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Large scale translocation and habitat compensation of amphibian and reptile populations in the course of the redevelopment of a waste disposal site

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Großflächige Umsiedlung von Amphibien- und Reptilien-Populationen sowie Anlage von Ersatzlebensräumen im Zuge einer Deponiesanierung

Die Sanierung einer ungeschützten Deponie (Klärschlamm und Hausmüll) südlich der Stadt Salzburg (Österreich) und die darauf folgende Umwandlung des Großteils dieses Areals in ein Gewerbegebiet, erforderte die Zerstörung von naturnahen Auwald- und Ruderalstrukturen in einem aufgelassenen Schotterabbau. Eine Vorstudie zur Verbreitung von Amphibien und Reptilien im Jahr 2001 ergab einen hohen Artenreichtum. Alle Arten der Herpetofauna sind im Bundesland Salzburg geschützt. Im Zuge eines UVP-Verfahrens seitens der verantwortlichen Behörden wurde eine umfangreiche Umsiedlung der Herpetofauna vorgeschrieben. Um die Amphibien- und Reptilienfauna umzusiedeln, wurden in den Monaten Juli und August 2002 an drei verschiedenen Stellen südlich des Eingriffsvorhabens neue Lebensräume in Form von insgesamt 10 Laichgewässern angelegt. Darüber hinaus wurde in unmittelbarere Nähe zur Salzach eine 2 000 m² großen Sukzessionsfläche mit Weidengebüsch gerodet und mit Eiablage- und Steinhaufen strukturiert. Nach dem Ende der Umsiedlung wurden im Umfeld des Eingriffsgebietes und in den drei Gebieten mit neuen Lebensräumen weitere 29 Stillgewässer, sowie zahlreiche terrestrische Strukturen für Reptilien und Amphibien angelegt. In der Zeit von 22. Juli 2002 bis 29. Juni 2003 wurden auf der ca. 15 ha großen zu räumenden Deponiefläche mittels 4 370 m Amphibienschutzzaun sieben Fangfelder errichtet. Zusätzlich wurden 20 Schlangenbleche und 20 Fangkreuze aus Holz installiert. Neben der täglichen bis zweitäglichen Kontrolle dieser Fangeinrichtungen wurden die in den Deponieflächen befindlichen Stillgewässer abgekeschert. Insgesamt wurden 8 125 Individuen (7 349 Amphibien, 776 Reptilien) aus 7 Amphibienarten (*Rana temporaria, Bufo bufo, Hyla arborea, Triturus alpestris, Triturus vulgaris, Triturus cristatus, Salamandra salamandra*) und 5 Reptilienarten (*Anguis fragilis, Lacerta agilis, Zamenis longissimus, Natrix natrix, Coronella austriaca)* gefangen. Ohne die Amphibienlarven waren es 2 208 Individuen – das entspricht dem 7,5-fachen, der im Zuge der 2001 durchgeführten Vorstudie festgestellten 291 Individuen. Ein in den Jahren 2003 bis 2005 durchgeführtes Monitoring ergab, dass alle neu angelegten Lebensräume besiedelt und mit Ausnahme der Schlingnatter (*Coronella austriaca*) und des Teichmolches (*Triturus vulgaris*) für alle Arten auch Reproduktion festgestellt wurde. Die verschiedenen Fangmethoden werden bezüglich der gefangenen Individuenzahlen empirisch verglichen. Es zeigt sich deutlich, dass die Fangzäune gegenüber den verwendeten Holzkreuzen und den Schlangenblechen am effizientesten funktionieren. Aus den Ergebnissen lässt sich folgern, dass sich Umsiedlungsaktionen mindestens über den Zeitraum eines gesamten Jahres erstrecken sollten. Aufbauend auf den vorliegenden Ergebnissen wird für künftige Fangaktionen ein engmaschiges Netz von Amphibienschutzzäunen in der Größenordnung von maximal 100 x 100 m Seitenlänge und einem Abstand der Fangbehälter von 20 m vorgeschlagen. Die Amphibienschutzzäune sind je nach Witterung 1- bis 2-mal täglich zu kontrollieren. In den Wintermonaten bleibt der Zaun stehen, allerdings werden die Fangbehälter mit Deckeln verschlossen.

Schlüsselbegriffe: Amphibia, Reptilia, Umsiedlung, Ersatzlebensraum, Salzburg, Österreich.

Abstract

The removal of sludge and domestic waste from an old disposal site south of the city of Salzburg was required in order to redevelop the area into a business park together with a slip road connecting the latter to the motorway nearby. A pre-study in 2001 showed high amphibian and reptile diversity in this area. Since all amphibian and reptile species are strictly protected by federal nature conservation laws, a strategy for translocation and compensation measures had to be worked out as one part of an environmental impact assessment (EIA). At the beginning of 2002, ten spawning ponds were created in three receptor areas of similar or larger size than the donor site. Additionally an area of 2 000 m² in a shrub encroachment dominated by willows (*Salix* spp.) at receptor site 02 was cleared and restructured with gravel heaps and egg deposition sites. The business park area itself was surrounded by a total of 5 000 m of concrete barriers to shut out amphibians, reptiles and other small terrestrial animals. Further 29 ponds and puddles and habitat structures for reptiles were created as compensation measures after the completion of the translocation. Altogether 8 125 specimens (7 349 amphibians, 776 reptiles) of seven amphibian (*Rana temporaria, Bufo bufo, Hyla arborea, Triturus alpestris, Triturus vulgaris, Triturus cristatus, Salamandra salamandra)* and five reptile species *(Anguis fragilis, Lacerta agilis, Zamenis longissimus, Natrix natrix, Coronella austriaca*) were captured and transferred to the new habitats. Leaving aside all amphibian larvae, a total number of 2 208 individuals were rescued, which is more than 7.5-times the number of pre-study recordings. Compared to the pre-study two further species were recorded in small numbers. During three years of monitoring (2003–2005) a total number of 181 observations of amphibians or reptiles in 69 localities were documented. In 33 of 39 (85 %) newly created ponds the presence of 2–7 amphibian species was documented. Successful reproduction of 1–6 species was observed in 10 ponds. Reproduction was also documented for four reptile species at receptor site 02. Only the smooth snake was observed just once without indication of reproduction. Different methods of capturing herpetofauna are discussed and general implications are proposed.

Key words: Amphibia, Reptilia, translocation, habitat compensation, Salzburg, Austria.

Introduction

Protected animal species are frequently subject of conflicts between development and conservation in Europe. In such cases there are several options applicable, including compensation, habitat enhancement and translocations (e. g. PLATENBERG & GRIFFITHS 1999). While translocations earlier have been used for reintroduction or augmentation

(e. g. GRIFFITH et al. 1989, FISCHER & LINDENMAYER 2000), a further type involves the temporal or permanent removal of individuals or populations from locations that are scheduled for development into new habitats (e. g. NOWAK & ZSIVANOVITS 1981, COOKE & OLDHAM 1995, PLATENBERG & GRIFFITHS 1999, EDGAR et al. 2005). The number of published translocations of amphibians and reptiles is comparably low (FISCHER & LINDENMAYER 2000). There are controversial views concerning the conservation value and the evaluation of such exercises (e. g. HENLE et al. 1999, MARSH & TRENHAM 2001, SEIGEL & DODD 2002). Several sets of guidelines and recommendations for dealing with protected species in cases of land use conflicts have been published (e. g. LANGTON & BURTON 1997, ENGLISH NATURE 2001, BLANKE 2004). However case studies mostly refer to translocations of single species in small habitats (e. g. ZIMMERMANN 1993, PLATENBERG & GRIFFITHS 1999, OLDHAM & HUMPHRIES 2000).

In this study we present the results of a project in the lower Salzach valley south of the city of Salzburg, an area that is coming under increasing pressure from infrastructure, intensive agriculture and suburban development. Along the river a narrow and patchy band of lowland forests still exists, which is no longer dynamic, due to hydroelectric power plants and river regulations. Nevertheless it still comprises an area of high biodiversity and is of great regional value as a migration corridor (KYEK et al. 1993). The project consisted of the large scale »rescue« translocation of a herpetofaunal community, accompanying habitat compensation and enhancement. Furthermore we will discuss the value of pre-(liminary) studies for the determination of the impact of development and the magnitude of necessary compensation and monitoring efforts.

Methods

Donor site

The site »Urstein-Au« is located about 10 km south of the city of Salzburg, close to the village »Puch« (430 m a. s. l.) on the banks of the river Salzach (Fig. 1). In this area 15 hectares of land were used as a disposal site for sludge and domestic waste for several decades. In the early 1990´s, when the disposal had stopped, the place gradually redeveloped into a highly structured habitat, consisting of small patches of different succession stages. The dominant habitats were alluvial forest, gravel banks covered by thin vegetation areas of tall forbs and several ponds and puddles, shrub encroachments dominated by willows (*Salix* spp.) and forests dominated by spruce (*Picea abies*) (Fig. 2). In 2001 local authorities decided that the waste had to be removed, leading to the total destruction of these habitats. After the clearing of the waste the redevelopment of the area into a business park together with a slip road connecting the latter to the motorway nearby, was planned. At this date the occurrence of 4 amphibian and 3 reptile species had been documented for this area (KYEK unpubl. data). Since all amphibian and reptile species are strictly protected by the federal nature conservation law, a strategy for translocation and compensation measures had to be worked out as one part of an environmental impact assessment (EIA).

Fig. 1: Location of the donor and receptor sites south of Salzburg.
Lage des Entnahmegebietes und der Aussetzungsbereiche südlich der Stadt Salzburg.

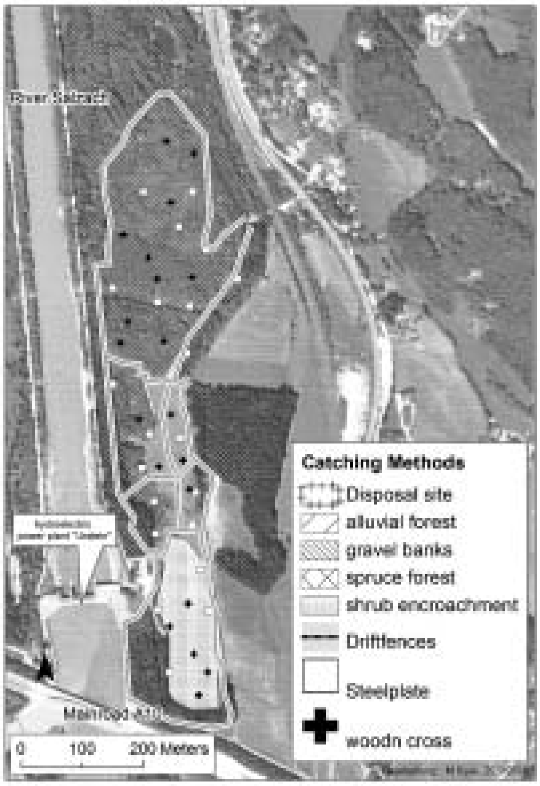

Fig. 2: The donor site with different habitat types and the position of the facilities for capturing amphibians and reptiles.
Die verschiedenen Habitattypen und die Position der verschiedenen Fangeinrichtungen für Amphibien und Reptilien im Entnahmegebiet.

Pre-study

In a pre-study in spring and summer 2001, the status of the herpetofaunal community was surveyed using standardized assessment methods. During five field days with favourable weather conditions, habitat types and the distribution of amphibians and reptiles were investigated. All sightings of individuals as well as spawning sites were recorded. Interviews with local amateur naturalists were also included in the findings. On this basis we tried to predict the impact of development and determined the dimension of compensation measures.

Habitat compensation and enhancement

The compensation and enhancement of habitats was carried out in two steps. In the beginning of 2002 new habitats for the translocation were created in three localities of similar or larger size than the donor site.

Receptor site 01 (Schlossallee und Schlosspark Urstein) is located 1 km south of the donor area in the surroundings of a small palace where 3 new ponds were built.

Receptor site 02 is a protected area of lowland forest, 2 km south, where one pond (size 1000 m²) with a breeding population of about 500 common toads (*Bufo bufo*)

Fig. 3: At deposition site 02 additionally an area of 2 000 m² in a shrub encroachment dominated by willows (*Salix* spp.) was cleared and restructured with gravel heaps and egg deposition sites.
Im Aussetzungsgebiet 02 wurde zusätzlich eine 2 000 m² Sukzessionsfläche mit Weidengebüsch (*Salix* spp.) gerodet und mit Schotter- und Eiablagehaufen gestaltet.

already existed. Close to this pond an area of 2 000 m² in a shrub encroachment dominated by willows (*Salix* spp.) was cleared and restructured with gravel heaps and egg depositon sites, mainly due to the needs of reptiles (Fig. 3). The egg deposition sites were composed in order to the claims of habitat of *Zamenis longissimus* and *Natrix natrix*. These sites were chosen comparatively close to the donor site to render a later

Fig. 4: New pond at receptor site 03, created especially for the tree frog (*Hyla arborea*) with large shallow water areas.
Neuer Teich im Aussetzungsbereich 03, der mit ausgedehnten Flachwasserzonen speziell für den Laubfrosch gestaltet wurde.

Fig. 5: Most of the 39 ponds were sealed by foil to maintain permanent water bodies.
Die Mehrzahl der 39 Teiche wurde mit Folien abgedichtet, um eine ganzjährige Wasserführung zu gewährleisten.

migration from receptor sites to enhanced areas in the surroundings of the donor site possible after the completion of all measures.

Receptor site 03 (Freimoos) is a small protected wetland area, 14 km south, where a small and threatened tree frog (*Hyla arborea*) population already existed. Two new ponds were created especially for the needs of this species (Fig. 4).

Fig. 6: The whole business park area was surrounded with concrete barriers to shut out amphibians, reptiles and other small terrestrial animals.
Der gesamte Gewerbepark wurde mit einer dauerhaften Barriere (Sperreinrichtung aus Beton) umgeben, um Amphibien, Reptilien und andere terrestrisch lebende Kleintiere fernzuhalten.

As a second step during and after the translocation additional habitats and migration corridors were created at receptor site 02 and in the direct surroundings of the business park. Altogether 39 new puddles and ponds with sizes of 30–7 000 m^2 and a total water surface of approximately 17 000 m^2 were built. Ponds with surface areas up to 1.000 m^2 were sealed by foil (Fig 5). These habitats were designed as buffer zones, while the business park area itself was surrounded by a total of 5 000 m of concrete barriers to permanently shut out amphibians, reptiles and other small terrestrial animals (Fig. 6). Furthermore a corridor close to nature of 50 m minimal extension between the river banks and the business park was structured including the relocation of a small stream to enhance migration and dispersal. Also on a length of 1 200 m 7 puddles and 1 pond were integrated in the corridor (Fig 5), as stepping stones. Most parts of the forest were changed in natural oriented deciduous forest.

Translocation

Between July 22nd 2002 and June 29th 2003, 4 370 running meters of double sided drift fence with a total number of 356 pitfall traps, 20 metal sheets (size 1m^2, thickness 1,5 mm) and 20 wooden crosses (4 m length) with 4 pitfall traps each, were positioned continuously throughout the area. To extend the size of catching facilities, drift fences split the area in 7 compartments, mainly following the prominent habitat structures (Fig. 2). All catching facilities were checked once or twice a day with exception of January and February 2003, when weather conditions did not allow herpetofaunal activity. All captured animals were translocated on the same day. Additionally all water bodies were dip-netted several times to capture most of the amphibian larvae. Furthermore we searched for adult tree frogs in several night excursions.

Tree frog larvae and adults were translocated only to receptor site 03. Newts were only set free at receptor site 01, while frogs and toads were transported to sites 01 and 02 in equal numbers. The same is true for all reptiles, though the main part was set free at the receptor site 02.

The habitats were destroyed step by step. Therefore it was possible to consecutively relocate animals from the compartments with highest individual numbers for two additional months, while the clean-up of the disposal site had already started. A drift fence without pitfall traps surrounded the disturbed area during the clean-up, to avoid the return of translocated animals and a possible immigration from the surroundings.

Monitoring

During 2003 and 2004 a systematic monitoring was impossible due to incomplete compensation and enhancement measures as well as the ongoing construction work. Nevertheless especially the receptor sites were surveyed 2–3 times throughout the season. In 2005 all new habitats were visited during 13 field days between March 29th and August 8th. Amphibians were assessed using spawn counts, dip-nets, bottle traps (e. g. GRIFFITHS 1985) and two night excursions. Reptiles were searched for in the field and especially at locality 2 with the help of three metal sheets (size 1 m^2, thickness 1.5 mm). Observations of local amateur herpetologists were used as additional data on the status of amphibian and reptile populations.

Data acquisition and processing

All mapping and monitoring data were recorded and processed by means of Biooffice 2.0 database (©Biogis) and Arc View 9.1 for GIS (© Esri).

Results

Pre-study

A total number of 6 amphibian species (*Rana temporaria, Bufo bufo, Hyla arborea, Triturus alpestris, Triturus vulgaris, Salamandra salamandra* – 43 % of all species in Salzburg) and 4 reptile species (*Anguis fragilis, Lacerta agilis, Zamenis longissimus, Natrix natrix*, – 57 % of all species in Salzburg) were recorded. The most frequent species were common frog (*Rana temporaria*) and tree frog (*Hyla arborea*), as well as sand lizard (*Lacerta agilis*) and Aesculapian snake (*Zamenis longissimus*). Altogether sightings of 213 amphibians and 78 reptiles were counted in 37 localities (Tab. 1). The most observations were made in the abandoned gravel pits and along the forest edges.

Translocation

Altogether 8 125 specimens (7 349 amphibians, 776 reptiles) were captured and transferred to new habitats. Leaving aside all amphibian larvae (5 917 individuals), a total number of 2 208 individuals were rescued, which is more than 7.5 times the number of

Tab. 1: Comparison of total numbers of translocated animals and their age classes, as well as the results of the pre-study (L = larvae, J = juveniles, SA = subadults, Ad = adult males or females, Ad (?) = adults without sex determination).

Vergleich der Anzahl der umgesiedelten Individuen und ihrer Altersklassen, sowie Ergebnisse der Vorstudie (L = Larven, J = juvenile, SA = Subadulte, Ad = Adulte Männchen oder Weibchen, Ad (?) = Adulte, Geschlecht unbestimmt).

	Number of translocated individuals							Pre-study
	L	J	SA	Ad (♂)	Ad (♀)	Ad (?)	Total	Total
Amphibia								
Bufo bufo	-	445	155	224	59	12	895	18
Hyla arborea	5 751	4	-	37	4	0	5 796	58
Rana temporaria	46	33	11	66	70	14	240	126
Salamandra salamandra	59	19	4	12	16	4	114	3
Triturus alpestris	61	175	13	17	29	2	297	7
Triturus cristatus	-	-	-	-	1	-	1	-
Triturus vulgaris	-	1	-	4	1	-	6	1
Reptilia								
Anguis fragilis	-	137	57	-	-	200	394	4
Coronella austriaca	-	2	-	-	-	6	8	-
Lacerta agilis	-	100	26	44	73	4	247	38
Natrix natrix	-	66	16	-	-	9	91	8
Zamenis longissimus	-	9	5	-	-	22	36	28
Total (classes)	5 917	991	287	404	253	273	8 125	291

Tab. 2: Number of individuals per species captured terrestrial with different facilities.
Anzahl der mit verschiedenen Methoden terrestrisch gefangenen Individuen pro Art.

	Capture methods				
	Terrestrial				Aquatic
	No tools	Drift fences	Wooden crosses	Metal sheets	Dip-netting
Amphibia					
Bufo bufo	5	814	7	-	69
Hyla arborea	3	4	-	-	5789
Rana temporaria	63	42	-	-	135
Salamandra salamandra	2	47	1	-	64
Triturus alpestris	-	209	-	-	88
Triturus cristatus	-	1	-	-	-
Triturus vulgaris	-	2	-	-	4
Reptilia					
Anguis fragilis	49	321	4	20	-
Coronella austriaca	7	1	-	-	-
Lacerta agilis	157	57	6	27	-
Natrix natrix	48	42	-	1	-
Zamenis longissimus	28	8	-	-	-
Total	362	1548	18	48	6149

pre-study recordings. Dominant species now were common toad (*Bufo bufo*), Alpine newt (*Triturus alpestris*) and slow worm (*Anguis fragilis*). Crested newt (*Triturus cristatus*) and smooth snake (*Coronella austriaca*) were recorded as additional species in small numbers. Altogether the translocation covered individuals from 65 % of the species recorded in Salzburg (Tab. 1 and 2).

The majority of translocated common toads (*Bufo bufo)* were captured at the south-western border of the donor site. During the whole year of translocation mainly subadult individuals, trying to migrate from the south along the river Salzach under the motorway bridge into the investigated area, were captured there.

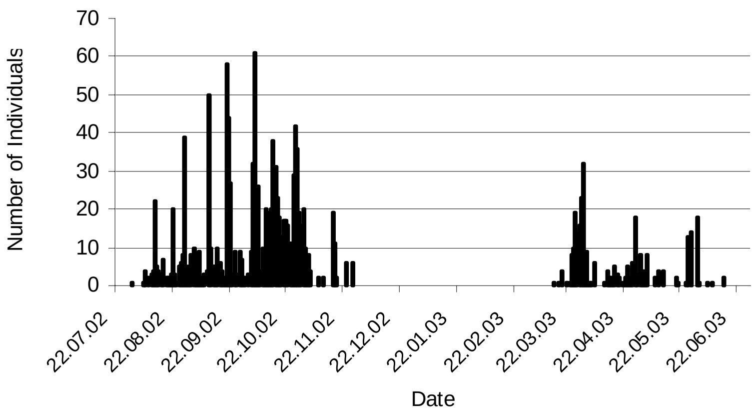

Fig. 7: Phenology of amphibians (larvae excluded) during translocation between July 2002 and June 2003.
Verlauf der Aktivitätsphasen der Amphibien während der Umsiedlung zwischen Juli 2002 und Juni 2003.

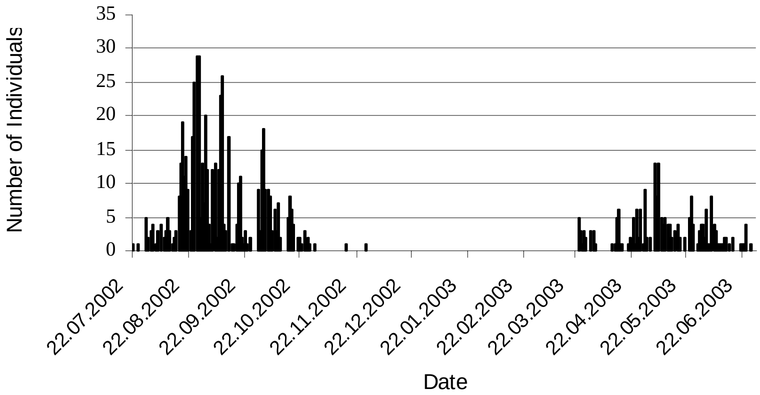

Fig. 8: Phenology of reptiles during translocation between July 2002 and June 2003.
Verlauf der Aktivitätsphasen der Reptilien während der Umsiedlung zwischen Juli 2002 und Juni 2003.

No amphibian and reptile activity was recorded between November 28th, 2002 and March 14th, 2003 (March 24th for reptiles). About four weeks before the scheduled end of the translocation the number of observed and captured individuals dropped abruptly for all amphibian and reptile species. This was observed even during favourable weather conditions (Figs. 7 and 8).

Apart from amphibian larvae that were captured with dip-nets, the highest proportion of individuals was captured at the drift fences (70.1 %). Post-metamorphic amphibians of all species were to the largest extent captured in pitfall traps at drift fences (78.1 %), dip nets (16.2 %) were effective for *Triturus alpestris* and *Rana temporaria*, while animals captured manually without traps (5 %) were less frequent, and wooden crosses with pitfall traps were completely ineffective (0.6 %). Surprisingly the same is true for reptiles, with the highest proportion in pitfall traps at drift fences (55.3 %). They were especially effective for *Anguis fragilis*. Manual captures were also frequent (37.2 %) and the best method for *Lacerta agilis*, while metal sheets (6.2 %) only worked well for *A. fragilis* and *L. agilis* and wooden crosses (1.3 %) were less efficient (Tab. 2).

Monitoring

During the three years of monitoring (2003–2005) a total number of 181 observations of amphibians or reptiles in 69 localities were documented. In 2005 we observed the presence of 2–7 amphibian species in 33 of 39 (85 %) newly created ponds. Successful reproduction of 1–6 species was observed (eggs and/or larvae) in 10 ponds. Reproduction was also documented for 4 reptile species (juvenile individuals) at the receptor site 02. Only the smooth snake was observed just once without indication of reproduction. We further observed a strong colonisation by tree frogs in the new ponds and puddles at receptor sites 01 and 02. These individuals were not released there and presumably migrated into this area from the surroundings after the habitat situation improved. 13 ponds were colonised with reproduction in 5 ponds. The number of calling males per pond reached from 1 to 70. The edible frog (*Rana esculenta*) was found as new species in 3 localities close to the business park area (Tab. 3).

Tab. 3: Summary of species specific monitoring data from 69 localities within the newly created habitats in the year 2005.
Zusammenfassung der artspezifischen Monitoringergebnisse von 69 Fundorten innerhalb der neu angelegten Habitate im Jahr 2005.

	Localities	Observations	Observed reproduction	Individuals (range)
Amphibia				
Bufo bufo	16	21	12	1–500
Hyla arborea	19	34	5	1–70
Rana esculenta	3	4	0	1–3
Rana temporaria	30	46	14	1–902
Salamandra salamandra	1	1	1	20
Triturus alpestris	9	12	3	1–14
Triturus cristatus	4	5	2	1–7
Triturus vulgaris	5	5	0	1
Reptilia				
Anguis fragilis	3	11	1	1–12
Coronella austriaca	1	1	0	1
Lacerta agilis	9	11	1	1–2
Natrix natrix	11	15	1	1–2
Zamenis longissimus	8	10	1	1–4

Discussion

Comparability to other translocation studies

This particular project differs to other published herpetofaunal translocations due to the magnitude of the involved area, the diverse capturing facilities, the high number of species and individuals as well as the duration. While in Anglophone countries like Great Britain or the U. S. there is some history on projects concerning the translocation of species of the herpetofauna (see FISCHER & LINDENMAYER 2000, EDGAR et al. 2005), only very little records are known from Austria or other countries in Central Europe (but see NABROWSKY 1987, BREUCKMANN & KUPFER 1998). Hence there were no standardized methods for large scaled translocations present that we could follow.

The size of the investigation area is not mentioned in most comparable studies. In the translocation of a slow worm (*Anguis fragilis*) population published by PLATENBERG & GRIFFITHS (1999) the area of the translocation site was only about 10 000 m². From July to October they captured a total of 103 individuals manually and with the help of metal sheets. Statistical models showed that in their case there was no significant evidence that the population was depleted. A study by ZIMMERMANN (1993) reports the translocation of 17 smooth snakes (*Coronella austriaca*) within a vineyard area in south-western Germany. A survey on crested newt (*Triturus cristatus*) mitigation in England done by means of data base sampling and questionnaires showed that in 139 projects with available data between 1990 and 2001 a total number of 23 894 post-metamorphic newts were translocated (EDGAR et al. 2005). In that study only figures about the size of the destroyed breeding pond but no information about the whole developed area is given.

Differences between pre-study and translocation

During a standard mapping of the herpetofauna in highly structured areas it is obviously impossible to detect the majority of animals. However, the huge difference in the total number of individuals on the one hand and the dominant species during translocation compared to the pre-study on the other was remarkable. Some interesting findings turned up in this context. Common (e. g. *Rana temporaria*) and highly detectable species (*Hyla arborea, Lacerta agilis*) were most prominent during the pre-study but only *Hyla arborea* and *Zamenis longissimus* showed no large difference in the number of individuals detected in the pre-study and during translocation. In amphibians the number of post-metamorphic individuals was more than 18-times (*Salamandra salamandra*) and even more than 33-times (*Triturus alpestris*) higher than in the pre-study. The number of most reptile species also showed a large increase. The translocated number of slow worms (*Anguis fragilis*) was nearly 100-times the size of pre-study recordings, which means more than 26 individuals per ha with large parts of the cleared habitats being not standard habitats for this species in our region (e. g. CABELA et al. 2001, KYEK & MALETZKY 2006). These figures can be compared with the study of PLATENBERG & GRIFFITHS (1999) and show that especially for species with a hidden pattern of life the number of individuals in certain richly structured habitats is often underestimated. The appearance of two further species (*Triturus cristatus* and *Coronella austriaca*), although in low numbers, that additionally are listed in the EU-habitats directive, gives further evidence that usual mapping procedures are not precise enough in such special cases.

A further considerable factor is the amount of possible migration of individuals into the area. For *Bufo bufo* the number of detected individuals was 10 during the pre-study and increased to 895 during the translocation. This high number was mostly covered by subadult and adult animals which were migrating northwards along the river from receptor site 2 into possible summer habitats within the developed area.

In conclusion we assume that using conventional mapping procedures a underestimation of population sizes and perhaps even the number of affected species is inevitable. This might lead to imprecise conclusions regarding the magnitude of conservation efforts.

Capture methods

Our aim was not to provide statistical information about the efficiency of capture methods. It was necessary to catch as many individuals of all species as possible within a limited time range. Therefore we used a combination of methods which were affordable and not too complex.

It turned out that for post-metamorphic individuals of most species the preferable tool is to use drift fences (Fig. 1), that proved very useful not only for amphibians but also for *Anguis fragilis* and subadult and adult snakes. On the one hand drift fences work as a barrier, on the other hand the direct surroundings have scarce or no vegetation and represent new structures for basking, foraging or easier locomotion. So we observed a lot of amphibians and reptiles along the drift fences during the daily control of pitfall traps.

Metal sheets or other kinds of artificial refuges are also very useful for the qualitative proof of the occurrence of several reptile species in an area (see BLANKE 2006). In our study we captured a comparatively high number of *A. fragilis* and *Lacerta agilis*, but still in both cases drift fences were more effective. One reason for the low number of individuals captured with this method may be the high number of natural refuges on the one hand and the sheet colour on the other. It is better to use black and white striped sheets compared to black ones, because the temperature is lower if they are exposed to the sun (BLANKE 2006).

The efficiency of wooden crosses was comparatively poor. One possible explanation might be that the wooden construction of 4 m was too short. Gauze fences, as used in previous studies (e. g. PINTAR 1984), instead of a wooden construction might have been more appropriate.

The most important factor is sufficient time to carry out the translocation. Different age classes of different species of course show different periods of activity. Not all individuals of amphibian populations reproduce each year. In our case we observed a sharp decline in observed and captured individuals after 10 months of translocation. So we propose that the catching facilities should be present for at least a whole year to make sure that the largest part of the population can be saved. LANGTON & BURTON (1997) suggest that even two years are necessary.

Receptor sites

The receptor sites for reptile species should not be populated by the target species before translocation. This would lead to problems in habitat capacity (e. g. BLANKE 2004). In this study the new habitats for reptiles were created completely new and there was no evidence that populations of these species were already present. The same is true for all amphibian species except individuals of *Bufo bufo* which used the donor site as terrestrial habitat and were translocated to the surroundings of their breeding pond, and *Hyla arborea* which were used to support an endangered population at receptor site 03.

The receptor sites for all species except *Hyla arborea* are less than 2 km distant from the original habitats, which along with the enhancement of the migration corridor along the river banks allows individuals to disperse again after the construction work has finished.

Habitat compensation and enhancement

Most important for the conservation of local populations was the habitat compensation by creation and/or enhancement of at least the same extent of habitats that were destroyed. This contains recreation of highly structured environments, which are designed for the habitat requirements of the present species (for example ponds, puddles, semi-natural forest edges, brooks) in the direct surroundings of the developed area. Because on the one side it is impossible to catch all individuals of the whole populations within one year and on the other side in our case there were a lot of individuals migrating along corridor at the river banks, which need functional habitat structures there.

Monitoring

Two years of monitoring have shown that the newly created habitats at the receptor sites were accepted by amphibians and reptiles and reproduction was observed for all species apart from *Coronella austriaca*. The new ponds at receptor site 03 additionally were colonised by yellow-bellied toads (*Bombina variegata*) and crested newts (*Triturus cristatus*) which also reproduced.

All additional ponds and puddles that were built for habitat compensation and enhancement were rapidly colonised by amphibians and reptiles. Although there were no documented breeding ponds and calling males of *Hyla arborea* at the surroundings of receptor sites 01 and 02 and therefore no individuals were translocated there, this species colonised a large number of the new ponds with up to 70 calling males. Tree frogs depend on dynamic habitats and are able to colonise new ponds fast but often use different ponds for calling and reproduction (e. g. TESTER 1990). The colonisation started directly after the ponds were created. In the second year of monitoring calling males were observed in 13 ponds, successful reproduction occurred in 5 ponds. Comparable colonisations have been described several times (e. g. CLAUSNITZER 1996, SCHWARTZE 2002). While edible frogs (*Rana esculenta*) as a further rapidly colonising species turned up shortly after the completion of the new habitats, no individuals of *Bombina variegata* were found.

As described above, the business park area itself was surrounded by a total of 5 000 m of concrete barriers. So there is no danger for terrestrial small animals which migrate back to the donor site. In this context the migration rate was not the first question for the monitoring. Time and effort of monitoring was comparatively low compared to the translocation and habitat enhancement due to the high costs of the complete project. Nevertheless our aim was to evaluate whether new habitats were accepted and colonised by as many species of the local herpetofauna as possible.

General implications

The destruction of large valuable habitats of protected species like amphibians and reptiles is irreversible and cannot be accepted without protecting the affected populations. In times of rising pressure on natural habitats due to growing human land use, the protection of such areas must have top priority for conservationists. Case studies like ours can only be allowed after detailed consideration of alternatives in the course of an environmental impact assessment (EIA). Nevertheless, in the presented case study, public interest caused by the rising danger of ground water pollution due to the enormous amount of deposits made the measures necessary.

The EIA gave the possibility to create an overall concept of sustainable development in larger landscapes and to implement parts of it into practical conservation work. A precise evaluation of the corridors along the river Salzach south of the city of Salzburg was carried out. Deficites in habitat structure and connectivity were depicted. By creating 39 water bodies and a semi-natural composition of the business park surroundings, a sustainable enhancement of this corridor was achieved. In this way EIA´s can be motors for local and regional conservation programs.

Some main implications for possible similar projects in the future can be supplied by the experiences gained in the course of this project. We propose a pre-study lasting at least one full year and including drift fence transects and metal sheets as survey methods. The evaluation of at least 1 km buffer zone circumscribing the area of development has to be an integral part of the pre-study. Better knowledge about the occurring species is needed to plan translocation and new habitats properly. The most favourable method for catching the majority of individuals is drift fences with pitfall traps. We propose that they be set up in a 100 ∗ 100 m patter. The receptor sites should be located close enough that a return of individuals to enhanced areas surrounding the impact area is possible. A migration of individuals directly into the developed area has to be prevented. All measures taken have to be accompanied by monitoring procedures.

Three years after completion the project can be regarded as successful, but only the following years will show whether the measures were sufficient to build up new and stable populations.

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