SHORT NOTES

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INCREASED USE OF PONDS BY BREEDING NATTERJACK TOADS, *BUFO CALAMITA*, FOLLOWING MANAGEMENT

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Natterjack toads, *Bufo calamita*, breed at fewer than 50 sites in the UK (Banks, Beebee & Cooke, 1994). The species was originally more widespread, but since the beginning of the 20th Century they have disappeared from more than 70% of their former localities, most notably from heathland in south-east England (Banks *et al.*, 1994). Much of the decline is a consequence of habitat loss, or pond acidification resulting from atmospheric pollution (Beebee *et al.*, 1990).

The natterjack toad colonies around the Solway coast represent one of the few remaining strongholds for this species in the UK. Despite their location at the north-western limit of the European range, in the early 1990s they accounted for up to 23% of the total British population (Banks *et al.*, 1994). One of the largest Solway populations breeds in pools on saltmarsh and adjoining agricultural land at Caerlaverock, south-west Scotland. On the Wildfowl and Wetlands Trust (WWT) reserve at Eastpark Farm, Caerlaverock, an extensive network of ponds has been surveyed annually for evidence of natterjack toad breeding attempts since 1991. After two years of poor breeding success in 1994 and 1995, WWT initiated an intensive management programme involving clearance of aquatic vegetation, excavation and redefinition of existing ponds. Although this approach has been adopted at several other sites (Banks & Beebee, 1987; Fleming, Mearns & Race, 1996; Beebee, Denton & Buckley, 1996), as far as we are aware, the WWT programme is the first to be conducted on such a large scale, with a total of 17 ponds excavated or cleared since 1995.

This paper documents changes in pond usage at WWT Caerlaverock over a nine-year period, and in particular, highlights the effectiveness of pond management as a tool for natterjack toad conservation. This is the first published account of natterjack toad breeding at the WWT reserve at Caerlaverock, and the first study to determine the average time lag between excavation and colonization or re-colonization for such a large sample of managed ponds.

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The WWT reserve at Caerlaverock (54°58'N 3°27'W) is adjacent to a National Nature Reserve managed by Scottish Natural Heritage (SNH), where natterjacks were studied previously in a small number of ponds (e.g. Banks *et al.*, 1994). At the WWT reserve, natterjacks breed in shallow pools (<1m deep) about 10m a.s.l. These pools were created in 1970-71 when soil was excavated from field margins to form banks which screened access to two bird observation towers (see Fig. 1). During the winter months, the toads hibernate in the soft, sandy soil forming the banks. Many of the pools are subject to occasional inundation by seawater on high spring tides during the winter, and tend to dry out by the end of most, but not all summers. Both processes are presumed to reduce the number of aquatic predators of natterjack tadpoles during the spring. Each of 24 distinct pools was assigned a unique code in 1991, and a further three were distinguished when the numbering system was updated in 1995.

WWT initiated a management programme in 1995, part-funded by SNH, involving excavation and redefinition of part or all of the existing ponds using heavy machinery. The purpose was primarily to clear all emergent vegetation and encroaching rushes (*Juncus* spp.) down to the bare soil, and leave a vegetation-free base of comparable depth to the original pond. This work was carried out in the autumn, after the end of the natterjack breeding season, and began with the ponds that were most overgrown, in some cases with very little open water remaining. In spring 1997, one additional pond (B2) was constructed (primarily for waterfowl) at a distance of c. 100m from the nearest bank (Fig. 1). In recent years, electric fences were also placed around all monitored ponds during the summer to exclude any cattle or sheep grazing in the adjacent pasture. The electric fences were removed after toadlet emergence had ceased, allowing access for cattle to crop the sward and trample the vegetation, slowing the rate at which ponds were overwhelmed by marginal vegetation and creating suitable habitat around the margin for foraging adult natterjacks the following spring.

All monitored pools (see Fig. 1) were visited on a minimum of 4 occasions, and generally more frequently, during May-August, 1991-1992 and 1994-1999, to check for evidence of breeding natterjacks (spawn strings, tadpoles or toadlets). Natterjack tadpoles were distinguished from common toad *Bufo bufo* and common frog *Rana temporaria* tadpoles on the basis of size, colour and the presence of a white throat patch. In most years, additional evening visits were made in May and June to record numbers of spawning adults. All fieldwork was carried out under licence from SNH.

Counts of the number of adult natterjack toads present during the evening were very variable within and between years. We do not know how much of this variation was due to differences in timing of our visits in relation to weather, so we do not regard the counts as reliable indicators of population size (see also Fleming *et al.*, 1996). However, the highest number counted on

FIG. 1. Location of study site and map of pond network (ponds coded A-Z).

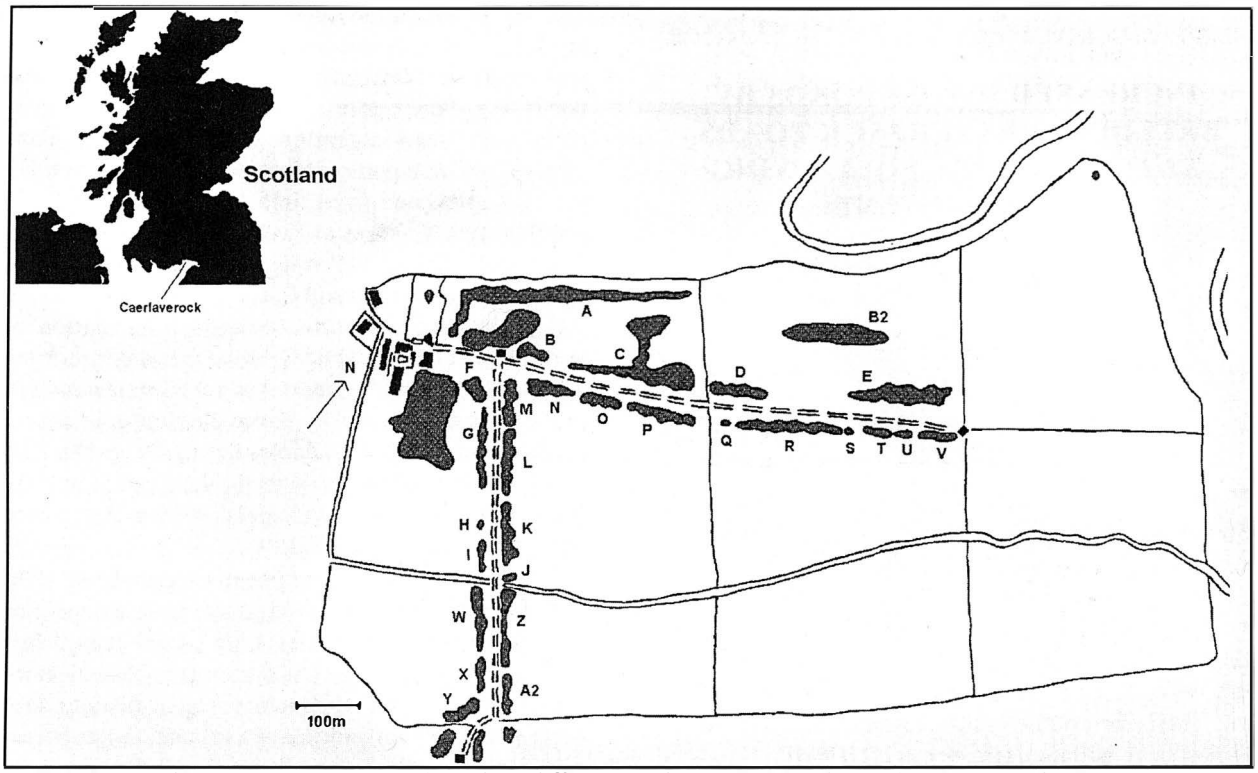

TABLE 1. Breeding attempts by natterjack toads in different ponds at WWT Caerlaverock, 1991-92 and 1994-99. The arrows indicate that vegetation clearance and re-shaping of at least part of a pond occurred in the autumn of the previous year. Note that pond B2 (see Fig. 1) was excavated as part of a separate project in spring 1997. N/d: No data; N/p: No pond.

Pond	Year							
	1991	1992	1994	1995	1996	1997	1998	1999
A					⇒	*	*	
B								
C					*	⇒	*	*
D	*			*	*	* ⇒	*	*
E	*	*	*	*	*	*	*	*
F	*	*			*			
G	*		*		*		*	*
H								⇒
I					*		*	⇒ *
J								
K						⇒	*	*
L	N/d	N/d	N/d		⇒ *	* ⇒	*	*
M	*		*		⇒ *	*	*	*
N	*	*	*	*	⇒ *	*	*	*
O					⇒ *	*	*	*
P				*	*	*		
Q			N/d					
R			*	*	*		*	
S			N/d			*	*	
T	*					⇒ *	*	*
U						⇒ *	*	*
V						⇒ *	*	*
W					*	*		⇒ *
X						⇒ *	*	*
Y					⇒ *	*	*	*
Z	*	*	*	*	*	*	*	*
A2	*	*		*	*		*	
B2	N/p	N/p	N/p	N/p	N/p	⇒ *	*	*

the WWT reserve on a single night was 390 adults, on 1 May 1995. The actual population size was obviously in excess of this, as not all males are likely to call or females to be present on a single night (Beebee, 1979).

Changes in the use of pools by spawning natterjacks in relation to maintenance is indicated in Table 1. In eight cases where pools had not been used by natterjacks for the previous two or more years, spawning took place in the spring following management work (ponds K, O, T-V, X and Y) or in the next spring (pond A). In no case where a pond was used previously by natterjack toads (ponds C, D, I, L-N and W) did pond maintenance in the autumn result in abandonment of that pond for breeding the next year. Of the pools cleared in 1995, five out of six were used in the four seasons up until 1999. Of those cleared in 1996, all were used by natterjacks for breeding in every season up to and including 1999. Furthermore, pond B2, which was excavated in early 1997 (although not specifically for natterjacks), held tadpoles in 1997, 1998 and 1999.

Considering the original 11 pools that were left unmanaged until at least 1998 (coded B, E-G, J, P-S, Z and A2; see Table 1), the number showing positive signs of natterjack breeding changed little throughout the study period (Fig. 2). In contrast, use of the 12 pools (coded A, C, D, K, M-O, T-V, X, Y) that were actively managed in 1995-1998 increased from four to 11 ponds during the period 1991-1999.

By 1997-99, natterjack tadpoles were recorded in a total of 23 different ponds on the WWT reserve at Caerlaverock. In 1999, in addition to these regularly-monitored sites, natterjacks used six other pools on the reserve or adjacent NNR, and although no systematic searches were made, it is likely that spawning occurred in other pools on the upper saltmarsh. There are only an estimated 250-300 individual pools used regularly by natterjacks in the UK and of the 47 extant colonies in 1989, only 12 held 100s to 1000s of adults (Banks *et al.*, 1994). With 29 or more breeding ponds in current use and a breeding population of at least 400 adults, the Caerlaverock area is clearly of considerable national importance in terms of natterjack conservation. The size of the local population presumably reflects a high density of suitable sites for breeding, including both saltmarsh pools subject to occasional tidal inundation, and ephemeral ponds on adjacent farmland which generally dry up during the late summer. Either set of conditions serves to eliminate or reduce the numbers of potential predators of tadpoles in the spring, which can significantly reduce tadpole survival, especially in deeper, more permanent ponds (Banks & Beebee, 1988; Beebee, Fleming & Race, 1993).

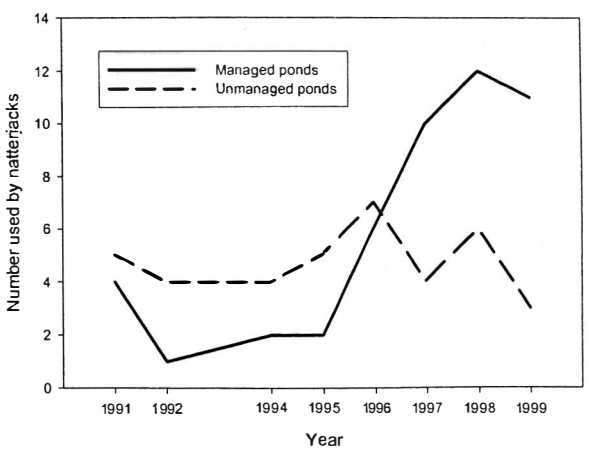

FIG. 2. Changes in number of unmanaged ponds (n=11) and ponds managed in 1995-1997 (n=12) with evidence of breeding natterjacks, 1991-1992 and 1994-1999.

Excavation and clearance of emergent vegetation and encroaching rushes from ponds at WWT Caerlaverock had an immediate effect on their attractiveness to natterjacks, with a significant increase in the median number of ponds used from 6.5 during 1991-1995 to 15.5 during 1996-1999 (Table 1). However, it is worth noting that in the long-term, one potential disadvantage to natterjacks of increasing the availability of ponds by effective management may be a concomitant increase in numbers of common frogs and toads. Growth rate and survival of natterjacks are reduced and emerging toadlets are smaller in high-density single- and mixed-species ponds (Griffiths, 1991; Tejedo & Reques, 1994; Bardsley & Beebee, 1998). Moreover, given a choice, female natterjacks will avoid breeding in ponds with high tadpole densities (Banks & Beebee, 1987). Although there is no information on population trends, common frogs and toads are both reasonably abundant at the WWT reserve, and for example were found in 76% of pools used by natterjacks in 1998 (WWT, unpublished data). Therefore, the possibility that inter-specific competition might become a problem in the future for natterjacks cannot yet be excluded.

In almost every case, managed ponds at Caerlaverock were colonized by natterjacks in the spring immediately following clearance of encroaching vegetation and redefinition of ponds in the autumn. These ponds were the most overgrown and in need of re-instatement. The ability to colonize new sites is a characteristic of natterjacks and facilitates the rapid exploitation of ephemeral ponds in unpredictable habitats (Beebee, 1979). In addition, modification of existing breeding pools at Caerlaverock never resulted in desertion. That natterjacks continued to use these pools for breeding despite substantial alterations further underlines their high degree of flexibility as regards site selection. Most importantly from a conservation perspective, it suggests that a similar management programme, if adopted elsewhere, would be unlikely to have a detrimental effect on spawning rates. This is especially noteworthy, as simply from the rate at which they have declined in recent decades, natterjack toads might otherwise be regarded as a highly sensitive species. However, our results indicate that increasing the number and presumably also the variability of pools is an extremely effective strategy for natterjack conservation. This is likely to be particularly useful at sites with low botanical interest where potential reduction in plant diversity is not an issue.

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