

Volume 6, Number 2

April 1996
ISSN 0268-0130

THE HERPETOLOGICAL JOURNAL



Published by
THE BRITISH HERPETOLOGICAL SOCIETY

Indexed in
Current Contents

HABITAT OCCUPANCY BY JUVENILE NATTERJACK TOADS (*BUFO CALAMITA*) ON GRAZED AND UNGRAZED HEATHLAND

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Habitat utilization by natterjack toads (*Bufo calamita*) during their first two years of life was investigated using a series of replicated 20 x 20 metre squares demarcated on several distinctive habitat types on a heathland in southern England. Two sets of squares, one on ungrazed heathland and one in an area grazed at low density by domestic cattle, were employed and the fate of toadlets released on the squares monitored over three successive years. Habitat use by resident adult natterjacks, and common toads *B. bufo*, was also recorded as was habitat selection over the site as a whole outside the experimental squares. Although toadlet survival was apparently low (though it was not possible to distinguish mortality from emigration), this and habitat selection by adults were unaffected by the presence of livestock. Juvenile natterjacks utilised the same range of habitats as adults, but the former showed greater preference for damp pond basins and rather less for dry bryophytes compared with mature animals. Common toads were rare in all habitats favoured by natterjacks, but were more often found in ungrazed rather than in grazed terrain.

INTRODUCTION

The juvenile life of pond-breeding amphibians between metamorphosis and sexual maturity is notoriously difficult to study but is probably of considerable importance with respect to population dynamics. Mortality rates, though usually lower than those of aquatic larvae, are high by comparison with adults in most species (e.g. Beebee, 1996). It is also a time at which selection may operate strongly, and genotype frequencies in *Bufo boreas*, for example, change significantly during early growth (Samollow, 1980). Juvenile *B. calamita* behave differently from adults at least during their first summer of life, being largely diurnal in Britain despite the problem of water conservation consequent upon a high surface area: volume ratio, and without the physical strength required to dig deep burrows (Beebee, 1983). This might mean that toadlets require special habitats in order to survive, and in this study we set out to investigate this aspect of toadlet ecology. We also wanted to determine whether grazing heathland with low densities of domestic animals, an increasingly popular management method, affected survival or habitat occupancy of both juvenile and adult natterjacks.

METHODS

The study was carried out at Woolmer Forest, a lowland heath in southern England with a small natterjack toad population that has been studied intensively for more than 20 years (Banks, Beebee & Denton, 1993). Adult natterjacks at this site show a strong preference for open, almost unvegetated terrestrial habitats including sand thinly covered with bryophytes and areas where trees have recently been clearfelled (Denton & Beebee, 1994). A total of fourteen 20 x 20 metre squares of terrestrial habitat were demarcated at the start of the experiment to include: (a) four bryophyte

areas; (b) four areas of grassy clearfell, which were partly vegetated with low-growing grasses; (c) four areas of completely bare sandy clearfell; and (d) two patches of recently-mown callunetum heath, with an average stem height of about 5 cm. Two each of (a)-(c) were within an area grazed from May-September each year by domestic (highland) cattle at a density of approximately one adult animal per three hectares of heathland. There were no mown patches within the grazed areas. The squares were separated from each other by at least 10 metres but were not enclosed, and animals were free to emigrate or immigrate at all times. The habitat types demarcated by squares were intermixed and not separated in clearly defined zones, and no particular habitat type was consistently nearer the breeding ponds than any other. In the first year of the experiment (1992), *B. calamita* tadpoles were reared to metamorphosis and toadlets grown in captivity, feeding them with hatchling crickets, to an average length of 15 mm. Seventy-five toadlets were released on each experimental square in late summer, and each square was provided with two or three tiles (Denton & Beebee, 1992) as cover to increase initial survival. During the second year of the experiment a further batch of toadlets (averaging 16 mm long) were given individual toe-clip marks and 20 released onto each experimental square in late summer.

Squares were inspected twice monthly during the activity periods of year one (late summer/autumn after first release), year two (April-September) and year three (April-September) and all sightings of toadlets recorded without attempting to identify individuals. Each square was searched for about 15 minutes during each visit, including the inspection of potential refugia, and always on bright sunny days when toadlets were expected to be active (Beebee, 1983). Adult natterjacks and common toads present in the squares were also recorded, as well as animals present on the

TABLE 1. Effects of grazing and habitat type on habitat occupancy. Data are averages for squares where these were paired, with standard deviations in parentheses, and represent total sightings of toadlets summed over the study period, and total separate individuals of adult *B. calamita* and *B. bufo*, pooled in all cases over three years

(A) SURVIVAL AND ABUNDANCE WITHIN EXPERIMENTAL SQUARES

Habitat	<i>Bufo calamita</i> Released toadlets		Resident adults		<i>Bufo bufo</i> Resident adults	
	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed	Grazed
Bryophytes	16.0(14.1)	26.5(16.3)	8.5(7.8)	6.5(3.5)	0(0)	0(0)
Grassy clearfell	12.5(9.2)	10.5(4.9)	5.0(7.1)	9.5(10.6)	1.0(1.4)	0.5(0.7)
Bare clearfell	10.5(7.8)	0.5(0.7)	2.5(3.5)	0(0)	1.0(1.4)	0(0)
Mown heath	1.5(2.1)	/	0(0)	/	0(0)	/
Total sightings/nos.	81	75	32	32	4	1

(B) TOAD DISTRIBUTIONS OUTSIDE EXPERIMENTAL SQUARES

Habitat	<i>Bufo calamita</i> Released toadlets		Resident adults		<i>Bufo bufo</i> Resident adults	
	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed	Grazed
Bryophytes	20.0(2.8)	5.0(1.4)	35.5(0.7)	5.0(0)	0(0)	0(0)
Grassy clearfell	5.5(3.5)	5.5(4.9)	2.5(2.1)	3.0(0)	2.0(2.8)	0(0)
Bare clearfell	5.0(0)	0(0)	4.0(1.4)	0(0)	0(0)	0(0)
Mown heath	0(0)	/	0(0)	/	0(0)	/
Pond basins	14.5(0.7)	6.5(0.7)	2.0(0)	1.0(1.4)	5.0(0)	0(0)
Total	45	17	44	9	7	0

same habitats outside the squares on all parts of the study site. Adults were identified and recorded as individuals rather than total sightings, based on throat spot patterns and other morphological features (Denton & Beebee, 1993). Numbers were log-transformed and subjected to statistical analysis using the MINITAB package on an IBM PC.

RESULTS

Total records for the experimental squares, cumulative over the three years of study, are shown in Table 1A. No attempt was made to distinguish individual toadlets on the replicated squares, and no more than three were seen on any one square during a single visit. Since a total of 95 toadlets was released onto each square during the experiment, mortality or emigration was presumably high though the proportion of toadlets present that were actually observed could not be estimated. In any case, high (>95%) mortality or emigration rates are to be expected at this phase of life (Beebee, 1983; Banks, Beebee & Denton, 1993). Adult toads, on the other hand, could be individually recognised and data for them represent numbers of animals using the squares over the three years. Repeat observations of the same individual were therefore not scored. The entire area occupied by natterjacks at Woolmer was also inspected at regular intervals and toadlets as well as adults quantified in the same way, as shown in

Table 1B. Grazed and ungrazed areas were very different in total extent (6 ha and >30 ha respectively) and thus numbers of animals on them were not comparable in absolute terms.

Two-way analysis of variance indicated no significant differentiation of habitat occupancy between the three major types studied or as a function of grazing regime for either natterjack toadlets or adults within the experimental squares (Table 2). However, use of bare clearfell by all age groups was consistently lower in grazed areas than in ungrazed ones both inside and outside experimental squares. Common toads were rarely encountered in the open habitat types preferred by natterjacks and the small numbers seen precluded formal analysis, but there was a strong indication that this species was disfavoured by the grazing regime. Eleven common toads were recorded in prime natterjack habitat outside the grazing area but only a single one within it.

Toadlet survival in the first winter of the study (1992-3) was apparently higher than that of first-year animals (both natural metamorphs and releases) in later ones, though this was not quantified directly and may have related to climatic variation (see Discussion). Interestingly, there was no evidence of size-related selection for survival during the first winter of this study. Thus in October 1992 the mean size of 20 toadlets sampled from a range of squares was 23.3

TABLE 2. Analysis of variance of grazing and habitat effects in experimental squares. ANOVAs compare abundances in (i) grazed and ungrazed; (ii) bryophyte, grassy and bare clearfell habitats.

(A) NATTERJACK TOADLETS

Source	df	SS	MS	F	P
Grazing	1	5.13	5.13	1.41	0.27
Habitat	2	19.20	9.60	2.63	0.13
Error	8	29.18	3.65		
Total	11	53.51			

(B) NATTERJACK ADULTS

Source	df	SS	MS	F	P
Grazing	1	0.02	0.02	0.0	0.96
Habitat	2	49.90	24.95	3.07	0.10
Error	8	65.12	8.14		
Total	11	115.03			

(C) MEAN NUMBERS OF NATTERJACKS IN SELECTED TREATMENTS

Treatment	Adults	Toadlets
Ungrazed	5.3	13.0
Grazed	5.3	12.5
Bryophytes	7.5	21.3
Grassy clearfell	7.3	11.5
Bare clearfell	1.3	5.5

mm, with a range of 16-33 mm, whereas another random sample of 12 toadlets in spring 1993 showed no significant difference with a mean of 25.0 mm and a range of 18-33 mm.

There was some evidence that toadlets, although accommodating to the same types of habitat used by adults, did not show exactly the same preferences. Pooling observations on both types of clearfell and comparing total observations on the site outside experimental squares (i.e. those of Table 1B), in the ungrazed area toadlets were found less often in bryophyte habitat and more often in pond basins than expected by chance compared with adults ($\chi^2 = 24.38$, $df=2$, $P<0.001$). The same was true within the grazed area ($\chi^2 = 13.20$, $df = 2$, $P<0.01$), but since the observations did not distinguish individual toadlets (and could therefore include pseudoreplication) this statistical test merits cautious interpretation. Nevertheless, the occupancy of damp pond basins by toadlets in their first year of life persisted long after metamorphosis, and in autumn many were observed making their first burrows in this habitat.

DISCUSSION

Interpretation of the observations described in this paper must be made with caution for several reasons. Firstly, there could be differences between the habitats in toadlet visibility which would bias recording. However, all the habitats studied were open and sparsely vegetated and we do not believe that differential observability was a substantial cause of variation. Sightings of more than one toadlet on a square during a single visit, for example, were not confined to particular habitat types but were apparently random in this respect. Secondly, the animals were free to wander into and out of the squares and we cannot distinguish between mortality and emigration as determinants of observation frequency. However, we were only concerned with whether the habitats were comparable in their suitability for toadlets and sightings should still reflect this whether or not mortality or migration was the dominant influence, or even whether or not it varied between habitat types. Thirdly, for toadlets we scored sightings rather than individuals because we did not find it possible to make identifications with certainty. Although some toadlets were given specific toe-clips in the second year of study, survival of marked animals was extremely low and therefore not very useful to the investigation. This experiment did, however, indicate how mobile young toadlets can be since two marked individuals were found in pond basins several hundred metres from their release points. Fourthly, data on experimental squares could have been confused by immigration of toadlets produced by the natural breeding ponds. We believe that this is unlikely to have made a significant impact, partly because natural levels of metamorphosis were low (almost zero) during the critical first year of the study period and partly because most of the squares were well away from the breeding ponds. The results of the statistical tests must also be considered carefully within the limitations of the methodology employed, and it remains possible that the available statistical power in this situation was insufficient to distinguish real differences that might have been present.

Taking account of the above caveats, we nevertheless draw two tentative conclusions from this study. Firstly, we found no evidence of extra microhabitat requirements specific to toadlets over and above those needed by adults at some time during the year. Inside or outside experimental squares (natural metamorphs presumably predominating in the latter category) we never observed toadlets in habitat types unused by adults, although the occupancy of desiccated but still damp pond basins by young toadlets, sometimes for months after metamorphosis, was notable. Secondly, the low-density livestock grazing regime in place on part of the heath was apparently compatible with natterjack survival and may benefit them by disadvantaging the competitively-superior *Bufo bufo* (Banks & Beebe, 1987). Grass snakes *Natrix natrix*, a

major predator of *B. calamita* at Woolmer, also tended to avoid ponds inside the grazed area presumably because cover around the pond margins was much reduced (unpublished observations) while cattle dung stimulated growth rates of natterjack tadpoles in the oligotrophic heathland ponds (Denton & Beebee, in preparation). Only on bare sand within the grazing area were natterjacks of all ages scarce or absent, but this was almost certainly because the bare sandy clearfell in the grazed zone was subject to heavy winter flooding (and thus not strictly comparable with otherwise similar terrain outside it), a difference not realised until after the experiment was underway. The limited space within the grazing area did not, in any case, allow for selection of alternative bare clearfell areas. We suspect that winter flooding substantially increases mortality of young natterjacks at Woolmer, which was apparently high in all parts of the site during the wet winters of 1993-4 and 1994-5 but much lower under the drier conditions of 1992-3. Cattle trampling, by contrast, was extremely beneficial on grassy clearfell where it broke up turf and facilitated burrowing. More toadlets were found in these sites in year three compared with years one and two, indicating a progressive improvement in habitat quality over several seasons. Grazing regimes should bring many benefits to heathland conservation provided the density of animals is not too high, and at Woolmer the stocking rate of one cow per three hectares dramatically reduced the extent of invasive *Molinia* grasses as well as impacting upon scrub and pine (*Pinus sylvestris*) encroachment with minimal damage to areas of mature callunetum.

There is still much to learn about the first years of life of wild amphibians. Methods to address this problem are few and difficult, and at present are less able than comparable work on adults or larvae to produce clear results. The study reported here has generated some extra information on juvenile life that should be useful in planning conservation management for a species currently endangered in Britain and some other parts of northern Europe.

ACKNOWLEDGEMENTS

We thank the Ministry of Defence for access to the study site, Iain and Sarah Scott of "Wildlife For All" for rearing toadlets in 1993, and English Nature (especially Dr Tony Gent) for financial support.

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Accepted: 8.11.95