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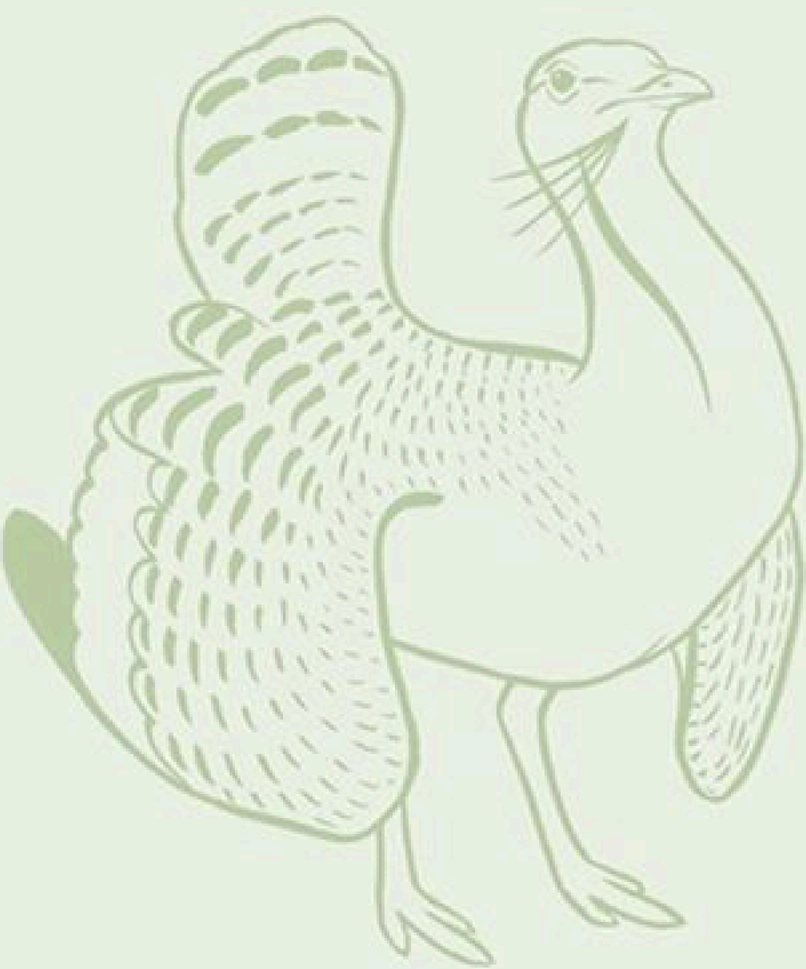

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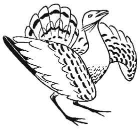
Should the Common Buzzard be hunted?

Tibor Csörgő[1], Richárd Zornánszky[2], Tibor Szép[3], Péter Fehérvári[4]



Tibor Csörgő, Richárd Zornánszky, Tibor Szép, Péter Fehérvári 2012. Should the Common Buzzard be hunted? – Ornis Hungarica 20(2): 1–12.

Abstract The Common Buzzard is a widespread and abundant raptor in Europe. Recently, game keepers have argued that the buzzard population has increased in Hungary and is threatening valuable small game species. Hunting of the buzzard has been prohibited since 1933, and since 1954 it has also been protected by law, in Hungary. Here we review scientific literature on recent population changes of the species, prey composition, and anatomical constraints of foraging.

We show that according to the Common Bird Monitoring Program the breeding population remained stable in 1992–2012. Because of its anatomy and its hunting techniques it is not able to hunt efficiently for valuable small game. According to studies made with different methods in different parts of Europe in the last century, most of its prey species are small mammals. Therefore, the Common Buzzard population may help sustain rodent populations, thus providing essential ecosystem services for agriculture. Game species can also occur in the diet, however the proportion is negligible and buzzards usually acquire such prey as carcasses or handicapped individuals. We found no justification in favour of lifting the hunting ban of Common Buzzards in Hungary.

Keywords: population change, anatomy, foraging method, wildlife management, prey composition

Összefoglalás Az egerészölyv Európa egyik leggyakoribb ragadozó madara. A hazai állomány is jelentős, 10 ezres nagyságrendű. 1933 óta élvez lelövési tilalmat, 1954 óta védett. Ennek ellenére az utóbbi években újra felmerült, hogy gyéríteni kellene a faj hazai állományát, mert annak nagysága jelentősen nőtt, ezért kártétele fokozódott.

Az MMM 1999–2012-es felmérései szerint a faj állománya ebben az időszakban stabil volt.

Anatómiai sajátosságai, vadásztechnikái miatt nem képes nagyobb testű, a vadgazdálkodásban érintett fajokat elejteni. Zsákmányállatainak nagyobb része – az utóbbi száz évben Európa különböző területein többféle módszerrel elvégzett vizsgálatok szerint – a mezőgazdaságban kártevő kisemlősökből kerül ki, amivel kimondottan nagy hasznot hajt. Mivel a táplálékmaradványokból ezek azonosítására kisebb az esély, mint a vadgazdálkodás szempontjából számbajöhető nagyobbakénak, ezek a számok még bizonyosan alá is becsülik az arányukat. A nagyobb testű állatok, vadgazdálkodás szempontjából hasznos fajok egyedei is szerepelhetnek az ölyv étlapján, de ezekhez legtöbbször az ember vagy valamely ügyesen vadászó ragadozó madár segítségével jut hozzá. Tevékenységük mindenképpen hasznosnak tekinthető, vadászatukat semmi nem indokolja.

Kulcsszavak: állományváltozás, anatómiai sajátosságok, vadásztechnikák, vadgazdálkodás, táplálékösszetétel

[1] Department of Anatomy, Cell and Developmental Biology, Eötvös Loránd University, 1117 Budapest, Pázmány Péter sétány 1/c, Hungary, e-mail: csorgo@elte.hu
[2] Department of Zoology and Animal Ecology, Szent István University, 2100 Gödöllő, Páter Károly utca 1., Hungary
[3] Institute of Environmental Sciences, College of Nyíregyháza, 4400 Nyíregyháza, Sóstói út 31/b, Hungary
[4] Department of Zoology, Hungarian Natural History Museum, 1088 Budapest, Baross utca 13., Hungary

Introduction

The Common Buzzard (hereinafter: buzzard) is amongst the most abundant and widespread raptors in Europe. This species is divided into 6–8 distinct subspecies out of which the Hungarian population belongs to the subspecies *B. b. buteo*. Ring recoveries show that buzzards are predominantly resident in the Carpathian Basin, however a small proportion of birds may move to neighbouring southern countries for winter. The wintering population is also complemented with birds from Scandinavia and the Baltic Region (Tóth 2009, Saurola *et al.* 2013). The birds of the eastern subspecies *(B. b. vulpinus)* rarely migrate through Hungary (Hadarics & Zalai 2008). Since 1933 the hunting of the buzzard has been prohibited, and since 1954 it has been protected by law (Haraszthy & Bagyura 1983). Game keepers, farmers and other stakeholders recently raised the issue of lifting the protected status, thus legalizing hunting as a form of controlling buzzards. These stakeholders argue that the population has considerably increased in recent years and that these birds pose a serious risk for small game species with high economic value. This debate justified that BirdLife Hungary elected the species as the 'Bird of the year' in 2012 (http://www.mme.hu/component/content/article/19-hirek-archivum/1395-a-joev-ev-egyik-eselyes-madara-segitseget-ker.html), raising wide public awareness of the issue.

Here we aim to review the international (British, Spanish, French, Danish, Norwegian, Polish, Czech, Slovak, Romanian) and Hungarian studies conducted on Common Buzzards in relation to this debate.

Population change

The European population increased between 1970 and 1990, then showed a slight decrease. At the turn of the century the estimated number of breeding pairs was 710 thousand. The species' status is evaluated as secure (BirdLife International 2004).

The Hungarian population of the species in recent decades of the last century – thanks to nature conservation legislation and public awareness – has increased (Haraszthy 2000). For instance in Békés county it went up to 150 pairs from 100 pairs between 1990 and 1995 (Tóth 1995 in Haraszthy 2000). At the turn of the century the breeding population was estimated to be between 10–20 thousand pairs (Hadarics & Zalai 2008).

Based on representative countrywide sampling (Szép & Nagy 2002), the Hungarian Common Bird Monitoring Program (MMM) estimated the population trends to be stable for 1999–2012 (Szép *et al.* 2013). The mean annual population change in this period (trend analysis, TRIM software package, Pannekoek & van Strien 2001) did not show a significant increase or decrease (slope= 0.5% (SE=1.1%) *(Figure 1)*.

The National Game Management Database on the other hand shows a somewhat different trend; the numbers provided for these years are significantly higher, moreover they show a 50% increase. In the 2003-2004 hunting season they estimated 62911 individuals, while in 2012-2013 this number was 96237 (http://www.ova.info.hu/vadgazdalkodasi_statisztikak.htm). The underlying reason in the deviation of the two estimates is the different applied methodology. The most obvious deviation is that the Common Birds Monitoring Program is a survey (i.e. systematic sampling of a population) while the National Game Management Database

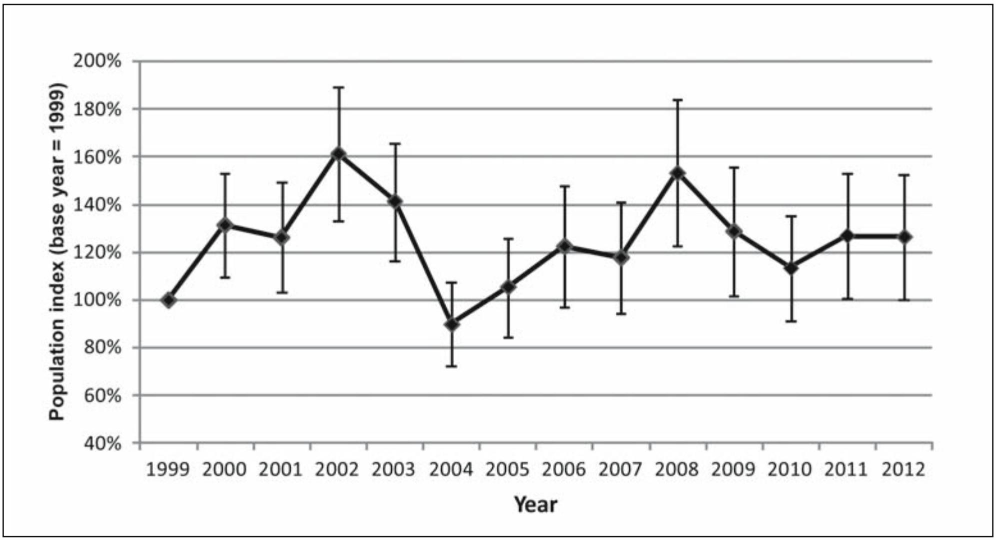


Figure 1. Population index of the Hungarian breeding population of the Common Buzzard according to data by the Common Bird Monitoring Program. The values of annual population indices and estimated indices SE are specified in comparison to the base year (1999)

1. ábra Az egerészölyv magyar fészkelő állományának változása az MME Mindennapi Madaraink Monitoringja (MMM) adatai alapján. Az éves populációs indexek (imputed index) és a becsült indexek SE értékei a bázis évhez (1999) viszonyítva vannak megadva

relies on a census (counting of all individuals of a population). Furthermore, there is a temporal difference between the two data series; the Common Bird Monitoring Program only uses data that derive strictly from the breeding season (http://www.mme-monitoring.hu/prog.php?datid=56) whereas the game management database only requests that data providers count the number of individuals present and presumably inhabiting the game management area, without any temporal restrictions (http://www.vmi.szie.hu/adattar/pdf/adatlapok-2013/becsles_terv-utmutato_2013.pdf).

The common bird census program estimates an average 30000 individuals (i.e. 15000 pairs) for the country. Typically clutch size is 2–4 eggs (Cramp & Simmons 1980), however fledging success is considerably lower, only 0.42–2.13 in the Swabian Alb (Rockenbauch 1975), in other regions of Germany it is 0.42–2.17, in the Pilis hills the estimated mean is 2.21 (Haraszthy & Ott 1984), and in Békés county it is 1.2–2 (Tóth 1995 in Haraszthy 2000). In general, mean fledging success is less than 2 birds per nest. An indirect support of this general value is that the proportion of youngsters among observed birds is 31–51% in the Danish Strait every year (Forsman 2003). Returning to the potential number of buzzards in the Hungarian population; it is plausible that 50–55 thousand individuals may be present in the post-fledging period for a short time, but due to natural and human induced mortality (electrocution on medium voltage pylons, poisoning, illegal hunting etc.) this number certainly decreases by autumn and winter. According to ringing data the mortality rate of the birds in their first year is 46.4% (Germany), 65% (Sweden), 77.6% (Great-Britain) (Cramp & Simmons 1980). Furthermore, individuals from northern Europe also migrate through or overwinter within the Carpathian basin as suggested by ring recoveries, however assessing the ratio of resident vs. migrant buzzards is currently impossible.

An equally important deviation between the two datasets is that they are acquired on different spatial scales. The Common Bird Monitoring Program covers a smaller spatial extent as the sampling is carried out on a fraction of the total area of Hungary, although the sites and the observation points are randomly chosen, thus allowing statistically sound estimates. On the other hand the National Game Management Database holds information on the whole extent of Hungary, since all game management units are legally obliged to present data annually. However, the lack of defined methodology allows data providers to report numbers acquired with various techniques for each game management unit. Previously we have detailed that simply the timing of field observations within the season may remarkably influence the number of counted birds. Moreover, the game management database does not specify how to control for multiple counts of individuals, or for the spatial aggregation of individuals. Buzzards and other raptor species often aggregate in areas with high prey densities, like alfalfa fields or along large roads especially in winter. The reason for the latter is that road-kills are often consumed by buzzards, and also that roadside ditches are less likely to be influenced by rodenticides-but are often mowed- thus presenting larger densities of prey with high prey accessibility compared to other areas. A data provider may easily overestimate the number of buzzards present in the area based on observing these aggregations.

In the breeding season buzzards are territorial with variable territory sizes; in the Pilis hills between 1977 and 1981 the number of breeding pairs per 100 km^2 varied between 40.8–437.3 annually, the territory of one pair was between 209–245 hectares (Haraszthy & Ott 1983), on the Northern-Borsod-Karst on 30 thousand hectares 100–165 pairs bred between 1986 and 1991 (Varga & Rékási 1993). This large variation may yield considerable estimation bias if not controlled for.

In summary, both methods have advantages and disadvantages, however when assessing the countrywide breeding population of buzzards, the Common Bird Monitoring Program offers a more valuable estimate compared to the National Game Management Database. Nonetheless, the demand for better understanding the breeding population size and trends of common diurnal raptors, MME/BirdLife Hungary launched a national Raptor Survey program that will hopefully allow an even more precise estimate of these figures in the future (http://www.mme-monitoring.hu/php/dl.php?drid=2971).

Body structure and hunting method

The body structure of the buzzard determines the spectrum of accessible prey species.

Its feet, toes and talons are comparatively shorter than the sympatric and similar sized Goshawk *(Accipiter gentilis)*. This later species is considered to prey predominantly on birds (Widén 1987, Rutz & Bjilsma 2006) in forest habitats and therefore is built for high maneuverability (Drennan & Beier 2003). Buzzards however have broader wings and shorter tails and thus are less maneuverable in flight (Norberg 1995). They can only hunt prey with a maximum weight of 500 gramms, moving slowly on the ground, but since it is an opportunistic predator, the prey is typically much smaller (Cramp & Simmons 1980).

The predation of buzzards is characterized by three strategies. In most cases they perch and wait either on the ground or on a vantage point and drop themselves on the prey moving on the ground at a smaller distance. Buzzards can often be seen crouching on molehills or on the mounds of the Mound-building Mouse *(Mus spicilegus)*. These individuals often do not even wait until their prey comes up to the surface, instead they catch them by grabbing the moving sloppy soil (Skoczen 1962, Kalotás 1980).

Food

During more than a century, many different methods have been used to analyze and observe the food of birds of prey. These include for example stomach content, pellet- and food remain analysis, observation, use of cameras (Vasvári 1930, Witherby *et al.* 1939, Glutz von Blotzheim *et al*. 1971, Brown 1976, Cramp & Simmons 1980, Kostrzewa 2008). In general, food spectrum of buzzards varies with climate, thus the predominant prey species in different populations may be diverse along the breeding range. In most of the range the main prey species are small mammals, dominantly the Common Vole *(Microtus arvalis).* This is also proven by the fact that other than Hungarian, there are also many other languages where we can find the word mouse in the name of the species: German: Mäusebussard, Danish: Musvage, Icelandic: Músvákur, Norwegian: Musvak, Finnish: Hiirihaukka, Spanish: Ratonero Común, Polish: Myszolow, Slovak: Myšiaka Horneho (Sandberg 1992), Serbian: Mišar. In Great Britain where the Common Vole is not indigenous, the main prey species are birds, Rabbit *(Oryctolagus cuniculus) Lepus* species and Field Vole *(Microtus agrestis)* (Tubbs 1967, Graham *et al*. 1995, Swann & Etheridge 1995, Kenward *et al*. 2001). In Romania, the typical prey species are reptiles (Dombrowski 1912), while in Spain, beside reptiles also insects and Rabbits constitute bulk of the prey items (Palaus Soler 1960, Garzón Heydt 1974, Bustamante 1985, Mañosa & Cordero 1992).

In some areas food composition can vary with season. This may also be true for even Mediterranean areas where inter-seasonal deviation of temperature is relatively low. The most abundant prey in the breeding period in Northeast Spain is the Rabbit. Buzzard breeding season coincides with, or is possibly timed to the emergence of juvenile Rabbits. The second most frequent prey are reptiles, dominantly Ocellated Lizard *(Lacerta lepida)*. Also the importance of smaller birds became slightly stronger at this time of the year. This tendency was also supported by another investigation conducted in Spain (Bustamante 1985). Furthermore, the role of reptiles may be less pronounced in the colder season, however amphibians can appear in large numbers in their diet as species of this taxa tend to aggregate around at specific sites (Mañosa & Cordero 1992).

Sex specific dietary differences are less pronounced compared to seasonal variation. In a study conducted in Spain the stomachs of males were empty more often, and smaller amphibians were found compared to females. Remains of bigger rabbits were only found in the stomachs of females. These differences were explained by reversed sexual dimorphism (Mañosa & Cordero 1992). In contrast, other studies have not found significant sex specific differences in the diet in regards to the species and size of their prey (Bustamante 1985).

Prey composition may correlate with nestling size; smaller nestlings may receive smaller prey species (e.g. earthworms and voles), while larger nestlings are fed with more profitable prey like moles in a study conducted by Meier *et al.* (2000).

Studies have shown high individual differences in diet composition as well. For instance a male buzzard was observed to forage on Slow Worms *(Anguis fragilis)*, Sand Lizards *(Lacerta agilis),* European Adders *(Vipera berus)*, with only a single observation of vole as prey (Melde 1971). In contrast, Kalotás' (1985) observations suggest that Mole consumption of some buzzard pairs can reach 40–50%.

Even though some individuals can be real specialists, the species is overall a generalist, its food is basically limited by food availability.

The most common prey of buzzards is the Common Vole in most parts of the European breeding range and thus the Carpathian Basin. According to a Slovakian study the Common Vole can reach up to 96% of the winter food composition (Salaj 1972). This vole species is active during the day and can reach high densities in arable fields where food abundance may be practically unlimited. Every few years it manifests itself in gradation. In other years their numbers can drastically drop, mainly due to climate factors (Gubányi & Horváth 2007). In vole gradation years the proportion of the Common Vole in the prey composition is much bigger, than in normal or poor vole years (Mebs 1964, Kalotás 1985, Kostrzewa 2008).

The proportion of some animal groups can vary in the food composition depending on whether we take into consideration their weight or their relative frequency (Kostrzewa 2008). Despite this fact the proportion of the Common Vole is dominant both in vole gradation years and between these years according to both indices in a study in Poland. In vole gradation years the average frequency was 75%, the weight proportion was 74%, while in low vole years these numbers were 40% and 48%. In these years the proportion of earthworms, insects and amphibians increased significantly while the proportion of other mammals increased insignificantly (Kostrzewa 2008).

Some buzzard pairs can be affected in different ways by different food availability. For some of them in the years when there is a lack of voles, the breeding can fail, or they lay fewer eggs. It can also occur that they interrupt breeding, in extreme situations; their nestlings starve to death depending on how the breeding and the period of the food shortage overlap with each other. As opposed to this, there are buzzard pairs, which raise nestlings, though less in low vole years. These shift food composition, the proportion of birds grows among prey animals (Kostrzewa 2008). The Mole can also be an alternative prey in Europe.

In studies conducted in Poland the Mole appeared in larger numbers, than the Common Vole (Czarneczki & Foksowitz 1954). The food consisted of 50% Moles and 33% Common Voles. According to the age studies based on dentition analysis the proportion of juvenile Moles was 86,5% compared to other age groups in the whole sample. This is the result of the behaviour of young Moles in the start of their independent lives, in which the activity near the surface or even above the surface is very typical (Skoczen 1962).

In contrast to continental Europe, the dominant prey species in the British Isles are Rabbits, while alternative prey are Field Voles and birds (Graham *et al.* 1995).

Predators can react to the changes in prey abundance in two ways. Generalist species utilize alternative prey, while specialist species are less flexible hence their density changes. In case of the Common Buzzard, we can observe the combination of the two reactions (Reif *et al.* 2004).

According to the previous statements, the Common Buzzard can change its food, if the density of the preferred prey animal decreases, while there is a connection between the size of the vole population and the density of breeding pairs, clutch size and breeding success (Mebs 1964, Rockenbauch 1975, Reif *et al.* 2004).

According to a study conducted in Germany, the number of breeding pairs increased by 1/5 in vole gradation years, compared to low vole years. In high voles years the ratio of the clutches with 3-4 eggs was 91%, while in the low vole years this value decreased to 20%. The breeding success (i.e. relative frequency of clutches that fledged) was 70.8%, and 50%, respectively (Mebs 1964). According to a study conducted in Finland, nesting rate (i.e. number of active nests / number of all territories) and its productivity (i.e. number of nestlings / number of all territories) positively correlated with the studied years' Microtus species density (Reif *et al.* 2004).

In none field vole mediated environments, the changes in densities of the main prey species show a similar correlation with buzzard reproductive success, in Great-Britain with the Rabbit (Moore 1957, Graham 1995, Swann & Etheridge 1995), while in forest environment with the Bank Vole *(Myodes glareolus)* (Weber & Stubbe 2000).

The population of buzzards depends not only on food availability, at least three other factors can play a part in the success of breeding. As buzzards breed in unsheltered twig-nests, the amount of rainfall in May is important. In rainy years the nestlings can get soaked, thus they may chill and die. In dry years fledging success is higher than in wet years. Other factors influencing reproductive success are interspecies competition and habitat quality. For instance, buzzards breeding in nests near Goshawk territories were less successful, because the Goshawks often carried away their nestlings. The more stable the breeding population is, the bigger the breeding success will be, and the bigger sight fidelity is typical for habitats optimal for the species (Kostrzewa & Kostrzewa 1994). The number of breeding pairs is also controlled by intraspecies competition (Moore 1957, Cramp & Simmons 1980, Newton & Marquiss 1986 in Kostrzewa & Kostrzewa 1994, Weber & Stubbe 2000).

Among the winter weather factors, the temperature and the snow cover influence the survival just in extreme cases (Joensen 1968, Kostrzewa & Kostrzewa 1991). If severe cold is accompanied by thick and permanent snow cover, they starve to death in large numbers (Mebs 1964).

Studies conducted in different parts of Europe (Rörig 1903, Dombrowski 1912, Uttendörfer 1952, Czarnecki & Foksowicz 1954, Moore 1957, Sladek 1957, Toufar 1958, Palaus Soler 1960, Pinowski & Ryszkovszki 1962, Skoczen 1962, Mebs 1964, Tubbs 1967, Joensen 1968, Thiollay 1968, Melde 1971, Salaj 1972, Ryszkovszki *et al.* 1973, Garzón Heydt 1974, Rockenbauch 1975, Bustamante 1985, Kostrzewa & Kostrzewa 1991, 1994, Mañosa & Cordero 1992, Graham *et al.* 1995, Swann & Etheridge 1995, Meier *et al*. 2000, Weber & Stubbe 2000, Kenward *et al*. 2001, Reif *et al.* 2004, Kostrzewa 2008), and also the inland studies (Nozdroviczky 1907, Barthos 1908, Greschik 1910, Bessenyei 1917, Greschik 1924, Tarján 1939, Kalotás 1980, 1982, 1983, 1985, Rékási 1981, Balogh & Varga 1983, Varga 1984, Varga & Rékási 1993, Fenyősi 1994, Bereczky 2010, Zornánszky *et al*. 2013) proved that the species eat primarily small rodents, dominantly Common Voles. From spring to autumn – in changing proportion – insects and their larvas, amphibians, reptiles are also on its diet everywhere, and mainly in winter, when these prey animals are not accessible, it also eats different types of carrion for example fish (Toufar 1958, Sladek 1961, Kalotás 1982, 1985, Varga 1984). It can also capture fledglings or nestlings in small numbers (Glutz von Blotzheim *et al.* 1971, Salaj 1972, Kalotás 1985, Swann & Etheridge 1995). Although according to some observations it attacks Hare *(Lepus europaeus)* (Nozdroviczky 1907, Bereczky 2010), Grey Partridge *(Perdix perdix)* (Bessenyei 1917) and Pheasant *(Phasianus colchicus),* but these are caught as youngsters or in an injured, weakened, sick state (Vasvári 1930, Glutz von Blotzheim *et al.* 1971).

Bigger animals, valuable game species can also be on the diet of buzzards, but in most cases these are obtained with the help of humans or other more skilful birds of prey (Uttendörfer 1952, Toufar 1958). It cannot cope with an adult Hare (Balogh & Varga 1983).

The dominance of the main prey animals did not change, where they artificially raised and released Pheasants (Kalotás 1982, 1985, Kenward *et al*. 2001), or it is present naturally in high numbers (Rékási 1981).

According to studies conducted in the '80s, the Pheasants present in the diet of buzzards are from two large sources; a) from killed or injured birds, typically caused by mowers (Farkas 1977), and b) sick or poisoned birds (Farkas 1980).

Kalotás (1985) in 1981, during the peak of a vole gradation, could only prove one instance of buzzards foraging on Pheasants (0.9%), but the Common Vole was present in 63.6% of the samples. In 1982, relatively often, in 38.5% of the cases the author found Pheasant remains in the stomachs of buzzards, but in half of these cases (15.4%), it could be detected, that it was consumed while already dead, because the Pheasant remains were contaminated by fly larvae. In 19.2% of the samples he found the remains of Pheasants younger than 7 weeks. The relatively big occurrence of Pheasants can be the effect of the collapse of the Common Vole population after the gradation in 1981. In 1982 altogether 34.6% was the proportion of the Common Vole in their diet.

In the southern part of Great-Britain they collected food remains from 40 nests, and followed the movement of 136 buzzards with radio telemetry with the aim of finding a connection between the rate of predation, the presence of buzzards, movement zone and the characteristics of the Pheasant pens. They found fresh Pheasant remains in 7% of the controlled nests. Only 8% of the radio-tagged buzzards had significantly more association than other buzzards with pens. The characteristics of the pens (small canopy coverage) and the release (lot of Pheasants in one pen) made it easy for the buzzards to catch them. The proportion of Pheasants of the diet was not more than 2.6% (Kenward *et al.* 2001).

In general, dietary studies show that small rodents dominate both in proportion of weight and frequency of buzzard diet throughout the European breeding range. Smaller taxa are less likely to be discovered in dietary analyses, therefore the proportion of small mammals is probably even underestimated in these studies (Mebs 1964, Kalotás 1985, Graham *et al.* 1995, Kostrzewa 2008). In addition, the parents are likely to consume the smaller animals on the spot of the capture, and bring only the bigger ones to the nest (Mañosa & Cordero 1992, Graham *et al.* 1995). The analysis of pellets also cannot give a perfect idea of the spectrum of prey animals, because the diurnal birds of prey digest most of the bones (Vasvári 1930, Uttendörfer 1952, Mebs 1964, Glutz von Blotzheim 1971, Kalotás 1982), the bigger ones are more likely to remain, so these are also overrepresented (Uttendörfer 1952). The bromatologyc analyses can only provide information on the prey caught directly before the shooting (Vasvári 1930). The use of mechanisms placed above the nest, collecting the prey animals dropped into the nest by the parents can give a more complete idea about the spectrum of prey animals and their proportion (Czarnecki & Foksowicz 1954). Taking and analyzing of footage and pictures also do so (Meier 2000, Zornánszky *et al.* 2013), but probably the smaller prey animals are consumed by the parents more frequently than the bigger ones, because carrying them to the nest is more profitable.

In general, we found that the Hungarian breeding population of the buzzard is stable, and according to studies conducted with different methods in different areas and in different time periods throughout the past century, the proportion of valuable game species in the diet of buzzards is negligible. Presumably, this is caused by the fact that they are anatomically less capable of foraging on relatively large game species like Pheasants or Hares. The buzzards are most likely to catch sick, injured individuals (Vasvári 1930, Salaj 1962, Mebs 1964, Glutz von Blotzheim *et al.* 1971, Kalotás 1982), so their activity can be regarded even useful.

It was already stated a century ago – in a period with a completely different approach to birds of prey – that the agricultural benefit of buzzards surpasses the harm caused to game management (Greschik 1910, 1924, Toufar 1958, Salaj 1972, Kalotás 1980, 1982, 1983, 1985). Naturally the buzzards cannot abolish gradation, but can effectively participate in the reduction of the population's number (Ryszkowski *et al.* 1973).

The demand to control buzzard populations to reduce foraging pressure on game species is not substantiated based on our review of the vast literature cited in this paper. On the contrary, reducing the buzzard population would presumably result in less controlled Field Vole gradations.

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Population trends of common breeding and wintering birds in Hungary, decline of long-distance migrant and farmland birds during 1999–2012

Tibor Szép[1], Károly Nagy[2], Zsolt Nagy[2], Gergő Halmos[2]

Tibor Szép, Károly Nagy, Zsolt Nagy, Gergő Halmos 2012. Population trends of common breeding and wintering birds in Hungary, decline of long-distance migrant and farmland birds during 1999–2012. – Ornis Hungarica 20(2): 13–63.

Abstract Based on the Hungarian common bird monitoring scheme (MMM), which is the longest running country-wide monitoring using formal sampling design with representative data for the main habitats in Central-Eastern Europe, we investigated the population trends of common breeding and wintering species. Habitat preference and occupancy of the common breeders, migration strategies and relationships among these characteristics could act behind the population trends. We pointed out that long distance migrant bird species had strong decreasing trends in Hungary and very probably in the entire Pannonian biogeographical region, whereas the partial and short migrant species has increasing trends. Farmland birds had declining trend, which trend became more obvious since the joining of Hungary to the EU. The negative changes in the farmland habitat could influence bird species nesting/foraging mainly in this habitat independently from their migration strategies. Our investigations let us to develop indicators on the basis of migration strategy and habitat usage of common birds to provide regular information about condition of groups of species and their habitats in Hungary and the Pannonian region. The MMM database provide unique opportunity for further investigations of several species, habitats and area specific in a part of Europe where this kind of information is rare yet.

Keywords: monitoring, Pannonian region, biodiversity indicators, Farmland Bird Indicator (FBI), climate change, migration strategies, habitat preference and occupancy

Összefoglalás A Mindennapi Madaraink Monitoringja (MMM) a leghosszabb ideje futó országos léptékű olyan monitorozó program Közép-, Kelet-Európában, amely random mintavételi stratégia alkalmazásával reprezentatív adatokkal szolgál a régió madárállományairól és főbb élőhelyeiről. Munkánkban a gyakori fészkelő és telelő fajok állomány trendjeit, a gyakori fészkelők élőhely preferenciáját és használatát, valamint vonulási stratégiáját vizsgáltuk az állományváltozások hátterében zajló folyamatok feltárása érdekében. Kimutattuk, hogy a hosszútávon vonuló madárfajok esetében jelentős állománycsökkenés van Magyarországon és feltehetően az egész Pannon biogeográfiai régióban. Ugyanakkor a részlegesen és rövidtávon vonuló madárfajoknál növekedő állomány a jellemző. A mezőgazdasági élőhelyekhez kötődő fajoknál csökkenő állományok vannak, amely jelleg különösen Magyarország EU tagsága után erősödött fel. A mezőgazdasági élőhelyeken zajló kedvezőtlen változások az ott fészkelő/táplálkozó madárfajok helyzetét jelentősen befolyásolhatják e fajok vonulási stratégiájától függetlenül. Vizsgálatunk lehetőséget ad a gyakori madárfajok vonulási és élőhelyi jellemzőin alapuló olyan indikátorok fejlesztésére, amelyek rendszeres információval szolgálnak adott fajcsoportok és az azok által használt élőhelyek állapotáról Magyarországon és a Pannon régióban. Az MMM adatbázis egyedülálló lehetőséget ad nagyszámú faj, élőhely és terület további részletes vizsgálatára Európa olyan részén, ahol ezen információk még igen ritkák napjainkban.

Kulcsszavak: monitorozás, Pannon régió, biodiverzitás indikátor, Mezőgazdasági Élőhelyek Indikátora (FBI), klímaváltozás, vonulási stratégia, élőhely preferencia és használat

[1]Institute of Environmental Sciences, College of Nyíregyháza, 4400 Nyíregyháza, Sóstói út 31/b, Hungary, e-mail: partifecske@freemail.hu
[2]MME/BirdLife Hungary, 1121 Budapest, Költő utca 21., Hungary, e-mail: halmos.gergo@mme.hu

Introduction

Biodiversity in Europe showed large changes during the last decades, most of these changes could cause unprecedented loss without effective conservation action based on adequate information about condition of biodiversity (Balmford *et al*. 2003). Biodiversity monitoring schemes with relevant design in relation to the questions they want to answer, to the progress they want to follow, and to the taxa and scales they want to investigate are key for having proper information (Yoccoz *et al.* 2001). Monitoring of common birds species using random sampling design at national, regional and continental levels is one of the most proper biodiversity monitoring approach which could provide important information about such essential questions as the influence of habitat loss and degradation, farming practices and climate change on size and distribution of numerous bird species and on the ecological system they belong to (Gregory *et al.* 2005, Jiguet *et al.* 2012). The birds are very proper taxa for monitoring because of the large and extended network of observers, the national and international NGOs for organising and scientifically coordinating all parts of the work (design, field work, database, analysis, cooperation with scientific communities), the scientific background nationally and internationally for analysing and interpreting the information and the large interest from the public towards these species (Greenwood 2007, Gregory & van Strien 2010).

Following the success of the Breeding Bird Survey (BBS) started in 1994 in the UK, (Gregory *et al.* 1996) which was the first national common bird monitoring scheme in Europe using random sampling design, the European Bird Census Council (EBCC) started to initiate similar schemes in several other European countries to form Pan-European Common Bird Monitoring Schemes (PECBMS) based on common birds at the end of the 20th century (Gibbons 2000). The EBCC invited the MME/BirdLife Hungary in 1997 to start a new country-wide common breeding bird monitoring scheme in Hungary based on a formal design (Szép & Gibbons 2000).

After the first pilot year in 1998, when the concept of the random sampling design and field protocol was tested with contribution of more than hundred observers and experts of the EBCC, the new scheme called Mindennapi Madaraink Monitoringja (MMM – Monitoring of Common Birds) has started with the final, existing protocol in 1999 as the first common bird monitoring scheme in Central and Eastern Europe using random sampling design and collecting representative data on the level of country (Szép & Gibbons 2000). The MMM scheme is able to monitor not only the breeding population in Hungary but by using the same field protocol data is collected from wintering populations of common bird species since 2000 (Szép & Nagy 2002).

A number of monitoring schemes already existed in Hungary before the start of the MMM (Báldi *et al.* 1997), mostly organised and executed within the umbrella of MME/BirdLife Hungary: White Stork, *Ciconia ciconia*, surveys since 1958; waterfowl counts since 1974; surveys of rare birds of prey species since 1974; Actio Hungarica ringing programme since 1974; integrated population monitoring of breeding Sand Martins, *Riparia riparia*, along the river Tisza since 1986. A scheme to monitor rare and colonial birds (known by the acronym 'RTM') was started in 1992 and uses territory mapping within observer-chosen 2.5×2.5 km UTM squares (Szép & Waliczky 1993). Fieldwork is undertaken by a hundred or so volunteers and is mostly concentrated within Important Bird Areas (IBAs). The first country-wide monitoring of common breeding birds using a standardised counting method was started only in 1988. This used the point count method to monitor breeding passerines, with a total of 20–40 areas covered annually by 20–50 participants (Waliczky 1991). Sites were selected by the observers and were mainly in forested areas. Because of the low level of participation, the bias towards forested habitats in relatively few geographical regions of Hungary and observer choice of sites, population trend data produced by this scheme cannot be taken as representative of trends for common breeding birds in Hungary as a whole.

The information provided for breeding and wintering common bird species by the MMM scheme in Hungary since 1999 using standard methods for trend analysis (TRIM, Pannekoek & van Strien 2001) has importance not only for Hungary but for large part of Central and Eastern part of Europe, covered by the countries of the former Eastern Bloc, many of them joined to the EU since in 2004. In most of those countries, monitoring of common birds, representative on the level of country has not or partly existed before 1999 and new monitoring schemes in these countries follow the PECBMS standard has started later then the MMM. The different geographic, climatic, economic, political and environmental conditions of these countries compared to former EU member countries makes it important to have proper database, compatible with existing databases in Europe for analysing the kind of effects e.g. as Common Agricultural Policy (CAP), Agri-Environment Schemes (AES) of EU (Butler *et al.* 2010) and climate change (Both *et al.* 2010).

Biodiversity indicators based on annual indices of common bird species related to specific habitat has an increasing importance in the World (Butchart *et al.* 2010) following the successful application of it in the European Union (Gregory & van Strien 2010). The farmland bird indicator (FBI) is the most widely used such multi-species indicator in Europe, which based on population trends of common bird species related to farmland habitat and indicates the adverse changes in this habitat in relation to the Common Agricultural Policy (CAP) in many EU countries (Gregory *et al.* 2005). Several countries and the EU are increasingly using these measures to assess sustainable development strategies, environmental and ecosystem health (Gregory & van Strien 2010).

The concept developed by Gregory *et al.* (2003, 2005) let to consider more indicators for other habitats or group of species when relevant classification of species available based on quantitative data and/or expert judgement guided by additional information. The classification of species to a specific habitat generally could be proper for most of the species in each region and country in Europe, however in the case of some species marked differences exist among regions and countries because of natural and human related (e.g. different farming practices) reasons. The EBCC has recognised this problem and suggested different species for the main European biogeographical regions to calculate indicators for farmland, forest and others habitat types nationally, regionally and continentally (http://www.ebcc.info) (Gregory & van Strien 2010), based on Tucker and Evans (1997) and on experts (invited from most of the European countries) judgement. The common bird monitoring schemes with random sampling design can make it possible to use quantitative approaches to classify species to specific habitats depending on the available habitat information (Julliard *et al.* 2003, 2006).

In Hungary, country-wide habitat survey was carried out in the frame of the CORINE land cover program between 1998–2003 producing a high resolution 1:50 000 GIS database (Büttner & Maucha 2006), which coincided with the start of the MMM scheme where locations of field observations are in a GIS database. These databases allow us to investigate the habitat preference and habitat occupancy of the common bird species at the level of landscape and to verify existing classification for the Hungarian populations of these species and developing further indicators considering habitat and migration strategies of the breeding species based on ringing data (Csörgő *et al.* 2009).

Our aim in this paper to provide an overview of the main characteristics of the Hungarian common bird monitoring scheme (MMM), from the sampling design, monitoring protocol until the trend estimation. We aim to provide information about the frequency and trends of bird species observed during the breeding and wintering season in Hungary. Based on the MMM database with combination of existing CORINE land cover GIS data, we overview the habitat occupancy and preference of the common breeding bird species in Hungary, considering the four main habitat types (urban, farmland, forest, wetland) which provide option to develop relevant habitat related indicators in this region. We investigate differences in population trends between species groups with different habitat classification, occupancy and preference and with different migration strategies.

Material and Methods

The Hungarian common bird monitoring scheme (MMM) is based on point count in grid cells with semi-random sampling design. The surveyed sites are 2.5×2.5 km UTM squares (Universal Transverse Mercator geographic coordinate system), randomly selected for each observer within a minimum of 10 km radius area around a locality specified by the observer. Observers carried out 5 minute long point counts at 15 points, randomly selected from the 25 potential points within the 2.5×2.5 km UTM squares, where points were separated by 500 m. The staff of the MMM scheme send high resolution map (1:15 000) of the selected 2.5×2.5 km UTM squares which contains position and 50, 100 m radius area of the 25 points within the squares. Coordinates of the UTM square and 25 points in a GoogleEarth format are available for the observers on the MMM website (mmm.mme.hu). Selection of the points within the UTM squares done in the first year of the selection of the UTM squares. In the first year the observers received a list of the 15 selected points (using latin square approach) from the staff of the MMM, which they must survey within the UTM squares. The observers could change some points to another one only in the case of specific situation (closed area, very difficult to reach by e.g. river, highway etc.) using a random list of points to change the formerly suggested to another one. The points which were selected and surveyed in the first year investigated during the following years. Each year, the observers asked to draw a simple map for the 100 m radius area of each point in a specific field book to show the different habitat patches, using Hungarian habitat classification codes (Á-NÉR; Fekete *et al.* 1997). During the five minute counts the observers asked to indicate in the field book the distance of the observed birds using 0–50, 51–100, 100–200 m distance categories and a separate category for birds flied over the 100 m radius area of the points.

Survey of the breeding population happen twice per spring with minimum 2 weeks between sampling sessions from mid April to mid June since 1999. The count at the selected points took place between 5 and 10 am, when wind speed is less then 5m/s and there is no rain. Survey of the wintering population happen once in January since 2000. The count at the selected points took place between 6 and 16 hour, when wind speed is less then 5m/s and there is no raining/snowing. Time of the observation and wind speed (Beaufort scale) recorded at each point in the field book.

Observers asked to fill a form (which contains all bird species occurring in Hungary) after the field work in which form they indicated for each species their skill of identification of the species using four categories (by view, by sound, by view and sound, uncertain). This confidently handled database let us to consider the reason of absence of species in the surveyed 2.5×2.5 km UTM square, when large number of observers (~1000 observers) with various identification skills were contributed (Szép & Gibbons 2000).

For each species, we retained the maximum count per point for the two spring sessions and one count for the winter session. Counts were summed for the 15 points within each square for each year. Between 1999 and 2012, 15199 points in 984 pieces of 2.5×2.5 km UTM squares were surveyed during the breeding season by 762 observers. Between 2000–2012, 5768 points in 401 pieces of 2.5×2.5 km UTM squares were surveyed during the wintering season by 302 observers.

For the analysis, we considered only the field data of points which matched the requirement of field protocol and only for data of species where the given observer was able to identify the species by view and/or sound. In the case of the spring survey, there were 12219 points in 824 pieces of 2.5×2.5 km UTM squares which were surveyed according to the standard field protocol *(Figure 1a)*. 240 bird species were seen/heard at these points, 389 542 individuals of 214 species surveyed within 100 m radius area of these points *(Supplement 1).* In the case of the winter survey there were 5380 points in 371 pieces of 2.5×2.5 km UTM squares which were surveyed according to the standard field protocol *(Figure 1b)*. 143 bird species were seen/heard at these points, 307 675 individuals of 140 species were surveyed within 200 m radius area of these points *(Supplement 2).*

Frequency of the surveyed breeding/wintering species was calculated annually by using the ratio of 2.5×2.5 km UTM squares where the given species was seen/heard to all 2.5×2.5 km UTM squares where the given species was surveyed by observers who were able identify the given species by view and/or song. Mean frequency with SE was estimated from annual frequency of the 1999–2012 years for breeding populations and from 2000–2012 years for wintering populations, observed minimal and maximal annual frequency values are given as well *(Supplement 1, 2)*.

Habitat occupancy and preference of the surveyed species (Chamberlain & Fuller 1999) during the breeding season were investigated on the base of CORINE land cover CLC50 GIS database made between 1998–2003 in Hungary (Büttner & Maucha 2006). The spatial resolution of the CORINE CLC50 is 4 ha (1 ha for water bodies). We used this database to classify the habitat

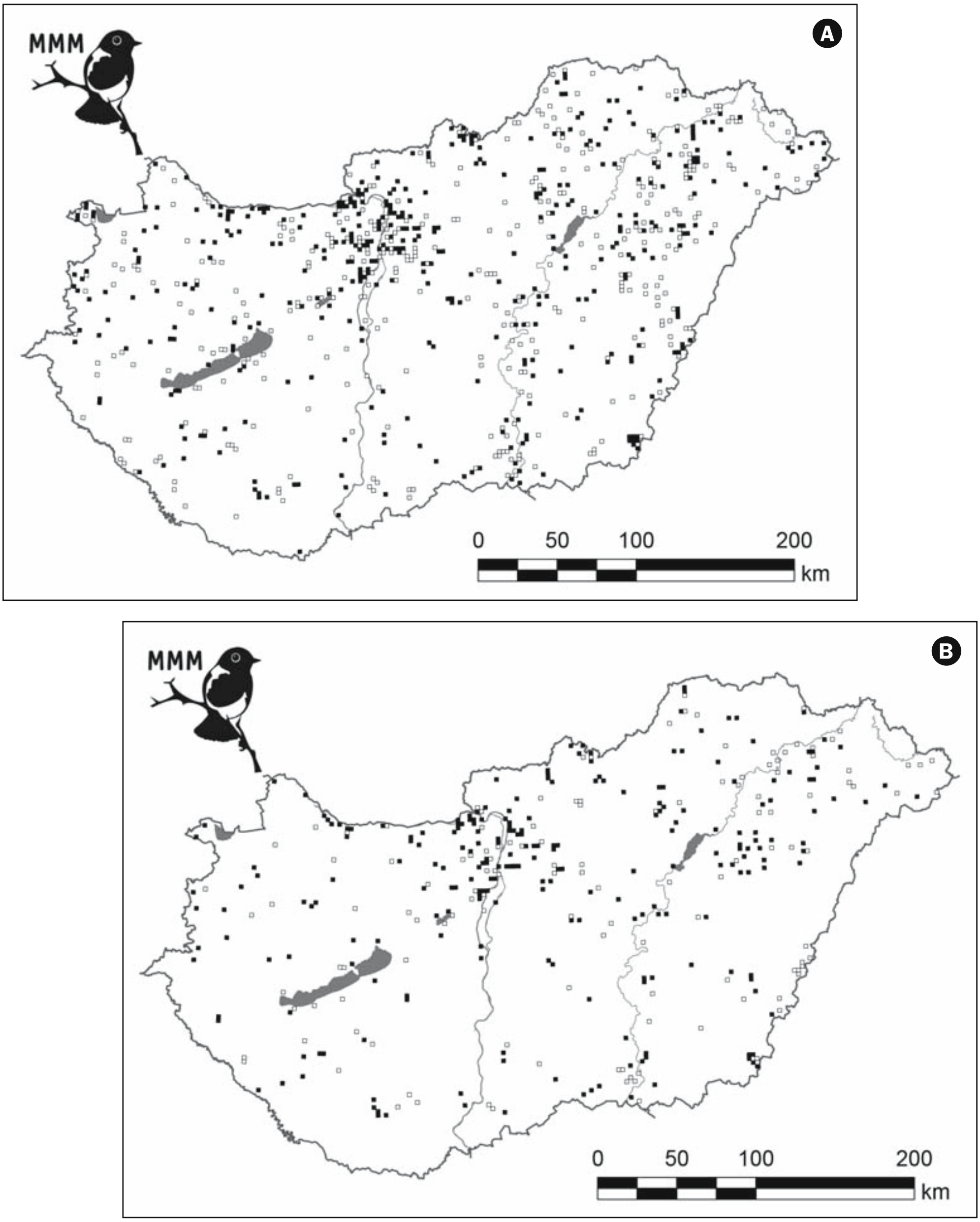


Figure 1. 2.5×2.5 km UTM squares in Hungary surveyed following the standard protocol of the MMM (a) during the breeding seasons of 1999–2012, (b) during the wintering seasons of 2000–2012. Open squares indicated UTM squares surveyed in one year, black squares surveyed more than one year

1. ábra Azon 2,5×2,5 km UTM négyzetek Magyarországon, amelyeket az MMM standard protokollja alapján mértek fel (A) a fészkelési időszakban 1999–2012 során, (B) a telelési időszakban 2000–2012 során. Az üres négyzetek azokat az UTM négyzeteket jelzik, amelyeket csak egy évben, a fekete négyzetek azokat, amelyeket több mint egy évben mértek fel

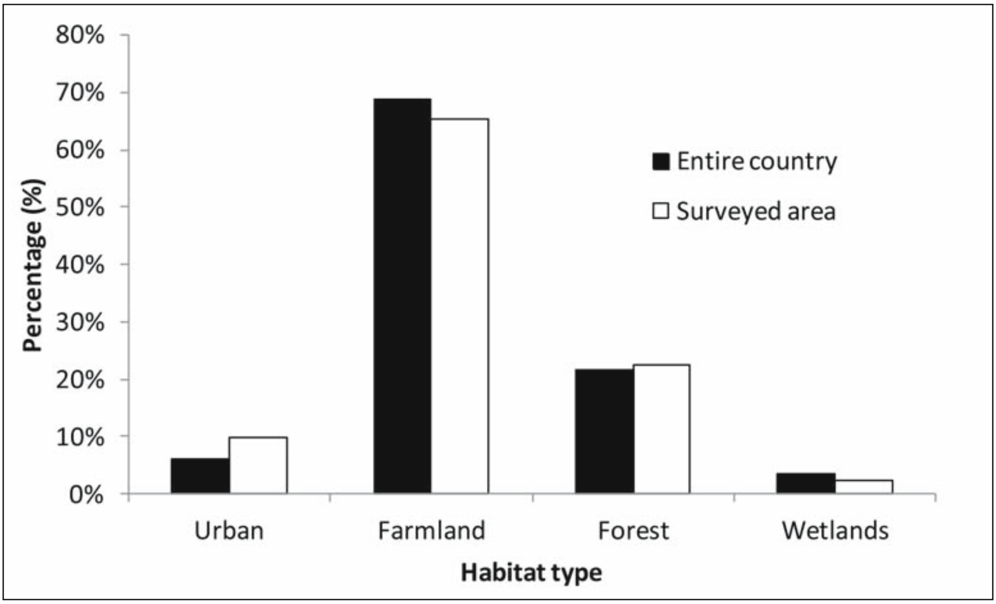


Figure 2. Distribution of the studied four main habitat categories (based on CORINE land cover) in the entire area of Hungary and in the 100 m radius area of the surveyed points (surveyed following the standard protocol of the MMM)

2. ábra A vizsgált négy fő élőhely típus (urbán, mezőgazdasági, erdei, vizes, CORINE land cover adatbázis alapján azonosítva) százalékos területi aránya Magyarországon (Entire country) és az MMM keretében standard módon felmért 100 m sugarú megfigyelési pontok területén (Surveyed area)

types of 100 m radius area of each surveyed points. Habitat was classified into four coded categories: farmland, forest, wetlands and urban habitats on the base of CORINE 1:50000 scale Land Cover first level of habitat description (1: urban, 2: farmland, 3: forest, 4-5: wetlands). Some CORINE habitats (3.2.1.1., 3.2.1.2., 3.3.3.1., 3.3.3.2., 3.3.3.3.) which mainly used for farming instead of forestry in Hungary were classified as farmland habitats. Percentage of the investigated four main habitat categories within the 100 m radius areas of the surveyed points (points surveyed following standard protocol considered, n=12 219) showed similar distribution as the percentage of these habitats in the entire country *(Figure 2)*. The percentages of the urban and forest habitats were little higher in the surveyed area compared to the country total.

Habitat preference of the species was investigated by comparing the relative density of the species in the studied four main habitat categories (Chamberlain & Fuller 1999). The habitat with the highest relative density was identified as preferred habitat of the species. Species regarded as having mixed habitat preference, when relative density was high in more than one habitat. The relative density (observed individual per km^2 in the breeding season) of each species in each main habitat type was calculated on the base of individuals counted in 100 m radius area of the points where more than 2/3 (66%) of the 100 m radius area covered by the given main habitat type (11062 points, 90.5% of the all surveyed 12219 points were considered) *(Supplement 3)*. In the case of points where survey was made for several years, the mean relative density value was used. All points were considered where the observers were able to identify the given species by view and/or song including zero observations. There were 175 points where birds were not observed, and 97% of these points were covered with farmland habitat type.

We investigated the distribution of the Hungarian breeding population of the species among the four main habitat categories to investigate the habitat occupancy of the species in Hungary, based on the relative density of the species estimated by the MMM *(Supplement 3)*. On the basis of mean relative density of the species in the studied four habitat types, we estimated the population size for each species for the four main habitat categories, using the size of the area of the given habitat types in Hungary and investigated the proportion of the estimated population size in the given habitat to the country total. The main habitat type used by the species in Hungary was selected when more than 2/3 (66%) of the estimated population of the given species observed in the given habitat type (urban, farmland, forest, wetlands). Habitat occupancy regarded as mixed in other cases.

The annual population trends for each species were calculated using TRIM software (Pannekoek & van Strien 2001) which allows for missing counts in the time series and produces unbiased yearly indices and standard errors using Poisson regression (log-linear models; McCullagh & Nelder 1989). TRIM is used frequently in the case of national common bird monitoring schemes in Europe (Gregory *et al.* 2008, 2009). In the case of the breeding population, we used annual counts within the 100 m radius area of the surveyed 15 points in the 2.5×2.5 km UTM squares for trend analysis, whereas in the case of the wintering population, we used annual counts within the 200 m radius area, because of the lower bird density and better detectability in winter. For the analysis of the trend we considered only 2.5×2.5 km UTM squares, which were surveyed at least in two years (407 UTM squares in the breeding season, 239 UTM squares in the wintering season).

For the trend modelling we used the 'Time Effect' basic model of the TRIM (expecting effects for each site and year) (Pannekoek & van Strien 2001). In the case of less common species for which no data was available for some years, linear trend with change points (for years when data available) model of TRIM (Pannekoek & van Strien 2001) was used following the suggestions of the PECBMS for national trends (www.ebcc.info/pecbm/html). The counts were weighted to handle the oversampling in some counties (larger percent of area surveyed in the given county, in the given year for the given species comparing to the entire surveyed area than the ratio of the area of the given county to the entire country). Missing counts of particular sites were estimated ('imputed') from changes in all other sites (Pannekoek & van Strien 2001). The TRIM produced imputed yearly indices for each species which were used for calculating indicators (available: mmm.mme.hu). Indices of the first year of the survey (breeding season: 1999, wintering season: 2000) was the base year with value 1 and all other indices were calculated relative to this base time point. In addition, serial correlation was taken into account. The estimated slopes of the population trend (overall additive slope, based on imputed data, TRIM) reflect average percentage change per year. The overall slope estimate in TRIM software is converted into discrete categories (trend classification, van Strien *et al.* 2001). The category depends on the overall slope as well as its 95% confidence interval. Based on the EBCC classification we categorized the bird species on a five-point scale: steep decline (–2), moderate decline (–1), stable (0), moderate increase (+1), and strong increase (+2). Steep decline or strong increase classified by TRIM when slope was lower/higher than (–/+) 5% per year, ((–/+) 5% would mean halving/doubling in abundance within 15 years) (van Strien *et al.* 2001). Moderate decline/increase was considered when the trend was significant but its level does not reach the level of steep decline/increase. When the trend was not significant but the confidence limits were sufficiently small, the species was classified as a stable population. If the trend of the given species was not significant and the confidence limits were large, the population trend was classified as uncertain (van Strien *et al.* 2001). During comparison of trends of different groups of species we only considered species which trend was significantly increasing, decreasing or classified as stable. Calculating different indicators we considered species with uncertain trends as well but we excluded data of species from our analysis for which uncertain trend coincided with large standard error of the estimated slope (SE>0.1) to avoid potential biases arising from substantial changes remaining unnoticed due to the large standard errors of the trend estimate.

Migratory strategy of breeding species in Hungary was classified as resident, partial and short distance and long-distance migrant on the base of the Hungarian Bird Migration Atlas (Csörgő *et al.* 2009). We used the Hungarian Bird Migration Atlas (Csörgő *et al.* 2009) to classify the wintering species in Hungary in categories as species formed fully/partly by Hungarian breeding population and as species formed fully by foreign populations.

Indicators, based on groups of species classified by migration strategies, habitat occupancy/preference, sources of wintering population in Hungary and EBCC PECBMS list for Continental biogeographical regions of Europe (version 2013 http://www.ebcc.info), calculated by geometric mean of annual indices (with standard error) of the species considered in the given group following Gregory *et al.* (2005). We used linear regression to analyse the trends of the indicators.

Results

Species frequency in the breeding and wintering season

In the breeding season, from the observed 240 species, mean annual frequency of 106 bird species was higher than 5% *(Supplement 1)* and these species were considered for further analysis *(Table 1)*. During the winter, 140 species were detected from which mean annual frequency of 57 species was higher than 5% *(Supplement 2)* and considered for trend estimation of wintering species *(Table 2)*.

Habitat occupancy and preference of common bird species in the breeding seasons

There were 211 species which were observed within 100 m radius area of the 11062 points where main habitat type was classified on the basis of CORINE land cover *(Supplement 3)*. Habitat occupancy, classified by habitat where more than 2/3 of the population of the given species observed, showed that among the investigated 106 species the farmland habitat was the most used (44 species, 41.5%), the second was the forest habitat (21 species, 19.8%), the third was the wetland (4 species, 3.8%). There was no species where 2/3 of the population observed in urban habitat, however there were 37 species (34.9%) where the population occurred in large percent in more than one habitat, which were categorized to mixed habitats *(Table 3)*.

Each species which preferred the farmland habitat (20 species) were observed in that habitat to the largest percentage as well. In the case of species with preference of forest habitat (36 species), more than half of them observed in the forest habitat type (58.3%) and the rest (41.7%) used mixed habitats dominantly. In the case of species which preferred the wetland habitat (22 species), most of them (50%) occurred dominantly in the farmland habitat, the second most used habitat was the mixed type (31.8%) and only 4 species (18.2%) observed dominantly in wetland habitat. Species with main preference of urban habitat (16 species) occurred the most in mixed habitats (62.5%) and the rest in farmland (37.5%). Species with no specific habitat preference (12 species) occurred the most in farmland habitat (58.3%) and the rest in mixed habitats (41.7%) *(Table 3)*.

Habitat classification

For some species the habitat classification for the Continental part of Europe suggested by the Pan-European Common Bird Monitoring Scheme (PECBMS) differs from the results we obtained for the population breeding in Hungary. Based on the available data there is opportunity to consider additional/different species and categories for classification.

Among the 22 species classified as farmland bird species in the PECBMS there were two *(Emberiza citrinella, Streptopelia turtur)* which density was the highest in forest habitats and the habitat occupancy indicated mixed habitats (farmland and forest) in Hungary, thus the best to consider these species as species using mixed habitats *(Table 1)*. There were 17 species in the PECBMS list suggested as common birds which use 'others' habitats (no farmland/forest birds or using mixed habitats), however more than 2/3 of the population of these species occurred in farmland habitats in Hungary, thus the breeding population of these species was highly dependent on farmland habitats. Among these 17 species, there were four species *(Phasianus colchicus, Merops apiaster, Anthus campestris, Locustella naevia)* which species preferred the farmland habitats, the rest preferred the urban habitat *(Pica pica, Carduelis carduelis)*, the wetland habitat *(Ardea cinerea, Circus aeruginosus, Tringa totanus, Acrocephalus schoenobaenus, Acrocephalus palustris, Acrocephalus arundinaceus)* or had no obvious preference (mixed habitats) *(Buteo buteo, Upupa epops, Motacilla alba, Oenanthe oenanthe, Corvus corone cornix)*. Above the formerly mentioned species, there were 7 breeding species which populations dominantly (2/3) occurred in farmland habitat in Hungary and needed to reconsider as species highly related on farmland. Among these species three preferred farmland *(Circus pygargus, Coturnix coturnix, Tringa glareola)*, three preferred wetland *(Botaurus stellaris, Egretta alba, Riparia riparia)* and one preferred urban habitat *(Falco subbuteo)*.

In the case of 22 species classified as forest bird by PECBMS, there were 6 species *(Accipiter nisus, Picus viridis, Anthus trivialis, Sylvia atricapilla, Phylloscopus trochilus* and *Muscicapa striata)* which used mixed habitats in Hungary on the base of habitat occupancy and their populations depend on more than one habitat (farmland and forest). There were five species *(Dendrocopos major, Lullula arborea, Erithacus rubecula, Parus caeruleus, Fringilla coelebs)* which suggested as species with 'others' habitat occupancy by PECBMS, however these species preferred the forest habitat and more than 2/3 of the population occurred in forest habitat in Hungary.

There were four species among the 106 most common species *(Phalacrocorax carbo, Nycticorax nycticorax, Anser anser, Locustella luscinioides)* which population dominantly (2/3) occurred in wetland habitat in Hungary.

There were 37 species where dominant part of the population occurred in more than one habitat type in Hungary and we regard them as species using mixed habitat type. Habitat preference of these species: (27%) urban, (40.5%) forest, (18.9%) wetland, (13.5%) no preference (mixed habitat). 25 species of these species were classified in 'others' category by the PECBMS as well.

Population trend and migration strategies

There were 26 species with decreasing, 28 species with increasing and 20 species with stable population trends and 33 species with uncertain trend on the basis of trend classification criteria of the TRIM program *(Table 1)*. There was a significant difference in the population trends (decreasing, stable, increasing) regarding the different migration strategies (resident, partial and short distance migrant, long distance migrant) *(χ^2=14.494, P=0.005, Fisher's Exact Test) (Figure 3)*.

There was no difference in the population trend between resident and partial and short distance migrant species *(χ^2=0.284, P=1, Fisher's Exact Test)*. The number of species with increasing trend was higher (52.6%, 53.6%) than the number of species with decreasing or stable trend (26.3%, 21.4%).

Comparison of population trends of long distance migrant species to resident and partial and short distance migrant species showed that long distance migrant species had different population trends *(χ^2=14.420, P<0.001, Fisher's Exact Test)*. In the case of the long distance migrant species the proportion of species with decreasing population trend (57.8%) was higher than species with increasing (7.7%) and stable population trend. Among the long distance migrant species there were only two species *(Jynx torquilla, Ficedula albicollis)* with increasing population trend.

Population trends and habitat occupancy

The population trends showed different pattern among species using different habitats classified by habitat occupancy (farmland, forest and mixed) *(χ^2=15.714, P=0.003, Fisher's Exact Test) (Figure 4)*. There was significant difference in the trends between the number of species mainly using farmland habitat compared to the number of species mainly using forest habitat *(χ^2=15.192, P<0.001, Fisher's Exact Test)*. More than half (51.6%) of the species which dominantly occurred in farmland habitat had decreasing trends, and only 16.1% had increasing trends. In the case of species which mainly occurred in forest habitat, increasing trends found for 73.3% of the species and only one species *(Lullula arborea)* of this group (6.7%) had decreasing trend.

Decreasing trends were more common among farmland birds compared to species with mixed habitat usage but the differen-

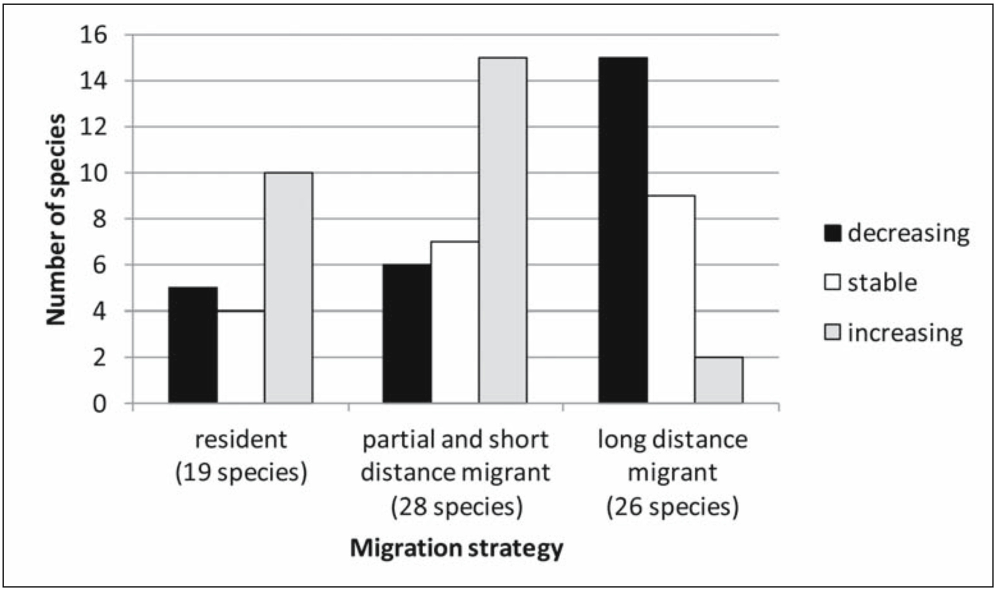


Figure 3. Population trends and migration strategies of species for which significant decreasing, increasing and stable trend were properly estimated by the TRIM software

3. ábra A TRIM program alapján szignifikáns csökkenő, stabil és növekedő állomány trendet mutató fajok száma a vizsgált három vonulási stratégiával (állandó, részlegesen/rövidtávon vonuló, hosszútávon vonuló) jellemezhető csoportok esetében. A csoportonként figyelembe vett fajok száma zárójelben megadva

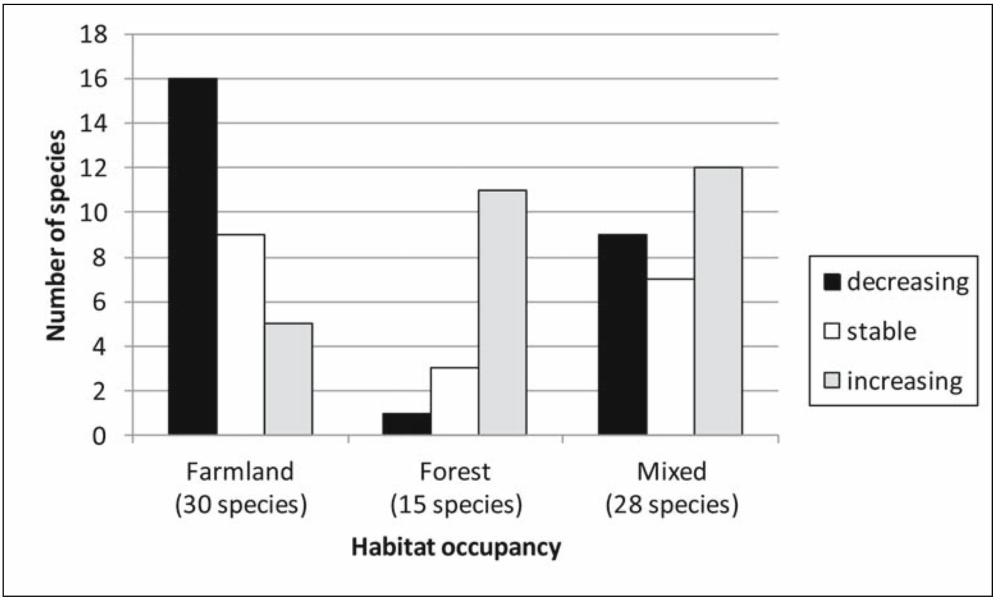
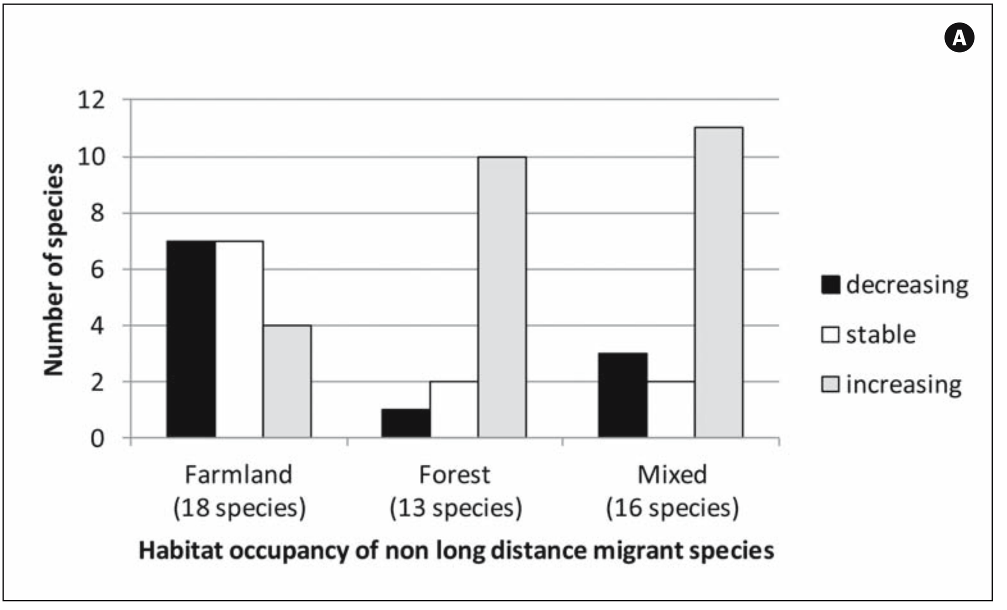


Figure 4. Population trends and habitat occupancy of species for which significant decreasing, increasing and stable trend were properly estimated by the TRIM software

4. ábra A TRIM szoftver alapján szignifikáns csökkenő, stabil, növekedő állomány trendet mutató fajok száma a vizsgált három élőhely használattal (mezőgazdasági, erdei, vegyes) jellemezhető csoportok esetében. A csoportonként figyelembe vett fajok száma zárójelben megadva



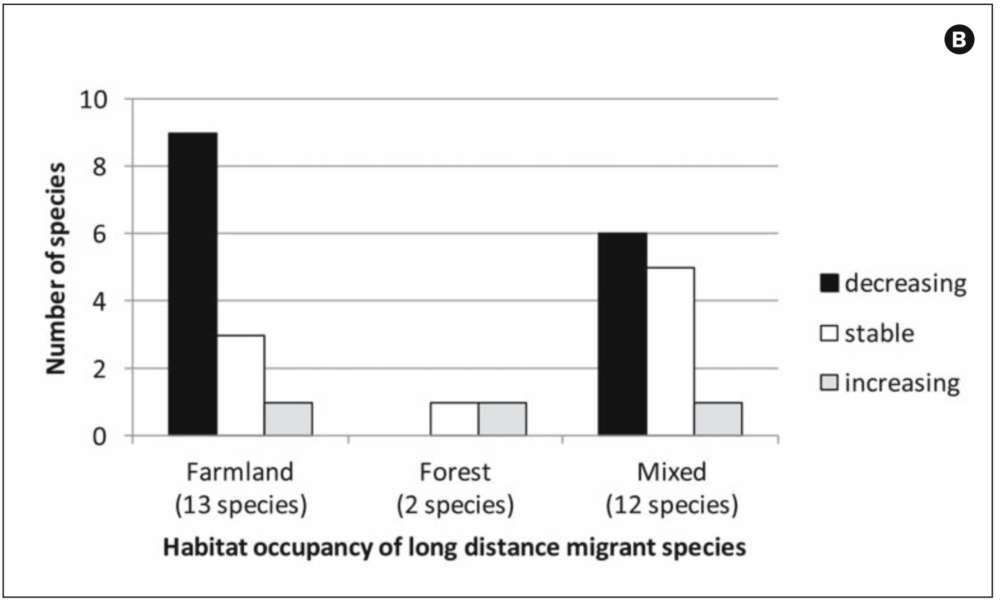


Figure 5. Population trends and habitat occupancy of (A) resident, partial and short distance migrant species and (B) long distance migrant species for which significant decreasing, increasing and stable trend were properly estimated by the TRIM software

5. ábra A TRIM program alapján szignifikáns csökkenő, stabil, növekedő állomány trendet mutató, (A) nem hosszútávon vonuló, (B) hosszútávon vonuló fajok száma a vizsgált három élőhely használattal (mezőgazdasági, erdei, vegyes) jellemezhető csoportok esetében. A csoportonként figyelembe vett fajok száma zárójelben megadva ce was not significant *(χ^2=5.126, P=0.087, Fisher's Exact Test)*. Increasing trend among species which use forest habitat was more common than among species which use mixed habitat but the difference was not significant between these groups *(χ^2=4.383, P=0.107, Fisher's Exact Test)*.

Population trends, migration strategies and habitat occupancy

Among the 47 non long distance migrant species (resident and partial and short distance migrant), there were significant difference between number of species with increasing, stable and decreasing trends using different habitats *(χ^2=11.341, P=0.018, Fisher's Exact Test) (Figure 5a)*. Population increase was less common (22.2%) among species which use mainly farmland habitat, comparing to the number of species mainly using forests (76.9%) *(χ^2=8.814, P=0.015, Fisher's Exact Test)* and compared to number of species which mainly use mixed habitat (68.8%) *(χ^2=7.269, P=0.026, Fisher's Exact Test)*. There was no significant difference between the number of species which use mainly forest and mixed habitats *(χ^2=0.832, P=0.844, Fisher's Exact Test)*. In the case of these groups the most species had increasing trends.

In the case of the 27 long distance migrant species for which proper trend data was available to classify population trends (decreasing, stable, increasing) there was no significant difference between groups of species with different habitat occupancy *(χ^2=5.106, P=0.262, Fisher's Exact Test) (Figure 5b)*.

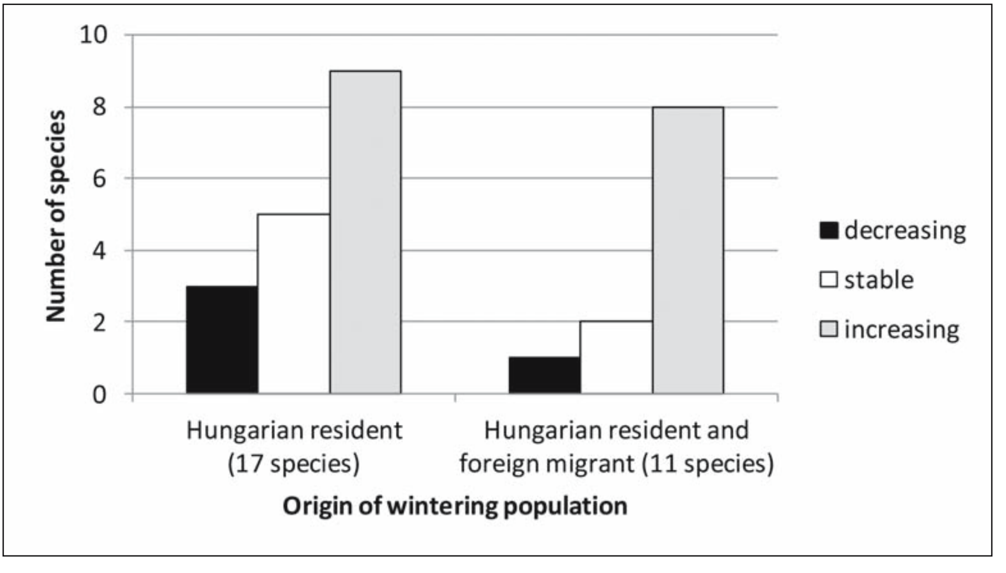


Figure 6. Population trends of wintering species and origin of these populations (1) mainly from Hungarian resident population, (2) from Hungarian resident and foreign migrant populations, for which significant decreasing, increasing and stable trend were properly estimated by the TRIM software

6. ábra A TRIM program alapján szignifikáns csökkenő, stabil, növekedő állomány trendet mutató telelő fajok száma az állományok származása alapján (1- főként magyar állandó állomány, 2- magyar és külföldi vonuló állomány) jellemezhető csoportok esetében. A csoportonként figyelembe vett fajok száma zárójelben megadva

Population trend of the wintering species in Hungary

There were 4 species with significantly decreasing population, 7 species with stable population trend and 17 species with significantly increasing population *(Table 2)* based on the trend classification criteria of the TRIM.

Population trends of the species which wintering population mainly formed by the Hungarian resident population did not show difference from species formed by mixed Hungarian resident and foreign wintering populations *(χ^2=1.063, P=0. 638, Fisher's Exact Test) (Figure 6)*.

Indicators of the breeding season

For the calculation of indicators of different migration strategies and habitat occupancy, we considered the annual indices of 101 species. From the 106 species for which trends were estimated, we excluded data of five species *(Anser anser, Circus pygargus, Tringa glareola, Apus apus, Anthus pratensis)* with extremely uncertain trends, which showed very high standard error of the estimated slope (SE>0.1).

Migration strategies

We calculated three indicators from the annual population indexes of the studied spe-

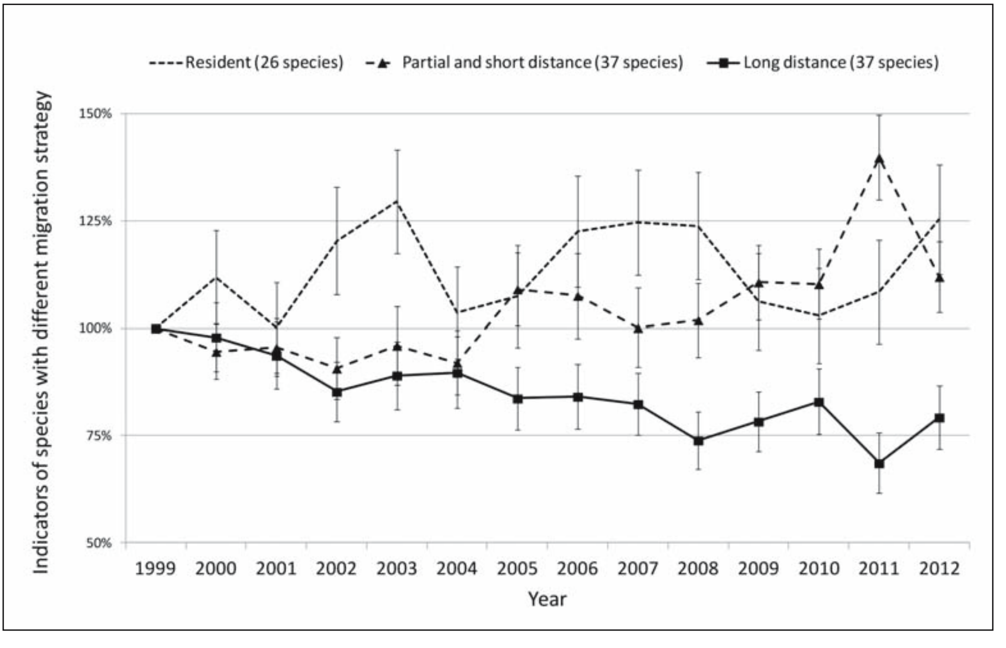


Figure 7. Indicators values of resident, partial and short distance migrant and long distance migrant bird species for the period of 1999–2012 in Hungary. Geometric mean (SE) calculated for each groups on the base of annual imputed index produced by TRIM software. Number of species considered for each groups is given in bracket

7. ábra Állandó, részlegesen/rövidtávon vonuló és a hosszútávon vonuló madárfajok indikátor értékei Magyarországon 1999–2012 között. Mértani átlag, annak hibája (SE) számolva minden csoport esetében a TRIM program éves imputed index értékei alapján. A csoportonként figyelembe vett fajok száma zárójelben megadva cies on the basis of migration strategies as: 1- resident species indicator (26 species), 2- partial and short distance migrant species indicator (37 species) and 3- long distance migrant species indicator (37 species) *(Figure 7)*.

In the case of the indicator of long distance migrants there was a significantly decreasing trend *(slope= -0.018 (SE=0.003), F=41.083, df=1,12, P<0.001, R^2=0.774)*.

Indicators of partial and short distance migrant species showed significantly increasing trends during the studied period *(slope= 0.021 (SE=0.006), F=12.597, df=1,12, P=0.004, R^2=0.512)* whereas trend of the indicator of resident species was not significant *(F=0.690, df=1,12, P=0.422)*.

Habitat usage

We calculated indicators from the annual population indices of the studied species based on the habitat occupancy for 1- farmland habitat (FAH) (41 species), 2- forest habitat (FOH) (21 species) and 3- mixed habitats (MIH) (36 species) *(Figure 8a)*.

The indicator based on all bird species using dominantly farmland in Hungary (FAH) showed significant decrease *(slope= -0.011 (SE=0.003), F=10.801, df=1,12, P=0.007, R^2=0.474)*.

Indicators of species using forest (FOH) showed significantly increasing trend *(slope= 0.031 (SE=0.004), F=57.468, df=1,12, P<0.001, R^2=0.827)*, whereas trend of the indicator of species using mixed habitats (MIH) was not significant *(F=0.258, df=1,12, P=0.620)*.

We calculated indicators using the PECBMS list for Continental part of Europe as well: 1- Farmland Bird Indicator (FBI) (21 species), 2- forest bird indicator values (22 species) and indicators for 'others' species using mixed and/or other habitats (45 species) *(Figure 8b)*.

Farmland Bird Indicator (FBI) based on the PECBMS list showed significant decreasing trend *(slope= -0.020 (SE=0.005), F=13.551, df=1,12, P=0.003, R^2=0.530)*.

Indicator of forest birds has significant increasing trend *(slope= 0.028 (SE=0.005), F=32.080, df=1,12, P<0.001, R^2=0.728)*. Indicator of species classified as 'others' in the PECBMS list showed no significant trend *(F=2.324, df=1,12, P=0.153)*.

In the case of farmland habitat indicator (FAH) we calculated three partial indicators based on the habitat preference: 1- farmland birds with preference of farmland habitat (FAFH) (17 species), 2- farmland birds with preference of wetland habitat (FAWH) (11 species), 3- farmland birds with preference of urban and mixed habitat (FAMH) (13 species) *(Figure 9)*.

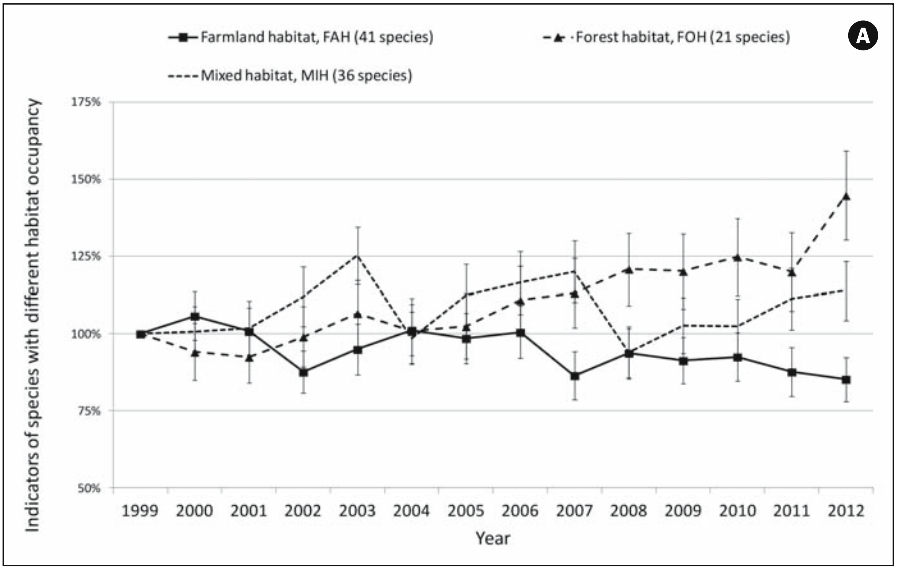
In the case of indicators based on species preferred the farmland habitat (FAFH) there was a significant decline *(slope= -0.026 (SE=0.004), F=53.560, df=1,12, P<0.001, R^2=0.817)*.

Indicators of farmland species with urban/mixed habitat preference (FAMH) and indicators of farmland birds with preference of wetland habitats (FAWH) there was no significant trend (FAMH*: F=0.162, df=1,12, P=0.694;* FAWH: *F=0.195, df=1,12, P=0.666*).

Migration strategy and habitat usage of breeding population

We calculated specific indicators for considering migration strategy (long distance migrant vs. non long distance migrant) and habitat occupancy *(Figure 10)*.

Indicators of non long distance migrant species with farmland habitat occu-



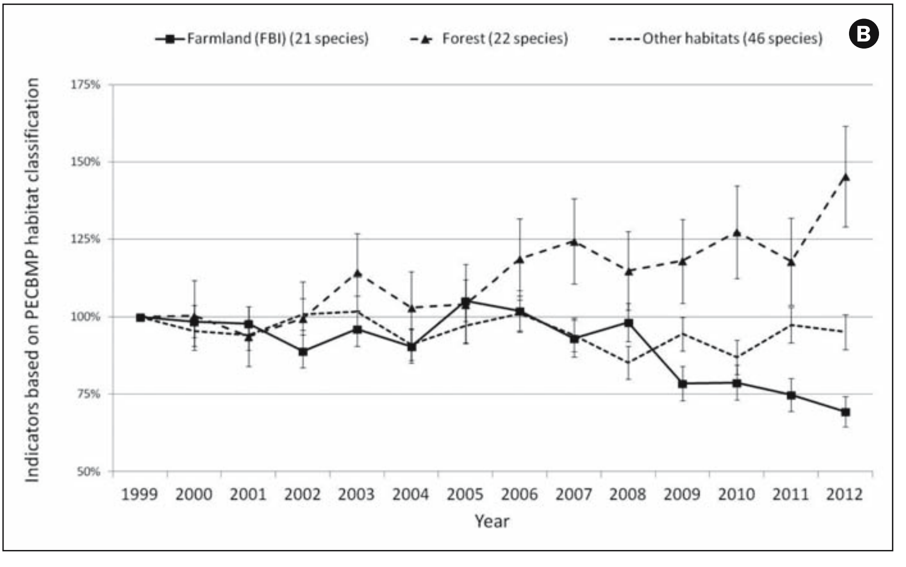


Figure 8. Indicators values of species grouped (A) on the base of habitat occupancy in Hungary (B) on the base EBCC PECBMS list for Continental Europe. Species considered as using mixed habitat if less than 2/3 of the population occurred in the most used main habitat type (urban, farmland, forest, wetland). Species grouped to other habitats when use other habitats than farmland and forest or use several habitats. Geometric mean (SE) calculated for each groups on the base of annual imputed index produced by TRIM software. Number of species considered for each groups is given in bracket

8. ábra Indikátor értékek (A) a magyarországi élőhely használat, és (B) az EBCC PECBMS Kontinentális lista élőhelyi besorolása alapján alkotott fajcsoportok esetében. Amennyiben adott faj hazai állományának kevesebb, mint 2/3-a volt megfigyelve egy adott fő élőhely típusban (urbán, mezőgazdasági, erdei, vizes) a fajt vegyes (mixed) élőhely használatúként volt kezelve. Az EBCC PECBMS esetén az egyéb (others) csoportba azokat a fajokat sorolták, amely nem mezőgazdasági (FBI) vagy erdei, illetve vegyes élőhellyel jellemezhető. Mértani átlag, annak hibája (SE) számolva minden csoport esetében a TRIM program éves imputed index értékei alapján. A csoportonként figyelembe vett fajok száma zárójelben megadva

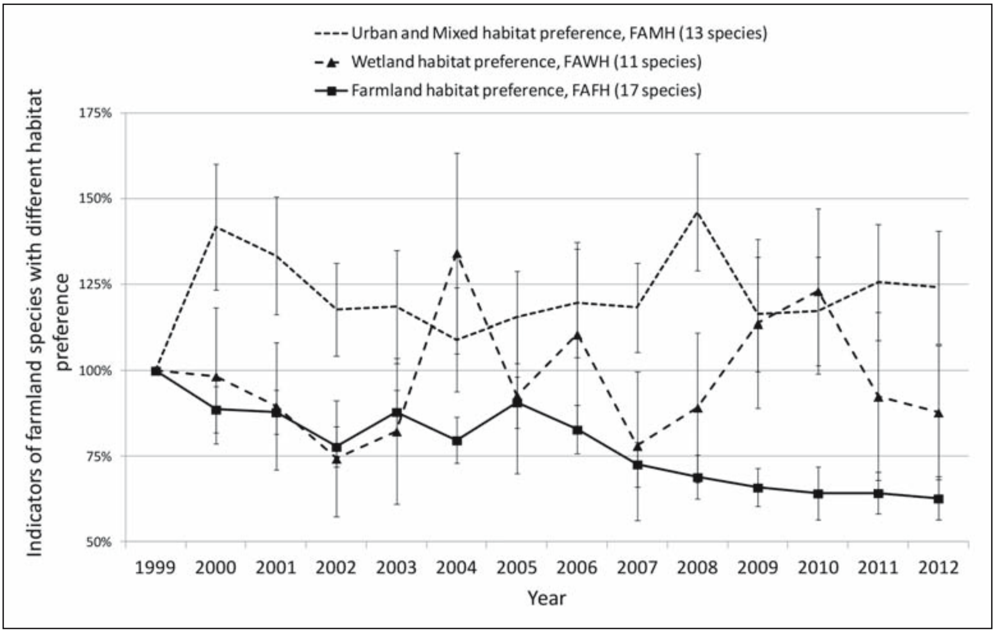


Figure 9. Indicators values of species use mainly the farmland habitat and grouped on the base of habitat preference in Hungary. Species preferred urban and mixed habitat types handled in one group. Geometric mean (SE) calculated for each groups on the base of annual imputed index produced by TRIM software. Number of species considered for each groups is given in bracket

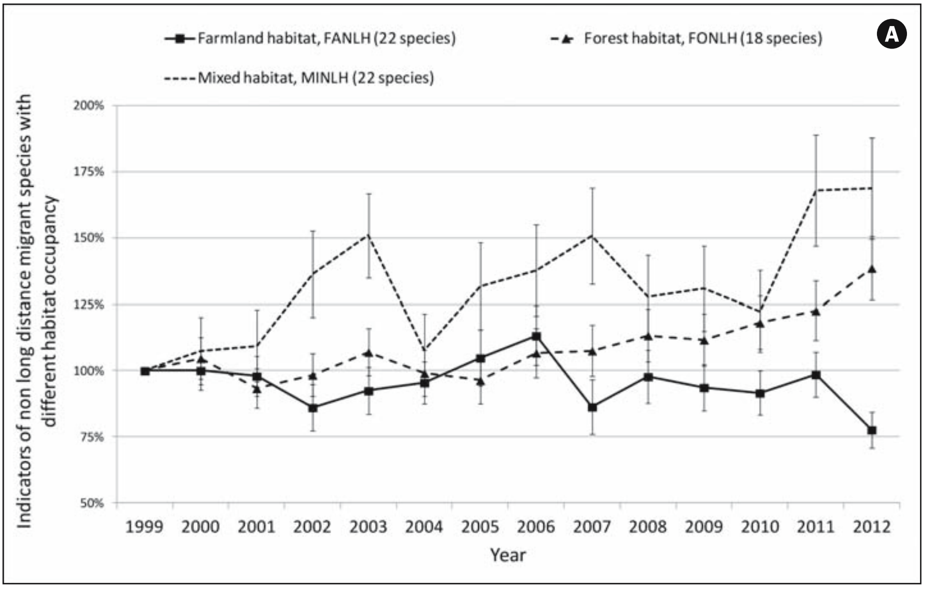
9. ábra Indikátor értékek a Magyarországon a mezőgazdasági élőhelyet használó és különböző élőhely preferenciával (urbán és vegyes, vizes, mezőgazdasági) jellemezhető fajcsoportok esetében. Az urbán és vegyes élőhelyeket preferáló madárfajok egy csoportba sorolva. Mértani átlag, annak hibája (SE) számolva minden csoport esetében a TRIM program éves imputed index értékei alapján. A csoportonként figyelembe vett fajok száma zárójelben megadva

pancy (FANLH) had no significant trend *(F=1.384, df=1,12, P=0.262)*, whereas indicators of species with similar migration strategy but different habitat occupancy (forest, mixed habitat) had significant increase (FONLH: *slope= 0.026 (SE=0.005), F=26.203, df=1,12, P<0.001,* R^2*=0.704*; MINLH: *slope= 0.033 (SE=0.012), F=7.036, df=1,12, P=0.022,* R^2*=0.39*) *(Figure 10a)*.

Indicators of long distance species with farmland and mixed habitat occupancy showed significant decreasing trends, the level of decrease was higher for indicator of species with mixed habitat occupancy (FALH: *slope= -0.015 (SE=0.005), F=8.856, df=1,12, P=0.012,* R^2*=0.425*; MILH: *slope= -0.028 (SE=0.005), F=29.060, df=1,12, P<0.001,* R^2*=0.708*) *(Figure 10b).*

Indicators based on population trends of the wintering species in Hungary

From the 57 species for which trends were estimated, we excluded data of seven species *(Anser fabalis, Anser albifrons, Anser anser, Haliaeetus albicilla, Accipiter gentilis, Larus ridibundus, Fringilla montifringilla)* with very high standard error of the estimated slope (SE>0.1).



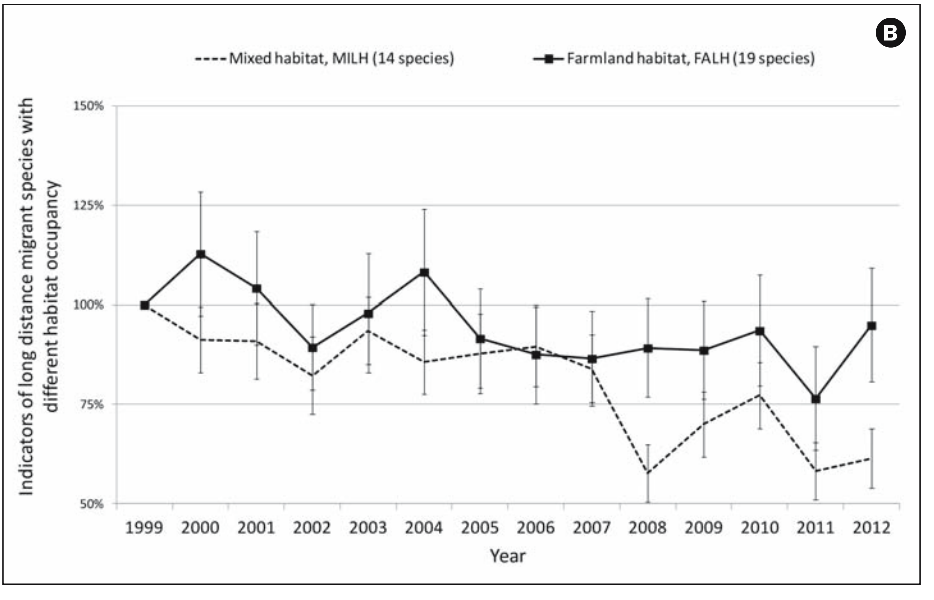


Figure 10. Indicators values of (A) non long distance migrant (resident, partial and short distance) species (B) long distance migrant species grouped on the base of habitat occupancy in Hungary. Species considered as using mixed habitat if less than 2/3 of the population occurred in the most used main habitat type (urban, farmland, forest, wetland). Geometric mean (SE) calculated for each groups on the base of annual imputed index produced by TRIM software. Number of species considered for each groups is given in bracket

10. ábra Indikátor értékek (A) nem hosszútávon vonuló (állandó, részlegesen/rövidtávon vonuló), (B) hosszútávon vonuló fajok különböző élőhelyeket (mezőgazdasági, erdei, vegyes) használó fajcsoportjaik esetében. Amennyiben adott faj hazai állományának kevesebb, mint 2/3-a volt megfigyelve egy adott fő élőhely típusban (urbán, mezőgazdasági, erdei, vizes), a fajt vegyes (mixed) élőhely használatúként volt kezelve. Mértani átlag, annak hibája (SE) számolva minden csoport esetében a TRIM program éves imputed index értékei alapján. A csoportok esetében figyelembe vett fajok száma megadva a zárójelben

We calculated indicators for wintering species, which wintering population in Hungary formed fully or partly by the Hungarian breeding population, based on the habitat occupancy of the Hungarian breeding population: 1- wintering species with farmland habitat occupancy (WFAH), 2- wintering species with forest habitat occupancy (WFOH), 3- wintering species with mixed habitat occupancy (WMIH) *(Figure 11)*.

Indicators of wintering species with farmland habitat occupancy and mixed habitat occupancy in the breeding season showed significant increasing trends during 2000–2012, species with mixed habitat occupancy had the strongest increase (WFAH: *slope= 0.049 (SE=0.020), F=6.261, df=1,11, P=0.029,* R^2*=0.363*; WMIH: *slope= 0.101 (SE=0.013), F=60.017, df=1,11, P<0.001,* R^2*=0.845*).

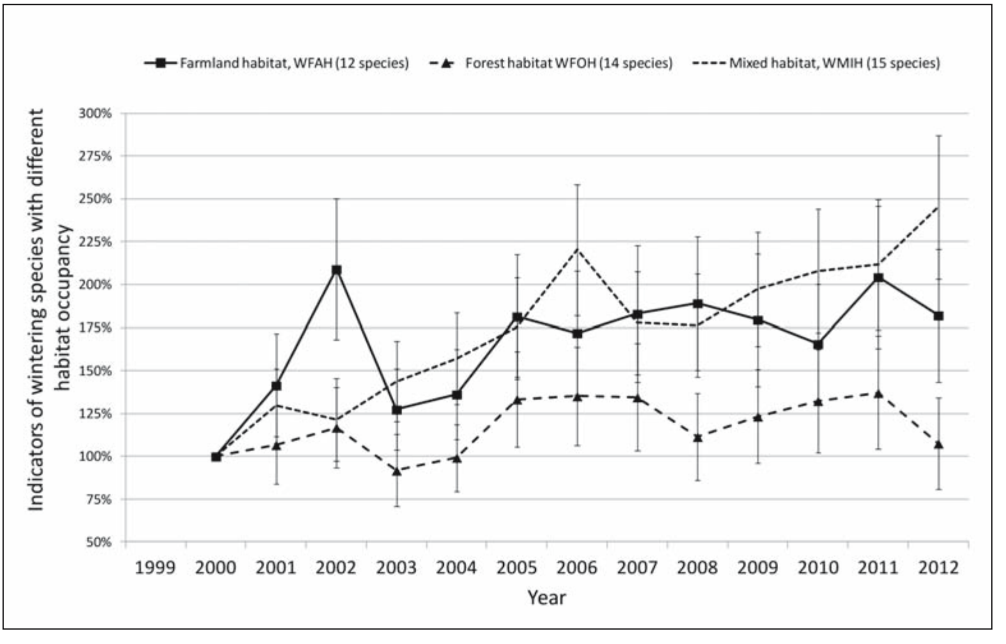


Figure 11. Indicators values of wintering species grouped on the base of habitat occupancy in Hungary in the breeding season. Only wintering species were considered which wintering population formed fully and/or partly by Hungarian breeding population. Species considered as using mixed habitat if less than 2/3 of the population occurred in the most used main habitat type (urban, farmland, forest, wetland) in the breeding season. Geometric mean (SE) calculated for each groups on the base of annual imputed index produced by TRIM software. Number of species considered for each groups is given in bracket

11. ábra A különböző élőhelyeket használó (mezőgazdasági, erdei, vegyes), Magyarországon telelő fajcsoportok indikátor értékei. Csak azon telelő fajok figyelembe véve, amelyek telelő állománya részben vagy egészben a hazai fészkelő állományhoz tartozik. Amennyiben adott faj hazai állományának kevesebb, mint 2/3-a volt megfigyelve egy adott fő élőhely típusban a fészkelési időszakban (urbán, mezőgazdasági, erdei, vizes), a faj vegyes (mixed) élőhely használatúként volt kezelve. Mértani átlag, annak hibája (SE) számolva minden csoport esetében a TRIM program éves imputed index értékei alapján. A csoportok esetében figyelembe vett fajok száma megadva a zárójelben

Indicator of wintering species with forest habitat occupancy (WFOH) had a weak not significant increasing trend (*slope= 0.021 (SE=0.011), F=3.853, df=1,11, P=0.075*).

Discussion

The MMM monitoring scheme provided the first relevant information about the frequency of the breeding and wintering species in Hungary, based on quantitative data of representative sampling of the main habitats and covering the entire country. We were able to identify 106 breeding and 57 wintering common species in Hungary, proper for investigating the habitat relation of these species and estimating trends in the scale of the country. The standardised field protocol let to compare frequencies of bird species active during daylight but this protocol was not proper for rare species and for species with high activity at night as most owl or crake species. During the comparison of the estimated frequencies the differences in the detectability of the species (Bibby *et al.* 2000) has to be considered as well.

We used information based on trend classification by TRIM (increase, stable, decline) to investigate the species trends first because it provides a more conservative and robust approach than considering the value of estimated slope of each investigated species, including species with uncertain trends. We have developed indicators for migratory strategies and habitat occupancy considering these characteristics in combination, using Gregory *et al.* (2005) approach based on annual population indices produced by the TRIM. These indicators could provide detailed information about groups of species and habitats they use by considering more species than the former analysis based data of species only with trend classification.

Among the 74 breeding species for which direction of the population trends were classified, there was significant difference on the basis of migration strategy among the species. Population decline was significantly more common among the long distance migrant species than among resident, partly or short migrant species. Among the 27 investigated long distance migrant common species in Hungary, more than half had significant decline. There was an opposite situation in the case of the 47 resident, partial and short migrant species, where more than half of them has increasing trend in Hungary. Indicators of migration strategies of common breeding bird species in Hungary, in accordance with the analysis based on species with trend classification, showed continuous decline of the long distance migrant birds and an opposite increase of the partial and short distance species *(Figure 7)*.

Our result is in concordance with several studies which showed the most threatened status of long distance migrant species in Europe comparing with species with other migration strategies (Berthold *et al.* 1998, Sanderson *et al.* 2006, Møller 2008, Heldbjerg & Fox 2008, Jiguet *et al.* 2009). The decline of the long distance migrants is a general phenomenon in Europe and presumably the climate change has an important role (Both & Visser 2001, Both *et al.* 2006) among others as habitat change, agricultural intensification. Opposite trends of partial and short distance migrant species comparing to long distance migrant species in Hungary support the importance of climate change related issues to explain the found processes (Jiguet *et al.* 2010). The observed trends are usually a combination of breeding and non-breeding area effects, which both affected by climate change (Morrison *et al.* 2013).

Monitoring of common bird species with formal sampling protocol let us to monitor not only the given species but the condition of habitats these species use for breeding/foraging (Bibby 1999, Gregory *et al.* 2005). One of the main purpose of the MMM like common bird monitoring schemes in Europe (e.g. Gregory *et al.* 1996, Del Moral *et al.* 2010, Jiguet *et al.* 2012) is to use groups of species as indicators of the main habitats, for which species selection has a crucial importance (Gregory *et al.* 2005). In the case of the most common bird species in Europe, the classification of species in relation to the habitat to which the species highly related as Tucker and Evans (1997) present, allow to form groups for indicators. However, investigation of the list of species considered as indicators of a given habitat in a given country or region is needed using quantitative data over the expert judgement (see Gregory & van Strien 2010), because of the differences of species habitat use among these geographical areas (frequency, importance of the given habitat type in nesting/foraging which could differ among countries)

In our work, we used the CORINE land cover GIS database of Hungary (Büttner & Maucha 2006) to investigate the habitat preference and habitat occupancy of the most common breeding species in Hungary on the base of the observation data of MMM at known localities between 1999 and 2012. There was no similar investigations in Hungary before, the existing general overview of Hungarian breeding species (Haraszthy 1998), contains information about habitat related information, based on studies which used different methods and carried out on varying spatial and temporal scale. The spatial resolution of the used CORINE habitat database let us to investigate mainly at the level of landscape the relation of the given species to the four main habitat types (urban, farmland, forest, wetland). Estimating the relative densities of the given species in the main studied habitat types with knowing the extension of these habitats in Hungary allowed to estimate the distribution of the Hungarian population of these species among these main habitats which let us to investigate the habitat occupancy of these species.

Investigation of habitat occupancy of common species showed the large importance of farmland habitats on breeding fauna, more than 40% of the species dominantly use these habitats for nesting/foraging. The classification of habitat preference by comparing the relative densities of the species in the studied main habitat types, expecting the largest density in the preferred habitat (Brown 1969, Fretwell & Lucas 1970), allow to investigate in more detail the relation of the given species to the studied habitats. This kind of approach of habitat preference admitted that e.g. the most *Acrocephalus* species preferred the wetland habitat, however at the same time dominant part of the population use the farmland habitat in Hungary. The spatial resolution of the used CORINE land cover is coarse, and it is not possible to identify the smaller than (1–4 ha) size wetland patches in the farmland areas, which can explain the 'contradiction'. However, these small patches of wetland habitat are important part of the farmland landscape in Hungary, management and using (e.g. melioration) is highly related to the practice in this habitat in Hungary which suggests to consider these species for indicator of farmland habitat as well.

Considering the habitat occupancy of the studied species altogether with habitat preference (Chamberlain & Fuller 1999), using estimations based on large relevant dataset, allow us to verify the internationally suggested list of indicators (PECBMS) for the region of Hungary and to develop country specific new indicators of habitats. In the case of the list of farmland bird indicator (FBI) of the PECBMS (22 species), we found that the FBI largely consider species with obvious usage of farmland habitats in Hungary. We identified two species only in the FBI list *(Streptopelia turtur* and *Emberiza citrinella)* where nor the habitat occupancy and nor the habitat preference did not relate dominantly to farmland habitat in Hungary. Among the 44 species, which breeding populations in Hungary dominantly use the farmland habitat, we identified three groups on the base of the habitat preference (farmland, wetland, urban and mixed habitat). On the base of these groups, we developed specific indicators of the farmland habitats which allow to use country specific farmland bird indicators, which could indicate processes in the farmland in more detail, than using only one simple indicator. Our work let us to investigate the species list of forest and mixed habitat indicators of PECBMS and to develop country specific list for these indicators as well.

Significant declining population trends were more common among those breeding species, which dominantly use the farmland habitat in Hungary *(Figure 4)*. More than half of farmland species with trend classification had significant decline whereas in the case of species with forest habitat occupancy, more than 2/3 of species had significant increasing trend. We have found the same direction in the case of indicators based on habitat occupancy. The farmland birds had significant declining trend and the birds of forest had significant increasing trend. Our results are similar as found on the level of Europe (Gregory *et al.* 2007, Gregory & van Strien 2010). This general pattern can be observed in most European countries, but the detailed trends and the underlying causes can be very different (Wretenberg *et al.* 2006, Reif *et al.* 2008). Considering the species selection of the PECBMS for habitat indicators yield similar results as habitat indicators based on classification of our habitat occupancy data which considered more species. The decline of farmland species was more steep using PECBMS species list (FBI) comparing to indicators based on habitat occupancy (FAH) in Hungary. In the case of indicators of the farmland habitat based on habitat occupancy data (FAH) more species (41 species) were considered than in the case of farmland bird indicator (FBI) of the PECBMS (21 species) and FAH formed by species with different habitat preference which condition we need to consider. We developed three separate indicators for species dominantly use the farmland habitat in Hungary on the base of the habitat preference. Indicator of farmland bird species with preference of farmland habitat (FAFH) showed steep significant decline, whereas indicators of farmland birds with preference of wetland and urban and mixed habitat did not show declining trends *(Figure 9)*. Our results showed that behind the decline of the farmland birds the farmland related effects could play the main role.

Our results suggest that in Hungary the indicator based on species with habitat preference and occupancy of farmland habitat (FAFH) could be the most adequate indicator to follow the condition of farmland habitat in Hungary and similar selection criteria could be adequate for forest habitat (FOH). All investigated indicators of farmland birds (FBI, FAH, FAFH) showed that declining trend has started after joining of Hungary to the EU in 2004.

The increase of forest birds, indicated by large number of these species with increasing trends and the increasing trends of indicators of forest birds *(Figure 4, 8)* very probably indicate the extension of the areas of forest in Hungary. The forested area increased with 7% in Hungary during 2000–2012 (www.ksh.hu) mainly by acacia and poplar afforestation in areas used for farming formerly. The afforestation could explain the decrease of several farmland species as well (Butler *et al.* 2010). The observed pattern is very similar to found in the Czech Republic (Reif *et al*. 2007).

To interpret the found population trends we need to consider the migratory strategy of these species above the habitat usage because of the opposite processes of long distance versus non long distance migrant species in Hungary. Among non long distance migrants, for which the increase were the commonest trend, species with farmland habitat occupancy were not able to benefit the same level of the potentially climate related positive changes (Jiguet *et al.* 2010) as species with forest and mixed habitat occupancy. Only the 22% of species which use dominantly the farmland habitat had significant increase, while the declining and stable trends are more common *(Figure 5)*. Indicators combining migration strategy and habitat occupancy, in concordance with analysis of trend classification, showed that indicators of non long distance migrant, which dominantly use the forest and the mixed habitat had significant increase but for species using farmland there was no similar trend *(Figure 10a)*. Populations of non long distance migrant species, using dominantly the farmland habitat, were not able to realise the benefit of climate related changes, which indicate the habitat related adverse effects independently from the influence of the migration strategy. Indicators of long distance species which use dominantly farmland and mixed habitat showed significant decline in both of these habitats.

The MMM provided the first relevant information about trends of wintering common bird species in Hungary. Among the investigated 57 species, the trends were classified for 28 species. Nearly 2/3 of the wintering species in Hungary had significant increasing trend and only 4 species had decreasing trends. The available data did not show marked difference in the distribution of these trends between wintering population of species formed mainly from Hungarian populations and wintering population of species formed partly or fully from foreign populations. Based on the existing trend data, the wintering condition probably became more favourable than adverse in Hungary during 2000–2012. Indicators of wintering species, grouped on the basis of habitat occupancy of the Hungarian population in the breeding season showed contradictory results. Indicators of species with farmland and mixed habitat occupancy had increasing trend during the wintering whereas indicators of forest species there was no obvious trend. Indicators of the farmland species had decreasing trend during the breeding season in Hungary and behind the opposite trend of the indicator of farmland habitat during the wintering season, one can expect the influence of the foreign wintering populations, mainly arrive from northern, northeast and east directions to Hungary. These large areas probably covered mainly with non EU member countries, however we have limited information about origin and size of these populations.

We pointed out that long distance migrant bird species had strong decreasing trends in Hungary and very probable in the entire Pannonian biogeographical region, based on the

Hungarian common bird monitoring scheme (MMM), which is the longest running country-wide monitoring using formal sampling design with representative data for the main habitats in Central-Eastern Europe. We showed that partial and short migrant species has increasing trends, in accordance with expectation of effects of climate change (Jiguet *et al.* 2010), which admitted by the increasing trend of common wintering species in Hungary. Beside the climate related effects, that habitat related influences are important factors as well behind the found processes. We pointed out that farmland birds had declining trend, which trend became more obvious since the joining of Hungary to the EU.

Our work show, that negative changes in the farmland habitat could influence bird species nesting/foraging mainly in this habitat independently from their migration strategies. Our results show the increasing importance to monitor the effects of Common Agricultural Policy (CAP) and the efficiency of the mitigation of the adverse effect of the CAP in the frame of Agri-Environmental Schemes (AES) (Butler *et al.* 2010) in Hungary as the modelling of future land-use changes in this region suggest further declines of farmland birds (Schoelfield *et al.* 2011). In concordance with Both *et al.* (2010), our results suggest that long distance migrant species are in most severe condition in highly seasonal habitats. Our investigations of habitat occupancy and preference of the common bird species let us to develop indicators on the base migration strategy and habitat usage of common birds to provide regular data about condition of group of species and their habitat in Hungary and the Pannonian region. The MMM database provide unique opportunity for further investigations of several species, habitats and area specific in a part of Europe where this kind of information is more than rare yet, as several former studies done (Nagy & Szép 2009, Mag *et al.* 2011, Seres *et al.* 2012).

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Table 1. Mean frequency (SE), type of trend with slope (SE) values, habitat occupancy, preference, EBCC PECBMS list for Continental Europe habitat classification and migration strategy of the most common 106 bird species (frequency larger than 5%) during the breeding season between 1999–2012 in Hungary on the base of MMM data. Mean frequency (SE) estimated from the annual frequencies (n=14). Trend type: (–2) steep decline, (–1) moderate decline, (0) stable, (1) moderate increase, (+2) strong increase, (u) uncertain trend. Habitat categories of habitat usage, habitat preference and PECBMS (EBCC): (1) urban, (2) farmland, (3) forest, (4) wetlands, (5) mixed/others. Migration strategies: (1) resident, (2) partial and short distance migrant, (3) long-distance migrant (*: P<0.05, **: P<0.01, # uncertain migration strategy)

1. táblázat A leggyakoribb 106 fészkelő madárfaj átlagos gyakorisága, átlag hibája (SE), a trend típusa és az átlagos éves változás értéke, átlag hibája (SE), élőhely használata, élőhely preferenciája, EBCC PECBMS Kontinentális Európa élőhely klasszifikációja és a vonulási stratégiája a Magyarországon az MMM keretében, a fészkelési időszakban 1999 és 2012 között gyűjtött adatok alapján. Az átlagos gyakoriság az évenként számolt gyakorisági értékek alapján számolva (n=14). Trend típus: (–2) erős csökkenés, (–1) mérsékelt csökkenés, (0) stabil, (1) mérsékelt növekedés, (+2) erős növekedés, (u) bizonytalan trend. Az élőhely használat, preferencia és a PECBMS (EBCC) besorolásnál használt élőhely típusok: (1) urbán, (2) mezőgazdasági, (3) erdei, (4) vizes élőhely, (5) vegyes/egyéb. Vonulási stratégiák: (1) állandó, (2) részlegesen, rövidtávon vonuló, (3) hosszútávon vonuló (*: P<0.05, **: P<0.01, # bizonytalan a vonulási stratégiájú)

Species	Mean frequency		Trend				Habitat			Migration
	(%)	(SE)	type	slope	(SE)		usage	pref.	EBCC	strategy
Phalacrocorax carbo	7.8	0.8	u	0.041	0.076		4	4		2
Botaurus stellaris	6.8	1.1	u	–0.075	0.058		2	4		2
Nycticorax nycticorax	7.6	1.0	u	–0.065	0.059		4	4		3
Egretta alba	19.7	2.2	2	0.242	0.064	**	2	4		2
Ardea cinerea	35.0	1.5	2	0.142	0.031	**	2	4	5	#
Ardea purpurea	5.6	0.4	u	0.026	0.059		5	4		3
Ciconia ciconia	30.2	1.1	u	–0.010	0.021		2	4	2	3
Anser anser	5.8	1.1	u	0.095	0.147		4	4		2
Anas platyrhynchos	44.9	1.7	u	0.026	0.014		5	4	5	2
Circus aeruginosus	43.0	1.2	u	–0.032	0.018		2	4	5	3
Circus pygargus	5.1	0.6	u	0.058	0.240		2	2		3
Accipiter gentilis	6.4	0.4	u	–0.008	0.080		5	3		1
Accipiter nisus	12.6	0.9	u	0.022	0.062		5	3	3	1
Buteo buteo	80.3	1.0	0	0.005	0.011		2	5	5	1
Falco tinnunculus	30.0	1.3	u	–0.021	0.023		2	2	2	2
Falco subbuteo	8.0	0.6	u	0.167	0.083		2	1		3
Perdix perdix	5.4	0.7	–1	–0.107	0.040	**	2	2	2	1
Coturnix coturnix	44.4	1.4	–1	–0.064	0.011	**	2	2		2
Phasianus colchicus	90.8	0.7	0	–0.001	0.006		2	2	5	1
Fulica atra	10.5	0.9	u	0.057	0.034		5	4	5	2
Vanellus vanellus	36.5	1.2	0	0.003	0.013		2	2	2	2
Tringa totanus	10.8	0.8	–1	–0.062	0.030	*	2	4	5	2
Tringa glareola	5.7	1.1	u	–0.093	0.220		2	2		3

Species	Mean frequency		Trend				Habitat			Migration
	(%)	(SE)	type	slope	(SE)		usage	pref.	EBCC	strategy
Larus ridibundus	19.2	1.5	u	0.073	0.044		5	4		2
Columba livia f. domestica	30.0	1.7	u	0.051	0.026		5	1		1
Columba oenas	13.4	1.4	1	0.073	0.035	*	3	3	3	2
Columba palumbus	69.4	1.7	1	0.061	0.010	**	5	5	5	2
Streptopelia decaocto	65.8	0.7	1	0.030	0.006	**	5	1	5	1
Streptopelia turtur	72.7	1.0	0	–0.003	0.007		5	3	2	2
Cuculus canorus	89.6	0.6	–1	–0.021	0.007	**	5	5	5	3
Apus apus	9.1	0.6	u	–0.156	0.370		5	1	5	3
Merops apiaster	27.6	1.3	–1	–0.056	0.028	*	2	2	5	3
Upupa epops	30.3	0.8	u	–0.023	0.015		2	5	5	2
Jynx torquilla	28.2	1.0	1	0.045	0.017	**	5	3	5	3
Picus viridis	23.6	0.9	1	0.057	0.019	**	5	3	3	1
Dryocopos martius	23.3	1.3	u	0.032	0.020		3	3	3	1
Dendrocopos major	57.1	1.2	1	0.016	0.007	*	3	3	5	1
Dendrocopos syriacus	8.5	0.5	–1	–0.081	0.038	*	5	1	5	1
Dendrocopos medius	11.5	0.6	0	–0.001	0.022		3	3	3	1
Dendrocopos minor	9.5	0.8	u	–0.021	0.030		3	3	3	1
Galerida cristata	33.6	1.3	–1	–0.057	0.011	**	2	2	2	1
Lullula arborea	12.6	0.8	–1	–0.078	0.022	**	3	3	5	2
Alauda arvensis	85.1	1.0	–1	–0.023	0.004	**	2	2	2	2
Riparia riparia	9.7	0.7	u	–0.013	0.078		2	4		3
Hirundo rustica	79.2	1.1	–1	–0.070	0.011	**	2	1	2	3
Delichon urbica	42.2	1.5	–1	–0.071	0.018	**	5	1	5	3
Anthus campestris	8.6	1.0	u	–0.021	0.057		2	2	5	3
Anthus trivialis	26.6	1.4	0	–0.017	0.013		5	3	3	3
Anthus pratensis	5.2	0.6	u	0.090	0.103		2	2	2	2
Motacilla flava	45.5	1.2	0	0.008	0.007		2	2	2	3
Motacilla alba	47.1	1.4	0	–0.004	0.009		2	5	5	2
Troglodytes troglodytes	15.6	1.3	u	0.014	0.019		3	3	3	2
Erithacus rubecula	40.8	0.9	1	0.028	0.007	**	3	3	5	2
Luscinia megarhynchos	75.6	0.8	0	0.005	0.005		5	3	5	3
Phoenicurus ochruros	43.1	0.8	1	0.049	0.007	**	5	1	5	2
Saxicola rubetra	24.7	1.2	–1	–0.039	0.018	*	2	5	2	3
Saxicola torquata	63.8	1.1	–1	–0.023	0.008	**	2	4	2	2
Oenanthe oenanthe	12.7	0.6	u	–0.045	0.026		2	5	5	3
Turdus merula	82.9	1.2	1	0.018	0.004	**	5	1	5	2
Turdus philomelos	53.3	2.1	1	0.059	0.007	**	3	3	3	2
Turdus viscivorus	5.5	0.6	u	0.057	0.042		3	3	3	2
Locustella naevia	12.3	1.0	–2	–0.125	0.031	*	2	2	5	3
Locustella fluviatilis	23.7	2.2	–1	–0.072	0.018	**	5	4	5	3
Locustella luscinioides	18.6	1.1	u	–0.032	0.021		4	4		3
Acrocephalus schoenobaenus	27.5	1.5	–1	–0.037	0.015	*	2	4	5	3
Acrocephalus palustris	21.2	0.8	–1	–0.073	0.016	**	2	4	5	3
Acrocephalus scirpaceus	17.0	1.4	–1	–0.030	0.015	*	5	4	5	3

Species	Mean frequency		Trend				Habitat			Migration
	(%)	(SE)	type	slope	(SE)		usage	pref.	EBCC	strategy
Acrocephalus arundinaceus	46.1	1.4	0	–0.002	0.009		2	4	5	3
Hippolais icterina	5.6	0.4	u	–0.076	0.044		5	5	5	3
Sylvia nisoria	18.5	0.9	0	0.010	0.015		2	2	2	3
Sylvia curruca	34.0	1.4	0	–0.010	0.014		5	5	5	3
Sylvia communis	45.6	1.3	–1	–0.023	0.009	**	2	2	2	3
Sylvia borin	8.0	1.3	–2	–0.182	0.036	**	5	5	5	3
Sylvia atricapilla	74.6	1.0	1	0.043	0.004	**	5	3	3	2
Phylloscopus sibilatrix	26.7	2.0	0	0.007	0.014		3	3	3	3
Phylloscopus collybita	59.4	1.3	1	0.010	0.005	*	3	3	3	2
Phylloscopus trochilus	17.3	1.0	0	–0.009	0.016		5	3	3	3
Muscicapa striata	19.4	0.9	–2	–0.090	0.017	*	5	3	3	3
Ficedula albicollis	16.6	1.6	2	0.092	0.018	*	3	3	3	3
Aegithalos caudatus	25.8	1.0	1	0.063	0.015	**	5	3	5	1
Parus palustris	21.0	1.0	1	0.040	0.014	**	3	3	3	1
Parus ater	5.4	0.7	u	0.101	0.057		3	3	3	1
Parus caeruleus	36.6	1.4	1	0.045	0.009	**	3	3	5	2
Parus major	78.8	1.0	1	0.032	0.005	**	5	3	5	2
Sitta europaea	28.7	1.0	1	0.026	0.011	*	3	3	3	1
Certhia brachydactyla	9.5	0.8	u	–0.040	0.031		3	3	3	1
Oriolus oriolus	83.6	0.9	0	0.000	0.006		5	3	5	3
Lanius collurio	73.1	1.7	–1	–0.026	0.007	**	2	2	2	3
Lanius minor	17.7	1.3	–1	–0.054	0.020	**	2	2	2	3
Garrulus glandarius	49.8	1.4	0	0.012	0.009		3	3	3	1
Pica pica	49.3	1.0	1	0.018	0.009	*	2	1	5	1
Corvus frugilegus	21.1	0.9	u	–0.049	0.048		2	5	2	1
Corvus corone cornix	55.1	2.1	1	0.057	0.015	**	2	5	5	1
Corvus corax	24.1	1.5	1	0.110	0.041	*	5	3	5	1
Sturnus vulgaris	91.7	0.9	0	0.016	0.010		2	2	2	2
Passer domesticus	59.7	1.7	–1	–0.023	0.007	**	5	1	5	1
Passer montanus	78.8	0.9	1	0.013	0.007	*	2	1	2	1
Fringilla coelebs	78.7	1.4	1	0.029	0.005	**	3	3	5	2
Serinus serinus	35.3	1.5	–1	–0.031	0.010	**	5	1	5	2
Carduelis chloris	73.4	1.2	1	0.025	0.007	**	5	1	5	2
Carduelis carduelis	71.5	1.1	0	0.015	0.008		2	1	5	2
Carduelis cannabina	24.8	1.2	0	–0.001	0.015		2	1	2	2
Coccothraustres coccothraustes	28.0	1.1	2	0.079	0.014	*	3	3	3	2
Emberiza citrinella	59.0	1.2	0	–0.001	0.005		5	3	2	2
Emberiza schoeniclus	18.0	1.2	1	0.044	0.020	*	5	4	5	2
Miliaria calandra	62.0	1.9	–1	–0.025	0.008	**	2	2	2	1

Table 2. Mean frequency (SE), type of trend with slope (SE) values and source of wintering population of the most common 57 bird species (frequency larger than 5%) during the wintering season between 2000–2012 in Hungary on the base of MMM data. Mean frequency (SE) estimated from the annual frequencies (n=13). Trend type: (–2) steep decline, (–1) moderate decline, (0) stable, (1) moderate increase, (+2) strong increase, (u) uncertain trend. Source of wintering population: (1) formed fully/partly by Hungarian breeding population, (2) formed fully by foreign breeding populations (*: P<0.05, **: P<0.01)

2. táblázat A leggyakoribb 57 telelő madárfaj átlagos gyakorisága, átlag hibája (SE), a trend típusa és az átlagos éves változás értéke, átlag hibája (SE) és a telelő állomány származása a Magyarországon az MMM keretében, a telelési időszakban 2000 és 2012 között gyűjtött adatok alapján. Az átlagos gyakoriság az évenként számolt gyakorisági értékek alapján számolva (n=13). Trend típus: (–2) erős csökkenés, (–1) mérsékelt csökkenés, (0) stabil, (1) mérsékelt növekedés, (+2) erős növekedés, (u) bizonytalan trend. A telelő állomány származása: (1) teljesen vagy részben a magyar állomány, (2) főként külföldön fészkelő állomány (*: P<0.05, **: P<0.01)

Species	Mean frequency		Trend				Wintering
	(%)	(SE)	type	slope	(SE)		population
Phalacrocorax carbo	7.2	0.5	u	0.072	0.052		1
Egretta alba	10.0	0.8	u	–0.015	0.044		1
Ardea cinerea	11.8	1.0	1	0.136	0.058	*	1
Anser fabalis	7.0	1.1	u	0.038	0.154		2
Anser albifrons	8.9	1.9	u	0.228	0.222		2
Anser anser	7.0	1.9	u	0.159	0.377		1
Anas platyrhynchos	18.9	1.7	1	0.135	0.045	**	1
Haliaeetus albicilla	5.4	1.0	u	–0.205	0.118		1
Circus cyaneus	22.3	2.5	u	0.041	0.089		2
Accipiter gentilis	5.6	0.5	u	–0.241	0.136	*	1
Accipiter nisus	26.2	0.9	u	–0.032	0.045		1
Buteo buteo	81.3	1.0	0	0.020	0.011		1
Buteo lagopus	9.5	1.8	u	0.122	0.083		2
Falco tinnunculus	13.7	1.3	u	0.007	0.033		1
Phasianus colchicus	50.3	2.0	–1	–0.033	0.016	*	1
Larus ridibundus	5.9	0.4	u	0.160	0.160		1
Columba livia f. domestica	22.3	1.6	2	0.154	0.044	*	1
Streptopelia decaocto	40.5	1.0	1	0.080	0.023	**	1
Picus viridis	14.8	1.5	1	0.071	0.032	*	1
Dryocopos martius	20.8	2.0	1	0.088	0.035	*	1
Dendrocopos major	58.0	1.1	0	0.010	0.011		1
Dendrocopos syriacus	6.8	1.1	u	0.098	0.075		1
Dendrocopos medius	10.5	0.8	u	0.068	0.039		1
Dendrocopos minor	9.8	1.1	–1	–0.108	0.041	**	1
Galerida cristata	15.9	0.9	u	0.048	0.047		1
Troglodytes troglodytes	25.0	2.0	0	–0.005	0.019		1
Erithacus rubecula	15.2	1.6	u	0.030	0.030		1
Turdus merula	65.8	1.8	0	0.015	0.011		1
Turdus pilaris	55.1	4.2	u	0.004	0.026		2

Species	Mean frequency		Trend				Wintering
	(%)	(SE)	type	slope	(SE)		population
Turdus viscivorus	18.4	1.4	–1	–0.087	0.031	**	1
Regulus regulus	12.5	1.3	u	–0.032	0.036		2
Aegithalos caudatus	28.7	1.4	1	0.048	0.023	*	1
Parus palustris	29.9	1.4	1	0.059	0.021	**	1
Parus ater	6.9	0.9	u	0.056	0.082		1
Parus caeruleus	60.8	1.5	0	0.002	0.013		1
Parus major	88.0	1.3	1	0.038	0.008	**	1
Sitta europaea	33.8	1.1	1	0.028	0.013	*	1
Certhia familiaris	7.3	0.7	–1	–0.015	0.069	*	1
Certhia brachydactyla	11.2	1.3	u	–0.021	0.045		1
Lanius excubitor	24.9	1.1	u	0.008	0.022		2
Garrulus glandarius	51.1	1.5	0	0.008	0.012		1
Pica pica	44.2	1.9	u	0.026	0.014		1
Corvus frugilegus	42.8	1.6	u	–0.045	0.026		2
Corvus corone cornix	40.7	2.4	1	0.094	0.025	**	1
Corvus corax	29.5	1.6	1	0.105	0.039	**	1
Passer domesticus	43.4	2.3	u	–0.021	0.017		1
Passer montanus	60.1	1.5	0	–0.007	0.015		1
Fringilla coelebs	39.3	1.4	2	0.136	0.027	**	1
Fringilla montifringilla	16.8	2.5	u	0.131	0.118		2
Carduelis chloris	55.3	1.4	2	0.106	0.024	*	1
Carduelis carduelis	74.5	1.7	2	0.126	0.025	**	1
Carduelis spinus	13.3	1.8	u	0.090	0.045		2
Carduelis cannabina	21.0	1.4	u	0.052	0.043		1
Pyrrhula pyrrhula	30.4	3.4	1	0.065	0.025	*	2
Coccothraustres coccothraustes	28.7	1.8	1	0.062	0.029	*	1
Emberiza citrinella	34.6	1.3	u	0.057	0.041		1
Emberiza schoeniclus	19.4	2.0	u	0.000	0.040		1

Table 3. Number of species in relation to the habitat occupancy (more than 2/3 of the population occurred in the given habitat in Hungary) and habitat preference (the highest relative density found in the given habitat in Hungary). Only species with more than 5% frequency in Hungary considered

3. táblázat A különböző élőhely használattal (a hazai állomány több, mint 2/3-a az adott élőhely típusban volt felmérve) és élőhely preferenciával (a legnagyobb relatív denzitás az adott élőhely típusban volt) jellemezhető fajok száma. Csak a Magyarországon leggyakoribb fészkelő fajok (átlagos gyakoriság nagyobb, mint 5%) figyelembe véve (élőhelyek: mezőgazdasági, erdei, vizes, vegyes/egyéb)

	Habitat occupancy				
Habitat preference	Farmland	Forest	Wetlands	Mixed	Total
Urban	6	0	0	10	16
Farmland	20	0	0	0	20
Forest	0	21	0	15	36
Wetlands	11	0	4	7	22
Mixed	7	0	0	5	12
Total	**44**	**21**	**4**	**37**	**106**

Supplements of article

Szép T., Nagy K., Nagy Zs., Halmos G. – Population trends of common breeding and wintering birds in Hungary, decline of long-distance migrant and farmland birds during 1999–2012

Supplement 1. Mean frequency (%) with standard error (SE) and observed minimum and maximum annual frequency (%) of the observed 240 bird species during the breeding season between 1999–2012 in Hungary on the base of MMM data. Mean number of annually surveyed 2.5×2.5 km UTM squares with standard deviation (SD) for each species is given. Only UTM squares were considered where the observers was able identify the species by view/song and field survey has carried out following the standard field protocol. Annual frequency was calculated by dividing the number of UTM squares where the given species was seen/heard on the ground/air at randomly selected points of the square with number of all UTM squares surveyed for the given species. Mean and SE estimated from the annual frequencies (n=14)

Melléklet 1. A megfigyelt 240 madárfaj átlagos gyakorisága (%), átlag hibája (SE), a megfigyelt éves gyakoriság minimum és maximum értékei (%) a Magyarországon az MMM keretében, a fészkelési időszakban 1999 és 2012 között gyűjtött adatok alapján. Az átlagosan évente felmért 2,5×2,5 km UTM négyzetek száma, az átlag szórása (SD) fajonként megadva. Csak azon UTM négyzetek figyelembe véve, ahol a felmérő látvány és/vagy hang alapján azonosítani tudta az adott fajt és a felmérés az MMM standard protokollja alapján történt. Éves gyakoriság azon UTM négyzetek hányadosa alapján megállapítva, ahol az adott fajt látták/hallották az UTM négyzeten belül lévő random elhelyezkedő megfigyelési pontokon a földön/növényzeten/repülve, osztva azon UTM négyzetekkel, ahol az adott faj jelenlétét/hiányát vizsgálták. Az átlagos gyakoriságot és az átlag hibáját (SE) az évenként számolt gyakorisági értékek alapján számolva (n=14)

Species	Mean frequency (%)	(SE)	Observed minimum annual frequency (%)	Observed maximum annual frequency (%)	Mean # of annually surveyed UTM squares	(SD)
Tachybaptus ruficollis	2.5	0.5	0.0	7.8	111	21.8
Podiceps cristatus	3.0	0.3	1.5	5.9	148	30.8
Podiceps grisegena	0.1	0.1	0.0	1.3	85	23.4
Podiceps nigricollis	0.6	0.2	0.0	1.7	95	21.9
Phalacrocorax carbo	7.8	0.8	4.4	15.1	157	28.7
Phalacrocorax pygmeus	0.9	0.5	0.0	6.3	97	20.2
Botaurus stellaris	6.8	1.1	1.2	19.1	143	25.8
Ixobrychus minutus	1.6	0.2	0.0	3.0	125	22.7
Nycticorax nycticorax	7.6	1.0	4.7	19.0	150	26.2
Ardeola ralloides	0.8	0.5	0.0	6.5	101	21.9
Egretta garzetta	3.2	0.5	0.5	7.4	147	26.2
Egretta alba	19.7	2.2	11.0	42.9	153	27.4
Ardea cinerea	35.0	1.5	28.1	47.2	158	28.4
Ardea purpurea	5.6	0.4	3.4	7.8	141	26.5
Bubulcus ibis	0.1	0.1	0.0	0.9	102	22.9
Ciconia nigra	4.7	0.8	1.8	12.9	159	28.8
Ciconia ciconia	30.2	1.1	23.4	35.9	161	29.1
Plegadis falcinellus	0.0	0.0	0.0	0.7	116	26.4
Platalea leucorodia	3.1	0.9	0.0	12.4	153	29.3

Species	Mean frequency (%)	(SE)	Observed minimum annual frequency (%)	Observed maximum annual frequency (%)	Mean # of annually surveyed UTM squares	(SD)
Cygnus olor	3.1	0.5	0.6	7.1	152	25.4
Cygnus cygnus	0.0	0.0	0.0	0.7	125	20.3
Anser fabalis	0.1	0.1	0.0	0.9	126	23.7
Anser albifrons	0.1	0.1	0.0	0.8	106	17.6
Anser anser	5.8	1.1	1.6	15.2	139	25.9
Tadorna tadorna	0.3	0.1	0.0	1.1	98	18.3
Anas penelope	0.3	0.2	0.0	2.6	90	17.4
Anas strepera	0.5	0.2	0.0	2.5	82	18.4
Anas crecca	0.4	0.2	0.0	2.1	111	24.8
Anas platyrhynchos	44.9	1.7	39.3	62.9	159	28.6
Anas acuta	0.1	0.1	0.0	1.2	98	21.9
Anas querquedula	4.2	0.8	0.0	9.7	110	24.9
Anas clypeata	1.1	0.3	0.0	3.4	129	26.5
Netta rufina	0.1	0.1	0.0	1.1	93	17.3
Aythya ferina	3.2	0.7	0.0	10.4	127	25.1
Aythya nyroca	2.3	0.6	0.0	8.8	130	26.4
Aythya fuligula	0.3	0.1	0.0	1.4	110	23.5
Bucephala clangula	0.1	0.1	0.0	1.1	103	25.1
Mergus albellus	0.1	0.1	0.0	0.9	81	17.6
Mergus merganser	0.2	0.1	0.0	1.4	83	16.8
Pernis apivorus	2.0	0.3	0.0	3.5	95	21.5
Milvus migrans	1.5	0.3	0.0	3.5	127	25.8
Milvus milvus	0.2	0.1	0.0	1.0	116	25.2
Haliaeetus albicilla	2.4	0.5	0.7	7.6	134	26.2
Circaetus gallicus	0.2	0.2	0.0	1.9	86	19.8
Circus aeruginosus	43.0	1.2	38.5	52.6	146	25.7
Circus cyaneus	1.5	0.3	0.0	3.1	104	19.3
Circus macrourus	0.3	0.2	0.0	2.0	79	18.4
Circus pygargus	5.1	0.6	0.9	8.9	106	21.5
Accipiter gentilis	6.4	0.4	4.7	9.6	145	27.6
Accipiter nisus	12.6	0.9	7.6	18.9	146	24.9
Buteo buteo	80.3	1.0	74.3	87.1	158	28.9
Buteo rufinus	0.1	0.1	0.0	1.5	64	17.4
Buteo lagopus	0.1	0.1	0.0	0.9	117	20.0
Aquila pomarina	0.2	0.2	0.0	2.0	64	15.1
Aquila heliaca	2.1	0.4	0.0	4.7	110	20.7
Hieraaetus pennatus	0.2	0.2	0.0	2.9	49	14.1
Pandion haliaetus	0.2	0.1	0.0	1.3	113	28.2
Falco tinnunculus	30.0	1.3	21.2	37.5	152	26.8
Falco vespertinus	4.2	0.6	0.8	8.6	141	26.3
Falco columbarius	0.2	0.1	0.0	1.1	74	13.9
Falco subbuteo	8.0	0.6	5.4	12.4	122	24.3
Falco cherrug	1.4	0.1	0.7	2.4	122	26.9
Falco peregrinus	0.9	0.2	0.0	2.4	118	24.3
Perdix perdix	5.4	0.7	0.6	9.3	150	27.7

Species	Mean frequency (%)	(SE)	Observed minimum annual frequency (%)	Observed maximum annual frequency (%)	Mean # of annually surveyed UTM squares	(SD)
Coturnix coturnix	44.4	1.4	33.3	52.2	154	28.5
Phasianus colchicus	90.8	0.7	85.7	94.9	161	28.6
Rallus aquaticus	1.7	0.6	0.0	8.9	107	22.7
Porzana porzana	0.3	0.3	0.0	4.5	64	15.1
Porzana parva	0.7	0.4	0.0	4.5	62	13.8
Crex crex	2.6	0.6	0.0	7.2	121	22.4
Gallinula chloropus	4.4	0.5	0.8	7.6	137	24.6
Fulica atra	10.5	0.9	5.8	17.4	155	29.2
Grus grus	1.6	0.2	0.0	3.0	153	27.9
Otis tarda	0.6	0.1	0.0	1.5	155	28.7
Himantopus himantopus	1.5	0.2	0.0	3.5	130	27.0
Recurvirostra avosetta	1.0	0.2	0.0	2.0	145	31.8
Burhinus oedicnemus	0.2	0.1	0.0	1.0	110	25.0
Glareola pratincola	0.7	0.2	0.0	1.8	96	19.8
Charadrius dubius	3.3	0.4	0.9	5.6	84	20.5
Charadrius hiaticula	0.2	0.1	0.0	1.4	66	13.9
Charadrius alexandrinus	0.1	0.1	0.0	1.2	78	16.8
Vanellus vanellus	36.5	1.2	30.4	49.6	158	29.6
Calidris minuta	0.3	0.2	0.0	2.2	50	12.8
Calidris alpina	0.1	0.1	0.0	2.0	45	11.1
Philomachus pugnax	3.0	0.4	1.3	6.3	105	24.6
Gallinago gallinago	2.4	0.6	0.0	9.1	115	19.7
Gallinago media	0.1	0.1	0.0	1.4	69	15.4
Scolopax rusticola	0.1	0.1	0.0	1.1	122	21.4
Limosa limosa	3.0	0.5	0.0	6.4	105	24.0
Numenius phaeopus	0.9	0.2	0.0	2.1	73	16.2
Numenius arquata	1.7	0.3	0.0	4.0	102	21.9
Tringa erythropus	1.4	0.4	0.0	3.4	62	15.5
Tringa totanus	10.8	0.8	6.1	14.9	112	24.6
Tringa stagnatilis	0.2	0.2	0.0	2.2	45	12.2
Tringa nebularia	1.1	0.4	0.0	4.7	57	13.2
Tringa ochropus	1.3	0.3	0.0	4.3	70	14.9
Tringa glareola	5.7	1.1	0.0	15.9	66	13.3
Actitis hypoleucos	2.6	0.5	0.0	6.9	93	17.5
Arenaria interpres	0.1	0.1	0.0	1.2	84	19.9
Larus melanocephalus	0.6	0.2	0.0	2.2	82	19.6
Larus minutus	0.3	0.2	0.0	2.6	46	10.5
Larus ridibundus	19.2	1.5	11.2	28.9	151	28.3
Larus canus	0.3	0.2	0.0	1.8	52	11.9
Larus fuscus	0.2	0.2	0.0	2.1	41	14.3
Larus argentatus	0.6	0.3	0.0	3.0	87	20.4
Larus cachinnans	4.3	0.8	0.0	10.5	61	13.5
Sterna caspia	0.1	0.1	0.0	1.4	73	16.1
Sterna hirundo	2.3	0.3	0.8	4.1	111	21.7
Chlidonias hybridus	3.8	1.2	0.0	17.5	83	20.0

Species	Mean frequency (%)	(SE)	Observed minimum annual frequency (%)	Observed maximum annual frequency (%)	Mean # of annually surveyed UTM squares	(SD)
Chlidonias niger	2.8	0.5	0.0	6.6	92	21.2
Chlidonias leucopterus	1.5	0.8	0.0	11.4	71	18.5
Columba livia f. domestica	30.0	1.7	12.3	38.1	107	16.0
Columba oenas	13.4	1.4	5.5	25.6	126	26.1
Columba palumbus	69.4	1.7	58.8	82.1	155	26.8
Streptopelia decaoto	65.8	0.7	62.1	71.9	161	28.9
Streptopelia turtur	72.7	1.0	63.7	77.1	155	27.1
Cuculus canorus	89.6	0.6	85.6	93.7	160	28.2
Otus scops	0.2	0.1	0.0	1.3	110	24.5
Bubo bubo	0.1	0.1	0.0	0.8	144	29.3
Athene noctua	1.4	0.4	0.0	5.4	147	28.7
Strix aluco	1.9	0.4	0.0	5.1	135	26.3
Asio otus	1.4	0.2	0.5	3.0	152	28.0
Asio flammeus	0.3	0.2	0.0	2.3	110	20.3
Caprimulgus europaeus	0.6	0.2	0.0	2.5	131	24.2
Apus apus	9.1	0.6	5.7	12.8	151	29.7
Alcedo atthis	2.8	0.5	0.6	7.4	156	28.9
Merops apiaster	27.6	1.3	18.8	35.7	159	29.4
Coracias garrulus	3.2	0.5	0.0	8.1	147	29.2
Upupa epops	30.3	0.8	25.4	35.9	160	29.0
Jynx torquilla	28.2	1.0	18.7	33.7	142	27.4
Picus canus	3.7	0.7	0.8	9.1	115	20.6
Picus viridis	23.6	0.9	18.6	28.5	156	26.7
Dryocopos martius	23.3	1.3	17.3	31.9	157	27.9
Dendrocopos major	57.1	1.2	51.1	64.7	155	25.8
Dendrocopos syriacus	8.5	0.5	6.3	12.1	141	24.8
Dendrocopos medius	11.5	0.6	7.8	15.4	138	24.6
Dendrocopos leucotos	0.8	0.2	0.0	2.4	112	21.1
Dendrocopos minor	9.5	0.8	4.4	14.6	148	23.4
Calandrella brachydactyla	0.5	0.3	0.0	3.0	62	16.0
Galerida cristata	33.6	1.3	24.3	39.5	158	28.5
Lullula arborea	12.6	0.8	6.9	16.3	108	18.8
Alauda arvensis	85.1	1.0	79.4	89.4	159	28.6
Riparia riparia	9.7	0.7	4.2	13.4	150	30.1
Hirundo rustica	79.2	1.1	68.3	83.8	160	29.2
Delichon urbica	42.2	1.5	32.0	49.3	159	28.2
Anthus campestris	8.6	1.0	4.1	15.8	75	16.1
Anthus trivialis	26.6	1.4	17.1	34.2	105	18.6
Anthus pratensis	5.2	0.6	2.3	10.9	70	12.7
Anthus cervinus	1.3	0.6	0.0	7.3	48	12.6
Anthus spinoletta	0.2	0.2	0.0	2.9	41	10.7
Motacilla flava	45.5	1.2	37.7	50.3	149	26.9
Motacilla citreola	0.1	0.1	0.0	1.0	70	11.6
Motacilla cinerea	1.6	0.3	0.0	4.5	115	22.1
Motacilla alba	47.1	1.4	40.4	57.5	160	29.3

Species	Mean frequency (%)	(SE)	Observed minimum annual frequency (%)	Observed maximum annual frequency (%)	Mean # of annually surveyed UTM squares	(SD)
Bombycilla garrulus	0.2	0.1	0.0	1.7	149	24.6
Cinclus cinclus	0.1	0.1	0.0	1.3	131	27.8
Troglodytes troglodytes	15.6	1.3	8.9	23.9	156	25.6
Prunella modularis	2.7	0.4	0.0	6.0	107	23.9
Erithacus rubecula	40.8	0.9	36.3	45.8	159	27.7
Luscinia luscinia	0.8	0.3	0.0	3.2	102	23.5
Luscinia megarhynchos	75.6	0.8	68.5	81.2	157	28.1
Luscinia svecica	1.5	0.5	0.0	5.5	141	26.8
Phoenicurus ochruros	43.1	0.8	35.9	48.7	159	27.8
Phoenicurus phoenicurus	2.6	0.4	0.0	5.6	151	27.5
Saxicola rubetra	24.7	1.2	15.0	29.6	131	26.6
Saxicola torquata	63.8	1.1	56.2	70.6	151	27.5
Oenanthe oenanthe	12.7	0.6	9.2	16.4	121	23.5
Turdus merula	82.9	1.2	75.5	89.4	161	28.9
Turdus pilaris	1.4	0.2	0.6	3.0	148	22.2
Turdus philomelos	53.3	2.1	41.8	64.0	151	24.9
Turdus iliacus	0.1	0.1	0.0	1.0	118	25.2
Turdus viscivorus	5.5	0.6	1.8	9.5	121	23.2
Locustella naevia	12.3	1.0	6.5	20.0	102	17.5
Locustella fluviatilis	23.7	2.2	8.9	38.9	115	18.7
Locustella luscinioides	18.6	1.1	12.9	30.0	117	22.1
Acrocephalus melanopogon	1.1	0.4	0.0	4.4	84	15.3
Acrocephalus paludicola	0.3	0.2	0.0	3.0	93	17.3
Acrocephalus schoenobaenus	27.5	1.5	18.7	40.6	99	20.7
Acrocephalus palustris	21.2	0.8	14.0	26.4	103	19.3
Acrocephalus scirpaceus	17.0	1.4	8.0	25.8	116	19.6
Acrocephalus arundinaceus	46.1	1.4	34.7	55.7	147	28.6
Hippolais pallida	0.2	0.2	0.0	1.6	51	11.7
Hippolais icterina	5.6	0.4	2.4	8.6	89	13.8
Sylvia nisoria	18.5	0.9	15.0	26.2	117	26.5
Sylvia curruca	34.0	1.4	27.8	43.0	101	21.8
Sylvia communis	45.6	1.3	35.1	52.9	123	24.9
Sylvia borin	8.0	1.3	3.0	16.0	105	18.4
Sylvia atricapilla	74.6	1.0	67.8	79.6	151	26.6
Phylloscopus sibilatrix	26.7	2.0	11.9	41.7	107	18.8
Phylloscopus collybita	59.4	1.3	50.9	69.4	147	25.4
Phylloscopus trochilus	17.3	1.0	11.8	23.0	110	19.2
Regulus regulus	2.1	0.3	0.7	5.2	139	25.8
Regulus ignicapellus	0.5	0.2	0.0	2.1	137	27.1
Muscicapa striata	19.4	0.9	15.7	25.2	122	26.3
Ficedula parva	0.9	0.2	0.0	2.2	103	20.5
Ficedula albicollis	16.6	1.6	7.2	27.5	129	25.0
Ficedula hypoleuca	2.6	0.4	0.0	5.4	127	24.0
Panurus biarmicus	1.8	0.4	0.0	4.9	138	26.7
Aegithalos caudatus	25.8	1.0	21.5	31.9	158	27.1

Species	Mean frequency (%)	(SE)	Observed minimum annual frequency (%)	Observed maximum annual frequency (%)	Mean # of annually surveyed UTM squares	(SD)
Parus palustris	21.0	1.0	15.9	27.5	150	25.4
Parus montanus	1.3	0.3	0.0	4.1	104	18.2
Parus cristatus	0.8	0.2	0.0	2.1	143	26.2
Parus ater	5.4	0.7	1.9	10.6	132	21.3
Parus caeruleus	36.6	1.4	25.3	43.0	160	28.4
Parus major	78.8	1.0	73.6	86.7	161	28.9
Sitta europaea	28.7	1.0	21.0	35.5	156	27.6
Certhia familiaris	4.0	0.7	0.0	8.8	81	13.8
Certhia brachydactyla	9.5	0.8	4.2	13.7	97	16.2
Remiz pendulinus	3.7	0.4	0.9	6.1	141	28.2
Oriolus oriolus	83.6	0.9	77.1	88.5	159	28.8
Lanius collurio	73.1	1.7	55.9	79.1	157	28.4
Lanius minor	17.7	1.3	10.3	24.2	130	28.5
Lanius exubitor	1.4	0.4	0.0	4.8	140	26.6
Garrulus glandarius	49.8	1.4	42.3	56.8	159	28.6
Pica pica	49.3	1.0	42.8	55.8	161	29.2
Corvus monedula	4.3	0.5	1.6	7.8	158	28.0
Corvus frugilegus	21.1	0.9	15.8	28.6	161	28.6
Corvus corone cornix	55.1	2.1	39.0	65.7	159	28.5
Corvus corax	24.1	1.5	14.2	35.9	159	27.6
Sturnus vulgaris	91.7	0.9	86.5	96.5	161	28.5
Sturnus roseus	0.1	0.1	0.0	1.0	101	25.6
Passer domesticus	59.7	1.7	44.0	68.1	161	29.3
Passer montanus	78.8	0.9	73.3	83.5	160	28.3
Fringilla coelebs	78.7	1.4	72.1	87.1	157	28.1
Fringilla montifringilla	0.5	0.2	0.0	1.4	134	22.1
Serinus serinus	35.3	1.5	26.5	44.1	144	25.3
Carduelis chloris	73.4	1.2	66.5	82.1	158	28.5
Carduelis carduelis	71.5	1.1	66.9	80.2	159	28.2
Carduelis spinus	2.2	0.5	0.7	5.2	138	25.7
Carduelis cannabina	24.8	1.2	19.9	32.6	138	22.6
Carduelis flammea	0.2	0.1	0.0	1.7	103	21.0
Loxia curvirostra	0.6	0.2	0.0	1.9	145	26.9
Pyrrhula pyrrhula	0.8	0.1	0.0	2.2	150	25.6
Coccothraustres coccothraustes	28.0	1.1	21.3	35.1	158	27.0
Emberiza citrinella	59.0	1.2	52.2	65.9	151	27.8
Emberiza cirlus	0.1	0.1	0.0	1.1	71	15.9
Emberiza cia	1.5	0.3	0.0	2.9	97	18.1
Emberiza hortulana	0.4	0.2	0.0	2.1	77	15.8
Emberiza schoeniclus	18.0	1.2	11.8	28.8	117	21.3
Miliaria calandra	62.0	1.9	51.4	76.2	141	23.3

Supplement 2. Mean frequency (%) with standard error (SE) and observed minimum and maximum annual frequency (%) of the surveyed 140 bird species during the wintering season between 2000–2012 in Hungary on the base of MMM data. Mean number of annually surveyed 2.5×2.5 km UTM squares with standard deviation (SD) for each species is given. Only UTM squares were considered where the observers was able identify the species by view/song and field survey has carried out following the standard field protocol. Annual frequency was calculated by dividing the number of UTM squares where the given species was seen/heard on the ground/air at randomly selected points of the square with number of all UTM squares surveyed for the given species. Mean and SE estimated from the annual frequencies (n=13)

Melléklet 2. A megfigyelt 140 madárfaj átlagos gyakorisága (%), átlag hibája (SE), a megfigyelt éves gyakoriság minimum és maximum értékei (%) a Magyarországon az MMM keretében, a telelési időszakban 2000 és 2012 között gyűjtött adatok alapján. Az átlagosan évente felmért 2,5×2,5 km UTM négyzetek száma, az átlag szórása (SD) fajonként megadva. Csak azon UTM négyzetek figyelembe véve, ahol a felmérő látvány és/vagy hang alapján azonosítani tudta az adott fajt és a felmérés az MMM standard protokollja alapján történt. Éves gyakoriság azon UTM négyzetek hányadosa alapján megállapítva, ahol az adott fajt látták/hallották az UTM négyzeten belül lévő random elhelyezkedő megfigyelési pontokon a földön/növényzeten/repülve, osztva azon UTM négyzetekkel, ahol az adott faj jelenlétét/hiányát vizsgálták. Az átlagos gyakoriságot és az átlag hibáját (SE) az évenként számolt gyakorisági értékek alapján számolva (n=13)

Species	Mean frequency (%)	(SE)	Observed minimum annual frequency (%)	Observed maximum annual frequency (%)	Mean # of annually surveyed UTM squares	(SD)
Tachybaptus ruficollis	2.1	0.4	0.0	4.1	70	15.5
Phalacrocorax carbo	7.2	0.5	4.3	10.0	99	22.6
Botaurus stellaris	0.4	0.2	0.0	2.3	89	20.7
Egretta alba	10.0	0.8	6.1	14.4	97	21.9
Ardea cinerea	11.8	1.0	7.8	19.0	99	22.3
Cygnus olor	2.7	0.6	0.8	8.0	97	22.9
Cygnus cygnus	0.2	0.2	0.0	2.5	82	19.2
Anser fabalis	7.0	1.1	2.2	13.0	78	17.7
Anser albifrons	8.9	1.9	2.5	25.6	70	16.3
Anser anser	7.0	1.9	0.0	21.2	88	19.5
Branta ruficollis	0.3	0.3	0.0	3.3	57	12.8
Anas penelope	0.2	0.1	0.0	1.4	58	13.7
Anas crecca	2.1	0.5	0.0	6.2	68	14.5
Anas platyrhynchos	18.9	1.7	12.1	30.2	101	22.4
Anas acuta	0.2	0.2	0.0	2.7	61	11.5
Aythya ferina	1.4	0.3	0.0	2.6	80	16.7
Aythya nyroca	0.2	0.1	0.0	1.3	79	17.1
Aythya fuligula	0.9	0.3	0.0	2.6	68	13.9
Somaterina mollissima	0.2	0.2	0.0	3.0	48	10.0
Bucephala clangula	3.2	0.5	0.0	6.8	63	12.7
Mergus albellus	0.5	0.4	0.0	4.7	49	12.3
Mergus merganser	0.6	0.2	0.0	2.1	52	11.2
Milvus milvus	0.1	0.1	0.0	1.2	74	16.0
Haliaeetus albicilla	5.4	1.0	1.3	12.9	84	19.3

Species	Mean frequency (%)	(SE)	Observed minimum annual frequency (%)	Observed maximum annual frequency (%)	Mean # of annually surveyed UTM squares	(SD)
Circus aeruginosus	2.0	0.5	0.0	5.1	92	20.0
Circus cyaneus	22.3	2.5	9.5	40.8	67	15.6
Accipiter gentilis	5.6	0.5	2.8	9.9	92	21.0
Accipiter nisus	26.2	0.9	21.0	30.9	93	21.9
Buteo buteo	81.3	1.0	74.8	87.2	101	22.2
Buteo rufinus	0.1	0.1	0.0	1.8	40	8.5
Buteo lagopus	9.5	1.8	2.4	20.2	76	17.8
Aquila clanga	0.3	0.3	0.0	4.2	35	7.7
Aquila heliaca	2.3	0.6	0.0	6.3	70	15.8
Aquila chrysaetos	0.2	0.2	0.0	1.7	58	11.2
Falco tinnunculus	13.7	1.3	6.5	21.9	97	21.6
Falco columbarius	3.2	0.6	0.0	7.4	48	12.1
Falco cherrug	0.8	0.4	0.0	5.0	74	16.5
Falco peregrinus	1.4	0.3	0.0	3.5	73	17.2
Perdix perdix	1.6	0.3	0.0	3.7	96	21.3
Coturnix coturnix	0.1	0.1	0.0	1.0	97	21.5
Phasianus colchicus	50.3	2.0	44.1	64.1	101	22.8
Rallus aquaticus	0.1	0.1	0.0	1.2	66	14.3
Gallinula chloropus	0.2	0.2	0.0	2.3	88	19.9
Fulica atra	1.5	0.2	0.0	2.8	97	20.9
Grus grus	0.7	0.3	0.0	4.0	97	22.5
Otis tarda	0.3	0.2	0.0	1.9	97	21.2
Vanellus vanellus	0.1	0.1	0.0	0.9	99	21.9
Gallinago gallinago	0.1	0.1	0.0	1.1	72	16.5
Scolopax rusticola	0.1	0.1	0.0	1.2	79	17.4
Tringa ochropus	0.3	0.2	0.0	2.6	41	10.2
Larus ridibundus	5.9	0.4	3.6	8.1	94	20.7
Larus canus	3.4	1.0	0.0	11.4	32	9.0
Larus fuscus	0.4	0.4	0.0	5.6	24	5.6
Larus argentatus	0.6	0.4	0.0	4.3	53	10.5
Larus cachinnans	3.2	1.1	0.0	12.5	39	9.9
Columba livia f. domestica	22.3	1.6	7.1	30.5	70	18.6
Columba oenas	4.7	0.8	1.4	10.5	78	19.6
Columba palumbus	0.9	0.2	0.0	3.0	98	22.0
Streptopelia decaoto	40.5	1.0	34.4	44.3	101	22.4
Streptopelia turtur	0.2	0.2	0.0	3.2	98	22.3
Tyto alba	0.1	0.1	0.0	1.1	94	20.7
Athene noctua	0.4	0.2	0.0	1.5	92	19.9
Strix aluco	0.7	0.2	0.0	2.3	84	18.1
Strix uralensis	0.3	0.2	0.0	2.0	56	11.1
Asio otus	1.6	0.3	0.0	3.3	96	22.0
Asio flammeus	0.8	0.5	0.0	5.8	69	15.8
Alcedo atthis	1.1	0.2	0.0	2.2	98	21.3
Picus canus	2.9	0.8	0.0	9.2	73	16.9
Picus viridis	14.8	1.5	5.9	26.2	98	22.1

Species	Mean frequency (%)	(SE)	Observed minimum annual frequency (%)	Observed maximum annual frequency (%)	Mean # of annually surveyed UTM squares	(SD)
Dryocopos martius	20.8	2.0	11.8	32.1	99	22.5
Dendrocopos major	58.0	1.1	51.8	66.7	98	23.3
Dendrocopos syriacus	6.8	1.1	1.8	13.5	89	21.1
Dendrocopos medius	10.5	0.8	5.4	14.6	86	19.6
Dendrocopos leucotos	0.4	0.2	0.0	1.2	70	16.7
Dendrocopos minor	9.8	1.1	3.5	15.2	94	22.2
Galerida cristata	15.9	0.9	11.4	20.5	100	22.8
Lullula arborea	0.1	0.1	0.0	1.1	69	15.8
Alauda arvensis	2.4	0.6	0.0	8.2	100	22.4
Eremophila alpestris	0.4	0.4	0.0	4.8	30	7.5
Anthus pratensis	2.0	0.7	0.0	8.3	46	9.9
Anthus spinoletta	1.9	1.4	0.0	18.4	26	6.0
Motacilla cinerea	0.1	0.1	0.0	1.3	72	14.8
Motacilla alba	0.6	0.2	0.0	2.0	101	21.9
Bombycilla garrulus	1.8	0.8	0.0	7.7	94	21.6
Troglodytes troglodytes	25.0	2.0	14.4	38.0	99	22.7
Prunella modularis	1.0	0.3	0.0	2.9	67	15.4
Erithacus rubecula	15.2	1.6	2.2	25.5	99	22.4
Phoenicurus ochruros	0.7	0.3	0.0	2.9	101	22.4
Saxicola torquata	0.1	0.1	0.0	1.0	93	19.9
Turdus merula	65.8	1.8	54.2	76.3	101	22.7
Turdus pilaris	55.1	4.2	25.7	73.8	95	22.7
Turdus philomelos	3.5	0.8	0.9	10.0	95	20.7
Turdus iliacus	3.5	0.9	0.0	10.9	75	16.1
Turdus viscivorus	18.4	1.4	10.3	27.8	74	15.0
Sylvia atricapilla	0.2	0.1	0.0	1.1	94	19.6
Phylloscopus collybita	0.1	0.1	0.0	1.0	92	20.0
Regulus regulus	12.5	1.3	4.3	20.6	88	19.3
Regulus ignicapellus	0.6	0.3	0.0	2.5	87	17.8
Panurus biarmicus	1.1	0.4	0.0	5.1	87	18.9
Aegithalos caudatus	28.7	1.4	18.4	34.9	101	22.8
Parus palustris	29.9	1.4	19.4	39.6	95	22.2
Parus montanus	2.0	0.5	0.0	5.0	68	16.9
Parus cristatus	0.9	0.2	0.0	2.1	90	19.8
Parus ater	6.9	0.9	2.4	12.2	83	19.4
Parus caeruleus	60.8	1.5	47.6	70.6	101	22.7
Parus major	88.0	1.3	80.9	95.8	101	22.6
Sitta europaea	33.8	1.1	26.0	42.7	99	22.9
Certhia familiaris	7.3	0.7	3.4	12.5	51	12.5
Certhia brachydactyla	11.2	1.3	4.2	19.4	64	18.3
Remiz pendulinus	0.8	0.4	0.0	5.0	88	18.4
Lanius exubitor	24.9	1.1	19.2	32.2	89	19.6
Garrulus glandarius	51.1	1.5	41.4	58.5	101	22.2
Pica pica	44.2	1.9	32.3	54.0	101	22.9
Nucifraga caryocatactes	0.1	0.1	0.0	1.6	69	14.4

Species	Mean frequency (%)	(SE)	Observed minimum annual frequency (%)	Observed maximum annual frequency (%)	Mean # of annually surveyed UTM squares	(SD)
Corvus monedula	4.2	0.6	1.7	8.9	99	23.1
Corvus frugilegus	42.8	1.6	36.1	56.0	101	22.9
Corvus corone cornix	40.7	2.4	28.3	52.2	100	22.8
Corvus corax	29.5	1.6	20.2	37.2	100	23.0
Sturnus vulgaris	3.4	0.8	0.0	9.8	101	22.7
Passer domesticus	43.4	2.3	33.0	59.0	102	22.6
Passer montanus	60.1	1.5	50.5	68.6	101	22.7
Fringilla coelebs	39.3	1.4	29.8	47.3	98	21.4
Fringilla montifringilla	16.8	2.5	3.9	39.2	85	17.8
Serinus serinus	0.8	0.3	0.0	3.0	91	19.3
Carduelis chloris	55.3	1.4	48.4	65.9	99	22.9
Carduelis carduelis	74.5	1.7	66.4	84.3	100	22.1
Carduelis spinus	13.3	1.8	3.7	26.9	85	18.1
Carduelis cannabina	21.0	1.4	13.9	30.3	89	19.2
Carduelis flavirostris	0.7	0.5	0.0	6.5	40	9.7
Carduelis flammea	0.9	0.3	0.0	2.7	64	12.6
Loxia curvirostra	1.2	0.8	0.0	10.8	90	19.1
Pyrrhula pyrrhula	30.4	3.4	16.7	54.4	95	21.0
Coccothraustres coccothraustes	28.7	1.8	20.7	43.8	99	22.9
Calcarius lapponicus	0.4	0.4	0.0	5.0	30	8.5
Plectrophenax nivalis	0.7	0.3	0.0	2.9	57	13.5
Emberiza citrinella	34.6	1.3	26.0	40.2	94	20.1
Emberiza cirlus	0.5	0.3	0.0	2.3	44	8.0
Emberiza cia	0.1	0.1	0.0	1.5	60	12.2
Emberiza schoeniclus	19.4	2.0	11.8	32.4	74	17.2
Miliaria calandra	4.6	0.8	1.1	12.1	88	20.2

Supplement 3. Relative density (individual/km^2) in the main habitat types (mean, SE and number of points considered), habitat occupancy of the surveyed population in the main habitat types (% of the estimated population in the given habitat compared to the entire population) and number of estimated individuals of the given species on the base of the relative density and area of habitat types in Hungary, using data collected between 1999–2012 following the MMM standard protocol in Hungary

Melléklet 3. Az MMM keretében 1999–2012 során megfigyelt fészkelő madárfajok relatív denzitása (egyed/km^2) a fő élőhely típusokban (urbán, mezőgazdasági, erdei, vizes) (átlag, átlag hibája (SE) , a megfigyelt pontok száma), élőhely használata (az adott élőhelyen megfigyelt állomány aránya (%) a négy fő élőhelyen becsült állományhoz képest), a négy fő élőhelyen együttesen élő egyedek számának becslése a fő élőhelyeken becsült relatív denzitás és az adott élőhely magyarországi kiterjedése alapján

Species	Relative density (individual/km²)												Habitat occupancy (%)				Estimated
	Urban	SE	n	Farmland	SE	n	Forest	SE	n	Wetlands	SE	n	Urban	Farmland	Forest	Wetlands	# of ind.
Tachybaptus ruficollis	0.000	0.000	577	0.100	0.043	5 294	0.030	0.022	1 601	0.363	0.194	137	0.0	78.1	7.4	14.5	8 239
Podiceps cristatus	0.118	0.118	811	0.043	0.017	6 716	0.011	0.011	1 973	3.152	1.666	156	4.7	19.6	1.6	74.2	14 003
Podiceps nigricollis	0.000	0.000	491	0.001	0.001	4 639	0.000	0.000	1 219	0.263	0.160	125	0.0	7.3	0.0	92.7	935
Phalacrocorax carbo	0.000	0.000	843	0.008	0.003	6 965	0.025	0.012	2 128	0.581	0.306	157	0.0	17.7	17.4	64.9	2 945
Phalacrocorax pygmeus	0.030	0.030	533	0.008	0.005	5 039	0.000	0.000	1 434	0.921	0.799	121	4.5	13.2	0.0	82.2	3 688
Botaurus stellaris	0.000	0.000	755	0.147	0.025	6 625	0.010	0.008	1 933	1.069	0.364	152	0.0	71.7	1.5	26.8	13 151
Ixobrychus minutus	0.035	0.025	663	0.013	0.008	5 873	0.000	0.000	1 697	1.006	0.520	144	4.5	19.4	0.0	76.1	4 357
Nycticorax nycticorax	0.085	0.053	747	0.105	0.048	6 709	0.005	0.004	2 056	4.710	3.098	150	2.1	29.5	0.4	67.9	22 844
Ardeola ralloides	0.000	0.000	516	0.014	0.009	4 999	0.000	0.000	1 384	0.522	0.367	122	0.0	34.4	0.0	65.6	2 621
Egretta garzetta	0.000	0.000	753	0.069	0.025	6 585	0.016	0.014	2 060	0.733	0.733	152	0.0	61.8	4.5	33.8	7 153
Egretta alba	0.077	0.055	825	0.559	0.129	6 873	0.047	0.027	2 083	2.908	1.133	153	0.9	76.6	2.0	20.4	46 942
Ardea cinerea	0.166	0.118	863	0.594	0.122	7 067	0.091	0.030	2 176	2.180	0.600	161	1.9	79.3	3.8	14.9	48 210
Ardea purpurea	0.000	0.000	718	0.039	0.011	6 456	0.005	0.003	1 944	1.150	0.402	155	0.0	39.4	1.7	58.9	6 436
Bubulcus ibis	0.000	0.000	529	0.006	0.006	4 958	0.000	0.000	1 396	0.000	0.000	121	0.0	100.0	0.0	0.0	413
Ciconia nigra	0.000	0.000	883	0.128	0.091	7 019	0.021	0.015	2 174	0.000	0.000	157	0.0	95.0	5.0	0.0	8 700
Ciconia ciconia	0.771	0.283	894	0.886	0.079	7 124	0.116	0.048	2 230	1.096	0.503	162	6.4	84.7	3.5	5.4	67 355
Platalea leucorodia	0.000	0.000	831	0.069	0.036	6 870	0.000	0.000	2 124	1.976	1.246	153	0.0	40.5	0.0	59.5	10 937
Cygnus olor	0.447	0.328	783	0.018	0.014	6 753	0.018	0.015	2 096	1.984	1.449	157	23.7	11.0	3.4	61.9	10 560
Anser anser	0.044	0.044	729	0.398	0.166	6 424	0.017	0.017	1 871	13.465	4.898	150	0.3	36.3	0.5	62.9	70 546
Anas penelope	0.000	0.000	404	0.029	0.021	4 373	0.000	0.000	1 203	1.079	1.079	118	0.0	34.5	0.0	65.5	5 430
Anas strepera	0.000	0.000	477	0.007	0.005	4 252	0.000	0.000	1 185	0.516	0.516	111	0.0	19.9	0.0	80.1	2 122
Anas crecca	0.000	0.000	584	0.002	0.002	5 263	0.000	0.000	1 434	0.421	0.273	131	0.0	6.6	0.0	93.4	1 485
Anas platyrhynchos	1.761	0.868	885	2.232	0.222	7 054	1.121	0.250	2 197	33.616	6.687	159	3.4	50.1	7.9	38.6	287 080
Anas acuta	0.000	0.000	474	0.000	0.000	4 866	0.000	0.000	1 320	0.053	0.053	120	0.0	0.0	0.0	100.0	175
Anas querquedula	0.000	0.000	548	0.182	0.053	5 237	0.000	0.000	1 489	4.830	1.657	134	0.0	42.4	0.0	57.6	27 623
Anas clypeata	0.000	0.000	654	0.008	0.005	6 061	0.000	0.000	1 792	0.218	0.157	146	0.0	42.3	0.0	57.7	1 245
Aythya ferina	0.924	0.924	620	0.094	0.046	5 912	0.021	0.019	1 732	5.435	2.218	133	17.5	20.5	1.5	60.6	29 562
Aythya nyroca	0.312	0.312	715	0.051	0.027	6 218	0.006	0.006	1 791	3.667	1.453	138	10.1	19.0	0.7	70.2	17 210

Species	Relative density (individual/km^2)													Habitat occupancy (%)			Estimated
	Urban	SE	n	Farmland	SE	n	Forest	SE	n	Wetlands	SE	n	Urban	Farmland	Forest	Wetlands	# of ind.
Aythya fuligula	0.000	0.000	609	0.000	0.000	5 304	0.000	0.000	1 470	0.343	0.263	130	0.0	0.0	0.0	100.0	1 129
Bucephala clangula	0.000	0.000	525	0.000	0.000	4 954	0.027	0.027	1 410	0.000	0.000	137	0.0	0.0	100.0	0.0	551
Mergus albellus	0.076	0.076	421	0.000	0.000	4 197	0.000	0.000	1 114	0.000	0.000	112	100.0	0.0	0.0	0.0	423
Mergus merganser	0.000	0.000	450	0.000	0.000	4 386	0.003	0.003	1 106	0.026	0.026	111	0.0	0.0	38.3	61.7	139
Pernis apivorus	0.000	0.000	433	0.010	0.007	4 608	0.011	0.009	1 407	0.000	0.000	118	0.0	72.7	27.3	0.0	843
Milvus migrans	0.000	0.000	627	0.004	0.003	5 798	0.000	0.000	1 781	0.079	0.079	135	0.0	49.6	0.0	50.4	514
Milvus milvus	0.000	0.000	563	0.003	0.002	5 438	0.000	0.000	1 598	0.000	0.000	132	0.0	100.0	0.0	0.0	179
Haliaeetus albicilla	0.000	0.000	708	0.013	0.005	6 202	0.013	0.010	1 803	0.000	0.000	147	0.0	75.0	25.0	0.0	1 078
Circus aeruginosus	0.240	0.124	791	0.908	0.067	6 592	0.067	0.027	2 013	4.238	1.061	154	1.8	77.8	1.8	18.6	75 139
Circus cyaneus	0.066	0.066	481	0.011	0.007	5 006	0.000	0.000	1 419	0.032	0.032	123	30.9	60.2	0.0	8.9	1 199
Circus pygargus	0.000	0.000	489	0.037	0.013	5 184	0.000	0.000	1 387	0.259	–	123	0.0	73.8	0.0	26.2	3 258
Accipiter gentilis	0.041	0.041	771	0.023	0.008	6 601	0.139	0.049	2 020	0.000	0.000	151	5.1	32.6	62.3	0.0	4 535
Accipiter nisus	0.139	0.066	753	0.070	0.017	6 490	0.195	0.059	2 053	0.054	0.040	151	8.3	47.6	42.2	1.9	9 410
Buteo buteo	0.411	0.120	855	1.806	0.084	7 035	2.071	0.157	2 208	2.153	0.725	158	1.4	69.3	25.1	4.2	167 818
Aquila heliaca	0.000	0.000	604	0.007	0.006	5 560	0.000	0.000	1 510	0.000	0.000	135	0.0	100.0	0.0	0.0	442
Falco tinnunculus	0.423	0.170	782	0.667	0.053	6 755	0.070	0.025	2 114	0.105	0.066	158	5.0	91.2	3.0	0.7	47 074
Falco vespertinus	0.047	0.047	680	0.170	0.047	6 424	0.000	0.000	1 957	0.000	0.000	151	2.3	97.7	0.0	0.0	11 178
Falco subbuteo	0.742	0.301	615	0.161	0.051	5 819	0.027	0.020	1 685	0.000	0.000	136	27.5	68.9	3.6	0.0	15 081
Falco cherrug	0.000	0.000	646	0.013	0.008	5 756	0.002	0.002	1 771	0.000	0.000	138	0.0	96.2	3.8	0.0	864
Falco peregrinus	0.000	0.000	588	0.001	0.001	5 434	0.010	0.010	1 684	0.000	0.000	137	0.0	16.7	83.3	0.0	252
Perdix perdix	0.045	0.039	818	0.426	0.090	6 818	0.047	0.027	2 043	0.000	0.000	151	0.9	95.8	3.3	0.0	28 628
Coturnix coturnix	0.136	0.064	796	3.284	0.130	6 883	0.161	0.035	2 087	0.242	0.135	152	0.4	97.8	1.5	0.4	216 279
Phasianus colchicus	2.406	0.329	898	11.450	0.258	7 149	5.146	0.289	2 234	6.907	1.236	159	1.5	84.0	11.9	2.6	878 131
Rallus aquaticus	0.000	0.000	579	0.058	0.017	5 190	0.005	0.005	1 503	1.544	0.531	132	0.0	41.7	1.2	57.1	8 907
Porzana porzana	0.000	0.000	334	0.008	0.006	3 417	0.000	0.000	847	0.000	0.000	103	0.0	100.0	0.0	0.0	500
Porzana parva	0.000	0.000	352	0.006	0.006	3 451	0.009	0.009	862	1.213	0.826	105	0.0	8.6	4.1	87.3	4 579
Crex crex	0.000	0.000	611	0.048	0.012	5 822	0.003	0.003	1 716	0.267	0.244	131	0.0	76.7	1.3	22.0	4 009
Gallinula chloropus	0.058	0.046	734	0.119	0.026	6 250	0.095	0.056	1 847	1.029	0.393	149	2.4	57.7	14.5	25.4	13 328

	Relative density (individual/km^2)												Habitat occupancy (%)				Estimated
Species	Urban	SE	n	Farmland	SE	n	Forest	SE	n	Wetlands	SE	n	Urban	Farmland	Forest	Wetlands	# of ind.
Fulica atra	1.937	1.929	825	0.541	0.109	6 931	0.080	0.039	2 068	15.358	5.209	157	11.1	35.6	1.7	51.7	97 922
Grus grus	0.000	0.000	824	0.196	0.107	6 805	0.000	0.000	2 101	0.000	0.000	150	0.0	100.0	0.0	0.0	12 610
Otis tarda	0.000	0.000	834	0.018	0.009	6 907	0.000	0.000	2 091	0.000	0.000	154	0.0	100.0	0.0	0.0	1 138
Himantopus himantopus	0.095	0.095	669	0.058	0.023	6 108	0.000	0.000	1 820	0.293	0.231	141	10.1	71.4	0.0	18.4	5 250
Recurvirostra avosetta	0.041	0.041	768	0.022	0.008	6 637	0.000	0.000	1 960	1.466	1.125	152	3.6	21.8	0.0	74.6	6 473
Glareola pratincola	0.000	0.000	489	0.030	0.022	4 659	0.000	0.000	1 278	0.000	0.000	121	0.0	100.0	0.0	0.0	1 931
Charadrius dubius	0.000	0.000	484	0.034	0.013	4 583	0.016	0.014	1 193	0.838	0.573	122	0.0	41.6	6.3	52.1	5 295
Vanellus vanellus	0.595	0.252	820	5.303	0.290	7 031	0.217	0.180	2 137	3.818	1.275	157	0.9	94.4	1.2	3.5	361 796
Calidris minuta	0.000	0.000	231	0.121	0.092	2 640	0.000	0.000	651	0.000	0.000	96	0.0	100.0	0.0	0.0	7 764
Philomachus pugnax	0.000	0.000	503	1.696	0.861	5 286	0.000	0.000	1 443	0.000	0.000	129	0.0	100.0	0.0	0.0	109 187
Gallinago gallinago	0.000	0.000	481	0.210	0.066	5 282	0.000	0.000	1 643	0.277	0.241	134	0.0	93.7	0.0	6.3	14 429
Scolopax rusticola	0.000	0.000	529	0.000	0.000	5 684	0.009	0.009	1 827	0.000	0.000	133	0.0	14.5	85.5	0.0	207
Limosa limosa	0.492	0.492	518	0.192	0.089	5 153	0.000	0.000	1 291	0.296	0.296	129	17.1	76.8	0.0	6.1	16 094
Numenius phaeopus	0.000	0.000	406	0.209	0.166	3 648	0.000	0.000	984	0.000	0.000	115	0.0	100.0	0.0	0.0	13 484
Numenius arquata	0.000	0.000	549	0.033	0.014	4 923	0.000	0.000	1 324	0.059	0.059	124	0.0	91.5	0.0	8.5	2 307
Tringa erythropus	0.000	0.000	274	0.003	0.003	3 215	0.000	0.000	803	12.411	9.890	99	0.0	0.5	0.0	99.5	41 100
Tringa totanus	0.000	0.000	563	0.554	0.103	5 597	0.002	0.002	1 486	0.820	0.376	137	0.0	92.9	0.1	7.0	38 419
Tringa nebularia	0.000	0.000	297	0.009	0.005	3 091	0.000	0.000	796	0.000	0.000	98	0.0	100.0	0.0	0.0	578
Tringa ochropus	0.000	0.000	319	0.066	0.060	3 456	0.000	0.000	1 116	0.174	0.174	110	0.0	88.1	0.0	11.9	4 822
Tringa glareola	0.090	0.090	352	0.521	0.170	3 438	0.000	0.000	923	0.112	0.087	110	1.5	97.5	0.0	1.1	34 390
Actitis hypoleucos	0.000	0.000	430	0.161	0.094	4 476	0.000	0.000	1 372	0.403	0.231	114	0.0	88.6	0.0	11.4	11 685
Larus minutus	0.000	0.000	277	0.013	0.013	2 512	0.000	0.000	598	1.049	1.049	91	0.0	19.1	0.0	80.9	4 273
Larus ridibundus	0.439	0.201	821	0.969	0.362	6 799	0.652	0.375	2 027	21.274	7.978	161	1.7	42.1	8.9	47.3	148 163
Larus argentatus	0.000	0.000	462	0.002	0.002	4 271	0.000	0.000	1 189	0.000	0.000	123	0.0	100.0	0.0	0.0	148
Larus cachinnans	0.000	0.000	346	0.030	0.022	3 379	0.000	0.000	937	0.035	0.035	101	0.0	94.4	0.0	5.6	2 056
Sterna hirundo	0.000	0.000	540	0.007	0.003	5 149	0.000	0.000	1 431	0.121	0.098	135	0.0	52.7	0.0	47.3	839
Chlidonias hybridus	0.640	0.640	398	0.209	0.101	4 190	0.000	0.000	1 144	2.486	1.332	121	14.2	53.3	0.0	32.5	25 214
Chlidonias niger	0.000	0.000	463	0.251	0.169	4 805	0.000	0.000	1 212	0.562	0.396	119	0.0	89.7	0.0	10.3	18 029

Species	Relative density (individual/km²)												Habitat occupancy (%)				Estimated
	Urban	SE	n	Farmland	SE	n	Forest	SE	n	Wetlands	SE	n	Urban	Farmland	Forest	Wetlands	# of ind.
Chlidonias leucopterus	0.000	0.000	345	0.121	0.064	3 730	0.000	0.000	952	0.000	0.000	106	0.0	100.0	0.0	0.0	7 820
Columba livia f. domestica	30.114	4.698	646	3.347	0.781	4 903	0.037	0.025	1 416	0.063	0.063	113	43.8	56.0	0.2	0.1	384 978
Columba oenas	0.000	0.000	590	0.091	0.030	5 753	1.678	0.193	1 846	0.021	0.021	135	0.0	14.6	85.2	0.2	40 044
Columba palumbus	5.249	0.671	832	3.021	0.195	6 833	4.685	0.245	2 123	2.740	0.690	156	8.9	59.3	29.0	2.8	328 216
Streptopelia decaoto	37.699	1.610	898	4.635	0.218	7 136	2.079	0.196	2 220	1.893	0.607	163	37.8	53.5	7.6	1.1	557 832
Streptopelia turtur	3.382	1.270	838	4.119	0.222	6 925	8.717	0.344	2 185	2.306	0.602	157	4.0	56.6	37.8	1.6	469 038
Cuculus canorus	1.783	0.284	889	3.223	0.119	7 100	7.347	0.265	2 234	7.210	1.137	159	2.6	53.1	38.2	6.1	390 659
Athene noctua	0.189	0.137	739	0.018	0.008	6 690	0.016	0.016	1 985	0.000	0.000	149	41.6	45.5	12.9	0.0	2 534
Strix aluco	0.007	0.007	653	0.014	0.010	6 236	0.047	0.021	1 960	0.000	0.000	142	2.1	47.5	50.5	0.0	1 881
Asio otus	0.000	0.000	815	0.079	0.025	6 755	0.046	0.024	2 058	0.140	0.110	152	0.0	78.7	14.2	7.1	6 500
Asio flammeus	0.000	0.000	576	0.007	0.005	5 313	0.000	0.000	1 448	0.000	0.000	134	0.0	100.0	0.0	0.0	463
Caprimulgus europaeus	0.000	0.000	689	0.001	0.001	6 055	0.000	0.000	1 861	0.000	0.000	141	0.0	100.0	0.0	0.0	86
Apus apus	3.260	1.899	846	0.188	0.067	6 652	0.035	0.027	2 042	0.000	0.000	156	58.7	39.0	2.3	0.0	31 061
Alcedo atthis	0.000	0.000	857	0.014	0.007	6 959	0.021	0.016	2 130	0.603	0.300	163	0.0	27.3	13.0	59.7	3 325
Merops apiaster	0.527	0.408	855	1.443	0.212	7 074	0.519	0.136	2 195	0.078	0.062	163	2.8	87.1	9.9	0.2	106 693
Coracias garrulus	0.000	0.000	765	0.129	0.027	6 632	0.124	0.073	2 094	0.000	0.000	156	0.0	76.7	23.3	0.0	10 852
Upupa epops	0.307	0.091	873	0.696	0.058	7 034	0.656	0.078	2 210	0.312	0.212	158	2.8	73.6	21.9	1.7	60 909
Jynx torquilla	0.210	0.057	726	0.581	0.050	6 318	1.269	0.136	1 996	0.403	0.242	143	1.8	56.9	39.3	2.0	65 707
Picus canus	0.055	0.055	580	0.002	0.001	5 139	0.249	0.063	1 618	0.000	0.000	132	5.6	2.4	92.0	0.0	5 496
Picus viridis	0.646	0.194	871	0.259	0.031	6 828	1.234	0.121	2 182	0.193	0.097	157	7.9	36.2	54.6	1.4	45 999
Dryocopos martius	0.056	0.028	853	0.068	0.013	6 948	1.859	0.138	2 190	0.423	0.247	159	0.7	9.9	86.2	3.2	43 861
Dendrocopos major	2.318	0.287	859	1.041	0.066	6 792	10.321	0.324	2 203	1.848	0.605	157	4.4	22.6	70.9	2.1	295 958
Dendrocopos syriacus	0.912	0.169	755	0.192	0.030	6 332	0.600	0.101	1 875	0.000	0.000	156	17.2	41.7	41.1	0.0	29 691
Dendrocopos medius	0.442	0.121	723	0.134	0.025	6 332	1.674	0.172	1 981	0.083	0.066	145	5.4	19.0	75.0	0.6	45 419
Dendrocopos leucotos	0.000	0.000	561	0.000	0.000	5 284	0.107	0.059	1 536	0.000	0.000	120	0.0	0.0	100.0	0.0	2 168
Dendrocopos minor	0.205	0.071	810	0.102	0.020	6 512	0.923	0.115	2 081	0.096	0.069	143	4.3	24.5	70.0	1.2	26 793
Calandrella brachydactyla	0.000	0.000	286	0.022	0.014	3 232	0.000	0.000	684	0.000	0.000	99	0.0	100.0	0.0	0.0	1 411
Galerida cristata	1.966	0.351	877	3.585	0.175	6 964	0.125	0.043	2 159	1.006	0.504	154	4.4	93.2	1.0	1.3	247 728

	Relative density (individual/km²)												Habitat occupancy (%)			Estimated
Species	Urban	SE	n	Farmland	SE	n	Forest	SE	n	Wetlands	SE	n	Urban	Farmland	Forest	Wetlands	# of ind.
Lullula arborea	0.131	0.076	512	0.188	0.035	4 835	1.332	0.167	1 558	0.046	0.046	116	1.8	30.2	67.6	0.4	40 045
Alauda arvensis	2.583	0.444	873	43.425	0.963	7 047	2.785	0.285	2 202	20.726	9.558	157	0.5	95.3	1.9	2.3	2 935 468
Riparia riparia	0.560	0.319	815	2.468	1.037	6 806	0.603	0.256	2 033	8.335	6.193	159	1.6	78.8	6.1	13.6	201 761
Hirundo rustica	24.609	2.214	894	8.573	0.476	7 090	1.618	0.284	2 213	6.028	2.585	163	18.5	74.4	4.4	2.7	742 444
Delichon urbica	19.166	3.265	882	3.025	0.320	7 048	0.611	0.182	2 186	3.519	2.623	158	32.9	59.7	3.8	3.6	326 019
Anthus campestris	0.082	0.082	388	0.436	0.063	3 679	0.003	0.003	1 006	0.000	0.000	105	1.6	98.2	0.2	0.0	28 615
Anthus trivialis	0.782	0.306	509	0.867	0.084	4 656	3.776	0.289	1 514	0.705	0.350	117	3.1	40.1	55.1	1.7	139 339
Anthus pratensis	0.000	0.000	387	0.274	0.058	3 440	0.031	0.031	1 040	0.000	0.000	110	0.0	96.6	3.4	0.0	18 243
Anthus cervinus	0.000	0.000	268	0.012	0.009	2 557	0.000	0.000	587	0.000	0.000	87	0.0	100.0	0.0	0.0	802
Motacilla flava	0.703	0.233	773	11.865	0.331	6 651	0.382	0.173	1 984	8.570	1.690	153	0.5	95.0	1.0	3.5	803 905
Motacilla citreola	0.163	0.163	390	0.000	0.000	3 661	0.000	0.000	985	0.000	0.000	116	100.0	0.0	0.0	0.0	913
Motacilla cinerea	0.000	0.000	554	0.039	0.019	5 201	0.218	0.063	1 649	0.021	0.021	137	0.0	35.6	63.4	1.0	6 978
Motacilla alba	2.859	0.368	895	2.398	0.135	7 088	1.133	0.332	2 211	3.123	0.747	158	7.9	75.8	11.3	5.0	203 735
Bombycilla garrulus	0.000	0.000	768	0.000	0.000	6 556	0.059	0.036	2 069	0.000	0.000	149	0.0	0.0	100.0	0.0	1 199
Troglodytes troglodytes	0.132	0.066	848	0.156	0.023	6 861	2.576	0.199	2 142	0.339	0.147	151	1.2	15.6	81.5	1.7	64 295
Prunella modularis	0.006	0.006	528	0.023	0.014	5 029	0.158	0.043	1 511	0.000	0.000	121	0.7	31.5	67.8	0.0	4 740
Erithacus rubecula	0.814	0.186	884	0.661	0.053	6 982	14.978	0.438	2 207	1.142	0.371	158	1.3	12.0	85.7	1.1	355 455
Luscinia luscinia	0.077	0.061	553	0.013	0.008	4 870	0.042	0.019	1 394	0.000	0.000	108	20.3	39.5	40.2	0.0	2 117
Luscinia megarhynchos	3.873	0.389	860	5.963	0.187	6 977	9.196	0.415	2 176	6.800	1.112	160	3.5	62.4	30.4	3.6	615 046
Luscinia svecica	0.000	0.000	706	0.067	0.017	6 200	0.000	0.000	1 896	1.790	0.568	144	0.0	42.2	0.0	57.8	10 200
Phoenicurus ochruros	16.153	0.807	884	1.430	0.097	7 028	0.474	0.116	2 163	0.541	0.300	157	46.6	47.5	5.0	0.9	193 850
Phoenicurus phoenicurus	0.400	0.181	800	0.109	0.025	6 891	0.049	0.024	2 077	0.015	0.015	149	21.7	68.2	9.6	0.5	10 329
Saxicola rubetra	0.534	0.208	587	2.129	0.148	5 768	0.200	0.064	1 761	2.027	0.627	142	2.0	90.9	2.7	4.4	150 841
Saxicola torquata	1.764	0.325	773	5.637	0.177	6 673	1.319	0.165	2 027	5.559	0.988	153	2.4	86.8	6.4	4.4	417 951
Oenanthe oenanthe	0.787	0.291	633	0.592	0.060	5 596	0.092	0.039	1 673	0.243	0.188	135	9.7	84.3	4.2	1.8	45 224
Turdus merula	44.112	2.297	901	7.492	0.238	7 169	27.577	0.578	2 253	5.432	1.332	163	18.9	36.9	42.9	1.4	1 307 953
Turdus pilaris	0.210	0.135	757	0.039	0.018	6 550	0.118	0.040	2 066	0.000	0.000	151	19.3	41.1	39.6	0.0	6 087
Turdus philomelos	3.366	0.419	780	1.507	0.083	6 628	12.416	0.373	2 150	0.980	0.359	154	5.1	26.1	67.9	0.9	371 635

Species	Relative density (individual/km^2)													Habitat occupancy (%)			Estimated
	Urban	SE	n	Farmland	SE	n	Forest	SE	n	Wetlands	SE	n	Urban	Farmland	Forest	Wetlands	# of ind.
Turdus iliacus	0.000	0.000	573	0.003	0.003	5 365	0.006	0.006	1 651	0.000	0.000	124	0.0	59.4	40.6	0.0	322
Turdus viscivorus	0.028	0.021	601	0.034	0.011	5 366	0.524	0.084	1 794	0.000	0.000	134	1.2	16.9	81.9	0.0	13 016
Locustella naevia	0.111	0.071	506	0.501	0.054	4 912	0.214	0.052	1 488	0.182	0.114	128	1.6	85.3	11.5	1.6	37 870
Locustella fluviatilis	0.158	0.121	542	0.654	0.067	5 125	1.556	0.184	1 521	2.342	0.739	138	1.1	51.1	38.4	9.4	82 349
Locustella luscinioides	0.051	0.037	518	0.653	0.064	5 503	0.251	0.076	1 525	13.162	1.531	137	0.3	46.3	5.6	47.8	90 799
Acrocephalus melanopogon	0.000	0.000	378	0.043	0.017	3 904	0.000	0.000	1 129	0.259	0.182	123	0.0	76.4	0.0	23.6	3 606
Acrocephalus paludicola	0.000	0.000	428	0.016	0.010	4 380	0.027	0.027	1 162	0.000	0.000	121	0.0	64.3	35.7	0.0	1 560
Acrocephalus schoenobaenus	0.294	0.211	480	3.475	0.200	4 941	0.295	0.097	1 274	23.729	2.907	130	0.5	72.3	1.9	25.3	309 565
Acrocephalus palustris	0.232	0.113	494	0.946	0.094	4 859	0.181	0.067	1 362	3.656	0.982	136	1.7	78.2	4.7	15.5	77 949
Acrocephalus scirpaceus	0.087	0.061	548	1.000	0.092	5 434	0.122	0.054	1 446	17.310	2.244	142	0.4	51.8	2.0	45.9	124 364
Acrocephalus arundinaceus	1.176	0.337	744	2.738	0.152	6 653	0.668	0.122	1 946	16.728	2.333	149	2.6	70.1	5.4	21.9	251 544
Hippolais pallida	0.000	0.000	201	0.026	0.026	2 449	0.000	0.000	609	0.000	0.000	67	0.0	100.0	0.0	0.0	1 674
Hippolais icterina	0.263	0.170	423	0.075	0.017	4 038	0.154	0.052	1 229	0.884	0.506	108	11.9	39.0	25.4	23.6	12 334
Sylvia nisoria	0.138	0.116	557	0.607	0.061	5 455	0.495	0.112	1 675	0.157	0.110	136	1.5	77.5	20.0	1.0	50 473
Sylvia curruca	1.456	0.270	485	0.966	0.074	4 542	1.391	0.160	1 412	1.024	0.402	107	8.0	61.0	27.7	3.3	102 026
Sylvia communis	0.925	0.195	647	2.806	0.129	5 649	1.438	0.157	1 651	1.749	0.539	135	2.3	81.8	13.2	2.6	220 852
Sylvia borin	0.389	0.132	470	0.129	0.025	4 835	0.344	0.084	1 412	0.100	0.100	127	12.2	46.6	39.4	1.9	17 795
Sylvia atricapilla	7.051	0.563	838	5.154	0.167	6 639	26.603	0.593	2 104	5.378	1.071	151	4.2	35.7	58.2	1.9	930 045
Phylloscopus sibilatrix	0.378	0.141	524	0.283	0.049	4 694	5.317	0.348	1 562	0.303	0.268	120	1.6	14.1	83.5	0.8	129 463
Phylloscopus collybita	1.725	0.255	813	1.640	0.093	6 379	22.226	0.528	2 073	2.735	0.892	143	1.7	18.3	78.4	1.6	576 243
Phylloscopus trochilus	0.217	0.097	590	0.388	0.053	4 899	2.190	0.205	1 524	0.568	0.549	116	1.7	34.4	61.3	2.6	72 636
Regulus regulus	0.000	0.000	731	0.009	0.006	6 277	0.452	0.105	1 936	0.000	0.000	145	0.0	5.9	94.1	0.0	9 782
Regulus ignicapellus	0.000	0.000	710	0.008	0.006	6 140	0.076	0.039	1 877	0.000	0.000	147	0.0	25.6	74.4	0.0	2 072
Muscicapa striata	0.809	0.174	628	0.355	0.046	5 763	1.512	0.162	1 814	0.617	0.225	139	7.5	38.0	51.1	3.4	60 134
Ficedula parva	0.035	0.035	457	0.009	0.004	4 717	0.038	0.013	1 504	0.000	0.000	118	12.7	36.6	50.7	0.0	1 540
Ficedula albicollis	0.655	0.265	640	0.229	0.045	5 749	4.315	0.311	1 871	0.041	0.041	141	3.4	13.9	82.5	0.1	106 313
Ficedula hypoleuca	0.008	0.008	574	0.040	0.012	5 734	0.181	0.045	1 783	0.000	0.000	135	0.7	40.6	58.7	0.0	6 269
Panurus biarmicus	0.000	0.000	705	0.065	0.020	6 321	0.022	0.017	1 923	3.938	1.541	148	0.0	23.8	2.6	73.7	17 615

	Relative density (individual/km^2)													Habitat occupancy (%)			Estimated
Species	Urban	SE	n	Farmland	SE	n	Forest	SE	n	Wetlands	SE	n	Urban	Farmland	Forest	Wetlands	# of ind.
Aegithalos caudatus	1.995	0.673	884	0.723	0.117	6 968	4.534	0.437	2 157	1.368	0.762	159	7.2	30.1	59.7	2.9	154 426
Parus palustris	1.534	0.553	819	0.248	0.033	6 709	3.681	0.250	2 122	2.596	2.112	152	7.9	14.8	69.3	7.9	107 988
Parus montanus	0.013	0.013	491	0.022	0.015	4 765	0.279	0.178	1 521	0.000	0.000	114	1.0	19.8	79.2	0.0	7 162
Parus cristatus	0.000	0.000	747	0.003	0.001	6 361	0.092	0.041	2 005	0.000	0.000	151	0.0	8.7	91.3	0.0	2 043
Parus ater	0.039	0.022	684	0.009	0.007	5 722	0.773	0.102	1 836	0.000	0.000	140	1.3	3.4	95.3	0.0	16 512
Parus caeruleus	2.224	0.489	886	0.715	0.066	7 080	8.347	0.412	2 219	1.846	0.588	159	5.3	19.6	72.4	2.6	234 323
Parus major	20.693	1.541	897	6.970	0.274	7 163	37.082	0.747	2 231	10.167	1.673	159	8.6	33.2	55.8	2.5	1 352 189
Sitta europaea	0.460	0.108	885	0.206	0.031	6 891	8.914	0.354	2 179	0.666	0.286	158	1.3	6.7	91.0	1.1	199 322
Certhia familiaris	0.000	0.000	449	0.016	0.010	3 859	0.490	0.110	1 262	0.000	0.000	102	0.0	9.5	90.5	0.0	11 017
Certhia brachydactyla	0.000	0.000	535	0.044	0.019	4 573	1.553	0.165	1 461	0.203	0.180	119	0.0	8.1	90.0	1.9	35 085
Remiz pendulinus	0.044	0.044	731	0.061	0.014	6 403	0.078	0.042	1 896	1.864	0.566	153	2.1	33.0	13.3	51.7	11 881
Oriolus oriolus	3.024	0.331	895	3.632	0.132	7 085	9.364	0.375	2 222	4.996	1.019	163	3.7	51.1	41.6	3.6	457 678
Lanius collurio	2.396	0.328	810	6.865	0.182	6 968	3.911	0.259	2 186	2.970	0.667	159	2.5	81.1	14.6	1.8	544 776
Lanius minor	0.272	0.199	662	0.735	0.059	6 082	0.151	0.045	1 836	0.531	0.291	140	2.8	88.2	5.7	3.3	53 646
Lanius exubitor	0.000	0.000	712	0.083	0.023	6 376	0.027	0.020	1 949	0.000	0.000	145	0.0	90.6	9.4	0.0	5 887
Garrulus glandarius	1.139	0.205	877	1.078	0.104	7 009	7.384	0.323	2 222	0.682	0.275	162	2.8	30.4	65.8	1.0	228 189
Pica pica	7.549	0.905	896	2.948	0.137	7 139	0.938	0.130	2 225	3.199	0.868	159	16.1	72.5	7.3	4.0	261 643
Corvus monedula	2.082	1.182	877	0.256	0.107	6 933	0.005	0.005	2 131	0.000	0.000	156	41.3	58.3	0.4	0.0	28 201
Corvus frugilegus	3.454	0.934	888	4.389	0.788	7 124	0.185	0.059	2 177	0.201	0.201	158	6.3	92.2	1.2	0.2	306 342
Corvus corone cornix	1.623	0.274	883	2.072	0.136	7 054	0.496	0.122	2 188	3.265	0.879	159	5.6	81.7	6.2	6.6	163 315
Corvus corax	0.084	0.047	850	0.386	0.133	7 044	0.609	0.111	2 191	0.075	0.075	155	1.2	65.4	32.7	0.6	37 943
Sturnus vulgaris	26.887	4.461	899	38.016	2.922	7 073	19.547	1.698	2 236	23.517	####	163	4.9	79.6	12.9	2.5	3 073 227
Passer domesticus	137.415	5.246	900	14.600	0.751	7 164	1.795	0.370	2 240	9.623	4.308	163	43.3	52.9	2.1	1.8	1 777 090
Passer montanus	36.899	2.900	882	32.973	1.088	7 084	5.028	0.541	2 210	21.496	5.122	156	8.2	84.8	4.1	2.8	2 502 622
Fringilla coelebs	7.347	0.648	846	4.899	0.185	6 935	40.280	0.766	2 230	6.219	1.390	161	3.4	26.4	68.5	1.7	1 196 194
Fringilla montifringilla	0.033	0.033	643	0.014	0.011	5 962	0.092	0.042	1 951	0.000	0.000	139	6.2	30.3	63.5	0.0	2 962
Serinus serinus	10.814	0.741	758	1.167	0.094	6 252	0.588	0.095	1 950	0.663	0.314	147	40.4	50.2	8.0	1.5	149 803
Carduelis chloris	18.837	0.925	894	4.812	0.196	6 996	4.879	0.336	2 219	3.883	0.936	158	20.0	58.8	18.8	2.4	527 232

Species	Relative density (individual/km^2)												Habitat occupancy (%)				Estimated
	Urban	SE	n	Farmland	SE	n	Forest	SE	n	Wetlands	SE	n	Urban	Farmland	Forest	Wetlands	# of ind.
Carduelis carduelis	18.105	1.169	892	8.021	0.388	7 072	3.385	0.390	2 210	5.594	2.610	163	14.4	73.3	9.8	2.6	705 011
Carduelis spinus	0.350	0.124	715	0.063	0.022	6 194	0.174	0.056	1 909	0.038	0.038	141	20.3	41.7	36.7	1.3	9 650
Carduelis cannabina	2.049	0.417	707	1.174	0.104	6 064	0.337	0.099	1 846	0.351	0.183	138	12.1	79.5	7.2	1.2	95 048
Carduelis flammea	0.000	0.000	481	0.004	0.003	4 975	0.006	0.006	1 383	0.000	0.000	127	0.0	67.3	32.7	0.0	357
Loxia curvirostra	0.000	0.000	744	0.000	0.000	6 454	0.013	0.009	2 053	0.000	0.000	152	0.0	0.0	100.0	0.0	263
Pyrrhula pyrrhula	0.021	0.013	759	0.016	0.008	6 515	0.063	0.028	2 078	0.000	0.000	153	4.9	41.9	53.3	0.0	2 405
Coccothraustres coccothraustes	0.372	0.091	862	0.503	0.082	6 917	4.783	0.295	2 187	0.256	0.148	157	1.6	24.4	73.4	0.6	132 570
Emberiza citrinella	1.593	0.282	789	4.897	0.192	6 610	15.170	0.545	2 117	2.258	0.605	150	1.4	49.3	48.2	1.2	640 201
Emberiza cirlus	0.000	0.000	309	0.000	0.000	3 434	0.005	0.005	1 072	0.000	0.000	94	0.0	0.0	100.0	0.0	101
Emberiza cia	0.000	0.000	487	0.007	0.007	4 562	0.067	0.040	1 378	0.215	0.174	121	0.0	17.8	54.0	28.1	2 521
Emberiza hortulana	0.000	0.000	382	0.006	0.004	3 744	0.000	0.000	1 105	0.000	0.000	104	0.0	100.0	0.0	0.0	404
Emberiza schoeniclus	0.028	0.020	613	0.951	0.080	5 465	0.172	0.063	1 536	9.435	1.465	138	0.2	63.8	3.6	32.4	95 964
Miliaria calandra	1.569	0.333	698	8.555	0.240	6 152	1.073	0.135	1 925	3.056	0.986	143	1.5	93.1	3.7	1.7	591 537

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Sources of variation in haematocrit in the Collared Flycatcher *(Ficedula albicollis)*

Nóra Boross[1], Gábor Markó[1, 2], Miklós Laczi[1], László Zsolt Garamszegi[3], Gergely Hegyi[1], Márton Herényi[1], Dorottya Kiss[1], Gergely Nagy[1], Balázs Rosivall[1], Eszter Szöllősi[1], János Török[1]

Nóra Boross, Gábor Markó, Miklós Laczi, László Zsolt Garamszegi, Gergely Hegyi, Márton Herényi, Dorottya Kiss, Gergely Nagy, Balázs Rosivall, Eszter Szöllősi, János Török 2012. Sources of variation in haematocrit in the Collared Flycatcher *(Ficedula albicollis)*. – Ornis Hungarica 20(2): 64–72.

Abstract The haematocrit rate of the blood shows the individual physiological state. As the haematocrit grows, the higher erythrocyte number results in more efficient oxygen uptake capacity which can lead to better performance and probably a better survival rate of an individual. Hence we assume that the high value of haematocrit reflects good health state. Altogether 308 blood samples were collected from a wild population of Collared Flycatchers *(Ficedula albicollis)* in two breeding stages during a period of 2008–2010. We tried to elucidate the relationship between condition and haematocrit level of an individual and studied the haematocrit changes of an individual between years. The haematocrit values differed between years. Females had higher haematocrit values than males in 2010 but not in 2009. At courtship the haematocrit level of males was higher, than during nestling care. The different environmental effects and energy demands of the individuals may be the driving force behind the observed changes in haematocrit level. Analysing the changes between two years, there was a positive correlation between changes in condition index and haematocrit of individuals. The haematocrit values of an individual were repeatable between years. This finding suggests that haematocrit can be informative about the individual's general health state.

Keywords: bird, blood, repeatability, health state, energy demand

Összefoglalás A vér hematokritértéke az egyed fiziológiai állapotáról nyújt információt. Feltehetőleg a magas hematokritszint jó egészségi állapotot tükröz, mivel a vörösvérsejtek megemelkedett szintje nagyobb oxigénfelvételi kapacitást és hatékonyabb oxigénszállítást tesz lehetővé a szövetekhez, ami az egyed jobb teljesítőképességét eredményezi. A Pilis hegységben 2008 és 2010 között odútelepeken költő örvös légykapókon *(Ficedula albicollis)* vizsgáltuk a hematokritérték évek és ivarok közötti eltérését, majd hímek esetében az udvarlás és a fiókanevelés stádiumában mért mintázatát. Vizsgáltuk az egyedek hematokritértékének és kondíciójának kapcsolatát. Továbbá számoltuk az egyedek hematokritértékének évek közötti repetabilitását. A hematokritértékek évek között több esetben eltértek. A hímek udvarlás alatti hematokritszintje magasabbnak bizonyult, mint fiókanevelés alatt. Az egyedek hematokritértékének repetabilitása magas volt, évek közötti eltérése pedig pozitívan korrelált kondíciójuk változásával. Feltehetőleg az évek közötti varianciát az eltérő környezeti feltételek okozhatták, míg az udvarlás alatt mért magas hematokritszint a megelőző vonulás nagy energiaigényének következménye lehet. Bár a hematokritérték változása volt megfigyelhető az évek és a szaporodási stádiumok között, az egyeden belül évek között mégis repetabilitást mutatott. Az egyedi hematokritértékek évek közötti repetabilitása lehetővé teszi, hogy a jelleg az egyed aktuális állapota mellett általános egészségi állapotáról is informáljon.

Kulcsszavak: madár, vér, repetabilitás, egészségi állapot, energiaigény

[1] *Behavioural Ecology Group, Department of Systematic Zoology and Ecology, Eötvös Loránd University, 1117 Budapest, Pázmány Péter sétány 1/c, Hungary, e-mail: borossnori@yahoo.com*
[2] *Department of Plant Pathology, Corvinus University of Budapest, 1118 Budapest, Ménesi út 44., Hungary*
[3] *Department of Evolutionary Ecology, Estación Biológica de Doñana (CSIC), c/Americo Vespucio, s/n 41092 Seville, Spain*

Introduction

Haematocrit is a generally measured physiological object in human clinical processes, and it is emerging as a measure for the health state of individuals in natural populations (e.g. Hõrak *et al.* 1998, Ots *et al.* 1998, Hargitai *et al.* 2006, Kilgas *et al.* 2006).

Haematocrit shows the rate of packed cell volume to the volume of whole blood. Through the erythrocyte number haematocrit reflects oxygen uptake capacity and transport efficiency (Ots *et al.* 1998), which in turn could affect the survival of an individual. Low haematocrit level can indicate anaemia and associate with low available oxygen level (Phillips *et al.* 1985), therefore suggesting that birds may use anaerobically metabolized energy which may impair flight performance.

Birds can increase their haematocrit level as an adaptive response when their energy demand grows and more oxygen uptake is needed. This was shown in a brood size manipulation study of Great Tits *(Parus major)* (Hõrak *et al.* 1998) and a tail elongation study of Barn Swallows *(Hirundo rustica)* (Saino *et al.* 1997a). Both interventions resulted in increased haematocrit level.

Many studies assume that haematocrit is a good and reliable fitness related trait because it can reflect the condition and disease status of an individual (e.g. Svensson & Merilä 1996, Saino *et al.* 1997a, Sánchez-Guzmán *et al*. 2004). However, haematocrit can change very quickly as the effect of changing energy demand or different environmental factors (Fair *et al.* 2007), such as food availability (Merino & Potti 1998, Hoi-Leitner *et al.* 2001, Santangeli *et al*. 2012) or parasite infection (Heylen & Matthysen 2008, Palinauscas *et al*. 2008). Hence, there is a dispute about its potential to reliably reflect individual quality.

Our goal was to examine the patterns of haematocrit in a wild population of Collared Flycatchers: (1) to compare the within- and between-year variation in haematocrit among sexes, (2) to test the relationship between the condition index and the haematocrit of an individual and (3) to analyse the within-individual repeatability of haematocrit between years.

Materials and Methods

Study area and field methods

Our study was carried out in the Pilis Mountains (47°43’ N, 19°01’ E), located 30 km North of Budapest in Hungary. We studied a population of Collared Flycatchers breeding in artificial nest-boxes in an oak-dominated woodland from 2008 to 2010. The Collared Flycatcher is a long-distance migratory, insectivorous passerine.

We caught the individuals in their nest-boxes. Males were captured twice: firstly, during courtship, after arrival from migration, when they occupy nest-boxes (21 and 87 males in 2008 and 2010, respectively) and secondly, during nestling care, when nestlings were 6 days old (41 and 71 males in 2009 and 2010, respectively). Females were captured during nestling care (41 and 47 females in 2009 and 2010, respectively).

A blood sample (50–70 μl) was taken from the brachial vein into heparinized capillaries within 20 minutes of capture and centrifuged at 10.000 r.p.m. for 10 minutes on the same day. The haematocrit value was calculated as the ratio of the length of the capillary occupied by red blood cells and the length of the capillary occupied by total blood.

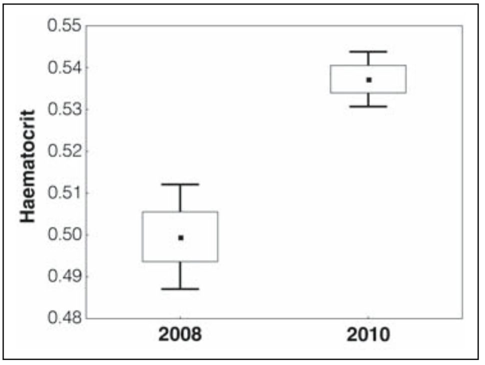

Figure 1. The haematocrit values of male Collared Flycatchers during the courtship in 2008 and 2010
n_{2008}=21; n_{2010}=87
Note: on the boxplot: the points are the means of the values, the squares show the standard errors, and 95% confidence intervals are presented as whiskers.

1. ábra Örvös légykapó hímek udvarlási periódusban mért hematokritértékei 2008-ban és 2010-ben
n_{2008}=21; n_{2010}=87
Megjegyzés: A boxplot ábrán a pont az értékek átlagát mutatja, a négyzet a standard hibát ábrázolja, a vonallal jelzett tartomány a 95%-os konfidencia intervallumot jelöli.

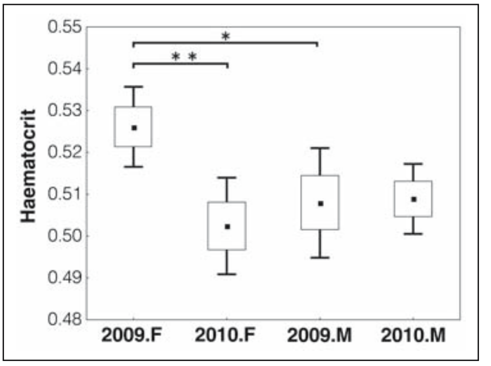

Figure 2. The difference in haematocrit levels between years and sexes (F=female; M=male) during nestling care
$n_{2009, female}$=41; $n_{2010, female}$=46; $n_{2009, male}$=41; $n_{2010, male}$=70
*Note: for the explanation of the boxplot see Figure 1 * p=0.027; ** p=0.0025*

2. ábra A hematokritértékekben megmutatkozó évek és ivarok közötti különbség (F=tojó; M= hím) nevelési fázisban
$n_{2009, tojó}$=41; $n_{2010, tojó}$=46; $n_{2009, hím}$=41; $n_{2010, hím}$=70
*Megjegyzés: a boxplot magyarázatát lásd 1. ábra; * p=0,027; ** p=0,0025*

Birds were weighed with Pesola spring balance (to the nearest 0.1 g) and the length of the tarsus was measured with a sliding calliper (to the nearest 0.1 mm). Body condition was calculated as the residual of a linear regression of body mass on tarsus length.

Statistical analyses

We performed all statistical analysis in the R software (version 2.12.2[1]). Unless stated otherwise, we used linear regression models and Pearson correlation to test the interrelation of variables. We calculated the change in haematocrit and condition by subtracting their values in 2010 from the values in 2009. We estimated the repeatability of haematocrit between years using the method developed by Lessels and Boag (1987).

Results

During courtship, the haematocrit level of males was higher in 2010 than in 2008 (F=27.02; df=106; p<0.0001; *Figure 1*).

During nestling care, we studied the variation in haematocrit level between 2009 and 2010 and between the sexes *(Figure 2)*. Comparing the years separately by sexes, haematocrit level of females showed a higher level in 2009 than in 2010 (F=9.75; df=84; p=0.0025). Years did not have any significant effects on the haematocrit level of males (F=0.016; df=109; p=0.899). Comparing the sexes in both years, we found that females had higher haematocrit values than males in 2009 (F=5.057; df=79; p=0.027), but there was no difference between sexes in 2010 (F=0.866; df=114; p=0.35; *Figure 2*).

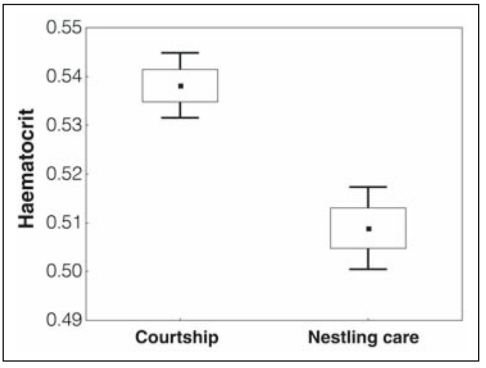

Figure 3. The haematocrit levels of male Collared Flycatchers during courtship and nestling care, in 2010
$n_{courtship}$=70; $n_{nestling\ feeding}$=87
Note: for the explanation of the boxplot see Figure 1

3. ábra Örvös légykapó hímek hematokritértékei udvarlási és fiókanevelési stádiumban, 2010-ben
$n_{udvarlás}$=70; $n_{fiókanevelés}$=87
Megjegyzés: a boxplot magyarázatát lásd 1. ábra

In 2010, blood samples were taken from males in two breeding stages which revealed a higher haematocrit level during courtship than during nestling care (F=33.48; df=123; p<0.0001; *Figure 3*).

As differences between years, sexes and breeding stages were detected in haematocrit, the correlation between the condition and the haematocrit level of individuals was analysed separately for years and sexes during nestling care. No correlation was found between the two individual traits (all p>0.5; *Table 1*).

However, the change in condition was positively correlated with the change in individual haematocrit level between 2009 and 2010 during nestling care (F=7.086; df=13; p=0.02; *Figure 4*). Sexes were examined together.

The haematocrit values of birds captured in 2009 and also in 2010 during nestling care showed high repeatability between years (repeatability: 0.676; p=0.038; *Figure 5*).

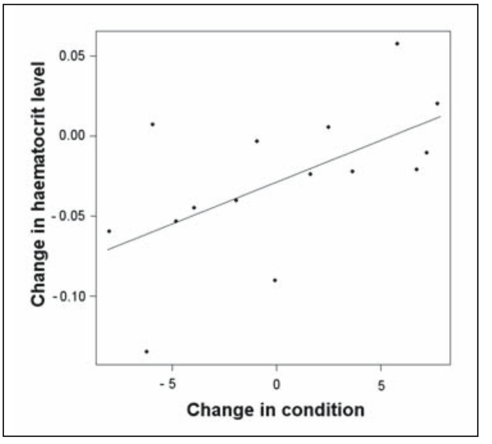

Figure 4. The relationship between the change in condition and haematocrit level of individuals, between 2009 and 2010. Traits were measured at nestling feeding period
n_{female}=6; n_{male}=9

4. ábra 2009-ben és 2010-ben nevelési stádiumban visszafogott egyedek hematokrit- és kondícióváltozásának kapcsolata
$n_{tojó}$=6; $n_{hím}$=9

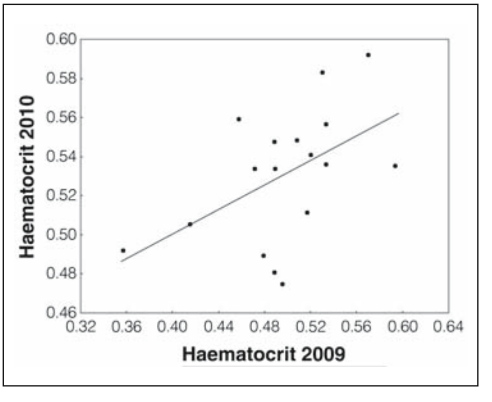

Figure 5. The repeatability of individual haematocrit levels between years. Birds were captured in 2009 and recaptured in 2010, during nestling care
n_{female}=6; n_{male}=11

5. ábra Az egyedi hematokritértékek évek közötti repetabilitása. Fiókanevelési stádiumban 2009-ben mért, majd 2010-ben visszafogott madarak alapján
$n_{tojó}$=6; $n_{hím}$=11

	2009				2010			
	Estimate	SE	t	p	Estimate	SE	t	p
Male condition	<0.001	0.002	0.1	0.921	<0.001	0.001	-0.58	0.564
Female condition	<0.001	0.001	0.08	0.936	<0.001	0.001	-0.16	0.875

Table 1. The relationship between condition and haematocrit level of individuals. The analyses were made separately for years and sexes during nestling care

1. táblázat A madarak kondíciójának és hematokritértékének kapcsolata fiókanevelési stádiumban mérve, ivarok és évek szerint

Discussion

To shed light on the sources of variation in haematocrit in the investigated wild population of Collared Flycatcher, firstly, we compared the haematocrit levels between years. The differences we have found between years support the sensitivity of haematocrit to environmental factors. Comparing birds captured during courtship in 2008 and 2010, the haematocrit level significantly differed. The difference between 2009 and 2010 was also significant when females during nestling care were compared, but not in the case of males.

The genetic and environmental components of the variation in haematocrit were previously examined in Barn Swallows (Cuervo *et al.* 2007) and Pied Flycatchers *(Ficedula hypoleuca)* (Potti *et al.* 1999). According to the cross-fostering experiments the measured variation in haematocrit level of the fledglings in these species is explained more by the nest where they were reared than the nest to which they genetically belonged.

The environmental influence on haematocrit level was demonstrated in experiments where increased food availability resulted in increased haematocrit level (Merino & Potti 1998, Hoi-Leitner *et al.* 2001, Santangeli *et al.* 2012), while fasting birds decreased their haematocrit values (Boiesmenu *et al.* 1992, Merilä & Svensson 1995). Török *et al.* (2004) studied the varying food availability in our study site between years. One of the main food type of the Collared Flycatcher is the caterpillar, which showed a high biomass variance estimated by caterpillar frass collection (Török *et al.* 2004). Further experimental studies are required to assess the role of the environmental factors in the variance of haematocrit level.

Literature is contradictory about the fact whether the sexes differ in terms of haematocrit (e.g. Hõrak *et al.* 1998, Potti *et al.* 1999, Fair *et al.* 2007). We found ambiguous patterns in our flycatcher population, as well, with a difference between sexes in 2009 but not in 2010.

As mentioned before, the haematocrit level can change with growing energy demand. Prior to feeding the nestlings, the nest building, egg laying and incubating all belong to the female's investments, which could have an effect on the high haematocrit level of females in 2009. However, males occupy and guard nest-boxes, and after the hatching both parents feed the nestlings, which could cause similar haematocrit rates between sexes.

Beside the effect of the changing energy demand, erythropoesis is generally suppressed during egg laying, causing reproductive anemia by females (Sockman *et al.* 2006, Wagner *et al.* 2007, 2008, Willie *et al.* 2010). Haematocrit decreases to the first-egg stage and the recovery is relatively long-lasting, extending through incubation and hatching period (Wagner *et al.* 2008). This recovery can be regulated by high plasma prolactin level which is typical during incubation (Sockman *et al*. 2006). In an experimental study, increased prolactin caused increased haematocrit in hypophysectomized pigeons (Höcker 1969). Anti-estrogen (tamoxifen) treatment reduced the decrease in haematocrit during egg production in female Zebra Finches, which indicates that the decrease in haematocrit may have been due to antagonistic pleiotropic effects of estrogens (Wagner *et al.* 2007). Females captured during nestling feeding should be in recovery phase from anemia, which would mean a relatively low haematocrit level, something we did not observe when compared to males. However the postnuptial moult usually commences earlier in males than females, and may partly overlap with nestling feeding. During moulting the haematocrit level is decreasing (Chilgren & deGraw 1977, Driver 1981, Merino & Barbosa 1996). The presumably increasing haematocrit level of females during recovery phase and the decreasing level of males during early postnuptial moulting could equate the haematocrit level of sexes during nestling feeding. We did not find any effect of the sexes on haematocrit in 2010, as Potti *et al.* (1999) also did not find a difference between sexes by studying a sister species, the Pied Flycatcher. These stage-specific factors may have environment-dependent effects on the haematocrit level of the sexes which may have led to the sex difference in haematocrit in one year but not in another.

In 2010 we captured males during courtship and also during nestling care. Comparing the haematocrit values between the two breeding stages, we found that during the courtship the haematocrit level was significantly higher. We captured males at courtship a few days after arrival from migration. Because haematocrit is proportional to the metabolic activity during periods of days before blood sampling (Carpenter 1975, Ots *et al.* 1998), the high energy demand of long distance migration could have caused the increased haematocrit level by males sampled at courtship. Landys-Ciannelli *et al.* (2002a) pointed out the haematocrit-increasing effect of long-term flying with Bar-tailed Godwits *(Limosa lapponica)*. In addition to the highly increased energy demand of long-term migration, hormonal changes could also affect the haematocrit level. Several studies have shown the growing plasma corticosterone level just before and during migration (Holberton 1999, Piersma *et al.* 2000, Landys-Ciannelli *et al.* 2002b), which could directly increase the haematocrit level of birds. The testosterone level of males is also increasing until courtship and has the highest level during the mating period. During the breeding period this level must decrease, because high testosterone holds back the nestling feeding mechanisms (Wingfield *et al*. 1990). Experimental studies have shown that testosterone treatment increases erythropoesis and haematocrit level in some bird species (Domm & Taber 1946, Robinzon & Rogers 1979, Thapliyal *et al*. 1983). In another study, testosterone and haematocrit were simultaneously growing with sexual maturity of the male turkey (Cecil & Bakst 1991). In line with our findings, the decreasing haematocrit level during the breeding period was also experienced by Barn Swallows (Saino *et al.* 1997b). The observed differences between the two breeding stages may be due to the highly increased energy demand of long-term migration and the changing level of the hormones testosterone and corticosterone.

We assumed that haematocrit reflects the health state of an individual and could play a role in survival. Based on this, we expected a positive correlation between condition and haematocrit level of individuals. However, these traits were not correlated with each other.

Due to the life history trade-off theory, we would expect a negative relation between two costly fitness-related traits. However, because of individual optimisation and because probably both of the studied traits are related to fitness, we could also expect a positive correlation. Still, it happens that fitness related traits do not correlate with each other. Hegyi *et al.* (2002) showed that forehead patch size is unaffected by body condition in the same population of Collared Flycatcher that we studied. Even so, both of the traits can reflect individual fitness. In a Swedish population of Collared Flycatchers the forehead patch size was positively related to lifetime reproductive success (Gustafsson *et al*. 1995). Two uncorrelated fitness-related traits could reflect different aspects of the complex individual quality.

A significantly positive relationship appeared in the change of haematocrit and condition, which may partly be due to the possible quick changes in their value. Both of them are capable of reflecting the current physiological status of individuals. Sánchez-Guzmán *et al.* (2004) found the same relationship in Northern Bald Ibises *(Geronticus eremita)*, and Rattner *et al.* (1987) showed a relationship between the growing weight and the haematocrit level of American Black Duck fledglings *(Anas rubripes)*.

When we compared the haematocrit levels of birds captured in two different years but in the same breeding stage, the haematocrit of individuals showed high repeatability. Studying a Pied Flycatcher *(Ficedula hypoleuca)* population, Potti *et al.* (1999) also found that haematocrit was repeatable between years.

To summarize, our results indicate the sensitivity of haematocrit: (1) to environmental factors, indicated by differences between years, and (2) to growing energy demand and the hormonal background, suggested by the high haematocrit value after migration, at courtship. We observed that a relationship with condition only appeared when we compared the changes of the traits, possibly due to the combination of the short-term flexibility of the two traits and their similar sensitivity to large-scale environmental factors. Finally, possibly our most interesting result is that despite its variability, the individual's haematocrit was repeatable between years. This finding suggests that haematocrit may not only reflect the current status of an individual (condition change associated with haematocrit change), but it may also be capable of informing us about the individual's general health state.

Acknowledgements

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VERSITA

Autumn migration of soaring birds in North Dobrogea, Romania: a study with implications for wind farm development

Attila Fülöp[1, 2, *], Lőrinc Bărbos[1], Gábor M. Bóné[1], Szilárd J. Daróczi[1], Luca A. Dehelean[1], Réka B. Kiss[1], István Kovács[1], Attila Nagy[1], Tamás Papp[1]

Attila Fülöp, Lőrinc Bărbos, Gábor M. Bóné, Szilárd J. Daróczi, Luca A. Dehelean, Réka B. Kiss, István Kovács, Attila Nagy, Tamás Papp 2012. Termikelő madarak őszi vonulása Észak-Dobrudzsában, Romániában: szempontok a szélerőmű parkok tervezéséhez. – Ornis Hungarica 20(2): 73–85.

Abstract In Dobrogea, a core area for wind energy exploitation in Romania, existing knowledge regarding the intensity and pattern of bird migration is limited. In the absence of enumerated data, wind farms may be constructed in areas where large aggregations of migrants pass. In this study we recorded the intensity of the autumn migration of soaring birds in three locations within the Măcin Mountains, where wind farms are planned to be built. The locations chosen were at Văcăreni, Greci and Cerna villages. Furthermore we categorized all migrating individuals as threatened or non-threatened by the planned wind farms, based on their migration routes and height at local scale. At Văcăreni 4.716 individuals were counted, 3.394 raptors and 1.322 non-raptors, at Greci 2.387 individuals, 2.064 raptors and 323 non-raptors, and finally at Cerna, 5.268 individuals, 4.529 raptors and 739 non-raptors. At all three sites a significant proportion of birds, both raptors and non-raptors, were found to be threatened by the proposed wind farms. At Văcăreni 68.33% of raptors and 84.95% of non-raptors were at threat, at Greci 44.48% and 54.18% respectively, and at Cerna 59.37% and 94.86%. As such we conclude that intensive migration occurs in North Dobrogea and wind farms would have a considerable negative impact on migrants in the studied areas.

Keywords: Măcin Mountains, migration corridor, raptors, wind energy, impact

Összefoglalás A madárvonulás intenzitásáról és mintázatáról Dobrudzsa területéről, mely egy kulcsfontosságú régiót jelent Románia számára, a szélenergia hasznosítása szempontjából csekély mennyiségű ismerettel rendelkezünk. A megfelelő információk hiányában a szélerőmű parkokat olyan területekre építhetik, ahol jelentős madár tömegek vonulnak el. Vizsgálatunkban a termikelő madarak őszi vonulását követtük a Măcin-hegység térségében, Văcăreni, Greci és Cerna települések határában, ahova a közeljövőben szélerőmű parkokat terveznek létesíteni. Az átvonuló egyedeket megszámoltuk, majd minden madár esetében megállapítottuk, összehasonlítva a vonulási útvonalát és magasságát a tervezett szélerőművek hatáskörzetével, hogy veszélyeztetett-e vagy sem a tervezett a szélturbinák által. Văcăreni-nél összesen 4716 egyedet észleltünk, 3394 ragadozót és 1322 nem ragadozót, Greci-nél 2387 egyedet, 2064 ragadozót és 323 nem ragadozót, és végül Cerna-nál 5268 egyedet, 4529 ragadozót és 739 nem ragadozót. Văcăreni-nél a ragadozók 68,33%-a és a nem ragadozók 84,95%-a vonult a veszélyes zónában, Greci-nél a ragadozók 44,48%-a, a nem ragadozók 54,18%-a, Cerna-nál a ragadozók 59,37%-a, valamint a nem ragadozók 94,86%-a repült át a veszélyes területen. Eredményeink alapján megállapíthatjuk, hogy Észak-Dobrudzsában jelentős őszi madárvonulás figyelhető meg, valamint a tervezett szélerőmű parkok jelentős kockázatot jelentenének a vonuló madarakra, ha megépülnének.

Kulcsszavak: Măcin-hegység, vonulási folyosó, ragadozók, szélenergia, veszélyforrás

[1] Milvus Group – Bird and Nature Protection Association, Crinului street 22, 540620 Târgu Mureş, Romania, e-mail: fafeldolgozo@gmail.com
[2] MTA-DE "Lendület" Behavioural Ecology Research Group, Department of Evolutionary Zoology and Human Biology, University of Debrecen, Egyetem tér 1, 4032 Debrecen, Egyetem tér 1., Hungary
** Correspondence to Attila Fülöp: e-mail: attila.fulop@milvus.ro, address: Milvus Group – Bird and Nature Protection Association, Crinului street 22, 540620 Târgu Mureş, Romania*

Introduction

The move to alternative energy sources has become one of the most important strategies in the European Union for the reduction of greenhouse gas emissions (Nagy & Körmendi 2012). Along with solar power, hydroelectric power and geothermal energy, wind is an important renewable energy source which, when exploited through wind turbines, can produce electricity with minimal carbon emissions. Currently wind energy provides for 5.3% of the EU's energy consumption. However, this is set to rise steeply over the next two decades as the EU moves towards its target of generating 28.5% of its electricity usage by 2030, according to some scenarios (EWEA 2011). This implies intensive proliferation of wind farms, and already a constant increase can be spotted all over Europe, including Romania, and inside Romania especially in Dobrogea.

Dobrogea is a region situated in the South-Eastern part of the country, between the Danube River and the Black Sea. It is characterized by an arid climate and windy weather, which shows a high intensity over the whole period of the year (Lungu *et al.* 2009). Due to its climate, Dobrogea constitutes a priority area for Romania to exploit wind energy (RWEA 2011) and as such the number of wind farms has increased significantly in this region in the last few years, with the total capacity of the approved projects until January 2012 reaching 5000 MW power (CN Transelectrica SA 2012).

Although wind farms are generally recognized as a 'green' energy source with various benefits, several adverse effects of wind farms on flying animals (e.g. birds and bats) can be highlighted, which cannot be neglected (reviewed by Drewitt & Langston 2006, Hötker *et al.* 2006, Kunz *et al.* 2007, Drewitt & Langston 2008). As a primary impact on birds, (1) wind farms cause habitat disturbance, both during building (Pearce-Higgins *et al.* 2012) and during functioning (Garvin *et al.* 2011, Carrete *et al.* 2012, De Lucas *et al.* 2012). Beside habitat disturbance, (2) wind farms also produce a barrier-effect in the course of passing individuals (Drewitt & Langston 2006, Pruett *et al.* 2009), and, (3) most significantly, there is a high risk of collision for flying animals with the moving rotor blades (Drewitt & Langston 2006), which can occur both during local movements, or during migration. Thus sedentary and migrating individuals can be affected as well (Drewitt & Langston 2006). Collision risk, hence mortality rate, of birds at wind farms can be highly variable over the year (De Lucas *et al.* 2008) and it depends on a wide range of factors, like bird species, number and behavior of individuals, flight strategy, migratory behavior, weather conditions and surface topography (reviewed by Drewitt & Langston 2006, Drewitt & Langston 2008), as well as from turbine height and elevation above sea level (De Lucas *et al.* 2008). It has been shown previously that the most affected groups are birds using the soaring-gliding flight style, like raptors (Garvin *et al.* 2011). Therefore, based on our present knowledge, the scenario with the highest collision risk would be a flock of soaring birds flying at the height of the wind farms in bad weather conditions, over a migration route (Kikuchi 2008).

Raptors and other soaring birds migrate over well-established migration routes (or migration corridors) and generally use geographical bottlenecks (e.g. Bosporus, Gibraltar, Suez) to cross large water surfaces (Ferguson-Lees & Christie 2001). Over these migration routes and bottlenecks large concentrations of migrating birds can be counted (Newton 2008). In Romania, Dobrogea is defined as an important migration corridor for birds coming from the Northern- and North-Eastern part of Europe and heading to Africa through the Bosporus, following the Via Pontica flyway, a section of the Eurasian – East African Flyway which runs down the Western coast of the Black Sea (Domahidi *et al.* 2004, Newton 2008, Michev *et al.* 2012). Large numbers of birds pass every autumn over Dobrogea (Domahidi & Komáromi 2004, Domahidi *et al.* 2004, Komáromi 2005, Milvus Group 2008, Pârâu 2011). The geographical distribution of the migrants is relatively uniform, however migration intensity tends to be more accentuated on the Western- and Eastern parts of the region (Milvus Group 2011).

In the present study we provide data on the magnitude of autumn migration of several raptors and other bird species in three different regions of North Dobrogea, all located within the area of Măcin Mountains, where wind farms are planned to be constructed in the near future. All three study sites are part of a Natura 2000 site (ROSPA0073) or are in the near vicinity of it, thus represent areas of high conservation priority. Beside the number of migrating individuals we try to assess the potential impact of wind farms on the migrants, based on the migration route and height of individuals compared to the operating range of wind turbines at local scale. Our study highlights the importance of this region as a migration corridor and the potential negative effect of the wind farms on migrants.

Material and Methods

Species of interest

We focused our study on several bird species which may be negatively influenced by the presence of wind farms in the course of their migration. Typically such groups include all raptors and other large-sized soaring birds (e.g. Storks, Pelicans, Cranes). Beside the enumerated taxa we also recorded the species belonging to the following groups: Cormorants, Herons, Geese, Ducks, Gulls and Pigeons. Most of these birds are large-sized, thus they can be detected and counted from long distances.

Study sites

We made our observations from three different count points simultaneously. Count points were located in the area of Măcin Mountains, in the vicinity of the villages of Văcăreni (N 45.265267°, E 028.227751°), Greci (45.136395°, E 028.263373°) and Cerna (N 45.068871°, E 028.346660°). In all the three places wind farms are planned to be built with various number of wind turbines: 35 at Văcăreni (APM Tulcea 2011a, APM Tulcea 2011b, APM Tulcea 2011c, As Orimex New SRL 2011a, As Orimex New SRL 2012a), 24 at Greci (As Orimex New SRL 2011b, As Orimex New SRL 2012b, As Orimex New SRL 2012c) and 27 at Cerna (APM Tulcea 2011d, As Orimex New SRL 2011c, As Orimex New SRL 2013). Observation points were placed on the top of hills to have good visibility on the study areas and to maximize the chance to observe migrating birds over large distances (see *Figure 1*).

General survey procedures

We recorded the 'visible' migration of birds in the autumn of 2012 during two different periods, between 20–30 September and 5–14 October, summing 21 observation days in total. Survey periods were chosen

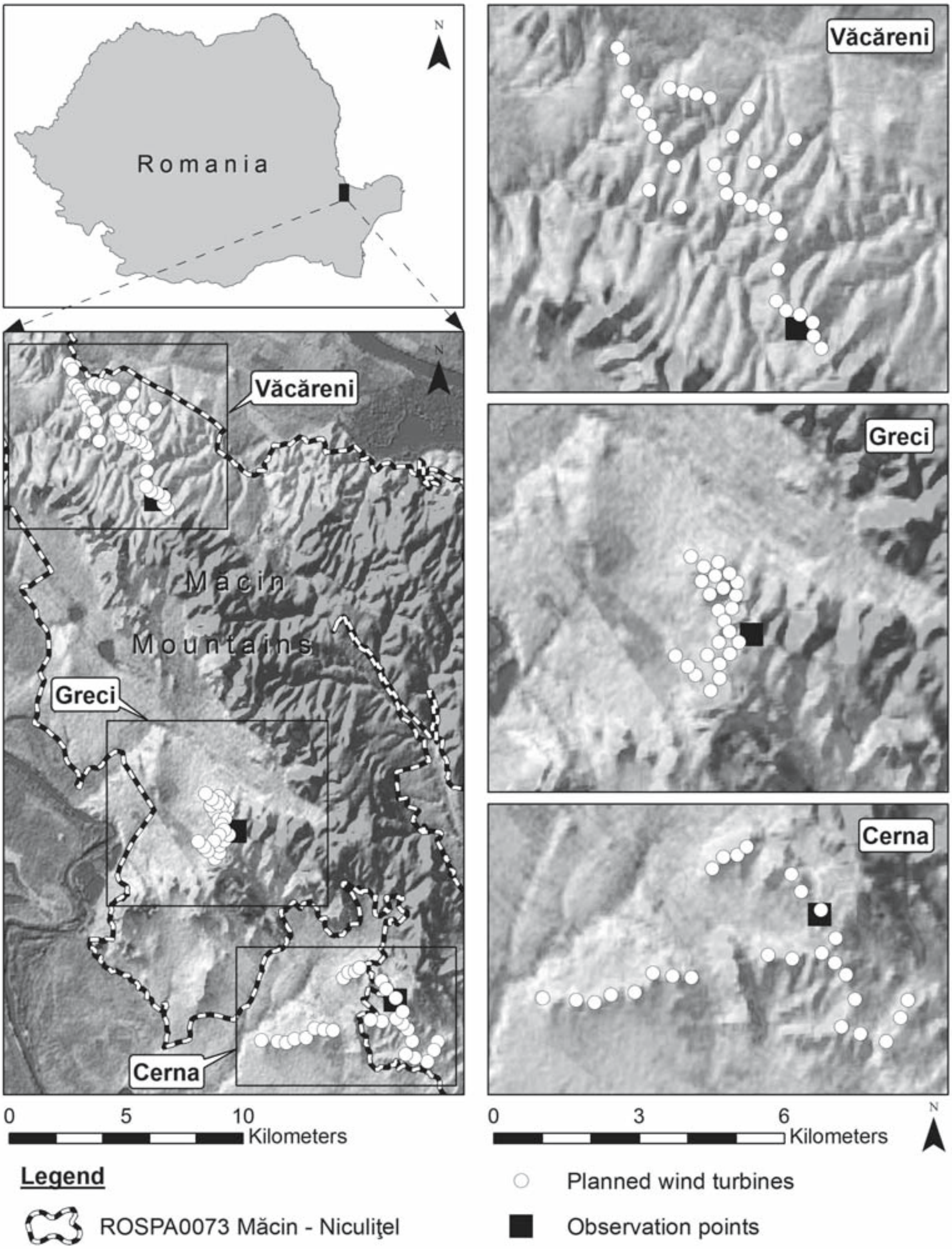

Figure 1. Map showing the location of the study sites in Măcin Mountains. A highlighted view of each site shows the positioning of the count points in relation to the distribution of the planned wind turbines and surface topography

1. ábra A vizsgált területek elhelyezkedése a Măcin-hegység térségében (bal oldal). Az egyes mintaterületeket külön-külön ábrázoló térkép, mely a megfigyelőpont elhelyezkedését szemlélteti a tervezett szélturbinák helyzetéhez és a felszín domborzatához viszonyítva (jobb oldal) to cover the migration peak of the two most abundant migrating raptors in Dobrogea in this period, the Lesser Spotted Eagle *(Aquila pomarina)* and the Common Buzzard *(Buteo buteo)* respectively (Pârâu 2011). According to previous studies (Domahidi *et al.* 2004, Pârâu 2011) the migration peak of the Lesser Spotted Eagles in the area of Măcin Mountains is in the second half of September. The abundance of migrating Common Buzzards fluctuates over time, but the highest numbers were recorded between 20 September and 15 October (Domahidi & Komáromi 2004, Komáromi 2005, Pârâu 2011).

We carried out our observations every day between 9 AM and 6 PM according to the method described by Bird & Bildstein (2007). During these hours 2-4 ornithologists were present on every survey point, actively searching for migratory birds arriving from the North, North-East or North-West, but without disregarding the other directions either. Surveyors were equipped with binoculars (Leica Ultravid HD 10×42) and spotting scopes (Kowa TSN-883, eyepieces 30× and 20-60×). Observations were suspended only in case of bad weather conditions (rain or fog), when the visibility decreased significantly and counting became impossible. We recorded all the observed migrating individuals or flocks in standard data sheets. Migrating birds were identified at species level. If accurate determination was impossible, birds were determined at genus level or marked as unknown. Unidentified raptors were noted using a common reference as '*Rapaces sp.*'. Beside the number of individuals we recorded the flight direction, distance from the count point and presence or absence in the risk zone. Wandering individuals were also noted (e.g. birds coming from South).

Safe zone and risk zone

Within the three study sites we determined the risk zone and the safe zone. The risk zone was delimited as the total operation range of the planned wind turbines. This took into account the altitude gradient, ranging between 0–200 meters above the ground level, to give the approximate range of motion of an average wind turbine. Individuals flying within the described altitude limits inside the area of a wind farm are considered as presenting a high collision risk with operating wind turbines. The safe zone was defined as all the area outside of the planned wind farms, or the altitude >200 meters above ground inside the area of the wind farms, the height from which most migrating birds can safely cross above the wind farm area.

Double counts and data manipulation

Double counting inside the same study area was prevented by following every bird or flock during its transition over the region, heading mainly from North to South, from the moment of its first detection until the moment of disappearance. Double counting between the count points cannot be completely avoided due to the positioning of the points along an approximate North-South gradient. Although the count points were at relatively large distances from each other, overestimates in the total number of individuals cannot be excluded.

The number of observed migrants was summed and the proportion of threatened and non-threatened individuals was calculated in the case of every species at all the three count points separately.

SPECIES NAME		Threatened	Proportion of threatened (%)	Non-threatened	Proportion of non-threatened (%)	Total at count point (100%)
Raptors						
European Honey-buzzard	*Pernis apivorus*	4	66.67	2	33.33	6
Osprey	*Pandion haliaetus*	1	33.33	2	66.67	3
Black Kite	*Milvus migrans*	2	100.00	0	0.00	2
Short-toed Eagle	*Circaetus gallicus*	28	66.67	14	33.33	42
White-tailed Eagle	*Haliaeetus albicilla*	6	85.71	1	14.29	7
Northern Goshawk	*Accipiter gentilis*	1	100.00	0	0.00	1
Eurasian Sparrowhawk	*Accipiter nisus*	130	65.66	68	34.34	198
Levant Sparrowhawk	*Accipiter brevipes*	2	100.00	0	0.00	2
Western Marsh Harrier	*Circus aeruginosus*	59	79.73	15	20.27	74
Hen Harrier	*Circus cyaneus*	14	82.35	3	17.65	17
Pallid Harrier	*Circus macrourus*	11	73.33	4	26.67	15
Common Buzzard	*Buteo buteo*	1495	63.83	847	36.17	2342
Long-legged Buzzard	*Buteo rufinus*	2	50.00	2	50.00	4
Rough-legged Buzzard	*Buteo lagopus*	1	100.00	0	0.00	1
Lesser Spotted Eagle	*Aquila pomarina*	431	82.57	91	17.43	522
Greater Spotted Eagle	*Aquila clanga*	3	75.00	1	25.00	4
Booted Eagle	*Aquila pennata*	3	42.86	4	57.14	7
Common Kestrel	*Falco tinnunculus*	3	75.00	1	25.00	4
Red-footed Falcon	*Falco vespertinus*	82	100.00	0	0.00	82
Eurasian Hobby	*Falco subbuteo*	19	79.17	5	20.83	24
Saker Falcon	*Falco cherrug*	1	33.33	2	66.67	3
Peregrine Falcon	*Falco peregrinus*	6	75.00	2	25.00	8
Unidentified raptor	*Rapaces sp.*	15	57.69	11	42.31	26
Total raptors		**2319**	**68.33**	**1075**	**31.67**	**3394**
Non-raptors						
Mute Swan	*Cygnus olor*	0	0.00	1	100.00	1
Great White Pelican	*Pelecanus onocrotalus*	133	100.00	0	0.00	133
Great Cormorant	*Phalacrocorax carbo*	8	38.10	13	61.90	21
Pygmy Cormorant	*Phalacrocorax pygmeus*	1	100.00	0	0.00	1
White Stork	*Ciconia ciconia*	11	84.62	2	15.38	13
Black Stork	*Ciconia nigra*	235	72.98	87	27.02	322
Black-headed Gull	*Chroicocephalus ridibundus*	2	100.00	0	0.00	2
Yellow-legged/Caspian Gull	*Larus michahellis/cachinanns*	0	0.00	3	100.00	3
Common Wood Pigeon	*Columba palumbus*	491	92.82	38	7.18	529
Stock Dove	*Columba oenas*	142	91.61	13	8.39	155
Unidentified pigeon	*Columba sp.*	100	70.42	42	29.58	142
Total non-raptors		**1123**	**84.95**	**199**	**15.05**	**1322**
TOTAL		**3442**	**72.99**	**1274**	**27.01**	**4716**

Table 1. Total number of migrating individuals recorded at Văcăreni study site during the full study period. The distribution of migrants between the risk zone (marked as Threatened) and safe zone (marked as Non-threatened) shows the potential impact of wind farms

1. táblázat A Văcăreni-i megfigyelőponton, a teljes vizsgálati időszak alatt rögzített, átvonuló egyedek összessége. Az egyedek eloszlása a veszélyes, illetve a nem veszélyes zónában a tervezett szélerőmű parkok potenciális hatását mutatják

SPECIES NAME		Threatened	Proportion of threatened (%)	Non-threatened	Proportion of non-threatened (%)	Total at count point (100%)
Raptors						
European Honey-buzzard	*Pernis apivorus*	6	60.00	4	40.00	10
Osprey	*Pandion haliaetus*	3	100.00	0	0.00	3
Black Kite	*Milvus migrans*	1	100.00	0	0.00	1
Short-toed Eagle	*Circaetus gallicus*	13	50.00	13	50.00	26
White-tailed Eagle	*Haliaeetus albicilla*	1	12.50	7	87.50	8
Griffon Vulture	*Gyps fulvus*	2	100.00	0	0.00	2
Eurasian Sparrowhawk	*Accipiter nisus*	94	58.39	67	41.61	161
Levant Sparrowhawk	*Accipiter brevipes*	2	100.00	0	0.00	2
Western Marsh Harrier	*Circus aeruginosus*	23	67.65	11	32.35	34
Hen Harrier	*Circus cyaneus*	9	81.82	2	18.18	11
Pallid Harrier	*Circus macrourus*	3	60.00	2	40.00	5
Common Buzzard	*Buteo buteo*	572	38.49	914	61.51	1486
Long-legged Buzzard	*Buteo rufinus*	1	100.00	0	0.00	1
Rough-legged Buzzard	*Buteo lagopus*	1	100.00	0	0.00	1
Lesser Spotted Eagle	*Aquila pomarina*	168	59.79	113	40.21	281
Greater Spotted Eagle	*Aquila clanga*	2	100.00	0	0.00	2
Booted Eagle	*Aquila pennata*	3	100.00	0	0.00	3
Common Kestrel	*Falco tinnunculus*	0	0.00	1	100.00	1
Eurasian Hobby	*Falco subbuteo*	7	100.00	0	0.00	7
Unidentified raptor	*Rapaces sp.*	7	36.84	12	63.16	19
Total raptors		**918**	**44.48**	**1146**	**55.52**	**2064**
Non-raptors						
Dalmatian Pelican	*Pelecanus crispus*	0	0.00	2	100.00	2
Great Cormorant	*Phalacrocorax carbo*	1	5.56	17	94.44	18
White Stork	*Ciconia ciconia*	2	66.67	1	33.33	3
Black Stork	*Ciconia nigra*	93	53.76	80	46.24	173
Yellow-legged/Caspian Gull	*Larus michahellis/cachinanns*	1	25.00	3	75.00	4
Common Wood Pigeon	*Columba palumbus*	78	63.41	45	36.59	123
Total non-raptors		**175**	**54.18**	**148**	**45.82**	**323**
TOTAL		**1093**	**45.79**	**1294**	**54.21**	**2387**

Table 2. Total number of migrating individuals recorded at Greci study site during the full study period. The distribution of migrants between the risk zone (marked as Threatened) and safe zone (marked as Non-threatened) shows the potential impact of wind farms

2. táblázat A Greci-i megfigyelőponton, a teljes vizsgálati időszak alatt rögzített, átvonuló egyedek összessége. Az egyedek eloszlása a veszélyes, illetve a nem veszélyes zónában a tervezett szélerőmű parkok potenciális hatását mutatják

SPECIES NAME		Threatened	Proportion of threatened (%)	Non-threatened	Proportion of non-threatened (%)	Total at count point (100%)
Raptors						
European Honey-buzzard	*Pernis apivorus*	13	68.42	6	31.58	19
Osprey	*Pandion haliaetus*	1	100.00	0	0.00	1
Black Kite	*Milvus migrans*	3	50.00	3	50.00	6
Short-toed Eagle	*Circaetus gallicus*	24	88.89	3	11.11	27
White-tailed Eagle	*Haliaeetus albicilla*	2	100.00	0	0.00	2
Northern Goshawk	*Accipiter gentilis*	1	50.00	1	50.00	2
Eurasian Sparrowhawk	*Accipiter nisus*	157	65.69	82	34.31	239
Levant Sparrowhawk	*Accipiter brevipes*	11	100.00	0	0.00	11
Western Marsh Harrier	*Circus aeruginosus*	51	70.83	21	29.17	72
Hen Harrier	*Circus cyaneus*	7	63.64	4	36.36	11
Pallid Harrier	*Circus macrourus*	8	100.00	0	0.00	8
Montagu's Harrier	*Circus pygargus*	3	75.00	1	25.00	4
Common Buzzard	*Buteo buteo*	1968	66.22	1004	33.78	2972
Lesser Spotted Eagle	*Aquila pomarina*	384	35.59	695	64.41	1079
Greater Spotted Eagle	*Aquila clanga*	1	100.00	0	0.00	1
Eastern Imperial Eagle	*Aquila heliaca*	1	100.00	0	0.00	1
Booted Eagle	*Aquila pennata*	4	66.67	2	33.33	6
Common Kestrel	*Falco tinnunculus*	2	66.67	1	33.33	3
Red-footed Falcon	*Falco vespertinus*	16	84.21	3	15.79	19
Eurasian Hobby	*Falco subbuteo*	13	65.00	7	35.00	20
Saker Falcon	*Falco cherrug*	3	100.00	0	0.00	3
Peregrine Falcon	*Falco peregrinus*	1	100.00	0	0.00	1
Unidentified raptor	*Rapaces sp.*	15	68.18	7	31.82	22
Total raptors		**2689**	**59.37**	**1840**	**40.63**	**4529**
Non-raptors						
White Stork	*Ciconia ciconia*	4	66.67	2	33.33	6
Black Stork	*Ciconia nigra*	218	98.64	3	1.36	221
Great Cormorant	*Phalacrocorax carbo*	10	30.30	23	69.70	33
Yellow-legged/Caspian Gull	*Larus michahellis/cachinanns*	1	50.00	1	50.00	2
Common Wood Pigeon	*Columba palumbus*	291	98.31	5	1.69	296
Stock Dove	*Columba oenas*	17	100.00	0	0.00	17
Unidentified pigeon	*Columba sp.*	160	100.00	0	0.00	160
Dalmatian Pelican	*Pelecanus crispus*	0	0.00	4	100.00	4
Total non-raptors		**701**	**94.86**	**38**	**5.14**	**739**
TOTAL		**3390**	**64.35**	**1878**	**35.65**	**5268**

Table 3. Total number of migrating individuals recorded at Cerna study site during the full study period. The distribution of migrants between the risk zone (marked as Threatened) and safe zone (marked as Non-threatened) shows the potential impact of wind farms

3. táblázat A Cerna-i megfigyelőponton, a teljes vizsgálati időszak alatt rögzített, átvonuló egyedek összessége. Az egyedek eloszlása a veszélyes, illetve a nem veszélyes zónában a tervezett szélerőmű parkok potenciális hatását mutatják

Results

At Văcăreni count point 4.716 birds were counted, 3.394 raptors and 1.322 non-raptors *(Table 1)*. At Greci station a total of 2.387 birds were seen migrating, 2.064 raptors and 323 non-raptors *(Table 2)*. The highest number of migrating individuals was registered at Cerna count point, with 5.268 individuals, 4.529 raptors and 739 non-raptors, counted *(Table 3)*. At Văcăreni 68.33% of raptors and 84.95% of non-raptors migrated through the risk zone *(Table 1)*. At Greci count station 44.48% of raptors and 54.18% of non-raptors migrated through the risk zone *(Table 2)*, and finally at Cerna 59.37% of raptors and 94.86% of non-raptors migrated through the risk zone *(Table 3) (Figure 2)*.

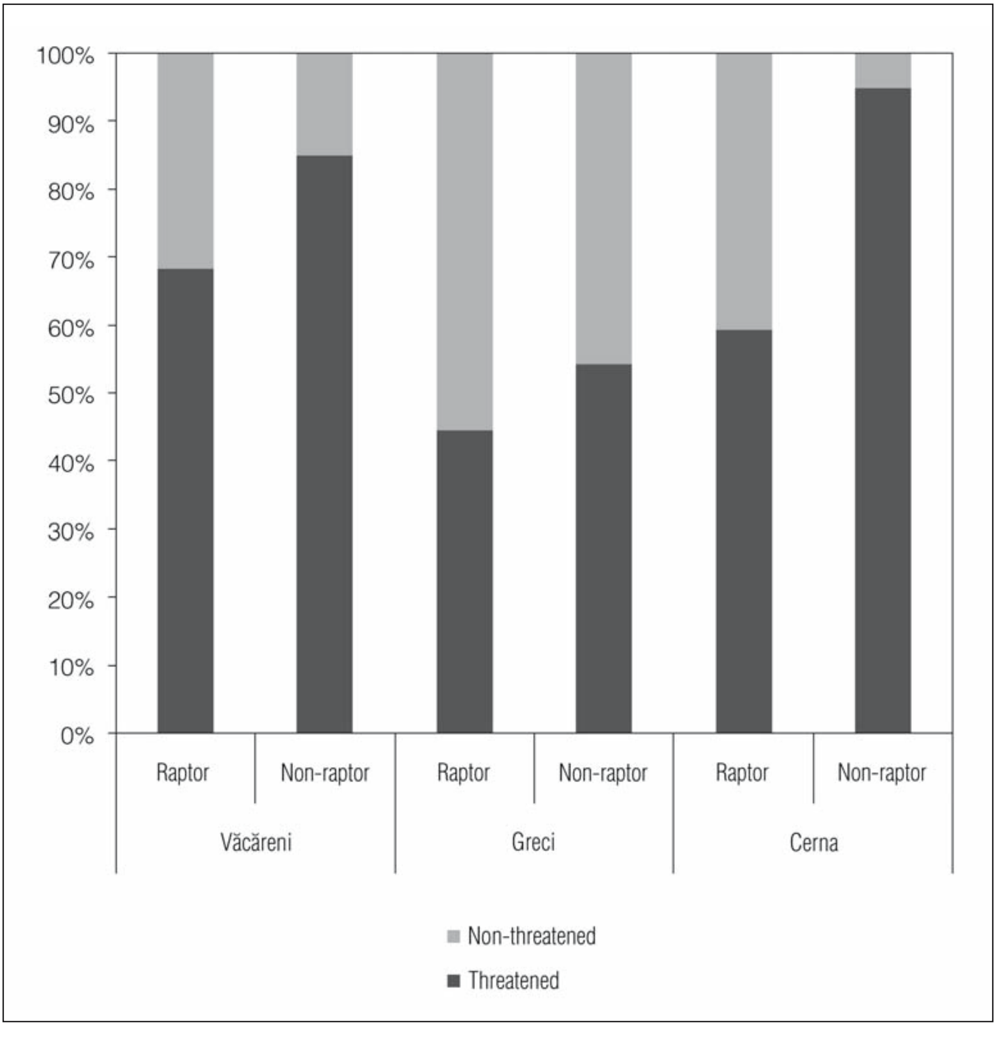

Figure 2. The proportion of threatened and non-threatened migrants observed at the three study sites during the full study period

2. ábra A teljes vizsgálati időszak alatt rögzített, a tervezett szélturbinák által veszélyeztetett, valamint nem veszélyeztetett átvonuló egyedek aránya a három mintaterületen

Discussion

The impact of the intensive wind farming over the migrant birds is a subject prone to long debates between nature conservationists and entrepreneurs, especially in the case of Dobrogea, the core area for Romanian wind farming, where several interests overlap. On one side Romania, as a member state of the EU, has ambitious renewable energy targets to meet. But on the other side Dobrogea is a natural heritage with very high biodiversity, with 50.38% of its total surface area protected for nature conservation (MMSC 2011). Beside the interest of the government, the exploitation of renewable energy sources represents a highly profitable business opportunity for private companies. Not surprisingly, as a result of multiple conflicts of interest, the potential impact of wind farms on wildlife is generally underestimated in official reports, both intentionally and unintentionally, due to several reasons: lack of information about the different areas due to the limited number of studies available, lack of experts and superficiality of environmental impact assessment studies.

Our study aimed to fill this gap of information, at least partially, in the area of Măcin Mountains, which is also a Natura 2000 site. Our results demonstrate that (1) intensive migration occurs in Northern Dobrogea and (2) wind farms would have a significant negative impact on migrating birds, affecting a substantial part of the migrating individuals from our study areas. According to previous studies (Domahidi & Komáromi 2004, Domahidi *et al.* 2004, Komáromi 2005, Milvus Group 2008, Pârâu 2011), we found that the Common Buzzard is the most abundant migrating raptor species. During this period of the year the *vulpinus* subspecies of the Common Buzzard is the most numerous in this area, due to its different migratory strategy compared to the *buteo* subspecies, *Buteo buteo vulpinus,* a long term migrant that winters in Africa (Forsman 1999). The second most abundant raptor species was the Lesser Spotted Eagle. This species occurs also in large numbers in this area during late autumn, as does the Eurasian Sparrowhawk *(Accipiter nisus)*, which was the third most abundant raptor (Domahidi & Komáromi 2004, Domahidi *et al.* 2004, Komáromi 2005, Milvus Group 2008, Pârâu 2011). Previous studies demonstrated that the European Honey Buzzard *(Pernis apivorus)* migrates also in large numbers over Dobrogea (Milvus Group 2008). Hovewer the migration peak of the species is at the end of August – beginning of September (Cramp & Simmons 1980). The most abundant non-raptors were Pigeons (*Columba* sp.) and Black Storks *(Ciconia nigra)*. White and Black Storks migrate in large numbers over Dobrogea (Domahidi & Komáromi 2004, Komáromi 2005). The migration peak of the White Storks *(Ciconia ciconia)* is during August, in the second part of the month until early September (Cramp & Simmons 1977), which explains the small number of individuals counted during our study. In contrast, the migration peak of the Black Stork is one month later, at the end of September to early October (Cramp & Simmons 1977), which explains the relative high proportion of Black Storks compared to other non-raptor species recorded during the study.

We have shown that a high proportion of both the raptors and non-raptors migrated across the risk area, therefore would be negatively affected by wind farms. In case of migratory birds the effect of wind farms can manifest in two ways: (1) either through a barrier-effect, or (2) by the increased risk of collision. Collision can be avoided by changing the flight trajectory or by increasing the flight height (De Lucas *et al.* 2004). But deviance from the optimal migration route increases the flight distance, which means elevated energy expenditure for the migrants (Hötker *et al.* 2006). The highest proportion of individuals migrating through the risk zone was at Văcăreni count station, at over 72%. Soaring birds use the soaring-gliding flight style, hence they depend on the presence of thermals during their migration, which generally form on hillsides. But 'wind strength is greatest at the break of the slope at ridge tops, so these are also the primary locations for wind energy' exploitation as well (Drewitt & Langston 2008). Placement of wind turbines in these areas can be particularly dangerous, leading to increased levels of collision mortality for species that frequently use thermals to rise (Drewitt & Langston 2008). The high proportion of birds entering the risk zone at Văcăreni count station might be explained by the presented phenomenon, as the study area covers a long slope on the Northern side of the Măcin Mountains and it is the transition zone between the floodplain of the Danube and the Northern ridge of the mountains. In the case of Greci and Cerna count stations the proportion of the individuals entering the risk zone was approximately 45% and 64% respectively, which is smaller compared to Văcăreni station, but still not negligible. The two count points are positioned in the South-Western part of the Măcin Mountains, thus birds might adopt a different migratory strategy at local scale as a consequence of the local surface topography, resulting a slightly smaller, but still considerable risk of the potential collision with wind turbines.

Based on our results we conclude that the planned wind farms in the three study areas may have a negative effect on migratory birds, especially at Văcăreni and Cerna stations, if constructed. Although our study fails to cover the whole autumn migration period, we have shown that large concentrations of birds migrate over North Dobrogea, one of the most abundant raptor being the Lesser Spotted Eagle, a species of international conservation interest. The significant part of this raptor's global population migrates along the Western coast of the Black Sea, over Dobrogea. In addition we have detected several species that migrated through the risk zone which, though represented in small numbers, are Red Listed (IUCN 2012) (e.g. Greater Spotted Eagle *Aquila clanga*, Eastern Imperial Eagle *Aquila heliaca*, Red-footed Falcon *Falco vespertinus*, Saker Falcon *Falco cherrug*). Also detected was Griffon Vulture *(Gyps fulvus)*, a species which is a rarity for Romania, therefore giving our observation a high faunistic value. Further studies are needed to cover the whole migration period from mid-August to late October.

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VERSITA

Birds as disseminators of ixodid ticks and tick-borne pathogens: note on the relevance to migratory routes

Sándor Hornok[1], Zsolt Karcza[2, 4], Tibor Csörgő[3, 4]

Sándor Hornok, Zsolt Karcza, Tibor Csörgő 2012. Birds as disseminators of ixodid ticks and tick-borne pathogens: note on the relevance to migratory routes. – Ornis Hungarica 20(2): 86–89.

Összefoglalás A madarak gyakran kullancsfertőzöttek, így szerepük – különösen vonulásuk során – a kullancs közvetítette kórokozók terjesztésében és az ezek által okozott betegségek járványtanában régóta ismert és kutatott terület. A hazánkban végzett első ilyen molekuláris epidemiológiai felmérés kapcsán azonban érdemes kitérni az ilyen és hasonló vizsgálatok egy új, ornitológiai jelentőségű aspektusára. A közép- és hosszútávú vonuló madarakról eltávolított kullancsok és a bennük található kórokozók molekuláris szintű azonosítása (azaz egyes génjeik nukleotid sorrendjének meghatározása) lehetőséget nyújt azok nemzetközi (génbanki adatokkal való) összehasonlítására. Ez alapján valószínűsíteni lehet a kullanccsal való fertőződés hozzávetőleges helyét, tehát a vonulás hozzávetőleges útvonalát is.

Kulcsszavak: madárvonulás, *Hyalomma*, *Rickettsia*, *Francisella*, szekvenálás

Absract It has been a long studied issue, that birds are frequently infested with ixodid ticks, and consequently play a significant role in disseminating tick-borne pathogens (especially during their seasonal migration) and influence the epidemiology of relevant diseases. In connection with the first Hungarian molecular epidemiological survey on this topic the authors would like to note, that a new, ornithological aspect of similar researches may deserve future attention. Ticks removed from mid- and long-distance migratory birds and the tick-borne pathogens they may contain can be molecularly identified (i.e. with sequencing certain genes), and their sequences could be compared with others internationally available (deposited in the GenBank). This may provide clues for determining the place or country where the bird most likely acquired its tick-infestation, and thus for the probable route of seasonal migration.

Keywords: bird migration, *Hyalomma, Rickettsia, Francisella,* sequencing

[1]*Department of Parasitology and Zoology, Faculty of Veterinary Science, Szent István University, 1078 Budapest, István utca 2., Hungary, e-mail: Hornok.Sandor@aotk.szie.hu*
[2]*Birdlife Hungary, 1021 Budapest, Költő utca 21., Hungary*
[3]*Department of Anatomy, Cell and Developmental Biology, Eötvös Loránd University, 1117 Budapest, Pázmány Péter sétány 1/c, Hungary*
[4]*Ócsa Bird Ringing Station, 1089 Budapest, Orczy út 43., Hungary*

Birds are the most mobile animals taking into account the large distance they can cover in the course of a few days, particularly during their seasonal migration. Additionally, birds are long known for their epidemiological role as carriers of ticks (Hoogstraal *et al.* 1963), implying that ticks attached to them – as well as the tick-borne pathogens – can also be transported by them to places far away from the original habitats. This is a well studied issue from the point of view of ticks and tick-borne pathogens. However, in most (if not all) of the reports concerned about the import of exotic tick species and tick-borne pathogens by birds into regions formerly exempt of them focus on epidemiological implications. Therefore in this note the authors would like to highlight that some findings in the first molecular study on ticks and tick-borne pathogens associated with migratory birds in Hungary (Hornok *et al.* 2013) show that tracking the possible geographical origin of DNA sequences from ticks or tick-borne pathogens carried by birds may be relevant to their migratory routes (and vica versa).

Ticks (Acari: Ixodidae) were removed from birds mist-netted at the Ócsa Bird Ringing Station in 2011. From 1.786 birds caught in the spring 108 subadult ticks were collected (Hornok *et al.* 2013). The majority (96.3%) of them was *Ixodes ricinus*, but three *Hyalomma* immatures (two moulting larvae and one nymph) were also collected from a Robin *(Erithacus rubecula)*. Molecular analysis of these revealed 100% sequence homology only to an isolate of *H. marginatum* from Morocco (accession number AF150034 for the 12S rRNA gene).

This tick species occurs in most of the Mediterranean basin and is not indigenous in Hungary, thus the infestation probably originated from the Mediterranean. Robins ringed in Hungary have mostly been recaptured while wintering in south-western Europe, some of them have even crossed the Mediterranean to winter along the northern shores of Algeria (Gyurácz & Csörgő 2009). Although until now recaptures of Robins did not link Morocco to Hungary, the present data may indicate that the relevant bird arrived from the region of Morocco *(Figure 1)*.

Hyalomma marginatum is a two-host tick (i.e. its larva moults to the nymph stage without detachment from the host) and therefore the immature stages remain for a prolonged period (12–26 days) on the host (Farkas *et al.* 2013). The average migration speed of Robins is 65 km/day, however, this may show considerable daily variations; some birds may fly even hundreds of kilometers daily (Remisiewicz *et al.* 1997). This means that ticks carried by them (or by similar mid-distance or even long distance migrants) may arrive from 2–3.000 kilometers away.

Although we can not exclude that the Moroccoan genotype of *H. marginatum* can be found in other parts of the Mediterranean basin in Europe, the possible African origin of these ticks is supported by yet another finding. In all three specimens of these ticks *Rickettsia aeschlimannii* was identified, also for the first time in Hungary (Hornok *et al.* 2013). This bacterial pathogen is responsible for spotted fever in humans and is endemic to the Mediterranean countries. This *Rickettsia* genotype showed 100% sequence similarity to an isolate from Egypt (HQ335153). Considering that Hungarian Robins overwinter in the Western Mediterranian promts the question whether this genotype may also occur in North-Western Africa.

Additionally, from an *I. ricinus* larva also obtained from a Robin the sequence of a

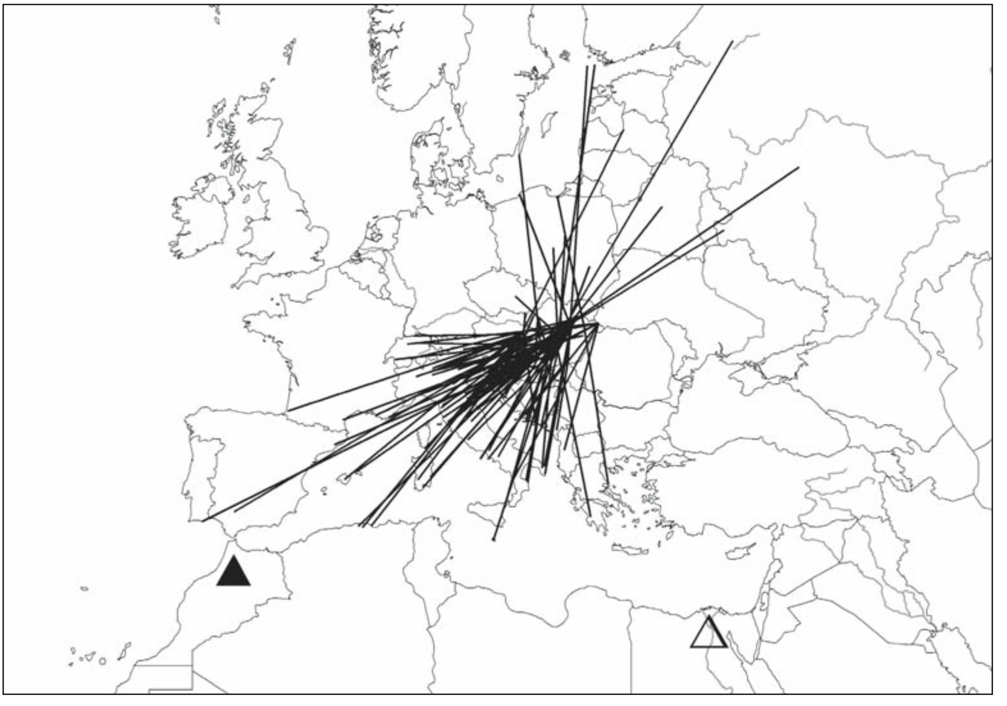

Figure 1. Recaptures of Robins ringed in Hungary.
Triangles show the likely origin of *H. marginatum* ticks collected from a Robin in 2011 in Hungary (▲) and the likely origin of *Rickettsia aeschlimannii* carried by these ticks (Δ) as judged by comparisons of genetic sequences

1. ábra A magyarországi vonatkozású vörösbegy visszafogások eloszlása.
Egy hazai vörösbegyről 2011-ben gyűjtött *H. marginatum* kullancsokhoz (▲) és az általuk hordozott *Rickettsia aeschlimannii* (Δ) baktériumokhoz genetikailag hasonló kullancsok, illetve baktériumok ismert előfordulása a Mediterráneumban

novel *Francisella*-like genotype was identified (Hornok *et al.* 2013). This endosymbiont is taxonomically close to the causative agent of tularemia in mammals. The new genotype showed the closest (99%) similarity to endosymbionts detected in *Dermacentor reticulatus* in Central-Europe. Accordingly, although the geographical range of *I. ricinus* extends to southern Europe, the relevant tick most likely attached to its avian host in Central-Europe shortly before capturing.

In conclusion, bird ticks and associated pathogens may be used as tracers (indicators) of migratory routes because their molecular analysis provides a basis for genetic comparison with internationally available data. However, the unfolding of this new approach to track bird migration depends on and necessitates the availability of target sequences from many or most countries of possible places of departure/destination.

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