ACA Grants in Biodiversity
2022-2024 Funding Application Form
PART B

Alberta Conservation Association

Applicant Name (Last, First, Middle):	**Date:**
Henry, Tanisha, Cavell	November 1, 2021

Department:	**Institution:**
Biological Sciences	University of Calgary

Type of Applicant:

Ph.D. ☐ Masters ☒ Not yet in graduate school ☐

On April 1, 2022, how many years will you have been registered in the program indicated? Please round to the nearest quarter year; e.g. 1.25 years. (See "Instructions for Completing Application" for written materials that must be provided)

Years: 1.5

Project Title:

Is there an association between male Rocky Mountain bighorn sheep (*Ovis canadensis*) horn morphology and their reproductive success?

Your application package will include:

- PART A - one original
- Attachments as indicated on the checklist – one copy (attached to Part A Application Form)
- PART B - one original

E-mail the completed package as outlined in the Application Instructions. The package must be received by the Grants Coordinator by 4:00pm Wednesday, December 1, 2021.

NAME: Tanisha Cavell Henry

RESEARCH PROPOSAL (*This page and 2 additional freeform pages are allowed)*

Use the following headings:

1. Scope and rationale for the research
2. Research objectives
3. Research methods
4. Schedule
5. Significance

SCOPE AND RATIONALE FOR THE RESEARCH

Intra- and intersexual selection often leads to exaggerated secondary selected traits, which may confer the bearer fitness benefits (Hunt et al. 2009). The phenotypical expression of these traits varies depending on the species, but generally includes, large antlers or horns, colourful plumage, large tails, and appendages. Traits are often displayed using courtship behaviours which include calls, dances, rituals, and fights. These secondary traits are considered "handicaps" as they are costly to develop and/or maintain and are thus considered an honest signal of an individual's quality to potential mates (Zahavi 1975).

Rocky Mountain bighorn sheep (*Ovis canadensis*) males grow very large horns, compared to those of females (Geist 1971). Prior to the rut season in the fall, bighorn rams engage in competitive interactions - kicking, head butting, clashing, pre-orbital gland rubbing, mounting, and displacements - to establish a dominance hierarchy, which later determines their mating tactic and access to estrus ewes (Geist 1971). Dominant males employ the tending tactic, where they guard an estrus female copulating with her regularly and defending her against subordinate rams (Hogg 1984). Subordinate males employ an alternative high-risk tactic, termed coursing (Hogg 1984), which involves fighting to separate an estrus ewe from a dominant male; a chase may then ensue if the ewe runs, while males compete for copulations (Hogg and Forbes 1997). Males who become dominant sire a higher percentage of lambs than subordinates (Hogg and Forbes 1997) and thus typically have a higher lifetime reproductive success. Females may also make themselves available to more 'attractive' males during the rut (Geist 1971), indicating a degree of female mate choice. To do so, an estrus ewe can either move between mating groups to access a different set of males or she can start a coursing event by running (Geist 1971).

Until the age of six, age is a strong predictor of a ram's dominance rank (Geist 1971). Afterwards, other factors including horn length, body size, social experience, previous history and personality begin to influence whether a ram will become dominant or remain subordinate. Furthermore, horn size can also be an indicator of "breeding value" (Coltman et al. 2003). Males with long, rapidly growing horns tend to be in better overall health, have increased longevity, and typically are older, with more social experience (Coltman et al. 2003; Zahavi 1975). Rams have been observed presenting their horns, both to other rams during conflict and to females, when courting her (Geist 1971). This behaviour may signal fighting ability to other rams and genetic quality to females. However, there is little known about how horn shape might influence rank and subsequently, male reproductive success. My proposed research is to test whether there is an association between a ram's horn shape, its dominance rank, and mating success.

Figure 1. Left: Horn model developed using photogrammetry. Right: ram presenting his horns to other rams.

RESEARCH OBJECTIVES

Objective # 1: Is there an association between metrics of horn shape and male dominance rank thus influencing male reproductive success?
Hypothesis: The shape of a ram's horn will influence his rank in the dominance hierarchy.
Prediction: Rams with larger horns will rank higher in the dominance hierarchy and therefore have higher reproductive success as large horns may signal better fighting ability (Johnston et al. 2013).

Objective #2: Is there an association between metrics of horn shape and female mate choice thus influencing male reproductive success?
Hypothesis: The shape of ram horns will influence female mate choice.
Prediction: Ewes will make themselves available to mate with rams who have more symmetrical horns thus influencing reproductive success such as symmetry may signal better genetic quality (Cooley 2004).

RESEARCH METHODS

My study population resides in Sheep River Provincial Park (SSRP), Alberta (50^{o} 40'22.01''N, -114^{o} 57' 26.50''W). I use the University of Calgary's R.B. Miller Field Station located in SSRP for the field-based portion of my study, which runs from mid-September to late December. The bighorn sheep belonging to this population are marked with unique ear tags, which facilitate identification. These animals are habituated to our presence, making observation of social interactions easy and reliable. During the pre-rut and rut (October-end of December), I collect detailed behavioural data pertaining to the male dominance hierarchy (kicks, clashes, mounts, displacements), identify mating pairs, describe male mating tactics, and female behaviour towards the rams using the focal, *ad libitum* or all occurrences' methods (Altmann 1974).

I also collect photo series of both horns for each ram which are used to evaluate horn morphology/shape. To analyze horn morphology, I use two non-invasive photographic techniques. To measure horn length, I analyze photographs taken with a known scale imposed using 2 parallel lasers mounted on a digital camera (Bergeron 2007), using ImageJ software (Rasband 2018). I measure both the total length and annual growth (distance between two annuli) for both horns of each sheep. To assess the shape of living ram horns, I use photogrammetry with the software AgiSoft Metashape Professional (2020) to create 3D models. Metrics of horn shape including volume, circumference at each annulus, curl width and symmetry are analyzed using 3D geometric morphometrics. Correlation between length and curl width can be accounted for using principal component analysis. Both techniques have been calibrated using photographs of sheep with known horn measurements (either from capture or from post-mortem measurements) and provide reliable, non-invasive methodologies for horn measurement. I will develop hypothetical dominance hierarchies based on horn shape and compare them to those established using behavioural interactions.

We currently have DNA samples from all individually marked bighorn sheep (>90%) and can use those samples in addition to ewe-lamb interactions (known mother) to assess paternity using the CERVUS software (Marshall et al. 1998) given the different mating pairs and tactics employed.
In addition to data collected in the field, I also have access to the long-term data set (compiled by Dr. Kathreen Ruckstuhl and her collaborators since 2006), which includes behavioural observations relating to male dominance hierarchies, mating tactics, and female choice, horn measurements, and paternity. I will acquire data for all living rams in the SSRP populations and thus have a sample size of approximately 30 individuals, this sample size can be increased using the historic data and potentially Alberta's compulsory registration dataset.

SCHEDULE

I plan to complete this project by September 2023. Two full field seasons will be needed to collect the necessary data – photograph series for each living ram and behavioural observations pertaining to the male dominance hierarchy, reproduction, and female mate choice. The 2021 field season is currently in progress. I will require one field/lab assistant for the 2022 field season. In the field, this individual will help me to document social interactions between rams including fighting ability (kicks, clashes), mating tactic (tending or coursing), male display of horns (to other rams and to females) as well as behaviours pertaining to female mate choice including mating group composition. This individual will also assist me in photographing the rams from numerous angles as well as digitally measuring horn length and developing 3D models (lab work).

SIGNIFICANCE

Given that rams with large horns are typically of higher genetic quality (Coltman et al. 2003) it is important to study how natural and artificial external factors might influence their growth. Previous studies have found that changing climatic and weather patterns (Büntgen et al. 2014) as well as density dependent factors (Douhard et al. 2017) such as resource availability and disease transmission can impact how sexually selected traits grow in large ungulates. When environmental conditions are not optimal, rams face a trade-off in energy allocation between mass gain and horn growth (Mysterud et al. 2005). In Alberta, ~150 rams are legally harvested each year. The removal of large males may have some social and genetic implications for the population as small-horned rams achieve increased reproductive success in the absence of larger horned males because they are less likely to be harvested (Coltman et al. 2003; Pigeon et al. 2016). However, these implications are not currently a conservation concern, due to regulation by minimum size restrictions for harvest. A thorough exploration of various horn morphology metrics is a necessary step in better understanding associations between horn shape, social interactions, population genetics and any interference from artificial and natural pressures. This may play a role in future management decisions and conservation initiatives.

The photographic techniques used to analyze horn morphology have not been widely applied in wildlife research. Moreover, the methods used provide a non-invasive way to measure horn morphology as opposed to the previous reliance on sedation and capture. Further development and application of these methods will support similar studies in other species (i.e., deer, moose, elk) as well as monitoring programs. These methods remove stress experienced by the animal during and after handling. Additionally, these photographic techniques are less time consuming and more economical than repeated capture throughout an animal's life.

NAME: Tanisha Cavell Henry

LITERATURE LIST (*This page only)*

Use this page for your bibliography or list of literature cited.

AgiSoft Metashape Professional Version 1.6.1. 2020. Retrieved from https://www.agisoft.com/downloads/installer/

Altmann, J. 1974. Observational Study of Behaviour: Sampling Methods. *Behaviour*, 49(3): 227-267

Bergeron, P. 2007. Parallel Lasers for Remote Measurements of Morphological Traits. *The Journal of Wildlife Management*, 71(1): 289-292

Büntgen, U., A. Liebhold, H. Jenny, A. Mysterud, S. Egli, D. Nievergelt, N.C. Stenseth, and K. Bollmann. 2014. European springtime temperature synchronises ibex horn growth across the eastern Swiss Alps. *Ecology Letters*, 17: 303-313

Chiyo, P.I., V. Obanda and D.K. Korir. 2015. Illegal tusk harvest and the decline of tusk size in African elephant. *Ecology and Evolution*, 5 (22): 5216-5229

Coltman, D.W., P. O' Donoghue, J.T. Jorgenson, J.T Hogg, C. Strobeck and M. Festa-Bianchet. 2003. Undesirable evolutionary consequences of trophy hunting. *Nature,* 426: 655-658

Cooley, J.R. 2004. Asymmetry and Mating Success in a Periodical Cicada, *Magicicada septendecim* (Hemiptera: Cicadidae). *Ethology*, 110: 745-759

Douhard, M. G. Pigeon, M. Festa-Bianchet, D.W. Coltman, S. Guillemette, and F. Pelletier. 2017. Environmental and evolutionary effects on horn growth of male bighorn sheep. *Oikos*, 126: 1031-1041

Geist, V. 1971. Mountain Sheep: A Study in Behaviour and Evolution. The University of Chicago Press, Chicago.

Hogg, J.T. 1984. Mating in Bighorn Sheep: Multiple Creative Male Strategies. *Science*, 225: 526- 529

Hogg, J.T. & S.H. Forbes. 1997. Mating in bighorn sheep: frequent male reproduction via a high-risk "unconventional tactic. *Behavioural Ecology and Sociobiology*, 41: 33-48

Hunt, J., C.J. Breuker, J.A. Sadowski, and A.J. Moore. 2009. Male-male competition, female mate choice and their interaction: determining total sexual selection. *Journal of Evolutionary Biology*, 22: 13-26

Johnston, S.E., J. Gratten, C. Berenos, J.G. Pilkington, T.H. Clutton-Brock, J.M. Pemberton, and J. Slate. 2013. Life history trade-offs at a single locus maintain sexually selected genetic variation. *Nature*, 502: 93-95

Marshall, T.C., J. Slate, L.E.B. Kruuk and J.M. Pemberton. 1998. Statistical confidence for likelihood-based paternity inference in natural population. *Molecular Ecology*, 7: 639-655

Milner, J.M., E.B. Nilsen and H.P. Andreassen. 2007. Demographic side effects of selective hunting in ungulates and carnivores. *Conservation Biology*, 21: 36-47

Mysterud, A., E. Meisingset, R. Langvatn, N.G. Yoccoz, and N.C. Stenseth. 2005. Climate-dependent allocation of resources to secondary sexual traits in red deer. *Oikos*, 111:245-252

Pigeon, G., M. Festa-Bianchet, D.W. Coltman and F. Pelletier. 2016. Intense selective hunting leads to artificial evolution in horn size. *Evolutionary Applications*: 521- 530.

Rasband, W.S. 2018. *ImageJ*. U.S. National Institutes of Health. Maryland, USA https://imagej.nih.gov./ij/

Zahavi, A.1975. Mate Selection – A Selection for a Handicap. *Journal of Theoretical Biology*, 53: 205-214

NAME: Tanisha Cavell Henry

BUDGET for research in this proposal.

Amount requested from ACA cannot exceed $20,000. Budget must fit on this page; blank lines may be removed.

Category	Description	$ Amount requested from ACA	$ Funding needed from other sources	$ Total
Costs of Assistants (in your proposal please state duties of each individual):				
Assistant One	Salary for an assistant for one field season at 4 months (total 4x 1500)	6,000	-	6,000
Field Travel (calculate mileage reimbursement at $0.50 per km for budgeting):				
Transport	Vehicular transport to and from the field site (mileage =$0.50/km x 20 round trips x 100km)	2,000	-	2,000
Subsistence ($15 per diem):				
Field Subsistence	Subsistence for time spent in the field (1 field season x 4 months: 160 days x $15/day)	1,200	-	1,200
Materials and Supplies:				
Equipment	Tripod and Pendtax PF-65EDA II Spotting Scope - 70967	1,000	-	1,000
Equipment	DSLR Camera to photograph rams (~2,000), lens (~1,500), tripod	-	3,500	3,500
Equipment	3D printer and film	-	1,000	1,000
Other Required Expenditures:				
Rent	Field Station Fee (1 field season at 4 months each; 4 x $700/ month)	2,800	-	2,800
Salary/ Stipend	Salary/ stipend for Tanisha Henry	-	20,000	20,000
TOTAL COSTS ($)		**13,000**	**24,500**	**37,500**

NAME: Tanisha Cavell Henry

Additional Budget Information (to be completed jointly with supervisor)

Indicate other sources of funds applied for in support of this program or the larger program within which this project falls. Include support sought/received and indicate current status: Applied (A) or Held (H).

Money required to complete this project	**37,500**
a) From this application:	13,000
b) From other sources	24,500

Short title of project	Agencies applied to	Amount Requested	Status (Applied or Held)
Is Bigger Better? The Impact of Selective Hunting on Rocky Mountain Bighorn Sheep Horn Morphology, Male Reproductive Success and Female Mate Choice	Y2Y Sarah Baker Memorial Fund	5,000	A
The Impact of Bighorn Sheep Horn Morphology on Male Reproductive Success and Female Mate Choice	Michael Mappin Award	2,800	H
The Impact of Bighorn Sheep Horn Morphology on Male Reproductive Success and Female Mate Choice	Alberta Graduate Excellence Award	11,000	H

Additional Support – Comments
List amount of either financial and/or logistical support available to student; please identify type and amount of support expected (i.e., logistical, computer time, laboratory equipment and analyses, financial support).

From Department: Teaching Assistantships and scholarships for salary
From Supervisor: NSERC grant moneys for stipend 8,000/year, lab space (100%), and miscellaneous items needed in the field, such as binoculars, vehicle, write in the rain books etc.