Zeitschrift für Feldherpetologie, Supplement 15: 317–326 November 2009
M. Hachtel, M. Schlüpmann, B. Thiesmeier & K. Weddeling (Hrsg.): Methoden der Feldherpetologie

The use of fish funnel traps for monitoring crested newts (*Triturus cristatus*) according to the Habitats Directive

Daniel Bock[1*], Veit Hennig[1] & Sebastian Steinfartz[2]

[1]University of Hamburg, Dept. of Biology, Research Group of Animal Ecology and Conservation, Martin-Luther-King-Platz 3, D-22609 Hamburg
[2]University of Bielefeld, Dept. Animal Behaviour, Research Group of Molecular Ecology and Behaviour, Morgenbreede 45, D-33615 Bielefeld
*Author for correspondence: Daniel Bock, University of Hamburg, Dept. of Biology, Research Group of Animal Ecology and Conservation, Martin-Luther-King-Platz 3, D-22609 Hamburg, daniel.bock2@gmx.de

Der Einsatz von Kleinfischreusen für das Monitoring des Kammmolches (*Triturus cristatus*) im Rahmen der Fauna-Flora-Habitat-Richtlinie

Das Monitoring von Amphibien unter den Vorgaben der Fauna-Flora-Habitat-Richtlinie (Richtlinie 92/43/EWG) stellt eine der wichtigsten Pflichten des angewandten Naturschutzes in Europa dar. Kammmolche (*Triturus cristatus*) werden in Deutschland in den Anhängen II und IV der FFH-Richtlinie geführt, woraus sich ergibt, dass der Erhaltungszustand ausgesuchter Kammmolch-Populationen durch entsprechende Monitoring-Maßnahmen überwacht werden muss. In der vorliegenden Studie haben wir mit vier unterschiedlichen methodischen Ansätzen den Einsatz von Kleinfischreusen zum Bestands-Monitoring von Kammmolch-Populationen in insgesamt 22 Gewässern im Gebiet der Stadt Hamburg untersucht. Im einzelnen beinhalteten die Ansätze folgende Vorgehensweisen: i) Kontrolle der Reusen an einem Tag zu zwei unterschiedlichen Tageszeiten mit einer Wiederholung nach drei Wochen; ii) Kontrolle der Reusen über einen Zeitraum von drei Tagen jeweils morgens und abends; iii) Kontrolle der Reusen über einen Zeitraum von 24 Stunden jeweils alle zwei Stunden; iv) Verwendung von zwei Reusengrößen, um auf Abhängigkeit der Fängigkeit von der Größe der eingesetzten Reuse zu prüfen. Im Gegensatz zu früheren Studien, die mit Fischreusen durchgeführt worden waren, konnten wir in keinem der vier Untersuchungsansätze geschlechtsspezifische Unterschiede bezüglich der Häufigkeit gefangener Kammmolche feststellen. Sowohl die Methode des 3-Tage-Untersuchungsansatzes als auch das 24-Stunden-Monitoring ergaben signifikant höhere Fangzahlen an Kammmolchen in der Nacht als am Tag, was mit Sicherheit auf eine höhere Aktivität der Kammmolche während der Dunkelheit zurück zu führen ist. Die detaillierte Analyse der Perioden des 24-Stunden-Monitorings zeigte zudem, dass die Kammmolche ihre größte Aktivität während der späten (ca. 23:00 Uhr) und frühen Dämmerungsphasen (ca. 3:00 Uhr) hatten. Die Aufenthaltsdauer in den Reusen korrelierte positiv mit der Reusengröße, allerdings hatte die Reusengröße keinen messbaren Effekt auf die Größe der gefangenen Kammmolche. Nur 15 von 220 individuell registrierten Kammmolchen konnten wieder gefangen werden. Unsere Untersuchung zeigt, dass Kleinfischreusen ein effektives Mittel für das Monitoring von Kammmolchen sind, wobei die Kontrolle der Reusen sich am Aktivitätsmaximum der Molche, welches in den Dämmerungsphasen liegt, orientieren sollte. Die geringe

Wiederfangrate trotz intensiven Monitorings bestätigt die Befunde einer Parallelstudie aus Krefeld, die andeutet, dass Populationen des Kammmolches deutlich größer sein können als oft angenommen wird.

Schlüsselbegriffe: Monitoring, Nachweismethoden, Amphibien, Kammmolch, *Triturus cristatus*, FFH-Richtlinie, Fischreuse.

Abstract

The monitoring of amphibians under the Habitats Directive (92/43/EEC) is a major challenge for applied conservation biology in Europe. Great crested newts (*Triturus cristatus*) are listed under annex II and IV of the Habitats Directive, and the conservation status of the species should thus be continuously monitored. In this study, we monitored *T. cristatus* populations in the federal state of Hamburg in Germany using fish funnel traps in four distinct study designs, with the aim of improving monitoring efficacy. Study designs included i) checking traps on two separate occasions separated by three weeks; ii) daily checking of traps in the morning and in the evening over a period of three days; iii) checking traps every two hours over a 24-hour time period, with individuals monitored by their ventral pattern; and iv) testing large *versus* small trap size for catch ability. In contrast to previous studies using fish traps, we did not find a sex bias for caught newts in any of the four study setups. The 3-day and 24-hour monitoring approaches resulted in significantly higher catch rates at night than during the daytime, due to higher crested newt activity at night. Detailed analysis of the 24-hour monitoring period showed that newts were most active during the twilight hours (i.e., around 11 p. m. and 3 a. m.). Duration of their stay in the trap was correlated positive with trap size, but trap size was not related to the average total body length of caught newts. Only 15 of 220 individually marked newts were recaptured. Overall, our study showed that fish traps are an efficient tool for monitoring crested newts, but that monitoring occasions should be centred on the activity peaks of crested newts during twilight hours. The low recapture rate of crested newts despite the intense monitoring effort was in line with a parallel study in Krefeld, showing that crested newt populations are larger than originally believed.

Key words: Monitoring methods, amphibians, crested newt, *Triturus cristatus*, catch ability, Habitats Directive, fish trap.

Introduction

Worldwide, amphibians are experiencing the greatest decline among all vertebrate classes (STUART et al. 2004). There are several possible reasons for this trend, including habitat fragmentation, infectious diseases and climate change (NYSTROM et al. 2007, LIPS et al. 2008, SODHI et al. 2008). In the face of declining amphibian populations, effective monitoring of endangered amphibian species becomes increasingly important.

The basic approach when monitoring amphibian populations is to estimate the population size while minimizing the disturbance of individuals arising from monitoring efforts. Population sizes of newt species are generally estimated by catching individuals with dip nets, drift fences around the reproduction habitat (in most cases ponds), or funnel traps. The efficiency of these methods has been debated in the literature. BAKER (1999) found fish traps to be more effective than drift fences and ARNTZEN

(2002) found that dip netting was the best way to standardize catching efforts across different ponds.

In this study, we tested the efficiency of techniques for monitoring populations of the crested newt (*Triturus cristatus*) near Hamburg in Germany. Crested newts normally reproduce in ponds offering rich sub aquatic vegetation (ARNTZEN 2003). Previous studies were able to capture between 20 and 40 adult individuals in a single pool (ARNTZEN 2003), and estimates of the population size ranged from 29–1 408 individuals (THIESMEIER et al. 2009). *Triturus cristatus* is listed under annex II and IV of the Habitats Directive ((92/43/EEC) and is therefore strictly protected in Europe. In Germany, each federal state is responsible for fulfilling reporting requirements under the Directive including the monitoring of population sizes. While each state has created its own monitoring program for the species under Habitats Directive, cost-effectiveness is a superior necessity.

In Hamburg, a federal state of Germany, monitoring of crested newts under the Habitats Directive is performed with three inspections. For the first two inspections, funnel traps are used to sample the adult population. In the third inspection, newt larvae are sampled as an indicator of reproductive success. The maximum number of traps required to sample adult newts in a single pond is ten for one inspection. Traps are distributed evenly around the pond one meter from the pond's edge. The distance between traps should be approximately equal.

In this study, we tested the efficiency of monitoring crested newts under the Habitats Directive as practiced by the Department of Urban Development and Environment (Behörde für Stadtentwicklung und Umwelt) of the federal state of Hamburg. Our study design included four different setups ranging from standard monitoring procedures as practiced by the Department of Environmental Protection in Hamburg to a 24 hours monitoring approach to study activity patterns of crested newts. Finally, we checked whether the size of the traps affected the capture success rate for crested newts.

Materials and Methods

Monitoring setups

The study sites »Höltigbaum« and »Stellmoorer Tunneltal« are located in the east of Hamburg (Germany; see fig. 1) and have been nature reserve areas since 1998. In 2004, the sites were designated as special areas of conservation. Since then, a total area of 743 ha has been protected under the Habitats Directive. Streams and drumlins are characteristic of our study area. Twenty two ponds distributed over an area of 6–7 km were selected for monitoring crested newt population sizes (see fig. 1 for details).

Pond size ranged from small (23 m²) to large (3 943 m²) bodies of water. Crested newts were caught from the middle of May until the middle of July in 2006 using two different sizes of fish traps: a small one (25 x 25 x 43 cm) and a larger one (25 x 25 x 81 cm). Newts were able to use two quadratic (5.5 x 5.5 cm) openings to enter traps that were

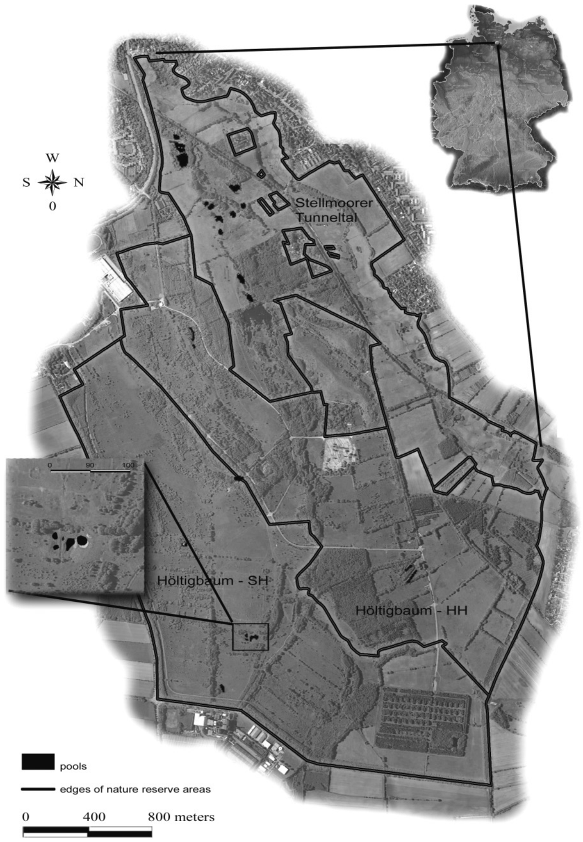

Fig. 1: Map of the study area (taken from Google Earth and www.weltkarte.de). Study sites are shown in black. Karte des Untersuchungsgebietes (Quelle: GoogleEarth und www.weltkarte.de). Untersuchungsorte sind schwarz markiert.

covered with 5-mm mesh gauze. Traps were fitted with buoys so that there was always some part of the trap above water surface to avoid drowning of newts. Figure 2 shows a picture of a small trap in use during the study.

Traps were equally distributed across the pools one meter from the edge of the pool. Following a guideline of the Behörde für Stadtentwicklung und Umwelt of the federal state of Hamburg, the responsible executive body for conducting monitoring according to Habitats Directive, trap density was one per 10 m^2 of surface area in a pool. The maximum number of traps per pool was not allowed to exceed ten. If pools harboured poor conditions for newts – e. g., high density of fish, low levels of sunlight or low amount of suitable water plants for egg deposition – the number of traps was reduced to a maximum of five.

We used four different approaches to monitor crested newts with fish traps:

i) Traps were each checked in the morning and the evening on two different occasions (days) separated by a time interval of three weeks. Newts were measured and released after the check.

ii) Traps were checked every morning and evening over the course of three days. Newts were measured and released after the check.

iii) Traps were checked every two hours over a 24-hour period and all individuals were recorded by their ventral pattern and placed back in the trap. After each check, a status notation considering the status before and after the check was given to each individual found in the trap. If an individual was in the same trap before and after a check, it received the status »stay-stay«. An individual that was previously in the trap but left during the two-hour period received the status »stay-go«. If the individual was not in the trap before and entered during the intervening two hours, it received the status »come-stay«. Finally, if an individual was not in the trap before and after the check, it received the status »come-go«. An overview of the single status and its notation is presented by table 1.

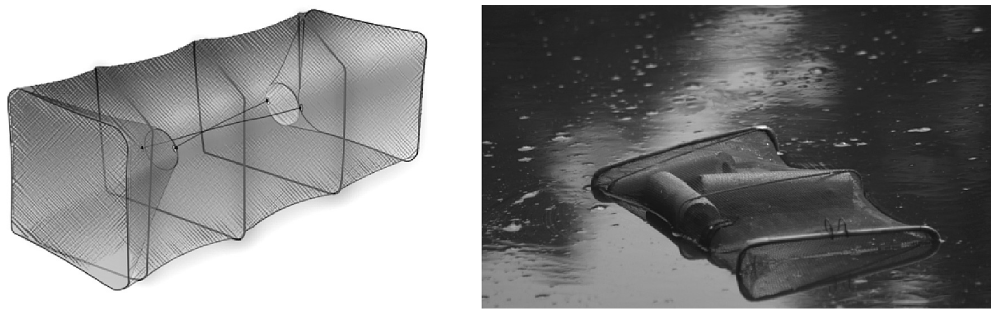

Fig. 2: Schematic illustration of a fish funnel trap used for monitoring crested newts (left) and funnel trap in use (right).
Schematische Darstellung einer Kleinfischreuse, wie sie zum Monitoring für Kammmolche verwandt wurde (links), und Kleinfischreuse im Einsatz (rechts).

In order to determine the fluctuation rate of newts in a trap, the number of individuals caught within four hours (i. e., two temporally adjoined control intervals) was summed. Twice the number of newts present in a single trap across both control intervals was subtracted from this sum. The three pools that were part of this monitoring approach were separated from each other by 1.2–1.3 km.

Tab. 1: Overview of the status notation based on the check and the control before and after the check (X = present; - = absent).
Überblick der Statusbenennungen basierend auf der Kontrolle und der entsprechenden vorherigen und nachfolgenden Kontrolle (X = anwesend; - = abwesend).

Before check	Check	After check	Status notation
X	X	X	stay-stay
X	X	-	stay-go
-	X	X	come-stay
-	X	-	come-go

iv) Newts were counted over a 24 hour period as described in iii) in only one pool with two trap sizes: a small one (25 x 25 x 43 cm) and a larger one (25 x 25 x 81 cm). Five pairs of traps (a small and a larger one) were equally distributed across the pool in similar locations to assure the comparability of catching results.

Statistical analysis

All data were entered into a Microsoft Access database. The program SPSS (Version 15.0.1 © SPSS Inc.) was used to perform Chi-square and contingency tests for nominal data. Mann-Whitney-U tests were used for ordinal data, and t-tests for metric data. Before performing t-tests, metric data were tested for a normal distribution using a Kolmogoroff-Smirnoff test using SPSS.

Results

During the study period (mid-May to mid-June, 2006), 401 adult crested newts were registered in the traps of 22 ponds. During the 24-hour control period setup, 186 individual catches were registered. Overall, the number of males caught was not significantly higher than the number of females caught (99 males and 116 females, Chi²: χ^2 =

Number of individual	Sex	Pool	Time interval	Study part
1	male	1	9.5 h	i
26	male	15	7 d	i/iii
32	male	15	6 d	i/iii
59	male	21	33 d	i/iii
70	male	21	33 d	i/iii
117	male	21	22 d	ii/iii
199	female	21	39 h	ii
200	male	21	35 h	ii
210	female	21	15 h	ii
125	female	21	2 h	iii
125	female	21	2 h	iii
153	male	21	4 h	iii
180	female	21	6 h	iii
184	female	21	2 h	iii
184	female	21	4 h	iii

Tab. 2: Breakdown of recapture events of newts with regard to sex, pool number, time interval of recapture event and study part.
Überblick über die Wiederfangereignisse von Kammmolchen mit Geschlecht, Gewässernummer, Zeitintervall zwischen den Fängen und dem Untersuchungsteil.

1.344; n. s. $p = 0.246$; df = 1; n = 215). Crested newts were significantly more active at night than during the day, with traps exhibiting a significantly increased nocturnal catching rate (59 catches during day, 156 during night; Ch²: $\chi^2 = 43.763$; $p < 0.001$; df = 1; n = 215). Only 13 of 220 individually marked newts were recaptured during 15 recapture events (see tab. 2 for a detailed list of all recapture events).

We found the following results for our four different study designs (i–iv):

i) The ratio of males to females captured did not differ between the first and second sampling (1.21/1.83 contingency interval: $\chi^2 = 1.813$; n. s. $p = 0.176$; df = 1; n = 139). The ratio of newts caught in the daytime to newts caught at night also remained unchanged from the first to the second sampling (4.29/2 ratio, contingency interval: $\chi^2 = 3.293$; n. s. $p = 0.070$; df = 1; n = 139).

ii.) Altogether, 75 crested newts were caught over a period of three days (see tab. 3).

Over the three days, the ratio of day to night catches differed (contingency interval: $\chi^2 = 8.272$; $p < 0.05$; df = 2; n = 75), but no sex bias between caught individuals was observed (Chi²: $\chi^2 = 0.216$; n.s. $p = 0.642$; df = 1; n = 75).

iii.) The 24-hour monitoring setup showed a high amount of activity for newts throughout the entire period. In the three pools, 186 catch events were recorded. The

Tab. 3: Numbers of newts caught during the 3-day catch interval in three pools. For each pool the number of caught males and females as well as the percentage distribution of catches according to the time of the day is given.
Anzahl der während des 3-Tagefangs registrierten Kammmolche in drei Gewässern. Für jedes Gewässer ist die Anzahl der gefangenen Männchen und Weibchen sowie die prozentuale Verteilung der Fänge, aufgeteilt nach der Tageszeit, angegeben.

	Pool 3	Pool 6	Pool 21	Total across the three pools
Males	6	6	23	35
Females	8	17	14	39
Total	14	23	38	**75**
Day	7.1 %	34.8 %	39.5 %	32.0 %
Night	92.9 %	65.2 %	60.5 %	68.0 %

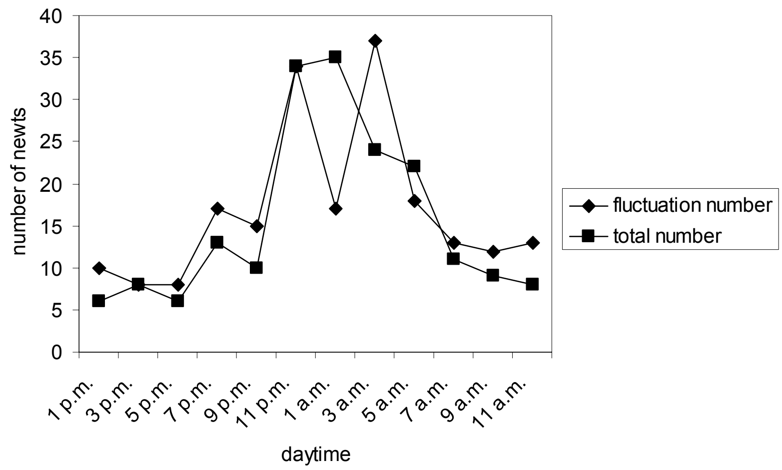

Fig. 3: Temporal-dependent abundance of newts in relation with the fluctuation number of crested newts during the 24-hours monitoring approach (see methodological description in iii in the Material and Method section for details).
Vergleich der zeitlich basierten Abundanz der Kammmolche mit der Fluktuation der Tiere während des 24-Stunden-Monitorings (siehe methodische Beschreibung in iii bei Material und Methoden).

highest number of individuals (35) was recorded at 1:00 a. m., and the fewest individuals (6) were recorded at 1:00 p. m. and 5:00 p. m.. This trend was not fully reflected by the fluctuation rate. The highest number of changes was found at 3:00 a. m. (see fig. 3).

There was no discrepancy between the sexes during the 24-hour period (Ch²: χ^2 = 0.232; n. s., p = 0.630; df = 1; n = 178). Males and females showed no difference in their

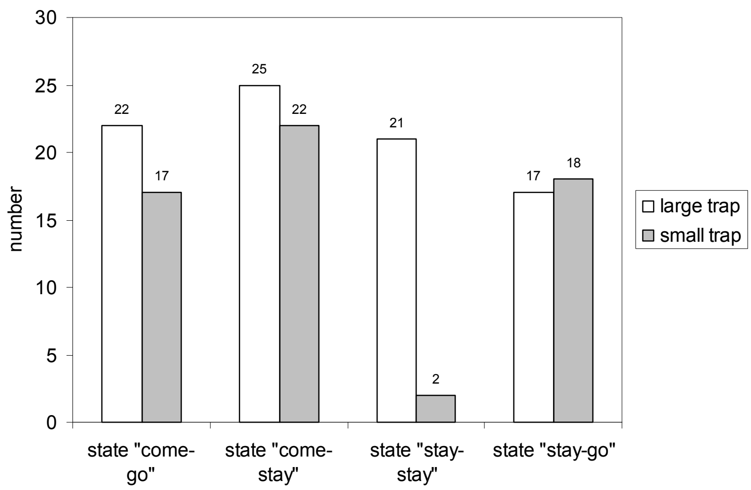

Fig. 4: Duration of newt behavior in the large and small fish traps according to the classifications »come-go«, »come-stay«, »stay« and »stay-go« (see study design iv).
Aufenthaltsdauer der Kammmolche in den kleinen und großen Kleinfischreusen für die Klassifikationen »come-go«, »come-stay«, »stay« und »stay-go« (siehe Versuchsdesign iv).

pattern of mobility over the day if catch events were only analyzed according to the status »stay-stay«.

iv.) 82 individuals were caught in the five pairs of traps. When all catch events were evaluated using the approach in iii.), larger traps had significantly more individuals in »stay-stay« status than the smaller traps (Ch²: $\chi^2 = 15.696$; $p < 0.001$; df = 1; n = 23). For the other three conditions, we observed no differences (Chi²: status »stay-go«: $\chi^2 = 0.243$; n. s., p = 0.622; df = 1; n = 47; status »come-stay«: $\chi^2 = 0.191$; n. s. p = 0.662; df = 1; n = 37; status »come-go«: $\chi^2 = 0.029$; n. s. p = 0.866; df = 1; n = 35). Figure 4 shows the numbers of newts in the four different conditions in the two traps.

As with the other study designs, we did not detect any sex-specific differences of catch ability when using different-sized traps (Ch²: $\chi^2 = 0.892$; n. s. p = 0.345; df = 1; n = 136). The total time the newts stayed in the traps was also not influenced by trap size (2/2, Mann-Whitney-U: Z = -0.936; n. s. p = 0.349; n = 81). Finally, the trap size did not select for larger total body length (t-test: F = 2.350; t = -1.190; n. s., p = 0.238; n = 82).

Discussion

The main objective of this study was to apply different approaches for monitoring crested newts (*Triturus cristatus*) using fish funnel traps. The relatively large number of newts caught in our study (220 individuals) documents the general utility of applied funnel traps (see fig. 2) for monitoring middle- to large-bodied newts typically found in Germany and other middle European pond habitats. Handling, usefulness and cost efficiency of funnel traps for monitoring newts has been discussed in detail by e. g. KUPFER (2001) and HAACKS & DREWS (2008). A recent study by ORTMANN et al. (2005) showed further that funnel traps are much better suited for estimating population sizes than usually applied drift fences. Possible sex-biased catch rate introduced by the application of funnel traps using have been studied by different teams with quite different results. BAKER (1999) found an equal proportion of caught males *versus* caught females in funnel traps, whereas BEEBEE (1990) found that more males than females were caught. ORTMANN et al. (2005) found a sex-bias in trapped crested newts towards males. In all of the four different monitoring approaches used in this study, covering monitoring periods ranging from 24 hours to three weeks, we did not find any evidence for sex-biased catching of *T. cristatus* in fish traps. One possible reason for the quite different outcomes might be that sex-ratio fluctuate over the different seasons.

Another issue raised by KUPFER (2001) was that funnel traps might only catch 27–69 % of a given population of crested newts based on the comparison between the number of caught individuals and the extrapolated number of individuals in two mark-recapture studies. This might lend support for the hypothesis that only a small portion of individuals of a respective crested newt population might participate in reproduction (ARNTZEN & TEUNIS 1993, HALLEY et al. 1996) or that simply only a fraction of individuals are caught. Estimates of population sizes based on Capture-Mark-Recapture (CMR) data would be an accurate tool to address this question. In our case we did not perform such an analysis as the number of recaptures were rather low.

Still, the assumption that crested newts normally remain in a specific pond for the entire breeding period (GRIFFITHS 1996, JEHLE 2000, JEHLE & ARNTZEN 2000, PERRET et al. 2003), a high rate of recapture events would be expected, especially in smaller ponds. The fact that only 13 of 220 initially captured-marked newts were recaptured in our study, despite intensive monitoring efforts and a constant catch rate, might hint that population size of crested newts in our study area is rather high. Indeed, catch data for 4 390 individuals and an estimated population size around 8 000 individuals for a newt population in Krefeld (Germany; ORTMANN 2007) further suggests that populations of crested newts sometimes may be much larger than hitherto assumed.

In the 3-day (approach iii; table 2) and 24-hour catch trials (approach iv; fig. 4) significantly more newts were caught at night than during the daytime, reflecting a higher activity level for newts at night. In order to avoid biased and inaccurate estimates, we recommend that inspections aimed at estimating the population size of crested newt populations should be carried out when the circadian activity of newts is at its highest. Assuming that the number of newts caught in the traps is correlated with their activity, the peak activity period is during the twilight periods (around 11:00 p. m. and 3:00 a. m.) and not during the darkest time (around 1:00 a. m.). Therefore, our data suggest that inspections in the course of monitoring crested newt populations should be carried out during/include the twilight hours and not only restricted to the day time.

By using different-sized funnel traps, we tested the impact of trap size on the catching success of crested newts. Newts stayed in larger traps significantly longer than they did in the smaller ones, as revealed by the difference in »stay« status between inspection times. This suggests that the size of the trap was related to the duration of time the newts spent in the trap, and that it is more difficult for newts to leave larger than smaller traps.

Conclusion

Our study shows that fish funnel traps can be used for monitoring crested newt populations. However, inspections should account for the circadian activity of the newts and funnel traps should be exposed over night (minimal one night). Our data are in line with other studies showing that the population size of crested newts might be severely underestimated and suggest that some populations might be unexpectedly large. Thus, the use of CMR techniques is strongly recommended to assure accurate populations size estimates. New and intensive monitoring/research approaches aimed at determining the size and dimensions of crested newt populations are required to provide the basis for an effective long-term management strategy for this unique European newt species.

Acknowledgements

We thank the Stiftung Naturschutz Schleswig-Holstein, especially JUTTA SANDKÜHLER for their help and cooperation, JOANNE ULLRICH for comments on the paper and MICHALA GOHLKE for help with some of the graphics. The Behörde für Stadtentwicklung und Umwelt in Hamburg and the LANU of Schleswig-Holstein kindly allowed us to carry out this study.

References

ARNTZEN, J. W. (2003): *Triturus cristatus* Superspezies – Kammmolch-Artenkreis In: THIESMEIER, B. & K. GROSSENBACHER (Hrsg.): Handbuch der Reptilien und Amphibien Europas. Band 4/II A: 425–514 – Wiebelsheim (Aula).

ARNTZEN, J. W. (2002): Seasonal Variation in sex ratio and asynchronous presence at ponds of male and female *Triturus* newts. – Journal of Herpetology 36: 30–35.

ARNTZEN, J. W, R. S. OLDHAM & D. M. LATHAM (1995): Cost effective drift fences for toads and newts. – Amphibia-Reptilia 16: 137–145.

ARNTZEN, J. W. & S. F. M. TEUNIS (1993): A six year study on the population dynamics of the crested newt (*Triturus cristatus*) following the colonisation of a newly created pond. – Herpetological Journal 3: 99–110.

ARNTZEN, J. W., G. ESPREGUEIRA THEMUDO & B. WIELSTRA (2007): The phylogeny of crested newts (*Triturus cristatus* superspecies): nuclear and mitochondrial genetic characters suggest a hard polytomy, in line with the paleogeography of the centre of origin. – Contributions to Zoology 76: 261–278.

BAKER, J. M. R. (1999): Abundance and survival rates of great crested newts (*Triturus cristatus*) at a pond in central England: monitoring individuals. – Herpetological Journal 9: 55–63.

BEEBEE, T. J. C. (1990): Crested newts rescue: how many can be caught? – British Herpetological Society Bulletin 32: 12–14.

GRIFFITHS, R. A. (1996): Newts and Salamanders of Europe. – London (Academic Press).

HAACKS, M. & A. DREWS (2008): Bestandserfassung des Kammmolchs in Schleswig-Holstein – Vergleichsstudie zur Fängigkeit von PET-Trichterfallen und Kleinfischreusen. – Zeitschrift für Feldherpetologie 15: 79–88.

HALLEY, J. M., R. S. OLDHAM & J. W. ARNTZEN (1996): Predicting the persistence of amphibian populations with the help of spatial model. – The Journal of Applied Ecology 33: 455–470.

JEHLE, R. (2000): The terrestrial summer habitat of radiotracked great crested newts (*Triturus cristatus*) and the marble newts (*T. marmoratus*). – Herpetological Journal 10: 137–142.

JEHLE, R. & J. W. ARNTZEN (2000): Post-breeding migration of newts (*Triturus cristatus* and *T. marmoratus*) with constrating ecological requirements. – Journal of Zoology 251: 297–306.

KUPFER, A. (2001): Ist er da oder nicht? – eine Übersicht über die Nachweismethoden für Kammmolche (*Triturus cristatus*). – Rana Sonderheft 4: 137–144.

LIPS K. R., J. DIFFENDORFER, J. R. MENDELSON & M. W. SEARS (2008): Riding the wave: Reconciling the roles of disease and climate change in amphibian declines. – Plos Biology 6: 441–454.

NYSTRÖM, P., J. HANSSON, J. MANSSON, M. SUNDSTEDT, C. RESLOW & A. BROSTRÖM (2007): A documented amphibian declineover 40 years: Possible causes and implications for species recovery. – Biological Conservation 138: 399–411.

ORTMANN, D (2007): Kammmolch Monitoring Krefeld (KMK) – Abschlussbericht. Stadt Krefeld, unveröff.

ORTMANN, D., M. HACHTEL, U. SANDER, P. SCHMIDT, D. TARKHNISHVILI, K. WEDDELING & W. BÖHME (2005): Standardmethoden auf dem Prüfstand: Vergleich der Effektivität von Fangzäunen und Unterwassertrichterfallen bei der Erfassung des Kammmolches, *Triturus cristatus*. – Zeitschrift für Feldherptologie 12: 197–209.

PERRET, N., R. PRADEL, C. MIAUD, O. GROLET & P. JOLY (2003): Transience, dispersal and survival rates in newt patchy populations. – Journal of Animal Ecology 72: 567–575.

SODHI, N. S., D. BICKFORD, A. C. DIESMOS, T. M. LEE, L. P. KOH, B. W. BROOK, C. H. SEKERCIOGLU & C. J. A. BRADSHAW (2008): Measering the meltdown: Drivers of global amphibian extinction and decline. – Plos one 3: 1–8.

STUART, S. N., J. S. CHANSON, N. A. COX, B. E. YOUNG, A. S. L. RODRIGUES, D. L. FISCHMAN & R. W. WALLER (2004): Status and trends of amphibian declines and extinctions worldwide. – Science 306: 1783–1786.

THIESMEIER, B., A. KUPFER & R. JEHLE (2009): Der Kammmolch. 2. Aufl. – Bielefeld (Laurenti).