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Data Paper

# Small rodent monitoring at Birkebeiner Road, Norway

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## Abstract

### Background

Northern small mammal populations are renowned for their multi-annual population cycles. Population cycles are multi-faceted and have extensive impacts on the rest of the ecosystem. In 2011, we started a student-based research activity to monitor the variation of small rodent density along an elevation gradient following the Birkebeiner Road, in southeast Norway. Fieldwork was conducted by staff and students at the University campus Evenstad, Inland Norway University of Applied Sciences, which has a long history of researching cyclic population dynamics. The faculty has a strong focus on engaging students in all parts of the research activities, including data collection. Small rodents were monitored using a set of snap trap stations. Trapped animals were measured (e.g. body mass, body length, sex) and dissected to assess their reproductive status. We also characterised the vegetation at trapping sites.

## New information

We provide a dataset of small rodent observations that show fluctuating population dynamics across an elevation gradient (300 m to 1,100 m a.s.l) and in contrasting habitats. This dataset encompasses three peaks of the typical 3-4-year vole population cycles; the number of small rodents and shrews captured show synchrony and peaked in years 2014, 2017 and 2021. The bank vole *Myodes glareolus* was by far (87%) the most common species trapped, but also other species were observed (including shrews). We provide digital data collection forms and highlight the importance of long-term data collection.

## Keywords

arvicolinae, vole, shrews, trapping, occurrence, database, dissection

## Introduction

Voles and lemmings in boreal, alpine and arctic ecosystems are renowned for their multi-annual population cycles (Elton 1924, Hansson and Henttonen 1985, Kendall et al. 1999). The fluctuating population dynamics amplify the population's integral roles in the ecosystem food web (Boonstra et al. 2016) as vectors of diseases, prey and plant consumers Nystuen et al. 2014, Magnusson et al. 2015, Kouba et al. 2021. Many decades of studies on population cycles have brought insights into the complexity of mechanisms involved in the dynamics and ecology of populations (Stenseth 1999, Myers 2018, Oli 2019 ). However, many questions remain to understand the generality of small rodent population dynamics (Andreassen et al. 2021).

The focus of this study is the understanding and exploration of the population dynamics of arvicoline rodent species, particularly the field vole *Microtus agrestis* (Linnaeus, 1761) and the bank vole *Myodes glareolus* (Schreber, 1780), which are amongst the most widespread and abundant mammals in the European boreal biome. Moreover, the ongoing changes in climate and biodiversity, particularly warmer winters, are expected to affect these population dynamics and, consequently, the role these small rodents play in the ecosystem (Cornulier et al. 2013). In general, long-term studies are much needed to understand such effects; especially when controlling for phase dependence in multi-annual cycles. Here, we contribute to the research on population dynamics and the intricate mechanisms involved, by providing a dataset that encompasses three population cycle peaks. We include data on small mammal occurrences, physiological measures on captures and habitat descriptions.

## General description

**Purpose:** Assessing changes can only be observed by comparing the new state with a previous one. Thus, systematic long-term data collection efforts are vital to reveal changes in nature or the lack thereof. Nevertheless, due to long-term data's innate high degree of replication, the credibility and usefulness of such time series are high in research, management and policy (Clutton-Brock and Sheldon 2010, Magurran et al. 2010). Ironically, as the need for long-term time series increases, the persistence of established long-term studies is weakened and the establishment of new ones is rare (Hughes et al. 2017).

Evenstad is located in the southeast of Norway and is a campus at Inland Norway University of Applied Sciences. Evenstad has a long history in ecological investigations (e.g. Mathisen et al. (2012), Neby et al. (2021)), including researching population dynamics (e.g. Pedersen et al. (2011), Johnsen et al. (2017)). Furthermore, the faculty has a strong focus on engaging students in all parts of the research activities, including research data collection. In 2011, we started a student-based research activity to monitor small rodent populations. After more than ten years, the time series is still young in terms of observing cyclic phenomena. Nonetheless, the data include three high-density periods (i.e. peaks). We hope this paper will motivate long-term maintenance of the time series and facilitate data and knowledge sharing.

## Project description

**Title:** Birkebeinervegen monitoring (alias Birkebeinervegen rodent trapping).

**Personnel: Personnel**: Over different years, the co-authors have led the sampling in the field and/or lab, with a yearly turnover of student participation.

**Study area description**: The study area is located in the southeast of Norway, in Innlandet Municipality (61°N, 11°E, Fig. 1). Here, arvicoline small rodents are known to exhibit cyclic population dynamics (Andreassen et al. 2020, Sonerud 2022) and the area is characterised by a semi-humid and continental climate. The study area is situated across an elevation gradient following the east-west orientated Birkebeiner Road with gradients in temperature, precipitation and vegetation (Table 1). The area is dominated by mixed coniferous forests with Norway spruce *Picea albies* and Scots pine *Pinus sylvestris* at low altitudes and more open areas with mountain birch *Betula pubescens* at higher elevations. The understoreys are dominated by dwarf shrubs, such as the bilberry *Vaccinium myrtillus* in the low elevations and lichens and grasses higher up.

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## Sampling methods

**Description: Study design**: The Birkebeiner Road connects the two large valleys Gudbrandsdalen and Østerdalen from east to west over approximately 60 km (40 km straight line distance). The locations for the trapping stations were selected to obtain 100 m a.s.l. intervals between each station ranging from 300 m to 1,100 m a.s.l. (Fig. 1). This resulted in stations being between 0.5 and 4 km apart. This minimised the chances of trapping stations overlapping home ranges of small rodents.

Table 1.

Weather statistics in representative locations to the trapping transect area (MET Norway, 2022).

| | **Western endpoint** | **High elevation point** | **Eastern endpoint** |
|---|---|---|---|
| Elevation (m a.s.l.) | 500 | 1100 | 300 |
| Weather station name | Lillehammer - Nordsetervegen | Sjusjøen - Storåsen | Evenstad |
| - Elevation (m a.s.l.) | 562 | 930 | 255 |
| - Temperature ($^0$C) | 4.2 | 2.1 | 4.0 |
| - Mean daily precipitation (mm) | 2.3 | 2.9 | NA |

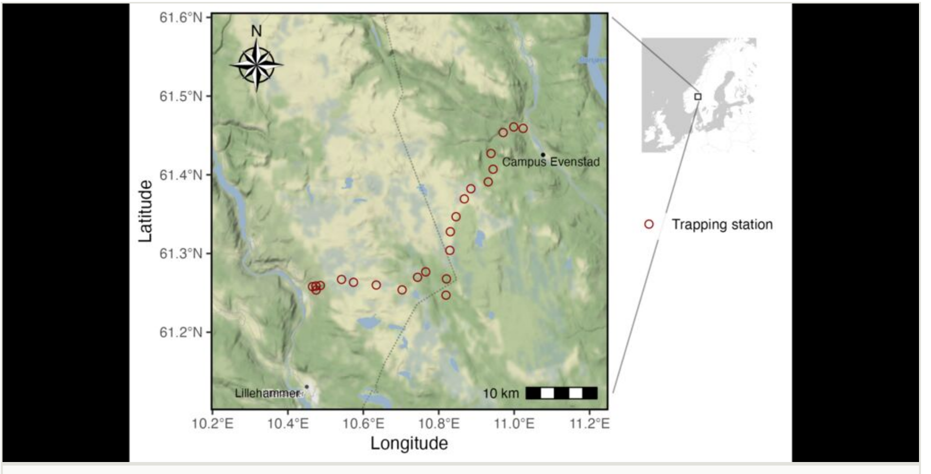


Figure 1. doi

Study area and the 23 trapping station locations (red circles) situated along the Birkebeiner Road. Each station contains a transect of 10 traps with fixed locations. The vegetation descriptions were taken close to the traps. The captures were further described and dissected at the University campus Evenstad (marked with a black dot).

In the initial setup for each trapping station, starting 10 m from the road, 10 metal snap traps (numbered 1-10, with trap 1 being closest to the road) were placed systematically 10 m apart along a transect at a right angle from the road. These trap locations were registered using handheld GPS devices (ca. 5 m accuracy), marked with coloured ribbons that were left out all year and their coordinates were reused the following years. The traps were placed in the understorey at the exact GPS location, however, slightly adjusted from 2022, when the traps were placed in the understorey in the most suitable location (i.e. close to holes, rock boulders, tree roots etc.) within one metre from the GPS location in order to maximise catches within the microsite.

**Small mammal data**: The trapping sessions consisted of five days of fieldwork. The trapping session was started by activating and baiting the traps with pieces of carrots mixed with peanut butter during the first morning. The three following mornings, all traps were checked and, if necessary, re-baited and/or re-activated. During these procedures, the trap's status was noted (e.g. animal captured, broken trap etc., see a complete set of variables and definitions in the Data Resources section below in the DynamicProperties description in the Event dataset) and trapped animals were collected. On the last day of the session, traps were monitored as usual and retrieved from the field.

We carried out trapping sessions in autumn from years 2011 onwards and also in spring during the years 2011–2015. This translates into a total effort of 690 trap-nights per trapping session (see details in Table 2) with large inter-annual variation in the number of caught animals (Fig. 2, Table 2) and with the bank vole (*Myodes glareolus*) as the most common catch (87%).

Table 2.

Trapping history with number of total captures during trapping season. When we were unable to find a trap or it was broken, these were subtracted from the default number of 690 trap nights (i.e. default 230 traps over three nights).

| Year | Month | *Apodemus flavicollis* | *Apodemus sylvaticus* | *Lemmus lemmus* | *Microtus agrestis* | *Microtus oeconomus* | *Microtus* sp. | *Myodes glareolus* | *Myodes rufocanus* | *Myopus schisticolor* | *Sorex* sp. | Unidentified | Total captures | Number of trap nights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2011** | June | 1 | - | 2 | 1 | 1 | - | 33 | - | 1 | - | - | 39 | 690 |
| **2011** | September | - | - | - | - | - | - | 38 | 6 | - | 2 | - | 46 | 689 |
| **2012** | June | 1 | - | - | - | - | - | 11 | 1 | - | 2 | - | 15 | 690 |
| **2012** | September | 1 | 1 | - | - | - | - | 42 | 2 | - | 9 | - | 55 | 690 |
| **2013** | June | - | - | - | 4 | - | - | 21 | 1 | - | 1 | 1 | 28 | 689 |
| **2013** | September | - | 1 | - | 12 | - | - | 166 | - | - | 3 | 3 | 185 | 686 |
| **2014** | June | - | - | 2 | 20 | 1 | - | 92 | - | 1 | - | 4 | 120 | 688 |
| **2014** | September | - | - | 1 | 13 | 2 | - | 186 | - | - | 8 | - | 210 | 682 |
| **2015** | June | - | - | - | - | - | - | 7 | - | - | - | - | 7 | 690 |
| **2015** | September | - | - | - | - | - | - | 11 | - | - | 1 | - | 12 | 685 |
| **2016** | September | - | - | - | 1 | - | - | 47 | - | - | 4 | - | 52 | 688 |
| **2017** | September | - | - | 1 | 9 | - | - | 184 | - | - | 2 | 1 | 197 | 639 |
| **2018** | September | - | - | - | 2 | - | - | 137 | - | - | 5 | - | 144 | 687 |
| **2019** | September | - | - | - | - | - | - | 22 | - | - | - | - | 22 | 685 |
| **2020** | September | - | 4 | - | 3 | - | - | 72 | - | - | 2 | - | 81 | 677 |
| **2021** | September | - | 2 | - | 23 | - | - | 92 | - | - | 4 | 3 | 124 | 690 |
| **2022** | October | - | - | - | - | - | 1 | 83 | 4 | - | 6 | - | 94 | 690 |

The collected animals were either brought into a laboratory immediately or frozen at -20$^{o}$C until dissection. Here, the animals were examined further including dissection for reproductive trait measures (see a complete set of variables and their description in Table 3). By using the variables eventID, occurrenceID or locationID, the datasets can be joined.

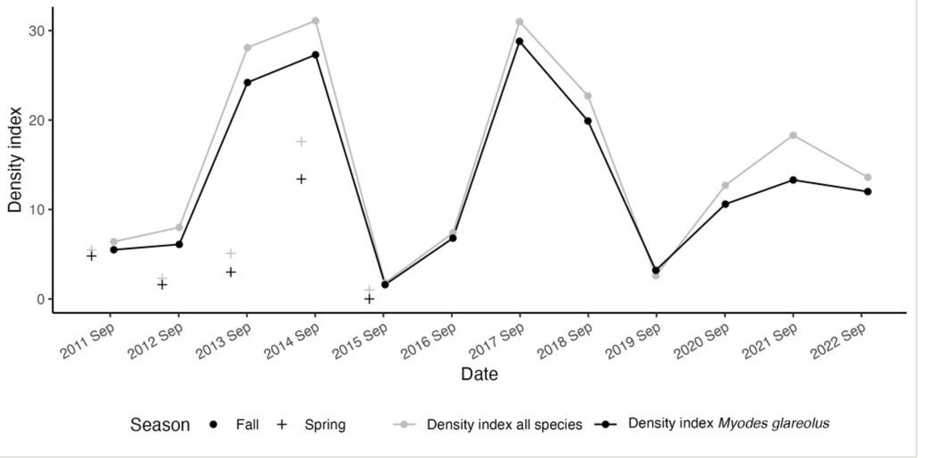


Figure 2. doi

The density index is estimated by the number of captured animals (grey) and captured bank voles *Myodes glareolus* (black) per 100 trap nights for annual autumn trappings (filled circle). The first years of trapping also included trapping during the spring season (+).

Table 3.

The animals that were trapped were further analysed in the laboratory and several variables were measured. These measures are named with the prefix "anim" in Extendedmeasurementorfact dataset.

| **Variable** | **Variable description** |
|---|---|
| MaturityOutside | An age/maturity approximation of the animal, either adult, juvenile or unidentified based on cues on the outside of the animal (Variable type: text) |
| BodyMass | The body mass of the animal is given in grams. (Variable type: numeric) |
| Tail | The length of the tail in mm (Variable type: numeric) |
| HeadWidth | The width of the head/skull in mm (Variable type: numeric) |
| BodyLength | The length of the whole body including the tail in mm (Variable type: numeric) |
| MaturityInside | Maturity approximation based on immature females having a transparent uterus and mature females having a milky-white uterus (Variable type: text) |
| LitterSize1 | Placental scars were used to estimate litter size. First litter. Number of scars from the freshest litter (darkest scars) (Variable type: integer) |
| LitterSize2 | Placental scars were used to estimate litter size. Second litter. Number of scars of the next litter back in time (Variable type: integer) |
| LitterSize3 | Placental scars were used to estimate litter size. Third litter (Variable type: integer) |

| Variable | Variable description |
|---|---|
| LitterSizeSummed | The total number of placental scars. Independent of litter (Variable type: integer) |
| EmbryoCount | Count of embryos, total (Variable type: integer) |
| EmbryoLength | Embryos were extracted from the body and measured in millimetres. Measured all and calculated<br>average (Variable type: numeric) |
| EmbryoResorption | The number of embryo resorption. Small and less developed embryos are subject to resorption<br>(Variable type: numeric) |
| TestesVisibleOutside | Visibly swollen testes on the outside prior to dissection (Present or absent) (Variable type: text) |
| TestesLength | Total length in mm of testes measured during dissection (Variable type: numeric) |
| Tubili_epididimysPresent | Tubili present in the epididymis or absent. The body next to the testes containing whitish coiled tube<br>signifies maturity in males (Variable type: text) |
| Tubili_epididimys | Length of tubuli epididymis during dissection in mm (Variable type: numeric) |
| ObserverLab | An anonymised identifier of the observer in the lab (Variable type: integer) |
| ObserverField | An anonymised identifier of the observer during fieldwork (Variable type: integer) |

**Vegetation data**: Within a five-metre radius of each trap, we monitored the vegetation by describing the dominant habitat, tree layer, bush layer and field layer. We characterised these variables according to the descriptors given in Table 4. In 2020, each station's habitat was described in further detail (Table 5), named with the prefix "ext" in the Extendedmeasurementorfact dataset.

Table 4.

Vegetation measures performed during each trapping season. Here, the nearby surroundings of each trap were described using the following fixed variables. These measures are named with the prefix "min" in the Extendedmeasurementorfact dataset.

| Dominant habitat | Dominant tree layer | Dominant shrub layer | Dominant field layer |
|---|---|---|---|
| Open | *Picea* sp. | *Picea* sp. | Bryophytes |
| Forest | *Pinus* sp. | *Pinus* sp. | Dwarf shrubs |
| Shrubs | Deciduous | Deciduous | Graminoids |
| - | *Juniperus* sp. | *Juniperus* sp. | Lichens |
| - | None | None | Herbs |
| - | - | - | Bare ground |

**Data availability**: The data are available on Dataverse (DOI: https://doi.org/10.18710/OOJYQ0) and consist of three datasets that can be joined using the variables eventID, occurrenceID or locationID. The data and R script to ease download and import (including producing Fig. 2) are available at https://gitlab.com/becodyn/birkebeiner. Updates from future monitoring will be available on these services.

Table 5.

Extended vegetation measures were performed in 2020 and 2021. Here, the nearby surroundings of each trap were described in more detail using the following fixed variables. These measures are named with the prefix "ext" in the Extended measurement or fact dataset.

| Dominant habitat type | Forest cutting class | Cutting class description | Field layer cover variables | Field layer cover alternatives |
|---|---|---|---|---|
| Forest | 0 | 0: impediment (non-productive forest) | Bilberry | absent |
| Bog | 1 | 1: fresh clearcut, ready for planting and regrowth | Cowberry | seldom < 5% |
| Shrub | 2 | 2: young forest before first thinning, trees up to 10-12 m | Other heather | frequent < 5% |
| Alpine tundra | 3 | 3: young forest in thinning stage | Grasses | 5-25% |
| - | 4 | 4: forest ready to be harvested | Herbs | 25-50% |
| - | 5 | 5: old-growth forest | Mosses | 50-75% |
| - | - | - | Lichens | 75-100% |
| - | - | - | Stones | - |
| - | - | - | Old wood | - |
| - | - | - | Bare ground | - |

**Quality control**: We used standardised field forms to note observations which were followed by import to MS Excel (2011-2019 and 2021) and with predefined digital forms using KoboCollect (https://www.kobotoolbox.org/) from 2020 and onwards (with the exception of 2021) to reduce transcribing errors. The digital forms are available as .XML in the repositories and can be imported to KoboToolbox, ODK or similar services. Permits for trapping are given by The Norwegian Ministry of Climate and Environment.

**Sources of error**: Snap trapping provides only a relative density index. There are also local sources of error that potentially affect within and between-year values, such as: 1) trapping in various weather conditions affecting trapping success, 2) trap placement in more/less risky/suitable microhabitats, 3) trap placement in general could be an issue in spatio-temporal analysis, 4) molar teeth were not always checked on *Microtus* sp., thus there may be species level uncertainty between species identified as *M. oeconomus* and *M. agrestis*.

## Geographic coverage

**Description: Description**: Birkebeiner Road, Innlandet County, Norway.

**Coordinates:** 61.460856 and 61.247073 Latitude; 11.023757 and 10.465131 Longitude.

## Taxonomic coverage

### Taxa included:

| Rank | Scientific Name | Common Name |
|---|---|---|
| kingdom | Animalia | Animal |
| phylum | Chordata | |
| subphylum | Vertebrata | |
| class | Mammalia | |
| order | Rodentia | |
| order | Eulipotyphla | |
| family | Cricetidae | |
| family | Soricidae | |
| family | Muridae | |
| subfamily | Arvicolinae | |
| genus | *Apodemus* | |
| genus | *Lemmus* | |
| genus | *Microtus* | |
| genus | *Myodes* | |
| genus | *Myopus* | |
| genus | *Sorex* | |
| species | *Apodemus flavicollis* | Yellow-necked mouse |
| species | *Apodemus sylvaticus* | Wood mouse |
| species | *Lemmus lemmus* | Norway lemming |
| species | *Microtus agrestis* | Field vole |
| species | *Microtus oeconomus* | Tundra vole |
| species | *Myodes glareolus* | Bank vole |
| species | *Myodes rufocanus* | Grey red-backed vole |
| species | *Myopus schisticolor* | Wood lemming |

## Temporal coverage

**Notes:** We monitored all trapping plots in the fall during the period from 07-06-2011 to 20-10-2022. During the years 2011-2015, we also performed a trapping session during the spring. The monitoring is planned to continue in the years ahead.

## Usage licence



## Data resources

**Data package title:** Birkebeinervegen monitoring

**Resource link:** DOI: https://doi.org/10.18710/OOJYQ0

**Alternative identifiers:** https://gitlab.com/becodyn/birkebeiner

**Number of data sets:** 3

**Data set name:** Event

**Character set:** UTF-8

**Download URL:** https://doi.org/10.18710/OOJYQ0

**Data format:** Darwin Core Archive

**Data format version:** 1.2

**Description:** A Darwin Core formatted file that describes an occurrence of an event, such as a trapping survey.

| Column label | Column description |
|---|---|
| eventID | An identifier for the set of information associated with an Event. The values consist of the trapping station and the trap number separated by a T (Trap) and the date of the event. (Variable type: text) |
| eventDate | The date which an Event occurred in the format 'YYYY-MM-DD'. (Variable type: text). |
| locationID | An identifier for the set of Location information consisting of the trap station (1-23) and trap number (1-10) separated by T (Trap). (Variable type: text). |
| verbatimCoordinates | The verbatim original spatial coordinates of the Location. (Variable type: text). |

| | |
|---|---|
| verbatimCoordinateSystem | The spatial coordinate system for the verbatimCoordinates of the Location. (Variable type: text). |
| verbatimSRS | The spatial reference system (SRS) upon which coordinates given in verbatimCoordinates are based. (Variable type: text). |
| decimalLongitude | The geographic longitude (in decimal degrees). (Variable type: numeric). |
| decimalLatitude | The geographic latitude (in decimal degrees). (Variable type: numeric). |
| coordinateUncertaintyInMeters | The horizontal distance (in metres) from the given decimalLatitude and decimalLongitude describing the smallest circle containing the whole of the Location. (Variable type: numeric). |
| geodeticDatum | The ellipsoid, geodetic datum or spatial reference system (SRS) upon which the geographic coordinates given in decimalLatitude and decimalLongitude are based. (Variable type: text). |
| dynamicProperties | A list of additional measurements, facts, characteristics or assertions about the record. The keys (i.e. TrapReleased, BaitPresent, Capture, TrapRetrieved, TrapMoved, TrapConditionOK) and values (i.e. Yes or No) are separated by colons and properties separated by commas for a data interchange format, such as JSON. (Variable type: text). |
| minimumElevationInMeters | The lower limit of the range of elevation (altitude, usually above sea level), in metres. (Variable type: text). |
| maximumElevationInMeters | The upper limit of the range of elevation (altitude, usually above sea level), in metres. (Variable type: text). |

**Data set name:** Occurrence

**Character set:** UTF-8

**Download URL:** https://doi.org/10.18710/OOJYQ0

**Data format:** Darwin Core Archive

**Data format version:** 1.2

**Description:** A Darwin Core formatted file that describes the recorded instance of an organism at a particular time and place given in event.txt file. It includes information about the taxonomy and other relevant details. Further details on the trapped animals are given in the dataset Extendedmeasurementorfact and further described in Table 3.

| Column label | Column description |
|---|---|
| eventID | An identifier for the set of information associated with an Event. (Variable type: numeric). |
| occurrenceID | An identifier for the Occurrence, here numbers in an ascending sequence from 1. (Variable type: text). |

| | |
|---|---|
| scientificName | The full scientific name, with authorship and date information, if known. Includes the name in lowest level taxonomic rank that can be determined. (Variable type: text). |
| taxonRank | The taxonomic rank of the most specific name in the scientificName. (Variable type: text). |
| sex | The sex of the biological individual(s) represented in the Occurrence. (Variable type: text). |

**Data set name:** Extendedmeasurementorfact

**Character set:** UTF-8

**Download URL:** https://doi.org/10.18710/OOJYQ0

**Data format:** Darwin Core Archive

**Data format version:** 1.2

**Description:** A Darwin Core formatted file that contains additional measurements or facts about the occurrences that are not included in the core occurrence.txt file, e.g. vegetation measurements included. The variable measurementType is further described in Tables 3, 4, 5.

| Column label | Column description |
|---|---|
| measurementID | An unique identifier for the MeasurementOrFact here numbers in an ascending sequence from 1. (Variable type: text). |
| eventID | If relevant, an identifier for the set of information associated with an Event. Join with event.txt to include additional details, such as coordinates. (Variable type: text). |
| occurrenceID | If relevant, an identifier for the Occurrence. Join with occurrence.txt to include additional details, such as body mass of a trapped animal. (Variable type: text). |
| locationID | If relevant, an identifier for the location that can be joined with event.txt. (Variable type: text). |
| measurementDeterminedDate | The date on which the MeasurementOrFact was made. (Variable type: text). |
| measurementType | The nature of the measurement, fact, characteristic or assertion. The vocabulary uses three types of prefixes: 'anim' for animal measures; and 'min' for minimum and 'ext' for extended habitat measures, the latter two separating the two methods used for describing the habitat associated with locationID. These are further described in Tables 3, 4 and 5, respectively. (Variable type: text). |
| measurementValue | The value of the measurement, fact, characteristic or assertion. Values include text and numeric values depending on the MeasurementType, see Tables 4, 5. (Variable type: text). |
| measurementUnit | The units associated with the measurementValue, for example, body mass is given in grams (g). (Variable type: text). |

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## Author contributions

BZ, HPA and SP conceived the study and designed the scientific protocol; all authors led the student-orientated fieldwork, lab work and were involved in data management processes (each in different years); MN wrote the original manuscript, prepared figures and performed data curation; all authors contributed to the final manuscript.

## References

- Andreassen HP, Johnsen K, Joncour B, Neby M, Odden M (2020) Seasonality shapes the amplitude of vole population dynamics rather than generalist predators. Oikos 129 (1): 117-123. https://doi.org/10.1111/oik.06351
- Andreassen HP, Sundell J, Ecke F, Halle S, Haapakoski M, Henttonen H, Huitu O, Jacob J, Johnsen K, Koskela E, Luque-Larena JJ, Lecomte N, Leirs H, Mariën J, Neby M, Rätti O, Sievert T, Singleton GR, van Cann J, Vanden Broecke B, Ylönen H (2021) Population cycles and outbreaks of small rodents: ten essential questions we still need to solve. Oecologia 195 (3): 601-622. https://doi.org/10.1007/s00442-020-04810-w
- Boonstra R, Andreassen HP, Boutin S, Hušek J, Ims RA, Krebs CJ, Skarpe C, Wabakken P (2016) Why do the boreal forest ecosystems of northwestern Europe differ from those of western North America? Bioscience 66 (9): 722-734. https://doi.org/10.1093/biosci/biw080
- Clutton-Brock T, Sheldon BC (2010) Individuals and populations: the role of long-term, individual-based studies of animals in ecology and evolutionary biology. Trends in Ecology & Evolution 25 (10): 562-573. https://doi.org/10.1016/j.tree.2010.08.002
- Cornulier T, Yoccoz NG, Bretagnolle V, Brommer JE, Butet A, Ecke F, Elston DA, Framstad E, Henttonen H, Hörnfeldt B, Huitu O, Imholt C, Ims RA, Jacob J, Jędrzejewska B, Millon A, Petty SJ, Pietiäinen H, Tkadlec E, Zub K, Lambin X (2013) Europe-wide dampening of population cycles in keystone herbivores. Science 340 (6128): 63-66. https://doi.org/10.1126/science.1228992
- Elton CS (1924) Periodic fluctuations in the numbers of animals: Their causes and effects. Journal of Experimental Biology 2 (1): 119-163. https://doi.org/10.1242/jeb.2.1.119
- Hansson L, Henttonen H (1985) Gradients in density variations of small rodents: the importance of latitude and snow cover. Oecologia 67 (3): 394-402. https://doi.org/10.1007/BF00384946

- Hughes B, Beas-Luna R, Barner A, Brewitt K, Brumbaugh D, Cerny-Chipman E, Close S, Coblentz K, Nesnera K, Drobnitch S, Figurski J, Focht B, Friedman M, Freiwald J, Heady K, Heady W, Hettinger A, Johnson A, Karr K, Mahoney B, Moritsch M, Osterback A, Reimer J, Robinson J, Rohrer T, Rose J, Sabal M, Segui L, Shen C, Sullivan J, Zuercher R, Raimondi P, Menge B, Grorud-Colvert K, Novak M, Carr M, et al. (2017) Long-term studies contribute disproportionately to ecology and policy. Long-Term Studies Contribute Disproportionately to Ecology and Policy, BioScience 67 (3): 271-281. https://doi.org/10.1093/biosci/biw185
- Johnsen K, Boonstra R, Boutin S, Devineau O, Krebs CJ, Andreassen HP (2017) Surviving winter: Food, but not habitat structure, prevents crashes in cyclic vole populations. Ecology and Evolution 7 (1): 115-124. https://doi.org/10.1002/ece3.2635
- Kendall BE, Briggs CJ, Murdoch WW, Turchin P, Ellner SP, McCauley E, Nisbet RM, Wood SN (1999) Why do populations cycle? A Synthesis of statistical and mechanistic modeling approaches. Ecology 80 (6): 1789-1805. https://doi.org/10.1890/0012-9658(1999)080[1789:WDPCAS]2.0.CO;2
- Kouba M, Bartoš L, Bartošová J, Hongisto K, Korpimäki E, et al. (2021) Long-term trends in the body condition of parents and offspring of Tengmalm's owls under fluctuating food conditions and climate change. Scientific Reports 11 (1). https://doi.org/10.1038/s41598-021-98447-1
- Magnusson M, Ecke F, Khalil H, Olsson G, Evander M, Niklasson B, Hörnfeldt B, et al. (2015) Spatial and temporal variation of hantavirus bank vole infection in managed forest landscapes. Ecosphere 6 (9): 1-18. https://doi.org/10.1890/es15-00039.1
- Magurran AE, Baillie SR, Buckland ST, Dick JM, Elston DA, Scott EM, Smith RI, Somerfield PJ, Watt AD, et al. (2010) Long-term datasets in biodiversity research and monitoring: assessing change in ecological communities through time. Trends in Ecology and Evolution 25 (10): 574-582. https://doi.org/10.1016/j.tree.2010.06.016
- Mathisen K, Pedersen S, Nilsen E, Skarpe C (2012) Contrasting responses of two passerine bird species to moose browsing. European Journal of Wildlife Research 58: 535-547. https://doi.org/10.1007/s10344-011-0601-3
- Myers JH (2018) Population cycles: generalities, exceptions and remaining mysteries. Proceedings of the Royal Society B: Biological Sciences 285 (1875). https://doi.org/10.1098/rspb.2017.2841
- Neby M, Kamenova S, Devineau O, Ims RA, Soininen EM (2021) Issues of under-representation in quantitative DNA metabarcoding weaken the inference about diet of the tundra vole *Microtus oeconomus*. PeerJ 9: 11936. https://doi.org/10.7717/peerj.11936
- Nystuen K, Evju M, Rusch G, Graae B, Eide N, et al. (2014) Rodent population dynamics affect seedling recruitment in alpine habitats. Journal of Vegetation Science 25 (4): 1004-1014. https://doi.org/10.1111/jvs.12163
- Oli M (2019) Population cycles in voles and lemmings: state of the science and future directions. Mammal Review 49 (3): 226-239. https://doi.org/10.1111/mam.12156
- Pedersen S, Andreassen HP, Persson I-L, Julkunen-tiitto R, Danell K, Skarpe C (2011) Vole preference of bilberry along gradients of simulated moose density and site productivity. Integrative Zoology 6 (4): 341-351. https://doi.org/10.1111/j.1749-4877.2011.00260.x

- Sonerud GA (2022) Predation of boreal owl nests by pine martens in the boreal forest does not vary as predicted by the alternative prey hypothesis. Oecologia 198 (4): 995-1009. https://doi.org/10.1007/s00442-022-05149-0
- Stenseth NC (1999) Population cycles in voles and lemmings: Density dependence and phase dependence in a stochastic world. Oikos 87 (3): 427-461. https://doi.org/10.2307/3546809