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ORIGINAL PAPER

Method of releasing and number of animals are determinants for the success of European ground squirrel (*Spermophilus citellus*) reintroductions

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Abstract Reintroductions are considered an important part of the action plans and recovery strategies of endangered ground squirrel species, but so far little is known about their proper methodology. We collected primary data on 12 European ground squirrel reintroduction projects carried out at 14 localities in the Czech Republic, Slovakia and Poland since 1989. We focused on seven methodological aspects of each reintroduction: selection of release site, method of releasing, date of releasing, origin of released animals, total number of released animals, mean number of released animals per season and reintroduction site management. The method of releasing was found to be the key factor in determining the settlement of animals at the target locality. Only soft releasing methods, i.e. the use of enclosures and/or artificial burrows, ensure that animals remain at the target locality. The other factors significantly determining reintroduction success are the number of released animals per season (at least 23 animals required) and the total number of released animals (a minimum of 60

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individuals). Long-term management of the site and regular monitoring of the newly established population are necessary. Our recommendations, based on experience with the successes and failures of previous reintroductions, could largely improve the efficiency of future reintroductions of highly endangered species.

Keywords Translocation · Endangered species · Rodentia

Introduction

The International Union for the Conservation of Nature and Natural Resources defines a reintroduction as "an attempt to establish a species in an area which was once a part of its previous historical range" (IUCN 1998). In general, reintroduction, translocation or repatriation projects are intensive, expensive, species-focused conservation actions intended to contribute to the restoration of biodiversity. Although reintroductions are frequently used tools in conservation biology and wildlife management, the average success rate for endangered species is only about 25% (Griffith et al. 1989; Fischer and Lindenmayer 2000).

Ground squirrels and prairie dogs (genera *Spermophilus* and *Cynomys*) have long been considered agricultural pests and exterminated by poisoning or shooting (Grulich 1960; Van Horne 2007). Their typical steppe biotopes were also reduced by conversion to fields or by development (Biedrzycka and Konopiński 2008; Grulich 1960; Hoogland 2007; Matějů et al. 2010a). At present, 8 out of 47 *Spermophilus* and *Cynomys* species are endangered by extinction or considered vulnerable, and negative population trends have been observed in another nine species (IUCN 2011).

Reintroductions of ground squirrels are considered an important part of the action plans and recovery strategies of endangered species from the genus *Spermophilus* (e.g. Hafner et al. 1998; Matějů et al. 2010a; U.S. Fish and Wildlife Service 2003). Compared to frequent translocations of prairie dogs of the genus *Cynomys* (Hoogland 2007; Roe and Roe 2003; Truett et al. 2001), translocations of *Spermophilus* species are still uncommon and little is known about the proper methodology (Hapl et al. 2006; Van Vuren et al. 1997). This lack of information is probably due to the common practice in wildlife management of not publishing negative results from reintroduction projects (MacNab 1983) even if subsequently repeating the same mistakes could be prevented (Short et al. 1992).

The European ground squirrel, *Spermophilus citellus* (Linnaeus, 1766), inhabits central and southeastern Europe, ranging from the Czech Republic, Austria and Slovakia in the northwest to the European part of Turkey, northern Greece and western Ukraine in the southeast (Mitchell-Jones et al. 1999; Wilson and Reeder 2005; see Fig. 1). Previous studies have reported an almost continuous distribution of the *S. citellus* throughout the agricultural landscape of Central Europe (e.g. Jacobi 1902; Werth 1936; Grulich 1960; Spitzenberger 2001). In the 1950s, *S. citellus* abundance began an ongoing decline and it became extinct in Germany (Feiler 1988) and Poland (Meczynski 1985). The dramatic decline of the species' area and abundance was most likely caused by the intensification of agricultural practices, i.e. alteration of meadows and pastures into fields and the absence of regular mowing in the remaining grasslands, resulting in habitat loss and fragmentation (Cepáková and Hulová 2002; Koshev 2008; Matějů et al. 2008). Comparing older data about *S. citellus* occurrence in the Czech part of the former Czechoslovakia (Grulich 1960) with the recent situation shows that the current *S. citellus* distribution is only relict in character. In 2008, the *S. citellus* in the Czech Republic was found at only 35 sites and the overall abundance was estimated to be ca 3,600 individuals. The remaining ground squirrel colonies are restricted to grasslands regularly managed by humans (Matějů et al. 2008). The decline of the *S. citellus* abundance and distribution pattern in Austria, Slovakia, Hungary and Bulgaria is similar (e.g. Spitzenberger 2001; Ambros 2008; Koshev 2008). The decline in ground squirrel abundance may also negatively affect the abundance of some specialised predators such as the European marbled polecat (*Vormela peregusna*) or steppe polecat (*Mustela eversmannii*; IUCN 2011). Analogously, the predatory black-footed ferret (*Mustela nigripes*) was almost wiped out in response to the poisoning and disappearance of prairie dogs in North America (Lockhart et al. 2006; Lockhart 2009).

The total decline across the *S. citellus* range has been estimated to be about 30% in the past 10 years; the species was thus included as a vulnerable species in the Red List of Threatened Species (IUCN 2011) and is protected by the European directive 92/43/EHS "the Habitat Directive". National laws of particular countries also protect the European ground squirrel as an endangered species. The protection of this species is important for both governmental and non-governmental wildlife management institutions across Central Europe (e.g. Ambros 2008; Baláž et al. 2008; Enzinger et al. 2008; Gedeon et al. 2011; Hapl et al. 2006; Kala and Kepel 2006; Matějů et al. 2010a), but a critical review of past reintroduction attempts is still missing. The main objectives of this work were (1) to review and evaluate the methods and results of all past reintroduction projects of the *S. citellus* within Central Europe and (2) to suggest specific recommendations for future *S. citellus* reintroductions.

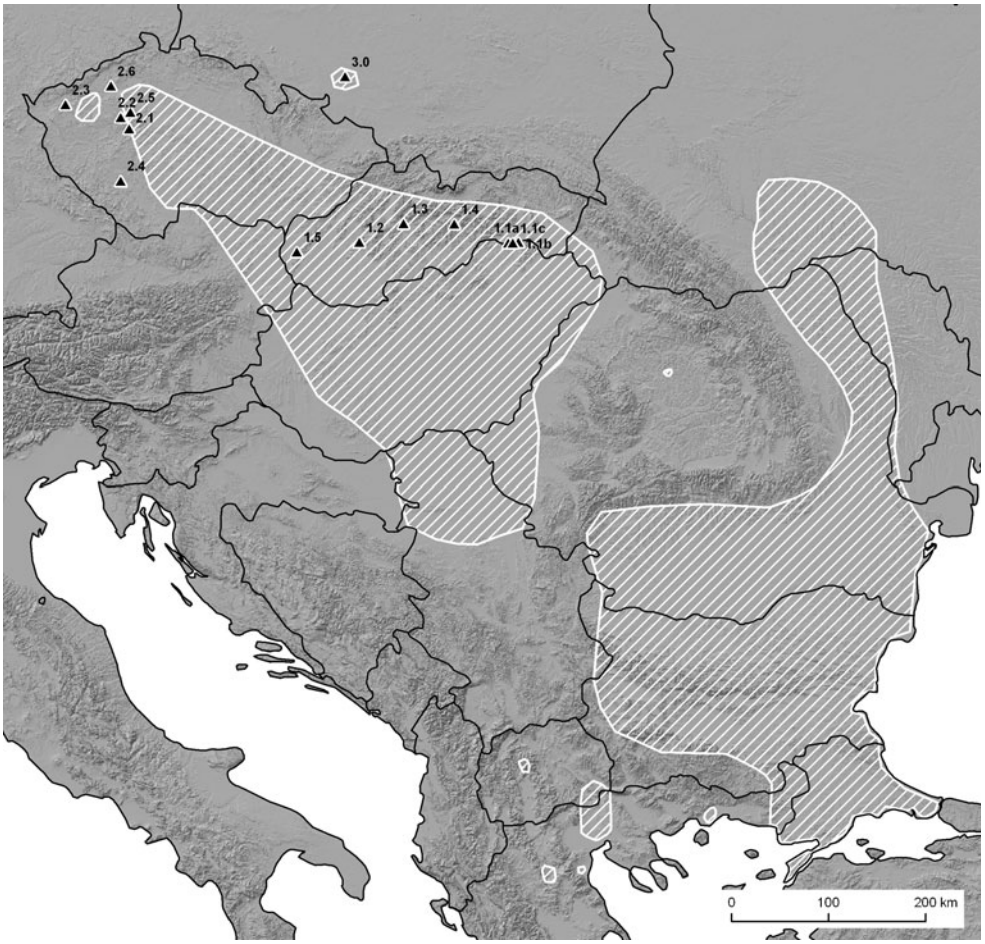

Fig. 1 Map of sites where European ground squirrels were reintroduced and the total distribution of the species in Europe (IUCN 2011) marked by *hatched lines*. Legend: Slovakia: *1.1a* Buzica, *1.1b* Milhosť, *1.1c* Perín-Chým, *1.2* Breziny, *1.3* Jakub, *1.4* Biele vody, *1.5* Kuchyňa; Czech Republic: *2.1* Zlatý Kůň, *2.2* Novina, *2.3* Vítkův vrch, *2.4* Řepické rybníky, *2.5* Velká Dobrá, *2.6* Písečný vrch; Poland: *3.0* Kamień Śląski

Methods

Data collection

We collected data from electronic journal databases, databases of national libraries, web searches and personal references. At least in six cases, data about *S. citellus* reintroductions and translocations in Central Europe that have never been published were also included. We also asked wildlife managers from several governmental and non-governmental institutions about their experience with ground squirrel reintroductions. Wildlife managers provided us detailed and mostly unpublished information about reintroductions that were part of wildlife rescue projects as well as about any reintroduction attempts. Raw data, including detailed descriptions of reintroduction projects but without a detailed evaluation, were published by Matějů et al. (2010b).

Data analysis

Information about *S. citellus* reintroduction projects have a high variability in the quality of data, with some parameters missing. Therefore, we selected particular aspects of reintroductions and evaluated these separately. Some reintroduction projects consisted of releasing the *S. citellus* at a few distinct sites, with no possibility for released animals to disperse among them. In such cases, reintroductions at these sites were considered and evaluated as independent projects.

We focused on the following aspects:

1. Site selection—non-specific, based on the opinion of wildlife managers; or specific, based on the former occurrence of ground squirrels
2. Methods of releasing—we used a division according to Beck et al. (1994), i.e. hard and soft. Hard releasing means that animals were released directly at the site without any preadaptation period or artificial support after release (Beck et al. 1994). Soft releasing means releasing of animals into abandoned or artificial burrows with a retention cap and/or enclosures, occasionally also with a food supply
3. Date of releasing—in the spring (during the mating season, focused on the transfer of females in the early stage of gestation) and/or late summer (after weaning of juveniles)

4. The origin of released animals—from the wild or mixed groups of wild animals and animals bred in captivity
5. Number of released individuals during the whole project
6. Mean number—mean number of released individuals per season and
7. Management of release site—management could be either insufficient (absent or insufficient—low frequency of mowing or low intensity of grazing—high vegetation cover and presence of shrubs/high intensity of grazing—destruction of vegetation cover and soil surface) or sufficient (mowing and grazing provided at optimal frequency and intensity—height of vegetation cover never exceed 20 cm, only sporadic shrubs are present).

Success of the reintroduction project was evaluated according to three criteria: survival of the animals after release (phase I), settlement of the released individuals at the site of release (phase II) and proven reproduction of the released animals (phase III; Letty et al. 2003; Teixeira et al. 2007).

Statistical analysis

Site management was not included in the statistical analyses because it was not known in five cases. Firstly, we looked for important factors influencing classification of the reintroduction to one of the three success criteria, performing a classification tree analysis in STATISTICA 8.0 (StatSoft Inc. 2007). This method is nonlinear and nonparametric. The stop criterion for splitting was based on misclassification. For computational details involved in determining the best split conditions to construct a simple and informative tree see Breiman et al. (1984) for a discussion on their CART® algorithm.

Then, we analysed the probability of settlement (yes/no) and reproduction (yes/no) in relation to the evaluated predictors. These analyses were done by forward selection in generalised linear models (GLM) for binomial distribution with a logit link function in the programme R 2.12 (http://cran.r-project.org/). The best model was selected based on Akaike information criterion.

Results

We summarised all available information and analysed aspects of 12 ground squirrel repatriation projects in Central Europe. Within these 12 projects, about 2,500 ground squirrels were released at 14 distinct sites (see Fig. 1 and Table 1). In Slovakia, five projects have been organised since 1992 (one of them is still in process). They were usually not primarily focused on *S. citellus* conservation, but as support for the foraging base of the saker falcon (*Falco cherrug*) and the imperial eagle (*Aquila heliaca*; "LIFE" projects). One of the Slovak projects (Repatriation of *S. citellus* in the Košice region) was evaluated as three separate reintroductions because it comprised releases of animals at three distinct sites in the Košice region (Budayová 1995). Six projects are known from the Czech Republic during 1988–2007, and one project starting in 2000 is still in progress in Poland. All reintroduction projects in the Czech Republic and Poland were primarily focused on conservation of the *S. citellus*. Aspects and results of these repatriation projects are reviewed in Table 1.

Site selection

More than half of the reintroduction projects (8 of 14) used specific site selection based on the previous occurrence of ground squirrels at the site or in the close surroundings (see Table 1). Five of these projects were successful and reproduction of released animals was observed. In one case during repatriation at Vítkův vrch (CZ), animals moved ca 400 m from the site of release, but then also settled and started to reproduce. Two projects reached phase II (settlement of released animals), but ground squirrel populations at the localities were destroyed by cattle in one case (Perín-Chým, SK) (Budayová 1995). In the second case (Řepické rybníky, CZ), the reason the population went extinct is unknown. The last of these projects (Písečný vrch, CZ) failed shortly after the release of animals (between phases I and II).

Non-specific site selection was used in six cases (see Table 1). In projects using non-specific site selection, released individuals moved into the surroundings or they dispersed to suitable places and repatriation usually failed. Only two of these projects (Kuchyňa, SK and Velká Dobrá, CZ) resulted in a sustainable colony because animals found appropriate habitats near the site of the release.

Methods of releasing

In 11 of 14 reintroductions in Central Europe, the soft method of releasing was used (see Table 1). One of these projects (site Jakub) failed soon after the release of animals, probably due to the dissipation of individuals to the surroundings. The survival and settlement of ground squirrels at the site was successful in three projects, but reproduction was not observed. Seven projects resulted in colonies with reproduction observed in the year following release. Hard or combined (first hard and then soft) releasing was used in only three projects, and all failed.

Date of releasing

For two of the reintroduction projects, the season of release is not known. Releasing in early spring was used in three

Table 1 Overview of the European ground squirrel reintroduction projects taking place in the Czech Republic, Slovakia and Poland

Reintroduction project, duration, site name	Site selection	Method of releasing	Date of releasing	Origin of animals	No. of released individual	No. of seasons/ mean per season	Site management	Success of project
Košice fold—SK (1992–1993), Buzica	Specific	Soft	Spring	Wild	66[a]	2/33.00[a]	No data	Phase III—reproduction
Košice fold—SK (1992–1993), Milhosť	Specific	Soft	Spring	Wild	66[a]	2/33.00[a]	No data	Phase III—reproduction
Košice fold—SK (1992–1993), Perín-Chým	Specific	Soft	Spring	Wild	66[a]	2/33.00[a]	Insufficient[a]	Phase II—settlement
Protected Landscape Area Ponitrie—SK (2003–2006), Breziny	Non-specific	Soft	Summer	Wild	47	4/11.75	No data	Phase II—settlement
Nízké Tatry Mts. National Park—SK (2005–2006), Jakub	Non-specific	Soft	Spring and summer	Wild	74	2/37.00	No data	Phase I—survival
Muránská planina National Park—SK (2000–2009), Biele Vody	Specific	Soft	Spring and summer	Wild	1,057	10/105.70	Sufficient	Phase III—reproduction
Malé Karpaty Mts. Protected Landscape Area—SK (2004–2010), Kuchyňa	Non-specific	Soft	Spring and summer	Wild	950	7/135.70	Sufficient	Phase III—reproduction
Český kras Protected Landscape Area—CZ (1989–1992), Zlatý Kůň	Non-specific	Combined	No data	Mixed	58	4/14.50	Sufficient	Phase II—settlement
Protected Landscape area Křivoklátsko—CZ (1994–1998), Novina	Non-specific	Hard	Spring and summer	Mixed	39	5/7.80	Sufficient	Phase I—survival
Protected Lanscape Area Slavkovský les—CZ (2000–2001), Vítkův vrch	Specific	Soft	Summer	Wild	60	2/30.00	First sufficient, lately insufficient	Phase III—reproduction
Repatriation project in Strakonice District—CZ (1989–1990), Řepické rybníky	Specific	Soft	Summer	Wild	30	2/15.00	No data	Phase II—settlement
Velká Dobrá—CZ (2007)	Non-specific	Soft	Summer	Wild	10	1/10.00	Sufficient	Phase III—reproduction
Písečný vrch u Milé Natural Monument—CZ (1992)	Specific	Hard	No data	Wild	4	1/4.00	Insufficient	Phase I—survival
Reintroduction of the *S. citellus* to Poland (2005–2008), Kamien Śląski	Specific	Soft	Spring and summer	Mixed	306	4/76.50	Sufficient	Phase III—reproduction

[a] Estimated data; success of project—see "Methods" for details

repatriation projects in the Košice region (SK). During April, ground squirrels were released at three target localities. At two sites survival and reproduction of released animals were observed, while at the Perín-Chým locality settlement was observed, but the population was later destroyed by wintering cattle that completely crush vegetation cover and turn soil surface in to mud (Budayová 1995).

Transfers of animals in summer (from June to early September) were attempted in four projects. In two of them, animals were reported to settle at the site of release, and in the other two projects reproduction was also successful.

Both early and late releases were performed in five projects; in two of them survival, but not the settlement of released animals, was observed at the target locality. Three projects were successful and resulted in populations with successful reproduction.

In summary, spring, late summer and combined periods of transfer all resulted in stable populations in some cases. For overview, see Table 1.

Origin of animals

Animals from wild populations were used in all of the reintroduction projects studied here. They usually came from nearby abundant populations or as rescue transfers from populations threatened by destruction (e.g. construction, ploughing, etc.). At three sites, Novina (CZ), Zlatý Kůň (CZ) and Kamien Śląski (PL), animals first reproduced in captivity and their offspring were also released. At Zlatý Kůň the survival and settlement of released animals was observed, but the colony later vanished (Jansová 1992). During the Novina reintroduction project, there was a severe infection of ground squirrels in captivity by ectoparasites (mostly fleas) and the mixed population of wild and captive individuals disappeared before reaching phase II (Hulová 2005). In Poland, none of the above-mentioned negative events were observed and the project seems to be successful.

Number of individuals

The number of released individuals varied greatly among both the reintroduction projects and seasons. The lowest number of animals used for reintroduction was 4 and the highest 1,057 individuals. As expected, the success of reintroduction increases with the number of released animals, but the mean number of reintroduced individuals per season is statistically more important than their total amount during the whole project (see below).

Management of the release site

Of the 14 repatriations, 5 reintroductions lack information on the subsequent management of vegetation cover at the release site. In six projects, management of the release site was sufficient (i.e. was sufficiently mowed or grazed). As mentioned above, at Novina, CZ released animals survived but did not settle, and at Zlatý Kůň, CZ animals survived and settled, but later they vanished (Jansová 1992). At four sites (Kuchyňa, Muránská planina, SK; Velká Dobrá, CZ and Kamien Śląski, PL), the reproduction of released ground squirrels was observed.

Insufficient vegetation cover management caused the extinction of the colony at the locality Perín-Chým (SK) (Budayová 1995). Repatriation at Písečný vrch (CZ) probably also failed due to insufficient management as well as the small number of released individuals. The project at Vítkův vrch (CZ) demonstrates the importance of appropriate release-site management. Regular management of the locality was halted during the project and the overgrowing vegetation probably caused released animals to move to a different site.

Analysis of the reintroduction programmes

Based on statistical analysis, the method of releasing was identified as the main factor leading to the three possible scenarios of the reintroduction programme (survival, settlement and reproduction; Fig. 2). Hard releasing leads only to the survival of individuals, not to settlement or reproduction. When a soft or combined (used only at the site Zlatý Kůň, CZ) release method was used, the median number of animals released per season was the essential factor. The crucial number of animals was 23, and when more animals were released, the project was nearly always successful and animals reproduced.

The probability of settlement itself is only influenced by the release method (forward selection GLM, chi square= 7.3, df=1, p=0.007). The probability of reproduction depends only on the median number of released animals per season (forward selection GLM, chi square=6.4, df=1, p=0.011) (Fig. 3).

Discussion

Reintroductions of ground squirrels and similarly living prairie dogs were rare until the 1990s and only limited information about this topic was published (e.g. Brown et al. 1974; Panzer and Schipp 1986). As such, it is clear that the first reintroductions of the *S. citellus* in Central Europe were based only on the judgement and enthusiasm of wildlife managers (Jansová 1992; Budayová 1995; Hulová 2005).

From the seven aspects of *S. citellus* reintroductions analysed, the method of releasing and number of animals released per season were identified as the key factors in

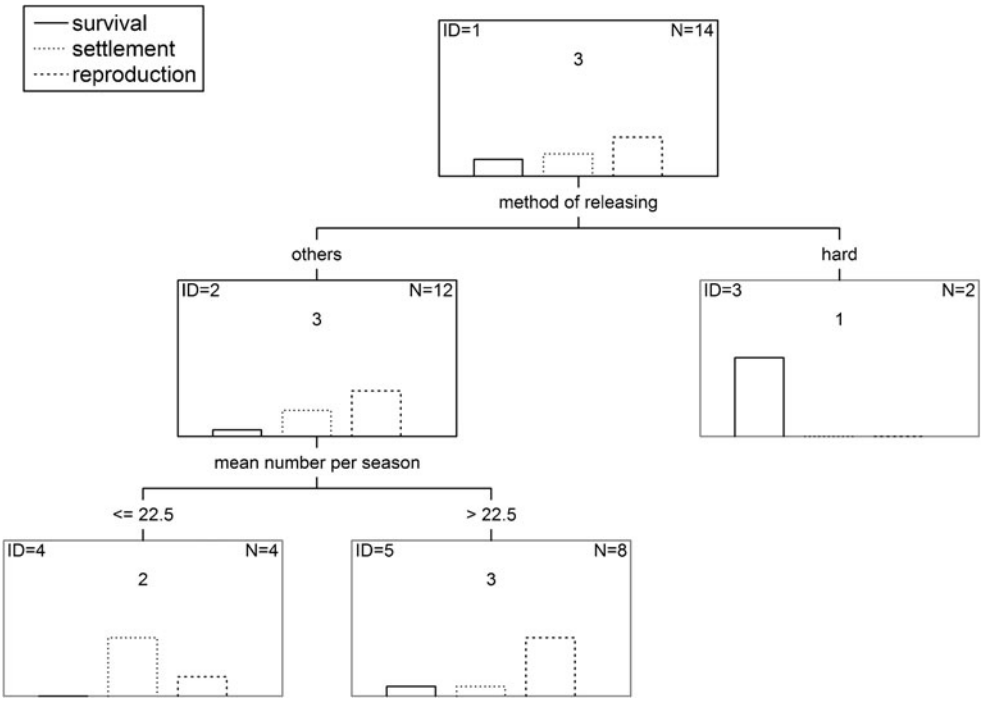

Fig. 2 A regression tree showing significant aspects affecting the results of reintroduction attempts. Success of reintroduction depends first on the method of releasing and second on mean number of individuals released per season. *ID*—sequence number of splitting node, *N*—number of reintroduction attempts in each particular group

determining success. In agreement with Gedeon et al. (2011), we found that a soft method of releasing (usage of artificial burrows and/or fences) is essential for a successful reintroduction (Fig. 2). Soft releasing methods prevent animals from panicking, moving erratically and rapidly leaving the release site. The panic reaction of ground squirrels was well documented during the first season of the reintroduction programme at the locality Zlatý Kůň, where two individuals were found to have been run over on a nearby road a short time after releasing (Jansová 1992). It is necessary to keep animals at the release site and allow them to get familiar with their new surroundings, establish a new social order and locate food sources (Short et al. 1992). Soft release methods result in more animals settling and remaining at the release site (e.g. Van Vuren et al. 1997).

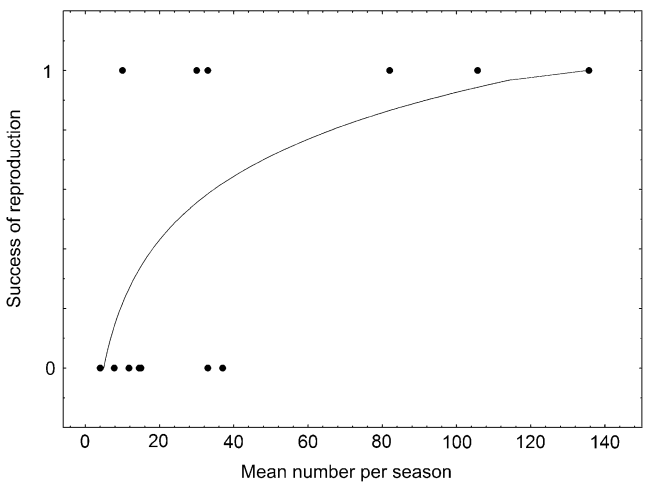

Fig. 3 Relationship between the mean numbers of European ground squirrel released per season and the probability of reproduction success (phase III). *Each dot* represents one reintroduction attempt

Maintaining the animals at a release site can be attained using artificial burrows and/or enclosures. The clear advantage of artificial burrows is that they protect animals against unsuitable weather conditions including hypo- and hyperthermia (Long et al. 2005; Gedeon et al. 2011). Enclosures lack this function; however, they also ensure retention of the animals at the release site. Their advantage compared to artificial burrows is that they protect the released animals against predators (e.g. Hapl et al. 2006; Truett et al. 2001). For instance Hapl et al. (2006) observed systematic predation of ground squirrels released into artificial burrows by the European badger (*Meles meles*). A combination of both artificial burrows and enclosures appears to be most advantageous. When the usage of enclosures is too expensive, it is recommended to substitute their protective function by directly guarding the release site for at least 2 or 3 days, 24 h a day (Hapl et al. 2006). Reduction of post-release stress and dispersal tendencies can be achieved by supplementary food and water (Truett et al. 2001). As one would expect, the success of reintroduction is increased by releasing more animals at the site (e.g. MacArthur and Wilson 1967). In the projects reviewed here, the number of individuals varied considerably, from 4 to 1,057 (Table 1). The number of animals in successful projects had almost the same range (from 10 to 1,057). In our analysis, the median number of released individuals per season was a more important factor affecting reintroduction success than the total numbers during the whole project. The critical number

was an average of 23 individuals per season (Fig. 2), but as estimated by the best GLM, the minimum number for a successful reintroduction is approximately 60 individuals per season (Fig. 3). A similar number has also been recommended for reintroductions of black tailed prairie dogs (*Cynomys ludovicianus*; Robinette et al. 1995). Dullum et al. (2005) found no significant difference in survival between released groups of 60 and 120 prairie dogs, but they recommend releasing a minimum of 120 individuals, since the more numerous groups had a higher population growth rate and hence a greater proportional increase in colony size.

There are no data on the duration of reintroductions and frequency of animal releases. However, from our data it is clear that for the successful establishment of a new population it is necessary to release animals within a short period (a maximum of two or three seasons). Conversely, it is unsuitable to release animals into a locality several times, in small numbers and with long time gaps (even years) between individual release attempts (as was done e.g. at Novina, CZ). The positive effect of newly released individuals is probably reduced in this situation because the population abundance may already be decreased due to predation, unsuitable weather conditions, etc. In extreme cases the subsequent release may act as a new (independent) reintroduction attempt, as formerly released individuals may have completely disappeared from the locality (e.g. Breziny, SK).

Differences in the two release periods studied here, spring versus late summer, are probably not critical. In both cases, the animals probably have enough time to get used to a new site, establish social interactions and store fat reserves for the coming hibernation.

The origin of animals was also not found to be very important. With the exception of Poland, the animals used in these projects were mainly from the wild, with a minority from captivity. McPhee (2003) demonstrated two effects of captive breeding on the deer mouse (*Peromyscus polionotus subgriseus*): a decrease in reaction to predators and higher behavioural variance, which could translate into increased variability in survivorship during reintroduction. Aaltonen et al. (2009) observed higher mortality, predominantly caused by aerial predators, in captive bred Vancouver Island marmots (*Marmota vancouverensis*). Such detailed data are not available for the *S. citellus* though Budayová (1995) warned about such problems. However, none of these problems were reported during the reintroductions in Poland.

Due to lacking information, it was not possible to evaluate the management of release sites. However, from regular monitoring data (Matějů et al. 2008) and field experience (Grulich 1960; Hapl et al. 2006), it is evident that mowing or grazing localities to maintain low grass cover is crucial for a long-term prosperous and stable ground squirrel population. Similarly, Truet et al. (2001) mentioned vegetation management as the most commonly cited management needed for prairie dog (*Cynomys* spp.) colonies.

Recommendations for the future

We hope to call attention to the procedures used in successful projects so that basic mistakes can be avoided and meaningful reintroductions can be performed. Appropriate conditions at the site of release, i.e. prepared burrows, protection from predators and additional food, seem to be critical for the acclimatisation of animals and their successful settlement at the locality. In future reintroduction attempts, we should target efforts on breeding of the species in captivity. For example, reproduction of the Vancouver Island marmot (*M. vancouverensis*) endemic to Vancouver Island in British Columbia has been accomplished at several captive breeding centres across Canada, and reintroductions back to the wild have been successful (Vancouver Island Marmot Recovery Team 2008; Aaltonen et al. 2009).

Another important factor is that newly reintroduced populations should not be isolated. To establish a new stable population is the first step, but it is not feasible to sustain a viable population resistant to unpredictable events (weather extremes, predation stress, diseases, etc.) without the possibility of immigration from neighbouring populations. In addition, small and isolated populations can be affected by inbreeding depression (mating between related animals) (Allendorf and Luikart 2007; Hulová and Sedláček 2008). Thus, a combination of the soft releasing of a sufficient number of animals and continued site maintenance will result in the best chance for a successful reintroduction.

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References

Aaltonen K, Bryant AA, Hostetler JA, Oli MK (2009) Reintroducing endangered Vancouver Island marmots: survival and cause-specific mortality rates of captive-born versus wild-born individuals. Biol Conserv 142:2181–2190

Allendorf FW, Luikart G (2007) Conservation and the genetics of populations. Blackwell, Malden

Ambros M (2008) Stav poznania rozšírenia sysľa pasienkového (*Spermophilus citellus*) na Slovensku v rokoch 1996 až 2008 [Current knowledge on the distribution of the European ground squirrel (*Spermophilus citellus*) in Slovakia in 1996–2008]. Lynx 39:219–233, in Slovak, with a summary in English

Baláž I, Jančová A, Ambros M (2008) Reštitucia sysla pasienkového (*Spermophilus citellus)* na Slovensku [Restitution of the European

ground squirrel (*Spermophilus citellus*) in Slovakia]. Lynx 39:235–240, in Slovak, with a summary in English

Beck BB, Rapaport LG, Stanley Price MR, Wilson AC (1994) Reintroduction of captive-born animals. In: Olney PJS, Mace GM, Feistner ATC (eds) Creative conservation: interactive management of wild and captive animals. Chapman and Hall, London, pp 265–286

Biedrzycka A, Konopiński MK (2008) Genetic variability and the effect of habitat fragmentation in spotted suslik *Spermophilus suslicus* populations from two different regions. Conserv Genet 9:1211–1221

Breiman L, Friedman JH, Olshen RA, Stone CJ (1984) Classification and regression trees. Wadsworth & Brooks/Cole Advanced Books & Software, Monterey

Brown DE, Todd RL, Levy SH (1974) Proposal for the reintroduction of the Black-tailed Prairie Dog into Arizona. Arizona Small Game Investigations 1972–1973–1974, p. 5

Budayová J (1995) Skúsenosti z repatriácie sysľa obyčajného (*Citellus citellus* L. 1758) v Košickej kotline [Experiences with repatriation of the European souslik in Košická basin]. In: Urban P, Baláž D (eds) Výskum a ochrana cicavcov na Slovensku II [Mammal Research and Conservation in Slovakia II]. Štátna ochrana prírody SR, Banská Bystrica, pp 103–107, in Slovak, with a summary in English

Cepáková E, Hulová Š (2002) Current distribution of the European souslik (*Spermophilus citellus*) in the Czech Republic. Lynx 33:89–103

Dullum JAL, Foresman K, Matchett MR (2005) Efficacy of translocations for restoring populations of Black-tailed prairie dogs. Wildl Soc Bull 33:842–850

Enzinger K, Holzer T, Walder C (2008) Management of European ground squirrel habitats in Lower Austria—origin, options and objectives. Lynx 39:345

Feiler A (1988) Über das ehemalige Zieselvorkommen in der DDR (Rodentia, Sciuridae, *Spermophilus citellus* L. 1766). Rudolfstädter Naturhistor Schr 1:115–118

Fischer J, Lindenmayer DB (2000) An assessment of the published results of animal relocations. Biol Conserv 96:1–11

Gedeon CI, Vászi O, Koósz B, Altbäcker V (2011) Morning release into artificial burrows with retention caps facilitates success of European ground squirrel (*Spermophilus citellus*) translocations. Eur J Wildl Res. doi:10.1007/s10344-011-0504-3

Griffith B, Scott JM, Carpenter JW, Reed C (1989) Translocation as species conservation tool: status and strategy. Science 245:477–480

Grulich I (1960) Sysel obecný *Citellus citellus* L. v ČSSR. [European Ground Squirrel *Citellus citellus* L. in Czechoslovakia]. Práce Brněnské Zákl Českosl Akad Věd 32(11):473–563, in Czech, with a summary in English

Hafner DJ, Yensen E, Kirkland GL Jr (eds) (1998) North American rodents. Status, survey and conservation action plan. IUCN/SSC Rodent Specialist Group. IUCN, Gland

Hapl E, Ambros M, Olekšák M, Adamec M (2006) Reštitucia sysla pasienkového (*Spermophilus citellus*) v podmienkách Slovenska [Restitution of the European ground squirrel (*Spermophilus citellus*) under conditions of Slovakia]. Metodická príručka. Štátná ochrana prírody SR, Banska Bystrica, in Slovak

Hoogland JL (2007) Conservation of prairie dogs. In: Wolff JO, Sherman PW (eds) Rodent Societes: an ecological and evolutionary perspective. The University of Chicago Press, Chicago

Hulová Š (2005) Hodnocení realizovaných a probíhajících projektů aktivní ochrany sysla obecného (*Spermophilus citellus*) v České republice [Evaluation of effected and ongoing active measures of European ground squirrel protection in the Czech Republic]. In: Kumstátová T, Nová P, Marhoul P (eds) Hodnocení projektů aktivní podpory ohrožených živočichů v České republice [Evaluation of active protection measures of endangered animals in the Czech Republic]. AOPK ČR, Praha, pp 397–405 (in Czech)

Hulová Š, Sedláček F (2008) Population genetic structure of the European ground squirrel in the Czech Republic. Conserv Genet 9:615–625

IUCN (1998) Guidelines for re-introductions: prepared by the IUCN/SSC Re-introduction Specialist Group. IUCN, Gland

IUCN (2011) IUCN Red List of Threatened Species. Version 2011.1. Available at http://www.iucnredlist.org/apps/redlist. Accessed 07 May 2011

Jacobi A (1902) Der Ziesel in Deutschland. Arbeiten Biol. Abt. Land- und Forstwirtschaft Kaiser. Gesundheitsamte 2(4):506–511

Jansová A (1992) Projekt na záchranu sysla v Českém krasu [The project for saving of European Souslik in Český kras]. In: Anonymous (eds) Metody a výsledky studia drobných savců [Methods and results of the small mammals studies]. Nasavrky 30.3.-2.4.1992, Chrudim, pp. 31–34 (in Czech, with a summary in English)

Kala B, Kepel A (2006) Reintroduction programme of *Spermophilus citellus* in Poland. In: Anonymous (eds) First European Ground Squirrel Meeting. Book of Programme and Abstracts. 20–24. Oct. 2006, Felsőtárkány, Hungary

Koshev YS (2008) Method of releasing and number of animals are determinants for the success of European ground squirrel (*Spermophilus citellus*) reintroductions. Lynx 39:251–261

Letty J, Aubineau S, Clobert J (2003) Effect of translocation on survival in wild rabbit (*Oryctolagus cuniculus*). Mamm Biol 68:250–255

Lockhart JM (2009) Reintroduction of the Black-footed ferret to the Great plains of North America: Do we really have the capabilities, resources and socio/political will to recover critically endangered species in the United States? An opinion. In: Vargas A, Breitenmoser C, Breitenmoser U (eds) Iberian Lynx ex situ conservation: An interdisciplinary approach. Fundación Biodiversidad, Madrid, Spain, pp 478–488

Lockhart JM, Thorne ET, Gober DR (2006) A historical perspective on recovery of the black-footed ferret and the biological and political challenges affecting its future. In: Roelle JE, Miller BJ, Godbey JL, Biggins DE (eds) Recovery of the Black-footed Ferret: Progress and Continuing Challenges. U.S. Geological Survey, pp 6–19

Long RA, Martin TJ, Barnes BM (2005) Body temperature and activity patterns in free-living Arctic ground squirrels. J Mammal 86:314–322

MacArthur RH, Wilson EO (1967) The theory of island biogeography. Princeton University Press, Princeton

MacNab J (1983) Wildlife management as scientific experimentation. Wildl Soc Bull 11(4):397–401

Matějů J, Nová P, Uhlíková J, Hulová Š, Cepáková E (2008) Distribution of the European ground squirrel (*Spermophilus citellus*) in the Czech Republic in 2002–2008. Lynx 39:277–294

Matějů J, Hulová Š, Nová P, Cepáková E, Marhoul P, Uhlíková J (2010a) Action plan for the European ground squirrel (*Spermophilus citellus*) in the Czech Republic. Univerzita Karlova v Praze & AOPK ČR, Praha

Matějů J, Říčanová Š, Ambros M, Kala B, Hapl E, Matějů K (2010b) Reintroductions of the European ground squirrel (*Spermophilus citellus*) in Central Europe (Rodentia: Sciuridae). Lynx 41:175–191

McPhee ME (2003) Effects of captivity on response to a novel environment in the Oldfield mouse (*Peromyscus polionotus subgriseus*). Int J Comp Psychol 16:85–94

Meczynski S (1985) Czy susel moregowany, *Spermophilus citellus* Linnaeus, 1766, wystepuje jeszcze w Polsce [Does the European ground squirrel, *Spermophilus citellus* Linnaeus, 1766, still occur in Poland?]. Przeglad zool 29:521–526, in Polish, with a summary in English

Mitchell-Jones AJ, Amori G, Bogdanowicz W, Kryštufek B, Reijnders PJH, Spitzenberger F, Stubbe M, Thissen JBM, Vohralík V, Zima J (1999) The atlas of European mammals. Academic, London

Panzer R, Schipp M (1986) Franklin's ground squirrel translocated to an Illinois prairie preserve. Restor Manag Notes 4:27

Robinette KW, Andelt WF, Burnham KP (1995) Effect of group size on survival of relocated prairie dogs. J Wildl Manag 59:867–874

Roe KA, Roe CM (2003) Habitat selection guidelines for black-tailed prairie dog relocations. Wildl Soc Bull 31:1246–1253

Short J, Bradshaw SD, Giles J, Prince RIT, Wilson GR (1992) Reintroduction of macropods (Marsupialia: Macropodoidea) in Australia—a review. Biol Conserv 62:189–204

Spitzenberger F (2001) Die Säugetierfauna Österreichs. Bundesministerium für Land- und Fortswirtschaft, Umwelt und Wasserwirtschaft, Graz

Teixeira CP, Schetini De Azebedo C, Mendl M, Cipreste CF, Young RJ (2007) Revisiting translocation and reintroduction programmes: the importance of considering stress. Anim Behav 73:1–13

Truett JC, Dullum JLD, Matchett MR, Owens E, Seery D (2001) Translocating prairie dogs: a review. Wildl Soc Bull 29:863–872

U.S. Fish and Wildlife Service (2003) Recovery plan for the Northern Idaho ground squirrel (*Spermophilus brunneus brunneus*). U.S. Fish and Wildlife Service, Portland

Van Horne B (2007) Conservation of Ground Squirrels. In: Wolff JO, Sherman PW (eds) Rodent societes: an ecological and evolutionary perspective. The University of Chicago Press, Chicago, pp 463–471

Van Vuren D, Kuenzi AJ, Loredo I, Leider AL, Morrison ML (1997) Translocation as a nonlethal alternative for managing California ground squirrels. J Wildl Manag 61:351–359

Vancouver Island Marmot Recovery Team (2008) Recovery strategy for the Vancouver Island marmot (*Marmota vancouverensis*) in British Columbia. B.C Ministry of Environment, Victoria

Werth E (1936) Zur Verbreitung und Geschichte des Ziesels. Arbeiten Biol Reichsanstalt Land- und Forstwirtschaft 21:255–267, 637

Wilson DE, Reeder DE (eds) (2005) Mammal species of the world. A taxonomic and geographic reference, 3rd edn. Johns Hopkins University Press, Baltimore