UNIVERSITY OF SOPRON
FACULTY OF FORESTRY

Thesis of doctoral (PhD) dissertation

Home Range Analysis of the Golden Jackal *(Canis aureus)* Based on GPS-telemetry

Erika Csányi

Sopron
2025

Doctoral School:

Roth Gyula Forestry and Wildlife Management Doctoral School

Head of the Doctoral School:

Prof. Dr. Faragó Sándor

Program:

Wildlife management (E5)

Supervisor:

Dr. habil. Sándor Gyula, Associate Professor

1. Introduction

One of the most current examples of the population growth of medium-sized European predators is the golden jackal *(Canis aureus)*. After a significant decline by the mid-20th century, the golden jackal population began to increase again, and its expansion across Europe has been so rapid and extensive that the species is often referred to as an invasive species. Not only has it reclaimed its former range, but it has also expanded northward and westward into several European regions, a process that is still ongoing. This population and distribution growth is particularly remarkable in Hungary, where the species is a native predator but had become rare and only locally present. Its adaptability and opportunistic and generalist ecological strategy have enabled it to establish itself in various habitats. In addition to its exponential population growth, the species has expanded its distribution area in Hungary from 0.32% of the country's territory in 1995 to 85% today.

My doctoral dissertation aims to enhance the scientific understanding of this phenomenon. My research focuses on the movement ecology of the golden jackal, particularly its home range within the framework of a large-scale study. By analyzing home range size, its correlation with sex and age, and its spatial shifts, we can draw conclusions about the species' overall movement ecology. Investigating home range differences between sexes may provide insights into how sexual dimorphism – specifically differences in body and skull size – contributes to our understanding of the species' ecology.

To gain a deeper understanding of this process, I have also examined sexual dimorphism in body and skull size alongside telemetry studies. Investigating sexual dimorphism in both home range and morphological traits is essential for understanding the species' ecological role and adaptive capabilities, as these factors can significantly influence home range size, reproductive success, and population dynamics. Understanding the golden jackal's ecological role is paramount, especially given the limited knowledge about the species. This research provides fundamental insights for wildlife management, conservation, and agriculture. It also contributes to our understanding of processes such as the species' expansion in Europe and its social and trophic interactions. Furthermore, the findings may help guide management and conservation strategies while enhancing our understanding of the species' ecological significance.

2. Objectives

My research primarily aimed to analyze the movement ecology of the golden jackal, including its home range, using GPS telemetry. At the beginning of the study, I defined the following objectives:

1. To examine the extent to which the home range size of the golden jackal varies based on (a) sex, (b) age group, and (c) body mass.

2. Investigate whether the species' home range size varies across biologically significant periods (mating, cub-rearing, and non-breeding) according to (a) sex and (b) age group.

3. To assess how characteristic home range shifting is in the species and whether it varies based on (a) sex and (b) age group.

4. Additionally, to determine whether jackals that change their home range differ in habitat use compared to those that do not, particularly concerning distances from the edges of habitat types (land cover categories).

5. From a behavioral ecology perspective, this study analyzes the interactions among individuals regarding the phenomenon of pair replacement.

6. My goal was to examine the differences in body and skull dimensions in relation to (a) sex and (b) age group, while highlighting body mass as a potential factor influencing home range size.

3. Hypothesis, predictions

H1: The home range of the golden jackal is highly variable; however, owing to its tendency to expand, extensive or multi-member home ranges are expected in many cases. Based on the resource distribution hypothesis, I assumed that the home range of the jackal in a forest-agricultural – that is, semi-natural – ecosystem would be more extensive, especially compared to that of those in densely populated areas that humans have significantly transformed. The scattered but year-round availability of resources – including food, water, and shelter – justifies this assumption.
H2: The home range of the golden jackal is influenced by biological and ecological factors. I assumed that the home range of the golden jackal would change based on seasonal reproduction, alloparental care of offspring, and high ecological plasticity. My predictions (Ps) were as follows: Males have more extensive home ranges than females (P1); the home ranges of young individuals (1 to 2 years old) differ from those of adults (P2); the temporal variations in home ranges are significant based on the biologically important life cycles of jackals (P3); young individuals are more likely to change home ranges than adult jackals (P4); the home ranges of jackals that change home ranges are larger than those of residents (P5); and the home range changes are associated with different habitat use – that is, I expected differences between resident groups and home range – changing groups (P6).
H3: Home range changes are independent of seasons. Based on the large sample size (n = 45), I expected unique movement patterns – not revealed in the case of the golden jackal – that have been observed in other related species (e.g., the grey wolf and the coyote). Owing to the intensive hunting of the jackal, individuals in the alpha position are expected to drop out during the year. This occurred, and although it was unplanned, it was possible to study the interaction between the individuals marked with GPS collars – specifically the phenomenon of mate replacement – based on their movement patterns. The discovery of this phenomenon, which is also interesting from a behavioural ecological point of view, may serve as an essential contribution to understanding the expansion flexibility of the golden jackal.
H4: Sexual (body) size dimorphism (SSD) and skull shape dimorphism (SShD) occur in body and skull sizes. According to my prediction (P7),

males' body and skull sizes will be larger than those of females in both the young and adult age groups.

H5: The home range of the golden jackal is related to body mass. My hypothesis is derived from the relationship that the home range increases with body mass among different predatory mammal species. My prediction (P8) is that this relationship applies within the species, particularly in those with a highly variable home range size, such as the golden jackal. I hypothesize that greater body mass is associated with a larger home range size.

4. Materials and methods

4.1. Study area, data collection

We conducted GPS collaring of golden jackals and collected morphological examination data in Somogy County (SEFAG Zrt., Dél-Dunántúli Fauna Vt.) from 2020 to 2023. The study area is a lowland region, predominantly covered in forest (62%). The golden jackal is the largest predatory mammal in the region, and its population has significantly increased over the past two decades. In Somogy County, golden jackal harvest data represents 20–24% of the country's total hunting bag.

We captured 45 golden jackals (22 females and 23 males) using baited box traps from 2020 to 2023. The captured jackals were fitted with Vertex Lite 1C Iridium GPS satellite collars (Vectronic Aerospace GmbH, Berlin, Germany), programmed to transmit hourly (24 times per day). The animals were tracked for an average (±SE) of 244 (±15) days. A total of 236 675 location coordinates were recorded (localization points: males, n = 122 638; females, n = 114 037).

4.2. Data Processing

Methodology of Home Range Size Analysis: To analyze GPS localization data, the study period was divided into three biologically relevant phases based on the life cycle of the jackal and observations from camera traps:

1) Breeding season (mating and pregnancy): January–March

2) Pup-rearing season (when pups require parental care): April–June
3) Non-breeding period (outside the breeding and pup-rearing seasons): July–December.

Four different methods were used to analyze home range sizes, based on a selected portion of localization points (100%, 95%, 90%, 60%, and 50%):

1) Minimum Convex Polygon (MCP) – MCP100, 95, 50
2) Kernel Density Estimation (KDE) – KHR95, 90, 60, 50
3) Alpha Concave Hull (ACH)
4) Autocorrelated Kernel Density Estimation (AKDE) – AKDE95, 90, 60.

Ultimately, KHR provided the most consistent results and was the least sensitive to special point patterns; therefore, we chose this estimation method for our further analyses.

Using trajectory segmentation analysis, including Lavielle's segmentation method, Net Squared Displacement, and General Linear Mixed Model (GLMM) alongside visual analysis, we classified the tracked jackals as residents or non-residents (irruptive nomads) based on their observed space-use patterns during the study period.

We defined jackals as residents if they remained within a single, identifiable home range throughout the study period, and as nomads if they occupied multiple separate home ranges (shifting from their previous home range). By graphically examining the decreasing trend of the contrast function, we used the number of segments where clear breaks were evident on the slope. When no break was present, we classified jackals as residents, regardless of their home range size. When multiple breaks were present, we determined the optimal number by visually comparing the potential segments and selecting the one with the least spatial overlap. We considered the distance between the centroids of different home ranges as the dispersion distance. We calculated centroids as the arithmetic mean values of the longitude and latitude coordinates. We analyzed (PERMANOVA) both resident and nomadic groups to determine from which land-use category edges individuals moved away and to what extent.

Methodology for Investigating the Pair Replacement of the Golden Jackal:
The movement patterns of three golden jackals (two females: F07 and F10, and one male: M08) were examined in de-

tail during data processing. Genetic analyses of fur and blood samples confirmed that these individuals are unrelated. We utilized the 95% and 50% kernel density estimation methods (kernel home range; KHR95, KHR50) with an ad hoc smoothing parameter to ascertain the sizes of home ranges and core areas. The home range overlap among the golden jackal individuals was assessed using percent overlap (the proportion of animal i's home range that overlapped with animal j's home range) and the Utilization Distribution Overlap Index (UDOI) to identify differences in movement ecology between the two periods (before and after the death of F10 female). The distances between the hourly localization points of M08 and F07 were measured in QGIS and analyzed for comparison between the periods before and after the death of F10.

Methodology for the Study of Sexual Dimorphism in the Golden Jackal: To examine the differences in body and skull size among golden jackals, we analyzed data from 719 harvested individuals (*n* = 362 females, *n* = 357 males) from the study area. The individuals were classified into two age categories: young and adult, based on the wear of the upper incisors and the first upper molars. We recorded body weight, six body measurements, and 22 skull measurements. The normality of the data was tested using the Shapiro–Wilk test, while homogeneity of variance was assessed with Levene's test. When necessary, the Welch test was applied. We used principal component analysis (PCA) to reduce the dataset's dimensionality and identify patterns within the skull measurements of both juveniles and adults. The first principal component (PC1) is typically considered a general size axis, whereas the remaining principal components represent shape space. Two types of PCA analysis were performed in both age groups: a raw PCA and a PCA on log-shape ratios. MANOVA and *t*-tests were performed to examine which principal components showed significant differences between sexes in the two age groups. Next, we identified the variable combinations that provided the highest classification accuracy. In the case of raw PCA, the PC1 × PC3 variable combination produced the highest predictive power in distinguishing between the sexes. The predictive power of the principal components was further tested using linear discriminant analysis (LDA) to evaluate the degree of skull size separation between males and females. The relationship between home range size (KHR95) and body weight was examined using bivariate regression analysis. Regression analysis was performed for all individuals collectively and for four distinct groups: resident females, resident males, nomadic females, and nomadic males. The mean body weights of resident and nomadic individuals were compared using a two-sample *t*-test. For all statistical tests, the significance level was set at 5%.

5. Results

5.1. Home range

Trajectory segmentation analysis identified 28 resident and 17 nomadic jackals based on their movement patterns.
Resident jackals: The mean (± SE) home range size of the 28 resident jackals was 14.38 ± 2.27 km², based on the KHR95 calculation method. The mean home range size of males was 2.5 times larger than that of females (19.29 km² vs. 7.4 km², $p = 0.015$). According to the GLMM analysis, young jackals had a significantly larger home range than adults (14.76 km² vs. 14.27 km², $p = 0.003$); however, this difference is not biologically significant. Jackals expanded their home ranges during the pup-rearing period (17.18 km²) compared to the mating period (11.24 km²) and the non-breeding period (13.07 km²) ($p = 0.005$). The age group × period interaction ($p = 0.002$) is noteworthy, as young jackals exhibited the largest home ranges during the breeding period (37.78 km²), after which their home ranges significantly decreased. In contrast, adult jackals had the most extensive home ranges during the pup-rearing period (17.25 km²).
Nomadic jackals: Of the 45 GPS-tagged jackals, half of the young individuals (14/7), nearly one-third of the adults (31/10), half of the females (22/11), and almost one-quarter of the males (23/6) were identified as nomadic. Path segmentation analysis of 17 nomadic jackals revealed that 13 individuals (76.5%) changed home ranges once, while individuals (23.5%) changed home ranges twice.
The mean (± SE) home range size of nomadic jackals was 92.44 ± 20.59

km^2. Home range size was not influenced by sex or age group but by the order of home range changes. The largest home range size was recorded in the third range (first range = 83.41 km^2, second range = 79.64 km^2, third range = 185.26 km^2, $p < 0.001$).
Significant interactions were observed for sex × range order and age group × range order. The home range size of males did not change significantly between range shifts (mean: 37.16–59.43 km^2). However, females exhibited a substantial increase in home range size after the second range change (mean: first home range = 96.4 km^2, second home range = 100.40 km^2, third home range = 333.37 km^2, $p = 0.003$). The home range size of young jackals decreased, whereas that of adults increased during range changes ($p = 0.001$).
Based on the distances between movement area centroids, the mean (± SE) dispersal distance (migration distance) was 14.37 ± 2.72 km, ranging from 1.46 km to 56.43 km, with movements occurring in multiple directions. Our analysis showed that the distances of localization points from the edges of different land cover categories (habitat types) varied between resident and nomadic jackals (two-way PERMANOVA, $F_4 = 800.55$, df = 4, $p < 0.001$), revealing a significant interaction between nomadic jackals and land cover category. However, the distances did not differ between resident and nomadic jackals ($F_2 = -3015.10$, $p = 1.00$) but varied according to the land cover categories ($F_4 = 2063.20$, $p < 0.001$).
The distances of nomadic jackals' localization points from the edges of various land cover categories changed significantly before and after home range shifts, as the interaction between range change and land cover category was notable. After a range shift, jackals moved further away from artificial surfaces and wetlands but closer to water bodies than they had before.

5.2. Pair Replacement of Golden Jackals Outside the Breeding Season

The three adult jackals (F10 female, M08 male, and F07 female) were unrelated. The adult jackals F10 and M08 were identified as a pair. Genetic analysis supported this conclusion, as did significant overlap in their movement ranges and photographic documentation. The spatial and temporal characteristics of the home ranges suggest that all three individuals were residents using well-defined areas regularly. F10 and M08 used the same area between May and August 2021 until the death of F10. The home ranges of F10 and M08 were 6–7 km^2, almost completely overlapping. F1 was shot on the evening (21 h) of August 21, 2021. F07 shifted her movement pattern, entered the home range of the former M08–F10 pair, 6 hours later circled the site where F10 was shot, and occupied F10's home range within a day. The hourly localizations of F07 before the death of F10 fell between 107–5 789 m away from the localizations recorded at the same time for M08 (mean ±SD = 1554 ±953 m, median = 1 432 m); after the death of F10, these distances decreased to 1–3050 m (943 ± 920 m, median = 622 m), which were very similar to the 'former' distances between M08 and F10 (range = 0–3820 m, 677 ± 637 m, median = 613 m). F07 did not return to her previous home range, closely associated with M08, and used the same home range as previously F10-M08 until M08's death (shooting date: October 20, 2021) and after. Staying in the new area indicates that F07 may have replaced a deceased alpha female.

5.3. Sexual Dimorphism in Golden Jackals

The results of the present study support our hypothesis that sexual size dimorphism (SSD) and sexual shape dimorphism (SShD) exist among golden jackals in an overpopulated habitat in Hungary, across both juvenile and adult age groups. Descriptive statistics revealed significant SSD in body and skull measurements within both age categories, with males generally larger than females, particularly in body mass (11.72% in juveniles and 13.37% in adults). Most skull dimensions differed significantly between sexes and age groups, with exceptions for foramen magnum height, foramen magnum width, postorbital breadth among juveniles, and foramen magnum height and postorbital breadth among adults. Based on the principal component analyses (PCA) on raw dimension data and the log shape ratio method to extract shape information. Linear discriminant analysis (LDA) investigated skull SShD between sexes. Notably, our study achieved over 71% accuracy (highest: 75.4%) in sex classification, demonstrating the clear presence of SShD of the skull in golden jackals across both age groups. Sexual dimorphism in golden jackals was evident among the 45 GPS-col-

lared individuals in both age groups. In both juveniles and adults, males had significantly greater body weight than females (Student's t-test: juveniles: df = -2.310 (12), $p = 0.020$; adults: df = -2.085 (29), $p = 0.023$).
When analyzing the body weights of the two groups (resident vs. nomadic jackals) of GPS-tracked golden jackals, we found that nomadic individuals had significantly lower body weights than resident individuals (two-sample t-test: mean ± SD = 9.58 kg ± 1.34 kg vs. 10.75 kg ± 1.15 kg, $t = 3.01$, $p = 0.0043$).
In a linear regression model (y = –34.99x + 465.51, $n = 45$), the relationship between body weight and home range size (KHR95) was weak and statistically insignificant (F = 2.5528, $p = 0.1174$). Overall, this weak correlation suggests that body weight alone is not a significant predictor of home range size in golden jackals.

6. New Scientific Results, Thesis

1. The proportion of nomadic individuals (dispersing or shifting home ranges) is significant within the golden jackal population. Among the 45 GPS-collared jackals, we identified half of the juveniles (7/14), nearly one-third of the adults (10/31), half of the females (11/22), and one-quarter of the males (6/23) as nomads. Route segmentation analysis of 17 nomadic jackals revealed that the majority (13 individuals – 76.5%) changed their home range once, while the remainder switched twice during the tracking period.
2. The home range size of the tracked golden jackals showed significant variability, with individual differences reaching up to 100–200-fold. The home range of resident jackals (those that did not shift their home range, $n = 28$) was, on average (± SE), 14.38 ± 2.27 km² (range: 1.06–106.83 km² based on kernel density estimation [KHR95]). In contrast, the nomadic individuals ($n = 17$) had an average home range of 92.44 ± 20.59 km² (range: 3.18–637.86 km²). This demonstrated ecological flexibility in movement, which may be a key driver of behind the species' success and expansion in Europe.
3. Among resident golden jackals, males exhibited larger home ranges

than females. Juvenile jackals (1–2 years old) had the most expansive home ranges during the breeding season, whereas adult jackals (2 years or older) exhibited the largest home ranges during the pup-rearing period. However, sex and age class did not significantly affect the home range size of nomadic jackals.

4. Home range shifts among golden jackals were observed throughout the year, occurring in all three biologically significant periods (breeding, pup-rearing, and non-breeding seasons). This indicates that jackal dispersal is not limited to the breeding season but occurs continuously throughout the year.
5. In forest-agricultural landscapes, resident and nomadic jackals primarily utilized the habitat edges of forests and cultivated areas in both groups. Additionally, residents stayed closer to water bodies, while nomadic individuals – especially after shifting their home range – tend to move closer to artificial surfaces (e.g., human settlements).
6. This study provides the first documented evidence of the adaptive response of monogamous golden jackals to partner loss. In this case, when an alpha male lost his partner, a new female replaced the deceased mate within a single day, and adhered to a "stay and wait for vacancy" strategy. This rapid restoration of family structure may contribute to the species' quick population growth and substantial expansion.
7. I presented, for the first time, a large-scale morphometric dataset (n = 719) of the Hungarian golden jackal population. The dataset confirmed sexual dimorphism in both juvenile and adult individuals, with males showing larger body and skull measurements. Sexual dimorphism in skull shape was also proven.
8. I provided the first evidence that resident golden jackals have significantly greater body weight than nomadic individuals.
9. I proved that body weight alone does not predict home range size in the Hungarian golden jackal population, indicating no strong correlation between body weight and home range size.

7. Summary

Our research represents the first analysis conducted in Hungary and Europe on the movement ecology of golden jackals within a well-defined time interval and region. By utilizing GPS telemetry and frequent (hourly) data collection with a large sample size (*n* = 45), these findings may indicate the spatial ecological characteristics of the Central European golden jackal population. Our results provide valuable insights into the factors driving the species' westward and northward expansion in Europe.

The new scientific findings from my dissertation provide a basis for further, more detailed analyses of habitat use and inter- and intraspecific interactions (e.g., jackal-fox, jackal-ungulate dynamics). Understanding the mechanisms driving the expansion of golden jackals is crucial for developing effective population management and conservation strategies and determining management and protection priorities.

The combination of literature data and my results suggests that the social behavior, spatial flexibility, and sexual dimorphism of golden jackals are closely interconnected. Understanding these aspects is crucial for comprehending the species' ecology and adaptive strategies. Overall, the uniqueness and novelty of our research lie in examining multiple facets of golden jackal ecology, including home range size, morphological characteristics, individual movement patterns, and their interrelations. The large sample allowed us to test and compare the most commonly used home range estimation methods, ultimately enabling an unbiased approach to deliver more reliable results. The data collected contribute to a deeper understanding of the species' spatial behavior and population dynamics and serve as a foundation for developing effective conservation and population management strategies.

8. List of the author’s publications related to the topic

8.1. Peer-reviewed journal article

1. Gaál, D., Heltai, M., Sándor, Gy., Schally, G. & Csányi, E. (2025): Ecotones in the Spotlight – habitat selection of the golden jackal *(Canis aureus* Linnaeus 1758) in the agricultural landscapes of Southern Transdanubia. **Animals** 15(5): 760. https://doi.org/10.3390/ani15050760
2. Csányi, E., Gaál, D., Heltai, M., Pölös, M., Sándor, Gy., Schally, G. & Lanszki, J. (2024): Home ranges of roaming golden jackals in a

European forest-agricultural landscape. **Journal of Wildlife Management** 89:e22688 https://doi.org/10.1002/jwmg.22688
3. Csányi, E. & Sándor, Gy. (2024): Az aranysakál *(Canis aureus)* párzási időszakon kívüli párpótlása. **Magyar Apróvad Közlemények** 16. pp. 277-288. ISSN 1418-284X
4. Csányi, E. & Sándor, Gy. (2024): Sexual dimorphism in the Hungarian golden jackal population: analysing body and skull size and shape. **Mammalian Biology** 104: 647–660. https://doi.org/10.1007/s42991-024-00436-0
5. Csányi, E., Heltai, M., Lanszki, J., Pölös, M., Schally, G. & Sándor Gy. (2023): The first evidence of the monogamous golden jackal's adaptive response to partner loss. **Applied Animal Behaviour Science** 269: 106095. doi.org/10.1016/j.applanim.2023.106095
6. Ninausz, N., Fehér, P., Csányi, E., Heltai, M., Szabó, L., Barta, E., Kemenszky, P., Sándor, Gy., Jánoska, F., Horváth, M., Kusza, Sz., Frank, K., Varga, L. & Stéger, V. (2023): White and other fur colourations and hybridization in golden jackals *(Canis aureus)* in the Carpathian basin. **Scientific Reports** 13(1): 21969. doi: 10.1038/s41598-023-49265-0.
7. Csányi, E., Sándor, B. & Sándor, Gy. (2023): Morphometric Measurements of Red Foxes (Vulpes vulpes) in Somogy County, Hungary. **Magyar Apróvad Közlemények** 15. pp. 11-21. ISSN 1418-284X
8. Csányi, E., Németh, S., Tari, T. & Sándor Gy. (2022): „Move or not to Move" - Red Deer Stags Movement Activity during the Rut. **Animals** 12(5): 591. https://doi.org/10.3390/ani12050591
9. Balog, T., Nagy, G., Halász, T., Csányi, E., Zomborszky, Z. & Csivincsik, Á. (2021): The occurrence of Echinococcus spp. in golden jackal *(Canis aureus)* in southwestern Hungary: Should we need to rethink its expansion? **Parasitology International** 80:102214.

8.2. Other journal articles, book chapters

1. Csányi, E. & Sándor, Gy. (2023). A vadbiológia tudatos használata a vadgazdálkodásban. **Nimród** 4: 12-17.
2. Csányi, E. & Sándor, Gy. (2023): Az állatok magánélete: A GPS-tel-

emetria használata a vadbiológiában, vadgazdálkodásban. **Nimród** 7: 20-25.

3. Csányi, E. & Horváth, M. (2021): Auf leisen Sohlen: Wissenschaft im Dienst der Jagdpraxis. **Wild und Hund** 23(2): 14-19.
4. Csányi, E. (2020): A hazai nagyvadállomány becslésének lehetőségei, valamint a XXI. század technikájának alkalmazhatósága a vadgazdálkodásban. In: Jámbor, László (szerk.) **Vadászévkönyv.** Hatvan, Magyarország : Dénes Natur Műhely Kiadó (2020) 184 p. pp. 40-48., 1 p.

8.3. Conference Proceedings, Abstract Book

1. Csányi, E., Lanszki, J., Heltai, M., Pölös, M., Schally, G. & Sándor, Gy. (2024): Első bizonyíték a monogám aranysakál partnerelvesztésre adott válaszára. In: Emri, Zsuzsa; Cserkész, Tamás; Kiss, Csaba; Csorba, Gábor (szerk.) **III. Emlőskutatók Szakmai Napja: konferencia és workshop.** Biológus Szakmai Nap (Workshop) : absztrakt füzet. Eger, Magyarország: Líceum Kiadó.143 p. pp. 19-19. 1 p.
2. Gaál, D. & Csányi, E. (2023): Home range of the golden jackal in a predominantly agricultural habitat In: **36th Congress of International Union of Game Biologists:** Quo vadis wildlife management? The future of wildlife management in the evolving social and environmental realities. Warsaw, Lengyelország 126 p. pp. 106-107., 2 p.
3. Csányi, E. & Sándor, Gy. (2023): Quick pair replacement of the monogamous golden jackal *(Canis aureus)*. In: **36th Congress of International Union of Game Biologists:** Quo vadis wildlife management? The future of wildlife management in the evolving social and environmental realities. Warsaw, Lengyelország. 126 p. pp. 37-38., 2 p.
4. Csányi, E., Heltai, M., Horváth, M., Lanszki, J., Németh, S., Pölös, M., Trefán, G., Varga, Gy. & Sándor, Gy: (2022): Home range and movement activity of golden jackal *(Canis aureus)* in Central Europe. In: Heltai, Miklós (szerk). 3rd International Jackal Symposium. Abstract Book Gödöllő, Magyarország: **Hungarian University of Agriculture and Life Sciences, Institute for Wildlife Management and Nature Conservation** p. 18., 1 p.

5. Ninausz, N., Fehért, P., Csányi, E., Heltai, M., Szabó, L., Barta, E., Kemenszky, P., Sándor, Gy., Horváth, M., Kusza, Sz., Frank, K., Varga, L. & Stéger, V. (2022): Coat colour variations and possible hybridisation of Golden jackals *(Canis aureus)* in Hungary. In: Heltai, Miklós (szerk.). 3rd International Jackal Symposium. Abstract Book. Gödöllő, Magyarország: **Hungarian University of Agriculture and Life Sciences, Institute for Wildlife Management and Nature Conservation.** p. 60., 1 p.
6. Nagy, T., Csányi, E., Alnajjar, M., Fehér, P., Ninausz, N., Feró, O., Skage, M., Kollias, S., Fekete, Zs., Kontra, L., Sándor, Gy., Heltai, M., Székvölgyi, L., Stéger, V. & Barta, E. (2022): The golden jackal *(Canis aureus)* reference genome assembly and annotation. In: Heltai, Miklós (szerk.) 3rd International Jackal Symposium. Abstract Book. Gödöllő, Magyarország: **Hungarian University of Agriculture and Life Sciences, Institute for Wildlife Management and Nature Conservation** p. 61., 1 p.

Photos: Márk Gschwindt