University of Sopron

Faculty of Forestry

PhD Thesis

TROPHIC RELATIONSHIPS BETWEEN RED FOX (*VULPES VULPES*) AND GOLDEN JACKAL (*CANIS AUREUS*) IN SOUTHERN ROMANIA

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1. Introduction, objective

The rise of the golden jackal (*Canis aureus* Linnaeus, 1758) in Eastern and Central Europe has brought new challenges to the managers of these habitats in newly occupied areas. Our knowledge about the impact of the species on indigenous biodiversity is scarce. As a predator species, golden jackal is mainly suspected of predation, but it can also affect the widespread indigenous red fox (*Vulpes vulpes*, Linnaeus, 1758) through competition. One precondition for competition is the overlap between ecological needs and the scarcity of vital resources. The two resources of vital importance are food and living space. Among these, nutritional biology studies can analyze the consumption of certain food sources. The nutritional niche breadth of each species can be calculated and, in the case of co-existence of several species, the nutritional niche overlaps between them may be quantified.

The author investigated the nutritional characteristics of the golden jackal and red fox and the trophic relationships between them. The sample collection methodology also made examining the simultaneous use of living space – the other vital resource – possible.

Objectives

During his work, the author sought to answer the following questions:

1. Do the characteristics (structure and richness) of the habitat determine the territorial distribution of golden jackals and foxes in areas poor in anthropogenic food sources, or is this a consequence of competition?
2. Are there any significant differences between the population dynamics of foxes living in areas occupied by jackals and the populations of foxes from areas with no permanent jackal presence?
3. What characterizes the nutritional biology of the two species when they are sympatric and is there a detectable discrepancy in the nutrition of foxes living in the two areas?
4. How important are certain food items for the golden jackal and red fox?

2. Material and method

Study area

The total surface of the 10 hunting areas examined was 88,185 ha. These are located in the southern parts of Romania, at the confluence of the Olt and the Danube rivers. The area is mostly typical lowland farmland with large-scale tillage under intensive cultivation and a forest cover of approximately 8%. Among potential game species the golden jackal can hunt, wild boar (*Sus scrofa*) was abundant while roe deer (*Capreolus capreolus*), hare (*Lepus europaeus*) and pheasant (*Phasianus colchicus*) densities were extremely low. Supervised grazing (sheep and goats) was a common activity in the study area. Anthropogenic food sources such as big game or domestic animal viscera and carrion were scarce.

Predator control

During the period of 2013 – 2015, a non-selective and intensive culling – using firearms – of predator mammals and birds was implemented in the study area. The hunting bag data from these activities provided the database of spatial distribution for each species. Hunting bag data analysis clearly distinguished areas with constant jackal presence from those with only random jackal occurrence. The divided areas based on predator control hunting bag data were classified into "with jackals" and "jackal-free" categories.

Habitat characteristics

The author investigated the habitat type diversity and the abundance of unique habitat types per 1000 hectares in the areas with constant jackal presence and in the jackal-free areas, which were categorized according to the spatial distribution of hunting bag data.

Population dynamics and biometrics

In the case of more than 75% (n = 118) of the culled jackals and 41% of the foxes (n = 251) the author examined, were in a deeply frozen state. This made it possible to determine the age group, sex, and body weight of the animals.

Nutritional biology studies

With the majority of the golden jackal and red fox carcasses bagged during predator control activity (117 jackal and 235 foxes), the author was able to collect the entire stomach and then examine their contents later. This procedure allowed the author to establish the proportion of empty stomachs, identify the food items found in non-empty stomachs, and record their frequency of occurrence. Based on the occurrence frequency of certain food items, the author calculated nutritional niche breadths, nutritional niche overlap, and the food spectrum diversity for sympatric golden jackals and red foxes.

Statistical data processing

The author analyzed the data by species, areas, years, and seasons. Predator species stock densities in certain hunting grounds and body weight data were compared with a t-test of dependent samples. Habitat characteristics and young/adult ratios were compared with t-tests, independent, by groups. Sex ratio comparisons of each age class or species from different areas were performed with 2x2 Pearson chi-squared tests. Nutritional characteristics were tested with Pearson chi-squared tests and Kruskal-Wallis tests. Diversity values were investigated using Hutcheson's t-test.

Data processing was performed using Microsoft Excel, Statistica 13.4.0.14 version software, and PAST 2.17 software. The level of significance applied was always $\alpha = 0.05$.

3. Results

A significant difference in jackal density in the two areas was determined by examining the distribution of the predators in areas classified as “with jackals” and those classified as “jackal-free” ($t = 3.236$; $df = 28$; $p = 0.003$). In hunting areas defined as “with jackals”, the density of the jackal hunting bags was on average 1.21 individuals/1000 hectares, while the average density in the jackal-free areas was 0.06 individuals/1000 hectares.

Fox hunting bag densities were also higher in areas with jackals (average 3.15 individuals/1000 hectares) than they were in jackal-free areas (average

1.65 individuals/1000 hectares) and this difference was significant ($t = 2.127$; $df = 28$; $p = 0.042$).

The number of unique habitat types per 1000 hectares was greater in the areas with jackals than in the jackal-free areas ($t = 5.507$; $df = 4$; $p = 0.005$; $\alpha = 0.05$). The difference between the diversity indices of the areas with jackals and those of jackal-free areas was also significant ($t = 93.966$; $df = 88183$; $p < 0.001$), with higher diversity indices in the areas with jackals.

In the fox populations living sympatric with jackals, the sex ratio was shifted for the benefit of males at both age groups (1:0.58 and 1:0.56), but the sex ratios of the age groups were similar ($N = 157$; $\chi^2 = 0.012$; $df = 1$; $p = 0.9132$). Thus, during their entire life history, the sex ratios of the populations of red foxes living sympatric with the golden jackal sharply shifted to the benefit of the males.

In the jackal-free areas, fox sex ratios were much more balanced and slightly shifted in favor of the females (1:1.09). However, this is not typical for both age groups and the differences between the sex ratios of each age group were not relevant ($N = 94$; $\chi^2 = 1.002$; $df = 1$; $p = 0.3169$).

However, there was a notable difference between the sex ratios of foxes from areas with jackals and those from jackal-free areas ($N = 251$; $\chi^2 = 6.033$; $df = 1$; $p = 0.0140$).

The average number of juveniles per one adult individual, referring to reproductive potential, was 0.16 in the case of jackal; 0.74 in the case of foxes living sympatric with jackal; and 1.19 in case of foxes from jackal-free areas. The number of juvenile jackals per one adult specimen was considerably lower than that of foxes living sympatric with jackals ($N = 275$; $\chi^2 = 27.102$; $df = 1$; $p < 0.0001$). However, between the foxes from areas with jackals and those of jackal-free areas, the number of juveniles per one adult individual did not differ significantly ($N = 251$; $\chi^2 = 3.165$; $df = 1$; $p = 0.0752$).

The average body weight of juvenile foxes living sympatric with jackals was considerably smaller for both sexes ($p = < 0.001$; < 0.001) than those of their conspecifics living in the jackal-free areas. In adult foxes, co-existence with

a jackal had no detectable effect on the average body weight neither on males ($P = 0.081$) nor of females ($p = 0.144$).

Frequency of empty stomachs (CV%) was 13.68% in the case of golden jackals, 18.59% for foxes living sympatric with jackals, and 12.66% for foxes from jackal-free areas. These values were not substantially different in comparisons ($p = 0.248$-0.837). In the incidence of empty stomachs, there were no detectable differences between jackal and foxes, nor between the foxes from different areas ($p = 0.101$-0.635).

There was a notable difference between the diet composition of sympatric golden jackals and red foxes, and between the jackals and foxes from jackal-free areas ($\chi^2 = 70.24$; $df = 16$; $p < 0.000001$ and $\chi^2 = 50.74$; $df = 17$; $p = 0.000017$), but the diet of foxes from different areas did not differ significantly ($\chi^2 = 20.56$; $df = 16$; $p = 0.1961$). The golden jackal consumed a substantially higher degree of vegetable-derived food and wild boars; the red fox consumed more voles and pheasants.

The diets of foxes from areas with jackals and those of from jackal-free areas, were similar in the annual, seasonal, age group, and sex-based comparisons.

The nutritional niche breadths of golden jackals and red foxes from different areas were similar throughout the study period, both in the years and the seasons.

Depending on the calculation method, nutritional niche overlap between golden jackal and the sympatric red fox was $P_{jk} = 65.49\%$ and $\alpha_{ij} = 76.39\%$. The nutritional niche overlap values between the foxes which live sympatric with the jackal and those of from jackal-free areas were $P_{jk} = 85.69\%$ and $\alpha_{ij} = 95.74\%$. Nutritional niche overlap values were not significantly different during the years and seasons.

Based on the aggregate data of the entire study period, the diet of the golden jackal was more varied than that of the sympatric red fox ($t = 2.403$; $df = 409.42$; $p = 0.0167$), but the diversity of the diets of foxes from different areas was similar ($t = 1.207$; $df = 214.15$; $p = 0.2287$).

4. Theses

T1: Based on the hunting bag data of medium-sized carnivores, the areas which were constantly inhabited by the golden jackal and those on which there was no permanent jackal presence were sharply distinguished. At the same time, red fox stock density estimated from the hunting bag data were significantly higher in those areas where the presence of the golden jackal was constant. The areas more densely populated by both the golden jackal and red fox were characterized by considerably higher values of habitat richness (Lucherini & Lovari 1996) and specific structural diversity values expressed by the Shannon-Wiener diversity index compared to the jackal-free areas. Therefore, it was concluded that both medium-sized predatory species were linked to areas richer in resources and that the presence of the golden jackal under certain stock densities did not negatively affect sympatric red fox population densities.

T2: In the case of foxes from the areas where they live sympatric with jackal and foxes from jackal-free areas, the number of juveniles per one adult specimen was not significantly different. Irrespectively, the hunting bag data reflects the real population structure or the differing sensitivity to predatory control pressure of certain age groups; as such, it could be concluded that the coexistence with the jackal did not affect the age structure of the sympatric red fox. In addition, the 0.16 juvenile specimen extracted per one adult suggests golden jackals exhibit more effective parental care than red foxes do.

T3: In the case of cohabitation with the golden jackal, the average body weights of juvenile red foxes were smaller than those of foxes from jackal-free areas regardless of sex. At the same time, the average body weight of adult foxes did not depend on the presence of the golden jackal.

T4: The study areas were poor in anthropogenic food sources available in the form of viscera and carrion resulting from big game hunts or household garbage. In these circumstances, based on the incidence of empty stomachs, winter and spring were the most critical periods for the effective tracing of food sources for the golden jackal. The critical period was passed by the high consumption of plant origin food sources and wild boar.

The incidence of empty stomachs of foxes from areas with jackals and those of foxes from jackal-free areas did not differ significantly in any season.

In the prevalence of empty stomachs, there was no significant difference either between the jackal and sympatric foxes or between the foxes from different areas.

T5: Although the golden jackal's larger body size and higher social skills fulfilled every precondition for lethal interactions with the red fox, such events were not detected. Nor was evidence of intraguild predation found.

T6: The diet of the golden jackal and sympatric red fox differed significantly based on the aggregate data as well as certain sample collection years. This suggests a nutritional niche segregation, which previously has been detected only in areas rich in anthropogenic food sources. Seasonal analyses of the consumption of certain food items have also shown the function of nutritional niche segregation. The diets of the golden jackal and the sympatric red fox were similar in short time intervals, but considerably different at a yearly or multiannual scale. The different levels of consumption of the certain food items were inconsistent; hence, a dynamic nutritional niche segregation was experienced, facilitating the coexistence of the two medium-sized predatory species.

T7: There was no discrepancy between the diet of foxes from areas where they live sympatric with jackal and those of foxes from jackal-free areas based on either aggregated data or on annual, seasonal, age, or sex scales.

5. Publications

Publications in periodicals

1. JÁNOSKA FERENC, **FARKAS ATTILA**, MAROSÁN MIKLÓS, FODOR JÓZSEF-TAMÁS (2018): Wild boar (*Sus scrofa*) home range and habitat use in two Romanian habitats. ACTA SILVATICA ET LIGNARIA HUNGARICA 14(1): 51 – 63. doi: 10.2478/aslh-2018-0003.
2. **FARKAS ATTILA**, JÁNOSKA FERENC, FODOR JÓZSEF-TAMÁS, NÁHLIK ANDRÁS (2017): The high level of nutritional niche overlap between red fox (*Vulpes vulpes*) and sympatric golden jackal (*Canis aureus*) affects the body weight of juvenile foxes. European Journal of Wildlife Research 63: 46. doi: 10.1007/s10344-017-1101-x.
3. **FARKAS ATTILA**, BIDLÓ ANDRÁS, BOLODÁR-VARGA BERNADETT, JÁNOSKA FERENC (2017): Accumulation of metals in liver tissues of sympatric golden jackal (*Canis aureus*) and red fox (*Vulpes vulpes*) in the southern part of Romania. Bulletin of Environmental Contamination and Toxicology 98(4): 513 - 520 doi: 10.1007/s00128-017-2035-4.
4. JÁNOSKA FERENC, KEMENSZKY PÉTER, **FARKAS ATTILA**, VARJÚ JÓZSEF, HORVÁTH ZSOLT (2016): Műfészek-predációs vizsgálatok egy erősen mozaikos somogyi élőhelyen. Erdészettudományi Közlemények 6 (2): 161 – 173. doi: 10.17164/EK.2016.013.
5. VARGA ZOLTÁN, **FARKAS ATTILA** (2016): A borz (*Meles meles* L.) táplálkozásának vizsgálata Komárom-Esztergom megye területén. Erdészettudományi Közlemények, 6(2): 189-197. doi: 10.17164/EK.2016.015.

Conference proceedings in Hungarian

1. **FARKAS ATTILA**, FODOR JÓZSEF-TAMÁS, JÁNOSKA FERENC (2015): Az aranysakál (Canis aureus) és vörös róka (Vulpes vulpes) közötti táplálkozási kompetíció vizsgálata Romániában. In: Bidló A., Facskó F. (szerk.): Nyugat-magyarországi Egyetem Erdőmérnöki Kar V. Kari Tudományos Konferencia Absztraktkötet. Nyugat-magyarországi Egyetem Kiadó Sopron. 167-173.

2. FODOR JÓZSEF-TAMÁS, JÁNOSKA FERENC, **FARKAS ATTILA** (2013) – Vaddisznó mozgáskörzetének összehasonlító vizsgálata

különböző romániai élőhelyeken (Részeredmények), Nyugat-magyarországi Egyetem, Erdőmérnöki Kar, Kari Tudományos Konferencia, Dr. Kőhalmy Tamás zoológiai és vadgazdálkodási szekció. Előadás 245-249.

3. **FARKAS ATTILA**, FODOR JÓZSEF-TAMÁS, JÁNOSKA FERENC (2013) – Az aranysakál és a róka táplálkozásának összehasonlító vizsgálata Romániában, Nyugat-magyarországi Egyetem, Erdőmérnöki Kar, Kari Tudományos Konferencia, Dr. Kőhalmy Tamás zoológiai és vadgazdálkodási szekció. Előadás 224-228.

Conference proceedings in a foreign language

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2. BANEA OVIDIU, ACOSTA ILYA, **FARKAS ATTILA**, NEMOLA FRANCESCA, COMAZZI CARLO (2018): Invasibility study on jackal suitable habitats from the Danube Delta using bioacoustic monitoring and camera trapping methods. In: Giannatos G., Banea O.C., Hatlauf J., Sillero-Zubiri C., Georgiadis C. and A. Legakis (Eds.) (2018) Proceedings of the 2nd International Jackal Symposium, Marathon Bay, Attica Greece 2018. Ell. Zool. Arch./Hell. Zool. Arch., Number 9, November 2018, ISSN: 1106-2134, pp. 46–48.

3. BANEA C. OVIDIU, **FARKAS ATTILA**, STOYANOV STOYAN, ĆIROVIĆ DUŠKO, JÁNOSKA FERENC, SELANEC IVANA, HAUTLAUF JENNIFER, HACKLÄNDER KLAUS (2018): Red fox and golden jackal hunting bag differences in countries from Central and Southeastern Europe. Population trend and management aspects. In: Giannatos G., Banea O.C., Hatlauf J., Sillero-Zubiri C., Georgiadis C. and A. Legakis (Eds.) (2018) Proceedings of the 2nd International Jackal Symposium, Marathon Bay, Attica Greece 2018. Ell. Zool. Arch./Hell. Zool. Arch., Number 9, November 2018, ISSN: 1106-2134, pp. 121–122.

4. FARKAS ATTILA, JÁNOSKA FERENC, NÁHLIK ANDRÁS (2017): Current distribution of golden jackal (Canis aureus L.) in Romania and its

effects on competitors and prey species. In: Proceedings of the 4th Edition of the Integrated Management of Environmental Resources Conference, Suceava, November 3-4. 2017, pp. 22-29.

5. FODOR, JÓZSEF-TAMÁS, JÁNOSKA FERENC, **FARKAS ATTILA** (2014): The Comparative Analysis of the Habitat Use of Wild Boar in Different Romanian Habitats. Proceedings of the Biennial International Symposium „FOREST AND SUSTAINABLE DEVELOPMENT" Braşov, 24-25th of October 2014. 365–370.

Presentations in Hungarian

1. **FARKAS ATTILA** (2019): Mezőgazdasági vadkár megelőzési és objektív rendezési lehetőségei Romániában - Ökológiai, gazdasági és jogi aspektusok In: Arad Megyei Magyar Gazdák Egyesülete és CEED Közép – európai Gazdaságfejlesztési Hálózat Nonprofit Kft. Mezőgazdasági Vadkár, Szakmai konferencia, Arad, 2019. február 28. előadás.

2. **FARKAS ATTILA** (2018): A Kárpáti barnamedve (*Ursus arctos*) ökológiája és etológiája - Avagy miért is nem játék a medve? In: Tarisznyás Márton Múzeum, Esztenafesztivál, Gyergyószentmiklós 2018. június 16.

3. **FARKAS ATTILA** (2018): Paradigmaváltás szükségessége és lehetőségei a vadászat ügyének képviseletében (frissített verzió). In: LAM Alapítvány és Vadon Egyesület. Az erdő- és vadgazdálkodás ökológiai és gazdasági hatásai a Kárpát-kanyarban, Szakmai konferencia, Sepsiszentgyörgy – Benedekmező, 2018. május 25. előadás.

4. **FARKAS ATTILA** (2018): A Romániai védett ragadozók radikalizálódó szemléletek és érdekek kereszttüzében. In: Nemzeti Élelmiszerlánc-biztonsági Hivatal, A hazai vadegészségügy és vadgazdálkodás aktuális kérdései, Budapest, 2018 március 20. előadás.

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7. **FARKAS ATTILA** (2016): Paradigmaváltás szükségessége és lehetőségei a vadászat ügyének képviseletében. VI. Székelyföldi Vadásznapok. Erdőszentgyörgy: 2016. október 21. előadás.

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2. **FARKAS ATTILA,** FODOR JÓZSEF-TAMÁS (2014): Cursele de reținere prin cablu – Posibile unelte noi în managementul cinegetic autohton. [Visszatartó kábeles csapdák – lehetséges új eszközök a hazai vadgazdálkodásban]. Romániai Sport- vadászok és halászok országos kongresszusa, Bákó, 2014. május 10. Előadás.