

## Predation on artificial nests in relation to the numbers of small mammals in the Krušné hory Mts, the Czech Republic

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**A b s t r a c t.** The alternative prey hypothesis suggests that generalist predators switch from their primary prey to secondary when the former is scarce. We tested this hypothesis during a two-year study combining data on predation of ground dummy nests and the numbers of small mammal populations in a highly fragmented landscape in the Krušné hory Mts, the Czech Republic. A significant decrease of small mammal numbers between 2002 and 2003 was followed by a considerable increase of predation on artificial nests from 34% to 76%. Most of the nests (64.7% of the documented cases in 2002) were predated by medium-sized mammals such as marten and fox, common in our study area. Only 8.8% were predated by avian predators (corvids) occurring infrequently in our study area. The results support the alternative prey hypothesis and suggest that in the Krušné hory Mts the nesting success of ground nesting birds may vary strongly from year to year depending on the cycle phase of small mammals, the main prey of dominant predators.

**Key words:** alternative prey hypothesis, fragmented landscape, predation pressure, vole cycles, *Tetrao tetrix*, *Vulpes vulpes*

### Introduction

The predator-prey hypothesis as mathematically described by the Lotka and Volterra model suggests oscillations in population numbers of predators in relation to the fluctuations of their prey (B e g o n et al. 1990). The alternative prey hypothesis suggests that non-specialised predators may switch from their primary, cyclic prey to secondary (alternative) prey when the former is scarce and may then cause changes in its numbers (L a c k 1954, A n g e l s t a m et al. 1984, H ö r n f e l d t et al. 1986, M o s s & W a t s o n 2001). For example, results of a nine year experiment conducted in the Northern Baltic, M a r c s t r ö m et al. (1988), confirmed that a link between vole and tetraonid numbers was mediated by red foxes (*Vulpes vulpes*) and pine marten (*Martes martes*). Similarly in a time series of 27 years in Sweden, K j e l l a n d e r & N o r d s t r ö m (2003) demonstrated that this hypothesis is applicable to the system involving red foxes, microtine voles and roe deer (*Capreolus capreolus*) fawns.

The above mentioned studies have concentrated on the influence of mammalian predators on adults and broods, however we may theoretically also expect a similar effect on nests. Such an idea is supported by the results of monitoring of small mammal occurrence, their predators, especially arctic fox (*Alopex lagopus*) and the predation of wader (Limicolae) nests in the tundra of Russia in 1996 and 1997 (T o m k o v i c h & Z h a r i k o v 1997,

1998). Similarly, a link between lemming cycles and nesting success of geese (*Anser albifrons*, *A. caerulescens* and *Branta canadensis*) was found in the Canadian High Arctic (Bêty et al. 2001, Wilson & Bromley 2001).

Most existing studies on predator-prey relationships have been done on guilds of predators and prey species in boreal and tundra ecosystems with marked seasonal oscillations in weather conditions and population numbers. However, Saniĝa (2002) refers to the mediating effect of small mammal cycles on nest survival of capercaillie (*Tetrao urogallus*) and hazel grouse (*Bonasa bonasia*) in forested mountains of Slovakia, Central Europe, between 1983 and 2001. Although cycles are more prominent in northern areas and disappear towards the south (Hansson & Henttonen 1985), Tkadlec & Stenseth (2001) found that there exists a geographical gradient from more stable northerly populations of the common vole (*Microtus arvalis*) in coastal Poland to cyclic populations in the southernmost parts of the Slovak Republic, i. e. in a reversed pattern than was previously found in Fennoscandia. A clear link between rodent abundance and mallard nest predation rates has also been reported in marshlands in California (Ackerman 2002).

The aim of the present study was to assess the differences in predation pressure on artificial ground nests in a highly fragmented and deforested landscape of the Krušné hory Mts, Northern Czech Republic, between two consecutive years differing in small mammal abundances. We selected black grouse (*Tetrao tetrix*) nests as similar as possible. Black grouse is an abundant species in the Krušné hory Mts with a population of approximately 400–450 lekking males observed in 2000 (Málková 2000) and may thus represent a suitable model for our experiment. The use of artificial nests allowed us to eliminate potentially confounding effects other than the predation pressure on nests (e. g. the restricted food supply for incubating females as suggested by Hörnfeldt et al. 1986). We tested whether the difference in nest predation and small mammal abundance is negatively correlated, as a possible result of different feeding activities of the prevailing predators in compliance with the alternative prey hypothesis.

## Study Area

The experiment was conducted in the Eastern part of the Krušné hory Mts, the Czech Republic. The study area of 33 km<sup>2</sup> was situated between the villages Klíny, Český Jiřetín and Dlouhá Louka (50°38' – 50°42' N, 13°33' – 13°39' E, 750–870 asl.).

Under the long-term impact of industrial emissions, spruce (*Picea abies*) growths began to dieback during the 1970's, while small islands of full-grown spruce and beech (*Fagus sylvatica*) have been preserved at some locations. Even though forest regeneration has so far been carried out in most air-polluted regions, the reforestation process has not been successful in some areas due to the presence of the expanding bushgrass *Calamagrostis villosa* causing natural succession slowdown (Šýkora 1983). This process has caused a high fragmentation of the landscape composed of preserved patches of old growths alternating with open habitats (meadows, pasture fields, clearcuts) and different-aged young coniferous and mixed growths. They are composed of artificially planted *Picea pungens*, *P. abies* along with a lower proportion of *Betula alba*, *Sorbus aucuparia*, *Larix decidua* and *Pinus contorta*, with a well developed herb layer of dominating bushgrass on xeric sites. Furthermore, the area is interspersed with a forest infrastructure used by forest managers and a centrally passing state road.

## Material and Methods

### Sampling of small mammals

Small mammals were captured using the snap trapping method with a species non-selective bait. Within the young coniferous and mixed growths, the trapping was conducted on three sites (three replicas) using the quadrat method of 100 x 100m with a regular pattern of 121 trapping points in which a total of 242 traps were installed (two traps per point). Moreover, additional habitats were monitored applying the line method: beech woodland in the edges of emission affected growths (5 lines), meadows (1 line) and emission clearcuts (1 line). The linear traps were laid every 5 meters, 100 traps per one line. The traps were controlled and baited daily, always for a period of three days. A total of 10 sites (3 areas and 7 lines) were monitored. During both years, we adhered to the same site, timing (June), exposition time and the number and placement of traps.

### Design of the nest experiment

The artificial nests were constructed by digging small ground depressions laid out with small amounts of dry plant material. Each nest was baited with two domestic hen eggs, one of which was filled with wax for predator identification in 2002. Each wax egg was fixed in the nest pit with a string and nail, preventing egg loss by being carried away by the predator. Each nest location was marked with a short (20 cm) piece of flagging tape at a distance up to 5 m from the nest and, when possible, at the observer's eye level.

The nests were installed in young growths of 10–30 years which probably represent one of the black grouse's most typical nesting habitat within this study area (Š í m o v á 1996). Nests were laid close to coniferous tree branches reaching to the ground and remained conspicuous, i.e. to be visible by at least 75% from an above vertical view.

The mean distance between adjoining nests was > 100 m (the minimal distance 50 m) to minimise the probability of nearby nests being discovered by an intensively searching predator. Nests were evenly distributed along habitat edges and interiors in the same manner in 2002 and 2003. A habitat edge was defined as a 5 m strip of the habitat from its boundary with an adjacent one. As a habitat interior we considered the remaining inner area of the habitat but at least 50 m from the edge.

This study was a part of a more complex experiment which included 300 artificial nests constructed in the same manner in three habitats (mature forest, young growths, open landscapes) in 2002 and 276 nests in only one habitat (young growths) in 2003. Predation on the nests did not differ significantly among habitats in 2002 (unpublished data). However, only nests installed in that year in young growths are analysed in this study.

Habitats and distances were read from digital aerial orthophotomaps using the GIS software (ArcView GIS 3.2a; Environmental System Research Institute, Redlands, California, USA). First, the nests were distributed digitally and consequently, their geographic coordinates were applied into the GPS. In the field, the nests were installed by leading the workers according to these GPS coordinates, which ensured the retaining of all preliminarily defined habitat and distance criteria.

The experiment was initiated during the second week of June, which approximately corresponds to the black grouse's incubation period in the Czech Republic (H u d e c & Č e r n ý 1977). All nests were installed during the daytime within a period of four days.

Rubber boots were used with the aim of eliminating human scent. Each nest was checked only once within a 21-day exposure period, which also coincides with the mean length of the species' incubation period. A nest was considered depredated if at least one of the two installed eggs was damaged, removed or completely missing.

## Identification of potential predators

Predators of artificial nests (bird vs. mammal or a particular species) were identified by tooth or beak marks left on the wax eggs or, in some cases, from egg remains, which were compared with marks simulated by the skulls of potential mammalian predators (Nour et al. 1993). We distinguished among red fox, pine marten, small mammals of unknown species, an unidentified mammal, a corvid and an unidentified (avian or mammal) predator. Nest visits by small mammals, which prey on nests of passerine birds (Bureš 1997) leaving specific imprints of miniature teeth in the wax and fine wax grit inside the nest (13% nests in the sample) were excluded from the analysis because they were not considered as substantial predators of black grouse nests.

## Results

### Small mammal abundance

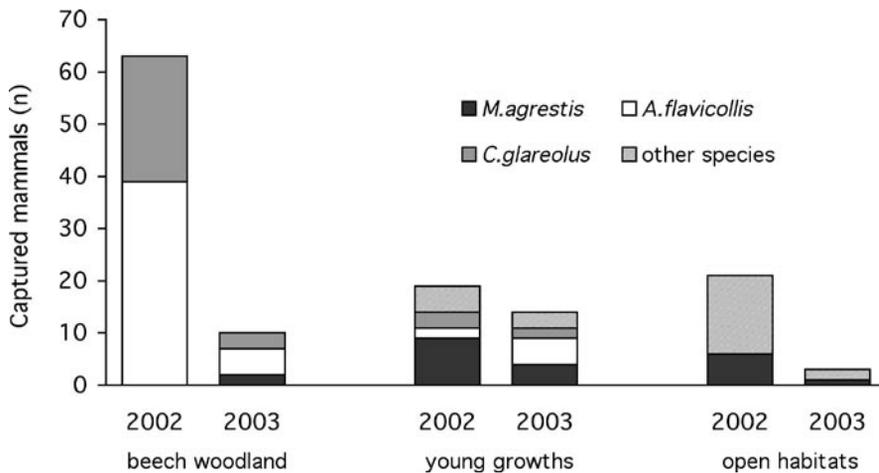
During the June trappings of 2002 and 2003 a total of 130 individuals of seven small mammalian species were captured, 103 (79.2%) in 2002. The dominant species were *Apodemus flavicollis*, *Clethrionomys glareolus* and *Microtus agrestis*, representing 39.2%, 24.6% and 16.9% (80.7% in total) of the sample, respectively.

The comparisons of all sites revealed a highly significant decrease of overall abundances of small mammals between the two years (Wilcoxon signed ranks test,  $Z = -2.675$ ,  $n = 10$ ,  $P = 0.007$ ). The most marked decline was found in *C. glareolus* (by 84.4%; Wilcoxon signed ranks test,  $Z = -1.848$ ,  $P = 0.065$ ). The abundance of *A. flavicollis* dropped by 75.6%, however not on all sites, therefore its decline was not proved to be significant in the total sample ( $Z = -1.577$ ,  $P = 0.115$ ). The smallest decline was recorded for *M. agrestis* (by 53.3%,  $Z = -1.378$ ,  $P = 0.168$ ). The small mammal abundance declined more visibly in beech woodland, on meadows and emission clearcuts than in young spruce growths (Fig. 1).

### Nest predation

The predation rate on artificial nests was monitored on a sample of 100 nests in 2002 and 276 nests in 2003. The predation within growth edges was comparable with that of the inner growths both years combined (61.6% and 67.5%,  $\chi^2$  with the Yates correction = 1.2,  $df = 1$ ,  $P = 0.27$ ), contradicting the impact of the edge effect and thus allowing the fusion of inner growth and edge nests for further analysis.

In 2002, 34% of the nests were predated, while this proportion increased to 76% in 2003 ( $\chi^2$  with the Yates correction = 55.9,  $df = 1$ ,  $P < 0.001$ ). From the 34 destroyed nests in 2002, only 8.8% (3 nests) was predated by an avian predator, while a medium-sized mammal predated in 64.7% of the cases (22 nests). The fox was proved to have predated nests three times more frequently than the marten (23.5% versus 8.8%). However, the predator remained unidentified in 26.5% of the cases, therefore the actual proportion may be slightly different.



**Fig. 1.** The overview of captured small mammals within the monitored areas of the Krušné hory Mts between 2002 and 2003. Open habitats include both meadows and emission clearcuts.

## Discussion

A highly significant decrease in small mammal abundance occurred between 2002 and 2003, at least when comparing the total samples. The non-significance of the decline of individual species may have been caused either by the overall small sample size, which decreased the power of the test, or the abundance oscillations may only have varied locally. However, nothing points to the hypothesis that generalist predators such as the fox and marten, which prevailed as predators of artificial nests, distinguish between individual small mammalian species when hunting. The significant increase in artificial nest predation by more than twofold may be satisfactorily explained by the stronger searching activity of predators in a landscape deprived of their main prey supply.

The guild of avian nest predators in the Krušné hory Mts is considered to be small compared to open agricultural landscape, especially due to the absence of abundant populations of large corvids such as the crow (*Corvus corone*) and black-billed magpie (*Pica pica*) (unpublished data). On the contrary, we have found foxes and martens as common predators in the study area (own observations). Especially foxes fed on insects and small mammalian species which were their main prey also on study plots (Klitsch 2000). Omnivorous corvids probably do not so tightly respond to fluctuating numbers of small rodents as do mammalian predators.

The results obtained in this study support the alternative prey hypothesis. We may assume that due to the prevalence of medium-sized mammalian predators, especially the fox, which is considered to be the main predator of nests and chicks of forest grouses (Selås 1998), ground nesting bird species, such as the black grouse, woodcock (*Scolopax rusticola*) or snipe (*Gallinago gallinago*), regularly nesting in the Krušné hory Mts (Štátný et al. 1997) may have had a lower nest survival in years of lower population densities of small mammals. However, the higher predation rate in 2003 may not be the result of a specific search for nests as an alternative food source. Wider spatial activity of predators followed by higher incidental predation in years of low rodent abundances would provide similar trend

(Vickery et al. 1992). Alternatively, the large increase of nest predation from 2002 to 2003 could be explained by significant year to year changes in numbers of medium-sized mammalian predators. However, sharp changes in numbers are perhaps more likely to occur in small mammals or over a longer-term (more than one year) period (cf. Selås 1998, Kauhala & Helle 2002).

The findings of this study may help to determine recommendations for nature conservationists and forest managers in minimising their efforts to extensively reduce the numbers of small mammals. Their decline may easily lead to a dramatic increase of predation pressure of larger mammals on nests of ground nesting avian species. Furthermore, other life stages such as nestlings or adults may also be similarly affected, even though we know that the influence of predators may vary markedly between these groups (Kauhala & Helle 2002).

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