interrelationships between various approaches devoted to different levels of biological integration. From molecular biology, gene products, genetics and chromosomes through cytology, histology, developmental biology, descriptive embryology, functional and comparative anatomy, physiology, ethology, ecology to systematics, phylogeny and evolution, the whole array of approaches is there, happily cooperating and interacting towards, at the same time, a more precise and a more general understanding of reptilian evolutionary biology.

For the scientists of some countries, where it appears that progress in a given scientific field can be achieved only if other fields are first killed for good, the apparent healthy situation of cooperation and open-mindedness conveyed by the book between various "classical" and "modernist" approaches in Biology will appear as a most refreshing and encouraging hope. But on the gloomy side, and even if, as a Festschrift, and hence dedicated to one outstanding scientist by his friends and former students, I regret that a book of such importance and magnitude has not better conveyed the truly international aspects of current researches on reptiles. It seems to me hard to believe that major scientific countries like the Soviet Union, Italy, Germany, Spain (which is currently performing a dramatic scientific come back in vertebrate evolutionary biology), South American countries, and many others, not to mention my own, should not have contributed more, at least at the level of cited bibliography, to the exciting content of this book.

To conclude, the Editor, Professor Marc Fergusson should be congratulated for a splendid job well done. This massive volume is a fitting monument dedicated to the scientific and teaching achievements of Professor d'A. Bellairs. It is obviously a "must" for the libraries of all universities, museums and similar institutions actively working in vertebrate evolutionary biology, and not only on reptiles. Shelves should be emptied again, for this magnificent book to secure a place proudly with such classics as C. Gans' *Biology of the Reptilia* and *Morphology and Biology of Reptiles* of B. Cox and . . . A. d'A. Bellairs.

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GARDEN PONDS AS AMPHIBIAN BREEDING SITES IN A CONURBATION IN THE NORTH EAST OF ENGLAND (SUNDERLAND, TYNE AND WEAR)

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ABSTRACT

A survey of the distribution of amphibians was carried out in Sunderland (Tyne and Wear). Five species were present in the area, but *Triturus cristatus* and *T. helveticus* were uncommon. All the amphibian species were declining or apparently extinct in wild ponds. Garden pools were less common than in other parts of England that have already been surveyed, and as a result of the low density of ponds many had not been colonised by amphibians. There was an encouraging number of colonies that had been started by deliberate introduction however. *Rana temporaria* and *T. vulgaris* were the only species that had colonised the ponds to any great extent. Both were found to be very susceptable to fish predation, and mechanisms for surviving in fish ponds are discussed. Another danger was the destruction of garden ponds which was astonishingly common.

INTRODUCTION

It is a well known fact that while amphibian breeding sites have been declining in the countryside, garden ponds have increased in popularity and are becoming important refuges for some species (Mathias, 1974; Beebee, 1979 and 1981; Cooke and Scorgie, 1983). In particular the common frog *Rana temporaria* and the smooth newt *Triturus vulgaris* seem to have been the most successful in this respect, while the common toad *Bufo bufo* has been less adaptable. The palmate newt *T. helveticus* has also been recorded in garden ponds, although Cooke and Scorgie stated that it was less common in these habitats by virtue of its being most common in areas that are less susceptable to urbanisation. The crested newt *T. cristatus*, however, has not been very successful in colonising this relatively new habitat.

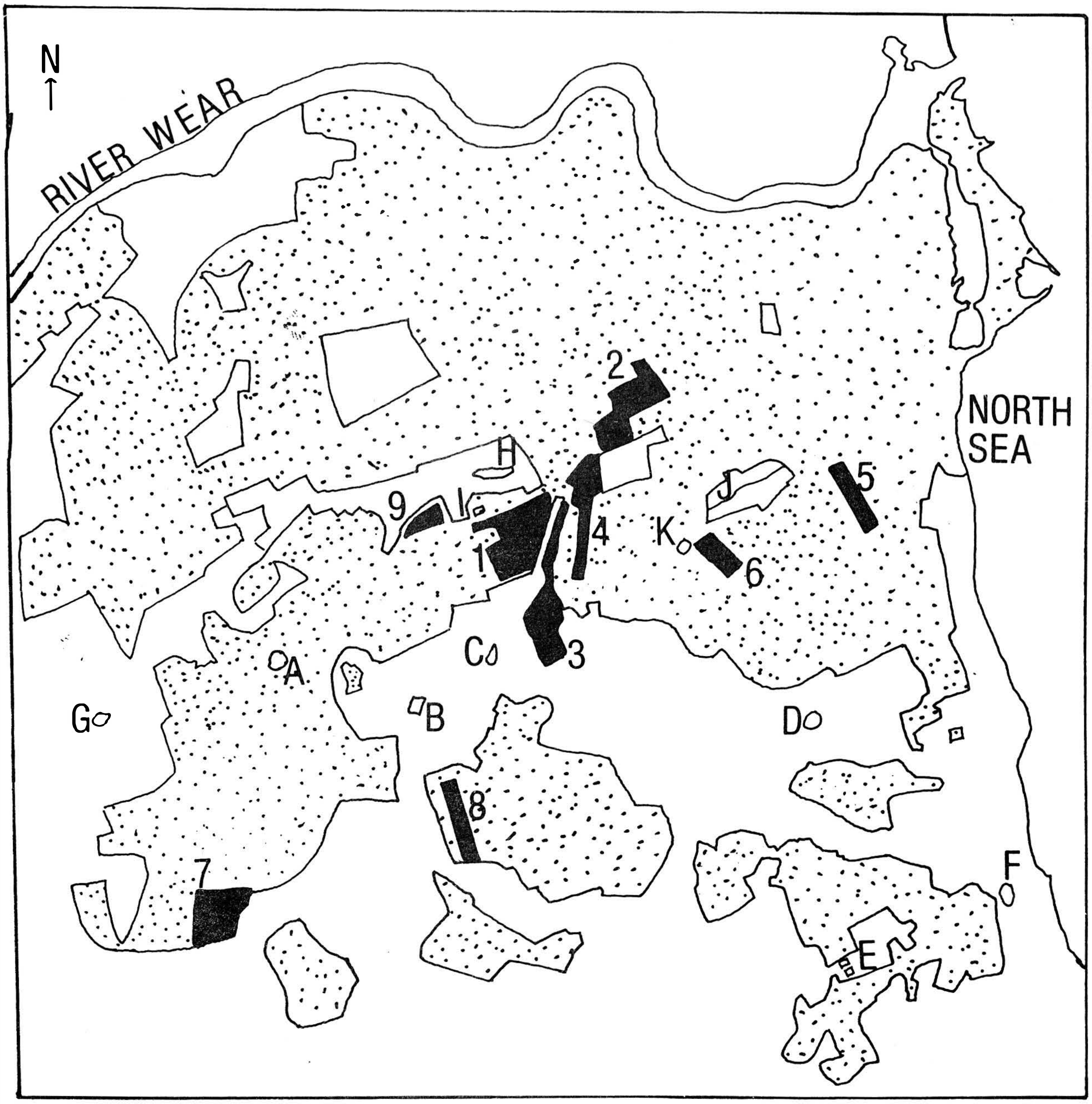
Mathias reported a recent increase in the number of garden ponds being built, while Beebee found that 16.5 per cent of gardens in Brighton had one or more. In Scotland, according to Cooke and Scorgie, the idea has been less favourable, and this was our initial impression of the situation in north east England. We therefore carried out a survey in Sunderland to determine the extent of amphibian breeding sites, public attitudes to garden ponds, and to see which (if any) of the amphibian species had succeeded in the urban environment. In addition we attempted to assess the status of wild populations living on undeveloped land in the survey area.

METHODS

A door-to-door survey was carried out between October 1981 and December 1982 in nine estates in different parts of Sunderland. Participants were asked if they had a garden pond, or if they had ever filled one in on their present property, and if they would ever consider creating one in the future. Prejudices against ponds were also recorded. If a pond did exist we enquired to see if fish or amphibians were using the pool, and the origin of the latter group was investigated. When amphibians were present we checked to ensure that they had been identified correctly. In addition any records of amphibians in garden ponds outside the estates surveyed, or of wild populations, were investigated. This was added to our knowledge of the area, gained by deliberate survey in recent years.

Fig. 1 The Study Area

- Study estates, numbered as described in the text.
- Built-up areas.
- Open countryside/parkland.
- Ponds, labelled A-K (see also Table 1).



Finally the first edition of Ordnance Survey maps (1853-1857) were examined, and the number of ponds within 1km of area 1 (see Fig. 1) was noted. These maps show the positions of many small ponds (some of which still existed in areas), and were regarded as being more accurate than their modern counterparts in this respect.

The Study Area: — A Historical Perspective, and the Present State

All the surveys were carried out in estates to the south of the River Wear, but records of amphibians in garden ponds were collected from all over Sunderland. At the turn of the century Sunderland was a much smaller town, and much of the survey area was rural with scattered pit villages. Small scale quarrying activities, gravel extraction, and mining activities resulted in the production of many man made ponds. The 1853 maps revealed no less than 28 ponds within 1km of estate 1. Since then the town has expanded rapidly, especially since 1930, with many large council and private housing estates being built, and this has resulted in the loss of many wetlands (Dunn, 1980). Further losses of ponds have also occurred on agricultural land surrounding the town.

The geology of the area probably has some influence on the abundance of *T. helveticus*, as will be discussed later. The bed rock of the area is Permian Magnesian limestone, overlaid by stagnogleyic brown earth (poorly drained calcareous soil), (Dunn, 1980). Fig. 1 shows the estates that were visited, these were as follows: 1. Humbledon Hill; 2. Thornhill area; 3. Silksworth Lane and Elstob estate; 4. Alexandra Road-St. Nicholas Avenue; 5. Grangetown; 6. Ashbrooke; 7. East Herrington; 8. Vicarage Estate; and 9. Plains Farm North. The first eight estates were privately owned, while the latter was a council estate.

Pool	Species present	+/– G.a.	Site description	Present status/fate
A.	Tc, Tv, Rt, Bb	?	Sand/gravel pits.	Built on before 1955.
B.	Rt, Bb, Tv.	+	Colliery pond.	Recently turned into boating/fishing pond.
C.	Rt, Bb, Tv.	+	Colliery Pond.	Recently turned into boating/fishing pond.
D.	Rt, Bb.	–	Pond.	Drained in 1983.
E.	Rt, Bb, Tv.	–	Cooling ponds.	Bb extinct since 1982, Rt very scarce.
F.	Rt, Bb, Tv.	?	Quarry ponds.	Apparently filled in.
G.	Rt.	–	Pasture ponds.	Still present in 1978.
H.	Rt.	+	Park pond.	Spawn present only in recent years, possibly introduced.
I.	Tv.	–	School pond.	Large population of unknown origin.
J.	Rt	+	Pools on edge of stream.	Present in low densities up to 1982, possibly colonised from adjacent gardens.
K.	Rt, Tv + ?	?	Pasture pond.	Drained in 1950's.

Summary

Species.	Number of populations recorded.	Number still extant.
Rt.	10	3 - 6
Bb.	6	0 - 2
Tv.	7	2 - 4

TABLE 1: Known breeding sites (past and present) in the study area

Abbreviations: Tc = *Triturus cristatus*, Tv = *T. vulgaris*, Rt = *Rana temporaria*, Bb = *Bufo bufo* and G.a. = *Gasterosteus aculeatus*. Variations in the numbers of populations still extant refer to the cases where species had not been recorded at some sites during the last two years, and there continued survival was in doubt.

Area	Age of estate	n.	Number of: Existing ponds (%)	Ponds being built	Ponds filled in
1.	post 1955	262	24 (9.1)	0	3
2.	pre 1939	84	9 (10.7)	1	3
3.	pre 1955	168	11 (6.5)	3	13
4.	pre 1955	86	6 (6.9)	0	1
5.	pre 1955	62	8 (12.9)	0	2
6.	pre 1955	200	7 (3.5)	0	3
7.	post 1955	200	3 (1.5)	0	3
8.	post 1955	126	4 (3.1)	0	0
9.	pre 1955	100	4 (4.0)	0	0
Total		1288	76 (5.9)	4	25

TABLE 2: Numbers of ponds in various estates

n. = the number of houses surveyed. (%) = the percentage of houses in each estate with garden ponds.

RESULTS

Distribution and Status of Wild Amphibians in the Study Area

Four amphibian species have definitely been recorded in the study area since the 1930s. The only record for *T. cristatus* was from site A (Fig. 1, Table 1), a series of ponds that were filled in before 1955. *R. temporaria, B. bufo* and *T. vulgaris* were still present in the area up until 1981, but as summarised in Table 1, all three species had suffered declines. These were due to drainage, human recreation (i.e. children fishing in pools B and C), and the cleaning of pool E shortly after the spawning season of *B. bufo*, for a series of years in the late 1970s. This pond also used to be notable for a population of *T. vulgaris* that contained many neotenous individuals, but these were also affected by the cleaning operations.

It should be noted however that the presence of *R. temporaria* at two sites was believed to be due to stock either spreading from garden ponds, or being translocated there as spawn.

Numbers and Sizes of Garden Ponds in the Study Estates, and the Attitudes of the Public

Questionnaires were completed for a total of 1288 households, resulting in the location of 76 gardens with ponds, and a further four in the process of being excavated. This yielded a total of 6.2 per cent of gardens with ponds. Of these 80 gardens, 78 contained only one pond, while the remainder had two and five ponds respectively. The estates varied widely in terms of the percentage of houses with ponds, with the highest value being 12.9 per cent (Table 2). It was noticed that there was a distinct neighbour effect, with the few gardens that had ponds often being close together. Table 3 illustrates the fact that when comparing the numbers of ponds expected and observed, in estates built before and after 1955, there was no significant difference when a chi squared test was applied (i.e. new estates contained just as many ponds as older ones).

Age of estate	n.	Number of existing ponds: O.	E.	X^2	p	Number of ponds destroyed: O.	E.	X^2	p
Pre 1955	700	45	41.3	0.70	>0.1	22	13.5	11.63	<0.001
Post 1955	588	31	34.6			3	11.5		

TABLE 3: X^2 analysis of the effect of the age of the garden on the numbers of ponds existing, and drained

n = number of houses sampled belonging to each age group. O = number of ponds observed, E = number of ponds expected in each age group.

A total of 25 ponds were found to have been filled in. As this was probably an underestimate (ponds may have been destroyed by previous occupants), at least 24 per cent of all the ponds ever made were subsequently lost. This time there was a significant difference between estates built before and after 1955, with more ponds than would be expected being lost in the older houses.

564 householders who did not have ponds were asked if they would like one in the future. Only 23 (4 per cent) gave a positive response. Of the remainder 328 (58 per cent) did not like, or were indifferent to ponds, while a further 118 (21 per cent) thought that their gardens were unsuitable (mainly too small). A further 95 (17 per cent) were against the idea because of the danger of drowning children or pets, and would fill a pond in if it was in their garden.

Most of the ponds were small, varying in surface area from $0.08m^2$-$18.0m^2$. Only one of the pools had a surface area greater than $9m^2$.

Use of Garden Ponds by Amphibians

37 (48 per cent) of the gardens with ponds were owned by fish-keepers, while 31 (40 per cent) of the gardens with ponds were amphibian breeding sites. A total of 21 ponds had neither fish nor amphibians (26 per cent). Table 4 shows that of all the garden ponds where amphibians were recorded (throughout Sunderland), *Rana temporaria* was the most common species, followed by *T. vulgaris*. *B. bufo* was very scarce, while the other two *Triturus spp.* were not recorded. *T. vulgaris* especially, and *R. temporaria* were found less often in ponds containing fish, although when X^2 tests were applied the results were not significant. Of the 13 ponds that contained both fish and *R. temporaria*, no less than eight of these were close to ponds in adjacent gardens that were fish-free. One of the four ponds containing *T. vulgaris* was in a similar arrangement. When these ponds were eliminated for both amphibians and the X^2 test was repeated, there was a significant excess of frog colonies in fish free ponds and a significant relationship also for *T. vulgaris*. In another of the ponds with both fish and *T. vulgaris* it was reported that newt larvae only metamorphosed in years when there was a dense growth of aquatic plants, which had been the case in recent years, following a deliberate introduction attempt.

Only four pond owners with amphibians regarded these amphibians as pests. One thought that the newts would eat her goldfish, and had tried (unsuccessfully) to eradicate them, while three other pond owners thought that the large depositions of frogspawn were unsightly. It seems that more pond keepers were keen to encourage amphibians in their gardens. Table 5 shows that a majority of the *R. temporaria* and *T. vulgaris* records were derived from stock deliberately introduced to their ponds. Further analysis of the data obtained from the study estates revealed that all the colonies of *R. temporaria* in the new estates were derived from introductions, while in the older estates more ponds were colonised naturally. In estates of both age groups *T. vulgaris* tended to be introduced more often, while both of the attempts by *B. bufo* to spawn in garden pools were the results of natural colonisation.

DISCUSSION

It is quite likely that in the past all of the 'commoner' British amphibian species were present in the study area. Although some areas of the magnesian limestone outcrop are quite dry, due to the permeability of the rock (Dunn, 1980), this was clearly not the case in Sunderland (south) in 1853. This situation had no doubt been improved by man's early industrial activities, and so at this time potential breeding sites were abundant.

Species		All known sites Number of records in ponds (+/-) fish		X^2	p		Excluding all pools with fish close to 'reservoir' site Number of records in ponds (+/-) fish		X^2	p
		+	–				+	–		
R. temporaria	O.	13	23	2.03	N.S.	O.	5	23	10.24	0.01
	E.	17.3	18.7			E.	13.4	14.6		
B. bufo	O.	2	1	N.T.						
	E.	1.5	1.5							
T. vulgaris	O.	4	11	2.73	N.S.	O.	3	11	3.95	0.05
	E.	7.2	7.8			E.	6.7	7.3		

TABLE 4: The effect of fish on the distribution of amphibian species

Expected values were obtained by assuming that fish should be present in 48% of the pools. Too few *B. bufo* records were obtained to allow any X^2 analysis (i.e. N.T.). N.S. = not significant. A reservoir site was a fish free pool adjacent to pools containing fish.

Species, and age of the estate	n.	Source of parental stock: Introduction	Colonisation	Unknown
R. temporaria				
All records	36	16	13	7
In garden built:				
before 1955		4	11	
After 1955		9	0	
B. bufo				
All records	3	1	2	0
In gardens built:				
Before 1955		0	2	
After 1955		0	0	
T. vulgaris				
All records	15	8	3	4
In gardens built:				
Before 1955		2	1	
After 1955		3	1	

TABLE 5: Origin of amphibians in garden ponds, and the effect of the age of the estate

'All records' refer to data obtained from both the study estates and other garden ponds that were visited in Sunderland. Records in houses built before and after 1955 are from the study estates only.

T. helveticus can still be found in two small pools 5km south of Sunderland, but it is generally rather uncommon, and this is in keeping with information on this species from other hard water areas in Britain (Cooke and Ferguson, 1975; Cooke and Frazer, 1976; Beebee, 1981; and Cooke and Scorgie, 1983). *T. cristatus* was certainly present up until at least the 1940s, but the fact that there was only one record for this large, attractive newt, and its absence from the remaining 'wild' pools, suggests that it too was uncommon. Its absence from four of the remaining ponds may be due to the large numbers of *Gasterosteus aculeatus* present in them, as these fish are known to be important predators of newt larvae (Cooke and Frazer, 1976; Beebee, 1981).

Judging by their wide distribution in the area, and their present relative abundance in the countryside to the south (personnel observations), the remaining three species would all seem to have been relatively common.

The present situation is that both *T. cristatus* and *T. helveticus* could not be found in the study area, while there have been extensive declines of *T. vulgaris*, *R. temporaria*, and *B. bufo* in the wild. Cooke and Scorgie (1983) quote the period from the 1940s to the 1960s as being the time of major declines of all amphibian species in Britain. This was probably the case in Sunderland, but even in the 1980s the trend is continuing relentlessly.

Garden ponds have generally been hailed as an important new habitat for amphibians, but what effect have they had in Sunderland? Our initial impression that garden ponds in this area were rather uncommon was confirmed. The figure of 6.2 per cent is much lower than the 16.5 per cent obtained by Beebee (1979) in Brighton, and even if the numbers of all those people intending to build a pond in the future is added to our total, the overall percentage would still only be 10.2 per cent. That this figure would be achieved seems unlikely due to the tendency of old ponds to be infilled, especially when houses are exchanged, and parents with young children move in.

The reasons for this difference between northern and southern England are probably complex. They may relate to the more affluent nature of the area studied by Beebee, or even to differences in the size of gardens, Whatever the reason, there is some cause for optimism. The fact that younger estates were almost as likely to have garden ponds in equal numbers to older estates may indicate a recent increase in the numbers of ponds being built, although it is more likely to be due to the increased chances of older ponds being infilled. The tendency of neighbours to be persuaded to build ponds after seeing them in other gardens indicates that the idea may yet become more fashionable. Increased media attention to wildlife gardening may also have a beneficial effect.

Not only were garden ponds less common in Sunderland, but they were also less likely to be used by amphibians than in Brighton (where 53 per cent were used, compared to only 40 per cent in the north east). Mathias (1974), Beebee (1979), and Cooke and Scorgie (1983), all stated that in garden ponds. *R. temporaria* has been the most successful at colonisation, followed by *T. vulgaris* and then *B. bufo*, with the other two newts being very scarce. This was exactly as we found in Sunderland, although the ratios of species records were slightly different. Comparing ratios of *R. temporaria*: *T. vulgaris*; *B. bufo*, Mathias and Beebee found the following ratios respectively, 4.87:1.15:1, and 3.5:1.48:1. Our ratio of species records in garden ponds was 12:5:1. In otherwords *B. bufo* was much less common compared to the other two species than in Leicester and Brighton. Whilst it is likely that both *T. helveticus* and *T. cristatus* were present in the study area at too low a density to be able to colonise the first garden ponds, this was clearly not the case with *B. bufo*, and two attempts have been made to colonise pools in area 3, presumably from stock derived from pools B or C. Both of these have been only marginally successful, with breeding only by the odd pair of toads, but not on a consistent annual basis. *T. vulgaris* and *R. temporaria* have been more successful in this respect. Beebee (1979) thought that *B. bufo* preferred older, larger pools, and these characteristics are certainly lacking from many of the garden pools in Sunderland. This cannot be the full explanation, since there seemed to have been more introductions of *R. temporaria* and *T. vulgaris* to garden ponds than of *B. bufo* (although unsuccessful attempts may not have been reported). The one case of deliberate introduction of this latter species had in fact been successful, with a viable colony established for 10 years. The difference between the numbers of introductions may be due to the relative ease of finding adult *T. vulgaris* or *R. temporaria* spawn, rather than *B. bufo* spawn, which is laid in strings that are harder to handle, and are laid in deeper water (Cooke, 1975). However the fact that four (of the known 16) introductions of *Rana temporaria*, and three (of the known eight) *T. vulgaris* introductions were of stock derived from garden colonies lends further weight to the hypothesis that *B. bufo* is markedly less well adapted to colonising garden ponds in this area.

The low percentage of ponds with amphibians was probably due to the very low densities of ponds in the area, limiting the chances of natural colonisation occuring. This would explain why so many fish-free pools had no breeding populations of amphibians. It is also well known that the presence of fish can prevent survival of amphibian larvae through to metamorphosis (Cooke, 1975; Cooke and Frazer, 1976; Beebee, 1981; and De Fonseca and Jocque, 1982), although Beebee noted that *R. temporaria* tadpole mortality in ponds with fish was not always catastrophic, especially when large quantities of spawn, or very few fish were present.

In Sunderland we came to the following conclusions regarding the effect of fish. One fish keeper reported that he kept koi carp (*Cyprinus sp.*), and that these did not eat the tadpoles. In this case the pond certainly had a viable colony of *R. temporaria*. The other ponds with fish all contained either goldfish (*Carassius auratus*), golden orfe (*Leuciscus idus*) or tench (*Tinca tinca*), and these were all reported to eat tadpoles, and amphibians were less likely to be found in these ponds. When amphibians were present in fish ponds we found that it was important that there were refuges where tadpoles could develop safely. These were provided either by dense patches of aquatic plants, or by the presence of fish-free ponds in adjacent gardens producing a regular output of metamorphosing amphibians. If *R. temporaria* populations become large enough, and there are few fish in a pond there is unlikely to be total mortality due to predation (as described by Beebee) especially since the fish may eliminate other tadpole predators such as newts or invertebrates.

In conclusion, therefore, although garden ponds in this region are still rather uncommon they have been of benefit to *R. temporaria* and *T. vulgaris* at a time when all the native amphibians are experiencing population declines in the wild. These habitats are most useful when there is a string of ponds in adjacent gardens as this reduces the risk of total predation by fish, or of all the ponds being filled in by new owners. The fact that so many colonies have been established by deliberate introduction is promising, as it indicates that conservation in the garden is becoming fashionable. Attempts to reintroduce *T. cristatus* back into garden ponds in this area (under license from the N.C.C., and into suitable ponds) would be a welcome step, as the species is probably too scarce to be able to colonise the ponds in the town naturally. Finally it would seem to be important to contact land owners with ponds to ensure that the few remaining wild populations are conserved if possible. The present survey of the county by Durham County Conservation Trust should be a help in this respect.

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