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Short Communication
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Funnel trapping yields largely unbiased sampling of crested and marbled newts (genus *Triturus*)

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Abstract – Amphibian populations are increasingly sampled with traps instead of the traditional dipnet, because of high yields at a comparatively low workload. Observations on sympatric newt species in the west of France uncovered a size effect in which the larger species *Triturus cristatus* and *T. marmoratus* were more frequently captured than the smaller species *Lissotriton helveticus* and *L. vulgaris*. The small juveniles of *T. cristatus* and the large *Triturus* interspecies hybrids fitted this series. The lightweight, collapsable, and easy to clean funnel traps here employed are useful for population studies because, due to a high capture efficiency, sampling biases can accurately be quantified and be accounted for.

Keywords: Catchability / *Lissotriton* / population biology / sympatry / *Triturus cristatus x T. marmoratus* hybrids

Surveying populations over time and space is an essential component to the study of wildlife for conservation and research. To this end, aquatic amphibians are increasingly investigated by using traps. In European newts aquatic trapping has been appreciated to be more productive at a lower workload compared to the traditional dipnet (Baker, 1999; Glandt, 2014) with results than can readily be compared over time and space (van Gelder, 1972). Trapping may also be less damaging to the habitat because it does not require the shaking and raking of aquatic flora and minimally affects pond water turbidity. Considering the high data yield that funnel trapping provides, accurate estimates of demographic parameters such as breeding population size and annual survival can possibly be obtained. I previously analysed funnel trap capture data in four sympatric newt species, namely *Lissotriton helveticus, L. vulgaris, Triturus cristatus* and *T. marmoratus* (Arntzen and Zuiderwijk, 2020) and here present additional data focussing on both *Triturus* species, with special attention to interspecies hybrids and *T. cristatus* juveniles that were not previously considered for scarcity of data.

Research was carried out in four field ponds in the municipality Jublains, département (dept.) Mayenne in the west of France from 2009 to 2024, except for 2020 due to travel restrictions during the COVID-19 pandemic. Pond ‘Ang1’ is a triangular field pond of 125 m^2 and a maximum depth of up to 130 cm in spring, ‘Ang2’ is a recently restored, permanent pond for fire-fighting purposes of 300 m^2 and a depth of 120 cm, pond ‘232’ is a circular cattle drinking pond (now garden pond) of 200 m^2 and a depth of 90 cm in spring, and pond ‘2D5’ is a cattle drinking pond at the edge of a forest of 45 m^2 with a depth of 70 cm in spring. Although both mentioned *Triturus* species and interspecies hybrids were observed in all four ponds, Ang1 and Ang2 had almost exclusively *T. cristatus*, 2D5 had almost exclusively *T. marmoratus* and pond 232 had substantial populations of both species as well as interspecies F_1 hybrids. These hybrids are straightforward to identify (Vallée, 1959; Arntzen *et al.*, 2021) and are analysed separately from the parental species *T. cristatus* and *T. marmoratus*. The presence of a juvenile cohort (*T. cristatus* only) is erratic but a fair number of data points could nevertheless be gathered. Published data on sympatric small bodied species *Lissotriton helveticus* and *L. vulgaris* from these and other local ponds are considered for comparison.

Sampling was done in spring and early summer with funnel traps as shown in Figure 1. For equipment manufacturing details see Arntzen and Zuiderwijk (2020). Series of overnight sampling sessions are together referred to as an ‘experiment’. When moved from one pond to the other, the traps were disinfected with a 1% (w/v) solution of Virkon® to prevent possible cross-contamination of e.g. chytrid fungus (Johnson *et al.*, 2003; Dejean *et al.*, 2010). The current work forms part of a long-term study on the population dynamics of related, coexisting and competing *Triturus* species (*e.g.*, Francillon-Vieillot *et al.*, 1990; Arntzen and Wallis, 1991; Jehle and Arntzen, 2000; Arntzen, 2024a). To allow individual recognition over time, captured individuals were marked through the insertion of a passive integrate transponder (PIT-tag). However, pattern mapping and toe clipping (Woodbury, 1956; Arntzen *et al.*, 2004) were used towards the end of the

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Fig. 1. Funnel trap used in the present study. The size of the entrance to the collecting chambre is 7 × 7 cm (see arrow) and the paper sheet is at the A4 format.

project, when additional PIT-tag usage was no longer deemed worth the expense.

Across 49 experiments, the number of installed funnel traps ranged from four to 13 (average 7.7) and the number of overnight sampling sessions ranged from three to nine (average 5.3). Sampling results were compared across experiments for sexes of the same species, for *T. cristatus* adults versus juveniles and for the two species and hybrids. For each subject group I determined N_{observed} (N_{o}, the number of newts irrespective of marking status) and $N_{\text{different}}$ (N_{d}, the number of unique individuals) so that the 'capture success' $\text{CS} = N_{\text{o}}/N_d$ gives the average number of times an individual was encountered. Capture success averaged at 2.2 ($1.0 < \text{CS} < 5.1$). I also calculated the relative capture success (RCS) which is CS for one group over the other ($\text{CS}_1/(\text{CS}_1 + \text{CS}_2)$.

No significant differences were observed for the sexes with data partitioned over six species/group/pond combinations, nor for the conglomerate (RCS ≈ 0.5, Wilcoxon signed rank test, standardized test statistic $|W| < 1.2$ in all cases, $P > 0.05$; Fig. 2). Within pond 232 no significant differences were found for *T. cristatus*/*T. marmorat*us ($W = 0.06$, $P > 0.05$) whereas the comparisons of parental species and hybrids was significant ($W = -2.05$, $P < 0.05$), indicating a higher catchability for hybrids. Finally, *T. cristatus* adults were more readily captured than juveniles in all 15 instances a juvenile cohort was present ($W = 3.30$, $P < 0.001$ over five experiments in ponds 232, six in Ang1 and three in Ang2). Considering the sizes of hybrids and juveniles compared to the parental species (Vallée, 1959; Cogălniceanu *et al.*, 2020; Arntzen, 2024b), the results indicate that the larger the size, the higher the catchability, to which groups can be arranged as hybrids > *T. cristatus* ≈ *T. marmoratus* >> *T. cristatus* juveniles. Although adult females are on average 6% larger than adult males (see body size data in Ivanović *et al.*, 2024), this is not reflected in significantly different catchabilities. Published data on four species (Arntzen and Zuiderwijk, 2020) were coded in Boolean 'true' versus 'false' format, confirming or denying that the capture success of one subject group is higher than the other, and were analysed by binomial tests (Tab. 1). Results reiterate a male bias in *Lissotriton* and not *Triturus*, no significant difference between congeneric species, and that small-bodied *Lissotriton* species have lower catchability than large-bodied *Triturus* species.

Out of 9830 observed *Triturus* newts 18 were found dead in the collecting chamber upon inspection of the funnel trap (0.18%). Most casualties were recorded in pond 232, possibly related to crowding conditions inside the funnel traps, but trap yields were not individually recorded. Adult *T. marmoratus* ($N = 10$) were more likely to succumb than adult *T. cristatus* ($N = 4$) (*G*-test of independence, df = 1, $G = 6.558$, $P < 0.05$). The material is preserved on ethanol at the Naturalis Biodiversity Center, Leiden, The Netherlands under collection numbers RMNH.RENA 47867, 48015, 51574, 53253-53266, and at the Batrachological Collection of the Institute for Biological Research 'Sinisa Stankovic', University of Belgrade, Serbia, under collection number 2822. Given the death toll I recommend that, when captures are substantial, overnight trapping sessions are not extended beyond the early morning.

By now a substantial body of literature exists on the performance of various kinds of traps in the study of amphibians, from which it is apparent that they perform well (van Gelder, 1972; Skelly and Richardson, 2010; Kronshage *et al.*, 2014; Weber *et al.*, 2023). The strengths and weaknesses of a variety of funnel trap types have been evaluated (Kronshage and Glandt, 2014) but fatalities as mentioned above are rarely quantified (see also references in Klemish *et al.*, 2013). The funnel traps here employed are lightweight, collapsable and easy to clean and operate. Newt catches are high, probably on account of a large catchment area not seen in other traps (Fig. 1). However, rather than to advocate one type of trap over the other it is here analysed if there are sampling biases to be reckoned with. A consistently observed bias relates to body size, in which larger individuals are more readily captured than smaller ones. This observations on *Triturus* can be extended to include the small bodied *Lissotriton* species with data from the literature. However, the strong sexual bias observed in *Lissotriton*, presumably reflecting a higher breeding associated locomotor activity in males over females (Griffiths, 1985; Arntzen and Zuiderwijk, 2020) was not apparent in the genus *Triturus*.

Capturing newts by funnel trapping is not just a case of individuals entering the trap, but also of (not) escaping from the trap (Weber *et al.*, 2023). Newt behaviour inside the collecting chamber is, however, yet to be studied. It may be that aquatic juveniles (*T. cristatus* only) with lower observed catchability, escape more easily than adults and/or leave the pond as in 'trap shyness' derived from the capturing and marking process, but these behaviours were not studied. While I observed that *Triturus* newts, especially *T. marmoratus*, make terrestrial feeding excursions during moist nights, adults are unlikely to prematurely emigrate from a pond because they are busy with reproductive activity, i.e., mating and egg-deposition.

The *complete* capture of populations may be crucial for the eradication of newts perceived to be a threat to the native fauna, such as *Ichthyosauara alpestris* and *Lissotriton vulgaris* that were illegally introduced in New Zealand and Australia (Bell, 2016; Reardon, 2017; Whinfield *et al.*, 2022) and may, with funnel traps as here evaluated, be within reach. For regular research the main strong points are ease of handling and a high capture efficiency so that sampling biases can accurately be quantified and be accounted for.

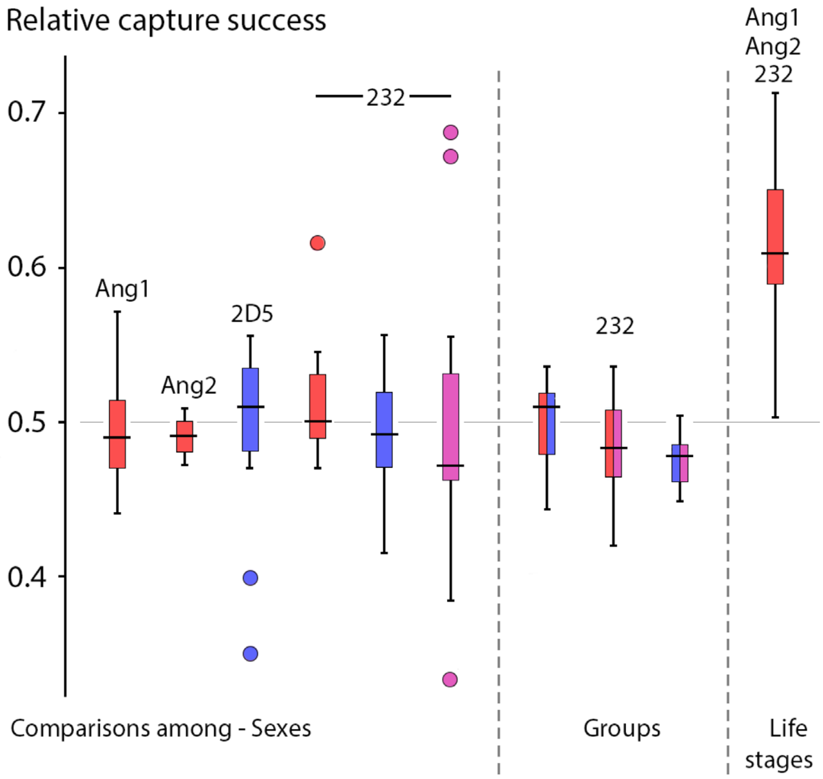

Fig. 2. Box-plots of relative capture success among groups of *Triturus* newts in four ponds in the department Mayenne in the west of France. Shown are the median – wide horizontal line, interquartile range – box, minimum and maximum – narrow horizontal lines and extreme cases – isolated round symbols. Left panel – comparisons for sexes (males over females), with *T. cristatus* in red, *T. marmoratus* in blue and interspecies hybrids in purple. Middle panel – comparisons for groups with *T. cristatus* versus *T. marmoratus* (red/blue), *T. cristatus* versus hybrids (red/purple) and *T. marmoratus* versus hybrids (blue/purple). Right panel – comparisons for life stages with *T. cristatus* adults versus juveniles. Locality numbers are shown on the top. For results of statistical analyses see text.

Table 1. Number of experiments in which the indicated group of newts was observed to have the higher capture success, with comparisons among sexes (top panel), species (middle panel), and genera (bottom panel). The 'small-bodied' newt species included are *Lissotriton helveticus* and *L. vulgaris*. The data are from Arntzen and Zuiderwijk (2020).

Comparison	Taxa involved		Groups compared		Significance
Sex			Males	Females	
	L. helveticus		21	9	*
	L. vulgaris		5	0	*
	T. cristatus		8	12	NS
	T. marmoratus		10.5	9.5	NS
Species			A	B	
	L. helveticus (A)	*L. vulgaris* (B)	3	6	NS
	T. cristatus (A)	*T. marmoratus* (B)	4	7	NS
Genus			A	B	
	Lissotriton (A)	*Triturus* (B)	3	31	***

Analysed by binomial test. Significance levels are: NS - not significant, * – P 0.05 and *** – P 0.001.

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