Technical manual for sampling small mammals in the Arctic

Version 1

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WARNING: Applying the techniques described in this manual cannot guarantee the welfare of captured animals under all circumstances and thus they should not be be used by untrained persons. Obtaining a federal and/or provincial/territorial permit is mandatory to conduct field research in northern Canada. Approval by an institutional animal welfare committee is also required in most situations before trapping animals for research purposes.

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1. Introduction

It is impossible to know the exact number of individuals of an animal or plant species occupying a given territory. This is why, over the years, biologists have developed various techniques to estimate their abundance, for instance by counting a subset of the population of interest or sampling portions of it. Estimating the abundance and studying the demography[1] of wildlife populations are key attributes to assess the biodiversity and make sound decisions about conservation. Wildlife management starts with a better understanding of how wildlife populations change over the years (Figure 1.1) and why: is the population declining or is it growing? Is the population abundance abnormally low? What environmental or human-related factors are associated with those changes?

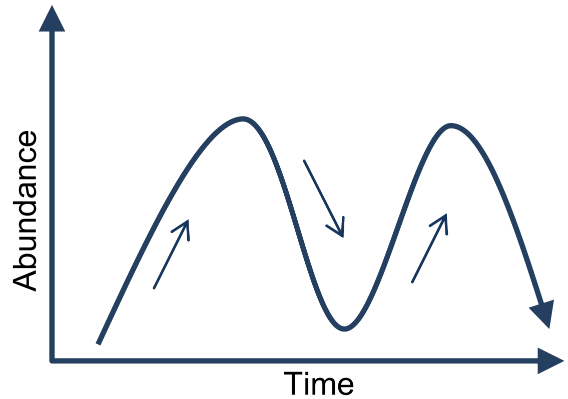

Figure 1.1. A population fluctuating regularly

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A brown lemming.

In the Arctic, several methods have been proposed to study lemming and vole populations. In this document, we review 7 sampling techniques that can be used to estimate the relative or absolute abundance of small mammals and provide information on population characteristics, such as species composition, age group, sex, reproductive condition and body weight. Each method has its own advantages and disadvantages and we thus highlight in the text the pros and cons of each of them. As you will discover in this manual, the methods that can be used in the field often depend on limitations imposed by financial or time constraints. Small mammals are an important component of many ecosystems and especially in the tundra because they are the main prey of several mammalian predators and birds of prey. They are also important for some plants as they help disperse their seeds. In forests, some small mammals have been shown to help control insect pests by eating larva and caterpillars while others can cause damage to plantations. Within cities and agricultural lands, they are often seen as pests because they carry diseases and they can damage crops. Their ecological importance has encouraged the development of many tools to study their populations (Krebs et al. 2008).

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A trap line for sampling small mammals.

[1] *The study of the growth and decline of an animal population and of the factors (reproduction, mortality) affecting this population (Krebs 2009).*

2. Basic sampling notions

Counting and measuring all individuals in an animal population is usually impossible, either because there are too many individuals, they move or they live under cover and are therefore difficult to see or catch. To circumvent this problem, we usually divide the populations in a number of smaller units called samples. These samples can be monitored with small plots or geographical lines (e.g. transect, see below) where we try to determine how many individuals are present (see Figure 2.1). Once the number of individuals has been determined for this small area, extrapolation can then be done to the whole area occupied by the population of interest. This process is called sampling, and the way these samples are spatially structured, a sampling design.

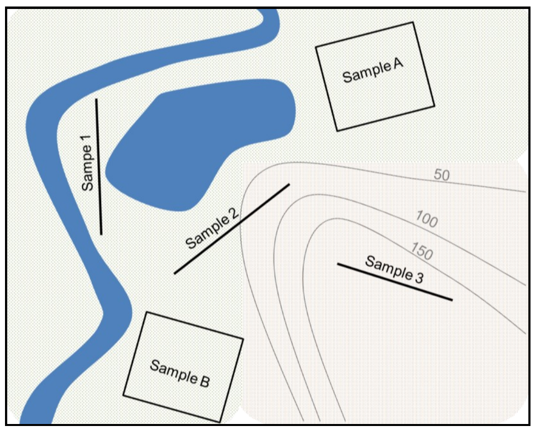

Figure 2.1. Example of samples geographically located in the landscape.

2.1. TRANSECT

2.1.1. General definition

A transect is a line geographically positioned and used in the field to carry out sampling. One person typically walks along the transect previously delimited on a map. This method is useful to find animals or objects that move little or can be located before they move. With the use of a Global Positioning System (GPS) receiver in the field, an oberver can walk along a pre-defined line while keeping an eye for the elements of interest. All observations of the elements of interest should be recorded (e.g. winter tracks, nests, burrows, runways or faecal deposits). Transects can also be used to set up trap lines (see Section 6 on snap trapping). A particular case of transect is what we call the line transect sampling. This sampling method requires the recording of very specific information, as explained below. It is thus important to distinguish the terms transect line (a general term to refer to any transect) from the line transect method.

2.1.2. Setting up a transect

1. Select a homogenous patch of habitat suitable for small mammals based on information available in the literature and by studying maps or by going directly in the field to examine the area and make sure that the selected patch does not include unsuitable areas. A transect crossing a lake is not very useful!
2. Typically, transects will follow straight lines defined by two geographical locations: the beginning and the end of the transect. GPS receivers can be used to draw a line between these two points (i.e. a route) so that the observer can walk along that line.
3. When the beginning of the transect is reached in the field, it is useful to use the "track" function so your GPS receiver can save your path for future reference.

2.1.3. Surveying a line transect

This particular form of transect was developed to account for the fact that as we walk along a transect, elements may not only be seen on the transect itself but also on either side of it, up to a certain distance. However, all these elements may not always be visible due to the uneven topography and the long distance separating the observer from some elements (Figure 2.2). The basic principle of this method is that we assume that all elements present on the line itself will be seen but the chance of detecting an element decreases the farther it is on either side of the transect.

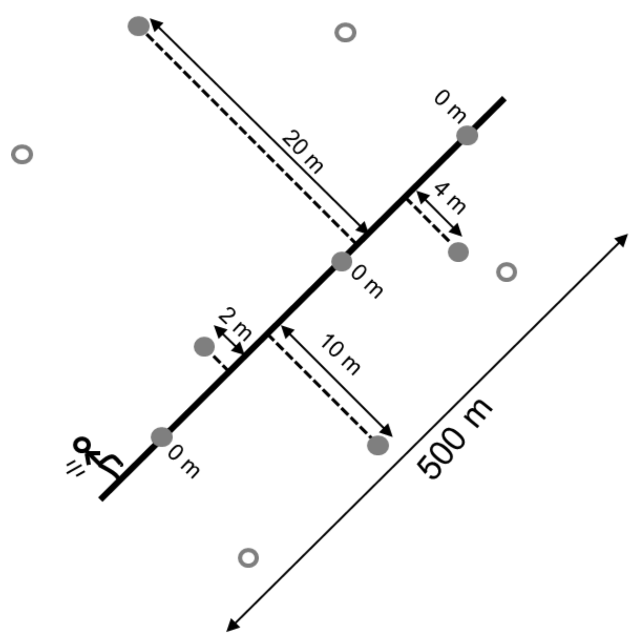

Figure 2.2. Schematic view of a line transect sampling. The thick line represents the transect. The solid dots are elements detected by the observer when walking along the transect while open dots were not detected either because of the uneven topography or their distance from the transect. The dashed line represents the perpendicular distance from each element to the transect line.

Here is how **a line transect** is sampled:

1. Walk slowly along the transect and make sure that you do not move away from it (look at your GPS). If you walk away from the transect, move back on the transect as soon as possible.
2. Depending on what is being surveyed, a GPS location of each element encountered (e.g. a nest, a burrow, etc.) is usually recorded.
3. Many (often the majority) of elements encountered will be located on the transect itself or fairly close to it (Figure 2.2). However, some will be seen away from it and you will need to record the perpendicular distance between each element encountered and the transect itself. This distance can be recorded directly in the field or later using a mapping software, if you have recorded the location of each element with your GPS receiver. This last measurement is used to estimate how far the objects can be seen and determine the area covered by the transect (i.e. length of the transect × maximum width).
4. Note that the type of habitat you are surveying, its topography (e.g. hummocks) or the environment (e.g. tall grass, willow bush) will affect your ability to detect all the elements of interest. As mentioned above, you have less chances of detecting an element that is far away from the transect than close to it. This is normal and is taken into account by this method. However, if you find a new element while moving away from the transect (e.g. to record the GPS coordinate of a newly detected element), you must not record that additional element because it was not detected while you were travelling on the transect path.
5. Record all the information collected in your field book. This information includes the exact coordinates (from your GPS receiver) of each element detected and the perpendicular distance from that element to the transect line (see Figure 2.2).

FAQ: HOW LONG SHOULD A TRANSECT BE?

The length of the transect will depend on the answers to the following questions:
A– What am I sampling?
B– Are all important habitats covered?
C– How many transects should be made to cover all the study area?

Based on experience, 500 m is often a good compromise between having transects long enough to cover a fair amount of ground within a single area while not taking too much time to sample. Adjustments to the transect length may be made once a few line transects have been completed but after these initial adjustments, all transects sampled should have the same length. More than one transects will be required to adequately sample your study area. Ten transects is often a minimum but the total number may depend of the abundance of what you are sampling. As a rule, the less abundant are the elements that you are sampling, the more transects will be required to obtain a reliable estimate.

2.2. PLOTS OR GRIDS

2.2.1. General definition

Plots (often referred to as ‘quadrats’) are areas of pre-defined shape and size where all elements of interest encountered are counted. Grids can be considered as a large plot divided into several stations following a Cartesian plane (i.e. lines intersecting each other perpendicularly). This method is extensively used for plant sampling but is also suitable for animals or objects that do not move a lot or can be captured by traps or fixed cameras.

A square or rectangle is the most popular shape used in grid or plot surveys because they are easier to set up in the field and their boundaries are easily defined. The shape chosen should be adapted to the habitat selected for the survey. For example, if the habitat patch is long and narrow, then a rectangular shape may be more appropriate than a square one.

2.2.2. Setting up and surveying plots or grids

Select a homogenous patch of habitat that is suitable for small mammals based on information available through the literature, by studying maps or by going directly in the field to examine the area.

1. Two methods can be used to locate the stations of a grid. The first method requires the use of a GPS receiver. Mark the first corner of the grid with a visible wooden stake at least 60 cm high, painted orange or marked with flag tape rolled around the stake. Avoid fixing the tape as a floating flag because strong wind and sunlight will degrade it rapidly and pieces of tape will be found all over the place. Then determine the distance and direction of the next station (20 or 30 m east/west/north/south from the current position). Walk with a GPS receiver to this new destination, record the position in your unit and mark the new station in the field. Do this until all stations have been positioned. The second method requires that all the stations have been pre-determined in a mapping software on a computer and their position entered in a GPS receiver. Once on site, the observer simply has to walk to each of those positions with its GPS receiver and mark each of them in the field.
2. The lines of a grid should be equally spaced out from one another, with lines running parallel to each other in one direction (e.g. left to right, rows) identified by a different number, and those running in the other direction (e.g. top to bottom, columns) by a different letter. For sampling tundra small mammals, each line should be typically spaced out by 20 to 30 m. Each station should be marked in the field with a small stake (e.g. a bamboo stick), labelled with the column and row ID (e.g. C05; see Figure 2.3).
3. To conduct a complete search of a large plot/grid, two or more observers should walk parallel lines approximately 5 m apart (or closer in more rugged terrain). When surveying a large grid in this manner, stations marked with stakes (as previously described) are very useful to stay on track because they can be used as landmarks or guides. When surveying a plot, make sure to keep your heading using a GPS receiver.

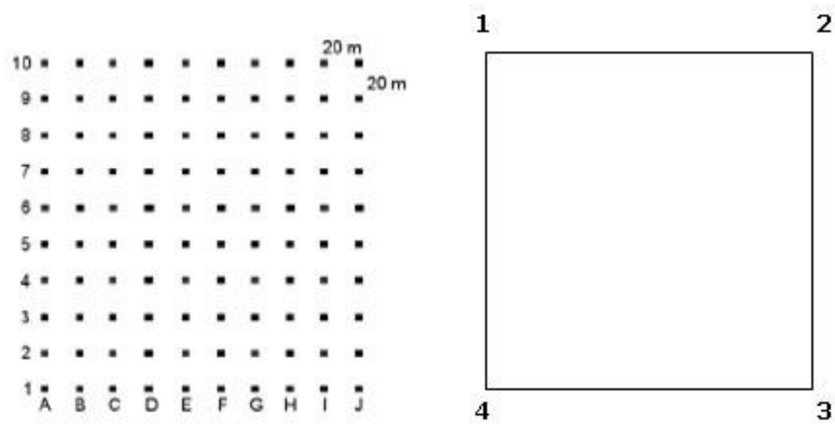

Figure 2.3. (left) Example of a 180×180 m grid with 100 stations at 20-m intervals. Letters are used to label the columns and lines are labelled using numbers; (right) example of a 180×180 m plot with the corner stakes numbered from 1 to 4.

4. Depending on what is being surveyed, GPS coordinates of each element (e.g. a nest, a burrow, etc.) sampled within the grid/plot should be recorded.
5. Record all the information collected in your field book.

FAQ: WHAT PLOT/GRID SIZE SHOULD BE USED?

The plot/grid has to be big enough to contain a minimum number of the elements of interest but small enough that the survey can be conducted in a reasonable amount of time. The number of people and time available for the survey can also help determine how big the plot/grid should be as well as how many should be surveyed. Grids made of 100 stations (10x10) separated by 20 to 30 m have been used successfully in other sites to monitor lemmings or their signs (e.g. their nests). However, if time or resources are limited, grids made of 64 stations can be used. If habitat is patchy (i.e. small disconnected areas), sampling several small grids may be the most interesting option. Under some conditions such as when small mammals are in low abundance, larger grids (e.g. 144 stations) may be preferable to increase chances of encountering enough individuals or signs of their activity.

2.3. THE USE OF FIELD BOOKS AND DATASHEETS

Field books are probably man's best friends when gathering data in the field. Regardless of the equipment needed to conduct field work, carrying a field book to write down data is an essential component and is often easier to use than carrying a clipboard with datasheets. The weather can also be unpredictable and losing a datasheet to the wind can mean losing a lot of precious information and time! However, depending on the survey being conducted, the amount of data that needs to be recorded in the field can sometimes be difficult to remember, especially if the list is long. Hence, it is a good idea to printout a small version of the datasheet with the codes that you may need to use and to keep it in your field book for reference when in the field. This way, you won't forget important details.

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It is important to note everything that is measured.

When sampling for small mammals, as with any other ecological surveys, notes recorded in field books should be transferred to hard copy datasheets as soon as possible when you get back to your base of operations. This will allow you to see if all the required information was correctly recorded in the field. These datasheet should also be entered in a computer spreadsheet software (e.g. Excel) or using specialised data entry forms (e.g. in Access) when returning from the field for long-term data storage. Recently, electronic tablets protected with rain-proof casings have been used directly in the field for rapid data entry but the cost of this method has to be considered.

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Two types of field books often used by ecologists.

3. WINTER TRACKS LEFT IN THE SNOW PACK

3.1. DESCRIPTION OF THE METHOD

Lemmings remain active under the snow throughout the winter and move while searching for food and building their nest for protection. When digging tunnels at the base of the snow pack, lemmings leave tracks that may be seen during snowmelt. However, certain weather and snow conditions may be necessary to create easily visible tracks at snow melt (see pictures). The principle behind this method is that the more lemmings there are, the more tracks will be found at snow-melt.

- Winter tracks may be best counted while walking along a transect (see Section 2.1.). Count all tracks seen from the transect but do not move away from it.
- We recommend using 500-m long transects running through a homogenous patch of habitat. Transects conducted in snow drift areas (e.g. along the embankment of a stream, parallel to the stream) are more likely to encounter small mammal tracks at snow melt. We recommend conducting several transects (10 or more) to have a good spatial coverage of the area. If resources are limited, you may reduce the length of each transect rather than the total number. While walking along the transect, all individual tracks should be counted. An individual track is one that does not connect with another track while branches are tracks that meet another one at a junction point (see Figure 3.1). Branching tracks can also be counted but separately: for example, you could count 31 individual tracks along a given transect and 132 branches.

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Winter tracks of lemmings exposed at snow-melt

3.2. TIME PERIOD

The survey should be conducted near the end of snow melt, when the base of the snow pack starts to be exposed. This should be in May or June, depending on the area. The time to conduct winter track surveys is very limited, though spatially variable: in snow drift areas, winter track surveys will occur later than in other areas due to the delayed snow melt at those sites. The time window to conduct such survey within a given habitat is likely to be only a few days, depending on the speed of snow-melt.

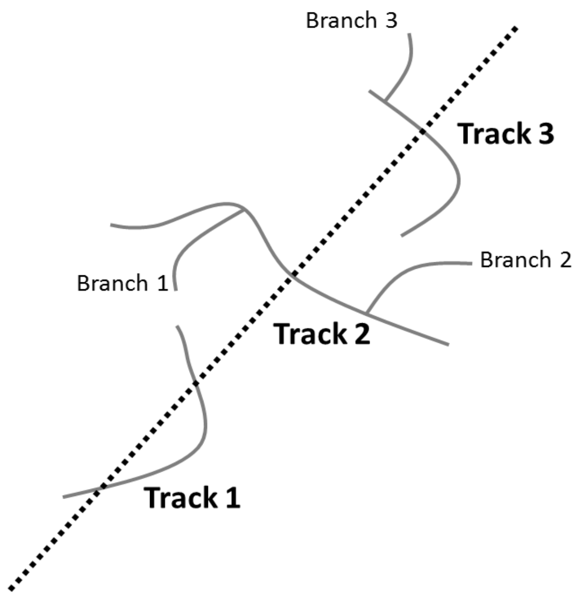


Figure 3.1. In this situation, there are 3 separate winter tracks. The first track has no branch, the second track has 2 branches, and the third track has one.

3.3. MATERIAL REQUIRED

- Field book and pencil
- GPS receiver
- Measuring tape
- Wooden stakes (optional)

PROS

- Cheap and fast
- Not necessary to kill or capture animals

CONS

- Imprecise abundance estimates (sometimes unclear if tracks are individual or a branch of another track)
- Dependent upon snow conditions
- Tracks visible only during a short period at snowmelt

4. Burrows and runways

4.1. DESCRIPTION OF THE METHOD

4.1.1. Burrows

Several species of small mammals that live in dry habitats such as the collared lemming can dig burrows in the ground to hide from predators during the summer. The relative abundance of these species can then be estimated by counting the number of active burrows in a specified area. The method, however, can be difficult to apply in areas where boulders are abundant because these provide natural hideaway for lemmings, which eliminates the need to excavate burrows.

Sampling small mammal burrows can be done using either a plot (systematic survey) or a simple transect line (see description of each sampling design in Section 2). As for other sampling methods, you should aim to count burrows on several plots or transects randomly scattered across your study area. A minimum of 50 plots (400 m²) or 10 transects of 500 m long may be necessary to obtain good estimates of abundance. Transects should be permanent and re -sampled every year.

Examine each burrow that you encounter while walking along your transect (or while surveying your plot) and classify them as active, inactive* or unknown. Count all burrows whether active or inactive.

*** TIPS! – Active burrows**

Active burrows can be recognized by **fresh digging** and **soil thrown out** of the burrow or by the presence of **fresh** (usually dark green or brown and sometimes still humid) **faecal pellets** down the entrance of the burrow. In habitats where the mineral soil is covered by a thick organic layer, burrows are often dug in the moss. *Inactive or old burrows* can be recognized by the presence of **spider webs** inside them or old, dead leaves that fill the entrance (e.g. willow leaves). Other clues found near the burrow such as freshly clipped grasses or browsed willows can indicate recent small mammal activity nearby.

4.1.2. Runways

Some species will consistently use the same paths to move around, often using natural features of the environment such as frost cracks or along a large rock. Repeated use of these paths will cause trampling of the vegetation, often accompanied by other signs such as grazing marks or faeces, and will result in runways that are clearly seen as mini superhighways through the vegetation. Surveying for small mammal runways should be conducted in habitats suitable

Active burrow

Active burrow

for the formation of runways, which are typically those with an extensive moss or herbaceous plant cover, such as in wet sedge meadows. The use of transects is probably the most suitable method for counting runways. As for burrows, you should aim at sampling several transects randomly scattered across your study area.

Transects can be done in exactly the same place year after year if they are permanently marked with stakes. Searching for runways can be tedious in some habitats because you may have to crawl on the ground while searching for covered runways such as those in frost cracks). The method proceeds as follows:

1. Lay out a measuring tape or a rope in a straight line across an area of suitable habitat. If possible, use permanent stakes to locate these lines.
2. Moving along the line, record for each 15-m segment the number of active runways* cut by the line. Some runways will snake back and forth across the transect line and will be counted several times.
3. Count enough 15-m segments to obtain a total of 500 m. When small mammal numbers are low, you may find few active runways.

An active runway (dashed line) with very few debris.

4.2. TIME PERIOD

Burrow and runway counts are best done in July or August.

* TIPS! – Active runways

The most difficult decision is to determine whether a runway is active or not. Lemming runways can last several months to over a year after populations have declined so one must be careful when determining if a runway is being used or not. You should look down the runway for **fresh faecal pellets** (usually green) or **fresh clippings** of sedges or grasses, and if you can find these signs **within a few meter** on either side of the transect line, the runway can be called *active*. Do not count inactive runways.

When more than one species of small mammal is present in the area, it may be possible to distinguish which species is using a runway based on the color, shape and size of the faecal pellets (see Section 10.1. below).

4.3. MATERIAL REQUIRED

- 50-m to 100-m measuring tape
- Field book and pencil
- GPS receiver
- Wooden stakes

PROS

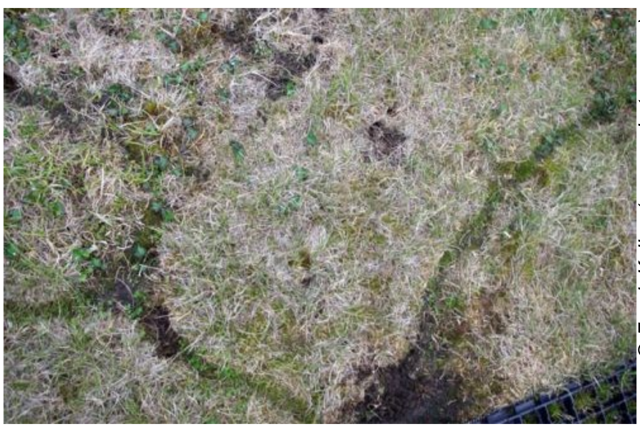
- Cheap and easy to do
- Not necessary to kill or capture animals

CONS

- Limited to species that dig burrows or use runways
- Presence of burrows/runways depends on the type of soil
- Require experience to make the distinction between active/inactive burrows
- Tedious work, could take a few hours to a whole day to survey an entire habitat
- Difficult to implement in areas with lots of boulders or some vegetation types (e.g. tussock tundra) because individuals will hide under rocks or large dead litter accumulation and will not dig burrows

4.4. EXAMPLES OF RUNWAYS

Lemming runway in the grass



Lemming runway in the grass

Lemming runway in the grass

Runway in a frost crack

5. Faecal deposits

5.1. DESCRIPTION OF THE METHOD

Sampling faecal deposits is one of the oldest and most classic methods to assess the relative abundance of wildlife populations, probably because of its simplicity and suitability for most ecosystems. Faecal deposits are typically monitored using transects. For species that produce well defined faecal masses, such as large or carnivorous mammals, the line transect method described in Section 2.1 can be used. However, this formal sampling method cannot be used with small rodents due to the small size of their faecal pellets and because faeces are often spread over relatively large areas. A more subjective approach must thus be used. An observer should walk along the transect and record all faecal deposits encountered on it. All faecal deposits that do not cross the transect are ignored. The same recommendations made for burrows/runways regarding the length and number of transects apply here. As with the previous methods, transects should be run in sites with suitable habitat for small mammals.

When a faecal deposit is encountered on the transect, the following information should be recorded:

- What species? More information on how to determine the species from faeces may be found in Section 10.
- How large is the faecal deposit? The size of the deposits could be classified according to a semi-quantitative scale: 1-10, 11-100, 101-1000, or >1001 pellets. The size of the deposits will depend on how long one individual used the local area and how many individuals used it.
- Is the faecal deposit recent (current year) or old (one year old or more)? The relative age of faecal deposits can be determined by the state of degradation of the faeces. Characteristics of old faeces are generally as follows: pale colour, dry, partly imbedded in the soil, and covered by dead vegetation. Recent faecal deposits are generally dark green or dark brown/ reddish, sometimes damp but often dry, and clearly on top of the soil or vegetation.

Faecal deposits of collared lemmings

Faecal deposits of brown lemmings

5.2. TIME PERIOD

Surveying for faecal deposits should be done during early to mid-July when there is no more snow and all deposits have been exposed. Ideally, surveys should be done under dry conditions because old faeces can become wet when it rains, which will make more difficult the evaluation of the freshness of the deposits.

5.3. MATERIAL REQUIRED

- Field book and pencil
- 50-m to 100-m measuring tape
- GPS receiver
- Wooden stakes

PROS

- Quick, cheap, and easy to do
- Provide a reliable index of presence/absence of a species in an area
- Not necessary to kill or capture animals

CONS

- Give imprecise estimates of abundance
- Difficult to determine when the faecal deposits were made (current vs. previous year)
- Determining species is not always easy
- Faecal deposits subject to washing by heavy rain

6. Winter nests

6.1. DESCRIPTION OF THE METHOD

Lemmings and some vole species build nests mostly made of dead herbaceous vegetation to keep warm and reproduce during the winter but they abandon them when spring comes. Once snowmelt is over, the nests appear on the tundra as small balls of dead vegetation (~10-15 cm in diameter). We can obtain an index of the winter abundance of small mammals by counting these nests after snow-melt. There are 2 possible approaches to sample winter nests: line transects and plots/grids.

If you know the species of small mammals present in your study area, you can concentrate your search effort into the habitats commonly used by these species in winter. For example, although brown lemmings tend to concentrate in wet sedge meadows during summer, they typically move to drier grounds such as mesic tundra for the winter (Duchesne et al. 2011b). Otherwise, it would be preferable to cover all potential habitats in our study area until you get a better feeling of their winter distribution. Whenever possible, it is also best to monitor the same transects or plots/grids every year to allow comparisons over time.

Transects should be surveyed following the method described in Section 2 above. The formal line transect method described in that Section is particularly well suited for sampling winter nests. Note that when applying these techniques to winter nests, the term "element" used in Section 2 will here refer to individual winter nests.

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A collared lemming winter nest

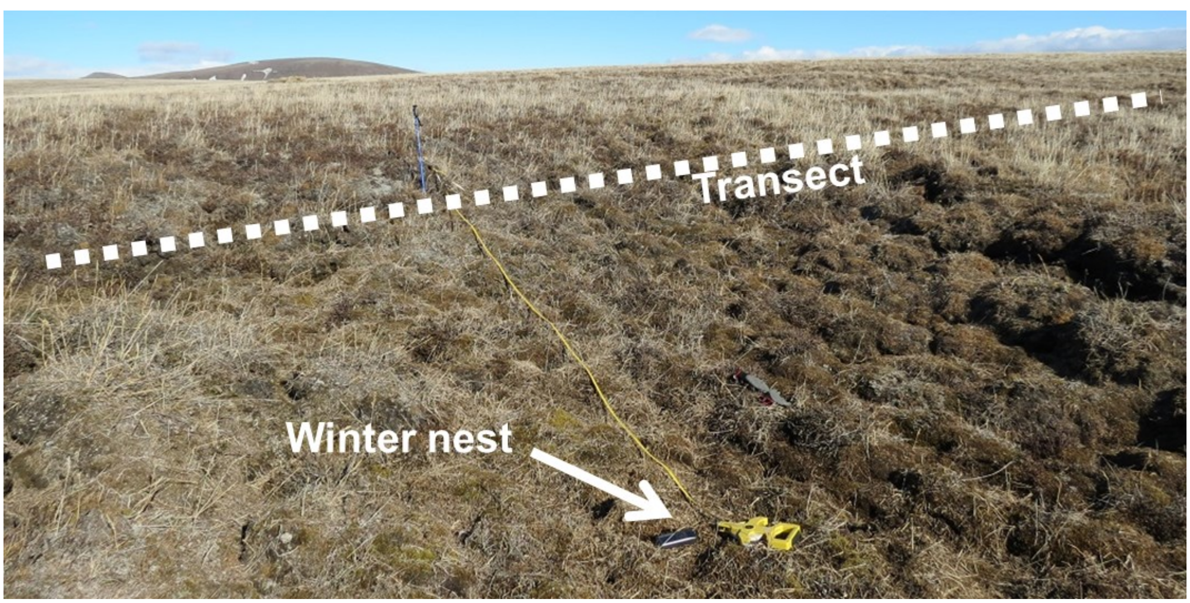
Line transects are best for long-term monitoring because they can cross a greater variety of habitats than plot/grid sampling. This approach is also more likely to provide good results for a reasonable sample size. However, if live trapping is already planned at your study site, surveying winter nests in the trapping grids as well would be ideal. Everytime you encounter a winter nest during a survey, you should:

- Assign a unique individual number for all *fresh nests** found during your survey
  - ⇒ For transects: record the GPS location and the perpendicular distance of each nest to the transect line (see Section 2.1 for more details).
  - ⇒ For grids: record the GPS location of each nest (see Section 2.1 for more details).

- All fresh nests should be brought back to the camp or laboratory in a plastic bag identified with the date, the nest and transect/plot numbers for further analysis (see Section 6.4 below).
- Old nests encountered during your sampling should also be noted and removed/destroyed to avoid counting them again in the future.
- If nests cannot be processed right away back to the camp, they should be transferred into a labelled paper bag and put in an oven to dry at 50°C for at least 48 hours to prevent them from rotting before they can be examined.

* TIPS!

Fresh winter nests are round balls of tan-coloured herbaceous vegetation (most often grasses and sedges, sometimes with mosses) while old nests (i.e. = ≥1 year old) are usually completely flattened due to winter snow accumulation and summer rain and the vegetation has a grey colour due to exposure to sunlight and withering. Winter nests vary in size depending on whether young lemmings were raised in them or if only an adult used it. Moreover, some nests may be abnormally small (i.e. <10 cm diameter) because their construction was interrupted by the small mammal's death or migration. Even though these nests are small, they still retain the round structure and are easily recognizable.



A winter nest located along a transect

6.1.1. Opportunistic nests

In years when small mammal abundance is low and very few winter nests are found along transects or on grids, collecting nests found opportunistically while walking in the field can also be useful to improve the precision of certain measurements. Although using these nests to determine annual abundance is not recommended (because they were not found using a systematic sampling design), they can provide additional information on reproductive activity or predation rate (see 6.4). The location of all fresh nests found opportunistically is also recorded with a GPS receiver for future reference. These nests should also be brought back from the field and their content analysed just as those found along transects or on plots.

6.2. TIME PERIOD

Nest surveys are best done as soon as possible after snowmelt (early in summer), since high winds can blow the nests around after snow melt. Rain will also flatten and discolor nests, which will make identification of fresh vs old nests more difficult.

6.3. MATERIAL REQUIRED

- 50 or 100-m measuring tape
- GPS receiver
- Plastic bag, label and permanent marker
- Small plastic tray of pale colour to examine content of winter nest (if done in the field)

6.4. DETERMINATION OF SPECIES, REPRODUCTIVE ACTIVITY AND PREDATION

Winter nests left behind by small mammals can provide precious information such as the species using the nest, the occurrence of reproductive activity or predation by weasels. This is usually determined based on hair, faecal material and bones or carcasses found inside nests. This is why all nests should be torn open to look for these signs. It is best to open the nests on a pale coloured plastic tray to sort through the debris for signs.

Note that when you have gained enough experience at identifying these clues, nests can be dissected directly in the field rather than in the laboratory. All nests processed in the field should be completely ripped apart to avoid recounting them the next year.

Here is a summary of the information that should be gathered when examining the content of winter nests. See also Section 10 for additional details.

6.4.1. Faecal material in/around winter nests

Small mammals spend a lot of time in their nests during winter and you will typically find high amounts of droppings inside them or just around it in the field. If a large pile of faeces is present just outside the nest, you should collect them along with the nest. Droppings from each nest should be carefully examined.

- The two lemming *species* can be identified by examining the size, color, shape and form of droppings (see Section 10 for details). Note that two different species sometimes use the same nest, and thus you may occasionally find nests with both types of faeces.
- The *reproductive activity* can also be derived from the size of faeces from the same species: smaller droppings indicate the presence of young* in the nest at some point over the winter. If >20% of all droppings examined (in this case, a minimum of 30 faeces should be examined (Duchesne et al. 2011a) are considered to be from young, then the nest can be categorised as having been used for reproduction. Otherwise, it is not conclusive and the nest should be rated as non-reproductive.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Pile of very small faeces from a young lemming at a winter nest

6.4.2. Bones and carcasses

- The presence of bones or body remains of small mammals inside the nest are a sure sign of *predation*. Fur attached on skin can also be found in nests but these are more subtle to find. In rare cases, intact, newly born but dead lemmings may be found in nests. This can occur either because the mother abandoned the young (possible in young females) or it was killed outside the nest. In this case, it is not clear if predation occurred or not even though recording this information is useful.
- Jaw bones, if present, can provide additional cues to identify *species*. Each species of small mammals has its own unique set of dentition (see details in Section 10). If carcasses are present and complete enough, it can also help the identification through other external characteristics unique to each species.

* TIPS!

Droppings of *young* are about 3 to 4 times smaller than those of *adults*.

Droppings from young are usually found in the center of the main nest cavity while *droppings of adults* are often found in another smaller chamber located alongside of the main cavity. Because of this segregation, it is important to dissect carefully the entire nest to avoid missing important information.

6.4.3. Hairs

Small mammals moult during winter and by moving inside the nest they sometimes leave a thin and very sparse layer of hair covering the walls of the nest cavity. However, when weasels kill small mammals in the nest, they often line the nest with hair removed from the carcass. Therefore, a thick layer of hair tufts, which is easy to distinguish from the sparse layer of hair due to the moult of the animal, is a sure sign of *predation* by a weasel (or ermine)*. This is important information and should be noted.

The microscopic cuticle patterns of hairs can in principle provide additional criteria to identify the *species* through. However, this can be tricky for the untrained person and it requires a set of hair collection for comparison as well as a microscope. This technique is beyond the scope of this manual and will not be discussed further.

*** TIPS!**

You may find very large winter nests, sometimes up to 30 cm or more in diameter and lined with a thick layer of fur tufts. These are small mammal nests turned into weasel (ermine) nests. Weasels hunt small mammals under the snow and convert their nests to their own use. Often you will find lemming frozen stomachs and bones left behind in those predated nests.

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Lemming nest predated and turned into an ermine nest.

PROS

- Cheap, relatively easy and quick to do
- Very good estimate of winter abundance
- Give information on reproductive activity and weasel predation
- Not necessary to kill or capture animals

CONS

- Provide no information of timing of use during the winter
- Some nests cannot be identified to species due to the lack of faecal material in them
- Nests sometimes used by more than one species (impossible to know who built it)

7. Snap trapping

7.1. DESCRIPTION OF THE TYPES OF TRAPS

Museum Special® and Victor® traps are two models of snap traps designed in the same way and are commonly used to trap small mammals. The bait pedal acts as the release mechanism. When a small mammal starts to feed on the bait the metal arm is released and the animal is killed instantly by cervical dislocation. The efficiency of each trap depends on the size of the species of interest. Generally, a bigger trap will be more efficient at capturing larger animals. Victor® traps come in 2 different sizes designed to capture primarily small house mice or large rats while the Museum Special® trap falls in between. The latter has been used extensively in ecology and is often recommended as the best option to trap lemmings and voles. However, they are becoming more difficult to find on the market.

© www.woodstream.com

© www.victorpest.com

A Museum Special trap (top) and a Victor trap (bottom).

7.2. DESCRIPTION OF THE METHOD

1. Sampling small mammals using snap traps is done using trapping lines, which are analogous to transects. The goal is to cumulate a trapping effort* of at least 500 trap-nights per trapping sites. Trapping should occur over a period of 3 to 4 days. Using longer periods is not recommended because since this method removes animals, you may start depleting the population after a few days, which would reduce trapping success in subsequent days/ weeks. Therefore, achieving 500 trapping-days over 3 days would require setting up about 170 traps each day. It is recommended to use the same trapping sites every year to allow for comparison. Trapping site selection
   - Choose sites that cover all potential small mammal habitats. For example, during summer brown lemmings prefer wet habitat while collared lemmings prefer dry

* TIPS! – Trapping effort

The *trapping effort* is expressed in “trap-nights” which is calculated by multiplying the number of traps set in the field by the number of nights (= days) they will be baited and surveyed. If you set and bait 5 traps for 10 nights then your trapping effort is 50 trap-nights (5 traps × 10 nights). The number of traps available for the survey usually determines the number of days the trapping period will last.

habitat.

2. Setting trap lines

   - The number of trap lines can vary from 2 to 4 depending on the size and shape of the habitat patch. Lines should be laid parallel to one another with a minimum distance of 100 m between each other. Trapping stations are staked out every 15 m along each trapping lines. Record the GPS position of each station for future references.
   - If the number of traps available for the survey is limited, each trapping line or group of lines can be set and baited one after the other. For example, set traps along 2 lines for 3 days and then move the traps to the next set of 2 lines for another 3 days.

3. Setting traps

   - Each station consists of 3 snap traps within a 2-m radius of the station. Each trap is attached to the station with a 2.5-m string to avoid them being carried away by other animals passing by. The 3 traps should be spaced out as much as possible and placed at sites with fresh signs of small mammal activity such as runways, burrows, fresh faeces or grass clippings whenever possible. Using more than one trap per station is recommended to avoid local saturation because once an animal is caught, a trap is no longer available to catch other animals passing by until it is reset the next day.

Trapping station with snap-traps attached with cords

   - Traps are placed flat on the ground and clear of any vegetation that could interfere with the trap operation. If the mechanism is blocked by the vegetation, the animal may only be injured and suffer unnecessary pain. Make sure traps can be located again. If the bushes are thick, putting a flag tape above each trap could be useful!

4. Baiting traps

   - Each trap is baited with a big pea-sized amount of peanut butter mixed with rolled oats. Flour can be added to the mixture to reduce the stickiness of the bait which makes it easier to clean traps afterwards.

5. Checking traps

- Ideally, traps should be checked once per day, at 24-hour interval, preferably early in the morning.
- If an animal (small mammal or other) is caught, you should first put on nitrile surgical gloves to avoid disease transmission. The animal is then collected and the following data needs to be recorded: the trapping line and station number, habitat, species, weight, age group (adult or juvenile) and sex (see Section 10 for criteria to identify species, age and sex). Re-bait and re-set the trap.

A brown lemming instantly killed by a snap trap

- If the animal captured cannot be properly identified in the field (or if there are any doubts), it should be brought back to camp (or laboratory) in a ziploc bag identified with the trapping line and station number for further analysis.
- In case of a *misfire** (i.e. trap is sprung but no animal was caught) it is important to also record that information as well as the trapping line and station number.

* TIPS! – Misfires

Misfires can be caused by…

- An animal being able to grab the bait before the trap is triggered; this may occur because the trap was not set properly or the release mechanism was not sensitive enough;
- Large animals such as caribous passing by and triggering the traps due to ground vibration;
- Strong wind and heavy rain;
- A predator (e.g. a fox) that removed the small mammal that had been captured (in this case, hairs or fresh blood from the dead animal can sometimes be seen on the trap and should be noted
- An old trap: the release mechanism can lose its ability to hold the trigger in place.

If a trap is repeatedly found misfired, it would be wise to check that it is functioning properly. If not, then discard the trap for subsequent repair and replace it with another one.

- In case of accidental captures (other species than a small mammal), the information should also be recorded along with the trapping line and station number.
- On the last day of trapping, traps are collected from the field and cleaned of any remaining peanut butter before being stored until next season to avoid rotting of the bait.

An excellent document showing in details how to set and run a snap-trap line for small mammals has been produced by the Government of the Northwest Territories and could also be consulted (ENR 2005c).

7.3. TIME PERIOD

Snap trapping should be conducted once per summer, ideally in mid to late July. In some species, especially lemmings, it is not recommended to do trapping at the end of the summer (e.g. August) because populations often start to decline by then.

7.4. MATERIAL REQUIRED

- Field book and pencil
- Field guide to small mammals
- GPS receiver
- Measuring tape
- Nitrile gloves
- Peanut butter mixed with rolled oats for baits (prepared in advance)
- Portable spring scale (with a weight capacity adapted to the species of interest)
- Roll of string
- Snap traps
- Wooden stakes
- Ziploc bags and permanent marker

PROS

- Give a good and precise estimate of abundance
- Can provide additional data on parasites and reproductive conditions through dissection
- Cost and time efficient

CONS

- Kill the animals captured
- Ethic concerns in some jurisdictions
- Capture of non-target species can occur
- Opportunistic predators can steal carcasses from the traps
- Museum Special traps are hard to find in Canada nowadays

8. Live trapping

8.1. DESCRIPTION OF THE TYPES OF TRAPS

8.1.1. Live traps

The two most common live traps used to capture live small mammals in North America are single-capture Sherman® and Longworth® traps. Multiple-capture live traps also exist (such as the Uglan trap commonly used in Scandinavia) but their large size makes them inconvenient for transportation and their effectiveness is not necessarily higher than single-capture live traps. We will thus not discuss them any longer. Sherman® traps come in 3 sizes (small, medium and large) and are often used to capture mice and voles while Longworth® traps are one size only but are suited to capture most species of small mammals (lemmings, voles and mice). The door of these traps is triggered when the animal goes far enough inside the trap and its weight releases the latch that holds the door open (i.e. a small horizontal rod in the Longworth trap entry tunnel or a pedal in the middle of the Sherman trap). Each model of traps has its advantages and disadvantages but, overall, the Longworth® should be preferred (especially for lemmings) when possible.

Longworth®

- Costly to purchase (40$ or more per trap)
- Not collapsible, bulky to carry in the field
- Trap door can be locked open easily between trapping session, allowing pre-baiting
- Provides more space and comfort for the animals in the trap
- Misfires rarely occur
- Bait and bedding do not interfere with trigger mechanism

Sherman®

- Cheap to purchase (~25$ for a large trap, ~19$ for a small trap)
- Collapsible and easy to carry in the field
- Trap door cannot be locked open
- More prone to misfires
- Bait or bedding can sometimes interfere with the trigger mechanism

A Longworth trap

A large Sherman trap

© Dominique Fauteux

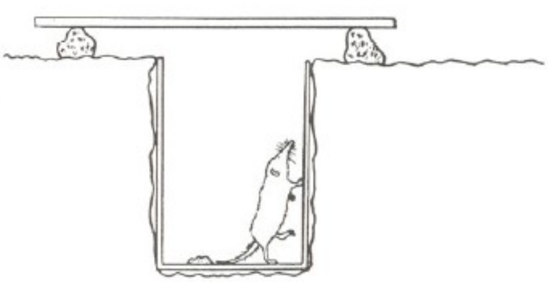
A Longworth trap in the field

© Dominique Fauteux

A small Sherman trap in the field

8.1.2. Pitfall traps

Pitfall traps basically consist of a hole in the ground into which unwary animal falls. These traps are homemade and usually consist of a metal can or a plastic bucket buried into the ground so the rim is flush with the surface. The size and the depth of the hole depend on the target species. The pitfall trap has to be big enough so that the animal is unable to crawl or jump out of the hole. Generally, they are at least 40-50 cm deep and 20-40 cm in diameter. To protect the captured individual from rain, sunlight, exposure and predators and to reduce mortality, a cover is often added on top of the hole. The cover should be larger than the trap opening to prevent runoff into the trap and propped by rocks or other material to allow for a space (~10 cm) between the cover and the rim of the bucket. Holes should also be drilled at the bottom of the can or bucket to help drain any water that would accumulate in the trap. Note that small rodents will often try to bite through the holes to find their way out of the bucket. It is thus imperative that if holes are made, it should be in a bucket made of sturdy material (e.g. avoid flimsy plastic). A piece of bait should be placed in the pitfall trap as well as bedding material to increase the comfort of animals.



© Hoekstra et al. 1977

A pitfall trap with a protective cover

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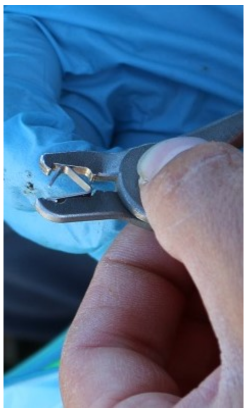
8.2. DESCRIPTION OF THE MARKING TECHNIQUES

8.2.1. Ear-tags

Ear-tags are the most common marker used in small mammal live trapping studies. It is a small aluminum marker that is put on the animal's ear flap (similar to an earring) with specially designed pliers. It usually has a unique 3 to 4-digit code stamped on one side of the tag to identify the animal if it is recaptured later.

An ear-tag.

© www.nationalband.com



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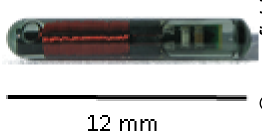
8.2.2. PIT tags (Passive Integrated Transponder)

A PIT tag is a small chip about the size a rice grain that is injected under the skin of the small mammal using a specialized syringe. This chip does not require any batteries. It is energized by an electromagnetic field produce by the PIT tag reader. It also has a unique code, usually 10-digit long. This type of chip was first used in research to study fish movements but it is now widely used by biologists for mammals, birds, reptiles and amphibians. It is also used by veterinarian to identify household pets as well as for tracking zoo animals and livestock.



A passive integrated transponder (PIT) tag.

© www.fishbio.com

© Marie-Christine Frenette

Injection of a PIT tag

8.2.3. Pros and cons of each marking method

Ear-tag

- Cheap to purchase (~15$ for 100 tags)
- Difficult to put on some lemming species due to small ear size
- Animals can lose tags if they get caught in vegetation or roots in burrows (especially in lemmings due to small ear size)
- Some individuals may try to remove the tag by themselves
- Tag code can be misread due to the small size of the marker

PIT tag

- Costly to purchase (~800$ for 100 tags)
- A PIT tag reader is needed to identify the animal
- Tag code can sometimes be misread due to the length of the code and the mix of numbers and letters involved
- If injected properly, they cannot be lost (injuries are extremely rare)
- Easier to install on the animal than ear-tags
- Can be re-used if tagged animals accidentally die in traps (the tag is then retrieved by dissection)

8.3. DESCRIPTION OF THE METHOD

Sampling small mammals using live trapping is usually done using square grids. The standard size of trapping grids is usually 100 trapping stations (10×10). However, the use of larger (144 stations, 12×12) grids in areas where small mammal density is low is recommended. Conversely, smaller grids (64 stations, 8×8) may be used if animal density is high or if resources are limited, but this may result in a loss of accuracy. It is best to use the same trapping sites and dates every year to allow comparison. Trapping sessions usually last 3 days, which would yield 6 visits per session when traps are checked twice a day (see Table 8.1).

Table 8.1. Example of trapping schedule within a 3-day session.

Trap visits	Visit number
Day 1 - 8:00	Set & bait traps
Day 1 - 20:00	Visit #1
Day 2 - 8:00	Visit #2
Day 2 - 20:00	Visit #3
Day 3 - 8:00	Visit #4
Day 3 - 20:00	Visit #5
Day 4 - 8:00	Visit #6 & trap closing

8.3.1. Field procedures for Longworth®/Sherman® traps

1. Setting traps
    - Set up the trapping grid lay out in the field with a stake at each station (see Section 2.2 above).
    - Place one trap near each station. Carefully search the area around each station for fresh signs of activity such as an active burrow or runway. If you find a good runway, place the trap on the runway. If there is a burrow, place the trap in front of the entrance but do not block the entrance. If there is no sign, place the trap under cover (when possible).
    - The distance of the trap from the station stake should not exceed half of the distance between stations (e.g., if grid markers are every 20-m, the trap should not be farther than 10 m from the station stake).
    - The station number (letter-number) should be indicated with a permanent marker on a duct tape sticked to the trap in case any confusion arises during subsequent visits as to which station a trap is associated to.
    - Bait the tap (see below), open the door and set the triggering mechanism. Make sure that the bait has not rolled over the trigger while setting the trap.
    - Make sure the trap is stable and flat or lightly inclined forward (never inclined backwards!) to avoid any accumulation of water in the trap during rainy days. When possible, the traps should also be oriented opposite to the dominant wind. The entrance of the trap should not hang in the air: it has to be on flat ground.
2. Baiting traps
    - Line the back of the trap with a handful of synthetic bedding for nesting material. Use just enough to create a warm nest but not too much that the animal might view it as a blockage as opposed to nesting material.
    - Place the bait in front of the bedding material: add one piece of apple (~¼ of a large apple) for water. A small pea-size ball of peanut butter mixed with rolled oats can also be added.
3. Checking traps and manipulating animals
    - Traps should be checked at least twice daily at 12-h intervals, early in the morning and in the evening. During hotter and colder days, it might be best to check traps every 8 hours.
    - If an animal is captured, you should first put on nitrile surgical gloves to avoid disease transmission. Indeed, some diseases borne by small mammals can be transmitted to humans and some cases have been reported in Scandinavia and southern Canada.
    - The animal should be transferred into a clear and strong plastic bag. Place the bag around the trap and make sure there is no opening where the animal could escape.

Open the trap in the bag and allow the animal to fall in it before taking the trap out of the bag.

- Handling a small rodent is usually done by grabbing the abundant skin found behind the neck between the thumb and the index. People doing this for the first time should practice until being comfortable. This will help avoid injuries for both the handler and the animal and will speed up the manipulations, which means less stress for everyone.
- For each capture, you should:

  A. Weigh the bag with the animal inside with a spring balance

  B. Remove the animal from the plastic bag by grabbing it by the nape of the neck and check if it already has a marker (visually for ear-tags or with a scanner for PIT tags). If it is a marked individual, record the code in your field book (always check it twice, misreading is the most common error in the field with these types of markers). If it does not have a tag*, it needs to be marked (see below, "Marking animals").

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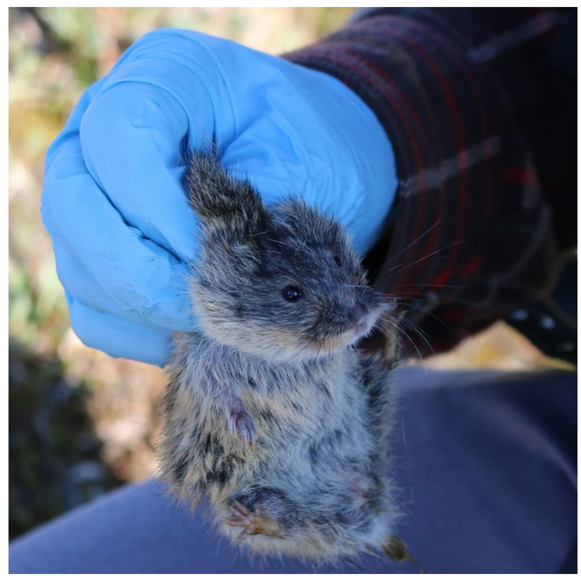
Weighing a lemming



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Grabbing a small mammal by the nape of the neck is the safest method for both the handler and the animal

* TIPS! – Torn ears

Some small mammals will accidentally lose their ear-tag which results in torn ears. Torn ears are easy to detect with a close inspection of the ears. These recaptured but unknown individuals can often be re-identified by matching them with previously captured individuals based on the station where they were captured (animals often move very little over a few days, though this is less true for adult males), body weight and sex. These animals should be tagged again before release, this time by placing a tag in the other ear.

C. Identify the animal captured to the species level (see Section 10.1. below for criteria)

D. Determine the sex of the animal (see Section 10.2. below for criteria)

E. Determine its reproductive condition (see Section 10.3. below for criteria)

F. Determine its age group (adult or juvenile) (see Section 10.4. below for criteria)

G. Weigh the bag and subtract from the initial weight of the animal with the bag to obtain the weight of the animal itself.

- After completing all the previous manipulations, release the animal. You then need to clean the trap, add new bedding material and a fresh bait and reset the triggering mechanism.
- If an animal is found dead in the trap, check it for the presence of a tag and record the rest of the data as if it was a live capture. Also record any information that could help determine the cause of death. Is the bait consumed? Is there a lot of faecal material in the trap? Is there any apparent wound on the animal's body? Is the animal's fur completely wet or is it dry?
- If you come upon a trap with a closed door but no capture (misfire), make sure the release mechanism is set properly. Check that the bait is still present and the bedding material is dry. If not, replace the synthetic bedding, put fresh bait and reactivate the trap.
- On the last trap check of a 3-day trapping session, you must decide if traps are to be removed or left in place. If other trapping session will be done later in the season, the traps can be locked open (only possible with in Longworth® traps) during the interval or closed (for Sherman® traps). If no more trapping will be done that year, then all traps should be collected, brought back to camp and cleaned thoroughly before storing them until next season.
- On the last visit of the last trapping session for the season, any new, unmarked animal does not need to be tagged but you do need to record all other information about its capture before releasing it.

4. Marking animals

With ear-tags:

- Locate its **left** ear and place the ear tag at the base of the ear flap, near the skull
- Make sure the tag pointed end has pierced through the ear flap, passed through the tag hole on the opposite side and folded over properly (check each tag alignment before placing in the pliers). Be careful not to clamp too much skin in the tag (increased risk of infection) but place the tag far enough into the ear so that it does not easily rip out*.
- **Record the tag number** in your field book.

* TIPS! – Ear-tagging lemmings

Collared lemmings have very small ears and you may need 2 persons to mark them properly if you are using ear-tags. The person handling the lemming can use both hands to hold it so that its right ear is exposed. The tagging person can use blunt tweezers to gently extend the ear flap with one hand and put the tag with the other hand. The ears of **brown lemmings** and *voles* are big enough to allow one person be to tag them without the use of tweezers. Collared lemming are often more agitated than other rodents so using an extra pair of hands for tagging is always recommended.

With PIT tags:

- Sterilize the end of the syringe needle with an antiseptic wipe as well as the PIT tag and insert the tag in the needle.
- While holding the animal by skin of the neck, insert the needle into the loose neck skin, under your finger, and inject the tag under the skin. Care should be taken not to insert the needle too far in the body, which could cause internal injuries to the animal.
- Make sure that the PIT tag has been injected properly and does not stick out of the fur when you remove the needle.
- Scan the lemming with the PIT tag reader to double-check that it is inside the animal.
- **Record the tag number** in your field book.

Another excellent document describing the methods of setting a live-trap transect or plot has been produced by the Government of the Northwest Territories and could also be consulted in parallel with the current text (ENR 2005b).

8.3.2. Field procedure for pitfall traps

For pitfall trap sampling, it is recommended to use trapping lines (minimum of 10) with at least 5 stations per line separated from each other by at least 60 m. It is best to use the same trapping sites and dates every year to allow comparison. Trapping sessions should last between 2 and 6 days depending on how many animals are captured.

1. Setting traps
    - Once the trapping lines are staked out, place a pitfall trap in a 10-m radius from each station, preferably at the intersection of 2 to 3 small mammal runways. Make sure the hole is deep enough so the top of the trap is flush with the ground and that it does not create an obstacle because animals should not have to climb.
2. Baiting traps
    - Put a handful of bedding material at the bottom of the trap.

- Add one piece of apple (~ ¼ of a large apple) for water. A small pea-size ball of peanut butter mixed with rolled oats can also be added.
- Don't forget to replace the trap cover to provide shade and protection for captured animals. If needed, put a rock on top of the cover to avoid it getting blown away.

3. Checking traps, manipulating and marking animals
    - Follow the same procedure as described for the Longworth®/Sherman® traps above.

8.4. TIME PERIOD

If only one live-trapping session can be done during the summer, we recommend conducting it in mid-summer (mid to late July) because in some species (especially lemmings) populations often start to decline by the end of the summer (August). Trapping can be conducted twice or three times during the summer if resources allow it. In that case, trapping sessions should be spaced out as much as possible. With two trapping session, the first one should be conducted in early summer (e.g. June), soon after snow-melt and the second one in late summer (e.g. August or September). If a third one is possible, it should be half-way between the two other sessions. Having more than 1 trapping session per year will allow tracking seasonal change in small mammal abundance and estimation of their survival rate (an important demographic parameter) based on the recapture of marked individuals between trapping sessions.

8.5. MATERIAL REQUIRED

When setting up a trapping grid:

- 50-m or 100-m measuring tape
- Apples (cut in quarters) and peanut butter mixed with rolled oats (prepared in advance) for bait
- Bamboo sticks to mark trapping stations
- Duct tape and permanent marker
- Field book and pencil
- GPS receiver
- Live traps
- Metal labels
- Synthetic bedding
- Wooden stakes to mark corners of the grid and beginning/end of lines

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Recording live-trapping data

During trap visits:

- Antiseptic wipe (e.g. benzalconium chloride) to clean syringe needle and PIT tag before injection
- Apples (cut in quarters) and peanut butter mixed with rolled oats (prepared in advance) for bait
- Blunt tweezer (for marking collared lemmings with a ear-tag)
- Field book and pencil
- Field guide to small mammals
- GPS receiver
- Garbage bag
- Knife to clean traps
- Permanent marker
- PIT tag syringe or tagging pliers
- PIT tag reader
- PIT tags or ear-tags
- Portable spring scale (100 g scale ideally)
- Strong Ziploc® bags for weighing and for accidentally killed animals
- Synthetic bedding

PROS

- **Provide the best abundance estimate without affecting the population for future surveys**
- **Captured animals captured can be easily identified at the species level**
- **Provide considerable information on population structure such as sex, age group, reproductive condition and body weight**
- **Mortalities are minimized with baits and bedding**
- **Method most often used for intensive ecological studies**

CONS

- **Costly material but cost is variable depending on traps and tagging method chosen**
- **Require relatively large time commitment**
- **Require training for handling small mammals**
- **Require training for correctly identifying reproductive conditions with external traits only**
- **Potential ethical issues (accidental mortalities)**

9. Photo trapping

9.1. DESCRIPTION OF THE CAMERAS

An automated camera. The model shown is a Silent Image® camera from RECONYX®

In the past 20 years, cameras automatically triggered by movements have been used extensively by hunters to track big game animals in their territory but they have also been used increasingly for monitoring wildlife. Infrared beams can detect movements during either night or day and trigger the camera to take pictures or videos. Cameras can also be programmed to take pictures at fixed intervals. Very large number of pictures can be accumulated over relatively short time periods though battery life and disk space will usually limit the number of pictures that can be collected. This is a modern, non-invasive technique to monitor wildlife over a wide range of condition. In some areas, automated cameras became the best tool to detect rare species such as large felines in tropical areas. Most cameras also have an infrared flash, which allows pictures to be taken in the dark. However, their lack of specificity regarding what is being photographed and the general absence of marks to differentiate individuals on pictures makes the technique less precise than traditional trapping methods to estimate abundance.

Cameras used for this type of monitoring are now manufactured by several companies: Bushnell®, RECONYX®, Acorn®, Spypoint®, etc. They are sometimes called «game cameras» or «trail cameras». We recommend RECONYX® or Bushnell® because they proved to be durable and we had good experience with these brands. These cameras are fairly rugged and can endure rough weather conditions, including the extreme cold of the Arctic winter. However, good cameras are relatively expensive, which makes this method less affordable for many projects involving wildlife monitoring. There is a wide price range for such cameras, usually from 100$ to 600$ per camera. However, additional expenses have to be considered for the memory cards to store pictures, the batteries, and physical supports (e.g. tripods) to deploy the cameras in the field.

9.2. DESCRIPTION OF THE METHOD

In order to conduct small mammal survey with automated cameras, we suggest deploying cameras in suitable habitats, either systematically (i.e. at fixed distance) or randomly across your study area. As this is still an experimental method that has not been used frequently with small mammals yet, it is difficult to provide more detailed recommendations on a specific sampling design. This method should be most useful to provide information on sites that are occupied by small mammals, the timing of occupancy, species involved and perhaps a relative index of abundance.

Cameras can provide information on small mammal activities during both summer and winter. However, some aspect of camera deployment will differ between these two seasons because in winter small mammals spend almost all their time under the snow. Therefore, this must be considered.

9.2.1. Summer deployment of cameras

1. Preparing the cameras
    - Before installing a camera in the field, it should be tested first to make sure that the mechanism is working properly and that pictures are correctly saved on the memory card.
    - Select in advance sites to deploy cameras in suitable habitat patches based on information available in the literature and by studying maps or by going directly in the field to validate the information.
2. Installing the cameras
    - Each camera should be set in an area showing sites of use by small mammals (e.g. runaways, faecal deposit, runaways) near each pre-selected site. The position of each camera should be recorded with a GPS receiver and marked with a permanent stake. For monitoring purpose, the same sites should be used over the years to allow comparison over time.
    - Cameras should be placed near the ground and aimed toward the area showing signs of use by small mammals and where plant cover will interfere minimally with the pictures. Cameras should be slightly tilted towards the ground to detect small mammals and avoid activation by non-target species such as foxes and birds. Some highly sensitive cameras may be triggered by vegetation blown by the wind.

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An automated camera deployed in the field to monitor a fox den during summer.

    - Tripods or any other devices supporting the cameras should be firmly anchored to the ground by steel wires and large nails or pegs for protection against strong winds and disturbance by large wildlife. The cameras should also firmly fixed to tripods to ensure that they do not move under strong wind.

3. Using baits
   - To increase detection of animals, especially when abundance is low, baits can be used.
   - Baits should be protected from non-target species and thus placed into a container that cannot be accessed by other animals. For instance, baits could be placed in the middle of PVC tubes (5 cm diameter, ~30 cm long). Care should be taken to ensure that animals entering by either end of the tube can be detected by the camera. A more expensive alternative could be to build small boxes made of clear plexiglass, which would allow observing the animal inside the box.
   - Baits should be added every week or whenever it has been depleted to ensure continuous sampling.
   - Peanut butter mixed with rolled oats and flour should be used as potential bait because it is rich and should last for several days before being depleted.
4. Operating and retrieving the cameras
   - Once the camera is installed, it should be activated with the required mode. Some modes include rapid photography so that 3 or more pictures are rapidly taken every time a movement is detected. New cameras can also capture videos of the detected animal.
   - Your programming should take into account the size of your memory card, the autonomy of your batteries and the frequencies at which cameras are visited to replace cards and batteries.
   - When the survey is completed, cameras should be removed from the field and safely stored.
   - All pictures taken by the cameras should be analysed and each time one small mammal is detected, it should be identified to species and entered into a database.

9.2.2. Winter deployment of cameras

This method has recently been used successfully to monitor small mammals under the snow in northern Norway (Soininen et al. 2015).

1. Preparing, operating and retrieving the cameras
   - Follow the same approach than for a summer deployment. However you should consider that during winter you may not be able to access the cameras as often. Therefore, you should program your cameras to ensure that the number of pictures taken does not exceed the capacity of your memory card or does not drain your batteries too rapidly. High capacity batteries such as lithium batteries must be used in

winter even tough they are more expensive.

2. Preparing, operating and retrieving the cameras
   - During winter, cameras must be installed in enclosed boxes. These boxes should be deployed in habitat suitable or lemmings such as snow beds where signs of winter use have been detected. Boxes and cameras should be installed in late summer/early fall, before the snow sets in.
   - Boxes originally designed to trap lemmings under the snow can be used to set cameras (Bilodeau et al. 2013). Small mammals can enter these boxes through PVC tunnels on either side of it and may even use them to build winter nests (see photo on the right). Cameras are set in the upper portion of these boxes, which have a chimney-like shape and aimed toward the bottom of the box to detect animals entering the box. Because focal distance is very short (~30 cm), care must be taken that the focus of the camera is adjusted accordingly, otherwise picture will be blurred. For a slightly different system, see Soininen et al. (2015).

© Dominique Fauteux

Wooden box holding an automated camera.

9.3. MATERIAL REQUIRED

- A computer
- Automated cameras
- Batteries for the cameras
- Field book and pencil
- GPS receiver
- In winter, wooden boxes of appropriate shape and size
- Memory cards for the cameras
- Memory card reader for the computer
- Physical supports (e.g. tripods, steel T-bars)

- PVC tubes and baits (if applicable)
- Steel wire with pegs

PROS	CONS
• Automated system with a high detection capacity • Provide species-specific estimation of occupancy • Can be used during any season • Require a low time investment once installed • Not necessary to kill or capture animals	• Costly but variable depending on type of camera • Allow only a gross estimation of abundance • Pictures not always clear and sometimes blurry due to movement (hard to identify species) • Subject to weather problems affecting visibility

10. Identifying small mammal species and their characteristics

10.1. SPECIES

Small mammals can be identified at the species level using several external characteristics, most of which can be applied directly in the field though others require more equipment (e.g. stereomicroscope to look at molar patterns of enamel) or dissection of the animal. It is always best to identify an animal based on more than one characteristic because some may be shared by more than one species. A good field guide of small mammals for your study area is always a good tool to start getting to know your potential captures. The Northwest Territories government (ENR 2005a) also produced a good document to identify northern small mammals

More than 15 species of small mammals have been surveyed in Nunavut and the Northwest Territories, though only a few species are commonly found (see Appendix). In Nunavut, only two species are common in the tundra: the brown lemming and the collared lemming. In this manual, we will focus primarily on criteria to distinguish these two species and to identify the sex, age and reproductive condition. The latter criteria, however, are not unique to these two lemming species and may be relevant to other lemming or vole species.

Collared lemming (*Dicrostonyx groenlandicus*)	**Brown lemming** (*Lemmus trimucronatus*)
Fur	
Winter: white coat; Summer: Back brownish-black with some buff, **dorsal dark stripe from snout to rump** commonly found, creamy-buff below.	Head greyish, reddish-brown back and rump; underparts creamy to medium brown. **Dorsal dark stripe from the snout to the base of the neck only**.

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COLLARED LEMMING

(*Dicrostonyx groenlandicus*)

BROWN LEMMING

(*Lemmus trimucronatus*)

Ears

Very short and **entirely concealed**

Well developed and round; **visible** through the fur

© Dominique Fauteux

© Dominique Fauteux

Front legs

Soles of the feet are **densely furred**; third and fourth fore claws **enlarged**.

© Guillaume Souchay

Fore claws of **normal size**.

© Frédéric Bilodeau

Faeces

Adult droppings **4-6 mm** long; often **pointed** at one or both extremities; generally **dark brown**.

Adult droppings **6-10 mm** long; **rounded** at both extremities; generally **light brown-green**.

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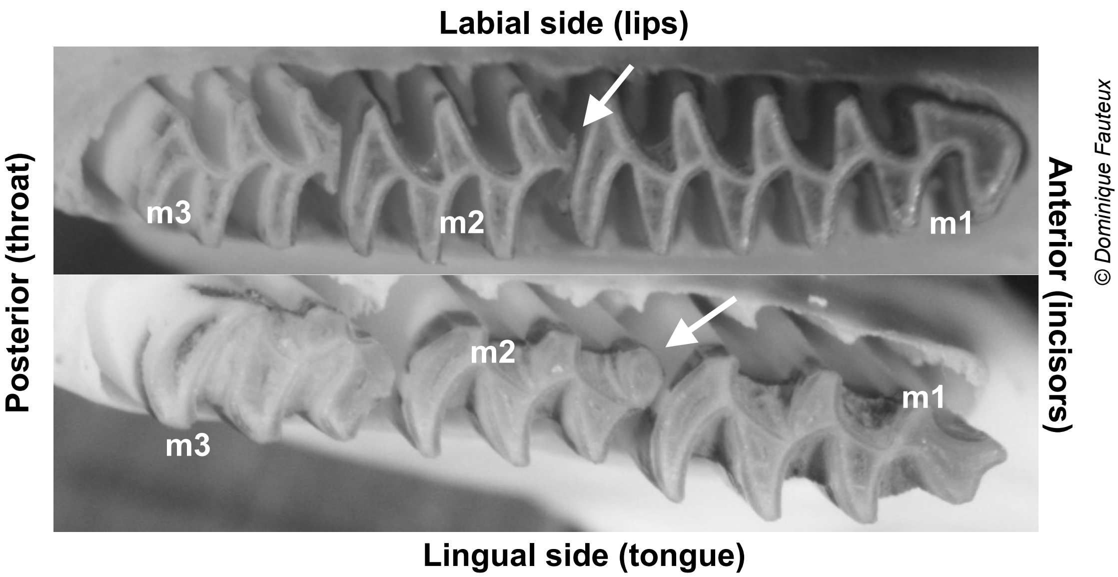
10.1.1. Dentition

When animals are found dead in the field it is also possible to identify them at the species level using their teeth. The animal must be dissected in the laboratory and its jaw bones are extracted to get a better view of the pattern of its dentition. Teeth need to be examined at least with a good magnifying glass or a stereomicroscope (10x to 40x). Figure 10.1 shows examples of one collared lemming and one brown lemming.



Jaw molars of a collared lemming (top) and a brown lemming (bottom). Collared lemmings have a very small loop of enamel on the anterior side of the second molar (m2; see arrows) while brown lemmings do not. The orientation of the pictures are indicated around the photos.

10.2. SEX

The gender of small mammals is fairly easy to determine. When the animal is grabbed by the nape of the neck (see Section 8.3 above), you can examine its ventral area to determine its sex. With your free hand, grasp and gently pull back its tail and hind feet to examine its external genitalia.

Male

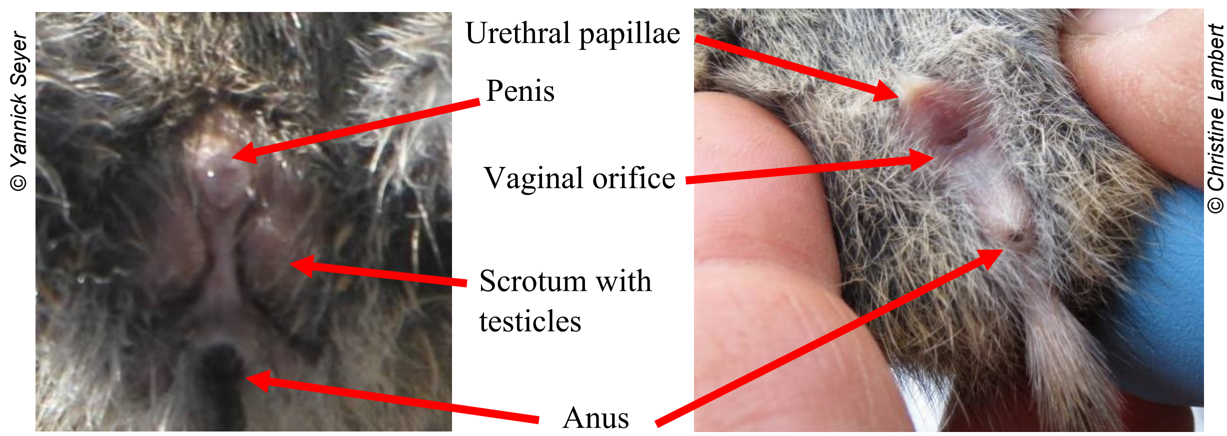
- Presence of a penis and scrotum
- Distance between the anus and penis relatively long
- In some males, the testicles will be pulled back inside the abdomen.

Female

- Presence of a urethral papillae (not to be confused with the penis)
- Presence of a vaginal orifice
- Distance between the anus and vaginal orifice relatively short

However, a small crest of skin (scrotal septum) running from the penis to the anus can be seen

- In young males, the scrotum is hard to discern but the scrotal septum can be seen when pulling the tail dorsally
- Presence of 2 rows of nipples on abdomen (as the nipples are hidden in the dense fur, it is best to blow air with your mouth on the abdomen of the animal to raise the hair and expose the nipples
- In young females, the vaginal orifice is closed but the absence of a scrotal septum (present only in males) when pulling the tail dorsally can be the best evidence



10.3. REPRODUCTIVE CONDITIONS

Within the same species of small mammals, the size of an individual is not an absolute criterion to decide of its ability to reproduce because sexual maturity can be achieved before or after adult body size is reached. The sexual maturity of individuals and thus their ability to reproduce must be determined based on the condition of their reproductive organs. When an animal is captured, you should try to categorize the animal into one of the following reproductive condition:

Females:

1. Immature;
2. Mature with perforated vagina only;
3. With enlarged nipples (lactating);
4. Pregnant.

Males:

1. Immature;
2. Mature with empty scrotum (abdominal testes);
3. Mature with testes in scrotum.

10.3.1. Females

Perforated vagina

The vagina is perforated when the hymen is gone and the vaginal orifice is 'open' (see arrow on the picture below). When the vaginal orifice is 'closed' it is almost invisible and the female would then be considered as non-reproductive (typically occurs in immatures but can happen in adults too).

Pregnant

In small mammals, the uterus presents itself as 2 horns (see arrows in picture below) in a V shape at the base of the abdomen. When a female is pregnant, you can feel the foetuses as small bumps when you **gently** feel the base of its abdomen, near the thighs. Pregnant females in advanced states will also have a conspicuously large abdomen.

© Christine Lambert

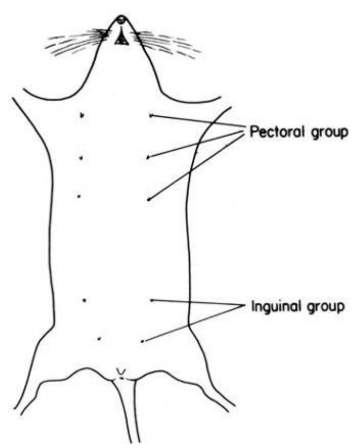
The vaginal orifice (opened)

© Dominique Fauteux

A dissected pregnant female brown lemming

Lactating

A female is considered as lactating if she is showing enlarged nipples on her abdomen. Enlarged nipples will be protruding from the skin of the animal whereas nipples of non-lactating females will appear as small dots on the skin. Because of the dense fur coat of lemmings, it is important to blow air on the abdomen with your mouth to expose the nipples.



© M.J. Cook, 1965

Location of nipples

10.3.2. Males

Scrotal testes vs. abdominal testes

In males, the only way to determine its reproductive status is to examine the region between the anus and the penis. Testes are considered 'scrotal' when they are prominent, well defined and inside the scrotum.

When testes are 'abdominal', the scrotum is well-developed but it is flat and empty. Palpating this body region (see picture below) is the only way to know if the scrotum is empty or not.

Mature males with testes in the scrotum

10.3.3. Non-reproductive female vs. non-reproductive male

If an animal does not fall into any of the conditions described above then it is considered non-reproductive. For some young individuals, their sex may be difficult to determine.

In young and non-reproducing males, the scrotum is difficult to see unless air is blown on the lemming fur. When the tail is pulled back you can sometimes see a thin line on the skin connecting the anus and the penis (see arrow on picture).

In young or non-perforated females (i.e. non-reproductive), it is also possible to observe a short line perpendicular to the anus-vagina axis at the base of the urethral papillae. This short line is the vaginal orifice that may still be closed due to the immature state of the animal or the absence of intercourse.

A non-reproductive male with an empty scrotum.

*** TIPS! – Relative age determined by weight**

Body weight can be used as a proxy for relative age by capturing 100 individuals or more of each sex and by determining the body weight threshold at which sexual maturity starts. On Bylot Island, there was a slight difference between male and female brown lemmings. Some exceptional individuals will reach maturity at very low body weight but they are not representative of the population. Thus, the first percentile (1%) of mature lemmings with the lowest body weight should be discarded to avoid an underestimation of the minimum threshold for maturity (see Appendix S3 in Fauteux et al. 2015 for details).

10.4. AGE GROUP

A small mammal can be classified in two age groups, 'adult' or 'juvenile' (or young) based on 2 types of information: its body weight and its reproductive condition. These two criteria can often be collected and used together to age an animal captured during snap trapping or live trapping surveys.

10.4.1. Body weight

On Bylot Island (NU), we have been live trapping brown and collared lemmings for more than 10 years and based on the body weight* recorded for each animal captured over the years, we have been able to develop a criteria (Table 10.1) that can accurately determine age* group for about 95% of the individuals in the field (Fauteux et al. 2015):

Table 10.1. Age classes of lemmings according to body weight

Sex	Brown lemming		Collared lemming	
Female	Juvenile	<28 g	Juvenile	<40 g
	Adult	≥28 g	Adult	≥40 g
Male	Juvenile	<30 g	Juvenile	<40 g
	Adult	≥30 g	Adult	≥40 g

10.4.2. Age and reproductive condition

There are always exceptions to every rule and occasionally the reproductive condition can overrule the age group of a captured individual when it was previously determined based on its body weight. As mentioned in Section 10.3, an animal can attain its sexual maturity before it has reached its adult size. However, certain reproductive conditions can only be associated to adults. These are: lactating female, pregnant female and male with scrotal testes (see Table 10.2 for more details).

Table 10.2. Possible age group association according to the reproductive condition

Reproductive condition	Female		Male	
	Juvenile	Adult	Juvenile	Adult
Non-reproductive	X	X	X	X
Perforated vagina	X	X		
Lactating		X		
Pregnant		X		
Scrotal testes				X
Abdominal testes			X	X

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12. APPENDIX

SMALL RODENT SPECIES OF ARCTIC CANADA

Here we present all the species present in the three Canadian territories (Naughton 2012): Yukon (YU), Northwest territories (NWT), and Nunavut (NU). The northern collared lemming and the brown lemming are the only two species present in the Canadian Arctic Archipelago. Other species present in Nunavut may be found on the southern continental area of the territory. The current work deals with methods for sampling small mammals in the Arctic Archipelago only but similar techniques described here may be applicable elsewhere considering the ecology of the other species present in the study area.

		YU	**NWT**	**NU**
Dicrostonyx groenlandicus	Northern collared lemming	X	X	X
Dicrostonyx nunatakensis	Ogilvie mountains collared lemming	X		
Dicrostonyx richardsoni	Richardson's collared lemming		X	X
Lemmus trimucronatus	Brown lemming	X	X	X
Microtus longicaudus	Long-tailed vole	X	X	
Microtus miurus	Singing vole	X	X	
Microtus oeconomus	Tundra vole	X	X	X
Microtus pennsylvanicus	Meadow vole	X	X	X
Microtus xanthognathus	Taiga vole	X	X	
Myodes gapperi	Southern red-backed vole		X	X
Myodes rutilus	Northern red-backed vole	X	X	X
Neotoma cinerea	Northern bushy-tailed rat	X	X	
Peromyscus keeni	Northwestern deer mouse	X		
Peromyscus maniculatus	Deer mouse	X	X	
Phenacomys intermedius	Heather vole	X	X	X
Synaptomys borealis	Northern bog lemming	X	X	
Zapus hudsonius	Meadow jumping mouse	X	X	

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