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Using GPS Technology and Parentage Testing in Rangeland Beef Breeding Systems to Evaluate Bull Power

Abstract

The objective of this study was to utilize GPS technology and parentage testing to provide a more accurate measurement of bull power. Our study fit 5 bulls from the same herd with GPS collars. Bull movement was tracked over a 90-day breeding season. The collars collected measurements of total distance traveled per day. Upon completion of the breeding season, collars were removed, and data retrieved. DNA samples were also collected from the bulls. At calving, biological material of 104 calves was collected and compared with the bull samples to determine parentage. Parentage testing revealed that 6 bulls sired calves during the 2018 breeding season. The ranch's bulls sired 72 calves. Thirty-two calves were sired by a bull from herds that grazed in a nearby pasture.

Introduction

The concept of bull power has long been discussed in beef operations. By definition, it is the number of bulls needed to effectively breed a specific number of cows during a breeding season. Traditional estimates of 1 bull per 20 to 30 cows, with a ratio of 1:20 for yearling bulls and 1:30 for mature bulls, have remained standard (Day 2022, Sprott et al., 2012). A study by Healy et al. (1993) validated a bull-to-cow ratio of 1:25 based on economic metrics and pregnancy rates different cow-to-bull ratios. However, no industry standard number for bull to cow ratio is given as previous research as shown deviations from the 1:25 ratio. Specifically, Timlin et al. (2021) reported bull-to-cow ratios in the range of 1:9 to 1:73, with an average of 1:31, without significant differences in pregnancy rates.

While bull power is typically the primary focus on effectively getting cows bred, many other factors can lead to bull fertility and the subsequent number of cows bred during a breeding season. The first is social hierarchies. In many western rangeland operations, multiple bulls are utilized simultaneously during breeding. As a result, older, more dominant bulls may service more cows than younger submissive bulls (Reiling, 2011). However, this may lead to the second factor impacting the number of cows a bull can service, which is semen quality. For example, suppose the bull servicing most of the herd has decreased semen quality (motility, absence of abnormalities, and low sperm count). In that case, the bull's inferior semen quality will significantly impact the pregnancy rate of the cow herd. The third characteristic that will impact bull-to-cow ratios is the soundness of the bull throughout the breeding season. In rangeland systems, a bull must remain physically sound to travel distances to breed cows. Therefore, if the bull becomes lame, injured, or suffers an injury to his reproductive organs during the breeding season, this will impact his ability to effectively service cows. Finally, the last characteristic relevant to a bull's ability to service cows is his libido or sex drive. Libido has been shown to be highly correlated with servicing capacity in rangeland settings (LeaMaseter and DuPonte, 2007). Unfortunately, this trait is difficult to measure or ignored during most breeding soundness exams. As such, proper

selection and evaluation of bulls before the breeding season is essential to avoid any potential pitfalls that may impact their ability to effectively service cows.

While a good amount of research has been conducted evaluating how cows utilize grazing landscapes (Sprinkle et al., 2020 and 2021), little to no research has been undertaken to evaluate bull behavior during a breeding season on a rangeland operation. Thus, the objectives of the current study were to evaluate bull behavior/movement during the breeding season and subsequently evaluate what factors contributed to the number of calves a bull sired during a controlled breeding season.

Methods

Experimental animals

A total of 5 registered Angus bulls expected to breed cows for 90 days on a public land allotment on the Utah, and Arizona border had ear notches collected with a pig ear notcher before the 2018 breeding season. The ear notches were preserved through freezing for future DNA extraction. All the bulls were also fit with GPS collars to evaluate behavior during the breeding season and had collars removed after breeding season to evaluate movement (Figures 1a-b). All bulls had breeding soundness exams conducted by a licensed veterinarian prior to breeding season and were deemed disease free and fit to breed. Bulls were exposed to a total of 110 cows during the breeding season resulting in a bull-to-cow ratio of 1:22, which is well within industry accepted standards. Bulls ranged in age from 6 years to 18 months of age (Table 1). The following calving season (2019), all calves (n=104) potentially sired by the 5 previously described bulls had an ear notch collected with a pig ear notcher when they were processed for weaning. Ear notches were then preserved by freezing for future DNA extraction. The DNA testing would then reveal which bulls sired which calves.

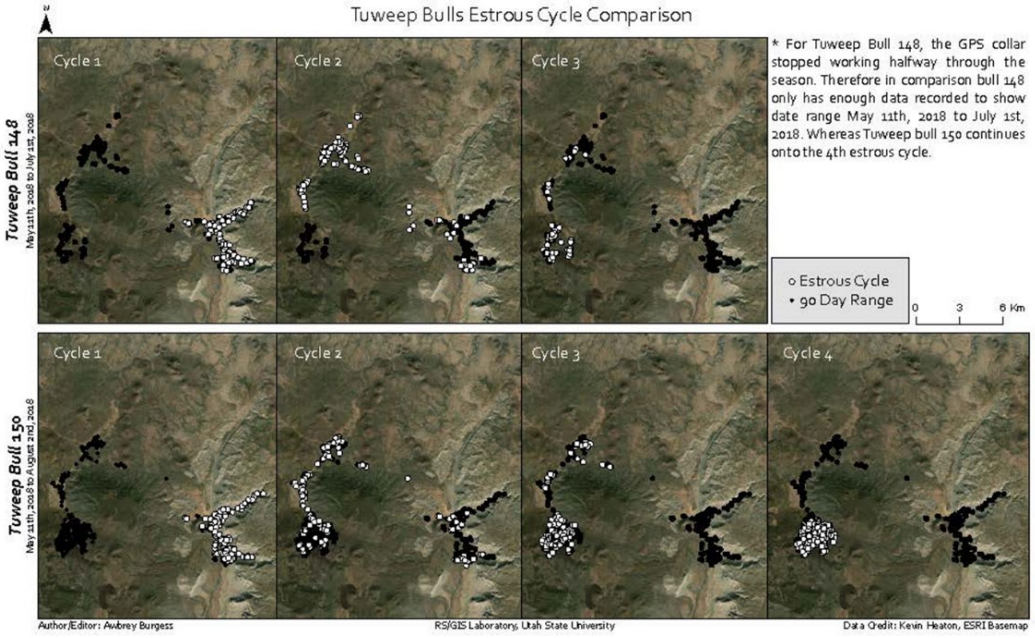

Figure 1a: Bulls 3 and 4 during the breeding season. White dots indicate individual movement patterns during the breeding season and panels from left to right are individual movements during a 21-day period. As indicated in the figure, bull 3's GPS collar stopped transmitting during the last cycle of the breeding season.

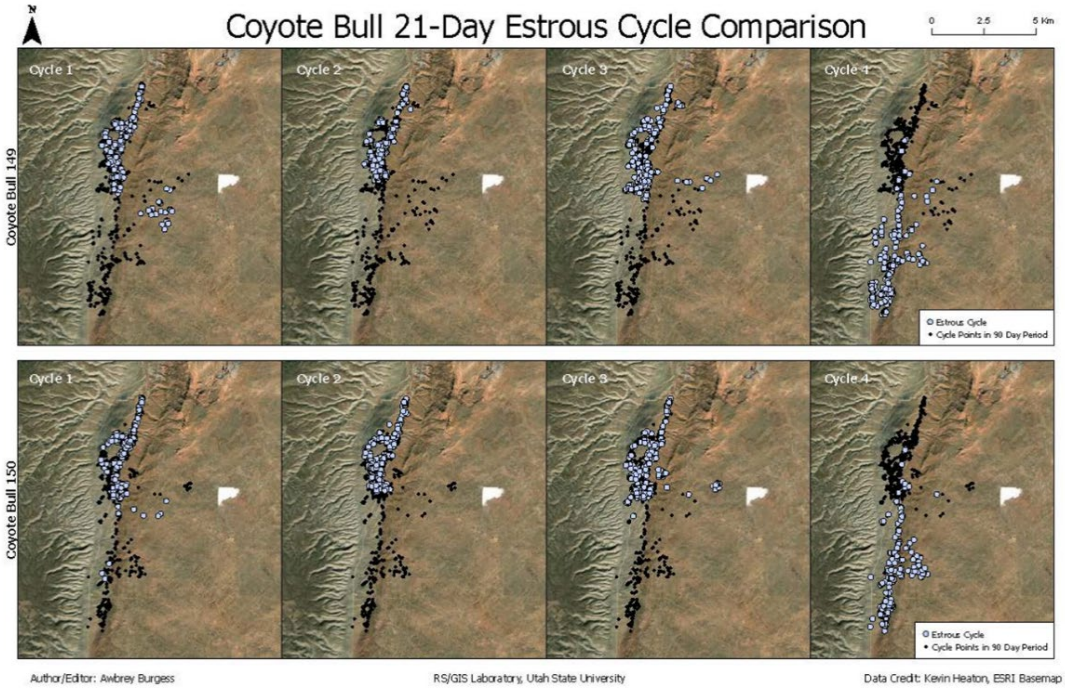

Figure 1b: Bull 1 and 2 during the breeding season. White dots indicate individual movement patterns during the breeding season and panels from left to right are individual movements during a 21-day period.

Table 1. Bull age and breed which were fit with GPS collars and sampled for biological material for DNA extraction

Bull ID	Breed	Age (years)
1	Angus	6
2	Angus/Gelbvieh	5
3	Angus	5
4	Angus	3
5	Angus/Gelbvieh	18 months

DNA extraction and parentage testing

Extraction of DNA was conducted using a saturated salt procedure previously described by Miller et al. (1988). DNA stock solutions were diluted to 25 ng/µl concentrations for future parentage testing. Extracted DNA samples from bulls and all 102 calves shipped overnight on dry ice to Neogen Inc. (Lincoln, NE) for parentage testing.

Table 2. Number of calves sired by individual bulls that were subsequently verified through parentage testing.

Bull ID	Number of Calves Sired
Bull 1	30
Bull 2	16
Bull 3	14
Bull 4	10
Bull 5	2
Unknown bull	32

Results and Discussion

When evaluating the animal population of the current study, the bulls utilized at a 1:22 bull to cow ratio provided a 95% conception rate with an identical weaned calf crop of 95%. Specifically, 104 of 110 cows were diagnosed as pregnant, and the same number of cows raised a calf to weaning. However, when evaluating bull movement during the breeding season, there were some issues with the GPS collars. Bull 5 lost his GPS collar within days of the trial beginning and the collar was never recovered. Bull number 3's collar stopped transmitting during the last 21-day cycle (Figure 1a). However, GPS data that was transmitted by the 4 collars that remained functional revealed no significant differences in the movement or behavior of the bulls during the breeding season. This could be explained by the fact that water locations were limited, and the bulls remained with cows located near water sources. This would agree with previous studies (Sprinkle et al., 2020 and 2021) which illustrated that grazing patterns and behavior was closely correlated with the location of water sources.

When evaluating the number of calves sired by each of the five bulls the results were somewhat unusual. Bull 1 sired the majority of the calves (n=30), with bulls 2 and 3 siring an almost equal number of calves (16 vs 14) and Bull 4 and 5 siring the least (10 vs 2; Table 2). These results agree with previous research (Reiling, 2011) showing that social hierarchy is a major contributor to the number of calves sired. Specifically, Bulls 1 and 2 were the most mature bulls with bulls 3, 4 and 5 being younger. However, even with the identification of calves associated with the five bulls utilized herein, 32 calves could not have parentage confirmed. Upon receiving these results, the collaborating rancher confirmed that a neighboring bull in an adjacent allotment was removed numerous times during the breeding season. The bull was always located alone so the assumption was made that he did not breed any cows. Upon collecting an ear notch sample from this bull, it was determined that he was the single sire to the 32 calves whose parentage initially could not be determined (Table 2). Furthermore, he was a mature bull, approximately five years of age, which would agree with the findings of this study that mature bulls sired a higher number of calves.

Conclusion

Study results were confounded due to the presence of the bull from the neighboring pasture. Due to the presence of the extra bull, the current study did not identify any significant differences in bull movement (Figures 1a and 1b) or behavior using GPS collars, the importance of parentage testing in multiple bull breeding pastures was validated for three main reasons. The first is that parentage testing helps validate what genetics the producer may be incorporating into their herd. Specifically, when keeping females as replacements, is the producer incorporating genetics from bulls that are optimal for replacement females? The second reason that parentage testing will prove valuable is to determine which bulls are breeding and at what levels. This information will help a producer determine if a bull needs to be culled or managed differently during a breeding season.

Finally, in multiple bull breeding pastures, grazing co-ops or even breeding pastures next to neighbors, parentage testing allows a producer to verify that they are actually incorporating genetics that they selected into their herds rather than genetics from sources that may not be compatible or desirable to their operational goals. The preliminary results presented herein will provide a foundation for future studies evaluating bull behavior and power. This study will help determine a phenotypical type of bull that successfully incorporates his genetics into a beef herd at acceptable levels.

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