

# Reducing mortality of shrews in rodent live trapping — a method increasing live-trap selectivity with shrew exits

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Shrews have very high metabolic rates and are often unintentionally starved in rodent live-traps during capture–mark–recapture (CMR) studies. Here, we suggest a shrew exit as a modification to rodent traps. To test whether this modification is (1) saving shrews and (2) not jeopardizing results of rodent captures, we compared captures in Ugglan traps with and without shrew exits, studying bank voles (*Myodes glareolus*) in a spruce forest in central Finland. Numbers of captured bank voles and body size of smallest juvenile bank voles were not affected by the shrew exit, while the number of captured common shrews (*Sorex araneus*) was reduced from 31 to 0 individuals per 100 trap nights. However, rare larger shrew species (> 8 g body weight) could not escape through the exit. A shrew exit can, therefore, save smaller shrew species in standard live-trapping of vole-sized rodents without affecting CMR data of the rodent.

## Introduction

Live trapping of mice and voles often has a side effect of unintentionally killing shrews. Shrews readily enter rodent traps, even if they contain no suitable shrew food, and die within a few hours (Little & Gurnell 1989). Their high metabolism and small size probably cause starvation since rodent bait is not appropriate for shrews (Younger *et al.* 1992), and trap-check intervals of 6–12 h designed for rodent captures are too long for shrews to survive. For monitoring diversity and abundance of small mammal species, alternatives to life trapping have been suggested such as hair trapping, in which species are identified from hair caught on sticky tape (e.g. Harris

& Yalden 2004, Pocock & Bell 2011) or tracking tubes, in which species are identified from footprints (Glennon *et al.* 2002). However, capture–mark–recapture (CMR) methods with live traps cannot be replaced in studies of demography or life history of small mammals, when identity, sex and reproductive state of the animal is important. Shrew fatalities when using standard trapping procedures and standard traps are rarely reported (but see Eccard & Ylönen 2001).

Rodent researchers have suggested several methods to avoid the bycatch of shrews when shortening the control interval (i.e., trap visitation) is not feasible because of large numbers of traps. Some provide extra food resources for shrews, for example worms and insect prey

(Younger *et al.* 1992), but this is not possible for all trap types, or in regions where larger carnivores may loot, dislocate or destroy protein-baited traps. Small exits in rodent traps, which would allow shrews to escape (e.g. Little & Gurnell 1989) are mandatory for example in Great Britain, however, this practice has hardly reached continental Europe. We suspect that researchers may fear the reduction of rodent catches by providing shrew exits. However, for reasons of species conservation and animal welfare, shrew bycatch should be reduced as much as possible.

In this experimental study, we determine the value of shrew exits in mammal life-traps by monitoring and measuring both shrew and rodent captures. We test the following hypotheses: as compared with conventional, unmodified rodent traps, shrew-exit traps capture (a) lower numbers of shrews, and (b) only the heavier and larger shrew species. We further expect that the exit traps capture the same number of rodents and the same size of the smallest juvenile rodent; however, for statistical reasons of classical hypothesis testing we hypothesize that exit traps, as compared with conventional, unmodified rodent traps, capture (c) lower numbers of adult and juvenile rodents and (d) the weight and body size of the smallest juvenile rodent is lower, and expect to refute hypotheses (c) and (d). We used spruce forests in central Finland as study sites, which are inhabited by the bank vole *Myodes glareolus* and the common shrew *Sorex araneus* in high densities, and with up to five other shrew species present.

## Methods

### Study site

Experiments were conducted in Konnevesi, central Finland (62°37'N, 26°20'E) in the autumn of 2003. The boreal forest zone in central Finland is inhabited by all Finnish shrew species; *Sorex araneus*, *S. minutus* and *Neomys fodiens*, which are distributed more or less all over Finland, and *S. isodon*, *S. minutissimus* and *S. caecuciens* reported only from central Finland (Hanski & Kaikusalo 1989). The bank vole *Myodes glare-*

*olus* is the most abundant forest rodent (e.g. Eccard & Ylönen 2001), and the common shrew *Sorex araneus* the most abundant forest shrew, with possibly synchronously fluctuating densities (Korpimäki *et al.* 2005). Other small mammals like the yellow-necked mice *Apodemus flavicollis* and the least weasel *Mustela nivalis* are rarely captured (Eccard & Ylönen 2001).

### Shrew-exits

Minimum diameters reported for voles passing through round holes were 12–14 mm, depending on body weight and species (Sundell & Norrdahl 2002, Sundell & Ylönen 2004). Experiments on selective passage size for different vole species found round holes of 13–16 mm diameter to be passable for bank voles but not for field voles, *Microtus agrestis* (J. A. Eccard unpubl. data).

We used Ugglan-special mouse and vole traps (Model 2, Grahns AB Sweden), that are commonly used for large-scale and long-term CMR studies on population cycles of voles and lemmings in northern Europe. Ugglan traps are made from a 6.5 mm metal grid lattice, surrounding the entrance, the trap door, and the container for trapped animals. The container has a flap door to remove captured animals from the trap, and can be left open to pre-bait the trap (Fig. 1). From the container, we cut out one cross of the lattice wire with pliers, thus merging four lattice cells to an opening of 13 × 13 mm (Fig. 1), creating a square shrew-exit. These cells are sometimes covered by a metal frame the wire mesh is soldered to, potentially narrowing the opening. If smaller than 10 × 10 mm, we chose the neighboring four cells. We chose the corner of the container because we assume that shrews with their wall seeking behaviour (Von Merten & Siemers 2012) may slow down at a corner, so an opening should be easier to find. Secondly, this position also allows the exit to be covered with an exit clip (Fig. 1) in case the researcher wants to use the trap for capturing shrews with sufficient short control intervals of 2–3 hours (Von Merten & Siemers 2012). In normal trapping procedures, the clip can be pushed over the exit without disturbing the flap mechanism.

**Fig. 1.** (a) Open Ugglan special trap No. 2 (Grahn AB; Sweden). White cross indicates location and wires to be removed to provide a shrew exit. (b) Corner of closed trap without a shrew exit, (c) with a shrew exit, and (d) with a shrew-exit clip to close the exit in case the trap is needed for shrew captures (photos: Antje Herde, measures and clips developed by Jana A. Eccard).



### Pilot test

Pilot tests with four litters of captured bank voles were conducted to test whether bank vole pups at weaning age (i.e. 18–20 days) are able to leave a trap through the shrew exit. This size class comprises the smallest body size of bank voles trappable in the field. We placed pups in the exit trap inside the mother's cage for 6 hours. The mother was not able to enter the trap. If pups would have been able to leave the exit trap, they should have left the trap during this time interval. However, no pup left the exit trap, which demonstrated that juvenile bank voles are indeed trappable with exit traps.

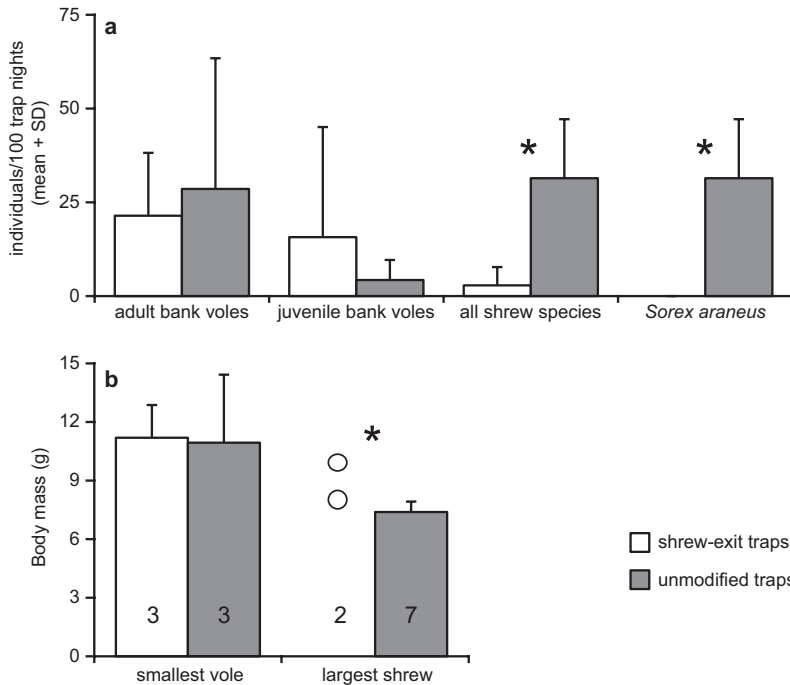
### Field test

Next, we tested the effects of trap exits on captures in the field in boreal forest habitats. We used ongoing, standard live-trapping of bank voles to collect animals for experimental purposes (permission 35/31.05.2004, Board for Animal Experimentation of the University of Jyväskylä) with unmodified rodent traps and our shrew-exit trap prototypes at the same location for comparison.

Traps were set near the Konnevesi Research Station in forest and hedgerows in lines consisting of 10 locations with 10-m spacing. At each location, we added a shrew-exit trap side by side

to the unmodified trap. Traps were put firmly on the ground under or close to a structure like a stone or a log, if available, close to the 10-m spacing point, since both rodents and shrews use structures for hiding from predators. We established 4 trap lines during the autumn of 2003 and used them twice with a pause of 1 week. One sample was without any captures and was therefore removed from the data set, resulting in 7 samples (trap lines) with 20 trap nights each, i.e. 10 trap nights with unmodified traps and 10 trap nights with exit traps (together 140 trap nights). All captured animals were removed from the location after the first round, and trap lines were pre-baited for a week to attract new animals; we therefore treated line-week as an independent sample. Capture rate depends on local densities and weather conditions, and size of the smallest bank vole depends on the age of the captured litter; we therefore conducted paired comparisons of numbers of animals between unmodified and exit-traps within samples, using a paired-Wilcoxon *Z*-test. For shrew body size we conducted an independent Mann-Whitney *U*-test, because in most samples observations of shrews in exit traps were missing.

Lines were pre-baited for two nights with sunflower seeds and fish pellets (pellets = 5 mm in diameter, containing fish oil and protein, used to feed salmonid fish in a nearby fish farm). Fish pellets are attractive to voles as a protein source, especially in the spring (Eccard



**Fig. 2.** (a) Numbers (mean + SD) of adult and juvenile bank voles and shrews captured in 7 trap lines with modified with shrew-exits and unmodified small-mammal live traps given as trap index (captures per 100 trap nights). (b) Body weight (g, mean + SD) of the smallest juvenile vole and of the largest shrew captured in each trap line. Numbers indicate trap lines with captures of voles or shrews, respectively, stars indicate significant differences and circles single values.

& Ylönen 2005). Because of their persistent, fishy-oily smell, we expected them to also attract shrews. For the sampling night, traps were baited and activated for 12 hours over night, a standard time interval to capture rodents. In the morning, we counted adult bank voles, juvenile bank voles and shrews for each trap line. Animals were weighed at the point of capture on a Pesola scale ( $\pm 0.5$  g). Bank voles were taken to the laboratory colony for breeding purposes, surviving shrews ( $n = 2$ ) were released at the point of capture. Dead shrews were weighed on an electric scale ( $\pm 0.01$  g) in the laboratory.

## Results

We captured a total of 46 bank voles [6 of the 7 samples (trap lines)], no other rodents, and 24 shrews (all 7 samples), of which 22 were common shrews, *Sorex araneus*. Shrew-exit traps captured not a single common shrew, while unmodified traps captured a total of 22 common shrews of which 20 were dead and 2 alive ( $31.4$  *S. araneus*/100 trap nights). Body weight of the largest common shrew per line was  $7.4 \pm 0.4$  g (mean  $\pm$  SD) (Fig. 2). Shrew exit-traps captured

two individuals of larger shrew species, a taiga shrew *S. isodon* (8.2 g) and a juvenile water shrew *Neomys fodiens* (9.9 g), both did not survive. Thus, shrews above 8 g seem not to be able to escape from the exit traps. No larger shrew was captured with the unmodified traps, indicating that the capture of these rare species seems to be a random event. The total number of shrews was lower in shrew-exit traps (5 samples with 0 shrews, 2 with 1 large shrew each) as compared with that in unmodified traps (1, 2, 2, 3, 4, 5, 5 common shrews per sample; Wilcoxon test:  $Z = -2.38$ ,  $p = 0.017$ ; Fig. 2), supporting hypothesis a. The body mass of the two large shrews was higher in shrew-exit traps than that of the heaviest common shrews in conventional traps (Mann Whitney *U*-test:  $U = 0$ ,  $p = 0.04$ ; Fig. 2) supporting hypothesis b.

We did not find a significant difference in the number of adult bank voles captured between the exit traps ( $2.1 \pm 1.7$ ) and the unmodified traps ( $2.9 \pm 3.5$ ) compared within lines (Wilcoxon  $Z = -0.8$ ,  $p = 0.416$ ; Fig. 2), refuting hypothesis c of a difference in rodent numbers between the two trapping methods in collecting adult bank voles. There were only three samples where juvenile voles were present, and they were present in both

trap types (exit/unmodified: 2/1, 8/1, 1/1). Thus, hypothesis c pertaining to juvenile rodents was also refuted, i.e. the mean number of juvenile bank voles per line was not lower with exit ( $1.6 \pm 2.9$ ) than without exit holes ( $0.4 \pm 0.4$ ,  $Z = -1.3$ ,  $p = 0.180$ ). Weight of the smallest juvenile vole was not higher in exit traps ( $11.2 \pm 1.4$  g) than in unmodified traps ( $10.9 \pm 1.3$  g,  $Z = -0.5$ ,  $p = 0.593$ ; Fig. 2) refuting hypothesis d. Our expectation that exit traps did not affect rodent captures was thus met.

## Discussion

The results of this study suggest a selectivity of traps by size of the exit holes, allowing shrews to escape while rodent captures were not affected. Shrews up to 8 g could escape through 13 mm exit holes. Modified exit-traps allowed smaller ( $< 7.5$  g) common shrews to escape. Even smaller pigmy shrews and least shrews, *S. minutus* and *minutissimus*, which were not abundant during our study year but can be common in other years (Eccard & Ylönen 2001), would surely have been able to escape. However, larger shrew species such as *S. isodon*, quite rare in spruce forests in central Finland (1/100 trap nights, Hanski & Kaikusalo 1989), and *N. fodiens*, confined to the vicinity of small water bodies (Hanski & Kaikusalo 1989), could not be saved.

Ever since performing this study in 2003, we have used shrew-exit traps when targeting *microtine* (*Microtus*, *Myodes* and *Arvicola*) and *murine* (*Apodemus*) rodent species (adult body weight  $> 15$  g) in forest and grassland habitats in central Europe. We nowadays hardly ever capture shrews. Clearly, the diameter of the hole will depend on the rodent species to be captured. Harvest mice *Micromys minutus*, for example, the smallest Eurasian rodent species (adult body weight 5–11 g), readily escape through the shrew exit in our traps (personal observation). When targeting harvest mice or shrews, we use exit clips (Fig. 1) and check traps every 2 hours.

Traps modified with shrew exits did not miss any of the bank vole size classes, and therefore can be used in CMR studies of similar sized or larger rodents without biasing results. The skull

shape of shrews and rodents probably allows for selectivity of the exit trap. Shrews have long and narrow skulls, while rodents with their large incisors have rounded skulls (for skull shapes compare any mammal handbook, e.g. Corbet & Ovenden 1980). We assume that this shape allows shrews to squeeze through smallest gaps, while rodent skull shape prevents the passage. Although we did not test the effects of the shrew exit for other trap types and other rodent species, we assume that our results apply rather to the size of the exit than to the trap model or brand, and to rodents of similar size as bank voles, i.e.  $> 10$  g. Shrew exits can easily be drilled in all trap models including Sherman and Longworth traps, since round holes  $< 12$  mm in diameter are impassable for voles (Sundell & Norrdahl 2002, Sundell & Ylönen 2004). Taking up our suggestion, the supplier of Ugglan traps (GrahnAB, Sweden) already sells their traps with shrew-exits, if ordered so.

It should be mentioned that on rare occasions, more anecdotal than quantifiable, rodents can get caught with the upper incisors in the exit, and once an adult *Apodemus flavicollis* got stuck half way in the exit. This relatively large rodent species (up to 60 g) is potentially long and strong enough to push against the other side of the trap to force the head through the exit. Therefore, carrying small pliers to cut the wires to free animals in an emergency is advised.

In conclusion, the shrew exit as a very simple measure can save many shrews in standard rodent live-trapping, while shrew exits do not seem to affect trapping results for a target species such as the bank vole.

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