

Overwintering of smooth and palmate newt larvae in the Gartcosh Nature Reserve, Scotland

D.C. McNeill* & J.R. Downie

Kelvin Building, University of Glasgow, Glasgow, G12 8QQ

*E-mail: Deborah.mcneill@glasgow.ac.uk

In temperate region amphibian communities, larvae that fail to complete metamorphosis by the end of the summer may remain in the ponds throughout the winter period. Metamorphosis occurs the following year (Werner, 1986; Griffiths, 1997). This is common in ponds characterized by higher altitudes, cooler temperatures and lower nutrient content (English Nature, 2001). The occurrence of overwintering as a strategy for amphibian larvae is widely acknowledged (e.g. Smith, 1951; Beebee & Griffiths, 2000; English Nature, 2001; O'Brien, 2016) but often unreferenced. There remains a paucity of records in the literature of UK, particularly of Scottish examples.

Overwintering in the UK has been shown to occur in the common frog (*Rana temporaria*) (Gadow, 1901; Archibald & Downie, 1996; Pintar, 2000; Bland, 2008; Walsh *et al.*, 2008). Common toads (*Bufo bufo*) were recorded to regularly overwinter in a pond in Yorkshire (Smith, 1951). Griffiths (1997) describes the potential of late cohorts of the three UK newt species to overwinter. *Triturus cristatus* (great crested newt) larvae are known to overwinter in water (English Nature, 2001) and several were observed in a garden pond, reportedly in poor condition (Atkins, 1998). Overwintering has been observed in *Lissotriton vulgaris* (smooth newt) larvae, indirectly (Smith, 1951) and directly (Bell

Lawton, 1975; Cooke & Cooke, 1993). *L. helveticus* (palmate newt) larvae have been observed overwintering in Scottish ponds (O'Brien & Miro, 2016; P. Minting, pers. comm.).

The Gartcosh Nature Reserve (GNR), South Lanarkshire, is home to one of the largest known populations of *T. cristatus*, as well as significant numbers of *L. helveticus*, *L. vulgaris*, *R. temporaria* and *B. bufo* (McNeill, 2010). This site provided the opportunity to investigate whether overwintering was occurring across the five species. GNR is a purpose-built site, created in 2003, containing 24 ponds. The GNR is split across four areas: Bothlin Burn (BB, 8 ponds), Garnqueen Hill (GQH, 7 ponds), Railway Junction (RJ, 6 ponds) and Stepping Stone (SS, 3 ponds).

Over a period of three years from 2004 to 2006, 13,361 adult, sub-adult and metamorphic amphibians (Table 1) were translocated to the GNR from a 10 Ha site approximately 600m away, known as the Amphibian Conservation Area, part of the Gartcosh Steel Mill Industrial Site (McNeill, 2010; McNeill *et al.*, 2012). Due to the large number of toads caught, a portion were moved to the GNR outside the zones, which were originally encircled with amphibian proof fencing. SS was considered part of BB for translocation purposes.

As part of an investigation into the effectiveness of the translocation, larvae were sampled during the months of May to August 2006 (McNeill, 2010). A long-handled dip net (0.2m x 0.25m, mesh size 5mm) was used to make 2m long sweeps of 10 randomly selected points around the ponds' circumferences. A peak count of 41 GCN larvae (June) and 377 'Small' larvae (July) were caught (Table 2). 'Small' is used to refer to either *L. helveticus* or *L. vulgaris*, as it is not possible to distinguish between the two species in the field at this life history stage.

Area	GCN				Smooth	Palmate	Frog	Toad
	M	F	sa	juv				
BB	285	246	118	74	1233	1142	578	913
GQH	217	208	79	107	996	1086	325	727
RJ	27	29	135	69	571	477	597	719
GNR								809
Total	529	483	332	250	2800	2705	1500	3168

Table 1. Total number of amphibians translocated to the GNR zones from 2004-2006. M, male; F, female; sa, sub adults; juv, early juveniles. Only Great crested newts (GCN) were recorded by sex and stage.

Area	GCN	Small
BB	17	205
GQH	19	67
RJ	4	77
SS	1	28
Total	41	377

Table 2. Peak count of GCN and ‘Small’ larvae across the GNR zones.

This informed pond selection for the overwintering survey, with a subset of nine ponds sampled based on known larval presence. Sampling took place over two days on 6th and 7th January 2007. A long-handled dip net (0.2m x 0.25m, mesh size 5mm) was used to make 2m long sweeps of 50 randomly selected points around the ponds’ circumferences. A further two ephemeral ponds (Eph) were included in the survey. These were swept only 20 times, reflecting the much smaller size. Snout-vent length (SVL) and body length (BL) in mm were recorded for all larvae, using calipers.

A total of 39 overwintering ‘Small’ larvae were captured during the two days of sampling (Table 3). No GCN larvae or other amphibian larvae were detected overwintering. ‘Small’ larvae were found in seven of the nine GNR ponds sampled and in one of the two ephemeral ponds. Smooth newt larvae metamorphose at approximately 30-45mm body length, palmate larvae between 25-40mm (O’Brien, 2016). Therefore, our overwintering larvae were within the size range where metamorphosis can occur in both species.

Causal factors in overwintering of amphibian larvae in temperate regions may include higher altitudes (as has been suggested for *T. cristatus* and *Rana aurora* (Californian red-legged frog): English Nature, 2001; Fellers *et al.*, 2001), lower water temperatures (all three UK newts and *R. temporaria*: Smith, 1951; English Nature, 2001;

O’Brien, 2016; Walsh *et al.*, 2016), lower nutrient content/food availability (*T. cristatus* and *R. temporaria*: Pintar, 2000; English Nature, 2001; Walsh *et al.*, 2016), late oviposition (all three UK newts, *Tylotriton verrucosus* (Himalayan newt), *Rana ridibunda* (marsh frog), *R. clamitans* (green frog) and North American ranids: Bell & Lawton, 1975; Collins & Lewis, 1979; Werner, 1994; Kuzmin *et al.*, 1996; Griffiths, 1997; Ivanova, 2002) and high larval density (*Rana sphenoccephala* (southern leopard frog), *R. catesbeiana* (North American bullfrog) and *R. clamitans*: Wilbur *et al.*, 1983; Werner, 1994). A further possibility could be exposure to sub-lethal levels of toxicants slowing rates of growth and increasing the time to reach metamorphosis (Carey & Bryant, 1995).

Protracted larval periods may lead to high overwintering larval mortality rates (Werner, 1994). Collins (1979) counters that remaining in the larval phase may allow growth in spring and autumn at times when metamorphs would be unable to grow, compensating for higher larval mortality rates. The elevated cost of overwintering is offset by metamorphosing into superior terrestrial conditions better suited for feeding and growth (Werner, 1986; Mitchell & Seymour, 2000) with a comparatively larger body size (Collins & Lewis, 1979; Verrell, 1985; Beebee & Griffiths, 2000; Denoel, 2016). Inclusion in the literature of additional occurrences of overwintering within the three newt species at a range of latitudes and altitudes across Scotland would be useful to further our understanding of this strategy and to consider the potential effect climate change may have on larval development.

With thanks to North Lanarkshire Council, Scottish Natural Heritage, Heritage Environmental Ltd, the Blodwen Lloyd Binns Bequest and the enthusiastic volunteers who helped with the fieldwork.

Area	# Ponds	# Larvae	BL (mm)		SVL (mm)	
			Mean	+/- SD	Mean	+/- SD
BB	3	22	36.1	3.2	16.4	1.3
GQH	2	2	39.7	3.1	17	1.1
RJ	1	10	32.5	4.2	14.7	1.5
SS	1	3	37.8	0.7	17.5	0.9
Eph	1	2	34.7	1.8	16.1	0.9
Total	8	39	35.4	3.8	16.02	1.6

Table 3. All overwintering larvae caught during sampling event in January 2007. BL, body length; SVL, snout vent length.

REFERENCES

- Archibald, I. & Downie, J.R. (1996). Overwintering common frog tadpoles. *The Glasgow Naturalist* 23, 61.
- Atkins, W. (1998). 'Catch 22' for the great crested newt. Observations on the breeding ecology of the great crested newt *Triturus cristatus* and its implications for the conservation of the species. *British Herpetological Society Bulletin* 63, 17-26.
- Beebee, T.J.C. & Griffiths, R.A. (2000). *Amphibians and Reptiles*. HarperCollins, London.
- Bell, G. & Lawton, J.H. (1975). The ecology of the eggs and larvae of the smooth newt (*Triturus vulgaris*). *Journal of Animal Ecology* 44, 393-424.
- Bland, K.P. (2008). Delayed metamorphosis of frog tadpoles at a high altitude in Perthshire. *The Glasgow Naturalist* 25, 87-88.
- Carey, C. & Bryant, C.J. (1995). Possible interrelations among environmental toxicants, amphibian development and decline of amphibian populations. *Environmental Health Perspectives* 103, Suppl. 4, 13-17.
- Collins, J.P. (1979). Intrapopulation variation in the body size at metamorphosis and timing of metamorphosis in the bullfrog, *Rana catesbeiana*. *Ecology* 60, 738-749.
- Collins, J.P. & Lewis, M.A. (1979). Overwintering tadpoles and breeding season variation in the *Rana pipiens* complex in Arizona. *South-West Naturalist* 24, 371-373.
- Cooke, A.S. & Cooke, S.D. (1992). A technique for monitoring the final phase of metamorphosis in newts. *British Herpetological Society Bulletin* 42, 10-13.
- Denoel, M. (2016). On the identification of paedomorphic and overwintering larval newts based on cloacal shape: review and guidelines. *Current Zoology* 63, 165-173.
- English Nature (2001). *Great Crested Newt Mitigation Guidelines*. Version: August 2001. English Nature, Peterborough.
- Fellers, G.M., Launer, A.E., Rathbun, G., Bobzien, S., Alvarez, J., Sterner, D., Seymour, R.B. & Westphal, M. (2001). Overwintering tadpoles in the Californian red-legged frog (*Rana aurora draytonii*). *Herpetological Review* 32, 156-157.
- Gadow, H. (1901). *Amphibia and Reptiles. The Cambridge Natural History. Vol. VII*. Macmillan & Co., London.
- Griffiths, R.A. (1997). Temporary ponds as amphibian habitats. *Aquatic Conservation: Marine and Freshwater Ecosystems* 7, 119-126.
- Ivanova, N.L. (2002). Marsh frog (*Rana ridibunda* Pall.) in cooling ponds in the middle Urals. *Russian Journal of Ecology* 33, 125-128.
- Kuzmin, S.L., Bobrov, V.V. & Dunaev, E.A. (1996). Amphibians of Moscow province: distribution, ecology and conservation. *Zeitschrift für Feldherpetologie* 3, 19-72.
- McNeill, D.C. (2010). *Translocation of a Population of Great Crested Newts (Triturus cristatus): a Scottish Case Study*. PhD Thesis, University of Glasgow.
- McNeill, D.C., Downie, J.R. & Ross, B. (2012). Gartcosh Great Crested Newts: the story so far. *The Glasgow Naturalist* 25, 87-91.
- Mitchell, N.J. & Seymour, R.S. (2000). Effects of temperature on energy cost and timing of embryonic and larval development of the terrestrially breeding moss frog, *Bryobatrachus nimbus*. *Physiological and Biochemical Zoology* 73, 829-840.
- O'Brien, D. (2016). Palmate newt; Smooth newt; Great crested newt. Pp. 72-117. In: McInerney, C.J. & Minting, P.J. (editors). *The Amphibians and Reptiles of Scotland*. Glasgow Natural History Society, Glasgow.
- O'Brien, D. & Miró, À. (2016). Amphibian survey-Evanton Community Woods. <http://s3.spanglefish.com/s/10095/documents/amphibian-survey-evanton-woods-2016.pdf>
- Pintar, M (2000). On overwintering larvae of the Common frog *Rana temporaria* Linnaeus 1758 (Anura: Ranidae). *Herpetozoa* 13, 181-186.
- Smith, M. (1951). *The British Amphibians and Reptiles*. Collins, London.
- Verrell, P. (1985). The emergence of post metamorphic smooth newts from a pond in southern England. *British Journal of Herpetology* 6, 430-432.
- Walsh, P.T., Downie, J.R. & Monaghan, P. (2008). Larval overwintering: plasticity in the timing of life history events in the common frog. *Journal of Zoology* 274, 143-149.
- Walsh, P.T., Downie, J.R. & Monaghan, P. (2016). Factors affecting the overwintering of tadpoles in a temperate amphibian. *Journal of Zoology* 298, 183-190.
- Werner, E.E. (1986). Amphibian metamorphosis: growth rate, predation risk and the optimal size at transformation. *American Naturalist* 128, 319-341.
- Werner, E.E. (1994). Ontogenetic scaling of competitive relations: size-dependent effects and responses in two anuran larvae. *Ecology* 75, 197-213.
- Wilbur, H.M., Morin, P.J. & Harris, R.N. (1983). Salamander predation and the structure of experimental communities: anuran responses. *Ecology* 64, 1423-1429.