Common Frogs in a Cambridgeshire garden over a twenty year period

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ABSTRACT — Breeding by Common Frogs, *Rana temporaria*, was studied from 1983 to 2002 in two ponds in a garden in Ramsey, Cambridgeshire. During this time, annual spawn output increased from a single clump to 148 clumps. There was no significant trend in spawn date. Frogs laid earlier and laid more spawn in the warmer of the two ponds. Although the population increased, reproduction frequently failed, with predation, cold weather, fungal infestation, non-viable spawn, poor water quality and a leaky liner being implicated.

IN Britain, garden ponds have become important for several species of amphibians, especially the Common Frog *Rana temporaria* (e.g. Beebee, 1979; Cooke & Scorgie, 1983; Hilton-Brown & Oldham, 1991; Beebee & Griffiths, 2000). Indeed the increase in garden ponds since the 1960s provided the Common Frog with an essential refuge during the time when its more natural habitats were being rapidly destroyed.

Despite the fact that breeding by frogs is relatively easy to observe in garden ponds, few articles on this subject have been published. The studies of Ashby (1969) and Beebee (1986, 1996) are notable exceptions. This short paper describes the establishment of a large population of Common Frogs in a garden over 20 years, beginning at a time when frogs were rare in this part of the country. While there have been few publications specifically on garden populations, literature on the ecology of this species is extensive; references quoted here are highly selective.

THE SITE

Although the garden is in a suburban area, it is in a part of Ramsey, Cambridgeshire, where gardens and other green space far exceed the area of buildings and roads. The property (grid reference TL 283846) extends to 0.53 ha; the house and other buildings occupy 0.04 ha, the remainder being formal and informal gardens (Figure 1). The main change in the garden since 1983 has been in the herbaceous borders; in the early 1980s, they contained few plants and were frequently hoed, but they now have dense and diverse vegetation. Frog reproduction has been monitored in the spring and summer in two ponds in the garden. Frogs have not been studied at other times of year, but are frequently encountered on land.

The 'concrete' pond ('Co' in Figure 1) had been in existence for many years when my wife and I bought the property in 1982. It is 2.1 m in diameter with a uniform depth of 0.45 m. Initially, no water plants occurred in the pond, but various species have been introduced over the years, and are now controlled so they cover about 50% of the surface area. This pond is shaded by mature trees. Goldfish *Carassius auratus* have been kept in the pond intermittently, and Smooth Newts *Triturus vulgaris* regularly breed.

The 'plastic' pond ('Pl' in Figure 1) was created with a vinyl liner, specifically for frogs, in the winter of 1983/4. It is sheltered, yet can receive the full sun for much of the day. This pond is 65 m from the concrete pond. It measures 2.9 x 1.8 m with a maximum depth of 0.25 m. Most of the pond is 0.05-0.15 m in depth. Variable amounts of aquatic vegetation have been planted in pots. Smooth Newts also breed in this pond. The original liner sprung a slow leak in 1990, and was eventually replaced in December 1991.

Ornamental ponds have been created in three of the domestic properties that border the garden. To the north, a small pond existed 35 m to the north

The concrete pond.

The plastic pond

west of the plastic pond. Frogs bred there regularly, but spawn clumps were never counted. The pond was destroyed in the winter of 1992/3. To the west, another pond has existed throughout the study period about 60 m to the south west of the plastic pond. Small numbers of frogs breed there each year (13 clumps in 2002), as do Smooth Newts. To the east, a deep pond was created in 1999 about 40 m south east of the concrete pond. Although 21 clumps of frog spawn were laid there in 2002, the open nature of the pond and the presence of large ornamental fish makes any survival of frog tadpoles unlikely.

AMOUNTS OF SPAWN LAID

On 18th March 1983, a submerged stone shelf was put in the concrete pond to create a shallow zone and make the pond more attractive to breeding frogs. Up until then no frogs had been seen in the garden, but, by the next day, a single clump of spawn had been laid.

The following year, five clumps of spawn were introduced from the pond in our previous garden in Ramsey into the newly-created plastic pond. No clumps were laid naturally that year in either of the two ponds. Since 1984, spawn has been laid in each of the 18 years in the plastic pond, and in 14 years in the concrete pond (Table 1). During those 18 years, at least four times as many clumps have been laid in the plastic pond, except in 1992. Replacement of the pond's vinyl liner in December 1991 may have partially deterred the frogs in the following spring.

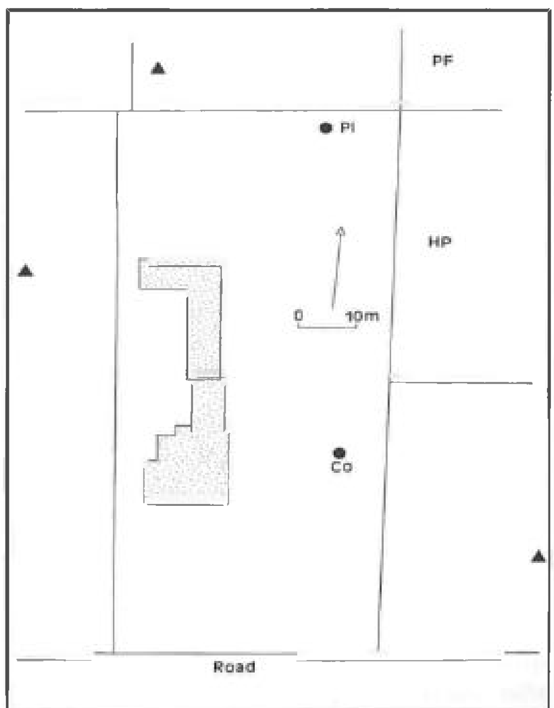

Figure 1. A map showing the positions of the two ponds in the garden (black dots, with 'Co' for the concrete pond and 'Pl' for the plastic pond) and those in adjacent gardens (black triangles). Buildings in the study garden are stippled, but those in adjacent gardens are omitted. The property is surrounded by gardens except for: 'PF' playing field; 'HP' horse pasture; and the road to the south. Apart from the access point to the road, the garden is entirely bordered by mature hedges.

Year	Plastic pond				Concrete pond	
	Date of spawning	Spawn clumps	Clumps hatching normally	Froglet emergence	Date of spawning	Spawn clumps
1983					19.3	1
1984		[5]*	5	+		0
1985	5.3	5	5	+	8.4	1
1986	17.3	12	12	+	23.3	2
1987	2.3	25	25	-	NR	1
1988	23.2	50	48	-	NR	6
1989	19.2	40	40	-	5.3	9
1990	21.2	66	9	-	12.3	3
1991	26.2	69	9	-	16.3	6
1992	2.3	26	5	-	18.3	23
1993	18.2	83	45	-	16.3	5
1994	19.2	87	50	(+)	6.3	8
1995	16.3	32	17	-	25.3	7
1996	24.3	44	10	(+)	13.4	2
1997	27.2	28	28	+	NR	1
1998	24.2	18	18	+		0
1999	22.2	24	24	+		0
2000	28.2	58	58	+		0
2001	7.3	140	140	+		0
2002	19.2	142	91	(+)	19.3	6

Table 1. Dates of first spawning and numbers of spawn clumps laid in the plastic and concrete ponds, 1983-2002. *Five clumps were introduced in 1984. NR = not recorded. Also shown for the plastic pond are numbers of clumps hatching normally (after deducting those translocated and those that failed) and froglet emergence: + good, (+) poor, - failed. For the concrete pond, the number of clumps hatching normally was the same as the number laid except for: 8 clumps in 1992, 3 in 1993 and 0 in 1997. No froglets emerged from spawn laid in the concrete pond.

The size of the frog population breeding in the garden has been followed by counting spawn clumps laid in both ponds (Figure 2). Number of clumps increased steadily up until 1991. In 1992, a reduction occurred, either because the frogs found the plastic pond with its new liner less attractive or because breeding failure in the previous five years (Table 1) was beginning to affect adult numbers. Destruction of the pond in the neighbouring garden to the north in the winter of 1992/3 may have been the reason behind the increases in spawn laid in 1993 and 1994. Following that, amounts of spawn decreased to a minimum in 1998 after ten years of poor breeding or total failure, 1987-1996 (Table 1). Amounts of spawn began to increase again in 1999, two years after successful breeding occurred in 1997. Successful breeding 1997-2001 has seen the frog population increase to its highest level so far in 2002.

In 2002, the spawn production in our garden and the neighbouring ones was 182 clumps. This suggests an adult population of several hundred in the vicinity of the garden, at a density probably approaching 100 per ha.

DATE OF SPAWNING

Dates when spawn was first seen in the two ponds are given in Table 1. For neither pond was there a significant trend in date over the 20 years (plastic pond, $r_s = -0.106$, $n = 18$; concrete pond, $r_s = 0.084$, $n = 12$). Spawn was always laid in the plastic pond first (paired *t* test, $P<0.01$), the average difference being 18 days. Spawning in the plastic pond was often exceptionally early for this area, with spawning in the concrete pond occurring at a much more typical time (Cooke, 1976).

To test whether the difference between spawn dates for the two ponds (and amounts of spawn laid) might be due to differences in water temperature, a maximum/minimum thermometer was maintained in each pond at a depth of about 10 cm for eight weeks from 6th February until 3rd April 2002. The thermometer in the plastic pond was in the centre, while that in the concrete pond was situated in the sunniest and warmest edge. There were no differences between mean daily minimum temperatures for any of the eight weeks. For maximum temperatures, however, the plastic pond was warmer for each week apart from the first one (*t* test or paired *t* test, $P<0.01$), despite siting the thermometer in the warmest part of the concrete pond. Weekly differences in mean daily maximum temperatures between the two ponds varied from 0.7 to 3.8°C.

FATE OF SPAWN AND TADPOLES

In total, 225 spawn clumps were translocated from the plastic pond to sites elsewhere. Most were moved during the period 1990-1994, in part because of concern about the potential effect of tadpoles being over-crowded. Seventeen spawn clumps were translocated from the concrete pond in 1992 and 1993.

No froglets were ever seen emerging from the concrete pond that were considered to have originated from naturally-laid spawn. Predation by fish and newts, particularly on newly-hatched tadpoles, was the most likely reason for this failure. When larger, free swimming tadpoles were moved to the concrete pond from the over-crowded plastic pond, froglet emergence was often good. As frog tadpoles grow, so predators such as Smooth Newts find it increasingly difficult to catch them (Cooke, 1974).

In the plastic pond, froglets were abundant in eight of the 19 years (Table 1); in three other years, very few froglets emerged, while in eight years there was total failure. In two years (1990 and 1991), failure was readily explained because the liner leaked and the pond dried out. Failure or near failure in the remaining nine years appeared to result from a variety of causes.

Spawn failure in the plastic pond

In four years, there was a significant amount of spawn failure. Many clumps were infested with fungus in 1994, 1995, 1996 and 2002, and these subsequently suffered low or zero hatch. It is not clear whether the fungus involved in such events is saprophytic or harmfully parasitic. Elsewhere cold weather has been blamed for fungal infestations (e.g. Greenhalgh, 1974), and the plastic pond was covered in ice after spawning in 1995 and 1996. However, very cold weather does not necessarily precede fungal infestation (Cooke, 1985). Early spawn in 2002 was briefly locked in ice on 2nd March, but spawn laid later in the spring also suffered infestation, despite there being no further hard frosts. On 24th February 2002, a typical fresh clump was divided and kept in pond water or rain water; both parts failed to develop and became infested, indicating either the effect of the frost on 2nd March or that the spawn was not viable. When a similar trial was undertaken in 1994, the spawn in rain water hatched normally, but that in pond water became infested with fungus and had a low hatch, pointing to problems with the pond water rather than with the spawn. Predation around hatching was not thought to be as important as in the concrete pond, because no fish were ever present and the ratio of spawn clumps to newts was probably much greater.

Tadpole failure in the plastic pond

Tadpoles that hatch from spawn that has had low hatching success because of fungal infestation or other reasons, have low survival rates, often dying soon after hatching (Cooke, 1981, 1985). The few tadpoles that hatched from the part-clump kept in pond water in 1994 all died within 20 days, whereas those in rain water survived normally. Of

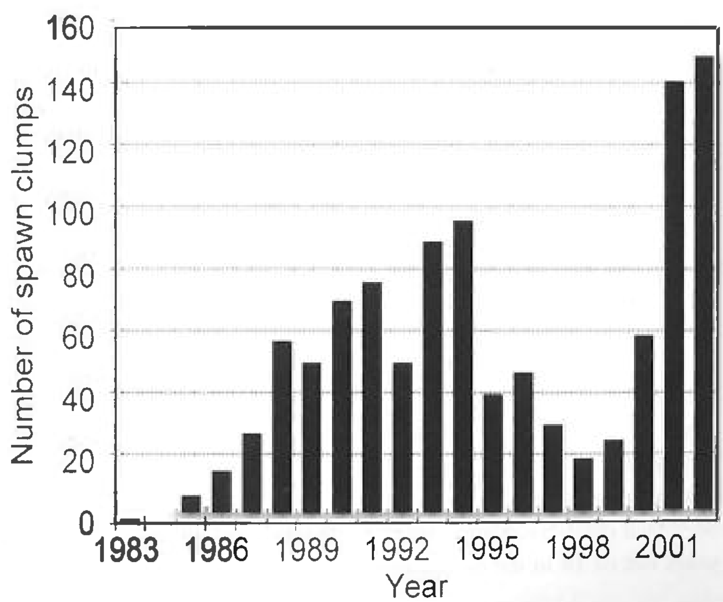

Figure 2. Total numbers of spawn clumps laid in the garden, 1983-2002.

the four years with fungal infestation: in 1994, a few tadpoles survived when heavy rain diluted the pond water above a dense mat of aquatic vegetation; in 1995, no tadpoles were seen; in 1996, a few tadpoles survived; in 2002, dead and dying tadpoles were noted during the month after hatching until very few were left. Problems were, however, not restricted to those years with spawn failure. Dead and dying tadpoles were seen in 1989; while in 1988, 1992 and 1993, tadpoles hatched satisfactorily, but disappeared completely soon after. Poor water quality might be implicated; for instance, decaying spawn and algae may have produced anoxic conditions in 2002.

Predation by newts will have contributed to losses, but, in this context, froglet success or failure was unrelated to the number of clumps hatching normally in the pond (Table 1). If newt predation was the main reason for tadpole losses, one might expect failure to have occurred more frequently when fewer tadpoles hatched. In the summer of 2002, there was no evidence of newt tadpoles in the pond; newt reproduction apparently failed, perhaps for the same reasons that precipitated large losses for the frog spawn and tadpoles. Over-crowding of tadpoles may also have contributed by reducing growth and development rates (eg in 1988, 1989 and 1993). However, over-crowding alone cannot fully explain failure in any one year, as all 140 clumps hatched successfully in 2001 yet froglet emergence was good. Conversely, tadpole losses occurred in 1992-4 despite translocation of much of the spawn. In summary, the factors responsible for spawn failure probably also had direct or delayed effects on the tadpoles.

CONCLUSIONS

The garden population which is the subject of this paper seems to have originated from the small number of frogs already present in 1983 and the spawn introduced in 1984. Since 1984, spawn has been laid every year in the plastic pond, and in 14 years out of 18 in the concrete pond.

Despite the current concerns about global warming, spawn dates in neither pond showed a significant trend to be earlier in response to higher spring temperatures. Although frogs may have the potential to spawn earlier in a warmer environment, Beebee (1995) also found his frogs did not spawn significantly earlier during 1979-1994. Spawning was always earlier in the plastic pond, and more spawn was deposited there. This may be explained by the water in the plastic pond attaining higher daily temperatures before and during the spawn season. Similarly, Beebee (1986, 1996) reported that frogs tended to spawn in the warmest pond in his garden.

Among the factors considered to be responsible for failure of spawn or tadpoles were predation, cold weather, fungus, non-viable spawn, poor water quality and a leaking liner. Over-crowding of tadpoles may also have contributed. As in the plastic pond, Beebee (1996) found almost total breeding failure from the late 1980s until the mid 1990s, blaming predation by newts. The main concern arising from this new study is the inability to explain fully the frequent breeding failure in the plastic pond, making it difficult to rectify the problem.

The population has fluctuated since the study began 20 years ago, but the total of 148 clumps laid in 2002 can be favourably compared with the single clump in 1983. The decline experienced during the 1990s has been reversed, but conclusions would have been different had this paper been written four years ago (Figure 2).

Common Frogs have recovered dramatically in this area since the 1970s, largely as a result of garden pond conservation. In 1973, I knew of only one garden with frogs in Ramsey, and, together with Peter Ferguson, estimated the breeding population of the old County of Huntingdonshire to be only 1500 frogs (Cooke, 1999). In 2002, in contrast, the breeding population in the vicinity of our garden will have numbered several hundred. Changes in the composition and structure of the herbaceous borders will have helped the garden support this number of frogs.

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