

## **Root vole, *Microtus oeconomus*, in Lithuania: changes in the distribution range**

Authors: Balčiauskas, Linas, Balčiauskienė, Laima, and Baltrūnaitė, Laima

Source: Folia Zoologica, 59(4) : 267-277

Published By: Institute of Vertebrate Biology, Czech Academy of Sciences

URL: <https://doi.org/10.25225/fozo.v59.i4.a1.2010>

---

BioOne Complete ([complete.BioOne.org](https://complete.BioOne.org)) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at [www.bioone.org/terms-of-use](https://www.bioone.org/terms-of-use).

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

---

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

# Root vole, *Microtus oeconomus*, in Lithuania: changes in the distribution range

Linus BALČIAUSKAS\*, Laima BALČIAUSKIENĖ and Laima BALTRŪNAITĖ

Nature Research Centre, Akademijos 2, LT-08412 Vilnius-21, Lithuania; e-mail: linasbal@ekoi.lt

Received 13 November 2009; Accepted 4 March 2010

**Abstract.** Lithuania is on the edge of the main distribution range of the root vole (*Microtus oeconomus*). It was found that the trappability of *M. oeconomus* did not depend on the trapping effort, the number of recorded species and individuals or the species diversity. All 13 localities with proportions of *M. oeconomus* constituting over 30% of the small mammal community are situated in the south and west of Lithuania. Analysis of data collected over 50 years confirms that the species has become more abundant, more widespread and its distribution range has spread north and east from the south and west of the country. The main habitats for *M. oeconomus* in Lithuania are reedbeds, meadows, shrubby areas and shores of water bodies. Abandoned former agricultural areas create suitable habitats for the species, thus promoting its increased abundance and wider distribution.

**Key words:** abundance, habitats, mammalian communities

## Introduction

The root vole (*Microtus oeconomus*) is a Holarctic species. In Europe, its main range extends from eastern Germany and northern Fennoscandia to Poland, Belarus and northern and central European Russia (IUCN 2007). Isolated relict populations are also found in the Netherlands, southern Scandinavia, on the Finnish coast, in Austria, Slovakia and Hungary (van Apeldoorn 1999, Shenbrot & Krasnov 2005). *M. oeconomus* is absent in Latvia and Estonia (van Apeldoorn 1999) and there are recent reports which mistakenly suggest an absence of the species in Lithuania too (Rácz et al. 2005). In Lithuania, *M. oeconomus* is a dominant species in some habitats, but 50 years ago it was considered the rarest vole species. It still remains a poorly documented species in publications.

This article analyses changes in distribution of *M. oeconomus* in Lithuania at the border of the restricted distribution of this species. The aim is to identify if species distribution and abundance are remaining stable over the long term period.

## Material and Methods

Historical data on the findings of *M. oeconomus* have been obtained from publications and grey literature (reports, student theses) cited as personal

communications. In addition, small mammals were trapped in various habitats in eleven districts between 1998 and 2008, including different types of forests, wetlands, meadows, reedbeds, shrubby areas, agricultural areas and ecotones of various habitat types. Trapping was done by snap trap lines, the traps being set at a distance of 5 m from each other, baited with bread and sunflower oil and, in most cases, exposed for three days and checked once or twice a day (Balčiauskas & Juškaitis 1997, Balčiauskas 2004). For older data such information may be missing.

The summarised data are presented in Appendix and mapped in Fig. 1. Where possible, the trapping effort in trap/days, number of trapped species and individuals, as well as diversity of the small mammal community (expressed as Shannon-Weaver diversity index,  $H'$ , on the base of  $\log_2$  according Krebs 1999) are presented. An additional dataset was obtained by analysing food remains and pellets of tawny owls (*Strix aluco*).

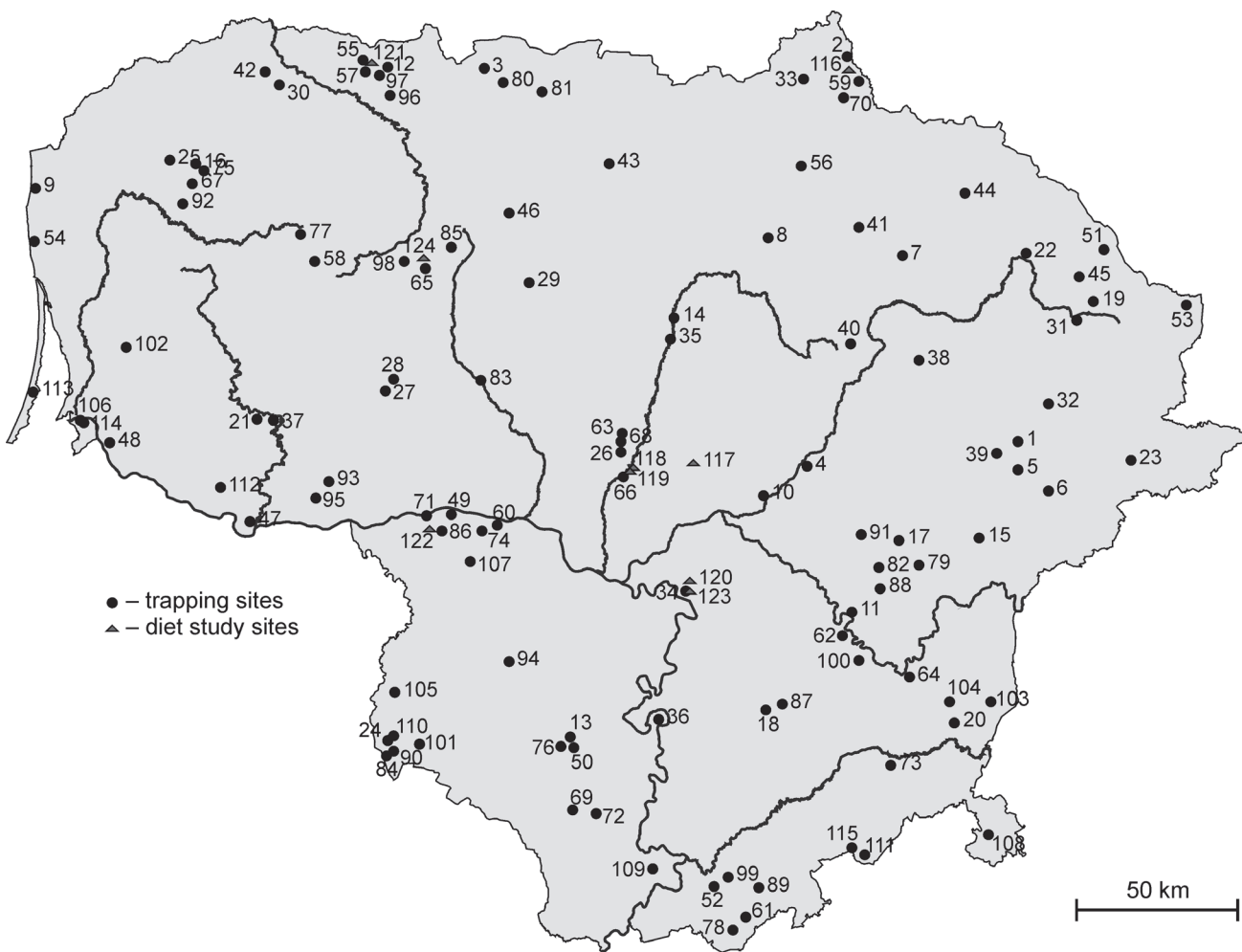
Food remains from nestboxes were collected in five districts (Balčiauskienė et al. 2005) and pellets in eight districts of Lithuania (Balčiauskienė et al. 2006). To ensure compatibility with trapping results, non-mammalian food items, along with bats, moles and weasels, were excluded from diet analysis. The

\* Corresponding Author

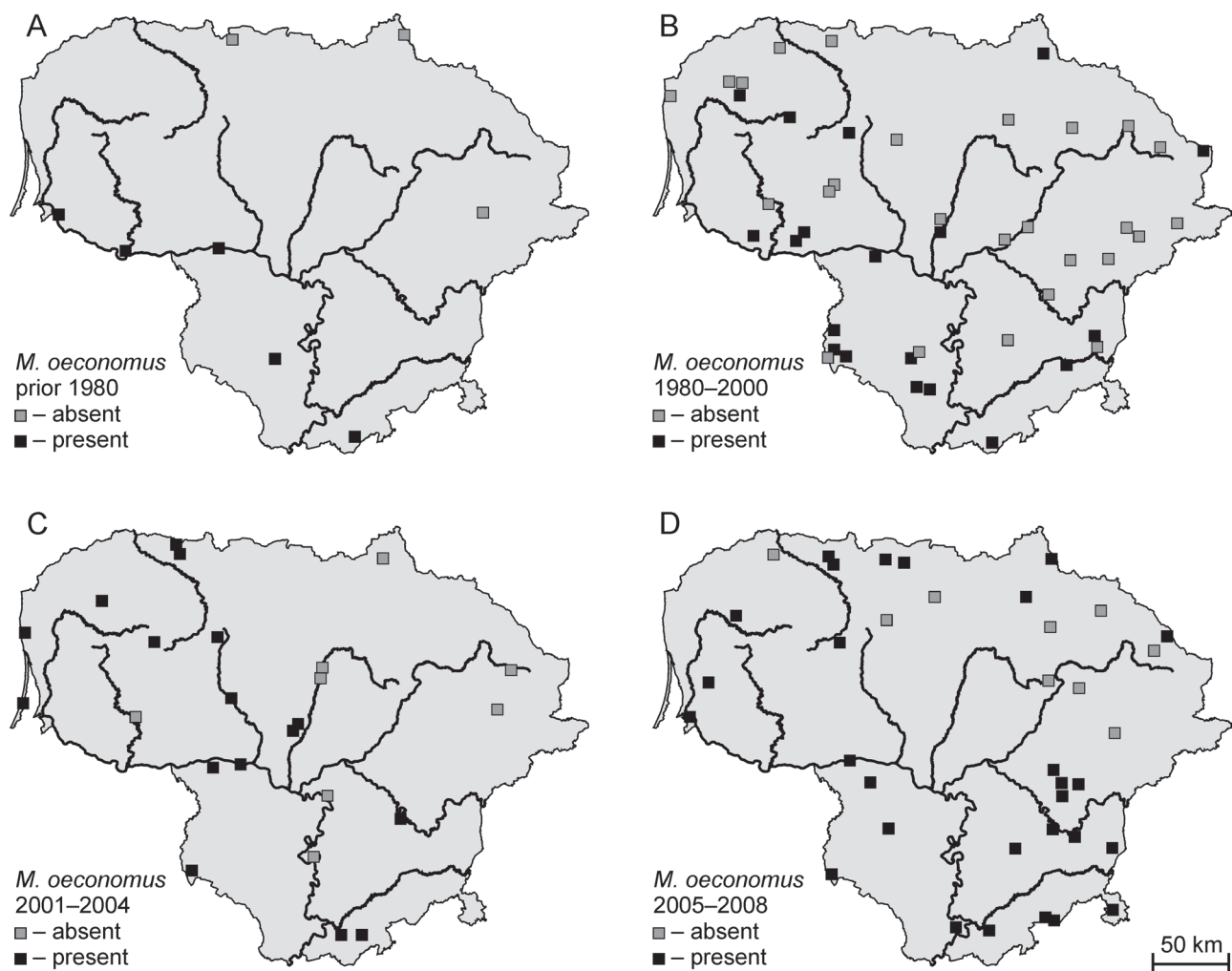
**Table 1.** Data on the presence of *M. oeconomus* from food remains and pellets of *S. aluco* (*n* – number of samples, *S* – number of species, *N* – number of individuals recovered, *H'* – Shannon-Weaver diversity index, *Moe%* – % of *M. oeconomus*).

No	Locality	Year	n	S	N	H'	Moe%
116	Biržai d. <sup>2</sup>	2003–2005	68	8	62	2.41	0
117	Jonava d. <sup>2</sup>	2005	77	7	99	1.99	0
118	Kėdainiai d. <sup>2</sup>	1999–2005	800	10	469	2.51	0.2
119	Kėdainiai d. <sup>1</sup>	2000–2005	53	13	1291	2.70	1.4
120	Kaišiadorys d. <sup>2</sup>	1999–2002	335	10	364	1.97	2.2
121	Akmenė d. <sup>1</sup>	2000–2002	9	15	74	3.11	2.7
122	Šakiai d. <sup>1</sup>	2000–2004	7	13	200	2.75	3.5
123	Kaišiadorys d. <sup>1</sup>	2000–2005	16	14	916	2.63	4.5
124	Kelmė d. <sup>1</sup>	1999–2002	5	15	185	3.25	10.3

<sup>1</sup> Balčiauskienė et al. (2005) (food remains); <sup>2</sup> Balčiauskienė et al. (2006) (pellets).



**Fig. 1.** Localization of analysed datasets in Lithuania, 1961–2008 (numbers of published data, trapping sites and sites where *S. aluco* prey remains from nest-boxes or pellets were collected correspond to data in Appendix and Table 1).



**Fig. 2.** Presence of *M. oeconomus* in small mammal communities in Lithuania, 1961–2008.

summarised data on *M. oeconomus* in *S. aluco* diet are presented in Table 1.

## Results

### Chronology of investigations

In Lithuania, *M. oeconomus* was first mentioned in 1964 (Ivanauskas et al. 1964). At that time, there were only five findings of *M. oeconomus*, all in the south and south-western parts of the country (Fig. 2A) and the species was identified as the rarest of the voles in Lithuania. In 1976, a single specimen was trapped in north Lithuania, near dystrophic Lake Kilučiai, overgrown with shrubs and reedbeds (L. Balčiauskas, pers. comm.). Thus, before 1980 only one of six inhabited localities was situated in north Lithuania.

The 1980s and 1990s were characterized by increased small mammal trapping efforts in Lithuania, especially between the two editions of the Mammal Atlas (Balčiauskas et al. 1997, 1999). Only two of the

19 localities where root voles were trapped were in north and east Lithuania (Fig. 2B). In the most eastern locality, intensive trapping was conducted over ten years on the borders of Lithuania, Latvia and Belarus (see Appendix). Ten individuals were trapped, seven of which were in Belarus, the other in Lithuania. In Latvia, despite trapping less than 10 km from the border, no root voles were recorded. Additionally, small mammal investigations were conducted in south-east Latvia in 2007 and in several localities across the country in 2007–2008, but *M. oeconomus* was not registered. To date, *M. oeconomus* has not been recorded in Latvia, not being found prior to the end of the last millennium (van Apeldoorn 1999), nor since (Zorenko 2008). Thus, the north-easterly range of the species distribution ends in Lithuania.

In 2001–2004, *M. oeconomus* was successfully trapped in the south, west and central parts of Lithuania and additionally, for the first time, in the north-west

(Fig. 2C). In the most recent period of trapping, 2005–2008, the only localities where *M. oeconomus* was not found were in north, north-east and east of Lithuania (Fig. 2D).

#### *Proportions of M. oeconomus in small mammal community*

Analysis of over one hundred trapping sessions with different trapping efforts shows that in the years 1976–2008 the proportion of *M. oeconomus* varied from 0 to over 50% (Appendix). On average, nearly 2000 traps per session yielded  $7.6 \pm 0.27$  species and  $222 \pm 38$  individuals trapped. The Shannon-Weaver diversity index varied from 0.59 to 3.03 (mean  $2.025 \pm 0.05$ ) and the average proportion of *M. oeconomus* in small mammal communities in Lithuania was  $8.45 \pm 1.31\%$ . Such proportion was not correlated with the trapping effort (Pearson's  $r$ ,  $n = 91$ ,  $r = -0.08$ , NS), number of species (Pearson's  $r$ ,  $n = 111$ ,  $r = -0.11$ , NS) or individuals trapped (Pearson's  $r$ ,  $n = 111$ ,  $r = -0.09$ , NS) nor with the diversity of a community (Pearson's  $r$ ,  $n = 111$ ,  $r = 0.03$ , NS).

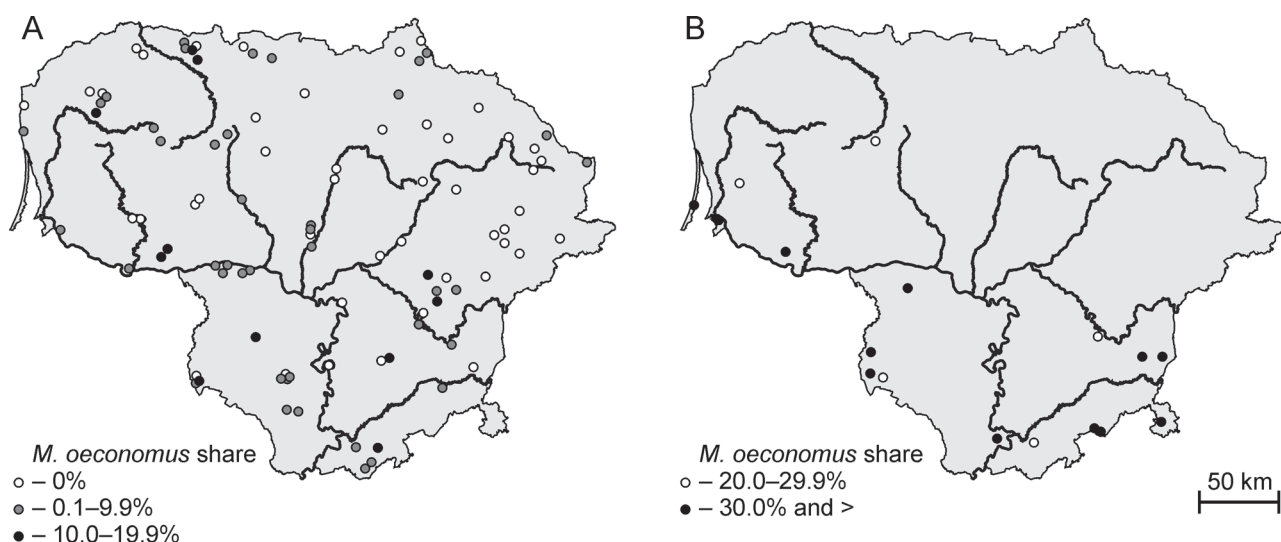
The sites where the species was absent or contributed less than 10% to the small mammal community were scattered across the country (Fig. 3A). Though many trapping sessions were performed in the eastern and north-eastern parts of Lithuania, only five of them registered the presence of *M. oeconomus*. Three of 11 trapping sessions with the proportion of *M. oeconomus* in the range 10.0–19.9% were done in the north-western part of the country. All localities where the proportion of *M. oeconomus* was over

20% were located in the western, south-western and southern parts of Lithuania (Fig. 3B).

A similar proportion of *M. oeconomus*, varying from 0 to 10 percent of all recorded small mammals, was found in the food remains and pellets of tawny owl (*S. aluco*) (Table 1). As *S. aluco* catches rare species more effectively than snap-traps do (Balčiauskienė & Naruševičius 2006, Balčiauskienė & Balčiauskas 2008), the absence of *M. oeconomus* in owl food could be related to the absence of the species in a certain locality. The highest proportion of *M. oeconomus* in owl food was characteristic of the districts situated in west and south-west Lithuania and, to a lesser degree, in central and northern Lithuania.

#### *Changes in M. oeconomus distribution*

In west Lithuania, where *M. oeconomus* was first recorded (Ivanauskas et al. 1964), the presence of the species was subsequently confirmed in all later investigations, namely those conducted in 1999 (Juškaitis & Ulevičius 2003, 2004), 2005 (dominance) and 2007–2008 (moderate presence) (G. Medvikytė, pers. comm.). In the period from 1999 till 2008, *M. oeconomus* was, on the whole, dominant in small mammal communities, though recorded as a sub-dominant small mammal species on the northern side of the River Nemunas 1991–2000 (Balčiauskas & Juškaitis 1997, Juškaitis & Uselis 2005). In north-west Lithuania *M. oeconomus* was absent in 1991–1995, but has been registered since (Balčiauskas & Juškaitis 1997, EPA 2009, P. Alejūnas & V. Stirkė, pers. comm.). In south-west Lithuania (Žuvintas SNR), investigations



**Fig. 3.** Share of *M. oeconomus* in small mammal communities in Lithuania, 1961–2008.



in 1961–1962 showed the presence of *M. oeconomus* with an abundance of 1.1–2.6 ind. per 100 trap/nights (The Reservation of Žuvintas 1968). In 1981–1983, *M. oeconomus* was already a subdominant species in moist habitats and, in 1993–1997, a moderate abundance of *M. oeconomus* was confirmed (Baleišis et al. 1993, Balčiauskas & Juškaitis 1997). The species was absent in the far south-west of Lithuania in 1994 (Vištytis RP). In 1995, however, *M. oeconomus* was found to be dominant in deciduous forests near Vištytis RP. A decade later, *M. oeconomus* comprised 14.1% of all trapped small mammals in Vištytis RP. In the last ten years, *M. oeconomus* has comprised 10–15% of all trapped small mammals (Balčiauskas & Juškaitis 1997, Juškaitis & Ulevičius 2003, EPA 2009).

In south Lithuania, the proportion of *M. oeconomus* in small mammal communities is increasing: it quadrupled in the period between 1978–1980 to 1991–1993 (Balčiauskas & Juškaitis 1997, Mažeikytė 2003) and increased from 0.3% in 1999–2004 to 12.9% in 2002 (Ulevičius & Juškaitis 2003, EPA 2009). A high abundance of the species was found in 2007 during investigations of moist meadows in the area. A growing dominance of *M. oeconomus* was also found in the far south-east of Lithuania. In 1997, the proportion of the species was only 5% (Balčiauskas & Juškaitis 1997), but in 2005 and 2008, the species was dominant in small mammal communities (J. Vilkova, pers. comm.). In southern regions near to central Lithuania, *M. oeconomus* was absent during first investigations in 1991–1994 (Balčiauskas & Juškaitis 1997), but in 2006–2008, the proportion of the species already reached 6.5–30.0%. A few individuals were also registered in the city of Vilnius (O. Grincevičiūtė, pers. comm.).

In central Lithuania, *M. oeconomus* was absent in most localities in 1983–2003 (Balčiauskas & Juškaitis 1997, EPA 2009), even in very suitable habitats (Pakeltytė & Andriuškevičius 2004, EPA 2009), with the exception of one district where high trapping efforts confirmed the presence of *M. oeconomus* in low concentrations (Balčiauskienė 2006, Balčiauskienė & Naruševičius 2006, EPA 2009). The proportion of *M. oeconomus* in *S. aluco* food was also low (Table 1), reaching only 4.5% (Balčiauskienė et al. 2005) and just 0.2–1.4% in two neighbouring districts (Balčiauskienė et al. 2006). The presence of *M. oeconomus* westward from central Lithuania was confirmed, except in Šiauliai town (D. Prielaidas, pers. comm.). The increase in species dominance was almost fivefold (Balčiauskas & Juškaitis 1997, Zalunskaitė & Lopeta 2005, EPA

2009).

In the north, north-east and east Lithuania, the distribution of *M. oeconomus* is the most interesting. The species was absent in 1997 and its proportion was less than 1% in 1999–2004, but had reached 7–20% in 2008 (Maldžiūnaitė 1980, Balčiauskas & Juškaitis 1997, Mačiulis 2002, EPA 2009, P. Alejūnas & V. Stirkė, pers. comm., E. Ginkuvienė, pers. comm.). In the most northern districts, *M. oeconomus* appeared only after 1999 and its proportion has not increased. In north-east Lithuania, *M. oeconomus* has not been registered yet (Balčiauskas & Juškaitis 1997, Mažeikytė 2002, 2003, Šinkūnas 2006, EPA 2009, P. Alejūnas & V. Stirkė, pers. comm.) and in the very east of Lithuania, only a few individuals have been trapped on lakeshores, though most investigations have not revealed the presence of the species (Balčiauskas & Juškaitis 1997, Balčiauskas 2005, Balčiauskas & Gudaitė 2006, Šinkūnas & Balčiauskas 2006).

#### *Habitats of M. oeconomus*

As indicated in Appendix, the main habitats for the species in Lithuania are reedbeds, meadows, shrubby areas and shores of water bodies. The species was first recorded in wet meadows, on the shores of water basins overgrown with lush vegetation, in reedbeds and near swamps. Flooded meadows and reedbeds in the Nemunas Delta still are the habitats of primary importance for the species. Later, the species was also found in mowed pastures, sparse forests, forest openings and clear cuts (Balčiauskas et al. 1999). The species was dominant in reedbeds (41.0% of all small mammals) and various meadows (82.6%), including very dry meadows and wastelands, but it was not found in forests of west Lithuania (Curonian Spit; Ulevičius et al. 2002, Juškaitis & Ulevičius 2003). In 2005–2008, root voles were trapped in flooded meadows, reedbeds and shrubby areas, river valleys, unmowed meadows, and near forests. In south-west Lithuania, the highest abundances were registered in reedbeds and moist meadows. In north Lithuania, the main habitat of the species were natural meadows. *M. oeconomus* was not found on lake islands (Balčiauskas & Juškaitis 1997, Šinkūnas 2006) and additionally, dry coniferous forests prevailing in south Lithuania are not suitable for root voles.

#### Discussion

Over recent decades, *M. oeconomus* has not only increased in numbers, but also spread through Lithuania in northerly and easterly directions. What were the driving forces of such changes in distribution?

First of all, we suppose that changes in distribution have been conditioned by changes in land use since 1990, with abandoned agricultural areas overgrowing with grass, weeds and shrubs. According to CORINE database, changes in land class usage in Lithuania between 1990 and 2000 were as follows: the area of forest and pasture shrank by about 1%, while the area of arable land, heterogeneous agricultural land and scrub/herbaceous vegetation expanded by 0.5%, 0.3% and approximately 0.8%, respectively (EIONET 2008). The latter two land classes are suitable habitats for *M. oeconomus*. In north Lithuania, half of land-use changes that occurred between 1957 and 2000 were related to renaturalization: farmland decreased by 8.3% and renaturalised areas increased by 3.9% (Bauža & Baužienė 2008).

The most pronounced changes in land use, and most favourable to *M. oeconomus*, were in north-east Lithuania. Before World War II, all suitable land was utilized for arable purposes. After the War, land reclamation improved land quality, but slopes unsuitable for use with heavy machinery were left for renaturalisation. In the period 1970–1990, the percentage of arable land remained stable, but in the years following 1990 more than 20% of arable land in north-east Lithuania was abandoned, subsequently overgrowing with grasses and shrubs. Shrubby areas expanded from 1.8% to 6.5% of the total area (Ribokas & Milius 2007).

Additionally, reedbeds are rather frequent in the territories where the former land reclamation systems were abandoned. The renaturalization of the land reclamation systems is a significant factor in north Lithuania (Bauža & Baužienė 2008) and north-

east Lithuania (Ribokas & Milius 2007). As such territories suit the ecological requirements of the species (damp sedge meadows and reedbeds with good cover and sufficient food resources, as stated by van Apeldoorn (1999) and Bieberich & Olson (2007)), former agricultural areas are suitable for the existence of *M. oeconomus*. Our results show that the distribution range of *M. oeconomus* has expanded from the south and west of the country in easterly and northerly directions.

The main distribution range of *M. oeconomus* in Europe occupies a warmer environment compared to that in Lithuania, but the species also inhabits much colder regions in Scandinavia, Siberia and Alaska (Bieberich & Olson 2007), thus temperature regime seems to be only a secondary factor. Though average annual temperatures have risen by 0.4–0.5°C in Lithuania in the 20<sup>th</sup> century (Bukantis 2007), an increase in temperature of 1.3°C had no influence on the *M. oeconomus* population inhabiting alpine meadows in China (Sun et al. 2005). Thus, climate warming as another possible reason for the expansion in the distribution range of *M. oeconomus* in recent decades requires clarification or a dedicated investigation.

## Acknowledgements

*Research into M. oeconomus in the period 2005–2008 was partly financed by the Lithuanian State Science and Studies Foundation. Re-structuring of the results chapter was aided by Professor K. Perzanowski and proof-reading and language editing was conducted by J. Stratford.*

## Literature

- Balčiauskas L. 2004: Methods of investigation of terrestrial ecosystems. Part I. Animal surveys. *VUL, Vilnius*. (in Lithuanian)
- Balčiauskas L. 2005: Results of the long-term monitoring of small mammal communities in the Ignalina Nuclear Power Plant Region (Drūkšiai LTER site). *Acta Zool. Lituanica* 15: 79–84.
- Balčiauskas L. & Gudaitė A. 2006: Diversity of small mammals in winter season in north-east Lithuania. *Acta Zool. Lituanica* 16: 137–142.
- Balčiauskas L. & Juškaitis R. 1997: Diversity of small mammal communities in Lithuania (1. A review). *Acta Zool. Lituanica* 7: 29–45.
- Balčiauskas L., Trakimas G., Juškaitis R., Ulevičius A. & Balčiauskienė L. 1997: Atlas of Lithuanian mammals, amphibians and reptiles. *Akstis, Vilnius*.
- Balčiauskas L., Trakimas G., Juškaitis R., Ulevičius A. & Balčiauskienė L. 1999: Atlas of Lithuanian mammals, amphibians and reptiles. *Akstis, Vilnius 2nd ed.*
- Balčiauskienė L. 2006: Feeding ecology of tawny owl (*Strix aluco*) and long-eared owl (*Asio otus*), based on craniometry of prey. *Abstract of doctoral dissertation, Vilnius*.
- Balčiauskienė L. & Balčiauskas L. 2008: Common dormouse as a prey item of breeding tawny owl in five

- districts of Lithuania. *Acta Zool. Lituanica* 18: 61–65.
- Balčiauskienė L. & Naruševičius V. 2006: Coincidence of small mammal trapping data with their share in the tawny owl diet. *Acta Zool. Lituanica* 16: 93–101.
- Balčiauskienė L., Jovaišas A., Naruševičius V., Petraška A. & Skuja S. 2006: Diet of tawny owl (*Strix aluco*) and long-eared owl (*Asio otus*) in Lithuania as found from pellets. *Acta Zool. Lituanica* 16: 37–45.
- Balčiauskienė L., Juškaitis R. & Atkočaitis O. 2005: The diet of the tawny owl (*Strix aluco*) in south-western Lithuania during the breeding period. *Acta Zool. Lituanica* 15: 13–20.
- Baleišis R., Bluzma P., Mažeikytė R., Mickus A. & Prūsaitė J. 1993: Mammals of the Žuvintas Reserve. In: Kontrimavičius V., Kairiūkštis L., Virbickas J., Zajančauskas P. & Prūsaitė J. (eds.), The Žuvintas Reserve. Results of the integrated investigations in 1979–1985. *Academia, Vilnius*: 446–461.
- Bauža D. & Baužienė I. 2008: Evaluation of landscape changes in Lithuania in the second half of the 20<sup>th</sup> century. *Geografija* 44 (2): 28–35.
- Bieberich C. & Olson L. 2007: *Microtus oeconomus*, Animal Diversity Web. Accessed on 22 December 2008. [http://animaldiversity.ummz.umich.edu/site/accounts/information/Microtus\\_oeconomus.html](http://animaldiversity.ummz.umich.edu/site/accounts/information/Microtus_oeconomus.html)
- Bukantis A. 2007: Indications and causes of climate change. In: Rimkus E. & Sinkevičius S. (eds.), The global change of environment. *Vilniaus universitetas, Vilnius*: 77–106.
- EIONET 2008, European Topic Centre on Land Use and Spatial Information: CLC changes database. Accessed on 13 January 2010. <http://etc-lusi.eionet.europa.eu/CLC2000/changes/ShowSpecificCountry?title=lithuania>
- EPA 2009: Reports on small mammal monitoring, 1999–2004. The Environmental Protection Agency. [www.aplinka.lt](http://www.aplinka.lt) (in Lithuanian)
- IUCN 2007: *Microtus oeconomus*. In: IUCN 2007, European Mammal Assessment. Accessed on 11 May 2007. <http://ec.europa.eu/environment/nature/conservation/species/ema/>
- Ivanauskas T., Likevičienė N. & Maldžiūnaitė S. 1964: Guide-book of Lithuanian mammals. *Valstybinė politinės ir mokslinės literatūros leidykla, Vilnius*. (in Lithuanian)
- Juškaitis R. & Ulevičius A. 2002: Small mammals of the Curonian Spit National Park. *Theriologia Lituanica* 2: 34–46. (in Lithuanian with English summary)
- Juškaitis R. & Ulevičius A. 2003: Species composition of small mammals in the Vilkaviškis and Šakiai districts. *Theriologia Lituanica* 3: 39–44. (in Lithuanian with English summary)
- Juškaitis R. & Ulevičius A. 2004: Small mammals in the environs of Piktupėnai and Natkiškiai (Šilutė district). *Theriologia Lituanica* 4: 67–68. (in Lithuanian with English summary)
- Juškaitis R. & Uselis V. 2005: Small mammals in the Viešvilė Strict Nature Reserve. *Theriologia Lituanica* 5: 40–50. (in Lithuanian with English summary)
- Krebs Ch.J. 1999: Ecological methodology, 2nd ed. *Addison-Wesley Educational Publishers, Inc., Menlo Park, CA*.
- Mačiulis M. 2002: Mammals of the Kamanos Strict Nature Reserve and its protective zone. *Theriologia Lituanica* 2: 21–32. (in Lithuanian with English summary)
- Maldžiūnaitė S. 1980: Small mammals in Žagarė reserve. In: Lekavičius A., Jankevičienė R. & Tučienė A. (eds.), Žagarės forest. *Mokslas, Vilnius*: 48–50. (in Lithuanian)
- Mažeikytė R. 2002: Small mammals of the Kanio Raistas Botanical-Zoological Reserve. *Theriologia Lituanica* 2: 58–69. (in Lithuanian with English summary)
- Mažeikytė R. 2003: Small mammals of the Baranava Botanical-Zoological Reserve. *Theriologia Lituanica* 3: 45–56. (in Lithuanian with English summary)
- Pakeltytė G. & Andriuškevičius A. 2004: Species diversity and abundance in small mammal community at monitoring sites of Nevėžis Landscape Reserve. *Theriologia Lituanica* 4: 43–52. (in Lithuanian with English summary)
- Rácz G.R., Gubányi A. & Vozár Á. 2005: Morphometric differences among root vole (Muridae: *Microtus oeconomus*) populations in Hungary. *Acta Zool. Acad. Sci. Hung.* 51: 135–149.
- Ribokas G. & Milius J. 2007: Shifts of land use structure in North-east Lithuania after restoration of state hood. *Annales Geographicae* 40 (2): 38–49. (in Lithuanian with English summary)
- Shenbrot G.I. & Krasnov B.R. 2005: An atlas of the geographic distribution of the arvicoline rodents of the world (Rodentia, Muridae: Arvicolinae). *Pensoft Publ., Sofia*.
- Sun P., Zhao X., Klein J.A. & Wei W. 2005: Local warming about 1.3°C in alpine meadow has no effect on root vole (*Microtus oeconomus* L.) population during winter. *Pol. J. Ecol.* 53: 123–127.



- Šinkūnas R. 2006: Small mammal communities in the isolated and fragmented habitats. *Doctoral Thesis, Vilnius. (in Lithuanian)*
- Šinkūnas R. & Balčiauskas L. 2006: Small mammal communities in the fragmented landscape in Lithuania. *Acta Zool. Lituanica* 16: 130–136.
- The Reservation of Žuvintas 1968: *Mintis, Vilnius. (in Lithuanian)*
- Ulevičius A. & Juškaitis R. 2003: Mammals of the Dzūkija National Park (except bats). *Theriologia Lituanica* 3: 11–29. (in Lithuanian with English summary)
- Ulevičius A., Juškaitis R., Pauža D., Balčiauskas L. & Ostasevičius V. 2002: Mammals of the Žemaitija National Park. *Theriologia Lituanica* 2: 1–20. (in Lithuanian with English summary)
- Van Apeldoorn R.C. 1999: *Microtus oeconomus*. In: Mitchell-Jones A.J., Amori G., Bogdanowicz W., Kryštufek B., Reijnders P.J.H., Spitzenberger F., Stubbe M., Thissen J.B.M., Vohralík V. & Zima J. (eds.), The atlas of European mammals. *Academic Press, London*: 244–245.
- Zalunskaitė S. & Lopeta V. 2005: Small mammals in the northern part of Kurtuvėnai Regional Park. *Theriologia Lituanica* 5: 51–57. (in Lithuanian with English summary)
- Zorenko T. 2008: Guide-book of mammals of Latvia. *Gandrs, Rīga. (in Latvian)*

**Appendix.** Data on *M. oeconomus* from publications and trapping (*n* – trapping effort in trap/days, *S* – number of species, *N* – number of individuals trapped, *H'* – Shannon-Weaver diversity index, *Moe%* – % of *M. oeconomus*, *na* – data not available, *res.* – nature reserve, *RP* – regional park, *NP* – national park, *SNR* – strict nature reserve, *q.* – quarry, *l.* – lake, *f.* – forest, *r.* – river, *d.* – district, *t.* – town; habitat: *m* – meadow, *p* – pasture, *s* – shrub, *f* – forest, *r* – reedbed, *b* – bog, *w* – shore of waterbody, *a* – agriculture, *v* – various, including ecotones).

No	Locality	Year	Coordinates (N; E)	Habitat	n	S	N	H'	Moe%
1	Aukštaitija NP <sup>8</sup>	1976–1977	25°45'27"; 55°17'03"	m,f,v	na	11	234	2.03	0
2	Biržų giria f. <sup>1</sup>	1977	24°56'39"; 56°19'39"	m,s	200	9	80	1.71	0
3	Žagarės f. <sup>25</sup>	1980	23°13'07"; 56°17'50"	m,f,s	na	10	493	1.67	0
4	Dukstynos res. <sup>1</sup>	1983	24°45'10"; 55°12'56"	f,m,b	300	7	206	2.20	0
5	Baranava res. <sup>8</sup>	1990	25°45'34"; 55°12'28"	f,b,m,w	1550	7	80	2.08	0
6	Kanio raistas res. <sup>4</sup>	1990	25°53'58"; 55°09'02"	f,s,b	1600	6	77	2.12	0
7	Kepurinė res. <sup>1</sup>	1990	25°12'23"; 55°47'17"	b,m,f	550	8	47	2.23	0
8	Žalioji giria res. <sup>1</sup>	1990	24°34'05"; 55°50'13"	f,m,w	1770	6	313	1.35	0
9	Kretinga d., Ošupio takas <sup>1</sup>	1991	21°05'09"; 55°58'21"	f,m	210	4	25	1.62	0
10	Vepriai <sup>1</sup>	1991	24°32'42"; 55°08'22"	m,v	210	5	31	1.61	0
11	Vilnius d., Dūkštos <sup>1</sup>	1991–1993	24°58'08"; 54°49'20"	f,m,b	900	8	260	1.51	0
12	Kamanos SNR, Peiliškiai <sup>1</sup>	1991–1993	22°45'42"; 56°18'01"	f,m	900	7	192	2.05	0
13	Žuvintas SNR, Grinkiškiai <sup>1</sup>	1991–1993	23°37'40"; 54°29'03"	f,m,b	600	6	88	2.08	0
14	Nevėžis res. <sup>9</sup>	1991–2003	24°07'27"; 55°37'17"	f,m,b	4000	8	386	2.40	0
15	Asveja RP <sup>1</sup>	1993	25°34'27"; 55°01'22"	f,m,b	400	5	45	1.67	0
16	Islands Plateliai l. <sup>3</sup>	1993	21°50'52"; 56°02'15"	f,m	na	4	112	1.62	0
17	Alionys res. <sup>1</sup>	1994	25°11'29"; 55°01'01"	f,m	100	6	21	2.46	0
18	Aukštadvaris RP <sup>1</sup>	1994	24°33'23"; 54°33'28"	f,m,w	100	2	7	0.59	0
19	Gražutė RP <sup>1</sup>	1994	26°07'04"; 55°39'48"	f,m	125	4	13	1.76	0
20	Kruopynė res. <sup>1</sup>	1994	25°27'25"; 54°31'15"	f,m,b	100	3	19	1.36	0
21	Pagramantis RP <sup>1</sup>	1994	22°08'18"; 55°20'37"	f,m,b	75	3	18	1.05	0
22	Sartai RP <sup>1</sup>	1994	25°47'34"; 55°47'42"	f,m,b	160	6	51	1.84	0
23	Sirvėta RP <sup>1</sup>	1994	26°17'32"; 55°13'57"	f,m,b	300	9	59	2.62	0

24	Vištytis RP <sup>1</sup>	1994	22°45'48"; 54°28'23"	f,m,b	125	6	52	1.86	0
25	Plungė d., Gintališkė <sup>1</sup>	1995	21°43'27"; 56°02'56"	f,m,s	225	4	52	1.10	0
26	Josvainiai f. <sup>1</sup>	1995	26°52'01"; 55°15'19"	f,m	175	7	54	2.07	0
27	Nemakščiai q. <sup>1</sup>	1995	22°45'07"; 55°25'22"	s,f	50	4	8	1.91	0
28	Valley Balčia r. <sup>1</sup>	1995	22°47'17"; 55°27'17"	w	110	6	12	2.28	0
29	Radviliškis d. <sup>1</sup>	1996	23°25'53"; 55°42'59"	m,v	1250	12	347	2.13	0
30	Mažeikiai d. <sup>1</sup>	1997	22°14'44"; 56°15'14"	m,v	500	9	162	2.52	0
31	Islands Antalieptė <sup>20</sup>	1998–2005	26°02'19"; 55°36'52"	f,m	8615	8	759	1.28	0
32	Aukštaitija NP <sup>23</sup>	1999–2004	25°54'03"; 55°23'17"	f,m,b	2700	7	204	1.64	0
33	Biržai RP <sup>23</sup>	1999–2004	24°44'22"; 56°15'59"	f,m,b	2700	10	892	2.27	0
34	Kauno Marios RP <sup>23</sup>	1999–2004	24°10'43"; 54°52'47"	f,m,b	2700	5	163	1.21	0
35	Krekenava RP <sup>23</sup>	1999–2004	24°06'16"; 55°33'50"	f,m,b	2700	8	588	2.24	0
36	Nemuno kilpos RP <sup>23</sup>	1999–2004	24°02'54"; 54°31'46"	f,m,b	2700	7	109	2.07	0
37	Pagramantis RP <sup>23</sup>	1999–2004	22°13'03"; 55°20'34"	f,m,b	2700	6	214	1.44	0
38	Islands Rubikiai I. <sup>20</sup>	2005	25°17'11"; 55°30'12"	m,f	700	5	149	1.37	0
39	Islands Stirniai I. <sup>20</sup>	2005	25°39'14"; 55°15'04"	m,f	700	6	118	1.52	0
40	Anykščiai d. <sup>14</sup>	2008	24°59'18"; 55°33'13"	m,f,s	na	3	12	0.81	0
41	Kupiškis d. <sup>14</sup>	2008	24°59'55"; 55°51'55"	m,f,s	na	7	46	2.25	0
42	Mažeikiai d. <sup>14</sup>	2008	22°10'40"; 56°17'10"	m,f,s	na	5	29	1.59	0
43	Pakruojis d. <sup>14</sup>	2008	23°48'51"; 56°02'15"	m,f,s	na	4	66	1.60	0
44	Rokiškis d. <sup>14</sup>	2008	25°30'18"; 55°57'30"	m,f,s	na	7	77	2.39	0
45	Zarasai d. <sup>14</sup>	2008	26°02'54"; 55°43'52"	m,f,s	na	6	16	2.37	0
46	Šiauliai t. <sup>18</sup>	2008–2009	23°20'15"; 55°54'10"	m,s	1650	7	51	2.35	0
47	Tauragė d., Pagėgiai <sup>28</sup>	1961	22°06'25"; 55°04'01"	m,w	na	na	na	na	+
48	Šilutė d., Rusnė <sup>28</sup>	1961	21°26'26"; 55°16'54"	m,w	na	na	na	na	+
49	Šakiai d., Gelgaudiškis <sup>28</sup>	1961	23°03'49"; 55°05'16"	m,w	na	na	na	na	+
50	Žuvintas SNR <sup>26, 28</sup>	1961–1962	23°38'39"; 54°27'08"	m,w	na	10	na	na	+
51	Zarasai d. <sup>22</sup>	2004–2006	26°09'50"; 55°48'20"	f,m,s,a	3295	9	427	1.27	0.2
52	Dzūkija NP <sup>23</sup>	1999–2004	24°18'38"; 54°04'29"	f,m,b	2700	9	309	1.15	0.3
53	Drūkšiai I. environs <sup>1</sup>	1981–1990	26°33'29"; 55°39'11"	m,f,b	58200	14	3820	1.73	0.3
54	Pajūris RP <sup>23</sup>	1999–2004	21°05'03"; 55°49'43"	m,f,b	2700	9	231	2.52	0.4
55	Kamanos SNR <sup>2</sup>	1999–2001	22°38'47"; 56°19'12"	m,f,b	1500	12	222	2.28	0.5
56	Biržai d. <sup>14</sup>	2008	24°43'41"; 56°01'58"	m,f,b,a	na	6	152	1.72	0.7
57	Kamanos SNR <sup>23</sup>	1999–2004	22°39'22"; 56°17'13"	m,f,b	2700	11	271	2.11	0.7
58	Varniai RP <sup>23</sup>	1999–2004	22°24'49"; 55°46'23"	m,f,b	2700	13	391	2.41	0.8
59	Biržų giria f. <sup>1</sup>	1998–2005	25°00'12"; 56°15'38"	m,s	na	12	309	2.70	1.0
60	Panemuniai RP <sup>23</sup>	1999–2004	23°17'05"; 55°03'24"	m,f,b	2700	11	176	2.36	1.1
61	Čepkeliai SNR <sup>8</sup>	1978–1980	24°27'51"; 53°59'41"	f,m,b,v	na	11	729	1.50	1.4
62	Neris RP <sup>23</sup>	1999–2004	24°55'15"; 54°42'23"	m,f,b	2700	6	126	1.92	1.6
63	Kėdainiai d., Graisupis <sup>21</sup>	1997–2004	23°52'38"; 55°18'23"	m,f,v	7200	12	969	2.27	1.7
64	Vilnius t. <sup>19</sup>	2007–2008	25°14'28"; 54°38'36"	v	1560	8	180	2.39	1.7

65	Kurtuvėnai RP <sup>1</sup>	1995–1996	22°56'24"; 55°45'18"	m,f,w,r	1550	12	355	2.49	2.0
66	Kėdainiai d., Labūnava <sup>21</sup>	1999–2000	23°52'44"; 55°11'22"	m,a,v	500	9	193	2.01	2.1
67	Žemaitija NP <sup>1</sup>	1997	21°50'05"; 55°59'05"	f,m,s,r,v	1800	10	363	2.46	2.2
68	Kėdainiai d. <sup>23</sup>	1999–2004	23°52'02"; 55°17'01"	f,m,v	2700	11	644	2.28	2.5
69	Meteliai RP <sup>1</sup>	1993–1994	25°38'15"; 54°17'01"	r,m,s,f	300	11	77	2.57	2.6
70	Biržai d.	1999	24°55'51"; 56°13'06"	m,f,w,s	750	11	227	2.88	3.5
71	Šakiai d., Gelgaudiškis <sup>13</sup>	2008	22°56'47"; 55°04'59"	m, v	1400	8	149	1.97	4.0
72	Meteliai RP <sup>1</sup>	1997	23°45'11"; 54°16'27"	m,r,s,v	1800	8	490	1.62	4.1
73	Šalčininkai d. <sup>1</sup>	1997	25°09'07"; 54°24'15"	m,r,s,f,w	405	8	59	2.59	5.1
74	Šakiai d. <sup>7</sup>	1999	23°12'37"; 55°02'29"	m,r,s,f	1000	12	293	2.63	5.8
75	Žemaitija NP <sup>23</sup>	1999–2004	21°53'09"; 56°01'07"	m,r,s,f	2700	8	277	1.97	5.8
76	Žuvintas SNR <sup>27</sup>	1981–1983	23°34'59"; 54°27'22"	m,w,r,f	na	12	303	3.03	5.9
77	Telšiai d. <sup>1</sup>	1997	22°20'52"; 55°50'47"	m,r,s,f,w	600	9	83	2.62	6.0
78	Čepkeliai SNR <sup>1</sup>	1991–1993	24°23'59"; 53°57'25"	f,m,b	900	5	77	1.47	6.5
79	Vilnius d.	2008	25°17'14"; 54°56'54"	m/b	300	9	46	2.84	6.5
80	Žagarė RP <sup>15</sup>	2008	23°18'34"; 56°15'31"	m,s,r,f,v	1950	11	592	2.60	6.6
81	Joniškis d. <sup>14</sup>	2008	23°29'51"; 56°14'03"	m,f,s	na	11	632	2.61	7.0
82	Širvintos d.	2008	25°05'39"; 54°56'30"	w, m/b	150	7	25	2.44	8.0
83	Dubysa RP <sup>23</sup>	1999–2004	23°12'20"; 55°26'57"	m,f,b	2700	8	408	2.03	8.3
84	Vilkaviškis d., Vištytis l.	2007	22°45'19"; 54°24'41"	m, w	100	4	11	1.79	9.1
85	Kurtuvėnai RP <sup>11</sup>	2003	23°03'49"; 55°48'35"	f,m,r,v	na	11	175	2.82	9.7
86	Šakiai d., Gelgaudiškis <sup>24</sup>	2001	23°01'09"; 55°02'23"	f,m	na	8	133	2.39	9.8
87	Trakai d.	2008	24°38'02"; 54°34'15"	w	50	4	10	1.85	10.0
88	Vilnius d.	2008	25°06'09"; 54°53'10"	w	100	3	16	0.87	12.5
89	Dzūkija NP <sup>6</sup>	2002	24°31'24"; 54°04'26"	m,r,s,f,w	1350	7	232	2.22	12.9
90	Vištytis RP <sup>23</sup>	1999–2004	22°47'29"; 54°26'34"	m,f,b	2700	12	326	2.64	14.1
91	Širvintos d.	2006	25°00'36"; 55°01'49"	w	150	4	7	1.84	14.3
92	Plungė d. <sup>14</sup>	2008	21°47'25"; 55°55'42"	m,s,f	na	5	7	2.12	14.3
93	Viešvilė SNR <sup>1</sup>	1991–1993	22°28'41"; 55°10'37"	m,f,b	2750	12	228	2.12	14.5
94	Vilkaviškis d.	2008	23°20'09"; 54°41'12"	w	300	5	39	2.11	15.4
95	Viešvilė SNR <sup>10</sup>	1992–2000	22°25'07"; 55°07'58"	m,f,b	na	12	159	2.89	18.9
96	Akmenė d. <sup>14</sup>	2008	22°46'30"; 56°13'26"	m,f,v	na	11	145	2.55	19.3
97	Kamanos SNR <sup>17</sup>	2008	22°43'20"; 56°16'43"	m,s,f	477	11	141	2.49	19.9
98	Kelmė d., Šaukėnai	2005	22°50'27"; 55°46'23"	v	50	3	5	1.37	20.0
99	Dzūkija NP	2007	24°22'42"; 54°06'14"	m, f, w,v	500	7	52	2.29	21.2
100	Trakai d.	2008	24°59'55"; 54°41'22"	w	200	8	16	2.78	25.0
101	Vilkaviškis d. <sup>7</sup>	1995	22°54'43"; 54°27'42"	m,f,s,b,r	1275	11	399	2.56	26.6
102	Šilutė d.	2007	21°30'59"; 55°32'29"	m	100	5	7	2.24	28.6
103	Vilniaus r.	2006	25°37'37"; 54°34'49"	w, m/b	200	7	20	2.55	30.0
104	Daubėnai res. <sup>1</sup>	1994	25°25'44"; 54°34'35"	f,m,b	100	6	39	2.23	30.8
105	Virbalgis res. <sup>1</sup>	1995	22°47'47"; 54°36'10"	m,f	450	7	119	2.30	31.1

106	Rusnė	2008	21°18'07"; 55°20'34"	r,m	1025	8	338	2.29	32.2
107	Šakiai d., Lukšiai	2005	23°08'41"; 54°57'02"	w	50	3	9	1.35	33.3
108	Šalčininkai d., Dieveniškės	2005	25°36'55"; 54°13'04"	w	50	3	6	1.52	33.3
109	Varėna d.	2007	24°01'13"; 54°07'25"	m/s	50	3	3	1.58	33.3
110	Drausgiris f. <sup>1</sup>	1995	22°47'17"; 54°29'07"	m,f	450	7	94	2.33	34.0
111	Šalčininkai d., Eišiškės <sup>12</sup>	2008	25°01'47"; 54°09'44"	m,p	2950	9	244	2.46	34.0
112	Šilutė d., Piktupėnai <sup>29</sup>	1999	21°57'48"; 55°09'30"	m,f,r	na	9	136	2.31	42.6
113	Kuršių Nerija NP <sup>5</sup>	2001	21°04'33"; 55°25'12"	r,m,f	1875	8	300	1.95	50.0
114	Rusnė <sup>16</sup>	2004–2006	21°18'54"; 55°20'10"	r,m	5655	10	621	1.94	54.9
115	Šalčininkai d., Eišiškės	2005	24°57'56"; 54°10'49"	m/b	50	2	4	0.81	75.0

References: <sup>1</sup> Balčiauskas & Juškaitis (1997); <sup>2</sup> Mačiulis (2002); <sup>3</sup> Ulevičius et al. (2002); <sup>4</sup> Mažeikytė (2002); <sup>5</sup> Juškaitis & Ulevičius (2002); <sup>6</sup> Ulevičius & Juškaitis (2003); <sup>7</sup> Juškaitis & Ulevičius (2003); <sup>8</sup> Mažeikytė (2003); <sup>9</sup> Pakeltytė & Andriuškevičius (2004); <sup>10</sup> Juškaitis & Uselis (2005); <sup>11</sup> Zalunskaitė & Lopeta (2005); <sup>12</sup> J. Vilkova, pers. comm.; <sup>13</sup> G. Medvikytė, pers. comm.; <sup>14</sup> P. Alejūnas & V. Stirė, pers. comm.; <sup>15</sup> P. Alejūnas, pers. comm.; <sup>16</sup> A. Janonytė, pers. comm.; <sup>17</sup> E. Ginkuvienė, pers. comm.; <sup>18</sup> D. Prielaidas, pers. comm.; <sup>19</sup> O. Grincevičiūtė, pers. comm.; <sup>20</sup> Šinkūnas (2006); <sup>21</sup> Balčiauskienė (2006); <sup>22</sup> Balčiauskas & Gudaitė (2006); <sup>23</sup> EPA (2009); <sup>24</sup> R. Juškaitis, pers. comm.; <sup>25</sup> Maldžiūnaitė (1980); <sup>26</sup> The Reservation of Žuvintas (1968); <sup>27</sup> Baleišis et al. (1993); <sup>28</sup> Ivanauskas et al. (1964); <sup>29</sup> Juškaitis & Ulevičius (2004).