

## Note

### Potential case of pseudo-hermaphroditism in Elk (*Cervus canadensis*) in Alberta, Canada

JACALYN NORMANDEAU<sup>1,\*</sup>, HANS MARTIN<sup>2</sup>, EVELYN H. MERRILL<sup>1</sup>, and MARK HEBBLEWHITE<sup>2</sup>

<sup>1</sup>University of Alberta, Edmonton, Alberta T6G 2E9 Canada

<sup>2</sup>Wildlife Biology Program, University of Montana, Missoula, Montana 59812 USA

\*Corresponding author: jacalyn@ualberta.ca

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#### Abstract

Cases of true and pseudo-hermaphroditism, in which animals possess both ovaries and testes or have a single chromosomal and gonadal sex but secondary features of the other sex, have been documented in several cervids, including *Odocoileus* (deer) and *Capreolus* (roe deer) species. Another form of intersexuality that has been well documented in Domestic Cattle (*Bos taurus*) and induced in Red Deer (*Cervus elaphus*) is freemartinism, where blood is shared between heterosexual twins leading to XX/XY chimeras. We report the first case of pseudo-hermaphroditism in wild Elk (*Cervus canadensis*), observed in the central east slopes of the Rocky Mountains of Alberta, Canada, from September through December 2019. The Elk had no antlers, exhibited female external genitalia, and displayed male secondary sexual characteristics, including colouring and breeding behaviour. To determine whether this is a case of true hermaphroditism, pseudo-hermaphroditism, or freemartinism would require blood analysis and inspection of internal sex organs by necropsy.

Key words: Hermaphrodite; pseudo-hermaphroditism; Elk; freemartinism; *Cervus canadensis*; Canada

For most cervid species, determination of sex in the field is based on antler presence or external genitalia. However, there are instances when variability in these features does not adequately represent the sex of the animal. For example, antlered females are well documented in the genus *Odocoileus* (deer) and *Capreolus* (roe deer; Rorig 1899, 1907 as cited in Wislocki 1954; Wislocki 1954, 1956; Donaldson and Doult 1965; Wishart 1985; Mysterud and Østbye 1999; Flis 2012), but less so in Red Deer (*Cervus elaphus*; Rorig 1899, 1907 as cited in Wislocki 1954) and Elk (*Cervus canadensis*; Buss and Solf 1959). Antlered females can be fertile, particularly if antlers stay in velvet, but females with polished antlers are more likely to be incapable of pregnancy (Donaldson and Doult 1965).

In contrast to antlered females with typical reproductive organs, various degrees of hermaphroditism have been documented in cervids. These anomalies arise during one of three stages in mammalian sex development: (1) sex chromosomes at fertilization, (2) gonadal differentiation into testes or ovaries

depending on the chromosomal sex and the *SRY* genetic factor that stimulates testes formation, and (3) differentiation into sex-specific phenotypes according to gonadal sex (Parma *et al.* 2016). The various outcomes of the abnormal development include true hermaphroditism, pseudo-hermaphroditism, and freemartinism, and these have been reported in cervid species since the early 1900s.

True hermaphroditism is rare and results in male and female gonads in the same individual (Parma *et al.* 2016). Pajares *et al.* (2009) reported a case in an Iberian Roe Deer (*Capreolus capreolus*) with XX chromosomes, antlers, female external genitalia, and both ovaries and testes. Pseudo-hermaphrodite describes an individual with gonads of one sex but the secondary sexual characteristics of the other sex, which can range from external genitalia to behavioural characteristics (Parma *et al.* 2016). Male pseudo-hermaphroditism has been documented in White-tailed Deer (*Odocoileus virginianus*). For example, an antlered deer exhibited female external genitalia (i.e., a vulva) but internal male reproductive organs,

i.e., undescended testes (Wislocki 1956; Scanlon *et al.* 1975; Kent *et al.* 1986). Distinguishing between instances of true and pseudo-hermaphroditism requires determination of chromosomal sex and a full dissection of an intact reproductive tract to confirm the presence of male and/or female gonads. In contrast, freemartinism occurs when there is vascularization of the placentae of heterosexual twins and blood is shared between twins, leading to XX/XY chimerism and often masculinization and sterility of the female twin's reproductive tract (Padula 2005). Freemartinism has been most commonly reported in Domestic Cattle (*Bos taurus*), but has also been documented in cervid species, including Red Deer that were treated with progesterone to induce twinning (Stewart-Scott *et al.* 1990).

Elk is a large, sexually dimorphic deer species with a wide distribution across North America (Toweill and Thomas 2002). Males exhibit an annual antler growing and shedding cycle that facilitates competition for females during the fall rut (mating season; Geist 2002). Here we report the potential first occurrence of pseudo-hermaphroditism in a free-ranging Elk in Alberta, Canada.

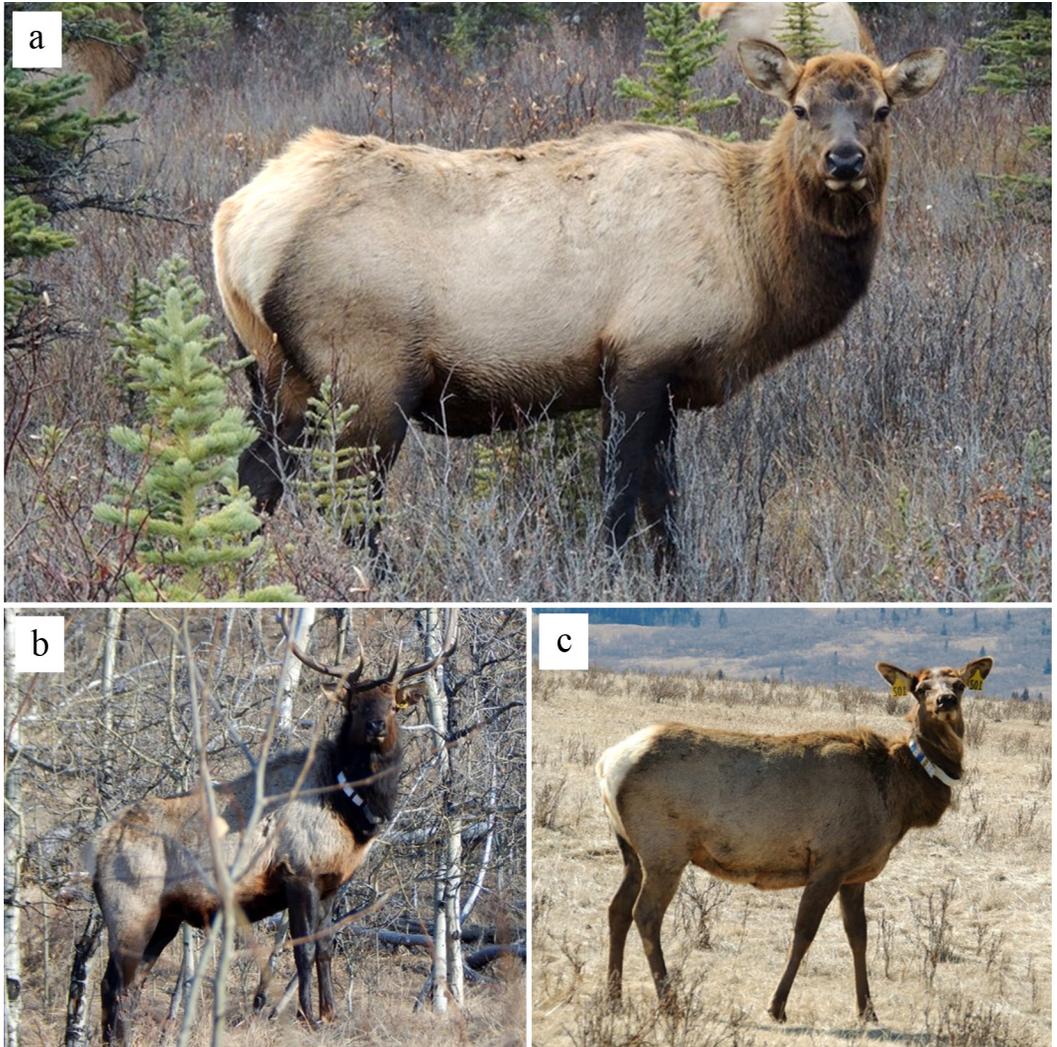
The Elk in question was observed in a partly migratory Elk herd that winters on the Ya Ha Tinda Mountain Rough-fescue (*Festuca campestris* Rydberg) grassland adjacent to Banff National Park in Alberta, Canada (51.7427°N, 115.5477°W). This Elk herd has been studied since the late 1980s (Morgantini and Hudson 1988) with intensive ongoing studies since 2000 (Hebblewhite *et al.* 2006, 2018). Based on aerial surveys, the wintering Elk population peaked in the early 1990s at ~2200 individuals and declined to 350–450 in 2019, where it has stabilized. The population decline is thought to be related to high predation rates, particularly by Gray Wolves (*Canis lupus*), which increased in the 1990s (Hebblewhite *et al.* 2018). In summer, Elk migrate west into high-elevation Banff National Park, east onto low-elevation industrial timberlands, or remain as “residents” of the Ya Ha Tinda year-round. Male Elk collect in bachelor herds mainly around the Ya Ha Tinda in winter and migrate to the same summer ranges as the females, although with more variation in timing and location.

As part of the intensive Elk studies starting in the early 2000s, regular observations using binoculars or a high-powered (20–45×) spotting scope from typical distances of 50–1000 m are made on Elk inhabiting the Ya Ha Tinda to document herd composition, group sizes, and calf survival. On 5 September 2019, we first observed an Elk that appeared to look and behave like a male but had female external genitalia. After initially noticing the Elk in a herd of 300 female Elk, the observer monitored it three times a week

between 5 September and 15 December 2019 for a total of ~20 h from a distance of 300–900 m using a spotting scope to record behaviour. Photos were taken with a Coolpix P510 digital camera (Nikon Corporation, Shinagawa, Tokyo, Japan) from horseback at a distance of 20–50 m to examine the external colouring, genitalia, and potential pedicles. The Elk showed typical male facial structure and colouring, but lacked antlers (Figure 1). However, part of a pedicle appeared to be present amid indentations in the hair on the head (Figure 2). The individual had female external genitalia and was observed urinating from a vulva-like structure; neither a scrotum nor penis was visible (Figure 3).

The Elk was originally believed to be a male lacking antlers because it was exhibiting typical male mating behaviour during the rutting season, including chasing females, sniffing their posteriors, flicking the tongue in and out rapidly while following females (Figure 4), and bugling (Figure 5). The Elk's bugling contained a typical gradual increase in sound frequency followed by an extended tonal frequency and a rapid decrease in frequency, but with a shorter duration than a typical male bugle and more frequency modulations during the increase in frequency (Feighny *et al.* 2006). The rate of bugling was less frequent than that of a male, at about one bugle in 20–60 minutes. The observed individual exhibited other behaviour typical of males during the rut: high rates of movement throughout the herd in search of females and increased vigilance during foraging bouts, presumably for rival males. However, the Elk was never observed mounting a female nor fighting with rival males. We did observe the individual lowering its head as if to bluff-charge females, but it never exhibited this aggressive behaviour toward yearling spike males or adult males. In particular, male Elk did not interact with this Elk unless it aggressively chased a female near a male, in which case the male would chase the Elk in question, which then displayed submissive behaviour and moved away from the female. The Elk remained with the main female Elk herd through the end of December when most males left after the rut to form bachelor groups separate from the main herd. We observed male behaviour in the pseudo-hermaphrodite Elk during the rut that declined in late November and early December after the second estrous cycle of the females (Hudson *et al.* 2002).

There are several explanations for the origin of this “intersex” individual. First, it did not resemble an antlered female because no antlers were present and because it also displayed other male secondary sexual behaviours. Although the origin could be freemartinism, natural freemartinism has not been



**FIGURE 1.** a. Potential hermaphroditic Elk (*Cervus canadensis*) with female external genitalia but male secondary sexual characteristics including pedicle-like growths on the head and lighter tan colouring with a darker ruff of the male (b) compared with the consistent darker brown colour of female Elk (c). Photos taken from 10 to 30 m at the Ya Ha Tinda, adjacent to Banff National Park, Alberta, Canada. Photos: J. Normandeau.

observed in Elk populations (Sysa and Kaluzinski 1984). However, it has been documented in closely related Red Deer that were treated with progesterone and gonadotrophin, which increased twinning. Of the eight sets of twins produced, two female XX/XY chimeras were observed that were both sterile (Stewart-Scott *et al.* 1990). In wild Elk, twinning rates are very low (<1%) making freemartinism unlikely (Hudson *et al.* 2002). In addition, freemartinism in cattle typically results in a sterile female twin with typical external genitalia without the male secondary sexual characteristics that we observed (Gregory *et al.* 1996).

Alternatively, the individual could be a pseudo-hermaphrodite through either an XX- or XY-sex reversal during development to show secondary sexual characteristics of the opposite sex. The individual may be a male pseudo-hermaphrodite with an XY-sex reversal if undescended testes are present along with a vulva, clitoris, and/or a blind vagina (that does not connect to reproductive organs) but a lack of ovaries. Elsewhere urination from a vulva-like opening associated with a retro-posed penis has been documented (Kropatsch *et al.* 2013). However, in this case, the external genitalia appeared similar to those of other



**FIGURE 2.** Pedicle-like formation on a potential hermaphroditic Elk (*Cervus canadensis*) exhibiting female external genitalia and male secondary sexual characteristics. Photo taken within 15 m at the Ya Ha Tinda, adjacent to Banff National Park, Alberta, Canada. Photo: J. Normandeau.

female Elk. Wislocki (1956) also documented a male pseudo-hermaphrodite White-tailed Deer with antlers, a normal-sized vagina with a blind ending, and a small, hypoplastic (underdeveloped) testicle in the abdomen, which is consistent with our observations, although we did not observe antlers. Because antler growth is regulated by hormones produced from the testes (Wislocki *et al.* 1947), hypoplastic testes could explain the lack of antler growth in a male pseudo-hermaphrodite (Wislocki 1954). We did note two symmetrical patches of depressed hair on the head of the Elk at Ya Ha Tinda where antler pedicles would form, and one image (Figure 2) shows a small greyish nub protruding over the hair, which may signal the partial formation of a pedicle. However, we also cannot rule out female pseudo-hermaphroditism or XX-sex reversal. Although we argue that this Elk likely is a case of pseudo-hermaphroditism, we cannot rule out true hermaphroditism without a necropsy, as the presence of both male and female gonads cannot be eliminated or confirmed.



**FIGURE 3.** Potential hermaphroditic Elk (*Cervus canadensis*) in Alberta, Canada, with female external genitalia but male secondary sexual characteristics. The individual displays evidence of pedicles but no antler growth, no external signs of a penis or scrotum, and what appears to be female external genitalia (a). The individual was observed urinating from a vulva-like opening below the anus (b). Photos: J. Normandeau.



**FIGURE 4.** Potential hermaphroditic Elk (*Cervus canadensis*) with female external genitalia and male secondary sexual characteristics following a female while flicking its tongue in and out during the rut in the fall of 2019, a typical male behaviour. Photo: J. Normandeau.



**FIGURE 5.** Potential hermaphrodite Elk (*Cervus canadensis*) with female external genitalia and male secondary sexual characteristics attempting to bugle during the rut in the fall of 2019. The Elk does produce a bugle-like sound, but much quieter than typical male Elk bugling. Photo: J. Normandeau.

As a result, we argue that this Elk is likely a pseudo-hermaphrodite. Whether it was born into the Ya Ha Tinda herd or joined the herd is unknown. The Elk was likely over two years old at the time of observation because it was larger than a yearling male Elk. We did not observe an Elk exhibiting these characteristics before fall 2019 despite over 250 h/year of observations from January to April in 2018 and 2019. It is possible that segregation of males from the main Elk herd reduced the probability of seeing the Elk in previous winters. It is also possible that, if the Elk was a yearling with spike antlers the previous year, the female external genitalia may have been overlooked. The fact that, in 2020, the Elk remained with the main female herd and did not disperse with other males at the end of the rut is evidence it may have been part of the main herd the previous year. If this were the case, it is unclear why the individual would not have grown antlers in subsequent years. Alternatively, the Elk may have joined the herd from another population if it displayed juvenile dispersal tendencies, which have been known in Elk (Petersburg *et al.* 2000). At the same time, interchange between the Elk population in the town of Banff, which is ~80 km southwest of the Ya Ha Tinda, is as low as 1% (M.H. unpubl. data). Genetic analysis might have allowed us to determine a potential source population, but this Elk was never captured to obtain a sample.

Our ability to document an individual Elk as a potential pseudo-hermaphrodite is related to the intensity with which the Ya Ha Tinda Elk population has been studied over an 18-year period with ~25% of the herd individually marked. We were not able to capture the individual to obtain blood or a genetic sample, and without a radio collar we are unlikely to obtain the remains of the individual soon enough after death to examine internal organs because of high predator abundance. Genetic characterization of chromosomal sex and the presence of the *SRY*-gene, which stimulates testes differentiation, would be necessary to determine which type of pseudo-hermaphroditism is present. At the same time, we argue that there is sufficient evidence to claim that, to our knowledge, this is the first documentation of either true or pseudo-hermaphroditism in Elk in North America.

### Author Contributions

Writing – Original Draft: J.N.; Writing – Review & Editing: J.N., E.H.M., M.H., and H.M.; Conceptualization: J.N.; Investigation: J.N.; Methodology: J.N.; Funding Acquisition: E.H.M., M.H., and H.M.

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