Testing animal welfare of snap and electrocution traps against house mice (*Mus musculus*)

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Abstract

The use of killing traps for rodent pest control is currently gaining relevance again. Despite this, most countries have no approval or authorization of rodent traps. Hence, a guidance for testing and evaluating animal welfare impact was recently published by the expert group on "Non-Chemical alternatives for Rodent control" (NoCheRo). Following to the NoCheRo guidance, we investigated the animal welfare impact of 10 house mice killing traps in semi-natural tests. All 10 traps proved to be attractive to the target organisms because more than 90% of house mice visited a trap at least once within few days, in 5 tests even on the first test day. Both tested electrocution traps and 3 of 8 snap traps met the animal welfare criteria. 95% of the test animals caught with criteria-compliant traps were irreversibly unconscious within 50 seconds, 90% within 30 seconds. 97 % of house mice were rapidly unconscious when hit at the head/neck by a snap trap. 5 traps were not in compliance with the animal welfare criteria, and tests were aborted when 2 animals were not unconscious within 120 seconds, which was the case after 2 respectively 3 tested animals in 3 tested traps. The results show that the NoCheRo guidance is suitable for testing and evaluating rodent traps for their animal welfare impact. Certification of such tested traps would provide a sound scientific basis for the selection of traps and thus improve animal welfare in rodent pest control overall.

Keywords: Animal welfare; *Mus musculus*; NoCheRo; Non-chemical alternatives; Rodent electrocution traps; Rodent snap traps

1. Introduction

House mice (*Mus musculus*) are controlled if they damage crops, products and infrastructure (Capizzi *et al.* 2014), threaten native species (Cory *et al.* 2011; Harris 2009) or pose a risk to humans and companion animals by the transmission of rodent-borne diseases

(Battersby 2015; Meerburg *et al.* 2009). Baits containing anticoagulant rodenticides (AR) are the most frequently used method to control house mice infestations resulting in prolonged suffering of poisoned animals as they bleed to death over several days (Mason and Littin 2003). Thus, slow acting AR “are generally not considered as a humane method to control rodents” by the Biocidal Products Committee (ECHA 2016) and rated as one of the killing methods with the worst animal welfare impact (Sharp and Saunders 2011). Driven by the global technological progress in the area of digitalization and automatization as well by the increasing regulation restrictions on the use of environmentally hazardous rodenticides, the use and development of rodent traps has experienced a renaissance in recent years. For example, advanced trap systems have been developed that are species-specific (Campbell *et al.* 2015). Further technical innovations include multi-capture traps, self-resetting traps and automated and remotely operated trap systems which enable real-time permanent monitoring of rodent as well as trap activity, thereby improving efficacy and minimizing the control effort of traps.

However, the animal welfare impact of killing mouse traps is not assessed in most countries worldwide (Littin *et al.* 2014). For many people, animal welfare plays only a subordinate role when it comes to rats and mice as pests (Buckland and Nattrass 2020; Meerburg *et al.* 2008). This attitude in combination with a missing regulation can lead to the development of non-animal welfare friendly products, such as disposable traps that cannot be opened to release animals that have been captured alive (Baker and Sharp 2015).

Most small rodent traps are snap traps killing by a striking bar/striker/bolt that ideally hits the target animal’s head or neck (snap traps) or act otherwise physically on the target rodent; other trap types kill by suffocation (e.g., killing snares), drowning, automatic shooting or electrocution (Broom 1999). Within and between each group of trap types, they differ largely in their animal welfare impact from long-lasting suffering (e.g., glue traps) to immediate death of the trapped animal (Broom 1999; Mason and Littin 2003; Meerburg *et al.* 2008). Snap traps crushing the skull are considered to kill most efficiently (Proulx and Barrett 1991; Mason and Littin 2003). However, systematically and uniformly collected data are lacking for such traps.

For separating traps that kill fast and reliably from those that do not, experts from science, industry and authorities started an initiative after an EU workshop on "Non-Chemical alternatives for Rodent Control" in 2018 (Fischer *et al.* 2019). The 1st aim was the development of a tiered trap testing approach (Friesen *et al.* 2020) that was recently published in the "NoCheRo (Non-Chemical Rodent Control)-Guidance for the evaluation of rodent traps / Part A break back/snap traps" (Schlötelburg *et al.* 2021). In the guidance, criteria and methods are described to evaluate snap traps regarding their animal welfare impact, besides their mechanical properties and efficacy.

We tested the animal welfare impact of 8 snap traps and 2 electrocution traps against house mice according to the NoCheRo-guidance (Schlötelburg *et al.* 2021). The testing was part of the listing process according to § 18 German Infection Protection Act, where manufacturers or distributors applied for listing their product as effective control measure. The test results are discussed on the basis of the following questions:

- Do traps vary in their attractiveness and animal welfare impact?
    - Do the time to the 1st trap visit and number of visits per day during the conditioning period vary among traps, trap types or depend on the use of a safety station?
    - Which body region of the test animals must be hit by snap traps so that the animal is quickly unconscious?
- Is the method proposed in the NoCheRo-Guidance suitable for assessing the animal welfare impact of house mice traps?

Although more data is needed to completely answer these questions, the 1st practical tests show if the protocol is suitable to identify traps with an acceptable/inacceptable animal welfare impact.

2. Material and Methods

2.1 Tested Traps and Animals

In the study period from August 2019 to March 2021, 8 snap traps and 2 electrocution traps against house mice were tested in a semi-field trial regarding their attractiveness and animal welfare impact. 7 snap traps had a step-on trigger and 1 trap had a trigger that had to be lifted (Tab. 1). 3 snap traps were tested without and 5 snap traps within a safety station. The electrocution traps were triggered when 2 metal plates on the trap ground were bridged. As the manufacturer or distributor applied voluntarily for the assessment of traps according to § 18 German Infection Protection Act, names of traps that failed the test and applicants must remain confidential.

During a conditioning period, in total 172 test animals could accustom to the traps, of which 86 animals were tested during the animal welfare test (Tab. 1). Tests were aborted if the required criteria based on 12 planned test animals (Tab. 2) could no longer be achieved. This resulted in different numbers of test animals for each trap (Tab. 1).

All test animals were adult house mice (*Mus musculus domesticus*) of a bred of wild strain animals. The rodent strain was hold in groups of mixed sexes. The offspring were separated by sexes at the age of about 2 months. Sex-separated groups of maximum 40 animals were kept in 2-chamber cages (H 450 x W 800 x D 400 mm) until the start of the test. Adult animals with an initial body weight of 16.3 to 30.7 g were used for testing. The sex ratio (Tab. 1) depended on their availability in the breeding colony.

2.2 Test Chambers and Materials

3 test chambers (H 2.3 x W 1.4 x L 2.6 m per chamber) were connected by closable passage tunnels, which had a diameter of 70 mm and a length of 300 mm. The chambers were fully tiled, and daylight through 2 windows was the only illumination, except for the control visits.

The 1st chamber provided 2 to 4 wooden nesting boxes (H 160 x W 190 x D 250 mm; board thickness: 20 mm; 2 square entrance openings: 40 x 40 mm; cellulose paper inside the boxes) and a plastic tray (H 35 x W 230 x D 350 mm) in each corner of the chamber with sawdust for the mice to urinate.

In the 2nd chamber, food consisting of a 3-grain mixture (70 % wheat, 25 % oats, 5 % sunflower seeds) in enamelled clay trays (diameter: 200 mm; H 35 mm) as well as water in a drinking trough were offered *ad libitum*. Furthermore, 4 traps (if applicable, in a safety station) were positioned on flat platforms (H [bottom] 850 x H [top] 350 x W 850 x D 400 mm) against the wall of the 2nd chamber (Fig. 1). Below the platforms, the antenna and logger system (TML133 air-core coil antenna with diameter: 40 mm; TCL122 reading device, PTS Technology & Systems GmbH, Erbach, Germany) were located inaccessible for the test animals. The antennas were positioned directly under the trap triggers. The antenna cables were protected by metal pipes that were also used as climbing possibilities by the test animals. Pipes were covered with a plastic collar at a height of 140 cm as climbing barrier. Only during the conditioning period, the traps were fixed by positioning them between the wall and a heavy object (brick). This ensured that no animal could move the trap and was registered right beside the trap by the antenna and logger system.

2.3 Test Procedure

The tiered test design ensures that only traps proven to be attractive to mice during the conditioning period were tested in the subsequent animal welfare test. The test procedures were in accordance with the NoCheRo-Guidance on the evaluation of rodent snap traps

(Schlötelburg *et al.* 2021) except that test animals were not selected by their weight and assigned to 2 different weight classes.

2.3.1 Conditioning Period

Prior to the release of the test animals in the test chambers, house mice were tagged for individual identification. Therefore, a passive-integrated transponder (1.4 x 8 mm; Mini ISO-Transponder with injector, Tierchip Dasmann, Tecklenburg, Germany) was injected under the neck skin. If an animal entered the trap, the antennas registered the individual transponder of the animal.

The traps were not activated but baited with peanut butter that was renewed daily if necessary. The number of visits to the trigger of the trap of each animal was determined daily. The conditioning period lasted until 90 % of animals had visited at least one trap within at least 3 and maximum 7 days. If less than 90% of animals had visited a trap in 7 days, the trap would be excluded from further tests.

2.3.2 Animal Welfare Test

If the trap was generally accepted by the animals, the welfare impact was tested with the previously conditioned animals using the same lure in the traps. The day before the test started, traps were not baited. When the test started, the animals were located in the 1st chamber with the food tray and drinking trough that had been removed from the 2nd chamber. Then, 1 to 3 animals were released to the 2nd chamber where the traps were baited and activated. These animals could trigger the trap within 1 hour, otherwise, they were excluded from further testing and transferred to a 3rd chamber with food, water and nesting opportunities.

After an animal had triggered the trap, the experimenters immediately entered the chamber and measured with a stop watch the time until the onset of irreversible unconsciousness and the stop of all body movements occurred. The onset of unconsciousness was determined by repeatedly blowing at the animal's eyes with an air-filled rubber ball (HADEO

Puster for drying BTE earpieces, Hansaton GmbH, Hamburg, Germany) to observe whether the corneal reflex was absent. In case a safety station was used, the lid was opened immediately after the trap had been triggered. If this affected the function of the trap, the station was opened 25 seconds after triggering (snap traps) or after stopping of the electrical current flow (electrocution traps). If the animal was not unconscious after 120 seconds or was hit at a peripheral region (e.g., tail or legs), it was euthanized immediately by cervical dislocation (insufficient hit). The death of test animals was verified with a stethoscope (3M™ Littmann® Classic II Pediatric Stethoscope, Neuss, Germany). The test animals were weighed after the experiment (Mettler PM4800 DeltaRange, Mettler-Toledo GmbH, Gießen, Germany).

The test procedure was repeated until 12 test animals had triggered the trap or the criteria for animal welfare (Tab. 2) could no longer be achieved: testing was aborted if the time to irreversible unconsciousness lasted longer than 120 seconds for 2 animals or longer than 60 seconds for 3 animals.

2.4 Statistical Analyses

All statistical analyses were conducted using R (version 4.1.0; R Core Team 2021) and RStudio (version 1.4.1717). We used the R packages "ggplot2" (Wickham 2016) and "tidyr" (Wickham 2021) for creating graphics, "lme4" (Bates *et al.* 2014) for fitting models with maximum likelihood (Laplace approximation), "multcomp" (Hothorn *et al.* 2008) for multiple comparisons of means (Tukey contrasts) and "RVAideMemoire" (Herve 2021) for multiple comparisons after Fishers exact test.

The time until 1st trap visit and number of visits per day were modelled with generalized linear models (GLM) following a negative binomial distribution with log link because models with Poisson distribution resulted in overdispersion. Both variables could be explained by trap type (snap or electrocution trap), trap ID (A-J) and use of safety station (yes or no). By backward selection, we found the minimal models with the lowest Akaike Information Criterion (AIC;

Akaike 1974). We calculated the dispersion parameters and checked model fit by graphically evaluating residuals. In 1 test, the logger system did not work from the 2nd to 4th test day. Therefore, this trap was excluded from the analysis.

For snap traps, the influence of the hit body on the differences in the numbers of sufficient or insufficient hits (defined as mice that were or were not irreversible unconscious within 120 seconds) were analyzed by Fishers exact test and multi comparisons. Mice that were caught at the limbs/tail (N=3) were excluded from this analysis because those animals were euthanized immediately.

3. Results

3.1 Attractiveness of Traps

All 10 tested house mice traps were attractive to the test animals because at least 90 % of test animals were registered at least once in a trap during the conditioning period. For 5 traps, at least 90 % of test animals were recorded on the 1st day, for 2 traps on the 2nd day and for 2 traps at the 4th day. GLMs showed that the time until the 1st trap visit and the mean number of visits per day for the 1st 90 % of test mice varied among traps but not among electrocution and snap traps or among traps with or without a safety station (Fig. 2).

3.2 Animal Welfare Impact of Traps

Both electrocution traps (Victor® Electronic Mouse Trap, Victor® Multi-Kill Electronic Mouse Trap) and 3 out of 8 snap traps (Anticimex® Smart Snap, NoSeeNoTouch Mausefalle, SuperCat® Mausefalle Pro) passed the animal welfare criteria and were classified as category A traps (Fig. 3; Tab. 2). 95 % of 60 house mice tested with these traps were irreversibly unconscious within 50 seconds, 90 % within 30 seconds. These traps are listed according to §18 German Infection Protection Act (https://www.umweltbundesamt.de/dokument/liste-ss-18-infektionsschutzgesetz) and belong to the control methods that must be used in case the control measure was ordered by the German health departments to prevent or control disease outbreaks.

3.2.1 Electrocution Traps

96 % of 24 test animals trapped by electrocution traps (Fig. 3) were unconscious within the defined time spans (Tab. 2). Mean times until onset of unconsciousness (± SE) were 23 (± 3) seconds (Trap I) and 22 (± 2) seconds (Trap J). However, the values for the onset of unconsciousness must be considered as a maximum because unconsciousness could only be determined after the electric current flow was terminated (lasting a maximum of 33 seconds). All animals hit sufficiently were already dead when the traps were opened but 1 mouse (4 %) was still conscious and could escape (Trap J).

3.2.2 Snap Traps

The snap trap with a lift-up trigger and without a safety station and 2 out of 7 traps with a step-on trigger in combination with a safety station met the animal welfare criteria (Tab. 2). 94 % of 36 test mice trapped with the 3 traps that positively passed the test were irreversibly unconscious within a max. time period until unconsciousness of 50 seconds, respectively 89 % within 30 seconds (mean ± SE of mice being unconscious within 120 seconds: 19 ± 4 s; Fig. 3). However, in 15 cases, the eyes of the trapped animal were inaccessible, so after about 25 seconds the trap was opened (in all cases, the animals were unconscious but not dead at this point). Therefore, these values demonstrate the maximum time periods. 2 mice (6%) were not unconscious within 120 seconds: 1 mouse could escape the trap (Trap A), the other was hit at the nose and was euthanized after 120 seconds (Trap G).

Both tests with traps with a step-on trigger but without safety station and 3 tests with traps with a step-on trigger and safety station were aborted after 2 animals were not unconscious after 120 seconds in each test. In total, 2 (Trap C), 3 (Trap B; H), 8 (Trap F) or 10 (Trap D) mice were tested until the criteria (Tab. 2) could no longer be achieved.

Hit Body Region

A hit on the head/neck ($p<0.001$) or thorax ($p<0.001$) was more likely to cause unconsciousness within 120 seconds than a hit on the abdomen, whereas the effect of hits on the head/neck and thorax did not differ ($p=0.097$). If the test animal was hit at the head/neck (N=35; Fig. 4), 97 % of mice were irreversibly unconscious within 45 seconds, 94 % of mice within 30 seconds, and 1 mouse (3 %) hit at the nose was euthanized 120 seconds after the trap was triggered. When mice were hit at the thorax (N=17), 82 % of mice were unconscious within 30 seconds, whereas 18 % were still conscious after 120 seconds. All 7 mice that were caught at the abdomen were not unconscious within 120 seconds, and 3 mice caught at the limbs or tails (N=3) were euthanized immediately.

4. Discussion

4.1 Attractiveness and Animal Welfare Impact of Snap and Electrocution Traps

All tested traps were attractive for house mice as the visit rate of 90 % during the conditioning phase was reached in all cases, often already on the 1st day (5 out of 9 traps). This suggests that, if applied correctly, killing traps can be an effective control method. Even with traps within a safety station, mice could be easily caught because neither time to 1st trap visit nor mean number of visits per day depended on the presence or absence of a safety station. However, data from field tests are needed to prove the efficacy of animal welfare-compliant traps under practical conditions.

Furthermore, the results of the tests show that both electrocution and snap traps can fulfil the criteria of the NoCheRo-guidance, and if they do so, represent an animal welfare-friendly alternative to rodenticide use. Half of the traps passed the test, and all successful traps corresponded to category A. 95 % of the animals caught with criteria-compliant traps were irreversibly unconscious within 50 seconds, 90 % even within 30 seconds but there was no obvious difference in the duration until the onset of irreversible unconsciousness among criteria-compliant traps (Fig. 3). However, a comparison of the time until the onset of unconsciousness is limited because in both electrocution traps and also in 2 snap traps the eyes of the test animals were not visible until the trap was opened after about 30 seconds. Despite the very rapid killing of animals with these traps, the other half of the traps did not meet the animal welfare criteria, and testing was aborted quickly after 2 respectively 3 tested animals in 3 of 5 tests with traps failing the animal welfare criteria.

Since both tested electrocution traps killed in accordance with the animal welfare criteria, compared to only 3 of the 8 tested snap traps, electrocution traps seem to kill more reliably. The only animal that was not unconscious when opening the trap could escape apparently unharmed, in contrast to most animals that were not hit sufficiently by snap traps. Hence, electrocution traps should be analysed for their electric properties. Additionally, further tests should be conducted to examine the animal welfare impact of other electrocution traps, and the functionality under field conditions that could be altered by weather, dirt at the electric contacts or battery discharge.

Killing in compliance with animal welfare was largely determined by the body region which was hit by a snap trap. For example, 34 of the 35 animals (97 %) hit on the head were irreversibly unconscious within 50 seconds, and 94 % of the animals were unconscious within 30 seconds. In contrast, all of the animals that were struck at the abdomen were not irreversibly unconscious within the required 120 seconds. A hit on the head can be more likely if the trap has a trigger that must be lifted by the animal. Our test with such a trap showed that 92% of the 12 test animals were hit on the head and neck area. However, traps with step-on triggers can principally also kill fast, although 5 of 7 snap traps did not pass the animal welfare criteria. The differences in mechanical forces greatly differ among snap traps and could lead to the differences in animal welfare performance (Baker et al. 2012). For example, clamping force values varied 4-5.5-fold and impact momentum 6-8-fold among traps for killing mice, rats and moles (Baker *et al.* 2021).

However, the clamping force of all tested traps seem to be sufficient for a rapid kill because 97 % of the test animals (including animals that were killed by traps failing the test) hit at the head/neck were unconscious within 50 seconds. Other mechanical forces (e.g., trigger force) or parameters (e.g., trigger type) might have a bigger influence on the hit body region than the clamping force. A high clamping force could even have a negative effect on the animal welfare impact if it is mechanically coupled with the trigger force, which then also becomes too high as a result. However, data are missing to determine the mechanical forces that are necessary for an animal welfare-compliant kill. Besides the mechanical forces, the combination of trap and safety station could influence the animal welfare impact because both traps tested without safety station failed the animal welfare criteria. It is likely that the velocity and direction from which mice approach traps has a great influence on the body region which will be hit.

In summary, traps that passed the animal welfare criteria killed by electrocution or, in case of snap traps, hit the target organism on the head/neck in most cases. A hit on this body region could be connected to the following features of the traps: i) a trigger that has to be lifted by the head of the target organism, ii) a safety station design which decelerates the running speed of the mice (e.g., guiding the animal around a corner) and leading the mouse frontally to the trap, or iii) several bars that ideally hit several body regions of the target animal.

4.2 NoCheRo Test Protocol

The NoCheRo test protocol is suitable to enable a differentiated assessment of snap and electrocution traps for mice into animal welfare-compliant and non-animal welfare-compliant traps. The proposed tiered approach ensures that as few test animals as possible are used in the animal welfare test that is aborted if i) the trap is not attractive, or ii) 2 respectively 3 animals are not unconscious in 120 respectively 60 seconds (the latter did not occur in our tests).

Compared to the "Agreement on international humane trapping standards between the European Community, Canada and the Russian Federation" (AIHTS; Harrop 1998), the NoCheRo guidance (Schlötelburg *et al.* 2021) sets stricter requirements for animal welfare of traps. According to AIHTS, the duration until irreversible unconsciousness may not exceed 300 seconds for 80 % of 12 animals, whereas 80 % of house mice must be unconscious within 120 seconds and 90 % within 60 seconds in the less stringent animal welfare category of NoCheRo.

The NAWAC (National Animal Welfare Advisory Committee) guidance (NAWAC, 2019) calls for different criteria for time to unconsciousness depending on sample size. Because the relation of criteria and number of test animals is non-linear, it is difficult to compare the requirements of the NoCheRo and NAWAC guidance. For example, NAWAC's requirements for a category A trap are stricter than the NoCheRo criteria if 15 test animals are used, but if 50 animals are tested according to NAWAC, longer time spans are accepted compared to NoCheRo. Therefore, in addition to providing detailed test protocols, the NoCheRo guidance can also be considered an improvement of existing guidance in terms of criteria selection. Regardless, the time spans for the onset of unconsciousness set in AIHTS, NAWAC and NoCheRo could be even shorter for mice traps because our testing showed that 90 % of mice were irreversibly unconsciousness within 30 seconds for traps that passed the criteria (Fig. 3). Furthermore, all 15 test animals that were not unconscious after 60 seconds had to be euthanized after 120 seconds showing that either a mouse is unconscious relatively fast or the animal will not be unconscious for probably a much longer period than 120 seconds.

Although the test design is well suited for evaluating snap traps regarding their killing ability in accordance with animal welfare criteria, tests with house mice could still be improved by:

- the recording of broken skulls/necks because this might be an indicator for a fast and efficient kill.
- the use of the pain withdrawal reflex (by pinching the foot sole/the skin between the toes) if the eye is not accessible to determine the state of unconsciousness.

- the use of 3 connected test chambers instead of 2 to better simulate a pest control situation where the traps should be set on the run path of mice between nesting and food chambers.
- the improvement of criteria for mice traps as mentioned before.

While animal welfare plays an important role in animal experiments, animal welfare in the context of rodent management has so far only been given secondary consideration (Paparella 2006, Meerburg *et al.* 2008). Using NoCheRo-compliant rodent traps can therefore improve efficacy and animal welfare of rodent control campaigns. By certifying NoCheRo-compliant traps, it is possible to make animal-welfare friendly traps visible on the market even without a legally based approval or authorization scheme which can only be established in the long term. Then, consumer, pest controllers and veterinarians have a scientific, transparent basis for trap selection. The next step according to NoCheRo would be to test animal welfare-compliant traps under real pest control conditions. In addition to testing the practical suitability (e.g., soiling of electrocution traps, effects of weathering, usability and effort of trap setting), efficacy of the traps and their impact on non-target organisms should be further investigated.

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Tables

Table 1: Characteristics of tested traps and number of tested house mice during the conditioning period and animal welfare test. All animals used in the animal welfare tests were previously accustomed in the conditioning period.

Trap ID	Trap characteristics			Number of test animals				
	Type	Step-on trigger	Safety station	Conditioning period		Animal welfare		
				Male	Female	Total	Male	Female
A[a]	Snap	No	No	9	9	12[b]	5	6
B	Snap	Yes	No	8	10	3	0	3
C	Snap	Yes	No	6	8	2	2	0
D	Snap	Yes	Yes	8	7	10	7	3
E[a]	Snap	Yes	Yes	7	9	12	4	8
F	Snap	Yes	Yes	16	0	8	8	0
G[a]	Snap	Yes	Yes	19	0	12	12	0
H	Snap	Yes	Yes	18	0	3	3	0
Total	**Snap**	**7 Y / 1 N**	**5 Y / 3 N**	**91**	**43**	**62[b]**	**41**	**20**
I[a]	Electric	No	Yes	5	13	12	4	8
J[a]	Electric	No	Yes	7	5	12[a]	7	4
Total	**Electric**	**0 Y / 2 N**	**2 Y / 0 N**	**12**	**18**	**24[b]**	**11**	**12**

[a] Trap A: SuperCat® Mausefalle Pro; Trap E: Anticimex® Smart Snap; Trap G: NoSeeNoTouch Mausefalle; Trap I: Victor® Electronic Mouse Trap; Trap J: Victor® Multi-Kill Electronic Mouse Trap

[b] 1 animal escaped from the trap before its sex could be determined.

Table 2: The time until irreversible unconsciousness [s] of at least 80% and 90% of trapped animals determines the category that a trap is assigned to. Based on 12 planned test animals, criteria of animal welfare could no longer be achieved if 2 animals were not irreversibly unconscious in 120 seconds and 3 animals in 60 seconds.

Category of animal welfare	**Time to irreversible unconsciousness**	
	≥ 80% of 12 test animals	**≥ 90% of 12 test animals**
Category A	≤ 30 s	≤ 60 s
Category B	≤ 60 s	≤ 120 s

Figures

Figure 1 The test chamber provided 4 traps on platforms covering the antenna logger system as well as a food tray and a drinking trough (during the conditioning period).

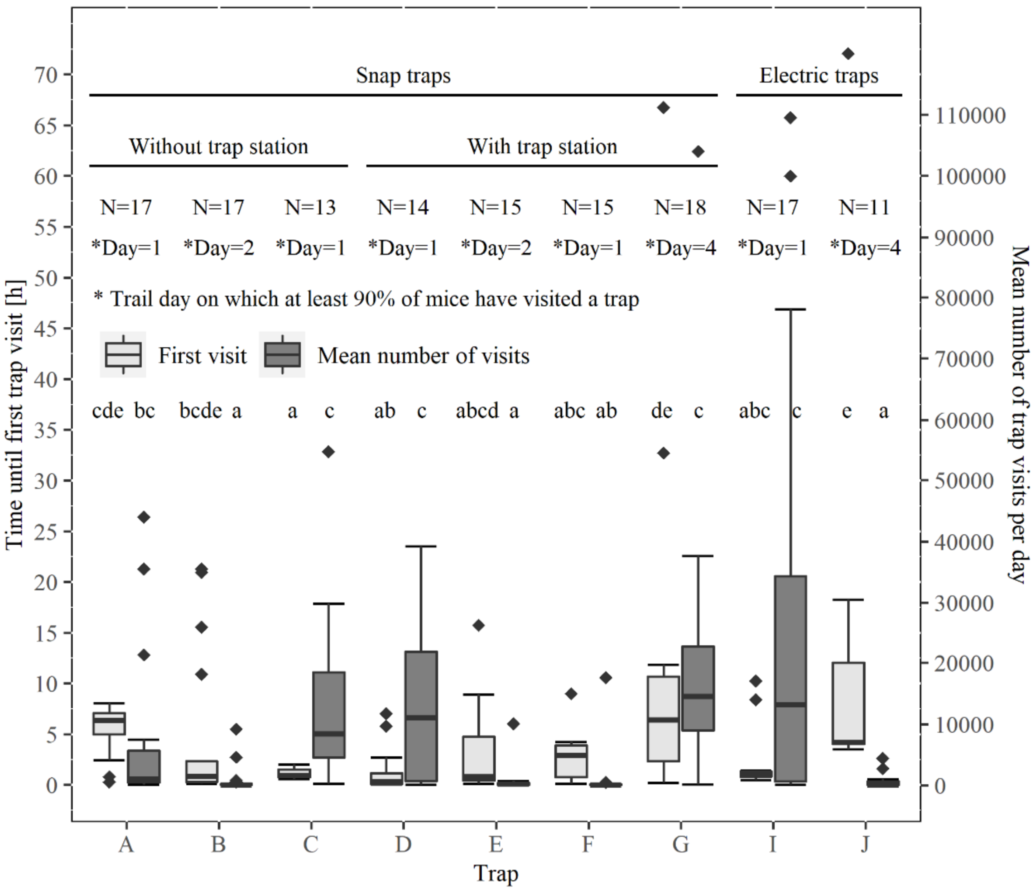

Figure 2 Attractiveness of traps measured as hours until the 1st visit (light boxplots) and the mean number of trap visits per day (dark boxplots) for 9 different traps in the conditioning period. Both variables were calculated for the 1st 90% of test animals because the animal welfare test was initiated when at least 90 % of mice have visited at least one trap (at the earliest after an acclimatization period of 3 days). 1 trap (H) was excluded from the analysis because the logger system did not work on 2 test days. The trial day on which at least 90% of mice have visited at least 1 trap is stated. N gives the number of tested animals. Different letters indicate significant differences between traps separately for time until 1st trap visit and mean number of trap visits (GLM results).

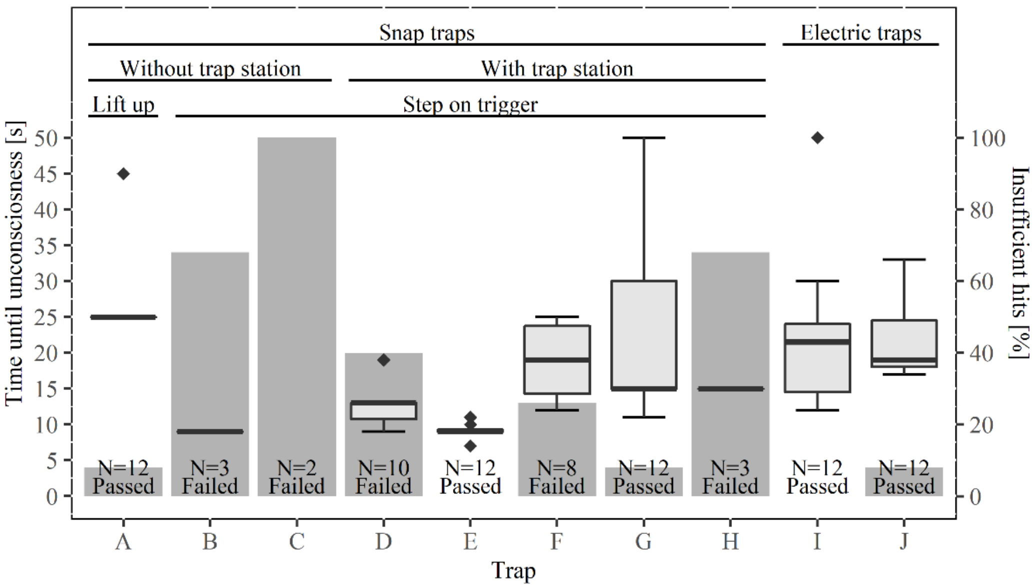

Figure 3 Seconds until unconsciousness for all mice that were irreversible unconscious within 60 seconds (sufficient hits; boxplots) and percentage of insufficient hits (bars) for each of 10 tested traps. N gives the number of tested animals (a test was aborted if the test criteria could not be met anymore). It is indicated if a trap met (passed) or did not meet (failed) the animal welfare criteria.

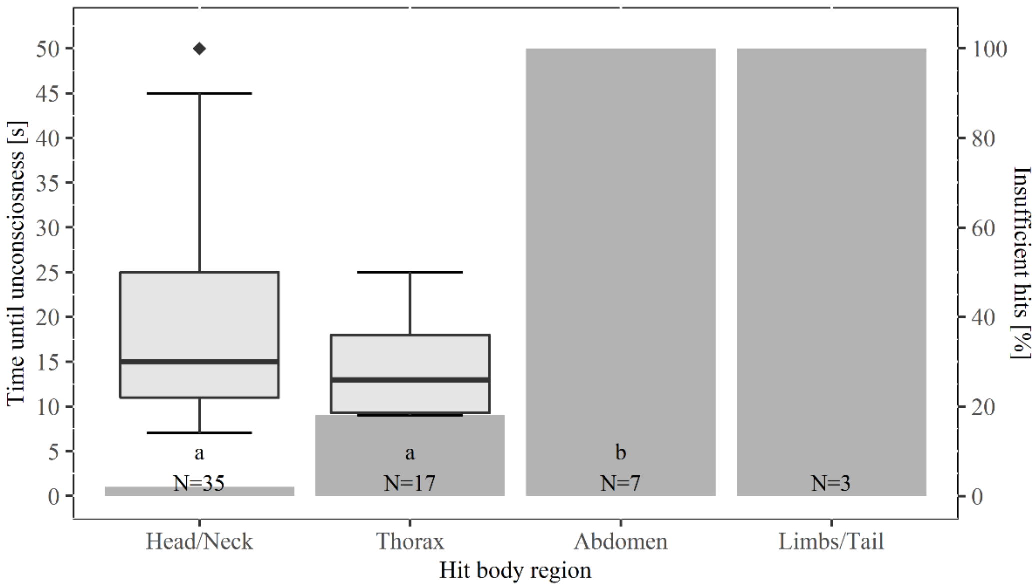

Figure 4 Seconds until unconsciousness for all mice that were irreversible unconscious within 60 seconds (sufficient hits; boxplots) and percentage of insufficient hits (bars) depending on the hit body region (head/neck, thorax, abdomen, limbs/tail) for 8 tested snap traps. Different letters indicate significant differences in the numbers of insufficient hits (Fishers exact test).