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RESEARCH PAPER | OPEN ACCESS

# Comparing trap and bait efficiency to record the great crested newts (*Triturus cristatus*)

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**Abstract –** A crucial aspect of conservation management for endangered newt species is the establishment of a monitoring methodology and the evaluation of trap efficacy to ensure the accuracy of data collection. In this study, we assessed three funnel trap types (prism shape, umbrella shape, and Ortmann's trap) to capture great crested newts (*Triturus cristatus*). We also tested three baits (chicken liver, chemical lights in glow sticks, and control traps without bait) and determined the optimal trap control time within a 12 h period. Our findings showed that the umbrella shape trap was most effective, catching five times more newts than the Ortmann's and prism shape traps. Surprisingly, the commonly used prism shape trap performed poorly. Bait type did not significantly impact newt captures compared to control traps. During the 12 h experiment, newts spent the longest time in the chicken liver-baited Ortmann's trap (averaging 4.5 h), while the umbrella shape trap with chicken liver bait had the highest turnover of individuals. We observed no behavioural response from "trap-shy" individuals. This study emphasizes the importance of selecting appropriate traps, considering bait choice, and trap control time for effective monitoring of endangered newt populations.

**Keywords:** Conservation management / funnel trap / Ortmann's trap / great crested newt (*Triturus cristatus*) / trap-shy response

## 1 Introduction

The evaluation of various sampling techniques is vital for successful amphibian monitoring (Antonishak *et al.*, 2017). Breeding season is a focal period for monitoring, due to the visibility of migrating adults or egg masses (Miller and Grant, 2015; Davis *et al.*, 2017). Capture success depends on factors such as body size, home range, activity patterns, trap avoidance, and weather conditions (Crosswhite *et al.*, 1999). Numerous techniques, including drift fences with pitfall traps, aquatic funnel traps, visual encounter surveys, and dip-net surveys, are employed in amphibian monitoring (Heyer *et al.*, 1994; Hutchens and DePerno, 2009; Willson and Gibbons, 2009). Notably, dip-netting is frequently used for capturing breeding newts in Europe (Malmgren *et al.*, 2005; Briggs *et al.*, 2006; Goverse *et al.*, 2006; NARRS, 2021; Skei *et al.*, 2006; Denoël *et al.*, 2013). However, studies have pointed out the effectiveness of fish traps over drift fences (Baker, 1999), and the benefits of funnel traps like Ortmann's trap for cost-effectiveness and efficiency (Ortmann, 2009; Willson and Gibbons, 2009; Drechler *et al.*, 2010). Most surveys to detect newts were performed at night, to maximise the detectability of target species (Halliday, 2006; Manenti *et al.*, 2019). The study and conservation of newts, many of which are endangered, heavily rely on effective surveying and monitoring (Kålås *et al.*, 2010; Arntzen and Zuiderwijk, 2020).

Our model species, the great crested newt (T. cristatus), falls under annex II and IV of the Habitats Directive (92/43/EEC), and is, as a result, stringently protected in Europe (Bock *et al.*, 2009). The effective conservation of great crested newt necessitates population monitoring, a task that has grown in significance (Graeter *et al.*, 2013). Given the species' amphibious nature—alternating between aquatic and terrestrial environments—it poses a challenge to secure representative samples for monitoring (Dervo *et al.*, 2014). Accurate determination of species abundance and composition might demand several short sampling periods throughout their active phase (Vogt and Hine, 1982). The capture-mark-recapture (CMR) technique, which employs the use of unique pattern mapping photography, can provide critical demographic parameter estimates, such as survival rates and abundance, hence supporting more effective conservation decision-making (Williams *et al.*, 2002; Nichols, 2014). Studying abundance dynamics can pose difficulties due to the need for strategic long-term sampling planning and employing suitable models to analyse the gathered data. For instance, population growth at a specific moment can be influenced by the density (Cayuela *et al.*,

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**Fig. 1.** Three types of traps used throughout this study. Prism shape (left), umbrella shape (middle) and Ortman's trap (right).

2019). Moreover, the likelihood of detecting individuals might be low, necessitating multiple surveys at each location during each sampling season to secure reliable abundance measures (Kellner & Swihart, 2014; Ficetola *et al.*, 2018; Falaschi *et al.* 2021; Falaschi *et al.*, 2022).

Aquatic funnel trapping is often used for surveying and monitoring pond-breeding amphibians (Adams *et al.,* 1997*)*. The first studies using aquatic traps were conducted in 1973 (Calef, 1973; van Gelder, 1973). A variety of funnel traps have been tried and tested, including lightweight, collapsible funnel traps designed for crayfish that are furnished with smaller mesh (Arntzen and Zuiderwijk, 2020). Commercially available cylindrical traps constructed of 6 to 4 mm mesh size galvanized wire, box funnel traps made of 3 mm mesh size galvanized wire, traps made from plastic beverage bottles (Calef, 1973; Richter, 1995), collapsible nylon mesh traps, and traps constructed with acrylic plastic sheet have also been used (Adams *et al.*, 1997). Most studies use funnel traps without bait to capture caudate amphibians, while others have used shrimp or salmon eggs as baits (Adams *et al.*, 1997). Commonly used baits include chicken liver, other entrails, parts of fish, salami, dog granules, or bits of raw beef (Jeřábková and Boukal, 2011; Baker, 2013; Sannolo and Gatti, 2017).

However, there are some shortcomings to the funnel trapping method. One study in France showed that in 95 out of 171 experiments (56%), the probability for an individual to go undetected was <1%, but the numbers captured decreased over time suggesting "trap shyness" (Arntzen and Zuiderwijk, 2020). The other risk could be transfer of agent of chytridiomycosis, but this problem would be solved by disinfecting with a 1% weight/volume (w/v) solution of Virkon® and drying the traps after every use (Johnson *et al.*, 2003; Dejean *et al.*, 2010). Light traps and light sticks are commonly used in studies of fish, particularly larvae (Marchetti *et al.*, 2004), but they have not been widely used to capture amphibians (Grayson and Row, 2007).

In the Czech Republic, by national guidelines a combination of funnel trap with chicken liver bait and dip netting methods are used for capturing newts (Jeřábková and Boukal, 2011). The main objectives of our study were to compare the sampling efficiency of three commonly used funnel trap shapes (prism, umbrella, and Ortmann's trap) and different baits (chicken liver, green, and yellow chemical lights in glow sticks) for capturing newts. Specifically, we aimed to analyse the effect of sex and body size on the trapping success using different traps and baits. Additionally, we evaluated the optimal trap control time during a 12 h experiment and assessed the ability of newts to escape from the traps.

## 2 Materials and methods

The study was carried out during the main breeding season (April-May) in 2018 and 2019 at a retention pond located in Tovéř, Czech Republic (49.6405478N, 17.3281758E, altitude 235 m). This site supports breeding populations of the great crested newt (*T. cristatus*), the smooth newt (*Lissotriton vulgaris*), and the alpine newt (*Ichthyosaura alpestris*). The pond has a surface area of 500 $m^2$ during the spring and a maximum water depth of approximately 1.9 m, which completely dries up in warm summers. The littoral zone is dominated by submerged grasses while the water surface layer is usually covered by a pondweed (*Lemna minor*). According to the Habitat Suitability Index (Oldham *et al.,* 2000;*ARG UK, 2010),* the Tovéř locality is categorized as good (with score 0,73) for T. cristatus occurrence. Based on our previous research, four places in the pond near the shore with depth from 25–50 cm with plenty of vegetation and high probability of occurrence of newts were selected. All traps were placed so that there was minimal space between the bottom and each trap. Woody sticks approx. two meters long were inserted into the bottom sediment and three traps, one of each type – the prism shape, the umbrella shape and the Ortmann's trap (Fig. 1) were attached around stick. The nylon prism funnel traps had a metal frame size of 45 × 22 × 22 cm covered with a green 5 mm mesh size nylon webbing and 3 cm holes on one side and 2 cm on the opposite side; elastic bands were secured between the entrance holes to maintain a funnel shape. The umbrella shape type has a hexagonal base with outer radius 52.5 cm with 6 entrances. Ensure constant air access, the net was placed or secured with polystyrene so that small part remains at the water surface (Jehle et al., 2011). The Ortmann's funnel trap was made of an empty 15 L bucket with four distinct openings in which half-cut inverted 1.5 L plastic bottles were inserted acting as funnels (Drechler et al., 2010). Counter-sunk in the respective habitat (e.g., pond), aquatic amphibians (adults and larvae) can easily enter the bucket through the funnels, but cannot leave it. The bottom of the bucket as well as the lower part of the bucket walls was perforated with little holes (smaller than 4 mm in diameter) to allow free movement of the larvae. The accompanying lid of the bucket is riddled with small holes to allow oxygen exchange and it is used as a cover for the bucket during an exposure. Two plastic bottles (0.5 L) placed at the upper part of the bucket wall fixed with a robust plastic string supported floating of the traps, so the caught newts were able to breathe (Drechler *et al.*, 2010).

**Table 1.** Summary of the linear mixed-effects model testing the effect of trap and bait on the number of caught newts. Test statistics for fixed effects and standard deviations for random effects are presented. Marginal $R^2$ indicates explained variability by fixed effects, conditional $R^2$ indicates explained variability by fixed and random effects together (Nakagawa and Schielzeth, 2013).

| Fixed | DF | *F*-value | *P*-value |
|---|---|---|---|
| Trap | (2,94) | 123.9 | <0.001 |
| Bait | (3,8) | 0.6 | 0.660 |
| Model $R^2$ | Marginal = 0.57 | Condition = 0.67 | |
| **Random** | **SD** | | |
| Day | 0.35 | | |
| Day/Location | 0.20 | | |

Trap installation occurred typically at 6–8 pm, and traps were emptied the following day between 7–10 am. This process was repeated for 2–4 consecutive days (29.4, 1.5., 3.5, 5.5, 7.5., 9.5., 13.5, 15.5., 17.5, 20.5, 23.5, 27.5 in 2018) after which traps were removed from the pond to allow time for animal regeneration and to avoid a trap-shy response. Three types of baits were used simultaneously (chicken liver, yellow chemical light – 15 cm length, Lightstick powder, green chemical light – 15 cm length, Lightstick powder), or traps were left without bait on each trapping night. Following the application of chicken liver, a one-week pause was included to prevent confounding effects of scent residuals in the water (Adams *et al.,*1997). All traps were cleaned and dried before reuse. For each captured newt, sex, body length snout-to-vent length (SVL), and belly patterns were recorded (Arntzen *et al.*, 2003; Jehle *et al.*, 2011). The effectiveness of different trap types and baits was evaluated using a linear model (lm function), and data were logarithmically transformed to meet statistical test requirements. Additionally, the relationship between trap preference based on sex or body size was evaluated using a linear model.

To assess the optimal trap control time, we conducted an experiment where 10 individuals (5 males and 5 females) of *T. cristatus* were placed in each trap and monitored for 12 h. The traps were checked every 2 h, starting at 6:00 pm and ending at 6:00 am the next morning. To avoid any influence from previous experiments, new individuals were used for each test. The experiment was conducted in three series in 2019, the first without any bait (9.-10.4, 24-25.4), the second using chicken liver as bait (14.-15.4, 29.4-1.5.), and the third using green chemical light as bait (19.-20.4, 5.-6.5). To ensure the correct identification of individuals, we obtained belly and side pattern maps for each captured newt, including the newly arrived individuals, and returned them to the same type of trap. To avoid excessive stress on the individuals from trapping, ten newts captured from another part of the pond were used for each capture night.

The data from the 12 h control time experiment was analysed using a generalized linear model assuming a Poisson distribution with the logarithmic link function. All analyses were performed using the statistical software R version 3.4.3 (R Core Team, 2014). We evaluated the efficiency, *i.e.*, the number of caught newts in a trap, the different types of traps and baits using a generalized linear model (the glm function in R). We included four explanatory variables (trap, bait, day of sampling, and location) in the model comparison process. We used day of sampling and location as confounding covariates since these variables were not of direct interest and performed forward selection as a model building procedure. After examining the data, we applied a conservative approach using a quasipoisson error structure due to the high overdispersion of the number of caught newts (estimated dispersion parameter of the model including day, trap type, and bait type was 6.5; for a Poisson error structure, it should be around 1 to meet model assumptions).

## 3 Results

In total, we captured 1386 individuals of *T. cristatus* (867 males and 519 females) and we also caught 87 individuals of *L. vulgaris* (47 males and 40 females) and 5 individuals of *I. alpestris* (4 males and 1 females) during 12 trapping nights. Due to the low numbers of those newt species, we further analysed only data for *T. cristatus*. Most of *T. cristatus* (1066 individuals) were found in the umbrella shape funnel trap, with an average of 22 individuals (±2.07) per a trap and night. A total of 239 individuals were trapped in Ortmann's trap, with an average of 4.98 individuals (±0.59) per a trap and night and 81 newts were captured in the prism shape trap, with an average of 1.69 individuals (±0.21) per a trap and night. The average number of individuals captured per trap entry is 3.67 individuals for the umbrella funnel trap, 1.49 individuals for the Ortmann trap, and 0.85 individuals for the prism trap (umbrella shape > Ortmann's trap > prism shape trap; Tab. 1, Fig. 2a).

We observed no significant effect of using bait as traps with a bait showed similar efficiency as those without (Fig. 2b). In terms of bait performance, we found only a slight difference between green chemical light and chicken liver, with traps using green chemical light catching an average of 14 (±2.93) newts, compared to 10 (±1.64) with yellow chemical light, 9 (±0.81) with no bait, and 7 (±1.72) with chicken liver. The only significant difference was between chicken liver and green chemical light (Fig. 2b; $p < 0.05$). We observed a higher capture rate of males than females, but no statistically significant differences were found between the different types of traps or baits and sex or newt body size ($p > 0.05$).

Our study revealed that both the type of trap and bait significantly impacted trapping time (Fig. 3). We found that *T. cristatus* captured in Ortmann's trap type with chicken liver as bait remained significantly longer in the trap compared to other trap types, with an average time of about 4.5 h. Interestingly, we also recorded individuals who repeatedly returned to the

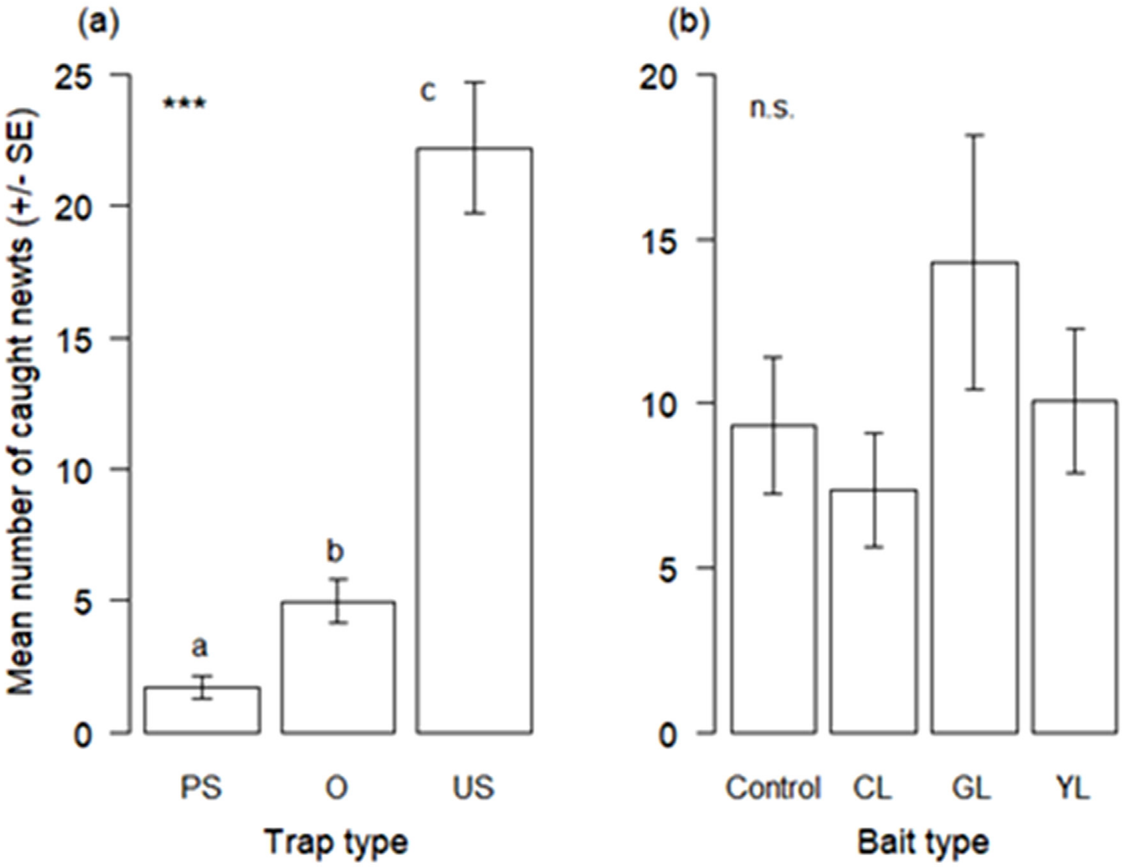


**Fig. 2.** Efficiency of a) three traps and b) three baits in terms of caught newts. Letters indicate the Abbreviations: PS = prism shape trap, O = Ortman's trap, US = umbrella shape trap, CL = chicken liver, GL = green light, YL = yellow light.

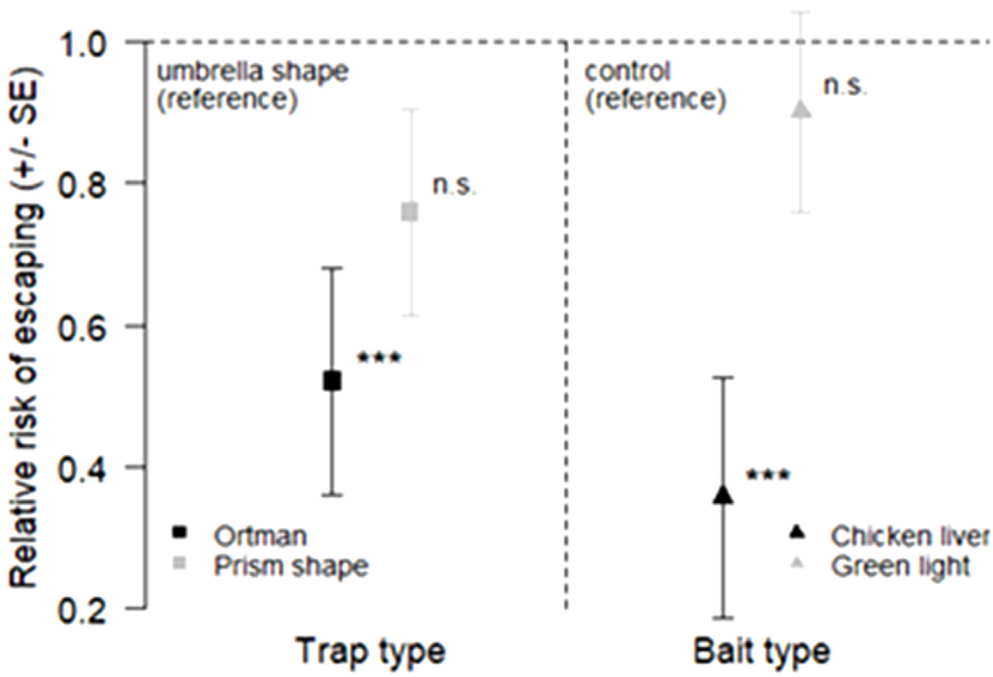


**Fig. 3.** Comparison between traps and baits in terms of relative risks of escaping during the 12 h monitoring experiments. Umbrella shape trap and control traps (without a bait) were used as the reference levels for the trap and bait comparison, respectively.

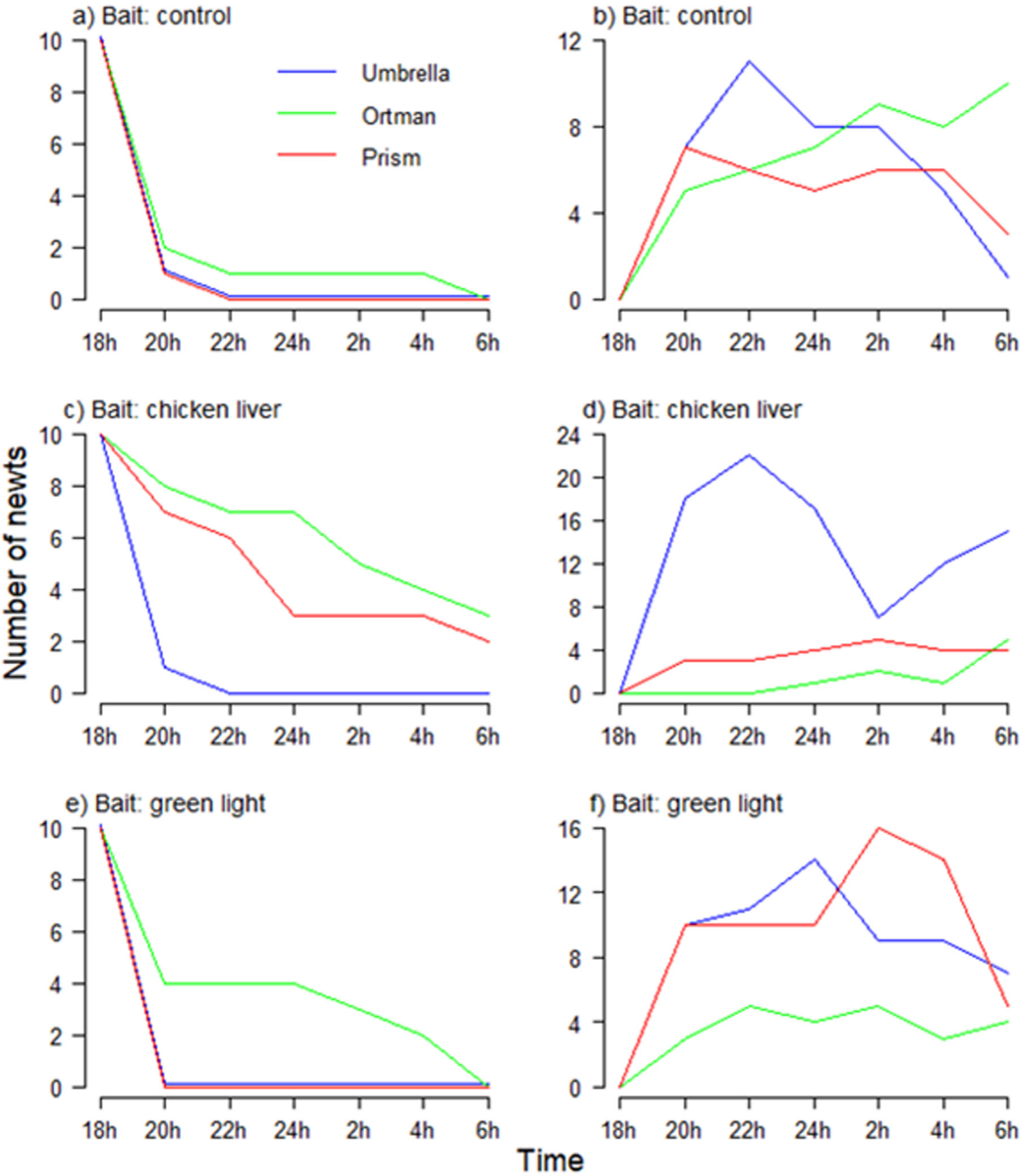


**Fig. 4.** Changes in the numbers of newts during the 12 h monitoring experiments in different kind of traps. a), c), e) denote newts putted at the beginning of the experiment; b), d), f) denote newcomers.

traps, with most newts returning to the Ortmann's trap without bait. Out of ten individuals placed in any of the three trap types at the beginning of the experiment, almost all were able to escape during the night.

Newts remained the longest in the Ortmann's trap and the shortest in the umbrella shape trap, where most individuals escaped before the first control 2 h after the start of the experiment (Fig. 4a). We also recorded the number of newcomers in each trap type. A total of 87 newcomers were recorded in the non-bait trap, 85 in the chicken liver bait trap, and 110 in the green chemical light trap (Fig. 4b). Regardless of the bait type, most newts in the umbrella shape trap were captured between 10:00 pm and 12:00 pm, in the Ortmann's trap between 2:00 am and 6:00 am, and in the prism shape trap between 8:00 pm and 2:00 am. We did not find a statistically significant relationship between sex and trapping time ($p > 0.05$). However, we did find that trap type and bait significantly affected trapping time ($p < 0.05$). Despite trapping the newts repeatedly and in different types of traps, we cannot confirm a trap-shy response.

## 4 Discussion

Monitoring of amphibians will become increasingly important for conservation decision-making due to population declines (Anderson *et al*.,2015; Davis *et al*.,2017). In this study, we found that the umbrella shape funnel trap was the most efficient at capturing T. cristatus compared to the Ortmann's trap and the commonly used prism shape trap (Fig. 2a) (Drechler *et al*., 2010; Pellet *et al*., 2010; Baker, 2013). The larger size and openings of the umbrella shape trap likely explain its higher efficiency. Conversely, the prism shape trap, despite being widely used for monitoring caudate amphibians, had the lowest efficiency (Bock *et al*., 2009; Pellet *et al*., 2010; Baker, 2013). Studies using prism traps to detect T. cristatus without a combination of CMR methods may underestimate the true population abundance. The low efficiency of the prism shape trap may be due to its small entrance, transparency, and size.

Studies on the use of baits in trapping amphibians have yielded contradictory results (Grayson and Row, 2007; Pellet *et al.,* 2010;Antonishak *et al*., 2017; Sannolo and Gatti, 2017). For example, Pellet et al. (2010) found no difference between traps with or without bait, and Sannolo and Gatti (2017) suggest that the presence of bait can reduce capture efficiency by attracting amphibian predators. However, the impact of predators on capture probability is unknown (Adams *et al*., 1997). Since T. cristatus has been shown to have color vision (Williams, 2014), the color of the bait and trap may also play a role. Antonishak et al. (2017) suggested that glow sticks could increase captures by providing a visual stimulus that attracts adult amphibians to the trap, which may explain the higher capture probability observed in this study.

The results of this study suggest that further investigation is needed to determine the difference between the efficiency of green and yellow light in capturing T. cristatus. The diminished effectiveness of chicken liver bait might stem from an unpublished study carried out at the same site, where newts were captured using prism-shaped traps baited with chicken liver and then subjected to gastric lavages. This experience could have led the newts to develop a bait aversion, which may continue to influence their behaviour over time. Males were found more frequently in the traps, possibly due to caution that drives females to stay deeper in the pond, as confirmed by Baker (2013), where traps were placed further from the shore and completely immersed in the water, resulting in a sex ratio opposite to the open water catch. Another possible explanation for the sex ratio could be the day of the year, as males tend to arrive at the site first during the migration from terrestrial to aquatic habitats (Langton et al., 2001; Gustafson, 2011) However, in this study, the difference in sex was not statistically significant. The Ortmann's trap combined with chicken liver bait was found to be the most effective in terms of trapping time and the ability of individuals to escape. The trapping time and escape ability were dependent on the type of trap and bait used. Drechsler *et al*. (2010) found that the newts remained the longest in the Ortmann's trap, which is consistent with the current study. Animals may seek traps as a safe place to hide, and the opaque Ortmann's trap may be particularly attractive for this reason (Griffiths, 1985). In contrast, newts were found to easily escape from the umbrella shape trap within 2 h of installation, possibly due to the large entries (Baker, 2013).

Funnel trapping is an effective technique for conducting amphibian inventories and monitoring trends (Adams *et al*., 1997). The use of traps allows for standardized experiments and more comparable results than dipnets .(Arntzen and Zuiderwijk, 2020). Aquatic funnel traps are non-destructive and suitable for surveying amphibians in lentic habitats, as opposed to dip-net surveys which may disturb aquatic vegetation and affect the water column through increased turbidity. Funnel trapping is recommended for sites where dense vegetation or woody debris limits visibility and inhibits dip-netting (Adams et al., 1997). Captured newts in aquatic funnel traps have been found to linearly scale with adult amphibian population density, suggesting captures as a reasonable estimate of adult population size (Wilson and Pearman, 2010). In the experiment during the year, the numbers of captured newts were higher at early sessions compared to late sessions (Arntzen and Zuiderwijk, 2020), irrespective of marking status. Consistently lower capture numbers at later sessions may indicate 'trap shyness,' where an animal's behaviour is altered after being caught for the first time, or conversely 'trap addiction' (Seber, 1982).

## 5 Conclusions

Based on our findings, we recommend using umbrella shape funnel traps for efficient monitoring of newts in ponds. The choice of monitoring strategy depends on the goal of the study. For determining the occurrence of newt species, traps dipped in the pond in the evening (22:00 pm) and checked the next morning (6:00 am) would suffice. However, for estimating population size, we suggest counting newts in traps continuously every 2 h during the night, as their numbers display high fluctuations with a peak at midnight. We did not find evidence of a trap-shy response in newts, as they were captured repeatedly in different types of traps. The use of funnel traps could also be effective for monitoring other endangered species, such as dytiscidae beetle adults and larvae, anisopteran larvae, or aquatic gastropods.

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## Supplementary Material

**Table S1.** Turnover of newts during the 12 h monitoring experiments. Ratios of total cumulative numbers of newts and numbers of newts recorded at the end of the experiment are presented for each trap and bait (total number of captured newts/numbers of remaining newts in parentheses).

The Supplementary Material is available at https://www.kmae-journal.org/10.1051/kmae/2023022/olm.

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