Herpetological Bulletin (2013) 123: 13-18

Research Article

Apparent influences of mechano-reception on great crested newt *Triturus cristatus* behaviour and capture in bottle-traps

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ABSTRACT - Increased knowledge of great crested newt behaviour may benefit the effectiveness of survey techniques. Factors associated with trap entry, distribution of each sex related to availability of display areas and quality of egg-laying sites were investigated in a small garden pond in Surrey England. Video-records of 50 newt entries into a trap funnel and eleven captures suggested water disturbance was a factor related to capture. From night-counts males appeared to seek out display areas unused by other males, and female presence correlated ($P < 0.05$) with the number of leaves large enough for crested newt egg deposition. Discrepancies in the totals of night-counts with over-night catch totals provided evidence supporting the view that mechano-reception is important for this species. In open water newts in front of and within 30 cm of the trap entrance were susceptible to capture.

INTRODUCTION

Surveying for this European protected species is most effective whilst newts are in their breeding ponds, and for qualitative data the methods used are night time bottle-trapping and torchlight counts (Griffiths et al., 1996; English Nature, 2001). Further analysis of earlier work (Hughes, 2012) found that more newts entered regions where traps faced into open water than where traps were absent. This was explored further in 2002. In 2007 effects on newt distribution related to availability of breeding resources and the expanse of vegetation free water in front of traps were investigated and whether swimming newts enter traps.

MATERIALS AND METHODS

The study site

Hughes (2012) described the 8 m^2 pond, trap design and procedures for bottle-trapping, night-counts and video-recording. Spaces, between 20 cm high plant baskets with vertical sides, were created for placing traps at 15 cm depth on the marginal shelf (Fig. 1). Plants trailing from the baskets into these spaces were removed. Normally traps faced the pond centre (Fig. 2) and were tilted at 30° to the horizontal (Hughes, 2012).

Experimental design

Entry into traps

Newt behaviour, both associated and un-associated with trap entry, was examined on an area (80 x 45 cm) of bare substrate (Fig. 3a). Traps placed facing the pond side allowed all activity in front of them to be video-recorded. Any shading (a preferred microhabitat feature (Hughes, 2012)) was minimised by using clear colourless, rather than green, bottle-traps placed horizontally on the 80 x 45 cm recorded area. As air reservoirs could not be enclosed escape holes were provided. Ten three-hour records commencing at sunset were obtained between 26 March and 17 May 2002. The trapezoidal funnel-sectors (Fig. 3a) had perimeters of 112 + 10 cm and 82 + 10 cm, the 10 cm being the trap diameter was taken as the trap threshold (Fig. 3b). To test for any tendency to cross this threshold into the trap funnel (Fig. 3b), for each newt entry into a funnel-sector the exit boundary was noted.

Factors potentially influencing capture were investigated by examining newt locations and activities associated with three events: capture, funnel-entry followed by retreat from the funnel and no funnel-entry by newts which settled

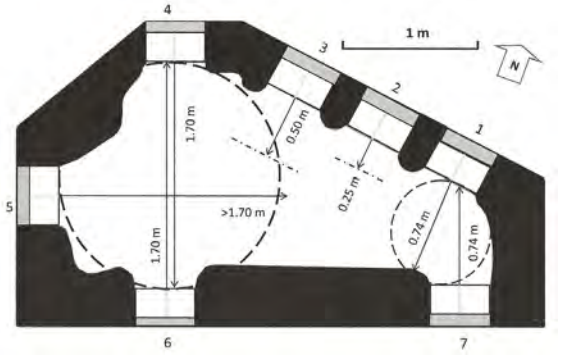

Figure 1. Plan view of the garden pond in 2007. Black regions denote plant baskets either side of spaces 1–7 and other vegetated regions on the shelf. When trapping, two curtains (Figure 2) were alternately positioned in front of spaces 2 and 3.

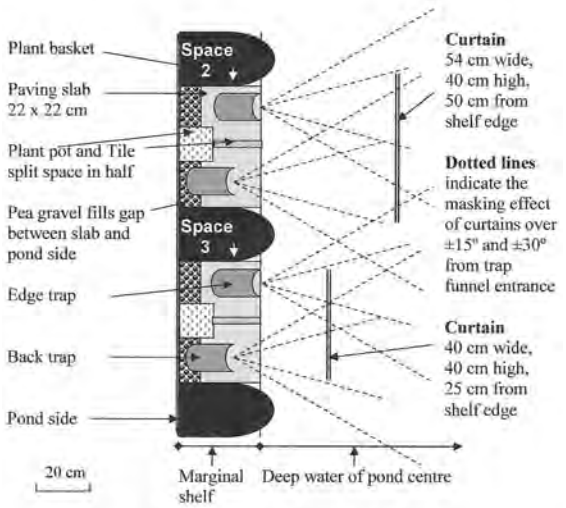

Figure 2. Plan view of spaces 2 and 3 when trapping. Spaces 1, 4, 5, 6 and 7 (Figure 1) were identical in structure except without curtains in front of the marginal shelf.

within five centimetres of a trap threshold. Prior to these events the newt was either beyond the trap funnel-sectors or in a funnel-sector plus the bordering coping stones (Fig. 3a).'Interacting' implies newts were within five centimetres of each other and usually a male was hand-standing. 'Scouting' refers to the predominate male activity observed: they would settle and were stationary on the substrate, but frequently re-orientated themselves or in stages moved across the substrate over < 10-25 cm often with a wave of the tail and outstretched fore legs then settled again. The arrival of another newt triggered an approach in the same manner, as a sequence of stages over short distances and settling as it progressed towards the new arrival. Of 32 arrivals 21 first landed > 20 cm away. 'Loner' is used describe single newts in the recorded area including males not apparently scouting.

Male distribution

The spaces on the shelf were used by males as display areas (Hughes, 2012). Using count data male distribution was examined with seven and 14 display areas. The surface of the seven 45 cm long spaces (Fig. 1) was composed of two paving slabs 22 x 22 cm placed one centimetre apart. By placing a vertical tile in the gap and pushing it against a small plant pot at the pond edge (Fig. 2) 14 separate display areas were created. Between 10 March and 27 April 2007, about two hours after sunset the number and sex of newts within each half space were counted on 24 nights, for 12 of these spaces were divided and traps set.

Female distribution

Female capture appears to be influenced by the amount of egg-laying material close to the trap (Hughes, 2012). The plant pots (Fig. 2) contained a mix of species used for egg deposition, *Myosotis scorpioides*, *Ranunculus flammula* and *Veronica beccabunga*. To rank the quality of each space for egg-laying, on 8 April 2007 the number of leaves judged to be large enough for crested newt oviposition was counted (17-42) and used to test for correlation with the total catches in each space and counts in undivided spaces.

Capture of swimming newts

Newt capture can occur when newts are in front of and on the same substrate as the trap (Hughes, 2012). Their susceptibility to capture when swimming in front of traps was investigated by comparing trap success between traps with substrate or deeper water at the threshold using pairs of traps, a back and edge trap (Fig. 2).

Extent of vegetation-free water in front of traps

If newts are randomly distributed in a pond and attracted to traps perhaps trap success would be related to the area of vegetation-free water in front of the trap. With floor vegetation, *Ceratophyllum demersum*, less than 20 cm high this could be explored in the 50 cm deep study pond, although later in the season in front of

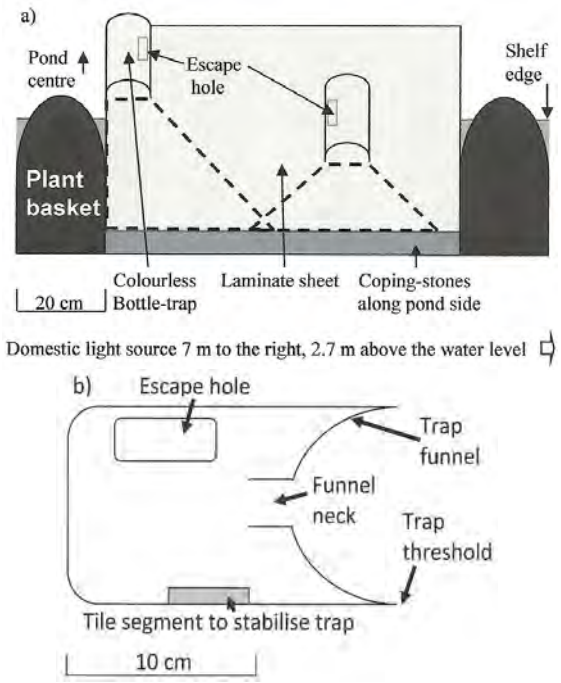

Figure 3. a) Plan view of an 80 x 45 cm laminate sheet; the video-recorded area of 2002. Facing the pond side traps were placed horizontally 30 and 15 cm from coping-stones. The dotted lines outline the trapezoidal funnel-sectors of each trap. b) Cross-section of a horizontal trap.

space 4 *Nuphar* leaves might be growing above this height. Three categories of 'extent' were defined. Spaces 4, 5 and 6 faced into a 2 m^2 circular vegetation-free region and spaces 1 and 7 into a 0.43 m^2 region (Fig. 1). Thirdly, when trapping, mesh curtains (mesh size 2.5 x 3.5 mm) limited the extent of unobstructed water in front of spaces 2 and 3 to alternately 25 or 50 cm (Fig. 2). Analysis of data after 12 sessions revealed an inconsistency between newts counted and caught in spaces 2 and 3. To investigate this, 12 further counts followed; six with spaces undivided and six with the dividing tiles and curtains in place, no traps were set.

RESULTS

Entry into traps

Using the four video-records where newt activity was highest there were 286 and 240 newt entries into the left and right funnel-sectors (Fig. 3a) respectively. For application of a G-Test this gave expected numbers of funnel-entries of 23.4 and 26.1. Observed values being similar, 26 and 24, indicated no tendency to approach a trap.

Eleven of these 50 funnel-entrants entered the trap. All incidents of newts settling at the trap threshold, but not entering the funnel (26) were examined on one video-record where newt activity was relatively high, but not too complex for analysis. Of the 50 funnel-entrants 94% were previously in the funnel-sector (Table 1) compared with 54% of those not entering a funnel and predominately scouting across all the recorded area. Prior to capture five newts entered a funnel-sector from the adjoining coping-stones, two of these first settled in the right hand funnel 17 cm away. The other three approached the more distant left hand funnel at 32 cm, in two to four stages. This 'scouting' like behaviour as they approached the funnel was similarly followed by the other six incipient captives. They all settled in the funnel before passing through the neck into the trap. Shortly after capture, about five to ten minutes later, they escaped through the hole provided. Capture could follow arrival in the funnel with or without other newts being in the funnel-sector. Three 'interacting' in the funnel were static females; the presence of a male at their side appeared to prompt them to enter the trap. Only on four occasions a captive was visible clawing at the trap envelope and simultaneously another newt was within the funnel-sector. These free newts appeared to be attracted to the trap resulting in four funnel-entries and one capture. Newts entering the funnel behaved as if they had detected a newt in the funnel or trap, in

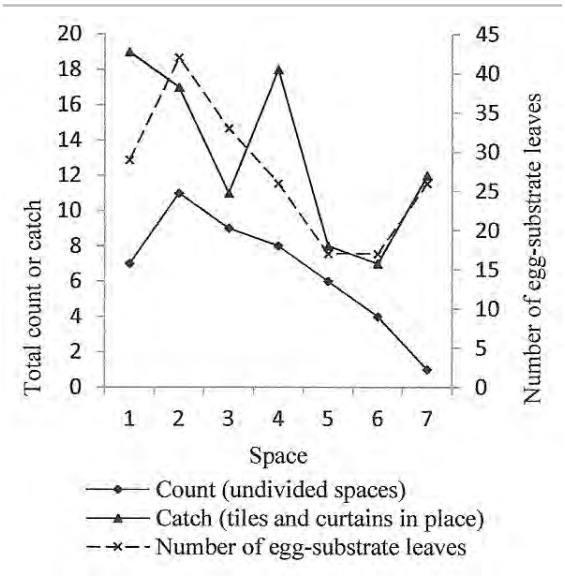

Figure 4. Total female count (18 sessions) and catches (12 sessions) related to the quantity of egg-substrate leaves in each space.

Condition	Funnel-entry then capture n = 11		Funnel-entry only n = 39		No funnel-entry n = 26	
	%	f	%	f	%	f
Previous location						
In funnel-sector	100	11	92	36	54	14
Outside funnel-sector	0	0	8	3	46	12
Previous activity						
Interacting	18	2	31	12	27	7
Scouting	18	2	46	18	62	16
Loner	64	7	23	9	12	3
Previous and during event						
A captive seen moving around within the trap		1		3		0
During event within a funnel-sector						
Interacting	27	3	28	11	15	4
Not interacting - only 1 newt present	36	4	49	19	65	17
Not interacting - >1 newt present	36	4	23	9	19	5

Table 1. Frequency (f) of conditions prior to and during the events; capture, funnel-entry only, no funnel-entry but newt settled at a trap threshold. Conditions are defined in the main text.

each case the water had or could have been recently disturbed by a newt(s).

Male distribution

With 14 separate half-spaces no instance of more than one male in a display area was observed. In the seven undivided spaces (12 + 6 sessions) there were a total of 106 male sightings (Table 2) and five instances with two males present in the same area. In three of these cases eight males were within the seven display areas. Males appeared to seek out display areas unoccupied by other males. Also with total counts within a space of 11-18, each space was similarly located.

Female distribution

The number of female sightings in each undivided space correlated with the number of leaves (r_s = 0.786, P < 0.05) and there was a similar trend for captures (Fig. 4).

Trapping from dusk till dawn (12 sessions) there were 92 female captures (Table 2) however from 18 night-counts the number of female sightings was 46. This indicates many females went uncounted as they were egg-laying in vegetation beyond the surveyed spaces, but overnight moved around the pond passing in front of traps.

Capture of swimming newts

In back traps and edge traps (Fig. 2) the total catches were 29 and 24 respectively for males, and 47 and 45 for females. For both sexes capture was similarly likely whether newts approached directly from water deeper than the trap (swimming) or could settle on the substrate at the trap threshold. These data show 37% of captives were male. The unique belly patterns of all 2007 captives had been photographed. Only nine (38%) of the 24 individuals caught were male. Both sexes were similarly susceptible to capture with traps facing into open water, but shielded within 10 cm from it on three sides, a result consistent with previous work (Hughes, 2012).

Extent of vegetation-free water in front of traps

Female data have been excluded from this aspect of the analysis as their distribution was influenced by the availability of egg-substrates. In spaces one to seven, six to ten males were caught (Table 2) with no indication of catch differences between the three 'extent' categories (G = 0.605, df 2, P > 0.05).

Comparing the male count data when traps were set, only one or two were seen in the spaces facing the curtains, elsewhere the counts,

Period of collection	Total	Number of sessions	Tiles and curtains	Space														All spaces	
				1		2		3		4		5		6		7			
				L	R	L	R	L	R	L	R	L	R	L	R	L	R	♂	♀
14.3 - 26.4	Catch ♂	12	Yes	7	3	4	5	5	3	2	4	5	1	5	3	3	3	53	
	Catch ♀			6	13	11	6	8	3	14	4	4	4	3	4	8	4		92
14.3 - 26.4	Count ♂	12	Yes	6	5	2	0	0	1	0	9	2	5	3	4	4	4	45	
	Count ♀			1	2	3	0	1	1	0	1	0	2	0	2	1	2		16
10.3 – 27.4	Count ♂	12	No	5	9	7	5	3	4	3	7	6	5	9	2	6	5	76	
	Count ♀			2	0	4	6	4	1	2	2	3	1	2	1	1	0		29
2.5 – 10.5	Count ♂	6	Yes	1	3	5	0	0	3	0	5	1	2	3	1	4	5	33	
	Count ♀			2	1	0	0	0	1	0	2	1	2	0	0	0	1		10
1.5 – 12.5	Count ♂	6	No	0	4	4	0	1	3	0	5	3	4	0	2	1	3	30	
	Count ♀			1	4	0	1	2	2	2	2	2	0	0	1	0	0		17

Table 2. Totals of catches and counts in the left (L) and right (R) half of the seven spaces (Figure 1). Counts were made both with and without spaces divided by tiles and curtains in place.

seven to eleven, were significantly higher (G_{adj} = 8.238, df = 1, P < 0.01). The total newt count for each half-space (18 sessions) with and without dividing tiles and curtains in place (Table 2) were compared. When undivided these totals were between six and seventeen, with curtains and tiles in place four to seventeen except in three half-spaces where it was zero or one. These half-spaces were the right half of space 2 and the left half of space 3, the half spaces nearest to the gap between the two curtains. Thirdly the left half of space 4; on examination the side of the left hand basket instead of being vertical sloped from the base into the space. These geometrical situations appeared to influence newt behaviour.

DISCUSSION

The lateral-line system is used by newts for detection of other newts (Stebbins & Cohen, 1995). Males frequently re-orientate themselves in their display areas (Green, 1989) possibly to advertise their presence (Krebs & Davies, 1993). Whilst stationary they would be receptive to waves (Roberts, 1986) created by other animals. A male's approach to a female commenced after she moved within about 20 cm of him (Green, 1989). With a light level of 5 lux (Hughes, 2012) males on the substrate immediately approached newts arriving near them, but usually > 20 cm away. The visual acuity of the great crested newt, maximum visual range 20 cm, declines below 10 lux (Roth, 1987). Courtship can take place in total darkness (Green, 1989) and turbid conditions (Frazer, 1983). Pheromones as the attractant from > 20 cm seems unlikely as these take time to disperse (Petranka et al., 1987) and compared with visual or water disturbance stimuli they would not give a precise directional cue (Himstedt, 1994). Mechano-reception may be important for the detection by males of the arrival of other newts in their display area. Also, from this study, it appears water disturbances reflected off trap funnels are interpreted by newts as indicating the presence of another newt to which they are attracted. Non-reflected disturbances caused by captives may result in more energetic waves emanating from the funnel and is consistent with occasional large catches (Oldham & Nicholson, 1986).

Newts move within their breeding pond (Hedlund & Robertson, 1989) to find the resources they require (Hayward et al., 2000). They use mechano-reception for spatial orientation (Wilczynski, 1992). Propelling themselves in open water then, whilst gliding/drifting, as some fish species (Bone & Marshall, 1982), presumably they could detect waves reflected from their surroundings that provide

navigational cues. This, and the design of my pond with display areas, and egg-substrates confined to the marginal shelf, suggest that newts stayed near this shelf. By following the shelf within 25 cm of the edge, each trap location would be passed with similar frequency.

There were two situations where newt presence was established by their capture, yet none were seen on the 22 x 22 cm area of substrate on which single traps were set. In close proximity there were two planes from which waves generated by a newt would be reflected back simultaneously. Interference between these two wave fronts may have caused confusing signals detected through the lateral-line system that the newts did not tolerate. If this assumption is correct newt-generated waves reflected off a vertical plane surface (area 40 x 54 cm) ≥ 50 cm distant were being detected.

In more heavily vegetated ponds Oldham et al. (2000) found bottle-trapping was less successful. From this study in open water newts apparently detected traps by mechano-reception and then approached them as they do other newts. This suggests capture is more likely in traps adjoining open water than those laid in highly vegetated areas.

ACKNOWLEDGEMENTS

I would like to thank Rob Oldham for his continued interest and encouragement along with helpful advice for the manuscript; Roger Avery and David Sewell for their suggestions to further improve this and Nick Hughes for assistance with the fieldwork that was done under licence from English Nature.

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