I Spy Through a Camera's Eye: *Divii* in the Gwich'in Settlement Area

by Sydney Goward

INTRODUCTION

Temperatures in the Arctic are increasing at a rate two to three times faster than the global average (Cohen et al., 2014), which is disproportionately impacting wildlife and Indigenous peoples residing in these landscapes (Ford and Smit, 2004; Parkinson and Berner, 2009; Brinkman et al., 2016). Climate change is altering tundra vegetation productivity and phenology, modifying snow conditions, and increasing the frequency and severity of extreme weather events (Mann et al., 2017; Myers-Smith et al., 2020). These ecological changes are further impacting vertebrate species in ways currently not well understood. Dall sheep (*Ovis dalli dalli*), a species of cultural, ecological, and economical significance, is an example of one species facing the current and looming threats of climate change. Uncertainty about the effects of ecological change on Dall sheep population demographics and mortality factors highlights the critical need for additional research to support effective stewardship decision making (Aycrigg et al., 2021).

Dall sheep surveys are critical for understanding population fluctuations and modelling future trends, and aerial surveys providing single snapshot views of a population are currently the accepted survey method (Whitten, 1996; Udevitz et al., 2006). However, aerial surveys are expensive, highly weather-dependent, and cause significant stress to sheep (Frid, 2003), limiting the frequency and coverage of data. Remote wildlife cameras, on the other hand, are an emerging non-invasive survey method that provides continuous sampling of entire mammal communities, which can be further evaluated to model population changes over time in relation to environmental variables and interactions among multiple species (Burton et al., 2015; Caravaggi et al., 2020; Kays et al., 2020). Using remote wildlife cameras to derive and model critical wild sheep population demographics is a novel application of the method (Taylor et al., 2022) and may serve as a viable alternative to aerial surveys.

The Northern Richardson Mountains in the Northwest Territories (NWT) are home to the northernmost population of Dall sheep (*divii* in Gwich'in [Gwich'in Language Dictionary, 2003]) in Canada. Though a species of significant cultural and ecological importance in the region (Gwich'in Elders, 1997; Shaw et al., 2005), this population has shown dramatic fluctuations since minimum count aerial surveys commenced in the 1980s (Lambert Koizumi et al., 2011). Extremely low numbers in 2014, limited demographic data, and lack of knowledge about causes of population fluctuations has prompted significant concern from local communities and government (Lambert Koizumi et al., 2011; Environment Yukon, 2019). It is from this concern that a Gwich'in community-based *divii* monitoring program was initiated in 2018. As part of this broader, community-based monitoring program, my MSc research is evaluating and modelling *divii* population demographics and mammal community interactions through the use of a combination of aerial surveys and novel methods using remote wildlife cameras. This project is being conducted in partnership with the Gwich'in Renewable Resources Board (GRRB) and in communication with the Ehdiitat, Tetlit, Nihtat, and Gwichya Gwich'in Renewable Resource Councils (RRCs).

RESEARCH APPROACH

Personal Location

As a non-Gwich'in outsider invited to the Gwich'in Settlement Area for this research, I have a responsibility to ensure I am working in a way that respects Gwich'in people, culture, knowledge, rights, self-determination, and self-governance. Continuing to build relationships with the GRRB, RRCs, and community members has been key in directing my work. To me, research is about finding ways to understand our world and communicate our ideas to others. It is not about discovery but is about searching for knowledge that already exists, is known by the animals, plants, and land. It is my job to listen with the tools I have and respectfully share these stories.

Study Area

Straddling the northern Yukon-NWT border in Canada, the Northern Richardson Mountains feature rugged terrain dominated by alpine tundra and exposed rock and underlaid by continuous permafrost (Danks and Downes, 1997). Dall sheep typically occupy high elevations that offer both predator escape terrain and foraging opportunity (Rachlow and Bowyer, 1998; Van de Kerk et al., 2020; Aycrigg et al., 2021). My MSc research focuses on the central-eastern portion of the Northern Richardsons near Mount Goodenough. This area was selected for the *divii* community-based monitoring program by the GRRB, based on advice from local *divii* knowledge holders.

Remote Wildlife Camera Data

Remote wildlife cameras (Fig. 1) have been deployed at 20 sites in the study area. Data for my analysis will span August 2018 to March 2022. Camera sites were selected by a previous GRRB wildlife biologist, Édouard Bélanger, in consultation with local knowledge holders, along known

FIG. 1. The author with a remote wildlife camera in the Northern Richardson Mountains, August 2021. Cameras are mounted in a bear-proof lock box to a steel pole that has been hammered deeply into the ground. Photo: Steve Andersen.

FIG. 2. Standard demography categories for divii *classification used in aerial surveys and remote wildlife camera images. A) lambs (left) and nursery sheep (includes all ewe-like sheep, yearlings, and young quarter-curl rams; right), B) half curl rams, C) three quarter curl rams, D) full curl rams.*

high use *divii* trails in order to maximize the detection rates and best capture *divii* population demography.

The remote wildlife cameras have produced almost 500,000 images to date. All images have been processed by MegaDetector, a machine learning model that improves tagging efficiency by identifying the images with animals present (Beery et al. 2019, Greenberg 2020). These images are then manually examined to identify the species and their demographic traits (Fig. 2) using Timelapse 2.0 software (Greenberg 2022).

Aerial Survey Data

Annual minimum count aerial surveys were conducted in 2019, 2020, and 2021 to provide standard population demographics to validate the remote camera data (Fig. 3).

FIG. 3. A group of divii in the Northern Richardson Mountains photographed during the 2021 aerial survey, September 2021. Photo: Steve Andersen.

Population Demography

In my MSc research I ask two questions. The first is, can remote camera traps reliably estimate demographics (recruitment, sex ratio, and ram classification) in an unmarked, semi-isolated population of *divii* compared to aerial survey data? In both the aerial surveys and camera trap images, *divii* are counted in consistent demographic categories: nursery sheep, lambs, and four classifications of rams based age and horn size (Fig. 2). Rams are classified using broadly accepted methods (Geist, 1966; Hemming, 1969; Krausman and Valdez, 1999; Bethune et al., 2016).

Using camera detection data that correspond to the timing of the aerial surveys, I will estimate key annual demographic parameters: productivity, sex ratio, and ram composition (Table 1). The total *divii* will be counted in three categories, standardized with aerial surveys (Fig. 2). I will directly compare the parameters derived from the aerial survey to those I derive from the cameras through quantitative analysis. I will assess comparability by examining if both parameters fall within the indication thresholds (i.e. whether the camera data and aerial data indicate if the population is growing, shrinking, or stable). For ram composition, I will calculate the percentage of rams in each category as a proportion of the total rams classified.

Table 1. Key *divii* demography parameters proposed to be evaluated by both aerial surveys and remote wildlife cameras.

Demography parameter	Analysis	Time period analyzed	Threshold	Indication
Birth rate	lamb: nursery ratio	May – June (2022 only)	25:100	Stable population (higher = growing; lower = shrinking)
Productivity	lamb: nursery ratio	August – October	25:100	Stable population (higher = growing; lower = shrinking)
Sex ratio	ram: nursery ratio	August – October	50:100	Healthy ratio (lower may indicate skewed mortality of males)
Ram composition	ram classification	August – October	N/A	Healthy ram age structure

Mammal Community Interactions

My second research question is, how are *divii* temporally sharing these high use sites with predators and competitors (Fig. 4)? I will explore this temporal niche partitioning using time-to-event analysis (Naidoo and Burton, 2020) and daily activity pattern analysis (Frey et al. 2017) for known predators and competitors, specifically, species of interest noted by Gwich'in communities (wolf, grizzly bear, muskox,lynx, wolverine, coyote). Both these analyses will build a foundation for understanding mammal community interactions.

SIGNIFICANCE

My MSc research aims to evaluate the effectiveness of camera traps as a novel alternative or compliment to aerial surveys in ways previously never studied for wild sheep. Using remote wildlife cameras to determine *divii* population demographics and species interactions on the landscape could revolutionize wild sheep research and management by providing a non-invasive, cost-effective tool that produces far more data than the status quo helicopter surveys (Taylor et al., 2022). Further, camera arrays have potential to be further networked across massive landscapes to achieve larger and more robust monitoring goals. By looking to remote wildlife cameras, we seek to pull the tools for scientifically sound wildlife monitoring from the out-of-reach clouds, back to the ground and in the hands of communities and local organizations.

This Indigenous-led, community-based effort to study *divii* is the first of its kind in North America for wild sheep and could serve as an empowering model for other communities and research projects. Not only is community-based monitoring important for capacity building and involving community in wildlife stewardship, but scientific research also benefits greatly from local traditional knowledge (Fast and Kovach, 2019; Hovel et al., 2020; Kovach, 2021). The GRRB and RRCs intend to braid this new scientific knowledge on the *divii* population (research question 1) with the ecosystem as a whole (research question 2) and with traditional knowledge to inform stewardship decisions in the immediate term, while also planning for the future impacts of climate change.

This project was born out of a community desire to develop new ways of monitoring and understanding *divii* and the animals they share this unique, special land with. By taking a step back from immediate management goals and focusing on core foundations of ecological niche theory and community ecology (O'Connell et al. 2011, Burton et al. 2015, Frey et al. 2017), we are offering *divii*, and potentially wild sheep across North America, a chance to tell their story.

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FIG. 4. Example of multiple species sharing the landscape at one camera site in the Northern Richardson Mountains. A. Grizzly bear (Ursus arctos; shih *in Gwich'in language); B., C., and F. Dall sheep (Ovis dalli dalli;* divii*); D. Wolf (Canis lupus;* zhòh*); E. Muskox (Ovibos moschatus;* dachan tat aak'ii*) (Gwich'in Language Dictionary, 2003). Photo: Gwich'in Renewable Resources Board.*

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