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ORIGINAL PAPER

# Translocation of an endangered insect species, the field cricket (*Gryllus campestris* Linnaeus, 1758) in northern Germany

**Axel Hochkirch · Kathrin A. Witzenberger · Anje Teerling · Friedhelm Niemeyer**

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**Abstract** Relocations of species have become a tool widely used in nature conservation, but insects have rarely been considered as targets. Here, we present a translocation project of the field cricket (*Gryllus campestris* L. 1758), which is a threatened species at the northern edge of its range. Only ten populations were left in Lower Saxony (Germany), illustrating the need for urgent conservation measures. After 10 years of monitoring and management of an isolated population, 213 nymphs were captured and released at another nature reserve in summer 2001. The size of the new population increased significantly from 27 singing males in spring 2002 to 335 singing males in spring 2005. The occupied area increased from 5.66 ha to 33.14 ha. Altogether, the translocation project was evaluated as successful, but the inland dune proved to be not as suitable for the species as initially expected. Our results indicate that translocations of highly reproductive insect species are promising, as long as the release locality contains sufficiently large areas of suitable habitat and a high number of wild juveniles from a closely located and large source population are released in a climatically favorable period. Management and restoration of habitats, as well as continuous monitoring are of crucial importance for the success of the translocation project. Moreover, the importance of a high quality of cooperation between conservationists, authorities, foresters, farmers, financiers and scientists cannot be overstated.

**Keywords** Heathland · Insect conservation · Orthoptera · Re-introduction · Relocation · Restoration

A. Hochkirch (✉) · K. A. Witzenberger
Department Biology/Chemistry, Division of Ecology, University of Osnabrück, Barbarastr. 11, Osnabrück D-49076, Germany
e-mail: hochkirch@biologie.uni-osnabrueck.de

A. Teerling · F. Niemeyer
BUND Diepholzer Moorniederung, Langer Berg 15, Wagenfeld D-49419, Germany

## Introduction

Animal relocations have become a widely used tool in conservation management. However, most re-introduction projects so far have focused on large vertebrates, such as birds and mammals (Sarrazin and Barbault 1996; Fischer and Lindenmayer 2000). In spite of the fact that invertebrates constitute a substantial proportion of the species richness and biomass, and play a significant role in ecosystem functioning, they rarely have been considered as relocation targets and are even often discounted in conservation management as a whole. Thus, invertebrates need to receive much more attention in nature conservation (Pyle et al. 1981; Dunn 2005). Relocation projects of highly reproductive invertebrates are much more promising than those of large vertebrates due to their small body size, the low costs, and the small spatial requirements (Pearce-Kelly et al. 1998). The few documented cases of invertebrate relocations mainly deal with Lepidoptera species (Rawson 1961; Dempster et al. 1976; Duffey 1977; Väisanen et al. 1994; Witkowski et al. 1997), but some examples of Orthoptera relocations have also been published (Pearce-Kelly et al. 1998; Sherley 1998; Berggren 2005).

Four different types of relocations are commonly distinguished (IUCN 1998): Re-introductions (attempts to establish a species within its historical range), translocations (attempts to establish new populations within the range), supplementations (addition of individuals of different genotype to an existing population), and conservation introductions (attempts to establish a species outside its natural range, but in an appropriate habitat). The aim of translocation projects is usually to reduce the risk of extinction for an endangered species by creating more self-sustaining populations (Sherley 1998). Fragmentation of habitats and loss of (sub-)populations have been recognized as main threats for many species (Primack 2002). The artificial establishment of new populations is, therefore, a consistent method for enhancing the survival probability of a species. However, only 26% of the relocation trials analyzed in a recent review have been classified as successful (Fischer and Lindenmayer 2000). There is a strong need for more thorough management of relocation experiments, with careful background research, choice of suitable release sites and release stocks, as well as monitoring before and after the relocation (IUCN 1998; Fischer and Lindenmayer 2000). Here we present the results of a translocation experiment of the field cricket (*Gryllus campestris* L. 1758) in northern Germany. We evaluate the success of the translocation project by using a strong criterion (significant increase in population size) as indicator of the success.

## Methods

### The study object

The field cricket (*Gryllus campestris*) is a rather well-known insect. It is a comparatively large cricket species (17–26 mm), characterized by a shiny black body coloration (Marshall and Haes 1990). The species mainly inhabits dry grasslands, and is restricted to heathlands and oligotrophic grasslands at the northern edge of its range (Kleukers et al. 1997), where it typically lives in burrows of approximately 30 cm depth (Regen 1906). The reproductive season of the univoltine species lasts from May until the end of June. Nymphs hatch in mid July and overwinter during their tenth or eleventh instar (Köhler and Reinhardt 1992). The final moult takes place at the end of April or at the beginning of May. While males are territorial and defend their burrows fiercely, females are vagrant and are attracted by singing males. They lay their eggs in bare ground either close to a burrow or into the burrow. The first instars can be found under bark or wooden pieces, but they also use old burrows of adults. Populations of *G. campestris* are known to undergo extreme fluctuations and are strongly affected by weather conditions (Remmert 1992).

The field cricket is a threatened species at the northern edge of its range, such as the UK (Pearce-Kelly et al. 1998), Germany (Ingrisch and Köhler 1997), the Netherlands (Kleukers et al. 1997), Denmark (http://redlist.dmu.dk, 2006) or Switzerland (Thorens and Nadig 1997). In Lower Saxony it is listed as Critically Endangered (Grein 2005), with only ten populations left (Grein 2000). The main reason for its decline is believed to be habitat loss. Due to its well-known song, the field cricket is a comparatively popular insect species. It probably represents one of the scarce examples of ''non-butterfly insects'', which are suitable as flagship species. For this reason, the species has been selected as *Insect of the Year 2003* by the ''*Kuratorium Insekt des Jahres*'' of the German Entomological Institute (Eberswalde) and the Federal Biological Research Center for Agriculture and Forestry (Braunschweig) in Germany. In Lower Saxony, only one isolated population remained west of the river Weser, at the eastern edge of the nature reserve ''Neustädter Moor''. This population has been monitored and managed intensely during the last 15 years by the non-governmental organization BUND (''Bund für Umwelt und Naturschutz Deutschland'' or ''Friends of the Earth - Germany''). From 1991 to 2001, the population increased from 32 to 949 singing males (Hochkirch 1996; Teerling and Hochkirch 2002). In order to reduce the extinction risk further, a translocation project was started in 2001, intending to establish a second self-sustaining population in a nearby nature reserve (''Renzeler Moor''). Although there are no former records of field crickets available for this nature reserve, it consists of many seemingly ideal but unoccupied habitats for field crickets and was thought to enable them to spread further. However, it is separated from the source population by a distance of 3.5 km, with the river ''Große Aue'' and wet grasslands acting as effective barriers for these flightless insects.

## The study area

The two study sites are located in the central part of the natural region ''Diepholzer Moorniederung'', an area between the towns Hannover, Bremen and Osnabrück (Lower Saxony, Germany). The region is characterized by large peat bogs, wetlands and dry alluvial sand ridges. These dry areas are naturally oligotrophic and were heavily overgrazed from the middle ages to the 19th century. During this period, heathlands, dunes and oligotrophic grasslands spread over northern Germany (Webb 1998). After the invention of artificial fertilizers and massive changes in land use, only small fragments of heathland have been left (Bakker and Berendse 1999). All peat bogs are strongly degraded, either by cultivation, peat cutting or dehydration. At the beginning of the 1970s, regional conservationists started a conservation project in order to save the remaining peat bog fauna, which has been continued by the BUND since 1983. With increasing experience the field of activities spread to other types of habitat, such as wet grasslands, dunes and heathlands, which surround the peat bog areas.

The nature reserves in the ‘‘Neustädter Moor’’ include the peat bog, as well as adjacent heathlands and wet grasslands at the western edge. The main part of the source population occurs east of these reserves, but it has spread into them during the last decade (Teerling and Hochkirch 2002). We chose two release sites on a former inland dune system in the northwestern part of the nature reserve ‘‘Renzeler Moor’’ (established in 1970). This area was used as farmland and pine forest during the past decades and transformed into meso- to oligotrophic grasslands at the beginning of the 1990s. Both reserves are maintained by extensive sheep grazing, which is also known to be advantageous for field crickets (Schmidt 1998).

## The translocation procedure

From 1990 to 2001, the population at the Neustädter Moor was intensely monitored and managed, leading to an approximately 30-fold increase in population size. In 2001 the population size was sufficiently large to start the translocation procedure, which was oriented towards a previous re-introduction project for the field cricket in England (Pearce-Kelly et al. 1998). The release sites at the Renzeler Moor were inspected by the authors and an additional expert (G. Grein) and there was general agreement that they represent suitable habitats for the field cricket. However, a detailed habitat analysis was not performed. Two localities were chosen as release sites: a meso- to oligotrophic pasture, which was managed by sheep grazing since 1992 and a restored inland dune, which was formerly forested with pines and deforested in the winter of 1990/91. The great habitat-diversity of the surrounding terrain was expected to allow further dispersal to suitable sites during the following years. Since the success of translocations can be increased by using wild animals as a source, releasing a large number of individuals and removing any detrimental factors (Fischer and Lindenmayer 2000), we followed these recommendations. In contrast to the breeding program presented by Pearce-Kelly et al. (1998), only wild nymphs were released during the translocation. Although the source population could be genetically rather invariable due to a bottleneck in 1991 (32 singing males), it was chosen to gain nymphs only from this well-monitored area, which is also the closest population to the release area. In order to increase the genetic diversity as far as possible, nymphs were collected from different subpopulations at the Neustädter Moor. The populations of both release and source area were monitored during the following years.

A total of 213 nymphs (instar 7–8) were collected on 4 days in July 2001. They were stored in boxes with swards of grass and heather to enable the nymphs to find shelter beneath them during the transportation. Fish food was supplied until they were released on 31 July 2001. Approximately half of the individuals (113 specimens) were introduced directly on the inland dune, the other half (100 specimens) on the pasture. Individuals from all subpopulations were released at each site to increase the genetic variability. During the first days pieces of bark where placed on the ground as shelter.

## Monitoring of the field crickets

The population size of *G. campestris* in the Neustädter Moor and Renzeler Moor was estimated by counting the number of singing males on each occupied site. The characteristic calling song of the field cricket is well suited for monitoring, since it can be heard up to 100 m, allowing a fast and comprehensive survey (Detzel 1998). Females and non-singing males were ignored, to allow comparability of the data between different years. Since not all males sing simultaneously, the data have to be regarded as minimum values. The study sites were checked on dry, warm and windless days during the main calling phase (from May to June). Densely populated sites were mapped preferably during the highest activity in the late afternoon or in the evening. All records were transferred to a map and analyzed with ArcView GIS 3.2. This method has been applied since 1990 in the study area (Hochkirch 1996; Teerling and Hochkirch 2002).

### Statistical analysis

We computed a linear regression model for population growth for the whole population as well as for three different habitat types (pasture, dune, peat bog) and tested for a positive increase in population size. All data were log-transformed prior to statistical treatment to comply with the model assumptions. The tests were carried out in ‘‘R 2.1.1’’ (R Development Core Team, 2004).

## Results

In total, 27 singing males were recorded in the Renzeler Moor in the spring of 2002 (Fig. 1). Assuming a balanced sex ratio, this corresponds to a survival rate of 25.4%. Considering that *G. campestris* is known to have a high mortality during the winter (Remmert 1992), the survival rate was surprisingly high. This led to the decision, not to supplement cricket nymphs in 2002. In the following year, 42 stridulating males were counted and the population had spread also spatially compared with 2002 (Fig. 1). Most of the males were found between the dune and a degraded part or the bog. After the unusual hot summer of 2003 (Ciais et al. 2005) the population increased up to 107 stridulating males in spring 2004. The majority of individuals (70%) were recorded on the pasture, whereas only 7% inhabited the inland dune (Fig. 2). In 2005, the population had grown immensely, reaching 335 stridulating males. Again the majority of crickets (77%) inhabited pastures and bog sites surrounding the inland dune (Fig. 2). Some initial subpopulations colonized sites approximately 250 m outside the nature reserve, such as adjacent fields and meadows. The occupied area increased from 5.66 ha in 2002 to 33.14 ha in 2005 (Fig. 1).

The overall population growth was significantly positive (linear regression model, $df = 2$, $t = 7.55$, $p = 0.017$, $R^2 = 0.9661$) and so was the increase of the occupied area (linear regression model, $df = 2$, $t = 4.53$, $p = 0.046$, $R^2 = 0.911$). However, after analyzing the data for the three habitats (dune, bog, pasture) separately, the subpopulation growth on the dune was not significant (linear regression model, $df = 2$, $t = 0.910$, $p = 0.459$, $R^2 = 0.293$), while the subpopulations increased significantly on the pasture (linear regression model, $df = 2$, $t = 8.695$, $p = 0.013$, $R^2 = 0.974$) and in the bog (linear regression model, $df = 2$, $t = 10.39$, $p = 0.009$, $R^2 = 0.982$).

## Discussion

Four years after the translocation of cricket nymphs, we evaluated the project as successful. The population persisted and increased significantly, indicating a high

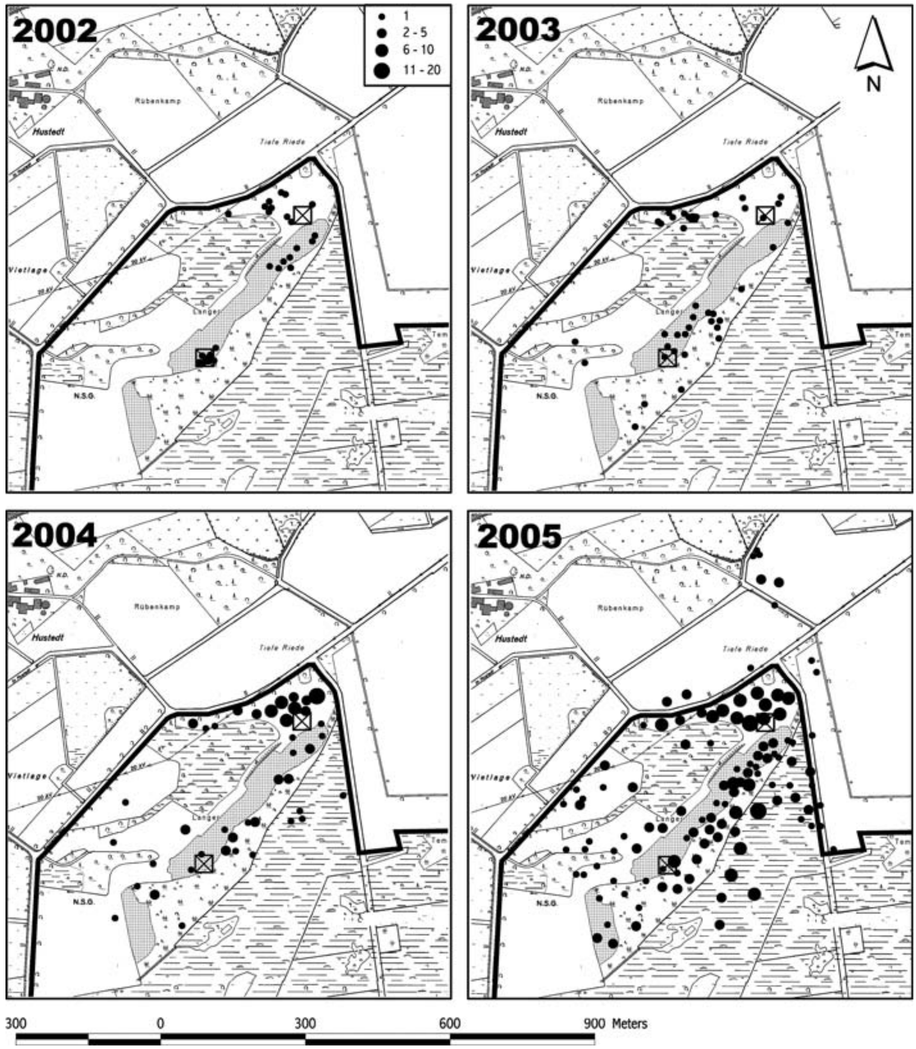


**Fig. 1** Dynamics of the new population of *Gryllus campestris* in the Renzeler Moor from 2002 to 2005 (black dots: singing males). The crossed squares represent the two release localities, the southern of which was located on the inland dune, the northern on a pasture. Peat bog sites (striped) are mainly situated southeast of the inland dune. The bold line marks the border of the reserve. Sites north of the reserve consist mainly of conventional farmland

quality of the release area as habitat for *Gryllus campestris*. However, despite of these overall results, the suitability of single sites (or habitat types) differed from our expectations. While the population size increased strongly on the pasture and degraded peat bog, the inland dune turned out to be much less suited than expected (Fig. 2). A possible reason for this might be found in inappropriate conditions for digging burrows (Köhler and Reinhardt 1992), due to either the dense cover of mosses and plant litter or the soil structure of the dune. As initially intended, the increase in population size also caused a considerable dispersal of the field cricket into adjacent areas. Some of these habitats, such as peat bog sites or arable fields, might not be

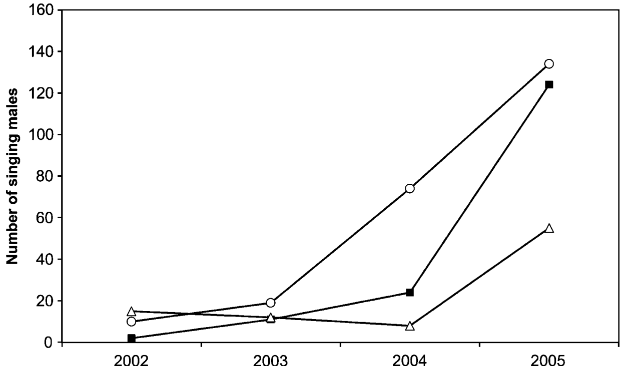


**Fig. 2** Comparison of the population development between the three main habitat types: grassland (open circle), peat bog (closed square), dune (open triangle)

suitable as persistent habitats, but they may serve as stepping stones for future expansion. In the source area (Neustädter Moor), degraded peat bog has been colonized permanently during the last decade, allowing dispersal to remote heathlands. Continuous monitoring of the source population showed that the loss of 213 nymphs had no negative consequences. In 2005, the source population reached a new maximum of 1945 singing males (unpublished data). We consider ten factors as crucial for the success of the translocation method, which can be grouped into three major classes: ecological factors, translocation procedure, scientific and administrative support.

## Ecological factors

Four ecological factors were probably of importance for the success. (1) The habitat quality in the release area was rather high, due to an intense habitat restoration and management since the end of the 1980s. Continuous management by sheep grazing and mowing is needed to counteract the increased nitrogen deposition from the atmosphere (Bakker and Berendse 1999). Although the dune was less suited for *G. campestris*, deforestation and extensive sheep grazing supported the development of large suitable habitats. The availability of high quality habitat is known to be the major determinant for the success of relocation projects (Rawson 1961; Griffith et al. 1989; Wolf et al. 1996; Sarrazin and Legendre 2000). (2) The high habitat heterogeneity (grasslands, degraded peat bog, dune) in the release area supported the success, as the field crickets were able to choose optimal sites and microhabitats. Orthoptera are known to perform an active habitat choice (Whitman 1987). Moreover, even less suited sites could be colonized in optimal years and serve as stepping stones for future dispersal (Hochkirch 1996). (3) The weather conditions were suitable for population growth from 2003 to 2005. This is probably of crucial importance, since field crickets (as many insects) are highly dependent on favorable weather at the northern edge of their range, which can influence the success of translocation projects immensely (Pearce-Kelly et al. 1998). From 2002 to 2003, the weather conditions were unfavorable (rainy), which is illustrated by a lower population growth (Fig. 2). Apparently, the habitat quality of the pasture was even suitable under these conditions, since the population persisted and increased slightly in that year. (4) *Gryllus campestris* is a univoltine species, which is known to produce high egg numbers leading to rapid population growth (Remmert 1992; Pearce-Kelly et al. 1998). Demography is generally thought to be of high importance for population survival (Lande 1988).

## Translocation procedure

We distinguish four major parameters of the translocation procedure, which assured the success. (1) Differently to the project of Pearce-Kelly et al. (1998) we had the chance to gain specimens from a sufficiently large wild population. Relocation projects using wild animals are generally more successful than those using captive animals (Griffith et al. 1989; Fischer and Lindenmayer 2000). Moreover, translocation success of wild-caught animals correlates positively with the density and increase of the source population (Griffith et al. 1989), which was also true for the population at the Neustädter Moor. (2) As the source population was located close to the release area, the translocated individuals were probably genetically adjusted to the local conditions. The higher success of translocations using founder groups from indigenous sources has been reported also from other taxa (Ebenhard 1995; Sarrazin and Barbault 1996; Singer et al. 2000). (3) Another important factor could be the use of nymphs for the translocation. Nymphs of *Gryllus campestris* are more mobile than adults, since they do not show any territoriality. They do not start to dig burrows before autumn (Detzel 1998). Results from population modeling suggest that the use of juveniles in translocation projects is generally more efficient than relocating adults (Robert et al. 2003). (4) We transferred a high number of individuals. It is noteworthy to mention that the relation between translocation success and the number of animals released is asymptotic (Griffith et al. 1989). Pearce-Kelly et al. (1998) introduced between 106 and 1200 nymphs of *G. campestris*, but the survival depended more upon the habitat quality than on the number of released insects. Although there is a minimum number of animals that should be released, translocations have low chances of success without high habitat quality (Griffith et al. 1989; Ebenhard 1995).

## Scientific and administrative factors

Two factors within this class were of importance for the translocation project. (1) Continuous monitoring of both source and release population has been performed since 1990, allowing the assessment of the translocation method as well as the influence of the removal of specimens from the source population. In many translocation projects, such intense monitoring measures are missing (Sarrazin and Barbault 1996). Moreover, the experience of ten years of monitoring and management facilitated the choice of suitable release sites. (2) The success of the translocation project was also promoted by the excellent cooperation of the local and regional administrations, foresters and farmers, financial supporters (see acknowledgements), the executing organization (BUND) and the scientific consultants (University of Osnabrück). There is a strong need for such a high quality of cooperation in nature conservation (Sarrazin and Barbault 1996).

Negative factors

Two factors could have had negative effects on the success of the translocation process. (1) The transferred crickets were gained from only one population, which passed through a genetic bottleneck at the beginning of the 1990s. It is rather likely that the established population is genetically impoverished as has been shown for other translocated populations (Stockwell et al. 1996). However, inbreeding need not always cause inbreeding depression (Lande 1988; Hoelzel et al. 1993; Leberg 1993) and the consequences of genetics on survival or reproduction are difficult to predict (Sarrazin and Legendre 2000). The strong population growth of the field cricket indicates that currently the suggested loss of genetic diversity does not cause any problems. Demography generally seems to be of higher importance for population dynamics than population genetics (Lande 1988). Moreover, by transferring specimens from a nearby locality, the risk of outbreeding depression is minimized (Griffiths et al. 1996, Sarrazin and Barbault 1996). (2) There is another caveat, which should receive a stronger consideration in future translocation projects. Based upon the initial inspection of the release area, two sites (the dune and the pasture) were regarded as suitable habitats for the field cricket. While the subpopulation on the pasture increased continuously from 2002 to 2005, the subpopulation on the dune decreased during the first three years (Fig. 2). The increase of the dune subpopulation in 2005 might be caused by continuous immigration from the surrounding sites. The success of the whole project was determined by the high performance of the pasture and the surrounding bog sites. Had only the dune been chosen as a release site, the project might have been less successful. Therefore, detailed habitat analyses should be performed prior to relocation projects (Holloway et al. 2003).

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## References

Bakker JP, Berendse F (1999) Constraints in the restoration of ecological diversity in grassland and heathland communities. Trends Ecol Evol 14:63–68

Berggren A (2005) Effect of propagule size and landscape structure on morphological differentiation and asymmetry in experimentally introduced Roesel's bush-crickets. Conserv Biol 19:1095–1102

Ciais Ph, Reichstein M, Viovy N, Granier A, Ogée J, Allard V, Aubinet M, Buchmann N, Bernhofer Chr, Carrara A, Chevallier F, De Noblet N, Friend AD, Friedlingstein P, Grünwald T, Heinesch B, Keronen P, Knohl A, Krinner G, Loustau D, Manca G, Matteucci G, Miglietta F, Ourcival JM, Papale D, Pilegaard K, Rambal S, Seufert G, Soussana JF, Sanz MJ, Schulze ED, Vesala T, Valentini R (2005) Europe-wide reduction in primary productivity caused by the heat and drought in 2003. Nature 437:529–533

Dempster JP, King ML, Laghani KH (1976) The status of the swallowtail butterfly in Britain. Ecol Entomol 1:71–84

Detzel P (1998) Die Heuschrecken Baden-Württembergs. Ulmer, Stuttgart
Duffey E (1977) The re-establishment of the large copper butterfly Lycaena dispar batava obth. on Woodwalton Fen National Nature Reserve, Cambridgeshire, England, 1969–73. Biol Conserv 12:143–158
Dunn RR (2005) Modern insect extinctions, the neglected majority. Conserv Biol 19:1030–1036
Ebenhard T (1995) Conservation breeding as a tool for saving animal species from extinction. Trends Ecol Evol 10:438–443
Fischer J, Lindenmayer DB (2000) An assessment of the published results of animal relocations. Biol Conserv 96:1–11
Grein G (2000) Zur Verbreitung der Heuschrecken (Saltatoria) in Niedersachsen und Bremen. Informationsdienst Naturschutz Niedersachsen 20:74–112
Grein G (2005) Rote Liste der in Niedersachsen und Bremen gefährdeten Heuschrecken mit Gesamtartenverzeichnis. 3. Fassung. Informationsdienst Naturschutz Niedersachsen 25:1–20
Griffith B, Scott JM, Carpenter JW, Reed C (1989) Translocation as a species conservation tool: status and strategy. Science 245:477–480
Griffiths HI, Davison A, Birks J (1996) Species reintroductions. Conserv Biol 10:923–930
Hochkirch A (1996) Die Feldgrille (*Gryllus campestris* L., 1758) als Zielart für die Entwicklung eines Sandheidereliktes in Nordwestdeutschland. Articulata 11:11–27
Hoelzel AR, Halley J, O'Brien SJ, Campagna C, Arnbom T, Le Boeuf B, Ralls K, Dover GA (1993) Elephant seal genetic variation and the use of simulation models to investigate historical population bottlenecks. J Hered 84:443–449
Holloway GJ, Griffiths GH, Richardson P (2003) Conservation strategy maps: a tool to facilitate biodiversity action planning illustrated using the heath fritillary butterfly. J Appl Ecol 40:413–421
Ingrisch S, Köhler G (1997) Rote Liste der Geradflügler (Orthoptera s. l.). In: Binot M, Bless R, Boye P, Gruttke H, Pretscher P (eds) Rote Liste gefährdeter Tiere Deutschlands, pp 252–254. Schriftenreihe für Landschaftspflege und Naturschutz 55, Bundesamt für Naturschutz, Bonn, pp. 252–254
IUCN (1998) IUCN Guidelines for Re-introductions. IUCN, Gland & Cambridge
Kleukers R, Nieukerken Ev, Odé B, Willemse L, Wingerden Wv (1997) De Sprinkhanen en Krekels van Nederland (Orthoptera). Nederlandse Fauna I, KNNV Uitgeverij & EIS-Nederland, Leiden
Köhler G, Reinhardt K (1992) Beitrag zur Kenntnis der Feldgrille (*Gryllus campestris* L.) in Thüringen. Articulata 7:63–76
Lande R (1988) Genetics and demography in biological conservation. Science 241:1455–1460
Leberg PL (1993) Strategies for population reintroduction: effects of genetic variability on population growth and size. Conserv Biol 7:194–199
Marshall JA, Haes ECM (1990) Grasshoppers and allied insects of Great Britain and Ireland. Harley books, Colchester, Essex
Pearce-Kelly P, Jones R, Clarke D, Walker C, Atkin P, Cunningham AA (1998) The captive rearing of threatened Orthoptera: a comparison of the conservation potential and practical considerations of two species' breeding programmes at the Zoological Society of London. J Insect Conserv 2:201–210
Primack R (2002) Essentials of Conservation Biology. 3rd edn. Sinauer Associates, Sunderland, MA
Pyle R, Bentzien M, Opler P (1981) Insect conservation. Ann Rev Entomol 26:233–258
Rawson GW (1961) The recent rediscovery of Eumaeus atala (Lycaenidae) in southern Florida. J Lepid Soc 15:237–266
Regen J (1906) Untersuchungen über den Winterschlaf der Nymphen von *Gryllus campestris* L. Ein Beitrag zur Physiologie der Atmung und Pigmentbildung bei den Insekten. Zoologischer Anzeiger 30:131–135
Remmert H (1992) Die Populationsdynamik von Feldgrillen und ihre Ursachen. In: Remmert H (eds) Ökologie: Ein Lehrbuch. Springer, Berlin, pp 196–200
Robert A, Sarrazin F, Couvet D, Legendre S (2003) Releasing adults versus young in reintroductions: interactions between demography and genetics. Conserv Biol 18:1078–1087
Sarrazin F, Barbault R (1996) Reintroduction: challenges and lessons for basic ecology. Trends Ecol Evol 11:474–478
Sarrazin F, Legendre S (2000) Demographic approach to releasing adults versus young in reintroductions. Conserv Biol 14:488–500
Singer FJ, Papouchis CM, Symonds KK (2000) Translocations as a tool for restoring populations of bighorn sheep. Restor Ecol 8:6–13

Schmidt K (1998) Zum Vorkommen und zur Bestandssituation der Feldgrille (*Gryllus campestris*) in SW-Thüringen unter besonderer Berücksichtigung des Wartburgkreises. Veröffentlichungen des Naturhistorischen Museums Schleusingen 13:79–87

Sherley GH (1998) Translocationg a threatened New Zealand giant orthopteran, *Deinacrida* sp. (Stenopelmatidae): some lessons. J Insect Conserv 2:195–199

Stockwell CA, Mulvey M, Vinyard GL (1996) Translocations and the preservation of allelic Diversity. Conserv Biol 10:1133–1141

Teerling A, Hochkirch A (2002) 10 Jahre Schutz der Feldgrille in der Diepholzer Moorniederung—Ziele, Erfolge und Perspektiven. Verhandlungen der Gesellschaft für Ökologie 32:407

Thorens P, and Nadig A (1997) Atlas de Distribution des Orthopteres de Suisse. Doc. Faun. Helv. 16, CSCF, Neuchâtel

Väisänen R, Kuussaari M, Nieminen M, Somerma P (1994) Conservation biology of *Pseudophilotes baton* in Finland (Lepidoptera, Lycaenidae). Annales Zoologici Fennici 31:145–156

Webb ND (1998) The traditional management of European heathlands. J Appl Ecol 35:987–990

Whitman DW (1987) Thermoregulation and daily activity patterns in a black desert grasshopper *Taeniopoda eques*. Anim Behav 35:1814–1826

Witkowski Z, Adamski P, Kosior A, Płonka P (1997) Extinction and reintroduction of *Parnassius apollo* in the Pieniny National Park (Polish Carpathians). Biologia 52:199–208

Wolf CM, Griffith B. Reed C, Temple SA (1996) Avian and mammalian translocations: update and reanalysis of 1987 survey data. Conserv Biol 10:1142–1154