

OVERVIEW OF ECOSYSTEM SERVICES PROVIDED BY LESSER KESTREL IN ITS MAIN-BREEDING HABITAT IN BULGARIA

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Abstract

The Lesser Kestrel (Falco naumanni, Fleischer, 1818) strongly attached to agro-environmental landscapes, showing high preferences towards extensively managed wheat crops and extensively grazed or otherwise maintained pastures. The colonies of that species are often nesting in urban areas usually surrounded by agricultural fields or open uncultivated grasslands, securing food resources. This defines the species as a typical representative of farmland birds, whose main foraging and breeding habitats in Bulgaria fall into two main types of ecosystems - agroecosystems and grassland ecosystems, and its breeding habitats cover urban ecosystems. The aim of the present study is to assess the potential ecosystem services provide by Lesser Kestrel after recovering the species as a breeder in Bulgaria by Green Balkans NGO. MAES Ecosystem classification and data from the largest colony of the species in the country, located within SPA Sakar, part of the ecological network NATURA 2000 used. As a result, two major ecosystem services provided by the species: the provision of regulating ecosystem services by suppressing arthropods, reptiles and rodents populations and cultural ecosystem services through opportunities of ecotourism, environmental education, birdwatching were identify. Because of the critically endangered status of the Lesser Kestrel in Bulgaria, the species further contributes to the protection of habitats and thus, to the ecosystem services they provide.

Key words: agroecosystems, *Falco naumanni*, farmland birds, grassland, NATURA 2000.

INTRODUCTION

The Lesser Kestrel (*Falco naumanni*, Fleischer, 1818) is strongly associates with agro-environmental landscapes, showing high preferences towards extensively managed wheat crops and extensively grazed or otherwise maintained pastures (Barov, 2002; Donazar et al., 1993; Franco et al., 2004; Garcia et al., 2006; Kmetova et al., 2012; Parr et al., 1997). The colonies of the species are often located in urban areas, perhaps since at least 2000-2500 years ago (Negro et al., 2000), as they provide nesting sites and reduced nest predation and are usually surrounded by agricultural fields or open uncultivated grasslands, securing food resources (Bustamante, 1997; Hiraldo et al., 1996). This defines the species as a typical representative of the farmland birds, whose main foraging habitats are grasslands, semi-natural grasslands, and cultivated non-irrigated croplands (Morganti et al., 2021; Christakis & Sfougaris,

2021; Assandri et al., 2022). These species are considered as a threatened farmland bird (de Frutos et al., 2010; Tella et al., 2020). As a strategy for the conservation of the Lesser Kestrel, the preservation of traditional cereal cultures with a number of field margins, and low treatment on the fields with biocides has been emphasized (Tella et al., 1998).

While, farmland landscapes provide key ecosystem services, the intensification of agroecological practices in the last century the capacity of these sources has significantly decreased these areas (Tscharntke et al., 2005; Emmerson et al., 2016). The last confirmed records of the Lesser Kestrel breeding in Bulgaria date back to the late 20th century (Iñigo & Barov, 2010). The primary aims of this study were to make an overview of ecosystem services provided by Lesser Kestrel after the reintroduction as a breeding species in Bulgaria by Green Balkans NGO (Gradev et al., 2016a) in its main-breeding habitat in Bulgaria.

MATERIALS AND METHODS

The study was carried out in the area of Levka village, Sakar SPA (BG0002021), part of the ecological network NATURA 2000 (MOEW 2013), where the species has been recovered as breeder in Bulgaria by Green Balkans NGO (Gradev et al., 2016a). For this purpose, a Lesser Kestrel Release and Adaptation Module (LKRAM) has been established. The building where LKRAM is located also houses the Environmental Centre of Levka village which has a demonstration and information hall. In the Environmental Centre the hosts offer the following options for tourists and guests: observation of Lesser Kestrels and other rare birds from the region; presenting various decorative nest box models, models of Lesser Kestrels and their eggs; diorama with the hunting and nesting habitats of the Lesser Kestrels, as well as other species typical for the region like Eastern imperial eagle, European ground squirrel, etc.; thematic lectures about the biodiversity of SPA Sakar; video surveillance of the Lesser Kestrels' colony; videos and films about environmental protection; information materials and souvenirs; educational activities for kids and teenagers; work with volunteers and trainees (www.lesserkestrellife.greenbalkans.org). This is Bulgaria's largest colony of the species, with the birds nesting primarily in nest boxes specially designed and placed to support the individuals of the restored colony. In addition to this one, there are two more colonies in our country at the moment (Gradev et al., 2021). In biogeographical terms, the area falls into the Southern biogeographical region and, more specifically, according to the biotic basis, it refers to the "Dolnomarishko - Dolnotundzhansky" subregion (Gruev & Kuzmanov, 1999), as Mediterranean influence penetrates the sub-region along the Maritsa and Tundzha rivers' valleys. The Lesser Kestrel is included in the subject and conservation objectives of the Sakar SPA (State Gazette 2010), it is subject of conservation under Annex 2 and Annex 3 of the Biological Diversity Act. According to Red Data Book of Republic of Bulgaria, conservation status of the species in Bulgaria is Critically endangered (CR) (Barov et al., 2015). At the international level, under the

IUCN Red List of Threatened Species, Lesser Kestrel listed as Least Concern (LC) (BirdLife International, 2021) and protected species by the EU Birds Directive 2009/147/EC, listed in Annex 1.

In order to determine the habitats used by the falcons in the target area, combined data from radio-telemetry of Lesser Kestrel (Zhelev et al., 2016), satellite tracking of birds originating from the recovered colony in Levka (Gradev et al., 2016b), and direct visual observations of birds of prey in the area were used. The established home ranges from these surveys cover areas ranging in size from 29.70 to 46.80 km² which are significantly overlapping in the field.

In order to determine the type of ecosystems and the ecosystem services potentially provided by them, data from project "Improving Bulgarian Biodiversity Information system", Activity №2 "Module for collecting, mapping and analysis of the status of the ecosystems and their services" and "Guidelines for Monitoring the Status and Development of Ecosystems and Ecosystem Services" (Chipev et al., 2017) was used. Also, the approach to evaluate ecosystem services related to the Lesser Kestrel and their habitats based on the MAES Ecosystem type is used (Maes et al., 2018).

RESULTS AND DISCUSSIONS

Our data on the foraging behaviours support the classification of the Lesser Kestrel as a species associated with agroecosystems and grassland ecosystems (Chipev et al., 2017). Based on Mapping and Assessment of Ecosystems and their Services - MAES (Maes et al., 2018) the habitats of Lesser Kestrel fall into 4 basic ecosystem pilots - Agroecosystem pilot, Urban pilot, Soil pilot and Nature pilot, and out of 12 described Ecosystem types, the habitats of the species are covered by a total of 3 types (25%) - Cropland, Grassland and Urban.

We identified two main categories of ecosystem services provided by the Lesser Kestrel - Regulating ecosystem services (suppressing arthropods, reptiles and rodents) and cultural ecosystem services (ecotourism, environmental education, birdwatching, conservation of natural resources, etc.) (Figure 1). In general, there are four categories of Ecosystem services described

- provisioning, regulating, supporting, and cultural services which also are provided by birds (Michel et al., 2020).



Figure 1. Lesser Kestrel with captured prey *Tettigonia* sp.

Lesser Kestrel in its main habitat in Bulgaria provide 50% of categories described for birds. (Figure 2).



Figure 2. Grassland ecosystems in Sakar SPA Lesser Kestrel's foraging habitats

Regulating ecosystem services provided by the Lesser Kestrel

These birds feed mainly on large insects (Orthoptera, Coleoptera) (Kok et al. 2000), lizards and some small mammals (Parr et al., 1997). The species is described as primarily insectivorous, as in Europe its prey consists mainly of grasshoppers, beetles and Myriapoda (Rodriguez et al., 2010). In Thessaly, Greece previous work has found that 98.9% of prey are arthropods (insects and centipedes), while mammals comprise only 0.9% (Makri et al., 2018). In Albania the diet of the species consists of mainly invertebrates and more specifically orthopteran insects (Krištin et al., 2020). Data

from Turkey suggest food preferences is mainly invertebrates, especially Orthoptera and Coleoptera; however, Rodentia and Sauria fragments (lizards), are frequently encountered in pellets (Avci, 2018). For the colony in Levka village, Sakar SPA that we study, the species diet comprises Orthoptera, *Scolopendra* sp., Cicadidae, and Coleoptera: 94% of observed food items used by the Lesser Kestrel are insects, 4% are rodents Muridae and Arvicolinae, and 2% reptiles, mainly green lizard (*Lacerta viridis*) (Mihtieva, 2015). Similar data are obtained from the analysis of a total of 54 pellets collected during May 2022 (Figure 3).



Figure 3. Collected pellets from Lesser Kestrel

Their analysis led to the identification of 74 prey items.

During the breeding season Lesser Kestrels, were feeding mainly on Coleoptera (60.5%), Hymenoptera (17.65%) Orthoptera (5.88%), as well as Scolopendromorpha (3.36%) and Rodentia (8.4%) (probably voles). *Bradyporus dasypus* recorded by us on 29.06.2014 and reported by Mihtieva, 2015, is not so frequent prey items for the birds from the colony in Levka village. We have also observed several cases when Lesser Kestrels' prey included *Passer* sp. These were mainly pulls whose nests situated in close proximity to the nest boxes where Lesser Kestrels were breeding. In the same colony, we have not detected even a single case of European Mole Cricket (*Gryllotalpa gryllotalpa*) among prey items unlike other colonies in neighbouring countries – Greece and Türkiye – where that is one of the most common preys of the Lesser Kestrel. Our field studies have revealed that prey items vary according to the life cycle of the prey and its abundance during different period of the Lesser Kestrel's breeding season. On 02.07.2020 in one of the checked Lesser Kestrel nest boxes were found 11 Common Voles (*Microtus arvalis*) (Figure 4).

Only one pair raising two chicks captured the prey in the morning hours no later than noon. This high intensity of foraging and oversupply with food is most probably caused by higher density and accessibility of prey used during that period.

Potential reasons for that are typical agricultural activities like ploughing of fields, hay mowing or other agricultural activity that expose voles making them easier prey for the Lesser Kestrel, as they prefer foraging habitat with low vegetation (Cioccarelli et al., 2022). The capture of House Mouse (*Mus musculus*) by Lesser Kestrel, is also registered by us, but in much rarer cases.



Figure 4. *Microtus* sp. caught by a Lesser Kestrel just a half day

Relative calculations of mass and quantity of consumed prey show that the studied colony uses as food hundreds of kilograms of insects, small mammals and reptiles. Petrov et al. (2022) reports that the minimum amount of food for raising a single Lesser Kestrel in ex-situ conditions during the breeding season is approx. 80 g of cut rats or 40 g chicken hearts, or 2 pcs mice, 2 pcs day-old chicks, as total mass of mice and day-old chicks is approx. 60-80 g/day. Based on this data, we can estimate the minimum amount of biomass that is required for the survival of a Lesser Kestrel in the wild. Probably for the free-living birds, which expend much more energy, it is higher than 80 g/day, but still this value can be conditionally accepted for the purposes of the present study. Considering that in 2022 in Lesser Kestrel colony, in Levka village, Sakar SPA (BG0002021) about adult 50 birds were observed, of which 17 pairs successfully raised young with Fledging success (FS), which is 3.58, hypothetically the following values can be calculated:

Table 1. Amounts of biomass per 2022 required for the survival of a Lesser Kestrel in the wild

Biomass used from adult birds during 01.04. - 31.07				
Total number of days in colony	Total number of birds in colony (individuals)	Food per day for one bird (kg)	Fledging success (individuals)	Used biomass (kg)
122	50	0.08	n/a	488
Biomass used from juveniles 01.06 - 31.07				
Total number of days in colony	Total number of successful breeding pairs	Food per day for one bird (kg.)	Fledging success (individuals)	Used biomass (kg)
62	17	0.08	3.58	301.87
Total used biomass from colony for one breeding season				789.87

Considering the amount of total biomass (over 789 kg) potentially exploited by the colony, as well as the individual mass of some of the taxa most commonly used for food by the Lesser Kestrel, the number of exploited individuals that are agriculture pests (Table 2).

Of course, the number of individuals of the individual species could be in these values only if the given taxon would be the only prey for the birds of the colony during the entire breeding season. Given that Lesser Kestrel always use a variety of prey and catch the most common or the most abundant prey, the number of individuals is most likely a combination of the above-described species in different proportions.

The data from the both Tables (1, 2) indisputably confirm regulating ecosystem services which Lesser Kestrel provided agroecosystems and prove the positive effect that this species has in maintaining biological control in agriculture.

Table 2. The calculated number of used prey individuals of Lesser Kestrel in SPA Sakar

Prey taxon	Source	Average ind. mass (kg.)	number of used individuals (thousands)
<i>Microtus arvalis</i>	Popov & Sedefchev, 2003	0.04	19,747
<i>Mus musculus</i>	Popov & Sedefchev, 2003	0.02	39,493
<i>Chilopoda</i>	Rodriguez et al. 2010	0.0023	343,420
<i>Gryllotalpi dae</i>	Rodriguez et al., 2010	0.0035	225,676
<i>Gryllidae</i>	Rodriguez et al., 2010	0.00067	1,178,904

Cultural ecosystem services provided by the Lesser Kestrel

All activities provided in the demonstration and information hall of the Environmental Centre in the LKRAM building are directly related with this type of ecosystem services - ecotourism, environmental education, birdwatching, conservation etc. In the yard of the Centre

created the only photo hide providing opportunity for photographing Lesser Kestrels in the country. Approx. 300 people annually visit the Centre and learn about the Lesser Kestrel and its habitats. Given that the permanent number of people in the village of Levka is ~300, the centre provides an important boost to the local economy.

Every year over 50 children from three different schools in Levka and the municipal centre town of Svilengrad visit the Centre. In addition to participating in lectures about the kestrel and biodiversity at Sakar SPA, children are involved in various training, painting, quizzes and other educational activities. The centre is also a place for conducting practical trainings and developing Bachelor, Master and PhD theses, as well as scientific papers. Together with professors and students from the leading universities in Bulgaria in the field of ecology, biology, veterinary medicine, zoo engineering and other Earth Sciences, including Agricultural University - Plovdiv, Trakia University - Stara Zagora, University of Plovdiv - Paisii Hilendarski, Sofia University, University "Prof. Dr. Asen Zlatarov" - Burgas and others. The Green Balkans team works to improve the qualifications of young people.

Green Balkans' Environmental Centre in the LKRAM is in partnership networking with the Historical Museum in Svilengrad, BSPB's Nature Conservation Centre Eastern Rhodopes in Madjarovo, Green Balkans' Wildlife Rescue Centre in Stara Zagora, and many others from which both organized and individual tourists and groups interested in nature in the region. In the yard and Information Hall of the LKRAM, exhibitions, events and Plain-Air dedicated to the International European Green Belt Initiative (organized in partnership with European Green Belt Association and EuroNatur), European Natura Day 2000 organized by the European Commission are held every year.

In addition, some initiatives of other European programs held here - Erasmus, INTERREG-IPA CBC Bulgaria - Türkiye Programme, etc. as well as many other informational, educational and public events.

CONCLUSIONS

As a result, two categories of ecosystem services provided by the Lesser Kestrel: the provision of

regulating ecosystem services by suppressing arthropods, reptiles and rodents populations and cultural ecosystem services through opportunities of ecotourism, environmental education, birdwatching were identified. Because of the critically endangered status of the Lesser Kestrel in Bulgaria, the species further contributes to the protection of habitats and thus, to the ecosystem services they provide. Strong correlation between biodiversity and cultural ecosystem services was found. Considering that birds are helpers of man in the fight against harmful species, further efforts have been done for conserving Lesser Kestrel and birds in general. This will contribute to the preservation of biodiversity and sustainable development at the regional level. Cultural ecosystem services (ecotourism, birdwatching and education), will increase public interest in biodiversity conservation and this will lead to improved human well-being.

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