

Review

Do We Look for the Right Ones? An Overview of Research Priorities and Conservation Status of Dormice (Gliridae) in Central Europe

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Abstract: There are differences regarding distribution, conservation status and protection according to national and European laws and directives between the four dormouse species (Gliridae) native to Central Europe. We question the coherence between scientific knowledge and conservation status of dormice in Europe and hypothesize that the species included in the Habitats Directive have been the subject of considerable research, while those not included have been neglected, despite having an unfavourable conservation status. We did a review of the research presented at the International Conferences on Dormice from 1990–2017 and published in the scientific literature since 1950 to see for which species the most research was done and whether the Habitats Directive had an impact. The number of presentations increased over time for the Hazel (*Muscardinus avellanarius*, N = 200) and the Edible dormouse (*Glis glis*, N = 150), while those on the Garden dormouse (*Eliomys quercinus*, N = 46) decreased until 2014 with an apparent increase only in 2017; the Forest dormouse (*Dryomys nitedula*, N = 67) does not show any trends. The number of published articles increased for all species except for the Garden dormouse. This focus does not adequately address the current threats of the species. The results can serve as a guide for the re-evaluation of future research priorities and conservation strategies as well as the implementation of new monitoring projects and ecological studies.

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1. Introduction

Increasingly more species are becoming threatened by extinction worldwide [1]. Scientific research may help develop effective conservation measures by providing accurate knowledge about species' biology and ecology and identifying main threats to biodiversity. It could also attract society's attention, generating support for conservation projects and mobilization of resources [2]. However, research may not be directed towards priority species that need the most attention.

In the European Union (EU), the main legislation on species conservation is the Habitats Directive (92/43/CEE). The obligation for Member States to regularly report to the European Commission on the status of species listed in the directive implies the allocation of resources for monitoring. Moreover, species listed in the Habitats Directive are consid-

ered a priority for conservation at the European level. Therefore, it is easier to obtain funding for their research. This can lead to an increase in knowledge about these species, but at the same time neglect many other species that are more at risk of extinction.

Small mammal species are often neglected in conservation biology, and only a few of them are protected by national and European laws and directives [3]. This also depends on the limited knowledge we have for many of them. For instance, during the first IUCN European Mammal Assessment, information on population trends was unavailable for one-third of the species [4].

Here we question the coherence between scientific knowledge and conservation status of a little-known group of terrestrial small mammals, the dormice (Gliridae) in Europe. We did a literature review to see for which species the most research was done and if the Habitats Directive had any effect. We hypothesise that the dormouse species included in the Directive have been the subject of considerable research, while those not included have been neglected, despite having an unfavourable conservation status.

2. Materials and Methods

Four dormouse species are native to Central Europe: the Hazel dormouse *Muscardinus avellanarius*, the Edible dormouse *Glis glis*, the Forest dormouse *Dryomys nitedula* and the Garden dormouse *Eliomys quercinus*. A fifth species, Roach's mouse-tailed dormouse *Myomimus roachi*, occurs on the southwestern edge of Europe in SE-Bulgaria and Turkish Thrace, which has been subject to only a very few studies yet and will therefore not be considered in this review (Table S1). Between the four Central European species there are differences regarding distribution, conservation status and protection according to European legislation and directives (Table 1).

Table 1. Current legal status and range of the dormouse species native to Central Europe (data from [5–8]). * A 'Vulnerable' status was suggested in the red list update, but the assessment is still under evaluation; ** [9]; *** [10].

| Species | Range Size | Bern Convention ¹ | Annex of Habitats Directive ¹ | IUCN Red List Status ² | Population Trend | Countries Where the Species Is Extinct or Nearly Extinct |
|------------------------|-----------------------------|------------------------------|------------------------------------------|-----------------------------------|------------------|--------------------------------------------------------------------------|
| <i>M. avellanarius</i> | 3.7 Million km ² | III | IV | LC | unknown | - |
| <i>G. glis</i> | 3.9 Million km ² | III | - | LC | unknown | - |
| <i>D. nitedula</i> | 7.5 Million km ² | III | IV | LC | unknown | Germany ** |
| <i>E. quercinus</i> | 2.4 Million km ² | III | - | NT * | decreasing | Lithuania, Finland, Slovakia, Belarus, Poland, Slovenia, Netherlands *** |

¹ Roman numerals indicate the number of annexes in which the species are reported in the Bern Convention of the Habitat Directive. ² LC = Least Concern; NT = Near Threatened.

Except for the Forest dormouse whose distribution extends from south-eastern Europe to central Asia, the range of the other species is restricted to Central and Western Europe where the Garden dormouse has the smallest range size compared to the other species (Table 1). The range of the Garden dormouse has dramatically declined in recent years and is therefore even smaller than currently indicated by the IUCN [10]. For this reason, [10] proposed to upgrade the IUCN status from "Near Threatened" to "Vulnerable". The other species are of "Least Concern" from a global perspective although they

can be rare on a local scale and are therefore listed as endangered species in several countries (e.g., Lithuania: [11]; United Kingdom: [12]; Poland: [13]; Belgium: [14,15]; Denmark: [16]).

We performed a review of scientific papers, retrieved from the Web of Science (WoS) database, concerning four species of dormice and published from 1950 to 2021. The search was conducted using the species scientific and common names. The first reporting period of systematic surveys of Habitats Directive-listed species began in 2001. To see if the listing of a species had an impact on research effort, we compared the number of published papers before and after 2001. We also reviewed abstract books and proceedings of the International Conferences on Dormice (IDC) organized in Europe every three years from 1990–2017, considering oral presentations and posters on the four species to find temporal trends in scientific engagement with the species. Studies on multiple species have been counted for each species.

3. Results

We extracted 758 articles from WoS (Figure 1) and 399 presentations from IDCs abstract books and proceedings (Figure 2). A total of 278 articles retrieved from WoS regarded the Edible dormouse, 234 the Garden dormouse, 185 the Hazel dormouse and 61 the Forest dormouse (see Table S1 for details on temporal trends). Articles published in the scientific literature on dormice were mainly on physiology (34%) of Edible and Garden dormice, and ecology (43%) of all species (Table 2). The number of published articles increased from 1950–2000 to 2001–2017 for all species (Hazel dormouse +143%, Edible dormouse +78%, Forest dormouse +671%) except for the Garden dormouse (−51%). The percentage increase was exceptionally high for the Forest dormouse, though the number of articles published before 2001 was low ($n = 7$).

Studies presented at the IDC concerned the Hazel dormouse in 200 cases (Mean \pm SD = 22.2 ± 9.0), followed by Edible ($N = 150$, Mean = 16.7 ± 5.9), Forest ($N = 67$, Mean 7.4 ± 4.2), and Garden ($N = 46$, Mean = 5.1 ± 2.8) dormouse (Table S2). The number of presentations increased over time for the Hazel (linear curve, $R^2 = 0.83$, $p < 0.01$) and the Edible (exponential, $R^2 = 0.71$, $p < 0.05$) dormouse, while those on the Garden dormouse decreased until 2014 (logistic, $R^2 = 0.72$, $p < 0.05$) with an apparent increase only in 2017 (Figure 2); the Forest dormouse does not show any trends.

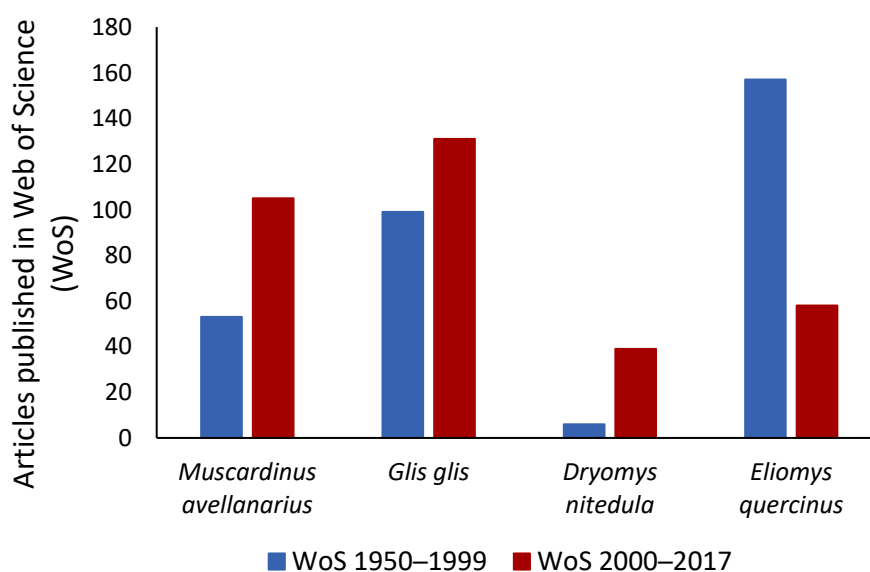


Figure 1. The number of articles on Central European dormouse species published in the scientific literature between 1950 and 2021 and divided before and after 2000 (Source: Web of Science 1950–2021).

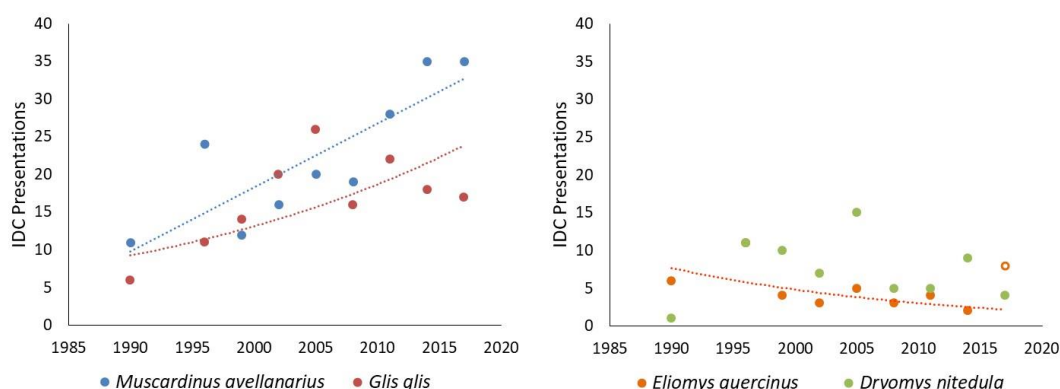


Figure 2. Presentations at International Conferences on Dormice (IDC) about Central European dormouse species from 1999 to 2017 (Source: abstract books and proceedings of the IDC. Dashed lines indicate significant regression lines; the regression line for *E. quercinus* is built excluding 2017).

Table 2. Number of articles on Central European dormice species according to research topics, 1950–2021, retrieved from Web of Science.

| Species | Genetics | Monitoring/ Management | Ecology | Physiology | Other | Total |
|------------------------|----------|---------------------------|---------|------------|-------|-------|
| <i>M. avellanarius</i> | 15 | 23 | 112 | 33 | 2 | 185 |
| <i>G. glis</i> | 27 | 7 | 107 | 113 | 6 | 278 |
| <i>D. nitedula</i> | 15 | 3 | 37 | 4 | 2 | 61 |
| <i>E. quercinus</i> | 17 | 5 | 68 | 143 | 1 | 234 |

4. Discussion

Evidence-based knowledge is crucial for the delineation and success of conservation actions. However, despite limited research resources, research efforts are often not aligned with conservation priorities [17]. In this review, we found a mismatch between research priorities and the conservation status of dormice in Central Europe. The majority of published studies have only examined two species, the Hazel and the Edible dormouse, while the ecology of the Forest dormouse and the Garden dormouse has rarely been studied. This is especially true for the relations between habitats and ecology of the species, as a recently published review shows [18]. On the other hand, Garden and Edible dormice were of special interest for physiologists as they are easy to breed in captivity and therefore became a standard model for research on hibernation.

The Hazel and the Forest dormouse are listed in Annex IV of the Habitats directive while the other two species are not. Comparing the research effort for the Hazel and the Garden dormouse, it is clear that the Habitats Directive has led to most research being focused on the listed species. The inclusion of the Hazel dormouse in the Habitats Directive has meant that the species must be monitored regularly, and conservation measures taken when necessary. As a result, the species has been the subject of much research to provide data for effective conservation. This increase has been confirmed by articles listed in the WoS as well as presentations at IDCs. The public also became more aware of the species. Among the results achieved during this process are two monographs on the species covering every aspect of its biology and ecology [19,20].

The increase in research papers on the Hazel dormouse due to the monitoring obligation connected with this listing is not yet seen in the Forest dormouse. One reason for

this could be that the main distribution area of the Forest dormouse is in the eastern member states of the EU. These so-called new member states have fewer resources than western countries and started later with collecting data for reporting under Article 17 of the Habitats Directive. Therefore, no effect on research on this species has been seen so far.

The Garden dormouse is one of the European mammals that has lost the largest proportion of its range in recent decades, becoming extinct or nearly so in at least seven countries without an apparent reason [10]. Therefore, there is an urgent need to deepen the knowledge on its distribution and ecology in order to take effective conservation measures. Despite this urgency, it is the only species where research efforts are declining. The number of research papers published on this species after 2000 has more than halved compared to the previous period, and the number of presentations at IDCs has also declined, with only the last conference showing an increase.

The exclusion of the Garden dormouse from protection under the Habitats Directive (1992) seems inexplicable. Considering the sharp decline of Garden dormouse populations in recent decades and the fact that no significant economic harm can be attributed to this species, its listing in the Habitats Directive, if reviewed, seems necessary and justified [10]. The lack of conservation status under the Habitats Directive (1992) means that there is no obligation for member states of the EU to monitor the range and population trends. As expected, we found no governmental monitoring programme for Garden dormice in Europe.

Given the large number of threatened species not covered by the Habitats Directive, halting biodiversity loss in the EU requires moving beyond the fixed lists that currently guide conservation efforts to better protect species at risk of extinction [21,22]. Consequently, the Garden dormouse was listed as a species for which Germany carries a high degree of responsibility for its future conservation as this country covers more than 10 % of the species' range [23–25]. This is not the case for many other member states. This responsibility is not legally binding but a voluntary measure to be implemented. One example could be the consideration of the species in action plans in Natura 2000 areas [22]. Currently, the basis for appropriate conservation measures seems to be scarce. To ensure that conservation problems can be identified, the implementation of specific monitoring projects, ecological research and public involvement in conservation efforts is needed. The main topics for studies on the Garden dormouse are the same that Morris [23] suggested during the first IDC back in 1990: distribution and habitats, population structure and dynamics, reproduction and lifestyle, movement and foraging. To overcome national shortcomings in mammal conservation [24], international cooperation could be helpful [25,26].

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su14159327/s1>, Table S1: Articles published in the scientific literature on European dormouse species (Source: Web of Science 1950–2021); Table S2: Studies presented at the International Conferences on Dormice (IDC) from 1990 to 2017 on European dormouse species (Source: abstract books and proceedings of the IDC).

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