Canadian Journal of Zoology
Revue canadienne de zoologie

Observation of a $p < 10^{-9}$ life history event: implications of record-late caribou birth on ungulate reproductive ecology and field studies.

Journal:	<i>Canadian Journal of Zoology</i>
Manuscript ID	cjz-2016-0245.R1
Manuscript Type:	Note
Date Submitted by the Author:	25-Nov-2016
Complete List of Authors:	Bonar, Maegwin; Memorial University of Newfoundland, Biology Laforge, Michel; Memorial University of Newfoundland, Biology Vander Wal, Eric; Memorial University of Newfoundland, Biology
Keyword:	birth date, caribou, LIFE HISTORY < Discipline, Newfoundland, <i>Rangifer tarandus</i> , UNGULATES < Taxon

Observation of a $p < 10^{-9}$ life history event: implications of record-late
caribou birth on ungulate reproductive ecology and field studies

M. Bonar*, Department of Biology, Memorial University, St. John's NL Canada, A1B 3X9.

m.bonar@mun.ca.

M. P. Laforge*, Department of Biology, Memorial University, St. John's NL Canada, A1B 3X9.

m.laforge@mun.ca.

E. Vander Wal, Department of Biology, Memorial University, St. John's NL Canada, A1B 3X9.

evanderwal@mun.ca.

Corresponding author:

M. P. Laforge

Department of Biology

Memorial University

St. John's NL Canada

A1B 3X9

m.laforge@mun.ca

Phone: (709) 864-6766

Fax: (709) 864-3018

*These authors contributed equally to the paper.

M. Bonar, M. Laforge and E. Vander Wal. Observation of a $p < 10^{-9}$ life history event: implications of record-late caribou birth on ungulate reproductive ecology and field studies

ABSTRACT: Life history traits in temperate ungulates are highly seasonal, with events corresponding to the seasonal availability of resources. An important example is birth date, with later born individuals typically having reduced survival compared to those born earlier in the season. Ungulates, especially those whose offspring that are at their mother's heel soon after birth, are typically born in a narrow window of time in late May–early June. In Newfoundland, mean birth date in caribou (*Rangifer tarandus* L., 1758; $n = 1175$), was 31 May. Here, we document a sighting of a caribou calf born ~25 July on Fogo Island, NL (~55 days after the mean birth date). Calving date was estimated using movement rate of the mother and validated by visual observations of the mother. We discuss the implications of this finding as it pertains to caribou ecology, and suggest that studies of ungulate birth date should ensure that observations are continued well past the initial birth pulse to guarantee that a complete picture of ungulate breeding ecology be maintained.

Key words: Birth date, caribou, life history, Newfoundland, *Rangifer tarandus*, ungulates.

Introduction

For ungulates in seasonal environments, life history events are strongly tied to specific times of year to make optimal use of resources (Bowyer et al. 1998; Côté and Festa-Bianchet 2001; Cook et al. 2004). Timing of birth is a notable example: early-born juveniles tend to be heavier compared to late-born juveniles (Clutton-Brock et al. 1987a; Adams and Dale 1998; Côté and Festa-Bianchet 2001; Feder et al. 2008). Highly synchronous births optimize the amount of time a female has to use and accumulate energy reserves between birth, weaning, and the rut (Guinness et al. 1978; Clutton-Brock et al. 1987a).

Ungulates generally exhibit birth pulses, the timing and duration of which can be highly variable (Rutberg 1987). Species inhabiting northern latitudes typically display rigid birth synchrony in spring, with most births occurring in May and June (Table 1; Lent 1974). Two main hypotheses exist to explain the short duration of the birthing season in ungulates, and they do not need to be mutually exclusive. The predator saturation hypothesis suggests that the birth pulse serves to swamp predators and improve survival of young born during the pulse (Estes and Estes 1979). The plant phenology hypothesis suggests that young are born at similar times in spring to maximize forage quality and availability to coincide with the period of energetically costly lactation (Estes and Estes 1979). Individuals born late may be unable to accumulate sufficient reserves to survive the winter and can therefore have reduced survival (Adams and Dale 1998; Côté and Festa-Bianchet 2001; Feder et al. 2008); conversely, being born too early could result in starvation or hypothermia (Clutton-Brock et al. 1982).

It is difficult to determine if a given reproductive interval is a consequence of seasonality or predation reduction (Rutberg 1987, Ims 1990), particularly in ungulates as it can depend on the neonatal security strategy used by the species (e.g., “hider–follower” continuum; Lent 1974;

Geist 1981). Follower species have less variation in their timing of birth and adopt a stricter birth synchrony to swamp predators (Estes and Estes 1979; Rutberg 1987). This is less important for hiders as they employ cryptic behaviour to avoid predation and thus show more variation in timing of birth (Rutberg 1987).

As a consequence of predation and plant phenology, we would expect there to be selective pressures to shrink the variation of the window of birth dates in ungulates. Furthermore, adherence to this high synchronicity in species closer to the “follower” end of the “hider–follower” spectrum (such as caribou, *Rangifer tarandus* L., 1758) may be maintained to allow mother and young to benefit from spatial strategies (e.g., aggregation on calving grounds) that reduce predation risk (Lent 1974). Sub-optimal reproductive timing could result in reduced offspring survival (Green and Rothstein 1993; Feder et al. 2008) with potential demographic consequences to a population depending on overall prevalence (Plard et al. 2014). Here, we describe, for the first time, an observation of a caribou calf born at the end of July. This represents the latest ever documented birth date for wild *Rangifer*. We discuss the implications of this finding on our understanding of caribou reproductive ecology and on studies monitoring birth dates of wild ungulates.

Methods

Study Area

The study area was on Fogo Island, Newfoundland, Canada (49° N, 54° W). Natural habitat consists of coniferous and mixed forests of balsam fir (*Abies balsamea* (L.) Miller), black spruce (*Picea mariana* Miller) and white birch (*Betula papyrifera* Marshall), as well as bogs, lakes, and barren rock. Fogo Island has a humid–continental climate with 1043.1 mm annual

mean total precipitation (1981–2010) at the nearest meteorological station, Murgave Harbour (~20 km from the island; Environment Canada 2016).

Presently, caribou populations are in decline across Canada and on a global scale (Festa-Bianchet et al. 2011). In Newfoundland, caribou populations have declined more than 60% in the last 10 years which has led the Committee on the Status of Endangered Wildlife in Canada to designate the caribou populations in Newfoundland as “Special Concern” (COSEWIC 2014).

Calf Observation and Age Determination

We fitted 15 adult female caribou on Fogo Island with GPS collars (1240 g, GPS 4400M, Lotek Wireless Inc., Newmarket, ON Can) in April 2016. We located each adult female every 10–15 days from ~1 week prior to the start of calving (mid-May) until late summer (end of August). During routine monitoring of these female caribou, we observed and photographed a collared female with a young (~10 day old) calf on 8 August, 2016 (Fig. 1). Initial estimate of calf age was field-assessed based on comparisons with field observations of other calves born during the spring and included calf mobility, colouration, and size. The female had also been 21 days prior, without a calf. We used Windows Live Photo Gallery 2012 to sharpen the images and reduce noise as well as to adjust saturation, contrast and brightness to enhance clarity. Animal handling and capture was conducted in accordance with all governmental and institutional laws and rules and conformed to the guidelines of the Canadian Council on Animal Care, Memorial University protocol ID# 16-03-EV.

To determine the birth date of the calf, we used a method for inferring birth and calf survival (DeMars et al. 2013). This method uses adult female step length (as a proxy for movement rate) in *a priori* models that assume that step length is exponentially distributed and any breaks in the scale parameter of the models (that is, mean step length) indicate birth and

offspring loss. We applied the model developed by DeMars et al. (2013) to the GPS data from the collared female to estimate the birth date. The estimated birth date was corroborated by visual observations made on the collared female (e.g., she was observed on 18 July without a calf). To determine the likelihood of a calf being born this late in the season in Newfoundland, we used a known distribution of calf birth dates ($n = 1175$) from Newfoundland between 1979–2012. We fitted this distribution to a negative binomial distribution and calculated a p -value to estimate the probability of an event this extreme using R version 3.2.1 (R Core Team, 2016). Our data represented count data that were non-normally distributed, therefore we opted to fit these data to a negative binomial (e.g., Poisson–Gamma mixture) distribution. We compared the fit of both the negative binomial distribution that we generated as well as a Poisson distribution to our data using a Kolmogorov-Smirnov test and found that the negative binomial distribution was a better fit to the data ($p = 0.259$) compared to the Poisson ($p < 0.001$).

Results and Discussion

We estimated that the calf in question was born between 19 July–3 August. The female was previously seen without a calf on 18 July 2016 in a previous survey, and the calf was relatively motile, such as being able to follow its mother through thick shrub, on the date of observation (8 Aug) which precluded the calf being younger than 5 days-old. The birth-date model (DeMars et al. 2013) estimated a birth date for this calf of 25 July 2016. The mean birth date for calves in Newfoundland between 1979–2013 was May 31 (median = May 30, Ellington 2015). The probability of a calf being born on the 25 July (55 days after the mean birth date [56 days after the median], $k = 2.95$, $\mu = 5.73$ of the negative binomial distribution) was $p < 10^{-9}$. To the authors' knowledge, this is the latest ever recorded date of birth for wild caribou by ~1 month (Fig. 2).

Of the studies listed in Table 1, only one study recorded births of a wild ungulate (red deer, *Cervus elaphus* L., 1758) further away from the mean/median date of birth for the population than our observation (Guinness et al. 1978). Red deer, however, are hidiers, that typically exhibit more variation in timing of births (Rutberg 1987), which is hypothesized to be due to less pressure to swamp predators (Estes and Estes 1979). Caribou, by contrast, are followers, and would be hypothesized to have less variation in birth timing due to selective pressures on predator swamping, making this observation of considerable note for ungulate life history.

When birth occurs outside the expected reproductive interval it can be due to individual differences, previous reproductive history, or failure to conceive at first oestrus which can be caused by a lack of mature males (Guinness et al. 1978; Mysterud et al. 2002; Noyes et al. 2002; Cook et al. 2004). Heavily hunted populations (such as those on Fogo Island) can result in selective harvesting and consequently a skewed sex ratio (McLoughlin et al. 2005) and a reduction in high 'breeding-value' males (Coltman et al. 2003). Skewed sex ratios have been shown to result in insufficient males to copulate with all the females during their first oestrus (Noyes et al. 1996; 2002) resulting in delayed conceptions and calving and a less synchronous calving season (Mysterud et al. 2002; Holand et al. 2003). A younger male population may also result in later birth dates as younger males have been shown to start rutting later than prime-aged individuals (Clutton-Brock et al. 1997; Yoccoz et al. 2002). Gestation length is often assumed to be relatively constant in ungulates (Mysterud et al. 2002), and variance in gestation time is typically associated with individuals who conceive late, shortening gestation to give birth at the optimal time (Berger 1992). Female body condition is also known to be a factor in determining date of birth, with females in poorer conditions typically giving birth later (Clutton-Brock et al.

1986; Cameron et al. 1993). This may well have been a factor in our observation as the female in question appeared to be in relatively poor condition (Fig. 1).

Giving birth outside the usual reproductive interval has been shown to be maladaptive (Green and Rothstein 1993; Côté and Festa-Bianchet 2001; Feder et al. 2008; Whiting et al. 2011). Caribou are in decline in many regions, with habitat loss being one of the main factors involved in their decline (Festa-Bianchet et al. 2011). Juvenile survival in ungulates is often highly variable and critical for population growth (Gaillard et al. 1998; 2000). The observation of birth ~2 months following the normal birth period may indicate a wider problem if late births become more prevalent, especially since late-born calves often have lower survival compared to calves born during the main birth pulse (Clutton-Brock et al. 1987a; Mysterud et al. 2002; Feder et al. 2008; Whiting et al. 2011). The magnitude of this problem, however, is contingent upon determining the true prevalence of very late births in caribou (and other ungulate) populations.

Our observation represents the latest observation of birth in wild *Rangifer*. This suggests it is likely an exceedingly rare event; alternately later investigations throughout the birthing seasons may reveal it to be more prevalent. Beyond calf survival, such a late calving date can have reproductive consequences for the female, as late calving can also reduce future fertility of female ungulates (Clutton-Brock et al. 1987b; Cameron et al. 1993), if determined to exist at a larger scale, this may result in long-term effects on the fitness and demography of a population.

Acknowledgements

The authors would like to acknowledge members of the Newfoundland Wildlife Division: C. Doucet, W. Barney, F. Norman, R. Otto, J. Neville, P. Saunders, T. Porter, P. Tremblett, S. Gullage, T. Hodder, D. Jennings, J. McGinn, and S. Mahoney for data on NL caribou birth dates. M. Frampton and P. McClement for data entry and management support. Statistical support was provided by D. Schneider. Logistical support was provided by L. Bixby. Funding was provided by the Natural Science and Engineering Research Council of Canada, The Newfoundland and Labrador Research Development Corporation and the Atlantic Computational Excellence Network (ACENET) Canada Fellowship Program. The authors would also like to acknowledge comments from two anonymous reviewers who helped improve an earlier draft of this manuscript.

Literature Cited

- Aanes, R., and Andersen, R. 1996. The effects of sex, time of birth, and habitat on the vulnerability of roe deer fawns to red fox predation. *Can. J. Zool.* **74**: 1857–1865.
- Adams, L.G., and Dale, B.W. 1998. Timing and Synchrony of Parturition in Alaskan Caribou. *J. Mammal.* **79**(1): 287–294. doi:10.2307/1382865.
- Berger, J. 1992. Facilitation of Reproductive Synchrony by Gestation Adjustment in Gregarious Mammals: A New Hypothesis. *Ecology*, **73**(1): 323–329.
- Bowyer, T.R., Van Ballenberghe, V., and Kie, J.G. 1998. Timing and synchrony of parturition in Alaskan moose: long-term versus proximal effects of climate. *J. Mammal.* **79**(4): 1332–1344.
- Cameron, R.D., Smith, W.T., Fancy, S.G., Gerhart, K.L., and White, R.G. 1993. Calving success of female caribou in relation to body weight. *Can. J. Zool.* **71**: 480–486. doi:10.1139/z93-069.
- Carstensen, M., Delgiudice, G.D., Sampson, B.A., and Kuehn, D.W. 2009. Survival, birth characteristics, and cause-specific mortality of white-tailed deer neonates. *J. Wildl. Manage.* **73**(2): 175–183. doi:10.2193/2006-107.
- Clutton-Brock, T.H., Guinness, F.E., and Albon, S.D. 1982. Red deer: Behaviour and ecology of two sexes. The University of Chicago Press, Chicago, IL.
- Clutton-Brock, T.H., Albon, S.D., and Guinness, F.E. 1986. Great expectations: dominance, breeding success and offspring sex ratios in red deer. *Anim. Behav.* **34**: 460–471.
- Clutton-Brock, T.H., Major, M., Albon, S.D., and Guinness, F.E. 1987a. Climate, Plant Phenology and Variation in Age of First Reproduction in a Temperate Herbivore. *J. Anim. Ecol.* **56**(1): 53–67.

- Clutton-Brock, T.H., Major, M., Albon, S.D., and Guinness, F.E. 1987*b*. Early Development and Population Dynamics in Red Deer. I. Density-Dependent Effects on Juvenile Survival. *J. Anim. Ecol.* **56**(1): 53–67.
- Clutton-Brock, T.H., Rose, K.E., and Guinness, F.E. 1997. Density-related changes in sexual selection in red deer. *Proc. R. Soc. Lond. B Biol. Sci.* **264**(1387): 1509–1516.
doi:10.1098/rspb.1997.0209.
- Coltman, D.W., O'Donoghue, P., Jorensen, J.T., Hogg, J.T., Strobeck, C., and Festa-Bianchet, M. 2003. Undesirable evolutionary consequences of trophy hunting. *Nature*, **426**: 655–658.
doi:10.1038/nature02187.1.
- Cook, J.G., Johnson, B.K., Cook, R.C., Riggs, R.A., Delcurto, T., Bryant, L.D., and Irwin, L.L. 2004. Effects of summer-autumn nutrition and parturition date on reproduction and survival of elk. *Wildl. Monogr.* **155**(1): 1–61. doi:10.2193/0084-0173(2004)155[1:EOSNAP]2.0.CO;2.
- COSEWIC. 2014. Wildlife Species Assessments November 2014. Available from http://www.cosewic.gc.ca/rpts/detailed_species_assessments_e.html.
- Côté, S.D., and Festa-Bianchet, M. 2001. Birthdate, mass and survival in mountain goat kids: effects of maternal characteristics and forage quality. *Oecologia*, **127**: 230–238.
doi:10.1007/s004420000584.
- DeMars, C.A., Auger-Méthé, M., Schlägel, U.E., and Boutin, S. 2013. Inferring parturition and neonate survival from movement patterns of female ungulates: A case study using woodland caribou. *Ecol. Evol.* **3**: 4149–4160.
- Ellington, E.H. 2015. Reconciling Estimates of Caribou Calf Survival Derived from Different Sources. Final report to Newfoundland and Labrador Department of Environment and

Conservation, Wildlife Division, Cornerbrook, NL.

Environment Canada. 2016. National climate data and information archive. Available from <http://climate.weather.gc.ca/> [accessed 21 November 2016].

Estes, R.D., and Estes, R.K. 1979. The birth and survival of wildebeest calves. *Z. Tierpsychol.* **50**: 45–95.

Feder, C., Martin, J.G.A., Céline, M.F., and Jon, B. 2008. Never too late? Consequences of late birthdate for mass and survival of bighorn lambs. *Oecologia*, **156**: 773–781.
doi:10.1007/s00442-008-1035-9.

Festa-Bianchet, M., Ray, J.C., Boutin, S., Côté, S.D., and Gunn, A. 2011. Conservation of caribou (*Rangifer tarandus*) in Canada: an uncertain future. *Can. J. Zool.* **89**(5): 419–434.
doi:10.1139/z11-025.

Gaillard, J.M., Festa-Bianchet, M., and Yoccoz, N.G. 1998. Population dynamics of large herbivores: Variable recruitment with constant adult survival. *Trends Ecol. Evol.* **13**(2): 58–63. doi:10.1016/S0169-5347(97)01237-8.

Gaillard, J.M., Yoccoz, N.G., Loison, A., and To, C. 2000. Components and Population Dynamics of Large Herbivores. *Annu. Rev. Ecol. Syst.* **31**: 367–393.

Geist, V. 1981. On the reproductive strategies in ungulates and some problems of adaptation. *In* Evolution today. Proceedings of the second International Congress of Systematic and Evolutionary Biology. Edited by G.G.E. Scudder and J.L. Reveal. Hunts Institute for Botanical Documentation, Carnegie - Mellon University, Pittsburg. pp. 111–131.

Green, W.C.H., and Rothstein, A. 1993. Persistent influences of birth date on dominance, growth and reproductive success in bison. *J. Zool. (Lond.)* **230**(2): 177–186.

Griffin, K.A., Hebblewhite, M., Robinson, H.S., Zager, P., Barber-Meyer, S.M., Christianson,

- D., Creel, S., Harris, N.C., Hurley, M.A., Jackson, D.H., Johnson, B.K., Myers, W.L., Raithel, J.D., Schlegel, M., Smith, B.L., White, C., and White, P.J. 2011. Neonatal mortality of elk driven by climate, predator phenology and predator community composition. *J. Anim. Ecol.* **80**(6): 1246–1257. doi:10.1111/j.1365-2656.2011.01856.x.
- Guinness, F.E., Gibson, R.M., and Clutton-Brock, T.H. 1978. Calving times of Red deer (*Cervus elaphus*) on Rhum. *J. Zool. (Lond.)* **185**: 105–114.
- Holand, Ø., Røed, K.H., Mysterud, A., Kumpula, J., and Nieminen, M. 2003. The Effect of Sex Ratio and Male Age Structure on Reindeer Calving. *J. Wildl. Manage.* **67**(1): 25–33. doi:10.2307/3803058.
- Ims, R.A. 1990. The Ecology and Evolution of Reproductive Synchrony. *Trends Ecol. Evol.* **5**(5): 135–140.
- Lent, P.C. 1974. Mother-infant relationships in ungulates. *IUCN Publ. New Ser.* 24: 14–55.
- Linnell, J.D.C., and Andersen, R. 1998. Timing and synchrony of birth in a hider species, the roe deer *Capreolus capreolus*. *J. Zool. (Lond.)* **244**: 497–504.
- McLoughlin, P.D., Taylor, M.K., and Messier, F. 2005. Conservation risks of male-selective harvests for mammals with low reproductive potential. *J. Wildl. Manag.* **69**(4): 1592–1600.
- Mysterud, A., Coulson, T., and Stenseth, N.C. 2002. The Role of Males in the Dynamics of Ungulate Populations. *J. Anim. Ecol.* **71**(6): 907–915.
- Noyes, J.H., Johnson, B.K., Bryant, L.D., and Findholt, S.L. 1996. Effects of Bull Age on Conception Dates and Pregnancy Rates of Cow Elk. *J. Wildl. Manage.* **60**(3): 508–517.
- Noyes, J.H., Johnson, B.K., Dick, B.L., and Kie, J.G. 2002. Effects of Male Age and Female Nutritional Condition on Elk Reproduction. *J. Wildl. Manage.* **66**(4): 1301–1307.
- Plard, F., Gaillard, J.M., Coulson, T., Hewison, A.J.M., Delorme, D., Warnant, C., and

- Bonenfant, C. 2014. Mismatch Between Birth Date and Vegetation Phenology Slows the Demography of Roe Deer. *PLoS Biol.* **12**(4): 1–8. doi:10.1371/journal.pbio.1001828.
- R Core Team. 2016. R: a language and environment for statistical computing. Version 3.2.1 [computer program]. R Foundation for Statistical Computing, Vienna, Austria. Available from <https://www.r-project.org/>.
- Rachlow, J.L., and Bowyer, T.R. 1991. Interannual variation in timing and synchrony of parturition in Dall's sheep. *J. Mammal.* **72**(3): 487–492.
- Rutberg, A.T. 1987. Adaptive hypotheses of birth synchrony in ruminants: an interspecific test. *Am. Nat.* **130**: 692–710.
- Whiting, J.C., Bowyer, R.T., Flinders, J.T., and Eggett, D.L. 2011. Reintroduced bighorn sheep: fitness consequences of adjusting parturition to local environments. *J. Mammal.* **92**(1): 213–220. doi:10.1644/10-MAMM-A-145.1.
- Yoccoz, N.G., Mysterud, A., Langvatn, R., and Stenseth, N.C. 2002. Age- and density-dependent reproductive effort in male red deer. *Proc. R. Soc. Lond. B Biol. Sci.* **269**(1500): 1523–1528. doi:10.1098/rspb.2002.2047.

Table

Table 1: Distribution of mean/median birth dates and latest recorded birth date from studies of northern ungulates. When twinning/triplet rates were reported, we report *n* as the number birthing events to reduce pseudoreplication of birth dates in the case of twins.

Species	Location	Mean or [median]	Latest date	Latest recorded birth date (days from mean)	<i>n</i>	Source
Caribou (<i>Rangifer tarandus</i> L., 1758)	Newfoundland	31 May	18 Jun	18	1175	Ellington 2015
Caribou	Alaska	[13 May–21 May] ^a	8 Jun	[9–18] ^a	302	Adams and Dale 1998
Reindeer (<i>Rangifer tarandus</i> L. 1758)	Finland	18 May–23 May ^b	20 Jun–27 Jun	28–36 ^b	154	Holand et al. 2003
Moose (<i>Alces alces</i> L., 1758)	Alaska	25 May [25 May]	10 Jun	16 [16]	47	Bowyer et al. 1998
Elk (<i>Cervus elaphus</i> L., 1758)	USA (OR, WA, ID, MT,	31 May [31 May]	16 Jul	46 [46]	2008	Griffin et al. 2011

	WY)						
Red deer (<i>Cervus</i>	Scotland	[31 May–13 Jun] ^c	26 Aug	[25–75] ^c	236	Guinness et al. 1978	
<i>elaphus</i> L., 1758)							
White-tailed deer	Minnesota	26 May	19 Jun	24	49	Carstensen et al. 2009	
(<i>Odocoileus virginianus</i>	USA						
Zimmerman, 1780)							
Roe deer (<i>Capreolus</i>	Norway	22 May	4 Jul	43	146	Linnell and Andersen 1998	
<i>capreolus</i> L. 1758)							
Roe deer	Norway	22 May	11 Jun	20	22	Aanes and Andersen 1996	
Dall's Sheep (<i>Ovis dalli</i>	Alaska	[18 May, 27 May] ^d	27 Jun	[17, 31] ^d	22	Rachlow and Bowyer 1991	
Nelson, 1884)							
Bighorn sheep (<i>Ovis</i>	Alberta,	7 Jun	18 Jul	41	206	Feder et al. 2008	
<i>Canadensis</i> , Shaw 1804)	Canada						
Mountain goats	Alberta,	28 May [26 May]	3 Jul	36 [38]	109	Côté and Festa-Bianchet	
(<i>Oreamnos americanus</i>	Canada					2001	
Blainville 1816)							

^a Min. and max. yearly values between 1987–1995

^b Across two locations $\times$ two years/sex ratio treatments

^c Min. and max. yearly values between 1971–1976

^d 1988, 1989

Draft

Figure captions

Fig. 1. Images of a young (~2 week old) caribou (*Rangifer tarandus* L., 1758) calf and its mother taken on 8 Aug, 2016.

Fig. 2. Frequency of caribou (*Rangifer tarandus* L., 1758) calves born ($n = 1175$) relative to mean birth date (~May 31) from 1979–2012 in Newfoundland (grey bars, Ellington 2015). Fitted negative binomial distribution plotted in red. Arrows indicate the latest date a caribou calf was born relative to mean birth date according to findings from a) Ellington 2015 (the plotted data), b) Adams and Dale 1998, and c) Holand et al. 2003, compared to d) the estimated birth date for the late-born calf in the case presented here.

Draft

Fig. 2. Frequency of caribou (*Rangifer tarandus* L., 1758) calves born ($n = 1175$) relative to mean birth date ($\sim$ May 31) from 1979–2012 in Newfoundland (grey bars, Ellington 2015). Fitted negative binomial distribution plotted in red. Arrows indicate the latest date a caribou calf was born relative to mean birth date according to findings from a) Ellington 2015 (the plotted data), b) Adams and Dale 1998, and c) Holand et al. 2003, compared to d) the estimated birth date for the late-born calf in the case presented here.

Fig. 2

762x317mm (72 x 72 DPI)