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Source: Journal of Vertebrate Biology, 71(21061)

Published By: Institute of Vertebrate Biology, Czech Academy of Sciences

URL: https://doi.org/10.25225/jvb.21061

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Journal of Vertebrate Biology

Open Access

J. Vertebr. Biol. 2022, 71: 21061 DOI: 10.25225/jvb.21061

SHORT NOTE

Food habits of the Eurasian lynx *Lynx lynx* in south-east Poland

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Received 16 August 2021; Accepted 23 October 2021; Published online 1 December 2021

Abstract. We studied diet and prey preferences of the Eurasian lynx (*Lynx lynx*) inhabiting south-east Poland, based on kills found during GPS-GSM telemetry and opportunistic winter tracking. Among 64 lynx kills were roe deer (*Capreolus capreolus*) (91%), red deer (*Cervus elaphus*) (3%) and brown hare (*Lepus europaeus*) (6%). From the ungulate community, lynx selected roe deer (D = 0.845) and avoided all other ungulates. We recorded one case of surplus and two cases of parallel killing. Lynx visited the same killed roe deer on average for 2.3 days, and for up to six days when surplus or parallel killing occurred. High numbers of the roe deer in south-east Poland supports the persistence of the lynx, but we urge managers to take under consideration food requirements of the lynx when planning game management.

Key words: predation, prey preferences, large carnivore conservation, game management

Introduction

Although historically present in the whole country (Bieniek et al. 1998), and strictly protected since 1995, at the start of the 21st century the Eurasian lynx *Lynx lynx* had the status of a near threatened species in Poland according to the IUCN Red List of Threatened Species criteria (Głowaciński 2002). Its status was mainly due to low population numbers and a range restricted to the Carpathians and large forest tracts in the eastern part of the country (Jędrzejewski et al. 2002b, Niedziałkowska et al. 2006). A low population status stimulated lynx reintroductions into the Kampinos National Park in central Poland (Böer et al. 1995) and reinforcement of local populations in Napiwoda-Ramuki and Pisz forests (north-eastern Poland), with individuals born in captivity or brought from Estonia (Jakimiuk 2015). The lack of a long-term monitoring programme, however, hindered assessment of the effects of those efforts (Linnell et al. 2009). After two decades of strict protection the range of lynx in Poland still roughly mirrored the situation at the beginning of the century, with only a few individuals reproducing in central Poland and several sporadically recorded in the western part of the country (Mysłajek et al. 2019, Chief Inspectorate of Environmental Protection 2021). In 2019 a lynx reintroduction project based on captive-bred individuals started, with 61 individuals having been released in north-west Poland up to the beginning of 2021. This project, however, is still in its early phase so it is not yet possible to evaluate its effectiveness (Western Pomeranian Naturalists Society 2021).

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It is surprising that despite substantial efforts dedicated to lynx protection, information on the ecology of natural populations of this species in Poland is rather limited. Detailed studies were only conducted in the Białowieża Forest along the border with Belarus (Jędrzejewski et al. 1993, 1996, 2002a, Okarma et al. 1997, Schmidt 1998, 1999, 2008, Podgórski et al. 2008, Kowalczyk et al. 2015) and in the Carpathians along the border with Slovakia, the Czech Republic and Ukraine (Śmietana et al. 2000, Mysłajek & Nowak 2004, Okarma et al. 2007, Duľa et al. 2021), while considerably less is known about populations in other parts of the country (Harmuszkiewicz 2011, Jakimiuk 2015).

Across its large and environmentally diverse range, the Eurasian lynx prey mainly on wild ungulates (Belotti et al. 2014, Andrén & Liberg 2015), although regionally other wild (Jobin et al. 2000, Helldin et al. 2006, Odden et al. 2006, Krofel et al. 2011), semi-domestic (Mattisson et al. 2011) or domestic (Gervasi et al. 2014) species may became important food items. Studies in north-eastern Poland have shown that prey depletion may affect lynx spatial organization and ultimately their density, thus management of wild ungulates, which are usually game species, is crucial for lynx protection (Schmidt 2008). Consequently, proper recognition of their food habits and prey preferences should precede conservation measures (Boitani et al. 2015).

In this paper we aim to identify prey preferences of the lynx population inhabiting south-eastern Poland, particularly the Roztocze National Park and local Natura 2000 sites that target protection of its habitats. The study area has a rich community of wild ungulates (Borowik et al. 2013, Sądel 2017), and other species known to be lynx prey, e.g. lagomorphs, tetraoninids and the dormouse (Sądel 2017, Jurczyszyn et al. 2018, Zawadzka et al. 2019). Our hypothesis was that, despite an availability of alternative prey species, lynx in this region select roe deer from the ungulate community.

Material and Methods

Study area

The study area (750 km^2) encompasses large parts of two neighbouring, though topographically different, regions; Roztocze and Biłgoraj Plain, situated in south-eastern Poland (50°36′ N 23°03′ E). Roztocze is an upland region with hills at a maximum elevation of ca. 390 m separated by steep gorges. There are several patches of beech *Fagus sylvatica*, oak *Quercus* ssp., and fir *Abies alba* forest, but local forests consist mainly of Scots pine *Pinus silvestris* stands. Patches of forest are divided by large agricultural areas and villages. In contrast, the Biłgoraj Plain is covered by the Solska Forest consisting mainly of managed Scots pine stands with patches of black alder *Alnus glutinosa* swamp forest. The climate of the whole area is transitional between Atlantic and continental, with the average temperature –2.4 °C in January and 19 °C in July, and with annual precipitation of ca. 700 mm.

There are several protected areas within the study area. The most important is the Roztocze National Park (84.8 km^2) which protects rich patches of mainly deciduous forests in the central part of Roztocze. The national park largely overlaps with a Natura 2000 Special Area of Conservation "Roztocze Środkowe" (PLH060017). Another Natura 2000 site located on the Biłgoraj Plain "Uroczyska Puszczy Solskiej" (PLH060034) protects large patches (346.7 km^2) of the Solska Forest. Both Natura 2000 sites are, among other purposes, dedicated to the protection of large carnivore habitats (Diserens et al. 2017). The network of local protected areas is complemented by landscape parks (Szczebrzeszyński, Krasnobrodzki and Puszczy Solskiej), several small nature reserves and some minor Natura 2000 sites. The area is inhabited by five wild ungulate species: moose *Alces alces,* red deer *Cervus elaphus*, roe deer *Capreolus capreolus*, fallow deer *Dama dama* and wild boar *Sus scrofa* (Borowik et al. 2013, Sądel 2017). In addition to Eurasian lynx (Niedziałkowska et al. 2006), the study area is also occupied by the gray wolf *Canis lupus* (Jędrzejewski et al. 2005).

Assessment of the lynx prey spectrum and selectivity

We collected data on the prey spectrum of the lynx based on two methods: 1) searching for remains of the prey of two radio-collared individuals, and 2) opportunistic winter tracking of lynx in areas outside the home-ranges of individuals followed using telemetry. The first lynx – an adult male, was captured with a box trap as part of a research project conducted in the Roztocze National Park. Telemetry lasted from 15. 2. 2019 to 16. 8. 2020 when the collar became detached. The second individual – a 9-months-old male – was rescued in the Roztocze region after its mother died in a road traffic accident. He was kept for three months in the Wildlife Rehabilitation Centre "Goldcrest" in Bielsko-Biała (Poland), and then released into

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Table 1. Species composition of lynx kills found during telemetry and snow-tracking in south-east Poland (SE Poland), 2019-2021.

Prey species	Telemetry		Snow-tracking	Total
	Adult male	Sub-adult male	Unknown	
Red deer	1 (2%)	-	1 (50%)	2 (3%)
Roe deer	46 (96%)	13 (81%)	1 (50%)	60 (91%)
Brown hare	1 (2%)	3 (19%)	-	4 (6%)
Total	48 (100%)	16 (100%)	2 (100%)	66 (100%)

the Roztocze National Park. Telemetry lasted from 4. 5. 2020 to 1. 11. 2020 when the individual departed from the study area. The collar schedule was set up to obtain at least five locations per day. Research procedures were accepted by the 1st Local Ethical Commission for Experiments on Animals in Warsaw, while permission to capture lynx in the Roztocze National Park was granted by the Polish Ministry of Environment. Both lynxes were equipped with GPS-GSM collars (Vectronic Aerospace, Germany).

We visited clusters of at least two telemetry locations that fell within 100 m of each other, and searched for remains of prey. When kills were found at each kill site, data about the sex and age category (adult > one year or young < one year) of prey remains were collected whenever possible. The duration of prey use by the lynx was estimated based on telemetry locations. The first location situated in the place where the prey was later found was treated as the day of hunting, and the end of the prey utilisation was marked as the day of the last location after which the lynx did not return to the prey. In the case of multiple killing, we attempted to distinguish between surplus killing (i.e. events when a lynx killed several animals during the same hunt) and parallel killing (i.e. events when a lynx completed additional kills while still consuming the carcass of the previous kill) (Duľa & Krofel 2020), based on species composition of prey, distribution of clusters of telemetry locations, and time of lynx arrivals and departures from locations where we found kills.

We assessed selectivity index D for ungulate species following Jacobs (1974) formula:

$$D = \frac{r - p}{r + p - 2rp}$$

Where r is the fraction of a species in the lynx diet and p is the fraction of that species in the ungulate community. The selectivity index, D, ranges from –1 (minimum negative selection) to 1 (maximum positive selection).

The species structure of the ungulate community in the study area was estimated using official data on game inventories provided by the Roztocze National Park and Zwierzyniec State Forest Districts for the season 2019/2020 (Forest Data Bank 2021, https://www.bdl.lasy.gov.pl). Although such data do not exactly document the actual numbers of species, they are reliable in showing the relative abundance of ungulates (Jędrzejewski et al. 2012).

Results

We found 64 lynx kills using telemetry and an additional two during snow-tracking (Table 1). Most kills were wild ungulates (94%), complemented with brown hare (6%). The adult male killed more ungulates, than the young male (98% and 81%, respectively), although this difference was negligible (χ^2 = 0.89, df = 1, NS). Among wild ungulates hunted by lynx, the roe deer clearly prevailed over the red deer (96.8% *vs.* 3.2%). The local ungulate community consisted of four species: moose (2.6%), red deer (22.9%), roe deer (71.7%) and wild boar (3%). From these species lynx selected roe deer (D = 0.845) and avoided all others (moose D = –1; red deer D = –797, wild boar D = –1).

All hares hunted by lynx were adults, while both red deer were calves (three and nine months old). Among roe deer for which age estimation was available (n = 58) adults (> 1 year) constituted 86% while fawns were 14%. We were able to identify the sex of 31 adult roe deer killed by lynx. These constituted 42% males and 58% females, and this sex ratio did not significantly deviate from 1:1 (χ^2 = 0.81, df = 1, NS).

We identified one case of surplus killing, when the young male lynx killed an adult female roe deer along with a fawn 30 m apart on the same day in

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August. We also identified two cases of parallel killing. The first instance occurred in June when the young male lynx killed an adult male roe deer and a brown hare within 50 m of each other, and the second instance when the same individual killed two adult female roe deer 160 m apart, on 19th and 20th of August.

Lynx visited the same killed roe deer (when a single prey item was obtained) for an average of 2.3 days (SD = 1.0, range 1-4), but when multiple killing occurred, lynx visited the prey for two days (adult roe deer + fawn), four days (adult roe deer + brown hare) and six days (two adult roe deer).

Discussion

Our study confirmed that in spite of the availability of several prey species, Eurasian lynx in south-eastern Poland hunt mainly roe deer. It is consistent with the results of studies in other parts of the Baltic lynx population (Jędrzejewski et al. 1993, Valdman et al. 2005). The roe deer is also a primary prey of Eurasian lynx in other European populations, i.e. Scandinavian (Odden et al. 2006), Karelian (Pulliainen et al. 1995), Carpathian (Śmietana et al. 2000, Mysłajek & Nowak 2004), Dinaric (Krofel et al. 2014), Balkan (Melovski et al. 2020), Bohemian (Belotti et al. 2015) and Alpine (Jobin et al. 2000). The same pattern was also recorded for individuals dispersing out of their permanent range (Duľa & Krofel 2020). In our study area male and female roe deer were preyed on in proportions similar to their abundance in the population (Sądel 2017) indicating a lack of lynx preference toward either sex.

The time that lynx spent consuming a single prey in our study fits well into data obtained across its range (Breitenmoser & Haller 1993, Okarma et al. 1997, Jobin et al. 2000, Odden et al. 2006). Several earlier studies showed cases of surplus or parallel killing by lynx of wild (Breitenmoser & Haller 1993, Jobin et al. 2000, Duľa & Krofel 2020), semi-domestic (Pedersen et al. 1999) and domestic species (Odden et al. 2013). In Poland comparable observations were previously made only in the Białowieża Forest, where lynx females and kittens killed small prey species (hare or hazel hen *Bonasia bonasus*) while still feeding on an ungulate carcass, and a male lynx utilized two kills at the same time, though in only one case were two individuals killed in close proximity (Okarma et al. 1997). Moreover, in the same forest, a surplus killing event was recorded when in a single night a lynx killed three roe deer kept in an enclosure (Kossak 1989). Our observations confirmed that surplus and parallel killing by lynx is more widespread than had been previously recorded.

Roe deer are the most abundant ungulate species in south-eastern Poland (Borowik et al. 2013, Sądel 2017) providing a staple food base for the local lynx population and the most likely explanation for the relatively low exploitation of other prey species. Even though lynx can prey on several mammal and bird species (Jędrzejewski et al. 1993, Sidorovich 2006), it tends to select roe deer even if that species occurs at low density (Odden et al. 2006). In south-east Poland, however, wolves also prey mainly upon roe deer; data collected in 2000-2003 revealed that this species constituted 54% of wolf kills and made up 57.7% of consumed biomass according to the analysis of their scats (Jędrzejewski et al. 2012). Therefore, to avoid undermining the food base of predators in the region, game management regarding roe deer should take under consideration the food requirements of both strictly protected species (Schmidt 2008, Jędrzejewski et al. 2012). It is especially important in protected areas such as Natura 2000 sites, where both large carnivores are subject to the protection measures that these designations provide (Trouwborst 2010, Diserens et al. 2017).

Acknowledgements

We are grateful to Michał Korga, Agata Olinkiewicz and Leszek Olinkiewicz for help in searching for lynx prey. We would like to express our gratitude to Sławomir Łyczko and Agnieszka Łyczko from the Wildlife Rehabilitation Centre "Goldcrest" in Bielsko-Biała (Poland) for the rehabilitation of an orphaned lynx, and Izabela Całus, MVD, from the Vet-House Veterinary Surgery in Bielsko-Biała (Poland) for the care on this individual. We are grateful to Dr. Christopher Young for English corrections. The study was financed by the Forest Fund of the National Forest Holding "State Forests" (Poland) within grant No. EZ.0290.1.15.2019 and EZ.0290.1.16.2020 obtained by Roztocze National Park. Author contributions: R.W. Mysłajek – conceptualization, methodology, investigation, formal analysis, writing original draft, review and editing, P. Stachyra – investigation, funding acquisition, M. Figura – investigation; S. Nowak – conceptualization, methodology, investigation, review and editing.

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