Lynx, n. s. (Praha), **54**: 121–136 (2023). ISSN 0024-7774 (print), 1804-6460 (online)

Threat assessment for dormice in Latvia – facts and assumptions (Rodentia: Gliridae)

Valdis PILĀTS[1], Laura TAUBE[2,4] & Digna PILĀTE[3]

[1] The Nature Conservation Agency, Baznīcas str. 7, Sigulda, LV–2150, Latvia
[2] Institute of Life sciences and Technology, Daugavpils University, Parādes str. 1A, Daugavpils, LV–5401, Latvia
[3] Latvian State Forest Research Institute "Silava", Rīgas str. 111, Salaspils, LV–2169, Latvia
[4] corresponding author: laura.taube@du.lv

received on 17 November 2023

Abstract. In Latvia, dormice were one of the less studied mammal taxonomic groups until the 21st century, due to their elusive way of life. Historical threat assessments of dormouse species conducted in the 1970s and 1990s were constrained by a scarcity of observations, primarily relying on accidental encounters. In 2021, a comprehensive reassessment of the threat status of four dormouse species recorded in Latvia – *Glis glis*, *Eliomys quercinus*, *Dryomys nitedula*, and *Muscardinus avellanarius* – was initiated, by applying the methodological framework developed by the International Union for Conservation of Nature (IUCN). Here we evaluate the outcomes of these reassessments in the context of previous threat assessments at the national level as well as in the regional context. Historical and current species status in neighbouring countries, as well as necessary protective measures in Latvia were also considered.

Key words. Red List, threat assessments, IUCN, edible dormouse, garden dormouse, forest dormouse, hazel dormouse, species occurrence, Latvia.

INTRODUCTION

In Latvia, the history of threat assessments or extinction risk assessment for plant and animal species dates back to the 1970s when compilation of the first Red List was started. The Red List was completed in 1979 and published as a book in 1985 (Aigare et al. 1985). Another threat assessment was done in the 1990s and the corresponding Red Data Book was published in several volumes starting from 1996. The volume covering mammal species was published in 2000 (Andrušaitis 2000). The first threat assessment included three dormouse species recorded in Latvia, while the second assessment listed four species: the edible dormouse *Glis glis*, garden dormouse *Eliomys quercinus*, forest dormouse *Dryomys nitedula*, and hazel dormouse *Muscardinus avellanarius*. In 2021, another species reassessment was started within the project Life for Species (Life19 GIE/LV/000857). Here we present the results of reassessments regarding dormouse species, and evaluate them with respect to previous threat assessments and in the context of the whole region formed by bordering countries (Lithuania, Estonia, Belarus, and Pskov Province of Russia). Moreover, we reflect on the future prospects and the necessary protective measures for threatened dormouse species in Latvia.

doi: 10.37520/lynx.2023.008

MATERIAL AND METHODS

Data collection

The main sources of data are results of dormouse monitoring started as a part of the national biodiversity monitoring program in 2016. It is focused on two species – *Dryomys nitedula* and *Muscardinus avellanarius* as they are listed in Annex IV of the EU Habitats Directive and are subjects of reporting under Article 17 of the Directive. Nevertheless, the monitoring enables data collection for other dormouse species too, as the use of nest boxes is the main method for dormice survey. The usefulness of nest boxes has been demonstrated by several small-scale dormouse studies (Pilāts et al. 2009). The focus of dormouse monitoring has been put mainly on the species' distribution in the country, as no nationwide dormouse surveys were carried out until 2016. Putting up nest boxes aimed at dormice surveys was started only in 2002 as a part of mammal inventories prior to the elaboration of management plans for specially protected nature areas

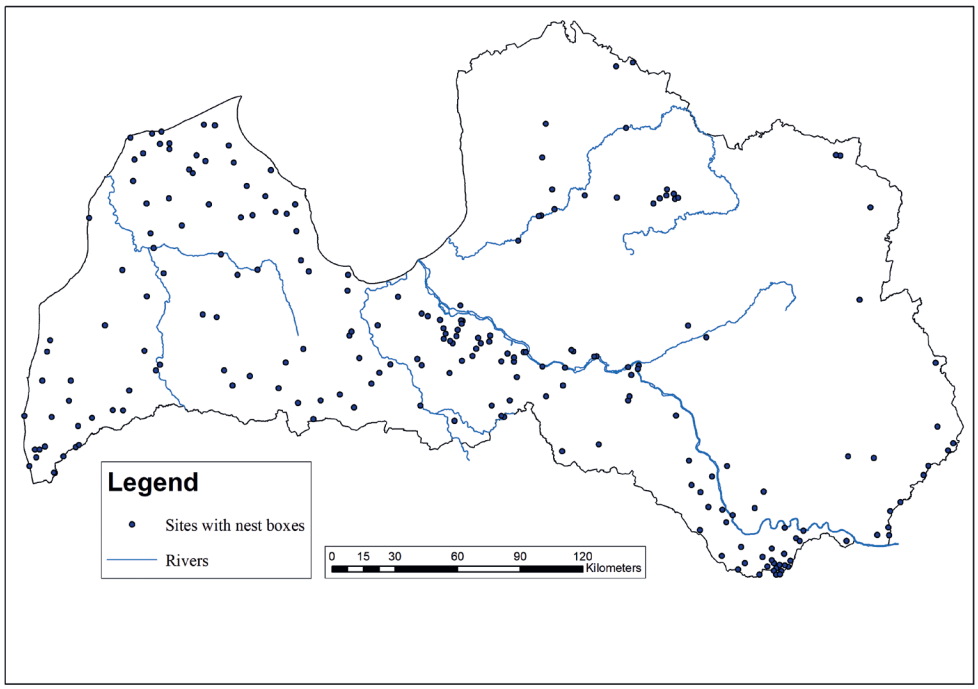

Fig. 1. Distribution of sites with nest boxes used for dormouse surveys. Besides data obtained during the surveys, the reports on accidental observations by people were also used. A great part of them is stored in the public database of nature observations at www.dabasdati.lv. All accidental observations were evaluated by their plausibility. Opportunities provided by citizen science were used to obtain data on the occurrence of dormouse species also in the countries bordering Latvia. Several data sets provided by various internet portals were reviewed. Various publications were also examined. Additionally, in 2017 two of the authors (DP & VP) visited a borderland area in the northwest of the Braslav District (Belarus) and with the support of the staff of the Braslav Lakes National Park Administration searched for *Dryomys nitedula*, by checking the nest-boxes (Anonymous 2017).

(nowadays known also as Natura 2000 sites). The nest box method involves the establishment of temporary small study plots in suitable habitats with 5–15 nest boxes in each plot to determine the presence of the species. Brief description of the hazel dormouse monitoring program is given by Pilāts & Pilāte (2022). Additionally, the dormouse presence was also checked in several places where nest boxes were put up for birds. Altogether the presence of dormice has been checked in more than 250 sites with nest boxes since 2002 (Fig. 1). Less attention was paid to the northeastern part of Latvia (north from the Daugava river) as only few reports on accidental dormouse observations were received and initial surveys do not reveal presence of dormice even in places with probable dormouse observations (except the cases with *Glis glis* in the Gauja river valley; see below).

Species threat assessment

Collected data were evaluated according to the methodology developed by the International Union for Conservation of Nature (IUCN), in particular: IUCN Red List categories and criteria (IUCN 2012a), Guidelines for Using the IUCN Red List Categories and Criteria (IUCN SPC 2022) and the IUCN Guidelines for Application of IUCN Red List Criteria at Regional and National Levels (IUCN 2012b). Species threat assessment must be carried out using five criteria based on population size and dynamics, geographic range as well as on extinction probability analyses. If data are limited, assessment can be based on only one criterion. The quantitative criteria determine which threat category is most appropriate for the species.

In Latvia, data on dormouse species are insufficient to estimate population size and the history of dormouse monitoring is too short to evaluate population dynamics. The only criterion we could apply was geographic distribution (criteria B). It has two forms: B1 – estimated extent of occurrence (EOO) and B2 – estimated area of occupancy (AOO). Additionally, three sub criteria (a – severely fragmented or few locations, b – continuing decline, c – extreme fluctuations) should be considered. In accordance with the Red List Guidelines, EOO for each dormouse species was calculated by applying a Minimum Convex Polygon (MCP) around the localities denoting species presence. AOO was measured by overlaying those localities with a 2×2 km map grid and counting the number of cells occupied (one cell corresponds to 4 km²). For those calculations we used all available data on species records collected since the year 2000.

RESULTS

Eliomys quercinus

The species was not detected within the dormouse monitoring and no reports on plausible observations of *Eliomys quercinus* were received since 2000. The last reliable species records are known from the 1980s and 1990s (V. Pilāts, unpubl. data). Those observations were made by professional and amateur ornithologists and included findings in the bird nest boxes. Of the reports known to the authors, the most recent reliable record comes from 1996. The species is considered vanished both in Estonia (Anonymous 2023) and Lithuania (Juškaitis 2018). Most probably it vanished from Belarus and the Pskov Province as well, since no records have been indicated from this regions from the 21st century (Gričik 2015a, Istomin et al. 2014, Gurkov 2023a, and according to data collected on the web portals Mammals of Belarus and Mammals of Rusia). Consequently, the species is assessed as Regionally Extinct (RE) also in Latvia.

Dryomys nitedula

This species is assessed as Critically Endangered (CR) in Latvia. The assessment is based on a fact that *Dryomys nitedula* is found in only one and very restricted area or location (the IUCN term used in threat assessments). The calculated EOO is even smaller than AOO: 12 and 32 km²,

respectively (Fig. 2). The IUCN guidelines (IUCN SPC 2022, page 50) state that if EOO is less than AOO, EOO should be changed to make it equal to AOO to ensure consistency with the definition of AOO as an area within EOO. In our case we did the opposite: changed the size of AOO to make it equal to EOO to ensure the above mentioned consistency. The threshold values for EOO and AOO of the threat category CR is <100 km² and <10 km², respectively (IUCN 2012a; Table 1).

The degree of isolation of the population dwelling the only known location was also evaluated. Most probably, this is a cross-border population, as *Dryomys nitedula* is found in nest boxes put up at the Latvian and Belarusian border (at the Latvian side: our unpubl. data). Nevertheless, no definite evidence of the species presence was found by the authors in 2017 and no definite species records have been known up to now at the Belarus side of the probable species location. Judging from the availability of suitable habitats for *Dryomys nitedula*, the EOO of the entire possible inhabited area of the species in the LV and BY border area most probably could not be more than 100 km².

The nearest populations of *Dryomys nitedula* are known in central Lithuania (Juškaitis 2003, 2021) about 170 km away and in northern Belarus at the village of Sosnovij Bor (Dmitrij Šamovič pers. comm.; and according to data collected on the web portal Observation.org)

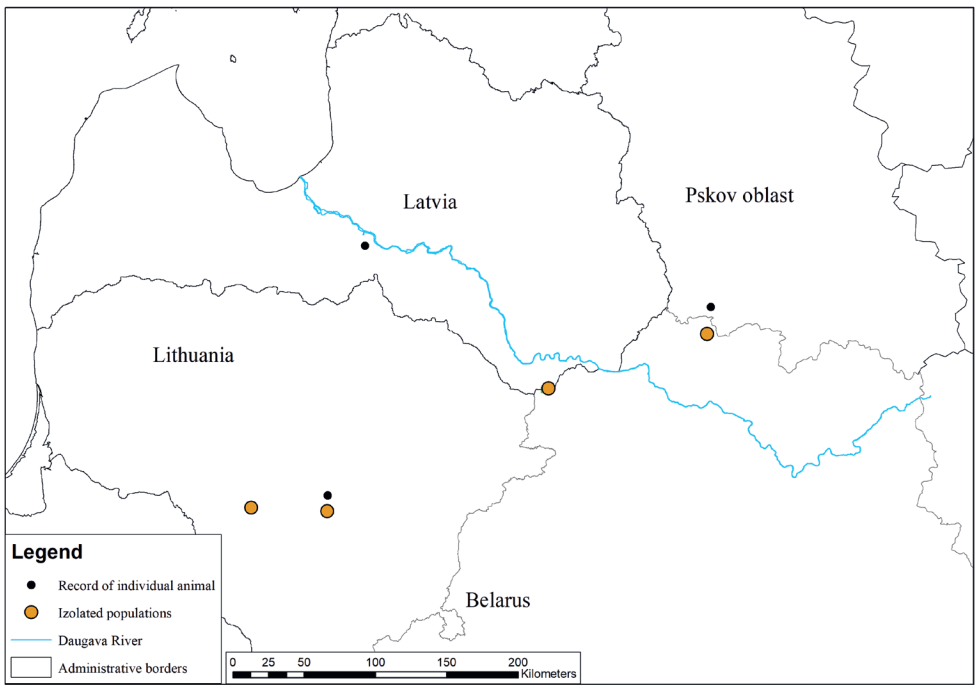

Fig. 2. Distribution of *Dryomys nitedula* in Latvia and adjacent territories. Data for Lithuania were taken from Juškaitis (2003) and R. Juškaitis pers. comm.; for northern Belarus from D. Šamovič pers. comm. and the portal Observation.org; for the Pskov Province from Fetisov (2005).

Table 1. Threshold values and calculated values of criterion B for dormouse species in Latvia. Legend: IUCN categories: CR – critically endangered, EN – endangered, VU – vulnerable; species acronyms: *Dn – Dryomys nitedula*, *Gg – Glis glis*, *Ma – Muscardinus avellanarius*

criterion	threshold values			calculated values		
B. Geographic range in the form of either B1 and/or B2	CR	NE	VU	*Dn*	*Gg*	*Ma*
B1. Extent of occurrence (EOO)	<100	<5,000	<20,000	12	2,706	46,372
B2. Area of occupancy (AOO)	<10	<500	<2,000	12	60	460

about 110 km away (Fig. 2). The latter population might also be a cross-border population, as *Dryomys nitedula* has been recorded ca. 20 km north of Sosnovij Bor, at Osyno in Russia (Fetisov & Smorkačeva 2002; cited from Fetisov 2008). Dormice movements between locations in Latvia, Lithuania, and Belarus seem to be impossible due to long distances and severe habitat fragmentation between the known locations.

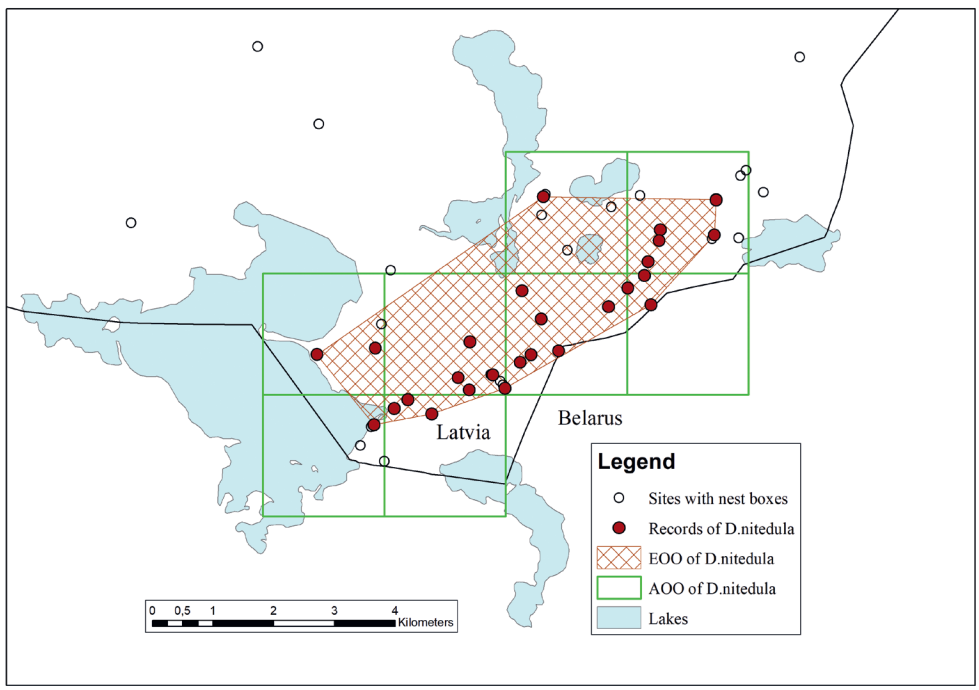

Fig. 2. (continued).

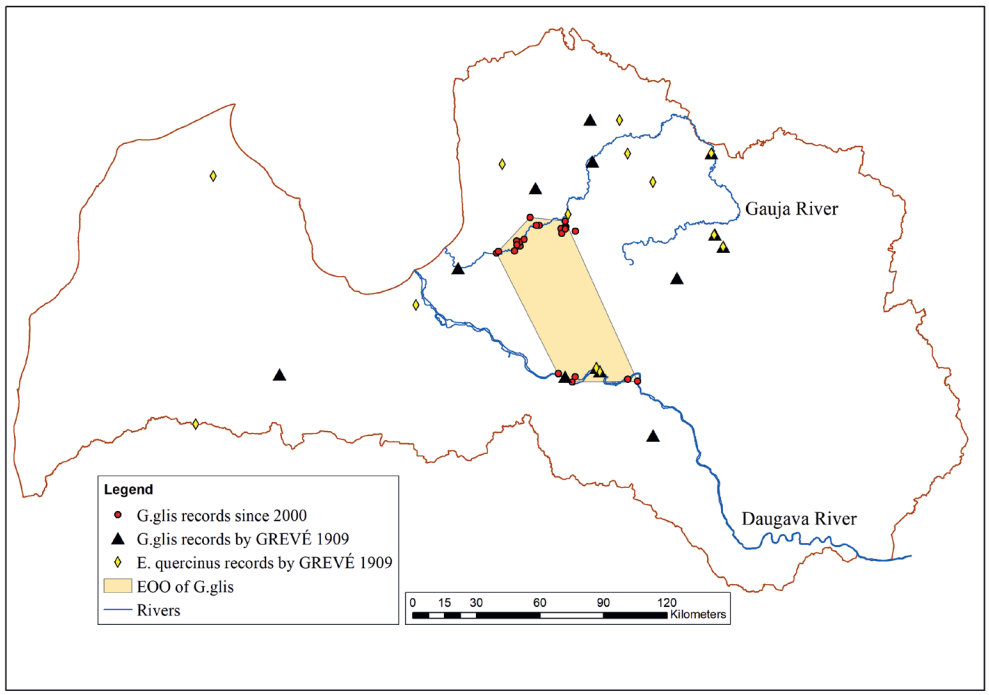

Fig. 3. Current distribution of *Glis glis* and historical records (according to Grevé 1909) of *Glis glis* and *Eliomys quercinus*.

In Latvia, the main threat to *Dryomys nitedula* is forest felling in dormouse habitats in the only known location. According to the data available on the Global Forest Watch online platform, in the territory inhabited by *Dryomys nitedula*, the total area of forested areas has decreased by about 6% during the 21st century. The authors' personal observations made while monitoring *Dryomys nitedula* in this area show that the decrease of suitable habitats happened because of forestry activities. Additionally, forestry activities are also negatively reflected in the monitoring results: dormice are not detected in study plots located in the areas affected by forestry activities (Pilāts 2021). Similarly in Lithuania (Juškaitis 2021), forest felling in dormouse habitats is recognized as the main threat to this species.

Glis glis

In Latvia, the species reachesthe northernmost border of its range, where it is represented by three known, isolated populations (locations) in the valleys of the Gauja and Daugava rivers (Fig. 3). The shortest distance between two Latvian locations of *Glis glis* is about 25 km but these locations are separated by the rather large Daugava river. Therefore, exchange of individuals between populations is quite unlikely. The nearest locations outside Latvia are most probably

those at the Nemunas river and Neris river in the southern part of Lithuania (Juškaitis 2021). The shortest distance between Latvian and Lithuanian localities of *Glis glis* is about 220 km.

In Latvia both the estimated EOO and AOO are relatively small: 2700 and 60 km², respectively. The actual size of the AOO is probably slightly larger, as not all forest areas dwelled by *Glis glis* have been identified. Estimated values fit within the threshold values for both parameters of the threat category EN – Endangered species (Table 1).

Observations made by the authors indicate that *Glis glis* is threatened by habitat quality decline. In the northern periphery of the species range, the main habitats of *Glis glis* are mature mixed forests with the pedunculate oak *Quercus rubra* and hazel *Corylus avellana* (Juškaitis et al. 2015). The reproduction of *Glis glis* even fails if the oaks do not produce acorns (Vekhnik et al. 2022). In the Gauja National Park, within the Gauja river valley, gradual withering of old oaks due to age as well as ecological succession and subsequent disappearance of oaks is observed in habitats of *Glis glis*. In the Daugava river valley, on the other hand, relatively intensive forest management is going on in the area inhabited by *Glis glis*. Therefore, the species is assessed as Endangered (EN) according to the IUCN criteria.

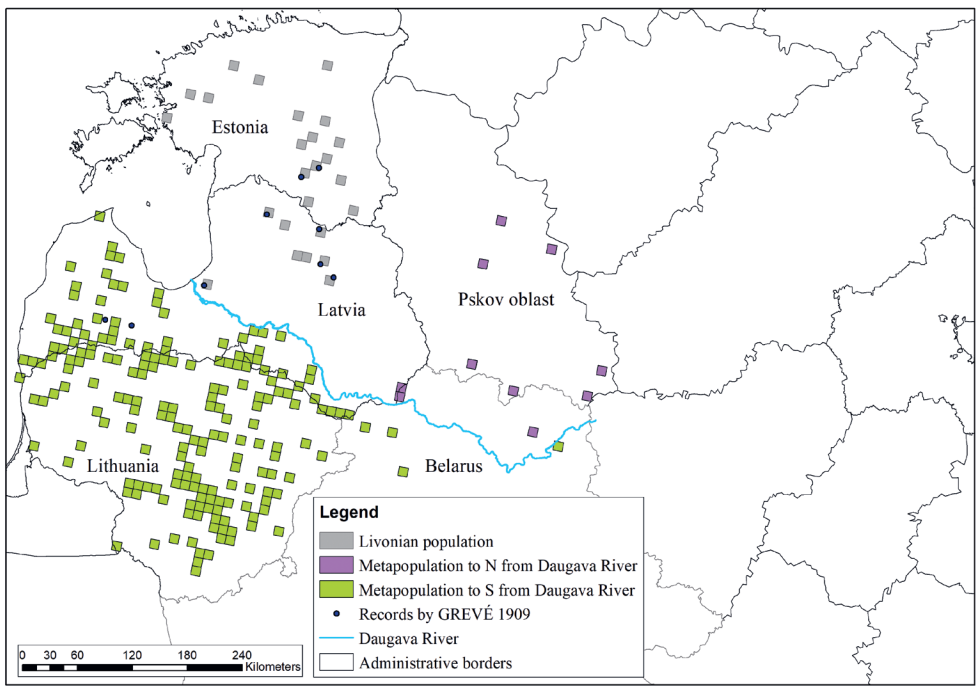

Fig. 4. Distribution of *Muscardinus avellanarius* in Latvia and adjacent territories. Data for southwestern Latvia and Lithuania were taken from HD Article 17 web tool; for Estonia and northeastern Latvia from Pilāts et al. (2022); for the Pskov Province from Istomin et al. (2014), Grigor'ev (2017), and Samockaâ (2017), and for northern Belarus from Gurkov (2023b) and the web portal inaturalist.org.

Table 2. Results of the threat assessments carried out so far in Latvia (IUCN categories: RE – regionally extinct, CR – critically endangered, EN – endangered, VU – vulnerable, NT – near threatened, DD – data deficient, LC – least concern, NE – not evaluated; for previous assessments different categories were used)

species \ year	1985	2000	2023
Eliomys quercinus	decreasing populations (EN/VU)	rare (NT)	RE
Dryomys nitedula	NE	rare (NT)	CR
Glis glis	threatened with extinction (CR)	decreasing populations (EN/VU)	EN
Muscardinus avellanarius	DD	rare (NT)	LC

Muscardinus avellanarius

The estimated AOO for this species is 460 km². Although the threshold values for AOO of EN and VU categories are <500 km² and <2000 km², respectively (Table 1), the species is assessed as Least Concern (LC). The estimated AOO is certainly smaller than the actual AOO (species occurrence in the wild), since not all areas occupied by *Muscardinus avellanarius* have been found and mapped up to now. According to the results of monitoring carried out in the last 6 years, new localities of the species are discovered every year. Therefore, the size of EOO and especially of AOO is expected to increase along with further dormouse surveys.

The species is rather widespread in Latvia. Currently, the main range within the country lies south of the Daugava river (Fig. 4). Dormice inhabiting this part of Latvia are most likely a part of a metapopulation that also inhabits Lithuania, where the species is even more widespread (Juškaitis 2008). Significant threats to the species were not identified.

DISCUSSION

In Latvia, dormice were one of the less studied mammal taxonomic groups until the 21st century, due to their elusive way of life. Threat assessments of dormouse species carried out in the 1970s and 1990s were based on a small number of accidental observations. As a result of the monitoring started 6 years ago, the knowledge about all four dormouse species, especially about *Muscardinus avellanarius*, has been significantly improved. Consequently, results of threat assessments performed three times (Table 2) differ mainly due to the different knowledge level, not due to changes in populations. Only for *Eliomys quercinus* both the knowledge and actual species status has changed.

Results of the recent threat assessment of dormouse species carried outin Latvia differ partly from those performed in the neighbouring countries and essentially from the global assessments (Table 3). The differences between threat categories at the global level on one side and at the national (BY, EE, LT, LV) and regional (Pskov Province) levels at the other side are mainly due to natural reasons. In case of all four dormouse species, Latvia and adjacent territories lie in the northern periphery of their global range. Consequences for dormouse species of being at the edge of the distribution range were analysed by Juškaitis et al. (2015).

Paradoxically, extinction on the national and even regional level has hit *Eliomys quercinus* – the dormouse species with the northernmost range edge, at least historically (see, e.g., Ajrapet′âns 1983, Mitchell-Jones et al. 1999). Nowadays the species is suffering significant ongoing decline and has disappeared from a large part of its former range, especially in the northeastern

part. Within the previous global threat assessment (Bertolino et al. 2008), *Eliomys quercinus* was rated as Near Threatened (NT). Later Bertolino (2017) pointed out that due to the range reduction over the ten year period the threat category should be raised to Vulnerable (VU).

In the past (19th century – the first half of the 20th century), *Eliomys quercinus* was most likely not only a relatively common but also most widespread dormouse species in Latvia. There is a reason to believe that a part of the records collected by Karl Grevé (1909) on *Glis glis* (Fig. 3) were sightings of *Eliomys quercinus* (see Valdis 2003). Commonness of *Eliomys quercinus* is also indirectly indicated by the statement that "garden dormouse (*Eliomys quercinus*) which is often found in all deciduous and mixed forests should be mentioned as very significant destroyer of bird nests" (Vilks 1939) as well as by the record of ten *Eliomys quercinus* specimens as the most abundant prey items in the nest of the tawny owl *Strix aluco* during one breeding season (Ūdris 1940).

In the second half of the 20th century, the lack of data on *Eliomys quercinus* and even a decrease of its population were announced (Tauriņš 1982, Aigare et al. 1985, respectively). Nevertheless, due to the absence of dormice monitoring, the extinction of *Eliomys quercinus* as an actual process remained unnoticed in Latvia. No exact reasons for the species extinction are identified either in Latvia or in other regions (Bertolino 2017). Bennett & Richard (2021) suggest that it might be an interaction between the land use change, habitat degradation and fragmentation, management practices and climate change, due to which the whole northeastern part of the species distribution range has become less suitable for the species.

Almost the opposite picture can be seen if we compare the earlier threat assessments with the current one regarding *Muscardinus avellanarius* in Latvia. Formerly considered a rare species it turns to be the most widespread dormouse species nowadays. Until the very beginning of the 20th century, it was identified only in few localities in the present Latvia, and at the same time, as far north as the southern part of the present Estonia (Grevé 1909; Fig. 4). In the 1950s in relation to the nest box use in different ornithological studies, it was found that *Muscardinus avellanarius* also occupies bird nest boxes and may be relatively abundant, at least locally (Štrauss 1959). Nevertheless, later and until the beginning of the 21st century almost only accidental additional observations of the species were collected and therefore it was assessed as rare (Pilāts 2000). In the 21st century the use of nest boxes to survey dormice, especially

Table 3. The comparison of national/regional and global threat assessments (sources of information: [1] elurikkus.ee, [2] Istomin et al. (2014), [3] Kačanovskij (2015), [4] Rašomavičius (2021), [5] www.iucnredlist.org; for Latvia and Lithuania both categories and used criteria and sub-criteria are indicated; for Belarus and the Pskov Province the national threat categories and corresponding IUCN categories are indicated in brackets)

species	category in country					global
	Latvia 2023	Estonia[1] 2019	Pskov Prov.[2] 2014	Belarus[3] 2014	Lithuania[4] 2021	category[5]
Eliomys quercinus	RE	RE	4 (DD)	3 (VU)	NE	NT (2008)
Dryomys nitedula	CR B1ab(iii)	–	4 (DD)	(LC)	EN B1ab(iii, iv)+2ab(iii, iv)	LC (2016)
Glis glis	EN B1,B2ab(iii)	–	–	3 (VU)	EN A2c; B2ab(iii,iv)	LC (2016)
Muscardinus avellanarius	LC	RE	4 (DD)	4 (DD)	NE	LC (2016)

as a part of dormice monitoring, revealed that the species is rather common in the southern and southwestern parts of Latvia bordering Lithuania (Fig. 4). In 2021, presence of the species was discovered at the Latvian eastern border with Belarus. As *Muscardinus avellanarius* is also known from the region north of the relatively large Daugava (Zapadnaâ Dvina) river both in Belarus (Gričik 2015b, Gurkov 2023b) and the Pskov Province (Istomin et al. 2014, Grigor′ev 2017, Samockaâ 2017), we can assume existence of another *Muscardinus avellanarius* metapopulation in the territory east of Latvia (Fig. 4). The area occupied by dormice of this metapopulation is most probably very limited within Latvia. We do not know if the dormice living on the Latvian side of the border are long-term residents or newcomers, since the historical maps (available at vesture.dodies.lv) show that this cross-border area was less forested about 100 years ago compared to nowadays.

The size of forest cover fluctuated in Latvia during the last millennium. Over the last hundred years the forest coverage has increased in the whole Latvia: e.g., from 26.9% in 1929 to 51% in 2015 (Ikauniece 2017a). Therefore, we can expect that EOO and especially AOO of *Muscardinus avellanarius* have also increased during the 20th century, and that the comparatively low number of localities (Fig. 4) pointed by Grevé (1909) might relatively objectively characterize the occurrence of the species 100 years ago. Of course, we can not exclude the possibility that *Muscardinus avellanarius* was observed by people less often than the other dormouse species because it does not tend to visit human settlements like *Glis glis* and *Eliomys quercinus* do (see, e.g., Büchner et al. 2018). Nowadays only one case in Latvia (V. Pilāts, unpubl. data) and several records in Lithuania (Juškaitis pers. comm.) are known where *Muscardinus avellanarius* was found inside buildings. The dormouse monitoring has revealed that there are forested areas with suitable habitats for *Muscardinus avellanarius* within its known range where the species is missing. One explanation is that *Muscardinus avellanarius* has vanished in those areas during the time periods with low forest coverage or intensive site management, e.g., the use of forest for cattle grazing, and have not returned after the habitat has regenerated. Historically the forests were widely affected by cattle grazing (Lārmanis 2017).

Despite possible increase in occupancy rate of *Muscardinus avellanarius* in the southern and southwestern parts of Latvia (south of the Daugava river), dormouse monitoring has not revealed presence of the species in the northeastern part of Latvia (north ofthe Daugava river), except a small area at the very eastern border. Also in Estonia, the last confirmed record of the species comes from the year 1986 and surveys undertaken in the 21st century were without positive results (Jaik 2014; unpubl. data of Estonian Theriological Society & U. Timm pers. comm.). Looking on a map (Fig. 4), we can assume existence of another, probably vanished population of *Muscardinus avellanarius* in northeastern Latvia and in Estonia (former Livonia). Most probably, this population was isolated from other populations both in the present territories of Latvia and the Pskov Province. At least the Daugava river seems to be a geographical obstacle for *Muscardinus avellanarius* to disperse from the southwestern part of Latvia to the northeastern part. No obvious reasons for vanishing of the presumptive Livonian *Muscardinus avellanarius* population can be identified. In contrast to *Glis glis* and *Dryomys nitedula*, *Muscardinus avellanarius* is more adaptable to forest management. The studies in Lithuania have revealed that clear cutting and regular thinning of regenerating clearings are forms of forest management that even favour *Muscardinus avellanarius* (Juškaitis 2020).

Some assumptions can be made also regarding the distribution of *Glis glis*. If we compare recent records with those collected by Grevé (1909), a remarkable difference can be seen (Fig. 3). Already earlier it was hypothesized that reports on *Glis glis* occurrence unrelated to the valleys

of the Gauja and Daugava rivers might be misidentification of the species (Valdis 2003). If so, no essential reduction of EOO has happened at least during the last 100–200 years. Insignificant decrease of EOO could have happened due to construction of three hydroelectric power plants and the related flooding of the part of the Daugava river valley in the 20th century. This suggests that even restricted populations can survive for a long time despite a "very high risk of extinction in the wild" as it is defined for the IUCN category EN. A risk turns into an event when adverse factors start to operate. In case of *Glis glis* in Latvia, one of the main adverse factors might be a natural process – the forest succession. As stated above, the pedunculate oak is the most important tree providing food (acorns) in the habitats of this dormouse species. Natural regeneration of the pedunculate oak in habitats dwelled by *Glis glis* is practically impossible, as it is a pioneer tree species whose seedlings can not survive shading caused by large trees and undergrowth (Ikauniece 2017b). Our observations in dormouse monitoring sites indicate that there are only few young oak trees to replace old oaks. We do not know whether *Glis glis* will be able to find old-growth forests with acorns producing new oaks during the next hundred years.

Compared to *Glis glis*, *Dryomys nitedula* has an even more limited distribution and higher uncertainty in Latvia. Despite the extensive dormouse surveys using nest boxes, presence of *Dryomys nitedula* was found neither in areas close to the only known locality nor elsewhere in Latvia. The species is missing in the area (in central Latvia; Fig. 2) from which a shot individual was brought to the museum in 1912 (Tauriņš 1982). The status of that individual is still unknown – was it a representative of another isolated and now vanished population or of another unknown origin. Similarly, also in Lithuania there is a record of *Dryomys nitedula* individual brought to the museum in 1934 but no later species observations in the particular area have been made (Juškaitis 1992, 2003, 2021).

In case of Belarus, *Dryomys nitedula* is not listed as a threatened species because it is regarded as the most common dormouse species occurring mainly in the southern part of country (Gurkov 2003c).

Completely isolated populations of *Dryomys nitedula* are scattered both along the edge of its range (Batsaikhan et al. 2016) and even within the range (see, e.g., Ajrapet′âns 1983, Pucek 2001). Most probably, isolated populations in Latvia, Lithuania, and northern Belarus are successors of a historical metapopulation which was established in the region within the Atlantic period (Motuzko & Ivanov 1996, Markova et al. 2003). What history is behind each of the current isolated populations is not known, as they have been discovered rather recently. In Latvia, the only known population was revealed in the 1960s (Kasparsons 1970). We do not know for how long *Dryomys nitedula* exists there as an isolated population as well as whether it is geographically conservative – related to the same location for a long time – for more than 100 years. Historical maps (available at vesture.dodies.lv) show that also this cross-border area of *Dryomys nitedula* occurrence was less forested about 100 years ago compared to nowadays, i.e., was less suitable for the species. It indicates two possibilities: the previously isolated population had an even smaller EOO, or dislocation of the population has happened. Our studies have shown that the species is dependent on rich forest undergrowth (Pilāts et al. 2012) while undergrowth vitality depends very much on forest succession and the type of forest management, i.e., it is variable in space and time. At least two scenarios are possible how *Dryomys nitedula* and its habitat coexist over time. The first one: population vitality follows the suitability of the forest in one and the same location. If habitats at the location become unsuitable, the species vanishes. The second scenario: the population follows the "migration" of suitable habitats. If one forested area becomes unsuitable for the species, dormice move to another, more suitable

nearby habitat. Our data obtained during the five-year period of *Dryomys nitedula* monitoring show that while the occupancy of nest boxes in one study plot is decreasing, it is growing in another study plot (Pilāts 2021). Although it has happened without notable changes in habitats within the study plots, this could point in favour of the second type of scenario. In case of this scenario, we cannot exclude the possibility that *Dryomys nitedula* is a relative newcomer in its current location. On the other hand, the distribution of the species in the present location remains limited, although suitable habitats – forests rich in undergrowth are found both in the immediate vicinity and throughout the country.

In Lithuania, one of local populations of *Dryomys nitedula* was discovered in 1985 and monitored since 1999. Although a high level of adaptability of *Dryomys nitedula* to local conditions (compared to *Muscardinus avellanarius*) was stated by Juškaitis (2015), possible extinction of the species at the study site was recorded later (Juškaitis 2021). The conclusion that "the environmental factors limiting the distribution of *D. nitedula* on the edge of the range are not yet understood" (Juškaitis 2015) seems to be correct. In other words: it is difficult to predict the future of an isolated population without knowing its full history and driving forces behind it.

CONCLUSIONS

Although the knowledge of dormouse species has recently improved in Latvia, we still have to rely on some assumptions. First, our understanding of the history of the dormouse populations is largely based on assumptions. Without knowing what processes affected the dormouse populations in the past, it is difficult to assess their needs in the future. By the threat assessment, we not only identify factors that threaten the species, but also indicate conservation measures to be taken. Theoretically all four dormouse species in Latvia require one or another form of protective measures. Although *Muscardinus avellanarius* as a species is doing relatively well (it is assessed as a LC species), there is an opportunity to further improve its status by restoring the eventually extinct population in the northeastern part of the country. Besides, even within the existing EOO there are quite many rather large, forested areas with suitable habitats for *Muscardinus avellanarius* where the species is missing. To improve the connectivity between the populations within the metapopulation as well as to increase EOO and AOO, it would be desirable to restore the presence of the species in suitable but empty habitats. This could be done by animal translocation. As a part of the mitigation measures, translocation is a rather widely used conservation method for *Muscardinus avellanarius* (see, e.g., Downs et al. 2020, Höcker et al. 2022).

Recovery of *Eliomys quercinus* in Latvia can be considered a logical goal. In theory, reintroduction could help, but to be successful, the causes of extinction must be addressed first. It is advisable to postpone the reintroduction actions until the reasons for the disappearance of the species in a large part of the range are understood.

Although *Glis glis* and *Dryomys nitedula* populations may have lived in isolation for a long time, the existence of isolated population may cease even if just natural processes take their course, especially in the case of *Glis glis*. To preserve mature oaks (as the essential food source for dormice) in the area, specific forest management is needed to stop or slow down succession in old forests along with creating conditions for oak regeneration (Ikauniece 2017b). In the case of *Dryomys nitedula*, it is necessary to preserve the undergrowth or promote its growth in the forest with appropriate management activities, which can also be supplemented by animal translocation. In this way, an attempt could be made to increase the area of EOO of the known population, as well as to create a new, additional population.

Acknowledgements

The threat assessment and preparation of the paper was done within the project of the EU LIFE Programme "Threatened species in Latvia: improved knowledge, capacity, data and awareness" (Life for Species; LIFE19 GIE/LV/000857).

REFERENCES

Ajrapet′ânc A. È., 1983: *Soni* [*Dormice*]. Izdatel′stvo Leningradskogo Universiteta, Leningrad, 189 pp (in Russian).

Aigare V., Andrušaitis G., Lipsbergs J., Lodziņa I. & Tabaka L., 1985: *Latvijas PSR Sarkanā grāmata. Retās un iznīkstošās dzīvnieku un augu sugas* [*Red Data Book of the Latvian SSR. Rare and Endangered Species of Animals and Plants*]. Zinātne, Rīga, 526 pp (in Latvian and Russian, with some general notes in English).

Andrušaitis G. (ed.), 2000: *Latvijas Sarkanā grāmata. Retās un apdraudētās augu un dzīvnieku sugas*, *6. Sējums. Putni un zīdītāji* [*Red Data Book of Latvia. Rare and Threatened Species of Plants and Animals. Volume 6. Birds and Mammals*]. Institute of Biology, University of Latvia, Rīga, 274 pp (in Latvian and English).

Anonymous, 2017: *Nacional'nij park* "*Braslavskie ozera*". *Monitoring semejstva sonevih Gliridae* [*Braslavskie ozera National Park*. *Monitoring of the Dormouse Family Gliridae*]. Upravlenie delami prezidenta Respubliki Belarus, Minsk. URL: www.udp.gov.by/special/ru/news-ru/view/-23331-2017 (in Russian).

Anonymous, 2023: *Eliomys quercinus* (*Linnaeus*, *1766*). *Red List Assessment*. URL: elurikkus.ee/bie-hub/species/56133?lang=en#redlist

Batsaikhan N., Kryštufek B., Amori G. & Yigit N., 2016: *Dryomys nitedula* (*errata version published in 2017*). *The IUCN Red List of Threatened Species 2016*: *e.T6858A115084761*. URL: dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T6858A22222806.en. [downloaded on 15 July 2021].

Bennett D. & Richard F. J., 2021: Distribution modelling of the garden dormouse *Eliomys quercinus* (Linnaeus, 1766) with novel climate change indicators. *Mammalian Biology*, **101**: 589–599.

Bertolino S., 2017: Distribution and status of the declining garden dormouse *Eliomys quercinus. Mammal Review*, **47**: 133–147.

Bertolino S., Amori G., Henttonen H., Zagorodnyuk I., Zima J., Juškaitis R., Meinig H. & Kryštufek B., 2008: *Eliomys quercinus*. *The IUCN Red List of Threatened Species 2008*: *e.T7618A12835766*. URL: dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T7618A12835766.en. [downloaded on 9 September 2022].

Büchner S., Trout R. & Adamík P., 2018: Conflicts with *Glis glis* and *Eliomys quercinus* in households: a practical guideline for sufferers (Rodentia: Gliridae). *Lynx*, *n. s*., **49**: 19–26.

Downs N. C., Dean M., Wells D. & Wouters A., 2020: Displacing and translocating hazel dormice (*Muscardinus avellanarius*) as road development mitigation measures. *Mammal Communications*, **6**: 1–9.

Grevé K., 1909: *Säugetiere Kur-Liv-Estlands*. *Ein Beitrag zur Heimatskunde*. W. Mellin u. Co, Riga, 183 pp.

Grigor′ev E.V., 2017: Orešnikovaâ sonâ *Muscardinus avellanarius* v Novorževskom rajone Pskovskoj oblasti [The hazel dormouse *Muscardinus avellanarius* in the Novorževskij District of the Pskov Province]. *Russkij Ornitologičeskij Žurnal*, **26**(1471): 2928–2932 (in Russian).

Gričik V. V., 2015a: Sadovaâ sonâ *Eliomys quercinus* [The garden dormouse *Eliomys quercinus*]. Pp. 14–15. In: Kačanovskij I. M. (ed.): *Krasnaâ Kniga Respubliki Belarus'. Životnye*: *redkie i nahodâšiesâ pod ugrozoj isčeznoveniâ vidy dikih životnyh* [*The Red Book of the Republic of Belarus*: *Animals: Rare and Endangered Species of Wild Animals*]. Belaruskaâ Encyklopediâ, Minsk, 320 pp (in Russian).

Gričik V. V., 2015b: Orešnikovaâ sonâ *Muscardinus avellanarius* [The hazel dormouse *Muscardinus avellanarius*]. Pp.: 12–13. In: In: Kačanovskij I. M. (ed.): *Krasnaâ Kniga Respubliki Belarus'. Životnye*: *redkie i nahodâšiesâ pod ugrozoj isčeznoveniâ vidy dikih životnyh* [*The Red Book of the Republic of*

Belarus: *Animals: Rare and Endangered Species of Wild Animals*]. Belaruskaâ Encyklopediâ, Minsk, 320 pp (in Russian).
Gurkov N., 2023a: Sadovaâ sonâ *Eliomys quercinus* [The garden dormouse *Eliomys quercinus*]. In: *Fauna Belarusi. Pozvonočnye* [*Fauna of Belarus. Vertebrates*]. URL: gurkov2n.jimdofree.com (in Russian).
Gurkov N., 2023b: Orešnikovaâ sonâ *Muscardinus avellanarius* [The hazel dormouse (*Muscardinus avellanarius)*]. In: *Fauna Belarusi. Pozvonočnye* [*Fauna of Belarus. Vertebrates*]. URL: gurkov2n.jimdofree.com (in Russian).
Gurkov N., 2023c: Sonâ lesnaâ *Dryomys nitedula* [The forest dormouse *Dryomys nitedula*]. In: *Fauna Belarusi. Pozvonočnye* [*Fauna of Belarus. Vertebrates*]. URL: gurkov2n.jimdofree.com (in Russian).
Fetisov S. A., 2008: Gibel′ ptic ot domašnih košek v Sebežskom nacional′nom parke [Death of birds from domestic cats in the Sebežskij National Park]. *Russkij Ornitologicheskij Žurnal*, **17**(407): 429–436 (in Russian).
Fetisov S. A. & Smorkačeva A. B., 2002: Lesnaâ sonâ (*Dryomys nitedula*) – novyj vid Pskovskoj oblasti i nacional′nogo parka "Sebežskij" [The forest dormouse *Dryomys nitedula* – new species for the Pskov Province and the Sebežskij National Park]. Pp. 114–115. In Anonymous (ed.): *RIO+10*: *ohrana okružaûŝej sredy*, *prirodopol'zovanie*, *obrazovanie. Materialy Pskovskoj oblastnoj ekologičeskoj konferencii. Vypusk 7* [*RIO+10*: *Environmental Conservation*, *Nature Management*, *Education. Proceedings of the Pskov Regional Environmental Conference. Issue 7*]. Velikolukskaâ gosudarstvennaâ sel′skohozâjstvennaâ akademiâ, Velikie Luki (in Russian).
Höcker L., Weiss K. & Dietz M., 2022: Protecting local populations of hazel dormice (*Muscardinus avellanarius*) by translocation: a long-term case study from North Rhine-Westphalia (Germany). In: Morris P., Nedyalkov N., Miteva S., Juškaitis R., Kryštufek B., Adamík P., Bertolino S., Fietz J., Büchner S. & Mouton A. (eds.): *ARPHA Conference Abstracts 5*: *e85236*. URL: doi.org/10.3897/aca.5.e85236.
Ikauniece S., 2017a: History of use and protection of forest habitats in Latvia. Pp. 21–26. In: Ikauniece S. (ed.): *Protected Habitat Management Guidelines for Latvia*. *Volume 6. Forests.* Nature Conservation Agency, Sigulda, 175 pp.
Ikauniece S., 2017b: 9160 Sub-atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion Betuli*. Pp. 114−128. In: Ikauniece S. (ed.): *Protected Habitat Management Guidelines for Latvia. Volume 6. Forests*. Nature Conservation Agency, Sigulda, 175 pp.
Istomin A.V., Musatov V. Û. & Možžina T. E. (eds.), 2014: *Krasnaâ kniga Pskovskoj oblasti* [*Red Data Book of Pskov Province*]. Izdatel′stvo Pskovskij gosudarstvennyj universitet, Pskov, 481 pp (in Russian).
IUCN, 2012a: *IUCN Red List Categories and Criteria*: *Version 3.1. Second Edition*. International Union for Nature Conservation, Gland & Cambridge, iv+32 pp.
IUCN, 2012b: *Guidelines for Application of IUCN Red List Criteria at Regional and National Levels*: *Version 4.0.* International Union for Nature Conservation, Gland & Cambridge, 41 pp.
IUCN SPC [IUCN Standards and Petitions Committee], 2022: *Guidelines for Using the IUCN Red List Categories and Criteria. Version 15.1. Prepared by the Standards and Petitions Committee*. International Union for Nature Conservation, Gland & Cambridge. URL: www.iucnredlist.org/documents/RedListGuidelines.pdf.
Jaik K., 2014: *Pähklinäpi* (*Muscardinus avellanarius*) *elupaigakasutus levila põhjapiiril*: *liigi esinemise tõenäosus Eestis* [*Habitat Use of the Hazel Dormouse* (*Muscardinus avellanarius*) *at the Northern Limits of its Distributional Range*: *Probability of Presence in Estonia*]. Unpubl. MSc. thesis. Tartu Ülikool, Tartu, 51 pp (in Estonian, with a summary in English).
Juškaitis R., 1992: Rasprostranenie i čislennost′ son′ (Gliridae) v Litve [The distribution and abundance of the dormice (Gliridae) in Lithuania]. Pp. 63–69. In: Kirk A., Miljutin A. & Randveer T. (ed.): *Materialy pervoj Baltijskoj teriologičeskoj konferencii* [*Tartu ülikooli toimetised*. *Proceedings of the First Baltic Theriological Conference*]. Tartu ülikooli toimetised, Tartu, 255 pp (in Russian, with a summary in English).
Juškaitis R., 2003: New data on distribution, habitats and abundance of dormice (Gliridae) in Lithuania. *Acta Zoologica Academiae Scientiarum Hungaricae*, **49**(Supplement 1): 55–62.

Juškaitis R., 2008: *The Common Dormouse Muscardinus avellanarius*: *Ecology*, *Population Structure and Dynamics*. Institute of Ecology of Vilnius University Publishers, Vilnius, 163 pp.
Juškaitis R., 2015: Ecology of the forest dormouse *Dryomys nitedula* (Pallas 1778) on the north-western edge of its distributional range. *Mammalia*, **79**: 33–41.
Juškaitis R., 2018: Dormouse (Gliridae) status in Lithuania and surrounding countries: a review. *Folia Zoologica*, **67**: 64–68.
Juškaitis R., 2020: Hazel dormice (*Muscardinus avellanarius*) in a regenerating clearing: the effects of clear-felling and regrowth thinning on long-term abundance dynamics. *European Journal of Wildlife Research*, **66**(4): 48.
Juškaitis R., 2021: Miškinė miegapelė *Dryomys nitedula* (Pallas, 1778) [The forest dormouse *Dryomys nitedula* (Pallas 1778)]. P. 300. In: Rašomavičius V. (ed.): *Lietuvos raudonoji knyga. Gyvūnai*, *augalai*, *grybai* [*Red Data Book of Lithuania. Animals*, *Plants*, *Fungi*]. Aplinkos ministerija, Vilnius, 684 pp (in Lithuanian, with a summary in English).
Juškaitis R., Balčiauskas L., Baltrūnaitė L. & Augutė V., 2015: Dormouse (Gliridae) populations on the northern periphery of their distributional ranges: a review. *Folia Zoologica*, **64**: 302–309.
Kačanovskij I. M. (ed.), 2015: *Krasnaâ Kniga Respubliki Belarus'. Životnye*: *redkie i nahodâšiesâ pod ugrozoj isčeznoveniâ vidy dikih životnyh* [*The Red Book of the Republic of Belarus*: *Animals: Rare and Endangered Species of Wild Animals*]. Belaruskaâ Encyklopediâ, Minsk, 320 pp (in Russian).
Kasparsons Ģ., 1970: Meža susura (*Dryomys nitedula* Pallas) atradums Latvijā [A record of the wood-dormouse (*Dryomys nitedula* Pallas) in Latvia]. *LVU Zooloģijas Muzeja Raksti*, **5**: 61–63 (in Latvian, with a summary in English).
Lārmanis V., 2017: 6530* Fennoscandian wooded meadows, 9070 Fennoscandian wooded pastures and 5130 Juniperus communis formations on heaths or calcareous grasslands. Pp. 228–272. In: Rūsiņa S. (ed.): *Protected Habitat Management Guidelines for Latvia. Volume 3. Semi-natural Grasslands.* Nature Conservation Agency, Sigulda, 449 pp.
Markova A. K., Simakova A. N. & Puzachenko A. Y., 2003: Ecosystems of eastern Europe at the Atlantic optimum of the Holocene based on floristic and theriological data. *Doklady Earth Sciences*, **391A**: 883–887.
Mitchell-Jones A. J., Amori G., Bogdanowicz W., Kryštufek B., Reijnders P. J. H., Spitzenberger F., Stubbe M., Thissen J. M. B., Vohralík V. & Zima J., 1999: *The Atlas of European Mammals*. Academic Press, London, 484 pp.
Motuzko A. N. & Ivanov D. L., 1996: Holocene micromammal complexes of Belarus: A model of faunal development during Interglacial epochs. *Acta Zoologica Cracoviensia*, **39**: 381–386.
Pilāts V., 2000: Mazais susuris *Muscardinus avellanarius* (Linnaeus, 1758) [The hazel dormouse *Muscardinus avellanarius* (Linnaeus, 1758)]. Pp. 232–233. In: Andrušaitis G. (ed): *Red Data Book of Latvia. Rare and Threatened Species of Plants and Animals. Volume 6. Birds and Mammals*. Institute of Biology, University of Latvia, Rīga, 274 pp (in Latvian and English).
Pilāts V., 2021: *Meža susura Dryomys nitedula monitorings. Atskaite par 2020. gadu.* [*Monitoring of the forest dormouse Dryomys nitedula. Report for the year 2020*]. Dabas aizsardzības pārvalde, Sigulda. URL: www.daba.gov.lv/lv/biologiskas-daudzveidibas-parskati (in Latvian).
Pilāts V. & Pilāte D., 2022: Monitoring of the hazel dormouse in Latvia: concept, options and limitations. Pp. 52–54. In: Ludwig M., Sutcliffe L., Büchner S. (eds.): *BfN-Skripten 621 – Monitoring of the Hazel Dormouse Under the EU Habitats Directive in Member States Around the Baltic Sea.* Federal Agency for Nature Conservation, Bonn, 73 pp.
Pilāts V., Pilāte D. & Dzalba I., 2009: The use of nest boxes to survey marginally distributed Fat dormouse *Glis glis* in Latvia. *Acta Universitatis Latviensis*, **753**: 7–18.
Pilāts V., Pilāte D., Ornicāns A. & Kārkliņš A., 2012: Microhabitat utilization by forest dormice (*Dryomys nitedula*) in boreo-nemoral forest- preliminary results. *Peckiana*, **8**: 77–85.
Pucek Z., 2001: *Dryomys nitedula* (Pallas, 1778). Koszatka. Forest dormouse. Pp. 77–79. In: Głowaciński Z. (ed.): *Polska czerwona księga zwierząt. Kręgowce* [*Polish Red Data Book of Animals. Vertebrates*]. Państwowe Wydawnictwo Rolnicze i Leśne, Warszawa, 452 pp (in Polish, with a summary in English).

Rašomavičius V. (ed.), 2021: *Lietuvos raudonoji knyga. Gyvūnai, augalai, grybai* [*Red Data Book of Lithuania. Animals*, *Plants*, *Fungi*]. Aplinkos ministerija, Vilnius, 684 pp (in Lithuanian, with an explanatory part in English).

Samockaâ V. V., 2017: Orešnikovaâ sonâ [Hazel dormouse]. *Elementy.* URL: elementy.ru/kartinka_dnya/353/Oreshnikovaya sonya (in Russian).

Štrauss U., 1959: Orešnikovaâ sonâ (*Muscardinus avellanarius* L.) v Latvijskoj SSR [The hazel dormouse (*Muscardinus avellanarius* L.) in the Latvian SSR. Pp. 233–236. In: Lūsis J. J. (ed): *Fauna Latvijskoj SSR i sopredel'nyh territorij. Tom 2.* [*Fauna of the Latvian SSR and Adjacent Territories. Volume 2.*]. Izdatel′stvo Akademii nauk Latvijskoj SSR, Riga (in Russian, with a summary in German).

Tauriņš E., 1982: *Latvijas zīdītājdzivnieki* [*Latvian Mammals*]. Zinātne, Rīga, 255 pp (in Latvian).

Valdis P. [Pilāts V.], 2003: The fat dormouse (*Glis glis*) in Gauja National Park – the most northern locality within the species' distribution range? *Acta Zoologica Academiae Scientiarum Hungaricae*, **49**(Supplement 1): 131–137.

Vekhnik V. A., Ruf T. & Bieber C., 2022: A review on the edible dormouse reproduction (*Glis glis* Linnaeus, 1766). *Journal of Wildlife and Biodiversity*, **6** (Special Issue): 24–45.

Vilks K., 1939: Putnu perēkļu postījumi [Damage to bird nests]. *Daba un Zinātne*, **1**: 51–54 (in Latvian).

Ūdris E., 1940: Manas meža pūces [My tawny owls]. *Latvijas Jaunatne*, **8**(164): 285–286 (in Latvian).