sciendo

Ornis Hungarica 2023. 31(2): 203–216.
DOI: 10.2478/orhu-2023-0030

Breeding and conservation status of the Western Barn Owl *(Tyto alba)* in Zala County, Hungary. An overview of 39 years of data

Ákos Klein[1*], Róbert Mátics[2,3,4] & Zoltán Schneider[1,3,4]

Received: September 13, 2023 – Revised: October 24, 2023 – Accepted: October 26, 2023

Presented at 3rd Hungarian Owl Research Conference held in Pécs on 8th September 2023

Klein, Á., Mátics, R. & Schneider, Z. 2023. Breeding and conservation status of the Western Barn Owl *(Tyto alba)* in Zala County, Hungary. An overview of thirty-nine years of data. – Ornis Hungarica 31(2): 203–216. DOI: 10.2478/orhu-2023-0030

Abstract In this study, we analysed the occurrence, nesting, and ringing data spanning 39 years for the Western Barn Owl *(Tyto alba)* population in Zala County. Data on Barn Owl surveys originate from 166 out of the total of 258 settlements in the county. During the examined period, nesting was recorded in 74 settlements, while an additional 28 locations have confirmed Western Barn Owl presence (pellets, owl sightings). Furthermore, surveys were conducted at least once in an additional 64 locations without any sign of the species. Based on Barn Owl presence and nesting data, preferred locations for the species can be identified at the local and landscape level. Nesting may be occasional in some places, while a few traditional nesting sites, which show nearly continuous occupation over decades, can be considered stable. The results from Zala County are in line with other research, highlighting the continued importance of church buildings for the species' nesting. Maintaining these buildings is essential for the conservation of a stable population. Given the decreasing number of accessible churches, there is a need for providing alternative nesting sites. In addition to building closures, the future doubling of the length of motorways in the county will pose another significant threat to the regional population.

Keywords: Common Kestrel, conservation biology, pole-mounted box, roadkill, traditional nest sites

Összefoglalás A gyöngybagoly *(Tyto alba)* Zala vármegyei populációjának 39 évet felölelő előfordulási, költési és gyűrűzési adatait elemeztük. A megye 258 településéből 166-ról származik valamilyen gyöngybagoly felmérési adat. A vizsgált közel négy évtizedből 74 településről ismert a faj költése, 28 további helységből van bizonyított gyöngybagoly jelenlét (köpet, észlelt bagoly), és további 64 helyen történt legalább egyszer felmérés a fajra utaló jelenlét nélkül. A gyöngybagoly jelenléti és költési adatok alapján kistáji léptékben és konkrét költőhelyeket illetően is megállapíthatók preferált helyek a faj egyedei számára. Egyes költőládákban a költés esetleges, míg van néhány stabilnak tekinthető tradicionális költőhely, amely évtizedeken keresztül szinte folyamatosan foglalt. A zalai eredmények – más hazai kutatásokkal összhangban – alátámasztják, hogy a gyöngybagoly költése szempontjából továbbra is kiemelt szerepük van az egyházi épületeknek, ezek fenntartása elengedhetetlen a stabil állomány megőrzéséhez. A baglyok számára elérhető templomok csökkenő száma miatt szükség van alternatív költőhelyek biztosítására is. Az épületlezárások mellett a megyei populáció másik jelentős veszélyeztető tényezője a gyorsforgalmi utak hosszának megduplázódása a következő években.

Kulcsszavak: oszlopláda, természetvédelem, tradicionális költőhelyek, úthálózat fejlesztés, vörös vércse

[1]*The Barn Owl Foundation, 8744 Orosztony, Temesvári utca 8., Hungary*
[2]*Institute of Behavioural Sciences, Medical School, University of Pécs, 7624 Pécs, Szigeti utca 12., Hungary*
[3]*Hungarian Nature Research Society, 8448 Ajka, Vadvirág utca 5., Hungary*
[4]*Doctoral School of Biology and Sport Biology, Faculty of Sciences, University of Pécs, 7624 Pécs, Ifjúság utca 6., Hungary*
** corresponding author, e-mail: kleinakos@gmail.com*
First and last authors contributed equally

Introduction

The Western Barn Owl *(Tyto alba)* (for simplicity referred to as Barn Owl in the text), has both a large geographical range and population size in Europe. Hence, in the most recent Red List Assessment of the International Union for Conservation of Nature (IUCN), the Barn Owl does not approach the thresholds for vulnerable (BirdLife International 2021). The previous assessment published in 2015 treated this species as a stable and Least Concern species (BirdLife International 2015). In most recent 2020 assessments, however, its population trend is regarded decreasing in Europe. This important alteration in the European population trend appears to be excessively careful, especially knowing the many early publications that reported local or regional population declines. In the major part of Europe, between 1970 and 1990 a decrease of 20% was reported (Osieck & Shawyer 1997), and the species became extinct in Malta. Bruce (1999) stated that its populations have been declining for about 50 years in Europe and North America. It must be noted that the trend analysis of the Barn Owl holds several uncertainties that makes the judgement of the population predictions unreliable (Barn Owl Trust 2012), but Barn Owl conservationists see a flashing emergency red light based on their field experiences. Conservationists cite changes to the global agricultural landscape (Colvin 1985), loss of nest sites and increases in vehicle traffic from expanding road networks (Massemin 1998, Mátics 2000, 2004, Fajardo 2001) as the most important factors in their decline.

A recent comprehensive overview of the Hungarian bird fauna underpins this concern. Conventionally, the population size of the Barn Owl in Hungary had been regarded between 800 and 1,000 breeding pairs (Hadarics & Zalai 2008). In contrast, based on the most recent evaluation models, this number falls only between 340–860 pairs (Klein 2021). The population fluctuation might be naturally extreme, since this bird species is very sensitive to harsh winter conditions (Altwegg *et al.* 2006). Interestingly, the average annual temperature in Hungary rose 1.15 °C between 1907 and 2017, outpacing the global average temperature change (+0.9 °C). In spite of mildening winters in Hungary, a poorer population resilience can be seen. Average winter temperature increased by 0.8–1.2 °C, and according to the climate change models, the number of frosty days will show a definite reduction by 14–15 days in winter by 2040 (International Energy Agency 2020). The slowly recovering Barn Owl populations in the series of several consecutive mild winters raises questions regarding unidentified or underrated endangering factors, that represses population resilience.

In this review, we summarise all the available data deriving from Zala County, an area that belongs to the Transdanubian hills. This geographical region in Hungary holds a robust Barn Owl population that can be acknowledged not only to the ideal landscape structure (Klein *et al.* 2022), but to the long-term intensive conservation efforts as well (Bank *et al.* 2019). The many negative processes both at nesting site and landscape levels indicate the importance of overviewing biotic data from time to time. This helps conservationists to identify endangering factors at an early phase. This is especially relevant for the declining Barn Owl, knowing the extensive traffic infrastructure development plans for the future. It has been widely discussed through the example of other nocturnal, seemingly common

owls, such as the Scops Owl *(Otus scops)*, that its significant population decline over the past 25 years in Slovenia can be acknowledged to the adverse landscape transformation that reaches even the last strongholds of this sensitive iconic species (Klein *et al.* 2020).

Materials and Methods

Study area

Zala County is located in the western part of Hungary *(Figure 1)*, adjacent to the border of Croatia and Slovenia. Zala is the second most densely forested county in Hungary (KSH 2021), that is not favourable for the Barn Owl (Bruce 1999, Marti *et al.* 2020), but the grasslands and extensively cultivated areas along the rivers and canals provide suitable habitats. The distribution of land use in the county is: 33% arable land, 31.6% forest, 26% non-agricultural, 7% grassland, 0.5% vegetable garden, 0.5% orchard, 0.5% vineyard, <0.5% reedbed and <0.5% fishpond (KSH 2022). The area of the county is 3,784 km^2 and there are 258 settlements with an average human population density of 71/km^2. Nationally, it falls into the category of moderately populated counties.

Figure 1. Location of Zala County in Hungary
1. ábra Zala vármegye elhelyezkedése Magyarországon

Data acquisition

During the research, we utilized three different sources of data related to Barn Owls. We analysed the ringing data from the Ringing Centre of BirdLife Hungary spanning the years from 1985 to 2022, historical records from the Zala County Group of BirdLife Hungary, and research data from the Barn Owl Foundation (BOF) collected between 1997 and 2023. The ringing data primarily provided information about the location of ringing and the age of the birds. In cases where the database indicated a nestling or a young bird, we considered it as evidence of breeding at that location in the respective year. The surveys conducted by the Zala County Group of BirdLife Hungary provided information regarding the presence and breeding of the Barn Owl for the period between 1984 and 1989. The data of the BOF indicate the presence of Barn Owls and their breeding are derived from building surveys and the inspection of interior and pole-mounted boxes. For each surveyed building, the type of the building, its suitability for nesting, presence of owl-related signs, breeding information, and if breeding occurred, the number of eggs and nestlings were recorded. Suitable buildings were re-inspected year by year, whereas buildings that became inaccessible for the owls due to human interventions, were left out from further surveys. Thus, for some breeding sites decade long datasets are available. Data from the three databases were combined to determine the long-term breeding characteristics and conservation status of the Barn Owl in the area. Due to different sampling protocols, for the first two databases (ringing and historical), we only utilized data indicating breeding or presence. In the case of the BOF's dataset, we incorporated additional variables as well (e.g. the presence of telecommunication devices, other notable endangering factors, presence of other species, etc.).

We summarized evidence of breeding or presence of the species. If a breeding or a young bird hatched in the particular nest box was observed, the given location (settlement) was considered as a nest site. In case only pellets, feathers or adult birds were found at a particular site, only the presence of the species was proven for that locality. If there had been a survey in a given locality but breeding or presence of the bird was not known, we assumed that the species was not present in that settlement. We have compiled the total number of breedings for each settlement over the course of 39 years. In cases where a settlement had breedings in two locations within a single year, we counted it as two instances. However, since second broods were not systematically surveyed, they were not included in the analyses. To determine the Barn Owl breeding population of the county, we annually summarized the number of breeding and roost sites (fresh pellets, adult birds). As the BOF commenced a systematic survey of the county's Barn Owl population in 2009, we conducted the assessment starting from that year.

As a conservation measure, a significant number of pole boxes as alternative breeding sites were installed in Zala County from 2008 onwards with a design based on Klein and László (2015). A total of 37 pole boxes were installed, out of which 25 were erected during the winter of 2022–2023. We also summarised the usage and frequency of breeding for these pole boxes by Barn Owls and Common Kestrel *(Falco tinnunculus)* and examined the speed of occupancy of the pole boxes and those placed inside the buildings.

We extracted data from the Hungarian Central Statistical Office (referred to as KSH in the references) to gain information about the road development in Zala County.

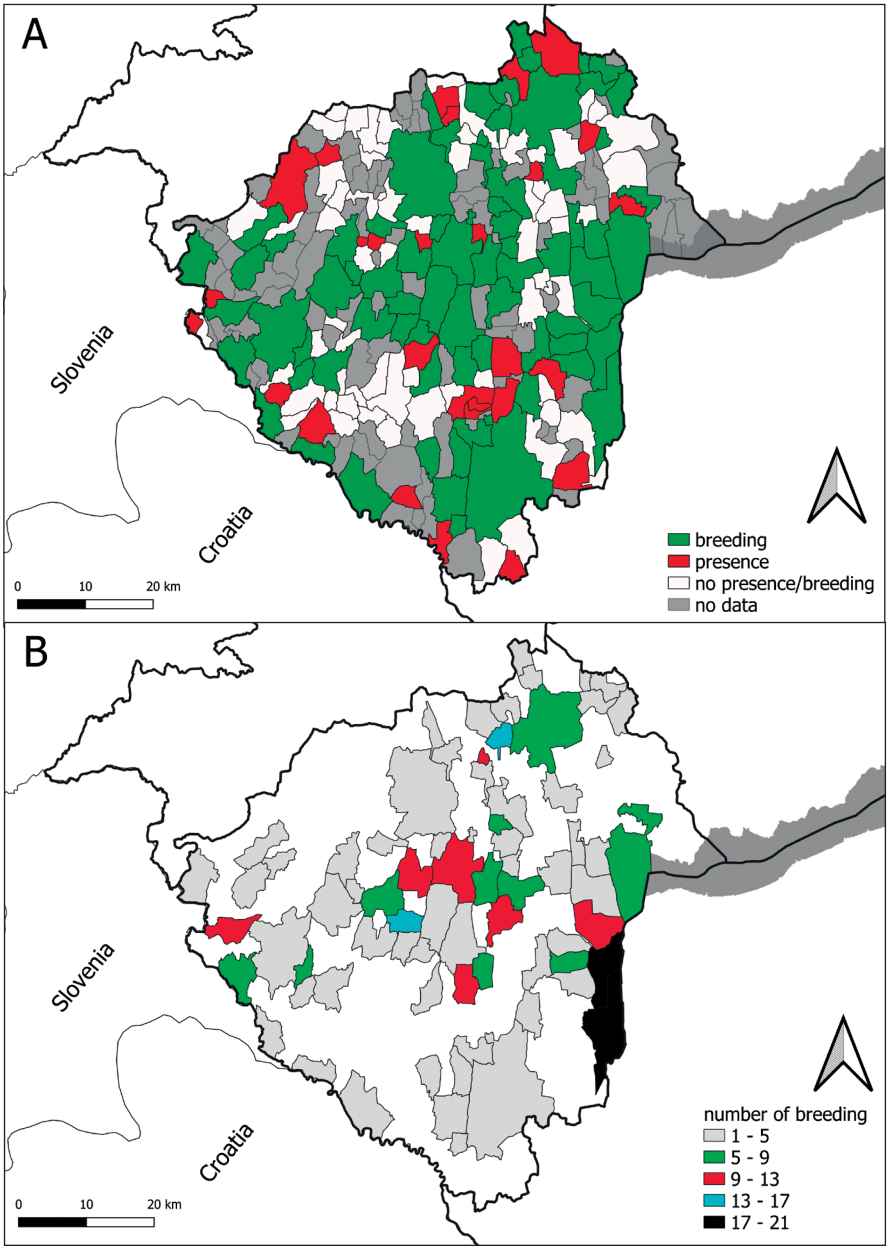

Figure 2. *A*: Distribution map of the Barn Owl in Zala County between 1984 and 2023 (absence/presence/breeding), *B*: Barn Owl breeding frequency per settlement between 1984 and 2023 in Zala County. Second broods were not included, while multiple nesting sites within the same breeding season were considered

2. ábra *A:* A gyöngybagoly hiányának/jelenlétének/költésének előfordulása Zala megyében 1984 és 2023 között, *B*: Az ismert gyöngybagoly költések gyakorisága településenként 1984 és 2023 között Zala megyében. A másodköltések nem kerültek beszámításra, míg az egy településen, de több helyen is jelenlévő költés igen

Results

Data related to Barn Owl surveys were available from 166 villages out of the total of 258 settlements in Zala County. There were 64 locations, where, despite the surveys, no signs of owls were found. In 28 settlements, the presence of the birds was detected, but breeding was not proved. Furthermore, there were 74 settlements where the birds' breeding is confirmed. Zalakomár and Balatonmagyaród are the settlements with the highest breeding frequency. Both settlements had breeding occurrences for 21 out of the examined 39 years *(Figure 2)*.

The number of surveyed buildings varied significantly each year, ranging from 50 to 128 *(Figure 3)*. Between 2009 and 2023, the number of documented Barn Owl breedings in the county ranged from 7 to 27. The years with the least breedings were 2013 and 2014, while in 2023 the highest number of Barn Owl nestings was observed.

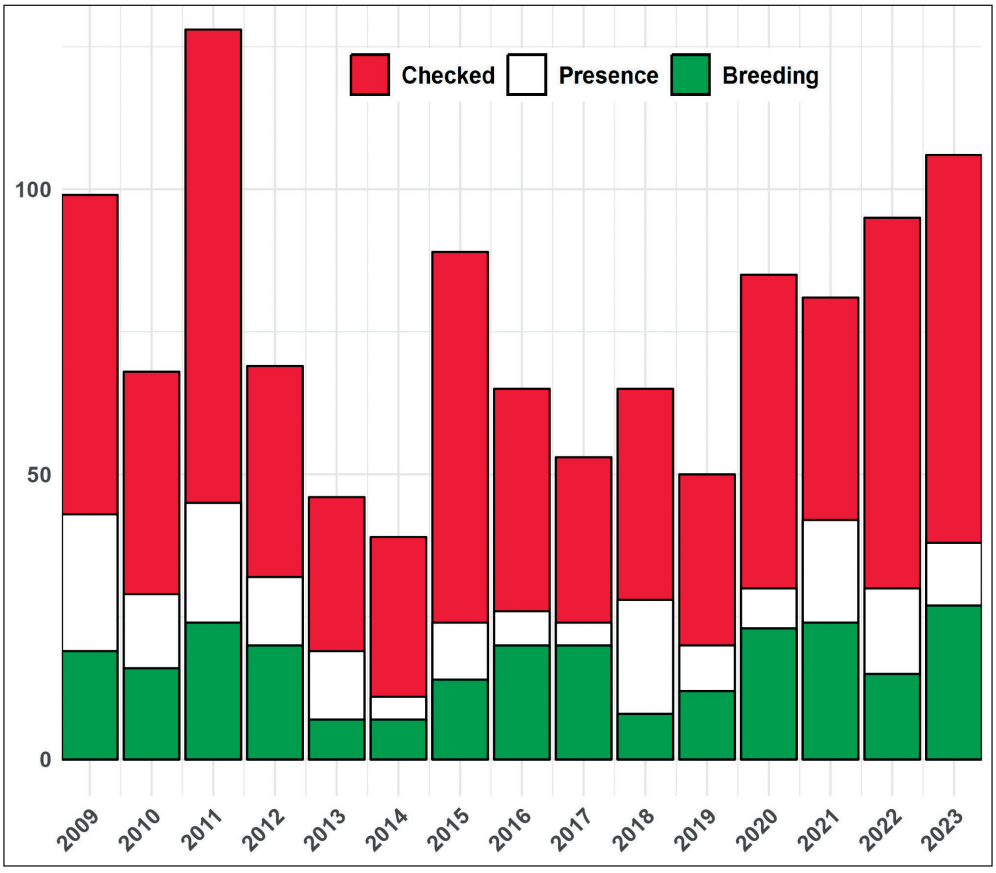

Figure 3. Number of buildings surveyed (red), roost sites (white) and breedings (green) between 2009 and 2023 in Zala County

3. ábra A gyöngybagoly felmérés során átvizsgált épületek (piros), a költés nélküli gyöngybagoly jelenlét (fehér) és a biztos költések (zöld) száma 2009 és 2023 között Zala vármegyében

Ringing

A total of 1,275 birds have been ringed in the past 38 years. The first Barn Owl ringing in the county took place in 1985. Prior to that, there are only records of dead recoveries: in 1956, a Barn Owl ringed in Croatia (Prelog, Međimurje), while in 1963, one from Germany (Niederfrohna) was found. A total of 22 ringers participated in the Barn Owl ringing activities, and ringing took place in 71 different settlements in the county *(Table 1)*.

Conservation status, pole boxes and road development

We identified 16 churches that had been surveyed previously and were accessible to owls, but by 2023 had been closed. Summing up the nesting outcomes of the pole-mounted boxes, we have determined that Barn Owl nesting has occurred in 14% of the erected boxes (a total of 11 nesting in five pole boxes); 36% of the pole boxes were occupied by the Common Kestrel at least once *(Figure 4)*.

In Zala County, the length of dual carriageways is continuously increasing. According to published governmental development plans, the construction of new sections of dual

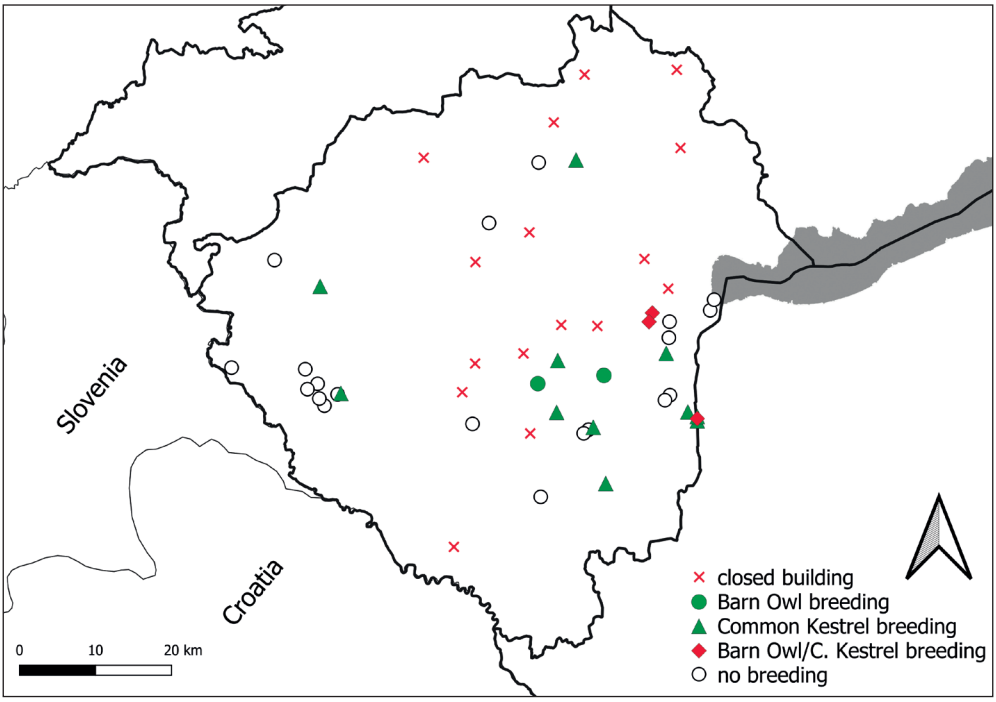

Figure 4. Lost nest sites in church buildings and the breedings of Barn Owls and Common Kestrels in pole-mounted boxes in Zala County

4. ábra Az ismert lezárt egyházi épületek, valamint gyöngybagoly oszlopládák helyzete a költési sikerükkel Zala megyében

Table 1. The number of Barn Owls ringed in Zala County by year and age group (P = pullus, F = age not determined, but not pullus, 1y = fledglings and birds within their first calendar year, 1+ = adults older than one year, 2y or 2+ = birds certainly in their second year or beyond second calendar year)

1. táblázat A Zala megyében gyűrűzött gyöngybaglyok száma évenként és korcsoportonként (P = fióka, F = fejlett, ismeretlen korú, 1y = első naptári éves fiatal madár, 1+ = adult, de bizonyosan idősebb egy évnél, 2y és 2+ = adult a második életévben vagy annál idősebb)

year	P	F	1y	1+	2y or 2+	Total
1985	3			2		5
1988		1				1
1989	15		1	2		18
1990	3		17			20
1991			3	1		4
1992			9			9
1993	30		8	1		39
1994	5	3		1		9
1995	14	1	8	5		28
1996	6		10	1		17
1997	17					17
1998	29	2	6			37
1999	26	1	2	1		30
2000	12					12
2001	14					14
2002	7					7
2003			1	1		2
2004	2					2
2005	1					1
2006	16			1		17
2007	28					28
2008	49					49
2009	60		1	5		66
2010	28			2		30
2011	87		20	1		108
2012	76		3	6		85
2013	16		1	5	1	23
2014	24			2		26
2015	60		1			61
2016	104			2		106
2017	94			5		99
2018	34	1		1		36
2019	50		12	1	2	65
2020	83	1		3		87
2021	65			3		68
2022	47			2		49
sum	**1105**	**10**	**103**	**54**	**3**	**1275**

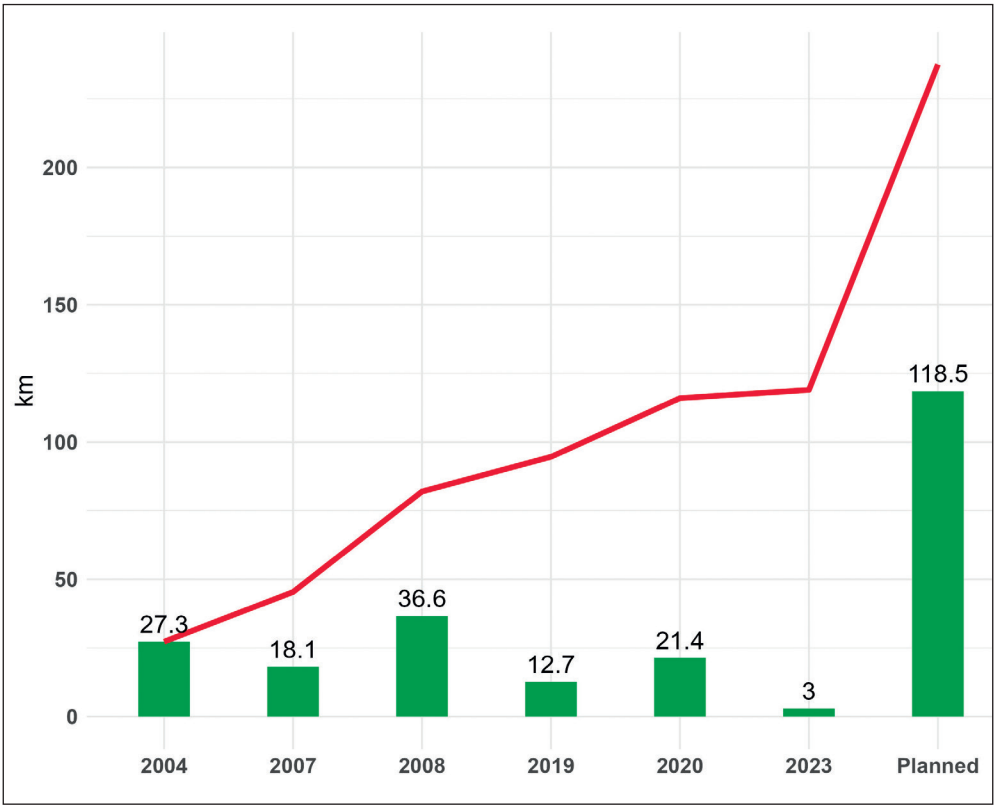

Figure 5. Development of the network of dual carriageways in Zala County. The columns represent the length of major roads built in a given year, while the line shows the cumulative length of the dual carriageways

5. ábra Zala vármegye gyorsforgalmi úthálózat fejlesztése. Az oszlopok az adott évben megépült úthosszt, a vonaldiagram az összeadódó teljes gyorsforgalmi úthálózat hosszát jelöli

Table 2. First owl signs and breedings in church-towers and in pole-mounted boxes (years after box installation). Pole-mounted box occupancy comprises data of Common Kestrel as well

2. táblázat A költőláda kihelyezést követő első gyöngybagoly nyom és költés épületben, és első költés oszlopládában években megadva. Az oszlopládák esetében a vörös vércse költése is beszámításra került

	First sign detected (building)	First nesting detected (building)	First nesting detected (pole box)
mean	4.2	4.6	5.5
max.	10.9	11.8	6.8
min.	0.6	0.3	0.3
SD	3.9	3.4	2.6
n	8	17	9

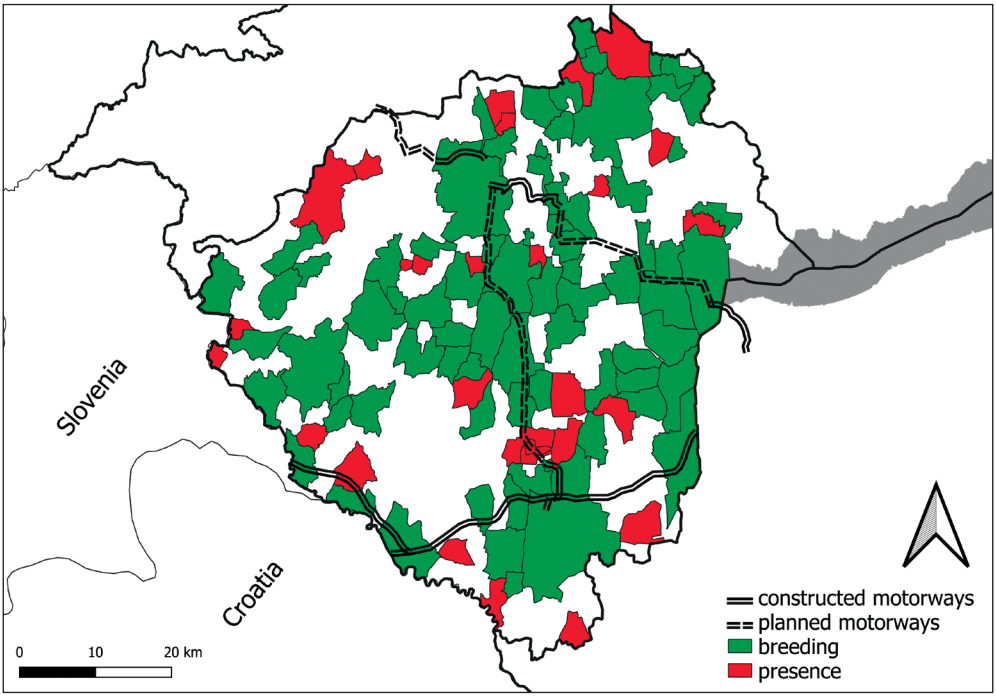

Figure 6. The current (double line) and planned (double dashed line) dual carriageway network in Zala County in relation to known Barn Owl nesting/roosting sites

6. ábra Zala vármegye jelenlegi (dupla vonal) és tervezett (szaggatott dupla vonal) gyorsforgalmi úthálózata az ismert gyöngybagoly előfordulások és költések függvényében

carriageways will double the already existing network by 2030 *(Figure 5)*. The comparison of the planned new motorway routes (nearly 120 km) with the currently known Barn Owl nesting and roost sites shows a notable overlap *(Figure 6)*.

Occupation dynamics of new nesting sites

The nest box occupation dynamics calculated from the data in the BOF conservation database shows practically no difference between nest boxes in buildings and pole boxes *(Table 2)*.

Discussion

In Zala County the highest registered number of breeding was 27 (2023), while the lowest was 7 (second clutches not included). Bank *et al.* (2019) studied the Barn Owl population in Baranya County between 1995 and 2018. The lowest recorded yearly number of breeding pairs was 7, and the highest 94, with box occupancy ranging from 9.7% to 73.4%. Despite Baranya County having an area 17% larger than Zala, the significantly higher breeding rate could be attributed to small-village structure characteristic to Baranya County, along with

a more favourable landscape and a well-established network of conservation activist. Also, due to its geographical location Baranya County has a milder Sub-Mediterranean climate (Bank 1990, Bank *et al.* 2019) important for the winter survival of the Barn Owls.

The most stable Barn Owl populations in Zala were found along river valleys and water courses (Kis-Balaton, Kerka-vidék, Principális canal). Two settlements around Kis-Balaton (Balatonmagyaród and Zalakomár) have exceptionally high number of breedings. Since 2009 there has been only 3 years without breeding in Balatonmagyaród. This nest box had been installed in the 1980s in the attic of a large community building, as the local church tower is closed.

The dual carriageway network in Zala County has shown continuous growth over the past two decades, with plans for construction to match the length of the already built roads. Since roadkill is a severe threat to Barn Owl populations (Massemin & Zorn 1998, Mátics 2000, 2004, Bozó & Csathó 2017, Borza *et al.* 2021, Monoki *et al.* 2022, Tamás & Kőhalmi 2022), this will increasingly become a significant problem for the local population. As Zala County has significant forest coverage and hilly areas, the newly planned major roads will primarily circumvent these areas by running through lowland regions and alongside canals and rivers, where the Barn Owl population density is the highest. The planned routes will, in fact, consistently intersect with settlements where the species' regular nesting is well documented. It is very probable that this infrastructure development will have a significant negative impact on the local population.

The Barn Owl is a strictly protected species in Hungary, yet, during building renovations the bird's interests are often overlooked. In Zala County, 16 buildings that were previously surveyed and found to be accessible to Barn Owls, have now been completely closed off. This includes 8 churches where Barn Owl nesting was confirmed earlier. If we also consider the non-surveyed churches, this ratio could potentially be much higher. Our results are consistent with a study from Poland showing that in Mazovia 59% of the buildings visited in the period 1989–1992 were occupied by Barn Owls and 79% of them were accessible to owls, whereas by 2000 this had decreased to 31% and 52% respectively (Golawski *et al.* 2003).

Three significant reasons can be identified behind the loss of nest sites in the churches: i) the installation of telecommunication devices within the towers (mobile phone aerials, signal amplifiers, internet antennas), ii) carelessly executed building renovations, and iii) dismissive attitude of the building managers. The installation of telecommunication device poses a particularly challenging concern due to the necessity of ongoing maintenance, resulting in more frequent disturbance, often coinciding with the breeding season. Furthermore, the large equipment very often completely occupies exactly those spaces in the church towers, where the nest boxes could be installed.

Pole-mounted boxes are commonly used in the conservation of Barn Owls (Leech *et al.* 2009, Barn Owl Trust 2012), especially in regions where biological pest control plays an important role in the agricultural practices (Richard 2012). The initial findings of our experimental pole box scheme highlight that properly installed pole boxes in well selected habitats may serve as alternative breeding sites. This alternative nest site provision can mainly gain importance in locations where owl-friendly conditions within traditional buildings

cannot be maintained anymore. However, based on our past experiences, it can take years for the pole boxes to be discovered by Barn Owls and for the first breeding to appear. We experienced the first occurrence of multiple nesting when there were simultaneous breedings of Barn Owls in the church tower and in a pole box located at the outskirts of the same settlement. The two nesting sites were 1,030 metres apart. Both nesting attempts proved to be successful (six and five fledglings left the boxes of the church tower and the pole box, respectively). To determine the extent to which these pole boxes can substitute traditional nesting sites in Hungary, further long-term studies are needed.

Common Kestrels are also beneficiaries of the Barn Owl nest site schemes in Zala County. In many cases, the pole-mounted box was already occupied by Common Kestrels shortly after the installation, and the nestlings also reached the fledging age. Very little data was known about Common Kestrel nesting in Zala County before our pole box scheme. Despite 36–39% of the Common Kestrel population in Hungary breeds in artificial nest boxes (Kotymán & Solt 2022), only three breeding instances were documented in Zala County during the period between 2010 and 2020.

The figures demonstrate that nest box occupation time varies strongly. In extreme cases conservationists have to wait longer than 10 years before the nest box is being used by Barn Owls. Our experiences reinforce the observations, that nest site fidelity is strong (Barn Owl Trust 2012). Traditional nest sites are re-occupied quicker after reopening, and newly created nest sites can remain unvisited by owls for a very long time. Even carefully designed attractive nest sites stay empty and the reasons behind this are hardly known. Factors like height from ground level (Wendt & Johnson 2017), exposition to wind, orientation (Charter *et al.* 2010), land use and landscape structure (Bond *et al.* 2005, Wendt & Johnson 2017), prey availability and the general quality of the hunting area, direct disturbance by human activities certainly must be taken into consideration. However, beyond these features, there might be further aspects that make certain nest sites appealing to owls.

The practical conservation consequence of the described phenomena is the strict protection of the traditional nest sites. Field data do not support the concept yet, that newly created nest sites efficiently and rapidly enough substitute the damaged historical ones.

Acknowledgements

We thank Zsolt Karcza and the Ringing Centre of BirdLife Hungary for providing us with all available ringing data. We also thank Zsolt Darázsi for obtaining access to the Zala County Group of BirdLife Hungary's past survey results. We are very grateful to all priests, pastors and land-owners who manage owl-friendly buildings in Zala County or participated in our Barn Owl conservation programme, as well as all ringers and volunteers who took part in the data collection, especially Cs. László, M. Árvay, B. Pataky, D. Fritz, K. Wéber, B. Zalai, B. Máté, B. Tamás, É. Fejes, I. Cs. Faragó, F. Sziva†, S. Palkó† and Cs. E. Fehér.

References

Altwegg, R., Roulin, A., Kestenholz, M. & Jenni, L. 2006. Demographic effects of extreme winter weather in the Barn Owl. – Oecologia 149(1): 44–51. DOI: 10.1007/s00442-006-0430-3

Bank, L. 1990. Az 1985–86. évi gyöngybagoly – (*Tyto alba* Scop., 1769) felmérés eredményei Baranya megyében [Estimation of the Barn Owl (*Tyto alba* Scop., 1769) population in Baranya County, 1985–1986]. – Aquila 96–97: 113–127.

Bank, L., Haraszthy, L., Horváth, A. & Horváth, Gy. F. 2019. Nesting success and productivity of the Common Barn Owl *Tyto alba*: results from a nest box installation and long-term breeding monitoring program in Southern Hungary. – Ornis Hungarica 27(1): 1–31. DOI: 10.2478/orhu-2019-0001

Barn Owl Trust 2012. Barn Owl Conservation. – Handbook Pelagic Publishing, Exeter

BirdLife International 2015. *Tyto alba* (Europe assessment). – The IUCN Red List of Threatened Species 2015: e.T22688504A59994105.

BirdLife International 2021. *Tyto alba* (Europe assessment). – The IUCN Red List of Threatened Species 2021:e. T22688504A166222469. DOI: 10.2305/IUCN.UK.2021-3.RLTS.T22688504A166222469.en

Bond, G., Burnside, N. G., Metcalfe, D. J., Scott, D. M. & Blamire, J. 2005. The effects of land-use and landscape structure on Barn Owl *(Tyto alba)* breeding success in southern England, U.K. – Landscape Ecology 20: 555–566. DOI: 10.1007/s10980-004-5037-7

Bozó, L. & Csathó, A. I. 2017. The status and population changes of the Little Owl *(Athene noctua)* in the south of Békés county (Hungary). – Ornis Hungarica 25(2): 23–33. DOI: 10.1515/orhu-2017-0013

Borza, S., Godó, L., Csathó, A. I., Valkó, O. & Deák, B. 2021. Negative effects of traffic on vertebrate species – A literature review from Hungary. – Természetvédelmi Közlemények 27: 1–17. DOI: 10.20332/tvk-jnatconserv.2021.27.1 (in Hungarian with English Summary)

Bruce, M. D. 1999. Family Tytonidae (Barn Owls). – In: del Hoyo, J., Elliott, A. & Sargatal, J. (eds.) Handbook of the Birds of the World. Vol. 5. Barn Owls to Hummingbird. – Lynx Edicions, Barcelona, pp. 34–75.

Charter, M., Meyrom, K., Leshem, Y., Aviel, S., Izhaki, I. & Motro, Y. 2010. Does nest box location and orientation affect occupation rate and breeding success of Barn Owls *Tyto alba* in a semi-arid environment? – Acta Ornithologica 45(1): 115–119. DOI: 10.3161/000164510X516164

Colvin, B. A. 1985. Common Barn Owl population decline in Ohio and the relationship to agricultural trends. – Journal of Field Ornithology 56(3): 224–235.

Fajardo, I. 2001. Monitoring non-natural mortality in the Barn Owl *(Tyto alba)*, as an indicator of land use and social awareness in Spain. – Biological Conservation 97(2): 143–149. DOI: 10.1016/S0006-3207(00)00091-4

Golawski, A., Kasprzykowski, Z. & Kowalski, M. 2003. The occurrence of the Barn Owl *Tyto alba* in sacred buildings in central-eastern Poland. – Ornis Hungarica 12–13: 275–277.

Hadarics, T. & Zalai, T. 2008. Nomenclator Avium Hungariae – An annonated list of the birds of Hungary. – MME Birdlife Hungary, Budapest, p. 145.

International Energy Agency 2020. Hungary Climate Resilience Policy Indicator – Analysis. – IEA https://www.iea.org/articles/hungary-climate-resilience-policy-indicator

Klein, Á. & László, Cs. 2015. A gyöngybagoly *(Tyto alba)* megtelepítésének lehetőségei [Various conservation methods to conserve the Barn Owl *(Tyto alba)*]. – Heliaca 15: 65–67. (in Hungarian with English Summary)

Klein, Á., Szentirmai, I., Dobos, Zs. & Laczi, M. 2020. Analysis of landscape structure, habitat selection and urbanisation in edge populations of Scops Owls *Otus scops* in Central Europe. – Ornis Hungarica 28(2): 24–36. DOI: 10.2478/orhu-2020-0015

Klein, Á. 2021. Gyöngybagoly [Western Barn Owl]. – In: Szép, T., Csörgő, T., Halmos, G., Lovászi, P., Nagy, K. & Schmidt, A. (eds.) Magyarország madáratlasza [Bird Atlas of Hungary]. – Agrárminisztérium, Magyar Madártani és Természetvédelmi Egyesület, Budapest, pp. 388–389. (in Hungarian with English Summary)

Klein, Á., László, Cs. & Mátics, R. 2022. Gyöngybagoly – *Tyto alba* [Western Barn Owl]. – In: Haraszthy, L. & Bagyura, J. (eds.) Magyarország ragadozó madarai és baglyai. 2. kötet. Sólyomalakúak és bagolyalakúak [Birds of Prey and Owls of Hungary, Falconiformes and Strigiformes]. – Magyar Madártani és Természetvédelmi Egyesület, Budapest, pp. 8–39. (in Hungarian)

Kotymán, L. & Solt, Sz. 2022. Vörös vércse – *Falco tinnunculus* [Common Kestrel]. – In: Haraszthy, L. & Bagyura, J. (eds.) Magyarország ragadozó madarai és baglyai. 2. kötet. Sólyomalakúak és bagolyalakúak [Birds of Prey and Owls of Hungary, Falconiformes and Strigiformes]. – Magyar Madártani és Természetvédelmi Egyesület, Budapest, Hungary, pp. 305–349. (in Hungarian with English Summary)

KSH 2021. Erdők vármegye és régió szerint [Woodland statistics by county and region in Hungary]. – STADAT
KSH 2022. Földterület művelési ágak, valamint vármegye és régió szerint. Összefoglaló Táblák [Land area by farming, county and region. Summary Tables]. – STADAT
Leech, D. I., Shawyer, C. R., Barimore, C. J. & Crick, H. Q. P. 2009. The Barn Owl monitoring programme: Establishing a protocol to assess temporal and spatial variation in productivity at a national scale. – Ardea 97(4): 421–428. DOI: 10.5253/078.097.0404
Marti, C. D., Poole, A. F., Bevier, L. R., Bruce, M. D., Christie, D. A., Kirwan, G. M. & Marks, J. S. 2020. Barn Owl *(Tyto alba)*. Version 1.0. – In: Billerman, S. M. (ed.) Birds of the World. – Cornell Lab of Ornithology, Ithaca
Massemin, S. & Zorn, T. 1998. Highway mortality of Barn Owls in northeastern France. – Journal of Raptor Reasearch 32(3): 229–232.
Mátics, R. 2000. Mortality of the Barn Owl in Hungary based on the ringing data. – Aquila 105–106: 125–133. (in Hungarian with English Summary)
Mátics, R. 2004. A gyöngybagoly *(Tyto alba)* természetes és nem természetes mortalitása: nő az utakon történő pusztulás jelentősége [Natural and non-natural mortality of the Barn Owl: growing importance of road death]. – Természetvédelmi Közlemények 11: 517–524. (in Hungarian with English Summary)
Monoki, Á., Nagy, G. & Kiss, Á. 2022. A gépjárműforgalom bagolyfajokra (Strigiformes) gyakorolt hatása Jász-Nagykun-Szolnok megyében [Impact of road traffic on owl species (Strigiformes) in Jász-Nagykun Szolnok County]. – Heliaca 18: 102–111. (in Hungarian with English Summary)
Osieck, E. & Shawyer, C. 1997. Barn Owl, *Tyto alba*. – In: Hagemeijer, E. J. M. & Blair, M. J. (eds.) The EBCC Atlas of European Breeding Birds: Their Distribution and Abundance. – T. & AD Poyser, London, UK., pp. 398–399.
Richard, N. R. 2012. Use of Barn Owls for sustainable rodent control in agricultural areas. – Proceedings of the Florida State Horticultural Society 125: 366–369.
Tamás, Á. & Kőhalmi, F. 2022. Az úthálózat hatása az Észak-Bácskában előforduló bagolyfajok (Strigiformes) mortalitására 2014 és 2020 között [Effect of road network on owl species' mortalaity in Northern Bácska Region between 2014 and 2020]. – Heliaca 18: 94–101. (in Hungarian with English Summary)
Wendt, C. A. & Johnson, M. D. 2017. Multi-scale analysis of Barn Owl nest box selection on Napa Valley vineyards. – Agriculture, Ecosystems and Environment 247: 75–83. DOI: 10.1016/j.agee.2017.06.023