INVERTEBRATE PREDATION ON LARVAE OF THE CRESTED NEWT (*TRITURUS CRISTATUS*)

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ABSTRACT.- Several authors have recently suggested that lack of desiccation in a breeding site for Crested Newts (*Triturus cristatus*) may lead to populations of predatory, aquatic invertebrates that are high enough to reduce metamorphic success of the newts. This issue has been examined in three newt breeding ponds at two sites by recording annual variations in numbers of both newts and invertebrates. While there was some evidence for an increase in invertebrate numbers in the absence of desiccation, under the conditions of the study, changes in invertebrate numbers could not be linked with any detrimental effect on newt metamorphic success.

ONE of the current dilemmas for the conservation of Crested Newts (*Triturus cristatus*) concerns the optimal degree of permanence of breeding ponds. Desiccation during the spring or summer will result in lack of metamorphosis that year, but may help in the longer term by eliminating predatory fish or by reducing numbers of aquatic invertebrates that take newt larvae (Arntzen & Teunis, 1993; Cooke, 1997; Oldham et al., 2000; Griffiths & Williams, 2000; Kupfer & Kneitz, 2000; Cooke & Arnold 2001). There is some information on the impact of fish (e.g. Oldham et al., 2000), but a lack of quantitative data on the effects of invertebrates on newt larvae. Effects on larvae of the Natterjack Toad (*Bufo calamita*) have been studied in detail by Banks & Beebee (1988), who found that invertebrate populations were generally higher in permanent ponds and were important in controlling numbers of Natterjack larvae, both in the field and in aquarium experiments.

In 1996, in an attempt to inform the debate on Crested Newts, I began collecting information on predatory invertebrates at two sites monitored for newts since the 1980s (Cooke, 1995, 1997). At the time, both studies were intended to be long-term, but ill health led to one being terminated from 1999. In view of the current interest in this subject, some results are presented in this paper focusing on (1) whether invertebrates increased in the absence of site desiccation and (2) whether increases in invertebrate numbers were related to decreases in newt metamorphic success, and vice versa.

SITES AND METHODS

The sites are at Shillow Hill in Cambridgeshire and Stanground near Peterborough. Descriptions are given in Cooke (1995 and 1997 respectively). Both sites have ponds that frequently dry out in the summer or autumn, but at Stanground there is a tap that has been used in some years by the Wildlife Trust to ensure wet conditions persist through to time of newt metamorphosis.

Top Pond, Shillow Hill: digging a sump in the dry bed of the pond during the drought of the early 1990s.

Year	When pond dried	Adult newts	Netting sweeps	Larval newts	Water-boatmen	Dragon-flies	Beetles
1996	Autumn	71±12	15±6	65±13	13±1	0.3±0.3	4.0±1.0
1997	Summer	9±4	0	-	-	-	-
1998	Autumn	102±24	38±2	80±23	11±2	0.0	9.5±1.8
1999	Did not dry	62±21	26±3	36±11	9.0±2.5	1.0±0.4*	2.3±1.0*
2000	Did not dry	76±22	37±4	119±16**	30±3**	7.8±0.6***	18±6*

Table 1. Top Pond, Shillow Hill: site desiccation and mean data (+SE) on counts of adult Crested Newts (based on 5 visits per year), and number of netting sweeps and newt larvae and invertebrates caught (4 visits). *t* tests used to test for significance between pairs of years shown in Table 3: * significantly different from previous year, P<0.05; ** P<0.01; *** P<0.001.

At Shillow Hill, the principal water body (Top Pond) was studied, while East and West Ponds were examined at Stanground. No fish were seen in any of these ponds during the course of the study, although fish have occurred in East Pond in the past (Cooke, 1997).

Numbers of adult Crested Newts were counted at night with a powerful torch: five times per breeding season at Shillow Hill, and three at Stanground. Newt larvae and predatory invertebates were caught with a pond net, examined, counted and released. Providing there was water in the ponds, each was netted on four occasions each year during July and early August, corresponding to the period when newt larvae were metamorphosing and starting to leave the water. Two metre sweeps were made in towards the edge, through the body of the water and the aquatic vegetation. At Shillow Hill, the number of sweeps was adjusted down from a maximum of 48 depending on the size of the pond (Cooke, 1995). At Stanground, a maximum of 15 sweeps was made in each of the two deepest parts of both ponds (see Cooke, 1997). The yearly mean total of newt larvae should provide an indication of relative abundance in a pond. This work was done under licence from English Nature.

Because of the study of Banks & Beebee (1988) and advice from M. Drake (pers. comm.) of English Nature, the following taxa of predatory invertebrates were routinely recorded: larval and adult Water-boatmen (*Notonecta* spp), dragonfly larvae (Odonata), and adult beetles at least 5 mm in length and beetle larvae (Coleoptera). A size limit was set for adult beetles because very small individuals were occasionally abundant but had no relevance with regard to predation of newt larvae. Very small Water-boatmen or dragonfly larvae were much less commonly found. Notes were kept of any other predatory invertebrates, such as Water Scorpions (*Nepa cinerea*), but these were few in number and will not be mentioned again in this paper. The technique should provide a comparative measure of summer numbers of the three main taxa.

RESULTS

The two issues (build up of invertebrate populations in the absence of desiccation and whether they reduce metamorphic success) can be evaluated by examining results over two or more summers (Tables 1 and 2). However, site desiccation in summer complicates this approach for both sites. At Shillow Hill, Top Pond contracted to its sump in the summer of 1996, and dried out completely in summer 1997. Mean number of netting sweeps reflected the variation between years (Table 1). Also adult newt numbers were very low in the depleted pond in the spring of 1997 (Table 1). At Stanground,

Pond/Year	When pond dried	Adult newts	Netting sweeps	Larval newts	Water-boatmen	Dragon-flies	Beetles
East Pond							
1996	Did not dry	29±5	26±4	11±2	18±10	1.8±1.2	8.0±2.8
1997	Did not dry	12±1*	30±0	19±4	39±11	2.3±0.8	5.3±2.2
1998	Did not dry	27±4*	30±0	36±5*	22±5	3.8±2.4	8.5±5.6
West Pond							
1996	Summer	13±3	13±8	13±0	22±20	0	0
1997	Autumn	44±4	30±0	6.3±0.3	35±18	0.5±0.3	3.2±0.6
1998	Did not dry	8±6**	30±0	19±7	96±17*	3.0±1.9	2.3±0.6

Table 2. East and West Ponds, Stanground: site desiccation and mean data (+SE) on counts of adult Crested Newts (based on 3 visits per year), and number of netting sweeps and newt larvae and invertebrates caught (4 visits).t tests used to test significance between pairs of years shown in Table 3: * significantly different from previous year, $P<0.05$; ** $P<0.01$

conditions remained wet in the summers of 1997 and 1998 because of use of the tap, and 30 sweeps were made on every occasion in each pond. In 1996, however, use of the tap was less successful; East Pond was reduced to its sump, while West Pond desiccated totally during July and was only netted on the first two occasions. Statistical evaluation between pairs of years is therefore restricted to when water persisted in the summer of both years through to newt metamorphosis and there were no significant changes in netting effort: 1998-2000 at Shillow Hill, 1996-8 at Stanground's East Pond and 1997-8 at West Pond (Tables 1, 2 and 3).

At Shillow Hill, there was little overall change in invertebrate numbers in 1999, following desiccation in the previous three years (Tables 1 and 3). However, lack of desiccation in 1999 was followed by increases in all three invertebrate taxa in 2000. In East Pond, Stanground, no increases were seen in invertebrates in 1997 or 1998, despite water persisting throughout this period, at least in the sump (Tables 2 and 3). In West Pond, desiccation in autumn 1997 was followed by an increase in numbers of Water-boatmen in 1998, rather than a decrease.

Results in Table 3 have been examined for evidence that predatory invertebrates might have an inverse effect on numbers of larval newts. At Shillow Hill, no significant change occurred for newt larvae in 1999, although dragonfly numbers increased and beetle numbers decreased. Numbers of all three invertebrate taxa increased in 2000, but newt larvae also increased in abundance. An unusually high, but unquantified, incidence of tail damage was noted among metamorphs in 2000. It is not known whether such lesions were caused by the invertebrates, by other newt larvae or by a different agent. Many larvae with tail damage had previously been seen in 1996 when high densities of newt larvae and invertebrates were observed as the pond contracted to the sump. On the last two visits in 1996, Crested Newt larvae exceeded 10 per sweep and Water-boatmen reached 2 per sweep (compared with means in 2000 of 3.2 and 0.85 respectively).

At Stanground, interpretation was made more complicated by significant changes in counts of breeding newts (Tables 2 and 3). In East Pond, a decrease in adult numbers in 1997 was not translated into any significant change in larval numbers. In 1998, both adults and newt larvae increased. There were no changes in invertebrate numbers in either year. In West Pond in 1998, numbers of newt larvae were maintained despite reductions in adult numbers and increases in invertebrates.

Pond/years compared	Pond dried first year?	Adult newts	Netting sweeps	Larval newts	Water-boatmen	Dragon-flies	Beetles
Shillow Hill							
1998 vs 1999	Yes	NC	NC	NC	NC	I	D
1999 vs 2000	No	NC	NC	I	I	I	I
Stanground East							
1996 vs 1997	No	D	NC	NC	NC	NC	NC
1997 vs 1998	No	I	NC	I	NC	NC	NC
Stanground West							
1997 vs 1998	Yes	D	NC	NC	I	NC	NC

Table 3. Changes between pairs of years when water persisted through to newt metamorphosis. This table summarises the statistical tests shown in Tables 1 and 2: NC = no significant change, I = increase, D = decrease.

DISCUSSION AND CONCLUSIONS

While relationships between species richness of invertebrates and pond permanence have been well studied (e.g. Collinson et al., 1995), this seems to be generally less true for abundance in relation to desiccation or permanence (M. Drake, pers. comm.). I had previously assumed that the latter relationship was a well-established entomological fact, and I suspect some other herpetologists have made the same mistake. A few studies do, however, exist that describe this effect (eg Downie et al., 1998). Also, the herpetologists, Brian Banks and Trevor Beebee (1988), noted that abundance of Odonata larvae and *Notonecta* increased as a function of site permanence in Natterjack pools. Results at Shillow Hill were consistent with populations of predatory invertebrates increasing in the absence of pond desiccation, but observations at the two Stanground ponds did not support this relationship.

Under the conditions of these studies, no evidence was found to associate lower metamorphic success of Crested Newts with increased numbers of predatory invertebrates. The most notable inter-year comparison was at Shillow Hill in 1999/2000, when all three invertebrate taxa increased, but so too did catches of newts. Predatory invertebrates will kill and eat newt larvae (e.g. Griffiths, 1996), but at these sites did not do so to a sufficient extent to outweigh other factors controlling numbers of newt larvae. The relationship between counts of adult Crested Newts and catches of newt larvae was discussed for Top Pond by Cooke & Arnold (2001).

The study ponds regularly desiccate, either totally or partially. For instance, Top Pond dried out in five years out of ten, 1991-2000, despite a sump being dug by hand in the early 1990s (Cooke & Arnold, 2001). West Pond dried out in six years out of ten up to 1998; East Pond did not dry totally during this period, but contracted to its machine-dug sump in five of these years (Cooke, 1997 and unpublished). Such a level of desiccation may mean that predatory invertebrates were unable to realise their full potential in terms of population size. The simple nature of this investigation should also be stressed. For instance, it remains possible that examination of mortality of younger, more vulnerable newt larvae might demonstrate effects.

Although work continues at Shillow Hill, the subject might be more profitably investigated in sites that desiccate less regularly or with captive animals under controlled conditions.

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