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ORIGINAL PAPER

# Diet of Eurasian lynx *Lynx lynx* in the northern Dinaric Mountains (Slovenia and Croatia)

## Importance of edible dormouse *Glis glis* as alternative prey

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**Abstract** The Eurasian lynx *Lynx lynx* (Linnaeus 1758) is an opportunistic predator that usually selects the smallest ungulate available. Its diet varies considerably among different regions; therefore it is important to study lynx diet in different parts of the species' range. We studied the diet of lynx from the endangered Dinaric population in Slovenia and Croatia by analyzing lynx scats, prey remains, and stomach contents. Dinaric lynx mainly killed European roe deer *Capreolus capreolus* (0.64 frequency of occurrence, 79% of all consumed biomass), which were used more frequently during winter and spring. Ungulates were killed more often by adult males than by lynx of other age and sex groups. In contrast to studies from other regions, lynx in the northern Dinaric Mountains also frequently fed on the edible dormice *Glis glis* (0.18 frequency of occurrence, 7% of all consumed biomass). This large rodent appears to be an important alternative prey, especially for females and young lynx, and was the reason for the highest use of rodents reported so far for the Eurasian lynx. Edible dormice in Dinaric forests have highly variable numbers of active animals. Seasonal and possibly annual variation in dormouse availability obviously affects lynx diet. This is a rare example where variability in the availability of the alternative prey and not the preferred prey leads to the dietary shift. This study confirms the opportunistic nature of Eurasian lynx and the regional variability of its diet.

**Keywords** Food · Predation · Scat analysis · Rodent · Carnivore

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## Introduction

During their evolution, most species of the *Lynx* genus developed specializations for hunting lagomorphs (Werdelin 1981). An exception to this is the Eurasian lynx *Lynx lynx* (Linnaeus 1758), the largest species of its genus, which is today together with the gray wolf *Canis lupus* the most important predator of large herbivores in Europe (Jędrzejewska and Jędrzejewski 1998; Kos et al. 2005). In general, Eurasian lynx are regarded as opportunistic generalist predators (Odden et al. 2006) that usually select the smallest ungulate available (Jędrzejewski et al. 1993). Throughout Europe, this is usually the European roe deer *Capreolus capreolus*, which is clearly the preferred prey of Eurasian lynx (Breitenmoser and Breitenmoser-Würsten 2008; Jędrzejewski et al. 1993). However, in some parts of their distribution other ungulates represent the main prey, such as chamois *Rupicapra rupicapra* in parts of Switzerland (Breitenmoser and Breitenmoser-Würsten 2008), red deer *Cervus elaphus* in parts of Austria (Gossow and Honsig-Erlenburg 1985) and Poland (Okarma 1984), semi-domestic reindeer *Rangifer tarandus* in parts of Scandinavia (Birkeland and Myrberget 1980; Pedersen et al. 1999), and introduced white-tailed deer *Odocoileus virginianus* in parts of Finland (Pulliainen et al. 1995). But Eurasian lynx can also thrive in areas without ungulates, such as in parts of northern Eurasia, where their diet shifts to lagomorphs and birds (Pulliainen

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1981; Sunde et al. 2000; Zheltukhin 1986). In such cases, the availability of small prey could have important effects on lynx population dynamics, as was suggested by Sunde et al. (2000) for the Scandinavian lynx in the first half of 20th century.

More than 30 different prey species have been recorded as prey of Eurasian lynx (Odden et al. 2006) and their diet varies considerably among different regions (Nowicki 1997). Because of this high regional variation, it is important to study lynx diet in different parts of the species' range. Except for a survey based on questionnaires distributed among hunters (Čop 1990), diet and patterns of predation have not been systematically studied for the endangered Dinaric lynx population that presently occurs in Slovenia, Croatia and Bosnia and Herzegovina. In this study, we analyzed the diet of Eurasian lynx from the Dinaric population in Slovenia and Croatia, based on the analysis of lynx scats, prey remains, and stomach content of dead lynx. We studied the relative importance of different prey species, as well as effects of season, and lynx sex and age on their diet patterns. We were particularly interested in the use of the edible dormouse *Glis glis*, which is absent in lynx diet in almost all other regions. The edible dormouse is a large (body weight, 62–338 g) long-lived rodent with annually variable cycles of seasonal dormancy and annually variable reproduction (Kryštufek 2007; Bieber and Ruf 2009). In the Dinaric forests, it is frequently used by several mammalian and avian predators, as well as by local people (Kryštufek 2007). In previous research, we observed that dormice are fed on by lynx (Krofel 2006; D. Huber et al., unpublished data), and this article is the first attempt to systematically investigate the role of dormice as lynx prey and effects of changes in dormouse availability on lynx diet.

## Study area

The northern Dinaric Mountains cover the southern parts of Slovenia and the northwestern parts of Croatia. The limestone and dolomite geology of the area results in a rugged karstic relief and abundant karstic structures, such as rock crevices, horizontal caves, vertical shafts, dolines, canyons etc. Altitudes range from the sea level to the peak of Mount Snežnik at 1796 ma.s.l. The climate is influenced by the Alps, the Mediterranean sea and the Pannonian basin, with an annual temperature in the region averaging 5–8°C, ranging from maximum of 32°C in July to a minimum of −20°C in January, and average annual precipitation of 1400–3500 mm. Most of the area is covered by Dinaric fir and beech forests (*Omphalodo-Fagetum* s.lat.), with four dominant tree species: common beech *Fagus sylvatica*, silver fir *Abies alba*, Norway spruce *Picea abies*, and sycamore maple *Acer pseudoplatanus*. Average human density in the Dinaric area of Slovenia is 54 people/km$^2$ (Perko and Orožen Adamič 1998) and 24 people/km$^2$ in the mountainous part of Gorski kotar in Croatia (Kusak and Huber 1998). Most settlements are concentrated in the valley bottoms leaving higher plateaus scarcely populated. Four native species of ungulates live in this area: roe deer, red deer, chamois, and wild boar *Sus scrofa*. There are also a few small and isolated introduced populations of mouflon *Ovis ammon* and fallow deer *Dama dama*. Besides Eurasian lynx, brown bear *Ursus arctos* and gray wolf are present in the area as well as several species of smaller carnivores. The Dinaric lynx population started to decline in the last 10–15 years, and today Eurasian lynx are regarded as the most endangered mammal in the region, with population estimates of 20–40 lynx for Slovenia and 40–60 lynx for Croatia (Sindičić et al. 2009).

## Material and methods

### Collection of samples and laboratory analysis

The majority of our samples were collected in the Notranjska and Kočevska regions of Slovenia and the Gorski kotar region of Croatia (45°–46°N, 13°30′–15°15′E), although small number of stomachs from harvested lynx also originate from other parts of the two countries. Lynx scats were found during snow tracking, at telemetry locations of radio-collared lynx and by chance during regular field work between 1993 and 2010. Individual lynx were actively tracked during favourable snow conditions (individual tracking sessions lasting from 1 to 4 days) and all scats found were collected. However, if more than one scat was found during the same snow-tracking session, only one (the first) was used for analysis to avoid pseudoreplication. Scats were oven dried at 60–70°C for at least 72 h and weighed. After removing them from the oven, scats were put into an air-tight glass jar with silica gel in order to prevent condensation while cooling. If more than one food item was observed in the same scat (which was evident from the different colours of different parts of the scat), we weighed each part separately. In one case when this was not possible, we visually estimated the proportion of each food item in the scat. Scats were then soaked with water for about 15 min and washed with tap water on a 0.5-mm mesh sieve. Material remaining on the sieve was dried and inspected macroscopically and under 100–400× magnification. From each scat, we collected (when present) all bone and teeth fragments, approximately 20 guard hairs and five feathers, placed them in 96% ethanol for 30 min to clean, and let them dry. Macroscopic (general form, size, colour, rigidness, shape of the apex) and microscopic (structure and pattern of cuticular scales, shape of the cross-section, shape and size of the medullar space) characteristics of hairs were noted. Microstructure of the cuticle was inspected using cuticular imprints made on celluloid plates with the use of acetone (Wachter et al. 2006). Species determination was performed according to Teerink (1991), Meyer et al. (2002) and with the help of our own reference material. Bird feathers were observed under the microscope and determined to the order level according to Day (1966). Teeth and bone remains of small mammals were identified according to Kryštufek (1999) and with the help of comparative osteological material. For identifying rodents, teeth were usually used.

Lynx kills were located during snow tracking, VHF or GPS-GSM telemetry of radio-collared lynx and by chance during regular field work between 1996 and 2010. Using telemetry data we searched for prey remains when the lynx was present (not necessarily uninterruptedly) for at least 8 h during the night in a radius of 200 m. In total, six lynx were radio-collared (two males, four females) and their kills represented 73% of prey remains found. Although on rare occasions we found prey remains of smaller prey (e.g., fox, hare, rodents), we used only data from prey remains of ungulates for further analysis because of the bias due to lower probability of finding small prey (see Mills 1992). We used data from prey remains to calculate relative shares of different species among ungulates and then incorporated this ratio into data from scat analysis (see below). When only small parts of the carcass were found, the species was determined using comparative osteological material. During part of the study, we also collected unconfirmed records of observations and prey remains found by hunters and local people. However, because we regarded these data as unreliable, we did not include them in the presented results and further analysis, although we mention some of them in the discussion as indication of the potential prey spectrum of the lynx.

An additional set of data came from samples of stomach content from lynx killed or found dead in Slovenia and Croatia between 1983 and 1998. Stomach content data are likely to be biased (Birkeland and Myrberget 1980), because some lynx were killed while scavenging at feeding places and some of the dead lynx were debilitated and were killed or found dead after approaching human settlements (Frković 2003; Kos et al. 2005; see also Discussion section). This is also reflected in the presence of garbage in stomachs, which we did not find in scats. Moreover, most of the stomachs were collected during the lynx hunting season, which lasted only a few months. Consequently, we do not regard stomach content as a representative sample for determining absolute values of individual food items in lynx diet in this area. However, for these samples the sex and approximate age of the lynx is known, so they are useful for comparing proportions of food items between different groups of lynx according to sex and age, especially in the proportion of cervids and dormice used by each of the groups.

Regarding the age of the lynx, samples were separated into two groups: adults (2 years and older) and juveniles (kittens and subadults). Samples were similarly distributed for all sex and age groups in regard to season. No data were available about the total weight for the majority of stomach samples. Other procedures for identification of material from stomach contents were similar to those described for scat analysis.

In total, 71 carcasses of ungulates killed by lynx, 49 lynx scats, and contents of 37 stomachs from dead lynx were analyzed.

## Data analysis

We pooled the data on all species of ungulates from scats into one group ("ungulates") and then used relative shares of roe deer, red deer and chamois from kills (found by snow-tracking and telemetry) to estimate the proportion of each species in the overall diet. This was done because data from prey remains have a higher reliability of determination (especially for cervids; Schmidt 2008) and a larger sample size was available compared to scats. Because of their large size, all three species of ungulates identified are expected to have approximately the same coefficients of digestibility (Baker et al. 1993).

Results from the diet analysis are presented as frequency of occurrence (FO; proportion of samples containing a given food item), relative frequency of occurrence (RFO; frequency of a given food item/the total number of occurrences of all food items), and as percent of total consumed biomass (% TCB; sum of estimated consumed biomass of a given food item in all scats/total estimated consumed biomass of all food items). Consumed biomass of mammals was estimated using the coefficients of digestibility for Eurasian lynx according to Rühe et al. (2007). For smaller species that were not included in the feeding trials, we calculated coefficients of digestibility using regression equation given by Rühe et al. (2007). For birds we used coefficient provided by Sunde et al. (2000). Coefficients of digestibility used in this study are presented in Table 1. We did not include plant material into calculations of TCB, because we only found it in small quantities, it has low nutritional value, and because it is assumed that lynx ingest it unintentionally or for reasons other than nutrition (Hucht-Ciorga 1988). Because of the lack of data for total weight of stomach contents, we could not calculate the proportions of biomass consumed for these samples, so the data of stomach content are presented with FO and RFO only.

To analyze seasonal patterns in lynx diet, we separated samples into four seasons: spring (March–May), summer (June–August), autumn (September–November) and winter (December–February). Due to the limited hunting season for lynx, stomach samples were not equally distributed among seasons. For this reason, we compared only two periods for these samples: summer/autumn (June–November) and winter

**Table 1** Diet of Eurasian lynx *Lynx lynx* in the northern Dinaric Mountains of Slovenia and Croatia according to combined data from prey remains of ungulates ($n$=71) and scats ($n$=49) collected in 1993–2010

| | FO | RFO | CF | TCB (g) | % TCB |
|---|---|---|---|---|---|
| Wild ungulates | 0.71 | 0.61 | 35.0 | 20,268 | 88.4 |
| *Capreolus capreolus* | 0.64 | 0.55 | 35.0 | 18,151 | 79.1 |
| *Cervus elaphus* | 0.05 | 0.05 | 35.0 | 1,513 | 6.6 |
| *Rupicapra rupicapra* | 0.02 | 0.02 | 35.0 | 605 | 2.6 |
| *Vulpes vulpes* | 0.04 | 0.04 | 23.0 | 142 | 0.6 |
| Rodentia | 0.20 | 0.21 | Variable | 1,773 | 7.7 |
| *Glis glis* | 0.18 | 0.16 | 15.3 | 1,581 | 6.9 |
| Muridae | 0.02 | 0.02 | 14.0 | 76 | 0.3 |
| Arvicollidae | 0.04 | 0.04 | 14.0 | 115 | 0.5 |
| *Lepus europaeus* | 0.02 | 0.02 | 28.0 | 425 | 1.9 |
| Birds | 0.02 | 0.02 | 18.7 | 52 | 0.2 |
| Domestic cattle (carrion) | 0.02 | 0.02 | 35.0 | 276 | 1.2 |
| Plant material | 0.10 | 0.09 | – | – | – |

Correction factors (CF) were used according to Rühe et al. (2007) and Sunde et al. (2000). Plant material was not included in the calculations of TCB

*FO* frequency of occurrence, *RFO* relative frequency of occurrence, *TCB* total biomass consumed by the lynx for each taxon

(December–February). Two stomach samples for which the dates of death were unknown were excluded from this analysis.

We compared use of the edible dormouse by the lynx between the years of high dormouse availability and years of medium to low dormouse availability. Years of high dormouse availability (1994, 1995, 1999, 2001, 2003, 2004, and 2007) were selected according to the data from Kryštufek and Zavodnik (2003) for the period 1993–2000, Kryštufek (2007) for 1999–2005, and Krofel et al. (unpublished data) for 2006–2010. Comparisons were made for all seasons and separately for the active (April–October) and hibernating period (November–March) of the edible dormouse in Slovenia (Kryštufek 2007).

To compare the diet composition between different age and sex groups, and between seasons, we used the chi-square ($\chi^2$) test for homogeneity. In order to satisfy test requirements (Zar 1999) we pooled data from the stomach content analysis into four food categories (cervids, dormice, domestic animals, other) and two season categories (summer/autumn, winter), and data from the scat analysis into three food categories (ungulates, dormice, other) and three season categories (spring, summer/autumn, winter). Fisher's exact test was used to test differences of dormouse use between years of high and low availability of dormice.

Food niche breadth ($B = 1/\sum p_i^2$, where $p_i$ is proportion of biomass of a given food item) was calculated according to Levins (1968).

## Results

### Diet composition

Among the prey remains of ungulates, 64 (90%) belonged to roe deer, five (7%) to red deer, and two (3%) to chamois. According to the combined data from analysis of scats and prey remains, roe deer were the most important prey species representing about 80% of all consumed biomass by the lynx (Table 1). This was followed by the edible dormouse which occurred in about a fifth of all scats and represented 7% of TCB. Other animal food items include (in decreasing importance) red deer, chamois, brown hare *Lepus europaeus*, domestic cattle, red fox *Vulpes vulpes*, voles Arvicollidae, mice Muridae and passerine birds Passeriformes. Plant material was present in 11% of scats. In two of the scats we found pellet droppings from a roe deer. Food niche breadth calculated according to data from prey remains and scat analysis was estimated to $B$=1.57.

Cervids and dormice were the most frequent food items also among stomach contents, followed by remains of domestic animals (Table 2). In addition, stomach contents included remains of wild boar, small carnivores (cat *Felis* sp. and marten *Martes* sp.), undetermined birds, invertebrates (ants, bumblebees and flies), plant material and garbage.

### Effect of lynx age and sex

Information about the sex and age of lynx were available for 35 (95%) samples from stomachs of dead lynx. Males used mainly ungulates, while females and juveniles also fed on dormice and domestic animals (Fig. 1). Other food items (wild boar, small carnivores, birds, invertebrates, and garbage) were only eaten frequently by juveniles. Remains of edible dormice were found in 50% of stomachs from adult females, in 27% for juveniles, and never in adult males. Diet composition was significantly different between adult males and adult females ($\chi^2$=7.99, $df$=3, $p$=0.046; $n$=24) and between adults and juveniles ($\chi^2$=10.83, $df$=3, $p$=0.013; $n$=35).

**Table 2** Frequency of occurrence (FO) and relative frequency of occurrence (RFO) of food items in stomachs of Eurasian lynx *Lynx lynx* from Slovenia and Croatia in 1983–1998

| | All samples ($n$=37) | | Summer/autumn ($n$=24) | | Winter ($n$=11) | |
|---|---|---|---|---|---|---|
| | FO | RFO | FO | RFO | FO | RFO |
| Cervidae | 0.84 | 0.40 | 0.79 | 0.40 | 0.91 | 0.48 |
| *Sus scrofa* | 0.03 | 0.01 | 0.00 | 0.00 | 0.09 | 0.05 |
| Small carnivores | 0.03 | 0.01 | 0.04 | 0.02 | 0.00 | 0.00 |
| *Glis glis* | 0.24 | 0.12 | 0.25 | 0.13 | 0.18 | 0.10 |
| Birds | 0.05 | 0.03 | 0.04 | 0.02 | 0.00 | 0.00 |
| Invertebrates | 0.08 | 0.04 | 0.13 | 0.06 | 0.00 | 0.00 |
| Domestic animals | 0.16 | 0.08 | 0.17 | 0.09 | 0.09 | 0.05 |
| Garbage | 0.11 | 0.05 | 0.13 | 0.06 | 0.00 | 0.00 |
| Plant material | 0.57 | 0.27 | 0.54 | 0.28 | 0.64 | 0.33 |

### Effect of season

Based on data from the scat and stomach samples, lynx killed ungulates more often in winter and spring, while the opposite is true for hunting dormice (Fig. 2, Table 2). According to the analysis of scats and prey remains, roe deer and dormouse were co-dominant in lynx diet during the summer and autumn. Surprisingly, dormice were also found in several scats and stomachs collected during midwinter, when this species is hibernating. In general, diet was more varied during autumn and winter. Larger ungulates (red deer and chamois) were caught by lynx only in winter and early spring. Differences in lynx diet in different seasons were statistically significant for scats ($\chi^2$=13.21, *df*=4, $p$=0.01; $n$=49), but not for stomach samples ($\chi^2$=0.69, *df*=3, $p$=0.875; $n$=35).

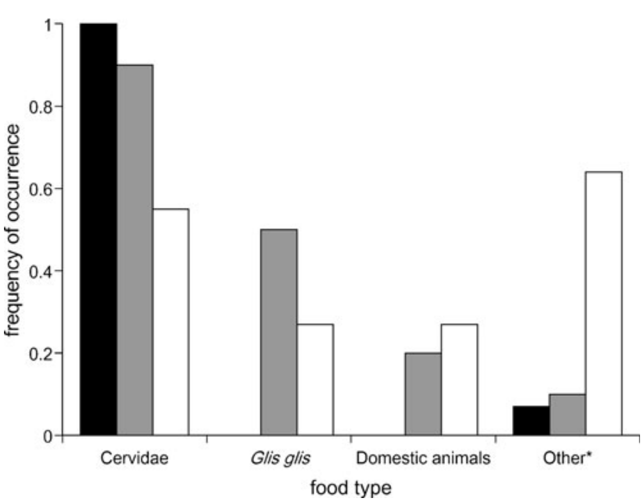


**Fig. 1** Frequency of occurrence of four food types in stomach content of adult males (*black*; $n$=14), adult females (*grey*; $n$=10), and juveniles (*white*; $n$=11) of Eurasian lynx *Lynx lynx* from Slovenia and Croatia in 1983–1998. Adult males vs. adult females: $\chi^2$=7.99, *df*=3, $p$=0.046; adults vs. juveniles: $\chi^2$=10.83, *df*=3, $p$=0.013. *Without plant material

### Effect of annual variation in dormouse availability

Edible dormouse was used by lynx more frequently in years with higher availability. During the hibernating period, use of dormice was similar in all years (Fisher's exact test, $p$=1, $n$=28), while during the period when dormice are active lynx use of dormouse was three times higher in years of high dormouse availability (Table 3). However, the differences were not statistically significant due to small sample sizes (all seasons: Fisher's exact test, $p$=0.46, $n$=49; summer: Fisher's exact test, $p$=0.28, $n$=21).

## Discussion

Similar to other areas in Europe, the Eurasian lynx in the northern Dinaric Mountains mainly prey on ungulates, especially the smallest species available, the European roe deer. However, in contrast to previous studies from all other regions hitherto studied, Dinaric lynx also frequently feed on edible dormice. This confirms the opportunistic predatory nature of Eurasian lynx.

Food niche breadth for lynx in the northern Dinaric Mountains is similar to that reported for pristine forests in Białowieża, Poland (Jędrzejewski et al. 1993). With increased sample size, we expect that the list of prey species rarely consumed would increase. For example, it is known that occasionally lynx in Slovenia also attack domestic sheep and goats (Kos et al. 2005), mouflons (Čop 1990) and snakes (unpublished data). However, the killing of these species is obviously infrequent and probably has little importance for lynx diet and limited effect on lynx foraging behaviour.

The remains of domestic animals were relatively common in the analyzed stomach content. This is likely due to scavenging, since the majority of the identifiable remains came from cattle, which are too large to be killed by lynx. In the past, remains of slaughtered cattle were regularly deployed

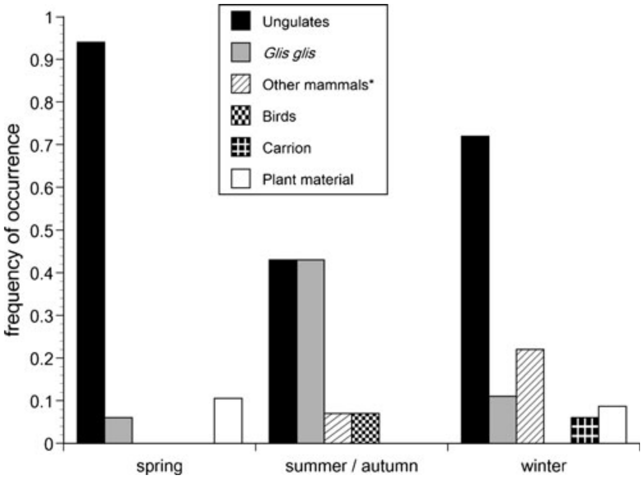


**Fig. 2** Seasonal difference in diet of Eurasian lynx *Lynx lynx* in the northern Dinaric Mountains, Slovenia and Croatia, according to scat analysis ($\chi^2$=13.21, *df*=4, *p*=0.01; *n*=49). *Other mammals include: red fox (*Vulpes vulpes*), voles (Arvicollidae), mice (Muridae) and brown hare (*Lepus europaeus*)

in the forest as bait for brown bears in the study region (Grosse et al. 2003). The proportion of domestic animals remains in stomachs is likely to be biased, as many of these lynx were killed while scavenging at feeding places or after consuming poisoned bait (Frković 2003; Kos et al. 2005). On the contrary, the proportion of domestic animals in scats was insignificant. However, it is possible that lynx diet changed somewhat during the last 30 years, so the difference could also be due to the different time periods. Because of new legislation, the use of slaughtered animals for bear feeding became forbidden in Slovenia in 2005, which could have affected the use of carrion by the lynx. Scavenging by Eurasian lynx is regularly, although always in rare cases, reported also from other parts of the species' range (e.g., Birkeland and Myrberget 1980; Breitenmoser and Breitenmoser-Würsten 2008; Odden et al. 2006; Pedersen et al. 1999; Selva et al. 2005).

Adult males preyed more frequently on ungulates compared to adult females and juveniles, which depended more on small prey. This is in accordance with studies from Poland

**Table 3** Frequency of occurrence of edible dormouse in scats of Eurasian lynx *Lynx lynx* in the northern Dinaric Mountains, Slovenia and Croatia, according to years of high and low dormouse availability

| | *n* | Years of high dormouse availability | Years of low dormouse availability | Ratio |
|---|---|---|---|---|
| All seasons | 49 | 0.25 | 0.14 | 1.8 |
| Active period | 21 | 0.43 | 0.14 | 3.0 |
| Hibernating period | 28 | 0.15 | 0.13 | 1.2 |

Data on dormouse availability from Kryštufek and Zavodnik (2003), Kryštufek (2007) and Krofel et al. (unpublished data)

(Okarma et al. 1997) and Switzerland (Molinari-Jobin et al. 2002). On the contrary, differences in lynx diet among different age and sex groups were rarely observed in studies from Northern Europe (Odden et al. 2006; Pulliainen 1981; Pulliainen et al. 1995; Sunde and Kvam 1997; however, see Birkeland and Myrberget 1980). Reasons for this difference between Northern and Central Europe are not clear.

Several studies have shown differences in diet of Eurasian lynx in relation to season (von Arx et al. 2004; Odden et al. 2006; Okarma et al. 1997). The general pattern observed is increased predation on larger prey in colder seasons and higher proportion of smaller prey in warmer seasons. The same pattern was confirmed in our study and was partly connected to the seasonal differences in availability of the edible dormouse (see below). Increased predation on larger herbivores (red deer, chamois) during colder months might be connected with their higher vulnerability in snow, as was suggested by Hucht-Ciorga (1988) and as was observed in gray wolves (e.g., Huggard 1993).

So far, it has not been reported, except for neonates (Haller 1992; Jobin et al. 2000), that lynx would feed on the digestive tracts of ungulates. Therefore, it was surprising to find roe deer pellets in the lynx scats, which indicate that lynx may occasionally also feed on the intestines. This has also been observed in other felids, e.g., ungulate pellets were found in seven out of 195 scats of cheetahs *Acinonyx jubatus* in Namibia (M. Krofel, unpublished data).

## Edible dormice in lynx diet

Analysis of both scat and stomach samples from the Dinaric Mountains suggests that the edible dormouse is an important alternative prey for the Eurasian lynx in this region, at least for females and juveniles. Despite the fact that edible dormice occur over a large part of Europe (Kryštufek 2007), our review of available published literature shows that this is the first study to indicate regular predation on this rodent by the lynx. The only other study that detected the use of edible dormice comes from the Jura Mountains in Switzerland, but even there dormice were found in less than 0.1% of lynx samples (Breitenmoser and Breitenmoser-Würsten 2008). The same differences in use of dormice between Dinaric Mountains and other regions were also reported for the diet of Ural owls *Strix uralensis* (Vrezec 2000). Dormouse densities in Dinaric Mountains are comparable to the other parts of Europe (Kryštufek 2007), so it is possible that dormice in the Dinaric Mountains are less arboreal in their behaviour because of their frequent use of karstic underground (Kryštufek 2007), which would make them more vulnerable to predation, at least for terrestrial predators like lynx. Further studies are needed to test this hypothesis.

The use of rodents by lynx is relatively low throughout its range (Nowicki 1997). Rodents were always reported to represent <1% of consumed biomass by lynx and so far they were never found in more than 12% of the samples (e.g., Breitenmoser and Breitenmoser-Würsten 2008; Jędrzejewski et al. 1993; Okarma et al. 1997; Odden et al. 2006; Pulliainen 1981; Pulliainen et al. 1995; Sunde and Kvam 1997; Zheltukhin 1986). In the majority of these studies, voles were the most important rodent prey. Edible dormice are considerably larger than voles (approximately four times), which makes them a more profitable prey to catch for a large predator. Positive effect of lynx's predation on dormice is probably decreased competition with sympatric gray wolf, which in the northern Dinaric Mountains mainly feed on wild and domestic ungulates (Krofel and Kos 2010). Catching dormice is also advantageous due to lower risk of injuries sustained during hunting. As was shown by Ross et al. (1995), accidents can be frequent for solitary felids hunting ungulates and this might be even more pronounced in the rugged, karstic terrain of the Dinaric Mountains. Such risks might be one of the reasons for the observed higher use of dormice by female and young lynx compared to larger males that more easily handle large prey.

The use of dormice by lynx in the Dinaric Mountains significantly differed between seasons. The shift in lynx diet during summer and autumn is most likely connected to dormice activity, as they usually start to become active in April and go to hibernation towards the end of October (Kryštufek 2007). The use of dormice is considerably reduced during winter and spring; however, presence of dormice remains in samples from mid-winter indicates that lynx are able to find them also during hibernation. This is similar to results from diet analysis of beech martens *Martes foina* in the same region (Polak 1994). As was already suggested by Polak (1994) for the beech martens, lynx most likely catch dormice in rock crevices and caves, which are abundant and regularly used by dormice during hibernation (Polak 1997). This is further supported by the observations from snow tracking of lynx in Slovenia, where it was noted that lynx frequently inspect caves, vertical shafts and other openings in the karstic landscape (Krofel 2010).

Obviously the use of dormouse by lynx depends on the availability of this prey species. This was confirmed by seasonal variation in dormouse availability, but it might also be true for annual variation. Populations of edible dormouse in Dinaric forests are notorious for their enormous annual oscillations in numbers of observed animals (Kryštufek and Zavodnik 2003). Recent studies suggest that the total number of dormice is actually relatively constant between the years and that it is the number of active animals that varies (Kryštufek 2007). This is in accordance with our data that suggest similar use of dormice during the hibernating period in different years. On the other hand, we observed 3-fold differences in the use of dormice in relation to the availability of active animals during the active period. However, more data are needed to confirm the hypothesis of the effects of annual variation in dormouse availability on lynx diet. At present we are also unable to test whether these changes in lynx diet might be a true prey switching in the ecological sense or merely a linear dietary shift due to differences in relative prey abundances (see Garrott et al. 2007).

Use of alternative prey in large carnivores often depends on the relative abundance of the preferred prey in relation to the alternative prey (Garrott et al. 2007). Previous studies suggested that Eurasian lynx shift their diet to the alternative prey only when the preferred prey is greatly reduced (e.g., Gossow and Honsig-Erlenburg 1985; Jędrzejewska and Jędrzejewski 1998; Odden et al. 2006; Schmidt 2008; Sunde et al. 2000). A different situation was observed in our study, where the abundance of the preferred prey (the roe deer) remained relatively stable between seasons and between years (Slovenia Forestry Service 2010) and it seems that the variation in availability of the alternative prey (edible dormice) was the reason for the changed ratio in availability of the two prey species and consequently in their use by the predator.

Future studies will have to show whether differences in dormouse availability and their use by the lynx could affect the predation rate on ungulates by lynx or the survival rate of juveniles and the reproductive success of females— the two groups of lynx that use dormice to the highest degree.

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