

## The impact of grazing animals on nesting success of grassland passerines in farmland and natural habitats: a field experiment

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**A b s t r a c t.** A study was made of the influence of trampling by grazing animals on the nesting success of real nests (meadow pipit, *Anthus pratensis*; water pipit, *Anthus spinoletta*; and skylark, *Alauda arvensis*) and simulated nests (caps from jam-jars filled by green plasticine) on pasture in the Orlické Mountains and on unmanaged alpine meadows in the Jeseníky Mountains (Czech Republic, Central Europe). While the pasture was continuously grazed by livestock at high densities, unmanaged alpine meadow was grazed only by wild large herbivores at far lower densities. Trampling was the primary cause of nest failure in the Orlické Mountains, but was infrequent in the Jeseníky Mountains. The number of real nests lost by trampling corresponded to simulated nests within the localities. Spatial distribution of simulated nests had no effect on their survival on intensively grazed fields. The results indicate that grazing animals negatively influenced the nesting success of real and simulated nests of grassland passerines on continuously grazed mountain pasture. The use of simulated nests was an adequate method of predicting trampling losses by natural nests.

**Key words:** grazing, trampling, artificial nests, nesting success, passerines

### Introduction

Although predation generally represents the major cause of nesting failure in altricial birds (Ricklefs 1969), a large proportion of ground nests on managed meadows are negatively influenced by agricultural activities (Beintema & Müskens 1987, Bradbury et al. 2000). Grazing by livestock is one agricultural activity that may affect nesting birds. It can influence birds indirectly by changing vegetation structure, food supplies and predation pressure, but also directly by damaging ground nests (Ammon & Stacey 1997, Fuller & Gough 1999). Grazing livestock can disturb breeding birds (Hart et al. 2002) and destroy nests by trampling or even predation (Beintema & Müskens 1987, Pennington 1992).

One way to evaluate the influence of different variables on nesting success is to use artificial nests. Artificial nests are commonly used to study nest predation (Major & Kendal 1996). They allow the effects of different variables to be assessed under controlled conditions and with an adequate sample size. However, a number of recent studies has shown that the use of artificial nests to assess mortality rates of natural nests may be of limited value (Wilson et al. 1998, Buler & Hamilton 2000, Weidinger 2001). Davison & Bollinger (2000) suggested that the use of unrealistic artificial nests and eggs could result in predation patterns that do not accurately reflect those of real nests, at least in grasslands. Confounding effects may also be caused by nest placement, olfactory cues left by investigators or the absence of parental activity (review in Major & Kendal 1996).

Some researchers have used clay pigeon targets as simulated nests to study separate effects of trampling on nesting success in grassland birds (K o e r t h et al. 1983, J e n s e n et al. 1990, P a i n e et al. 1997). The use of clay targets with no edible content can eliminate the confounding effect of predation. But the conspicuous clay targets can attract the attention of livestock and the consequential disturbance can make any comparison with natural nests unreliable (K o e r t h et al. 1983).

The aims of this study were (1) to evaluate and compare the effect of trampling on the nesting success of grassland passerines on intensively grazed pasture in the Orlické Mountains and on natural meadow in the Jeseníky Mountains that was grazed only by wild large herbivores at low densities; (2) to test the efficacy of a new type of simulated nest for evaluating trampling rates of real grassland bird nests; and (3) to test the effect of the spatial distribution of targets on their trampling rates.

## Study Areas

The nesting success of natural nests and the trampling rates of targets were studied on two mountain grassland localities in the Czech Republic (Central Europe) between 1999–2001. One study plot was enclosed pasture (20 ha) close to Olešnice in the Orlické Mountains (50°21' N, 16°20' E, 700–780 m a.s.l.). The density of continuously grazing livestock was 5–9 animals/ha and the proportion of sheep and cattle was about 30:1 (Table 3). The control study was carried out on natural alpine meadows on the Mt. Vysoká Hole in the Jeseníky Mountains (50°03' N, 17°15' E, 1400–1460 m a.s.l.). The control study plot was not grazed by livestock but it was grazed by wild vertebrate herbivores (mainly deer *Cervus elaphus* and chamois *Rupicapra rupicapra*) at density of 0.3 animals/ha (CHKO Jeseníky, unpublished data).

## Material and Methods

### Study species

Nesting success was studied in three ground-nesting passerine species (all about 20–30 g). Meadow pipit, *Anthus pratensis*, nests were the most abundant at both localities (69% and 92% of all nests found in the Orlické Mountains and in the Jeseníky Mountains, respectively). The remaining data were from water pipit, *A. spinoletta*, nests in the Jeseníky Mountains and skylark, *Alauda arvensis*, nests in the Orlické Mountains. All three species have similar nests (6–7 cm in diameter) concealed in the vegetation on the ground. The breeding density for all species combined was ca. 1 pair/ha in both localities (unpublished data). The average duration of a nesting attempt was 30 days for meadow pipit (4 days of laying – average clutch is about 4 eggs in the Czech Republic + 13 days of incubation + 13 days of feeding the chicks in the nest – H a l u p k a 1994, P a v e l et al. 2000). Therefore the exposure time 30 days was assessed for estimating the nesting success by the Mayfield method (see below).

### Natural nests

The natural nests were located by searching the fields systematically, by flushing an incubating bird or by watching a bird returning to its nest with food. In the ungrazed natural meadows the nests were marked with a plastic band (1 × 20 cm) fixed on a stick that was

placed 5 m away from the nest. The distance of 5 m prevented increasing mortality of nests due to marking. The nests were checked every 2–3 days. No special attention by predators or grazing animals to the marking stick was observed. In the livestock grazed plot the nests were marked only by a stick placed about 5 m away from the nest to avoid increasing the risk of trampling by exciting livestock. The nests were checked every 5 days

### Simulated nests

The simulated nests (“targets”) were 7 cm diameter discs from aluminium and plastic (caps from jam-jars) filled by green plasticine. The targets were positioned after the natural breeding season had started (April in the Orlické Mountains, May in the Jeseníky Mountains). The targets were positioned on the ground, concealed in the vegetation, in a similar way to natural nests (to avoid increasing attention of grazing animals). The targets were placed “nest-like” (in both localities during 1999–2001) and “regularly” (for the control group only in the Orlické Mountains in 2001). The spatial distribution of “nest-like” placed targets simulated nest site selection by birds, taking into account the distance from perches and water, vegetation type, and the microstructure of terrain (the importance of habitat structure on nest site selection in meadow pipit demonstrated e.g. Hötker & Sudfeldt 1982). The density was about 4 targets/ha. This was quadruple that of natural nests, but nest density probably does not affect trampling losses (Körth et al. 1983, Benteina & Müskens 1987). “Regularly” placed targets were located in a 50 m grid of 10 × 3 targets in the centre of a study area. They were also concealed in vegetation and density was similar to the “nest-like” placed targets. The distance from perches and water, vegetation type, and the microstructure of terrain was specified by the position in the grid. The targets were checked every 5 days and over a total exposure time of 30 days (to correspond with the nesting exposure time of meadow pipits). The targets were assumed to have been trampled, when obvious signs of destruction (footprint...) were recorded in the plasticine.

### Data analysis

The daily mortality rates were estimated by the Mayfield method (Hensler 1985). Exposure time was terminated at the midpoint between the last two visits for failed and successful nests, and on the last day when nests were observed to be active for nests with an uncertain fate (Manolis et al. 2000). The theoretical mortality rates caused separately by trampling, predation or the other factors (weather...) were calculated in natural nests and targets.

A generalized linear model with a logit link and binominal distribution of error (maximum-likelihood Chi-square tests) was computed to compare the observed losses or daily mortality rates between the study sites and nest types (Abisher 1999).

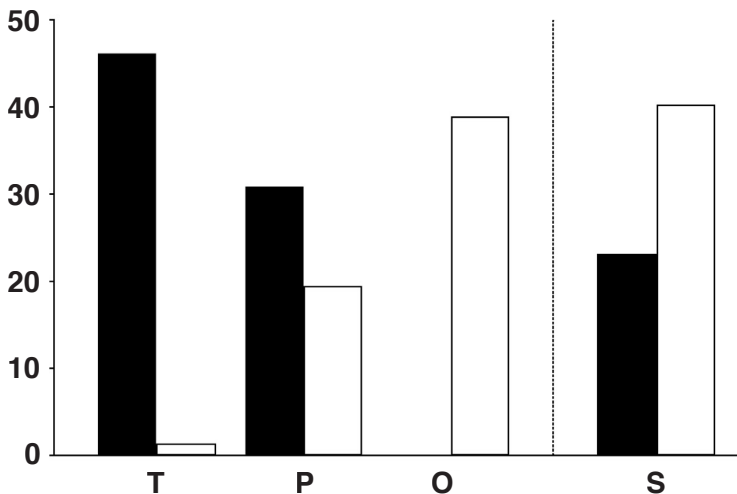
## Results

The fates of 72 natural nests from alpine meadows in the Jeseníky Mountains and 13 nests from pasture in the Orlické Mountains were recorded. Only a small number of nests were found at the second locality because of extremely high trampling rates by livestock. Most of the nests were probably disturbed quickly after initiation, and as a result it was difficult to find a nest before it was trampled.

The mortality rates of natural nests are presented in Table 1. Although the estimated total daily mortality rates did not significantly differ between the localities ( $\chi^2=2.23$ ,  $df=1$ ,  $P=0.13$ ), the analysis of proportional losses due to trampling, predation and other factors showed differences ( $\chi^2=28.00$ ,  $df=3$ ,  $P<0.001$ ; Fig. 1). The losses due to the trampling were higher in the Orlické Mountains ( $\chi^2=20.27$ ,  $df=1$ ,  $P<0.001$ ) and the losses due to the other

**Table 1.** Observed and estimated mortality rates ( $\pm$ SE) of natural nests on pasture in the Orlické Mountains (13 nests, 111 nest-days of observation) and on alpine meadows in the Jeseníky Mountains (72 nests, 817 nest-days of observation). Estimated mortality rates are presented for all losses together (total) and for theoretical losses due to trampling, predation and other factors (weather...) separately. Observed proportions of lost nests are shown for comparison.

|  | Trampling         | Predation         | Other             | Total             |
|--|-------------------|-------------------|-------------------|-------------------|
| Orlické Mountains                      |                   |                   |                   |                   |
| Number of lost nests                   | 6                 | 4                 | 0                 | 10                |
| Observed proportions of lost nests     | 0.461             | 0.308             | 0                 | 0.769             |
| Estimated daily mortality rates        | 0.054 $\pm$ 0.021 | 0.036 $\pm$ 0.018 | 0                 | 0.090 $\pm$ 0.027 |
| Estimated mortality rates over 30 days | 0.811 $\pm$ 0.129 | 0.667 $\pm$ 0.183 | 0                 | 0.941 $\pm$ 0.053 |
| Jeseníky Mountains                     |                   |                   |                   |                   |
| Number of lost nests                   | 1                 | 14                | 28                | 43                |
| Observed proportions of lost nests     | 0.014             | 0.194             | 0.389             | 0.597             |
| Estimated daily mortality rates        | 0.001 $\pm$ 0.001 | 0.017 $\pm$ 0.005 | 0.034 $\pm$ 0.006 | 0.053 $\pm$ 0.008 |
| Estimated mortality rates over 30 days | 0.036 $\pm$ 0.035 | 0.405 $\pm$ 0.083 | 0.649 $\pm$ 0.069 | 0.802 $\pm$ 0.049 |

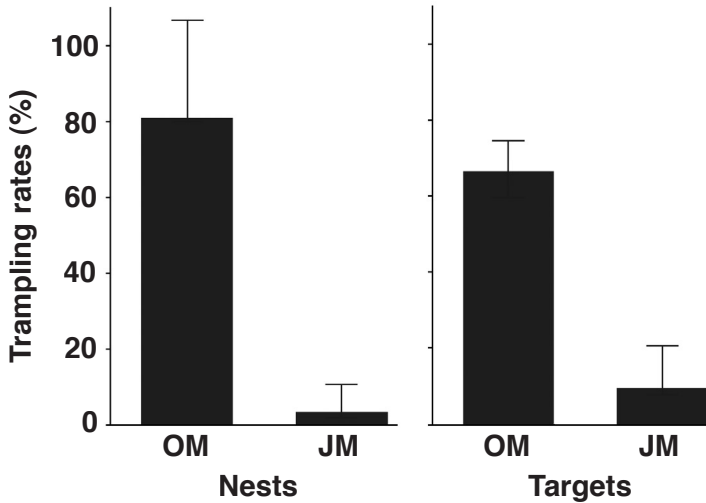


**Fig. 1.** Observed proportions of fates of natural nests in the Orlické Mountains in 1999–2001 (filled bars,  $N=13$ ) and in the Jeseníky Mountains in 1999 (unfilled bars,  $N=72$ ). Nests lost due to trampling (T), predation (P) and other factors (O); successful nests (S).

**Table 2.** Generalized linear model (binominal distribution of error, logit link) relating the daily trampling rates to locality (Orlické Mountains vs. Jeseníky Mountains) and nest type (natural nests vs. targets).

| Effect               | $\chi^2$ | P      |
|----------------------|----------|--------|
| Locality             | 39.25    | <0.001 |
| Nest type            | 0.29     | 0.59   |
| Locality x nest type | 1.61     | 0.20   |

df=1 for all effects.



**Fig. 2.** Mortality rates due to trampling over 30 days (length of the nesting attempt in the meadow pipit) of natural nests and of targets on pasture in the Orlické Mountains (OM) and on alpine meadows in the Jeseníky Mountains (JM). Whiskers indicate the approximate 95% confidence limits. Numbers of nests (targets) and nest-days (target-days) of observation are given in Tables 1 and 2.

factors (mainly weather) were higher in the Jeseníky Mountains ( $\chi^2=7.25$ ,  $df=1$ ,  $P=0.007$ ). The losses due to predation did not differ between the localities ( $\chi^2=1.52$ ,  $df=1$ ,  $P=0.22$ ).

Although the average number of livestock/ha was smaller in 1999 than in 2000 and 2001, the trampling rates on targets did not differ between the years in the Orlické Mountains ( $\chi^2=0.24$ ,  $df=2$ ,  $P=0.89$ ). Therefore data from the Orlické Mountains were pooled for further analyses.

The model relating the daily trampling rates to locality (Orlické vs. Jeseníky Mountains) and nest type (natural nests vs. targets) showed that trampling rates were markedly higher on pasture in the Orlické Mountains than on alpine meadows in the Jeseníky Mountains (the effect of locality was highly significant; Table 2) and suggested that there was no difference in mortality rates between natural nests and targets in this study (the effect of nest type was not significant; Table 2, Fig. 2).

There was no difference in mortality rates due to trampling between targets placed in “nest-like” and “regular” positions (control group) in the Orlické Mountains in 2001 ( $\chi^2=0.08$ ,  $df=1$ ,  $P=0.78$ ; Table 3).

**Table 3.** Observed and estimated trampling rates ( $\pm$ SE) of targets on pasture in the Orlické Mountains and on alpine meadows in the Jeseníky Mountains. Trampling rates are presented separately for individual years and also for all years together (total) in the Orlické Mountains. Targets were placed “nest-like” and “regularly” (control group in the Orlické Mountains in 2001). The average numbers of livestock (wildlife)/ha are presented for comparison.

|  | Orlické Mountains |                   |                   |                   | Jeseníky Mts      |                   |
|--|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
|  | 1999              | 2000              | 2001              |                   | Total             | 1999              |
|  | Nest-like         | Nest-like         | Nest-like         | Regularly         |                   | Nest-like         |
| Number of livestock (wildlife)/ha        | 5                 | 9                 | 9                 | 9                 | 7.7               | 0.3               |
| Number of targets                        | 30                | 30                | 30                | 30                | 120               | 30                |
| Number of trampled targets               | 21                | 22                | 21                | 20                | 84                | 3                 |
| Observed proportions of trampled targets | 0.700             | 0.733             | 0.700             | 0.667             | 0.700             | 0.100             |
| Target-days of observation               | 604               | 426               | 661               | 626               | 2314              | 858               |
| Estimated daily trampling rates          | 0.035 $\pm$ 0.007 | 0.052 $\pm$ 0.011 | 0.032 $\pm$ 0.007 | 0.032 $\pm$ 0.007 | 0.036 $\pm$ 0.004 | 0.003 $\pm$ 0.002 |
| Estimated trampling rates over 30 days   | 0.654 $\pm$ 0.080 | 0.796 $\pm$ 0.069 | 0.620 $\pm$ 0.080 | 0.622 $\pm$ 0.082 | 0.670 $\pm$ 0.040 | 0.100 $\pm$ 0.055 |

## Discussion

The results of this study showed that trampling was the main cause of nest failure for natural nests and targets on continuously grazed pasture in the Orlické Mountains, where livestock density was between 5 and 9 animals/ha. Nest losses due to trampling were low on natural alpine meadows in the Jeseníky Mountains, where density of grazing wildlife did not exceed 0.3 animals/ha. Although total mortality rates did not differ significantly between localities, the abnormally high mortality rates in the Jeseníky Mountains in 1999 (80%) were caused by extremely bad weather, when more than 30% of observed nests failed during a snowstorm at the end of June.

The differences in trampling rates between localities can be explained by the different densities of grazing animals. Although little is known about the influence of different densities of wild large herbivores on breeding birds in natural habitats (see e.g. Fuller 2001), it has been suggested that excessive densities of grazing livestock may have a negative influence on ground nesting birds on farmland. Bareiss et al. (1986) found that trampling losses on simulated nests of bobwhites, *Colinus virginianus*, and wild turkey, *Meleagris gallopavo*, were insignificant when livestock density was low (less than 2.5 animals/ha). However, a negative influence of grazing livestock even at very low densities has been recorded on breeding lapwings, *Vanellus vanellus* (Hart et al. 2002). Jensen et al. (1990) showed that densities above 4 animals/ha caused significant disturbance of ground nesting birds and that trampling losses of simulated nests (clay pigeon targets) increased with livestock density (especially when it was higher than 10 animals/ha). Increasing probability of nest trampling with higher livestock density caused by reduction of area allocated to grazing was also shown by Lapointe et al. (2000) in waterfowl. But in contrast Beintema & Müskens (1987) found in waterfowl a constant trampling rate per animal per day, regardless of livestock density and field size.

The high trampling rates in the Orlické Mountains, even at lower livestock densities in 1999, can be explained by the behaviour of the grazing animals, and by the size and heterogeneity of the pasture. Livestock may move more intensively and cover more ground (possibly resulting in high trampling rates) in larger pastures and during continuous grazing (K o e r t h et al. 1983). Animal movements may also increase when forage is not plentiful (P a i n e et al. 1996), e.g. on poorer mountain pastures. The studied pasture in the Orlické Mountains was a large continuously grazed mountain meadow, where vegetation growth was limited. The pasture was grazed continuously mainly by sheep that formed compact and very mobile groups. I suggest that sheep grazed continuously over 30 days of nest exposure and at livestock density of 5 animals/ha will damage most passerine nests except those that are situated on sites unattractive to sheep (i.e., sites with reduced amount of grass, or sites far from watering places and shelter).

Past studies that assess the value of using artificial nests to quantify nest predation have contradicting results. D a v i s o n & B o l l i n g e r (2000) suggested that the use of artificial nests to study nest predation in grasslands might be of limited use because it underestimates natural predation rates, probably because there was less predation by snakes on artificial nests. Similarly P a i n e et al. (1997) showed that clay pigeon targets attracted more attention from grazing cattle and were disturbed more often than artificial nests containing pheasant eggs. This reduces utility of using the simulated nests to study the impact of grazing animals on bird nests. In contrast J e n s e n et al. (1990) found no difference in trampling rates between clay pigeon targets concealed in vegetation and placed on open sites. The results of my study showed that the caps from jam-jars filled by green plasticine were efficient in evaluating the risk of trampling. Trampling rates on targets were similar to those of real nests at both localities, even though the density of targets was about quadruple that of natural nests (which also suggested that the percentage of trampling loss was not influenced by nest density – see also K o e r t h et al. 1983, B e i n t e m a & M ü s k e n s 1987).

Some studies have evaluated spatial patterns of trampling or disturbance of bird nests (J e n s e n et al. 1990, P a i n e et al. 1997). These studies stated that nest site location did not affect nest survival and that trampling appeared to be a spatially random process where chance plays an important role. The results of my study supported these suggestions. Trampling rates on targets placed in “nest-like” and “regular” array were almost identical in the Orlické Mountains in 2001. Any effort to simulate the spatial distribution of natural nests had no positive effect on the survival of targets.

In conclusion, this study showed that the caps from jam-jars filled by green plasticine were good estimators of trampling losses on natural nests of ground nesting passerines. Whilst wildlife (at natural densities) had a minimal influence on nest trampling risk to ground nesting birds, livestock at densities of 5 animals/ha or higher may cause more than 70% of nest losses on mountain pastures. Although nest predation was also important the losses due to trampling were the primary cause of nest failure on continuously grazed pasture.

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