The influence of breeding success on adult length in a population of Crested Newts

ARNOLD S. COOKE

13 Biggin Lane, Ramsey, Huntingdon, Cambs PE26 1NB

ABSTRACT. — The level of breeding success of Crested Newts (*Triturus cristatus*) was recorded at Shillow Hill, Cambridgeshire, annually from 1986 to 2001. Breeding failure, 1990-1992, presented the opportunity to study how adult length was affected from 1993 onwards. As was anticipated, the population in 1993 seemed to be composed of large, old adults. Mean length decreased to a minimum in 1996 as small recruits joined the breeding population, following successful breeding starting in 1993. Suggestions are made on how measuring samples of adults may help understand significant past and contemporary events in the absence of detailed knowledge of breeding success.

CRESTED Newts (*Triturus cristatus*) are relatively widespread and abundant in lowland Britain, yet are fully protected by law. This fact results in much management of newt populations, for reasons of both conservation and development-related mitigation (English Nature, 2001; Langton et al., 2001). There is, therefore, always a need for new field techniques to support management decisions.

The species usually seems to require two or three years to reach sexual maturity, and most newts continue to grow for several years beyond this time (Glandt, 1981; Oldham & Nicholson, 1986; Oldham, 1994; Baker & Halliday, 2000; Cummins & Swan, 2000; Kupfer & Kneitz, 2000). It is possible that studying the size frequency distribution of adult Crested Newts could inform an observer about recent recruitment to a breeding population (Oldham & Nicholson, 1986), although length is not an accurate indicator of age, especially for older adults (Hagstrom, 1977; Glandt, 1981). Cooke (2001a) described a translocation exercise involving Crested Newts rescued from a very shaded pond. The newts were all large adults, the inference being that breeding had failed for a number of years. Further evidence supporting this suggestion was obtained when, after several years of successful breeding, newts in the subsequent colony were found to be significantly smaller than the translocated individuals.

Crested Newts have been studied at Shillow Hill in Cambridgeshire since the 1980s (Cooke, 1995; Cooke & Arnold, 2001). A severe drought in the early 1990s resulted in dry summer conditions and almost total breeding failure over a period of three years. This provided an opportunity to determine whether detectable changes in the mean size of adult newts occurred during subsequent years. Recording any such changes might prove of value in indicating breeding success in other situations where direct observations on metamorphic output had not been made.

SITE AND METHODS

Shillow Hill has about 2 ha of artificial and semi-natural habitat and is situated at grid reference TL 28-82-. It is bordered on one side by the B 1040, but is otherwise surrounded by arable farmland. As far as is known there has never been any human translocation of newts into or out of the site. Throughout the 1990s, only the main pond at the site, Top Pond, has produced Crested Newt metamorphs. No other pond is shown closer than 500m on the 1:25000 Pathfinder map, with the nearest known Crested Newt site about 1 km away. Natural immigration can therefore be ruled out (eg see Baker & Halliday, 1999; Cooke, 2001a), and the maintenance of the population at Shillow Hill is dependent on its own progeny.

Providing there was water in Top Pond, it was netted for Crested Newt larvae on four occasions during July/August each year, 1986-2001. For each metre of shore, a 2 m sweep was made with a pond net through the water and aquatic vegetation towards the edge. After being counted, larvae were returned to the pond. The method was intended to provide an indication of relative larval abundance at metamorphosis (Cooke & Arnold, 2001; Cooke 2001b).

Year	Males			Females			Propⁿ. small newts in sample
	No in sample	Mean±SE (mm)	Range (mm)	No in sample	Mean±SE (mm)	Range (mm)	
1993	10	112±1	107-117	5	126±3	121-135	0.00
1994	5	117±2	113-126	6	126±1	122-130	0.00
1995	13	112±3	95-126	8	127±2	113-133	0.29
1996	12	102±1*[a]	93-108	8	118±3*	107-130	0.65[bc]
1997	17	108±2*	96-124	8	121±3	107-133	0.60
1998	8	115±3[a]	104-129	9	121±2	113-133	0.35
1999	3	113±5	106-123	6	125±4	108-137	0.33
2000	18	114±2	103-127	12	122±2	108-135	0.30
2001	6	117±1	113-123	7	122±2	117-129	0.23

Table 1. Total lengths of adult males and females in the yearly samples, 1993-2001. The proportion of small adults in each sample is also given (see text for method of calculation). * significantly different from previous year by t test, $P<0.05$; [a] significantly different from two years before by t test, $P<0.001$; [b] significantly different from previous year by chi-squared test, $P<0.05$; [c] significantly different from two years before by chi squared test, $P<0.001$.

To collect a sample of breeding adults from Top Pond for measurement, a pond net was used for about 30 minutes at night once each year between 14 April and 4 May, 1993-2001. Overall length of each newt, from tip of snout to end of tail, was measured to the nearest millimetre with a ruler. Newts were then returned to the pond. Two newts had appreciably shortened tails through injury, and were not measured. In 2001, the distance from tip of snout to the rear edge of the cloaca was also recorded to compare results with those of other authors for newts of known or suspected age.

RESULTS

Netting of larvae in Top Pond showed that the drought experienced during 1990-1992 resulted in a long period of metamorphic failure not otherwise experienced during the study (Figure 1). The pond dried completely in the summers of 1990 and 1992, while its sump allowed limited metamorphosis in 1991. So the great majority of adults in 1993 must have been at least four years old; it is likely that many were five years of age, the last good year for metamorphosis being 1988.

Measurements of newts caught in 1993 and thereafter are given in Table 1. The shortest newts caught in 1993 were: male 107 mm, female 121 mm. In this paper, newts shorter than these thresholds are referred to as 'small', the proposition being that these will have tended to be individuals aged three years or younger.

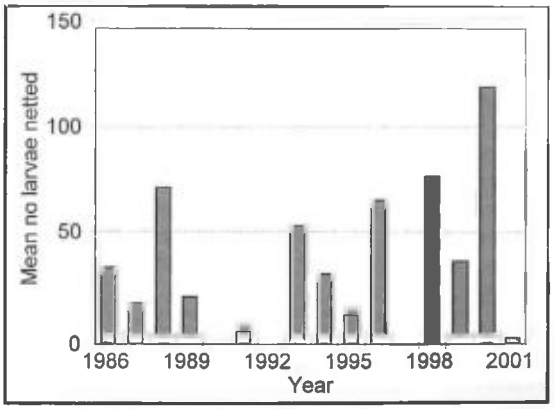

Figure 1. Mean number of Crested Newt larvae netted each summer, 1986-2001.

In 1994, all newts in the sample were longer than these thresholds (Table 1) indicating that no individuals were returning to breed from the 1993 cohort of metamorphs (Figure 1). The increase in length between males caught in 1993 and 1994 almost reached statistical significance ($0.05<P<0.1$), suggesting growth was continuing. By 1995, 29% of the combined sample of males and females were classified as "small", these presumably being among the first of the 1993 cohort to mature (Table 1). In 1996, the proportion of small newts increased significantly to 65%, and mean lengths of both males and females were less than previously; this influx of smaller newts will have been due to three year olds from 1993 or two year olds from 1994. After 1996, mean length increased, with a significant change being recorded for males. From 1998 to 2001, mean length was stable for both sexes and some small newts were recorded in each annual sample. The breeding failure during the isolated drought year of 1997 (Figure 1) was not translated into any discernible effect on subsequent adult body length.

Mean snout-cloaca lengths ±SE in 2001 were: large males 70.0±1.0 mm (n = 6, range 67-73 mm); large females 72.0±1.2 mm (4, 70-75 mm); small females 69.0±1.2 mm (3, 67-71 mm). No small males were caught in 2001.

Immature Crested Newts, presumably aged 1-2 years, are recorded in Top Pond during most breeding seasons (e.g. see Cooke (1995) for night count data). They tend to be more abundant during late spring and summer. Samples of newts were caught in the present study relatively early in the breeding season, and no immatures were identified among the adults examined and measured.

DISCUSSION

Despite an immense amount of recent conservation and rescue work on Crested Newt populations, there is relatively little published data from Britain on the length of newts of known age during the breeding season. Oldham & Nicholson (1986) described a cohort of adults breeding for the first time in their study population in 1984; they were at least two years of age, and many were 100-110 mm in total length. This is not dissimilar to the small adults of the current study which ranged between 93 and 120 mm. One would expect, though, that growth and body size might vary considerably between individuals in different populations or between years in the same population (e.g. see Hagstrom (1977) for Swedish populations). Baker & Halliday (2000), working on males of putative age, found their snout-cloaca lengths to be greater than those recorded in 2001 for larger males at Shillow Hill e.g. for males thought to be at least four years old, mean length was 84.5 mm (n = 9, range 75-90 mm). In contrast, Cummins & Swan (2000), working at a Cambridgeshire site only 11 km from Shillow Hill, recorded virtually identical sizes to the large newts at Shillow for individuals known to be four years old: mean snout-cloaca length for males 70.5 mm (n = 6, range 68-72 mm); females 72.7 mm (4, 69-76 mm).

In the study of Cummins & Swan (2000), there was no overlap in length for either sex between three year olds and four year olds. However, their sample sizes were small and they recorded growth of the same tagged individuals. In larger samples taken randomly from a population, the relationship between age and size may not be so clear cut (see Glandt, 1981; Oldham & Nicholson, 1986). While most 'small' newts at Shillow Hill may conceivably be less than four years of age, one might expect some older newts to occur in a sample of small individuals; and, conversely, some (two or) three year olds in a sample of larger newts.

While knowledge of age will aid prediction or interpretation of data, one aim of this exercise was to test a simple technique for use in the field. Unlike age determination, measurement of length is quick and easy. Data collected at Shillow Hill showed that, following three years of breeding failure during 1990-1992, length of adults was at least maintained for two years, then decreased to 1996 before increasing again. These observations are consistent with the appearance of recruits from the metamorphic cohort of 1993 initiating the reductions in mean length. Changes were more marked for males than for females.

Understanding events at Shillow Hill is facilitated by knowledge of past breeding success. At other sites without any direct observations on breeding success, one could deduce what might have happened from measuring annual samples of adults. If the observer has some knowledge of likely lengths for adults in a particular population, even a sample from a single year may provide clues, depending on the relative numbers of small and large adults (see Cooke, 2001a). Then samples collected in subsequent years can help to firm up on any tentative conclusion. It should be remembered that a high or increasing proportion of small newts may alternatively suggest an increasing population rather than one that is strictly recovering. Additional observations, such as monitoring adult numbers, will help to decide. On the other hand, if increases in length are noted from year to year this may indicate stabilisation of a population following a significant influx of recruits, or an ageing population in which there is little or no recruitment. Lack of recruitment may be due to poor survival of juveniles, as well as to low metamorphic success; and density dependent factors may operate. Again, monitoring numbers will help to inform the judgement, as will simple field observations on conditions in the breeding site e.g. whether water persists until metamorphosis. For the technique to detect an event such as breeding failure, it seems that event must be significant in its scale and/or persistence.

Had breeding success not been recorded at Shillow Hill until 1993, the changes in length, 1993-2001 (Table 1), could have been translated as suggesting little or no metamorphic success for several years up to and including 1992. The exact length of this period of failure would not have been known. It is hoped to produce another paper on the Shillow Hill data, focusing on population trends in relation to breeding success.

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