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RESEARCH AS A TOOL TO INFORM AMPHIBIAN CONSERVATION POLICY IN THE UK

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In the UK, research has improved our understanding of amphibian populations, their habitats, threats and the effectiveness of conservation measures. The greatest research effort has been directed to the protected and declining species, notably *Triturus cristatus*, *Bufo calamita* and *Rana lessonae*. However, several challenges arise when attempting to employ research findings as a tool to shape policy. Wild populations and threats to them are not often simple systems that invite straightforward investigation. Extrapolating from small studies to more comprehensive application can also generate problems, especially with widespread species. The standards of confidence commonly used in science may not be directly transferable to conservation policy, as in conservation it is often desirable to apply the precautionary principle. When constructing policies, it is important to be realistic about the constraints that may be imposed due to factors beyond the control of conservation agencies and researchers, notably those of a legislative or socioeconomic nature. There is a need for conservation practitioners to engage more closely with scientists, with a view to identifying the current knowledge gaps that hinder the achievement of conservation gains. The increasing success of *B. calamita* reintroductions provides an excellent illustration of such an application of scientific knowledge.

Key words: crested newt, natterjack toad, population ecology, research

INTRODUCTION

It is widely recognised that activities and policies aimed at conserving biodiversity should be based on sound ecological information (Semlitsch, 2002; IUCN, 1998). Whilst it is self-evident that conservation will not be achieved without an understanding of the species in question, the paradigm that links research with conservation policy may take various shapes according to the prevailing conservation status, mechanisms for achieving conservation and the state of scientific knowledge. This paper examines the relationship between ecological research and conservation policy in the UK, and makes recommendations aimed at maximizing biodiversity gain.

The United Kingdom has a depauperate amphibian fauna, with only three urodeles (*Triturus vulgaris*, *T. helveticus* and *T. cristatus*) and three anurans (*Rana temporaria*, *Bufo bufo*, and *B. calamita*) widely recognised as native species. Recent evidence strongly suggests that some populations of a further species, *R. lessonae* – previously assumed to be introduced – were also native prior to extinction in the 1990s (Beebee & Griffiths, 2000). Though small, the UK amphibian fauna is an instructive group with which to examine the relationship between research and conservation given that (1) the species exhibit a range in conservation status from widespread and locally abundant to extremely localized and rare (Beebee & Griffiths, 2000); (2) the ecology, distribution and conservation status of all species are well understood in comparison to the situation pertaining in most countries (Arnold, 1996; Swan & Oldham, 1993; Beebee & Buckley, 2001); (3) the species historically have been influenced by – and are currently vulnerable to – a wide range of threats; and (4) there is a comparatively well-documented history of amphibian conservation in the UK involving a range of government and non-government sectors (e.g. Hilton-Brown & Oldham, 1991; Banks *et al.*, 1994).

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RESEARCH ON UK AMPHIBIANS

Prior to the middle of the 20th century, published studies concentrated on species descriptions, basic natural history, taxonomy and anatomy (e.g. Bell, 1869). Although rarely referred to now because of their lack of detail in ecological terms, these early studies may be valuable from a conservation perspective as they contain qualitative descriptions of species and habitats prior to major human interference. Later studies progressed to descriptive ecological work, such as the Savage's (1961) monograph on *R. temporaria*. Such studies provided the baseline information for further more detailed investigation, including demography and migration (e.g. Gittins *et al.*, 1980), behaviour (Halliday, 1974), and habitat preferences (Beebee, 1979). Experimental studies (i.e. those in which manipulation occurred) were initiated mainly from the 1980s and provided further useful insights into ecological processes, for instance work on competition (Griffiths *et al.*, 1991). Although some amphibian studies at this stage touched on conservation issues, most were primarily aimed at enhancing ecological knowledge. The last decade however has witnessed a major increase in the publication of studies directed towards, or highly relevant to, key conservation issues (e.g. Cooke, 1997; Baker & Halliday, 1999; Hitchings & Beebee, 1997; for a general account see Lambert, 1997). This proliferation has been stimulated by growing concern about amphibian conservation status, and has been assisted by the development and increased accessibility of various techniques, notably genetic analyses. This later work has focused on the protected and more threatened species, *Triturus cristatus*, *Bufo calamita* and *Rana lessonae*. All of the UK amphibians also occur in mainland Europe, and a considerable amount of scientific study undertaken there has complemented domestic studies (e.g. Arntzen & Teunis, 1993; Miaud *et al.*, 1993).

RESEARCH AS A CONSERVATION TOOL

Research can perform the following functions in helping to inform conservation policy:

(1) Providing baseline ecological, taxonomic, distributional and status information. UK amphibian conservation is well served in this field, which covers a wide range of studies providing fundamental information required for species conservation. The areas covered include (i) ecology and behaviour, required for planning monitoring programmes and habitat management (e.g. studies of *B. bufo* breeding migrations, Slater *et al.*, 1985); (ii) genetic studies to clarify status and to inform reintroductions (e.g. relationships between pool frog populations, Zeisset & Beebee, 2001; genetic variation across UK *B. calamita* populations, Rowe *et al.*, 1999; consequences of isolation, Rowe & Beebee, 2003); (iii) collated and interpreted site records, which allow an assessment of conservation status and the setting of recovery targets (e.g. amphibian inventories, Swan & Oldham, 1993; Beebee & Buckley, 2001).

(2) Providing information on threats, and the responses of populations and habitats to them. Fewer studies have been published in this area, but some progress has been made in recent years. For instance, mapping work has provided an insight into the magnitude and timing of loss of breeding ponds (Boothby, 1997), and long-term monitoring has revealed the extent of development impacts (Cooke, 1997).

(3) Providing information on conservation measures, and the responses of populations and habitats to them. There remains much scope for published research in this area, but again there has been a recent trend for targeted investigations, such as the effects of pond management regimes on breeding success in *B. calamita* (Phillips *et al.*, 2002).

(4) Providing information on techniques critical to conservation. A key example is the comparative study of monitoring methods (e.g. Cooke, 1995; Griffiths *et al.*, 1996), where investigations of effectiveness are essential to inform surveillance programmes.

(5) Investigating findings from anecdotal reports, to assess whether there are real effects. The UK is fortunate in having a large complement of volunteers with an interest in amphibians, and suggestions of potential conservation issues from this group are worthy of consideration (for instance the reports of decline among lowland *B. bufo* populations investigated by Carrier & Beebee, 2003).

THE NATTERJACK TOAD: A CASE STUDY

An examination of the success of reintroductions of *B. calamita* serves as a composite example of the above functions, and demonstrates that research is often critical to achieving a real conservation benefit. *B. calamita* is restricted to three main habitat types in the UK (lowland heathland, sand dunes and upper saltmarsh) and has suffered considerable decline in the 20th century, largely through habitat destruction and successional changes. Approximately 50 populations currently remain, representing a significant loss in terms of the number of occupied sites and the geographic range (Banks *et al.* 1994). One strategy to address this decline has been to reintroduce *B. calamita* to suitably prepared sites, either from captive bred stock or by translocation from wild populations. Reintroductions were started in the late 1960s, and still form an important part of the national conservation strategy for this species (The UK Biodiversity Steering Group, 1995). The success of the reintroductions, as determined by the establishment of a breeding population, has improved considerably over this period (Fig. 1). Ecological research along the lines outlined in (1)-(5) above has played a key role in ensuring more favourable outcomes from reintroduction attempts. In particular there is now a better understanding of the preferred pond characteristics, the importance of terrestrial habitat structure, the importance of predators and competitors, and the significance of different founder stock characteristics (Beebee, 1983; Banks *et al.* 1994). This knowledge has informed improvements to conservation practice, such as the design of reintroduction ponds, selection of appropriate reintroduction sites, defining sympathetic habitat management regimes, and refining procedures for releases. Indeed, before research about the profile of preferred breeding ponds was initiated, the species actually suffered due to competitors invading inappropriately created or managed ponds. The failure of some recent reintroductions still gives cause for concern, but these seem to be restricted to one particular habitat type, indicating that further targeted research on this subject is desirable.

CHALLENGES IN TRANSLATING RESEARCH INTO POLICY

Conservation policy can operate at various levels, from prescribing the nature of land use at a broad scale, to recommending specific strategies or methods for habitat management and reintroductions. Perhaps the biggest challenge when using research to inform policy is the fact that natural ecosystems are so complex. This means that investigating conservation problems in truly natural situations can be fraught with difficulties. The

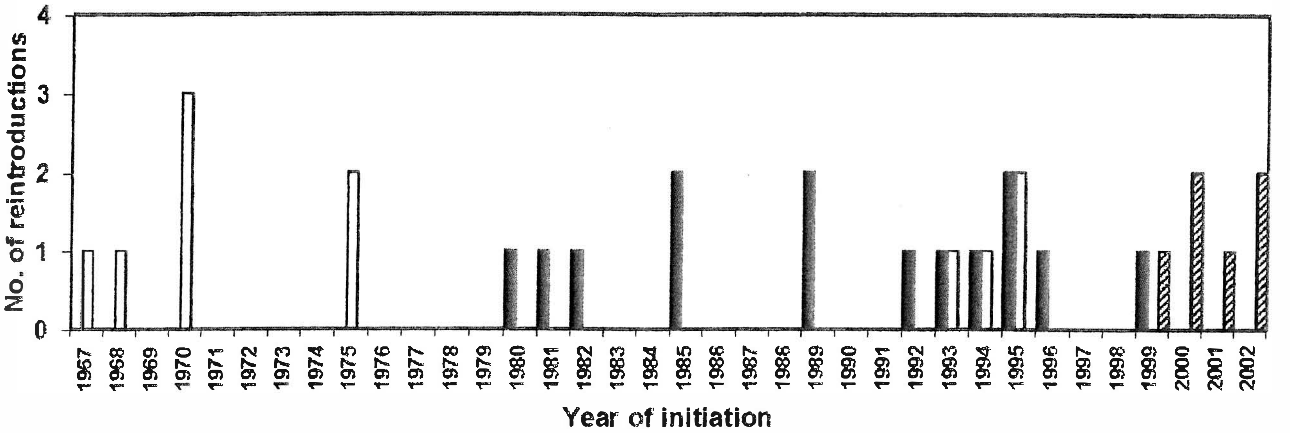

FIG. 1. The outcome of *B. calamita* reintroduction attempts in the UK, 1967-2002. Key to bars: open, failure; solid, success; hatched, as yet unproven.

problems arise because populations vary across many dimensions (e.g. habitats present, population size and demography, links to other populations, presence of competitors, climate, positive and negative management factors applying). Sample sizes required for sound hypothesis testing are often very large. Hence, establishing clear-cut relationships is problematic if not impossible. An example is a recent study seeking to recommend optimal fish control methods in amphibian ponds (Watson, 2002). The study concluded that selecting the appropriate technique must be based on an examination of a wide range of interacting site characteristics, such as substrate type, pond size, weather conditions, vegetation type and fish species. Undertaking observations in captive or semi-natural conditions can help to reduce variability, but at the same time often lessens the applicability of the results.

Linked to this point is the risk inherent in generalizing or extrapolating from single studies to more comprehensive application. Due to the variation across sites and the factors affecting them, the findings from a given detailed study (or small numbers of unrepresentative studies) may be misleading if applied across a wider range of situations. The study of amphibian dispersal provides a good example of this situation. Dispersal distances are important to inform decisions on, for example, the definition of protected area boundaries and the assessment of impacts by damaging activities. Field studies on the UK's most protected amphibian, *T. cristatus*, have revealed a range of observed maximum dispersal distances, from 95 m (Jehle, 2000) to 1290 m (Kupfer, 1998). Both studies are excellent investigations of newt ecology, but the results may be misinterpreted, and arguably misused, by policy makers and conservation workers if not set in context. The former study may be cited to contend that *T. cristatus* disperses over short distances and therefore more distant landuse changes will not affect populations. The latter study may be invoked to contradict this. In fact, such debates (which have occurred amongst those involved in site safeguard for this species in the UK) demonstrate the difficulty in using results from a given investigation to apply to other situations. Examination of the aims and methods of these studies clearly demonstrates that a simplistic inference of their maximum dispersal estimates to other populations is questionable; for instance Jehle (2000) specifically investigated post-breeding emigration of a sample of adults, thus other dispersal (for instance autumnal juvenile migration) was not examined. It should be stressed that these comments are in no sense a criticism of the individual published results; on the contrary they are designed to highlight the potential for misuse of the data by others. An overview of such studies, bringing together the common points, indicating the pitfalls of wider interpretation and placing them in a conservation context, may sometimes be required for them to be translated soundly into practical guidance (e.g. English Nature, 2001). It is suggested that the ease with which research can be used to inform policy varies by species, with for instance habitat specialists lending themselves more readily to direct application of research results (Fig. 2). This is not to suggest that where research reveals a complex situation it will be less likely to inform conservation policy, rather that those formulating the resulting policy will need to be especially careful to avoid pitfalls of over-simplification.

Traditional statistical standards of confidence may not always be appropriate when shaping conservation policy. This is because the standard hypothesis testing model may not be applicable and it is often difficult to establish a high degree of confidence in results of field studies, given the complexity of the systems being examined. Partially for such reasons, the application of the precautionary principle is often advised in conservation practice (United Nations, 1992; Department of Environment, 1994), and Bayesian statistical inference is better able to handle the associated statistical tests. Bayesian methods can incorporate inherent uncertainty and a consideration of conservation context, and permit the simultaneous assessment of several different hypotheses, giving relative probabilities for each (Wade, 2000). An example of Bayesian methods in amphibian conservation research is the investigation of the biogeographic range of *R. lessonae*, in which multiple

Ease of translating research into policy	Habitat specificity	Vagility	Species distribution	Threats to conservation status (number/ complexity)
Complex ↓ Simple	Generalist ↓ Specialist	High ↓ Low	Widespread ↓ Localised	Many/ complex ↓ Few/ specific

FIG. 2. Factors influencing the prospects for research on amphibian ecology to be translated into conservation policy.

populations were simultaneously assessed to give the most probable closest relatives of the native UK population (Zeisset & Beebee, 2001).

When dealing with potential threats, it is often simply not possible to empirically test the likely impacts, and so a balanced view based on the (often limited) evidence is required. The task for policy makers is most difficult when dealing with new situations that may have potentially devastating impacts, and which may demand drastic intervention, as with the discovery of novel pathogens and invasive species (Daszak *et al*., 1999; Mazzoni *et al*., 2003). When a non-native species is introduced, there needs to be a rapid judgment as to its likely impact on native ecosystems. Conducting a study of the actual impacts as the species establishes would provide interesting scientific evidence to support a view on the best course of action, but it would often be unwise as the conservation losses accruing during the study could be considerable. Where significant impacts are predicted, preventative action should be initiated and this in itself can result in useful data. Such a situation has occurred recently in the UK with the introduced North American bullfrog *Rana catesbeiana*, where useful information on the efficiency of control methods have been collected, though the outcome of these measures will not be known for several years (Banks *et al*., 2000).

Conservation practitioners are often presented with anecdotal or conflicting evidence, and whilst the precautionary principle may assist in dealing with such situations it does create problems of its own. If a particular threat to conservation status is implicated in one study but not supported by others, it often requires a meticulous examination of the circumstances combined with a degree of professional judgment in order to clarify whether a real issue has been revealed and if so, what relevance it has to wider conservation.

When assessing the implications of ecological research for policy, it is important to consider the context in which the resulting guidance will be employed. Research findings are (quite rightly) often presented without reference to the pragmatic constraints that accompany practical application. Foremost among such considerations are resource and financial limits on implementation, and the prevailing socioeconomic situation in which the policy will be employed. The former constraint is, for instance, a significant determinant of the design of amphibian monitoring programmes. Whilst sophisticated survey techniques as recommended by research findings are desirable in terms of data quality and resolution (see Schmidt, this volume), in practice there are limitations on the human resource for undertaking surveys (meaning that overall effort is constrained); the funding available will also place controls on implementation. In these circumstances, there is a need for a consideration of the trade-off between the power of the monitoring programme to detect conservation-relevant trends, and the resources required for proper implementation. This assessment is greatly aided where there are sound data on the performance of the available monitoring techniques, as is now the case for *B. calamita* in the UK (Beebee & Buckley, 2001; Herpetological Conservation Trust, 2002).

SUGGESTIONS FOR ENHANCING THE CONSERVATION VALUE OF FUTURE RESEARCH

Conservation practitioners are advised to engage more closely with researchers, and vice versa, so that mutually beneficial investigations can be undertaken. Priorities for pure research do not always coincide with conservation priorities, and given the complexity of natural systems there may be problems with designing programmes to deliver the answers to the precise questions required by conservation workers. This situation arises partly because university research priorities are led, to a large extent, by funding opportunities for international or over-arching studies. Thus, studies of local or even national conservation issues may not receive as much attention. Resulting high-level studies are obviously important but may not produce information that is useful at a local scale. However, there remain some interesting areas for conservation research in the UK that would also produce scientifically valuable results. A key first step, already progressed to some extent in the UK, is for those involved in designing and implementing policy to identify the main gaps in knowledge that frustrate progress towards conservation gain. Presently, we suggest, these areas include: the relationship between survey count data and actual population size; definitions of population status; viability and genetic impoverishment of small or isolated populations; impacts of extensive habitat management regimes used in the agricultural landscape; impacts of development and value of mitigation measures; factors affecting reintroduction outcome.

In order to advance towards this goal, the authorities that direct and fund ecological research need to foster, and more readily accept, proposals based on conservation priorities. Indeed, the discipline of conservation biology urgently requires wider recognition and its own financial support system if it is to provide an adequate science base. The recent initiation of the Biodiversity Research Working Group in the UK should help to address these issues.

Taking conservation-relevant research to its "end user" (land managers, surveyors, the public, etc.) will normally involve conversion into a different format from the original research publication. This often takes the form of published guidance, e.g. landowner-oriented habitat management advice based on published research (Langton *et al.*, 2001), but other channels include training courses, news releases for the media, or web-based advice. The co-operation of researchers and conservation practitioners at this stage will ensure that the accuracy and precision of the advice is maintained. Joint meetings, such as the symposium on *T. cristatus* hosted by the British Herpetological Society in 1998 (Cummins & Griffiths, 2000), can be beneficial in bringing together otherwise separate groups.

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