sciendo

Raptor Journal 2021, 15: 75–87. DOI: 10.2478/srj-2021-0005
© Raptor Protection of Slovakia (RPS)

Post-fledging dependence period, dispersal movements and temporary settlement areas in saker falcons (*Falco cherrug*)

Období dospívání, disperzní pohyby a oblasti dočasných útočišť u raroha velkého (*Falco cherrug*)

Marek KOUBA, Roman SLOBODNÍK & Jozef CHAVKO

Abstract: Information on mortality rates and their causes in raptors and owls during the post-fledging dependency period (PFDP) and subsequent dispersal is essential for their more effective protection, including more efficient use of funds. Despite the importance of the above data, these data are not yet available for most birds of prey. The study aimed to provide and expand the knowledge in this field for saker falcon. We used satellite telemetry to monitor a total of six young birds since they left the nest boxes. All young birds survived the PFDP, but none survived to adulthood and died during the period of dispersal movements. The PFDP lasted 47 days (median value hereinafter), and the distance of individuals from the nest boxes during this period was 3.2 km (maximum distance 9 km). The area of the home range of the PFDP calculated by the 100% minimum convex polygon (MCP) method was 81 km^2. During the period of dispersal movements, the monitored individuals set up five temporary settlement areas with an area of 422 km^2 according to 100% MCP, where they stayed for 37 days. All individuals' mean length of movement routes throughout the monitoring period was 3862 km. The main finding of the present study is the fact that none of the monitored individuals survived the dispersal period. At least half of them died due to human activity (electrocution, hunting), which is probably unbearable in the long term for wild populations of most animal species. This shows the need to start eliminating all types of artificial traps (e.g., electrocution, hunting, poisoning, etc.) without delay, thus helping to prevent the decline of populations of many species in the shorter or longer time horizon.

Abstrakt: Informace týkající se míry úmrtnosti a jejích příčinách u dravců a sov během období dospívání a následné disperze jsou zásadní pro jejich účinnější ochranu včetně efektivnějšího využití finančních prostředků. Navzdory důležitosti výše zmíněných dat, nejsou tato data doposud k dispozici pro většinu dravých ptáků. Cílem této studie bylo poskytnout a rozšířit znalosti v dané oblasti u raroha velkého. Pomocí satelitní telemetrie jsme sledovali celkem šest mláďat od chvíle, kdy opustila hnízdní budky. Všechna mláďata přežila období dospívání, ale žádné se nedožilo dospělosti a zemřela během období disperzních pohybů. Období dospívání trvalo 47 dnů (medián; hodnoty mediánu jsou uvedeny i nadále) a vzdálenost jedinců od hnízdních budek během tohoto období činila 3,2 km (maximální vzdálenost 9 km). Rozloha domovských okrsků období dospívání spočtená metodou 100% minimálního konvexního polygonu (MCP) byla 81 km^2. Během období disperzních pohybů si sledovaní jedinci zřídili celkem pět oblastí dočasných útočišť s rozlohou 422 km^2 dle 100% MCP, které obývali 37 dnů. Délka pohybových tras všech jedinců po celé období sledování činila 3862 km. Zásadním zjištěním předložené studie je skutečnost, že ani jeden ze sledovaných jedinců nepřežil období disperze, přičemž minimálně polovina z nich zemřela následkem lidské činnosti (zabití elektrickým proudem, lov), což je patrně dlouhodobě neúnosné pro divoké populace většiny živočišných druhů, a jasně to ukazuje nutnost, začít neprodleně odstraňovat všechny druhy umělých pastí (např. zabití elektrickým proudem, lov, otravy atd.) vytvořených lidskou činností, a napomoci tak zabránit populačním poklesům mnoha druhů v kratším či delším časovém horizontu.

Key words: mortality rate, causes of death, satellite tracking, breeding period, minimum convex polygon, home range

Marek Kouba (corresponding author), Department of Ethology and Companion Animal Science, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Kamýcká 129, 165 00 Prague – Suchdol, Czech Republic. E-mail: marekkouba8@gmail.com

Roman Slobodník, Jozef Chavko, Raptor Protection of Slovakia, Trhová 54, 841 01 Bratislava, Slovakia.

Acknowledgements: These results were obtained and analysed within the project LIFE19 NAT/SK/001023 Transnational conservation of birds along Danube River (https://danubefreesky.eu), supported by the European Commission under the LIFE Programme and the Ministry of Environment of the Slovak Republic. We would like to thank ANITRA System s.r.o. for providing transmitters. We are grateful to Tomáš Veselovský for help in the field with attaching transmitters. Last but not least, we would like to thank three anonymous reviewers for their comments and suggestions to the first draft of the manuscript.

Introduction

From the point of view of current knowledge, we know migration routes or wintering sites of many species of raptors (Cepák et al. 2008). Less known is the information about resting and temporary stops (the so-called stopover site/s or temporary settlement area/s, hereinafter only TSA/s), including the speed of movements between them (Belthoff & Ritchison 1989). Among the least researched knowledge, we include the duration of post-fledging dependence period (hereinafter only PFDP, i.e. the period between fledging and reaching independence) (e.g., Gamauf & Dosedel 2012; Kouba & Šťastný 2012; Kouba et al. 2013; Nemček et al. 2016, Literák et al. 2020), while these studies often focus on the survival/mortality rate within a defined period (Penteriani & Delgado 2009), in this case, the PFDP. It is the appearance and development of satellite telemetry that can not only accurately determine this period in time and space, but it can also determine risk factors (Nemček et al. 2014) or show geographical limits for movements (McGrady et al. 2003; Limiñana et al. 2007, 2012; Cadahía et al. 2010). Another advantage of satellite telemetry is that it allows monitoring, for instance, even individuals who disperse over considerable distances after becoming independent and which could no longer be monitored by conventional radio telemetry. For their physical parameters, hawks and eagles (Meyburg et al. 2006), falcons (McIntyre et al. 2009) and possibly owls (Penteriani et al. 2005) are a suitable target group for the use of satellite telemetry. On the other hand, commonly used backpack harnesses may negatively influence behaviour and survival of both adult and juvenile individuals (Paton et al. 1991; Petty et al. 2004; Sunde 2006). Satellite transmitters with added mortality sensors also make it possible to record the mortality rate and its causes even in individuals which may be tens of thousands of kilometres away from their natal areas, thus revealing the essential information needed to protect the biodiversity and save many different, not only critically endangered species (Cogan et al. 2012; Graham et al. 2012).

Saker falcon (*Falco cherrug*) is widespread species throughout Eurasia, from Central Europe to East China (Baumgart 1991; Ferguson-Lees & Christie 2001; Bauer 2020). Similarly to the Carpathian Basin, South-western Slovakia, Eastern Austria and the South-eastern Czech Republic is the westernmost border of its nesting area (Gamauf & Dosedel 2012; Kovács et al. 2014). Populations from Austria, Hungary and Slovakia are interconnected, as evidenced by movements, especially of young birds, and the nesting of birds from other countries in neighbouring countries (Slobodník 2008; Slobodník & Jenčo 2020). The population, for instance, in Ukraine and east Slovakia, after its recent increase, shows currently a slightly declining trend again (Chavko et al. 2019), which is related to the reclassification within the IUCN Red List from the category "vulnerable" to the category "endangered" (BirdLife International 2022). On the contrary, the population in Slovakia is slowly growing (Černecký et al. 2020), which is mainly due to its positive population trend in the western part of the country (Chavko & Deutschová 2012; Chavko et al. 2014, 2019).

This study aimed to determine the duration of the PFDP and the home range sizes inhabited during this period by the fledglings of saker falcon in Slovakia. Also, to describe the dispersal movements of the monitored individuals, identify possible TSAs set up during the dispersal and determine their duration and area. Finally, to determine the rate and causes of mortality of young saker falcons during the PFDP and dispersal movements.

Material and methods

Six young birds (3x two siblings) of a saker falcon from three nesting boxes placed on high voltage transmission towers (Fig. 1) in the south-west of Slovakia near the villages of Bernolákovo, Lehnice and Topoľníky, were ringed with aluminium and coloured rings (Tab. 1) and equipped with backpack-type transmitters (Anitra Sys-



J Chavko

Fig. 1. The environment in Slovakia, currently commonly inhabited by saker falcons and also used for its nesting, is given since artificial nesting boxes designed for the target species are often hung on massive high-voltage pylons.

Obr. 1. Životní prostředí běžně obývané a využívané ke hnízdění rarohem velkým na Slovensku je dáno tím, že umělé hnízdní budky určené pro cílový druh jsou často vyvěšovány na mohutných stožárech vysokého napětí.

Tab. 1. Basic breeding data, data related to satellite telemetry and monitoring of a total of six saker falcon fledglings (B1, B2, L1, L2, T1 and T2) and data describing the post-fledging dependence period of all monitored individuals.
Tab. 1. Základní údaje o hnízdění, data týkající se satelitní telemetrie a sledování celkem šesti mláďat raroha velkého (B1, B2, L1, L2, T1 a T2) a informace popisující období dospívání všech sledovaných jedinců.

evaluated characteristics	individual data						median	mean	SD
nestbox	Bernolákovo (B)		Lehnice (L)		Topoľníky (T)		-	-	-
date of nesting	26 March		19 March		19 March		-	-	-
date of hatching	25 April		18 April		18 April		-	-	-
no. of eggs	5		5		5		5	5	0
no. of hatchlings	5		5		5		5	5	0
no. of fledglings	5		5		5		5	5	0
ID of tracked individual	B1	B2	L1	L2	T1	T2	-	-	-
ring number (metal ring/colour ring)	D6791/A9	D6795/E9	D6714/P4	D6717/U4	D6758/A3	D9760/C3	-	-	-
sex	male	male	male	female	female	male	-	-	-
date fledging	10 June	10 June	1 June	2 June	1 June	1 June	-	-	-
no. of tracking days	102	81	52	128	168	80	92	102	38
no. of locations / fixes	60,728	4139	21,707	37,970	153,948	61,560	49,349	56,675	48,019
time spent moving (days)	20	14	7	15	37	14	15	18	9
time spent resting (non-moving; days)	82	67	45	113	131	66	75	84	29
length of movement route (km)	4583	4289	1693	3435	9086	2949	3862	4339	2322
overall average speed[a] (km/h)	1.89	2.19	1.34	1.11	2.25	1.55	2	2	0
average speed of movement[b] (km/h)	9.7	12.7	9.9	9.1	10.3	8.8	10	10	1
date of last record/death	19 September	30 August	23 July	7 October	15 November	19 August	-	-	-
cause of death	unknown	unknown	hunted	electrocuted	tornado	electrocuted	-	-	-
duration of PFDP[c] (days)	47	45	45	46	51	53	47	48	3
no. of locations / fixes during PFDP[c]	15,203	1713	9507	6385	10,609	14,776	10,058	9699	4685
distance from the nest during PFDP[c] (mean ± SD; km)	3.2 ± 2.1	3.2 ± 0.3	3.4 ± 2.2	3.1 ± 2.3	1.1 ± 0.9	1.7 ± 1.9	3.2	2.6	0.9
maximal distance from the nest during PFDP[c] (km)	16.0	4.6	8.5	13.6	6.2	9.1	9	10	4
home range size during PFDP[c] (100% MCP[d]; km^2)	78.7	23.5	84.2	108.4	19.8	84.8	81	67	33
home range size during PFDP[c] (95% MCP[d]; km^2)	63.3	6.1	81.2	45.3	9.0	45.0	45	42	27
home range size during PFDP[c] (80% MCP[d]; km^2)	32.1	5.6	69.9	41.9	4.1	20.8	26	29	23
date of independence	26 July	25 July	15 July	17 July	21 July	23 July	-	-	-

[a]Overall average speed of movement including both times spent moving and resting (non-moving) calculated automatically by BaseCamp software
[b]Overall average speed of movement including only time spent moving calculated automatically by BaseCamp software
[c]Post-fledging dependence period (PFDP)
[d]Minimum convex polygon (100%, 95%, 80% MCP)

Raptor Journal 2021, 15: 75–87. DOI: 10.2478/srj-2021-0005
© Raptor Protection of Slovakia (RPS)

tems s.r.o., Prague, Czech Republic), enabling their satellite telemetry monitoring, during the nesting season 2021. All the young birds were weighed, and their sex was determined based on their weight and size (females are ca 15% larger and ca 40% heavier than males) (Kovács et al. 2014). The transmitters used weighed 19 g and did not exceed 3% of the body weight of the marked individuals (e.g., Withey et al. 2001). The used partly solar GPS-GSM transmitters were programmed to collect data in a fixed five-minute interval. Still, these intervals were dynamically supplemented by a series of data collected in one-second interval started by flight detection when the transmitter batteries were sufficiently charged. Recording of positions at one-second intervals made it possible to create a detailed picture of the larger movements of the monitored individuals and their behaviour. Both types of data (five-minute and one-second) were merged before the whole analysis and were further always used all in together. The recorded GPS positions of individuals were first exported from the Anitra platform to GPX format and further analysed and processed using BaseCamp software (GARMIN®, Schaffhausen, Switzerland). The BaseCamp software automatically delivered results regarding time spent moving and resting (non-moving) and overall average speed and average speed of movement (Tab. 1). The GPS positions were then exported to the SHP (shapefile) format and further processed and evaluated in ArcGIS 9.5 (Esri, Redlands, USA). In this program in its freely available extension Home Range Tool for ArcGIS® (Rodgers et al. 2015) subsequently the areas of all home ranges listed below were calculated using the method of the minimum convex polygon (hereinafter only MCP) (Mohr 1947; Hayne 1949; Laver & Kelly 2008). The ranges were made for the 100% MCP variant and the 95% and 80% MCP with the setting "Selection Style:

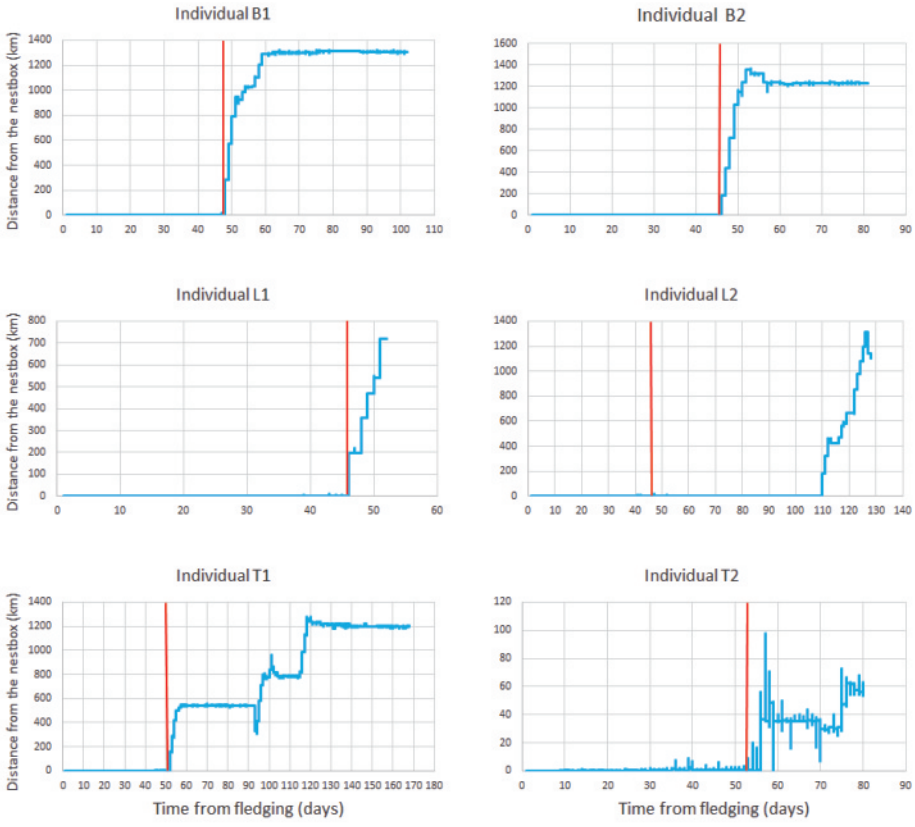


Fig. 2. Visualisation of the distance from the natal nest box and gradual moving of all six monitored young birds (B1, B2, L1, L2, T1 and T2) away from the nest box during the entire monitoring period (blue line). The vertical red line shows the end of the post-fledging dependence period and the beginning of the dispersal of individuals (only individual L2 dispersed later).
Obr. 2. Vizualizace pohybů a postupného vzdalování se od hnízdní budky všech šesti sledovaných mláďat (B1, B2, L1, L2, T1 a T2) po celou dobu jejich monitoringu (modrá čára). Svislá červená čára znázorňuje konec období dospívání a začátek období disperzních pohybů jedinců (pouze jedinec L2 zahájil disperzi později).

User Centre". Furthermore, the distances of all obtained locations of individual young birds from the nest box were evaluated, and the lengths of all their movement routes were measured. All map materials were also created in the same software.

The duration of the PFDP was individually determined based on an analysis of the movements of all individuals when five of them performed a sudden dispersal movement (Fig. 2), which clearly defined their PFDP. In the case of the sixth individual (L2), the length of the PFDP was also determined based on data from the scientific literature (Nemček et al. 2014; Prommer et al. 2014; Rahman et al. 2015; Dixon et al. 2019) and by comparison with other monitored young birds and particularly its sibling. The TSAs of monitored individuals established during dispersal movements were defined as areas where individuals spent longer time in a relatively small area within which they repeatedly occurred in the same places, which was in direct contrast to movement patterns and distances that individuals were able to cover during a single day of the dispersal movement. Also, in the case of TSAs, it can be stated that when evaluating data on the movements of individuals, these areas became very clear on their own.

Results

A total of six young birds (4 males and 2 females) of the saker falcon were observed in 2021 from leaving the nest until their death, which occurred in the same year for all of them, and thus none of them survived to adulthood. These were three pairs of siblings, always randomly selected from five siblings hatched from equally numerous clutches. The monitoring took place from 1 June to 15 November 2021 (Tab. 1). The individuals were monitored for 92 days (median value is stated hereinafter), and 49,349 locations were recorded for each of them. The total length of their movement routes was 3862 km (Fig. 3). The young saker falcons spent 75 days by resting (non-moving) and 15 days by moving at an average speed of 10 km/h, as shown by the automatic evaluation of satellite data by the BaseCamp software. The last coordinates sent from the used transmitters came between 23 July and 15 November 2021.

The PFDP of all six young birds lasted 47 days, during which 10,058 locations of their occurrence were recorded for each of them (Tab. 1). The distance of individuals from nesting boxes during the entire PFDP was 3.2 km, and the maximum recorded distance was 9 km. The area of home ranges of the PFDP calculated by the 100% MCP method was 81 km^2 (Fig. 4), 45 km^2 (95% MCP) and 26 km^2 (80% MCP). All the young birds successfully became independent between 15 and 26 July 2021.

Subsequent dispersal movements occurred in four individuals (B1, B2, L1 and T1) in a very similar way, when the individuals suddenly left their PFDP home ranges and began to move significantly away from them every day (Fig. 2). For example, the female T1 reached 160 km from the nest during the first day of dispersal, 290 km on the second day and 420 km on the third (Fig. 4). Both her movement route and duration of monitoring were the longest among all the young birds, and during the dispersal, she established three TSAs. A total of three of the four individuals mentioned above set up at



Fig. 3. Nesting boxes, overall movement routes and locations of the last records of six young saker falcons monitored by satellite telemetry in 2021.
Obr. 3. Hnízdní budky, celkové trasy pohybu a polohy posledních záznamů šesti mláďat raroha velkého sledovaných pomocí satelitní telemetrie v roce 2021.

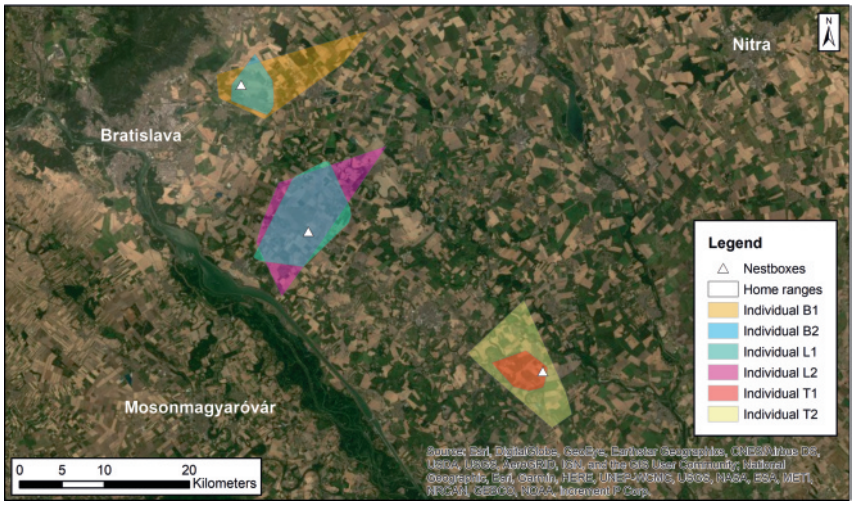


Fig. 4. Home ranges of the post-fledging dependence period recorded in the area of interest in Slovakia for six saker falcon fledglings from a total of three nests calculated by the 100% minimum convex polygon method.

Obr. 4. Domovské okrsky období dospívání zaznamenané v zájmovém území na Slovensku celkem pro šest mláďat raroha velkého úhrnem ze tří hnízd vypočítané metodou 100% minimálního konvexního polygonu.

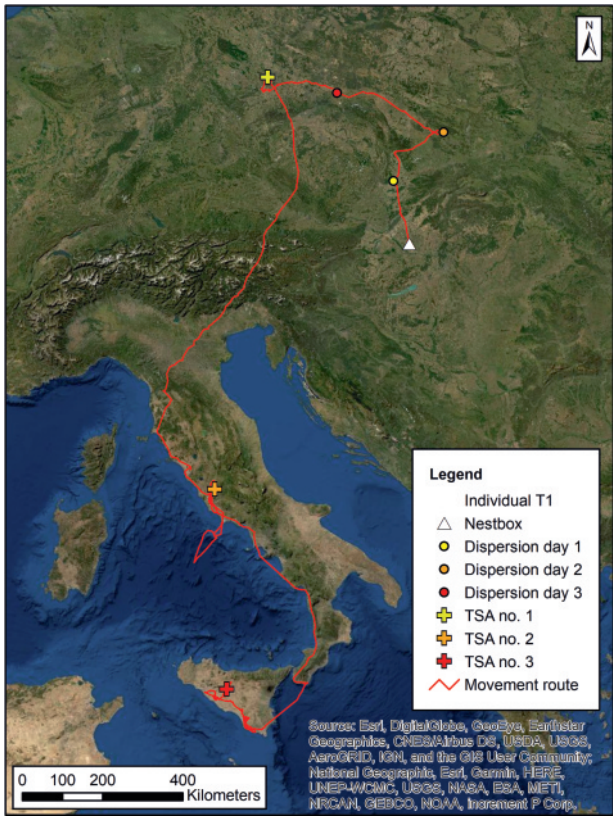


Fig. 5. The overall route of movement of the individual T1, including her occurrence at the end of the 1st, 2nd and 3rd day from the start of the dispersal (circles), including three temporary settlement areas (TSAs; crosses) established by this individual during dispersal movements.

Obr. 5. Celková trasa pohybu jedince T1, včetně jeho polohy na konci 1., 2. a 3. dne od zahájení disperzních pohybů (kroužky), včetně tří oblastí dočasných útočišť (TSA; křížky) zřízených tímto jedincem během disperze.

least one TSA during the dispersal (Figs. 5–9). Young saker falcons inhabited TSAs (n = 5 areas; individuals B1, B2, and T1; Tab. 2) for 37 days. Their recorded locations within the TSAs were 1203 km from the nest boxes (minimum and maximum distances were 1181 and 1221 km, respectively). The movement routes of individuals within the TSAs were 1582 km long. The TSAs of the three individuals mentioned above covered an area of 422 km^2, as calculated using the 100% MCP method, 326 km^2 (95% MCP) and 252 km^2 (80% MCP).

The female L2 stayed in an area (we also call it as TSA) that was directly related to the area inhabited throughout the PFDP, and this female remained near the natal nest box for a total of 110 days (Tab. 2). Only then a sudden dispersal movement followed in her case (Fig. 2). During the PFDP, this female stayed in an area of 108 km^2 according to 100% MCP and the subsequent TSA inhabited before dispersal movements occupied an area of 120 km^2 (100% MCP; Fig. 10).

The individual T2 did not set up any TSA, and his dispersal movements were quite different from those described above. After becoming independent, this young male moved in a wide area around the nest box until his death, specifically at a maximum distance of less than 100 km and an average distance of 39 ± 17 km (Fig. 11). According to 100% MCP, his home range during the PFDP covered an area of 85 km^2, and the area covered during his dispersal movements was 8884 km^2 (100% MCP; Fig. 11).

All monitored fledglings became independent, and the mortality rate was zero during the PFDP. However, none of the young birds most probably survived to adulthood, and all perished during the dispersal period.

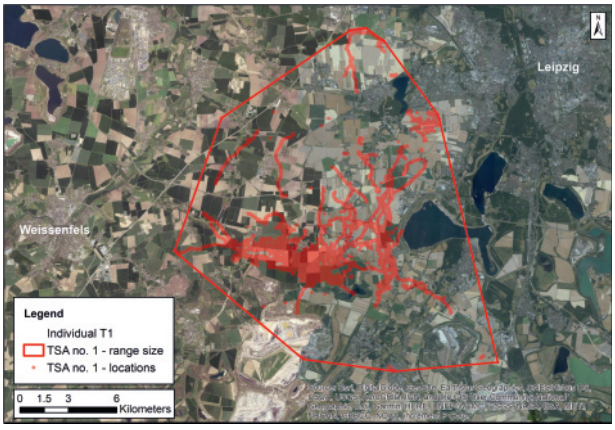


Fig. 6. Detail of the first temporary settlement area (TSA; calculated by the 100% minimum convex polygon method) set up during dispersal movements by the T1 individual in Germany near the city of Leipzig, including individual locations of her stay within this area.

Obr. 6. Detail oblasti prvního dočasného útočiště (TSA; spočteno metodou 100% minimálního konvexního polygonu) zřízeného během disperzních pohybů jedincem T1 v Německu u města Lipska, včetně jednotlivých lokací jeho pobytu v dané oblasti.

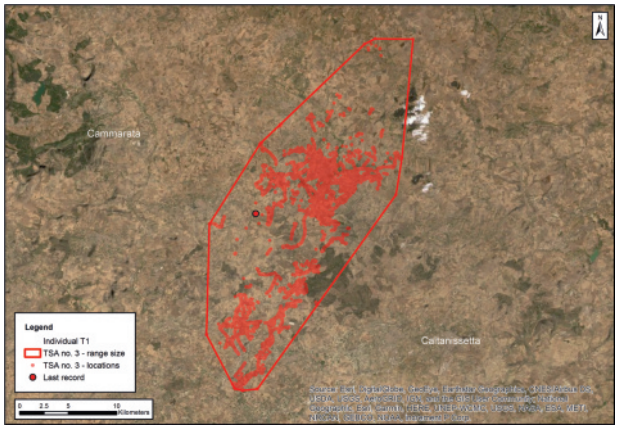


Fig. 8. Detail of the third temporary settlement area (TSA; calculated by the 100% minimum convex polygon method) set up during dispersal movements by the T1 individual in Italy in Sicily near the city of Caltanissetta, including individual locations of her stay within this area and the place of her assumed death.

Obr. 8. Detail oblasti třetího dočasného útočiště (TSA; spočteno metodou 100% minimálního konvexního polygonu) zřízeného během disperzních pohybů jedincem T1 v Itálii na Sicílii u města Caltanissetty, včetně jednotlivých lokací jeho pobytu v dané oblasti a místa jeho předpokládaného úmrtí.

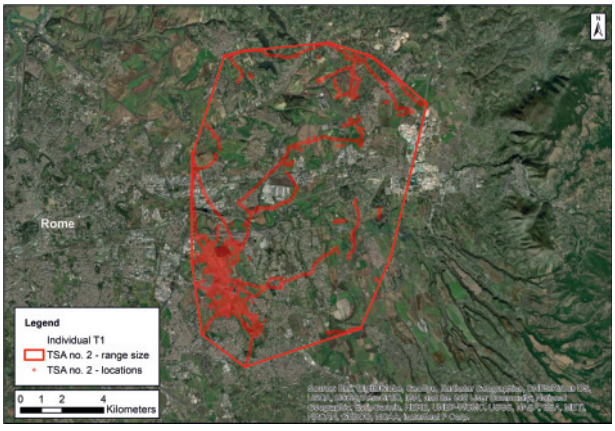


Fig. 7. Detail of the second temporary settlement area (TSA; calculated by the 100% minimum convex polygon method) set up during dispersal movements by the T1 individual in Italy near the city of Rome, including individual locations of her stay within this area.

Obr. 7. Detail oblasti druhého dočasného útočiště (TSA; spočteno metodou 100% minimálního konvexního polygonu) zřízeného během disperzních pohybů jedincem T1 v Itálii u města Říma, včetně jednotlivých lokací jeho pobytu v dané oblasti.

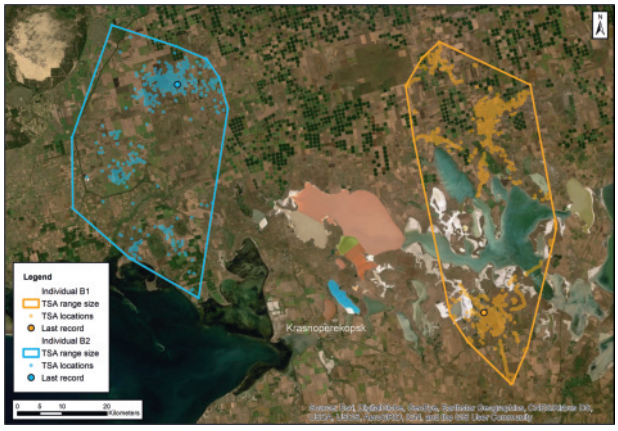


Fig. 9. Detail of the two temporary settlement areas (TSAs; calculated by the 100% minimum convex polygon method) established during dispersal movements by the B1 and B2 individuals at the border of Ukraine and Russia near the town Krasnoperekopsk, including individual locations of their stay within these areas and the places of their assumed death.

Obr. 9. Detail oblastí dvou dočasných útočišť (TSA; spočteno metodou 100% minimálního konvexního polygonu) zřízených během disperzních pohybů jedinců B1 a B2 na hranicích Ukrajiny a Ruska u města Krasnoperekopsku, včetně jednotlivých lokací jejich pobytu v daných oblastech a míst jejich předpokládaných úmrtí.

Two individuals (L2 and T2) were most likely electrocuted (Slovakia and Greece; Fig. 3 and 11; last records of both individuals were located exactly below electric pylons of 22 kV and their transmitters were probably

damaged by a short circuit), and one individual (L1) was caught by trappers (Kosovo; Fig. 3; Anonymous, in verb; illegal trapping on the same day at the site of the last GPS records of L1 individual was personally confirmed by local ornithologists who want to remain anonymous for security reasons). The longest living individual (T1) died in Sicily, most likely in connection with bad weather, when several tornadoes swept through Sicily at that time (Fig. 3 and 8; the transmitter stopped to move and subsequently also to transmit a signal on the day when the tornadoes swept through the area where the last GPS positions of T1 individual were recorded). The causes of death of the last two young birds (B1 and B2) could not be determined, but their last locations were in Ukraine near the Crimean Peninsula (Fig. 3 and 9). In these two cases, it is theoretically possible that their transmitters failed (though there were no signs of any issues with both transmitters, both were well charged, and no electric wires and pylons are in the area, sudden failures of hitherto well-functioning tags have already been documented [Anitra Systems s.r.o., in verb]).

Discussion

The data on mortality of the young birds can be considered the most important results of our study. While during the PFDP, we did not record the death of any of the six monitored saker falcons, which was a surprising finding since higher mortality of young birds of prey, as well as young birds of other species, is quite common in the period after leaving the nest (Adams et al. 2001; Keedwell 2003; Todd et al. 2003; Sunde 2005; Boileau & Bretagnolle 2014). On the other hand, the negative finding was that none of the six monitored individuals reached adulthood, and all died during the period of dispersal movements, although high mortality of young independent birds is quite common (Small et al. 1993; Prommer et al. 2012; Faccio et al. 2013), too. Low mortality (approximately 6%) of young saker falcons during the PFDP was also recorded in Mongolia, where most deaths were caused by birds of prey (Rahman et al. 2015). Low mortality of young birds of the target species during the PFDP was also found in Ukraine and Bulgaria (Prommer et al. 2014; Dixon et al. 2019). This coincidence could be because the saker falcon is a relatively large species, and the predation of its fledglings by other predators is not as common as it may be in smaller species of hawks, falcons or owls (Obuch & Bangjord 2016). Several studies also remarkably agree with our study regarding the high mortality rate of up to 100% in

Tab. 2. Data on a total of six temporary settlement areas set up by four young saker falcons (B1, B2, L2 and T1) during their dispersal movements.
Tab. 2. Údaje o celkem šesti oblastech dočasných útočišť zřízených čtyřmi mláďaty raroha velkého (B1, B2, L2 a T1) během jejich disperzních pohybů.

evaluated characteristics	individual data					median[f]	mean[f]	SD[f]
ID of tracked individual[a]	B1	B2	L2		T1	-	-	-
temporary settlement area – "TSA"	1	1	1	1	2	3	-	-	-
date of TSA establishment	7 August	6 August	18 July	27 July	12 September	3 October	-	-	-
duration of TSA (days)	44	25	64	37	12	44	37	32	12
No. of locations / fixes during TSA	33,221	1593	8867	25,397	15,577	32,681	25,397	21,694	11,906
length of TSA movement route (km)	1906	1582	581	1319	457	1941	1582	1441	542
distance of TSA from the nest[b] (mean ± SD; km)	1306 ± 7.7	1231 ± 4.3	2.8 ± 4.1	544 ± 2.9	785 ± 4.2	1203 ± 7.4	1203	1014	297
minimal distance of TSA from the nest[c] (km)	1284	1212	0.0001	531	775	1181	1181	997	293
maximal distance of TSA from the nest[d] (km)	1322	1246	19.1	554	791	1221	1221	1027	301
home range size of TSA (100% MCP[e]; km^2)	1657	1483	120	280	137	422	422	796	641
home range size of TSA (95% MCP[e]; km^2)	1585	1149	103	173	126	326	326	672	588
home range size of TSA (80% MCP[e]; km^2)	1156	894	74	94	57	252	252	491	449
date of TSA termination	19 September	30 August	19 September	1 September	23 September	15 November	-	-	-
cause of TSA termination	death	death	abandoned	abandoned	abandoned	death	-	-	-

◄ **Tab. 2.** Continuation.
◄ **Tab. 2.** Pokračovanie.

[a]Two monitored individuals, specifically L1 and T2, did not established any TSA
[b]Mean distance of all locations / fixes from the nest recorded for a given individual during the time of TSA duration
[c]Minimal distance from the nest recorded for a given individual during the time of TSA duration
[d]Maximal distance from the nest recorded for a given individual during the time of TSA duration
[e]Minimum convex polygon (100%, 95%, 80% MCP)
[f]Individual L2 was excluded from descriptive statistics calculations (n = 5; individuals B1, B2 and T1) because its TSA range was directly related to its PFDP home range

already independent young saker falcons recorded during the dispersal period (Gamauf & Dosedel 2012; Nemček et al. 2014; Prommer et al. 2014; Dixon et al. 2019; this study). One possible explanation is that the dispersal of this species is common over huge distances (up to tens of thousands of km) during which young saker falcons may encounter a vast range of possible dangers. Still, the really alarming fact is that electric lines and pylons cause most deaths of young saker falcons during this period (e.g., Nemček et al. 2014; Dixon et al. 2019). In our study, electrocution was reported in at least two cases. Power lines and pylons thus represent a significant cause of saker falcon mortality and can influence population demographics (Kovács et al. 2014; Demeter et al. 2018; Gális et al. 2019; Dixon et al. 2020).

The results of our study fit relatively well into the published information found on young saker falcons in terms of the duration of the PFDP and movement patterns during this period. We recorded an average duration of the PFDP 48 ± 3 days (range 45–53 days). The other two studies described the duration of the PFDP in the target species as 44 days (range 30–64 days) and 40 ± 4 days (range 31–52 days) (Prommer et al. 2014; Rahman et al. 2015). Thus, the duration of the PFDP does not seem to be affected by the specific area where the young saker falcons hatched (Ukraine, Mongolia or Slovakia). However, the question remains whether the duration of the PFDP of saker falcons is affected to a high degree by prey abundances, as described in other birds of prey (Alonso et al. 1987; Bustamante 1994; Kouba et al. 2013), as none of the above-mentioned

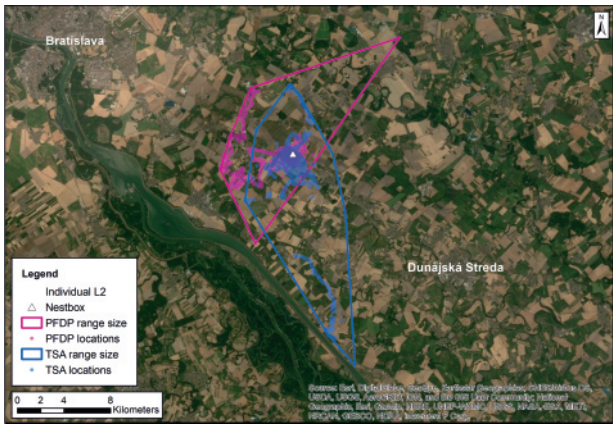


Fig. 10. Detail of the post-fledging dependence period (PFDP) home range of the L2 individual and her temporary settlement area (TSA; both ranges were calculated by the 100% minimum convex polygon method) set up after her independence, but still at the natal area in Slovakia near the town Dunajská Streda, including individual locations of her stay within both given areas.
Obr. 10. Detail domovského okrsku období dospívání (PFDP) jedince L2 a oblasti jeho dočasného útočiště (TSA; spočteno metodou 100% minimálního konvexního polygonu) zřízeného po nabytí samostatnosti včetně jednotlivých lokací jeho pobytu v obou daných oblastech. Oba okrsky na sebe u jedince L2 přímo navazovaly, a oba se tak nacházely v okolí hnízdní lokality na Slovensku u města Dunajská Streda, odkud jedinec pocházel.

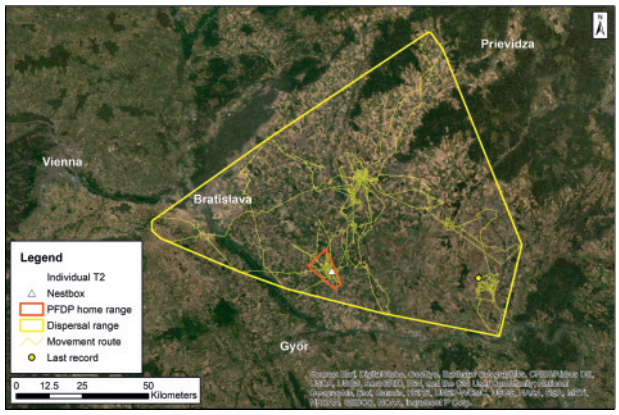


Fig. 11. The overall home range of the T2 individual recorded during the dispersal movement period and his home range of the post-fledging dependence period (PFDP; both ranges were calculated by the 100% minimum convex polygon method) located in Slovakia east of the capital Bratislava, including the movement routes recorded within both given areas and place of his assumed death.
Obr. 11. Celkový domovský okrsek jedince T2 zaznamenaný během období disperzních pohybů a jeho domovský okrsek období dospívání (PFDP; spočteno metodou 100% minimálního konvexního polygonu) nacházející se na Slovensku východně od hlavního města Bratislavy, včetně tras pohybů zaznamenaných v obou daných oblastech a místa jeho předpokládaného úmrtí.

studies on saker falcons estimated abundances of their prey. The same is true for the home range sizes throughout the PFDP of young saker falcons, as their home ranges have been described, but so far, no study has described the factors affecting the area of these ranges. In Mongolia, the average size of home ranges during the PFDP was recorded as 55 ± 24 km^2 (according to 100% MCP), but only for the period of 28 days from fledging. It is well comparable to the average area of 67 ± 33 km^2 (according to 100% MCP) found by us, recorded for the period approximately one third longer. Thus, it seems that even in the size of the home ranges during the PFDP, there are no fundamental differences across the habitats or continents where the target species breeds. However, significantly smaller home ranges during the PFDP were recorded in Bulgaria (14 km^2 according to 100% MCP), but these were recorded for reintroduced young birds tied to the releasing cages throughout the PFDP, where they regularly received supplementary feeding. In our opinion, these data are thus incomparable with our results.

An interesting behaviour has been described in many species of birds of prey during the dispersal movement period when individuals set up TSAs (e.g., Sielicki et al. 2009; Literák et al. 2020) in which they remain for different periods in a relatively small area. They repeatedly occur here in the same places, and then they suddenly leave the area and continue in probably random dispersal movements (Meyburg et al. 1995). The setting up of similar TSAs has also been recorded for saker falcons (Prommer et al. 2014; Nemček et al. 2016; Dixon et al. 2019). However, they have not yet been described in more detail. For example, Dixon et al. (2019) state the average time spent in each TSA as 27 days with the range of 2–66 days, and that individual TSAs can be used repeatedly. The TSAs recorded by us (excluding L2 individual for the reasons stated above, see the chapter Results) were maintained by individual falcons 32 ± 12 days on average (range 12–44 days). Their area was 796 ± 641 km^2 (mean ± SD; according to 100% MCP), and the locations recorded within these areas were 1014 ± 297 km away from the natal nest boxes. These data confirm that, within the dispersal, which takes place over vast distances, the TSAs are indeed relatively small, and the crucial question is why individuals set them up at all. The most probable reason is the high prey abundance in the given site, which the individual uses for some time, or until it is depleted (Dixon et al. 2017, 2020). It is also probably connected with transition from exploratory strategies, when animals have incomplete environmental information, to a more familiar way to exploit their activity areas as they get to know the environment better (Delgado et al. 2009).

Finally, we would like to make an appeal to the relevant authorities and all those responsible for installing high-voltage pylons and wires to make every effort to secure their electricity grids worldwide so that any organisms cease to be killed as a result. As our study and many others suggest, mortality as a result of injuries related to electric structures, posing a risk of collision or electrocution is enormous, reaching millions of birds worldwide each year (Jenkins et al. 2010), which is utterly unsustainable in the long term and, it is necessary to introduce measures that will reverse this very pessimistic trend as soon as possible (e.g., Šmídt et al. 2019).

References

Adams AAY, Skagen SK & Adams RD 2001: Movements and survival of lark bunting fledglings. Condor 103: 643–647.

Alonso JC, Gonzalez LM, Heredia B & Gonzalez JL 1987: Parental care and the transition to independence of Spanish imperial eagles *Aquila heliaca* in Donana national park, Southwest Spain. Ibis 129: 212–224.

Bauer H-G 2020: *Falco cherrug*. Saker falcon, 525. In: Keller V, Herrando S, Voříšek P, Franch M, Kipson M, Milanesi P, Martí D, Anton M, Klvaňová A, Kalyakin MV, Bauer H-G, Foppen RPB, eds. European Breeding Bird Atlas 2: Distribution, Abundance and Change. European Bird Census Concil and Lynx Edicions, Barcelona.

Baumgart W 1991: Der Sakerfalke. 3. Auflage. Ziemsen, Wittenberg, Neue Brehm Bücherei 514.

Belthoff JR & Ritchison G 1989: Natal dispersal of eastern screech owls. Condor 91: 254–265.

BirdLife International 2022: Species factsheet: *Falco cherrug*. Downloaded from: http://www.birdlife.org on 05/01/2022.

Boileau N & Bretagnolle V 2014: Post-fledging dependence period in the Eurasian kestrel (*Falco tinnunculus*) in Western France. Journal of Raptor Research 48: 248–256.

Bustamante J 1994: Family break-up in black and red kites *Milvus migrans* and *M. milvus*: is time of independence an offspring decision. Ibis 136: 176–184.

Cadahía L, López-López P, Urios V & Negro JJ 2010: Satellite telemetry reveals individual variation in

juvenile Bonelli's eagle dispersal areas. European Journal of Wildlife Research 56: 923–930.

Cepák J, Klvaňa P, Formánek J, Horák D, Jelínek M, Schröpfer L, Škopek J, Zárybnický J 2008: Atlas migrace ptáků České a Slovenské Republiky [Czech and Slovak bird migration atlas]. Aventinum, Prague. [In Czech]

Cogan C, D'Elia J, Convery K, Brandt J & Bulgerin T 2012: Analysis of California condor (*Gymnogyps californianus*) activity using satellite telemetry data. The Open Ornithology Journal 5: 82–93.

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 2013–2018 in Slovakia]. State nature conservancy of the Slovak republic, Banská Bystrica. [In Slovak]

Delgado MD, Penteriani V, Nams VO & Campioni L 2009: Changes of movement patterns from early dispersal to settlement. Behavioral Ecology and Sociobiology 64: 35–43.

Demeter I, Horváth M, Nagy K, Görögh Z, Tóth P, Bagyura J, Solt S, Kovács A, Dwyer JF & Harness RE 2018: Documenting and reducing avian electrocutions in Hungary: a conservation contribution from citizen scientists. Wilson Journal of Ornithology 130: 600–614.

Dixon A, Batbayar N, Bold B, Davaasuren B, Erdenechimeg T, Galtbalt B, Tsolmonjav P, Ichinkhorloo S, Gunga A, Purevochir G & Rahman ML 2020: Variation in electrocution rate and demographic composition of saker falcons electrocuted at power lines in Mongolia. Journal of Raptor Research 54: 136–146.

Dixon A, Li XH, Rahman ML, Batbayar N & Zhan XJ 2017: Characteristics of home range areas used by saker falcons (*Falco cherrug*) wintering on the Qinghai-Tibetan Plateau. Bird Conservation International 27: 525–536.

Dixon A, Ragyov D, Izquierdo D, Weeks D, Rahman ML & Klisurov I 2019: Movement and survival of captive-bred saker falcons *Falco cherrug* released by wild hacking: implications for reintroduction management. Acta Ornithologica 54: 157–170.

Faccio SD, Amaral M, Martin CJ, Lloyd JD, French TW & Tur A 2013: Movement patterns, natal dispersal, and survival of peregrine falcons banded in New England. Journal of Raptor Research 47: 246–261.

Ferguson-Lees J & Christie DA 2001: Raptors of the world. Christopher Helm, London.

Gális M, Naďo L, Hapl E, Šmídt J, Deutschová L & Chavko J 2019: Comprehensive analysis of bird mortality along power distribution lines in Slovakia. Slovak Raptor Journal 13: 1–25.

Gamauf A & Dosedel R 2012: Satellite telemetry of saker falcons (*Falco cherrug*) in Austria: juvenile dispersal at the westernmost distribution limit of the species. Aquila 119: 65–78.

Graham RT, Witt MJ, Castellanos DW, Remolina F, Maxwell S, Godley BJ & Hawkes LA 2012: Satellite tracking of manta rays highlights challenges to their conservation. PLoS One 7(5): e36834. doi: 36810.31371/journal.pone.0036834.

Hayne DW 1949: Calculation of size of home range. Journal of Mammalogy 30: 1–18.

Chavko J & Deutschová L 2012: Population of saker falcon (*Falco cherrug*) in Western Slovakia between 1976 and 2010. Aquila 119: 57–64.

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.

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: LIFE-project report 2011–2014. Slovak Raptor Journal 8: 73–86.

Jenkins AR, Smallie JJ & Diamond M 2010: Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. Bird Conservation International 20: 263–278.

Keedwell RJ 2003: Does fledging equal success? Post-fledging mortality in the black-fronted tern. Journal of Field Ornithology 74: 217–221.

Kouba M, Bartoš L & Šťastný K 2013: Differential movement patterns of juvenile Tengmalm's owls (*Aegolius funereus*) during the post-fledging dependence period in two years with contrasting prey abundance. PLoS One 8(7): e67034. DOI: 67010.61371/journal.pone.0067034.

Kouba M & Šťastný K 2012: Domovské okrsky mláďat sýce rousného (*Aegolius funereus*) během dospívání v imisních oblastech Krušných hor [Home ranges of Tengmalm's owl (*Aegolius funereus*) fledglings during postfledging dependence period in polluted

areas of the Krušné hory Mts.]. Sylvia 48: 115–125. [In Czech with English summary]

Kovács A, Williams NP & Galbraith CA 2014: Saker falcon Falco cherrug Global action plan (SakerGap), including a management and monitoring system, to conserve the species. Raptors MoU technical publication no. 2. CMS technical Series no. 31. Abu Dhabi, United Arab Emirates, Coordinating Unit - CMS Raptors MoU.

Laver PN & Kelly MJ 2008: A critical review of home range studies. Journal of Wildlife Management 72: 290–298.

Limiñana R, Soutullo A & Urios V 2007: Autumn migration of Montagu's harriers *Circus pygargus* tracked by satellite telemetry. Journal of Ornithology 148: 517–523.

Limiñana R, Soutullo A, Urios V & Reig-Ferrer A 2012: Migration and wintering areas of adult Montagu's harriers (*Circus pygargus*) breeding in Spain. Journal of Ornithology 153: 85–93.

Literák I, Balla M, Vyhnal S, Škrábal J, Peške L, Chrašč P & Systad G 2020: Natal dispersal of black kites from Slovakia. Biologia 75: 591–598.

McGrady MJ, Ueta M, Potapov ER, Utekhina I, Masterov V, Ladyguine A, Zykov V, Cibor J, Fuller M & Seegar WS 2003: Movements by juvenile and immature Steller's sea eagles *Haliaeetus pelagicus* tracked by satellite. Ibis 145: 318–328.

McIntyre CL, Douglas DC & Adams LG 2009: Movements of juvenile gyrfalcons from western and interior Alaska following departure from their natal areas. Journal of Raptor Research 43: 99–109.

Meyburg B-U, Haraszthy L, Meyburg C & Viszló L 1995: Satellite and ground tracking of a young imperial eagle *Aquila heliaca*: break-up of the family and dispersal (In German with English summary). Vogelwelt 116: 153–157.

Meyburg B-U, Meyburg C, Matthes J & Matthes H 2006: Satelliten und Bodentelemetrie bei einem jungen Kaiseradler *Aquila heliaca*: Famielienauflösung un Dispersion. Vogelwelt 127: 127–144.

Mohr CO 1947: Table of equivalent populations of north american small mammals. American Midland Naturalist 37: 223–249.

Nemček V, Chavko J & Deutschová L 2014: Movement of satellite-tracked juvenile saker falcons (*Falco cherrug*) in SW Slovakia. Slovak Raptor Journal 8: 97–103.

Nemček V, Uhrin M, Chavko J, Deutschová L, Maderič B & Noga M 2016: Habitat structure of temporary settlement areas of young saker falcon *Falco cherrug* females during movements in Europe. Acta Ornithologica 51: 93–103.

Obuch J & Bangjord G 2016: The Eurasian eagle-owl (*Bubo bubo*) diet in the Trøndelag region (Central Norway). Slovak Raptor Journal 10: 51–64.

Paton PWC, Zabel CJ, Neal DL, Steger GN, Tilghman NG & Noon BR 1991: Effects of radio tags on spotted owls. Journal of Wildlife Management 55: 617–622.

Penteriani V & Delgado MD 2009: Thoughts on natal dispersal. Journal of Raptor Research 43: 90–98.

Penteriani V, Delgado MM, Maggio C, Aradis A & Sergio F 2005: Development of chicks and predispersal behaviour of young in the eagle owl *Bubo bubo*. Ibis 147: 155–168.

Petty SJ, Appleby BM, Coles CF & Julliard R 2004: The long-term effect of fitting back-mounted radio tags to juvenile tawny owls Strix aluco. Wildlife Biology 10: 161–170.

Prommer M, Bagyura J, Chavko J & Uhrin M 2012: Migratory movements of Central and Eastern European saker falcons (*Falco cherrug*) from juvenile dispersal to adulthood. Aquila 119: 111–134.

Prommer M, Milobog Y, Gavrilyuk M & Vetrov V 2014: Juvenile dispersal of saker falcons in Ukraine according satellite telemetry. Bulletin of Cherkasy University 36: 129–134.

Rahman ML, Batbayar N, Purev-Ochir G, Etheridge M & Dixon A 2015: Influence of nesting location on movements and survival of juvenile saker falcons *Falco cherrug* during the post-fledging dependence period. Ardeola 62: 125–138.

Rodgers AR, Kie JG, Wright D, Beyer HL & Carr AP 2015: HRT: Home Range Tools for ArcGIS. Version 2.0. Ontario Ministry of Natural Resources and Forestry, Centre for Northern Forest Ecosystem Research, Thunder Bay, Ontario.

Sielicki J, Prommer M, Gamauf A & Kata M 2009: Saker falcon *Falco cherrug* in Poland (2008–2009), 273–285. In: Wiącek J, Polak M, Kucharczyk M, Grzywaczewski G & Jerzak L (eds), Ptaki – Środowisko – Zagrożenia – Ochrona [Biotop - Threatment - Protection]. Wybrane aspekty ekologii ptaków. LTO, Lublin.

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.

Slobodník V 2008: Summary on raptors and owls ringing in Slovakia in the period 2005–2006. Slovak Raptor Journal 2: 113–117.

Small RJ, Holzwart JC & Rusch DH 1993: Are ruffed grouse more vulnerable to mortality during dispersal? Ecology 74: 2020–2026.

Sunde P 2005: Predators control post-fledging mortality in tawny owls, *Strix aluco*. Oikos 110: 461–472.

Sunde P 2006: Effects of backpack radio tags on tawny owls. Journal of Wildlife Management 70: 594–599.

Šmídt J, Hapl E & Gális M 2019: Methodology of risk assessment for electricity distribution lines in Slovakia with regard to potential bird mortality due to collisions with power lines. Slovak Raptor Journal 13: 61–73.

Todd LD, Poulin RG, Wellicome TI & Brigham RM 2003: Post-fledging survival of burrowing owls in Saskatchewan. Journal of Wildlife Management 67: 512–519.

Withey JC, Bloxton TD & Marzluff JM 2001: Effects of tagging and location error in wildlife radiotelemetry sstudies, 43–70. In: Millspaugh JJ & Marzluff JM (eds), Radio tracking and animal populations. Academic Press, San Diego.

Received: 21. 1. 2022
Accepted: 10. 3. 2022