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EVALUATING THE SUCCESS OF GREAT CRESTED NEWT (*TRITURUS CRISTATUS*) TRANSLOCATION

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Published evidence from 178 great crested newt population translocations in the UK carried out between 1985 and 1994 emphasizes the need for continued monitoring following translocation. In more than half the cases, there was insufficient evidence for judging success, mainly due to lack of monitoring. Using the liberal criterion of the presence of a population one-year following translocation, 37% of all cases were successful and 10% unsuccessful. Most of the failures were predictable from existing knowledge of great crested newt requirements. Conflict between development objectives and great crested newt conservation at a site in northern England prompted a large-scale translocation of over 1000 individually photographed adults to a conservation area immediately adjacent to the development site. During the first year following translocation, adult newts showed a strong tendency to move towards their previous breeding site, some travelling 500 m in doing so, but none reaching home ponds 900 m away. At least 60% of the translocated newt population either escaped from – or attempted to leave – the conservation area. The remainder accepted the ponds in the conservation area, some of which were less than one year old, and bred successfully. Population sizes were extrapolated from the results of trapping both outside and within the conservation area. The estimated density of adults in the conservation area, at 150 ha^{-1}, was high compared to that in the proposed development site (about 5 ha^{-1}). Nevertheless, in the first year the population in the conservation area showed good production of metamorphs, and mortality consistent with that found in previous studies. Furthermore, most recaptured adults had grown (median of 18% gain in mass) during the season. This was probably the result of the increased habitat diversity in the conservation area, especially the aquatic habitat. It must be recognised that this translocation procedure can be applied only to the adult component of the population.

Key words: Triturus cristatus, great crested newt, translocation, conservation, population size, survival, site fidelity

INTRODUCTION

The protected status of the great crested newt in the UK commonly leads to difficulties in land-use planning. Translocation, referring to the intentional transfer of populations from one location to another, presents an attractive solution. Seemingly, at a stroke, it frees the land for development and preserves the newt population. In consequence, the strategy is widely adopted in the UK and commonly accepted as a solution to land-use conflicts by the statutory conservation authorities. However, difficulties with the strategy are serious.

Firstly, in the UK there is no published evidence that the procedure actually works. A recent summary of amphibian and reptile translocation procedures (Clemons & Langton, 1998) is replete with prescriptions for translocation, but contains no evidence that the process is successful and few references to relevant research. Cooke & Oldham (1995) provide a case study of the translocation of UK populations of the common toad and common frog. However, for the toad there was heavy mortality of adults in the first year following introduction to the new site.

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Secondly, even if it can be shown to work, there are often difficulties in selecting a suitable receptor site. Such a site must provide appropriate aquatic and terrestrial habitat and it may be difficult to establish that this is the case. An existing resident population at the receptor site provides good evidence, but in this case, the addition of new animals could result in the population size exceeding the carrying capacity of the habitat. In turn, this could increase the level of mortality of the combined populations, so defeating the objective of preserving the newts. A possible solution is to create new habitat or to enhance the habitat occupied by the existing population, but this presumes clear knowledge of the newt's requirements and the relationship between the environmental carrying capacity and the size of the introduced population. This is difficult to demonstrate, is usually taken on trust and – as will be seen below – is sometimes misinterpreted.

Thirdly, most – if not all – methods used to collect newts from doomed sites depend upon the collection of animals converging on, or leaving, breeding sites and so concentrate heavily on the adult component of the population. The limited evidence on newt life tables (Arntzen & Teunis, 1993, Halley *et al.* 1996) suggests that in a productive population about 70% of the population is comprised of non-breeding animals. Unless the process of interception is continued for several years, this non-breeding element is not included in the translocation.

The current paper addresses the first of these three issues. Two surveys of translocations conducted in the UK – the results of neither of which are widely available – will be reviewed, in search of evidence that the procedure is successful. The second part of the paper is concerned with an individual case study of translocation in northern England. This investigates whether a self-sustaining population of newts can be established in a "conservation area" following translocation. It reaches a reasonably encouraging conclusion, but with important provisos.

TEN YEARS OF TRANSLOCATIONS IN THE UK

Statutory protection was given to the great crested newt in the UK in 1982, following enactment of the Wildlife & Countryside Act 1981. In consequence, the Nature Conservancy Council (now English Nature) established a system of licensing to allow actions, including translocation, which would otherwise be prohibited under the Act (Gent & Howarth, 1998). Each successful applicant is permitted to undertake previously agreed actions, during a prescribed period, under a series of conditions. These include the requirement to provide details of the work carried out during the period covered by the licence. Since, in 1982 (or indeed today), there was no established method of ensuring successful translocation, the first licences were, in effect, granted for experimental translocations, based upon the best practice at the time. The accounts of translocations undertaken under licence thus, theoretically, provide an ideal opportunity to determine the factors militating for or against the progress of translocation efforts.

All the records held by English Nature up to 1990 were analysed by Oldham *et al.* (1991), partly as the result of commercial interest (British Coal). These covered eight years of recorded translocations, and included some cases undertaken earlier, before the enactment of the Wildlife & Countryside Act. Together these yielded a total of 86 exercises. The results were disappointing, with 26% – all from the pre-1982 period – having no quantitative records, and another 26% with records but with no attempt at monitoring. A further 20% involved garden ponds, important in a local sense, but unlikely to support viable long-term populations in their own right. For the remaining 25 field ponds (29% of the total) there were records of numbers moved and an effort to monitor. However, in eight of these cases the level of success could not be determined because there were already great crested newts at the recipient site and no means of distinguishing between residents and introduced animals. This leaves some 17 translocations (of between 8 and 540 newts, mean of 133) involving field ponds. Of these, 10 (12% of the original total) appeared to be successful, as newts were present in the receptor pond at least one year following translocation. However, at the time of the study, in 1990, the mean monitoring period was only three years. Furthermore, although newts were observed at the 10 sites in subsequent years, they were rarely counted (four cases). There was only a single case where the data indicated that a breeding population was established at the new site following translocation.

Absence of adequate guidance was reflected in the reasons for the failure of 14 of the translocations (seven each for garden and field ponds). In all but one case, the failures were the result of poor translocation technique. All could have been predicted, even at that time, based on the known characteristics of the host site (e.g. presence of fish or ducks) – an unnecessary and regrettable waste of effort and resources.

Five years later, in 1995, an identical survey covering the English Nature records for the preceding five years, was conducted by May (1996). All the translocations were now covered by the licensing section and the level of recorded detail had improved accordingly. There was an increase in the extent of the practice, 92 cases compared to 52 in the equivalent period in the earlier study, and quantitative information was now available for every case. However, monitoring was still not universal, occurring in only 64% of cases, and there was no consistency in the monitoring procedure. Ideally, the success of translocation depends upon evidence of a self-sustaining population at the new site. Practically, this would have been very difficult to demonstrate, especially within the period of the survey. However, the return of adults in subsequent years and then, in turn, the presence of eggs, larvae and metamorphs provide increasingly convincing evidence of the successful establishment of a population at the new site. Most of the evidence (78% of monitored cases) came from the return of adults; in only one of the cases studied was the emergence of metamorphs used as an indicator of success. Using the minimal criterion of the presence of at least one adult newt in the year following translocation, 92% of the 59 monitored cases (59% of all cases) were judged to be successful. Again, procedures were sometimes used which could have been predicted to lead to failure, with existing knowledge, such as the removal of newts to a site only 250 m distant and with no newt barriers.

The proportions of cases falling into each category, from the 178 records in both surveys, are illustrated in Fig. 1.

CASE STUDY OF GREAT CRESTED NEWT TRANSLOCATION

A public inquiry into a planning application for an opencast coalmine in Lancashire resulted in a ruling by the Secretary of State for the Environment that further work should be conducted on the effects of translocation. A proposal was prepared by a biological consultant which involved setting aside parts of the

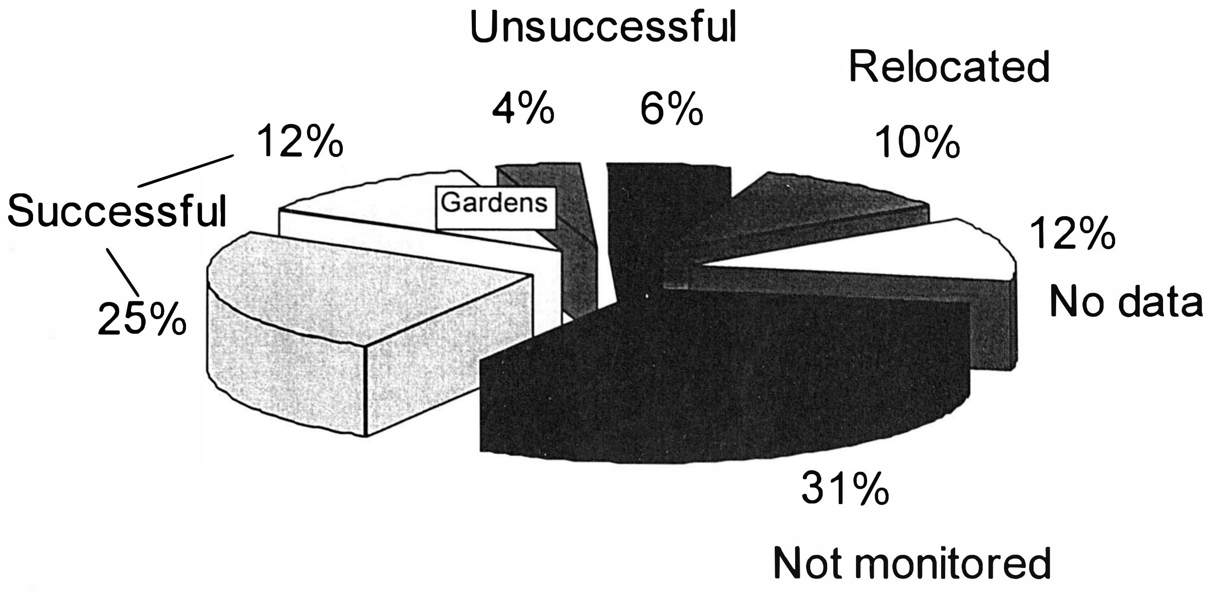

FIG. 1. The outcome of 178 translocations of crested newt populations in the UK before 1996. 'Relocated' newts were transferred to sites with existing populations. Most of the receptor sites were field ponds except for those labelled 'gardens'. (Data from Oldham *et al*., 1991; May, 1996)

proposed opencast site as conservation areas specifically for great crested newts (Humphries *et al*., 1991). Starting in 1991, newts were removed from several ponds within the proposed opencast coal site, their belly patterns were photographed, and then the animals were deposited into a single fenced conservation area, situated at one corner of the site. The effects of this translocation were investigated by monitoring the sites of recapture of a sample of the population (Horton & Branscombe, 1994).

The pilot conservation area – described by Horton & Branscombe (1994) – was 5 ha with a landscape typical of non-intensive agricultural use, containing pasture, hedgerows and five ponds (three permanent, two seasonal). The habitat was diversified by planting trees and shrubs and by introducing hibernacula. Three additional ponds were constructed. The conservation area was fenced using a polythene/chicken wire barrier, with newt pitfall traps inside and outside, to determine patterns of movement. A defect in the fence, overlooked by Horton & Branscombe (1994), was a four-metre gap on the south side, left to permit access of site vehicles. Newts were also monitored inside the conservation area by pitfall traps at fences surrounding some of the ponds, and by bottle-trapping (Griffiths, 1985) within the ponds.

Newts were intercepted during their seasonal migration to ponds on the proposed opencast site, using a combination of fences and traps. The interception programme continued for three years (1991 to 1993), but the current report is concerned only with the first two years, when 1090 newts were caught. They were all identified using photocopied belly patterns, then weighed, and following immersion in water for at least 12 hrs, transferred to a central release point inside the conservation area in each of the years. Those captured at the outer perimeter of the conservation area (a total of 216 newts in 1991 and 1992) and captures at the inner perimeter (whether new animals or recaptures) were also placed at the central release point. Those caught within the conservation area in bottle traps and outside the fences around individual ponds were placed into the ponds (473 newts in 1992).

The paper by Horton & Branscombe (1994) and an earlier internal report (Branscombe & Horton, 1992) provide an account of the procedures used in the pilot project and of the numbers of animals involved in the translocations. The current paper attempts an analysis of the results of matching belly pattern photographs of the newts captured during 1991 and 1992. This was undertaken by De Montfort University on behalf of British Coal and was originally described in an internal report to the company (Oldham, 1993). The objective was to determine whether, in the early stages of the experiment, the conservation area would be likely to sustain a viable great crested newt population. We looked for evidence of a healthy adult population in the conservation area, as indicated by appropriate levels of survival, growth and metamorph production, and examined the population density supported by the habitat. The results of monitoring also provided an opportunity to examine the impact of site fidelity – whether there was a tendency for translocated animals to return to their home pools or to accept the pools in the conservation area as breeding sites.

Following privatization of the coal industry in 1994 the site became the responsibility of RJB Mining Ltd and the experiment was abandoned. To date, the proposed conservation areas have not been established and the opencast site has not been developed.

DATA ANALYSIS

BELLY PATTERN ANALYSIS

The total collection of photocopies was sorted into sets based on site, year and sex; only males were used in the present exercise. The next subdivision was based upon belly pattern. Two attributes were selected: the presence or absence of (1) longitudinally oriented groups of mid-ventral spots; and (2) low spot density on the posterior half of the belly. These criteria were applied successively and each sub-sample was further sub-divided into three groups. Two of them were comprised of animals clearly either possessing or not possessing the first attribute, (positive and negative groups). The third contained newts whose categorization was in doubt (intermediates). During the matching exercise, each site/date set was matched, in turn, with each of the other appropriate sets. Animals caught at the opencast site ponds were matched against those captured in the conservation area in the same year, and against those captured at any site in the following year. The positive and negative groups from each set were matched, respectively, against the positives and negatives of the other sets, whilst the intermediates were matched against both positives and negatives.

Once a match was detected, the individual patterns are so distinctive that a direct comparison of photocopies left no doubt about its validity. However, the matching process involved nearly 1000 animals, even when restricted to one sex; it was time-consuming and arduous, and the possibility of missing a match was very real, especially when photocopies were of poor quality. Control trials, involving photocopied and toe-clipped animals showed that as many as 14% of matches were missed on initial scanning (Oldham & Nicholson, 1984). However, there is no reason to suspect that individuals from one location were more likely to be missed than those from any other location, so results involving proportions are unlikely to be biased by any lack of matching efficiency.

POPULATION PARAMETERS

Information on population size, survival, and patterns of newt movement were obtained by monitoring at the conservation area barrier and within the conservation area, coupled with belly pattern matching. The monitoring exercise provided information on the production of metamorphs. Knowledge of barrier efficiency and the likelihood of capture within the conservation area are important in the determination of population parameters. Much of the evidence hinges on the recapture history of the male newts introduced into the conservation area in 1991 from both the source ponds on the opencast site and from the outer perimeter of the conservation area. They were recaptured, in both 1991 and 1992, in the conservation area ponds, at fences surrounding some of these ponds, at the inner and outer perimeter of the conservation area, or – in some cases – back at the source ponds.

RESULTS

BARRIER EFFICIENCY

The males represented 47% of the total catch of newts on the proposed opencast site in 1991. Of those transferred into the conservation area in 1991 (Fig. 2a, 2b), 59 were recaptured in 1992 (Fig. 2d) – about half (53%) still inside the conservation area, at the ponds, but the remainder outside it, either at the outer perimeter (9%) or back at the source ponds (39%).The suggested fence efficiency of 53% is a rough estimate and depends both upon uniform motivation to leave the conservation area and a comparable probability of capture inside and outside of it in 1992. In fact, for the relatively small proportion of natives amongst the recaptures (about 20%), motivation to leave the conservation area might have been lower than for the translocated animals (see below). Secondly, the probability of capture outside the conservation area might be lower than that for inside, owing to lower survival of animals travelling towards the distant ponds. If both these possibilities apply then on both counts the fence efficiency of 53% described above is an overestimate. The efficiencies of the barriers surrounding the conservation area and the source ponds were probably similar to that at the conservation area, as they were both constructed in the same way.

LIKELIHOOD OF CAPTURE

Three hundred and thirty-eight male newts were introduced into the conservation area in 1991 during the translocation exercise – 286 from the source ponds and 52 from the outer perimeter (Fig. 2a,b). Of these 131 were recaptured in the conservation area later in the same year. Monitoring during the same period in 1992 (Fig. 2d) provided an additional 59 recaptures, 33 of which were recaptured for the first time since release in 1991. The 33 animals are known to have been present in the conservation area in 1991, but not recaptured in that year. This gives us an estimate of 44±13% (mean ± 95% confidence limits) for the likelihood of capturing newts from the male population in 1991.

POPULATION DENSITY

All the ponds on the proposed opencast site were studied intensively for several seasons prior to 1991 and all known great crested newt breeding sites were completely encircled with drift fences. Hence, assuming that newts breed every year, the catches at these fences, corrected for observed fence efficiency, can be used to estimate the density of adult great crested newts in the existing agricultural landscape of the site. There were approximately four ponds km^{-2} (0.04 ha^{-1}) in the study area. If we assume newts to be dispersed within a radius of 500 m from the breeding ponds (e.g. Oldham & Nicholson, 1986; Baker & Halliday, 1999), then their density in the opencast site is approximately five adults ha^{-1}. This compares with densities of between five and 32 adults ha^{-1} on agricultural sites in Leicestershire

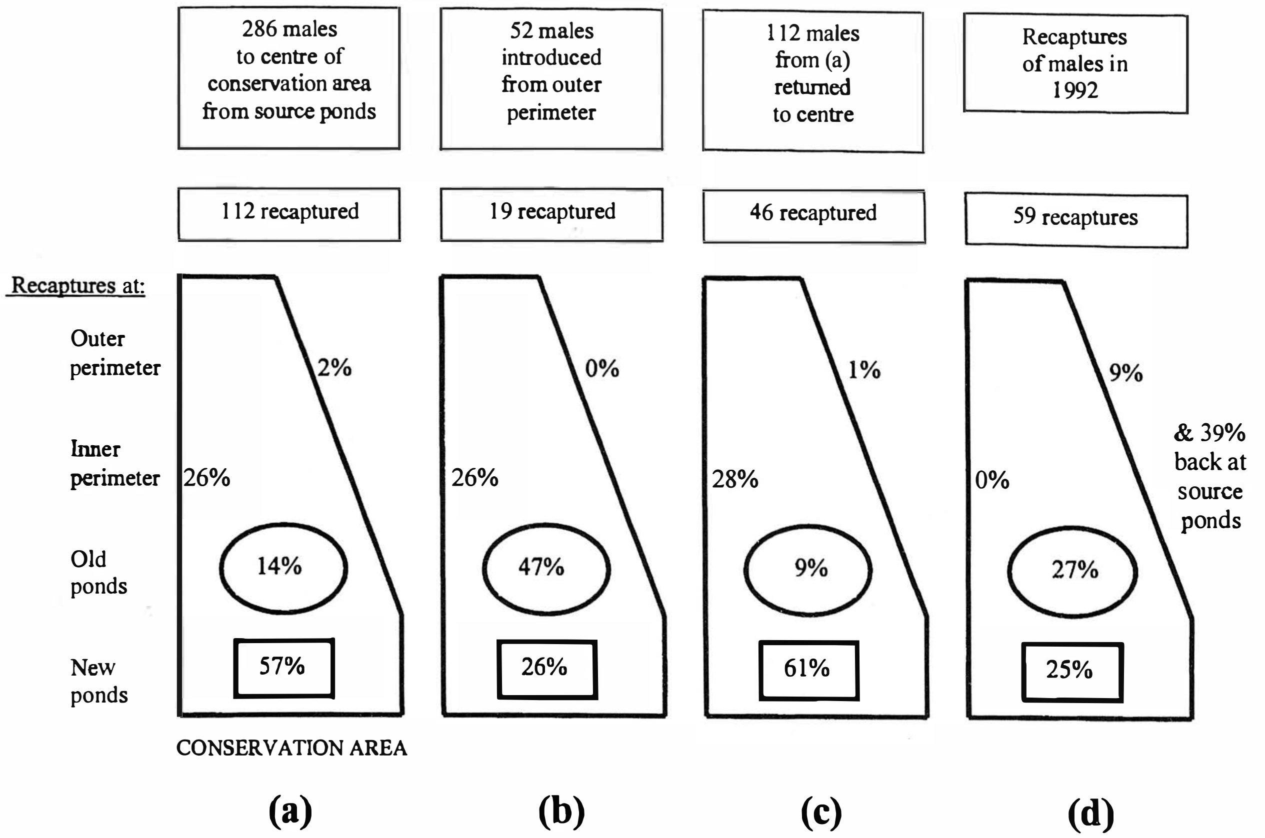

FIG. 2 Locations of recaptured newts following translocation: (a) from ponds mainly in the south and west into the centre of the conservation area in 1991; (b) from the outer perimeter of the conservation area, involving newts moving in from surrounding habitat in 1991; (c) returned again to the centre of the conservation area in 1991 after the first recapture (from (a)); (d) in 1992, involving newts first identified in 1991. The old ponds have existed for many years, whilst the new ponds were constructed early in 1991. Newts were collected from the inner and outer perimeter either from pitfall traps or from the base of the fence.

(Oldham, unpublished) and up to 1000 or more adults ha^{-1} in very good habitat (Latham *et al*., 1996).

Adult newt density within the conservation area itself in 1991 can be estimated from four components. Two of these are known precisely: the numbers introduced from both the opencast site ponds (610) and from the outer perimeter of the conservation area (100). The third component, numbers "leaking" into the area past the conservation area perimeter fence, can be estimated from the calculated barrier efficiency (53%, see above) and adds about 50 newts. The fourth component, natives already present before the barrier was constructed, is more difficult to determine. However, it can be estimated crudely from the numbers of unidentified males caught within the conservation area, after correcting for sex ratio, inward leakage, likelihood of capture and pattern matching efficiency. The estimate for natives so obtained, of about 300 animals (60 ha^{-1}), provides a considerably higher density of newts than the overall value for the opencast site of 5 ha^{-1}. This might be expected, however, given the high concentration of newt ponds in the conservation area, 20 times higher than outside, even before construction of the new ponds. Added to the numbers introduced, the overall adult total in the conservation area was estimated as 1060, about 210 ha^{1}. Even allowing for escapes, which would reduce the density to about 750 (150 ha^{-1}), this is probably higher than ideal in the context of this agricultural landscape.

SURVIVAL

Individuals were "marked" photographically in early 1991, and monitored in the conservation area both later in 1991 and again in an equivalent period in 1992, using comparable effort. Of 338 marked males, 131 were recaptured at least once in 1991, but only 59 were recaptured in 1992 (Fig. 2). The difference provides a male survival estimate of 45±9%, comparable with the value of about 50% for adults quoted by Arntzen and Teunis (1993). There is no reason to believe that the survival of females differed significantly.

METAMORPH PRODUCTION

Metamorph emergence within the conservation area is described by Horton & Branscombe (1994). One hundred and thirty-five metamorphs were observed leaving the three newly created ponds in 1991 (the other three ponds were not monitored), and 567 from all six ponds in 1992. This information on metamorph emergence is relevant to recruitment into the adult population in 1993 at the earliest.

Somatic Condition of Newts in the Conservation Area

Mass changes in a sample of 65 male newts recaptured during the 1991 season between early March and mid-July, during periods ranging between one day and 133 (median=44) days varied between the extremes of 52% gain and 29% loss. The median and mean changes in mass were both 18% gain. The largest gains occurred early in the season (an average of 1.6% per day during March), the smallest towards the end (0.2% between mid-April and mid-July). Horton & Branscombe (1994) noted that the mean masses of newts caught inside the conservation area were similar to those from outside it.

Homing after Translocation

There is direct evidence that newts passed the conservation area barrier and had returned to their original ponds of capture by the following season. Of the 23 males known to have returned to a pond outside the conservation area, the majority (65%) were recaptured at the pond at which they were intercepted in 1991. Most of the remainder reached an alternative pond more or less *en route* to their original pond of capture. The distances moved ranged between 200 m and 500 m (median 400 m). No recaptures were made at source ponds 900 m distant. About half the translocated animals did not escape from the conservation area, although they may have attempted to do so. There is evidence of such attempts in the 29 males recaptured at the inside barrier of the conservation area in 1991. These constituted 26% of the 112 males recaptured in 1991 (Fig. 2a); most of the remainder were in the ponds. All recaptures (including the 112 males) were returned to the central release point within the conservation area (Fig. 2c). Forty-six males were recaptured yet again, of which 28% were found at the inner perimeter and most of the remainder in the ponds, a similar recapture distribution to that following first translocation.

If the numbers of animals actually escaping are taken into account (about 47%, see *Barrier efficiency*, above) and added to those apparently attempting to escape (26% of the remainder), we have about 60% of the introduced animals tending to leave the area. Some continued their efforts to escape (Fig. 2c), despite being returned twice to the centre of the area and therefore having further opportunities to enter the new ponds. This expression of site fidelity is further indicated by the behaviour of the newts originally caught at the outer perimeter of the conservation area (Fig. 2b) – presumably for the most part, natives of the original conservation area ponds. None of these animals was recaptured in ponds outside the conservation area in 1992. Furthermore, of the males from this set, which were recaptured in ponds in the conservation area, 9 (47%) were found in the three original ponds, rather than the three newly constructed ponds (Fig. 2b). The equivalent number for the introduced males was 16 (14%, Fig. 2a). Although the numbers recaptured are small, there was a significant tendency (χ^2=12.0, P<0.01) for natives to be caught in the old ponds, and "foreigners" in the new ponds. This tendency appeared to have disappeared by the second year (Fig. 2d), when the proportions of recaptures in the new and old ponds were similar. In the first year following translocation site fidelity appears to be strong. Nevertheless, at least 28% of the 286 males (i.e. 80 of the recaptures) introduced from the external ponds (Fig. 2a) evidently accepted the conservation area ponds, especially the new ones, and used them as breeding sites.

Collectively, these data suggest that the newts transferred into the conservation area differed in their behaviour from the presumed natives of the area, those caught at the outer perimeter. If the translocated animals are treated as a separate set, then the proportion escaping or attempting escape rises to 70%, instead of 60% for the combined data.

DISCUSSION

One of the most striking aspects of the pilot project is the strength of the newts' tendency to return towards their previous breeding sites, and their ability to surmount carefully prepared barriers in doing so. Also striking, however, are the indications of the success of the translocation procedure. Despite the high density of newts in the conservation area there was evidence of acceptance of newly created ponds, reasonable metamorph emergence, individual mass gain and mortality comparable with other populations.

The calculated efficiency of the barriers used in this project are similar to those of between 18 and 69% (means of 42% for influx and 32% for exodus) determined in six studies of the great crested newt, using similarly constructed barriers (Amtkjaer, 1981; Verrell & Halliday, 1985; Franklin, 1993; summarized by Arntzen *et al*., 1995). Most of the barriers in these studies were made in the course of research projects, inevitably constrained by a shortage of financial resources and often concerned only with obtaining a large sample of the population, not a total sample. It is possible to provide efficient barriers, and during population rescue, it behoves the responsible parties to make adequate provision using robust barriers in this regard.

In the population study by Arntzen & Teunis (1993), juvenile survival (from the age of one to two years) was approximately 20% and adult survival approximately 50%, similar to the present study. At these rates, an annual production of 2.5 metamorphs per adult would be needed to maintain a stable population, equivalent to an annual production of at least 1875 metamorphs needed at the conservation area to maintain the 1991 population level. No estimates of fence efficiency are available for the metamorphs, but being so much smaller, they are even more likely than the adults to evade capture and the estimate of annual metamorph production (567) is probably a serious underestimate. The observed level of metamorph production in 1992 may have been adequate to maintain the population. In the following year, however, metamorph production reduced to 182 (Horton & Branscombe, 1994) and this may be a reflection of overpopulation in the conservation area.

The recorded median gain of 18% body mass of males in the conservation area in the 1991 season occurred mainly during their aquatic phase. This information must be considered against the background of mass loss commonly reported for newts during the breeding season (e.g. Arntzen *et al.* 1999). Mass gain in the current study is particularly encouraging in view of the relatively high density of newts in the conservation area. It emphasises the importance of aquatic habitat enhancement in conservation management for great crested newt conservation.

Fidelity of adult amphibians to their breeding sites is well-reported (e.g. Twitty *et al*., 1967; Oldham, 1967; Heusser, 1969; Sinsch, 1992). In extreme cases, individuals have been known to return to locations from which breeding sites have been obliterated (e.g. Jungfer, 1943; Heusser, 1964). There is some evidence, however, to suspect that fidelity might not be so marked in the great crested newt. Franklin (1993) has shown that new sites may be colonized by great crested newts within one year of their creation. This was also the case in the present study. The new ponds were made in the winter prior to the 1991 breeding season, yet 57% of the recaptured males (at least 22% of those introduced) used them (Fig. 2a). "Native" newts tended to use the old ponds (Fig. 2b). There was, however, marked variation in the acceptance of new sites by translocated adults. Allowing for catching efficiency it would seem that roughly 30 or 40% of the introduced animals quickly accepted the new ponds, whilst about 50% escaped from the area, some of them returning successfully to their previous breeding site. The remainder were captured at the inner boundary of the conservation area fence, apparently attempting to return. These animals attempted to return to their original site on more than one occasion, following replacement at the central release point (Fig. 2c). This tendency by part of the population might reduce the rate of population establishment at new receptor sites and it emphasizes the need to couple translocation with efficient barriers preventing the return of translocated newts.

In the current study, the maximum distance of translocation was 900 m and newts escaping from the conservation area returned only as far as 500 m. It is possible that animals transferred a greater distance, with cues from the home site unavailable, may accept the new site more readily than those that have been moved only a short distance.

The great crested newt spends a substantial part of its life in water. Terrestrial habitat is nonetheless important, especially for the largely terrestrial juvenile phase. In the present project efforts were made to enhance both (details in Horton & Branscombe, 1994), but with particular emphasis on the aquatic habitat. This strategy appears to have been successful, enabling individuals to breed and produce metamorphs in the first year of the project.

Finally, it is important to recognise that most of the above work is based upon the adult component of the population. We still have no reliable method of capturing a high proportion of the juveniles during the period, lasting from two to three years, between metamorphosis and sexual maturity. The only method of ensuring that this large component of the population is incorporated into the translocation is to continue trapping for at least three years.

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