A szalakóta (*Coracias garrulus*) diszperziójának vizsgálata a Dél-Alföldön

Kiss Orsolya[1], Dr. Tokody Béla[2]

1. *SZTE- MGK, Állattudományi és Vadbiológiai Intézet, 6800 Hódmezővásárhely, Andrássy út 15. email: kiss.orsolya@mgk.u-szeged.hu*

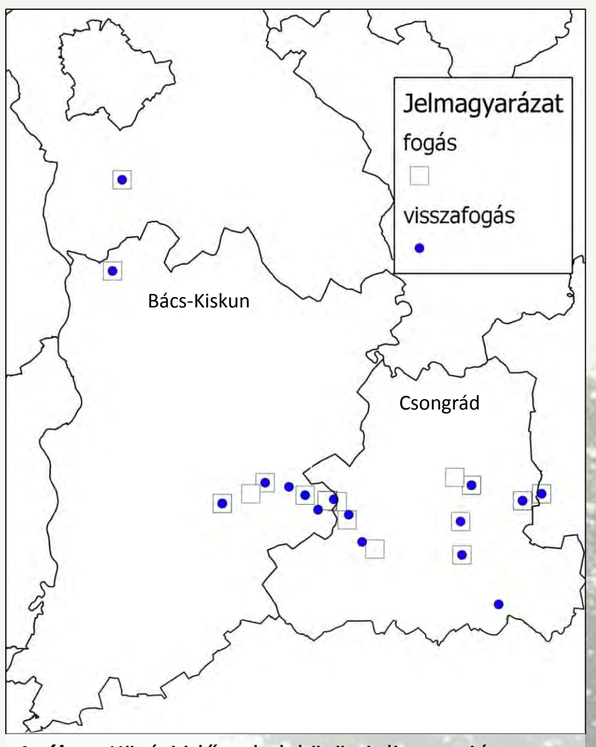
2. Magyar Madártani és Természetvédelmi Egyesület, 1121 Budapest, Költő u. 21. email: tokody.bela@mme.hu

A szalakóta (*Coracias garrulus*)

- Hosszú távú vonuló madárfaj
- A Kárpát-medencében odúban költő faj, zöld küllő illetve fekete harkály elhagyott odúit foglalja el
- Vártamadár, fő táplálékát nagytestű rovarok képezik, alkalmanként gerincesek

Diszperzió

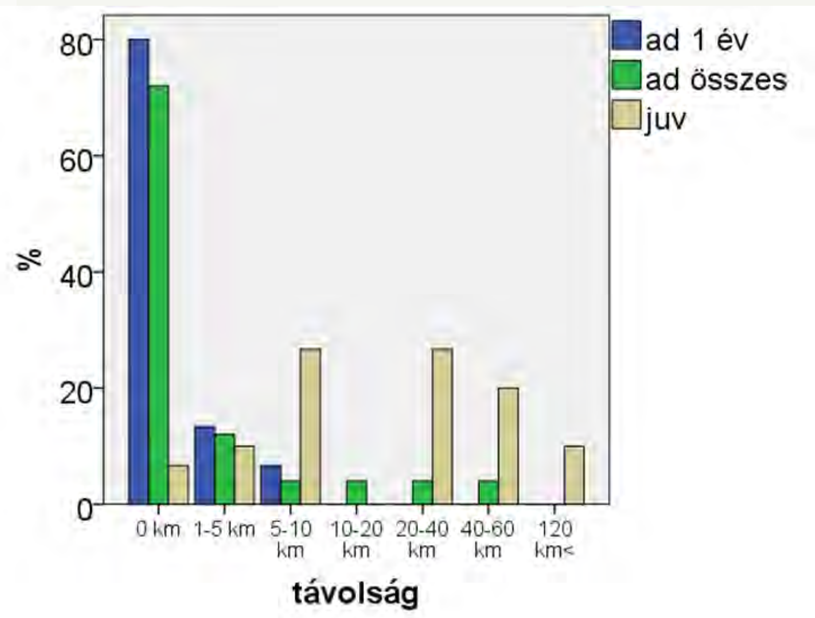
- A diszperzió az állatok egyik költőhelyről a másokra történő mozgását jelenti
  - költési diszperzió (*breeding dispersal*) esetén a kifejlett egyedek költési időszakok között vagy egy időszakon belül változtatnak fészkelő területet
  - Születés utáni diszperzó (*natal dispersal*) a születési hely és az első szaporodási hely közti mozgást jelenti
- A szalakóta területhűségéről keveset tudunk, irodalmi adatok alapján (Cramp et al. 1996) feltételezhetően az egyes territóriumokat, táplálkozó területeket évekig használják a madarak.
- Robel (1993) 13 fészkelő területet vizsgált Németországban, ahol legalább az pár egyik felének gyakori visszatérést találta a korábbi költőhelyre és lengyel vizsgálatok alapján is területhűséget mutatott a faj



1. ábra Kötési időszakok közötti diszperzió

Módszerek

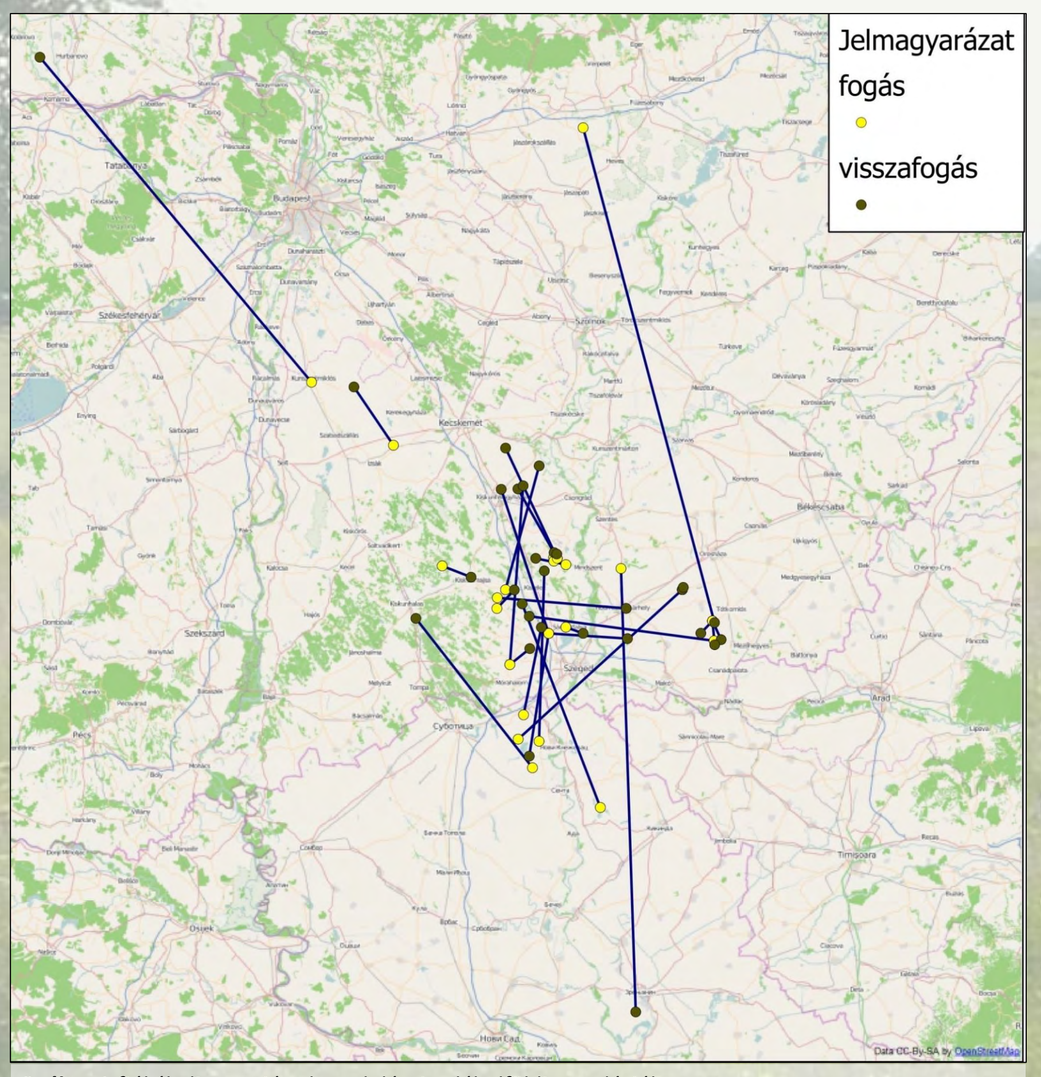
- 2009-2014 közötti Csongrád és Bács-Kiskun megyében leolvasott és visszafogott madarak adatait használtuk fel
- A költési időszakok közötti diszperzió esetében 2 kategóriát különítettünk el:
  - Következő évben visszafogott madarak (n=16)
  - Több év (2-3) év múlva megkerült madarak (n=9)
- A születés utáni diszperzió vizsgálatához a fiókaként jelölt egyedek következő éves megkerülését vettük figyelembe (n=30)



2. ábra Az adult egyedek és a fiókák diszperziós távolságai

Eredmények és értékelés

- Nagy területhűséget és kis diszperziós távolságokat találtunk az adult egyedek esetében (1. ábra)
  - A következő költési szezonban visszafogott madarak 81,3 % ugyanabban az odúban költött, 3 egyed több egymás utáni évben is ugyanazt a mesterséges odút használta,
  - Az átlagos diszperziós távolság 715 m volt, az összes adult egyed alapján pedig 2449 m
- A fiókák diszperziós távolsága szignifikánsan nagyobb volt (Mann-Whitney U = 5000, p = 0,001), mint az adult egyedek estében, átlagosan 36,7 kmre költöttek először a madarak és csak egy egyed került meg a kikelés helyén
- Mivel az adult egyedek hűek a korábbi költőodújukhoz, a legtöbb másodéves madár a kikelési helyétől 5-40 km körzetben kezd költeni (2. ábra)
- A fiókák között kisebb számban előfordul 120-150 km elmozdulás is, ami a távolabbi populációk közötti kapcsolatot biztosíthatja (3. ábra)
- A nagymértékű területhűség feltehetően a faj ritka költőhelyhez (nagyméretű költőüreg) való adaptációját jelentheti, mint ahogy az is, hogy nem mutat preferenciát a tiszta odúk iránt (Avilés et al. 2000)



3. ábra A fiókák diszperziós elmozdulásai a dél-alföldi populációban

Köszönetnyilvánítás

Köszönjük a terepmunkában nyújtott nélkülözhetetlen segítséget Balogh Gábornak, Borbáth Ernának, Domján Andrásnak, Kiss Tamásnak, Ludnai Tündének, Mészáros Csabának, Szűcs Péternek, a Kiskunsági Nemzeti Parknak és az MME önkénteseinek.

LIFE13/NAT/HU/000081

Irodalomjegyzék

Avilés J.M., Sanchez J.M. & Pajero D. 2000 The Roller Coracias garrulus in Extremadura (southwestern Spain) does not show a preference for breeding in clean nestboxes *Bird Study* **47:** 252–254

Robel, Detlef 1993 Nest site fidelity and breeding success in the roller (Coracias garrulus L., 1858) Beitraege zur Vogelkunde 39 (3) 194-198.

Loop migration in adult European rollers (*Coracias garrulus*) through the Middle East

Orsolya Kiss[1,2] & Béla Tokody[1]

1. BirdLife Hungary, 21. Költő str., Budapest, H-1121 email: orsolyakiss22@gmail.com
2. University of Szeged, Faculty of Agriculture, Institute of Animal Sciences and Wildlife Management, 15. Andrássy str. Hódmezővásárhely, H-6800

Introduction

- The European roller (*Coracias garrulus*) is a medium size, long-distance migrant bird species.
- Former studies found different migration pathways for central and northern population of European rollers (Finch *et al.* 2015) and suggested the use of Arabian-peninsula in spring based on ring recoveries (Finch et al. 2016).
- The aim of this study was to identify the migration route, stopover sites and wintering area of the Carpathian basin within the framework of LIFE13/NAT/HU/000081 LIFE+ project

Methods

- 6 adult European rollers were deployed with 5-g solar-powered PTT-100 satellite transmitters (Microwave Telemetry Inc., Columbia, MD, USA).
- The tagged birds represented the most significant roller subpopulations in Hungary.
- All rollers were tagged during the incubation period 2015 and 2016.
- 8-h ON/ 15-h OFF in 2015 and 10-h ON/ 24-h OFF duty cycle
- 7 spring ringing recapture data (1931-2017) was provided by the Hungarian Bird Ringing Centre

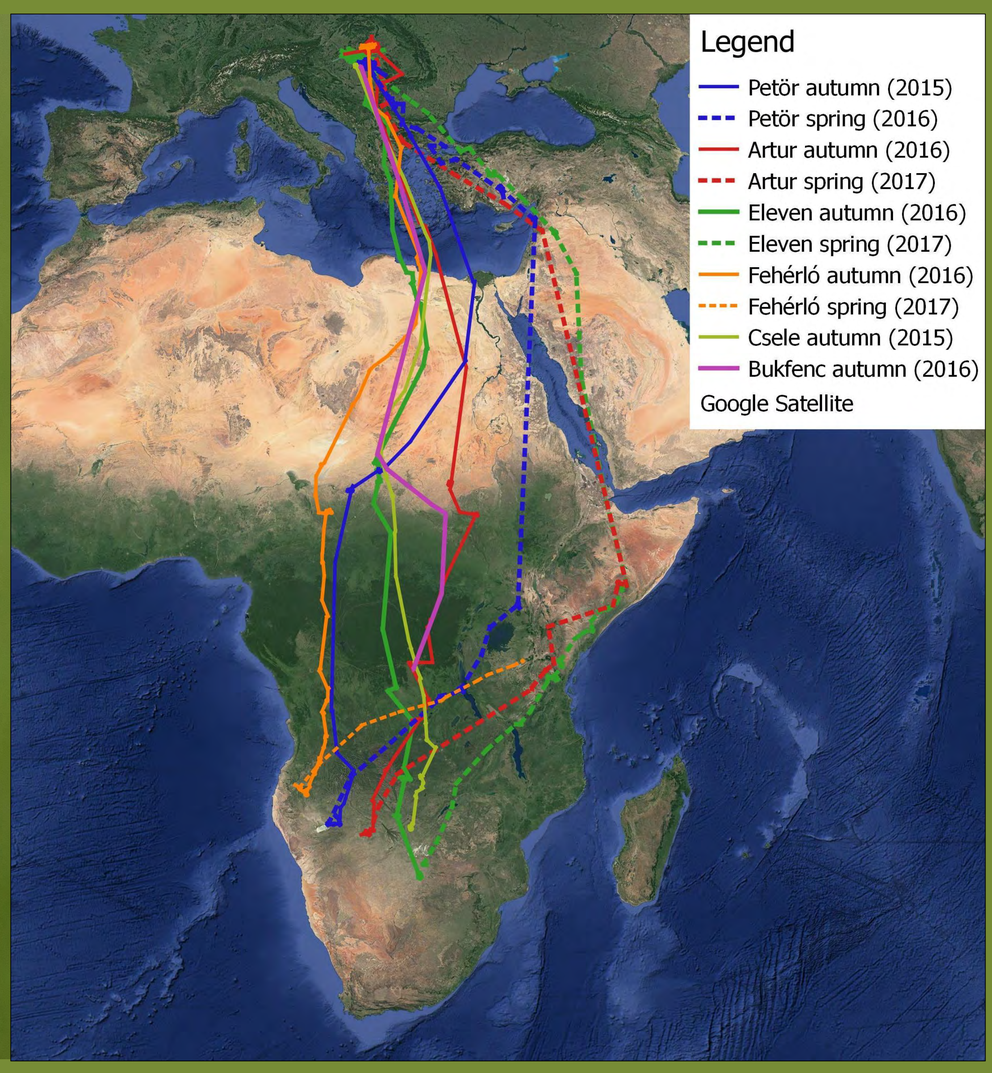


Fig. 1. Overview map of the migration of six European rollers from the Carpathian basin

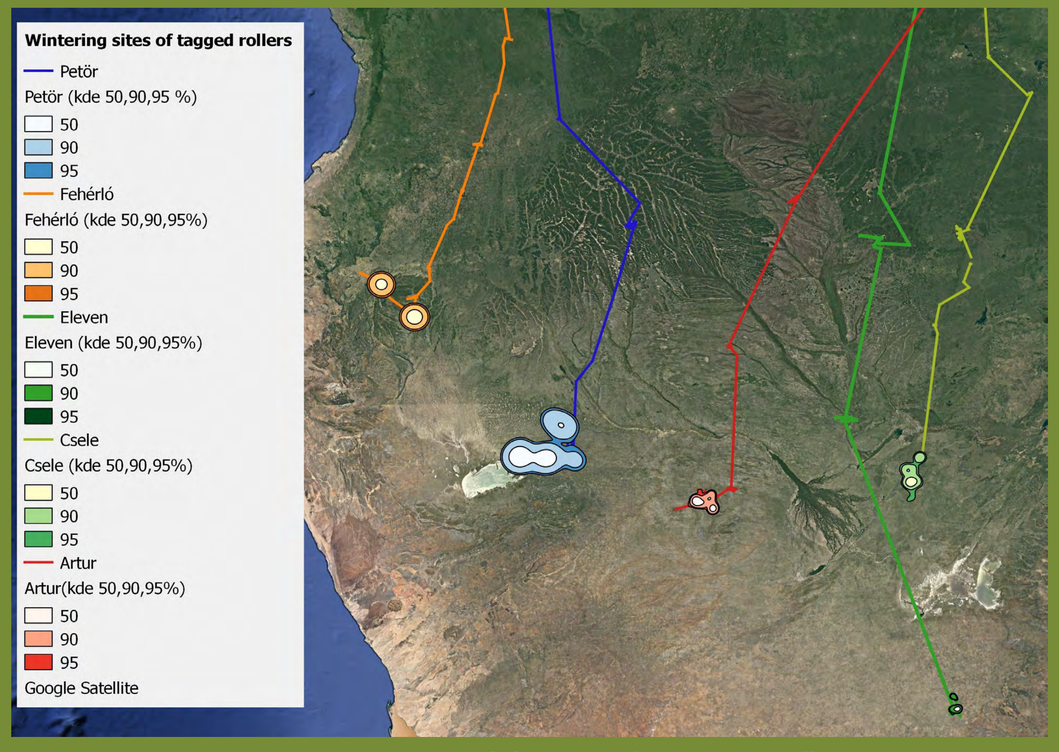


Fig. 2. Wintering sites of the tagged European rollers

Results

- 2 rollers died during the migration (after the rainforest zone and in Tanzania) and one during the wintering period.
- The spring migration pathway was longer in each bird then the autumn (9616±912 km vs 8341±765 km) and the duration was 18±6,5 days shorter .
- Wadi Fara region is Chad was used by 4 bird as a stopover sites for 8-27 days (Fig 3.)
- All of the tagged birds spent the winter in different countries (Angola, Namibia, Botswana) (Fig 1-2.)
- All of the rollers which has started the spring migration used the counter-clockwise loop pathway trough the Arabian peninsula (Fig.4.)

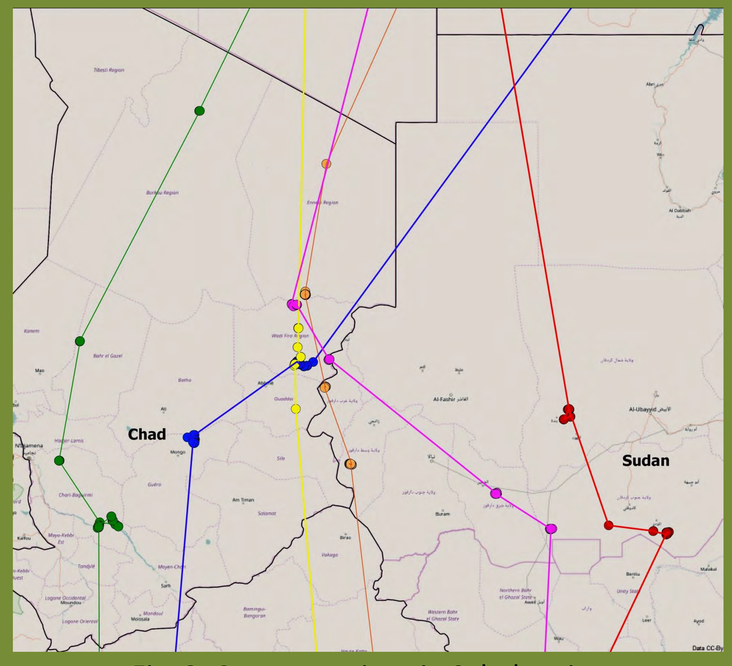


Fig. 3. Crossover-sites in Sahel region

Discussion

- However, Finch *et al.* (2015) found slightly clockwise migration in Austrian population, all of our tagged rollers follow counter-clockwise loop during spring migration
- This migration pattern was also found in the Latvian population, as well.
- We found weak migratory connectivity and rollers from the Carpathian basin most probably share wintering areas with the south-western roller populations (Finch *et al.*, 2015)
- Ring recoveries suggest the existence of an other migration pathway for the Hungarian roller population, but the counter-clockwise loop seems to be the most common migration route which occurs in any subpopulation in Hungary.
- The migration route was shorter but lasted longer in autumn than in spring.

Fig. 4. Spring migration of rollers through the Arabian-peninsula

Referencies

Finch, T., Dunning, J., Kiss, O., Račinskis, E., Schwartz, T., Sniauksta, L.,Szekeres, O.,Tokody, T.,Aldina Franco, A.,Butler, S.J. (2016) Insights into the migration of the European Roller from ring recoveries. J Ornithol. 158: 83–90.

Finch, T., Saunders, P., Avilés, J.M., Bermejo, A., Catry, I., de la Puente, J., Emmenegger, T., Mardega, I., Mayet, P., Parejo, D., Račinskis, E., Rodríguez-Ruiz, J, Sackl, P., Schwartz, T., Tiefenbach, M., Valera, F., Hewson ,C.M., Franco, A.M.A., Butler, S.J. (2015) A pan-European, multipopulation assessment of migratory connectivity in a near-threatened migrant bird. Divers Distrib 21:1051–1062

Rodriguez-Ruiz, J., de la Puente, J., Parejo, D., Valera, F.,Calero-Torralbo, M.A., Reyes- Gonzalez, J.M., Zajkova, Z., Bermejo, A. & Aviles, J.M. (2014)

Acknowledgements

We give special thanks to Péter Palatitz and Zsófia Sümegi for their help in bird tagging and we also would like to thank Lilla Barabás, Erna Borbáth, Balázs Csibrány, Róbert Enyedi, Péter Hencz , Éva Horváth, Zsolt Karcza, József Katona, Gábor Kaufmann, Viktor Kiss , Dorottya Kiss, Tamás Kiss, László Kotymán, Csaba Lendvai,Márk Luca, Katalin Lukács, Tünde Ludnai,Péter Ócsai, István Péntek,Szabolcs Solt, Bence Szántó,László Szász, Tamás Széles,Szűcs Péter, Gábor Tihanyi Hunor Török for their help on the field. The research was supported by „ Conservation of the European Roller (Coracias garrulus) in the Carpathian Basin (LIFE13/NAT/HU/000081)" LIFE+ NATURE project.

A klímaváltozás hatásának modellezése a szalakóta (*Coracias garrulus*) európai elterjedésére

Kiss Orsolya [1], Tokody Béla [2], Végvári Zsolt[3]

1. Állattudományi és Vadgazdálkodási Intézet, Szegedi Tudományegyetem, Hódmezővásárhely, Andrássy u. 15. orsolyakiss22@gmail.com
2. MME, 1121 Budapest, Költő u. 21.
3. Természetvédelmi Zoológiai Tanszék, Debreceni Egyetem - Hortobágyi Nemzeti Park Igazgatóság, 4024 Debrecen, Sumen u.2

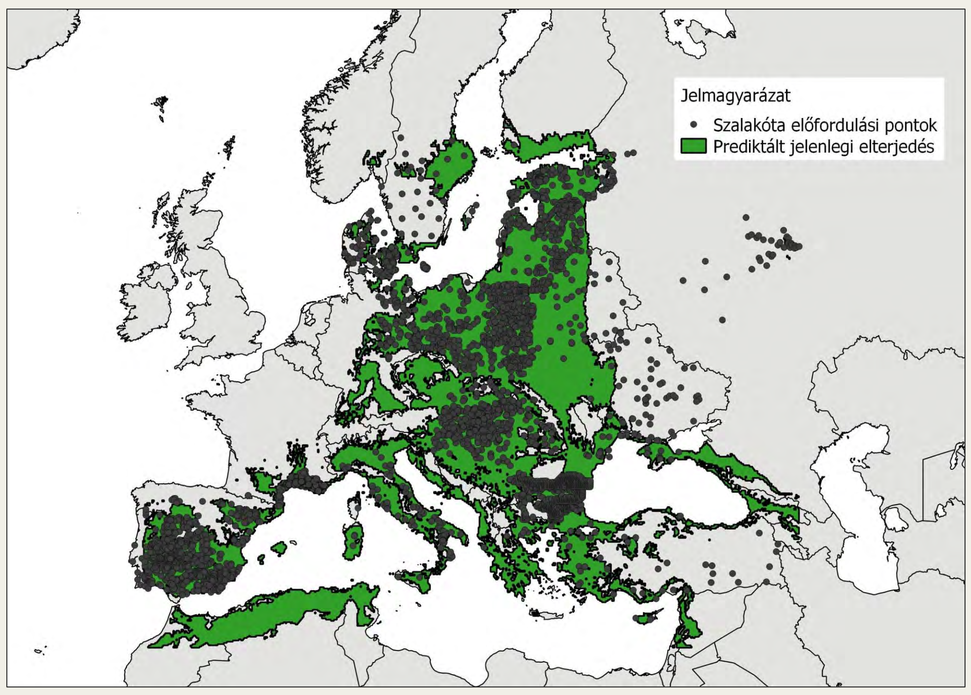
A szalakóta (*Coracias garrulus*)

- Széles északi-déli elterjedés, alapvetően melegkedvelő, hosszú távú vonuló faj
- Jelentős csökkenés az 1980-90-es években, továbbra is csökkenő északi populációk, növekedés délen
- Klímaváltozásra érzékeny (Huntley *et al.,* 2007)

Célkitűzések:

1. A jelenlegi,
2. jövőbeli: 2050 és 2070,
3. és múltbeli: LGM, közép- Holocén

elterjedés modellezése klimatikus változók alapján

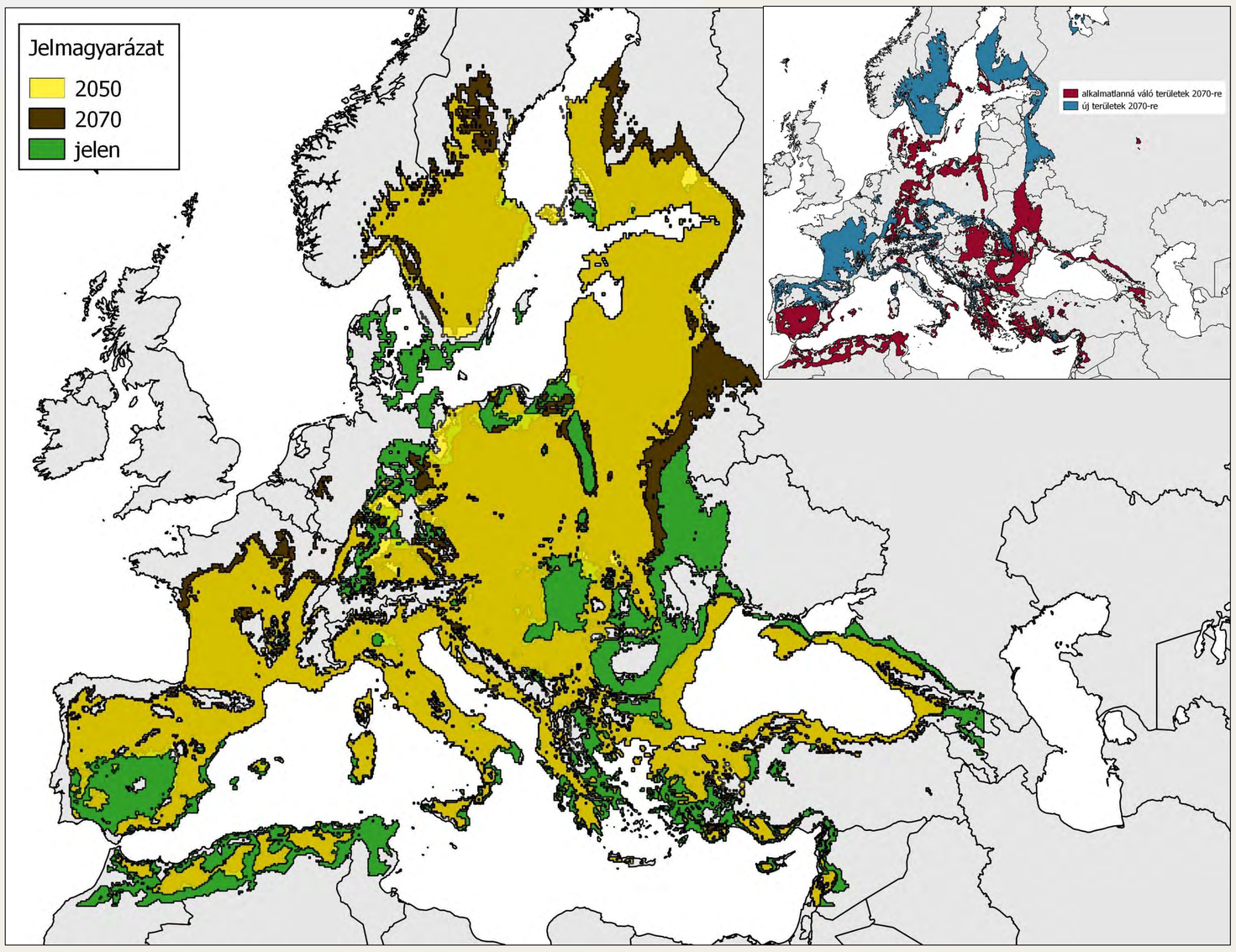


1. ábra A szalakóta előfordulási pontjai a 18. század közepétől és jelenlegi elterjedési predikciója

Bioklimatikus preditorok	változók részesedése
bio1 (Éves középhőmérséklet)	8.2642
bio4 (A hőmérséklet szezonalitása szórása)	6.0516
bio6 (A leghidegebb hónap min hőmérséklete)	3.9511
bio7 (A hőmérséklet éves tartománya)	**52.0676**
bio9 (A legszárazabb negyedév átlag hőmérséklete)	4.9932
bio10 (A legmelegebb negyedév átlag hőmérséklete)	**28.6235**
bio 11 (A leghidegebb negyedév átlag hőmérséklete)	2.3479

Módszerek

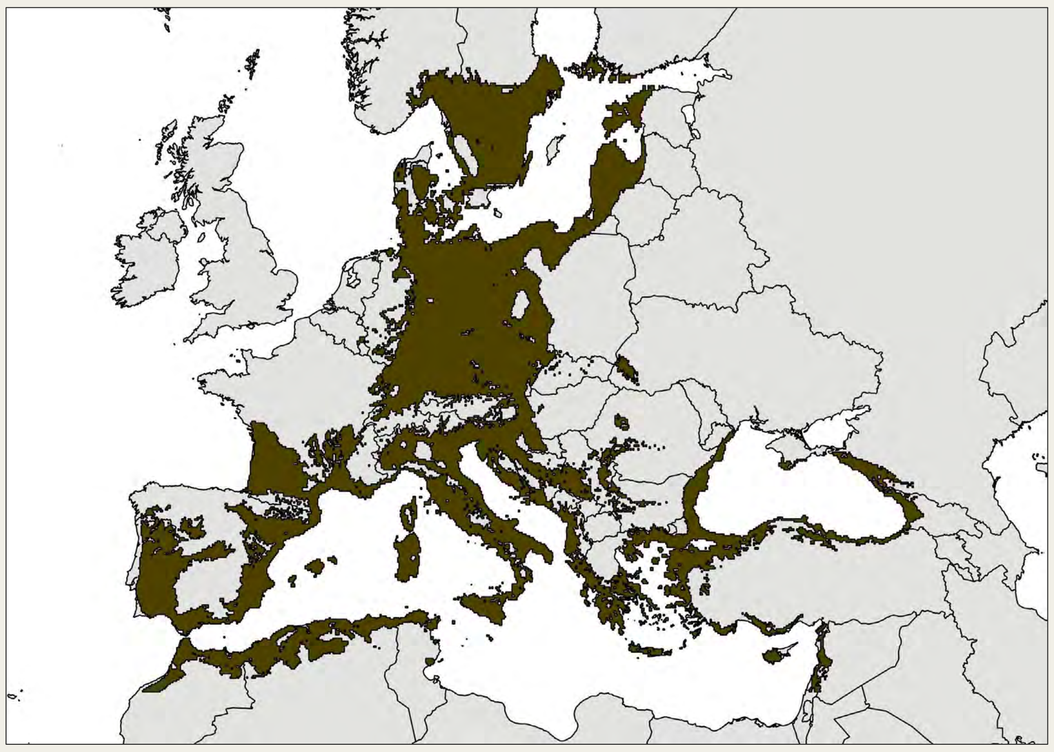
- 5937 db előfordulási pont Európából
  - archív adatok a Kárpát-medencéből (1898-1930, Aquila) és Ukrajnából
  - Geoferált előfordulási térképek (Balti állomok, Oroszország, Fehéroroszország, Olaszország, Spanyolország)
  - Országos felmérések eredményei (Bulgária, Franciaország, Portugália)
- WorldClim adatbázis a klimatikus változókra
- MaxEnt



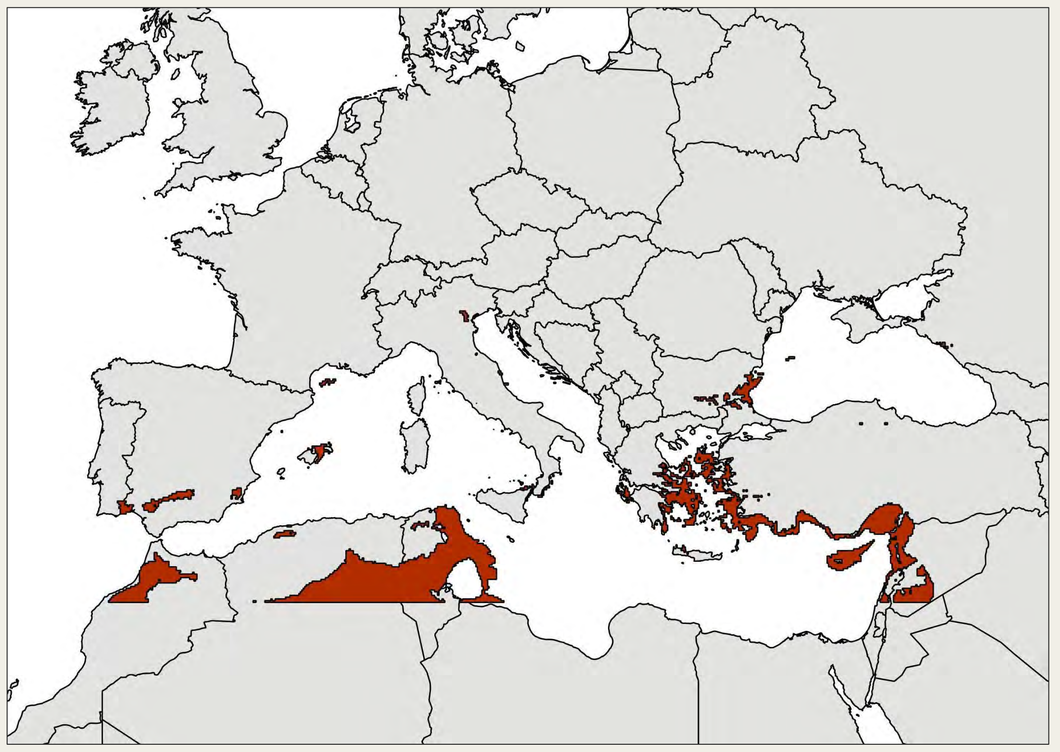
2. ábra A szalakóta jelenlegi és várható elterjedése 2050-re és 2070-re

Eredmények

- Az északi kiterjedés növekedése, a jelenlegi 61° -ról 63°-ra 65°-ra 2050-re és 2070-re
- Kisebb csökkenés az elterjedési terület nagyságában (7,1 % (2050) és 5,9% (2070)),
- de jelenlegi elterjedési terület 36.5% ill. 39.9% válhat nem megfelelővé a faj számára.
- Északi csökkenő vagy kipusztul populációknál területnövekedés várható, stabil vagy növekvő, nagy populációknál csökkenés kivéve Francia-és Olaszország



3. ábra A szalakóta elterjedése a közép Holocén időszak alatt



3. ábra A szalakóta elterjedése az LGM időszak alatt

Köszönetnyilvánítás

Szeretnék megköszönni a MME Monitoring központjából Nagy Károlynak és Görög Zoltánnak az archív adatok gyűjtésében való segítségét. A kutatás az ÚNKP (UNKP-17-4-I-SZTE-23) támogatásával valósult meg.

Előzetes eredmények a szalakóta (*Coracias garrulus*) otthonterületének vizsgálatáról

Kiss Orsolya[1], Prommer Mátyás[2], Török Hunor[3], Csibrány Balázs[1], Tokody Béla[1]

1. BirdLife Hungary, 1121, Budapest, Költő utca 21., kiss.orsolya@mgk.u-szeged.hu
2. Madárvilág Nonprofit Kft., Szentendre
3. Bükki Nemzeti Park Igazgatóság, Eger

Bevezetés

- A szalakóta (*Coracias garrulus*) Európa-szerte veszélyeztetett gyepekhez és mezőgazdasági területekhez kötődő faj
- Fő veszélyeztető tényezők: az intenzív agrár-és erdőgazdálkodás következtében kialakuló költő- és táplálkozóhely csökkenés és a vonulás/telelés során fennálló fenyegettségek, mint hosszútávú vonuló madárfaj
- Natura2000 jelölőfaj, mesterséges D-típusú odúval jól telepíthető, de a területhasználatáról kevés információval rendelkezünk

Célkitűzések

- A szalakóta védelme a Kárpát-medencében (**LIFE13/NAT/HU/000081**) LIFE+ projekt keretében megvalósuló szikes gyep- illetve fás legelő rekonstrukciók mintaterületein és a környező élőhelyeken költő szalakóta egyedek mozgásmintázatainak meghatározása

  - Mekkora az otthonterület mérete?
  - Változik-e a home-range mérete a költési időszak alatt?
  - Milyen tényezők befolyásolják a home-range méretét?

1. kép Jelölt szalakóta

Módszerek

- Jelölések az Alsó-Tisza-völgy SPA és a Borsodi Mezőség SPA mintaterületein
- 14 adult egyed befogása és jelölése a költési időszakban az ECOTONE cég „Pica”-típusú UHF loggereivel (1. kép)
- Otthonterület meghatározása: Minimum Konvex Poligon (MCP) (Mohr 1947) és Kernel Home Range (KHR) (Worton, 1989) módszer
  a) az összes rendelkezése álló adatból (14 egyed)
  b) június 1. és július 6. között két hetes időszakra (8 egyed)
  c) öt időszakra: 0:06.06-06.14; 1:06.15-06.22; 2:06.23.- 07.01; 07.02.-07.10; 5:07.11.-07.18. (4 egyed)

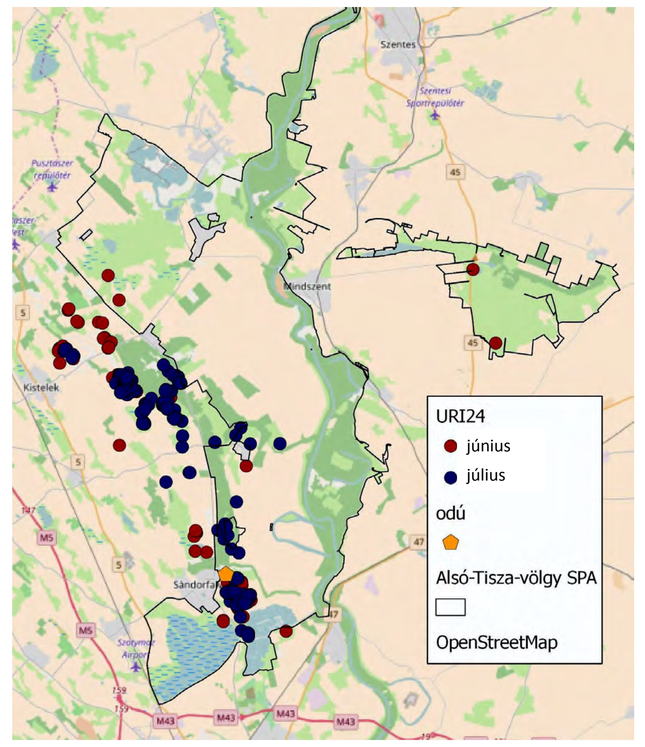
1. táblázat Otthonterület mérete június 1. és július 6. között 14 napos időszakra

Azonosító	Terület	KHR (50%) (ha)	KHR (90%) (ha)	KHR (95%) (ha)
URI23	Borsodi Mezőség SPA	2,5	18,6	31,0
UR19	Alsó-Tisza-völgy SPA	4,4	37,9	57,9
PIC5	Alsó-Tisza-völgy SPA	6,5	39,8	62,9
PIC4	Alsó-Tisza-völgy SPA	7,0	47,1	77,4
URI5	Alsó-Tisza-völgy SPA	7,4	51,2	83,1
URI21	Borsodi Mezőség SPA	8,2	59,7	90,2
URI14	Alsó-Tisza-völgy SPA	11,0	74,6	131,1
URI26	Alsó-Tisza-völgy SPA	22,4	94,3	134,9

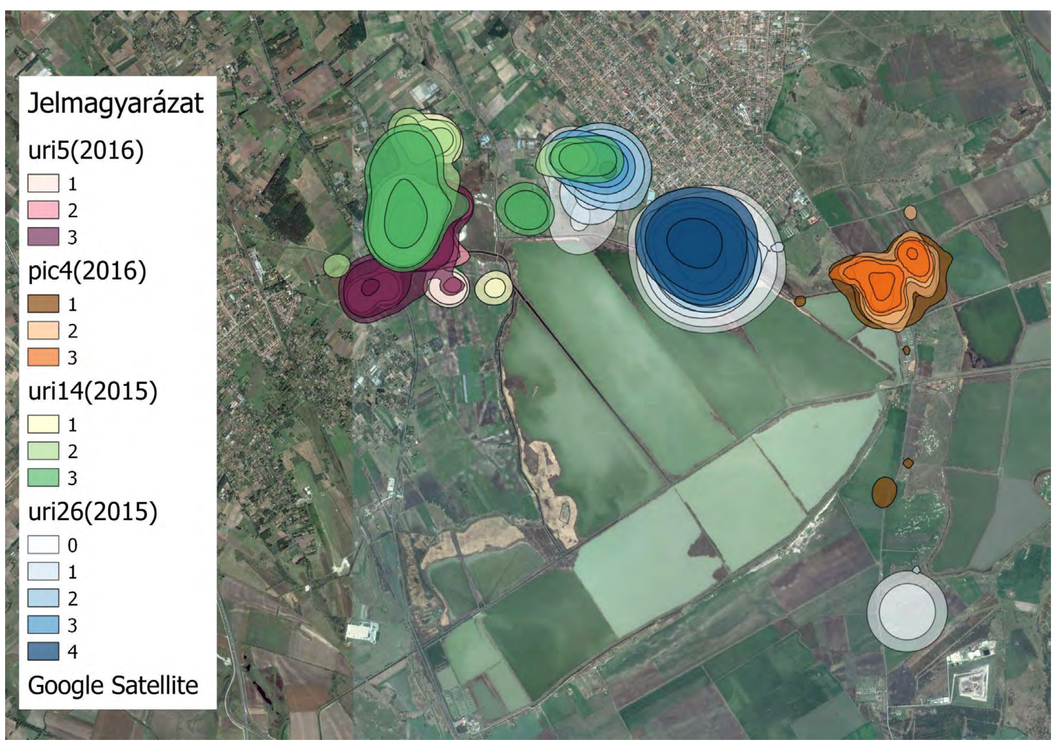
Eredmények és értékelés

- Átlagos home-range: 282±261 ha (MCP) ill. 115,8 ± 108 ha (KHR) (n=13)
- Gyepterületek százalékos borítása befolyásolta az otthonterület méretét (β=-1,588 (0,59SE), t=-2,693, p=0,036, R^2=0,547) a két hetes időszakban
- Sikertelen költés utáni mozgás (egy egyed) (MCP 95%: 15268,3 ha, KHR 95% 16622,5 ha, legnagyobb elmozdulás az odútól 22,9 km (1. ábra)
- KHR 95%-os valószínűségi szintnél két egyed esetében a használt terület nagysága növekedett (2,1-szer ill. 1,9-szer nagyobb területet a harmadik periódusban). Egy példánynál a második, illetve a harmadik periódusban mért home-range területe 71,5%-ra, majd 47%-ra csökkent. A 45 napig megfigyelt egyednél 1-4 időszakokban nem változott lényegesen az otthonterület mérete, de június 6-14 között 2,3-szor nagyobb területet járt (2.ábra).

- A korábbi publikált adatok (Molnár 1998) 50 %-os KHR méretnek felelnek meg
- A szalakóták átlagosan 100 ha körüli területet használnak a költési időszak alatt, és nagyrészt (50% KHR) ez az odú közelében lévő 10-20 ha kiterjedésű gyepeket jelenti (3.a ábra).
- Szezonálisan, rövid időre kiváló táplálkozó helyet jelentő friss kaszálásokat gyakran látogatják a madarak (3.b ábra).

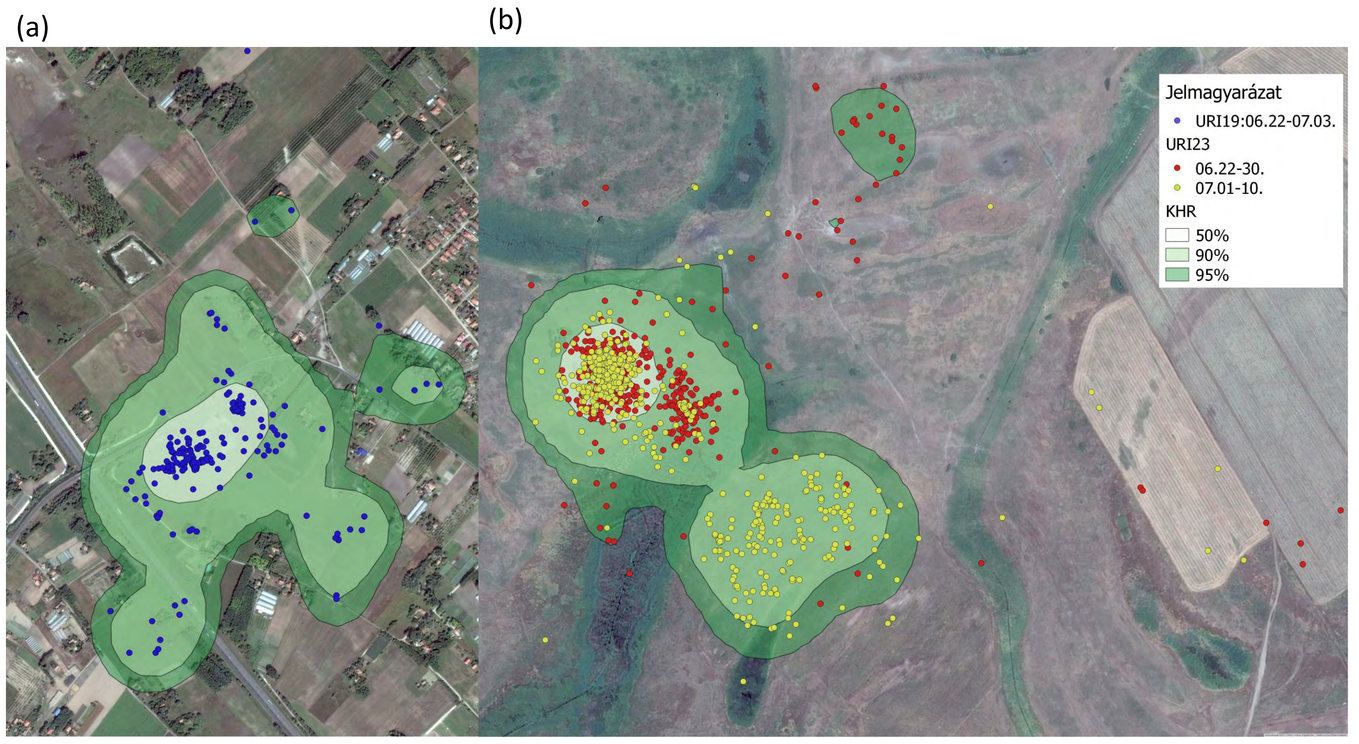


1 .ábra Mozgásmintázat meghiúsult költés után



2. ábra A home range változása a költési időszak alatt (95,90,50% KHR)

(a) (b)



3. ábra (a) Egy gyepfoltra koncentrálódott mozgás (Alsó-Tisza-völgy SPA) (b) friss kaszálások hasznosítása (Borsodi Mezőség SPA)

Irodalomjegyzék

Mohr C. O. (1947). Table of equivalent populations of North American small mammals. American Midland Naturalist 37(1): 223-249.

Worton, B. J. (1989). Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70(1): 164–168.

Molnár, Gy. (1998) A szalakóta (*Coracias garrulus*) költésbiológiájának és táplálkozásának vizsgálata a Dél-Alföldön mesterséges telepítése kapcsán. Ornis Hungarica 8 Suppl 1:119-124.

Köszönetnyilvánítás

Szeretnénk köszönetet mondani a Bükki- és a Kiskunsági Nemzeti Park Igazgatóságnak, hogy lehetővé tették a munkánkat, továbbá köszönjünk a segítséget Kiss Dorottyának és Szántó Bencének valamint minden önkéntesnek, aki részt vett a terepi munkákban. A kutatás „A szalakóta védelme a Kárpát-medencében (LIFE13/NAT/HU/000081)” LIFE+ projekt D1 akció monitoring programjának keretében valósult meg.

Loop migration in adult European rollers (*Coracias garrulus*) through the Middle East

Orsolya Kiss[1,2] & Béla Tokody[1]

1. BirdLife Hungary, 21. Költő str., Budapest, H-1121 email: orsolyakiss22@gmail.com
2. University of Szeged, Faculty of Agriculture, Istitute of Animal Sciences and Wildlife Management, Andrássy str.. Hódmezővásárhely, H-6800,

Introduction

- The European roller (*Coracias garrulus*) is a long-distance migrant which population has undergone a serious decline in the past few decades .
- Besides the lack of nesting and foraging site, threats during migration and wintering might also contribute to this decline.
- Former studies found different migration pathways for central and northern population of European rollers (Finch *et al.* 2015) and suggested the use of Arabian-peninsula in spring based on ring recoveries (Finch et al. 2016).
- The aim of this study was to identify the migration route, stopover site and wintering area of the Carpathian basin within the framework of LIFE13/NAT/HU/000081 LIFE+ project

Methods

- 6 adult European rollers were deployed with 5-g solar-powered PTT-100 satellite transmitters (Microwave Telemetry Inc., Columbia, MD, USA).
- The tagged birds represented the most significant roller subpopulations in Hungary.
- All rollers were tagged during the incubation period 2015 and 2016.
- Satellite transmitters were programmed with an about 8-h ON/ 15-h OFF duty cycle
- 7 spring ringing recapture data (1931-2017) was provided by the Hungarian Bird Ringing Centre
- ArcGis 10.2 with Home Range Tool and QGIS 2.8

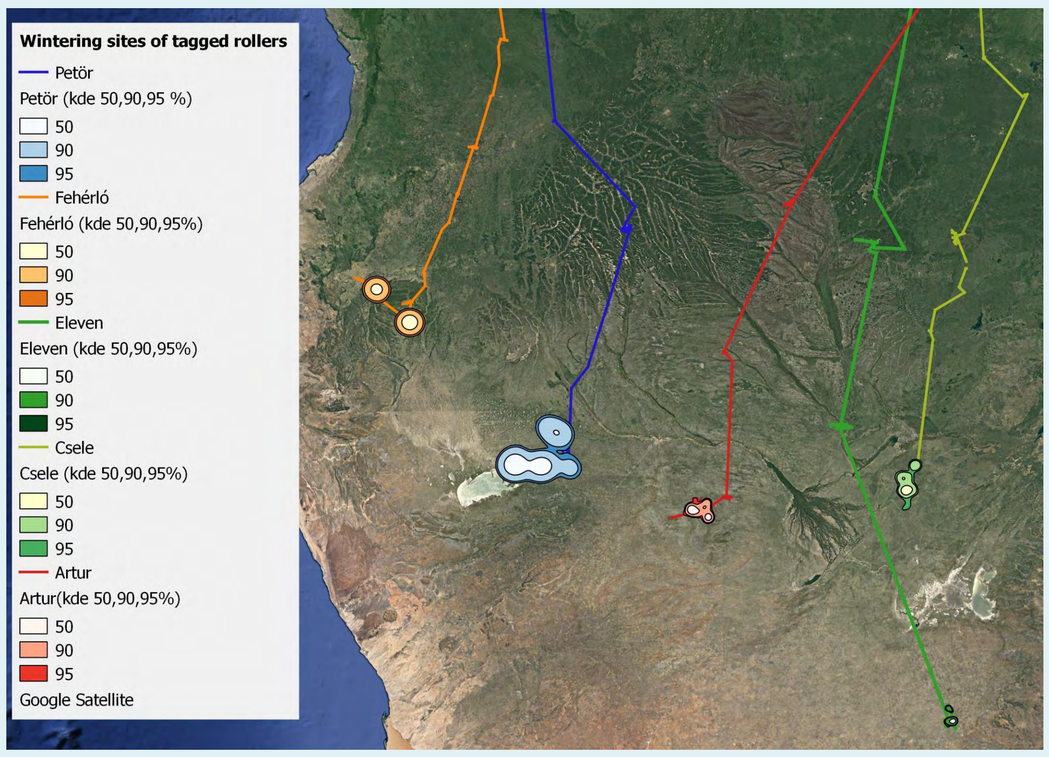


Fig. 2. Wintering sites of the tagged European rollers

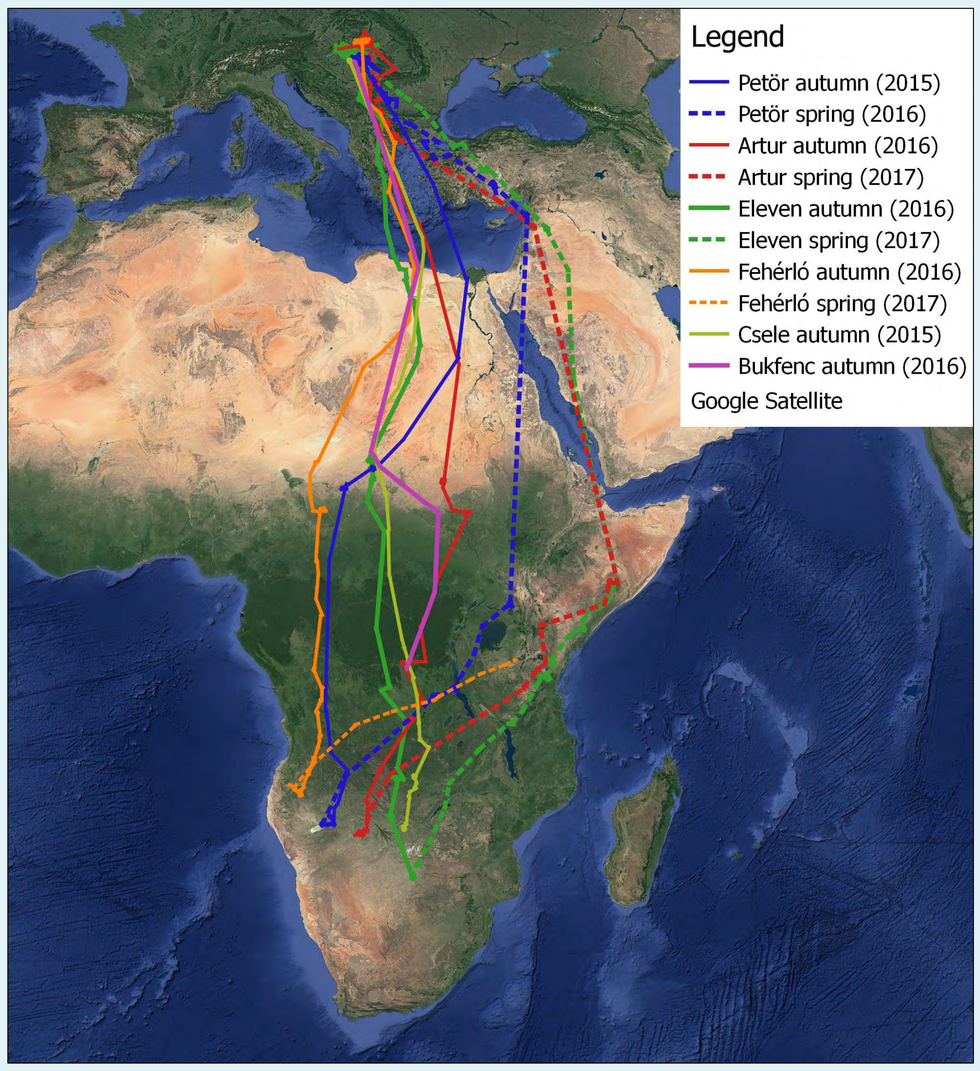


Fig. 1. Overview map of the migration of six European rollers from the Carpathian basin

Results

- 2 out of 6 tagged rollers died during the migration (after the rainforest zone and in Tanzania) and one during the wintering period.
- The spring migration pathway was longer in each bird then the autumn (9616±912 km vs 8341±765 km) and the duration was on average 18±6,5 days shorter .
- Most of the rollers migrated through the Balkan peninsula, but proceeded on a broad front across the Sahara (Fig.1.)
- Wadi Fara region is Chad was used by 4 bird as a stopover sites for 8-27 days and eastern Africa was found as an important stopover site during the spring migration
- All of the tagged birds spent the winter below the rainforest zone, but in different countries (Angola, Namibia, Botswana)
- The average area used by rollers during wintering was 5205 ± 5667km^2(95% Kernel Density Estimation (kde) (Fig.2.)
- All of the rollers which has started the spring migration used the counter-clockwise loop pathway trough the Arabian peninsula (Fig.3.)

Discussion

- However, Finch *et al.* (2015) found slightly clockwise migration in Austrian population, all of our tagged rollers follow counter-clockwise loop during spring migration
- This migration pattern was also found in the Latvian population, as well.
- We found weak migratory connectivity , and rollers from the Carpathian basin most probably share wintering areas with the south-western roller populations (Rodriguez-Ruiz *et al.,* 2014; Finch *et al.*, 2015)
- Ring recoveries suggest the existence of an other migration pathway for the Hungarian roller population, but the counter-clockwise loop seems to be the most common migration route which occurs in any subpopulation in Hungary.
- Stopover sites in Sahel belt were located in Chad and Sudan, four birds used the same region.
- The migration route was shorter but lasted longer in autumn than in spring.
- Crossing rain forest zone and wintering and eastern part of Africa can be challenging for adult rollers and highlight the importance of conservation measures in the countries of the Middle-East.

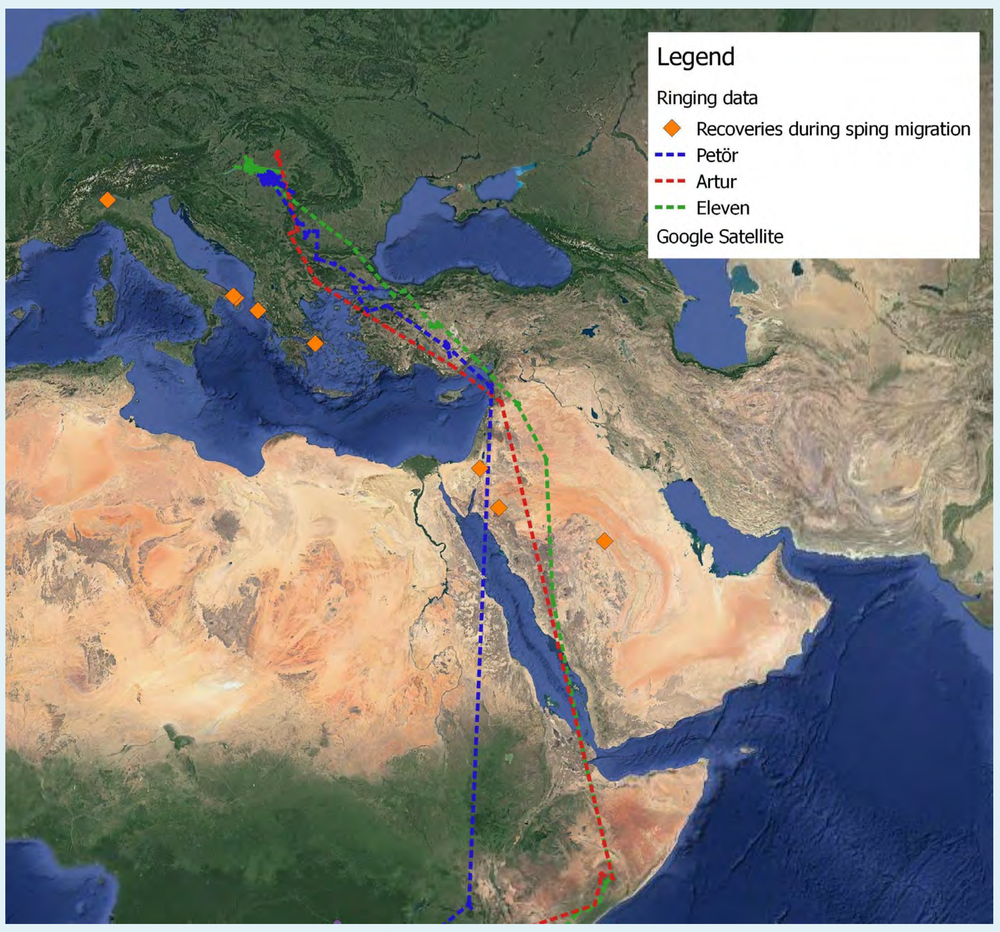


Fig. 3. Spring migration of rollers through the Arabian-peninsula

References

Finch, T., Dunning, J., Kiss, O., Račinskis, E., Schwartz, T., Sniauksta, L.,Szekeres, O.,Tokody, T.,Aldina Franco, A.,Butler, S.J. (2016) Insights into the migration of the European Roller from ring recoveries. J Ornithol. 158: 83–90.

Finch, T., Saunders, P., Avilés, J.M., Bermejo, A., Catry, I., de la Puente, J., Emmenegger, T., Mardega, I., Mayet, P., Parejo, D., Račinskis, E., Rodríguez-Ruiz, J, Sackl, P., Schwartz, T., Tiefenbach, M., Valera, F., Hewson ,C.M., Franco, A.M.A., Butler, S.J. (2015) A pan-European, multipopulation assessment of migratory connectivity in a near-threatened migrant bird. Divers Distrib 21:1051–1062

Rodriguez-Ruiz, J., de la Puente, J., Parejo, D., Valera, F.,Calero-Torralbo, M.A., Reyes- Gonzalez, J.M., Zajkova, Z., Bermejo, A. & Aviles, J.M. (2014) Disentangling migratory routes and wintering grounds of Iberian near-threatenedEuropean rollers Coracias garrulus. PLoS ONE, 9, e115615.

Acknowledgements

We give special thanks to Péter Palatitz and Zsófia Sümegi for their help in bird tagging and we also would like to thank Lilla Barabás, Erna Borbáth, Balázs Csibrány, Róbert Enyedi, Péter Hencz , Éva Horváth, Zsolt Karcza, József Katona, Gábor Kaufmann, Viktor Kiss , Dorottya Kiss, Tamás Kiss, László Kotymán, Csaba Lendvai,Márk Luca, Katalin Lukács, Tünde Ludnai,Péter Ócsai, István Péntek,Szabolcs Solt, Bence Szántó,László Szász, Tamás Széles,Szűcs Péter, Gábor Tihanyi Hunor Török for their help on the field. The research was supported by „ Conservation of the European Roller (Coracias garrulus) in the Carpathian Basin (LIFE13/NAT/HU/000081)" LIFE+ NATURE project.

Acta Zoologica Academiae Scientiarum Hungaricae 63(1), pp. 123–135, 2017
DOI: 10.17109/AZH.63.1.123.2017

THE EFFECTIVENESS OF NEST-BOX SUPPLEMENTATION FOR THE CONSERVATION OF EUROPEAN ROLLERS (*CORACIAS GARRULUS*)

Orsolya Kiss[1], Béla Tokody[2], Tünde Ludnai[3] and Csaba Moskát[4]

[1]*Institute of Animal Sciences and Wildlife Management, University of Szeged*
H-6800 Hódmezővásárhely, Andrássy út 15, Hungary; E-mail: orsolyakiss22@gmail.com
[2]*BirdLife Hungary, H-1121 Budapest, Költő u. 21, Hungary; E-mail: tokodyb@gmail.com*
[3]*Kiskunság National Park Directorate*
H-6000 Kecskemét, Liszt Ferenc utca 19, Hungary; E-mail: ludnait@knp.hu
[4]*MTA-ELTE-MTM Ecology Research Group, Biological Institute, Eötvös Lóránd University,*
H-1117 Budapest, Pázmány Péter sétány 1/C, Hungary
& Hungarian Natural History Museum, H-1088 Budapest, Baross u. 13, Hungary;
E-mail: moskat@nhmus.hu

Provisioning of artificial nest-boxes proved to be an effective method to make suitable breeding sites for secondary cavity nester birds due to the lack of natural hollows. The European roller (*Coracias garrulus*) is a threatened bird species in Europe, which suffered a serious decline throughout its breeding range. Changing agricultural practices seem to be the main causes attributed to the shortage of suitable breeding sites. In this study we aimed to investigate which factors affect the occupancy rate of newly provided nest-boxes. Four-year rollers' occupancy data were analysed by generalized linear models. Our results showed that nest-box characteristics (holder type and height above ground) and the presence of conspecifics significantly influenced rollers' nest-box occupancy. We conclude that nest-box visibility, height and the presence of conspecifics should also be considered when starting a nest-box supplementation program to ensure an effective method for the conservation of rollers.

Keywords: nest-box, occupancy, conspecific presence, habitat, bird conservation

INTRODUCTION

In the last few decades, the populations of many farmland and grassland bird species have decreased in Europe (Donald *et al.* 2006). However, these bird species did not share the same habitat requirements, they can be classified to different groups, such as true grassland species or edge and forest species, which need bushy or forest habitat as breeding or perching site (Virkkala *et al.* 2004). Although several species, like the woodpeckers (Picidae), can excavate their own nesting holes in dead trees, forest management practices may selectively eliminate such trees, causing the scarcity of their

optimal breeding places (Martin & Eadie 1999). Other cavity-nesting species occupy the abandoned hollows of woodpeckers, therefore their populations highly depend on the availability of these nesting holes, especially for species which need larger woodpecker hollows to breed. Good examples are stock doves (*Columba oenas*) and Tengmalm's owls (*Aegolius funereus*), which breed in the abandoned hollows of black woodpeckers (*Dryocopus martius*; Johnsson *et al.* 1993). The decrease in the availability of nesting sites is one of the main factors responsible for the population decline in many cavity-nesting birds (Sutherland *et al.* 2004).

Preserving suitable habitats by maintaining proper management practices or restoring degraded habitats is probably the best method in bird conservation, however, it is not always feasible. Therefore, a simple and frequently applied method in conservation of cavity-nesting bird species is the supplementation of artificial nest-boxes. This method is efficient in the conservation of secondary cavity-nesters and may contribute to the increase of population size in threatened bird species (Newton 1994, Avilés & Parejo 2004, Gottschalk *et al.* 2011, Olah *et al.* 2014). Although nest-box provisioning is typically helpful for bird conservation, it should be applied with caution, as nest-boxes in low-quality habitats may serve as ecological traps and make unsuitable sites attractive for birds with decreased reproductive success and increased mortality (Klein *et al.* 2007, Rodriguez *et al.* 2011). Providing artificial nesting places is usually labour-saving and costly, therefore conservation programmes need to evaluate their efficiency. To optimise conservation activity, several factors of nest-box design and their placement should be taken into consideration, as they may have various effects on breeding parameters (Korpimäki 1985, Lowther 2012, Lambrechts *et al.* 2012, Møller *et al.* 2014). For example, several bird species show clear preference for a certain orientation of the holes of nest-boxes (Goodenough 2008, Navara *et al.* 2011, Rodriugez *et al.* 2011). The various components of habitats, such as vegetation structure and habitat composition (Avilés *et al.* 2000, Tome 2004, Remacha & Delgado 2009, Lopez *et al.* 2010), may also play a role in nest site selection, influencing occupancy rate of artificial nest-boxes. Besides nest-box design and habitat characteristics, birds may use the presence/absence or breeding success of conspecifics and/or species with similar ecological requirements that provide valuable information on nest site suitability (Danchin *et al.* 2001, Pajero *et al.* 2004, Ward *et al.* 2004).

The European roller (*Coracias garrulus*) has undergone a serious population decline from the 1970's. It disappeared as a breeding species from Finland, Denmark, Germany and the Czech Republic (Cramp *et al.* 1998). A similar trend was also observed in the Hungarian population, as rollers disappeared from the western part of the country, and the stronger popula-

tion of the eastern region also showed a serious decline (Magyar *et al.* 1998). Consequently, the European roller is enlisted in Annex 1 of European Union' Bird Directive and become a priority species in 2012. The international action plan for the species was elaborated in 2008 (Kovács *et al.* 2008) to improve conservation measurements for rollers. Nowadays, roller populations show increasing trends in several countries, therefore its IUCN status was changed from Near Threatened (NT) to Least Concern (IUCN Red List Version 2015). The European roller has special habitat requirements; it is a secondary cavity-nesting species and in the Carpathian Basin, mostly uses the abandoned hollows of green woodpeckers (*Picus viridis*) and black woodpeckers (Szijj 1958). The method of nest-box supplementation for rollers proved to be successful in several countries, e.g. in Spain (Avilés & Sánchez 2000), Poland (Sosnowski & Chmielewski 1996), Austria (Sackl *et al.* 2004), and Hungary (Molnár 1998). Several aspects of this technique have already been revealed, such as the breeding parameters and potential threats (predation and decreased reproductive success) for rollers breeding in nest-boxes (Avilés *et al.* 2000, Avilés & Pajero 2004, Sackl *et al.* 2004, Rodriguez *et al.* 2011).

In the present study our primary goal was to identify the factors affecting the occupancy rate of rollers in newly provided nest-boxes. We investigated the effects of nest-box characteristics (holder type, height above ground and orientation), the land-use cover at the territory scale and the presence of conspecifics on occupancy rate of nest-boxes. We aimed to determine which factors are primarily responsible for occupancy. We hypothesized that the presence and location of conspecifics may determine whether a nest-box is occupied by rollers or not. Furthermore, we studied which factors influence the frequency of occupancy of nest-boxes. We hypothesized that besides nest-box characteristics the higher coverage of suitable feeding sites may promote the re-occupancy of newly established nesting sites.

METHODS

Study area and nest box installation

The study was conducted in southern Hungary in two neighbouring counties, Csongrád (total area: 4262.68 km², N46° 25′ 35.25″; E20° 14′ 05.75″) and Bács-Kiskun (total area: 8445.15 km², N46° 34′ 01. 59″; E19° 22′ 42.17″ (WGS 84)). The number of already installed nest-boxes was 299 in Csongrád county (mean distance: 548 m±728 s.d.) and 63 in Bács-Kiskun county (mean distance: 1548 m±4695 s.d.). This area is considered to have a core population of rollers in Hungary, although it also suffered from a significant decline of Rollers in Hungary in the 1970s and 1980s (Haraszthy 1984). The nest-box installation program began in southern Hungary in 1988. The estimated number of roller pairs based on territory mapping and nest-box checking was 407 in 2010, and 52% of them used artificial nest-boxes (Kiss & Tokody 2010). Nest-boxes involved in this study were installed in new

sites (68 in Csongrád and 64 in Bács-Kiskun counties) between the autumn of 2010 and early spring of 2011, within the frame of a conservation management program by local amateur ornithologists of BirdLife Hungary. All new nest-boxes were available for rollers during the breeding season of 2011.

Nest-box parameters and occupancy

The nest-box design was the same in all cases of the newly installed boxes (dimensions: 40 cm × 30 cm × 25 cm; Fig. 1). The following parameters of the boxes were recorded in the field after installation: orientation of entrance ("orientation"; N, NE, E, SE, S, SW, W, and NW), height above ground (m) and holder type (pylon or tree). We compiled occupancy records in nest boxes between 2011 and 2014. We considered a nest-box occupied by rollers if eggs or nestlings were present. We also registered any signs of nest failures. When adult rollers were regularly observed defending their nest-boxes, these were considered as nesting attempts. The occupancy of nest-boxes was checked at least once during June or July.

Landscape composition, nearest neighbour and density

We measured the components of landscape composition, the distance to nearest neighbour and calculated rollers' density. The land-use cover was measured around the nest-boxes in a circular plot with a 1 km radius. Rollers use this range most frequently as published observations suggest (Cramp *et al.* 1993, Molnár 1998, Avilés & Parejo 2004). Data on land-cover composition were extracted from the maps of the CORINE 50 Land

Fig. 1. Artificial nest-boxes placed on pylon (left = a) and in tree (right = b)

Table 1. Description and descriptive statistics (mean and se) of explanatory variables.

Variable (short name)	Description	Mean±SD (in scale variables)
Orientation	Orientation of nest-box entrance	N (8.3%), NE (9.1%), E (13.6%), SE (15.2%), S (14.4%), SW (7.6%),W (16.6%), NW (15.2%)
Height	Height of nest-box placement	4.3±0.76
Holder type	Type of nest-box holder	pylon (55.3%), tree (44.7%)
Closest natural territory	Distance to the observation of the closest natural breeder (m)	14765±15463
Closest occupied nest-box	Distance to a closest occupied nest-box in 2010 (m)	5195±5088
Density of occupied boxes	Number of occupied boxes in 10 km range in 2010	14.3±13.1
Large arable fields	Proportion (%) of large arable fields (CLC code: 2111)	9.7±17.3
Small arable fields	Proportion (%) of small arable fields (CLC code: 2112)	29.9±23.2
Orchards	Proportion (%) of orchards (CLC code: 222)	0.56±2.1
Grasslands	Proportion (%) of grasslands (CLC code: 231+321)	25.6±21.0
Complex cultivation	Proportion (%) of complex cultivation fields (CLC code: 242)	10.4±19.4

Cover 2006 program (Quantum GIS 1.8.0). The land cover types, which are considered as typical feeding sites for rollers, were included in the analyses such as grasslands, complex cultivation patterns, large and small arable fields and orchards (Table 1). The data of territory mapping and nest-box occupancy in 2010 were used to determine the initial roller population density in the area where the nest-boxes were installed. The number of all known breeding pairs within a 10 km radius around the nest-boxes was used for calculation (Table 1). The distance of nearest neighbours from the newly installed nest-boxes in 2010 was also calculated by using a GIS program (Quantum GIS 1.8.0).

Statistical analysis

We evaluated the effects of the environmental variables, nearby presence of rollers, and nest-box placement conditions (height above ground, holder type and orientation) on the occupancy rate of nest-boxes by linear models. Two main models were used: (i) the dependent variable was "ad-hoc occupancy", expressing the maximal potential usability of nest-boxes on the binary basis (occupied for at least once within the four-year study period). We used generalized linear model (binomial distribution with the logit link function) for revealing which factors and covariates are responsible for this preference for nest-box

Table 2. Results of generalized linear models for the prolonged nest-box occupancy by European rollers. The best fit model is shown (a), where variables with the highest explanatory value were retained. (The dependent variable expresses if the nest-box was occupied in the whole monitoring period between 2011 and 2014 on the binary bases: Y/N; factors: orientation, height above ground and holder type of nest-box; covariates: height, grasslands, large and small arable fields, orchards, grasslands, complex and distance of closest potential natural breeder, distance of closest occupied nest-boxes, number of occupied boxes within 10 km. See methods and Table 1 for more detailed explanations of the variables.) Parameter estimates for the best fit model is also shown (b).

(a) The best fit model	Wald χ^2	df	p
Holder type	11.596	1	**0.01**
Height above ground	3.896	1	**0.048**
Closest natural territory	14.234	1	**<0.001**

Model fitting: likelihood ratio $\chi^2 = 28.525$, df = 3, $p < 0.001$, AIC = 134.167, $AIC_{FULL} - AIC_{BEST} = 17.885$

(b) Parameter estimates	ß	se	Wald χ^2	df	p
Holder type (pylon)	1.744	0.512	11.598	1	**0.01**
Height above ground	0.619	0.314	3.896	1	**0.048**
Closest natural territory	–6.234E–5	1.652E–4	18.237	1	**<0.001**

occupancy. We ran variants of the model, from the full model which included all factors and variables toward the best fit model using the Akaike information criteria (AIC) for model selection (Burnham & Anderson 2002). (ii) We also used generalized linear model (multinomial distribution with the cumulative logit link function) to reveal how the former variables affect "frequency of occupancy" as the dependent variable. All analyses were done by the SPSS 22.0 software.

RESULTS

From the 132 newly provided nest-boxes 96 (72.7%) were occupied at least once by rollers during the four-year study period. Thirty-nine nest-boxes (29.5%) were occupied at the first time in 2011 (Fig. 2). Nineteen nest-boxes (14.4%) were occupied in each of the years in the four-year study period, 31 nest-boxes (23.5%) were occupied three times, 25 (18.9%) twice and 25 (18.9%) were used only once by rollers. A generalized linear model revealed which factors affected occupancy (yes/no) of the newly provided nest-boxes in the four-year study period, representing the preference for certain nest-boxes (Table 2). Consequently, 72.7% of the 132 nest-boxes were utilized for at least one year, and the rest (27.3%) were never used by rollers in any of the four years of the study. Among the nest-box characteristics, holder type, i.e. the nest-box was placed on a pylon or in a tree, as well as the height of the nest-boxes above ground had significant effects on rollers'nest-box occupancy (Table 2).

Interestingly, the presence of rollers potentially breeding in nearby natural breeding sites (closest natural territory) was also significant. However, we did not find any significant effect of land-cover compositon at the territory scale.

Another generalized linear model on the effects influencing nest-box occupancy within the four-year study period revealed similar results (Table 3). However, the second best fit model also showed that orientation of nest-boxes may also affect their occupancy, as the southward direction was not preferred by rollers ($\beta = -1.279$, se = 0.595, Wald $c^2 = 4.611$, df = 1, $p = 0.032$). Frequency of typical feeding sites, such as grasslands and small arable lands, did not influence the frequency of occupancy. Considering the importance of the presence of conspecifics we found a slightly positive effect of the proximity of breeding pairs both for nest-boxes and potential natural breeding sites (Fig. 2), although the higher population density around 10 km of the nests seems to affect negatively the repeated usage of nest-boxes, but this result was not significant (Table 3b).

DISCUSSION

The correct placement of artificial nest-boxes may fundamentally affect the usefulness of a bird conservation program for cavity-nesters. Therefore nest-box provisioning should consider all factors influencing nest-site selection of a given species. We found that nest-box characteristics significantly affected subsequent occupancy rates by rollers. The same three factors have the most important effect both on occupancy (yes/no) and frequency of oc-

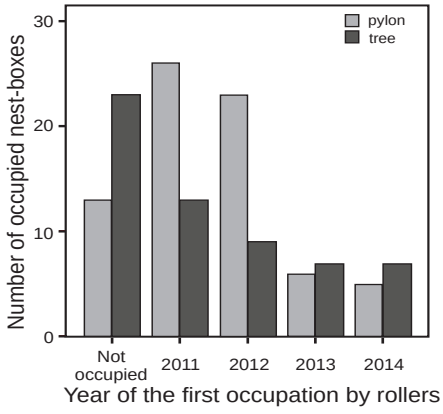


Fig. 2. Occupancy pattern of the newly provided nest-box during the study period

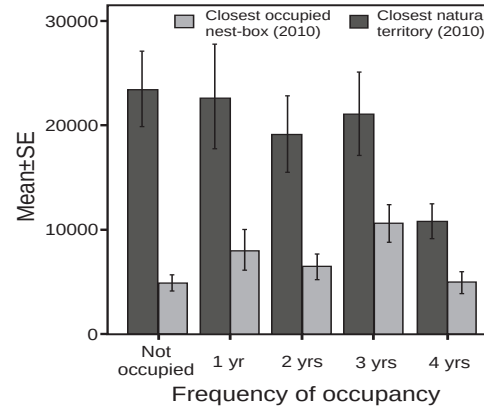


Fig. 3. The distance to the closest breeder in nest-box and potential natural breeding sites, as well as the length of occupancy of rollers in the four-year study period (horizontal axis)

Table 3. Results of generalized linear models for the frequency of nest-box occupancy by rollers in a four-year study period. The best fit (a) and the second best fit (b) models are shown, where variables with the highest explanatory value were retained. The dependent variable expresses the frequency of occupancy during the 4-year study period; factors: orientation, holder type, height above ground; covariates: height, distance of closest potential natural breeder distance of closest occupied nest-boxes, number of occupied boxes within 10 km, and land cover types in small and large arable fields, grasslands, orchards and complex cultivation patterns. Parameter estimates for the best fit model is also shown (c).

(a) The best fit model	Wald χ^2	df	p
Holder type	16.192	1	**<0.001**
Height above ground	5.698	1	**0.017**
Closest natural territory	16.958	1	**<0.001**
Model fitting: likelihood ratio $\chi^2 = 35.86$, df = 3, P < 0.001, AIC = 395.581, $AIC_{FULL} - AIC_{BEST} = 9.705$			
(b) The second best fit model	Wald χ^2	df	p
Orientation	10.379	7	0.168
Holder type	19.572	1	**<0.001**
Height above ground	3.847	1	**0.05**
Closest natural territory	18.237	1	**<0.001**
Closest occupied nest-box	3.698	1	0.054
Density of occupied boxes	3.003	1	0.083
Model fitting: likelihood ratio $\chi^2 = 50.63$, df = 12, P < 0.001, AIC = 398.804, $AIC_{FULL} - AIC_{BEST} = 6.482$			

(c) Parameter estimates for the best model	ß	se	Wald χ^2	df	p
Holder type (pylon)	1.416	0.352	16.192	1	**<0.001**
Height above ground	0.547	0.229	5.698	1	**0.017**
Closest natural territory	–5.642E–5	1.370E–5	16.958	1	**<0.001**

cupancy in the four-year study period. These were the conspecific presence, height and holder type. Nest-site selection of birds may also be influenced by the presence of conspecifics already settled for breeding in the area (see e.g. Danchin *et al.* 2001). In the present study we investigated several factors concerning the significance of the presence of conspecifics. We found that the distance to the closest occupied nest-box or natural breeding hollow may affect nest-box occupancy. This finding supports the result of a Spanish study (Václav *et al.* 2011), which showed that conspecific social attraction was important to the colonization of nest-boxes in the same season. Our results high-

light the significance of the presence of conspecifics from a conservation point of view. A preliminary survey of the local population before the starting of the nest-box provisioning program may increase its efficiency. However, we found that the closest natural breeders affected more occupancies than the closest pairs breeding in artificial nest-boxes.

Nest-box preference seems to be varying by region, probably reflecting to habitat structure, also including nearby feeding areas. In France, Bouvier *et al.* (2014) found that rollers breeding in natural hollows preferred lower natural holes (5.92±0.41 m, mean±s.d.), and Butler (2001) found strong preference for cavities with either south-westward or north-westward entrance orientation. One study from Slovakia reported much higher average height of natural breeding holes occupied by rollers (ca. 11 m) and the orientation was always toward open space suggesting the importance of direct flight paths from and into the cavities (Bohus 2002). In our study we found that rollers preferred nest-boxes located on pylons than those were placed on trees. Rodriguez *et al.* (2011) reported that rollers preferred more visible nest-boxes, however, pairs using these boxes showed lower breeding performance than others that occupied and bred in natural holes. Nest-boxes installed on electric pylons are more visible compared with nest-boxes placed on trees, where leaves normally serve as camouflage, therefore boxes should be placed with caution. However, Rodriguez *et al.* (2011) also found that rollers breeding in both exposed and concealed sites had similar individual quality and more frequent nest failures was explained by a higher risk of snake predation. The main predator in Spain was the Spanish Montpellier snake (*Malpolon monspessulanus*) (Parejo & Avilés 2011), but similar snake predators are absent from our study area.

Habitat selection of European rollers has already been investigated in several countries across Europe. In Austria rollers mainly use agricultural lands for foraging sites in the early breeding season, but they use fallows and grasslands from mid-summer (Sackl *et al.* 2004). In Spain rollers' breeding success suggested that woodland-free pastures were the most suitable habitats for this species, however, irrigated fields seem to be suboptimal (Avilés & Parejo 2004). In France fallows and meadows were the important favoured breeding sites (Bouvier *et al.* 2014). In this study we did not find any significant effect of the typical feeding sites on the frequency of nest-box occupancy at the territory scale. Contrary, former findings in Spain reported unfavourable agricultural intensification for rollers (Avilés & Pajero 2004, Donald *et al.* 2006), and also for several grassland birds in Hungary (Batáry *et al.* 2007). As the new nest-boxes were provided within the frame of a conservation program in our study, the primary goal was to supplement new nesting sites into suitable roller habitats, where proper feeding habitats were available

for rollers. However, we should consider that CORINE land-cover may not provide sufficient data to characterize the neighbouring area of nest-boxes properly and the effects of potential feeding areas on occupancy rate require further investigation. Brambilla (2009) showed that GIS-models may miss to identify important factors affecting species' occurrence. Although many farmland bird species and long distance migrants decreased recently in Hungary (Szép *et al.* 2012), the roller population seems to be affected primarily by the reduced availability of natural hollows used for breeding (Kovács *et al.* 2008). Consequently, nest-box supplementation proved to be a highly effective tool in the conservation of rollers in Hungary (Molnár 1998, Kiss *et al.* 2014), which stabilized the threatened and declining population in areas where landscape composition is favourable (Kiss *et al.* 2016) and high-quality feeding sites are available (Kiss *et al.* 2014). Other bird species in the same breeding habitat, such as the lesser grey shrike (*Lanius minor*), which typically breed in open-cup nests, seem to be more vulnerable (Lovászi *et al.* 2000). Our results revealed which factors affect the efficiency of nest-box supplementation programs in southern Hungary. Our results also revealed the importance of correct placement of nest boxes (height, holder type and habitat), but preservation of suitable breeding habitat must be involved into the long-term conservation management of the European roller.

*

Acknowledgements – We are grateful to Tamás Kiss, Csaba Mészáros, Péter Szűcs, Erna Borbáth, Gábor Balogh and the volunteers of BirdLife Hungary for their assistance in the field. We are thankful for the Kiskunság National Park Directorate for their logistic support and field assistance. The research was supported by HU-SRB IPA CBC project (HU-SRB 0910/122/120). The Ministry of Agriculture (former Ministry of Environment and Water) provided permission for research.

REFERENCES

Avilés, J. M. & Sánchez, A. (2000): Avian responses to nest-box installation in steppes of the south-west of the Iberian Peninsula (Extremadura). *Avocetta* **24**: 51–54.

Avilés, J. M., Sánchez, J. M. & Parejo, D. (2000): Nest-site selection and breeding success in the roller (Coracias garrulus) in the southwest of the Iberian Peninsula. *Journal of Ornithology* **141**: 345–350. https://doi.org/10.1017/S095927090400022X

Avilés, J. M. & Parejo, D. (2004): Farming practices and roller Coracias garrulus conservation in south-west Spain. *Bird Conservation International* **14**: 173–181. https://doi.org/10.1017/S095927090400022X

Batáry, P., Báldi, A. & Erdős, S. (2007): Grassland versus non-grassland bird abundance and diversity in managed grasslands: local, landscape and regional scale effects. *Biodiversity and Conservation* **16**: 871–881. https://doi.org/10.1007/s10531-006-9135-5

Bohus, M. (2002): On breeding biology of the roller (Coracias garrulus) in the Komárno town surroundings (SW Slovakia, Danubian Basin). *Sylvia* **38**: 51–59.

Bouvier, J. C., Muller, I., Génard, M., Lescourret, F. & Lavigne, C. (2014): Nest-site and landscape characteristics affect the distribution of breeding pairs of European rollers Coracias garrulus in an agricultural area of southeastern France. *Acta Ornithologica* **49**: 23–32. https://doi.org/10.3161/000164514X682869

Brambilla, M., Casale, F., Bergero, V., Crovetto, G. M., Falco, R., Negri, I., Siccardi, P. & Bogliani, G. (2009): GIS-models work well, but are not enough: Habitat preferences of *Lanius collurio* at multiple levels and conservation implications. *Biological Conservation* **10**: 2033–2042. https://doi.org/10.1016/j.biocon.2009.03.033

Burnham, K. P. & Anderson, D. R. (2002): *Model selection and multimodel inference. A practical information-theoretic approach*. 2nd ed., Springer, New York, 488 pp.

Butler, S. J. (2001): *Nest-site selection by the European roller (Coracias garrulus) in southern France.* MSc Thesis, University of York, UK, 610 pp.

Cramp, S. (ed.) (1998): *The complete birds of the western Palearctic on CD-ROM.* Oxford University Press, Oxford.

Danchin, E., Heg, D. & Doligez, B. (2001): *Public information and breeding habitat selection.* Pp. 243–258. *In:* Clobert, J., Danchin, E., Dhondt, A. A. & Nichols, J. D. (eds): Dispersal. Oxford University Press, Oxford.

Donald, P. F., Sanderson, F. J., Burfield, I. J. & Bommel, F. P. J. van (2006): Further evidence of continent-wide impacts of agricultural intensification on European farmland birds, 1990–2000. *Agriculture, Ecosystems and Environment* **116**: 189–196. https://doi.org/10.1016/j.agee.2006.02.007

Goodenough, A. E., Maitland, D. P, Hart, A. G. & Elliot, S. L. (2008): Nestbox orientation: a species-specific influence on occupation and breeding success in woodland passerines. *Bird Study* **55**: 222–232. https://doi.org/10.1080/00063650809461526

Gottschalk, T. K., Ekschmitt, K. & Wolters, V. (2011): Efficient placemet of nest-box for the little owl (Athene noctua). *Journal of Raptor Research* **45**: 1–14. https://doi.org/10.3356/JRR-09-11.1

Haraszthy, L. (ed.) (1984): *Magyarország fészkelő madarai [Breeding birds of Hungary].* Natura, Budapest, 247 pp. [In Hungarian]

Johnsson, K., Nilsson, S. G. & Tjernberg, M. (1993): Characteristics and utilization of old black woodpecker Dryocopus martius holes by hole-nesting species. *Ibis* **135**: 410–416. https://doi.org/10.1111/j.1474-919X.1993.tb02113.x

Kiss, O. & Tokody, B. (2010): A szalakóta (Coracias garrulus) helyzete és a védelmi intézkedések összefoglalása a Dél-Alföldön. (Roller population in southern Hungary.) *Heliaca* **8**: 108–11. [In Hungarian]

Kiss, O., Elek, Z. & Moskát, C. (2014): High breeding performance of European rollers Coracias garrulus in a heterogeneous farmland habitat of southern Hungary. *Bird Study* **61**: 496–505. https://doi.org/10.1080/00063657.2014.969191

Kiss, O., Tokody, B., Deák, B. & Moskát, C. (2016): Increased landscape heterogeneity supports the conservation of European rollers (Coracias garrulus) in southern Hungary. *Journal for Nature Conservation* **29**: 97–104. https://doi.org/10.1016/j.jnc.2015.12.003

Klein, Á., Nagy, T., Csörgő, T. & Mátics, R. (2007): Exterior nest-boxes may negatively affect barn owl Tyto alba survival: an ecological trap. *Bird Conservation International* **17**: 273–281. https://doi.org/10.1017/S0959270907000792

Korpimäki, E. (1985): Clutch size and breeding success in relation to nest-box size in Tengmalm's owl Aegolius funereus. *Holarctic Ecology* **8**: 175–180. https://doi.org/10.1111/j.1600-0587.1985.tb01168.x

Kovács, A., Barov, B., Orhun, C. & Gallo-Orsi, U. (2008): International species action plan for the European roller Coracias garrulus garrulus. Available at: http://ec.europa.eu/environment/nature/conservation/wildbirds/action_plans/docs/coracias_garrulus_garrulus.pdf

Lambrechts, M., Wiebe, K., Sunde, P., Solonen, T., Sergio, F., Roulin, A., Moller, A. P., Lopez, B. C., Fargallo, J., Exo, K. M., Dell'Omo, G., Costantini, D., Charter, M., Butler, M., Bortolotti, G., Arlettaz, R. & Korpimaki, E. (2012): Nest box design for the study of diurnal raptors and owls is still an overlooked point in ecological, evolutionary and conservation studies: a review. *Journal of Ornithology* **153**: 23–34. https://doi.org/10.1007/s10336-012-0919-y

Lopez, B. C., Potrony, D., Lopez, A., Badosa, E., Bonada, A. & Salo, R. (2010): Nest-box use by boreal owl (Aegolius funereus) in Pyrenees mountains in Spain. *Journal of Raptor Research* **44**: 40–49. https://doi.org/10.3356/JRR-09-32.1

Lovászi, P., Bártol, I. & Moskát, C. (2000): Nest site selection and breeding success of the lesser grey shrike (Lanius minor) in Hungary. *Ring* **22**: 157–164.

Lowther, P. E. (2012): Does nest-box size impact clutch size of house sparrows? *Wilson Journal of Ornithology* **124**: 384–389. https://doi.org/10.1676/11-166.1

Magyar, G., Hadarics, T., Waliczky, Z., Schmidt, A., Nagy, T. & Bankovics, A. (1998): *Nomenclator Avium Hungariae.* Hungarian Ornithological Institute, Budapest and Szeged, 202 pp.

Martin, K. & Eadie, J. M. (1999): Nest webs: A community-wide approach to the management and conservation of cavity-nesting forest birds. *Forest Ecology and Management* **115**: 243–257. https://doi.org/10.1016/S0378-1127(98)00403-4

Møller, A. P., Adriaensen, F., Artemyev, A., Banbura, J., Barba, E., Biard, C., Blondel, J., Bouslama, Z., Bouvier, J. C., Camprodon, J., Cecere, F., Chaine, A., Charmantier, A., Charter, M., Cichon, M., Cusimano, C., Czeszczewik, D., Doligez, B., Doutrelant, C., Dubiec, A., Eens, M., Eeva, T., Faivre, B., Ferns, P. N., Forsman, J. T., Garcia-del-Rey, E., Goldshtein, A., Goodenough, A. E., Gosler, A. G., Gozdz, I., Gregoire, A., Gustafsson, L., Hartley, I. R., Heeb, P., Hinsley, S. A., Isenmann, P., Jacob, S., Jarvinen, A., Juskaitis, R., Kania, W., Korpimaki, E., Krams, I., Laaksonen, T., Leclercq, B., Lehikoinen, E., Loukola, O., Lundberg, A., Mainwaring, M. C., Mand, R., Massa, B., Mazgajski, T. D., Merino, S., Mitrus, C., Mönkkönen, M., Morales-Fernaz, J., Moreno, J., Morin, X., Nager, R. G., Nilsson, J. A., Nilsson, S. G., Norte, A. C., Orell, M., Perret, P., Perrins, C. M., Pimentel, C. S., Pinxten, R., Priedniece, I., Quidoz, M. C., Remes, V., Richner, H., Robles, H., Russell, A., Rytkönen, S., Senar, J. C. Seppanen, J. T. da Silva, L. P., Slagsvold, T., Solonen, T., Sorace, A., Stenning, M. J., Török, J., Tryjanowski, P., van Noordwijk, A. J., von Numers, M., Walankiewicz, W. & Lambrechts, M. M. (2014): Clutch-size variation in Western Palaearctic secondary hole-nesting passerine birds in relation to nest box design. *Methods in Ecology and Evolution* **5**: 353–362. https://doi.org/10.1111/2041-210X.12160

Molnár, G. (1998): Breeding biology and foraging of rollers (Coracias garrulus) nesting in nest-boxes. *Ornis Hungarica 8. Supplement* **1**: 119–124. [in Hungarian, with an English summary]

Navara, K. J. & Anderson, E. M. (2011): Eastern bluebirds choose nest boxes based on box orientation. *Southeastern Naturalist* **10**: 713–720. https://doi.org/10.1656/058.010.0410

Newton, I. (1994): The role of nest sites in limiting the numbers of hole-nesting birds: a review. *Biological Conservation* **70**: 265–276. https://doi.org/10.1016/0006-3207(94)90172-4

Olah, G., Vigo, G., Heinsohna, R. & Brightsmith, D. J. (2014): Nest site selection and efficacy of artificial nests for breeding successof scarlet macaws Ara macao macao in lowland Peru. *Journal for Nature Conservation* **22**: 176–185. https://doi.org/10.1016/j.jnc.2013.11.003

Parejo, D., Danchin, E. & Avilés, J. M. (2004): The heterospecific habitat copying hypothesis: can competitors indicate habitat quality? *Behavioral Ecology* **16**: 96–105. https://doi.org/10.1093/beheco/arh136

Parejo, D. & Avilés, J. M. (2011): Predation risk determines breeding territory choice in a Mediterranean cavity-nesting bird community. *Oecologia* **165**: 185–191. https://doi.org/10.1007/s00442-010-1723-0

Remacha, C. & Delgado, J. A. (2009): Spatial nest-box selection of cavity-nesting bird species in response to proximity to recreational infrastructures. *Landscape and Urban Planning* **93**: 46–53. https://doi.org/10.1016/j.landurbplan.2009.06.004

Rodriguez, J., Avilés, J. M. & Parejo, D. (2011): The value of nestboxes in the conservation of Eurasian rollers Coracias garrulus in southern Spain. *Ibis* **153**: 735–745. https://doi.org/10.1111/j.1474-919X.2011.01161.x

Sackl, P., Tiefenbach, M., Ilzer, W., Pfeiler, J. & Wieser, B. (2004): Monitoring the Austrian relict population of European roller Coracias garrulus – a review of preliminary data and conservation implications. *Acrocephalus* **121**: 51–57.

Sosnowski, J. & Chmielewski, S. (1996): Breeding biology of the roller Coracias garrulus in Puszcza Pilicka Forest (Central Poland). *Acta Ornithogica* **31**: 119–131.

Szép, T., Nagy, K., Nagy, Z. & Halmos, G. (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**: 13–63. https://doi.org/10.2478/orhu-2013-0007

Szijj, J. (1958): Beiträge zur Nahrungsbiologie der Blauracke in Ungarn. *Bonn Zoological Bulletin* **9**: 25–39.

Sutherland, W. J., Newton, I. & Green, R. E. (2004): *Bird ecology and conservation*. Oxford University Press, New York, 404 pp. https://doi.org/10.1093/acprof:oso/978019852 0863.001.0001

Tome, R., Bloise, C. & Korpimaki, E. (2004): Nest-site selection and nesting success of little owls (Athene noctua) in Mediterranean woodland and open habitats. *Journal of Raptor Research* **38**: 35–46.

Václav, R., Valera, F. & Martinéz, T. (2011): Social information in nest colonisation and occupancy in a long-lived, solitary breeding bird. *Oecologia* **165**: 617–627. https://doi.org/10.1007/s00442-010-1848-1

Virkkala, R., Luoto, M. & Rainio, K. (2004): Effects of landscape composition on farmland and red-listed birds in boreal agricultural-forest mosaics. *Ecography* **27**: 273–284. https://doi.org/10.1111/j.0906-7590.2004.03810.x

Ward, M. P. & Schlossberg, S. (2004): Conspecific attraction and the conservation of territorial songbirds. *Conservation Biology* **18**: 519–525. https://doi.org/10.1111/j.1523-1739.2004.00494.x

Received December 14, 2015, accepted May 14, 2016, published March 3, 2017

Contributions to a Manual of Palaearctic Diptera

Edited by L. Papp and B. Darvas

Volumes 1–3, Appendix

The excellently illustrated volumes of the "Contributions to a Manual of Palaearctic Diptera" morphological, physiological, genetical, ecological and economic up-to-date knowledge of dipterous species (midges and flies), which have significant importance in genetics as model organisms, in plant cultivation as pests or beneficial parasitoids, in animal husbandry and human health as vectors of serious illnesses and which are important for ecosystem function, are treated. Morphological keys to generic level for adults and larvae are provided, which help readers with identification of dipterous pests and parasitoids, while readers in the field of applied dipterology will find suitable environmentally friendly methods against pests or biological control methods.

Volume 1 (published in 2000): 24 chapters of general and applied dipterology, by 31 specialists, on 978 pages with 956 figures on 176 plates.
Volume 2 (published in 1997): 38 dipterous family chapters, by 23 specialists, on 592 pages with 1895 figures on 258 plates.
Volume 3 (published in 1998): 56 dipterous family chapters, by 32 specialists, on 880 pages with 1773 figures on 294 plates.
Appendix (published in 2000): 16 dipterous family chapters, by 19 specialists, on 604 pages with 2134 figures on 207 plates.

ISBN 963 04 8836 1 (Series)
ISBN 963 04 8839 6 (Volume 1)
ISBN 963 04 8837 X (Volume 2)
ISBN 963 04 8838 8 (Volume 3)
ISBN 963 04 8840 X (Appendix)<R>

Publisher: Science Herald, Budapest

Order should be sent to
NEST Foundation, Budapest
E-mail: planta@ludens.elte.hu