Reducing shrew mortality in Longworth live-traps

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Abstract: During a four year field study period, several improvements were made to the method and mechanism of capturing shrews using Longworth live-traps, in order to reduce mortality after capture. The addition of extra food to the traps reduced mortality of common shrew (*Sorex araneus*) only slightly, indicating that insufficient food supply in the traps was not the main cause of death after capture. Mortality was largely reduced by checking all not-closed traps at every control round for signs of visits by shrews to the nestbox compartment and, subsequently, refilling these visited traps with food. Reducing the space beneath the treadle in the trap tunnel helped to lower shrew mortality further. The combined adaptations to the standard method and to the trapping mechanism reduced shrew mortality (both common shrew and water shrew, *Neomys fodiens*) by 83%.

Keywords: Longworth live-trap, common shrew, *Sorex araneus*, water shrew, *Neomys fodiens*, mortality.

Introduction

Longworth live-traps are widely used for capturing small mammals in many different biotopes (e.g. Bergers & La Haye 2000, Flowerdew et al. 2004). This type of trap consists of an entrance tunnel with the trapping mechanism and a nestbox in which nesting material and food can be placed. Trapping occurs when the animal steps on a treadle at the end of the tunnel. This causes the trapdoor at the entrance to fall down. The animal can make itself a secure place in the nestbox, which reduces stress, and food can be put in the nestbox to keep the animal alive until the trap is checked. However, mortality can be considerable in Longworth live-traps, especially for shrew species, which have a high metabolic rate compared to mice and voles (Rychlik & Jancewicz 2002, Taylor et al. 2013) and are more susceptible to stress.

De Onlanden is a nature reserve of about 25 km^2 near the city of Groningen, in the northern part of the Netherlands (figure 1). It has been designated as a water containment area by the Dutch government, as part of regional security measures against flooding. Therefore, over the past few years, De Onlanden has been drastically changed from a half-natural, extensively managed grassland biotope on peat soil into a wetland with large marshland areas and water levels that fluctuate greatly. Overall, the water levels in De Onlanden are now 30 to 70 cm higher than before.

Since 2009 the small mammal population in De Onlanden has been studied using Longworth live-traps. The aim of the study was to monitor the effects of the large and sudden biotope change on small mammal population, with special emphasis on the water shrew (*Neomys fodiens*). This study is still in progress and results will be published in the future.

The common shrew (*Sorex araneus*) has been abundant in De Onlanden during the study period and has often been captured in the traps. At first, using standard procedures for Longworth live-traps (Bergers & La Haye 2000), the mortality of this species after capture was high. During the research period a number of adjustments to the trapping procedure were tested in order to reduce the mortality of common shrews, and shrews in general, in Longworth live-traps. The results are described below.

Methods

Monitoring of small mammals in De Onlanden (53°10'N, 6°30'E) was carried out between 2010 and 2013 during the spring-summer period (end of May - end of September). Throughout the study, traps were placed in sets of two at ten points, approximately ten metres apart, along a straight line (trapline). At most locations in the study area, three traplines, 60 traps in total, were deployed. Distance between traplines was always at least 100 m, but usually they were placed much further apart. Since the main emphasis of the study was on water shrews, the traplines were mostly placed close to water, i.e. along the border of a ditch, pool or marsh area. The nestboxes of the traps were filled with nesting material (dry hay), and a piece of carrot and five living mealworms (*Tenebrio molitor* larvae) as food. Traps were left for two nights with the trapdoor mechanism inactivated, in order to let the mammals get used to the traps (prebait period). Next, another piece of carrot and approximately ten mealworms were added to the nestbox and the trapdoor mechanism was activated. Capture proceeded for three nights. Traps were checked every twelve hours, starting at dusk before the first night. So in total six trap checks were done. The described procedure was in accordance with the standard procedure for monitoring small mammals by live-trapping with Longworth live-traps used in the Netherlands (Bergers & La Haye 2000).

The small mammals captured in the traps, were weighed and marked (by clipping of the fur on the back) before release. Water shrews were not clipped, since this could negatively affect the water repelling properties of their fur, thereby reducing their fitness after release. Each trap that had been occupied was refilled with the standard amount of carrot and mealworms. Hay in the nestboxes was not refreshed on a regular basis after the prebait period, as described by Bergers & La Haye (2000), but only when considered necessary.

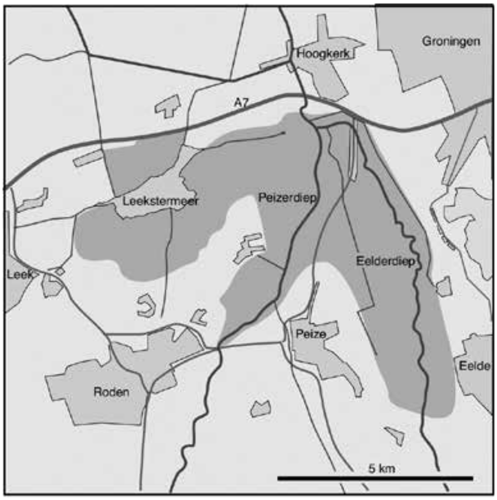

Figure 1. Location of De Onlanden (dark grey), the study area in the northern part of the Netherlands. *Map: H. Sips.*

Due to the constantly fluctuating water levels in the study area, traps could be flooded at any time during the prebait period or between two trap-checking sessions. In these cases the wet hay in the nestbox was refreshed. In the course of the study, modifications to the number of mealworms added to the trap as well as to the checking procedures were made. In consecutive years, these modifications consisted of: adding more mealworms to the traps, improving the checking procedure, and reducing the space beneath the treadle in the trap tunnels. Details of these modifications are described below, in the results section.

Results

The total numbers of captured shrews and other small mammals in De Onlanden in different years are given in table 1. In all years, large numbers of common shrew were captured, water shrew was captured mainly in the last two years, whereas pygmy shrew (*Sorex minutus*) was only very rarely captured throughout the study. Other small mammals were captured in relatively low numbers, com-

Table 1. Total numbers of captured animals, and of animals found dead in the Longworth live-traps per year for *Sorex araneus* (Sa), *Sorex minutus* (Sm), *Neomys fodiens* (Nf) and other small mammals (other); percentage dead = (dead/captured) x100.

Year	Total captured				Dead				Percentage dead			
	Sa	Sm	Nf	other	Sa	Sm	Nf	other	Sa	Sm	Nf	other
2010	147	3	0	22	19	0	0	1	12.9	0	0	4.6
2011	215	0	27	325	20	0	0	2	9.3	0	0	0.6
2012	211	0	119	93	12	0	4	1	5.7	0	3.4	1.1
2013	355	8	124	27	8	0	2	0	2.3	0	1.6	0

pared to shrews, except for 2011 when common vole (*Microtus arvalis*) was abundant. Very few field vole (*Microtus agrestis*), bank vole (*Myodes glareolus*), wood mouse (*Apodemus sylvaticus*), harvest mouse (*Micromys minutus*) and water vole (*Arvicola amphibius*) were captured.

In 2010 the standard method for monitoring small mammals that was described above was used. Mortality for common shrews in traps was 12.9% (table 1). In traps with dead shrews all the mealworms were eaten. Therefore, starvation was assumed to be the primary cause of this high mortality rate. In 2010 one common vole was found dead in the traps on a total of 17 captures of this species.

In order to reduce shrew mortality, in 2011 the standard amount of mealworms added to the traps after prebaiting was raised from approximately 10 to at least 20 per trap. Common shrew mortality decreased to 9.3% (table 1). Low numbers of water shrews were captured in 2011, of which none died. In this year, one common vole and one harvest mouse died when trapped, on a total of 246 and 16 captures, respectively.

In 2011 it was noticed regularly that nestboxes had been visited by a mammal without the trapdoor closing (figure 2). This occurred only at locations where common shrews were present. Apparently, these small mammals (and possibly pygmy shrews as well) were able to enter the nestbox by passing under the treadle, or by going over it without putting enough pressure on the treadle to release the trapdoor. All, or part of the mealworms in the nestbox could thus be eaten by the shrew, leaving the trap open for the next visiting shrew, which would have a reduced amount of food, or none, left when trapped. Mice and voles would not be affected by this lack of mealworms, since they can also feed on the carrot in the trap. Shrews however do not feed on carrot and would have a greater chance of dying by starvation when locked in an already visited trap. This might explain at least part of the continued high mortality of shrews in 2011, despite the extra amount of mealworms in the traps.

Therefore, from 2012 on, at every control round the nestboxes of all traps were checked for signs of shrew visits. New mealworms (always at least 20) were added to the traps that had been visited. A record was kept of visited traps. In 2012, a total of 100 nestboxes were found to have been visited by shrews between two checking sessions without the trapdoor closing. Thus, on a total of 330 captures of shrews, approximately 23% of the shrews visiting a nestbox had not been captured on the first or subsequent entries. Common shrew mortality in 2012 was 5.7% (table 1), which was considerably lower than in previous years. In 2012 large numbers of water shrew were captured as well. Water shrew mortality was in the same range as of common shrew (table 1). Sometimes, the relatively large holes in the hay and large scats found in the tunnel of traps that had been visited, suggested that water shrews were also able to enter and leave

Figure 2. View inside a Longworth live-trap. The tunnel made in the nesting material is clear evidence that a mammal has visited the nestbox without the trapdoor closing. *Photo: W. van Boekel.*

the nestbox without the trapdoor closing, but no conclusive evidence was found for this. In 2012 one bank vole was found dead in the traps on a total of 20 captures of this species.

In 2013, the number of visits to nestboxes by shrews without being caught was largely reduced by adjustment of the trapping mechanism of the Longworth live-traps. By placing a piece of rubber (a section of bicycle inner tube was used) in a slit at the exterior of the tunnel next to the treadle (figure 3), the space beneath the treadle was reduced from the standard 13 mm to 8-10 mm, making it more difficult for shrews to pass under the treadle. The adjustment also helped to reduce the pressure needed to release the trapdoor when a shrew passed over the treadle. In 2013, at four out of 27 traplines small numbers (1 or 2 individuals) of pygmy shrews were caught, next to common shrews and water shrews. The pygmy shrews were probably still able to pass under the lowered treadle, but their presence, compared to the other shrew species, was too low to contribute significantly to the total numbers of visited nestboxes. In 2013, a total of 80 traps were visited by shrews without trapdoor closure on a total of 479 captured shrews. Thus, the adjustment of treadle height reduced the amount of non-captured shrews to 14% (cf. 23% in 2012). Common shrew mortality in 2013 was 2.3% and water shrew mortality was 1.6% (table 1).

Discussion

It is well known that the high metabolic rate of shrews makes them vulnerable to starvation when kept captured over longer periods with a limited food supply, as is the case in live-traps. However, in most reports on field studies using Longworth or other types of live-traps, mortality rates for captured shrews are not, or only summarily, mentioned (van Bemmel & Voesenek 1984, Bergers & La Haye 2000, van der Linden & van der Weijden 2011). Shonfield et al. (2013) give mortality rates of 10-93% for shrews in a review of 16 Northern American small mammal monitoring studies. In these studies no food suitable for shrews was added to the traps.

In field experiments, Bekker & Dekker (2009) showed that standard adding of food (mealworms) to Longworth live-traps had a larger positive effect on survival of captured common shrews than shortening the period between trap controls from 12 to 8 hours. In their experiments, the mean mortality of common shrew in Longworth live-traps permanently stocked with ten mealworms (D.J. Bekker, personal communication) and checked every twelve hours was 13.2%. This is comparable to the mortality of 12.9% found in the first year of this study.

In laboratory experiments, common shrews died within eight hours when left without food (Saarikko 1989). In the field this period may be shorter. The lower habitat temperature and probable higher activity level of the animal, compared to laboratory situations, will lead to a higher energy demand. The length of the survival period for a shrew after capture in a live-trap will thus depend on the amount of food and on the thermal conditions in the trap. In laboratory experiments, using metabolic cages at room temperature, Churchfield (1979) found that common shrews consumed,

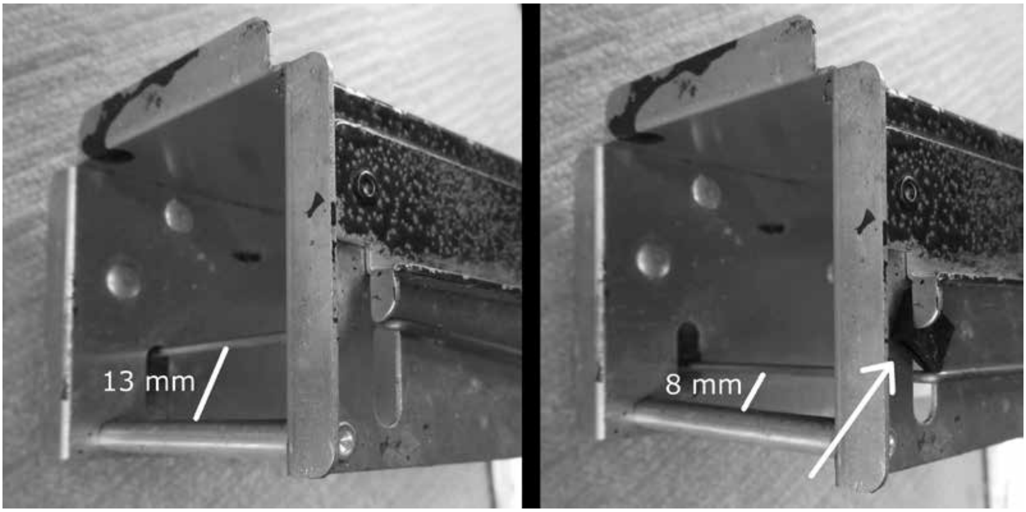

Figure 3. The space beneath the treadle in the tunnel of a Longworth live-trap is reduced from 13 mm (left) to 8 mm (right) with the use of a small strip of rubber inserted above the treadle on the outside of the tunnel (arrow on photo at the right). *Photo: W. van Boekel.*

on average, 8.3 g (mean wet weight) of bowfly (Calliphoridae) pupae per day. Using the energetic value of bowfly larvae of 8.4 kJ/g wet weight given by Rychlik & Jancewicz (2002), it can be calculated that on average the common shrews in Churchfield's study consumed 69.7 kJ food per day. The energetic value of mealworms given by Rychlik & Jancewicz (2002) is 10.5 kJ/g wet weight. The mean weight of the mealworms used in De Onlanden was 0.1 g (based on weighing 350 mealworms). The 10 or 20 mealworms added to the traps would therefore represent an energetic value of 10.5 and 21 kJ, respectively. Applying Churchfield's data to the situation in the present study, it can be concluded that theoretically an average common shrew that was captured in a trap containing 20 mealworms had enough food to sustain it for at least seven hours. Since it is likely that most shrews remained captured for periods (far) shorter than twelve hours, it can be assumed that the amount of 20 mealworms in the traps would be sufficient to cover the largest part of the energy demand of a common shrew after capture. Also, it is likely that the animal would be able to survive for several hours after depletion of the food in the trap, as mentioned above. For pygmy shrews, Churchfield (1979) found an average consumption of 4.9 g of bowfly pupae per day, indicating an energy consumption of 41.2 kJ/day for this species. Pygmy shrews in De Onlanden would thus theoretically have found sufficient food in the traps containing 20 mealworms to sustain them even when they remained captured for twelve hours. Churchfield (1979) found that food consumption by the large water shrews was low compared to common shrews. Water shrews ate 7.3 g of bowfly pupae per day, equivalent to an energy consumption of 61.3 kJ/day. Water shrews would probably also be able to survive for a longer period without food, compared to common shrews, due to their larger size. In general, shrews captured in De Onlanden in traps containing 20 mealworms had a good chance of surviving their capture. However, when the mealworms in the trap were eaten by a visiting shrew that was not captured, there might have been not enough food left in the trap for the next shrew.

Bekker & Dekker (2009) made no mention of the phenomenon of shrews visiting traps without capture. Usually, in field studies using Longworth live-traps, traps are quickly checked for closed doors, without looking inside all traps to see if they have been visited. In this study it is shown that shrew mortality can be largely reduced by checking each trap at each control round for signs of visits by shrews and subsequently adding new mealworms to traps that have been visited.

Reduction of the space beneath the treadle largely improved the yield of the trapping mechanism of Longworth live-traps, thereby further reducing shrew mortality in the traps. In studies that focus on voles and mice, a high position of the treadle in Longworth live-traps is beneficial, since less traps will be occupied by (unwanted) shrews. In studies that aim at investigating all small mammals present in the field, Longworth live-traps with lower treadles would be more suitable, since this increases the chance of capturing shrews. Gurnell & Flowerdew (2006) mention the use of treadle ramps to prevent animals passing under the treadle of Longworth live-traps. However, it is still not clear whether these ramps are effective and reliable in field studies.

Dry hay, used in the present study as nesting material, has a better thermal insulating capacity than moist or wet hay. Due to the field conditions in the present study, most traps could not be kept dry over longer periods and the hay in the nestboxes was often moist or even wet. The effect of the condition of the nesting material on shrew mortality in the traps was not taken into account here. However, this effect can be assumed to have been small, since mortality was already reduced by 83% even though the overall condition of the nesting material remained constant. Each year, trapping was done in the summer period (June-August) when night temperatures generally are above 10 °C. Most likely, the effect of moist nesting material on survival of shrews will be larger in colder seasons.

Shrews are known to die easily in stressful situations. For instance, in the present study two lively common shrews died suddenly during the weighing procedure after capture (own data). There are, however, no indications that shrews died as a result of stress during captivity. In all the traps with dead shrews, no food was left and often clear signs of nest building activity in the tunnel part of the trap indicated that the shrew had been acting in a natural way. However, it cannot be excluded that animals became stressed after depletion of the food in the trap and that this contributed to the death of the animal.

Shrew mortality can also be reduced by increasing the frequency of control rounds. In studies focusing on shrews, the period between control rounds is often 2-4 hours (e.g. Churchfield 1984, Rychlik 2005). However, whether all shrews survive entrapment under these circumstances is mostly not clearly mentioned. If circumstances allow, a high checking frequency of the traps will be the best way to reduce mortality of all captured animals. In the present study, a high checking frequency was not feasible and would also have caused an unacceptable amount of disturbance in the nature reserve. However, the adaptations to the method and to the trapping mechanism presented here reduced shrew mortality considerably. The remaining trap deaths will probably have been caused by shrews being captured in traps that had been visited before by a shrew within the twelve hour period between two controls.

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Samenvatting

Verminderen van sterfte van spitsmuizen in Longworth inloopvallen

In het natuurgebied De Onlanden werd gedurende vier jaar de muizenpopulatie gevolgd met behulp van Longworth inloopvallen. In het eerste jaar werd de standaardmethode voor het vangen van muizen gebruikt. In de jaren daarna werd deze methode aangepast om de sterfte van spitsmuizen (gewone bosspitsmuis, *Sorex araneus*) en waterspitsmuis (*Neomys fodiens*)) in de vallen omlaag te brengen. De sterfte onder bosspitsmuizen was in het eerste jaar hoog door voedselgebrek. Toevoegen van extra voedsel in het tweede jaar leidde tot een geringe verlaging van de sterfte. Spitsmuizen bleken vaak onder de beweegbare drempel in de tunnel van de Longworth inloopvallen door te kruipen. Zo omzeilden ze het valdeurmechanisme. Ook als de spitsmuis wel over de drempel heen ging, bleek de val niet altijd dicht te gaan. Veel vallen werden zo door spitsmuizen, vooral bosspitsmuis maar mogelijk ook dwergspitsmuis (*Sorex minutus*), bezocht zonder vangst. Hierdoor was er geen, of te weinig, voedsel in de val voor de volgende spitsmuis die de val bezocht en deze wel dicht liet gaan. In het derde jaar van de studie werden daarom alle vallen, bij elke controle, nagekeken op bezoek van spitsmuizen (gangen in het hooi, keutels in de tunnel). Zo nodig werd de val bijgevuld met voedsel. De sterfte van spitsmuizen nam in dit jaar aanzienlijk af. Om de kans op bezoek van spitsmuizen aan vallen zonder vangst te verminderen werd in het vierde jaar de ruimte onder de drempel in de tunnel verkleind. Hierdoor nam de sterfte onder de gevangen spitsmuizen nog verder af. De gezamenlijke maatregelen leidden tot 83% lagere sterfte van spitsmuizen in de Longworth inloopvallen, ten opzichte van de standaardmethode.

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