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Loss of anti-predator behaviors in cattle and the increased predation losses by wolves in the Northern Rocky Mountains

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ABSTRACT

Managing livestock near Yellowstone National Park has become an increasing challenge since conservation of wolves restricts ranchers from interfering. Even though wolves are beneficial for the ecosystem, rising predation incidences on livestock (depredations) create animosity in local farmers. Temperament selection of cattle, measured by the facial hair whorl pattern (HW)[1], occurred during the last 15 years and the industry prefers calmer temperament animals. Six HWs occur in cattle (high, middle, low, abnormal, multiple and none), which are mutually exclusive and can be identified by using the eye-line as a reference point. We analyzed depredation of calves near Council, ID in 2011. A herd of 588 Black Angus × Charolais crossbreds (age range: 5 - 17 years) was observed. By analyzing the HW and age of cows in relation to depredations, we could identify a connection between these three factors (P < 0.001). The HW of a cow influenced the probability of losing the calf to predation (P < 0.001). Cows without the facial HW faced an increased percentage of losses (probability of 19.6% of losing the calf) compared to other HW (probability between 0% - 6.1%). An age effect on the probability of losing the calf was also found (P = 0.023). Cows over the age of 10 years are more likely to lose their calves. Our findings suggest that behavioral differences between cows with different HWs exist. Differences in protectiveness or vigilance towards the surroundings in cows without a facial HW may lead to an increased probability of losing their calves.

[1]HW = hair whorl pattern.

Keywords: Cattle; Depredation; Hair Whorl Pattern; Temperament Selection; Wolves (*Canis lupus*)

1. INTRODUCTION

A natural conflict arises when the home ranges of predator and prey species overlap. By reintroducing Canadian gray wolves (*Canis lupus*) in Yellowstone National Park (YNP) and Central Idaho in 1995/96 [1] naïve prey species were suddenly exposed to predation. Wolves were extinct in YNP and surrounding areas for 70 years. Elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*) populations reproduced intensely during this period, thereby over-browsing riparian sites and various tree species [2,3]. A trophic cascade occurred by reintroducing wolves [4]. Wolf populations decreased elk and deer numbers which, as a result, released the next lower trophic species of cottonwoods, aspen and willows from suppression [5,6]. A detailed map of the complexity of interactions in YNP can be found in Smith *et al*., 2003 [7]. The change in predator-prey species abundance was beneficial for the ecosystem [8]. In YNP and Idaho, wolves were mainly preying on elk (90%) and only occasionally killed livestock [7,9]. Overall, the reintroduction was seen as a great success because wolf populations became established after only two years [10] instead of the predicted 3 - 5 years after reintroduction.

The almost exponential reproduction of wolves resulted in increased predation losses of livestock, called depredation. Stalking, harassment and depredation of wolves on domestic livestock is creating public concerns, causes financial problems for ranchers and animosity [11]. Overall, livestock depredations are minimal but the ramifications for an individual producer are significant because depredations are not distributed evenly. Certain producers experience higher losses than others [12] cre-

ating a challenge for wolf conservation and management in these areas [11]. In the presence of wolves, wild ungulates change their behavior [13,14] and movement patterns to avoid predation [15]. Anti-predator behaviors of elk during summer months include habitat changes by moving to higher elevations with steeper slopes [16,17] and increasing the group size [18-20]. Due to increased fear, prey animals also increase their vigilance level [21-24]. With elk being out of reach during summer months, wolves start to prey on livestock [25].

Anti-predator behaviors of our domesticated livestock species, such as cattle and sheep, are however poorly developed because of artificial selection towards calmness over many generations [26,27]. Most livestock species do not regularly face predators and show weak or no response to predator presence compared to wild ungulates [28]. Welp *et al.*, 2004 [29] reported vigilance levels of dairy cows as a potential measure of fear. Cows in their experiment differed in vigilance level based on the environment and novelty of the stimulus. In general, cattle vigilance is increased and foraging behaviors decreased when wolf stimuli are present; contrariwise, vigilance decreases when deer stimuli are presented [30]. The former study was able to shed light on the connectedness of ungulate-predator behaviors. Other research found that the vigilance level after parturition of beef cattle varies according to the facial hair whorl position (HW) of the cow [31]. Cows with middle spiral HW and multiple HWs pay more attention to their surrounding and react earlier to an unknown approaching object (at a greater distance) than cows with other HWs [31]. Increased vigilance in areas with high predation pressure could potentially make the difference between life and death for an animal. The facial HW is frequently used as a measure of temperament and can be identified easiest when the animal is in a squeeze chute [32,33]. Limousine breeders were using temperament selection during the last 15 years, thereby altering and improving the docility of cattle [34].

Advantages of temperament selection are higher average daily gain of calmer cattle [35], improved human-cattle interactions [36], easier transport [37] and reduced fear [38]. However, recent increases in depredation raise the question if we out-selected protectiveness and fearfulness of our livestock species. The present study tries to identify a connection between the temperament of an animal, measured by the facial HW, and depredation losses of cattle in areas with increased predation.

2. MATERIAL AND METHODS

Observations were made in compliance with Colorado State University Animal Care and Use Committee Protocol IACUC # 10-2267A.

2.1. Animals and Environment

This study was conducted on a commercial cow-calf ranch near Council, Idaho, USA, in December 2011. The age range of cows was 5 - 17 years (average age: 7.4 years) and the total herd consisted of 588 cows (commercial Black Angus × Charolais crossbreds). During winter months, cows graze at lower elevations close to the barn (public land: ~15.000 acres, deeded land: ~5.000 acres) and are fed supplement and hay. During summer months cows graze at higher elevations on public and deeded land (public land: ~120.000 acres, deeded land: ~20.000 acres). Summer pastures consist of steep slopes and rough terrain which can only be accessed on horseback in most areas. Wolves represent the main predator during summer months and frequently injure and kill calves and even cows since grazing pastures and wolf territories overlap.

2.2. Cow Age and Hair Whorl Pattern (HW) Collection

Age and HW on the forehead of all cows were recorded while cows were in a squeeze chute for pregnancy diagnoses. The experimenter identified the HW position and drew it on a piece of paper. Hair whorls were classified as being high, middle or low position [32]. Using the eye-line as a reference point, HW were further classified as being abnormal, multiple (more than one, all with a clear center) or none (no HW on forehead). Classifications are mutually exclusive and animals were classified into one of these six groups.

2.3. Statistical Analyses

All data was analyzed using SPSS 20.0 (SPSS, Inc.). A binomial logistic regression was performed to analyze the probability of losing a calf. The dependent variable in the model is the “loss of a calf” (1 = alive/0 = dead). Covariates are the hair whorl pattern (high, middle, low, abnormal, multiple and none) and the age of the cow (age range: 5 - 17 years). The logistic regression allows calculating the probability of losing a calf due to the hair whorl pattern and age of the cow. A Wald chi-square test is integrated in the model to indicate how well the logistic regression fits the data. The significance level was set to $P < 0.05$ for this study.

3. RESULTS

By analyzing the HW pattern and age of cows in relation to depredations, we could identify a connection between these three factors ($P < 0.001$). The numbers and percentages of cows in each HW group are shown in **Table 1**. The average age of a cow in this herd was 7.4 years.

Table 1. Distribution of hair whorl pattern in the observed herd and distribution of calves alive/dead observed in 2011.

Hair Whorl Pattern	n	Alive	Alive in %	Dead	Dead in %
High	35	34	97.1%	1	2.9%
Middle	214	201	93.9%	13	6.1%
Low	179	171	95.5%	8	4.5%
Abnormal	53	53	100%	0	0%
Multiple	51	48	94.1%	3	5.9%
None	56	45	80.4%	11	19.6%
Overall	588	552	93.9%	36	6.1%

3.1. Calf Losses by HW Pattern

The average percentage of losing a calf to predation varied with the HW ($P < 0.001$; **Table 1**). Even though cows with middle and low HW are numerically represented highest in the herd, the total number of losses within these two groups was relatively low. No cows with an abnormal HW lost a calf in 2011. The group of cows without a HW, on the other hand, lost 19.6% of calves.

3.2. Calf Losses by Cow Age

The age of the cow further influences the probability of losing the calf due to predation ($P = 0.023$). **Figure 1** shows the probability of losing the calf in relationship to the age and HW of the cow. Cows in the age range of 5 to 10 years with high, middle, low, abnormal or multiple HWs have a probability between 2% - 8% of losing the calf to predation. Cows without a HW have a much higher probability of losing the calf starting at 15% and increasing up to 25%. The overall distribution of calf losses by the age of cows is shown in **Table 2**. Twenty young cows in the age of five and six years lost their calf, only a few middle aged cows were subject to predation and ten cows at age 14 lost their calf.

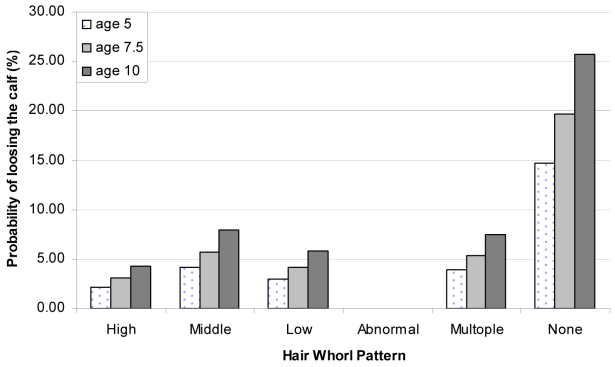

Figure 1. Probability of losing the calf to predation based on the age and the hair whorl position of the cow. Presented are probabilities for losing the calf for the age groups 5, 7.5 (average age of a cow in this herd) and 10 years. Probabilities for cows with an abnormal hair whorl are not shown since no depredation occurred in 2011.

Table 2. Distribution of calf losses by hair whorl pattern, age of cow (ranging from 5 - 17 years) and the overall number of cows per age group.

		Hair Whorl Pattern						
Age	n	High	Middle	Low	Abnormal	Multiple	None	Overall
5	**150**	**-**	**2**	**3**	**-**	**1**	**5**	**11**
6	**129**	**-**	**6**	**2**	**-**	**-**	**1**	**9**
7	**82**	**-**	**-**	**1**	**-**	**-**	**-**	**1**
8	**64**	**1**	**1**	**-**	**-**	**-**	**1**	**3**
9	**47**	**-**	**-**	**-**	**-**	**-**	**1**	**1**
10	45	-	-	-	-	-	-	0
11	24	-	-	-	-	-	-	0
12	**18**	**-**	**-**	**1**	**-**	**-**	**-**	**1**
13	7	-	-	-	-	-	-	0
14	**14**	**-**	**4**	**1**	**-**	**2**	**3**	**10**
15	4	-	-	-	-	-	-	0
16	2	-	-	-	-	-	-	0
17	2	-	-	-	-	-	-	0
Overall:	588	**1**	**13**	**8**	**0**	**3**	**11**	36

4. DISCUSSION

We identified a connection between the facial hair whorl (HW) pattern as well as the age of the cow and the probability of losing the calf to predation. The type of HW on the forehead of the cow can be associated with the probability of losing the calf. In our study, cows with high and abnormally shaped HW had the least number of losses in the herd. This may be explained by the increased vigilance of cows with high and abnormal HW as observed in the research of Flörcke *et al.*, 2012 [31]. Cows in the former study paid more attention to their surroundings, thereby allowing themselves and their calf more time to react and retreat in case of a predator approach. Vigilance is an indicator for fearfulness as shown in dairy cows by Welp *et al.*, 2004 [29]. By being less vigilant and fearful, cows in the present study may have lost their calf to predators.

Cows without a facial HW have a five-time higher probability of losing the calf to predation compared to cows with other HW patterns. In humans, the skin, neural tube and the nervous tissues develop during the third and fourth week of gestation [39] and this is comparable to cattle. Hair follicles start to develop at week 10 and are

extruded by week 18 of gestation in humans and cattle [40,41]. The hair whorl, or cowlick (in humans) can give information about the neuronal development. For simplicity purposes we will refer to cowlicks as hair whorl as well. Failures of proper development during early gestation can lead to a 'hair collar' in humans [39]. Neuronal changes underlying a hair collar can be agenesis of the corpus callosum or a Dandy-Walker malfunction. In humans, abnormal scalp-hair patterning can indicate brain malfunctions [40]. Without a parietal hair whorl, infants show severe brain deficits and most stillborns do not have a parietal HW [42,43]. Cows without a facial HW pattern lost more calves than any other group of cows in the present study. The absence of a facial HW pattern may imply that cows without a HW have neuronal aberrations compared to other cows.

While collecting observational data on maternal protectiveness, the first author noted abnormal behaviors of young calves without a HW. The temperament of an animal, measured by the facial HW, has a moderate heritability (German Angus 0.61 ± 0.17, Simmental 0.59 ± 0.41 [44]). Without paternity testing, we are however unable to determine the HW pattern of the calf, since both, the maternal and paternal HW pattern can shape the calf's HW. It is unlikely that paternal behavioral influences occur during the calf's development. Bulls are kept separately from the cow herd and the behavior of calves is most likely shaped by the mothers influence. Cows are hider species and calves stay hidden between bushes during the first days while cows are foraging nearby [45]. The normal reaction of a calf to an approaching unknown object/person is to jump up, call loudly for the mother and to run away. Calves without a HW pattern, on the other hand, kept lying between bushes and allowed the first author to pet them all over the body. In case of an approaching predator this calf would probably die. The high number of calf losses of cows without a facial HW pattern might be a combination of the reduced fear of the calf and possibly lower levels of protection of the cow. Cattle research in Canada identified alterations of the movement pattern and nearest neighbor distance in response to predator presence [46]. Anti-predator behaviors of cattle in the former study seemed, however, erratic and inconsistent. Since most cattle do not experience predation during their lifetime the question arises if the industry is selecting against anti-predator behaviors [47]?

The age of a cow further influenced the probability of losing the calf to predation. The age range of cows observed in this study was 5 - 17 years, with an average of 7.4 years which represents a typical beef herd in the US. (http://www.agtoursusa.com/BeefCattleUSA.htm). Several young cows (5 and 6 years of age) lost their calves to predation. Younger cows may have less experience when encountering predators [48] and react unadept. Social animals, such as cattle, are able to learn and alter their behavior based on their own or a conspecifics experience [49]. Usually, wolf depredations increase in later summer (August and September) as shown by [50], whereas bears and coyotes attack younger calves in early summer. Other studies also confirmed that calves younger than 9 months are the most frequent killed animals within the herd [51]. To our knowledge, this is the first study showing an age effect of the mother on the probability of losing the calf to predation. While immature younger cows are at risk during calving (unpublished data), it appears that older cows over the age of 10 years have an increased probability of losing their calf. Anti-predator behaviors are most likely to occur when the predator and prey species naturally occur within the same area. This was found by Parsons *et al.*, 2007 [51], who showed that a familiar predator species (dingo (Canis dingo)) can elicit an anti-predator behavior in gray kangaroos (Macropus giganteus) whereas an unfamiliar predator species (coyote (Canis latrans)) elicits a much weaker response. Here, the inexperience of younger cows (5 and 6 years of age) may have contributed to depredation losses since slightly older cattle show a reduced amount of losses. Ongoing research in the areas of predator-prey/livestock interactions, human-wild-life conflict and animal behavior will be needed to support carnivore conservation and maintain ranch practices.

5. CONCLUSION

Temperament selection of livestock species and especially cattle during the last 15 years has led to calm and easy to handle cattle. With the reintroduction of Canadian gray wolves in the Northern Rocky Mountains, ranchers face a new challenge. Without defined protective abilities, losses in cattle have increased since cows perform only minor protective behaviors in response to a predator approach. Our study showed an age and temperament effect on the probability of a cow to lose the calf to predation. The hair whorl pattern (HW) on the forehead of cows was used as a measure of temperament. While cows with high, middle, low abnormal and multiple HWs have an average probability of 0% - 6.1% of losing the calf, cows without the facial HW have a greatly increased probability of 19.6%. Further, with increasing age the predation probability increases, too. To our knowledge, this is the first study showing a connection between animal temperament and predation losses in cattle. Further research around livestock-predator interaction needs to be conducted to continue wolf conservation in areas with high predation pressure.

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