

The distribution of the Pannonic root vole (*Microtus oeconomus mehelyi* Ehik, 1928) in Austria

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Abstract: As part of a LIFE project about the Pannonic root vole (*Microtus oeconomus mehelyi*) in Slovakia we also have investigated its occurrence in the nearby Austrian part of its range. Reports of the vole go back to 1897, when the presence of the species in Austria was first published. Apart from studying literature on the species' distribution, we have analysed owl pellet data and data of trapped specimens available from records at the Natural History Museum of Vienna (NMW) to illustrate the species' distribution in Austria up until 2010. For more recent years (2011-early 2015) we investigated its distribution in Austria by using snap and live-traps, and by analysing owl pellets. In this period we found the Pannonic root vole on the eastern and western side of the Neusiedler See. There are some indications that the root vole may have disappeared from the northern side of the lake due to habitat loss. We give recommendations for habitat management that can help conserve the species.

Keywords: *Microtus oeconomus*, *Microtus oeconomus mehelyi*, root vole, Austria, Neusiedler See, Seewinkel.

Introduction

The Pannonic root vole (*Microtus oeconomus mehelyi*) is a priority taxon of Annex II of the Habitats Directive and this subspecies is also listed on Annex IV of this directive. In consequence EU member states are obliged to inform the European Commission every six years about its conservation status. This publication has been written as part of the LIFE project "The conservation of root vole *Microtus oeconomus mehelyi*". The project provides a baseline study of the current status of the Pannonic root vole.

The root vole (*Microtus oeconomus*) has a continuous holarctic distribution from eastern Germany and northern Scandinavia, throughout all of Russia and Alaska and to north-western Canada. In addition there are

isolated populations in southern Scandinavia, on Finnish islands in the Gulf of Bothnia, in the Netherlands, southern Hungary (Balaton and Kiskunság) and at the point where Austria, Hungary and Slovakia meet (Shenbrot & Krasnov 2005). These isolated populations have been described as separate subspecies; with populations in Austria, Hungary and Slovakia representing the Pannonic root vole (*Microtus oeconomus mehelyi* Ehik, 1928). Its known distribution, based on available literature and our own data, is presented in figure 1A. One record from near the river Drava in southern Hungary, published in the Hungarian Atlas of Mammals (Gubányi 2007), proved to be erroneous (A. Gubányi, personal communication). Pachinger (2003) published an isolated record in an owl pellet from eastern Slovakia.

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The recent situation in Hungary and Slovakia is relatively well-known. In southern Hungary the root vole is decreasing. It disappeared from Kiskunság in the 1960s (Demeter & Topál 1987), but is still present around Lake Balaton (e.g. Lanszki & Rozner 2007, Horváth et al. 2012, Purger 2014) and in the Hungarian part of the Neusiedler See and Hanság (Gubányi et al. 2002). Along the Danube it is present on Small Rye Island (Szigetköz / Malý Žitný Ostrov, Kleine Schüttinsel) and Great Rye Island (Žitný Ostrov, Große Schüttinsel) and at several localities just north and east of the larger island (Gubányi et al. 2009, Miklós et al. 2014). It was feared that it had disappeared from Great Rye Island because of hydrological changes caused by the Gabčíkovo hydroelectric power plant (Pachinger 1995). But Gubányi et al. (2009), in their review of the species' occurrence along the Hungarian/Slovakian Danube since 1902, and Miklós et al. (2011, 2014) have shown that the root vole is still present at several localities on Great Rye Island.

An overview of the distribution of the species in Austria was given by Spitzenberger & Bauer (2002) - based on earlier publications (Mojsisovics von Mojsvár 1897, Bauer 1953, 1960, Spitzenberger 1966, Hoi-Leitner 1989) and data from material at the Natural History Museum of Vienna (NMW). Since then presence of the root vole in Austria has been mentioned by Mühlböck (2003), for the Westliche Wörtenlacke, in the Seewinkel. For the national report under article 17 of the Habitats Directive, a survey with live-traps was carried out in the Seewinkel area in August 2011. In this survey the Pannonic root vole was only recorded at the Östliche Wörtenlacke (Ch. Walder, personal communication).

Given this, it was considered important to study more closely the current and recent status of the root vole in the Austrian part of the Neusiedler See area, including Seewinkel and Waasen / Hanság (figure 1B). In consequence, in the framework of the LIFE project, root vole experts from the Dutch Mammal

Society (Dick Bekker, Rob Koelman, Wesley Overman and Johan Thissen) and Barbara Herzig and Katharina Spreitzer from the NMW joined forces to map the root vole on Austrian territory east and west of the Neusiedler See. The work focused on the east side, mainly the Seewinkel area, as analysis of owl pellets had demonstrated that the root vole is still present there while positive results for its presence in the western area were only very recently derived from owl pellets. This publication describes the history of the distribution in more detail and the current and recent status of the root vole in Austria.

The LIFE project “Conservation of root vole *Microtus oeconomus mehelyi*”

The general objective of the LIFE project “The conservation of root vole *Microtus oeconomus mehelyi*” (LIFE08/NAT/SK/000239, www.broz.sk/microtus/en) is to improve the recently unfavourable conservation status of the species in Slovakia, whose population is currently heavily fragmented and is potentially susceptible to extinction. In the project a strategic basis is developed for the successful recovery of this endangered subspecies, i.e. through habitat restoration or habitat improvement on specific sites important for the root vole.

The main threats to the root vole are habitat loss, fragmentation and degradation due to a changed water regime, the abandonment of traditional management of lowland meadows and reed beds and the genetic degradation of isolated populations. The main causes of these threats are large-scale land reclamation and drainage schemes, the ploughing of lowland meadows, the draining of wetlands and the overall intensification of agricultural production.

The most effective solution for conserving this rare species is therefore to reintroduce

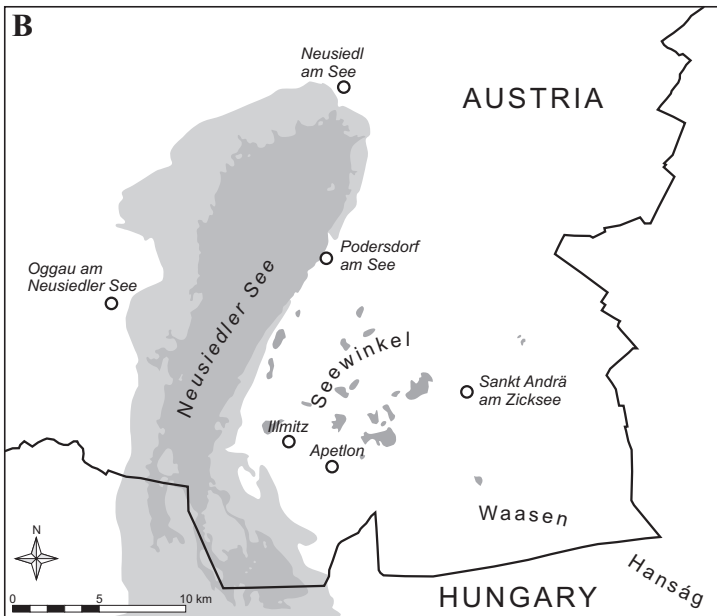
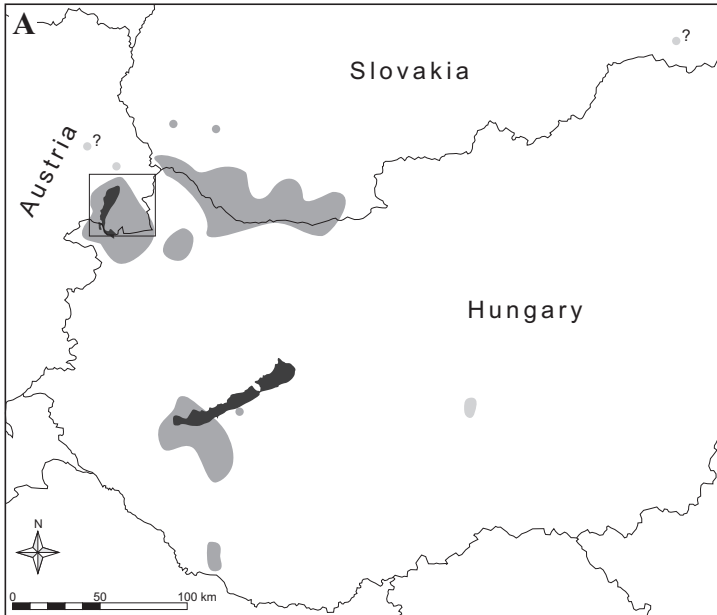


Figure 1. A. Distribution of *Microtus oeconomus mehelyi*. Compiled from published sources and own data: Slovakia – (Gubányi et al. 2009, Krištofik & Stollmann 2012, Pachinger 2003); Hungary – (Demeter & Topál 1987, Gubányi 2007, Gubányi et al. 2002, 2009, Purger 2014); Austria – (Spitzenberger & Bauer 2001 and own data). Presumably extant populations are shown in dark grey and reportedly extinct populations and questionable records (indicated by a question mark) are in light grey. The location of the study area is indicated by the black frame. B. Map of the study area. Water bodies and reed stands are shown as dark grey and light grey shading respectively.

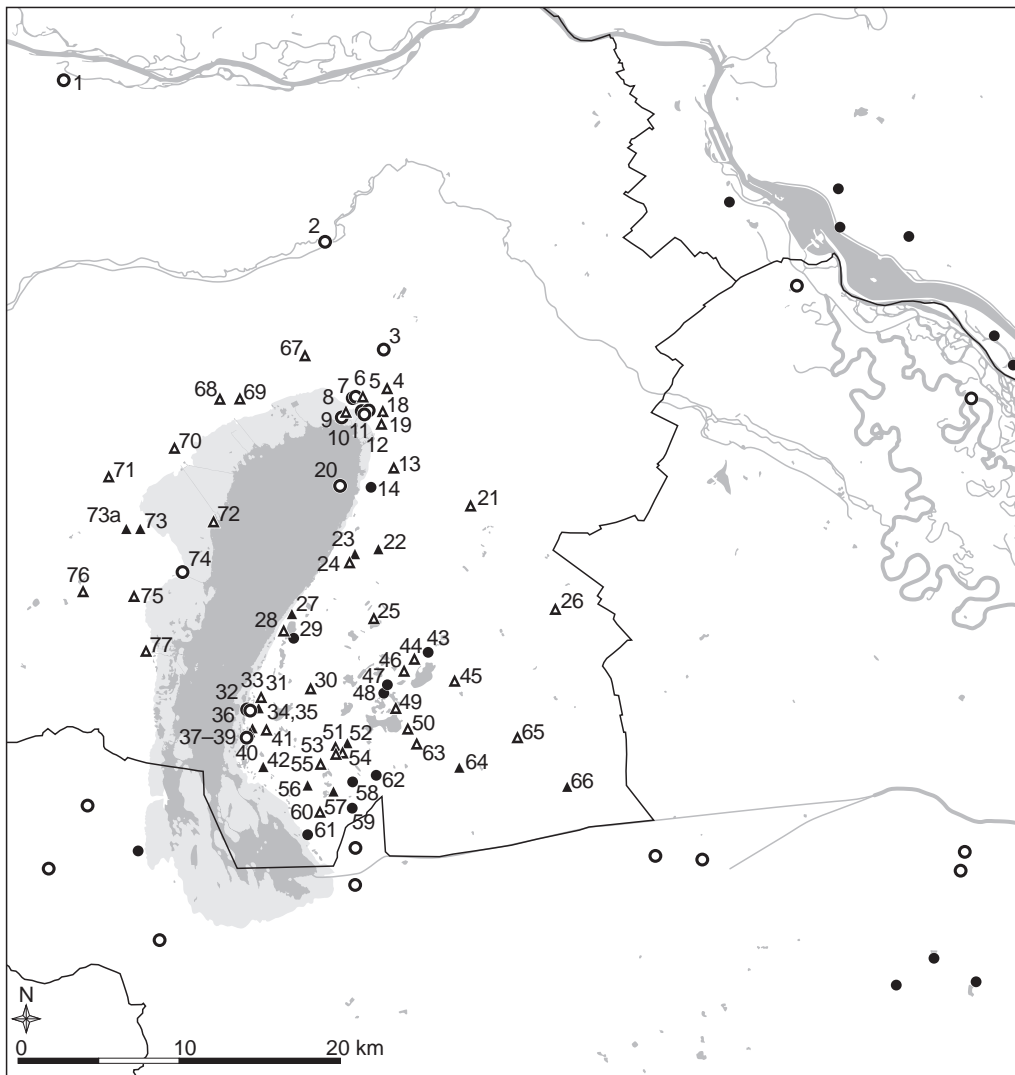


Figure 2. Records of *Microtus oeconomus mehelyi* from Austria. Direct records (trapped specimens, direct observations) are mapped as dots and records from owl or raptor pellets as triangles. Open symbols refer to records before the year 2000, filled symbols to records between 2000 and 2015. Extralimital records from Slovakia and Hungary have been extracted from Gubányi et al. (2002, 2009). Numbers refer to table 1 and the appendix.

traditional methods of agricultural production and to restore wetlands and bank vegetation in areas still inhabited by the root vole. The main objectives of the project are to restore a 33.5 km long stretch of the Čiližský brook and its adjacent wetlands, to restore 100 hectares of wet grasslands and 360 hectares of

marshlands important for the target species and to cut 150 hectares of reed beds, all on Great Rye Island. There is also lack of scientific data and awareness, which are addressed by the LIFE project. Miklós et al. (2011, 2014), in their work for this LIFE project, have recently trapped the root vole at several local-



Figure 3. Records of *Microtus oeconomus mehelyi* in the Lake Neusiedl area from 1939 to 2010, divided into three periods: before 1971, 1971-1990 and 1991-2010. Filled symbols are trapping records, open symbols are records from owl pellets.



Figure 4. Recent proved distribution of *Microtus oeconomus mehelyi* (2011 to 2015). White dots show localities of successful trapping and circles ($r=2$ km) are drawn around the localities where owl pellets that included remnants of *Microtus oeconomus mehelyi* were collected.

ities in the centre and the south of the Great Rye Island, including at Čiližský brook, and at many localities at the confluence of the Váh Danube and Nitra rivers, just east of the Great Rye Island.

Methods

The historical distribution (figure 2) of the root vole in Austria until 2010 was determined by using data from literature and from the mammal collection of the NMW. The NMW collection contains specimens from the years 1952 to 1964, 1969 and 1983 to 1986. Trapping in these years was done with commercial snap traps. In 2003 Mühlböck (2003, 2008) used live-traps (wooden box live-traps and wire cage traps; both from DeuFa GmbH, Neuburg, Germany) when studying small mammal communities on a pasture. All these collection localities are situated at the north and east side of the Neusiedler See. Records of the species from west of the lake were published by Hubálek et al. (1979) and Hoi-Leitner (1989) who both used snap trapping.

In the NMW collection also samples of owl pellets collected (in some years) between 1939 and 2015 from both sides of the lake were available. The majority of this material originated from the Seewinkel area in the east. These pellets were mainly from barn owl (*Tyto alba*) and to a lesser extent from short-eared owl (*Asio flammeus*), long-eared owl (*Asio otus*), little owl (*Athene noctua*) and falcons (*Falco* spp.).

From 2003 to 2014 Vinzenz Waba, a ranger at the Neusiedler See – Seewinkel National Park, collected a total of 97 samples of barn owl pellets that all originated from the southeastern side of the Neusiedler See. This area runs south from Podersdorf to Illmitz and Apetlon, covering about twelve square kilometres (figure 1B). Pellets were collected from 17 sites. Most samples (34) came from a locality known as Apetloner Hof, near the village of Apetlon, and there were twelve samples



Pannonic root vole (*Microtus oeconomus mehelyi*) in the Seewinkel area, Austria, 10 September 2011. Photo: Rob Koelman.

from the Hölle locality, at Illmitz. There were also six localities from which only one sample was collected. The barn owl has an overriding importance when collecting information about the presence of small mammals as, of all owls in Austria, it is the least specialised on any single prey type and its pellets thus show a wide prey spectrum. The amount of pellets per sample varied from one to a couple of hundred (conditions did not always permit exact counts).

Prior to 2007 owl pellets were sorted out by several well trained people, using (remains from) calvaria and mandibles for identification. Since 2007 the owl pellets have been sorted out in the same way by K. Spreitzer. The remains of 285 samples of owl pellets are stored in the mammal collection of the NMW. While in another 19 cases only identification protocols but no remains of the small mammals were available.

To investigate the recent distribution (2011 to March 2015) of the root vole in the Neusiedler See area we also analysed owl pellets from the east and the west side of the lake. From



Wesley Overman and Johan Thissen, while weighing Pannonic root voles in an area with moist reed and sedge vegetation at Westliche Wörtenlacke, Seewinkel, Austria, 10 September 2011 (locality 48 in figure 2 and in the appendix). *Photo: Rob Koelman.*

2011 to 2015 only ten samples of owl pellets were collected in the west while by contrast 26 samples of pellets were received from the eastern side of the lake during this period. Five of the ten samples from the west were just single pellets of long-eared owl while the rest were barn-owl pellets. A study of the situation of the barn owl in eastern Austria in 2006-2009 (Donnerbaum & Frühauf 2010) had shown that barn owls were very rare on the western side of the Neusiedler See. In 2011 we received just one sample of barn owl pellets from the west. No other nesting or roosting sites of barn owls were located at that time and even special nest boxes mounted in the area in 2006-2009 had not (yet) been occupied. Currently, however,

the situation of the barn owl seems to improve (A. Ranner, personal communication).

Altogether, 302 (1939-March 2015) samples of pellets from the area were investigated during this study, 133 of them contained the remains of one or more specimens of the root vole.

In addition, live trapping was done in the Seewinkel around Apetlon in the years 2011 and 2012. In September 2011 live trapping was done over 600 trap nights and in October 2012 over 280 trap nights. At every locality we had ten pairs of two Longworth live-traps during two nights in the field. The pairs of traps were 5-10 m apart. The live-traps were supplied with hay and baited with carrot and a commercial mix of rodent food. Living larvae of

Tenebrio molitor (mealworms) were added to reduce mortality of caught shrews. The traps were not pre-baited. Root voles caught in live-traps were marked by cutting hairs from the back with a scissor and a tissue sample was taken from an ear with a biopsy punch. In October 2012 we used snap traps baited with peanut butter, in an exercise that coincided with the collection of voucher specimens of other species, on the western and eastern side of the Neusiedler See (near Oggau and in Zitzmannsdorfer Wiesen - north of Podersdorf respectively). 180 snap traps were positioned in both these areas for one night.

Live trapping was restricted to biotopes which were considered to be appropriate for the root vole, based on our own experiences in the Netherlands, i.e. reedbeds with a well-developed understory of *Carex* vegetation and *Schoenetum*, while snap trapping also covered adjacent habitats

Results

Distribution

Results about the distribution presented here are divided into different time periods to illustrate the very uneven distribution of data - since most material was collected randomly. Only in recent years from 2011 till 2015 we were specifically looking for the root vole.

Before 1971

The first probable record of the root vole from present-day Austrian territory is from Fischamend, Lower Austria (locality 1 in figure 2 and appendix) (Mojsisovics von Mojsvár 1897). It is based on a note communicated to A. Mojsisovics von Mojsvár by August von Pelzeln, former curator of the ornithological and mammalogical collections of the NMW. The year of recording remains unknown. As August von Pelzeln died in 1891, that year is the *terminus ante quem* of the record. In the absence of voucher specimens or any other

supporting documentation at the NMW, this record, which would also represent the earliest record of the Pannonic subspecies, was often regarded as questionable. However, in view of the present distribution of the species, further downstream along the Danube, and given that the Danube was not completely regulated in those days, the presence of the root vole near Fischamend seems plausible.

At least 60 years later, in 1951, Kurt Bauer (re)discovered the species in Austria at the Neusiedler See (Bauer 1953). Since then the root vole has been documented at several localities along the northern and eastern reed belt of the Neusiedler See (Bauer 1960, Spitzenberger 1966). It also has been documented for the area west of the lake by records from owl pellets from 1939 onwards (figure 3). Between 1958 and 1964 the species was found in two, most likely isolated localities: east of Bruck an der Leitha (locality 2 in figure 2 and appendix) and in the Teichwäldchen / Neusiedl am See (locality 3 in figure 2 and appendix). These isolated populations also corroborate the earlier presence of the species near Fischamend although this population is now considered to be extinct (Spitzenberger & Bauer 2002). These records prove the distribution of the root vole all around the lake during this period, including the western side and in adjacent areas in the east (Seewinkel and Waasen/Hanság) (figures 2 and 3).

1971-1990

During the second period 1971-1990 (figure 3) remains of root vole were found in several samples of owl pellets collected from around the Austrian part of the lake, as well as in the Seewinkel and the Waasen/Hanság. A few catches of root voles during this period indicate their presence to the west, north and east of the lake in 1977 (Hubálek et al. 1979) and 1985/86 (Hoi-Leitner 1989).

1991-2010

Remains from owl pellets from this period prove the presence of the root vole on the east-

Table 1. Results of small mammal trappings in 2011-2012 in the Neusiedler See area, Austria, aimed at finding root vole.

Nr in fig. 2 and Appendix.	Location name	Latitude	Longitude	Date	# Trap Nights L: live-traps s: snap traps	<i>M. oeconomus</i> (number of different individuals)	Other species Trapped (number of catches)
48	between Westliche and Östliche Wörtenlacke, Apetlon	47°46'43"	16°52'21"	Sept. 2011	40 L	9 (7m, 2f)	1 Na, 9 Sa
48	N of Westliche and Östliche Wörtenlacke, Apetlon	47°46'44"	16°52'20"	Sept. 2011	40 L	4 (2m, 2f)	3 Sa
59	E Zicksee, St. Andrä/Zicksee	47°47'47"	16°54'27"	Sept. 2011	40 L	-	1 Na, 3 Sa, 2 Mg, 23 Aa, 1 Af
58	Xixsee, Apetlon	47°45'44"	16°50'25"	Sept. 2011	40 L	-	2 Sa, 2 Sm, 19 Ma, 1 Mm, 3 Aa
	S Apetloner Hof, Apetlon	47°42'44"	16°50'38"	Sept. 2011	40 L	1 m	1 Sa, 4 Aa
	N Apetloner Hof, Apetlon	47°43'34"	16°50'39"	Sept. 2011	40 L	10 (9m, 1f)	2 Sa, 3 Ma, 3 Aa
	S Martentaulacke, Apetlon	47°43'54"	16°50'54"	Sept. 2011	40 L	-	2 Sm, 7 Mm
	N Martentaulacke, Apetlon	47°44'08"	16°51'05"	Sept. 2011	40 L	-	1 Sa, 10 Ma, 2 Mm, 1 Aa
43	N Zicksee, St. Andrä/Zicksee	47°47'48"	16°54'23"	Sept. 2011	40 L	1 f	1 Na, 1 Ma, 18 Aa, 2 Af
	Illmitz dam, Illmitz	47°45'13"	16°44'46"	Sept. 2011	40 L	-	3 Ma, 24 Aa, 3 Af
	0.7 km NW Herrensee, Illmitz	47°44'52"	16°45'35"	Sept. 2011	40 L	-	2 Mg, 17 Aa
29	NE Unterer Stinkersee, Illmitz	47°48'16"	16°47'33"	Sept. 2011	40 L	6 (4m, 2f)	1 Sa
	E Biologische Station, Illmitz	47°46'07"	16°45'51"	Sept. 2011	40 L	-	3 Aa
	W Biologische Station, Illmitz	47°46'09"	16°45'51"	Sept. 2011	40 L	-	6 Ma, 52 Aa
	0.6 km W Herrensee, Illmitz	47°44'38"	16°45'47"	Sept. 2011	40 L	-	4 Sa, 1 Ma, 8 Ms, 32 Aa, 1 Mm
62	0.9 km NE Martentaulacke, Apetlon	47°43'47"	16°51'49"	Sept. 2011	-(dogs)	3 (1 m, 2f)	Note: no traps were placed
61	Neudegg, Apetlon	47°41'49"	16°48'29"	Oct. 2012	40 L	4 (2m, 2f)	1 Aa, 16 Mm
	Neudegg, Apetlon	47°41'35"	16°48'36"	Oct. 2012	40 L	-	3 Aa, 6 Asp
	Neudegg, Apetlon	47°41'41"	16°48'39"	Oct. 2012	40 L	-	7 Aa, 1 Ma, 8 Mm
	Zwikisch, Apetlon	47°42'17"	16°48'47"	Oct. 2012	40 L	-	5 Aa, 4 Asp, 2 Mm
	Zwikisch, Apetlon	47°42'15"	16°48'46"	Oct. 2012	40 L	-	3 Asp
	Zwikisch, Apetlon	47°42'21"	16°49'06"	Oct. 2012	40 L	-	6 Asp, 1 Sa
14	0.8 km S Apetloner Hof, Apetlon	47°42'50"	16°49'37"	Oct. 2012	40 L	-	2 Aa, 2 Asp, 5 Ma
	Viehhüter, Zitzmannsdorferwiesen, Neusiedl am See	47°53'26"	16°51'23"	Oct. 2012	180 s	1 m	10 Sa, 1 Cl, 9 Ma, 1 Asp, 1 Aa
	Steinriegel, Oggau am Neusiedler See	47°51'50"	16°41'40"	Oct. 2012	180 s	-	1 Sa, 7 Ma, 2 Asp, 4 Aa, 6 Mm

Species abbreviations: Aa – *Apodemus agrarius*, Af – *A. flavicollis*, As – *A. sylvaticus*, Asp. – *Apodemus* spp. (*A. flavicollis*, *A. sylvaticus*, *A. sylvaticus*, *A. sylvaticus*), Cl – *Crocidura leucodon*, Ma – *Microtus arvalis*, Mg – *Myodes glareolus*, Ms – *Microtus subterraneus*, Mm – *Micromys minutus*, Na – *Neomys anomalus*, Sa – *Sorex araneus*

Table 2. Temporal steadiness (TS) and proportion of *Microtus oeconomus* (pMo) in owl pellets (Ta – *Tyto alba*, Ao – *Asio otus*) from localities re-sampled more than three times. Sample size is expressed as the minimum number of vertebrate prey items (MNVP). Samples were pooled by year for calculating TS and pMo. MNVP was calculated for every sample and these values were then pooled by year. For pMo and MNVP the mean and the range (in brackets) are given. TS was calculated as the number of years in which *M. oeconomus* was present, divided by all sampled years at a given locality. pMo was calculated as a percentage: $100 * \text{Minimum number of } M. oeconomus / \text{MNVP}$. Only annual samples with $\text{MNVP} \geq 100$ were used.

Locality	Years	Owl	TS	pMo	MNVP
56	10 (2003–2013)	Ta	1.00	1.04 (0.16–5.55)	555 (103–1420)
39	6 (2003–2010)	Ta	1.00	2.83 (0.72–4.52)	308 (242–421)
42	6 (1991–2013)	Ta	0.67	1.65 (0.00–6.83)	516 (269–1025)
19	5 (1951–1955)	Ta	0.80	0.65 (0.00–1.71)	544 (210–1301)
27	5 (1984–2011)	Ta	0.60	1.18 (0.00–4.11)	421 (114–973)
23	4 (2006–2009)	Ta	0.25	0.19 (0.00–0.76)	400 (285–557)
51	4 (1985–2014)	Ao	1.00	9.77 (0.68–14.52)	450 (146–1024)

ern side of the lake, in the Seewinkel and the Waasen/Hanság (figure 3) at this time. However we did not have a single sample of pellets from the western side of the lake from this period. Berg & Ille (2002) identified remains of root vole in owl pellets from Neusiedler See area between 1990 and 2000, but the precise original data are unfortunately not available any more. Trapping, in this case live trapping, of small mammals in this area was only done in 2001 and 2002 by Mühlböck (2003, 2008) just northeast of the Westliche Wörtenlacke (locality 47 in figure 2 and appendix). He trapped eleven individuals in 2001, and none in 2002.

2011- March 2015

In September 2011 we had 39 catches of root voles (31 different individuals) with Longworth live-traps (600 trap nights) at six out of 15 localities (figure 2, table 1). At locality 62, while we were putting out traps, the dogs of the Director of the National Park caught three root voles. As this already confirmed the presence of the species, we immediately removed the traps we had set out at this locality. In the course of the trapping with 180 snap traps to the east of the Neusiedler See during one night in October 2011 we caught a root vole in the Viehhüter reedbed in the Zitzmannsdor-

fer Wiesen, north of Podersdorf (locality 18 in figure 2 and appendix). In the course of the trapping with Longworth live-traps in October 2012 (280 trap nights) we caught four different root voles at one of seven localities.

The plan to trace root voles on the west side of the Neusiedler See by finding their remains in owl pellets could not be satisfactorily carried out. From 2011 to March 2015 only 10 samples of owl pellets were obtained from this side of the lake. The single sample of pellets of a barn owl in 2011 from the western side did not contain any root vole remains. A further five samples from this area collected during this period were just single pellets produced by long-eared owls and none of them contained any remains of root voles. Finally, remains in two barn owl pellet collections from 2013 and another two from March 2015, proved the current presence of the root vole on the west side of the Neusiedler See.

The presently proven distribution of the species is shown in figure 4. In the east there is a good spatial correspondence between the records from the pellets and the results from trapping, with the exception of the record from the southeastern corner of the study area (locality 66 in figure 2 and appendix). In the summer of 2014 remains of a root vole

were found in a pellet of a short-eared owl in the Sankt Andräer Wiesen. This is the only recent record from the Austrian part of the Waasen / Hanság area, although the species is known to occur in the Hungarian part of this area (Gubányi et al. 2002).

Temporal steadiness and proportion in pellets

Sufficient samples illustrating the steadiness of the root vole in a longer period were only available from the Seewinkel. Owl and raptor pellet samples containing root vole from the years 1939 to 2014 ($n=85$) document the presence of the species at 55 localities. On the basis of these samples we made the following calculation. The minimum number of vertebrate prey items (MNVP) in samples of pellets containing the remains of root voles ranged from 4 to 1999. The majority, 88% ($n=75$), of the analysed owl and raptor samples of pellets were from just two species of owls, barn owl ($n=62$) and long-eared owl ($n=13$). Other owl and raptor species in whose pellets the root vole was recorded are: short-eared owl, little owl and falcons. The root vole made up between 0.2% and 14.8% (mean = 2.4%) of the MNVP of barn owl and between 0.2% and 31.8% (mean = 9.4%) of the MNVP in samples of pellets of long-eared owl (only samples with MNVP ≥ 100).

Samples of pellets were collected from seven localities over four or more years (table 2). There were marked annual fluctuations in the proportion of root vole found in most of these samples, although the temporal steadiness was higher than 0.5 in six of the seven localities, indicating a more or less stable presence of the root vole in the area.

Habitat

In 2011 we caught root voles at moist to dry

habitats around small water bodies and in 2012 in the reed belt of the Neusiedler See itself. In one case the traps were placed in a vast *Carex* field with *Lycopus* spp., *Juncus* spp., *Molinia caerulea* and *Lythrum salicaria*, but without reed *Phragmites australis*. At all other further localities we placed the traps at the edge of some reed areas. The reed was mainly mixed with *Carex* spp. with undergrowth of the following combinations:

- *Lycopus* spp., *Mentha aquatica*, *Epilobium* spp.
- *Lycopus* spp., *Althea officinalis*, *Sonchus* spp.
- *Potentilla anserina*
- *Lycopus* spp., *Symphytum* spp., *Typha angustifolia*, *Lysimachia vulgaris*
- *Agrostis stolonifera*, *Molinia caerulea*, *Sonchus* spp., *Mentha aquatica*, *Schoenus nigricans*

The three specimens caught by dogs (see above) were found in a slightly unusual habitat: a dry mowed part of a meadow with *Cladium* and reed.

Discussion

This study confirmed the recent distribution of the root vole in the Seewinkel area east of the Neusiedler See. Besides, we found proof of its occurrence west of the Neusiedler See. However, the number of samples of recent pellets from the west is insufficient to draw further conclusions about the root vole's overall distribution in this area. Nowadays there are only very few barn owls present there.

The only sample of barn owl pellets from the west in 2011 and a few pellets from long-eared owls in 2014 failed to show any sign of root voles, yet samples from the same area taken in 1986 always delivered positive results. Besides, we also failed to trap any root voles at a nearby location with 180 snap traps in one night in 2011. However, two barn owl pellet samples collected in 2013 and 2015 from a restricted area northwest of Oggau proved

again the presence of the root vole there. Further localities will have to be investigated by trapping in the future.

The sites where root vole was formerly caught to the north of the lake, near the village Neusiedl am See, have completely changed. The reed belt is now mostly a built up area, offering insufficient habitat for root voles. The root voles in the second area, the Teichwäldchen, at the edge of the Parndorfer Platte, were already regarded extinct by Spitzenberger & Bauer (2002). In recent years this former small wetland has deteriorated due to water regulation.

The second area where the root vole's presence in Austria was confirmed, also the best surveyed area since the 1980s, is located east of the Neusiedler See. It comprises the Seewinkel and Waasen/Hanság areas, including the reedbelt in the Neudegg area south of Apetlon, on the eastern shore of the lake. Data indicate rather stable populations in these restricted areas. Most of the sites are in the Neusiedler See – Seewinkel National Park, thus putting a special responsibility on the park management.

Our trapping mainly took place in reedbeds with a developed understory of *Carex* vegetation and *Schoenetum*. In the 1950s the biotope selection of the root vole in the Neusiedler See – Seewinkel area was broader, including wet woods (alder and willow carrs) and *Molinietum* vegetations (Bauer 1953, 1960). In the 1980s Hoi-Leitner (1986) was unable to catch the root vole in woods and *Molinietum* vegetations, suggesting that increased competition from other voles, e.g. bank vole (*Myodes glareolus*) in woods as a reason for this. This process of displacement may have been enhanced by the planting of more wood samples and rows of trees in the region. A main competitor vole in reedbeds, the field vole (*Microtus agrestis*), is absent in the area, so the root vole could stand its ground in that habitat.

Conclusions and recommendations for management

Since the 1960s the distribution of *Microtus oeconomus mehelyi* decreased on the northern side of the Neusiedler See. The species might even be extinct there. The distribution on the west of the lake needs to be investigated thoroughly. On the east side of the lake catches of the Pannonic root vole were quite numerous, which indicates that the species still occurs in reasonably good numbers in this part.

The root vole needs moist meadows with sedges, *Lycopus* or reed with understory of sedges. These biotopes can be found around the lake and around small water bodies in the Seewinkel area and need to be conserved. This implies no, or less, mowing of those meadows and reed beds, removing cut reed and restricting year-round grazing on the shores of water bodies. These conservation strategies need to be implemented by the management of the Neusiedler See - Seewinkel National Park and the political institutions in Austria.

To preserve the ecological niche for the Pannonic root vole, we recommend stopping-up drainage systems and returning agricultural land into marsh areas so that the connectivity of these populations can be maintained. Core areas should be separated from each other no more than three km, with stepping stones and corridors in between (Bergers et al. 1998).

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References

- Bauer, K. 1953. Zur Kenntnis von *Microtus oeconomus mehelyi* Ehik. Zoologische Jahrbücher. Abteilung für Systematik, Ökologie und Geographie der Tiere 82 (1/2): 69–94.
- Bauer, K. 1960. Die Säugetiere des Neusiedlersee-Gebietes (Österreich). Bonner Zoologische Beiträge 11 (2–4): 141–344.
- Berg, H.-M. & R. Ille 2002. Zur Situation der Schleiereule (*Tyto alba* Scop.) in Ostösterreich. Egretta 45 (1–2): 122–134.
- Bergers, P.J.M., B. van den Boogaard, D.P.E.M. Friszen & W. Nieuwenhuizen 1998. De noordse woeilmuis in het Deltagebied. Richtlijnen voor beheer en inrichting. IBN-rapport 365. IBN, Wageningen, the Netherlands.
- Demeter, A. & G. Topál 1987. Mammals of the Kiskun-ság. In: S. Mahunka (ed.). The fauna of the Kiskun-ság National Park. Volume 2: 446–452. Akadémiai Kiadó, Budapest, Hungary.
- Donnerbaum, K. & J. Frühauf 2010. Artenschutzprojekt Schleiereule Ostösterreich, Umsetzungsphase 2006–2009. BirdLife Österreich, Vienna, Austria.
- Gubányi, A. 2007. Északi pocok *Microtus oeconomus* (Pallas, 1776). In: Z. Bihari, G. Csorba & M. Heltai (eds.). Magyarország emlőseinek atlasza: 164–165. Kossuth Kiadó, Budapest, Hungary.
- Gubányi, A., S. Kalmár & F. Mészáros 2002. Insectivores and rodents from the Fertő–Hanság National Park and its surroundings. In: S. Mahunka (ed.). The fauna of the Fertő–Hanság National Park. Volume 2: 787–798. Hungarian Natural History Museum, Budapest, Hungary.
- Gubányi, A., A. Dudich, A. Stollmann & M. Ambros 2009. Distribution and conservation management of the root vole (*Microtus oeconomus*) populations along the Danube in Central Europe (Rodentia: Arvicolinae). Lynx (n.s.) 40: 29–42.
- Hoi-Leitner, M.K. 1989. Zur Veränderung der Säugetierfauna des Neusiedlersee-Gebiets im Verlauf der letzten drei Jahrzehnte. Bonner Zoologische Monographien 29: 1–104.
- Horváth, G.F., B. Horváth, N. Sali & R. Herczeg 2012. Community-level response to different human disturbances and land use of small mammals in two marshland habitat patches in Hungary. Archives of Biological Sciences 64 (2): 613–628.
- Hubálek, Z., W. Sixl, Z. Šebek, D. Stünzner, H. Troger & M. Valová 1979. Adiaspiromycosis of wild small mammals in Austria. Folia Parasitologica 26: 159–164.
- Krištofík, J. & A. Stollmann 2012. Hraboš severský – *Microtus oeconomus*. In: J. Krištofík & Š. Danko (eds.). Cicave Slovenska: rozšírenie, bionómia a ochrana: 115–118. VEDA (vydavateľstvo Slovenskej akadémie vied), Bratislava, Slovakia.
- Lanzski, J. & G. Rozner 2007. Kisemlősök vizsgálatá, különös tekintettel az északi pocok (*Microtus oeconomus* ssp. *mehelyi* (Ehik, 1928)) elterjedésére a Balatoni Nagyberekben. Natura Somogyiensis 10: 365–372.
- Miklós, P., D. Žiak, M. Ambros, A. Dudich, A. Stollmann & V. Hulejová Sládkovičová 2014. Records of Pannonian root vole (*Microtus oeconomus mehelyi*) in the south–western Slovakia in 2011. Folia faunistica Slovaca 19 (1): 57–63.
- Miklós, P., D. Žiak, M. Ambros & A. Stollmann 2011. Nové nálezy hraboša severského panónskeho (*Microtus oeconomus mehelyi*) v oblasti Podunajskej roviny. Folia faunistica Slovaca 16 (1): 19–23.
- Mojsisovics von Mojsvár, A. 1897. Das Thierleben der österreichisch-ungarischen Tiefebene. Alfred Hölder, Wien, Austria.
- Mühlböck, P. 2003. Kleinsäuger auf beweideten und unbeweideten Flächen im Nationalpark Neusiedlersee-Seewinkel (mit populationsbiologischen und ökologischen Beiträgen). Diplomarbeit. Universität Wien, Wien, Austria.
- Mühlböck, P. 2008. Einfluss der Beweidung auf die

Kleinsäugerzönosen im Nationalpark Lake Neusiedl – Seewinkel (Burgenland, Österreich). Abhandlungen der Zoologisch-Botanischen Gesellschaft in Österreich 37: 325–344.

- Pachinger, K. 1995. Habitat a perspektívy prežitia hraboša severského panónskeho (*Microtus oeconomus mehelyi* Éhik, 1928) na Slovensku. In: P. Urban & D. Baláž (eds.). Výskum a ochrana cicavcov na Slovensku [1]: 37–40. Slovenská agentúra životného prostredia – centrum Banská Bystrica & Stredoslovenská pobočka Slovenskej zoologetickej spoločnosti SAV Zvolen, Banská Bystrica, Slovakia.
- Pachinger, K. 2003. Restitution der Pannonischen Nordischen Wühlmaus (*Microtus oeconomus mehelyi* Éhik, 1928) in der mittleren Donauregion – Methoden und Erkenntnisse. In: M. Stubbe & A. Stubbe (eds.). Methoden Feldökologischer Säugetierforschung. Volume 2: 373–380. Gesellschaft für Wildtier- und Jagdforschung e.V. and Institut für Zoologie / Arbeitsgruppe Tierökologie der Martin-Luther-Universität Halle-Wittenberg, Halle (Saale), Germany.
- Purger, J.J. 2014. Survey of the small mammal fauna in north-western Somogy county (Hungary), based on barn owl *Tyto alba* (Scopoli, 1769) pellet analysis. *Natura Somogyiensis* 24: 293–304.
- Shenbrot, G.I. & B.R. Krasnov 2005. An atlas of the geographic distribution of the arvicoline rodents of the world (Rodentia, Muridae, Arvicolinae). Pensoft, Sofia, Bulgaria.
- Spitzenberger, F. 1966. Ein Beitrag zur Ökologie und Biologie von Neusiedler Feldmäusen (*Microtus arvalis*). *Natur und Land* 52 (1): 18–21.
- Spitzenberger, F. & K. Bauer 2002. Sumpfwühlmaus, Nordische Wühlmaus *Microtus oeconomus* (Pal-

las, 1776). In: F. Spitzenberger (ed.). Die Säugetierfauna Österreichs: 456–461. Austria Medien Service, Graz, Austria.

Samenvatting

De verspreiding van de Pannonische noordse woelmuis (*Microtus oeconomus mehelyi* Éhik, 1928) in Oostenrijk

Als onderdeel van een LIFE project voor de Pannonische noordse woelmuis hebben we het voorkomen in Oostenrijk onderzocht. Deze ondersoort, met een beperkt areaal rond het drielandenpunt van Oostenrijk, Slowakije en Hongarije, is in 1897 voor het eerst voor Oostenrijk vermeld. Het voorkomen in de periode tot 2010 brachten we in beeld aan de hand van literatuur, braakbalpartijen en documentatie over verzamelde exemplaren, aanwezig in het Natuurhistorisch Museum in Wenen. In de periode 2011–2015 onderzochten we gericht het huidige voorkomen door analyse van braakbalpartijen en vangen met inloopvallen en klemmen. In deze recente periode werd de noordse woelmuis binnen Oostenrijk aangetroffen aan de oost- en westzijde van de Neusiedler See, terwijl de soort vroeger ook ten noorden van dit meer aanwezig was. Tenslotte geven we aanbevelingen voor het beheer van leefgebieden van de Pannonische noordse woelmuis.

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Appendix

List of root vole specimens and owl pellets used in this survey. The numbers correspond with those in figure 2.

Specimens: locality [coordinates, elevation], collecting date, number and sex (m, f, ind), museums inventory number or field number, collector's name, citation.

Owl pellets: locality, collecting date, number of specimens (MNVP of the pellet sample), museum inventory number or protocol number, collector's name, citation.

Coordinates of collection localities of all owl pellets and of specimens caught before 2010 are given in degrees and minutes, thus marking the south-western corner of the minute quadrant in which the locality is located. For owl pellets we accepted this coordinate accuracy (to minutes) for the whole study period (i.e. to date), while for specimens caught during the period of 2011-2014 we used (more accurate) coordinates to the nearest second of the collecting locality.

Niederösterreich

Fischamend

1. Fischamend [c. 48°07'N, 16°36'E], no date [before 1891]: [no voucher known, see discussion in the main text for this questionable locality] (Mojsisovics von Mojsvár 1897)

Bruck an der Leitha

2. E Bruck an der Leitha [c. 48°01'N, 16°49'E], 8 Nov. 1964: 1 ind. (voucher in coll. Steiner; leg. H.M. Steiner) (Spitzenberger & Bauer 2001)

Burgenland

Neusiedl am See

3. Teichwäldchen [47°57'N, 16°52'E, 160 m], 3 Feb. 1958: 1m (NMW 17319; leg. F. Spitzenberger) (Spitzenberger & Bauer 2001)
4. Kalvarienberg [47°56'N, 16°52'E, 160 m], Apr. 1957: 2 ind. in *Asio* sp. pellets (22) (NMW 'pellet files' G1957-4, no vouchers; leg. K. Bauer)
5. barrack [47°56'N, 16°51'E, 125 m], May 1951: 5 ind. in *T. alba* pellets (25) (NMW 'pellet files' G1951-5, no vouchers; leg. K. Bauer)

6. Bahnwärter [47°56'N, 16°51'E, 117 m], 21–22 Aug. 1964: 2 ind., 9m, 18f (NMW 9977–9996, 10000–10006, 10008, 10009; leg. F. Spitzenberger) (Spitzenberger 1966)
7. siltation area at Bad Neusiedl train station [47°56'N, 16°50'E, 116 m], 27, 28 Jul. 1952: 1m, 2f (NMW 56169–56171; leg. K. Bauer), 30 Jul. 1952: 2m, 3f (NMW 56172–56176; leg. K. Bauer) [one specimen donated to Museum Wiesbaden], 10–11 Aug. 1952: 4m, 2f (NMW 56183–56188; leg. K. Bauer), 26–27 Aug. 1952: 1m, 2f (NMW 56189–56191; leg. K. Bauer), 29 Aug. 1952: 2f (NMW 56192, 56193; leg. K. Bauer), 7 Nov. 1952: 1m, 2f (NMW 56177–56179; leg. K. Bauer), 10 Nov. 1952: 1f (NMW 56180; leg. K. Bauer), 18 Jul. 1953: 1m (NMW 56181; leg. K. Bauer), 18 Nov. 1953: 1m (NMW 56182; leg. K. Bauer), 7 Apr. 1962: 1m (NMW 56198; leg. K. Bauer)
8. former Seemuseum [47°55'N, 16°50'E, 116 m], 4 Apr. 1951: 10 ind. in *T. alba* pellets (179) (NMW 'pellet files' G1951-1, no vouchers; leg. E. Pieler)
9. siltation area, behind the former Seemuseum (= near the former Vogelwarte) [47°55'N, 16°50', 116 m], Jun. 1952: 1 ind. (NMW 9341; leg. E. Sochurek), 30 Aug. 1952: 1m (NMW 62670; leg. K. Bauer), 31 Aug. 1952: 1m (NMW 56197; leg. K. Bauer), 7 Nov. 1952: 2f (NMW 62671, 62672; leg. K. Bauer), 30 May 1964: obs. (H.M. Steiner) (Spitzenberger 1966), 6 Jul. 1964: 1m (NMW 9915; leg. F. Spitzenberger), 18 Jul. 1964: obs. 1 ind., swimming (M. Dangel) (Spitzenberger 1966), 29–30 Jul. 1964: 1m, 6f (NMW 9929, 9930, 9933–9937; leg. F. Spitzenberger) (Spitzenberger 1966), 30 Oct. 1964: 1m, 1f (NMW 10033, 10034; leg. F. Spitzenberger) (Spitzenberger 1966)
10. siltation area, SW Kote 123 [47°56'N, 16°51'E, 116 m], 8–9 Aug. 1952: 1m, 3f (NMW 56199–56202; leg. K. Bauer), 16 Aug. 1952: 1m, 1f (NMW 56203, 56204; leg. K. Bauer), 16–17 Nov. 1952: 1m, 2f (NMW 56205–56207; leg. K. Bauer)
11. siltation area [47°56'N, 16°50'E, 120–123 m], 22 Sep. 1958: 1m (NMW 17320; leg. F. Spitzenberger), 26 Oct. 1961: 1 ind., 1m, 2f (NMW 7958–7961; leg. K. Bauer), 19 Jun. 1962: 1m (NMW 17321; leg. F. Spitzenberger), 5 Nov. 1984: 2 ind. (NMW 54167, 54168; leg. M. Leitner), 16 May 1985: 1f (NMW 54169; leg. M. Leitner), 3 Jul. 1985: 3m,

- 2f (NMW 54170–54174; leg. M. Leitner), 6 Dec. 1985: 1m, 3f (NMW 54175–54178; leg. M. Leitner), 21 Dec. 1985: 3m, 1f (NMW 54179–54182; leg. M. Leitner), 12 Jun. 1986: 1m (NMW 54166; leg. M. Leitner), 31 Jul. 1986: 2f (NMW 54183, 54184; leg. M. Leitner), 1 Aug. 1986: 3m (NMW 54185–54187; leg. M. Leitner), 3 Aug. 1986: 1m (NMW 54188; leg. M. Leitner)
12. siltation area, reed storage place [47°56'N, 16°51'E, 123 m], 4 Sep. 1952: 1m, 1f (NMW 56194–56195; leg. K. Bauer), 8 Sep. 1952: 1f (NMW 56196; leg. K. Bauer), 4–6 Jul. 1964: 3m, 7f (NMW 9870–9872, 9876, 9884, 9885, 9894, 9906, 9907, 9914; leg. F. Spitzenberger) (Spitzenberger 1966), 31 Jul. 1964: 1m, 1f (NMW 9943, 9947; leg. F. Spitzenberger) (Spitzenberger 1966), 30 Oct. 1964: 2m (NMW 10043, 10044; leg. F. Spitzenberger)
13. Ebendorf, Neusiedler Wiesen [47°53'N, 16°52'E, 118 m], 14 Apr. 1977: 1 ind. in owl pellets (20) (NMW G1977-69-4; leg. A. Triebel)
14. Zitzmannsdorfer Wiesen [47°52-53'N, 16°51-52'E, 117 m], May 1954: 1 ind. in *A. flammeus* pellets (32) (NMW 'pellet files' G1954-8, no vouchers; leg. K. Bauer), Mar. 1957: 1 ind. in *T. alba* pellets (26) (NMW 'pellet files' G1957-2, no vouchers; leg. K. Bauer), 20 May 1985: 1 ind. in *A. otus* pellets (140) (NMW G1985-27-2; leg. M. Leitner), 4 Jul. 1985: 1m (NMW 54164; leg. M. Leitner), Viehhüter 47°53'26,79"N, 16°51'23,627"E Oct. 2011: 1m (NMW SE11/55; leg. S. Engelberger, N. Hattinger & B. Herzig)
15. Not mapped: Neusiedl am See [c. 47°56'N, 16°51'E], Jun. 1952: 2 ind. (NMW 9339, 9340; leg. E. Sochurek), 11–14 Jul. 1969: 1m (NMW 15349; leg. [E.] Lukoschus)
16. Not mapped: "reed belt", 19 Oct. 1985: 1m (NMW 54165; leg. M. Leitner)
17. Not mapped: between Neusiedl am See and Weiden [c. 47°56'N, 16°51'E, 123 m], Dec. 1983 – Jan. 1984: 1f (NMW 62339; W. Grüner)
19. church [47°55'N, 16°52'E, 127 m], 27 Jun. 1951: 11 ind. in *T. alba* pellets (1017) (NMW 'pellet files' G1951-10, no vouchers; leg. K. Bauer), Sep. 1951: 3 ind. in *T. alba* pellets (284) (NMW 'pellet files' G1951-12, no vouchers; leg. F. Wolf), Summer 1952: 1 ind. in *T. alba* pellets (417) (NMW 'pellet files' G1952-2, no vouchers; leg. K. Bauer), Jul. 1955: 1 ind. in *T. alba* pellets (502) (NMW 'pellet files' G1954-4, no vouchers; leg. K. Bauer), 5 ind. in *T. alba* pellets (292) (NMW 'pellet files' G1955-10, no vouchers; leg. K. Bauer), Mar. 1957: 1 ind. in *T. alba* pellets (19) (NMW 'pellet files' G1957-1, no vouchers; leg. K. Bauer)
20. Podersdorfer (=Weidener) Schoppen [47°53'N, 16°50'E, 115 m], 18 Apr. 1951: 15 ind. in *A. flammeus* pellets (27) (NMW 'pellet files' G1951-3, no vouchers; leg. E. Pieler), 28 May 1951: 2 ind. in *A. flammeus* pellets (8) (NMW 'pellet files' G1951-6, no vouchers; leg. K. Bauer), 28 Jun. 1951: 2 ind. in *A. flammeus* pellets (4) (NMW 'pellet files' G1951-11, no vouchers; leg. K. Bauer), no date [before 1961]: obs. of nests (K. Bauer) (Bauer 1960: 302–303)

Mönchhof

21. church [47°52'N, 16°56'E, 131 m], 4 Jul. 1971: 1 ind. in *T. alba* pellets (303) (NMW G1972-20-10; leg. W. Walter)

Gols

22. equestrian stadium [47°51'N, 16°51'E, 120 m], 25 Feb. 2009: 1 ind. in *T. alba* pellets (307) (NMW G2009-14-6; leg. V. Waba)

Podersdorf

23. NE margin of the settlement [47°51'N, 16°50'E, 122 m], 14 Jun. 2005: 1 ind. in *T. alba* pellets (75) (NMW G2006-9-4; leg. V. Waba), 10 May 2006: 4 ind. in *T. alba* pellets (523) (NMW G2006-17-5; leg. V. Waba)
24. barn [47°51'N, 16°50'E, 120 m], Spring–Summer 1984: 6 ind. in *T. alba* pellets (509) (NMW G1985-4-6; leg. J. Steiner)
25. Podersdorfer Heide, N Birnbaumlacke [47°49'N, 16°51'E, 122 m], May 1956: 1 ind. in *A. flammeus* pellets (20) (NMW 'pellet files' G1956-7, no vouchers; leg. K. Bauer)

Halbtorn

26. Albrechtsfeld [47°48'N, 17°00'E, 130 m], 7 Apr. 1963: 1 ind. in *A. otus* pellets (>517 [only mammals counted]) (HMS 63/1, in coll. Steiner?; leg. A. Howorka)

Illmitz

27. Hölle [47°49'N, 16°47'E, 118 m], Spring–Summer 1984: 10 ind. in *T. alba* pellets (973) (NMW G1985-5-7; leg. J. Steiner), 14 Mar. 2008: 17 ind. in *T. alba* pellets (397) (NMW G2009-2-9; leg. V. Waba), 4 Apr. 2008: 3 ind. in *T. alba* pellets (130) (NMW G2008-12-7; leg. V. Waba), 17 Apr. 2008: 1 ind. in *T. alba* pellets (43) (NMW G2008-7-6; leg. V. Waba), 15 Feb. 2011: 1 ind. in *T. alba* pellets (127) (NMW G2011-07-7; leg. V. Waba)
28. Oberstinker [Oberer Stinkersee], SW-Ufer [47°48'N, 16°47'E, 129 m], May 1957: 1 ind. in *A. flammeus* pellets (16) (NMW 'pellet files' G1957-6, no vouchers; leg. K. Bauer)
29. NE Unterer Stinkersee [47°47'22" N, 16°46'51" E], Sep. 2011: 6 ind. (this study)
30. Gemeindewald [47°47'N, 16°46'E, 117 m], 19 Oct. 1980: 7 ind. in *A. otus* pellets (219) (NMW G1984-22-2; leg. R. Triebel)
31. Albersee [47°46'N, 16°46'E, 117 m], Apr. 1964: 37 ind. in *A. flammeus* pellets (465) (NMW G1971-5-4; leg. ?)
32. Stationskanal [47°46'N, 16°45'E, 117 m], 5 Apr. 1964: 3m, 1f (NMW 11143–11146; leg. M. Ganso)
33. Seedamm at the Biologische Station [47°46'N, 16°45'E, 117 m], 3 Feb. 1985: 1 ind. in *A. otus* pellets (16) (NMW G1985-22-2; leg. M. Leitner), 11 Jul. 1985: 1m (NMW 54163; leg. M. Leitner)
34. Biologische Station [47°46'N, 16°45'E, 117 m], 2 May 1985: 15 ind. in *A. otus* pellets (25) (NMW G1985-33-2; leg. M. Leitner), 3 Mar. 2005: 7 ind. in *A. otus* pellets (262) (NMW G2005-11-3; leg. A. Grüll), 6 Apr. 2005: 26 ind. in *A. otus* pellets (1229) (NMW G2006-11-7; leg. A. Grüll), Jan.–Mar. 2013: 9 ind. in *T. alba* pellets (16) (NMW G2013-08-1; leg. V. Waba), 14 Jun. 2013: 9 ind. in *T. alba* pellets (149) (NMW G2013-04-7; leg. V. Waba)
35. woodlot E Biologische Station [47°46'N, 16°46'E, 117 m], 16 Mar. 1985: 2 ind. in *A. otus* pellets (31) (NMW G1985-20-2; leg. M. Leitner)
36. Seewäldchen Nord [47°45'N, 16°45'E, 117 m], Pferdekoppel, 31 Aug. 2007: 6 ind. in *T. alba* pellets (130) (NMW G2007-30-6; leg. V. Waba), 8 Sep. 2008: 3 ind. in *T. alba* pellets (159) (NMW G2008-16-9; leg. V. Waba)
37. Seewäldchen Süd [47°45'N, 16°45'E, 117 m], Seekoppel, 22 Apr. 2008: 8 ind. in *T. alba* pellets (457) (NMW G2009-04-8, NMW G2008-8-7; leg. V. Waba)
38. Illmitzer Wäldchen [47°45'N, 16°45'E, 118 m], 25 Mar. 1964: 5 ind. in *A. otus* pellets (71) (NMW G1978-2-4; leg. M. Ganso), 30 Nov. 1975: 2 ind. in *A. otus* pellets (50) (NMW G1975-13-4; leg. M. Staudinger)
39. paddock "Warmblutkoppel" [47°45'N, 16°45'E, 117 m], 28 Apr. 2003: 3 ind. in *T. alba* pellets (161) (NMW G2003-16-6; leg. V. Waba), 21 Jun. 2003: 7 ind. in *T. alba* pellets (264) (NMW G2003-21-10; leg. J. Waba), May 2005: 9 ind. in *T. alba* pellets (242) (NMW G2006-2-8; leg. V. Waba), 2 Jun. 2006: 1 ind. in *T. alba* pellets (114) (NMW G2006-4-6; leg. V. Waba), 26 Apr. 2006: 6 ind. in *T. alba* pellets (207) (NMW G2006-14-4; leg. V. Waba), 27 Apr. 2007: 9 ind. in *T. alba* pellets (273) (NMW G2007-12-8; leg. V. Waba), 24 Jun. 2008: 15 ind. in *T. alba* pellets (155) (NMW G2009-3-7; leg. V. Waba), 11 Jun. 2010: 2 ind. in *T. alba* pellets (278) (NMW G2010-04-11; leg. V. Waba)
40. Illmitzer Kanal, 2 km W Illmitz [47°45'N, 16°46'E, 115–117 m], 30 Mar. 1964: 1f (NMW 54309; M. Ganso), 20 Mar 1985: 3 ind. in *A. otus* and *T. alba* pellets (101) (NMW G1985-23-4; leg. M. Leitner), 1 May 1985: 7 ind. in *A. otus* pellets (101) (NMW G1985-30-3; leg. H. Hoi)
41. reed storage place [47°45'N, 16°45'E, 115 m], 5 Jan. 1964: 1 ind. in *T. alba* pellets (67) (NMW 'pellet files' G1964-4, no vouchers; leg. H. Freundl), 5 Jan. 1964: 2 ind. in *A. flammeus* pellets (77) (NMW G1971-9-6; leg. M. Ganso), 24 Mar. 1964: 6 ind. in *A. flammeus* pellets (72) (NMW 'pellet files' G1964-3, no vouchers; leg. H. Freundl)
42. Sandeck [47°44'N, 16°46'E, 119 m], 25 Mar. 1964: 6 ind. in *Asio* sp. pellets (10) (NMW G1991-11-1; leg. H.-H. Bergmann), 4 Feb. 1965: 6 ind. in *A. flammeus* pellets (262) (NMW G1966-1-4; leg. E. Freundl), Mar. 1965: 4 ind. in *Asio* sp. pellets (40) (NMW 'pellet files' G1976-65, no vouchers; leg. H.

Freundl), 21 Apr. 1965: 5 ind. in *Asio* sp. pellets (50) (NMW G1974-27-2; leg. ?), 1 May 1985: 71 ind. in *A. otus* pellets (327) (NMW G1985-29-4; leg. H. Hoi), 21 Mar. 1986: 70 ind. in *A. otus* pellets (220) (NMW G1986-10-3; leg. M. Leitner), 4 Jun. 1987: 2 ind. in *T. alba* pellets (4) (NMW G1987-3-2; leg. M. Leitner), Spring 2005: 3 ind. in *T. alba* pellets (4) (NMW G2005-2-2; leg. V. Waba), 26 Apr. 2006: 5 ind. in *T. alba* pellets (299) (NMW G2006-1-6; leg. V. Waba), 4 Mar. 2009: 9 ind. in *T. alba* pellets (621) (NMW G2009-12-10; leg. V. Waba), 29 May 2010: 1 ind. in *T. alba* pellets (94) (NMW G2010-05-8; leg. V. Waba), 20 Mar. 2013: 61 ind. in *T. alba* pellets (786) (NMW G2013-02-9, NMW G2013-01-11; leg. V. Waba), 31 May 2013: 9 ind. in *T. alba* pellets (233) (NMW G2013-06-11; leg. V. Waba)

Sankt Andrä am Zicksee

43. N Zicksee [47°47'47" N, 16°54'25" E], Sep. 2011: 1 ind. (this study)
44. Ziegelhof at the Zicksee [47°47'N, 16°53'E, 121 m], Dec. 1961: 2 ind. in *T. alba* pellets (75) (NMW G2003-12-5; leg. P. Schubert), 16 Apr. 1962: 46 ind. in *T. alba* pellets (1127) (NMW G1962-7-13; leg. M. Ganso)
45. premises "Fa. Bruck" [47°47'N, 16°56'E, 122 m], 11 Jan. 1985: 5 ind. in *T. alba* pellets (116) (NMW G1985-1-6; leg. M. Leitner), 21 Mar. 1986: 2 ind. in *T. alba* pellets (22) (NMW G1986-9-2; leg. M. Leitner)

Apetlon

46. S Auerlacke [47°47'N, 16°53'E, 121 m], 24 Aug. 1977: 1 ind. in owl (*Asio* sp.?) pellets (39) (NMW G1977-86-2; leg. J. Reid)
47. N Östliche Wörtenlacke [47°46'46"N 16°52'40"E], Aug 2011: 1 ind.(Ch, Walder), [47°46'46"N 16°52'45"E], Aug. 2011: 5 ind. (Ch. Walder)
48. between Westliche- and Östliche Wörtenlacke, N bank [47°46'46"N, 16°52'12"E, 118 m], 7–12 Aug. and 6–12 Sep. 2001: 11 ind.; one voucher 6.Sep. 2001: 1f (NMW 63438; leg. P. Mühlböck) (Mühlböck 2003, 2008), reedbed [47°46'43"N, 16°52'21"E], Sep. 2010: 9 ind. (this study), low vegetation [47°46'44" N, 16°52'20" E], Sep. 2010: 4 ind. (this study)

49. E Wörtenlacken [47°46'N, 16°52'E, 118 m], 15 May. 1985: 6 ind. in *A. otus* pellets (8) (NMW G1985-21-2; leg. M. Leitner)
50. Seewinkelhof [47°45'N, 16°53'E, 119 m], 30 Jun. 1971: 1 ind. in *Athene noctua* pellets (24) (NMW G1971-19-5; leg. W. Walter)
51. cemetery [47°44'N, 16°49'E, 120 m], 10 Jan. 1985: 5 ind. in *A. otus* pellets (226) (NMW G1985-3-3; leg. M. Leitner), 16 Mar. 1985: 13 ind. in *A. otus* pellets (162) (NMW G1985-17-3; leg. M. Leitner), 1 May 1985: 11 ind. in *A. otus* pellets (53) (NMW G1985-35-2; leg. M. Leitner), 20 Jun. 1985: 81 ind. in *A. otus* pellets (667) (NMW G1985-36-6; leg. M. Leitner), 21 Mar. 1986: 42 ind. in *A. otus* pellets (320) (NMW G1986-12-2; leg. M. Leitner), 10 May 1992: 45 ind. in *A. otus* pellets (310) (NMW G2003-34-3; leg. M. Ganso), 3 Jan. 2014: 1 ind. in *Asio* sp. pellets (99) (NMW G2014-01-3; leg. B. Herzig)
52. Rebschulgasse [47°44'N, 16°50'E, 120 m], 8 Jul. 2005: 3 ind. in *T. alba* pellets (164) (NMW G2006-7-7; leg. V. Waba), 6 Jun. 2006: 2 ind. in *T. alba* pellets (64) (NMW G2006-8-7; leg. V. Waba)
53. church [47°44'N, 16°49'E, 120 m], Jun. 1957: 11 ind. in *T. alba* pellets (922) (NMW 'pellet files' G1957-8, no vouchers; leg. K. Bauer)
54. Ried Neufeld [47°44'N, 16°50'E, 120 m], 15 Jun. 1992: 1 ind. in *A. flammeus* pellets (20) (NMW G1997-128-2; leg. V. Waba)
55. Apetlon-Rohrung [47°44'N, 16°49'E, 120 m], 7 Sep. 1992: 1 ind. in *A. flammeus* pellets (26) (NMW G1997-94-2; leg. V. Waba)
56. barn "Gaurinderstall" [47°43'N, 16°48'E, 118 m], 11 Jun. 2013: 5 ind. in *T. alba* pellets (163) (NMW G2013-07-9; leg. V. Waba), 23 Sep. 2013: 5 ind. in *T. alba* pellets (159) (NMW G2013-09-9; leg. V. Waba)
56. Apetloner Hof [47°43'N, 16°49'E, 117 m], 9 Apr. 2003: 1 ind. in *T. alba* pellets (283) (NMW G2003-25-7; leg. [V. Waba]), Spring 2004: 31 ind. in *T. alba* pellets (534) (NMW G2005-3-11; leg. V. Waba), 16 Jul. 2004: 2 ind. in *T. alba* pellets (65) (NMW G2005-5-5; leg. V. Waba), 1 Jul. 2005: 1 ind. in *T. alba* pellets (59) (NMW G2006-5A-4; leg. V. Waba), 2 Jun. 2006: 1 ind. in *T. alba* pellets (234) (NMW G2006-6-7; leg. V. Waba), 11 May 2006: 2 ind. in *T. alba* pellets (38) (NMW G2006-

- 16-5; leg. V. Waba), 15 Jan. 2007: 1 ind. in *T. alba* pellets (106) (NMW G2007-16-5; leg. V. Waba), 2 May 2007: 1 ind. in *T. alba* pellets (90) (NMW G2007-10-6; leg. V. Waba), 27 Feb. 2008: 1 ind. in *T. alba* pellets (233) (NMW G2009-05-5; leg. V. Waba), 1 Jul. 2008: 1 ind. in *T. alba* pellets (108) (NMW G2008-5-7; leg. V. Waba), 1 Sep. 2009: 2 ind. in *T. alba* pellets (222) (NMW G2010-01-13; leg. V. Waba), 26 Nov. 2009: 2 ind. in *T. alba* pellets (689) (NMW G2010-02-11; leg. V. Waba), 4 Feb. 2011: 1 ind. in *T. alba* pellets (239) (NMW G2011-04-8; leg. V. Waba), 14 Apr. 2011: 3 ind. in *T. alba* pellets (221) (NMW G2011-03-7; leg. V. Waba), 2 Mar. 2012: 1 ind. in *T. alba* pellets (55) (NMW G2012-03-6; leg. V. Waba), 15 Mar. 2012: 1 ind. in *T. alba* pellets (124) (NMW G2012-02-6; leg. V. Waba), 7 May 2012: 1 ind. in *T. alba* pellets (321) (NMW G2012-04-9; leg. V. Waba), 31 May 2013: 1 ind. in *T. alba* pellets (103) (NMW G2013-05-9; leg. V. Waba)
58. N Apetloner Hof [47°43'34" N, 16°50'39"E], Sep. 2010: 10 ind. (this study)
59. S Apetloner Hof [47°44'44" N, 16°50'38" E], Sep. 2010: 1 ind. (this study)
60. Neudegg [47°42'N, 16°49'E, 116 m], 24 Mar. 1985: 1 ind. in *T. alba* pellets (11) (NMW G1985-25-3; leg. A. Grüll),
61. Neudegg 47°41'49" N, 16°48'29 "E, Oct. 2011: 2 m, 2 f (this study)
62. 0.9 km NE Martentaulacke [47°43'47"N, 16°59'49"E], Sep. 2010: 3 ind. (this study)
- Pamhagen**
63. Schwarzseelacke [47°44'N 16°53'E, 118 m], 31 Mar. 1981: 1 ind. in *Falco* sp. pellets (10) (NMW G1991-13-2; leg. A. Grüll)
- Wallern**
64. premises "Fa. Mosony" [47°43'N, 16°56'E, 120 m], Jun. 2005: 1 ind. in *T. alba* pellets (51) (NMW G2006-3-4; leg. V. Waba)
- Tadten**
65. Tadtener Meierhof [47°45'N, 16°59'E, 119 m], 19 Sep. 1984: 3 ind. in *T. alba* pellets (1011) (NMW G1984-11-8; leg. F. Reithner)
66. St. Andräer Wiesen [47°43'N, 17°03'E, 111 m], 8 Jun. 2014: 1 ind. in *A. flammeus* pellets (4) (NMW G2014-6-1; leg. H.-M. Berg)
- Jois**
67. forest strip E Jois [47°57'N, 16°48'E, 160 m], Apr 1957: 6 ind. in *Asio* sp. pellets (337) (NMW 'pellet files' G1957-3, no vouchers; leg. K. Bauer)
- Breitenbrunn**
68. church [47°56'N, 16°44'E, 136 m], 23 Sep. 1958: 2 ind. in *T. alba* pellets (344) (HMS 58/15, in coll. Steiner; leg. H.M. Steiner)
69. Hannesgraben [47°56'N, 16°45'E, 117 m], 22 Mar. 1983: 5 ind. in mainly *T. alba* pellets (72) (NMW G1984-9-9; leg. A. Grüll & R. Szesemsky)
- Purbach**
70. church [47°54'N, 16°41'E, 128 m], 26 Oct. 1984: 20 ind. in *T. alba* pellets (520) (NMW G1984-26-8; leg. M. Leitner)
- Donnerskirchen**
71. church [47°53'N, 16°38'E, 190 m], summer 1952: 12 ind. in *T. alba* pellets (392) (NMW 'pellet files' G1952-1, no vouchers; leg. K. Bauer)
72. Wulka estuary [47°52'N, 16°42'E, 120 m], 15 Oct. 1939: 3 ind. in *T. alba* pellets (19) (NMW G2003-11-2; leg. A. Seitz & R. Lugitsch)
- Oggau**
73. mill "Seemühle an der Wulka" [47°52'N, 16°40'E, 120 m], 7 Jan 1962: 98 ind. in *T. alba* pellets (947) (NMW G1985-24-8; leg. F. Sauerzopf), 20 Sep. 1986: 22 ind. in *T. alba* pellets (930) (NMW G1986-13-9; leg. A. Seitz & R. Lugitsch)', 22 May 2013: 11 ind. in *T. alba* pellets (27) (NMW G2015-01; leg. J. Sommer), 20 Mar 2015: 3 ind. in *T. alba* pellets (211) (NMW G2015-03; leg. J. Sommer, A. Ranner, K. & A. Graf, B. Herzig)
- 73a. yard "Seehof an der Wulka" [47°52'N, 16°39'E, 125 m], 22 May 2013: 5 ind. in *T. alba* pellets (26) (NMW G2015-02; leg. J. Sommer), 20 Mar 2015: 1 ind. in *T. alba* pellets (172) (NMW G2015-04; leg. J. Sommer, A. Ranner, K. & A. Graf, B. Herzig)
74. reed belt near Oggau [c. 47°50'N, 16°42'E, 120 m], 2 Jun. 1977: 5m (no vouchers) (Hubálek et al. 1979; pers. comm. Z. Hubálek, May 2014)

75. church [47°50'N, 16°40'E, 130 m], 10 Jul. 1971: 7 ind. in *T. alba* pellets (202) (NMW G1973-2-9; leg. W. Walter)

Oslip

76. church [47°50'N, 16°37'E, 133 m], 26 Oct. 1984: 7 ind. in *T. alba* pellets (1994) (NMW G1984-27-12; leg. M. Leitner)

Rust

77. church "Fischerkirche" [47°48'N, 16°40'E, 123 m], Jul. 1955: 6 ind. in *T. alba* pellets (122) (NMW 'pellet files' G1955-1, no vouchers; leg. K. Bauer)
78. Not mapped: Rust, 1964: 2 ind. in *T. alba* pellets (68) (NMW G1991-5-5; leg. H. Langer)