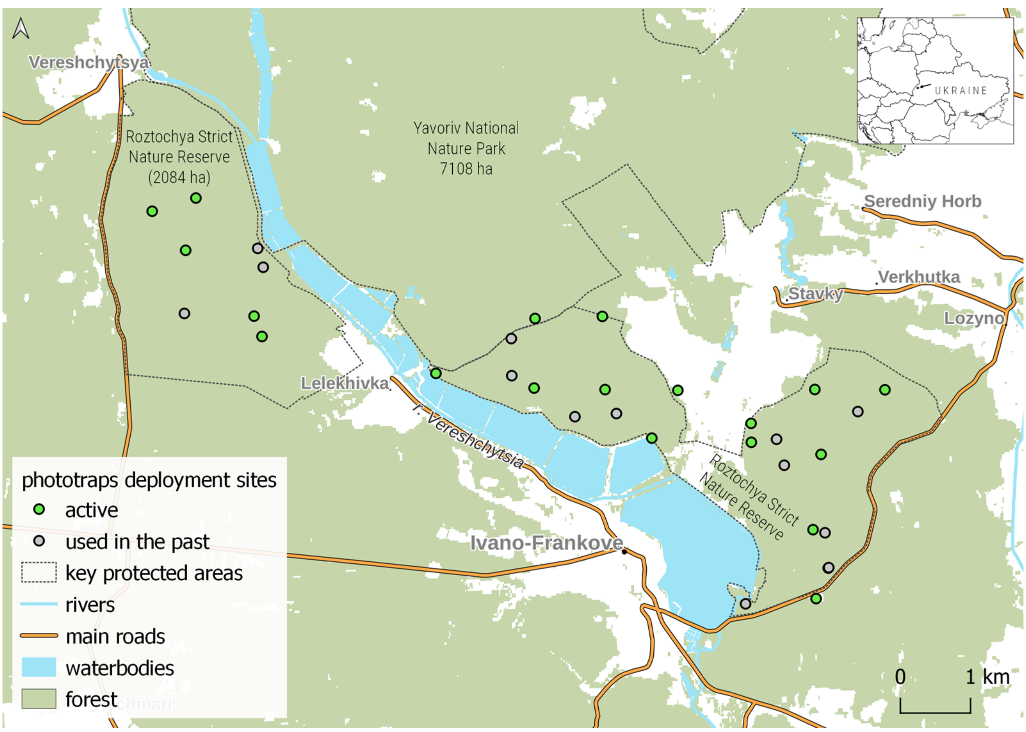

Fig. 1. Map of the main survey routes and camera trap deployment sites in the Roztochya Nature Reserve

From 2021 to 2023, the number of cameras was increased to 13–15 with the addition of Suntek HC-900A and HC-910A models. Starting from 2024, we transitioned to deploying cameras at the centroids of a regular 1×1 km grid. This approach ensures more unbiased site selection, statistical independence of observations, and data representativeness (Rovero & Zimmermann, 2016), although it also creates additional risks for the cameras (5 units were stolen over the 5-year period). Thus, by 2024, the number of concurrently operating cameras reached 20.

Camera locations were changed only during the first six months of the study; thereafter, all cameras remained active at their initial deployment sites. As of this writing, some cameras in the reserve have been operating continuously at the same location for 5 years. The long-term operation of the camera traps was ensured by regular battery replacement, external cleaning of sensors and lenses, and memory card swaps every few months. Occasionally, cameras malfunctioned, or their field of view became obstructed by vegetation. In such cases, the batteries drained faster than expected, resulting in incomplete temporal coverage. To account for this, we calculated the number of active operational days for each camera (presented in **Table 2**).

Data analysis. To assess annual fluctuations in species abundance, we calculated a relative abundance index (RAI) using the formula:

$$\mathrm{RAI} = n \cdot 100/\mathrm{ctd}$$

where: RAI is the relative abundance index; n is the number of detection days for a species; and ctd is the total camera-trap days.

All collected photo materials were reviewed manually to identify animals. Since 2024, we have also experimentally used the DeepFaune automatic image classification tool (Rigoudy *et al*., 2023), with subsequent manual verification of all photographs. For greater research transparency, all photos were aggregated into one observation per species per day per location and uploaded to the iNaturalist.org platform. There, observations undergo additional verification by volunteers and are automatically ingested into the Global Biodiversity Information Facility (gbif.org) database (Strus *et al.*, 2025). This dataset is dynamic and will continue to grow as more materials are processed and camera trap monitoring continues in the future.

Statistical analysis. All statistical calculations were performed in the R software environment (version 4.3.3; R Core Team, 2023. Results were considered statistically significant at a significance level of $\alpha = 0.05$.

Temporal trend analysis. To statistically analyze the temporal dynamics of the relative abundance indices (RAI) for each species, we employed non-parametric trend tests, justified by the short observation period. The primary method was the Mann–Kendall trend test (*Kendall* package for R (McLeod, 2022)), which checks for a monotonic trend. To confirm the results and assess the strength of the relationship between year and RAI, we additionally calculated Spearman's rank correlation coefficient (ρ). To assess the stability of the detected RAI trends, a bootstrap procedure (10,000 iterations) was applied to calculate 95 % confidence intervals for the annual indices of three key species: wild boar, European roe deer, and red fox.

Seasonal pattern analysis. To assess whether camera trap detections exhibited significant seasonal variation, Chi-square (χ^2) goodness-of-fit tests were performed for each species. The null hypothesis (H^0) stated that detections are uniformly distributed across months. Two complementary analyses were conducted: (1) year-by-year tests examining seasonal patterns separately for each full year of monitoring, and (2) a combined test using pooled detection data across all years. For the combined analysis, raw detection counts were first summed across years for each month, and months with zero detections were excluded. Effect sizes were quantified using Cramér's V statistic, with values interpreted as negligible ($V < 0.1$), small ($0.1 \le V < 0.3$), moderate ($0.3 \le V < 0.5$), or large ($V \ge 0.5$).

Ethical statement. This research was based on non-invasive observational methods (track surveys and camera trapping). No animals were captured, handled, or otherwise disturbed during the study. All procedures adhered to the ethical guidelines for animal research and the legal requirements of Ukraine.

RESULTS AND DISCUSSION

Historical monitoring (1984–2019): a qualitative baseline and critical assessment. Data on large mammals collected from 1984 to 2019 were partially summarized in the Chronicles of Nature (the Roztochya Nature Reserve, 1986–2024) and other publications (Huzii, 1997). These records provide a general overview of the theriofauna's composition and dynamics before 2020 (**Table 1**).

According to these traditional surveys, the large mammal fauna showed multidirectional trends. Among the lagomorphs, the European hare (*Lepus europaeus*) was a permanent resident, albeit with notable fluctuations in its abundance indices. Among the rodents, the red squirrel (*Sciurus vulgaris*) exhibited significant fluctuations, while the Eurasian beaver (*Castor fiber*), absent at the beginning of the period, began to be recorded and gradually re-establish its population from the mid-1990s.

The artiodactyl community (*Artiodactyla*) also demonstrated considerable dynamics. The European roe deer (*Capreolus capreolus*) remained the most abundant species, though its survey indicators varied. The wild boar (*Sus scrofa*) was also consistently present, but its population experienced more pronounced fluctuations. In contrast, the red deer (*Cervus elaphus*) and the moose (*Alces alces*) were recorded irregularly, indicating their low abundance.

The carnivore community (*Carnivora*) was characterized by the stability of some species and changes in the status of others. The red fox (*Vulpes vulpes*) was consistently the most numerous predator. The pine marten (*Martes martes*) was the second most abundant forest predator, while the stone marten (*Martes foina*) remained an uncommon synanthropic species associated with the outskirts of settlements. The European badger showed stable indices with a tendency to increase, confirmed by data on 19 sets recorded between 1992 and 2003, with a density of 7–8 individuals per 1000 ha of suitable habitat (Dykyi, 2001). The Eurasian otter (*Lutra lutra*) population, though not large, was stable and began to recover at the end of the 20th century. The invasive raccoon dog (*Nyctereutes procyonoides*) was consistently present, primarily inhabiting wetland biotopes.

The status of large and rare carnivores deserves special attention. The grey wolf, absent in the second half of the 20th century, began to be regularly recorded from the early 2000s, with a peak in numbers in the mid-2010s. The European wildcat (*Felis silvestris*) had no reliable records for a long time, appearing only in isolated records in the

Table 1. **Dynamics of relative abundance or presence[1] of selected mammal species in the Roztochya Nature Reserve based on traditional survey data from the Chronicles of Nature (1986–2019)**

Species	Unit of measurement[2]	1986–1990	1991–1995	1996–2000	2001–2005	2006–2010	2011–2015	2016–2019[3]
Lepus europaeus	ind/5km	20–38	14–45	31–39	4–7	4–9	3–6	2–5
Sciurus vulgaris	ind/5km	9	19	18	6–19	4–6	2–5	4
Castor fiber	f	-	-	r	-	-	-	3f
Sus scrofa	ind / ind/5km[4]	23–36	5–9	1–8	5–9/5km	5–12/5km	7–12/5km	10–13/5km
Capreolus capreolus	ind / ind/5km[4]	35–41	14–30	24-28	7–16/5km	9–14/5km	12–26	7–27
Cervus elaphus	ind	1+j	1–4	1	-	-	-	-
Alces alces	ind	1–3	2	1	2+j	1	1	1
Felis silvestris	ind	-	-	-	-	1	-	-
Lynx lynx	ind	-	-	-	-	1	-	-
Canis lupus	ind	-	-	-	2+j	1-3	1–2	1–2
Vulpes vulpes	ind/10km	9–18	5–10	6–10	7–8	2-7	6–7	2–6
Nyctereutes procyonoides	ind/6km	-	-	-	3–4	4	-	2–3
Meles meles	f	-	3–4	4	+	3	3	3
Lutra lutra	f	-	1	-	2	2	2	2
Martes martes	ind / ind/5km[4]	6–7	10–13	7–10	3–4/5km	3–7/5km	3–6/5km	5–5
Mustela putorius	ind/5km / f[5]	1	1–2	3	1–2	2	2	2–3f
Mustela erminea	ind/5km	1+j	2	1–2	1–3	3–4	2–3	2
Mustela nivalis	ind/5km	1	-	1	1–2	1–2	2–3	2
Mustela lutreola	ind	-	-	1	-	-	-	-
Canis familiaris	ind	+	+	+	+	+	+	+

Notes: 1. The table presents the range (minimum-maximum) of recorded values for the specified period or other information on presence. Calculation of mean or statistical values is not feasible due to data heterogeneity (see text).
2. Primary unit of measurement used for the species; ind – individuals (absolute number, likely estimated); ind/Nkm – encounter index (individuals or tracks per N km of transect); f – families or active burrows; + – species recorded, without quantitative assessment; - – species not recorded; ? – data missing or uncertain; r – recorded in the region; j – juveniles/brood recorded.
3. The period 2016–2019 covers 4 years.
4. For wild boar, roe deer, and pine marten, the unit of measurement changed over the observation period (from ind to ind/5km), complicating direct comparison. The ranges are presented according to the units used in the respective periods.
5. For European polecat, both ind/5km and f (families) were used.

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late 2000s. The Eurasian lynx (*Lynx lynx*) was not recorded within the reserve (the last mention in the chronicles dates back to 1957), although data on its appearance in adjacent territories emerged in the late 2000s. Among smaller mustelids, the stoat (*Mustela erminea*) showed an increase in numbers, while the least weasel (*Mustela nivalis*) and the European polecat (*Mustela putorius*) were recorded irregularly. It is important to note that the European mink (*Mustela lutreola*) was considered extinct for most of the period, while the invasive American mink (*Neogale vison*) was recorded rarely and has not been detected recently.

However, an analysis of these historical data reveals significant methodological limitations. The fragmentary, irregular, and predominantly qualitative nature of the data („present," „rare"), combined with variability in methodologies, units of measurement (ind, ind/km, f), and observers, introduced systemic heterogeneity and subjectivity. Furthermore, the historical species identification based solely on track warrants critical skepticism, particularly regarding small mustelids. Distinguishing the tracks of the stoat from those of the least weasel is notoriously difficult due to the significant overlap in footprint dimensions between the sexes of these species (King *et al*., 2006). Similarly, historical records of the European mink from the late 1990s are likely misidentifications of the invasive American mink. By that period, the European mink had undergone a catastrophic decline and was largely extirpated from most of its range in Eastern Europe due to competition with the American mink (Maran *et al*., 2016). Since the tracks of these two mink species are virtually indistinguishable in the field, and given the rapid expansion of the invasive species, the presence of European mink in the later historical records is highly doubtful. The dependence of surveys on unstable snow cover and the absence of primary data for many periods make verification and standardized recalculation impossible. Therefore, this historical dataset should be regarded as a valuable qualitative baseline that reflects general trends within the constraints of the methodologies available at that time. These limitations justify the transition to standardized monitoring using camera traps to obtain more accurate quantitative data.

Quantitative insights from camera trap monitoring (2020–2025). The implementation of camera traps since 2020 has been a significant step forward, allowing for the acquisition of objective, standardized, and verifiable data. This modern method provides 24/7, continuous monitoring that minimizes disturbance and eliminates the subjectivity of species identification, proving particularly important for secretive or rare species like the European wildcat, as demonstrated in this study (O'Connell *et al*., 2011; Zwerts *et al*., 2021). From 2020 to mid-2025, the expanding camera network (from 4 to 20 devices) yielded a substantial dataset of 2008 detection-days for 13 mammal species across various locations (**Table 2**).

The data analysis reveals an uneven distribution of detections. The European roe deer was the most frequently recorded species (~53.4 %), followed by the red fox (~17.7 %) and wild boar (~10.3 %). The increased monitoring effort over time, with cumulative camera-trap days growing from 538 in 2020 to 4315 in 2024, resulted in a greater number of recorded species, with the highest diversity (13 species) observed in 2024. This highlights the method's effectiveness in documenting community composition, especially for species that were previously unrecorded or only appeared sporadically, such as the European wildcat and European polecat, both first detected in 2024.

Table 2. **Statistics of mammal detections by camera traps and dynamics of monitoring intensity for 2020–2025**

Species	Number of species detection days at different locations per year						Total detections per species
	2020[1]	2021	2022	2023	2024	2025[2]	
Total cameras in use	6	9	13	13	20	20	
Trap-days used for analysis[3]	538	2798	2848	2241	4315	1208	
Lepus europaeus	-	2	1	5	19	3	30
Sciurus vulgaris	-	-	-	-	5	-	5
Sus scrofa	2	3	2	12	137	50	206
Capreolus capreolus	16	70	57	141	512	276	1072
Cervus elaphus	-	3	1	7	11	3	25
Alces alces	4	3	6	5	23	9	50
Felis silvestris	-	-	-	1	22	11	34
Canis familiaris	-	28	22	30	8	11	99
Canis lupus	-	-	-	-	1	-	1
Vulpes vulpes	14	89	49	50	105	49	356
Meles meles	-	10	34	25	32	11	112
Martes martes	1	1	1	-	7	2	12
Mustela putorius	-	-	-	-	4	2	6
Total observations	37	209	173	276	886	427	2008

Notes: 1. Camera trap deployment began in September 2020, so the data cover only autumn and part of winter.
2. This report was prepared in mid-2025, when not all data from the devices had been retrieved.
3. The number of active camera-trap days for the respective year used in the analysis.

The analysis of the relative abundance index (RAI) reveals clear inter-annual trends (**Fig. 2**). Most significantly, the European roe deer's RAI rose from 2.0-3.0 in 2020–2022 to a preliminary 22.8 in mid-2025, suggesting a substantial increase in its population or activity. The wild boar also showed a strong recovery, with its RAI increasing from very low values (0.1-0.5) to 3.2-4.1 in 2024-2025.

The dynamics of other species were more stable. Species like the red deer, the moose, and the European hare had consistently low indices. Statistical analysis of seasonal activity revealed no significant patterns for the European hare ($\chi^2 = 8.87$, $p = 0.545$), the red squirrel $\chi^2 = 0.2$, $p = 0.655$), the pine marten ($\chi^2 = 2.36$, $p = 0.883$), the European polecat ($\chi^2 = 1$, $p = 0.963$), and the domestic dog (*Canis familiaris*) ($\chi^2 = 8.95$, $p = 0.347$). For the grey wolf, data were insufficient for a seasonal analysis.

Although the seasonal activity of domestic dogs did not show significant patterns, their regular presence (99 detection days, **Table 2**) indicates persistent anthropogenic pressure from nearby settlements. The presence of free-ranging dogs poses a potential threat to wildlife through disturbance, competition, and disease transmission (Doherty *et al.*, 2017), necessitating strict control of the reserve's perimeter.

While camera trapping offers robust quantitative data, the method has limitations (Zwerts *et al*., 2021). The high cost of equipment and risk of theft (5 cameras were stolen) pose a financial burden. Furthermore, camera placement can influence detection probability (Rovero & Zimmermann, 2016), and the method is less effective for small or arboreal mammals. Consequently, species like the stoat, the weasel, and the raccoon dog are practically absent from this dataset, despite their known presence. Processing large datasets (approximately 50,000 photos over 5 years) is time-consuming, even with the use of automated classification tools (Rigoudy *et al*., 2023) that still require manual verification. Nevertheless, the systematic placement of cameras and calculation of standardized indices like the RAI allow for more robust comparisons of species activity over time and space, providing a solid foundation for the detailed species-specific analysis that follows (Carbone *et al*., 2001; Dolapchiev *et al*., 2024).

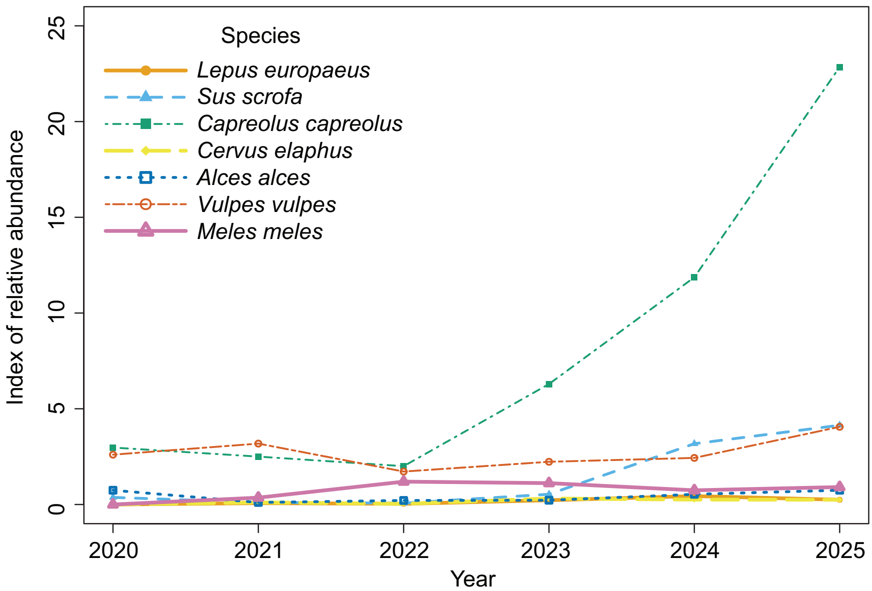

Fig. 2. Dynamics of the relative abundance index for mammals in the Roztochya Nature Reserve from 2020–2025

Seasonal activity of mammals in the Roztochya Nature Reserve. The wild boar, a species with historically fluctuating numbers, shows both a strong seasonal activity pattern (**Fig. 3**) and a notable recent recovery in abundance (**Fig. 2**). After several years of low indices, its activity increased significantly in 2024–2025 (RAI ~3.2–4.1). While the overall trend for the entire 2020–2025 period was not statistically significant (Mann–Kendall test: $\tau = 0.6$, $p = 0.133$; Spearman's correlation: $\rho = 0.77$, $p = 0.072$), the bootstrap analysis reveals that this is due to a pattern of low stability followed by a sharp, recent increase after 2023 (**Fig. 4**). The wide confidence intervals in the later years reflect high variability in detections, which may explain the lack of statistical significance for the overall trend. The increasing trend may suggest that the population is rebounding from a nationwide decline caused by African Swine Fever (ASF) (Sauter-Louis *et al*., 2021; EFSA *et al*., 2024), and is likely amplified by the 2022 hunting ban (Morelle *et al*., 2015; Thurfjell *et al*., 2013).

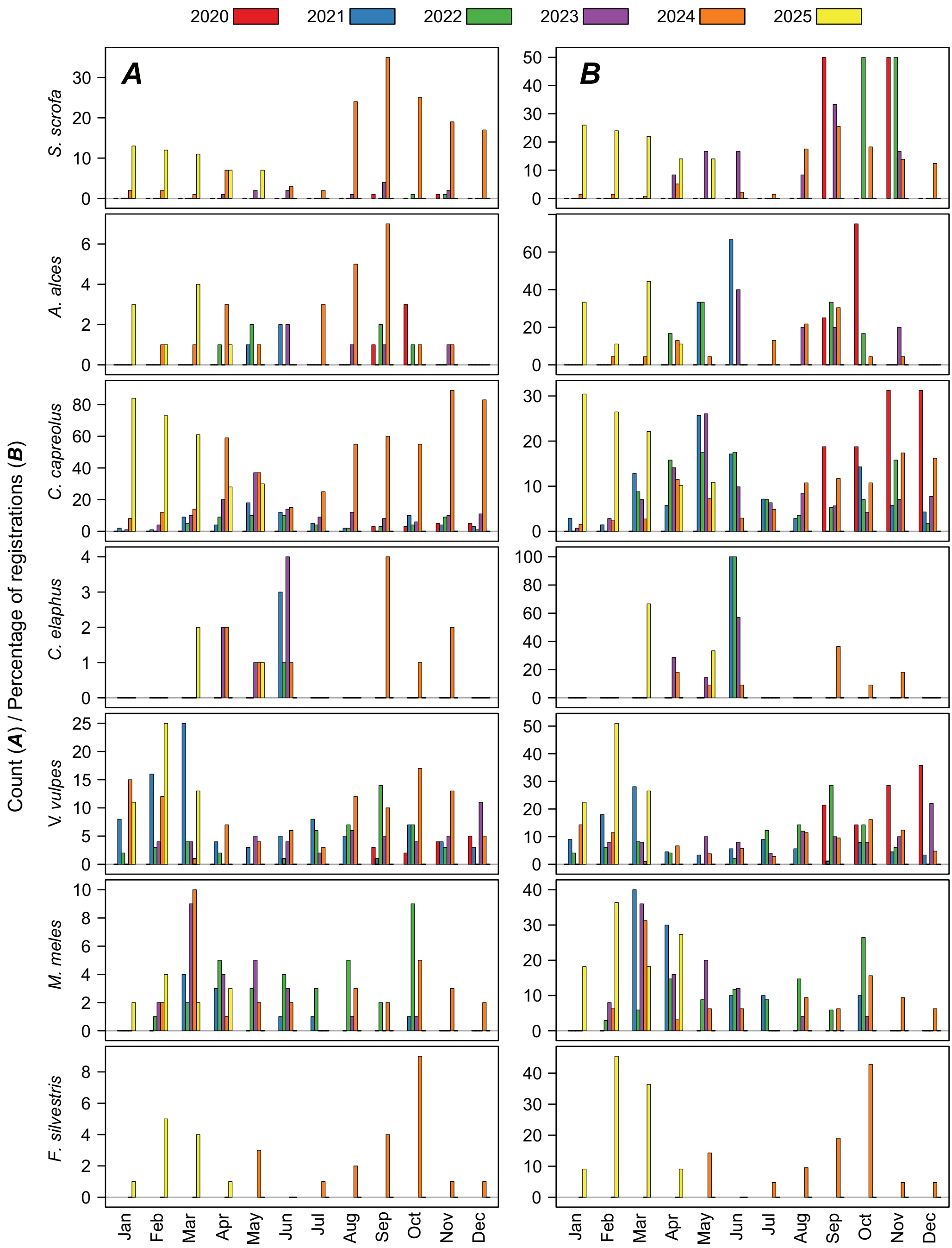

Fig. 3. Seasonal activity patterns of seven mammal species in the Roztochya Nature Reserve (2020–2025). The left column (***A***) displays the absolute number of detection days per month. The right column (***B***) shows the monthly percentage of total annual detections, calculated for each full year of observation

The seasonal activity of the wild boar is strongly pronounced, with a primary peak in autumn (August–November) (**Fig. 3**). The Chi-square test confirmed that this seasonal pattern is statistically significant ($\chi^2 = 70.04$, df = 11, $p < 0.001$), although the effect size was small (Cramér's V = 0.177). This pattern is driven by the availability of mast, particularly acorns, which are a critical dietary component influencing their demography (Mikulka *et al*., 2018; Touzot *et al.*, 2020). The high activity observed in autumn 2024 (**Fig. 3*A***), likely a mast year, reflects intensive foraging. Mast years, as a pulsed resource (Kelly, 1994; Pearse *et al*., 2016), fuel high autumn activity and lead to an increased reproductive success the following year (Bieber & Ruf, 2005; Servanty *et al*., 2011; Gamelon *et al*., 2021). Consequently, this suggests a potential demographic increase in 2025, and the elevated detections in early 2025 may be the first evidence of this trend.

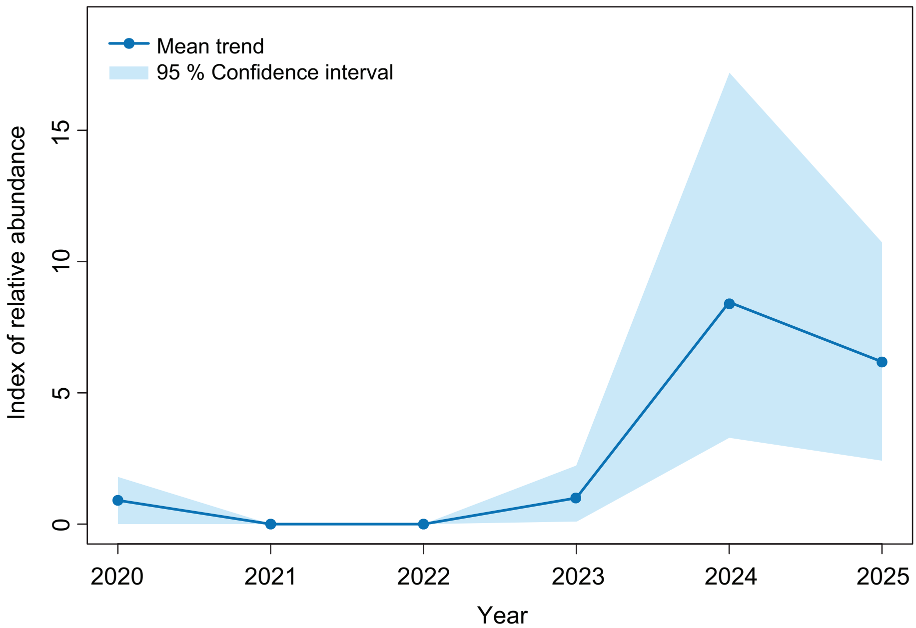

Fig. 4. Bootstrapped trend in the relative abundance index (RAI) for wild boar from 2020 to 2025. The solid line represents the mean trend based on 10,000 bootstrap iterations. The shaded area indicates the 95 % confidence interval, visualizing the uncertainty of the estimate

In other seasons, activity is lower. During spring, the diet shifts to underground plant parts (Baubet *et al*., 2004), while in summer, a wider range of forage is consumed, and activity can be limited by heat (Thurfjell *et al*., 2009). The low number of detections in these periods, especially in 2020–2023, is consistent with these ecological patterns. However, ASF remains a major risk factor, and the species' long-term dynamics will depend on the interplay between food availability, protection regimes, and the epizootic situation.

The moose has historically been an uncommon species in the reserve (**Table 1**), a status confirmed by recent camera trap data (RAI 0.1-0.7; **Fig. 2**), with no significant trend detected over the study period (Mann–Kendall test: $\tau = 0.47$, $p = 0.260$; Spearman's correlation: $\rho = 0.43$, $p = 0.397$). However, repeated sightings of a female with twin calves suggest favorable food conditions, as twinning is more frequent when resources are abundant (Franzmann, 1981).

The notable increase in moose detections in 2024 aligns with the broader European trend of large mammal recovery (Henttonen *et al*., 2007; Chapron *et al*., 2014) and the species' comeback in Poland following a hunting moratorium (Dziki-Michalska *et al*., 2019). In Ukraine, the situation remains complex due to a preceding period of population decline (Boreiko & Parnikhoza, 2023), which led to the implementation of conservation measures and the listing of the species in the Red Data Book of Ukraine in 2017 (Ministry of Environmental Protection and Natural Resources of Ukraine, 2021). The hunting ban in the country since 2022 likely creates more favorable conditions for the species and reinforces the reserve's role as a refugium.

The seasonal activity of moose in the reserve is characterized by irregular detections throughout the year. Statistical analysis confirmed the lack of a significant, consistent seasonal pattern (Chi-square test: $\chi^2 = 13.8$, df = 10, $p = 0.182$), which is likely due to the low number of detections and high inter-annual variability. Despite the absence of a fixed pattern, detections tended to be more frequent during summer and autumn (**Fig. 3**). For instance, activity peaked in June in 2021 and 2023, but was more concentrated in August–September in 2024. The general trend of reduced activity during winter and hot summer periods is consistent with the species' sensitivity to thermal stress and changes in food availability (Best *et al*., 1978; Broders *et al*., 2012). The reserve's diverse habitats, including suitable forest types and crucial wetland areas for feeding and thermoregulation (Wall *et al*., 2010; Bobek *et al*., 2024), support this potential recovery. Therefore, the recent rise in detections may signal the beginning of positive population dynamics, which warrants continued monitoring.

The European roe deer demonstrates a strong and consistent increase in relative abundance, confirming its status as the most numerous ungulate in the reserve. Its RAI rose from 2.0-3.0 in 2020–2022 to a preliminary 22.8 in mid-2025 (**Fig. 2**). While this sharp increase is visually striking, the overall trend for the short 2020–2025 period has not yet reached statistical significance (Mann–Kendall test: $\tau = 0.6$, $p = 0.133$; Spearman's correlation: $\rho = 0.77$, $p = 0.072$). The bootstrap analysis helps to interpret this result: it shows a period of stability or slight decline (2020-2022) followed by a steep and continuous increase (2023–2025) (**Fig. 5**). The lack of overlap between the 95 % confidence intervals of the later and initial years provides strong evidence of a recent, genuine increase in relative abundance. This substantial growth is consistent with historical data on its abundance and is likely the result of several factors, including favorable winters, food availability, and a significant reduction in disturbance following the nationwide hunting ban enacted in 2022.

The species exhibits a pronounced bimodal seasonal activity pattern, with a spring peak (April–May) and an autumn-winter peak (October–December), separated by a summer decline (**Fig. 3**). This bimodal pattern was found to be statistically significant ($\chi^2 = 91.2$, df = 11, $p < 0.001$), confirming a strong deviation from uniform year-round activity. However, the effect size was negligible (Cramér's V = 0.088), likely because the high number of detections, even during the months of lower activity, tempers the overall magnitude of the seasonal variation. The strength of both peaks, particularly the high absolute number of detections in 2024 and early 2025, was likely amplified by the removal of hunting pressure (**Fig. 3**).

The biological drivers for these peaks are well-established. The spring peak is associated with increased territoriality before the mating season (Linnell & Andersen, 1998; Melis *et al*., 2004; Debeffe *et al*., 2014) and the emergence of protein-rich forage

(Pagon *et al*., 2017). The autumn-winter peak corresponds to a period of intensive foraging to accumulate fat reserves, influenced by shorter photoperiods and changes in food availability (Parker *et al*., 1999; Loe *et al*., 2005; Tixier *et al*., 1997). Interestingly, the percentage distribution of detections (**Fig. 3*B***) suggests that as overall activity increases, it may be becoming more evenly distributed throughout the year. This pattern warrants further investigation, potentially using GPS-tracking to better understand the interplay of resources and other factors (Stache *et al*., 2013).

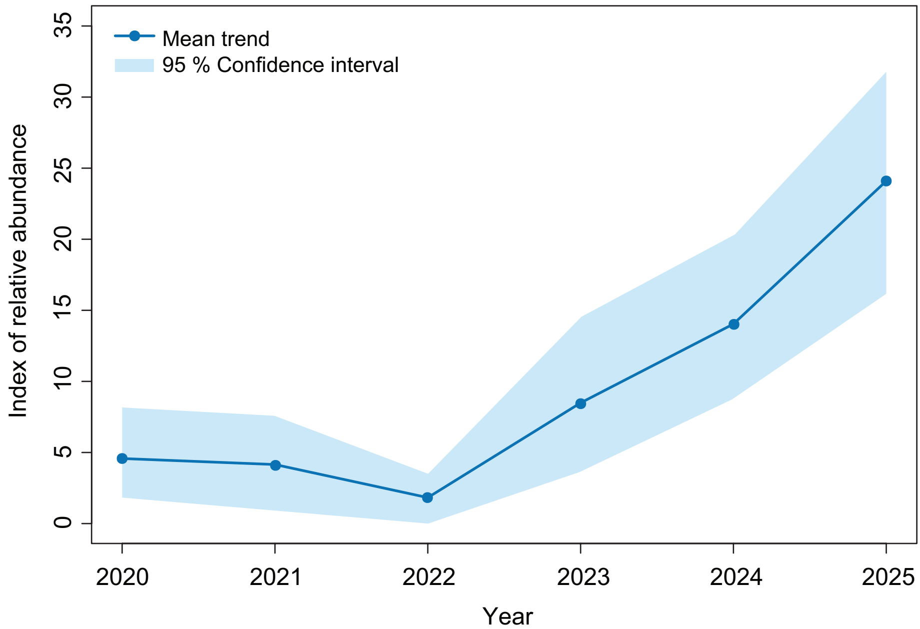

Fig. 5. Bootstrapped trend in the relative abundance index (RAI) for the European roe deer from 2020 to 2025. The solid line represents the mean trend based on 10,000 bootstrap iterations. The shaded area indicates the 95 % confidence interval

The red deer remains an uncommon species in the reserve, consistent with historical data (**Table 1**). Its relative abundance index is consistently low (RAI 0.1-0.3; **Fig. 2**), and no significant temporal trend was detected over the study period (Mann–Kendall test: $\tau = 0.47$, $p = 0.260$). The species' presence is highly seasonal, confirming its status as a transient or seasonal visitor. Detections are concentrated almost exclusively in two short periods: spring-summer (March–June) and autumn (September–November), with a near-complete absence in between (**Fig. 3**). While this bimodal pattern is visually distinct, it did not reach statistical significance, likely due to the low total number of detections (Chi-square test: $\chi^2 = 11.68$, df = 6, $p = 0.07$).

The timing of these peaks aligns with key aspects of the species' biology. The spring peak is likely linked to migrations towards areas with optimal forage for calving and rearing young, a pattern confirmed in the nearby Carpathians (Albon & Langvatn, 1992; Kropil *et al*., 2015). This migratory behavior, influenced by factors like population density (Mysterud *et al*., 2011), often follows the “forage maturation hypothesis” (Debeffe *et al*., 2017). The autumn peak coincides with the rutting season, when temporary mixing of the sexes contrasts with their segregated habitat use for most of the year (Bowyer, 2022), leading to increased movement, particularly by males (Clutton-Brock *et al*., 1982; Bonenfant *et al*., 2004).

These findings suggest that the Roztochya Nature Reserve serves as an important transit area or temporary habitat during spring migrations and the autumn rut, rather than a year-round residence. The low detection frequency indicates either a low overall population density in the region or that the species' core habitats lie outside the reserve's boundaries.

The red fox, historically the region's most numerous predator, demonstrates a stable presence in the reserve, with its RAI fluctuating between 1.7 and 4.1 (**Fig. 2**), and no significant trend over time (Mann–Kendall test: $\tau = 0.2$, $p = 0.707$; Spearman's correlation: $\rho = 0.14$, $p = 0.787$). This stability is further supported by the bootstrap analysis, which showed widely overlapping 95% confidence intervals across all years of the study, indicating a lack of significant change in its relative abundance (**Fig. 6**). This pattern aligns with its status as an adaptive and ecologically flexible species (Kobryn *et al*., 2023). The fluctuations observed, such as the RAI peak in 2021, likely reflect the species' numerical response to cyclical changes in rodent density, a key food source in the region (Castañeda *et al*., 2022; Martsiv *et al*., 2021; Cano-Martínez *et al*., 2021; Panzacchi *et al*., 2009).

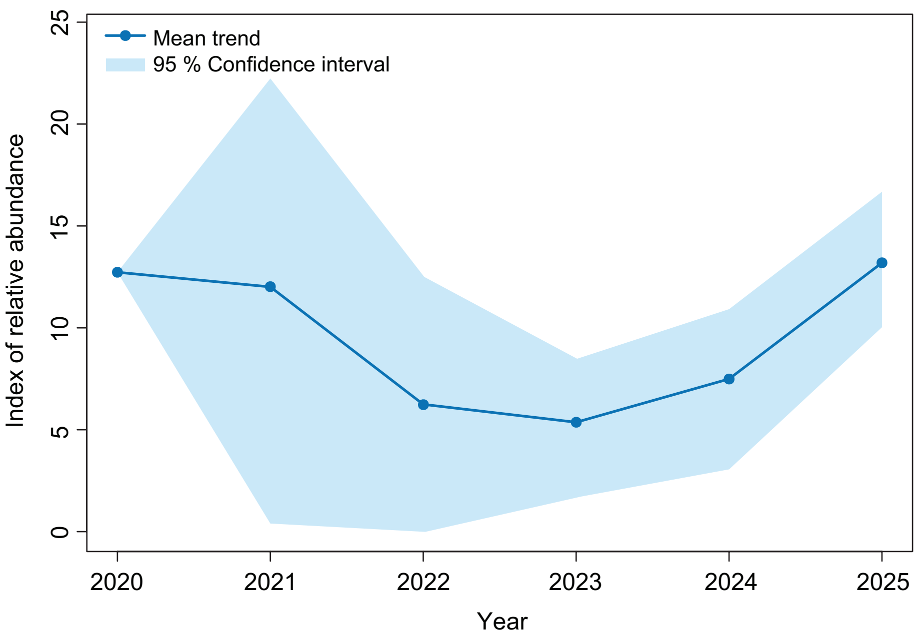

Fig. 6. Bootstrapped trend in the relative abundance index (RAI) for the red fox from 2020 to 2025. The solid line represents the mean trend based on 10,000 bootstrap iterations. The shaded area indicates the 95% confidence interval

Seasonal activity is primarily characterized by a winter peak (January–March), a pattern confirmed as statistically significant (Chi-square test: $\chi^2 = 75.8$, $df = 11$, $p < 0.001$; Cramér's $V = 0.139$). This peak coincides with the mating season, when increased movement is driven by mate-searching and territorial behavior, especially in males (Cavallini & Santini, 1995; Cavallini & Lovari, 1991; Oehler *et al*., 2025). Conversely, reduced activity in spring and summer corresponds to the pup-rearing period, when female movement becomes more localized around the den (Baker *et al*., 2000), while a less pronounced autumn peak reflects juvenile dispersal (Oehler *et al*., 2025). Although the overall pattern is driven by reproduction, the inter-annual variability in the timing of peak months (**Fig. 3**) suggests that its expression is flexible. In summary, these dynamics reflect the species' stable presence, its sensitivity to food base fluctuations, and clear seasonal patterns linked to its reproductive cycle.

The European badger, historically a stable species, shows a constant presence in the reserve. After no detections in 2020, it has been recorded regularly since 2021 (**Table 2**). The RAI peaked in 2022 (RAI = 1.2) (**Fig. 2**) and has since stabilized at a high level (~0.7–1.1). Statistical analysis confirmed the absence of a significant overall trend during the study period (Mann–Kendall test: $\tau = 0.33$, $p = 0.452$; Spearman's correlation: $\rho = 0.49$, $p = 0.329$). This stability may suggest that the population is near the environment's carrying capacity, limited by available resources and territory (Johnson *et al*., 2002).

Seasonal activity is distinctly bimodal, with peaks in spring (primarily March–April) and autumn (September–October) (**Fig. 3**). This bimodal pattern was confirmed as highly significant by the Chi-square test ($\chi^2 = 65$, df = 11, $p < 0.001$), with a small effect size (Cramér's V = 0.23). These peaks correspond to the emergence from winter dormancy and intensive pre-hibernation foraging, respectively (Kowalczyk *et al*., 2003; Goszczyński *et al*., 2005). Winter activity is minimal, an energy-saving strategy that involves metabolic depression (Kowalczyk *et al*., 2003; McClune *et al*., 2015). The characteristic summer decline in activity may be linked to changes in food availability or environmental stressors (Kruuk & Parish, 1981; Sugianto *et al*., 2023). While both absolute and percentage distributions of detections confirm this bimodal pattern, some inter-annual variability in peak timing and duration is evident (**Fig. 3**), potentially reflecting a more extended activity period in certain years.

The European wildcat provides the most striking example of the benefits of modern monitoring techniques. Previously considered practically absent based on traditional surveys, its regular detection by camera traps since February 2024 has fundamentally changed its regional status. This finding may indicate genuine population growth, range expansion, or simply the effectiveness of the new survey method in detecting this elusive species. The increasing frequency of detections is supported by a statistically significant positive trend in its RAI since its appearance (Mann–Kendall test: $\tau = 0.89$, $p = 0.027$; Spearman's correlation: $\rho = 0.94$, $p = 0.005$).

Seasonal activity peaks were observed in autumn (September–October) and late winter/early spring (February–March) (**Fig. 3**). This seasonal pattern was found to be statistically significant ($\chi^2 = 21.62$, df = 10, $p = 0.017$), with a small effect size (Cramér's V = 0.26). This pattern is likely linked to the species' reproductive cycle (e.g., mate searching, juvenile dispersal) and prey availability. The increased detections of wildcats alongside the high activity of the red fox raise questions about their coexistence. As studies elsewhere suggest that these species can mitigate competition through spatial segregation and niche differentiation (Rodríguez *et al*., 2020), further analysis of biotope use is needed to assess the long-term prospects for the local wildcat population in the reserve. It is noteworthy that while domestic cats (*Felis catus*) were not recorded by camera traps during this study, their potential presence in the reserve's periphery cannot be ruled out. Given the proximity of human settlements, the risk of introgressive hybridization remains a significant conservation concern for the recovery of the European wildcat population (Mattucci *et al*., 2013). Future monitoring should incorporate non-invasive genetic sampling to assess the genetic purity of the local population.

The grey wolf, whose presence in the region has been known since the early 2000s, was detected by a camera trap only once during the study period (June 15, 2024). This single record confirms its status as a transient species for the reserve's territory itself, which likely forms a small part of the larger home ranges of regional packs.

The Eurasian lynx was not detected by camera traps at all.

CONCLUSION

This 40-year study provides a comprehensive assessment of the large mammal community in the Roztochya Nature Reserve, leading to several key conclusions. The transition from traditional surveys to systematic camera trapping proved essential for obtaining reliable quantitative data, allowing for a fundamental revision of the conservation status of several species.

The observed population trends, such as the increase in the roe deer and the recovery of the wild boar and moose, align with broader processes in Eastern Europe. These dynamics are likely amplified by the nationwide hunting ban since 2022, underscoring the reserve's role as a refugium and a potential ecological corridor for large carnivores like the grey wolf.

Based on the robust data from camera trap monitoring, we propose a critical revision of the regional status of several species:

- the European wildcat: the status should be changed from "likely extirpated/extremely rare" to "permanent resident with low abundance," which requires increased attention as a species listed in the Red Data Book of Ukraine and the Bern Convention;
- the grey wolf: the status of "regular transient species" for the reserve's territory is more accurate than „occasional visitor," considering its stable presence in the region;
- the European polecat: the confirmation of its presence by camera traps (6 detections since 2024) after a period of uncertainty in historical data allows it to be classified as "present," although its precise status requires further investigation; its NT status in Europe increases the significance of this finding;
- the red deer: the status of "seasonal visitor" better reflects the actual character of territory use than "permanent resident with low abundance";
- the Eurasian lynx: the absence of detections by both traditional methods within the reserve and camera traps confirms its status as "absent or extremely rare occasional visitor" for the NR, despite its possible presence in the wider Roztochya region.

In summary, the implementation of camera trap monitoring in the Roztochya Nature Reserve has not only refined our understanding of the population dynamics of common species but has also enabled a crucial re-evaluation of the status of rare mammals. This highlights both the transformative impact of modern monitoring technologies and the vital role of the reserve in preserving regional biodiversity. Considering the proven efficiency and objectivity of this method, we strongly recommend implementing systematic camera trap monitoring in other objects of the Nature Reserve Fund and hunting grounds. This would ensure standardized data collection and enable reliable comparisons of wildlife populations across different regions.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest: the authors declare that they have no conflict of interest.

Human Rights: this article does not contain any studies with human subjects performed by any of the authors.

Animal Studies: this article does not contain any studies with laboratory animals.

AUTHOR CONTRIBUTIONS

Conceptualization, [Yu.S.; V.S.; I.D.]; methodology, [Yu.S.; I.D.]; validation, [Yu.S.; V.S.; I.D.; A.T.]; resources, [Yu.S.; V.S.]; data processing, [Yu.S.]; writing – original draft preparation, [V.S.]; writing – review and editing, [Yu.S.; V.S.; I.D.]; visualization, [Yu.S.] supervision, [I.D.]; project management, [Yu.S.; V.S.; I.D.]; funding search, [Yu.S.; V.S.].

All authors have read and agreed to the published version of the manuscript.

REFERENCES

Akimov, I. A. (Ed.). (2009). *Chervona knyha Ukrainy. Tvarynnyi svit* [*Red Data Book of Ukraine. The animal world*]. Kyiv: Globalkonsalting.
Google Scholar

Albon, S. D., & Langvatn, R. (1992). Plant phenology and the benefits of migration in a temperate ungulate. *Oikos*, 65(3), 502–513. doi:10.2307/3545568
Crossref ● Google Scholar

Andriienko, T. L., Popovych, S. Yu., Parchuk, H. V., Havrylenko, V. S., & Priadko, O. I. (2002). *Prohrama Litopysu pryrody dlia zapovidnykiv ta natsionalnykh pryrodnykh parkiv* [*Program of the Chronicle of Nature for Nature Reserves and National Nature Parks*]. Kyiv: Akademperiodyka. (In Ukrainian)
Google Scholar

Apollonio, M., Andersen, R., & Putman, R. (Eds.). (2010). *European ungulates and their management in the 21st century*. Cambridge University Press.
Google Scholar

Baker, P. J., Funk, S. M., Harris, S., & White, P. C. (2000). Flexible spatial organization of urban foxes, *Vulpes vulpes*, before and during an outbreak of sarcoptic mange. *Animal Behaviour*, 59(1), 127–146. doi:10.1006/anbe.1999.1285
Crossref ● PubMed ● Google Scholar

Baubet, E., Bonenfant, C., & Brandt, S. (2004). Diet of the wild boar in the French Alps. *Galemys*, 16(1), 101–113. doi:10.7325/galemys.2004.ne.a8
Crossref • Google Scholar
Best, D. A., Lynch, G. M., & Rongstad, O. J. (1978). Seasonal activity patterns of moose in the Swan Hills, Alberta. *Alces*, 14, 109–125.
Google Scholar
Bieber, C., & Ruf, T. (2005). Population dynamics in wild boar *Sus scrofa*: ecology, elasticity of growth rate and implications for the management of pulsed resource consumers. *Journal of Applied Ecology*, 42(6), 1203–1213. doi:10.1111/j.1365-2664.2005.01094.x
Crossref • Google Scholar
Bobek, B., Furtek, J., Merta, D., & Wojciuch-Płoskonka, M. (2024). The influence of forest site types on the distribution of moose *Alces alces* in north-eastern Poland. *Scandinavian Journal of Forest Research*, 39(5), 257–262. doi:10.1080/02827581.2024.2388113
Crossref • Google Scholar
Bonenfant, C., Loe, L. E., Mysterud, A., Langvatn, R., Stenseth, N. C., Gaillard, J. M., & Klein, F. (2004). Multiple causes of sexual segregation in European red deer: enlightenments from varying breeding phenology at high and low latitude. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, 271(1542), 883–892. doi:10.1098/rspb.2003.2661
Crossref • PubMed • PMC • Google Scholar
Boreiko, V. Ye., & Parnikhoza, I. Yu. (2023, August 2). Pidstavy dlia okhorony losia v Ukraini [Rationale for protection of the moose in Ukraine]. Expediciya XXI. Retrieved from https://expedicia.org/pidstavi-dlya-okhoroni-losya-v-ukraini
Bowyer, R. T. (2022). *Sexual segregation in ungulates: ecology, behavior, and conservation*. Baltimore: Johns Hopkins University Press. doi:10.56021/9781421445076
Crossref • Google Scholar
Broders, H. G., Coombs, A. B., & McCarron, J. R. (2012). Ecothermic responses of moose (*Alces alces*) to thermoregulatory stress on mainland Nova Scotia. *Alces*, 48, 53–61.
Google Scholar
Cano-Martínez, R., Carricondo-Sanchez, D., Devineau, O., & Odden, M. (2021). Small rodent cycles influence interactions among predators in a boreal forest ecosystem. *Mammal Research*, 66(4), 583–593. doi:10.1007/s13364-021-00590-7
Crossref • Google Scholar
Carbone, C., Christie, S., Conforti, K., Coulson, T., Franklin, N., Ginsberg, J. R., ... & Wan Shahruddin, W. N. (2001). The use of photographic rates to estimate densities of tigers and other cryptic mammals. *Animal Conservation*, 4(1), 75–79. doi:10.1017/s1367943001001081
Crossref • Google Scholar
Castañeda, I., Doherty, T. S., Fleming, P. A., Stobo-Wilson, A. M., Woinarski, J. C., & Newsome, T. M. (2022). Variation in red fox *Vulpes vulpes* diet in five continents. *Mammal Review*, 52(3), 328–342. doi:10.1111/mam.12292
Crossref • Google Scholar
Cavallini, P., & Lovari, S. (1991). Environmental factors influencing the use of habitat in the red fox, *Vulpes vulpes*. *Journal of Zoology*, 223(2), 323–339. doi:10.1111/j.1469-7998.1991.tb04768.x
Crossref • Google Scholar
Cavallini, P., & Santini, S. (1995). Timing of reproduction in the Red fox, *Vulpes vulpes*. *Zeitschrift fur Saugetierkunde*, 60(6), 337–342.
Google Scholar
Chapron, G., Kaczensky, P., Linnell, J. D., von Arx, M., Huber, D., Andrén, H., ... & Boitani, L. (2014). Recovery of large carnivores in Europe's modern human-dominated landscapes. *Science*, 346(6216), 1517–1519. doi:10.1126/science.1257553
Crossref • PubMed • Google Scholar

Clutton-Brock, T. H., Guinness, F. E., & Albon, S. D. (1982). *Red deer: behavior and ecology of two sexes*. University of Chicago Press.
Google Scholar

Convention on the Conservation of European Wildlife and Natural Habitats. (1979, accessed 21 March 2025). Annex II – strictly protected fauna species. Retrieved from https://rm.coe.int/168078e2ff

Debeffe, L., Focardi, S., Bonenfant, C., Hewison, A. J., Morellet, N., Vanpé, C., ... & Cagnacci, F. (2014). A one night stand? Reproductive excursions of female roe deer as a breeding dispersal tactic. *Oecologia*, 176(2), 431–443. doi:10.1007/s00442-014-3021-8
Crossref • PubMed • Google Scholar

Debeffe, L., Maren Rivrud, I., Brekkum, Ø., Meisingset, E. L., & Mysterud, A. (2017). Implications of the forage maturation hypothesis for activity of partially migratory male and female deer. *Ecosphere*, 8(12), e02050. doi:10.1002/ecs2.2050
Crossref • Google Scholar

Doherty, T. S., Dickman, C. R., Glen, A. S., Newsome, T. M., Nimmo, D. G., Ritchie, E. G., ... & Wirsing, A. J. (2017). The global impacts of domestic dogs on threatened vertebrates. *Biological Conservation*, 210, 56–59. doi:10.1016/j.biocon.2017.04.007
Crossref • Google Scholar

Dolapchiev, N., Popova, E., & Chanev, M. (2024). Spatial and temporal relationships between predators in the "Sinite Kamani" Nature Park, Bulgaria. *Ecologia Balkanica*, 16(2), 70–79.
Google Scholar

Dykyi, I. V. (2001). Current state of the badger (*Meles meles* L.) population in Western Ukraine. *Visnyk of Lviv University. Biological series*, 27, 151–155. (In Ukrainian)
Google Scholar

Dziki-Michalska, K., Tajchman, K., & Budzynska, M. (2019). Increase in the moose (*Alces alces* L. 1758) population size in Poland: causes and consequences. *Annals of Warsaw University of Life Sciences – SGGW. Animal Science*, 58(3), 203–214. doi:10.22630/aas.2019.58.3.20
Crossref • Google Scholar

European Food Safety Authority (EFSA), Ståhl, K., Boklund, A. E., Podgórski, T., Vergne, T., Abrahantes, J. C., & Mur, L. (2024). Epidemiological analysis of African swine fever in the European Union during 2023. *EFSA Journal*, 22(5), e8809. doi:10.2903/j.efsa.2025.9436
Crossref • PubMed • PMC • Google Scholar

Franzmann, A. W. (1981). *Alces alces*. *Mammalian Species*, 154, 1–7. doi:10.2307/3503876
Crossref • Google Scholar

Gamelon, M., Touzot, L., Baubet, É., Cachelou, J., Focardi, S., Franzetti, B., Nivois, É., Veylit, L., & Sæther, B. (2021). Effects of pulsed resources on the dynamics of seed consumer populations: a comparative demographic study in wild boar. *Ecosphere*, 12(5), e03395 doi:10.1002/ecs2.3395
Crossref • Google Scholar

Goszczyński, J., Juszko, S., Pacia, A., & Skoczyńska, J. (2005). Activity of badgers (*Meles meles*) in Central Poland. *Mammalian Biology*, 70(1), 1–11. doi:10.1078/1616-5047-00171
Crossref • Google Scholar

Huzii, A. I. (1997). *Fauna i naselennia khrebetnykh Zakhidnoho rehionu Ukrainy. Tom 1. Roztochchia* [*Fauna and populations of vertebrates of the western region of Ukraine. Vol. 1. Roztochia*]. Kyiv: Ukrainian State Forestry University. (In Ukraine)
Google Scholar

Henttonen, H., Kranz, A., Stubbe, M., Maran, T., & Tikhonov, A. (2007). *Alces alces* ssp. *alces* (Europe assessment). *The IUCN Red List of Threatened Species*. Version 2007: e.T41782A10539156
Google Scholar

Johnson, D. D., Jetz, W., & Macdonald, D. W. (2002). Environmental correlates of badger social spacing across Europe. *Journal of Biogeography*, 29(3), 411–425. doi:10.1046/j.1365-2699.2002.00680.x
Crossref ● Google Scholar

Kays, R., Arbogast, B. S., Baker-Whatton, M., Beirne, C., Boone, H. M., Bowler, M., ... & Spironello, W. R. (2020). An empirical evaluation of camera trap study design: how many, how long and when? *Methods in Ecology and Evolution*, 11(6), 700–713. doi:10.1111/2041-210x.13370
Crossref ● Google Scholar

Kelly, D. (1994). The evolutionary ecology of mast seeding. *Trends in Ecology & Evolution*, 9(12), 465–470. doi:10.1016/0169-5347(94)90310-7
Crossref ● PubMed ● Google Scholar

King, C. M., Powell, R. A., & Powell, C. (2006). *The natural history of weasels and stoats: ecology, behavior, and management*. New York: Oxford University Press. doi:10.1093/acprof:oso/9780195322712.001.0001
Crossref ● Google Scholar

Kobryn, H. T., Swinhoe, E. J., Bateman, P. W., Adams, P. J., Shephard, J. M., & Fleming, P. A. (2023). Foxes at your front door? Habitat selection and home range estimation of suburban red foxes (*Vulpes vulpes*). *Urban Ecosystems*, 26(1), 1–17. doi:10.1007/s11252-022-01252-5
Crossref ● Google Scholar

Kowalczyk, R., Jędrzejewska, B., & Zalewski, A. (2003). Annual and circadian activity patterns of badgers (*Meles meles*) in Białowieża Primeval Forest (eastern Poland) compared with other Palaearctic populations. *Journal of Biogeography*, 30(3), 463–472. doi:10.1046/j.1365-2699.2003.00804.x
Crossref ● Google Scholar

Kropil, R., Smolko, P., & Garaj, P. (2015). Home range and migration patterns of male red deer *Cervus elaphus* in Western Carpathians. *European Journal of Wildlife Research*, 61(1), 63–72. doi:10.1007/s10344-014-0874-4
Crossref ● Google Scholar

Kruuk, H., & Parish, T. (1981). Feeding specialization of the European badger *Meles meles* in Scotland. *The Journal of Animal Ecology*, 50(3), 773–788. doi:10.2307/4136
Crossref ● Google Scholar

Linnell, J. D. C., & Andersen, R. (1998). Territorial fidelity and tenure in roe deer bucks. *Acta Theriologica*, 43, 67–75. doi:10.4098/at.arch.98-5
Crossref ● Google Scholar

Loe, L. E., Bonenfant, C., Mysterud, A., Severinsen, T., Oristland, N. A., Langvatn, R., & Stenseth, N. C. (2005). Climate predictability and breeding phenology in red deer: timing and synchrony of calving. *Journal of Animal Ecology*, 74(4), 579–588. doi:10.1111/j.1365-2656.2005.00987.x
Crossref ● Google Scholar

Maran, T., Skumatov, D., Gomez, A., Põdra, M., Abramov, A. V., & Dinets, V. (2016). *Mustela lutreola*. The IUCN red list of threatened species 2016: E. T14018A45199861. Accessed on January, 5, 2024. doi:10.2305/iucn.uk.2016-1.rlts.t14018a45199861.en
Crossref ● Google Scholar

Martsiv, M., Syrota, Y., & Dykyy, I. (2021). Diet composition of the red fox, *Vulpes vulpes* Linnaeus, 1758 (Canidae, Carnivora) in Western Ukraine. *Acta Biologica Universitatis Daugavpiliensis*, 21(1), 71–81.
Google Scholar

Marynych, O. M. (Ed.). (1993). *Heohrafichna entsyklopediia Ukrainy* [*Geographical encyclopedia of Ukraine*] (Vols. 1–3). Kyiv: Ukrainian Soviet Encyclopedia named after M. P. Bazhan. (In Ukraine)
Google Scholar

Mattucci, F., Oliveira, R., Lyons, L. A., Alves, P. C., & Randi, E. (2016). European wildcat populations are subdivided into five main biogeographic groups: consequences of Pleistocene climate changes or recent anthropogenic fragmentation? *Ecology and Evolution*, 6(1), 3–22. doi:10.1002/ece3.1815
Crossref • PubMed • PMC • Google Scholar

McClune, D. W., Kostka, B., Delahay, R. J., Montgomery, W. I., Marks, N. J., & Scantlebury, D. M. (2015). Winter is coming: seasonal variation in resting metabolic rate of the European badger (*Meles meles*). *PLoS One*, 10(9), e0135920. doi:10.1371/journal.pone.0135920
Crossref • PubMed • PMC • Google Scholar

McLeod, A. I. (2022). Kendall: Kendall rank correlation and Mann–Kendall trend test (Version 2.2.1). doi:10.32614/cran.package.kendall
Crossref • Google Scholar

Melis, C., Cagnacci, F., & Lovari, S. (2004). Site fidelity of male roe deer in a Mediterranean fragmented area. *Hystrix*, 15(1), 63–68.
Google Scholar

Mikulka, O., Zeman, J., Drimaj, J., Plhal, R., Adamec, Z., Kamler, J., & Heroldová, M. (2018). The importance of natural food in wild boar (*Sus scrofa*) diet during autumn and winter. *Folia Zoologica*, 67(3-4), 165–172. doi:10.25225/fozo.v67.i3-4.a3.2018
Crossref • Google Scholar

Ministry of Environmental Protection and Natural Resources of Ukraine. (2021, January 19). *Pro zatverdzhennia perelikiv vydiv tvaryn, shcho zanosiatsia do Chervonoi knyhy Ukrainy* (*tvarynnyi svit*)*, ta vydiv tvaryn, shcho vykliucheni z Chervonoi knyhy Ukrainy* (*tvarynnyi svit*) [*On approval of the lists of animal species included in the Red Data Book of Ukraine* (*Animal World*)*, and those excluded from it* (*Animal World*)] (Order No. 29). Retrieved from https://zakon.rada.gov.ua/laws/show/z0260-21#Text

Morelle, K., Podgórski, T., Prévot, C., Keuling, O., Lehaire, F., & Lejeune, P. (2015). Towards understanding wild boar *Sus scrofa* movement: a synthetic movement ecology approach. *Mammal Review*, 45(1), 15-29. doi:10.1111/mam.12028
Crossref • Google Scholar

Mysterud, A., Loe, L. E., Zimmermann, B., Bischof, R., Veiberg, V., & Meisingset, E. (2011). Partial migration in expanding red deer populations at northern latitudes – a role for density dependence? *Oikos*, 120(12), 1817–1825. doi:10.1111/j.1600-0706.2011.19439.x
Crossref • Google Scholar

O'Connell, A. F., Nichols, J. D., & Karanth, K. U. (Eds.). (2011). *Camera traps in animal ecology: methods and analyses* (Vol. 271). New York: Springer. doi:10.1007/978-4-431-99495-4
Crossref • Google Scholar

Oehler, F., Hagen, R., Hackländer, K., Walton, Z., Ashish, K., & Arnold, J. (2025). How do red foxes (*Vulpes vulpes*) explore their environment? Characteristics of movement patterns in time and space. *Movement Ecology*, 13(1), 4. doi:10.1186/s40462-024-00526-1
Crossref • PubMed • PMC • Google Scholar

Pagon, N., Grignolio, S., Brivio, F., Marcon, A., & Apollonio, M. (2017). Territorial behaviour of male roe deer: a telemetry study of spatial behaviour and activity levels. *Folia Zoologica*, 66(4), 267–276. doi:10.25225/fozo.v66.i4.a9.2017
Crossref • Google Scholar

Panzacchi, M., Linnell, J. D. C., Odden, M., Odden, J., & Andersen, R. (2009). Habitat and roe deer fawn vulnerability to red fox predation. *Journal of Animal Ecology*, 78(6), 1124–1133. doi:10.1111/j.1365-2656.2009.01584.x
Crossref • PubMed • Google Scholar

Parker, K. L., Gillingham, M. P., Hanley, T. A., & Robbins, C. T. (1999). Energy and protein balance of free-ranging black-tailed deer in a natural forest environment. *Wildlife Monographs*, 143, 3–48.
Google Scholar

Pearse, I. S., Koenig, W. D., & Kelly, D. (2016). Mechanisms of mast seeding: resources, weather, cues, and selection. *New Phytologist*, 212(3), 546–562. doi:10.1111/nph.14114
Crossref ● PubMed ● Google Scholar

Pejsak, Z., Truszczyński, M., Niemczuk, K., Kozak, E., & Markowska-Daniel, I. (2018). Epidemiology of African swine fever in Poland since the detection of the first case. *Polish Journal of Veterinary Sciences*, 21(1), 119–125. doi:10.2478/pjvs-2014-0097
Crossref ● PubMed ● Google Scholar

Plhal, R., Kamler, J., Homolka, M., & Adamec, Z. (2011). An assessment of the applicability of photo trapping to the wild boar population density in a forest environment. *Folia Zoologica*, 60(3), 237–246. doi:10.25225/fozo.v60.i3.a8.2011
Crossref ● Google Scholar

Pryrodnyi zapovidnyk "Roztochchya" [*Roztochya Nature Reserve*]. *Litopys pryrody* [*Chronicle of nature*]. (1986–2024). Annual reports submitted to the Ministry of Environmental Protection and Natural Resources of Ukraine. Ivano-Frankove: Roztochya Nature Reserve. (In Ukrainian)

R Core Team. (2023). R: a language and environment for statistical computing. R Foundation for Statistical Computing. Retrieved from https://www.R-project.org

Rigoudy, N., Dussert, G., Benyoub, A., Besnard, A., Birck, C., Boyer, J., ... & Chamaillé-Jammes, S. (2023). The DeepFaune initiative: a collaborative effort towards the automatic identification of European fauna in camera trap images. *European Journal of Wildlife Research*, 69(6), 113. do:10.1007/s10344-023-01742-7
Crossref ● Google Scholar

Rodríguez, A., Urra, F., Jubete, F., Román, J., Revilla, E., & Palomares, F. (2020). Spatial segregation between red foxes (*Vulpes vulpes*), European wildcats (*Felis silvestris*) and domestic cats (*Felis catus*) in pastures in a livestock area of Northern Spain. *Diversity*, 12(7), 268. doi:10.3390/d12070268
Crossref ● Google Scholar

Rovero, F., & Zimmermann, F. (Eds.). (2016). *Camera trapping for wildlife research*. Pelagic Publishing. doi:10.2307/jj.28833751
Crossref ● Google Scholar

Sauter-Louis, C., Conraths, F. J., Probst, C., Blohm, U., Schulz, K., Sehl, J., ... & Blome, S. (2021). African swine fever in wild boar in Europe – a review. *Viruses*, 13(9), 1717. doi:10.3390/v13091717
Crossref ● PubMed ● PMC ● Google Scholar

Servanty, S., Gaillard, J. M., Toïgo, C., Brandt, S., & Baubet, E. (2011). Pulsed resources and climate-induced variation in the reproductive traits of wild boar under high hunting pressure. *Journal of Animal Ecology*, 80(6), 1278–1290. doi:10.1111/j.1365-2656.2009.01579.x
Crossref ● PubMed ● Google Scholar

Soininen, E. M., & Neby, M. (2024). Small rodent population cycles and plants – after 70 years, where do we go? *Biological Reviews*, 99(1), 265–294. doi:10.1111/brv.13021
Crossref ● PubMed ● Google Scholar

Stache, A., Heller, E., Hothorn, T., & Heurich, M. (2013). Activity patterns of European roe deer (*Capreolus capreolus*) are strongly influenced by individual behaviour. *Folia Zoologica*, 62(1), 67–75. doi:10.25225/fozo.v62.i1.a10.2013
Crossref ● Google Scholar

Sugianto, N. A., Newman, C., Macdonald, D. W., & Buesching, C. D. (2023). Effects of weather and social factors on hormone levels in the European badger (*Meles meles*). *Zoology*, 158, 126093. doi:10.1016/j.zool.2023.126093
Crossref ● Google Scholar

Tatarynov, K. A. (1973). *Fauna khrebetnykh zakhodu Ukrainy* [*Vertebrate Fauna of Western Ukraine*]. Lviv: Lviv University Press. (In Ukraine)
Google Scholar

Thurfjell, H., Ball, J. P., Åhlén, P. A., Kornacher, P., Dettki, H., & Sjöberg, K. (2009). Habitat use and spatial patterns of wild boar *Sus scrofa* (L.): agricultural fields and edges. *European Journal of Wildlife Research*, 55(5), 517–523. doi:10.1007/s10344-009-0268-1
Crossref ● Google Scholar

Thurfjell, H., Spong, G., & Ericsson, G. (2013). Effects of hunting on wild boar *Sus scrofa* behaviour. *Wildlife Biology*, 19(1), 87–93. doi:10.2981/12-027
Crossref ● Google Scholar

Tixier, H., Duncan, P., Scehovic, J., Yant, A., Gleizes, M., & Lila, M. (1997). Food selection by European roe deer (*Capreolus capreolus*): effects of plant chemistry, and consequences for the nutritional value of their diets. *Journal of Zoology*, 242(2), 229–245. doi:10.1111/j.1469-7998.1997.tb05799.x
Crossref ● Google Scholar

Touzot, L., Schermer, É., Venner, S., Delzon, S., Rousset, C., Baubet, É., Gaillard, J., & Gamelon, M. (2020). How does increasing mast seeding frequency affect population dynamics of seed consumers? Wild boar as a case study. *Ecological Applications*, 30(6), e02134. doi:10.1002/eap.2134
Crossref ● PubMed ● Google Scholar

Wall, W., Belisle, M., & Luke, L. A. (2010). Moose (*Alces alces*) wildlife habitat decision aid. *Journal of Ecosystems and Management*, 11(3), 45–49. doi:10.22230/jem.2010v11n3a46
Crossref ● Google Scholar

Zagorodniuk, I., Gavrilyuk, M., Drebet, M., Skilsky, I., Andrusenko, A., & Pirkhal, A. (2014). Wildcat (*Felis silvestris* schreber, 1777) in Ukraine: modern state of the population and eastwards expansion of the species. *Studia Biologica*, 8(3-4), 233–254. doi:10.30970/sbi.0803.372
Crossref ● Google Scholar

Zahorodniuk, I., & Yemelianov, I. (2012). Taxonomy and nomenclature of mammals of Ukraine. *Proceedings of the National Museum of Natural History*, 10, 5–30. (In Ukraine)
Google Scholar

Zwerts, J. A., Stephenson, P. J., Maisels, F., Rowcliffe, M., Astaras, C., Jansen, P. A., ... & van Kuijk, M. (2021). Methods for wildlife monitoring in tropical forests: comparing human observations, camera traps, and passive acoustic sensors. *Conservation Science and Practice*, 3(12), e568. doi:10.1111/csp2.568
Crossref ● Google Scholar

РЕЗУЛЬТАТИ МОНІТОРИНГУ КРУПНИХ ССАВЦІВ У ПРИРОДНОМУ ЗАПОВІДНИКУ "РОЗТОЧЧЯ" ЗА 40 РОКІВ СПОСТЕРЕЖЕНЬ (1984–2025)

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Обґрунтування. Довготривалий моніторинг дикої природи має вирішальне значення для розуміння динаміки популяцій та обґрунтування стратегій збереження. У цьому дослідженні представлено 40-річний аналіз угруповань великих ссавців у Природному заповіднику "Розточчя" (захід України). Досліджуваний період охоплює два різні методологічні підходи: традиційні обліки (1984–2019), які забезпечили дані зі значними обмеженнями для кількісного аналізу, та сучасний моніторинг за допомогою фотопасток, розпочатий у 2020 р. з метою подолання цих недоліків і отримання об'єктивних, верифікованих даних про фауну регіону.

Матеріали і методи. Проведено критичний огляд історичних даних за 1984–2019 рр., зібраних за допомогою маршрутних обліків та обліків по слідах. З 2020 до середини 2025 р. було впроваджено систематичний моніторинг за допомогою фотопасток, мережа яких розширилася з 4 до 20 приладів. Аналіз зосереджували на видовому складі, частоті реєстрацій і сезонних патернах активності. Ми розрахували індекс відносної чисельності для виявлення сучасних тенденцій популяцій і порівняли ефективність обох підходів до моніторингу.

Результати. Моніторинг за допомогою фотопасток зафіксував понад 2000 днів реєстрацій для 13 видів ссавців. Найчастіше реєстрованим видом була козуля європейська (*Capreolus capreolus*, ~53,4 %), за нею йшли лисиця звичайна (*Vulpes vulpes*, ~18 %) та кабан звичайний (*Sus scrofa*, ~10 %). Значне збільшення кількості реєстрацій спостерігали для козулі та кабана у 2023–2024 рр. Ключовим результатом стало підтвердження регулярної присутності кота лісового (*Felis silvestris*) з 2024 р., що змінило його статус із надзвичайно рідкісного на постійного мешканця. Також підтверджено транзитний статус вовка (*Canis lupus*).

Висновки. Перехід до моніторингу за допомогою фотопасток забезпечує більш точну оцінку угруповання ссавців, підтверджуючи ефективність для виявлення рідкісних і потайних видів. Ці результати дають змогу критично переглянути природоохоронний статус кількох ключових видів, зокрема, кота лісового. Дослідження підкреслює важливість Природного заповідника “Розточчя” як ключового рефугіуму й екологічного коридору на динаміку популяцій якого, ймовірно, вплинули нещодавні загальнонаціональні зміни в управлінні полюванням.

Ключові слова: фотопастки, ссавці, моніторинг, Природний заповідник “Розточчя”, динаміка популяцій

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