ARCTIC
VOL. 66, NO. 1 (MARCH 2013) P. 32–36

Evaluation of a Technique to Trap Lemmings Under the Snow

FRÉDÉRIC BILODEAU,[1,2] ALICE J. KENNEY,[3] B. SCOTT GILBERT,[4] ELIZABETH HOFER,[3] GILLES GAUTHIER,[1] DONALD G. REID,[5] DOMINIQUE BERTEAUX[6] and CHARLES J. KREBS[3]

(*Received 14 March 2012; accepted in revised form 31 May 2012*)

ABSTRACT. We attempted to live trap lemmings under the snow in their preferred winter habitat at two sites in the Canadian Arctic using chimney-like boxes. Lemmings used the boxes during winter, but we had very low trapping success in April and May. During spring trapping, in contrast to most of the winter, subnivean temperatures became colder than ambient air temperatures. We hypothesize that our low success in spring resulted from lemmings' leaving the deeper snow areas where our boxes were located and moving to shallower snow or exposed tundra. We suggest that the trapping boxes could be successful if trapping occurred earlier during winter.

Key words: lemmings, trapping, subnivean temperature, snow, *Dicrostonyx*, *Lemmus*

RÉSUMÉ. Nous avons tenté de capturer des lemmings sous la neige dans leur habitat hivernal préféré en utilisant des boîtes en forme de cheminée à deux sites situés dans l'Arctique canadien. Les boîtes ont été utilisées par les lemmings durant l'hiver mais nous avons eu un très faible succès de capture en avril et mai. Contrairement à la majorité de l'hiver, les températures sous-nivales étaient plus froides que les températures de l'air pendant que nous avons trappé au printemps. Nous émettons l'hypothèse que notre faible succès au printemps est dû au déplacement des lemmings des sites de fort enneigement, où nos boîtes étaient installées, vers ceux de faible enneigement ou vers la toundra exposée. Nous suggérons que les boîtes de trappage pourraient être plus utiles si le trappage se faisait plus tôt au courant de l'hiver.

Mots clés : lemmings, trappage, température sous-nivale, neige, *Dicrostonyx*, *Lemmus*

Révisé pour la revue *Arctic* par Nicole Giguère.

INTRODUCTION

Our understanding of the winter ecology of Arctic lemmings (*Dicrostonyx* and *Lemmus* spp.) remains poor despite almost a hundred years of study (Elton, 1924). New information has come to light in recent decades (MacLean et al., 1974; Sittler, 1995; Korslund and Steen, 2006; Kausrud et al., 2008; Gilg et al., 2009; Duchesne et al., 2011a; Ims et al., 2011; Reid et al., 2012), but much of it has been acquired indirectly. Lemmings live under the snow for up to eight months in the Arctic and build nests of vegetation as insulation from the cold. Much of our understanding of their winter ecology comes from sampling and analyzing these nests at snowmelt (MacLean et al., 1974; Sittler, 1995).

Our understanding would increase dramatically if we could live-trap lemmings through the snow and employ mark-recapture, radio-telemetry, and repeated tissue sampling. Some early attempts to trap small rodents through the snow had some success. In Russia, for example, Denisenko (1986) dug chimney-like shafts through the snow, installed snap traps near active subnivean lemming burrows, covered the traps, and then added back the snow. Though successful, such methods are time-consuming and result in repeated disturbance of the snow pack and subnivean space, significantly altering the habitat (Fay, 1960; Iverson and Turner, 1969). Therefore, we tested a less disruptive technique using trapping boxes that required little or no digging to access traps and allowed repeated access, as required by live-trapping techniques. These boxes were based on the design of Pruitt (1959) and had previously been used by Korslund and Steen (2006) to trap voles through the snowpack. In this paper, we describe the use of trapping boxes and a test of their effectiveness in trapping lemmings in winter at two sites in the Canadian High Arctic. Because the technique was not very effective during the time periods when we tested it, we provide some testable

[1] Département de Biologie et Centre d'Études Nordiques, Université Laval, 1045 Avenue de la Médecine, Québec, Québec G1V 0A6, Canada
[2] Corresponding author: frederic.bilodeau.4@ulaval.ca
[3] Department of Zoology, University of British Columbia, Vancouver, British Columbia V6T 1Z4, Canada
[4] Renewable Resources Management Program, Yukon College, Whitehorse, Yukon Y1A 5K4, Canada
[5] Wildlife Conservation Society Canada, 39 Harbottle Road, Whitehorse, Yukon Y1A 5T2, Canada
[6] Chaire de recherche du Canada en conservation des écosystèmes nordiques et Centre d'Études Nordiques, Université du Québec à Rimouski (UQAR), Rimouski, Québec G5L 3A1, Canada

hypotheses to explain this failure and recommend possible improvements.

METHODS

Study Area

The study was conducted on the south plain of Bylot Island in Sirmilik National Park, Nunavut (73˚08′ N, 80˚00′ W), and on Herschel Island, Yukon (69˚34′ N, 138˚55′ W). On Bylot Island, the study area (70 km^2) comprised upland plateaus and rolling hills dominated by mesic tundra and wetter lowland areas with tundra polygons, thaw lakes, and ponds. Small, intermittent streams running through upland areas supported riparian wetland vegetation. (Duchesne et al., 2011a). On eastern Herschel Island (50 km^2), two types of drier upland plant community—tussock tundra and prostrate-shrub heath—were dominant, with infrequent small wetlands (Reid et al., 2012). Both study areas supported cyclic populations of collared lemming (*Dicrostonyx groenlandicus*) and brown lemming (*Lemmus trimucronatus*; Gruyer et al., 2008, Krebs et al., 2011). On Herschel Island, lemmings were in their low phase in spring 2009 (Krebs et al., 2011). On Bylot Island, both species were in their increase phase in spring 2010; brown lemmings increased further to reach a peak in spring 2011, but collared lemming populations had crashed before that spring (G. Gauthier and F. Bilodeau, unpubl. data).

Selecting Trapping Sites

Trapping took place in spring 2009 on Herschel Island and in spring 2010 and 2011 on Bylot Island. We selected trapping sites with a high probability of winter use by lemmings. Wintering lemmings prefer heterogeneous microtopography and deep snow cover (≥ 60 cm), conditions that are typically found in hilly mesic tundra and along gullies bordering streams (Duchesne et al., 2011a). During early June 2009 on Bylot Island, we measured snow depth at 100 sites and pre-selected those with depths over 60 cm. After snowmelt, we checked these sites for evidence of lemming use during winter and then selected 40 sites with the highest density of sign at which to install the trapping boxes. Boxes were spread over 98 ha, and the distance between boxes ranged from 42 to 155 m. On Herschel Island, we mapped lemming winter nests after snowmelt in June 2007 and June 2008. In September 2008, we chose trapping sites where there had been clusters of winter nests during the previous two winters and placed 27 trapping boxes on one 9 ha area, and four trapping boxes on another 2.5 ha area.

Trapping Boxes

To allow placement of live traps at ground level and access to those traps through the snow pack, we built chimney-like boxes (60 cm high, 40 cm long, and 20 cm wide) of 1.3 cm plywood, with a removable lid insulated with 5 cm of foam (Fig. 1). Once installed, trapping boxes were secured to the ground with two 2 m metal stakes to resist wind and disturbance by caribou. The interior floor of a box was large enough for a Longworth® live trap, with extra space for lemmings to move around. Lemmings could enter the boxes through two plastic tubes, each 20 cm long and 5 cm in diameter, located on opposite sides of the box at ground level. At both study areas, a trap with cotton bedding was locked open and placed inside each box at the end of summer. At Herschel Island, we opened the boxes just before snowmelt in April 2009, examined them for signs of lemming use, and baited the traps with apple. The traps were set for two days and checked every two hours. At Bylot Island, we opened the boxes in early May and set traps with cotton bedding, baiting them with apples and peanut butter. We visited traps every six hours for 10 days in May 2010 and 5 days in May 2011. We inferred lemming use of boxes during winter from feces or nests left in the boxes. We judged lemming species and determined whether reproduction had occurred on the basis of feces size, shape, and colour, according to Duchesne et al. (2011b).

On Bylot Island, we installed 20 temperature loggers (i-buttons®) on the floor of boxes (16 in 2009 and 4 in 2010) in late August and 60 outside at ground level each year to compare temperatures inside the boxes with those in the surrounding subnivean space during winter. Of the sites outside boxes, 55 (33 in 2009 and 22 in 2010) were covered by 60 cm or more of snow, and 65 (27 in 2009 and 38 in 2010) had less than 60 cm of snow cover and were chosen at random.

Snowmelt

We monitored snowmelt by measuring snow depth along two 250 m long transects every two days until all snow had disappeared. Monitoring began each year on 19 May on Bylot Island and 21 May on Herschel Island.

RESULTS

At Herschel Island, on the 2.5 ha area, all four boxes, when checked in late winter, contained winter nests built by brown lemmings but later taken over by weasels (likely *Mustela nivalis*, judging by feces size). Each box had the remains of one or two lemmings. On the 9 ha area, only one box had a winter nest (built by a collared lemming), while 12 of 27 boxes contained feces, a sign that collared lemmings had visited the boxes at some time. Winter nests were also found within 5 m of four boxes. Two days after baiting, the apple had disappeared from four boxes, but only one juvenile male collared lemming (28.5 g) was captured.

At the Bylot Island site, lemmings left sign indicating use or visitation at 13 of 40 boxes in 2010 and 31 of 40 boxes in 2011. They had built nests in some boxes (0/40 in 2010 and 10/40 in 2011). In 2010, boxes were used by collared

FIG. 1. Picture of a trapping box on Herschel Island.

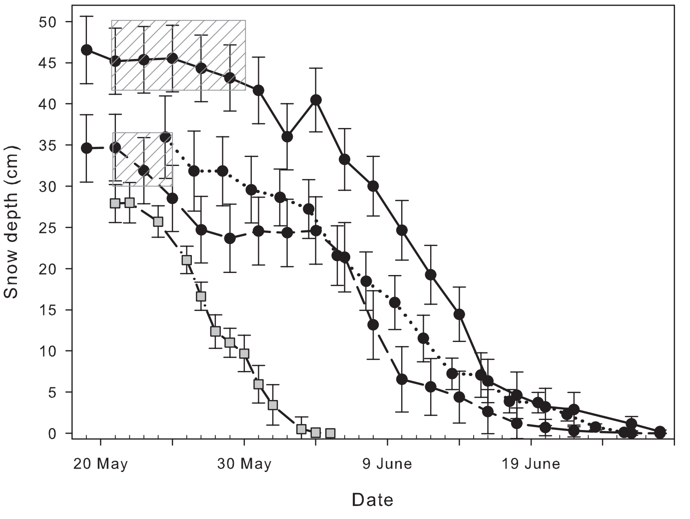

FIG. 2. Change in snow depth along transects during snowmelt on Herschel Island in spring 2009 (gray boxes, dashed-dotted line) and on Bylot Island (black circles) in spring 2010 (solid line), spring 2011 (dashed line), and the long-term mean for 1995–2011 (dotted line). Error bars represent SE. Hatched areas represent periods when trapping took place on Bylot Island each year.

lemmings (7/40), brown lemmings (2/40), or both species (4/40), but only brown lemmings used the boxes in 2011. Signs of reproduction were found in one box in 2011 and none in 2010. Winter nests were also found near 15 boxes in 2010 and 19 boxes in 2011. Stoats (*Mustela erminea*) used some boxes (1/40 in 2010 and 4/40 in 2011) to store lemmings they had killed in the surrounding area or, in one case, the lemmings occupying a nest built inside a box. No lemmings were caught in the boxes in spring, despite all the sign of winter use and even though lemmings were at high densities during both winters (G. Gauthier and F. Bilodeau, unpubl. data).

Snow depth at the end of winter on Bylot Island was near average in 2011 but much deeper in 2010 (Fig. 2). Our trapping occurred during early snowmelt in both years. Snowmelt was faster during trapping in 2011 (6.2 cm loss in five days) compared with 2010 (3.5 cm loss in 10 days). Tunnels leading into the boxes were not blocked by hard snow or ice, suggesting that lemmings could have accessed traps easily during the trapping period.

From early December to late April on Bylot Island, subnivean temperatures were higher than ambient air temperatures, whereas temperatures inside boxes were slightly higher than those at random subnivean sites covered by less than 60 cm of snow but lower than those at sites with 60 cm or more of snow cover (Fig. 3). However, the situation was reversed during May, when trapping occurred. In May 2010 and 2011, respectively, average temperatures in boxes were 6.6˚C and 6.3˚C lower than ambient temperatures and 0.4˚C and 1.4˚C lower than those at random sites, but 1.0˚C higher in 2010 and 1.1˚C lower in 2011 than sites with 60 cm or more of snow.

DISCUSSION

Unlike previous studies that used boxes similar to ours to trap voles under the snow (Sullivan et al., 2004; Korslund and Steen, 2006), we had poor success trapping lemmings under the snow during late winter in the Canadian Arctic. Yet, lemmings used our trapping boxes extensively sometime during winter. On Herschel Island, where we were able to trap before snowmelt, we caught one lemming, and bait from several boxes had been eaten. Lemming population density on Herschel Island was relatively low by spring that year (Krebs et al., 2011) and would have contributed to our low trapping success.

Snow is a good insulating material, as shown by the higher subnivean compared to ambient air temperatures we recorded during winter. Temperatures were also higher inside our boxes than at random subnivean sites in winter, so the boxes provided a suitable temperature regime for lemmings. Lemmings are attracted to warmer subnivean sites in winter (Duchesne et al., 2011a; Reid et al., 2012), so we presume that lemmings mostly used the boxes in winter. However, in late winter or early spring, the temperature profile in the snow pack changes, so ambient air is generally warmer than the subnivean space. In May of both years, temperatures inside our trapping boxes were actually colder than those at all other sites available to lemmings. After this thermal inversion, lemmings therefore had a clear thermal advantage in moving to exposed tundra without snow or to sites with shallow snow. We hypothesize that the colder temperatures inside boxes in May explain why we caught no lemmings on Bylot Island in that month.

When we were trapping on Bylot Island, snow had started to melt and snow depth was continually decreasing

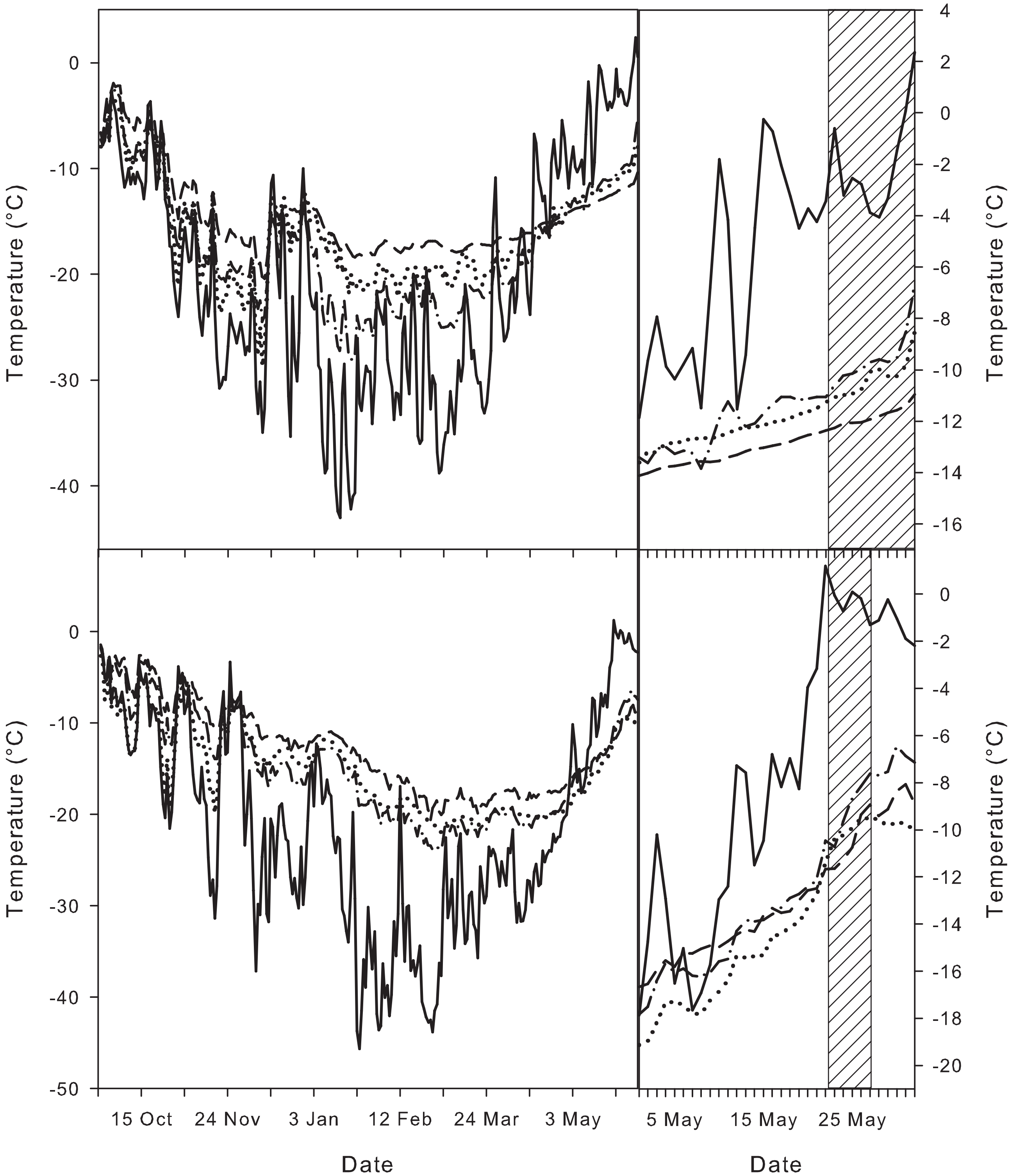

FIG. 3. Comparison of daily temperatures on Bylot Island during winters 2009–10 (upper panel) and 2010–11 (lower panel). Lines show temperatures of ambient air (solid line), subnivean space with 60 cm or more of snow cover (dashed line), subnivean space with less than 60 cm of snow cover (dashed-dotted line), and trapping boxes (dotted line). Hatched areas represent periods when trapping occurred.

(Fig. 2). During melt, ice can form in the subnivean space, potentially restricting access to food plants, and meltwater may flood low-lying areas. Lemmings may have moved out of areas with deeper snow pack in anticipation of these spring events and to gain better access to early growing plants on exposed tundra.

There is a concern that use of the boxes by weasels and stoats may have deterred lemmings from using the same boxes. However, brown lemmings readily go into live traps, even those baited to catch stoats (F. Bilodeau, pers. obs.), so the past use of boxes and their traps by stoats is unlikely to be a factor reducing lemming trappability.

CONCLUSION

We hypothesize that trapping with our boxes would be more successful if conducted during winter and before the spring overturn of the temperature gradient in the snow pack. This hypothesis could be tested at field sites with easier winter access than ours. To improve the insulative capacity of the boxes, especially before snow depth accumulates to 40 or 50 cm, we recommend increasing the thickness of foam insulation in the lid. Prior studies that successfully trapped small mammals during winter (Schweiger and Boutin, 1995; Sullivan et al., 2004; Korslund and Steen, 2006) suggest that trappability could also be improved by (1) deploying the boxes with baited traps prior to snowfall, so that the traps become an established feature of the environment for the target animals, and (2) maintaining a fairly frequent live-trapping regime, including pre-baiting, within the boxes so that the bait provides fairly consistent and frequent positive reinforcement for rodents during the entire winter. Differences in capture rates between boxes submitted to such trapping protocols and boxes without them should be tested to determine whether the protocols improve capture success.

ACKNOWLEDGEMENTS

We thank S. Pellerin for her help in building the boxes, M. Desnoyers and E. Soininen for help during trapping, and B. Sittler and O. Gilg for their comments on an earlier version of this paper. The research benefited from the logistic assistance of the staff of the Polar Continental Shelf Program (PCSP, Natural Resources Canada), the Rangers of Yukon's Herschel Island Territorial Park, and the staff of Sirmilik National Park. The research was funded by the Natural Sciences and Engineering Research Council of Canada, the Canadian federal government's International Polar Year program (Project MD-021), and the Northern Scientific Training Program (both administered by Aboriginal Affairs and Northern Development Canada), the Fonds québécois pour la nature et les technologies of the Quebec government, the Canadian Network of Centres of Excellence ArcticNet, and the PCSP.

REFERENCES

Denisenko, A.M. 1986. Population dynamics of lemmings (*Lemmus sibiricus* and *Dicrostonyx vinigradi*) on Wrangel Island. Fauna of Wrangel Island. [in Russian] Vladivostok: Academy of Science of the USSR. 109–114.

Duchesne, D., Gauthier, G., and Berteaux, D. 2011a. Habitat selection, reproduction and predation of wintering lemmings in the Arctic. Oecologia 167(4):967–980.

———. 2011b. Evaluation of a method to determine the breeding activity of lemmings in their winter nests. Journal of Mammalogy 92(3):511–516.

Elton, C.S. 1924. Periodic fluctuations in the number of animals: Their causes and effects. Journal of Experimental Biology 2(1):119–163.

Fay, F.H. 1960. Technique for trapping small tundra mammals in winter. Journal of Mammalogy 41(1):141–142.

Gilg, O., Sittler, B., and Hanski, I. 2009. Climate change and cyclic predator–prey population dynamics in the high Arctic. Global Change Biology 15(11):2634–2652.

Gruyer, N., Gauthier, G., and Berteaux, D. 2008. Cyclic dynamics of sympatric lemming populations on Bylot Island, Nunavut, Canada. Canadian Journal of Zoology 86(8):910–917.

Ims, R.A., Yoccoz, N.G., and Killengreen, S.T. 2011. Determinants of lemming outbreaks. Proceedings of the National Academy of Sciences 108(5):1970–1974.

Iverson, S.L., and Turner, B.N. 1969. Under-snow shelter for small mammal trapping. Journal of Wildlife Management 33(3):722–723.

Kausrud, K.L., Mysterud, A., Steen, H., Vik, J.O., Østbye, E., Cazelles, B., Framstad, E., et al. 2008. Linking climate change to lemming cycles. Nature 456(7218):93–97.

Korslund, L., and Steen, H. 2006. Small rodent winter survival: Snow conditions limit access to food resources. Journal of Animal Ecology 75(1):156–166.

Krebs, C.J., Reid, D., Kenney, A.J., and Gilbert, S. 2011. Fluctuations in lemming populations in north Yukon, Canada, 2007–2010. Canadian Journal of Zoology 89(4):297–306.

MacLean, S.F., Jr., Fitzgerald, B.M., and Pitelka, F.A. 1974. Population cycles in Arctic lemmings: Winter reproduction and predation by weasels. Arctic and Alpine Research 6(1):1–12.

Pruitt, W.O., Jr. 1959. A method of live-trapping small taiga mammals in winter. Journal of Mammalogy 40(1):139–143.

Reid, D.G., Bilodeau, F., Krebs, C.J., Gauthier, G., Kenney, A.J., Gilbert, B.S., Leung, M.C.-Y., Duchesne, D., and Hofer, E. 2012. Lemming winter habitat choice: A snow-fencing experiment. Oecologia 168(4):935–946, doi:10.1007/s00442-011-2167-x.

Schweiger, S., and Boutin, S. 1995. The effects of winter food addition on the population dynamics of *Clethrionomys rutilus*. Canadian Journal of Zoology 73(3):419–426.

Sittler, B. 1995. Response of stoats (*Mustela erminea*) to a fluctuating lemming (*Dicrostonyx groenlandicus*) population in North East Greenland: Preliminary results from a long-term study. Annales Zoologici Fennici 32(1):79–92.

Sullivan, T.P., Sullivan, D.S., Reid, D.G., and Leung, M.C. 2004. Weasels, voles, and trees: Influence of mustelid semiochemicals on vole populations and feeding damage. Ecological Applications 14(4):999–1015.