Importance of winter rape for small rodents

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ABSTRACT

Winter rape stands are important habitat for the common vole (*Microtus arvalis*) and the pygmy field mouse (*Apodemus microps*). In autumn, the common vole is dominant in this habitat (*D* = 75%) and reproduces in it (17% of population). This species also dominates the small mammal community of winter rape in early spring (*D* = 87%), and its reproduction begins in this habitat early; under suitable meteorological conditions 44% of the population of common vole reproduce in March. Analyses of the spring and autumn diet of *M. arvalis* in winter rape have shown that green leaves of this species form the dominant component of its diet. During the period when the rape crop is ripening, the population abundance of the common vole decreases as green food at ground level decreases. The pygmy field mouse (*A. microps*) has a contrasting response to winter rape, and it is almost absent from the rape crop from autumn to late spring. However, when winter rapeseeds begun to ripen, the pygmy field mouse concentration in this habitat is in large numbers (dominance *D* = 76%) and rapeseeds dominate its diet (*v*% = 72). After the harvest of winter rape, when shed seeds begin to grow, both small mammal species live for some weeks on rape plots.

Keywords: *Brassica napus*; *Microtus arvalis*; *Apodemus microps*

Over the past 10 years the area of oil-bearing crops under cultivation was in the Czech Republic about 15% of arable land (about 400 000–450 000 ha). The most important oil-bearing crop is winter rape (*Brassica napus*), which is grown on 325 000–350 000 ha. It is a high yield crop, likely to be favoured under European Union agriculture policy. Consequently, we focused on the presence and development of the population density of small rodent species in association with this crop. Small mammal species were previously trapped in South Moravia rape crops but the area under rape cultivation was small and the results have served principally as pilot studies (Zejda and Nesvadbová 1996). Thus far, little attention has been paid to this crop as a habitat for small rodents. State plant protection workers biannually monitor the numbers of rodent burrows in the most important crop species including winter rape. However, burrow numbers in the autumn and spring relate only to the most widespread rodent, the common vole (*Microtus arvalis*). Also Truszkowski (1982) is concentrated on the impact of this species on some selected crops in agro-ecosystems. Among other crops his research also deals with the winter rape and the vole possible impact on it. The presence of other rodents from the genus *Apodemus*, which are also abundant in arable land, are omitted from surveys because their highest abundance in the rape is concentrated in the time of rape seed ripening.

Our study was also concentrated on the diet of two most common species in winter rape, *Microtus arvalis* and *Apodemus microps* in southern Moravia agrocenoses. Common vole colonises an extensive spectrum of habitats and is able to adapt its diet to various crops. In its native steppe-type habitat a variety of different parts of grasses are consumed (Zapletal et al. 2001). Its diet is dominated by the green parts of plants, but in summer, autumn and winter it also consumes seeds (Holišová 1959). The pygmy field mouse (*Apodemus microps*) is a seed eating species (Holišová 1960, Holišová et al. 1962).

Our aim was to determine to what extent winter rape was suitable as habitat for the rodents under this study, from the point of view of their feeding ecology. The field study was complemented by the laboratory feeding trials with the purpose of explaining the impact of dominant species of rodents and estimates the possible losses of the

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crop to rodents. In the future research would be concentrated on field studies in relation to the rodent's population dynamics and impact on rape production.

MATERIAL AND METHODS

Winter rape crop fields were studied in South Moravia. The study area was 46 km^2 with a small proportion of forested areas (4%) with arable land predominating. The annual mean air temperature in the study area was 9.5°C and the annual total precipitation 545 mm.

Small rodents were trapped in snap traps baited with fried wick. The traps were laid in lines of 20 traps each, with traps spaced 5 m apart (the total length of each trap line was approximately 100 m). Trapping was conducted over the course of the year to take a representative sample of the population dynamic of the rodents in relation to the crop phenology. In autumn after germination when leaves rosette is developed (E), in spring on the beginning of prolongation growth (A), flowering starts (B), and before harvest (C). Attention was paid also to the period after harvest (D), when stubble was not yet ploughed and shed seeds had begun to grow and weed infestation started. As the common vole population express fluctuation, the years with extreme densities (minima and maxima of population number) were eliminated. The relative abundance (*rA*) of rodents was calculated as number of individuals caught on 100 traps per 1 night. The dominance (*D*) was calculated as the proportion of individuals on each species in the total catch of all rodents (as percentage). The trapped rodents were screened in the normal way and their sexual activity was identified (Zejda et al. 2002). The stomachs of captured individuals including their content were weighted and frozen until processing diet analyses in laboratory.

The diet of the common vole (*Microtus arvalis*) and pygmy field mouse (*Apodemus microps*), was examined by microscopic analysis of the stomach contents, with the percentage volume (*v*%) of individual items estimated (Obrtel and Holišová 1974). In addition the regular spring and autumn reports of plant protection workers from the years of 2000 to 2002 were evaluated. The number of active burrows was estimated per hectare. Active burrows were those with either food inside, fresh droppings, or freshly dug soil heaped outside. For comparison, the numbers of active burrows in winter wheat and alfalfa were also evaluated.

Three pairs of adult and sub-adult, non-breeding common voles and pygmy field mice were exposed to experimental feeding trials to determine the amount of winter rape consumed per day (common vole eat the vegetative parts and the mouse the seeds). For statistical evaluation Statistica for Windows was used. The differences in the numbers of burrows in three crops were calculated using the Mann-Whitney *U*-Test.

RESULTS

Dynamics of rodent abundance in the course of the year and its dominance (Figure 1)

In the autumn, when the winter rape was in the shape of a rosette, the fields were first colonised by the common vole. Its population dominance (*D* = 75%) and its relative abundance (*rA* = 6) were high. In this period, 17% of the common vole population was still engaged in reproduction. The abundance of the pygmy field mouse was low (*rA* = 2).

In spring, when winter rape began to grow (March) common voles dominated (*D* = 87%) and its relative abundance was high (*rA* = 13). At this time, 44% of population was sexually active. When rape started to flower, the importance of the crop to common voles lowered (*rA* = 7) and in time of ripening, before harvest its abundance (*rA* = 3) and dominance were low. In this period the pygmy field mouse dominated (*D* = 76%) with a high abundance (*rA* = 13). Because the food supply of seeds was high, the wood mouse was also presented (*D* = 6%). After harvest, when stubble weed infestation started and shed seeds began to grow, pygmy field mice remained the dominant species (*D* = 73%) with a high relative abundance (*rA* = 16). Common voles were less abundant (*D* = 23%), and wood mice sporadically appeared. After ploughing and when winter rape was newly sown it was again colonised initially by the common vole.

Foraging strategy of small rodents in winter rape

Winter rape over-winters as a rosette of leaves that provide the common vole during the winter with a high quality and easy accessible food (94% on average by volume in the diet from autumn – E to spring – A period, Figure 2) and cover. Voles attacked the sappy parts of the leaf blades and avoided the stems. When rape starts to flower it also begins to lignify, with leaves close to soil drying and the biomass of green parts of the plants decreasing. At this time voles also consume the stems and lignified parts of the plant. During ripening, rape was eaten in smaller amounts by the common vole and the consumption of weed increased. However, rapeseeds formed a dominant item in the diet of the pygmy field mouse (72% on average by volume in the diet, Figure 3). Other dietary items included

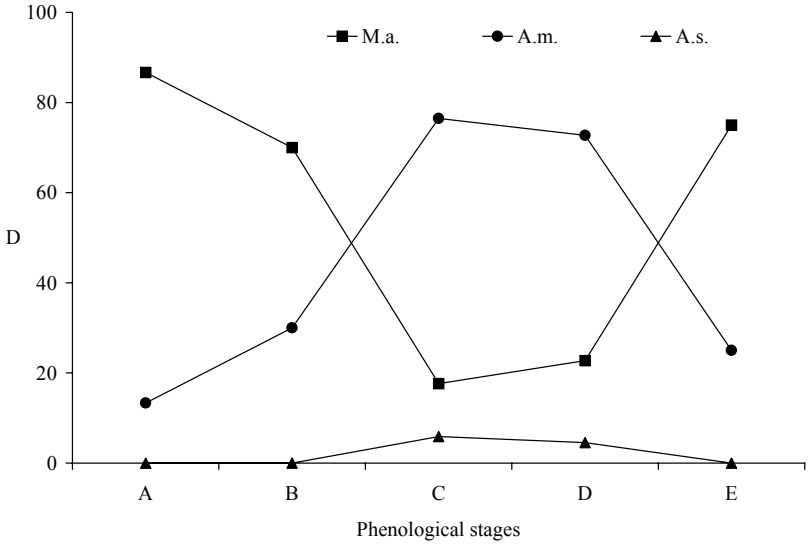

Figure 1. Dominance of small rodents (M.a. – *Microtus arvalis*, A.m. – *Apodemus microps*, A.s. – *Apodemus sylvaticus*) in winter rape fields in relation to its main growing phases

the seeds of weeds and animal food. In the period after harvest, weed seeds predominated (93% by volume). Common voles also fed on rape at this stage, and 60% of the diet by volume was seedling rape, which continued until fields were ploughed. The trend of vole consumption of rape during the year was downward that of weed leaves upward one (Figure 2).

Fluctuation of the burrow numbers (Figure 4)

The presence of small rodents (in this case the common vole) in crop fields was indicated by the number of active burrows. The number of active burrows counted in spring (March to April) and autumn (October) were compared for winter rape, alfalfa and winter wheat to determine which crop is able to support the wintering rodents best. The differences between the autumn and spring numbers of burrows were low in rape and highest in alfalfa fields (Table 1). The lower differences indicate better conditions and lower mortality in winter rape for common vole overwintering population. Low number of burrows in autumn 2002 was due to extreme meteorological conditions in the second half of the growing season and these data were not statistically compared.

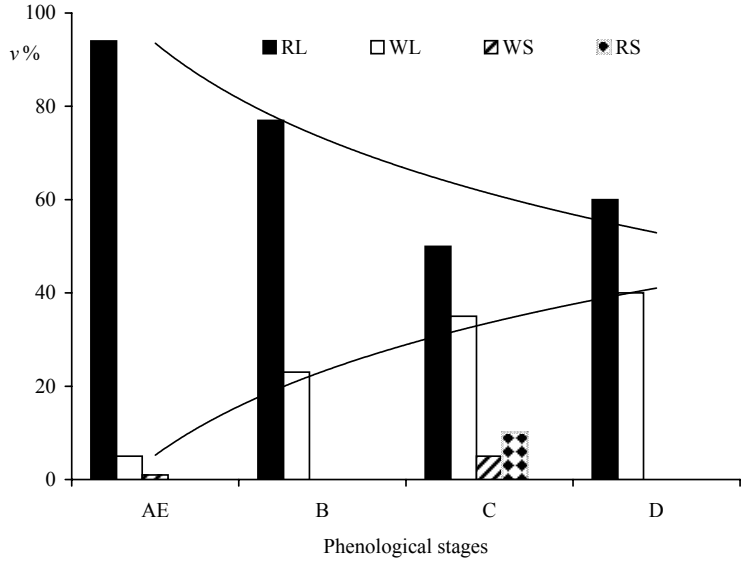

Figure 2. Diet of *Microtus arvalis* in winter rape fields in relation to its main growing phases (RL – rape leaves, RS – rape seeds, WL – weeds leaves, WS – weed seeds)

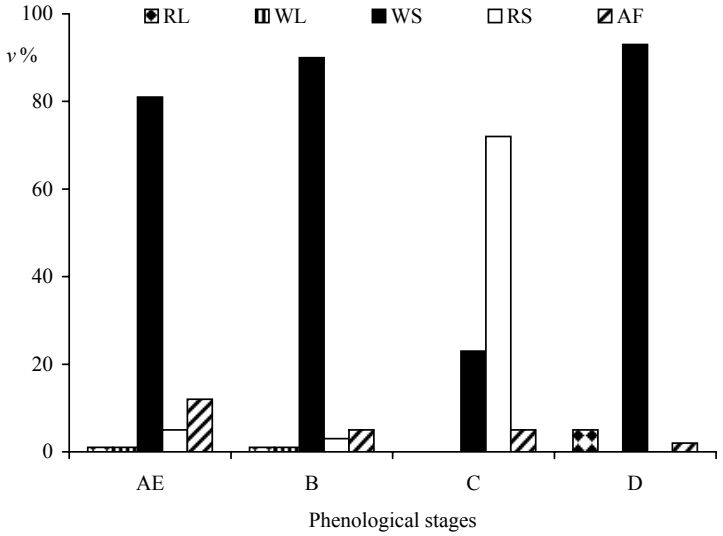

Figure 3. Diet of *Apodemus microps* in winter rape fields in relation to its main growing phases (RL – rape leaves, RS – rape seeds, WL – weeds leaves, WS – weed seeds, AF – animal food)

Food supply, feeding trials and approximate estimation of losses

Food supply for common vole was investigated in the winter rape fields. The parts of fields without the vole presence were evaluated. Forty-nine plants were counted per l m^2 on average (30–55, *SD* = 48.82) and their biomass was 1.6 kg/m^2 (1–2.10, *SD* = 0.28). Each plant with average weight 33 (25–45, *SD* = 6.69) g had 3–15 (10 on average, *SD* = 3.37) leaves.

Feeding experiments were completed on common voles and pygmy field mice from the autumn population. The weight of individual voles was 18 to 23 g (20 g in average, *SD* = 1.91). The average consumption of green biomass consumed was 21.5 g (18 to 25 g, *SD* = 2.46) each day.

Voles consumed the winter rape in the rosette growth stage for about 6 months, with one vole being able to consume 3870 g. This biomass was from about 117 rape plants. This estimate excluded the loss of biomass due to wastage (omitting the leaf stem) and ignored a lower consumption rate during the winter.

Before the winter rape harvest, siliqua numbers on single plants were estimated. There were 90 (65 to 115, *SD* = 16.18) siliqua having 18 (15–20, *SD* = 1.59) seeds on one plant on average. The weight

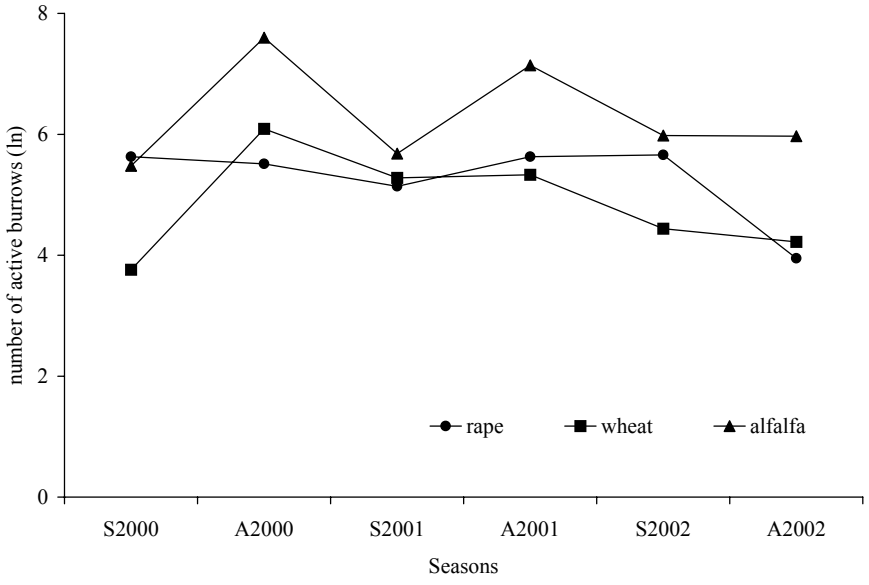

Figure 4. Numbers of burrows (*n*/ha) in three crops important for common vole overwintering in the years 2000 to 2002 (A – autumn, S – spring)

Table 1. Differences in the number of burrows in autumn (A) and in the following spring (S) in three crop fields

	N	A2000:S2001	A2001:S2002
Winter rape	704	NS	NS
Alfalfa	376	***	***
Winter wheat	968	***	**

$^{NS}p > 0.05$ (nonsignificant differences), $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

of 1000 seeds was 5 g. The yields of seeds would be than about 8.1 g per plant.

In the feeding experiment, the weight of pygmy field mouse was 15 to 20 g (17.3 g on average, *SD* = 2.08). One individual ate 1.4 to 3 g (2 g on average, *SD* = 0.58) of rapeseed each day. Preference for rapeseeds was estimated by comparing the amount of rapeseed consumed with that of wheat – a highly preferred food item. Differences were not statistically significant ($n = 20$, $p = 0.08$) and so the rapeseed appeared to be also a preferred food item in the diet.

Based on consumption rates of pygmy field mice, we estimated that the seeds of one plant were consumed during 4 days. The presence of this species in the ripening rape crop was estimated to be for about 20 days during which seeds from 5 plants were calculated to be eaten. This calculation was approximate and did not including wastage (not all seeds were always eaten, with the best-developed siliqua preferred).

The weight of stomachs

In 2000 in Southern Moravia (Hodonice locality) in the winter rape crop, a high population density of small mammals was recorded. After application of rodenticides, cadavers of 114 animals were obtained. The stomachs were weighed and the diet analysed under the microscope. The average weight of stomachs was 2.28 g (0.8–4.6, *SD* = 0.88). This estimate corresponded to the 10.4% of their body mass on average. This body/stomach ratio was compared with one obtained from an alfalfa field. It was significantly higher in the rape crop ($p < 0.001$), suggesting that food consumption in winter rape at the beginning of the reproductive season was intensive.

DISCUSSION

In recent years the area of arable fields sown with rape has increased and this crop has become economically highly important (Vašák 2000, Volf 2002). The population dynamics of rodents in a rape field was, like that for other crops, influenced by diet supply specific to the crop species (Zejda and Nesvadbová 2000) and its changes over the course of the year.

According to forage analysis tables (Sommer 1994) the nutrition in the leaf blades varies during growth. In spring, the amount of nitrogen in leaves was highest (NL = 171 g/kg) and that of crude fibre lowest (194 g/kg). With successive stages of growth, flowering and seed development, the amount of nitrogen was lower (NL = 144 g/kg) and crude fibre higher (273 g/kg). The common vole utilized rape most at the stage of highest nitrogen content and lowest crude fibre. The seeds of rape were highly nutritive (Zeman 1995, NL = 207 g/kg) and oily seeds are consumed and also stored by the *Apodemus* sp. and can support its population during winter.

Many previous studies have dealt with the problem of the glucosinolate content in the green parts and seeds of rape and its negative influence on livestock and game ungulates. Studies by Van Etten and Tookey (1979), Kalač and Míka (1997) summarized the main results of these studies. The effect on monogastric animals is mainly strumigenous, but at a high rate of consumption, or with a high content of glucosinolates in the plant, liver and kidney injury can occur. There has been no research done on small rodents in field conditions. Based on data in the present study (body size and sexual activity of rodents), a negative influence was not evident.

Zukalová and Honsová (1990) monitored the content of glucosinolates in two varieties of rape. The higher content was found in stems compared to leaves blade in young plants. The common vole preferred leaf blades to stems in their diet. The content of glucosinolates decreases during growth and voles also began eating the stems when rape was in flower. By following this feeding behaviour voles lowered the toxicity of their diet.

The highest yield of rapeseed is attained when the rape density is low, at 30 to 40 plants per 1 m^2 (Vašák 2000). Therefore, feeding by voles may be, to some extent, beneficial if they thin the crop to the optimum density. Despite this positive effect, the burrows of a colony of voles can damage large areas of crops. Voles eat plants close to their burrow and then seek more distant plants. Sites without vegetation around burrows grow and can later connect with other bare areas. In high population densities large areas of crop can be damaged and the field infested with invasive weeds (Zejda et al. 2002).

The negative influence of *Apodemus* sp. on winter rape has yet to be determined. *Apodemus*

microps as dominant species in rape fields during the harvest have, by our observation during the feeding experiments, the ability to climb up the plant and to pick up the whole siliqua. Also from our crop control on fields, it was observed that mice were removing whole siliqua that were heaped in feeding places. They did not eat all the siliqua and seeds from a plant but chose those that were most developed. The seeds of rape were also stored in burrows making it difficult to reliably calculate yield losses.

For the best yield of rape, the long autumn vegetation season is important. Rape is then able to grow a sufficiently large root system for overwintering. Rape plants are able to survive even without leaves if the roots concentrate enough nutrient reserves for spring regeneration (Vašák 2000). Voles ate the rape plant gradually, consuming the leaves in the rosette initially. They consume the growing apex and then the root collar (root neck) last. In winter 2002 to 2003, fields with winter rape were badly damaged by frost. Leaves were brown and often only the growing apex was green. The vole changed its feeding strategy and concentrated its feeding only on the growing apex and root collar.

By Truszkowski (1982), in years of average numbers of the voles its population consumes 0.36% of rape primary production. In rape the factor of most importance to man is the effect exerted by the vole on grain crop, which the vole causes by feeding on the green parts. It also depends on the plants capacity for regeneration. By this author, and in according with our data, it was found that rape reacts unfavourably to nibbling from autumn to early spring, after which the vole practically ceases to be a pest in this crop.

Maximum losses of rape are recorded in the winter and early spring. Rape plants are able to compensate by increasing the number of branches and also the number of siliqua. Vašák (2000) believed an acceptable harvest losses from 7 to 22%. The rate of losses to rodents has not yet been estimated. However, by the State plant protection practice information, agricultural companies used rodenticides in the years 2001 and 2002, when average number of open and active burrows was 582 ($n = 69$) per ha. This number probably indicates losses higher than acceptable.

Winter rape is suitable habitat for small rodents from the point of view of feeding ecology in particular seasons. As to common vole, its population is concentrated in rape for a long period from autumn to spring until the crop ripens. At high population densities common voles may be an important pest species for rape. The pygmy field mouse and the wood mouse are concentrated in rape crops during the time of ripening and harvesting of seeds. Mice are also important as seed-eating pest species. A full economic evaluation of rodent impacts on rape has yet to be completed.

CONCLUSION

Winter rape is a potentially important crop species in Southern Moravia. Small rodents, predominantly the common vole, utilise the food supply of green, highly nutritional food from rape mostly out of the growing season. This enables them to reproduce for longer in the autumn and earlier in spring and to reach higher population densities than in other crop species. Later, when rape is in flower and seeds are ripening, this food supply is less attractive and they migrate to neighbouring crops. The pygmy field mouse and the wood mouse are concentrated in rape crops during the time of ripening and harvesting of seeds and also in the stubble after the rape harvest where they have access to weed seeds as well as fallen rape seeds.

At high population densities common voles may be an important pest species for rape. Its population is concentrated in rape for a long period from autumn to spring until the crop ripens. Mice are also important as seed-eating pest species. A full economic evaluation of rodent impacts on rape has yet to be completed.

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ABSTRAKT

Význam ozimé řepky pro drobné hlodavce

Ozimá řepka je významným biotopem pro hlodavce hraboše polního (*Microtus arvalis*) a myšici malookou (*Apodemus microps*). Na podzim je v porostech řepky hraboš polní dominantním druhem (*D* = 67%) a také se v nich rozmnožuje (17% populace). Z drobných savců zde převažuje také přes zimu až do jara (*D* = 87%), kdy se začíná množit, a to v těchto porostech velmi brzo (při příznivých povětrnostních podmínkách se 44% populace rozmnožuje již v březnu). Potravní analýzy ukázaly, že řepka je od podzimu do jara pro hraboše polního hlavní a kvalitní potravní složkou. V době zrání řepky se však jeho populace v této plodině snižuje, neboť tu v dosahu svých možností nenachází dostatek zelené potravy. V tomto období osidluje porosty řepky ve větším počtu myšice malooká (*Apodemus microps*, dominance *D* = 76%), jejíž hlavní potravou jsou zralá semena řepky (*v*% = 72). Oba sledované druhy zde nalézají potravu i po sklizni, kdy vzchází výdrol a vzrůstá zaplevelení plochy, až do doby orby.

Klíčová slova: *Brassica napus*; *Microtus arvalis*; *Apodemus microps*

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