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Distribution, abundance, and breeding of the imperial eagle (*Aquila heliaca*) in Western Slovakia in 1977–2022

Rozšírenie, početnosť a hniezdenie orla kráľovského (*Aquila heliaca*) na západnom Slovensku v rokoch 1977–2022

Jozef CHAVKO, Leonidas PREŠINSKÝ & Roman SLOBODNÍK

Abstract: The distribution, abundance, breeding success, and habitats of the imperial eagle in the mountains and adjacent lowlands of Western Slovakia were studied over the last 45 years (1977–2022), with a total of 65 breeding pairs documented. Of the 589 breeding attempts (range 2–42 per year) that were recorded, 420 were successful (74%) and produced 718 chicks altogether. Breeding success varied considerably across the years, with an average of 1.2 chicks per initiated and 1.7 chicks per successful breeding attempt. Three chicks fledged from 10.7% of the successful breeding attempts, two chicks from 50.2%, and one chick from 39.1% of them. Breeding numbers increased slowly between 1977 and 1997, with a marked increase after 1998. In two of the most recent years, 2020 and 2021, breeding numbers more than doubled. Since 2000, we have observed changes in breeding habitat preferences, where the population has shown more preference for lowland regions than mountains. Natural factors are probably driving the upward population trend, but there has also been action taken with several management measures. The conservation measures involved and their impact on population and range trends are analysed and discussed here.

Abstrakt: Rozšírenie, početnosť, hniezdny úspech a biotopy orla kráľovského boli skúmané za posledných 45 rokov (1977 – 2022) v pohoriach a priľahlých nížinách západného Slovenska. Celkovo sme zaznamenali 65 hniezdiacich párov a 589 zahniezdení (2 – 42 ročne), z toho 420 úspešných (74%). Z úspešných hniezd vyletelo spolu 718 mláďat. Úspešnosť hniezdenia v jednotlivých rokoch bola veľmi variabilná s priemerom 1,2 mláďaťa na započatý hniezdny pokus a 1,7 mláďaťa na úspešný hniezdny pokus. V 10.7% úspešných pokusov o hniezdenie vyleteli tri mláďatá, v 50.2% dve a v 39.1% jedno mláďa. V období rokov 1977 až 1997 početnosť hniezdení pozvoľne stúpala, od roku 1998 začal počet hniezdení výraznejšie stúpať a v posledných dvoch rokoch 2020 a 2021 stúpol počet hniezdení viac ako dvojnásobne. Od roku 2000 sme pozorovali zmenu preferencie hniezdísk, kde populácia začala preferovať nížiny pred pohoriami. Vzostupný populačný trend pravdepodobne súvisí s prirodzenými faktormi, ale aj s viacerými ochranárskymi opatreniami, ktoré sme zrealizovali.

Key words: birds of prey, breeding biology, distribution, Central Europe, population

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Introduction

The eastern imperial eagle (*Aquila heliaca*) inhabits the central and western Palaearctic realm from southern Moravia and Austria at the western edge of its range to Lake Baikal at its easternmost extent (Heredia 1996). In Europe, it occurs only in Pannonia, on the islets of the southern Balkans, central and eastern Ukraine, central and southern Russia, and western Kazakhstan (Keller et al. 2020). Population size was estimated between 1994 and 1996 for 363 to 604 pairs (Heredia 1996). Since then, the European population has risen to between 1,768 and 2,229 pairs (Demerdzhiev et al. 2011). Historical data on the raptor's occurrence in Slovakia had been previously summarised by Ferianc (1964), Mošanský (1972), Sládek (1959), and Hudec & Černý (1977). The eastern imperial eagle nests in two regions within Slovakia, approximately 160 kilometres apart from each other (Fig. 1). The distribution of the species continuously runs southward to breeding areas in Hungary (Horváth et al. 2020), western and north-western Austria and into the Czech Republic (Schmidt & Horal 2018).

The earliest reference to the eastern imperial eagle's presence in Western Slovakia comes from Tonhauzer (1954), who mentioned sightings in the Little Carpathian Mountains in 1953. Between 1963 and 1965, five breeding pairs were documented there (Ferianc 1964, Kalivodová & Brtek 1977), and an overview of the total occurrence of this species in Slovakia was later published by Danko and Chavko (1966, 2002) and Chavko et al. (2014). The causes for the expansion of the eagle's range in Central Europe and breeding in Slovakia were described by Sládek (1959), who mentioned the gradually warming climate as the main factor driving the expanded distribution.

Until recently, the Little Carpathians were considered to be the western limit of the eastern imperial eagle. In the last two decades, the frontier has shifted (e.g., Mikuš et al. 2008 Horal, 2008) to southern Moravia, almost to the White Carpathians, and even further west to breeding sites in Lower Austria. These areas are now regarded as the north-westernmost boundary for the Pannonian subpopulation (Šťastný et al. 2021, Schmidt & Horal, 2018, Vili et al. 2009).

Over 45 years (1977–2022), selected data was processed from all breeding records for the species documented in Western Slovakia since previously published data were only partial and breeding over recent decades had not been analysed in a continuous time series (Chavko 2002, Danko et al. 2011). Eastern imperial eagle population trends are accordingly described to underscore factors causing mortality. The discussion evaluates the impact of selected actions to conserve the species and confronts our results from western Slovakia with results from a study conducted in eastern Slovakia (Danko et al. 2020).

Methodology

Distribution and abundance

In Western Slovakia, the breeding range of eastern imperial eagles has been systematically monitored since 1977, with a total of 28 people involved over the years. Nests were directly searched to determine breeding distribution and abundance, using historical data from references and subsequently recording occurrences. While observations were made from selected observation posts that offered a good view, during the autumn and winter, nests were sought in forest growth at anticipated locations and then checked for occupancy in the spring. The distribution of the species was monitored annually by counting the number of occupied nests. Each nest was documented for breeding habitat, species of nesting tree, and interactions with other raptor species nesting in the same territory. Every breeding site was also photographically documented.

Breeding success

Nests were visited only once during the breeding season. Any further checking was carried out with a monocular and later, starting in 2019, with drones (e.g., Galleago & Sarasola 2021). Nests were physically inspected to band the chicks (Slobodník & Jenčo 2020), collect biological samples, and fit the chicks with satellite transmitters (Danko et al. 2011). Breeding was considered unsuccessful when the pair had nested and the female had laid eggs, but the pair produced no fledglings. Reproductive success was expressed as the ratio of the number of fledglings from 1) initiated and 2) successful breeding attempts. Factors causing nesting failure were recorded.

Mortality and conservation measures

Data was collected on cases of poisoning, unlawful shooting, and other illegal activities between 2003 and 2015 and again in 2016-22. During 2003-15, during a lower abundance of eastern imperial eagles, the mortality was monitored by volunteers. From 2016, mortality was monitored during the preventive conservation of bird populations starting with major projects like LIFE ENERGY, LIFE PANNON EAGLE, and LIFE DANUBE FREE SKY. Other activities under the aegis of these large projects included mapping the nesting sites, establishing protection zones around the nests, safeguarding the nests electronically, searching foraging and nesting territories

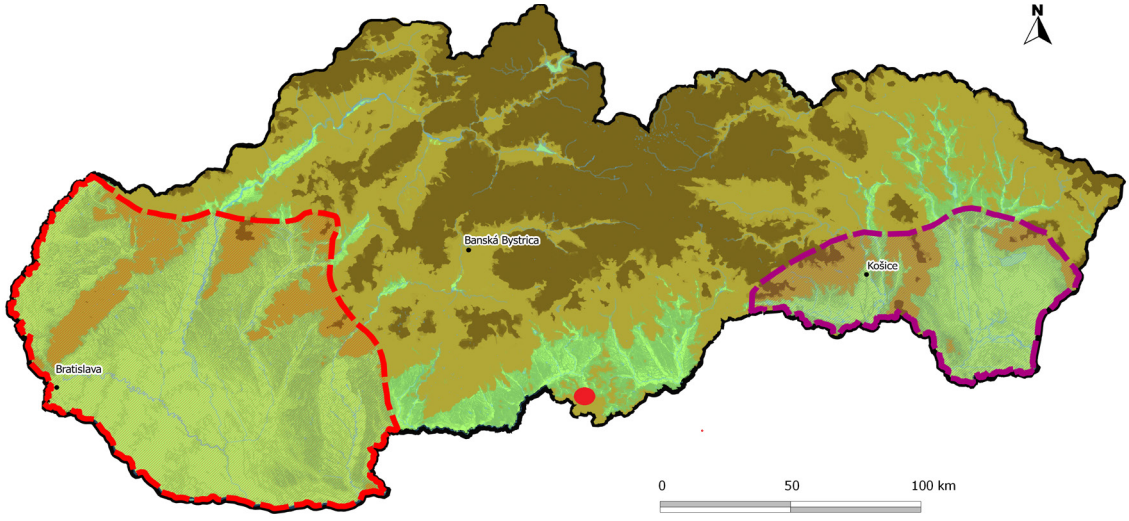

Fig. 1. Range of the eastern imperial eagle in Slovakia. The red dashed line indicates the range of the eastern imperial eagle's western population in Slovakia, the purple dashed line the eastern population, and the red circle marks an solitary nesting of an eastern imperial eagle pair in south part of cestral Slovakia.
Obr. 1. Výskyt orla kráľovského na Slovensku. Červená prerušovaná čiara označuje areál výskytu západnej populácie orla kráľovského na Slovensku, fialová prerušovaná čiara východnú populáciu a červený kruh označuje solitérne hniezdisko páru orla kráľovského na juhu stredného Slovensku.

for poisoned baits, banding the birds, tagging the chicks with satellite telemetry and subsequently ascertaining the causes of mortality as part of the monitoring. LIFE PANNON EAGLE has been partnering with Slovakia's national police authority since 2019 to organise field patrols, where trained sniffer dogs inspect for the presence of contaminated bait. Hunting grounds, in which repeated incidents of poisoning and other cases of bird crime had been reported in the past, were specifically targeted. Approximately 25-30% of eagle nesting and foraging territories in western Slovakia were checked yearly. Most police findings involving killed birds were subsequently published in the media to encourage prevention.

Electrocution mortality and mortality caused by collisions with power lines were monitored in 1993, 2006, and again in 2014-19, according to a methodology subsequently published by Galis (2020). In the earlier period, conservation measures were realized to less extent compared to the second period. Conservation measures were represented by the installation of protective and warning devices. Mortality data were obtained during the Life Energy project realization (2014-2019).

Results

Distribution and abundance

The first two occupied nests were discovered in 1977, one in the Little Carpathians (situated at an elevation of 600 metres) and the other in Považský Inovec Mountain (190 metres). Other nesting sites were later found in Považský Inovec Mountain (420 m.a.s.l.) and Tribeč Mountain (280 m.a.s.l.) and in the mountains of the Strážovské (740 m.a.s.l.). Until 2000, there were only two cases documented of eastern imperial eagles breeding in lower elevations. The first was recorded in the Danubian Plain (Pair 4 at 130 m.a.s.l., see Appendix 1) and the second in 1995 at a highland agrocenosis above the Žitava Žitavská highlands (Pair 34 at 200 m.a.s.l. in the Žitavská highlands pahorkatina, Krištín, 1999). As eastern imperial eagles slowly moved into new territories, the number of breeding pairs gradually rose. The bigger increase in numbers came after 2018, when 21 pairs bred, followed in 2019 by 31 pairs, then 37 pairs in 2020, 42 pairs in 2021, and finally, 46 pairs in 2022 (Fig. 2). Between 1977 and 2022, a total of 65 breeding sites were identified in Western Slovakia (Fig. 3, see details in Appendix 1). However, the first-ever successful breeding of an isolated pair was also recorded in 2021 and 2022 within the district of Rimavská Sobota in the south-central region of Slovakia (red circle in Fig. 1) and breeding was documented in 13 orographic units. In the 45 years of population monitoring, 589 cases of breeding were registered among the 65 known pairs. The closest active nests were 1.56 kilometres apart from

each other. When the population of eastern imperial eagles started to be monitored, there were only two to ten pairs registered. But the number of known pairs grew after 2000 as they settled in lower elevations. In 2016, there were 19 pairs, and by 2022 the number had risen remarkably to 46 breeding pairs (Fig. 2).

Breeding success

Of the total 589 observed breeding attempts, 420 (74%) were successful. These successful breedings (pairs) produced 718 fledglings (Fig. 2) in total, although nesting success rates varied from year to year (Fig. 5). The average nesting success was 1.2 fledglings per initiated and 1.7 fledglings per successful nesting attempt. When the nesting pairs were successful, they produced 164 broods (39.1%) with a single fledgling, 211 broods (50.2%) with two fledglings, and 45 broods (10.7%) with three fledglings. In the twenty years between 2002 and 2022, a total of 348 chicks were banded.

Changes in breeding habitats

Of the 589 known breedings, 381 pairs nested in mountainous areas and 208 pairs nested in lower elevations. In the early years of monitoring, nests were found predominately in the mountains and rarely in lower elevations (see above). A more pronounced settlement of the lowlands has been observed since 2000 and, starting in 2018, most pairs have been nesting in lowland regions, mostly in agrocenoses (Fig. 6). Seven pairs moved from mountainous areas to lowland regions (marked by an asterisk in Appendix 1). While the average elevation of the nests in the mountains was 423 ± 170.1 metres (± SD), ranging from 260 to 740 m, the mean elevation of the nests in lowland regions was 147 ± 145.1 m (mean ± SD, range 110 – 280 m). During the study period eastern imperial eagles nested on 14 different tree species used in different proportions (Fig. 7).

Mortality and conservation measures

Between 2003 and 2015, 17 eastern imperial eagles were found dead. Four of them had been poisoned with carbofuran and three were shot, including two individuals shot directly in their nests. In addition, there was one case where three chicks had been stolen from a nest and four cases where eagles were found dead but the cause remained unknown. In two cases, chicks were found dead in their nests where it was probable that the parents had been poisoned.

A total of 153 raptors from different species were unlawfully injured or killed in 2016-22. In eight of those cases (5%), the victims were eastern imperial eagles. The birds had either been poisoned or shot. Starting in 2017, we sought to document the mortality of eastern imperial

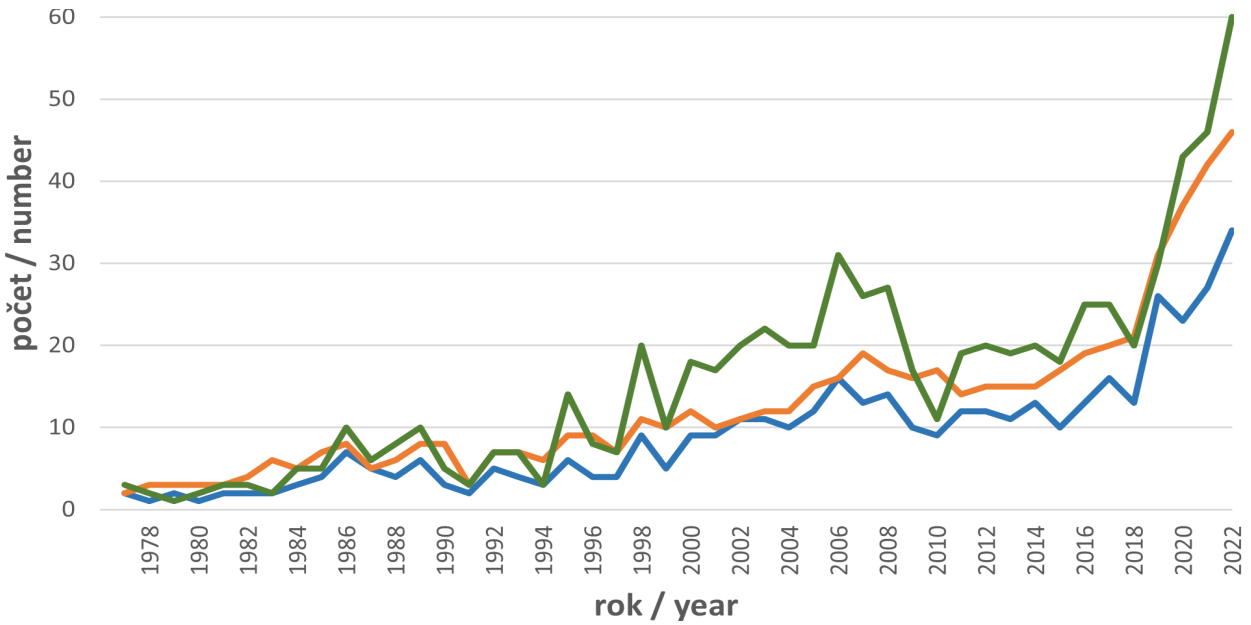

Fig. 2. Population trends for eastern imperial eagle in Western Slovakia (1977 – 2022). The blue line shows the number of successful breedings, the orange line shows the number of known breeding pairs, and the green line the number of chicks fledged.
Obr. 2. Populačný trend orla kráľovského na západnom Slovensku (1977 – 2022). Modrá čiara zobrazuje počet úspešných hniezdení, oranžová počet známych hniezdiacich párov a zelená čiara počet vyletených mláďat.

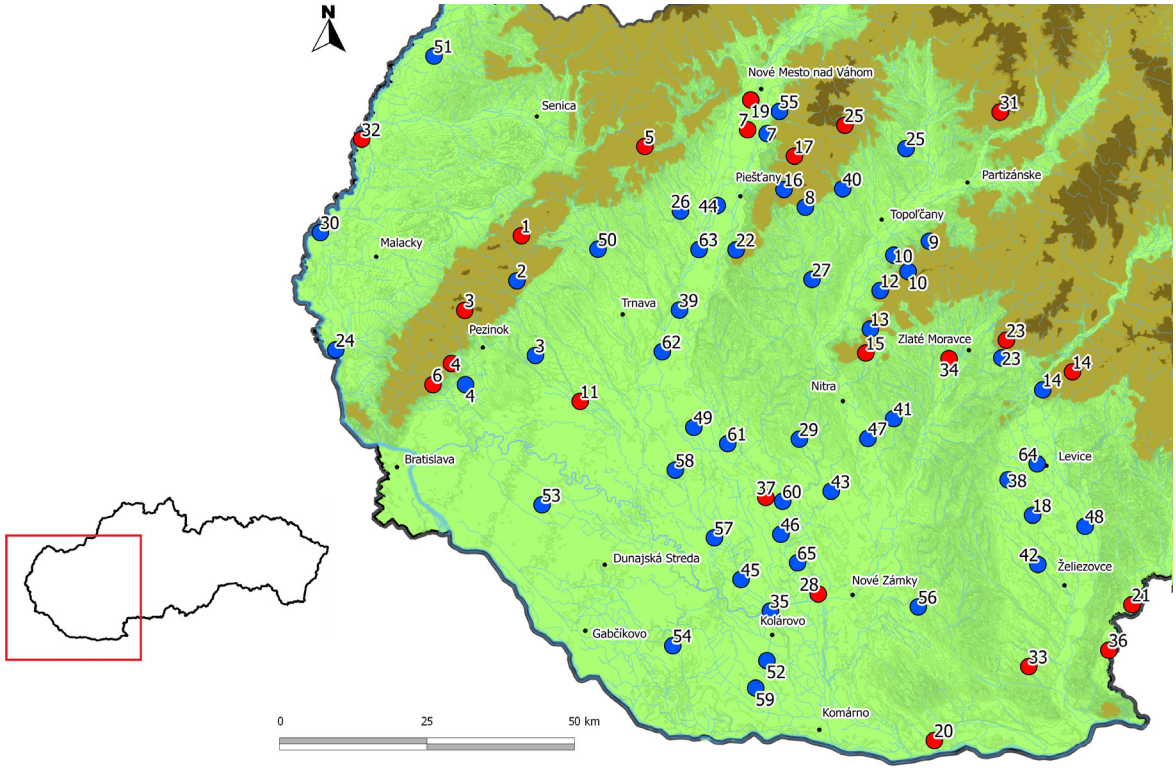

Fig. 3. Breeding places of eastern imperial eagles in Western Slovakia between 1977 and 2022 (each breeding pair was assigned a number). Pairs 4, 7, 8, 13, 16, and 25 had previously bred in mountainous areas. The blue dots are breeding places that were occupied in 2022, red dots indicate the other nesting places occupied since 1977 to 2021.

Obr. 3. Hniezdiská orla kráľovského na západnom Slovensku v rokoch 1977 až 2022 (každý hniezdny pár mal pridelené číslo). Páry 4, 7, 8, 13, 16 a 25 predtým hniezdili v pohoriach. Modré body sú hniezdiská, ktoré boli obsadené v roku 2022, červené body označujú ostatné hniezdiská obsadené od roku 1977 až 2021.

Fig. 4. Pair 16's nest, located in a European larch at the Považsky Inovec Mountain range, July 2009.

Obr. 4. Hniezdo páru 16, nachádzajúce sa na smrekovci opadavom pohorí Považský Inovec, júl 2009.

eagles annually. There were a total of three cases in 2017, two cases each in 2018 and 2019, one case in 2020, and none in 2021. Except for a single shooting, all of these cases involved carbofuran poisoning. A significant threat of injury or death for eastern imperial eagles has come from electrocution on 22-kilovolt power lines. In the period from 1993 to 2006, five eastern imperial eagles were found dead beneath high-voltage pylons, while six were likewise discovered dead during a shorter period between 2014 and 2019. In both of these periods, they were all juvenile and sub-adult individuals. No mortality of adult eastern imperial eagles was observed.

Discussion

Sládek (1959) mentioned eastern imperial eagles nesting in both western and eastern Slovakia in 1941-50, documented four nesting sites, and presumed the existence of a further

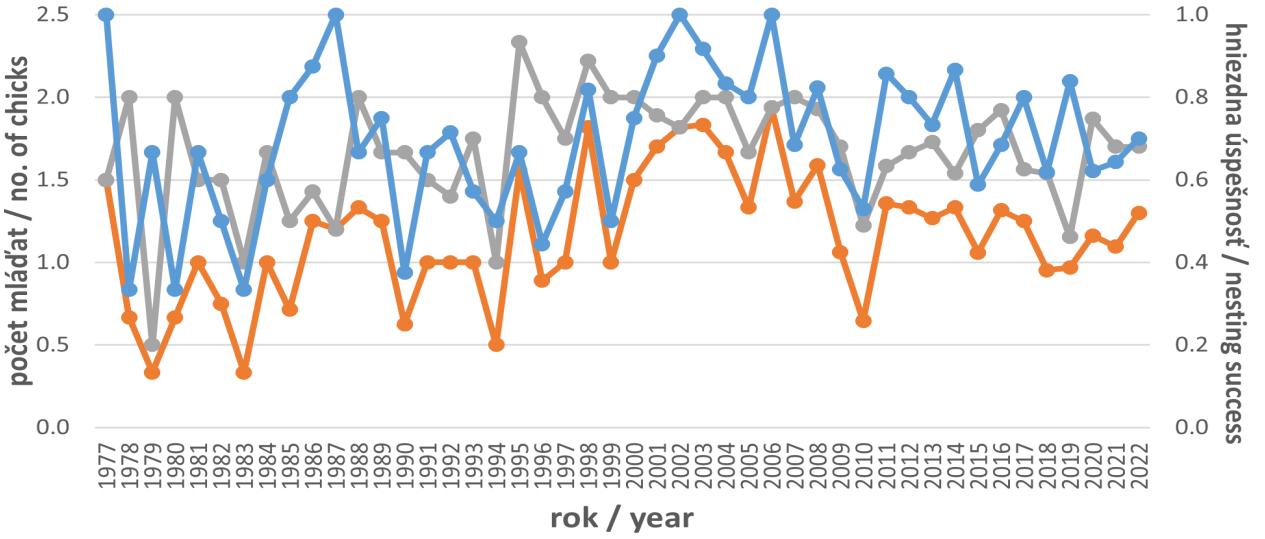

Fig. 5. Breeding success of the eastern imperial eagle in Western Slovakia (1977 – 2022). The orange line indicates the number of fledglings per initiated nesting and the grey line the number of fledglings per successful nesting (left axis), while the blue line indicates the nesting success ratio (right axis).

Obr. 5. Hniezdna úspešnosť orla kráľovského na západnom Slovensku (1977 – 2022). Oranžová čiara označuje počet mláďat na začaté hniezdenie a sivá čiara počet mláďat na úspešné hniezdenie (ľavá os), modrá čiara označuje pomer úspešnosti hniezdenia z daný rok (pravá os).

two sites. Even before then, Turček (1946) had published data on repeated shootings since 1932 of eastern imperial eagles in Western Slovakia, which occurred in the area around Veľký Tríbeč Mountain. Foresters provided evidence of a nest they had noticed in a tall beech tree on its eastern slope, which was the first recorded case of eastern imperial eagles nesting inside the territory of today's Slovakia. Although reports of breeding in the Považský Inovec range date back to 1945 (Kaňuščák 1988), it was only in 1955 that demonstrated breeding was documented (Víťaz & Kaňuščák 1999). Špaček & Kovář (1967) likewise found an occupied nest in the Považský Inovec range in 1958. Another remarkable finding was of a nest with four chicks, again in the Považský Inovec range, this time in 1973 (Víťaz & Kanuščák 2004).

The facts described above, and our results show the initial gradual increase of the eastern imperial eagle's population in Western Slovakia changed markedly trending upward after 2000. This positive trend consistently follows developments in Hungary, where the population had been rising since the 1980s. By 2019, it had grown to 282 known nesting pairs in Hungary (Horváth et al. 2020). The progressive increase of Western Slovakia's population corresponds to the trend seen in the study species in both Eastern Slovakia (Danko 2020) and across all of Europe (Demerdzhiev et al. 2011). There were 542 (70.4%) successful breeding attempts from 770 known cases of breeding and 883 fledglings in Eastern Slovakia between 1971 and 2018. The breeding success rate in the western population was 1.1 chicks per initiated and 1.6 chicks per successful nesting (Danko, 2020). Our results are in line with this study.

Generally higher breeding successes have been recently observed in Central Europe for other species in the same environment, especially at agrocenoses, such as the saker falcon (*Falco cherrug*) (Chavko 2019), the great bustard (*Otis tarda*) (Nagy 2018), the red-footed falcon (*Falco vespertinus*) (Slobodník et al. 2021), and the European roller (*Coracias garrulous*) (Repel et al. 2022). Measures to manage these species may have had a positive impact on their population (e.g., Chavko et al. 2014, Palatitz et al. 2015). Kovács et al. (2005) highlighted the eastern imperial eagle's upward population trend in recent years with the implementation of management measures and their survival has become increasingly dependent upon them. The overall positive impact of targeted conservation measures has led to a rise in the eastern imperial eagle population throughout

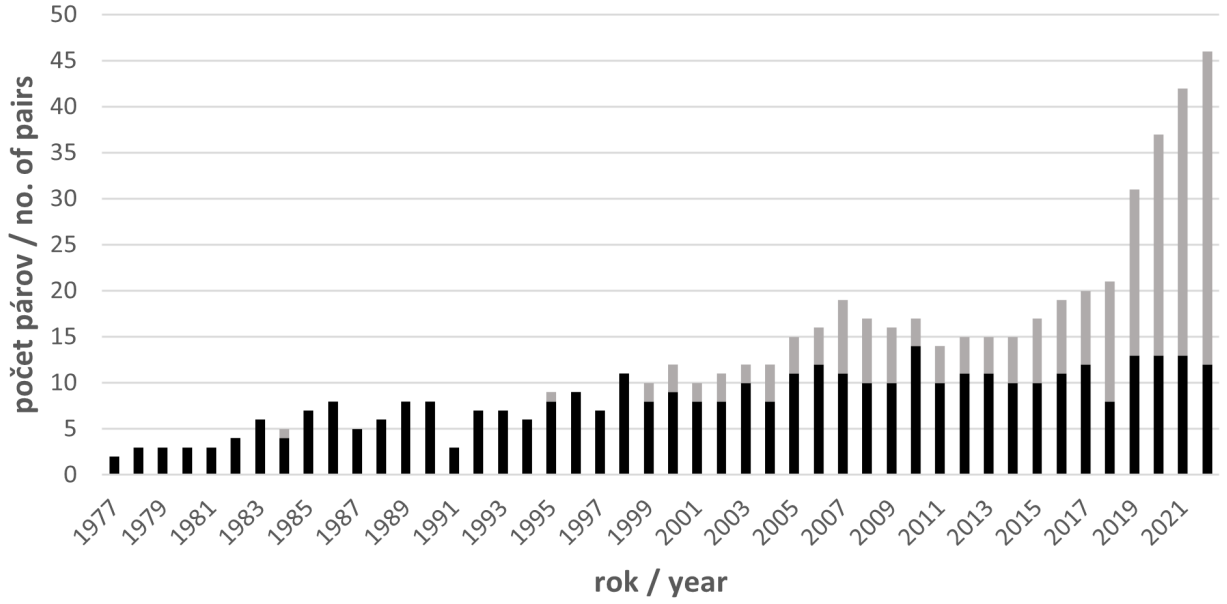

Fig. 6. Changes in breeding habitats of the eastern imperial eagle in Western Slovakia during 1977 – 2022 (black – mountains, grey – lowlands).

Obr. 6. Zmeny hniezdnych biotopov orla kráľovského na západnom Slovensku v rokoch 1977 – 2022 (čierna farba – pohoria, šedá farba – nížiny).

the Pannonian Basin (Keller et al. 2020, Schmidt & Horal, 2018). Alongside climatic conditions during the eagle's reproductive period, especially weather with little rainfall (e.g., Takagi, 2001, Weatherhead, 2005), these management measures are considered by us to be the key factors driving population growth.

From a management perspective, the success of the monitored population in western Slovakia has been limited by three following major anthropic factors. The most significant threats of eastern imperial eagles face are poisoned baits and illegal shooting, as direct mortality affects non-selectively both adults of reproductive age and also prospective juveniles (Abuladze, 1996, Heredia, 1996). Priorities to protect small game species against raptors have caused them to be persecuted and come into conflict with raptor conservation interests. The introduction of conservation measures like regular checking for the presence of poisoned baits (Fig. 8) and media coverage of confirmed cases demonstrated increased numbers of eastern imperial eagle breeding pairs and individuals occupying lowland regions (Horváth et al. 2020). This also corresponds with our results.

The second significant hazard is the high mortality caused by unsafe 22-kilowatt power lines (e.g., Gális et al. 2020, Horváth et al. 2006, Lazarová et al. 2020, Fig. 9). In response, a more efficient approach was taken to counteract the danger by involving the electricity network operator, Západoslovenská distribučná a.s., several implemented projects.

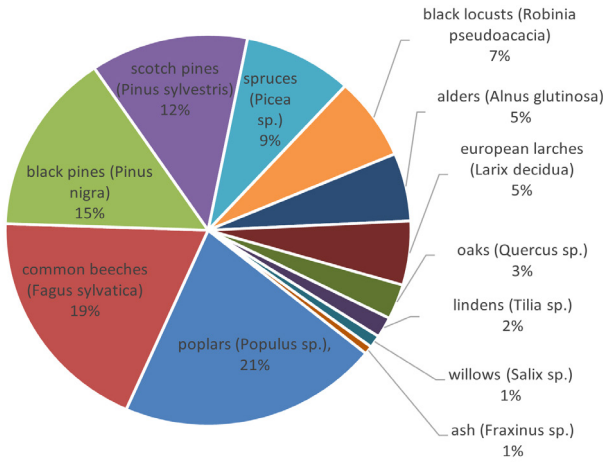

Fig. 7. Tree species of eastern imperial eagle nests [maple (*Acer* sp.) and elm (*Ulmus* sp.), each 0.17% of the total are not visualized in the figure.

Obr. 7. Druhy hniezdnych stromov orla kráľovského (javor (*Acer* sp.) a brest (*Ulmus* sp.), po 0,17% z celkového počtu nie sú na obrázku znázornené).

In recent years, protective elements have been installed at crucial points within the eastern imperial eagle's range to prevent injuries to the birds when they perch on high-voltage pylons and utility poles (Fig. 10 and 11). A total of 1,100 twenty-two-volt poles were treated by protective devices in territories of the eastern imperial eagle between 2018 and 2022 (Gális et al. 2020).

Changes in land use represent the third threat. The prioritization of commercial interests over primary environmental concerns has consequently diminished biodiversity in general and shrunk natural food sources for the eagles (Donald 2001, Vermouzek 2017). Critical declines in the abundance of European ground squirrels (*Spermophilus citellus*) and black-bellied hamsters (*Cricetus cricetus*) were particularly significant. Both species can be regarded as key prey species for eastern

Fig. 8. Police officer with a dog trained to search for poisoned bait.
Obr. 8. Policajt so psom vycvičeným na vyhľadávanie otrávených návnad.

imperial eagles (Chavko et al. 2012). Rodenticides applied against small mammals, which are a major component of the eastern imperial eagle's diet, also remain a significant threat to the birds (Demerdzhiev et al. 2022). The balancing of agrosystems' productive, ecological, and environmental functions can be considered inadequate even in terms of habitat protection. Non-forest vegetation has been degraded and trees eradicated to make land more accessible to agricultural machinery and for the production of woodchips. Not enough new trees have been planted to compensate for what has been removed. In combination with the degradation and decay of old stands, this leads to a reduction of nesting opportunities for eastern imperial eagles in lower elevations.

Fig. 9. Eastern imperial eagle electrocuted. Trnavská pahorkatina Higlands, April 2006.
Obr. 9. Orol kráľovský usmrtený elektrickým prúdom. Trnavská pahorkatina, apríl 2006.

Katzner et al. (2003) recorded the displacement of eastern imperial eagles to the periphery or the occupation of their original nests by golden eagles (*Aquila chrysaetos*), which corresponds to our observations. There were three cases recorded of eastern imperial eagle pairs displaced from their breeding territories by golden eagles after either directly occupying their nests or building new nests in their territories. Golden eagles began nesting at the breeding site of the eastern imperial eagle (Pair 14) in the Štiavnické mountains in 2011. The pair was found in 2022 at a newly occupied nest located on a black pine about six kilometres southwest of the original nest. At Považský Inovec Mountain, golden eagles began nesting at Pair 17's breeding territory in 2019 and at the breeding site of Pair 25 in 2016.

Fig. 10. Straight-line protective perch.
Obr 10. Priamy ochranný prvok.

Fig. 11. Triangular protective perch.
Obr. 11. Trojuholníková zábran.

A gradual transition in breeding habitat preference from mountainous areas to lowlands has also been documented in Hungary (Bagyura et al. 2002, Horváth et al. 2011). This gradual increase in the number of breeding sites in lowland regions (Fig. 12, 13) led to changes in the distribution of the trees where the nests were located, with trees that tend to grow in lower elevations such as poplars, black locusts, and alders beginning to predominate. In contrast, the proportion of nests in beeches and spruces declined markedly. To conclude, it is important to stress the importance of continued prevention of bird crime and the risk of injury from power lines (Kern et al. 2022, Lazarová et al. 2020), which have markedly impacted not only the population of eastern imperial eagles but also many other raptor species (Gonzalez et al. 2007, Smart et al. 2010, Demerdzhiev, 2014, Demeter et al. 2018, Dwyer et al. 2015).

Fig. 12. Breeding habitat of the eastern imperial eagle (Pair 42), Danubian Plain, May 2021. The nesting tree is marked with a orange circle.
Obr 12. Hniezdny biotop orla kráľovského (Pár 42), Podunajská nížina, máj 2021. Hniezdny strom je označený krúžkom.

Fig. 13. Breeding habitat of the eastern imperial eagle (Pair 56), Hronská pahorkatina Highlands, June 2021. The nesting tree is marked with a orange circle.
Obr 13. Hniezdny biotop orla kráľovského (Pár 56), Hronská pahorkatina, jún 2021. Hniezdny strom je označený krúžkom.

References

Abuladze A 1996: Ecology of the Imperial Eagle (*Aquila heliaca*) in Georgia, 447-457. In: Meyburg B-U & Chancellor R D (eds), Eagle Studies. World Working Group on Birds of Prey Berlin, London & Paris.

Bagyura J, Sitta T, Haraszthy L, Firmanszky G, Viszló L, Kovács A, Demeter I, Horváth M 2002: Population increase of Imperial Eagle (*Aquila heliaca*) in Hungary between 1980 and 2000. Aquila 107-108: 133–144.

Chavko J 2002: Sokol rároh (*Falco cherrug*) [The saker falcon (*Falco cherrug*)], 214–216. In: Danko Š, Darolová A & Krištín A (eds): Rozšírenie vtákov na Slovensku. [Birds Distribution in Slovakia]. Veda, Bratislava. [In Slovak with English summary]

Chavko J, Deutschová L, Danko Š, Mihók J, Landsfeld B, Pavelka J, Šnírer L Harvančík S, Dúbravský A, Prešinský L & Galaš R 2014: Status of the eastern imperial eagle population in Slovakia between 1977 and 2013. Slovak Raptor Journal 8 (1): 9–15. DOI: 10.2478/srj20140009.

Chavko J, Danko Š, Obuch J & Mihók J 2007: The Food of the Imperial Eagle (*Aquila heliaca*) in Slovakia. Slovak Raptor Journal 1: 1-18. DOI: 10.2478/v10262-012-0001-y.

Chavko J, Slobodník R, Deutschová L, Lipták J, Mihók J, Obuch J & Nemček V 2014: The saker falcon (*Falco cherrug*) population, diet and nest boxes in Slovakia: LIFEproject report 2011–2014. Slovak Raptor Journal 8 (2): 73–86. DOI: 10.2478/srj-20140009.

Chavko J, Obuch J, Lipták J, Slobodník R & Baláž M 2019: Changes in nesting habitat of the saker falcon (*Falco cherrug*) influenced its diet composition and potentially threatened its population in Slovakia in the years 1976–2016. Slovak Raptor Journal 13: 75–104. DOI: 10.2478/srj20190009.

Černecký J, Lešo P, Ridzoň J, Krištín A, Karaska D, Darolová A, Fulín M, Chavko J, Bohuš M, Krajniak D, Ďuricová V, Lešová A, Čuláková J, Saxa A, Durkošová J, Andráš P 2020: Stav ochrany vtáctva na Slovensku v rokoch 2013 – 2018 [Conservation status of birds in Slovakia in 2013 – 2018]. Banská Bystrica, State Nature Conservancy, 105 pages. [In Slovak]

Chavko, J. & Danko, Š. (2005). Orol kráľovský (Aquila heliaca). Správa za rok 2004. Dravce a Sovy 1(1): 12.

Chavko, J., Danko, Š. & Mihók, J. (2006). Orol kráľovský (*Aquila heliaca*). Správa za rok 2005. Dravce a Sovy 2(2): 13.

Chavko, J., Danko, Š. & Mihók, J. (2007a). Orol kráľovský (*Aquila heliaca*). Správa za rok 2006. Dravce a Sovy 3 (1): 6.

Danko Š & Chavko J 1996: Breeding of the Imperial Eagle Aquila heliaca in Slovakia, 415-423. In: Meyburg B-U & Chancellor R D (eds), Eagle Studies. World Working Group on Birds of Prey Berlin, London & Paris.

Danko Š, Chavko J, Demeter G, Mihók J, Izakovič J, Latková H, Siryová S, Noga M & Nemček V 2011: Conservation of eastern Imperial eagle in the Slovak part of the Carpathian basin – Results of the EULIFE-Nature project (2003–2007). Acta zoologica Bulgarica Supplementum 3: 71–78.

Danko Š & Chavko J 2002: Orol kráľovský [The imperial eagle (*Aquila heliaca)*], 199-200. In: Danko Š, Darolová A & Krištín A (eds): Rozšírenie vtákov na Slovensku. Birds Distribution in Slovakia. Veda, Bratislava. [In Slovak with English summary]

Danko Š & Chavko J 1995: Hniezdenie orla kráľovského (*Aquila heliaca*) na Slovensku v r. 1993 a 1994 [Breeding of imperial eagle (*Aquila heliaca*) in Slovakia in 1993 and 1994]. Buteo 7: 182–190. [In Slovak]

Danko Š, Mihók J, Chavko J & Prešinský L 2007: Substitute nesting by Imperial Eagles (*Aquila heliaca*) in Slovakia. Slovak Raptor Journal 1: 23–28.

Danko Š & Mihók J 2020: A parlagi sas (*Aquila heliaca*) kelet-szlovákiai állományának alakulása 1967 és 2018 között [The evolution of the Eastern Slovakian Eastern Imperial Eagle population between 1967 and 2018]. Heliaca 16: 7 – 11. [In Hungarian with English summary]

Demerdzhiev D, Horváth M, Kovács A, Stoychev S & Karyakin I 2011: Status and Population Trend of the Eastern Imperial Eagle (*Aquila heliaca*) in Europe in the Period 2000-2010. Acta zoologica Bulgarica Supplementum 3: 5-14.

Demerdzhiev D 2014: Factors influencing bird mortality caused by power lines within Special Protected Areas and undertaken conservation efforts. Acta Zoologica Bulgarica 66(2): 411–423.

Demerdzhiev D, Boev Z, Dobrev D, Terziev N, Nedyalkov N, Stoychev S & Petrov T 2022: Diet of Eastern Imperial Eagle (*Aquila heliaca*) in Bulgaria: composition, distribution and variation. Biodiversity Data Journal 10: e77746. https://doi.org/10.3897/BDJ.10.e77746.

Demeter I, Horváth M, Nagy K, Görögh Z, Tóth P, Bagyura J, Solt S, Kovács A, Dwyer J & Harness R 2018: Documenting and reducing avian electrocutions in Hungary: a conservation contribution from citizen scientists. The Wilson Journal of Ornithology 130(3): 600–614. DOI: 10.1676/17-031.1.

Donald P F, Green R E & Heath M F 2001: Agricultural intensification and the collapse of Europe's farmland bird populations. Proceedings of the Royal Society 268: 25–29. DOI: 10.1098/rspb.2000.1325

Dwyer J, Kratz F, Harness R E & Little S S 2015: Critical dimensions of raptors on electric utility poles. Journal of Raptor Research 49(2): 210–216. DOI: 10.3356/0892-1016-49.2.210

Ferianc O 1964: Stavovce Slovenska II. Vtáky I. [Vertebrates of Slovakia II. Birds I.] Vydavateľstvo SAV, Bratislava. [In Slovak].

Gális M, Naďo L, Hapl E, Šmídt J, Deutschová L & Chavko J 2020: Comprehensive analysis of bird collisions and electrocutions at distribution power lines in Slovakia. Raptor Journal 13: 1-25.

Gallego G D & Sarasola J 2021: Using drones to reduce human disturbance while monitoring breeding status of an endangered raptor. Remote Sensing in Ecology and Conservation 7 (3): 550-561. DOI: 10.1002/rse2.206.

Gonzalez L M, Margalida A, Manosa S, Sanchez R, Oria J, Molina J I, Caldera J, Aranda A & Prad L 2007: Causes and spatio-temporal variations of non-natural mortality in the Vulnerable Spanish Imperial Eagle Aquila adalberti during a recovery period. Oryx 41(4): 495-502. DOI: 10.1017/S0030605307414119.

Harvančík, S., Šnírer, L., Siklienka, R., Demeter, G., Dúbravský, A. (2008). Hniezdenie orla kráľovského (*Aquila heliaca*) v územnej pôsobnosti Správy Chránenej krajinnej oblasti Ponitrie v rokoch 2001 – 2007 [Breeding of imperial eagle (*Aquila heliaca*) in the territorial scope of the Administration of the

Protected Landscape Area of Ponitrie in the years 2001-2007]. Rosalia19: 2003-2008. [In Slovak].

Heredia B, Danko Š, Galushin V, Gretton A, Hallmann B & Haraszthy L 1996: International action plan for the Imperial Eagle (*Aquila heliaca*).

Horák P 1998: Úspěšné hnízdění orla královského (Aquila heliaca) na Moravě [Successful breeding of the imperial eagle (Aquila heliaca) in Moravia]. Crex 12: 27–28 s. [In Czech].

Horal D 2009: Imperial Eagle (*Aquila heliaca*) in the Czech Republic, 65. In: 6th International Conference on the Conservation of the Eastern Imperial Eagle. Topolovgrad. Bulgaria.

Horváth M, Haraszthy L, Bagyura J & Kovács A 2002: Eastern imperial eagle (*Aquila heliaca*) populations in Europe. Aquila 107–108: 193–204. [In Hungarian with English summary]

Horváth M, Kovács A & Gallo-Orsi U 2006: Action Plan for Imperial Eagle (*Aquila heliaca)* in the Southern-Caucasus.

Horváth M, Solti B, Fatér I, Juhász T, Haraszthy L, Szítta T, Ballók Z & Pásztory-Kovács S 2018: Temporal changes in the diet composition of the Eastern Imperial Eagle (*Aquila heliaca*) in Hungary. Ornis Hungarica 26(1): 1–26. DOI: 10.1515/orhu-2018-0001.

Horváth M, Demeter I, Fatér I, Firmánszky G, Kleszó A, Kovács A, Szítta T, Tóth I, Zalai T & Bagyura J 2011: Population Dynamics of the Eastern Imperial Eagle (*Aquila heliaca*) in Hungary between 2001 and 2009. Acta Zoologica Bulgarica 3: 61-70.

Horváth M, Fatér I, Juhász T, Deák G & Bereczky A 2020: The nesting population of Eastern Imperial Eagles (*Aquila heliaca*) in Hungary between 2017 and 2019. Heliaca 16: 42– 45. [In Hungarian with English summary]

Hudec K & Černý W (eds.) 1977: Fauna ČSSR Ptáci – Aves díl II. [Fauna ČSSR Birds - Aves volume II]. Academia Praha, 896. [In Slovak]

Kalivodová E & Brtek V 1977: Vtáctvo severnej časti Malých Karpát [Birds of the northern part of Malé Karpaty Mountains]. Biologické práce [Biological studies] XXIII (2): 7-107. [In Slovak]

Kaňuščák P 1988: Vtáctvo juhozápadnej časti Považského Inovca [Birds of the southwestern part of Považský Inovec Mountain]. Zprávy Moravského ornitologického sdružení [Reports of the Moravian Ornithological Association] 46: 9-58. [In Slovak]

Katzner T, Bragin E, Knick S, Smith A 2003: Coexistence in a Multispecies Assemblage of Eagles in Central Asia. The Condor 105: 538-551. DOI: 10.1093/condor/105.3.538.

Keller V, Herrando S, Voříšek P 2020: European Breeding Bird Atlas 2: Distribution, Abundance and Change. European Bird Census Council & Lynx Editions. Barcelona.

Kern M, Macák D, Struhárová E 2022: Aktuálna situácia a vývoj boja s "Bird Crime" na Slovensku, 38-39. In: Ornitologická konference ČSO Ptáci a svět pohybu 23.-25 Sept. 2022, Sborník abstraktu2. Mikulov. [In Slovak]

Kovács A, Demeter I, Horváth M, Fülöp G, Frank T & Szilvácsku Z 2005: Imperial Eagle Management Guidelines. MME BirdLife Hungary, Budapest. 156 pp.

Krištín A 1999: Ďalší údaj o hniezdení orla kráľovského (*Aquila heliaca*) v poľnohospodárskej krajine západného Slovenska [On breeding of Imperial Eagle (*Aquila heliaca*) in agricultural landscape of western Slovakia]. Tichodroma 12: 47-48. [In Slovak with English summary]

Lazarova I, Dobrev D, Gradev G, Petrov R, Stoychev S, Klisurov I & Demerdzhiev D 2020: Main mortality factors for the Eastern Imperial Eagle (*Aquila heliaca* Savigny, 1809) in Bulgaria. Ornis Hungarica 28: 120-134. DOI: 10.2478/orhu-2020-0021.

Mošanský A 1972: Dravce (Falconiformes) východného Slovenska I. Supy, orly, myšiaky, jastraby a haje [Birds of prey of eastern Slovakia I. Vultures, eagles, buzzards, hawks and kites]. Collection of the Eastern Slovakian Museum, Kosice XI-XII B (1970-71): 39 -125. [In Slovak]

Mikuš J, Noga M & Nemček V 2008: First breeding of the Imperial Eagle (*Aquila heliaca*) in the Borská nížina lowland (southwestern Slovakia). Slovak Raptor Journal 2: 87-90. DOI: 10.2478/v10262-012-0022-6

Nagy S 2018: International Single-species Action Plan for the Western Palaearctic Population of Great Bustard, Otis tarda. Version adapted for the Memorandum of Understanding on the Conservation and Management of the Middle-European Population of the Great Bustard (*Otis tarda*). 45 p.

Palatitz P, Fehérvári P, Solt S & Horváth É 2015: Breeding population trends and pre-migration roost site survey of the Red-footed Falcon in Hungary. Ornis Hungarica 23: 77-93. DOI: 10.1515/orhu-2015-0007.

Ranner A 1999: Rote Liste Porträt: Die Rückkehr des Kaisers. Vogelschutz in Österreich 15:12-13. [In German]

Repel M, Chrašč P, Ličák T, Palkoci E, Vozárik Š & Haluška L 2022: Dolný Zemplín domovom nových hniezdičov na Slovensku aj miestom návratu vzácnych druhov [Dolný Zemplín is the home of new nestors in Slovakia and the place of return of rare species], 14-15. In: : Kropil R & Lešo P (eds), Aplikovaná ornitológia. Zborník abstraktov [Applied ornithology. Book of the abstracts]. Zvolen. [In Slovak]

Schmidt M & Horal D 2018: Eastern Imperial Eagle (*Aquila heliaca*) on its most north-west distribution edge. Raptor Conservation, Supplementum 1 (Abstract of the II International Scientific and Practical Conference: "Eagles of Palearctic": Study and Conservation): 102-103.

Sládek J 1959: Príčiny rozširovania areálu orla kráľovského (*Aquila heliaca*) v strednej Európe a jeho hniezdenie na Slovensku [Reasons for the expansion of the range of the imperial eagle (Aquila heliaca) in Central Europe and its nesting in Slovakia]. Sylvia 16: 79–95. [In Slovak]

Slobodník R & Jenčo M 2020: Summary of raptor and owl ringing in Slovakia in the period from 2012 to 2019. Raptor Journal 14: 45–72. . DOI: 10.2478/srj-2020-0007

Slobodník R, Chavko J, Lengyel J, Noga M, Maderič B & Baláž M 2021: Corrigendum: Trend in an isolated population of the red-footed falcon (*Falco vespertinus*) at the edge of its breeding range (southwestern Slovakia). Raptor Journal 15: 89-90. DOI: 10.2478/srj20210004

Smart J, Amar A, Sim I M W, Etheridge B, Cameron D, Christie G & Wilson J D 2010: Illegal killing slows population recovery of a re-introduced raptor of high conservation concern – The Red Kite (*Milvus milvus*). Biological Conservation 143: 1278–1286. DOI: 10.1016/j.biocon.2010.03.002.

Špaček M & Kovář K 1967: Dravci v letu [Bird of prey in flight], Státní zemědělské nakladatelství, Prague 1967, 149 p. [In Czech]

Šťastný K, Bejček V, Mikuláš I & Telenský T 2021: Atlas hnízdního rozšíření ptáků v České republice 2014-2017 [Atlas of nesting distribution of birds in the Czech Republic 2014-2017]. Aventinum. Prague. [In Czech]

Takagi M 2001: Some effects of inclement weather conditions on the survival and condition of bull-headed shrike nestlings. Ecological Research 16: 55-63. DOI: 10.1046/j.1440-1703.2001.00371.x

Vermouzek Z & Zámečník V 2017: Indikátor ptáků zemědělské krajiny za rok 2017 [Taxonomy of birds in agricultural country in 2017]. Česká společnost ornitologická, Prague. [In Czech]

Vili N, Chavko J, Szabó K, Kovács S, Hornung E, Kalmár R & Horváth M 2009: Genetic structure of the Imperial Eagle (*Aquila heliaca*) population in Slovakia. Slovak Raptor Journal 2009, 3: 21–28. DOI: 10.2478/v10262-012-0029-z

Víťaz V & Kaňuščák P 1999: Správa o hniezdení orla kráľovského (*Aquila heliaca*) v poľnohospodárskej krajine na západnom Slovensku [Report on Imperial Eagle (*Aquila heliaca*) breeding in agricultural land in the western Slovakia]. Tichodroma 12:44-46. [In Slovak with English summary]

Víťaz V & Kaňuščák P 2004: Štyri mláďatá v hniezde orla kráľovského (*Aquila heliaca*) v Považskom Inovci na západnom Slovensku [Four chicks in a nest of Imperial Eagle (*Aquila heliaca*) in Považský Inovec mountain in westwern Slovakia]. Tichodroma 16: 64-67. [In Slovak with English summary]

Weatherhead P J 2005: Effects of climate variation on timing of nesting, reproductive success, and offspring sex ratios of red-winged blackbirds. Oecologia 114: 168-175. DOI: 10.1007/s00442-005-0009-4.

Tonhauzer P 1954: Bocian čierny a orol kráľovský v Malých Karpatoch [Black stork and imperial eagle in Malé Karpaty Mountain]. Myslivost 2: 108. [In Slovak]

Turček F 1946: Orly na Veľkom Tribeči [Eagles on Veľký Tríbeč Mountain]. Príroda 1 (4):79. [In Slovak]

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Príloha 1 Zoznam hniezdisk a časový priebeh hniezdenia jednotlivých párov za celé obdobie monitoringu 1977 – 2022.

Appendix 1. List of breeding places and breeding process of particular nesting pairs during years 1997 - 2022

pair´s ID	orographic unit	habitat	breeding period	pair´s ID	orographic unit	habitat	breeding period
kód páru	orografický celok	biotop	obdobie hniezdenia	kód páru	orografický celok	biotop	obd. hniezdenia
1	Malé Karpaty	mountains	1977-1989, 1990-2007	30	Borská nížina	lowlands	2016, 2018-2022
2	Malé Karpaty	mountains	1980-1994, 1998, 2000-2001, 2010-2012,2016-2022	31	Strážovské vrchy	mountains	1986, 1988-1990
3*	Malé Karpaty	mountains	1982-1990, 1995-1996, 2005-2006, 2008-2010, 2012-2013	32	Borská nížina	lowlands	2009, 2020
	Trnavská pahorkatina	lowlands	2004, 2014-2016, 2020-2021	33	Podunajská rovina	lowlands	2004
4*	Malé Karpaty	mountains	1989-1999	34	Žitavská pahorkatina	lowlands	1995
	Podunajská rovina	lowlands	1984, 2000-2022	35	Podunajská rovina	lowlands	2007, 2019-2022
5	Malé Karpaty	mountains	1985, 1990, 1992-1993, 1998-1999	36	Ipeľská pahorkatina	lowlands	2007
6	Malé Karpaty	mountains	1995-1998, 2000-2006	37	Podunajská rovina	lowlands	2010
7*	Považský Inovec	mountains	1977-1979, 1983-1987,1988-1998,2000-2012, 2017, 2019-2022	38	Pohronská pahorkatina	lowlands	2017-2022
	Trnavská pahorkatina	lowlands	1999	39	Trnavská pahorkatina	lowlands	2017-2022
8*	Považský Inovec	mountains	1990, 1992-2007, 2009-2010, 2012-2013, 2016-2017, 2019-2022	40	Považský Inovec	mountains	2018-2022
	Nitrianská pahorkatina	lowlands	2008	41	Nitrianská pahorkatina	lowlands	2018-2019, 2022
9	Tríbeč	mountains	1978-1983, 1996, 1998-2008, 2010-2011, 2014-2021	42	Pohronská pahorkatina	lowlands	2018-2022
10	Tríbeč	mountains	1979, 1985-1989, 1992-2010, 2012-2022	43	Nitrianská pahorkatina	lowlands	2018-2022
11	Trnavská pahorkatina	lowlands	1999-2000	44	Trnavská pahorkatina	lowlands	2018-2022
12	Tríbeč	mountains	1995-2022	45	Podunajská rovina	lowlands	2019-2022
13*	Nitrianská pahorkatina	lowlands	2007-2010	46	Podunajská rovina	lowlands	2019-2022
	Tríbeč	mountains	2013-2015, 2016-2021	47	Žitavská pahorkatina	lowlands	2020-2022
14	Štiavnické vrchy	mountains	1999-2010, 2022	48	Ipeľská pahorkatina	lowlands	2019-2022
15	Tríbeč	mountains	2015	49	Podunajská rovina	lowlands	2019-2022
16*	Považský Inovec	mountains	1986, 2003-2005,2008-2022	50	Trnavská pahorkatina	lowlands	2021-2022
	Trnavská pahorkatina	lowlands	2000, 2002	51	Borská nížina	lowlands	2019-2022
17	Považský Inovec	mountain	2002,2003,2005-2015	52	Podunajská rovina	lowland	2020-2022
18	Pohronská pahorkatina	lowlands	2001-2013, 2015-2022	53	Podunajská rovina	lowlands	2020-2022
19	Trnavská pahorkatina	lowlands	2003, 2005-2013,2014-2016	54	Podunajská rovina	lowlands	2020-2022
20	Pohronská pahorkatina	lowlands	2007-2008	55	Považský Inovec	lowlands	2019-2022
21	Ipeľská pahorkatina	lowlands	2005-2010, 2012-2013, 2015-2016	56	Podunajská rovina	lowlands	2021-2022
22	Považský Inovec	mountains	2006-2017, 2019-2022	57	Podunajská rovina	lowlands	2021-2022
23	Pohronský Inovec	mountains	2006-2022	58	Podunajská rovina	lowlands	2021-2022
24	Borská nížina	lowlands	2007-2009, 2011-2022	59	Podunajská rovina	lowlands	2021
25*	Považský Inovec	mountains	2012-2014	60	Podunajská rovina	lowlands	2022
	Nitrianská pahorkatina	lowlands	2017, 2019-2022	61	Podunajská rovina	lowlands	2022
26	Trnavská pahorkatina	lowlands	2014-2022	62	Trnavská pahorkatina	lowlands	2022
27	Nitrianská pahorkatina	lowlands	2015, 2017-2022	63	Trnavská pahorkatina	lowlands	2022
28	Podunajská rovina	lowlands	2016-2017	64	Ipeľská pahorkatina	lowlands	2022
29	Nitrianská pahorkatina	lowlands	2016, 2018, 2020-2022	65	Podunajská rovina	lowlands	2022

* pairs moved from mountains to lowland / páry presťahové z pohorí do nížin