Use of telemetry for guiding the reintroduction of Ural Owls (*Strix uralensis*) in Austria

Uso de telemetria para guiar a reintrodução de coruja dos Urales (*Strix uralensis*) na Áustria

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ABSTRACT

In the first half of the 20th century the Ural Owl *Strix uralensis* became extirpated from Austria. From 2008, the Research Institute of Wildlife Ecology (FIWI) and the Dürrenstein Wilderness Area Administration (WGD) began reintroducing the owls to Austria's woodlands. Between 2009 and 2018, 142 young Ural Owls were released into the Dürrenstein Wilderness Area. Telemetry was used to monitor success, improve reintroduction strategies and to expand the nest box network in the region. A total of 107 young owls were tracked, and the ideal age for release was determined (i.e., young at 90 days old). We found survival rates of about 75% in the first year after release, and recorded various causes of death (e.g., predation, starvation, endoparasites, etc.). As of 2018, 15 owl territories were identified, and of these, 10 were confirmed to have breeding activities. From 2012-2018, a total of 29 nests with 53 hatched chicks were found in the Wilderness Area region. Young owls routinely dispersed, with movements of 150 km recorded, providing proof of connections between the Wilderness Area and adjacent populations. Telemetry also informed about Ural Owls' biology including habitat selection, territory sizes, foraging preferences, and dependence on beech mast and small mammal cycles. Transmitters of five models employing three telemetry systems were used; GPS-GSM-telemetry has replaced the other telemetry systems because of its comparatively low cost, high accuracy, automatic storage of GPS-data and transfer via the GSM net. Telemetry will continue to be used in the reintroduction project to collect valuable data and guide success.

Keywords: Austria, dispersal, reintroduction, telemetry, *Strix uralensis*

RESUMO

Na primeira metade do século XX, a coruja dos Urales (*Strix uralensis*) extinguiu-se na Áustria. A partir de 2008, o *Research Institute of Wildlife Ecology* (FIWI) e a administração da Área Silvestre de Dürrenstein (WGD) iniciaram a introdução de corujas nas florestas austríacas. Entre 2009 e 2018, 142 corujas dos Urales juvenis foram libertadas na Área Silvestre de Dürrenstein. Através da telemetria, foi monitorizado o sucesso do programa de reintrodução, foram melhoradas as respetivas estratégias e foi expandida a rede de caixas-ninho na região. No total, 107 corujas juvenis foram seguidas, tendo sido determinada a idade ideal para a sua libertação (i.e. 90 dias de idade). A taxa de sobrevivência foi de ca. de 75% no primeiro ano após a libertação, tendo sido registadas várias causas de mortalidade (e.g., predação, fome, endoparasitas, etc.). A partir de 2018, foram identificados 15 territórios, tendo-se registado atividade reprodutiva em 10 destes territórios. No período 2012-2018, foram encontrados no total 29 ninhos com 53 juvenis eclodidos na região da Área Silvestre. No geral, as corujas juvenis dispersaram, tendo registado movimentos até 150 km, confirmando assim a ligação entre as populações da Área Silvestre e de áreas adjacentes. A telemetria permitiu ainda conhecer melhor a biologia da coruja dos Urales, incluindo seleção de habitat, dimensão dos territórios, preferências de alimentação e dependência dos ciclos de produção de sementes das faias e dos ciclos de micromamíferos. Foram usados cinco modelos de emissores e três sistemas de telemetria; a telemetria GPS-GSM substituiu outros sistemas de telemetria devido ao menor custo, maior precisão, armazenamento automático de dados de GPS e transferência através da rede GSM. A telemetria vai continuar a ser usada no projeto de reintrodução para recolha de dados e ajudar a melhorar o sucesso do mesmo.

Palavras-chave: Áustria, dispersão, reintrodução, telemetria, *Strix uralensis*

Introduction

Reintroducing Ural Owls to Austria

The Ural Owl *Strix uralensis* became extirpated as a breeding bird in Austria in the first half of the 20th century due to direct poaching and loss of massive trees with big cavities for breeding (Bauer 1997; Glutz & Bauer 1994; Sterry et al. 2000). Reintroduction projects are ambitious efforts with important requirements, including a monitoring component to provide information about the progress of the project and allow for adaptive management during project implementation. Early efforts of reintroducing the owl back into Austria failed (Engleder 2007). Along with the IUCN Guidelines for Reintroduction (1998), development of a Ural Owl reintroduction program was made. The program included clarification of genetic aspects (Kühn 2009), an action plan for the Ural Owl in Austria (Zink & Probst 2009), and a habitat evaluation for the Dürrenstein Wilderness Area region (Steiner 2007). The region was considered as suitable given the known habitat requirements of the Ural Owl (Bauer & Berthold 1997, Stürzer 1998, Mebs & Scherzinger 2008, Steiner 1999, Steiner 2001, Steiner 2007).

In 2008, our reintroduction project began, as a collaboration between the Dürrenstein Wilderness Area Administration and the Research Institute of Wildlife Ecology (FIWI) of the Veterinary University of Vienna. The reintroduction method was based on international experiences and results of efforts in the Bavarian Forest and Bohemian Forest national parks (Scherzinger 1987, Scherzinger 2006, Scherzinger 2007, Müller 2007). The goals of the reintroduction project were to establish a Ural Owl population in Austria, and to build population 'stepping stones' to reconnect the owls in the Bavarian Forest and the Bohemian Forest (Czech Republic) where in the last 40 years reintroductions were carried out, as well as Slovenia (Pietiäinen & Saurola 1997, Prešern & Kohek 2001, Scherzinger 1987, Scherzinger 2006, Scherzinger 2007, Svetličič & Kladnik 2001, Vrezec 2000a, Vrezec & Kohek 2002, Vrezec & Tutis 2003, Vrezec 2006, Mebs & Scherzinger 2008). Two release areas were established in the Wienerwald Biosphere Reserve in the surroundings of Vienna and in the Dürrenstein Wilderness Area in southwestern Austria.

Scherzinger (pers. comm. 2009) identified the following requirements for the success of the reintroduction project: breeding in captivity, natural rearing of the young owls, reaching fertility, species-specific habitat, species-specific behavior (habitat selection, foraging behavior, dispersion movements), display behavior, nesting, oviposition, breeding, brood care, social behavior, establishment of a viable population, age structure of the population, connection to the neighboring populations, integration into the wild population and species-specific polymorphism. In the Wilderness Area, the following monitoring tools were undertaken to fulfill the requirements of a comprehensive monitoring program: telemetry (radio-telemetry, satellite telemetry and GPS-GSM-telemetry), automated data collection receivers at the feeding table or in an owl territory, photo traps, light barrier cameras, recording owl display behaviors, direct observations, nest box checks, and the ringing and genetic analyses of released birds and owls hatched in the wild.

Telemetry is one of the best tools for evaluating reintroduction projects (Frölich 1986, Kenward 1987, Klaus et al. 2009, Kohl & Leditznig 2012, Leditznig 1999, Leditznig et al. 2007, Leditznig & Langer 2017, Nicholls & Fuller 1987, Schäffer 1990, Unsöld & Fritz 2014). Out of 142 released Ural Owls, transmitters were attached to 107 young owls. In the first few months after release, juvenile owls often made remarkable movements in the area around the Wilderness Area, affirm-

Figure 1- Dürrenstein Wilderness Area – IUCN category Ia (Strict Nature Reserve) and Ib (Wilderness Area) and UNESCO World Heritage Site, view to the Dürrenstein Mountain, 1893 m a.s.l. (photo: Ingrid Kohl).

Figura 1 - Área Silvestre de Dürrenstein – categoria Ia (Reserva Natural Estrita) e Ib (Área Silvestre) da IUCN e Sítio Património Mundial da UNESCO, vista para a montanha de Dürrenstein, 1.893 m (foto: Ingrid Kohl).

ing that a well-functioning tracking system was required. Telemetry enabled the determination of survival rates, dispersal timing and distances, habitat analyses, territory analyses, enabled the finding of nests in natural tree holes, and confirmed that owls were traveling between the two release areas and the broader regional populations. Based on the locations/territories of the owls, a network of nest boxes was established. The use of nest boxes pursued two main goals: a) compensate for the lack of natural breeding cavities, and b) provided a means of more readily monitoring the nesting success of the owls.

The focus of this paper is on how telemetry data has generated critical monitoring data and ecological insights that continue to enhance the reintroduction of Ural Owls in Austria.

METHODS

The Dürrenstein Wilderness Area (3,500 ha; 600 - 1,878 m a.s.l.; Fig. 1) including the Primeval Forest Rothwald (400 ha; Fig. 2) offers ideal owl habitat with an incomparably high abundance of deadwood and tree cavities. The Dürrenstein Wilderness Area is an IUCN Category Ia Strict Nature Reserve, Ib Wilderness Area and UNESCO World Heritage Site. Stand-forming tree species are Norway Spruce (*Picea abies*), European Silver Fir (*Abies alba*) and European Beech (*Fagus sylvatica*). Also the European Larch (*Larix decidua*) and the Sycamore Maple (*Acer pseudoplatanus*) play an important role. In particular, the Sycamore Maple and the Norway Spruce form cavities used by owls and other wildlife. The Wilderness Area includes

Figure 2 - Primeval Forest Rothwald (photo: Hans Glader).

Figura 2 - Floresta Virgem de Rothwald (foto: Hans Glader).

Figure 3 - One of two aviaries for release in the Dürrenstein Wilderness Area (photo: Christoph Leditznig).

Figura 3 - Um dos dois aviários para libertação na Área Silvestre de Dürrenstein (foto: Christoph Leditznig).

Figure 4 - Young Ural Owl on the feeding table (photo: Christoph Leditznig).

Figura 4 - Juvenil de coruja dos Urales na mesa de alimentação (foto: Christoph Leditznig).

important habitat for some owl species (e.g., Boreal Owl *Aegolius funereus*) as well as for woodpecker species (e.g., White-backed Woodpecker *Dendrocopos leucotos*). Geologically it is part of the Northern Limestone Alps with an annual precipitation of 1,700 to 2,400 mm. The topography is steep and mountainous.

In the years 2009 to 2017, 142 young Ural Owls were soft-released in the vicinity of the Dürrenstein Wilderness Area. The young owls were from the breeding network (led by R. Zink, FIWI), and brought to the Wilderness Area from owl and raptor stations, zoos and private breeders. In 2009 a release aviary was used in the Wilderness Area (Fig. 3), and a second breeding and release aviary in the vicinity of the Wilderness Area was added in 2010, managed by team member Franz Aigner. The two release aviaries were located at altitudes of 785 and 725 m a.s.l. Once at one of the two release aviaries, the young owls spent a few weeks adapting to the climate and the soundscape of the area before release; in most cases the young owls spent their last weeks with adult owls in order to be able to learn from their behaviors. Young owls were released at the age of about 90 days (the majority reach a suitable age for release around July). In the first weeks after their release, food (rats and poultry chicks) were offered to them on six 'feeding tables' (Fig. 4) until they learned to hunt independently.

Nest boxes offer additional support for cavity breeders, especially for the Ural Owl which requires big cavities for breeding (Englmaier 2007). Nest boxes made out of larch wood, of a size of 40 x 40 x 60 cm, with a hole of 15 x 20 cm, mounted at a height of 5 m, normally mounted at elevations below 1,000 m a.s.l., were offered for the reintroduced Ural Owls (Fig. 5). As of 2017, 101 nest boxes have been mounted in the Dürrenstein Wilderness Area region.

Figure 5 - Nest box of larch wood, 40 x 40 x 60 cm, 25 kg, at a height of about 5 m (photo: Christoph Leditznig).

Figura 5 - Caixa-ninho em madeira de pinheiro-negro, com 40 x 40 x 60 cm e 25 kg, a uma altura de cerca de 5 m (foto: Christoph Leditznig).

Different monitoring tools were implemented to survey the success of the project: telemetry, camera traps, light barriers in combination with cameras, monitoring of nest boxes, ringing, genetics, call surveys and direct sightings. During the breeding season all nest boxes, often in steep terrain with snow cover, are visited with a telescope stick and a camera (photo camera or video camera) for monitoring the breeding status of the Ural Owls. The genetic analyses was carried out by the Research Institute of Wildlife Ecology (FIWI).

Five different transmitter designs using three different telemetry systems were used in this project: VHF radio-telemetry, satellite telemetry, and GPS-GSM telemetry. The majority (n=92) of transmitters were attached to the owls with the pelvis harness (leg-loop) method. In the first nine years of the project more than 13,500 daily owl positions were registered by means of telemetry. Battery-powered GPS-GSM transmitters proved to be the best fit for our project. Details on the transmitters and telemetry systems used are described in a companion paper in this volume (see: Kohl et al. 2020).

Results

Survival rates and Mortality

With the use of telemetry it was possible to improve our reintroduction strategies over time. The age of the young owls at the time of release had a significant effect on their first-year survival rates. From 2009-2017, all owl releases occurred between 15 June and 6 September. Particularly dramatic were the consequences of the first releases in 2009. Young owls were mostly released in the second half of August, at the age of more than

Figure 6 - Ural Owl female with GPS-GSM-transmitter at the first brood in a natural tree cavity that was first found in 2014 (photo: Christoph Leditznig).

Figura 6 - Fêmea de coruja dos Urales com emissor GPS-GSM com a sua primeira ninhada, numa cavidade natural encontrada pela primeira vez em 2014 (foto: Christoph Leditznig).

120 days. As a result, no owls visited the feeding table and a mortality rate of 67% (6 of 9 birds) was recorded. Additionally, making the survival situation even more difficult that year, was that the small rodent population was at a minimum. The release strategy was changed in the following years and survival rates from 2010 and after increased significantly (Leditznig & Kohl 2013, Leditznig 2013). Releases of owls that were 90 days of age (depending on the hatching date, between mid-June and end of July), resulted in over-winter survival rates of about 78%. With an age of significantly more than 100 days at release, this value decreased to about 33% (Leditznig & Kohl 2013, Leditznig 2013). The perished birds died on average 43.3 days after release; two-thirds died during the first 50 days after release and the remaining third died within the next 50 days. Of the 19 owls that did not survive, mortality was determined to be: predation (25%), starvation (25%), endoparasites (25%), road kill (10%), electrocution (5%), heart defect (5%) and one unidentified case due to the late finding (5%). Young Ural Owls were predated by the Eurasian Eagle-owl (*Bubo bubo*), Golden Eagle (*Aquila chrysaetos*), Northern Goshawk (*Accipiter gentilis*) and Pine Marten (*Martes martes*).

Table 1 - Number and success of Ural Owl nests, 2010 to 2018.

Tabela 1 - Número de ninhos e sucesso reprodutor da coruja dos Urales de 2010 a 2018.

YEAR	TOTAL OWL NESTS	SUCCESSFUL NESTS (YOUNG TO FLEDGING)	FAILED NESTS (FAILED AT EGG OR YOUNG STAGE)
2010	0	0	0
2011	0	0	0
2012	2	2	0
2013	1	0	1
2014	4	3	1
2015	8	5	3
2016	7	7	0
2017	10	7	3
2018	0	0	0
Total	29	21	8

Breeding success

Successful nesting by owls began in 2012, and breeding success has been monitored since (Table 1) (Steiner 2007; Zink & Probst 2009; Böhm & Zink 2010; Leditznig & Kohl 2013). In 2011 the first pair of Ural Owls was found in the vicinity of the Wilderness Area. In 2012, the first two successful nests with a total of 11 eggs and 8 hatchlings were observed. One of the two breeding pairs that was first found in 2012 consisted of a one-year old male released in the Wilderness Area and a two-year old female released in the Wienerwald Biosphere Reserve. The finding of their nest confirmed the connection between the two release areas. In 2013, one Ural Owl nest was found, the egg was subsequently abandoned; one Tawny Owl nest was found, and its egg was also abandoned.

In 2014, a total of four nests were confirmed, including two in larch nest boxes. Two nests in 2014 were a special feature - for the first time in the history of the Austrian Ural Owl reintroduction, successful nests in natural tree cavities were confirmed (Figs. 6, 7). Remarkable was the timing of the nests. While two pairs started nesting in the first half of March, the two other pairs did not start to breed until the end of April, after heavy snowfalls in the first half of April. Both nests were found via females equipped with GPS-GSM transmitters, and each were in natural beech cavities. One of the natural cavity nests was about 10 km from the release area and it fledged four young. The second natural tree cavity was found in the vicinity of the Wilderness Area and fledged one young (before it could be ringed). The female at this latter site was a one-year-old female.

With GPS-GSM telemetry, we confirmed eight successful nests in 2015. Three of the eight nests were found in the eastern part of the Wilderness Area. Four of the successful nests had a total of 10 surviving juveniles. The pair with the last confirmed brood in

Figure 7 - Four young fledged from this tree cavity. Only through the use of telemetry it was possible to find Ural Owl broods in natural tree cavities (photo: Christoph Leditznig).

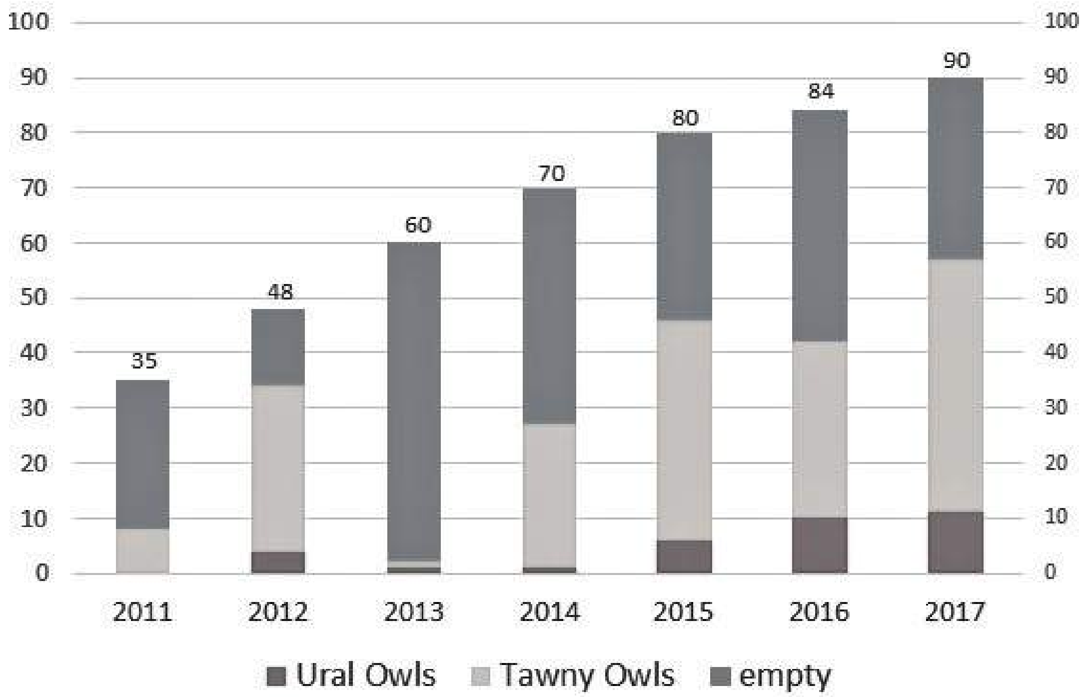
Figura 7 - Quatro juvenis foram criados com sucesso nesta cavidade natural. Apenas foi possível encontrar ninhadas de coruja dos Urales em cavidades naturais através do uso da telemetria (foto: Christoph Leditznig).

2014 started breeding about 27 April 2015. The female owl left the release area on the 25 September 2014 and moved to the south-east edge of the Kalkalpen National Park. The bird stayed there until 9 March 2015. Then she moved to Maria Seesal where she stayed one day before returning to Kalkalpen National Park on the 17 March. She left the Park on the 10 April to arrive in the final breeding area on 12 April (the linear distance between the Kalkalpen National Park and the breeding area was about 40 km). The start of breeding was about 2 weeks after her arrival. These valuable findings were only possible through the use of telemetry.

During the breeding seasons of 2016 and 2017, the total numbers of successful nests were seven and 10, respectively. Breeding success is highly dependent on the small rodent population. Peaks in small rodent numbers were 2012 and 2017, however, breeding success in 2017 was reduced by heavy snowfalls of up to 2 m of snow within 12 hr in late April.

Figure 8 - Results of the nest box occupancy checks between 2011 and 2017.

Figura 8 - Resultados da monitorização das caixas-ninho entre 2011 e 2017.



As of 2017, 15 owl territories were identified, and of these, 10 were confirmed to have breeding activities. Thus, from 2012-2017, a total of 29 nests with 53 hatched chicks were found in the Wilderness Area region.

In 2018, due to very low small mammal numbers, no Ural Owl nests were recorded.

Foraging preferences

Observations of breeding success during the last decade showed that successful nests are highly dependent on small rodent populations, especially the Bank Vole and the Yellow-necked Mouse. In peak small rodent years, one-year-old Ural Owls have had successful nests with up to six eggs, and up to 5 fledged young. In years with late snowfalls in April, Ural Owls started their nests either before or after the period with snow but not a single pair within the snow period. In years with very low small rodent populations (e.g., 2013, 2018) owls did not successfully breed. In such years adult Ural Owls become food generalists, feeding on Common Frog (*Rana temporaria*), Common Toad (*Bufo bufo*), insects, shrews (*Soricidae*) and birds (e.g., Eurasian Jay *Garrulus glandarius*). Within the last decade one case was observed of a female Ural Owl feeding on a Tawny Owl.

In the Wilderness Area beech masts take place about every 4-5 years resulting in small rodent population peaks (i.e., 2004, 2008, 2012 and 2017). The first two successful Ural Owl nests found in 2012 in the vicinity of the Wilderness Area benefitted from peaking populations of small rodents due to a beech mast in late 2011 and early 2012. During

2012, we were able to assess prey delivery rates and prey species analyses at breeding sites with a light barrier camera (Kohl & Leditznig 2012, Leditznig & Kohl 2013). An 8-day analysis with the camera at one of the two nests (5 eggs, 3 young owls fledged) reflected this situation: out of 123 recorded prey animals from one breeding pair, 100% were small mammals. Species or genus could be determined for 112 of the prey: 79 Bank Voles (*Myodes glareolus*; 70.5%), 29 individuals of *Apodemus* species – mainly Yellow-necked Mouse (*Apodemus flavicollis*) or Wood Mouse (*Apodemus sylvaticus*; 25.9%), and 4 individuals of *Microtus* species (3.6%); the other 10% (n = 11) of the prey mammals could not be determined. On average, 15.4 prey mammals were brought to the nest per day. Compared to the Tawny Owl that is mostly active at night (Melde 2004), Ural Owls also feed the nestlings regularly at daylight (Leditznig & Kohl 2013, Leditznig 2013). Since 2002, a small mammal monitoring has been carried out in the Dürrenstein Wilderness Area by the Institute of Wildlife Biology and Game Management of the University of Natural Resources and Life Sciences in Vienna (Kempter & Nopp-Mayr 2013) providing valuable data for the owl projects.

Movement routes

The dispersal of young Ural Owls varied over the years. There may be some correlation to availability of prey during small mammal cycles. In 2010, several released young started to disperse. With a radio-telemetry and search scheme initially focused within a 50 km radius of the release areas, we were able to relocate four of the owls. Two owls left the Wilderness Area region and were found within 20 days (in early- and mid-October) more than 100 km away from the release area (the two owls were released from two different release aviaries) in Upper Austria in the Traun valley. The two owls moved to Upper Austria on two different movement routes and found each other more than 100 km away to spend about six months in the same area until both dropped their telemetry transmitters in March and June 2011. In early 2012 when prey availability was very high, no spring dispersal occurred. In early 2013 there were at least three owls that started to disperse, after being relatively stationary during the winter. The furthest confirmed dispersal movement routes of young released Ural Owls so far were 150 km to the north (Sumava Forest, Czech Republic), 100 km to the west-northwest (Traun valley, Upper Austria), 80 km to the east (Schneeberg Mountain, Lower Austria) and 60 km to the southwest (Gesäuse National Park, Styria, and Kalkalpen National Park, Upper Austria) (Fig. 8). Importantly for the reintroduction program, the dispersal of owls to Lower Austria, and the Sumava Forest in the Czech Republic confirm the connectivity of owls to these areas of Ural Owl distribution.

Habitat selection

In the Lower Austrian Limestone Alps the preferred forest type of the Ural Owl are spruce-fir-beech-forests with different mixture proportions. The average size of breeding territories was 2.6 km², and the average size of territories of single birds 6.9 km², and the home range size was 4.2 – 9.8 km² (average 5.9 km²). Detailed analyses showed that the owls preferred territories with an exposure of southwest to southeast. Analyses showed that for the Ural Owl the description “forest owl” is justified. Around 75% of the habitat was covered by forest, 20% covered by open landscape such as meadows and temporarily unstocked area in the forest, and only 5% was covered by anthropogenic infrastructure. In each territory water bodies of different sizes were present. The Ural Owl does not prefer a special forest type but selects its territory based on the availability of small mammal prey, large, old cavity-bearing trees, often

Figure 9 - Overview of selected movements of Ural Owls from and to the Wilderness Area region between 2010 and 2017.

Figura 9 - Vista geral dos movimentos de corujas dos Urales de e para a região da Área Silvestre, entre 2010 e 2017.

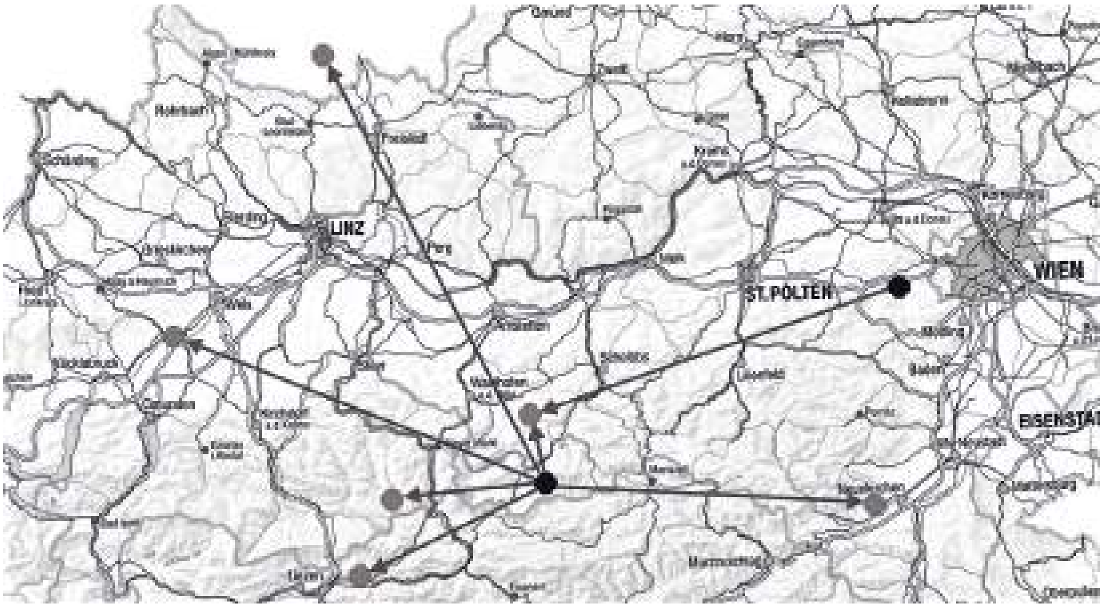
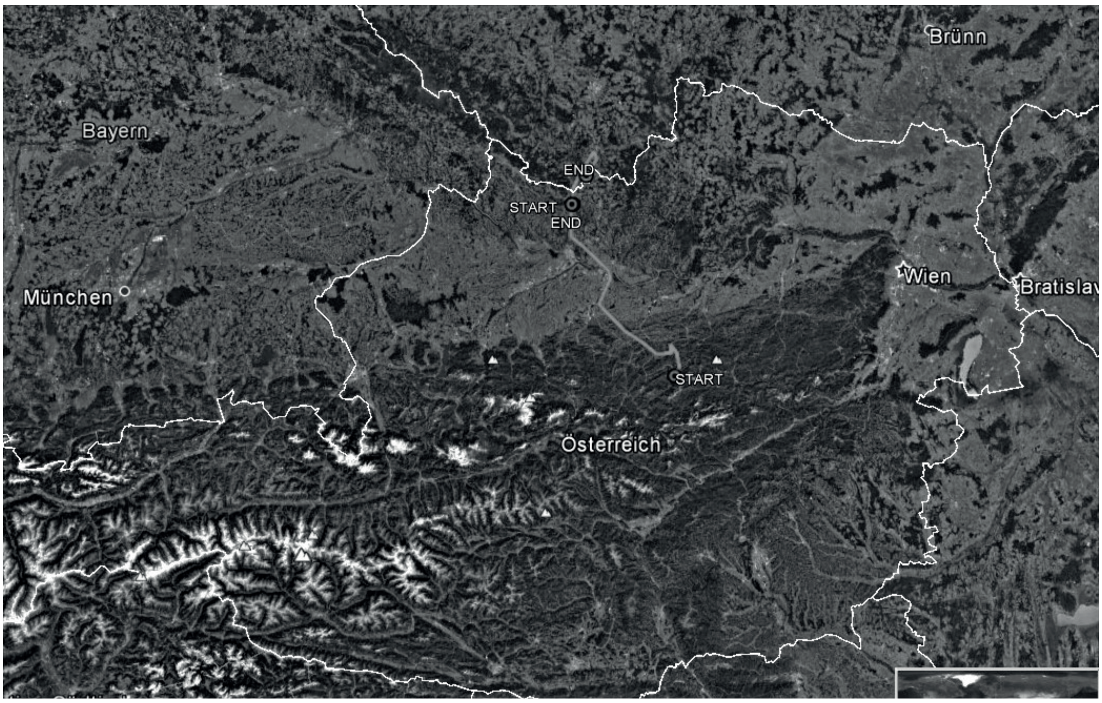


Figure 10 - Position of the 150 km movement route of a young Ural Owl released in July 2017 in the Dürrenstein Wilderness Area (Austria), migrating in August 2017 and reaching the Bohemian Forest (Czech Republic) in early September 2017.

Figura 10 - Rota de dispersão de 150 km de um juvenil de coruja dos Urales libertado em julho de 2017 na Área Silvestre de Dürrenstein (Áustria), migrando em agosto de 2017 e atingindo a Floresta da Boémia (República Checa) no início de setembro de 2017.



with dead tree trunks. More than 80% of the daily owl positions were located at elevations between 600 and 1,000 m, but only 50% of the study area was located in that range. Evergreen conifers are especially preferred during the inactive/resting daytime period.

DISCUSSION

With its central location between the Bavarian Forest, Sumava Forest and Slovenia, the Austrian study area was considered as an ideal stepping stone between existing populations of the Ural Owl. Scherzinger (1985 and 1996) describes the Ural Owl with its size and requirements for large tree cavities as a "primeval forest species", conditions that we confirmed with our decade of work in Austria.

Owl telemetry implies certain challenges due to the nocturnal activity of most owl species and the volume of their plumage. Within the last decade the Dürrenstein Wilderness Area Administration together with monitoring equipment companies developed different transmitter designs to find the ideal telemetry system for the telemetry of Ural Owls (Kohl & Leditznig 2017). The GPS-GSM-telemetry system and a battery-powered GPS-GSM-transmitter with temperature sensor, a hard cover and an internal antenna as protection against the owls' strong beak became our system of choice. The GPS-GSM-telemetry has replaced the other telemetry systems and transmitter models because of comparatively low costs, high accuracy, automatic storage of GPS-data and the automated transfer via the GSM net (Kohl & Leditznig 2017).

We established that the ideal age for the release of young Ural Owls was an age of about 90 days. The owls must be old enough to have a sufficient escape reflex and be able to fly accordingly. However, at the release they must not be so old that the intraspecific aggression potential and dispersal behavior are developed so far that the young owls no longer visit the feeding tables and avoid intraspecific social contacts (Scherzinger 2006). When older than 100 days - the owls start to be independent (Mebs & Scherzinger 2008) – they start to disperse, do not visit the offered feeding tables and immediately start hunting independently. While some birds may well be able to survive without a feeding table immediately after release, the majority of the young owls are dependent on the feeding tables as long as they learn to hunt independently. A few of some young owls that did not visit the feeding tables died of starvation or disease.

Survival rates of young in the wild are significantly lower during their first year of life than subsequent years. Rates can be around 60% and still fall significantly if there is a lack of prey (Mebs & Scherzinger 2008). In the first years of radio-telemetry 66 of 70 released owls were tracked daily. Twenty perished owls were found in the first years of the project (Kohl & Leditznig 2013), almost all owls that died were found during the first phase after release or in the first few weeks of independence before the beginning of winter. Nineteen mortalities (95%) were due to natural causes (predation, starvation, endoparasites, disease) and one case (5%) was anthropogenically caused by electrocution at a transformer during the dispersal phase). Between 2010 and 2013, the average survival rate was 79%. In later years with the GPS-GSM-telemetry also two cases of road kill were found. Mihok & Frey (2013) describe that the predation by the Golden Eagle (*Aquila chrysaetos*) seems to play an essential role. This also applies to the northern Limestone Alps. For example in the first years of radio-telemetry, two of the six young owls that were predated, were predated by the Golden Eagle (2 of 19 = 11% of natural losses). Two owls were predated by the Pine Marten, one owl by the Eurasian Goshawk and one owl by the Eurasian Eagle-owl. The Eurasian Eagle-owl seems to be one of the most important predators of Ural Owls in addition to the Golden Eagle. The location of the aviaries was therefore chosen to be as far as possible from known Eurasian Eagle-owl territories (Leditznig 1999, Leditznig & Leditznig 2006).

Breeding success of owls varies significantly with the small mammal populations regulated by the beech mast. Two extreme years were 2012 with a small mammal peak and very successful owl reproduction, and 2013 with a significant small mammal population decrease and no successful owl brood within the whole nest box network. While 2012 was a small mammal peak year, small rodent populations in the Dürrenstein Wilderness Area have been subject to a 4 to 5 year cycle, with population declines in 2009, 2010, and 2013 (Kempter & Nopp-Mayr 2013). The Ural Owl population in Finland runs synchronously with the 3-4 year cycles of voles (Pietiäinen & Saurola 1997, Brommer et al. 1998, Saurola 2003).

In 2012, when small mammal populations peaked, three of four breeding Ural Owls were one year old and one breeding bird was two years old. These results were surprising, as studies in Finland have established that Ural Owls there did not start to breed until an age of three to four years (Saurola 1992, Saurola 1997).

Nest boxes were a useful tool for our reintroduction efforts, even in areas relatively rich in cavity-bearing trees. Other species found nesting in our nest boxes included the Tawny Owl (*Strix aluco*), Stock Dove (*Columba oenas*), European Pied Flycatcher (*Ficedula hypoleuca*) and Eurasian Nuthatch (*Sitta europaea*). In Finland, where forestry actions have severely limited natural nest cavities, nest boxes have increased the nesting population of Ural Owls.

Like researchers in other regions, we also found that female Ural Owls tend to vigorously defend their offspring, especially during nest inspections. The females tend to attack people if they approach the nest too closely. Appropriate protection is essential for these visits, especially when ringing the chicks. Important for the protection of the owl as well as the ringer are a padded jacket and a helmet with a corresponding face shield for protection of the ringers' eyes. The padded jacket softens the attack of the adult bird and should prevent the female from being injured. In Finland, a pad is added to the top/back of the helmet for the safety of the owls' feet. There are significant individual differences in the behavior of the Ural Owls. While many females attack unflinchingly, others clearly hold back and make warning calls from neighboring trees. Ural Owl males hardly tend to attack, but usually show their presence by territory calls or warning calls (Leditznig & Kohl 2013, Leditznig 2013).

The food of Ural Owls in our study was very similar to that found in other regions. Vrezec (2001) describes the food composition of winter food in Slovenia by pellet analyses, regarding to the numbers of prey items, of 94% mammals, 2.7% insects, 1.6% birds and 1.6% amphibians. In contrast to the winter food, dormice are the main prey for the Ural Owl in Slovenia in summer time. Due to the dormouse population it is assumed that the females delay the oviposition (1 April to 11 June) in anticipation of a better prey situation ("waiting strategy hypothesis"). Hatchlings can be found until the beginning of July and fledglings until August (Vrezec & Kohek 2002). The autumn food in Slovenia, regarding to the number of prey items, consists of 59% dormice, 36% mice and 6% insects (Vrezec 2000b). Through radio-telemetry we could observe hunting behavior. Search flights were seen, but we mainly observed owls hunting while sitting on a tree and scanning the ground. For this kind of hunting, owls mostly used trees but also also used posts along the main road (Leditznig & Kohl 2013).

In the Dürrenstein Wilderness Area region we found Ural Owl home range sizes of 1.0-2.4 (average 1.7) pairs per 10 km². In Slovenia, a density of 2.2 pairs per 10 km² (4.5 km² per breeding pair) was reported (Vrezec 2000a, Prešern & Kohek 2001). Prešern & Kohek (2001) describe Ural Owl density of

2 to 5 pairs per 10 km^2. Pietiäinen & Saurola (1997) describe a density of 0.8 to 1.0 breeding pairs per 10 km^2 for Finland. In Sweden, Finland and Russia densities of 0.6 to 2.4 breeding pairs per 10 km^2 are found; in Poland 3 breeding pairs per 10 km^2.

In our Austrian study, more than 80% of the daily owl positions of Ural Owls were located at elevations between 600 and 1,000 m a.s.l. Mihelič et al. (2000) describes the elevational range of owls in Slovenia from 150 to 1,600 m a.s.l; the highest occurrence was 1,796 m. The distribution of owls in Slovenia is described as 700 to 1,100 m a.s.l., or an average of 850 m; during the breeding season, the majority of Ural Owls occur at elevations of 800 to 990 m a.s.l. (Prešern & Kohek 2001, Svetličič & Kladnik 2001, Mihelič et al. 2000). The distribution is more dependent on the habitat and the succession of forests where the percentage of old trees is high.

In the Dürrenstein Wilderness Area and the Primeval Forest Rothwald the abundance of tree stumps, hollow trees and tree cavities is incomparably higher than in commercial forests. Of preeminent importance for maintaining a vital, well-distributed owl population is the maintenance of natural breeding sites - cavities in large, old, dead or partially-dead trees. The larger goal must be in managing large, old forest conditions that provide the long-term nest site solution for the owls and other wildlife. Within this framework, the use of nest boxes should be considered only a transitional solution (Englmaier 2007, Lundberg & Westman 1984, Lohmus 2003, Scherzinger & Zink 2010, Lambrechts et al. 2012).

After the first successes of the project and the establishment of a basis for a future population of Ural Owls, it will be important (according to the criteria of W. Scherzinger), to take further steps towards a sustainable age distribution among the population, to connect the reintroduced animals to the "wild" population and to enhance the polymorphism that is typical for the species. It is planned to continue the reintroduction project for a few more years and to continue the telemetry of the young Ural Owls that will be released in the Dürrenstein Wilderness Area. Such work will make further efforts in closing distribution gaps, collect more valuable data for reintroduction projects, and especially to create awareness for the importance of deadwood in commercial forests – for our largest "forest owl" as well as for all wildlife.

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