

Climate change and assisted migration of montane mammals

Jeffrey Lane

Department of Biology, University of Saskatchewan

Progress Report prepared for the Biodiversity Management and Climate Change
Adaptation Project

March 2014



Disclaimer:

The material in this publication does not imply the expression of any opinion on the part of any individual or organization other than the authors. Errors, omissions or inconsistencies in this publication are the sole responsibilities of the authors.

The authors and ABMI assume no liability in connection with the information products or services made available by the institute. While every effort is made to ensure the information contained in these products and services is correct, the ABMI disclaims any liability in negligence or otherwise for any loss or damage which may occur as a result of reliance on this material.

CCEMC makes no warranty, express or implied, nor assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information contained in this publication, nor that use thereof does not infringe on privately owned rights. The views and opinions of the author expressed herein do not necessarily reflect those of CCEMC. The directors, officers, employees, agents and consultants of CCEMC are exempted, excluded and absolved from all liability for damage or injury, howsoever caused, to any person in connection with or arising out of the use by that person for any purpose of this publication or its contents.

Use of this material:

This publication may be reproduced in whole or in part and in any form for educational, data collection or non-profit purposes without special permission from the authors or ABMI, provided acknowledgement of the source is made. No use of this publication may be made for resale without prior permission in writing from the ABMI.

Suggested citation:

Lane, J. 2014. Climate change and assisted migration of montane mammals. *Prepared for the Biodiversity Management and Climate Change Adaptation project/ Alberta Biodiversity Monitoring Institute*. Edmonton AB. 12pp.

Corresponding author:

Dr. Jeffrey Lane
Department of Biology
University of Saskatchewan
Saskatoon, Saskatchewan, Canada S7N 5E2
Email: Jeffrey.Lane@usask.ca

Alberta Biodiversity Monitoring Institute

CW-405 Biological Sciences
University of Alberta
Edmonton, Alberta, Canada T6G 2E9
Phone: (780) 492-6322
E-mail: abmiinfo@ualberta.ca

This report was produced as part of the Biodiversity Management and Climate Change Adaptation Project. This project is led by the Alberta Biodiversity Monitoring Institute, with collaborators from the University of Alberta, the University of Saskatchewan and the Miistakis Institute. The project receives its core funding from the Climate Change and Emissions Management (CCEMC) Corporation.



CCEMC



MIISTAKIS
INSTITUTE

REPORT SUMMARY

REPORT SUMMARY

The Biodiversity Management and Climate Change Adaptation project is intended to provide knowledge and tools necessary to manage biodiversity in a changing climate. This report provides a summary of work completed during summer, 2013 on the influences of climate on a resident montane mammal, the Columbian ground squirrel. Through monitoring of wild populations and experimental translocation of individuals across populations, this research is providing essential knowledge on the natural adaptation of a resident mammal. In addition, it is assessing the utility of experimental translocation as a scientific and conservation tool to understand and mitigate biodiversity effects of climate change.

STATUS REPORT ON FIELD ACTIVITIES RELATED TO CLIMATE CHANGE AND ASSISTED MIGRATION OF MONTANE MAMMALS

Background

The fundamental niche of a population is defined as the range of conditions over which it can persist and the resources that it can use. At least two of the predominant abiotic factors comprising most species' fundamental niches, temperature and precipitation, are being affected due to widespread and ongoing climate change. Of concern for many mammalian populations, is the rates at which these factors are changing are projected to outpace the speed at which the populations can react (through range shifts to more hospitable locations; Schloss et al., 2012). Moreover, as range shifts are expected to be predominantly towards higher latitudes and elevations, species already residing in these locations (polar regions and mountain tops) risk being left with nowhere else to go. Population declines for many mammalian species are thus projected and adaptation *in situ* may represent the only process through which this fate may be averted.

Phenological adjustments represent an important form of *in situ* adaptation and, indeed, are the most often reported ecological response to climate change (Parmesan, 2006). Phenologies represent the seasonal timing of annually recurring life history events and are assumed to have evolved so as to synchronize energetically expensive events (i.e., reproduction) with seasonal peaks in resource abundance (Michener, 1983). As the timings of resource availabilities are shifting due to climate change, those species for which a phenological adjustment have not been observed or for which phenological adjustments have been insufficient so as to maintain synchrony with primary food

resources are more likely to suffer declines both in terms of individual fitness (Both et al., 2009) and population viability (Møller et al., 2008). For example, egg-laying dates of many insectivorous passerines have evolved so as to synchronize the subsequent fledging of nestlings with peaks in caterpillar abundances. As the component species in an ecosystem (insectivorous birds, folivorous caterpillars, and caterpillar host plants in this case) often respond differently to climate change, individual birds that are better able to adjust their phenologies are those that are most likely to be reproductively successful (Both et al., 2009).

In contrast to the impressive body of literature that has been compiled on bird phenologies, mammalian phenologies have received relatively little attention. As endotherms, mammals and birds are confronted with the similar energetic challenges of maintaining high and constant body temperatures and fuelling the energetic demands of reproduction. They do, however, meet these challenges with distinctly different ecologies. Many birds are considered ‘income breeders’ (i.e., rely on the consumption of food (e.g., insects) to fuel the demands of reproduction). In contrast, many mammals are considered ‘capital breeders’ (i.e., rely on previously accumulated resources (e.g., fat) to fuel reproduction). In addition, whereas many birds escape periods of resource shortages spatially (through migration), most mammals are sedentary and must cope with these periods on site. One such coping mechanism, widespread throughout the mammalian lineage, is hibernation.

Hibernation is characterized by a sustained period of behavioural dormancy and depressed body temperatures lasting weeks to months (Geiser & Ruf 1995). The amazing physiological and molecular mechanisms that enable such a transition have attracted

scientific interest for decades, resulting in an impressive number of laboratory studies designed to better understand these mechanisms. The ecological and evolutionary significance of variation in hibernation expression in the wild, however, is comparatively less well known. By extension, how hibernation phenology may respond to climate change and whether these adjustments may be sufficient so as to prevent population declines is poorly understood.

Columbian ground squirrels (*Urocitellus columbianus*) are small-mid sized rodents (< 1 kg) resident throughout the northern Rocky Mountains. They spend the majority of the year (~ 8-9 months) hibernating, emerging in mid-April for a brief (3-4 month) active season. We have recently shown that emergence date from hibernation is a heritable trait (i.e., it has the potential to evolve) and that there are strong genetic correlations between male and female emergence dates and between emergence date and mating date in females (Lane et al., 2011). The former correlation indicates that evolution in one sex is likely to lead to correlated evolution in the other sex and the latter provides support to the hypothesis that emergence dates from hibernation have evolved so as to synchronize subsequent reproduction with the timing of resource availabilities. We have also shown that, in contrast to the vast majority of reports of advancing phenologies in response to climate change, the emergence dates from hibernation of Columbian ground squirrels have actually been consistently delayed over the past two decades (Lane et al., 2012). This delay was due to a phenotypically plastic response to an increasing prevalence of late season snowstorms over the study period. Of concern, delayed phenologies are detrimental as the fitness of individuals and the viability of the population are decreased during years of later emergence. In total, dates of hibernation

emergence have the potential to respond to climate variation through both microevolution and phenotypic plasticity. These responses are likely consequential for the viability of the population and determining their relative influences are thus imperative.

In 2008, I initiated a reciprocal translocation experiment to better understand the relative roles of genetic differences and phenotypic plasticity in producing individual variation in hibernation phenology (Fig 1.). Phenologies of individuals naturally vary by up to one month along an elevation gradient in the Rocky Mountains (Murie & Harris, 1982) and I have completed three reciprocal translocations of individuals across it. Translocated individuals have been released into their new populations and now reside alongside resident individuals. This experimental approach is providing me with the ability to directly evaluate the role of genetic differences (by comparing the phenotypic similarity of transplanted individuals to resident individuals in their natal population) and environmental variation (by comparing the phenotypic similarity of transplanted individuals to resident individuals in their adoptive population) underlying phenotypic variation in hibernation phenology. Specifically, I am addressing the following four objectives:

1. What is the extent of phenotypic variation in hibernation emergence dates across two populations of Columbian ground squirrels that differ in elevation by ~500 m?
2. To what extent is observed phenotypic variation attributable to genetic differences versus environmental variation?
3. How does hibernation expression (body temperatures during hibernation) vary across the two populations?

4. Does translocation represent a viable scientific and/or conservation tool for investigating and/or managing climate change effects on wild mammal populations?

Field Activities 2013

Summer 2013 marked the sixth year of this study and the first conducted in collaboration with the Alberta Biodiversity Monitoring Institute and the Biodiversity Management and Climate Change Adaptation research group. During summer 2013, we caught and monitored 385 individual Columbian ground squirrels across the two populations.

Population A is in Sheep River Provincial Park, AB (50.7° N, 114.6° W, and 1500 m a.s.l.) and population B is at Hailstone Butte, west of Longview, AB (50.1° N, 114.3° W, and 2050 m a.s.l.). From population A, we caught and monitored 183 adults (92 males and 91 females) and from population B, we caught and monitored 120 adults (58 males and 62 females). We also caught 41 yearlings (born the previous year) in population A (23 males and 18 females) and 41 yearlings from population B (15 males and 26 females).

Among adults, males from population A had the earliest emergences (mean \pm SE Julian date = 118.94 ± 0.91 [ca. Apr 28]). Mean emergence (\pm SE) of females from population A was 124.94 ± 0.75 (ca. May 4). Mean emergence (\pm SE) of males from population B was 125.21 ± 1.13 (ca. May 5) and females from population B had the latest emergences at 130.30 ± 1.09 (ca. May 10).

From 2008 to 2010, I translocated 43 pregnant females across the two populations (23 females from population A to population B and 20 females from population B to population A). Including the 94 weaned offspring from these females (51 from

population A to population B and 43 from population B to population A), this resulted in 137 translocated individuals across the three years. In 2013, seven of these individuals (plus an additional 12 animals that served as treatment controls [moved within their natal meadow]) were still alive and monitored. In the coming months, these data will be added to the data collected across the full study duration to compare the emergences of translocated, treatment control and unmanipulated animals.

We collected temperature-sensitive collars (previously deployed in autumn 2012) from 30 adults (20 females and 10 males) in population A and from 19 adults (16 females and 3 males) in population B. To monitor body temperature profiles over the 2013-2014 hibernation period, 60 temperature-sensitive collars were placed on adults from population A (30 on females and 30 on males). We did not place collars on individuals from population B because severe flooding in southern Alberta limited our access to the study site. Collars will be retrieved from all surviving individuals in spring 2014.

Future Plans

We will continue population-level monitoring in 2014. However, while population A will be monitored according to previous protocols, population B will not be monitored. Severe flooding in southern Alberta in 2014 cut off our access to the study site (by washing out Highway 532). As predicted, individuals from population B did emerge later than those from population A (males ~ 7 days later and females ~ 5.5 days later). However, this level of variation is exceeded by between year variation within one population (Lane et

al., 2012). Consequently, in 2014, we will establish a different study population at a higher elevation (~ 2200 m, near Highwood Pass, AB).

The full, 6-year, data set will be compiled and analyzed during 2014 to compare the emergence dates of translocated, treatment control and unmanipulated animals. Survival rates and reproductive success among these three groups will also be compared to assess the validity of experimental translocation as a potential scientific and/or conservation tool for resident mammals. We have also deployed temperature-sensitive collars for five years, including the 60 collars deployed in autumn 2013. Upon collection of these collars in spring 2014, I will compile and analyze these data. Specifically, dates of behavioural entry into hibernation will be compared to dates of physiological entry (defined by sequestration in the hibernaculum and a drop in body temperature, respectively). Physiological and behavioural emergence (a rise in body temperature and emergence from the hibernaculum) will also be defined and compared for each individual. Lastly, the number and duration of periodic arousals to euthermia (i.e., temporary increases in body temperature to euthermic temperatures throughout the hibernation period; Fig 2) will be quantified for each individual. These data will be compared between each sex and each population and relationships among traits (e.g., do individuals/sexes/populations entering hibernation earlier in the autumn, emerge earlier the following spring?) will be investigated

In July 2013 I began a new position as an Assistant Professor in the Department of Biology at the University of Saskatchewan. During the 2014-2015, I anticipate recruiting 2 graduate students to undertake thesis projects on the Columbian ground squirrel system. I look forward to collaborating with the Alberta Biodiversity Monitoring

Institute and the Biodiversity Management and Climate Change Adaptation research group as I enter this new phase of research growth.

Acknowledgement of Funding Sources

This project has been made possible through generous funding from: CCEMC (Biodiversity Management and Climate Change Adaptation project), Royal Society of London (International Incoming Fellowship to Lane and Loeske Kruuk), Natural Sciences and Engineering Research Council of Canada (Discovery Grants to Stan Boutin and Jan Murie), Alberta Conservation Association (Grants Eligible Conservation Fund grants to Lane, Anne Charmantier and Stan Boutin), National Science Foundation (grant to Stephen Dobson) and Agence Nationale de la Recherche (grant to Anne Charmantier and Stephen Dobson)

Literature Cited

- Both, C., van Asch M., Bijlsma R. G., van den Burg A. B. & Visser M. E. 2009. Climate change and unequal phenological changes across four trophic levels: constraints or adaptations? *J. Anim. Ecol.* **78**: 73-83.
- Geiser, F. & Ruf, T. 1995. Hibernation versus daily torpor in mammals and birds: physiological variables and classification of torpor patterns. *Physiol. Zool.* **68**: 935-966.

- Lane, J. E., Kruuk, L. E. B., Charmantier, A., Murie, J. O. & Dobson, F. S. 2012. Delayed phenology and reduced fitness associated with climate change in a wild hibernator. *Nature* **489**: 554-557.
- Lane, J. E., Kruuk, L. E. B., Charmantier, A., Murie, J. O., Coltman, D. W., Buoro, M., Raveh, S. & Dobson, F. S. 2011. A quantitative genetic analysis of hibernation emergence date in a wild population of Columbian ground squirrels. *J. Evol. Biol.* **24**: 1949-1959.
- Michener, G.R. 1983. Spring emergence schedules and vernal behaviour of Richardson's ground squirrels: why do males emerge from hibernation before females? *Beh. Ecol. Sociobiol.* **14**: 29-38.
- Møller, A. P., Rubolini, D. & Lehikoinen, E. 2008. Populations of migratory bird species that did not show a phenological response to climate change are declining. *Proc. Natl. Acad. Sci. USA* **105**: 16195-16200.
- Murie, J. O. & Harris, M. A. 1982. Annual variation of spring emergence and breeding in Columbian ground squirrels (*Spermophilus columbianus*). *J. Mammal.* **63**, 431-439.
- Parmesan, C. 2006. Ecological and evolutionary responses to recent climate change. *Annu. Rev. Ecol. Evol. Syst.* **37**: 637-669.
- Schloss, C. A., Nuñez, T. A. & Lawler, J. J. 2012. Dispersal will limit ability of mammals to track climate change in the western hemisphere. *Proc. Natl. Acad. Sci. USA* **109**: 8606–8611.

Figure Legends

Figure 1. The experimental enclosures used in translocation experiment. Individual pregnant female Columbian ground squirrels were released into each enclosure and, after an acclimatization period, were permitted to dig out by cutting a hole into the bottom of the wire mesh. The top panel shows an enclosure on site in the high elevation population and the bottom panel shows an enclosure on site in the low elevation population. Both photos were taken on the same day, revealing the climatic differences across the two locations.

Figure 2. Body temperature profiles for two female Columbian ground squirrels. The top panel represents the profile for a female at the high elevation study site (50.1° N, 114.3° W, and 2050 m a.s.l.) and the bottom panel represents the profile for a female at the low elevation study site (50.7° N, 114.6° W, and 1500 m a.s.l.).

Figures

Fig. 1.



Fig. 2.

