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# The population dynamics of the Redfooted Falcon *(Falco vespertinus)* on the southwestern limit of its breeding range

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†This article is dedicated to the memory of Sándor Lukács (1948-2019).



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Abstract The western boundary of the Palearctic range of the Red-footed Falcon (*Falco vespertinus*) is located in the Carpathian Basin, with significant breeding areas in the northern part of Serbia, Voivodina Province. The size of the breeding population has been estimated and surveyed several times since the middle of the last century. The number of breeding pairs showed considerable variation, while estimates suggested a declining trend in the population size, though the dynamics of the Red-footed Falcon population was less known. This motivated us to perform censuses every year from 2000 until 2009. During that period, the number of confirmed breeding pairs varied from 61 to 179. We found that the number of breeding pairs decreased significantly (> 40%) after a 3-4 year of increase. The number of breeding sites and the extent of the distribution area changed in proportion to the increase or decrease of the population size. However, the change in population size was unrelated to the general proportion of pairs breeding in colonies (87–96%) and those breeding solitarily (4–13%).

Keywords: census, estimation, fluctuation, nesting strategies, Serbia, Voivodina

Összefoglalás A kék vércse palearktikus elterjedési területének délnyugati határa Észak-Szerbiában, Vajdaság tartományban van. A múlt század közepétől többször megbecsülték és felmérték a költőállomány nagyságát. A költő párok száma változó volt, a becslések a populáció csökkenő tendenciájára utaltak, azonban a populáció dinamikája kevésbé volt ismert. Emiatt 2000-től 2009-ig évente census felméréseket végeztünk. A vizsgált időszakban a bizonyítottan költő párok száma 61 és 179 között változott. Megállapítottuk, hogy a költő párok száma 3–4 éves növekedést követően jelentősen (> 40%) visszaesett. Az állomány növekedésével, illetve csökkenésével arányosan változott a költőhelyek száma és az elterjedési terület kiterjedése. A populáció nagyságának változásaival a telepekben (87–96%), illetve magányosan (4–13%) költő párok aránya viszont nem változott lényegesen.

Kulcsszavak: állományfelmérés, becslés, fluktuáció, fészkelési stratégiák, Szerbia, Vajdaság

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## Introduction

The western border of the Palearctic range of the Red-footed Falcon (*Falco vespertinus*) is located in the Carpathian Basin, with significant breeding areas in the eastern parts of Hungary and in the northern parts of Serbia, Voivodina Province (Cramp & Simmons 1980, Barna 2015, Kotymán *et al.* 2015). The Red-footed Falcon does not build a nest, but breeds

in colonies or solitarily in abandoned nests of corvids (Cramp & Simmons 1980). Thus, their populations are also affected by the number of available nests of the Rook (Corvus frugilegus), Hooded Crow (Corvus cornix) and Magpie (Pica pica). Pairs of Red-footed Falcons nesting in Rook colonies usually occupy less than 10-20% of available nests (e.g. Horváth 1955, 1963, Végvári et al. 2002). The reason for this is that at the time of their nest occupancy the nesting of Rooks is still ongoing, other bird species also compete for these nests, and very often there is a lack of open grasslands nearby with potential food sources (Fehérvári et al. 2009, Palatitz et al. 2011). The population in Hungary decreased from 2500 to 600 pairs between 1950s and 2006 (Keve & Sziji 1957, Palatitz et al. 2022). The drastic decrease was mainly caused by the lack of nesting sites due to organized extermination of Rooks (Fehérvári et al. 2009, 2012). Thus, only 30-40% of the breeding pairs of Red-footed Falcons in Hungary had bred in Rook colonies (Tóth & Marik 1999, Végvári et al. 2002), which is also a disadvantage, as the breeding success of solitary pairs is significantly lower than that of pairs breeding in colonies (e.g. Haraszthy & Bagyura 1993, Tóth 1994). In order to stop the unfavourable process, artificial colonies of nest-boxes have been established in the appropriate habitats since 1989 (Molnár 2000, Vilagosi 2005, Kotymán et al. 2015), but the population has started to increase gradually only since 2007 (Fehérvári et al. 2009, Palatitz et al. 2022). The population of the Red-footed Falcon in Voivodina was estimated to be 80–150 pairs in the second half of the last century (e.g. Ham 1977, Vasić et al. 1985, Vasić 1996), but the first census performed in 1990 showed that the number of breeding pairs exceeded 300 (Purger 1996). Estimates conducted in later years (e.g. Ham & Rašajski 2000, Puzović et al. 2003, 2009) and several censuses (Purger 2008) indicated significant fluctuations and a declining trend in population size. However, there were no monitoring surveys, so our knowledge about the extent, dynamics and influencing factors of fluctuations was incomplete.

The aim of our work was to perform a population survey in several consecutive years using the same method in order to 1) reveal the temporal and spatial changes in the size of the Red-footed Falcon population in Voivodina, 2) to determine whether there is relationship between breeding pairs and number of breeding sites, 3) whether there is a difference in the proportion of colonial and solitary breeding pairs in each year.

#### **Materials and Methods**

Voivodina Province is a region in Northern Serbia located in the south-eastern part of the Carpathian (Pannonian) Basin, encompassing the confluence area of the Danube, Sava and Tisa rivers covering a total area of 21,506 km<sup>2</sup>. The largest part of Voivodina (about 95%) is characterized by low altitudes ranging from 68 m to 120 m, while the southeast area stands out with low mountainous forms Fruška Gora (538 m) and Vršačke Planine (639 m). Sandy areas (Deliblato Sands and Subotica-Horgoš Sand), lower terrains, and alluvial plains are also situated in the Voivodina region. Forests comprise only about 7% of Voivodina and mainly occur in the mountains and terrains along the rivers, while agricultural lands occupy about 84% (Grujić *et al.* 2021). The climate of Voivodina is moderate continental, with





1. ábra A kék vércsék fészkelőterületei Vajdaságban a 2002 és 2009 között végzett állományfelmérések alapján

cold winters, and hot, humid summers, with huge range of extreme temperatures and a very irregular distribution of rainfall per month. The mean annual air temperature was 11.1 °C and annual amount of precipitation was 606 mm between 1949 and 2006 (Tošić *et al.* 2014).

Our survey of the distribution and population size of Red-footed Falcons covers the breeding period from 2002 to 2009 following the same routes in 1990 and 1991 (Purger 1996) and 2000 and 2001 (Purger 2008). Involving one or two observers, we drove all main roads and a lot of dirt roads, usually ca. 300-400 km per day. The census was carried out covering the entire territory of Voivodina, but focused on the known breeding sites of the Red-footed Falcon (Ham & Rašajski 2000, Barna 2015). The squares in which breeding was registered within the study period were highlighted on the  $10 \times 10$  km UTM (*Figure 1*). We followed the suggestion of Postupalsky (1974) who proposed at least two checks of each occupied nest per breeding season. The census was done every year between 20–30 June and 5–15 July in about 10–15 days. One or two days were spent in Srem (3,838 km<sup>2</sup> area between the Danube and the Sava and the Croatian state border), where breeding is probable in some years. Three-four days were spent in Bachka = Bačka, which region is an 8,956 km<sup>2</sup>

wide plain bordered by the Danube, the Tisa and the Hungarian state border, where nesting sites are mostly isolated. Seven-nine days were spent in Banat (8,886 km<sup>2</sup> area bordered by the Tisa, the Danube and the Romanian state border), because the main breeding sites are located in the northern and central parts of Banat (Purger 1996, 2008, Ham & Rašajski 2000). In earlier studies (Purger 1996, 2008) birds nesting in Rook colonies were considered "colony nesters" irrespective of the number of pairs, whereas those occupying Magpie or Hooded Crow nests were regarded as "solitary nesters". In this study, we considered solitary nesting if only one pair bred in a Rook colony. The number of the Red-footed Falcon pairs was determined during the first field trip on the basis of the birds sitting in and flying out of the nest. During the repeated fieldwork, we did not only search for a new nesting sites, but also refined the results of the previous survey, so each year we only considered the number of pairs that really breed. In the second survey, the nestlings were already sitting in the nests, but when we did not see them, nest checking was done using a mirror (Parker 1972).

For the analysis of the relationships between the number of breeding sites of the Redfooted Falcon and the number of breeding pairs in the colonies and solitarily, we used the PAST 3.17 software (linear bivariate model, ordinary least squares regression) (Hammer *et al.* 2001).

#### **Results and Discussion**

The Red-footed Falcon bred in Voivodina in 2000 and 2001 (Purger 2008) and between 2002 and 2009 in the area between the Danube and the Tisa rivers in Bachka (Table 1) and east of the Tisa river in Banat (Table 2, Figure 1), similar to previous decades (e.g. Purger & Mužinić 1997, Ham & Rašajski 2000). Based on our results of the monitoring, their population fluctuated between 61 and 179 pairs (Table 3). We found that the number of breeding pairs decreased significantly (> 40%) after a 3-4 year increase (Table 3). Such population declines occurred in 2001 (61 pairs) and 2006 (83 pairs), and then in 2010 (60 pairs) in the year following our study (Solt et al. 2010). Between 2000 and 2009, the Redfooted Falcon population in the study area was estimated to 100-150 pairs (Puzović et al. 2009), which is consistent with the results of our census. However, our monitoring was ended in 2009, as the placement of nesting boxes began in Voivodina from that year onwards and until 2014 the population surveys were carried out according to the Hungarian protocol (Fehérvári et al. 2012). The results of our monitoring of the Red-footed Falcon population in the period between 2000 and 2009 allowed to accurately describe the dynamics of fluctuations. The importance of precisely defined and performed census is shown by the example of the very different population size in 2009 as a result of simultaneous surveys conducted by different methods. That year, we proved the breeding of 179 pairs of Redfooted Falcon at 45 sites (Table 3). Ružić et al. (2009) reported the breeding of 164-171 pairs at 22 sites, but they did not provide details of the method of their survey. Solt et al. (2010) in the same year found 150 breeding pairs at 20 locations, but Barna (2015) suggested that the number of breeding pairs exceeded 200. The different results suggested that the same survey method should always be used for long-term surveys. According to

- Table 1.Number of breeding pairs of Red-footed Falcon in Bachka between 2002 and 2009 (1 –<br/>Breeding in Hooded Crow or Magpie nest)
- 1. táblázat Bácskában költő kék vércse párok száma 2002 és 2009 között (<u>1</u> költés dolmányos varjú vagy szarka fészekben)

UTM	Locality	2002	2003	2004	2005	2006	2007	2008	2009
CR57	Obzir		3	3	2	1	1		1
CR58	South-west part of Stanišić		7	4	5	5	10	1	5
	North-east part of Stanišić		3						1
	1 km east of Stanišić			<u>1</u>	<u>1</u>				
	1.5 km east of Stanišić				1				
	Stanišić			1	1				1
CR67	North-west part of Svetozar Miletić				1			1	2
CR68	4km north-east of Svetozar Miletić						1		
	2 km south-west of Aleksa Šantić			1					1
CR69	3 km north-east of Stanišić		<u>1</u>	<u>1</u>				1	
	4 km north-east of Stanišić				1			1	
CR77	2.5 km west of Gornja Rogatica	4	5	4	3	4	3	2	1
CR95	3 km south of Feketić	1	2	1	3				
	4 km south-east of Feketić				3	<u>1</u>	3	1	1
DR05	4 km east of Feketić	4	7	8	4		2		
	4 km east of Feketić	1							
DR15	12 km north-west of Bečej				2				1
	14 km north-west of Bečej						1		
DR29	2.5 km north-west of Zimonjić	6	2	2		1			
	2 km west of Zimonjić	1		1					1
	3 km south-west of Mali Pesak		24	9	26	2	7	9	12
	Total	21	54	36	53	14	28	16	27

Barna (2015), the number of breeding pairs following a decline in 2010 increased until 2012, then declined again in 2013 and 2014. For the 2008–2013 period, the number of Red-footed Falcons in Voivodina was estimated at 262–335 pairs (Puzović *et al.* 2015). The Red-footed Falcon population in Hungary has been monitored since 2003 and we can conclude that until the drastic decrease of the population in 2010, the number of pairs breeding in the territory of the two countries changed similarly from year to year (Palatitz *et al.* 2015). After that, the population in Hungary steadily increased until 2014, then declined again in 2015, but the decrease in the number of breeding pairs was smaller than in previous years, which can be explained by the positive effect of the nesting boxes. The Red-footed Falcon population in Hungary increased further and in 2019–2020 the estimated number of breeding pairs was 1,200–1,300, which is considered to be stable due to the usage of nest boxes (Palatitz *et al.* 2022). The fluctuation of the population depends on outbreaks of small mammal populations and weather conditions in spring (Fehérvári *et al.* 2011).

- Table 2.Number of breeding pairs of Red-footed Falcon in Banat between 2002 and 2009 (1 –<br/>Breeding in Hooded Crow or Magpie nest)
- 2. táblázat Bánátban költő kék vércse párok száma 2002 és 2009 között (<u>1</u> költés dolmányos varjú vagy szarka fészekben)

UTM	Locality	2002	2003	2004	2005	2006	2007	2008	2009
DR34	2 km north-west of Kumane							1	2
DR37	2 km east of Padej		1						2
	4 km east of Padej			1					
	1 km north of Padej			1				1	1
	2 km north-east of Padej						1		2
	2.5 km north-east of Padej								2
	3 km north-east of Padej							3	9
DR38	Ostojićevo (south part)	<u>1</u>							<u>1</u>
	1 km south of Ostojićevo				<u>1</u>				<u>1</u>
	1.5 km south of Ostojićevo								1
DR43	Okanj, 3 km south-west of Melenci		10	12	7	4		1	1
	5 km south-east of Melenci			<u>1</u>					
	Elemir (north part)			<u>1</u>					2
	1.5 km north of Elemir							3	1
DR44	3 km north-east of Melenci				9	8	5	4	
	Rusanda (north-west part of Melenci)				1	1	2	4	7
DR45	10 km east of Novi Bečej		13	15	34	12	12	7	10
DR47	1 km north-east of Sajan	<u>1</u>							
DR48	2 km south-east of Jazovo	28	3	11	13	22	40	46	43
	Jazovo (north part)		<u>1</u>				<u>1</u>		<u>1</u>
	4 km east of Jazovo						1	2	5
	5 km east of Jazovo							2	4
	1 km south-west of Banatski Monoštor			1	1				2
	5 km south of Crna Bara			<u>1</u>					
	6 km west of Mokrin				2				4
DR49	2 km south-west of Vrbica	3	12	17	10	11	22	20	9
	1 km east of Banatski Monoštor		<u>1</u>						
	5km north-west of Crna Bara								1
DR54	Torda (south-east part)	15	13	7	4	3	4	6	6
	2 km south of Torda	2	1	2	3				
	3 km west of Banatski Dvor						6	14	15
	4 km north-west of Banatski Dvor							1	
	7 km south-west of Bašaid								2

UTM	Locality	2002	2003	2004	2005	2006	2007	2008	2009
DR55	1 km south-east of Bašaid	1	2		5	3	3	6	7
	4 km north of Bašaid			5	3	3	3		1
	3.5 km south-east of Bašaid						<u>1</u>		
	1 km south of Bašaid							<u>1</u>	
	1 km south-west of Bašaid								1
	2 km south-west of Bašaid								<u>1</u>
DR57	Kikinda (west part)								<u>1</u>
	3 km west of Kikinda							<u>1</u>	<u>1</u>
DR58	Mokrin (Vašarište)	22	15	2					
	1 km north-west of Mokrin	4							
	4 km west of Mokrin			1					4
DR64	1.5 km north-west of Banatski Dvor	<u>1</u>		<u>1</u>		<u>1</u>			<u>1</u>
EQ18	Potporanj		2						
ER10	Margita				<u>1</u>				
ER20	3 km east of Vatin					1			1
	Total	78	74	79	94	69	101	123	152

 Table 3.
 The distribution of Red-footed Falcon colonial and solitary breeding pairs and nesting sites in Voivodina according to the census survey conducted by using the same method

 3. táblázat
 Telepekben, illetve magányosan költő kék vércse párok és a fészkelőhelyek számának megoszlása a Vajdaságban az azonos módszerrel végzett állományfelmérések alapján

Year	Colonial	Solitary	Total	Nesting sites	Source	
2000	108 (93%)	8 (7%)	116	17	Purger 2008	
2001	57 (93%)	4 (7%)	61	11	Purger 2008	
2002	92 (93%)	7 (7%)	99	17	this study	
2003	123 (96%)	5 (4%)	128	21	this study	
2004	102 (89%)	13 (11%)	115	28	this study	
2005	139 (95%)	8 (5%)	147	27	this study	
2006	77 (93%)	6 (7%)	83	17	this study	
2007	122 (95%)	7 (5%)	129	21	this study	
2008	128 (92%)	11 (8%)	139	25	this study	
2009	156 (87%)	23 (13%)	179	45	this study	

The number of breeding sites changed in proportion to the increase or decrease in the number of Red-footed Falcon pairs nesting in Voivodina (linear regression, n = 10, B = 0.245, t = 5.123, P < 0.001) (*Figure 2, Table 3*). This means that in the years when Red-footed Falcons breed in greater numbers and in more places than e.g. in 2005 or 2009 (*Table 3*), nesting sites are also scattered over a larger area. In this case, the boundary of the distribution area shifts to the west and south, as our previous survey results have already pointed out (Purger 1996, 2008). One of the most important factors influencing the



*Figure 2.* Relationship between the number of breeding pairs of Red-footed Falcon and the number of nesting sites

2. ábra A kék vércse költő párok és költőhelyeik száma közötti kapcsolat



*Figure 3.* Trends of sympatric solitary and colonial breeding pairs of Red-footed Falcon in Voivodina *3. ábra* A telepekben, illetve magányosan költő kék vércse párok számának alakulása a Vajdaságban

development of the population and the size of the occupied areas in Hungary was the lack of rookeries (Palatitz et al. 2022). According to our previous surveys in Voivodina, more than 90% of Red-footed Falcons used abandoned nests in Rook colonies for breeding (Purger 1996, 2008), suggesting that there was no shortage of suitable breeding sites here. This is supported by the fact that during our field trips we observed several abandoned rookeries in the previously known breeding sites of Red-footed Falcon. Nesting in colonies results in higher breeding success, therefore the proportion of birds breeding in colonies or solitarily may be important. In Voivodina, we could not find different trends in the number of solitary and colonial nesting pairs in the study period (linear regression, n = 10, B = 0.119, t = 2.359, P = 0.046) (Figure 3). The change in population size was unrelated to the proportion of pairs breeding in the colonies (87-96%) and solitarily (4-13%) did not change (Table 3). Our results did not support the previous assumption (Purger 2008) that in years when the number of breeding pairs is lower, the proportion of birds breeding in colonies increase to achieve higher breeding success. In Voivodina, the number of Rook nests in the 1970s exceeded 80,000 (Garovnikov 1976), but this halved by the end of the century (Puzović et al. 2003). A survey conducted in Bachka in 2009 (Tucakov et al. 2010) suggested a significant decline in Rook population (Tucakov et al. 2010). The population estimate for the period between 2008 and 2013 indicated a further decline (Puzović et al. 2015), but it was nevertheless concluded that the Rook population after 2000 remained stable (Puzović et al. 2015). The depletion of Rook affects the areas along the Danube and the Tisa rivers rather than the areas preferred by the Red-footed Falcon. The fluctuation of the Red-footed Falcon population is influenced by the number of nests suitable for breeding, and also by weather conditions and the proximity and richness of feeding sites (Fehérvári et al. 2011). Their clutch size and fledging success are affected by the nesting strategy (colonial or solitary) and also by the weather in early spring, which affects the birds' food availability, as well as the timing of nest occupying and beginning of breeding (Fehérvári et al. 2011, Palatitz et al. 2015).

In Voivodina, about 70% of the Red-footed Falcons were breeding in the IBA (Important Bird Area) during the period of our survey (Puzović *et al.* 2009), but there is still a lack of grasslands which provide food, as well as around steppe forest patches and bushes with suitable nesting place (Barna 2018). The effect of the amount and distribution of precipitation on the size of Red-footed Falcon population could be detected in Voivodina in 2001 and 2010, when precipitation was much higher than average (Popov & Svetozarevich 2021) and the number of breeding pairs reached its minimum (Purger 2008, Solt *et al.* 2010).

The results of our survey showed that between 2000 and 2009 Red-footed Falcon bred only in Bachka and Banat, mostly within their previously known nesting areas in Voivodina. Despite changes in the number and spatial distribution of breeding pairs, more than 90% of the birds nested in Rook colonies. The extent of fluctuations in the number of breeding pairs was not influenced by the limited availability of Rook nests, but rather by the rainy weather and limited food supply. The number of breeding pairs in Voivodina (N Serbia) from year to year developed similar to Hungary, despite that the nesting strategies (the proportion of colonial and solitary nesters) differ significantly in the two countries.

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#### References

- Barna, K. 2015. History and current status of Red-footed Falcon population size and conservation activities in Voivodina. – Ornis Hungarica 23(1): 94–100. DOI: 10.1515/orhu-2015-0008
- Barna, K. 2018. Conservation of the Red-footed Falcon in Serbia. In: Palatitz, P., Solt, Sz. & Fehérvári, P. (eds.) The Blue Vesper: Ecology and Conservation of the Red-footed Falcon. MME Birdlife Hungary, Budapest, pp. 173–180.
- Cramp, S. & Simmons, K. E. L. (eds.) 1980. Handbook of the Birds of Europe, the Middle East and North Africa, Vol. 2. – Oxford University Press, Oxford, pp. 302–308.
- Fehérvári, P., Harnos, A., Neidert, D., Solt, Sz. & Palatitz, P. 2009. Modelling habitat selection of the Redfooted Falcon (*Falco vespertinus*): a possible explanation of recent changes in breeding range within Hungary. – Applied Ecology and Environmental Research 7(1): 59–69.
- Fehérvári, P., Lázár, B., Palatitz, P., Solt, Sz., Kotymán, L. & Harnos, A. 2011. Hogyan befolyásolhatja a lokális időjárás egy hazai kistestű ragadozó madár fészekaljméretét? [How the local weather condition can influence the clutch size of a small bodied bird of prey?]. – "Klíma 21" füzetek 65: 53–63. (in Hungarian)
- Fehérvári, P., Solt, Sz., Palatitz, P., Barna, K., Ágoston, A., Gergely, J., Nagy, A., Nagy, K. & Harnos, A. 2012. Allocating active conservation measures using species distribution models: a case study of Red-footed Falcon breeding site management in the Carpathian Basin. – Animal Conservation 15(6): 648–657. DOI: 10.1111/j.1469-1795.2012.00559.x
- Garovnikov, B. 1976. Brojnost gačaca (*Corvus frugilegus* L. 1758) u Vojvodini u periodu 1974–1976. god. [Number of Rooks (*Corvus frugilegus* L. 1758) in Voivodina in the period 1974–1976]. – Priroda Vojvodine 2(2): 11–21. (in Serbian)
- Grujić, G., Vasin, J. & Belić, M. 2021. Soil salinisation in Vojvodina the Republic of Serbia. Current Opinion in Environmental Sustainability 50(6): 149–158. DOI: 10.1016/j.cosust.2021.03.015
- Ham, I. 1977. Stanje i mere zaštite ptica grabljivica Vojvodine sa posebnim osvrtom na Deliblatsku peščaru [Status and protection measures of birds of prey in Voivodina with special reference to Deliblato Sands].
   – Priroda Vojvodine 3: 49–52. (in Serbian)
- Ham, I. & Rašajski, J. 2000. Siva vetruška Falco vespertinus (Linnaeus, 1758) Red-footed Falcon Falco vespertinus (Linnaeus, 1758)]. In: Puzović, S. (ed.) Atlas ptica grabljivica Srbije: mape rasprostranjenosti i procene populacija 1977–1996 [Atlas of birds of prey of Serbia: their breeding distribution and abundance 1977–1996]. Zavod za zaštitu prirode Srbije, Beograd, pp. 153–158. (in Serbian with English Summary)
- Hammer, Ø., Harper, D. A. T. & Ryan, P. D. 2001. PAST: Paleontological statistics software package for education and data analysis. – Paleontologia Electronica 4: 1–9.
- Haraszthy, L. & Bagyura, J. 1993. A comparison of the nesting habits of the Red-footed Falcon (Falco vespertinus) in colonies and solitary pairs. In: Nicholls, M. K. & Clarke, R. (eds.) Biology and Conservation of Small Falcons. The Hawk and Owl Trust, London, pp. 80–85.
- Horváth, L. 1955. Reed-footed Falcons in Ohat-Woods, near Hortobágy. Acta Zoologica Academiae Scientiarum Hungaricae 1(3–4): 245–287.
- Horváth, L. 1963. A kék vércse (*Falco vespertinus* L.) és a kis örgébics (*Lanius minor* Gm.) élettörténetének összehasonlító vizsgálata I. A tavaszi érkezéstől a fiókák kikeléséig [Comparing life history of Red-footed Falcons (*Falco vespertinus* L.) and Lesser Grey Shrikes (*Lanius minor* Gm.) I. From spring arrival to hatching]. – Vertebrata Hungarica 5(1–2): 69–121. (in Hungarian)

- Keve, A. & Szijj, J. 1957. Distribution, biologie et alimentation du Facon kobez Falco vespertinus L. en Hongrie [Distribution, biology and food of the Red-footed Falcon Falco vespertinus L. in Hungary]. – Alauda 25(1): 1–23. (in French)
- Kotymán, L., Solt, Sz., Horváth, É., Palatitz, P. & Fehérvári, P. 2015. Demography, breeding success and effects of nest type in artificial colonies of Red-footed Falcons and allies. – Ornis Hungarica 23(1): 1–21. DOI: 10.1515/orhu-2015-0001
- Molnár, G. 2000. A kék vércse, a vörös vércse és az erdei fülesbagoly mesterséges telepítésének eredményei a Dél-Alföldön [The breeding of the Red-footed Falcon (Falco vespertinus), Kestrel (Falco tinnunculus) and Long-eared Owl (Asio otus) in artificial nest boxes in the Dél-Alföld region]. – Ornis Hungarica 10: 93–98. (in Hungarian)
- Palatitz, P., Fehérvári, P., Solt, Sz., Kotymán, L., Neidert, L. & Harnos, A. 2011. Exploratory analyses of foraging habitat selection of the Red-footed Falcon (*Falco vespertinus*). – Acta Zoologica Academiae Scientiarum Hungaricae 57(3): 255–268.
- Palatitz, P., Fehérvári, P., Solt, Sz. & Horváth, É. 2015. Breeding population trends and pre-migration roost-site survey of the Red-footed Falcon in Hungary. – Ornis Hungarica 23(1): 77–93. DOI: 10.1515/orhu-2015-0007
- Palatitz, P., Solt, Sz. & Fehérvári, P. 2022. Kék vércse *Falco vespertinus* (Linnaeus 1766) [Red-footed Falcon *Falco vespertinus* (Linnaeus 1766)]. In: Haraszthy, L. & Bagyura, J. (eds.) Magyarország ragadozó madarai és baglyai, 2. kötet, Sólyomalakúak és bagolyalakúak [Birds of Prey and Owls in Hungary, Vol. 2. Falconiformes and Strigiformes]. Magyar Madártani és Természetvédelmi Egyesület, Budapest, pp. 351–387. (in Hungarian)
- Parker, J. W. 1972. A mirror and pole device for examining high nests. Bird-Banding 43(3): 216-218.
- Popov, H. & Svetozarevich, J. 2021. Changes and contemporary trends in the annual amounts of precipitation in Serbia. – Journal of the Bulgarian Geographical Society 44: 73–79. DOI: 10.3897/jbgs.e77102
- Postupalsky, S. 1974. Raptor reproductive success: some problems with methods, criteria, and terminology. Raptor Research Report 2: 21–31.
- Purger, J. J. 1996. Number and distribution of Red-footed Falcon (Falco vespertinus) nests in Voivodina (Northern Serbia). – Journal of Raptor Research 30(3): 165–168.
- Purger, J. J. 2008. Numbers and distribution of Red-footed Falcons (*Falco vespertinus*) breeding in Voivodina (Northern Serbia): a comparison between 1990–1991 and 2000–2001. – Belgian Journal of Zoology 138(1): 3–7.
- Purger, J. J. & Mužinić, J. 1997. The breeding distribution and migratory movements of the Red-footed Falcon (*Falco vespertinus*) in province Voivodina (southern part of Carpathian basin). – The Ring 19: 1–2.
- Puzović, S., Simić, D., Saveljić, D., Gergelj, J., Tucakov, M., Stojnić, N., Hulo, I., Ham, I., Vizi, O., Šćiban, M., Ružić, M., Vučanović, M. & Jovanović, T. 2003. Ptice Srbije i Crne Gore – veličine gnezdilišnih populacija i trendovi: 1990–2002 [Birds of Serbia and Montenegro – breeding population estimates and trends: 1990– 2002]. – Ciconia 12: 35–120. (in Serbian with English Summary)
- Puzović, S., Sekulić, G., Stojnić, N., Grubač, B. & Tucakov, M. 2009. Značajna područja za ptice u Srbiji [Important Bird Areas in Serbia]. – Ministry of Environment and Spatial Planning, Institute for Nature Conservation of Serbia, Provincial Sectretariat of Environmental Protection and Sustainable Development, Beograd (in Serbian)
- Puzović, S., Radišić, D., Ružić, M., Rajković, D., Radaković, M., Pantović, U., Janković, M., Stojnić, N., Šćiban, M., Tucakov, M., Gergelj, J., Sekulić, G., Agošton, A. & Raković, M. 2015. Ptice Srbije: procena veličina populacija i trendova gnezdarica 2008–2013 [Birds of Serbia: breeding population estimates and trends for the period 2008–2013]. Bird Protection and Study Society of Serbia, Department of Biology and Ecology, Faculty of Sciences, University of Novi Sad, Novi Sad (in Serbian)
- Ružić, M., Rajković, D., Gergelj, J., Barna, K., Skorić, S., Kostin, P. & Ronto, L. 2009. Podaci o gnežđenju sive vetruške *Falco vespertinus* u nekim kolonijama u Bačkoj i Banatu tokom 2009. [Data on breeding of Redfooted Falcon *Falco vespertinus* in some colonies in Bačka and Banat in 2009]. – Ciconia 18: 122–127. (in Serbian with English Summary)
- Solt, Sz., Palatitz, P., Fehérvári, P., Gergely, J., Ágoston, A. & Barna, K. 2010. Az MME Kékvércse-védelmi Munkacsoport 2010. évi beszámolója [Red-footed Falcon Working Group Annual Report 2010]. – Heliaca 8: 17–21. (in Hungarian)
- Tošić, I., Hrnjak, I, Gavrilov, M. B., Unkašević, M., Marković, S. B. & Lukić, T. 2014. Annual and seasonal variability of precipitation in Vojvodina, Serbia. – Theoretical and Applied Climatology 117(1–2): 331–341. DOI: 10.1007/s00704-013-1007-9

Tóth, I. 1994. Kék vércse (Falco vespertinus) állományfelmérés és védelem Békés-megyében [Population survey and conservation measures of Red-footed Falcon (Falco vespertinus) in County Békés]. – Calandrella 8(1– 2): 115–119. (in Hungarian)

Tóth, I. & Marik, P. 1999. Kék vércse felmérés [Red-footed Falcon Survey]. - Madártávlat 6: 4-5. (in Hungarian)

- Tucakov, M., Radišić, D., Šćiban, M., Ružić, M., Janković, M., Hulo, I., Horvat, F., Sekereš, O., Hardi, B., Žuljević, A., Mere, T., Đapić, D., Rajković, D., Agošton, A., Vig, L., Balog, I., Ham, I., Gergelj, J., Barna, K. & Medveđ, A. 2010. Brojnost i distribucija kolonija gačaca *Corvus frugilegus* u Bačkoj [Numbers and distribution of Rook *Corvus frugilegus* colonies in Bačka]. – Ciconia 19: 110–116. (in Serbian with English Summary)
- Vasić, V., Grubač, B., Sušić, G. & Marinković, S. 1985. The status of birds of prey in Yugoslavia, with particular reference to Macedonia. – In: Newton, I. & Chancellor, R. D. (eds.) Conservation Studies on Raptors. – ICBP Technical Publication 5: 45–53.
- Vasić, V. F. 1996. European news: Red-footed Falcon Falco vespertinus. British Birds 89(6): 247-266.
- Végvári, Zs., Magnier, M. & Nogues, J-B. 2002. Kék vércsék (Falco vespertinus) fészekválasztása és állományváltozása a vetési varjak (Corvus frugilegus) állományváltozásának tükrében 1995–1999 között a Hortobágyon [Nest selection of Red-footed Falcons (Falco vespertinus) and their population changes in relation to population changes of Rooks (Corvus frugilegus) between 1995 and 1999 on the Hortobágy]. – Aquila 107–108: 9–14. (in Hungarian with English Summary)
- Vilagosi, J. 2005. Behaviour, nest-site selection and the use of artificial nest-sites by Red-footed Falcons in Hortobagy National Park, Hungary. – British Birds 98(6): 317–319.

