



ORIGINAL INVESTIGATION

**Effect of felling on red fox (*Vulpes vulpes*) and pine marten (*Martes martes*) diets in transitional mixed forest in Belarus**

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**Abstract**

In transitional mixed forests in northern and central Belarus the influence of intensified felling on the diets of red foxes *Vulpes vulpes* L. and pine martens *Martes martes* L. was investigated in two model forested terrains with sandy and clay top-grounds. A total of 1904 scats of red foxes and 1624 scats of pine martens were analysed over two periods differed by logging rate. When logging rate was conservative, red fox and pine marten diets were found to be similar, but under heavy logging feeding of the predator species shifted. In both model woodlands we found the same pronounced dietary trend of higher consumption of rodents, first of all, *Microtus* voles. The dietary changes were well related to the registered increase in *Microtus* vole numbers and total number of rodents in felling areas. The increased preying on rodents caused lower consumption of other food items, particularly medium-sized mammals (year-round) or/and birds or/and fruits (in the warm season) or/and mammalian carrion (in the cold season). In the conditions of intensified felling the food niches of the red fox and pine marten diverged mostly because of the great difference in the species structure of rodents consumed. Red foxes turned to preying on *Microtus* voles more frequently, but less on bank voles *Myodes glareolus*; while pine martens increased their taking of *Microtus* voles, continued foraging for bank voles and began taking slightly more of *Apodemus* mice. Before heavy logging dietary similarity between the red fox and pine marten was high and did not vary considerably through seasons and study areas, whereas after felling was intensified their diet overlap became lower.

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**Keywords:** *Vulpes vulpes*; *Martes martes*; Feeding ecology; Clearcut; Belarus

**Introduction**

In the European forest zone, woodlands are known to be considerably altered by felling. In Belarus, particularly

heavy impact of logging on forest ecosystems took place in the second half of the twentieth century. Nevertheless, in Belarus, as far back as 10–20 years ago many of woodlands looked lowly disturbed by forestry practice. Since the second half of the 1990s forest exploitation has been markedly intensified. Recent clearcuts appeared in numbers and occupied a substantial part of woodlands. In Belarus, intensified forest exploitation has turned to be patchy because of irregular distribution and different quality of forest roads.

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The red fox *Vulpes vulpes* and pine marten *Martes martes*, being common in woodlands and characterized by high feeding plasticity, respond quickly to ecological changes in forested terrain (e.g. Jędrzejewski et al., 1993a; Jędrzejewska and Jędrzejewski, 1998; Sidorovich et al., 2005, 2006a) and, therefore, appear to be suitable subject for investigating the felling impact on animal ecology. In Belarus and surrounding regions, both predators are found to consume small rodents more when the prey group grows in numbers (e.g. Jędrzejewski and Jędrzejewska, 1992; Jędrzejewski et al., 1993a; Sidorovich et al., 2005, 2006a). Intensified forest exploitation influences population density of the majority of rodent species (Hansson, 1978; Wołk and Wołk, 1982; Kirkland et al., 1985; Aksenova and Bulyuk, 1986; Carey and Johnson, 1995; Bryja et al., 2002; Sidorovich et al., 2008a). It shifts prey supply and diets of red foxes and pine martens and, consequently, may underlay the revealed changes in the predator numbers in recently logged woodlands (Sidorovich et al., 2008a).

The influence of forest exploitation on spatial population structure of the pine marten and red fox has been already investigated in several countries (Hargis, 1982; Steventon and Major, 1982; Thompson, 1986; Snyder and Bissonette, 1987; Bissonette et al., 1988; Hansson, 1994; Henttonen, 1989; Oehler, 1995; Kurki, et al., 1998; Virgos et al., 2002) including Belarus (Sidorovich et al., 2008a). In our mentioned study, red fox numbers was found to grow clearly with the increase in portion of recent clearcuts. Moreover, red fox trails were more frequently registered in clearcuts and their ecotones compared to low-disturbed forests. As to the pine marten, mild logging appeared to be beneficial for the species, but martens decreased in density in response to very intensive felling rates.

The recorded changes in prey supply and distribution of predator species in woodlands strongly altered by forest exploitation suggest that changes in the diet of predators should occur. Still there is a lack of studies on change in red fox and pine marten diets connected with logging. Nevertheless, such a question is worthwhile being investigated, as changed feeding of common predators could shift their predation impact on prey populations and interactions with other predators (Andren et al., 1985; Angelstam, 1986; Andren and Angelstam, 1988; Henttonen, 1989; Fahrig and Grez, 1996; Jędrzejewska and Jędrzejewski, 1998; Kurki et al., 2000; Krebs et al., 2001; Panzacchi et al., 2007a; Wegge and Kastdalen, 2007).

## Material and methods

When describing the study areas, besides general geographic description, we paid attention to the revealed patterns of rodent distribution, as the study is addressed to the red fox and pine marten that are both rodent

eat. Woodlands in northern and central Belarus mostly consist of deciduous small-leaved and coniferous trees. Such a mixed woodland is transitional between boreal coniferous forest and more southern broadleaf or coniferous-broadleaf forest. Seed crop in transitional forest is steady, but markedly lower than that in more southern broadleaf woodland of Europe (Jędrzejewski and Jędrzejewska, 1996). Therefore, in transitional woodlands, food supply for rodents is markedly more sustained on multiannual scale and populations of forest rodent species have only seasonal fluctuations with no recurrent cycles of outbreaks and crashes (Jędrzejewski and Jędrzejewska, 1996; Sidorovich et al., 2003, 2005). Conversely, in more southern woodlands of Europe, prevalence of masting broad-leaved trees, which produce intermittently a big amount of nourishing seeds important for rodents, leads to a pronounced cyclicity in forest rodent populations (Jędrzejewska and Jędrzejewski, 1998). Only *Microtus* voles favouring open grasslands and occurring rarely in forest habitats have intermittent between-year population dynamic with a periodicity of 4–5 years (Sidorovich et al., 2003, 2006a).

The data were collected in two areas substantially differing in top grounds that resulted in considerably different habitat carrying capacity for rodents and other prey (Solovej et al., 2001, 2003). The first study area (Minsk and Smolevichi district, Minsk region, central Belarus; 53°N, 27°E) was a densely forested terrain of 48 km<sup>2</sup> surrounded by a rural area. Surface ground deposits are rich in clay, which ensures good water supply and abundant trace elements, and, consequently, rich soil (hereafter “clay” area). Plant communities in the “clay” area have a high species diversity and productivity, and habitats with high carrying capacity for herbivores dominate. Therefore, species richness and population biomass of rodents in the “clay” area are high (Sidorovich et al., 2003). Before 1998 mature forests dominated by spruce made up about 60% of the woodland structure, and recent clearcuts, which are largely overgrown with grass or additionally covered with early reforestation, constituted less than 10%. In this woodland harboring on rich clay soil, rather high species diversity and biomass of herbal vegetation usually appeared in a year after felling. That immediately favours rodents, and their species richness and density markedly increased (Sidorovich et al., 2008a). To separate recent clearcut with some reforestation and already young forest, we used the feature of evident suppression of grass cover by thickening of young trees as a formal border. Besides mature spruce stands and recent clearcuts, remainder of the woodland (approximately 27%) was represented by mixed coniferous-deciduous forests. Among such mixed forest habitats, young thicket, mid-successional overgrowth and mature stands were present. Small glades with meadows were interspersed throughout the woodland. Intensive felling operations ran from autumn 1998 till the end of our study

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