Dietary patterns of the Eurasian lynx (*Lynx lynx*) in the Bohemian Forest

Zur Nahrungsökologie des Eurasischen Luchses (*Lynx lynx*) im bayerisch-böhmischen Wald

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Zusammenfassung: Seit Mitte des 19. Jahrhunderts war der Eurasische Luchs (*Lynx lynx*) in Westeuropa weitgehend ausgerottet. Durch verschiedene Wiederansiedlungen konnten die Tiere Teile ihres ursprünglichen Verbreitungsgebietes, wie die Schweizer Alpen, den Jura, die Vogesen und den Harz wiederbesiedeln. Die heute im Böhmerwald lebenden Luchse sind Nachkommen von zwei Wiederansiedlungsaktionen in Bayern und Tschechien in den 1970er und 1980er Jahren.

Die inselhaften Verbreitungsgebiete des Luchses in Deutschland (z. B. Harz, Bayerischer Wald) liegen in unmittelbarer Nähe zu besiedelten und fragmentierten Gebieten. Anders als der Wolf genießt der Luchs eine hohe Akzeptanz in breiten Bevölkerungsschichten und wird von der Fremdenverkehrsindustrie, nicht nur im Bayerischen Wald, gern als Imageträger genutzt. Ein hohes Konfliktpotenzial birgt jedoch die Prädation an Wildtieren. In den Jagdrevieren Ostbayerns ist das Reh (*Capreolus capreolus*) das wichtigste Jagdwild. Damit steht der Luchs in direkter Konkurrenz zum menschlichen Jäger. Aus diesem Grund stellt sich die Frage, wie der Einfluss des Luchses in die Rehwildabschussplanung miteinbezogen werden kann. Die Erforschung der Einwirkungen des Luchses auf seine Beutetierbestände ist somit von zentraler Bedeutung für die Akzeptanz bei den Jägern und damit für den Fortbestand der bayerisch-böhmisch-östereichischen Population.

Um sich dieser Thematik zu widmen, initiierte die Nationalparkverwaltung Bayerischer Wald 2005 ein Projekt zur Erforschung der Räuber-Beute-Beziehungen zwischen Luchs, Reh und Rothirsch. Alle trophischen Ebenen der Nahrungskette „Beutegreifer – Pflanzenfresser – Vegetation" sollten detailliert beleuchtet werden, um mit fundierten Ergebnissen im Spannungsfeld zwischen den einzelnen Interessengruppen besser vermitteln zu können. Ein Schwerpunkt war dabei die Erforschung der Nahrungsökologie des Luchses anhand von gefundenen Losungen (N = 130) und Rissen (N = 496) im Zeitraum von 2006 bis 2012.

Untersuchungsraum stellten die beiden Nationalparke Šumava und Bayerischer Wald dar, die Kernlebensraum für eine Vielzahl von bedrohten Tierarten wie z.B. wie Luchs (*Lynx lynx*), Fischotter (*Lutra lutra*), Auerhuhn (*Tetrao urogallus*), Schwarzstorch (*Ciconia nigra*) und Habichtskauz (*Stix uralensis*) sind.

Die Ergebnisse dieser Nahrungsanalyse sind in Tabelle 1 zusammengefasst, ergänzt durch die Abbildungen 1 bis 5, und werden im Folgenden verkürzt dargestellt. ***Risse:*** Am häufigsten wurden Rehe (82 %) erbeutet, gefolgt von Rotwild (14 %) (Fig. 1). Die Nahrungszusammensetzung unterlag saisonalen Schwankungen, in Bezug auf Rothirsch und Reh war der Unterschied signifikant (FISHER'S, $p < 0,05$) (Fig. 2). Bei Rehen wurden häufiger adulte (> 12 Monate) Tiere erbeutet. Weibliche und männliche Rehe wurden mit gleicher Häufigkeit gerissen. Bei Rothirsch wurden juvenile (1 – 12 Monate) und weibliche Tiere bevorzugt, auch wurden Rothirsche häufiger von Kudern gerissen (Fig. 3 und Fig. 4). ***Losungen:*** Hier war ebenfalls das Reh die häufigste Beutetierart (62 %), gefolgt jedoch von Kleinsäugern (13 %), und Rothirschen (6,8 %), Fig.1. Im Vergleich zu den Rissen konnten noch weitere Beutetierarten nachgewiesen werden,

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wie z.B. Marderartige oder Marderhund (Fig. 1). Auch bei den Losungen traten signifikante saisonale Unterschiede auf (Fig. 2).

Diese Studie ergänzt die Ergebnisse aus anderen europäischen Forschungsgebieten (vgl. z. B. SUNDE & KVAM 1997, JĘDZEJEWSKI et al. 1993) sehr gut. Das Reh ist Hauptbeutetierart, jedoch können auch Rothirsche vor allem im Winter und Kleinsäuger im Sommer einen größeren Anteil im Nahrungsspektrum des Luchses einnehmen (KROFEL et al. 2011). Für eine umfassende Untersuchung der Nahrungsökologie von Großprädatoren empfehlen wir sowohl die Suche nach Rissen also auch das Sammeln von Losungen.
Schlagworte: Eurasischer Luchs (*Lynx lynx*), Rothirsch (*Cervus elaphus*), Reh (*Capreolus capreolus*), Nahrungsanalyse, Nahrungsspektrum, Losungsanalyse, Risssuche

Abstract: Large carnivores in Central Europe were exterminated about 150 years ago, and their recent return has led to conflicts with humans. These conflicts are amplified because knowledge on how to coexist with these animals was lost during their absence. The main conflict is the competition of humans and carnivores for the same prey – livestock and wild ungulates.

To obtain more information on the predation patterns of the Eurasian lynx (*Lynx lynx*), we studied their diet composition based on found prey remains (N = 496) and scats (N = 130) collected between 2006 and 2011 in the Bohemian Forest.

The main prey remains were roe deer (*Capreolus capreolus*, 82 %), followed by red deer (*Cervus elaphus*, 14%), hare (*Lepus europeus*, 2 %), wild boar (*Sus scrofa*, 1 %), and fox (*Vulpes vulpes*, 0.8 %). The roe deer most often killed by lynx were adults of both sexes. The red deer killed were mostly calves and adult females. Red deer was less often taken by female lynx than by males. Red deer was a more important food item (20 %) during winter (November – April) than during summer (10 %).

The scats most often contained roe deer (62 % frequency of occurrence), followed by small mammals (13 %), wild boar (9.6 %), red deer (6.8 %), and hare (6.8 %). Other prey found in scats but not in remains included martens, and raccoon dog.

Our results confirm and complement results from other European study sites, but also show that a comprehensive understanding of lynx diet patterns can be obtained only when both prey remains and scats are sampled.

Key words: Eurasian lynx (*Lynx lynx*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), diet composition, diet analysis

Introduction

In Europe, the habitat of the lynx (*Lynx lynx;* Linnaeus, 1758) mostly overlaps with areas utilized by humans, and this can lead to conflicts. As predators, lynxes prey on wild ungulates as well as domestic animals. Humans therefore regard lynxes as competitors that kill game and threaten their livestock. To obtain information useful for mitigating these conflicts, we investigated the composition of the lynx diet by analyzing found prey remains and scats and with regard to the season and lynx sex.

This study was part of a lynx research project of the Bavarian Forest National Park and the Šumava National Park conducted from 2005 to 2012. The research covers an area of about 1000 km^2 in the two parks and 4300 km^2 in the surrounding landscape protection areas. These areas provide the core zone of a wildlife refuge for many protected species, such as river otter (*Lutra lutra*), ural owl (*Strix uralensis*), and capercaillie (*Tetrao urogallus*), and particularly for large wildlife species such as red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), moose (*Alces alces*), and lynx (*Lynx lynx*). A more detailed description of the study area can be found in HEURICH et al. 2011. Lynx occurs in the area since its planned reintroduction between 1982 and 1989 in the region of the present - day Šumava National Park (ČERVENÝ & BUFKA 1996).

Material and Methods

Between 2006 and 2011, eight lynxes (four males, four females) were trapped in double- door live traps (BREITENMOSER & HALLER 1993, HEURICH 2011) and fitted with GPS-GSM

collars (VECTRONIC Aerospace, Berlin, Germany). Lynxes were tracked with varied intensity, but at least one position per 24 h was recorded during midnight or midday. If the lynx stayed at least two nights at the same site, this site was controlled for prey remains after the lynx had left. For each found prey, the potential killing date, coordinates, and species were registered. For roe deer and red deer carcasses, the age class based on tooth wear and eruption (1 – 12 months, > 12 months) and the sex were determined when possible. Scats of the lynx were occasionally found during various field activities, e.g., ranger service, checking of resting or kill sites of the lynx, snow tracking, and radio telemetry. We prepared scats for analysis of the prey following the procedure described by JĘDZEJEWSKI et al. (1993). The prey species was identified based entirely on hair analysis. Hairs of mammals recovered in scats were identified by colour, length, and texture (TEERINK 1991), and by comparison with our own hair reference material. The frequency of occurrence of each food item in the scats was calculated according to the formula:

$100 / \sum$ of all occurrences × occurrences of a given food item.

Results and Discussion

We investigated four aspects of lynx dietary patterns: diet composition, seasonal variation in diet composition, sex and age of ungulates preyed upon, and differences in male and female lynx food habits (Table 1). Our results were partly similar to those of other European studies. We found a large number of roe deer in prey remains and scats (Fig. 1), as has also been found in earlier studies of this region (HUCHT-CIORGA 1988, CERVENY et al. 1998, HEURICH & WÖLFL 2002). Considering the trade-offs between the risk of injury while killing prey, the energy expenditure required to pursue prey, and the benefit of obtaining large amounts

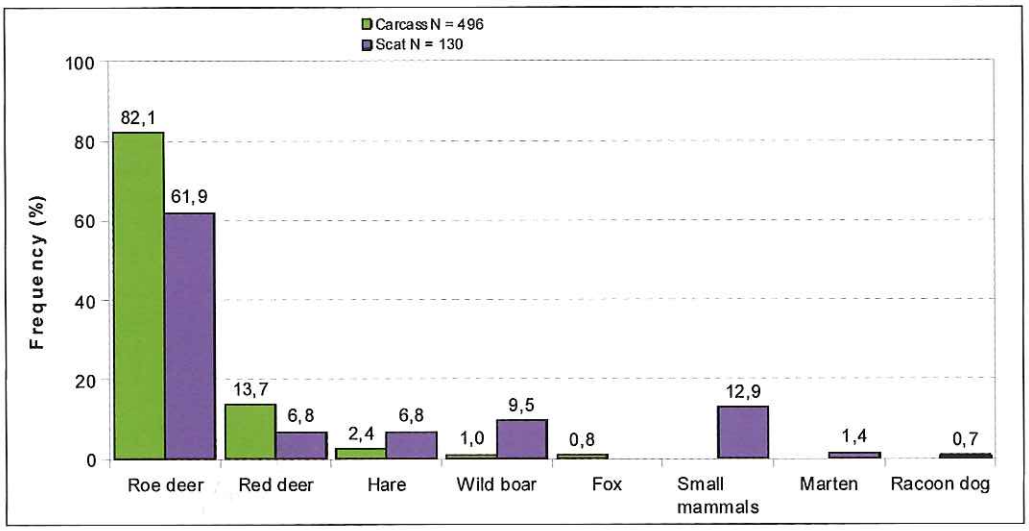

Fig. 1 Lynx diet composition based on analysis of prey remains and scats. Rodents and insectivores were pooled together as „small mammals". Carcasses are plotted as the absolute frequency. Scats are plotted as the frequency of occurrence, i.e., the frequency with which each food item occurs as a percentage of the total number of occurrences of all food items and not as the absolute frequency, i.e., not as the percentage of the total number of scats.

of meat, the roe deer is one of the most attractive prey animals for the lynx and is clearly preferred throughout Europe where the two species appear together (BREITEMNOSER & BREITENMOSER-WÜRSTEN 2008, JĘDZEJEWSKI et al. 1993).

Analyses of both prey remains and scats (Fig. 2) indicated that lynx mostly preyed upon ungulates in both summer and winter, but preyed on more red deer during winter than during summer. Analysis of scats indicated that lynx preyed on more small mammals during summer than in winter; small mammals were not identified in prey remains. Such prey patterns have also been observed in other studies (ODDEN et al. 2006, OKARMA et al. 1997). An explanation for the higher predation on the larger ungulates could be their higher vulnerability in months with snow cover, as suggested by HUCHT-CIORGA (1988) and reported in wolf studies (HUGGARD 1993, OKARMA 1995).

Lynx preyed upon female and male roe deer at similar frequencies, and adults were preyed upon more often than juveniles (Figs. 3 and 5). In contrast juvenile and adult female red deer were killed more frequently than adult males (Fig. 3). These differences in the killing of adult

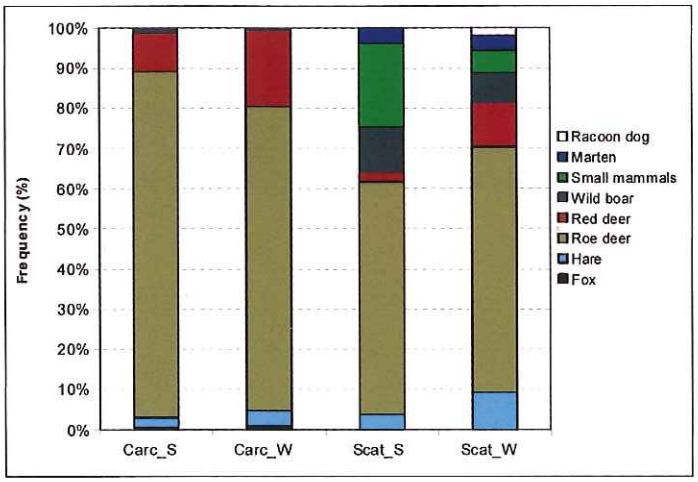

Fig. 2 Comparison of the summer (May – Oct: S) and winter (Nov – April: W) lynx diet based on prey remains and scats. During winter, 148 carcasses were found; 238 were found during summer. The differences between roe deer and red deer preyed upon during the two seasons were statistically significant (carc_S / W (roe / red): Fisher's $p < 0.05$). The differences in all food items between summer scats (N = 81) and winter scats (N = 54) were significant (scat_S / W: Fisher's $p < 0.05$).

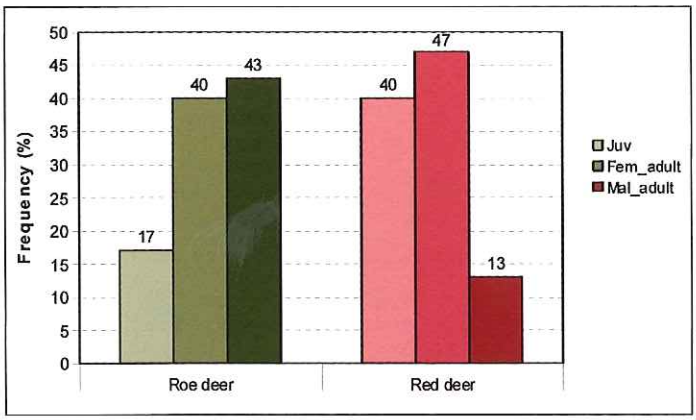

Fig. 3 Distribution of roe deer and red deer kills according to the prey sex and age class (juv: 1 – 12 months, adult: > 12 months).

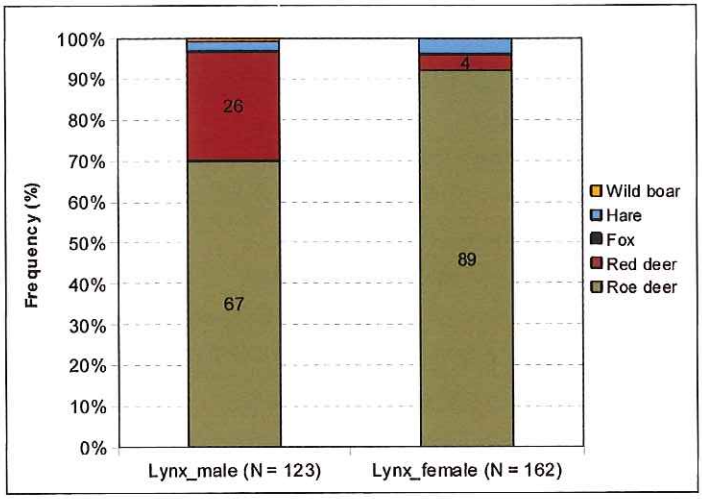

Fig. 4 Composition of prey killed by male and female lynx. The prey was identified in remains; a killing event by a female or male lynx was indicated when the lynx remained at the killing site for a longer period, signaled by GPS - GSM collars. The difference in the proportion of roe deer and red deer preyed upon by male and female lynxes was significant (lynx_male / female (roe / red): Fisher's $p < 0.05$).

male and female roe deer and red deer can be explained by the differences in size of the sexes. Male red deer are larger than female red deer, whereas male and female roe deer are of similar size. Hence both sexes of roe deer are equally vulnerable to lynx and should therefore be killed with equal frequency.

In contrast to the results of OKARMA et al. (1997) and MOLINARI - JOBIN et al. (2002), in our study, ungulates were preyed upon to the same extent by male and female lynx (Fig. 4). Such a predation pattern is more often observed in studies from Northern Europe (SUNDE & KVAM 1997, ODDEN et al. 2006). Also, both sexes of roe deer were preyed upon with equal frequency by male and female lynx (Fig. 5), as also observed by ANDERSEN et al. 2007. In contrast, red deer was more often preyed upon by male lynx than female lynx (Fig. 4), possibly because of the higher weight of the males, which would make it easier for the male lynx to overthrow the even larger red deer.

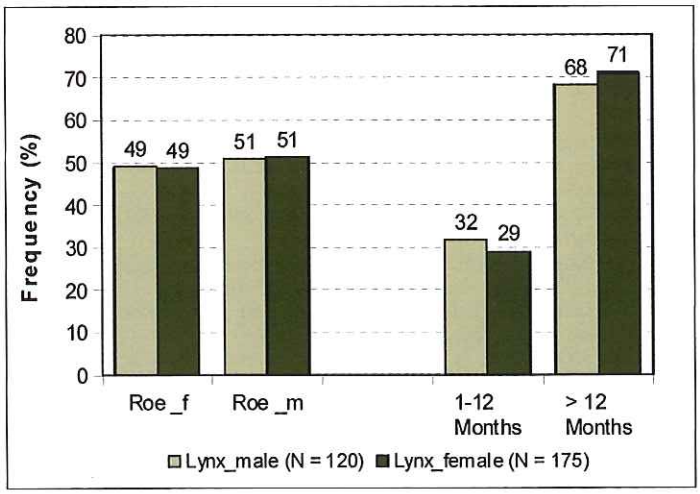

Fig. 5 Comparison of male (m) and female (f) lynx preying on roe deer. The prey was identified in remains; the killing event by a female or male lynx was indicated by the lynx remaining at the killing site for a longer period, signaled by GPS - GSM collars.

Tab. 1 Summary of the results.

Results	Figure
I. Diet composition → remains: mainly roe deer (82 %), followed by red deer (14 %) → scat contents: mainly roe deer (62 %), followed by small mammals (13 %)	Fig. 1
II. Seasonal variation in diet composition → remains: more red deer during winter → scat contents: more red deer and hare during winter → scat contents: more wild boar and small mammals during summer	Fig. 2
III. Sex and age of ungulates preyed upon → roe deer: more frequently adults, both sexes with equal frequency → red deer: more frequently juveniles and adult females	Fig. 3
IV. Differences in male and female lynx food habits → roe deer: no differences between male and female lynx → red deer: more frequently preyed by male lynx	Fig. 4, Fig. 5

The analysis of prey remains and the analysis of scats each has advantages and disadvantages. The location of remains of large prey is signaled via the GPS - GSM collars by the lynx remaining at a site for longer periods. However, smaller prey might be overlooked by the analysis of only prey remains because the lynx might stay only for a few hours at the prey site, thereby not giving any indication that it had killed a prey. Scat analysis is a means to detect such small prey. But the frequency method of scat analysis mainly suffers from the surface – to – volume ratio bias of varying prey sizes (CIUCCI et al. 1996), i.e., large species leave less hair in scats per unit mass consumed than small species. Thus, small mammals are overestimated by the frequency of occurrence data. To obtain a comprehensive understanding of the dietary patterns of the lynx and to even out the disadvantages of the two methods, we recommend analysis of both prey remains and scats.

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