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TEN YEARS OF GARDEN PONDS

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INTRODUCTION

It's become well-known that garden ponds can be excellent breeding sites for most of Britain's native amphibians provided they are made and maintained in suitable fashion. Having now spent 10 breeding seasons at our current abode, with the first pond installed a month or so after our arrival, it seemed like a good time to review the various successes and failures. This article reports the results of deliberately introducing 7 species of amphibians, 5 native and 2 alien, over the past 10 breeding seasons.

THE SITE

The garden dimensions are some 13 x 25 metres, set on a west-facing slope of the South Downs. The first pond installed (pond 1) is in a relatively cool area of the garden, though it receives sun for a good part of the day. It was made in February 1977, with overall dimensions c.3x4x0.6 (max) metres. It has multiple-depth shelves and a greater variety of plant life than the other 2 pools; these include an ornamental lilly, yellow flag iris, king cup, water soldier, water parsnip, Canadian pondweed, hornwort, groenlandia, curly potamogeton, square St John's Wort, tubular water dropwort and (sometimes) water crowfoot. Pond 2 was first made in 1978 but has been modified on many occasions; since 1983 it has been about 0.7x1.5x0.4m, with uniform depth and a glass side-window. It is in a warm and sunny position, but has relatively few plants (most notably water plantain and arrowhead, with some hornwort and Canadian pondweed). For much of the year it remains green and soupy with single-celled algae. Pond 3 is the largest (3x5.5x0.6 (max) metres), made in January 1979 in the sunniest part of the garden. It has only 2 depths; 80% is at the maximum, and 20% forms a uniformly shallow (7-8cm) shelf. Plants include blue iris, hornwort, Canadian pondweed, frogbit, water soldier, lesser yellow lilly and greater duckweed as the most abundant.

Table 1. Pond temperature

		Depth variation (Pond 1)			Variation between ponds (at 40mm depth)	
Season	Temp. measured	40mm	200mm	450mm	Pond 1	Pond 3
Winter	Minimum	2	4.5	5.5	4.1	3.3
	Maximum	9	7.5	5.5	9.1	8.2
Spring	Minimum	1	3	11	2*	4.3*
	Maximum	24	19.5	14.5	10.1	10.1
Summer	Minimum	15.5	15.5	14	10.9	12.3
	Maximum	37	26	21	20.7**	22.8**

Seasons for depth variation measurement were in fact single months (Jan, Apr & Jul) in which thermometers were left in place for 2-3 weeks before taking single (cumulative) readings. Seasons for variation between ponds were: Dec-Feb, Feb-Mar & Apr-Jun (all inclusive). In these cases measurements were taken at weekly intervals and the figures are the averages of these measurements. *, ** = pairs significantly different by t-test.

Ponds 1 and 3 are made from butyl, pond 2 is concrete. Fish are absent from all, though I have tried (unsuccessfully) to introduce 3 and 10-spined sticklebacks to pond 2. These have perished in the recent severe winters. I have stocked the ponds as richly as possible with invertebrates; pond 1 has water scorpions *(Nepa),* lesser and greater water boatmen, water spiders, horse leeches, damsel and dragonfly *(Libellula* and *Aeshna* type) nymphs, flatworms, *Limnaea* and ramshorn type snails and various small water beetles. Pond 3 is also rich; it has smaller leech species (not horse leeches), otherwise as in pond 1 but with healthy populations of great diving beetles and saucer bugs. Water lice and shrimps are common in all ponds, as are large blooms of daphnia in spring and early summer. Differences in the temperatures attained at different depths in pond 1, and at the same depth in ponds 1 and 3 are summarised in table 1, the results of some max/min thermometer measurements in 1985 and 1986. As expected, temperature variation was greatest in shallow areas which can get up to blood heat in summer. Pond 1 seemed to stay slightly warmer than pond 3 in winter (though the differences were not significant); in spring minimum temperatures in the shallows stayed higher in pond 3, and in summer pond 3 was certainly the warmer of the two.

METHODS

For the most part I have simply observed events (numbers of spawn clumps etc) and noted them; amphibians were however introduced to the ponds deliberately in the first instance (see below) either as spawn or adults, so colonisation was not natural. I made a conscious choice that the ponds would be for pleasure rather than science, a rule I broke only once in 1986 with mark/recapture exercise to estimate newt numbers. For this I did the following, over one 24-hour period at the end of April: (a) I went around the ponds 5 consecutive times after dark one evening, with a powerful torch and hand clicker-counter, registering the numbers of crested, alpine, male palmate, male smooth, and total "small" female newts in turn and separately for each pond. (b) I set Llysdinam-type newt traps (5 each in ponds 1 and 3, 2 in pond 2) late in the evening, and collected newts from them early next morning. All caught newts were toe-clipped, returned to the pond they came from, and left for 6 hours. (c) Later in the day, the ponds were netted vigorously for 15 minutes each and animals caught and counted (together of course with noting the numbers of marked individuals of each species in each pond). Population size for each species in each pond was calculated from the formula:

$$P=a(n+1)/(r+1)$$

Where P=estimated number; a=No. toe-clipped initially; n=number caught in second round (netting); r=no netted bearing mark. Standard deviation was calculated as:

$$SD = a^2 (n+1) (n-r)/(r+1)^2 (r+2)$$

These formulae are appropriate for single exercises involving less than 20 recaptures (as these did).

Table 2. Breeding activities of frogs and toads in the garden ponds

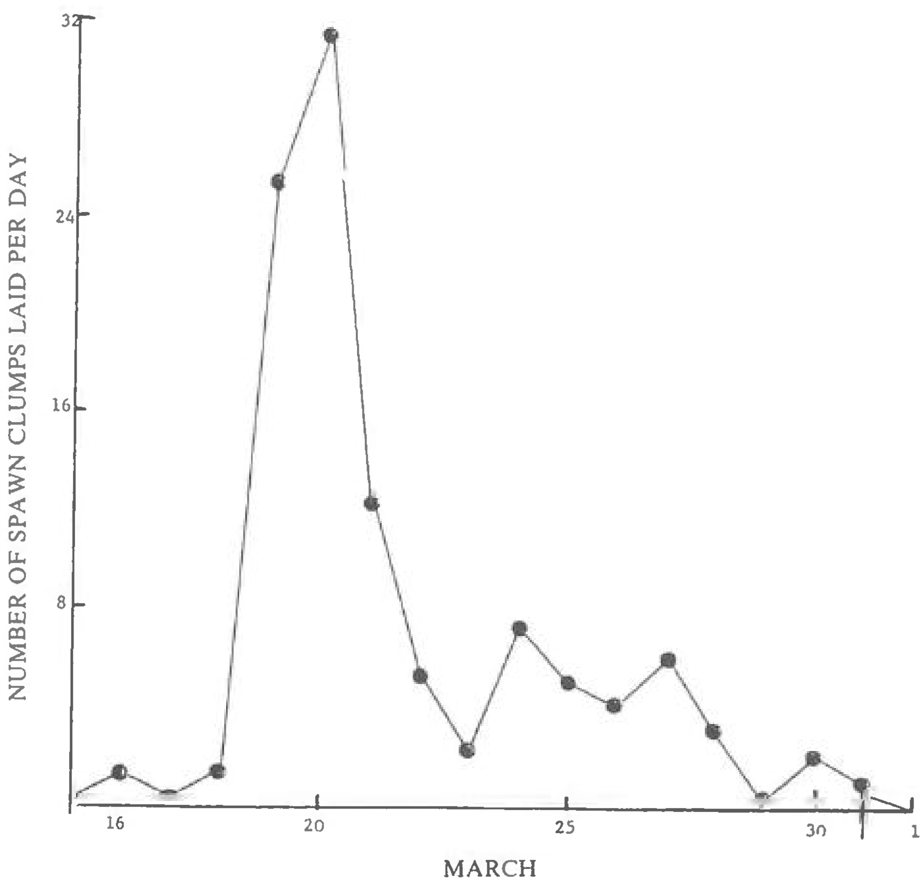
YEAR	SPECIES: COMMON FROG							COMMON TOAD	EDIBLE FROG
	First Spawn Laid	Last Spawn Laid	Spawn Period (Days)	No. Clumps	No. Frogs Killed M	F	Total	No. Strings In Pond	First Spawn Laid
1978	–	–	–	1(4)	–	–	–	(1)	June 17
1979	March 14	April 21	38	32	0	0	0	(3)	None laid
1980	Feb 21	March 24	33	56	0	0	0	(20)	None laid
1981	Feb 16	March 11	25	56	6	4	10	(1)	May 25
1982	March 4	March 21	17	130	2	1	3	1(2)	May 29
1983	Feb 23	March 19	24	110	23	12	35	2	June 9
1984	March 4	March 23	19	92	20	9	29	1(2)	June 9
1985	March 5	March 31	26	86	6	2	8	(5)	May 25
1986	March 16	March 31	15	105	22	9	31	1	June 17
Average	March 2	March 25	23	83*					June 6

*Excludes 1978. M=Male, F=Female

THE AMPHIBIAN STORY

The fate of frog and toad introductions is outlined in table 2. Common frog introduction actually began in 1977, with 11 clumps of spawn. This may not have been necessary, as there were certainly "native" frogs in the garden and 1 pair of these spawned in pond 1 in 1978. After a small booster of more spawn in 1978 I have added none since. The first progeny (from 1977) seem to have returned in numbers in 1979, where most still spawned in pond 1 though a few latecomers used the new pond 3. Since 1980 pond 1 has been completely abandoned for spawning, though it is still popular as an overwintering site, and all frog breeding (with occasional exceptions of odd clumps in pond 2) has subsequently been in the warmer pond 3. Numbers seemed to increase to a peak in 1982, fall off somewhat and most recently (after the severe winter of 1985/6) resurge again. Pond 3 teems with frogs in March, and breeding has been successful — with froglets emerging — every year so far. This success has not been without cost to the frogs, however. The breeding activity attracts predators, and in the peak years of 1983-4 considerable numbers, mainly males, were killed and left near the ponds. The cause turned out to be a vixen which had taken up residence at the end of the garden; she was caught in a live-trap and moved, since which time mortality rates from predation have apparently dropped sharply. However, this may be deceptive because foxes kill wastefully; sometimes only the head was eaten, often nothing at all (the frog just being bitten through). Other predators eat the lot and leave no trace and in the last 3 years I have watched a pair of crows visiting the pond and doing just that. These figures also do not include frogs dying from no obvious cause — presumably exhaustion — during or shortly after spawning. There are always a few of these, say 2 or 3 visible each year on average, but murky water and weed growth has prevented serious estimation. They seem to be mainly females. In the last 2 winters deaths from suffocation under ice have been significant, dramatically so in 1986. Almost all the visible mortality this year (see table 2) was from this cause, again selecting for females. Interestingly, no dead frogs were seen in pond 3 after the ice melted but 16 in the small pond 2 (including 6 immatures not listed in table 2) and 21 in pond 1.

Figure 1. Frog spawning pattern in 1986.



The starting date for spawning has varied by a full month, from mid-February to mid-March, over the past decade. The duration of spawning has also varied, from about 2 weeks (after the late thaw of 1986) to more than a month. Delays are of course often caused by intervening cold spells, but the pattern of 1986, a sharp peak with 2-4 nights of frantic activity, followed by a series of stragglers, is quite typical (figure 1). Usually 1/2 to 2/3 of the spawn is laid during the peak, which in turn usually comes within 4-5 days of the first spawn clump sighting. 1981 was unusual in this respect, with a gap of more than a fortnight between first spawn and the main activity.

The situation with common toads could scarcely be more different or less satisfactory. Despite persistent attempts, sometimes with substantial amounts of spawn (e.g. in 1980, when many toads were rescued from a cracked pond and spawned in captivity) there are no signs of a colony establishing. Odd pairs and males do turn up, and in recent years I have had 1 or 2 spawn strings laid; interestingly the toads always use pond 1 and avoid pond 3 completely, perhaps because there are so many frogs there. The spawn, however, has never given rise to toadlets. Sometimes it just dies (as this year), other times it develops slowly, tadpoles grow very slowly and disappear when about half-grown.

I first released edible frogs back in 1977 (8 adults from France); these bred in 1978 and then disappeared. In 1980 I introduced about 20 adults and juveniles caught in a Surrey claypit and these have spawned every year subsequently (always in pond 3). This too, however, has never come to anything. I suspect hatchlings are eaten or inhibited by the high density of common frog taddies, but even spawn put in tanks has fared poorly with slow growth rates and only once did I produce (tiny) froglets indoors. The colony is thus slowly diminishing, with only 6 adults in 1986. Their behaviour is interesting; males dominate pond 3 but females migrate to ponds 1 and 2 before and during the breeding season, except for a brief visit to pond 3 to mate. When the males calm down (usually by July) the females return to pond 3 until late summer; then there is a general move to pond 2, which receives a lot of afternoon sun in autumn, before disappearing into hibernation. Some females certainly overwinter in pond 3, because every spring I rescue at least 1 from amplexus by male common frogs.

Newts have, on the whole, fared better than anurans in my ponds. These have always been introduced as adults rather than spawn or tadpoles; in Spring 1977 I released about 20 smooth newts, 10 palmates, 5 great crested and 5 alpines into the newly-created pond 1. This was supplemented in 1978 with another 5 crested newts, and in 1981 with about 20 or more palmates. There were conspicuous increases in numbers of smooths, palmates and cresteds coming to the ponds in the spring of 1979, suggesting that these species can become mature (both sexes) within 2 years. Alpines, on the other hand, took off a year later implying a longer growth period for this newt in Sussex. Table 3 shows the first dates each year when I observed individuals of each species in my ponds. Careful observation, along with extensive netting and weed removal in November and December every year, has convinced me that there is essentially no overwintering by newts in my ponds; I have never seen a single adult of any species at this time, though a few larvae do remain. There were no significant differences between the 3 British species on this basis, but I am sure this measure is not really sufficient to describe what is going on. It has long been my impression that the bulk of the palmate population arrives earlier than the other 2 natives, and the mortality figures this year tend to confirm this notion. When the ice melted in March, there were 8 palmate newt corpses (4 of each sex) but only 2 male smooths (and no cresteds or alpines). These undoubtedly migrated in January before the severe weather descended. Alpine newts always arrive much later than the other 3, usually well into March. In the mildest winters of the decade (1983 and 1984) I watched female crested newts laying eggs in pond 1 well before the end of January.

I refrained from any serious attempts to estimate the size of my newt populations until this last year. The results of the mark/recapture exercise are shown in table 4. Since this was a single attempt, the numbers reflect only the newts present at one particular time in Spring (albeit when I judged numbers were near their peak, at the end of April) and should therefore be thought of as minimum figures. Smooth newts are obviously the commonest type, with several hundred present spread across all 3 ponds but especially abundant in warm pond 3. Alpine newts have done extraordinarily well, with at least 100 again using all 3 ponds. Palmates are outnumbered by smooth newts by at least 10:1, but seem to maintain a viable population at this low level. None

Table 3. Dates of first newt sightings

YEAR	SPECIES			
	Smooth	Great Crested	Palmate	Alpine
1978	Feb 26	Feb 26	Feb 26	April 9
1979	Feb 11	March 1	March 4	March 25
1980	Feb 3	Feb 4	Feb 5	March 2
1981	Jan 16	Jan 22	Jan 25	March 6
1982	Jan 23	Jan 30	Jan 30	March 9
1983	Jan 3	Jan 5	Jan 3	March 14
1984	Jan 2	Jan 2	Jan 2	No recorded
1985	Jan 28	Feb 2	Jan 28	March 4
1986	Jan 18	March 15	March 17	March 10
AVERAGE	Jan 25	Feb 4	Feb 4	March 14

were trapped in pond 2 but 5 subsequently netted there. Crested newts seem to have stabilised at low 10s of adults and, interestingly, seem to select slightly for the original pond 1. Adults are rarely seen in the small pond 2, and never stay there long. Certainly it is noticeable that far more large crested newt larvae are seen every year in pond 1 than in pond 3, and I believe that for some unknown reason most crested newt recruitment is still from this pond. It may be that newt eggs in pond 3 are predated by the large number of frog tadpoles and smooth newts present there.

Table 4. Newt population estimates

A

SPECIES	POND					
	1		2		3	
	No(SD)	% of Total	No(SD)	% of Total	No(SD)	% of Total
Smooth	115(32)	22	48(15)	9	364(111)	69
Palmate	8(3)	31	(5)	(19)	13(4)	50
Great Crested	12(4)	63	0	0	7(2)	37
Alpine	43(12)	44	16(8)	16	39(21)	40

B

SPECIES	M:1 Sex Ratio Estimate		Mark/Torching Estimates Ratio *	Numbers Counted Ratios**		
	In Traps	By Net		By Trap	By Net	By Torch
Smooth	1.3	1.2	1.89	1	3.4	4
Palmate	–	1.8	2.00	1	17	13
Great Crested	3.0	0.8	0.95	1	0.75	2.5
Alpine	3.5	1.3	2.00	1	1.2	1.8

*= Ratio of total numbers estimated to be present (in all ponds) by mark-recapture to the highest count of the species by torching (all ponds) on a single occastion.

**= Ratios of animals caught or seen by the 3 methods (totals for all ponds) during the mark-recapture study, setting the usual lowest (trap figure) at 1. This assumes torching counts of females can be divided into smooth: palmate at the proportion estimated by mark-recapture.

It was interesting to compare the population sizes calculated from mark/recapture with those measured directly by netting, torch counting and trapping. Torching stands out as a powerful and simple method for these small pools; essentially all of the large great crested newts can be seen directly, and probably about half of the smaller species. Trapping also produces a sex ratio which is probably inaccurate (biased towards males) for all 4 species.

DISCUSSION

It has been fascinating to see the enormous population densities that can build up, at least for some species, in the garden environment. Frogs are so abundant that many individuals show signs of poor health; those seen foraging in summer are often skinny and look in poor condition, and limb mutilations are frequent, suggesting pressures of food supply and predation. It is easy on a warm summer evening to find 30-35 adult frogs trying to scratch a living in a garden (to which they are not of course confined) of less than 1/6 acre. Interesting questions have also arisen, such as why do toads and edible frogs fail to breed, and what determines the relative numbers of the newt species? Only 7 hours up the road is a large pond with a thriving toad colony, probably assisted by pond size and the presence of fish (which predate competing frog tadpoles). But I suspect there are also more subtle problems, difficult to address, of water chemistry and suchlike. It is notable that pond 1 has become a miniature dewpond in terms of the amphibians using it (no anurans, lots of smooth newts, some cresteds and palmates). Frog and toad spawn simply will not survive in this pond now, though pressure from newts is less than in pond 3. It has proved possible to crop the amphibians doing well for the benefit of others wanting specimens; I have lost track of how many clumps of frogspawn, alpine and crested newts I have supplied over the years. I reckon that the ponds can withstand the abstraction of at least a couple of pairs of cresteds and a dozen or so alpines each season. Certainly the pleasure derived from these pools has been out of all proportion from the work involved installing and stocking them.