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ECOLOGICAL NICHE RELATIONSHIPS IN GOLDEN JACKAL'S CORE AREA OF DISTRIBUTION IN EARLY STAGES OF CUB REARING SEASON

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Abstract: *Despite of their indigenous status in Romania, the golden jackal (Canis aureus L.) act as a new species in many recently re-colonized habitats. In such areas, we have limited knowledge about the distribution of animal species within community assemblages. We identified a study site with resident breeding golden jackal populations, confirmed their constant presence with acoustic method and direct observations, then deployed there 20 remote cameras in 24 locations during 206 trap nights. The camera survey period was May – June 2018, known as the early stage of cub rearing season for most of indigenous wildlife species. We recorded 625 photos and video captures of 7 mammalian and 1 bird wildlife species across 18 camera stations in 174 trap days. On 6 camera stations were not detected any animal species, or the cameras disappeared, thus we excluded those from the analyses. Wild boar was recorded at 14 camera stations (74.78%), Golden jackal at 13 (72.22%), Roe deer at 9 (50.00%), the Red fox, Brown hare, and Pheasant were captured in 4 locations (22.22%), while Eurasian badger in 3 (16.67%), and Wild cat in one single location (5.55%).We did not find any significant differences between recorded species nor in number of days to first detection, neither in percent of days with photo or video captures per location. Regression analyses revealed statistically significant positive correlation based on presence or absence at camera stations between Red fox and Pheasant ($r=0.38$; $p<0.001$), Eurasian badger and Pheasant ($r=0.47$; $p<0.001$) as well as between Red fox and Badger ($r=0.38$; $p<0.001$). Ecological niche overlap calculations show relatively small values between the golden jackal and the other carnivore species (11.06%; 16.06%), while these values between the jackal and their potential prey species were slightly higher (17.66% - 34.89%). Conservation and management implications of our results are discussed.*

Key words: *Golden jackal, niche relationships, community assemblages, camera trapping, Romania.*

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1. Introduction

Within the current Romanian distribution area of the golden jackal (*Canis aureus* L.), there are habitats which can be considered as re-colonized, with stable resident breeding populations [9-10]. The scientifically based knowledge about the possible effects of the jackals on the indigenous animal communities is scarce. Studies typically focus on status, distribution, and expansion patterns [1, 18, 24], legal implications of range expansion [30], population densities [26] and feeding habits in different type of habitats [2, 5, 7, 16, 21, 23].

Regarding the species interactions there are available data of comparative studies between the red fox (*Vulpes vulpes* Frisch.) and golden jackal based on their diet [8, 12, 14-15, 17, 31]; the impact of the high level of nutritional niche-overlap on the body size of juvenile foxes [9] and fear behaviour of foxes against jackals [27]. Relationships between the golden jackal and the other sympatric species are less studied.

In Romania basic data about the animal species living in a certain habitat could be found from stock assessment results performed by the hunting organizations. These data are relevant on game management unit level whose minimum legal surface is 50 km^2, but the average size of Romanian hunting grounds is 102.44 km^2 [10]. About the habitat use patterns of the wild fauna inside game management units – without physical borders – there are no conclusive information. Moreover, effects of the relatively new appearance of the golden jackal on the animal community assemblages previously were not studied.

Complex vocalization repertoire – known as spontaneous howling – exhibited by golden jackals [11] makes possible the identification of habitat parts with constant jackal presence, at least in some periods of the nights starting with the sunset. Such study sites with confirmed golden jackal presence could be surveyed using remote cameras. Camera traps are considered reliable, minimally invasive, cost efficient and less time-consuming tools in surveying wildlife [3-4]. Former study results have proven that the camera traps can be efficiently used in surveying wild ungulates [25], birds [20], and carnivores [22]. Even the smallest body sized mustelids can be captured by camera traps but, the capture rate of these species varies from 0.4 to 4.5 captures per 100 days [19].

The purpose of this study was to inventory a terrestrial animal community where the golden jackal is the apex predator species and conduct an analysis of possible ecological niche relationships based on camera survey data.

2. Material and Methods

Using camera traps, we surveyed the whole animal community assemblages and the strength of their interactions, studied the latency to first detection for every species recorded and performed ecological niche overlap calculations.

2.1. Study Site

The study area was in the Golden jackal's core area of distribution in Romania, Teleorman county, game management unit (GMU) number 4 - Turnu Măgurele (Figure 1).

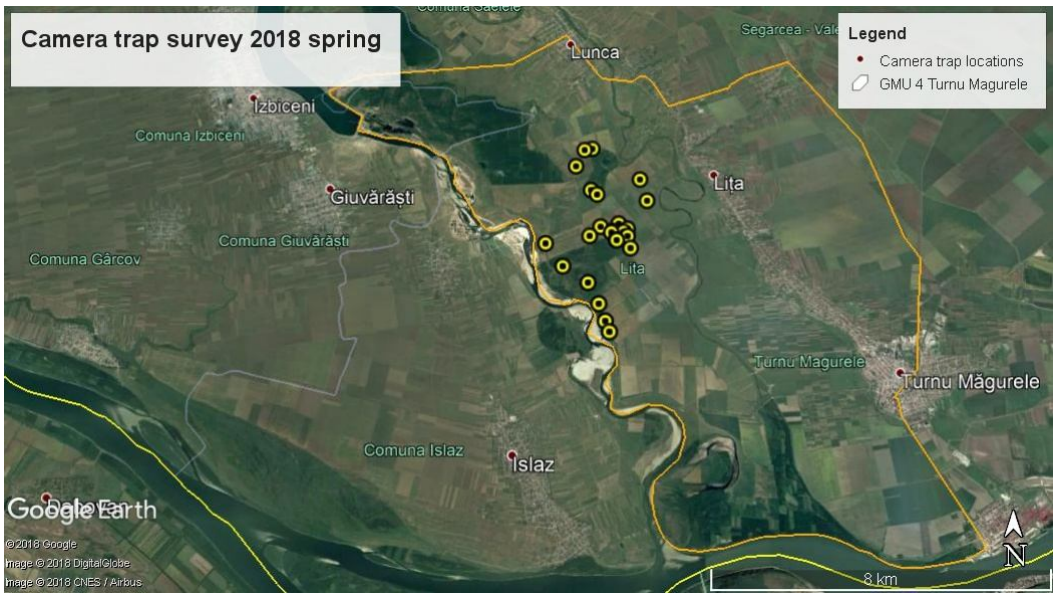

Fig. 1. Locations of camera traps across the GMU 4 Turnu Măgurele

This GMU was specially selected because previous study results conducted by us in the same area revealed that there are living the highest densities of golden jackal and red fox populations as well [9]. GMU no. 4 is a flatland (1-100 m a.s.l.) habitat with a total surface of 11,857 hectares, the Southern border being the Danube, and the country border, while the Western border follows the Olt river. Forests cover 1,718 ha (14.49%); agricultural arable lands occupy 8,115 ha (68.44%); pastures 1,850 ha (15.60%); water courses 105 ha (0.89%) and 69 ha (0.58%) of the GMU area are unproductive lands (localities, roads etc.). The mean multiannual temperature is 11.5°C and the average annual precipitation is 518 mm. The forests also have productive and protective functions and they are dominated by oak species (*Quercus* ssp.), ash species (*Fraxinus* ssp.) and white poplar (*Populus alba* Linn.). According to annual stock assessments performed by the game management organizations there are present in the GMU no. 4 the following wildlife species in decreasing order of density / 1000 ha: Pheasant – *Phasianus colchicus* (59.05), Brown hare – *Lepus europaeus* (57.68), Grey partridge – *Perdix perdix* (23.07), Roe deer – *Capreolus capreolus* (8.95), Wild boar – *Sus scrofa* (8.24), Golden jackal – *Canis aureus* (2.83), Red fox – *Vulpes vulpes* (1.68), Eurasian badger – *Meles meles* (1.15), Least weasel – *Mustela nivalis* (1.04), European polecat – *Mustela putorius* (0.88) and European pine marten – *Martes martes* (0.44). Golden jackal and red fox are the apex predator species of the area. About the protected animal species there are no available data.

2.2. Camera Trap Design

We deployed 20 remote cameras (10 Minox DTC 550 - IR, 2-12 MP, Minox GmbH, Germany; 4 PNI Hunting 2C - IR, 2-

8 MP, S.C. Onlineshop S.R.L., Piatra Neamt, Romania; 2 Moultrie M990i - IR, 0.5-10 MP, Pradco Outdoor Brands, Birmingham, AL, USA; 2 Uway NT 50B - IR, 0.3-8MP, Uway Outdoor Products, Lethbridge, AB, Canada; 1 Suntek HC-300M - IR, 5-12 MP, Shenzhen IME Technology Co., Ltd., Guangdong, China; 1 Ltl Acorn 5210MG - IR, 5-12 MP, Shenzhen Ltl Acorn Electronics Co. Ltd., Guangdong, China.) on 24 camera stations. One single remote camera was deployed at each station, in those parts of the habitat where constant presence of jackals was recorded based on spontaneous vocalizations. Positioning was random, but we also considered the avoidance of possible human presence especially the roads. Cameras were attached to trees or wooden posts with their standard mounting straps, approximately 0.4 – 1.0 m above the ground and were set facing the surveyed habitat type. We set cameras to medium sensitivity, fastest trigger rate, 8 MP resolution and to take one picture plus one 15 – 30 seconds long video at every detected motion. There were not activated any delay settings. According to the study objectives we did not used scent lure, food, or any other type of attractants for carnivores.

2.3. Ecological Niche-Overlap Calculations

The ecological niche overlap was calculated between golden jackal and the other recorded animal species (Figure 2, except wild cat, because of the single record) by the Renkonen index [13]: $P_{jk}=[\Sigma n(\text{minimum } p_{ij}, p_{ik})]100$, where P_{jk} is the percentage overlap between species j and species k; p_{ij} and p_{ik} are the proportion of photo + video captures at camera station i which is represented within the total photo + video captures with species j and species k (the minimum means that the smaller value should be used); n is the total number of the camera trap locations.

2.4. Statistical Analyses

The basic statistical parameters (range, mean, and the standard error of mean values) were calculated for number of camera nights deployed and latency to first detection of all species captured. For the comparison of the average number of nights to first detection within the studied animal community assemblage, we used independent t-test by samples. Numbers of nights to first detection of every species were treated as independent samples. The homogeneity of variance among the species was tested using Levene's test.

Pearson correlation between presence and absence of species at camera stations was calculated, the variables being the number of trap night per species captured. Comparisons were made on species pairs.

All variables were checked for normality. Statistical significance for all tests was inferred at $\alpha = 0.05$. Statistical analyses were carried out using STATISTICA version 13 [6] and Microsoft Excel.

3. Results

In the period of 08 of May and 14 of June 2018 we deployed 20 remote cameras in 24 stations located in the golden jackal's core area of distribution in Romania, during 206 trap nights. Our aim was to assess the animal assemblages in a habitat with constant presence of golden jackals and to study the ecological niche relationships in such communities.

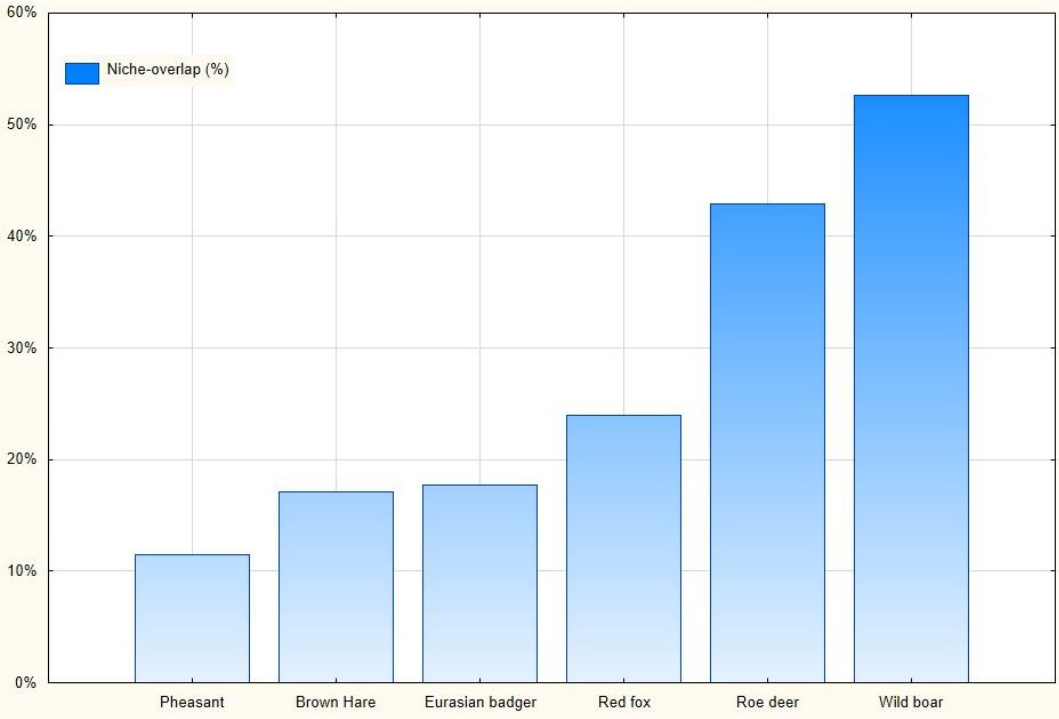

Fig. 2. Ecological niche-overlap between the Golden Jackal and other detected species

At 6 camera stations deployed during 32 camera trap nights we're not detected any animal species, or the cameras disappeared, thus we excluded those from the analyses. We recorded 625 photos and video captures of 7 mammalian and 1 bird wildlife species across 18 camera stations in 174 camera trap nights (Table 1). From the list of 11 species assessed by the hunting organization 7 were detected, plus the protected wild cat (*Felis silvestris*). The undetected species were the Grey partridge and the mustelid species with the smallest body size and lowest density.

3.1. Capture Rate and Latency to First Detection

The species with the highest frequency of occurrence was the wild boar captured at 74.78% of the camera stations followed by the golden jackal with a capture rate of 72.22%.

The mean number of nights to first detection for all species ranged between 2.50 and 5.67 (Table 1) without statistically significant differences between latency to first detection of the golden jackal and the other captured species within the studied animal community assemblage (Table 2).

Table 1

Number of cameras that detected wildlife species, range, mean and standard error of mean for total nights deployed and nights to the first detection per species captured

Species	No. camera stations with detection (%)	No. nights deployed			No. nights to first detection		
		Range	Mean	SE	Range	Mean	SE
Golden jackal	13 (72.22%)	7-13	10.15	0.63	1-8	4.15	0.54
Roe deer	9 (50.00%)	8-13	10.33	0.65	1-11	4.22	1.02
Pheasant	4 (22.22%)	9-13	10.75	0.85	2-10	5.50	1.85
Brown hare	4 (22.22%)	11-13	11.75	0.48	2-8	4.50	1.26
Red fox	4 (22.22%)	11-13	12.25	0.48	1-4	2.50	0.65
Wild boar	14 (74.78%)	5-13	9.64	0.68	1-11	4.93	0.77
Eurasian badger	3 (16.67%)	8-13	11.00	1.53	3-10	5.67	2.19
Wild cat	1 (5.55%)	13	N/A	N/A	3	3	N/A

3.2. Species Interactions in Animal Community Assemblage

Presence and absence of species at camera stations was tested by correlation analysis. Statistically significant differences were found only between Red fox and Pheasant ($r=0.38$; $p<0.001$), Eurasian badger and Pheasant ($r=0.47$; $p<0.001$) as well as between Red fox and Badger ($r=0.38$; $p<0.001$). Detailed results of correlation analysis are presented in Table 3.

Table 2

Comparisons between average number of nights to first detection of golden jackal and the other captured species within the studied animal community assemblage (T-test for independent samples)

Species groups (Gr_1 vs. Gr_2)	Mean Gr_1	Mean Gr_2	t-value	df	p
Golden jackal vs. Roe deer	4.153846	4.222222	-0.06404	20	0.949573
Golden jackal vs. Pheasant	4.153846	5.5	-0.97933	15	0.342951
Golden jackal vs. Brown hare	4.153846	4.5	-0.29152	15	0.774648
Golden jackal vs. Red fox	4.153846	2.5	1.57343	15	0.136472
Golden jackal vs. Wild Boar	4.153846	4.928571	-0.80879	25	0.426265
Golden jackal vs. Badger	4.153846	5.666667	-1.02484	14	0.322821

3.3. Ecological Niche-Overlap

Comparison of ecological niche-overlap between golden jackal and the other animal species in the studied community assemblage increased as follows: Golden jackal vs. Red fox (11.06%) <Golden jackal vs. Eurasian badger (16.06%) < Golden jackal vs. Brown hare (17.66%) < Golden jackal vs. Pheasant (18.18%) < Golden jackal vs. Roe deer (32.46%) < Golden jackal vs. Wild boar (34.89%).

4. Discussion

Our study results offer insights in the componence and niche relationships of animal community assemblages in habitats where the golden jackal is considered an indigenous predator, but after a few centuries of absence in many European countries (e.g. Hungary) as well as in Romania – in terms of intensive spreading – shows the characteristics of invasive species [10, 29].

Table 3

Coefficients of correlation and p-values of significance between presence and absence of species at camera stations. Bold marked correlations are significant at p < .05000

Species	Golden jackal	Roe deer	Pheasant	Brown hare	Red fox	Wild Boar	Badger
Golden jackal	1.0000	-.0128	-.0371	-.0089	-.0985	.1095	-.0987
	p= ---	p=.856	p=.597	p=.899	p=.159	p=.117	p=.158
Roe deer	-.0128	1.0000	-.0610	-.0506	-.0234	.0830	.0288
	p=.856	p= ---	p=.384	p=.470	p=.738	p=.236	p=.682
Pheasant	-.0371	-.0610	1.0000	-.0424	**.3837**	-.1228	**.4745**
	p=.597	p=.384	p= ---	p=.545	**p=.000**	p=.079	**p=.000**
Brown hare	-.0089	-.0506	-.0424	1.0000	.1195	-.1020	-.0424
	p=.899	p=.470	p=.545	p= ---	p=.087	p=.145	p=.545
Red fox	-.0985	-.0234	**.3837**	.1195	1.0000	-.1001	**.3837**
	p=.159	p=.738	**p=.000**	p=.087	p= ---	p=.152	**p=.000**
Wild Boar	.1095	.0830	-.1228	-.1020	-.1001	1.0000	-.0690
	p=.117	p=.236	p=.079	p=.145	p=.152	p= ---	p=.325
Badger	-.0987	.0288	**.4745**	-.0424	**.3837**	-.0690	1.0000
	p=.158	p=.682	**p=.000**	p=.545	**p=.000**	p=.325	p= ---

Camera trap captures revealed that the studied habitats are rich in game species and there is present also the protected wild cat. This result shows that in the studied habitats, camera trapping could be an appropriate method also for biodiversity estimates [32]; species abundance studies [19, 25, 28]; or spatial distribution analyses across habitats [22]. However, the grey partridge and the mustelids with smallest body sizes and lowest densities could not be detected in the studied habitats. Unequivocal explanation for the lack of detection was not found. Suspected causes could lay in lower real population densities of the grey partridge than the official stock assessment data, and the generally lower capture rates of small mustelids [19]. In the studied animal communities there are two dominant species (i.e. the wild boar and the golden jackal) with capture rates above 70%, the second most recorded species is the roe deer, and the frequency of occurrence of the rest of inventoried species is slightly similar (16 - 22%). The high frequency of capture rates of the jackal and the wild boar could be explained with the fact that, based on feeding habits studies performed in the same habitat, the wild boar is the most important prey species of the golden jackal in the spring period [7]. The top predator species of the animal community

are the jackal and the fox. The mean number of days to first detection at a camera station was 4.44 ±2.64 without any significant differences between the species. Furthermore, despite of variable numbers of camera stations with detection of certain species, the differences between percent of days with photo or video captures per day were not statistically significant either. Lack of significant differences suggests an even spatial distribution of species in studied community assemblages.

Minimum number of days to capture a certain species at all the camera stations with detections varied as follows: red fox 4 (n=4), golden jackal 8 (n=13), brown hare 8 (n=4), badger 10 (n=3), roe deer 11 (n=9), wild boar 11 (n=14) and pheasant 11 (n=4). In other words, after 4 to 11 nights – depending on the species – the number of camera stations with detection does not increased. Despite of apparent even spatial distribution of captured species, the variations in number of camera stations with detections suggest at least two group of species with different habitat use. The first group could consist from: golden jackal, wild boar and roe deer detected on at least 50% of deployed camera stations; while in the second list of species we could include the rest of the captured species with a percent of positive camera stations below 23%.

Regression analyses revealed statistically significant positive correlation based on presence or absence at camera stations between Red fox and Pheasant ($r=0.38$; $p<0.001$), Eurasian badger and Pheasant ($r=0.47$; $p<0.001$) as well as between Red fox and Badger ($r=0.38$; $p<0.001$). Ecological niche overlap calculations show relatively small values between the golden jackal and the other carnivore species (11.06%; 16.06%), while these values between the jackal and their potential prey species were slightly higher (17.66% - 34.89%).

Ecological niche overlap calculations between the golden jackal and the other detected species, also suggests the clustering suspected based on variation of number of camera stations with detection of a certain species. There are signs of spatial niche segregation between the golden jackal and the other sympatric carnivore species, which aspect needs further investigations.

5. Conclusions

Remote cameras are suitable tools to inventorying animal communities in certain habitats. Our results suggest some clustering of species in the studied animal community assemblage, but statistically significant differences were not found in the tested variables. Despite of lack of statistically significant differences the research activity must to be continued to reveal the structure and manifestation of the ecological niche relationships.

5.1. Conservation Implications

Remote cameras represent a new monitoring tool of the golden jackal populations. As species is listed on Annex Five of Council Directive 92/43/EEC (known as Habitats Directive), taking in the wild and exploitation may be subject to management measures. A correct approach from all aspects must to be based on reliable monitoring data. Remote cameras, together with other methods could increase the accuracy and confidence of a further golden jackal monitoring system.

5.2. Management Implications

The positioning of camera trap stations is a highly important issue because of the experienced 12.5% loss of cameras in approximately 2 weeks (13 days) study period (3 out of the total 20 cameras disappeared). Additional lack of records was found on 3 camera stations, by which the percent of ineffectual locations reached 25%. In the studied habitats, the losses or inefficiency makes necessary to be deployed a minimum number of 4 cameras to wildlife surveillance independently of the aims and scope.

The mean number of days to first detection at a camera station of 4.44 ±2.64 without significant differences between the species means that in a survey period of 7 days the first detection of resident species could be confirmed. However, the minimum number of days to capture a certain species at all the camera stations depends on the targeted species and varied between 4 and 11. That's mean that in maximum 11 days a certain species should be detected with camera traps if it is present in the covered area. In the studied habitats a minimum number of 4 remote cameras, deployed for a period of 7 – 11 days should show a conclusive image of species living in surveyed animal communities.

Conflicts of Interest

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