'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

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ABSTRACT

The Great Crested Newt is a widespread species of amphibian in northern Europe, with England and Wales representing areas of international significance. It has experienced a rapid decline of perhaps 50% over the past forty years or so and many populations have been lost or fragmented; as a consequence it receives full legal protection under British and European legislation. However, there is evidence that it continues to decrease and reasons for this may not always be addressed by legal protection alone. For example, pond loss due to neglect and succession and also the introduction of fish into ponds require a more detailed examination as they affect the breeding ecology of many newt populations.

The Crested Newt is more vulnerable to local extinctions than the other native newt species, the Smooth *Triturus vulgaris* and Palmate *Triturus helveticus* newts mainly because of its more restricted breeding requirements (only 2% of ponds sampled in a national survey had Crested Newts compared with around 25% for the other two species). In particular the larvae require relatively large but mainly fish-free ponds in which to develop; this is the 'Catch 22' at the centre of this article – the probability of fish presence in a waterbody increases with the size of the waterbody because of the decreased risk of desiccation. Thus the majority of Crested Newt populations tread an ecological tightrope, risking larval desiccation or starvation in ephemeral and small ponds or larval predation by fish in more permanent waterbodies such as large ponds and lakes.

Clearly Crested Newts do manage to survive well in suitable areas, and this is largely achieved by breeding successfully in a few ponds at a time which are within the range of a 'metapopulation' of animals. This means that some ponds may be temporarily unsuitable for breeding by virtue of fish presence or being dry, but others will be suitable and thus will offset the losses in the former type of pond. In time the suitability of a particular pond will change, but the metapopulation as a whole may persist.

Sometimes atypical populations exist where particular circumstances allow a different pattern to develop – for example several very large populations are known from old gravel workings and clay pits, where the waterbodies are several hectares in size – the isolation from river systems and other ponds as well as restricted access maintains their fish-free status, and the newts take full advantage. In rarer cases, coastal waterbodies may receive a winter dose of salt-water killing freshwater fish and 'cleansing' the ponds ready for the newts the next spring.

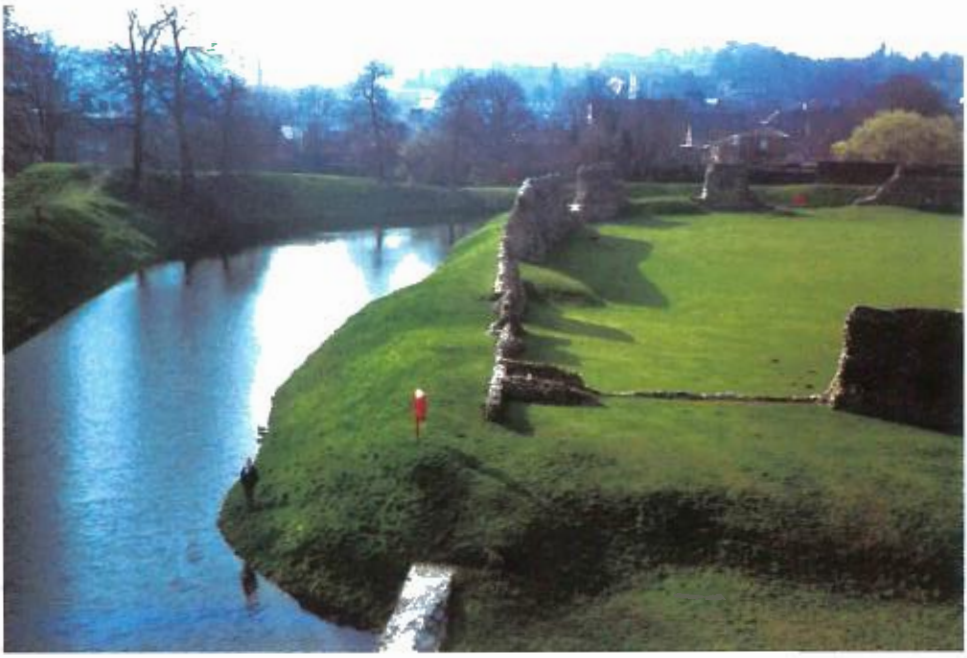

Plate 1: View of the widest arm of the castle moat, home to thousands of Crested Newts (see text for details).

Plate 2: A typical male Crested Newt from the 'large' size cohort found in the moat in 1993.

The final possible breeding population is one which relies on a single waterbody which dessicates often enough to maintain fish-free status but not so often that the newt population itself becomes extinct. Clearly the chances of finding a very large single waterbody Crested Newt population are low and such a situation could be worthy of designation as a SSSI (Site of Special Scientific Interest). The article finishes with a summary of ten years of observations on just such a single waterbody population which was estimated to contain between two and three thousand adult newts in the mid 1990's by several professional herpetologists; the newts breed in an ephemeral castle moat in southern England, where the nearest known ponds are roughly a kilometre from this. Only two years out of the previous ten have allowed successful metamorphosis before the water has disappeared and whether the current situation will permit the continued viability of the population is considered as well as recommendations for the conservation of the moated newts and the species in general.

INTRODUCTION

Long term data on the population dynamics of amphibians are scarce but urgently required in order to explain observed declines in many species as either genuine negative trends or simply part of the natural fluctuations characteristic of many amphibian species. At first glance, the Crested Newt would seem to be well buffered against short or medium term problems with its aquatic habitat, adults having a lifespan which can be measured at least up to a decade in some cases in the wild and with the potential to breed annually and for each female to lay several hundred eggs.

However the breeding niche used by the species is often much more narrow than for all native amphibians with the exception of the much rarer (in Britain) Natterjack Toad *Bufo calamita.* This is largely a reflection of the larger size of the newt when compared with the Smooth and Palmate newts. There are important consequences for the choice of suitable waterbodies for breeding; first, the larvae of the newts are larger than the other species – at up to 8cm they can be larger than some adult Smooth and Palmate newts. In turn this means that they require more food to complete their development successfully than the larvae of the smaller species and also that they require longer to develop as larvae before metamorphosing and thus becoming independent of the water. This means that a waterbody must have a higher carrying capacity for Crested Newt larvae and a greater degree of permanence (typically water should be present until September as a minimum to allow moderate success) than for smaller newt species. The National Amphibian Survey (Swan and Oldham, 1992) showed the typical area of a Crested Newt pond to be in the range of 500-750 square metres. This size may be described as 'large pond or farm pond' on the one hand or 'lake' on the other.

Some smaller and very common freshwater niches are thus rendered immediately unsuited to Crested Newts for successful breeding – these include various ditches, natural ephemeral ponds, flood marshes and of importance in the context of modern amphibian conservation, the phenomenon of the artificial garden pond.

Garden ponds are known to have offset the increased rarity of Smooth Newts and Common Frogs *Rana temporaria* and to a lesser extent Common Toads *Bufo bufo* and Palmate Newts in rural areas (see for example Beebee, 1996), but this effect has rarely occurred with Crested Newts. In cases where Crested Newts are found in garden ponds, they are atypical in that they may be close to a natural population and thus harbouring outlier animals, they may be 'farmed' especially for newts by enthusiasts (often doomed when the owners move house) or they may be large 'Victorian' type ponds in country houses or enclosed 'wild' ponds etc. My own experiments in garden pond Crested Newt

culture over the past fifteen years have shown the short term success and long term failure of Crested Newts in suburban ponds, and it is worth examining these semi-natural ecological 'manipulation' type experiments briefly to draw some general conclusions about the breeding biology of the animals.

I began with a pond whose total area was 4 square metres, and about 0.5 to 1 m deep. This tiny pond had its goldfish removed and a couple of pairs of Crested Newts were added under licence in 1984. Within a few years I could observe about 50 adults crammed into the pond managing somehow to maintain breeding condition for several months before leaving the water for the summer. Virtually no larvae survived to metamorphosis in the pond itself, being rapidly converted back to adult newt tissue by their cannibalistic parents. The vastly inflated number of adults was the result of some over-zealous rearing of larvae in aquarium tanks, which were themselves voracious feeders on *Daphnia*, *Tubifex* and other bought live-foods. Once they had metamorphosed, the newtlets were released into the typical suburban garden and my records show on average over a ten year period a metamorph to adult survivorship of 20%, a high figure. The adult annual survivorship was roughly 70%, and taken together they clearly show that the terrestrial component of a suburban or garden environment is admirably suited to the supporting of Crested Newts. The problem, as mentioned already, is the aquatic element of their habitat.

Clearly it is unreasonable to claim that Crested Newts cannot survive in small ponds through adult cannibalism of larvae when the number of adults was inflated artificially in the first place by rearing larvae in tanks (although it does suggest that crowding, aggression, territoriality, competition for food etc. between adults is not the major determining factor which limits the lower pond size for Crested Newts). The question still remained whether a small but stable population could persist in a garden pond without 'farming' ie. adding extra food for the larvae and a second experiment was required.

On moving to a new house, I constructed a larger pond measuring 5m by 3m mainly for Crested Newts. I allowed the population to develop without tank-rearing of larvae, but in the first year I added extra food for the larvae in the pond and about 60 metamorphs were produced. The following year, with the same number of adults present, I added no top-up food, and a handful of metamorphs resulted. Observations showed several larvae in poor condition in the pond overwintering, clearly thinner than 'normal' overwintering larvae and invertebrate food was scarce. All this suggests that even in those small ponds which may not dry out too early, that lack of sufficient larval food supply may determine the lower limit of ponds used successfully by Crested Newts.

In the 'wild' the smallest Crested Newt ponds of which I know are 30-40 sq m in area and often close to the other larger ponds which hold the species. One isolated pond has about a dozen adults breeding but until a few years ago was part of a system of ponds which have been fragmented by roads, housing developments and a new golf course. Since Crested Newts cannot use isolated small ponds effectively, it is worrying that the 1995 resurvey of all London Crested Newt ponds by the London Amphibian and Reptile Group for English Nature revealed not only a 42% decline in the number of waterbodies used for breeding by Crested Newts over the past fifteen years (ie. since statutory legal protection was introduced!) but also a contraction in range and that the number of populations in London relying on a single waterbody had risen from 30% to 70%. If problems of in-breeding recently raised for garden frog and isolated Natterjack populations are correct, then the London Crested Newts may face a more insidious genetic threat from isolation than simple dependence on a single pond for breeding, as well.

Under normal circumstances, the inability of a species to exploit a small habitat type for reproduction would be expected to be offset through the larger size of the animal permitting survival and breeding in larger habitats. Adult Crested Newts are indeed large – and toxic enough – to avoid predation by most fish species, but the larvae are not. In addition, another element of the 'Catch 22' of their ecology comes into play: smaller newt species can coexist with fish species in large ponds and lakes. Although their larvae are palatable to many fish including the most harmful species, Sticklebacks *Gasterosteus spp.*, they and their larvae are cryptic and occupy the shallower parts of the lake and most vitally the larvae use aquatic vegetation, especially filamentous algae, to hide and forage in. Crested Newts larvae, requiring much more food, as we saw earlier, soon become nektonic (that is, swim in open water, very visibly) and are predated apparently with devastating efficiency by Sticklebacks and also other fish. Ironically, the Stickleback is a common type of fish which can occupy very small ponds through to large lakes, and its adaptability reduces the number of waterbodies available for the Crested Newt dramatically.

There is a range of evidence to suggest that fish presence is of great importance as a factor causing the extinction of Crested Newt populations or preventing their colonisation of areas in the first place; for example, the deliberate introduction of Sticklebacks into one of his garden ponds by Trevor Beebee resulted in the complete extinction as a breeding species from the pond of only Crested Newts although the other newt species persisted in reduced numbers. In the London Crested Newt resurvey, only 5% of ponds with Crested Newts contained fish whereas around 30% of ponds are estimated to contain fish on average (National Amphibian Survey). Additionally, the 5% of ponds with fish tended to have only a few largely herbivorous fish such as Cyprinid species and not Sticklebacks. Conversely, the same survey found a pond which had dried out only the year before, killing the Sticklebacks, had been colonised by several Crested Newts from a nearby pond, whilst they had not been seen when the pond contained Sticklebacks (this almost suggests that adult newts have some way of detecting fish presence and abandoning a pond once used for breeding, but I am not aware of any experimental work having been done on this). An account by McLee and Scaife (1992) records the rapid colonisation by Crested Newts of a pond in a nature reserve where piscicide was applied to eliminate Sticklebacks which were previously present, and the newts were not.

To summarise so far: Crested Newts will always be less common than the smaller native species because of their specific requirements for breeding habitat. Being a large species with particularly voracious larvae, they cannot use small ponds for breeding, since the larvae will not metamorphose in sufficient numbers to maintain a population. Additionally, small ponds are prone to mid-season desiccation leaving the larvae 'high and dry' since they need longer to reach the critical size at which they can metamorphose than the larvae of the smaller newts. On the other hand, the potential breeding niche of large waterbodies is rarely available to the species since lakes, reservoirs etc. usually contain fish. Because of their food requirements, the larvae of Crested Newts are nektonic, ie. they occupy open water and search for food in the water column. This makes them highly vulnerable to fish predation, and although the adult newts are toxic and rarely predated, the population cannot sustain itself because of fish predation. As a result of these upper and lower pond size-limiting factors, Crested Newts will be rarer than smaller newts, more vulnerable to developments and less able to offset losses in the countryside of farm ponds etc. by using smaller garden ponds, which usually provide all the wrong conditions for the larvae, ie. small waterbodies with scant invertebrate prey and plenty of fish! Populations of Crested Newts may rarely exist in large numbers where the above factors are not applicable; most often this will mean a series of ponds

which alternate in suitability as breeding sites as time goes on, but overall the 'metapopulation' continues to exist because breeding is usually successful at least in a proportion of the ponds within its range. The implication is that a population of Crested Newts reduced to breeding in one or a few ponds will 'put its eggs in one basket' and be vulnerable to extinction if the pond silts up or is subject to a chance event such as fish introduction. Sadly, as stated earlier, for London Crested Newts this situation has become more the norm than fifteen years ago, with so many populations (70%) dependent on a single waterbody.

A second, much rarer situation in which Crested Newts might exist at unusually high densities could theoretically arise if a large body of water were available for breeding but without the danger of fish being present. This type of situation is rare because of the correlation of waterbody size, water permanence and therefore suitability for fish. One possibility might be a manmade waterbody located at a distance from rivers, other lakes etc; indeed there are several very large 'single-waterbody populations' of Crested Newts recorded from clay and chalk pits where this has occurred.

The final scenario is perhaps ecologically the most interesting. It is where a large shallow body of water occurs ephemerally in a site, holding water frequently and often enough to allow a large population of newts to build, whilst drying out at irregular intervals to prevent domination by fish. The rest of this article describes observations on the population dynamics at such a site, namely a castle moat in southern England.

THE MOAT POPULATION – A DESCRIPTION

It would be easy to overlook the newt population at the moat entirely for much of the time; indeed it was two years after I first walked around the site that the animals – or rather their eggs – revealed themselves, because this was the first time for at least two years that the moat had held water. Suddenly the moat in April revealed apparently by 'spontaneous generation' a wide variety of aquatic flora and attached to some of their leaves, the unmistakable large white-embryo eggs of Crested Newts.

A half hour torchlight count revealed 50 adults in just one corner of the moat, which now had several thousand square metres area of water in it. By late July the moat was dry and thousands of dead well-grown larvae were littering the moat bed. This raised various questions – first, would the population survive this apparent calamity? Answer, yes. Second, would the water stay long enough to allow successful breeding in future? Answer, gain yes. Thirdly for how many years can a population maintain its numbers, or even persist at all, without successful breeding? Of course this is a rather difficult question, but we can make some predictions based on trends observed from the late 1980's onwards.

Finally, a couple of conservation questions to be raised – first, why was the water apparently more reluctant to stay into early autumn with each passing year? Answer, probably a number of factors but mainly low rainfall and low aquifer levels over the past decade, like many areas in southern England. Secondly, could anything be done to help this unusual ecological situation involving several thousand highly protected and declining animals? Answer, nothing was achieved for many years in spite of achieving English Nature's threshold SSSI status counts of 100 adults comfortably for the three years successfully required. However there may be some hope of a little action being taken in future.

It could be argued that amphibian populations are naturally prone to large fluctuations and that if it is 'natural' for the moat population to wane after its waxing then we should allow it to happen. However Crested Newts are not as well adapted to this boom and bust cycling as Natterjack Toads for example, which are much more specialist at living life on the edge. Natterjacks share the ability to achieve fairly low mortality with Crested Newts and most other amphibians, but they lay more eggs and crucially their tadpoles are genetically programmed to develop at one of the fastest rates of any European amphibian, in complete contrast to the Crested Newt. As a result they may lose a year's breeding effort in a very dry year, but are able to exploit temporary pools in dunes and heaths etc. far better than Crested Newts. The odd season with no success is fine for the newts, but a sequence of 'blanks' will affect the population seriously.

I have only been able to trace two other examples of such 'single waterbody' Crested Newt populations. One is a current site in a pasture in Yorkshire where there is only a gentle dip to indicate that water may sometimes accumulate in part of the field, yet when it does, about a thousand newts appear from nowhere (the field is well grazed) and breed (T. Gent, pers comm). The other reference is from a seasonal dune slack near Cardiff in the 1920's (D. Frazer), where water apparently was present only during October to April, yet it was estimated to contain a thousand Crested Newts and tens of thousands of smaller Smooth Newts. The lack of water prevented fish colonising, yet it was supposedly present at the very time of year when newts do not breed! Perhaps the newts had shifted their breeding to autumn/winter in this mild part of Britain; more likely there was water present into late summer in a few years, often enough to allow the newt population to persist at high numbers but rarely enough to escape human attention.

RECORDS AT THE MOAT

After the 1990 season, I began to record several kinds of data at the moat:

(1) The number of adults counted breeding in the moat in those years when it held water, under standard methodology to allow a rough cross comparison from year to year. Additional to providing purely scientific data, peak counts can be used as a guideline to judging whether a population reaches the criteria to be designated with SSSI (Site of Special Scientific Interest) status. The accepted 'score' was taken to be three years of counts successively with a minimum of 100 adults in the waterbody.

(2) The years in which water was present in the moat and, for those years, when it dried out.

(3) The estimated 'breeding success' of the population. Without quantitative methods, this can only be a relative measure, hence it was defined arbitrarily as '100%' if the water was present throughout the year when most of the larvae would achieve metamorphosis, ie until the end of October, and '0%' for years in which the water dried up before the end of July, with a gradually ascending 'success' value in the intervening months.

The methodology for the breeding census was to use a standard series of walked transects along several areas of bankside using the 2m width of the torchbeam to give the transect width. All meteorological parameters were kept as constant as possible, with counts taking place in late evening during early to mid May. Since the moat is managed in winter and excess vegetation removed, the ease of surveying remained unchanged and the water was clear and not choked with aquatic plants. Thus I think it is fair to say that variables which could have affected surveying were controlled as fully as possible.

Overall, due to the steepness of banks in many places and the large perimeter available for surveying, less than 10% of the moat banksides were surveyed, with the transects being taken from several regions to provide a representative selection of the aquatic habitat of the moat.

Table of results

Crested Newt census and estimated breeding success results, 1989-1997 inclusive

Year	Number of adults counted	Estimated breeding success
1989	0	0%
1990	50 (partial census only)	5%
1991	0	0%
1992	0	0%
1993	263	100%
1994	190	100%
1995	259	5%
1996	0	0%
1997	0	0%

DISCUSSION OF RESULTS

From the tables above the following conclusions can be drawn:

(1) In the 9 years surveying, the moat has contained water in the spring in only 4 years, ie. less than 50% of the time.

(2) In only 2 of these years, ie. 1993 and 1994 has breeding been very successful, ie. less than 25% of the time.

(3) However, in two other years, 1990 and 1995, if water had remained for only another month or two, very successful years would also have resulted. This shows that there would have been considerable value in an artificial 'top up' of water **only in cases where water is present in spring** as a valuable management scheme.

(4) It was possible to undertake a census in the three consecutive years 1993, 1994 and 1995. The total number of adults counted each time was 263, 190 and 259 respectively, clearly exceeding the SSSI criteria described earlier. It was fortunate that there were three consecutive years allowing the counts, since irregular water is precisely the characteristic of this population, illustrating the inflexible and poorly thought-out original Crested Newt SSSI criteria. English Nature is now trying to adopt different and more flexible approaches than the one given above, and this is to be encouraged.

(5) The numbers given above resulted in an estimate of the total adult population at the site being made of between two and three thousand adults in 1995 by professional herpetologists Dr Tony Gent and Dr Richard Griffiths, making this the largest population in the county and probably the largest single-waterbody population in the country, at least in 1995.

OBSERVATIONS ON THE STRUCTURE OF THE POPULATION, 1993-1995

At first sight, it looks as if the newts are well buffered from breeding failure judging by the counts in these three years. The numbers are fairly similar, at 263, 190 and 259. At the start of this article I asked if there was evidence that Crested Newts could weather several poor years of breeding by virtue of their adult longevity and survivorship. The data appear to support this point of view, since the adult count remains high and even increases in the last of the three years.

However, the data are somewhat misleading. In fact the population fell fairly rapidly from 1993 to 1994, from 263 to 190 represents an annual adult mortality (or loss from the moat breeding population at least) of 30%, if we accept that survey variables were well controlled between the two years.

In 1995 the figure indeed rises by almost 30% from 1994, but to see what is happening it is necessary to look at the size of adults in 1995 and also their sex....

During the first census of 1993 the majority of newts were in a large size class, with a visual estimate of between 140 and 150mm total length of most adults. In 1995 the absolute number was only four fewer than in '93 but there had been a shift from large and older animals to small younger individuals of about 100 to 120mm. That these represented newly mature animals was confirmed by the male-biased sex ratio of 4 to 1 rather than 1 to 1 two years previously, as males seem to mature a year sooner than most females.
The key conclusion is that a population which from raw data alone seemed very stable when examined closely revealed itself to have changed rather dramatically over two years – relatively few adults from 1993 appeared to survive to breed in 1995, although this was offset by successful breeding in '93 producing large numbers of newly mature animals, mostly males, in 1995. Further evidence for the changing nature of the population is obtained by looking at the 1994 census, when the numbers although high had been reduced to 190, a decrease of 30% on the previous year. Because there was no successful breeding in 1992, this mortality was not offset by recruitment and so we can see the real vulnerability of the population.

All of this is of more than academic importance – it has an important message for Crested Newt conservation. What may appear to be a stable population is likely to require successful breeding at least every few years if the population is not to dwindle. A few elderly individuals will survive over a decade as with most amphibians, but these will be vulnerable to chance extinction. Furthermore, the old SSSI criterion of three years successive counts over 100 takes no account of the likely fluctuations in many newt populations, and might lead to a site not being included because of this. In fact in spite of actually obtaining the high counts required for SSSI status, the bureaucracy of the system prevented English Nature from designating the site anyway, so the effort was wasted from a conservation perspective. It would still be worthwhile trying to implement the 'top up'regime mentioned earlier, ie. to ensure that some water remains during the years when breeding is possible in the spring by adding water artificially to the moat to try and maintain the possibly uniquely high numbers of animals using a single waterbody. At the time of writing this article, in December 1997, the moat has been dry throughout the year, but recent heavy rain might perhaps permit another successful season next year. I hope so, because without it the moat population will dwindle to a handful of individuals early in the next millennium and we shall be ecologically poorer as a result.

ACKNOWLEDGEMENT

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