The effects of *Tritrichomonas foetus* and nutritional status on the fertility of cows on a community pasture in Saskatchewan

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Abstract — A prospective observational study of a breeding season in a Saskatchewan community pasture was carried out to determine the cause or causes of a chronic infertility problem. There were 774 cows, from 27 herds, divided into 4 breeding groups (A,B,C,D) on the pasture. Cows entering the pasture in May were weighed, had their body condition scored and height measured. All bulls received breeding soundness examinations and a preputial wash, which was cultured for *Tritrichomonas foetus* and *Campylobacter foetus* subsp. *venerealis*. In July, cows were also weighed and had their body condition scored and again when they left the pasture. In addition, cows were pregnancy checked when they left the pasture. Bulls were tested again for *Tritrichomonas foetus* at the end of the grazing season. Two breeding groups had *T. foetus*-positive bulls and an average pregnancy of 84%, which was significantly lower than that of the two *T. foetus* negative groups (93.5%) ($P = 0.0001$). A cow was 2.97 times less likely to be pregnant if she had been exposed to *T. foetus*-positive bulls. Cows with average daily gains above the mean for the pasture were 2.12 times more likely to be pregnant. Body condition score upon entering and leaving the pasture, height, age, and breeding group were significant predictors of average daily gain.

Résumé — Les effets de *Tritrichomonas fœtus* et de l'état nutritionnel sur la fertilité de vaches d'un pâturage communautaire de Saskatchewan. Une étude prospective d'observation d'une saison de reproduction dans un pâturage communautaire de Saskatchewan a été menée afin de déterminer la ou les causes d'un problème d'infertilité chronique. Il y avait sur le pâturage 774 vaches de 27 troupeaux divisée en 4 groupes de reproduction (A,B,C,D). À leur entrée au pâturage en mai, les vaches étaient pesées, leur condition physique était évaluée et leur taille était mesurée. Tous les taureaux ont subit un examen du système reproducteur ainsi qu'un lavage du prépuce à partir duquel on a effectué une culture afin d'identifier *Tritrichomonas fœtus* et *Campylobacter fœtus* sous-espèce venerealis. En juillet, ainsi qu'au départ du pâturage, les vaches ont de nouveau été pesées et leur condition physique évaluée. De plus, un examen de gestation a été réalisé au départ du pâturage. Les taureaux ont de nouveau été testés pour déterminer la présence de *Tritrichomonas fœtus* à la fin de la saison de pâturage. Deux groupes reproducteurs comprenaient des taureaux porteurs de *Tritrichomonas fœtus* et ils ont eu en moyenne de 84 % de gestation, ce qui était significativement plus bas que les 2 groupes négatifs à *Tritrichomonas fœtus*. Les vaches avec des gains quotidiens moyens plus élevés que la moyenne du pâturage avaient 2,12 fois plus de chance d'être gestantes. L'évaluation de la condition physique à l'entrée et au départ du pâturage, la taille, l'âge et le groupe reproducteur constituaient de bons facteurs de prédiction du gain quotidien moyen.

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Introduction

The importance and extent of the community pasture system in Western Canada is unique in the developed world. Community pastures may be provincially, federally, or privately owned and administered. Cows are brought by different owners to the pasture in spring and remain there throughout the summer for breeding and grazing. Some cows may be bred at their home farm but many farmers rely on bulls owned by the community pasture system to breed their cows. Cows from several herds are usually combined into a breeding group, which will remain as a unit for the grazing season.

The community pasture setting provides a unique environment for the study of disease and herd problems. It represents a combination of cows from a variety of winter management settings, brought together as a group for the breeding and grazing season. It also presents a unique problem when it comes to controlling infectious disease, because of the intermingling of animals from different herds.

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Tritrichomonas foetus is a well-documented cause of infertility in beef and dairy herds (1). Trichomoniasis is a concern for Western Canadian beef producers, since it has been isolated from a number of community pastures in Manitoba, Saskatchewan, and Alberta (1). Most research on bovine trichomoniasis has investigated factors that help control the spread of the parasite; little work as been done on other factors that may alter the fertility of the cow in the presence of the parasite. Nutritional status of the cow, as demonstrated by body condition and average daily gain (ADG), is a possible factor, as it has a known influence on fertility (2–8).

The primary objective of this prospective, observational cohort study was to determine the cause or causes for a chronic infertility problem in a southern Saskatchewan community pasture. The secondary objective was to determine the factors that affected the ADG of the cows on this pasture.

Materials and methods

The site was a federal community pasture, administered by the Prairie Farm Rehabilitation Administration (PFRA), that had experienced a high proportion of nonpregnant cows. It was estimated that 12%, 26%, and 18% of the cows, respectively, had not conceived or had not calved in the previous 3 y.

The investigation was carried out during the 1993 breeding and grazing season. Seven hundred and seventy-four cows, owned by 27 patrons, were separated into 4 breeding groups (A,B,C,D) of varying sizes. All of the breeding groups consisted of mixed-breed beef cows. Once a cow was in a breeding group, she remained there for the entire grazing period. All pastures were rotationally grazed. All cows began the grazing period on crested wheat grass pasture and were moved onto native pasture. The cows also had access to free choice minerals.

During the week of May 18, 1993, as they entered the pasture, each cow was tagged with a metal ear tag as a means of identification, and her height at the hip (HEIGHT), weight (WT1), body condition score (BCS1), age (if known), and calf identity (if known) were recorded. Body condition scoring was performed using the East of Scotland College of Agriculture (ESCA) condition scoring system for beef cattle, on a 1 to 5 scale (10). All calves were weighed and tagged independently.

On May 20, bulls owned by the PFRA (breeding groups A,B,C) and by patrons (breeding group D) had a standard breeding soundness examination, plus a preputial wash, prior to entering the pastures on May 23. The preputial washings were cultured for *T. foetus* and *Campylobacter foetus* subsp. *venerealis* (1). Breeding soundness evaluations were done by using the criteria recommended by the Western Canadian Association of Bovine Practitioners (11). The bull to cow ratios were 1:30 for group A, 1:22 for group B, 1:27 for group C, and 1:32 for group D. Breeding group A contained three 2-year-old bulls, one 3-year-old bull, and one 5-year-old bull. Breeding group B contained six 2-year-old bulls, one 3-year-old bull, and two 6-year-old bulls. Breeding group C contained eight 2-year-old bulls and two 4-year-old bulls; and breeding group D contained three 3-year-old bulls and two 4-year-old bulls. Libido testing was not performed on any of the bulls.

In the last week of July, the cows were weighed (WT2) and had their body condition scored (BCS2). All calves were weighed.

All of the bulls were removed on August 28. In the first week of October, before they left the pasture for winter, the cows were body-condition-scored (BCS3), weighed (WT3) and checked for pregnancy. All calves were weighed.

On October 6, the bulls that had remained on the pasture for the entire breeding season had a preputial wash, which was retested for *T. foetus*.

The same veterinarian did the body condition scoring throughout the project. All rectal examinations were performed by one veterinarian.

Statistical analysis

The data were entered into a computer spreadsheet program (Quattro Pro, version 5.0, Borland International, Scotts Valley, California, USA). The ADG was determined by subtracting the cow's weight on entering the pasture from her weight on leaving the pasture and dividing it by the number of days that she had been on the pasture.

A statistical package (BMDP, BMDP Statistical Software, Los Angeles, California) was used for all statistical analyses. A stepwise logistic regression was used to determine which variables were important in affecting the pregnancy status of individual cows (12). Both the ADG and the body condition scores were transformed into binary variables in this model for easier interpretation of the odds ratios. An arbitrary cutoff point of 0.36 kg/d was used to transform the ADG into a binary variable. This cutoff point was used, as it was just below the mean ADG of the cows. Body condition scores were transformed into a binary variable using a cutoff point at a score of 2.5.

Stepwise linear regression was used to determine the variables that were important in affecting an individual cow's ADG (13).

Adjustment for clustering by herd was done using the method described by Donald and Donner (14).

Analysis of variance was performed for pregnancy status and ADG by breeding groups, and statistically significant differences between breeding groups were determined using Tukey's method.

Results

Bulls

Three bulls were of questionable breeding potential, based on semen evaluation or scrotal circumference, and one bull was deemed an unsatisfactory potential breeder, based on semen evaluation. These bulls were culled and replaced with bulls that had were classified as satisfactory on breeding soundness examinations. There was no significant difference among the percentage of cows pregnant in each breeding group associated with these ratios. The pasture manager did not observe any significant libido or social dominance problems among the bulls.

Tritrichomonas foetus was cultured from one bull at the first evaluation. This bull was with the cows in

Table 1. Breakdown of pregnancy, average daily gain (ADG), *Tritrichomonas foetus* status, and number of cows, by breeding group

	Breeding Group			
	A	B	C	D
% Pregnant	78.8[a]	87.6[b]	93.1[b]	93.9[b]
<4 months	11.9	19.9	20.8	13.5
>4 months	66.9	67.7	72.3	80.4
% Nonpregnant	21.2	12.4	6.8	6.1
ADG(kg/d)	0.32[a]	0.5[c]	0.39[b]	0.41[b]
T. foetus status of bulls	1 positive	3 positive	negative	negative
Number of cows	151	196	264	163

Numbers with different superscript letters are significantly different ($P < 0.05$), as determined by Tukey's method

Table 2. *Tritrichomonas foetus* (TSTATUS) and average daily gain (ADG) as predictors for pregnancy with their respective odds ratios, confidence intervals, and *P* value

Variable	Odds ratio	Confidence interval	*P* value
TSTATUS	0.337	0.207–0.549	<0.0001
ADG	2.16	1.34–3.46	0.0013

Table 3. Basic descriptive statistics for all variables in the data set related to the average daily gain (ADG) of cows

Variable	Mean	Maximum	Minimum
ADG (kg/d)	0.40	2.031	−1.828
Age (y)	4.93	16	1
Body condition score (May)	2.56	5	1
Body condition score (July)	2.73	4	1.5
Body condition score (October)	2.71	4	1.5
Height at hip (cm)	133.64	154	117
Weight (kg, May)	491.77	792	250
Weight (kg, July)	533.73	843	303
Weight (kg, October)	549.63	854	342

Table 4. Coefficients for variables in the multiple linear regression for average daily gain

Variable	Coefficient
Constant	1.21508
Age	−0.02761
Body condition score in May	−0.12604
Body condition score in October	+0.25550
Breeding group	+0.03695
Height	−0.00827

breeding group B and was immediately removed from the cows. However, the cows had already been exposed to him for 2 wk. He was not replaced, as this breeding group already had a high bull to cow ratio. None of the bulls tested positive for *Campylobacter foetus* subsp. *venerealis*.

On the 2nd preputial wash, 3 of the bulls tested were positive for *T. foetus*. Two of the positive bulls were from breeding group B, and one was from breeding group A.

Pregnancy

The overall pregnancy for the entire pasture was 89.3%. Seventeen of the 27 patrons used a bull at home before bringing the cows to the pasture.

The overall pregnancy rate in the 2 breeding groups with *T. foetus*-infected bulls was 84%. The overall pregnancy rate for the 2 breeding groups with *T. foetus*-negative bulls was 93.5%. These rates are significantly different, as determined by a *t*-test ($P = 0.0001$). A breakdown of pregnancy percentages and presence of *T. foetus*-positive bulls by the 4 breeding groups is shown in Table 1. Table 1 also gives the relative percentages of cows in each breeding group that were in early or late gestation or were nonpregnant. There was no association between the proportion of pregnancies at less than 4 mo or greater than 4 mo gestation and exposure to *T. foetus*-infected bulls.

The ADG and the possibility of exposure to a *T. foetus*-positive bull (trichomonas status of a breeding group) were significant predictors of the pregnancy status of the individual cow, as determined by the stepwise logistic regression model (Table 2). Body condition score going onto pasture was a significant predictor before controlling for clustering by herd. It was not considered in the final model after adjusting for clustering by herd.

One-way interaction terms were offered to the model but they were not significant predictors of pregnancy status.

Average daily gain

The descriptive statistics for those variables associated with a cow's nutritional status are shown in Table 3.

Age, body condition score entering the pasture (BCS1), body condition score leaving the pasture (BCS3), breeding group, and height were significant predictors of the ADG, as determined by the linear regression model (Table 4).

A breakdown of the ADG by breeding group is shown in Table 1.

Discussion

Interpretation of the results was facilitated by the project being a "natural experiment," since 2 of the breeding groups had bulls that were positive for *T. foetus* and the other 2 breeding groups were *T. foetus*-free. With a natural experiment, the investigator has not performed a true experiment where all risk factors but one have been controlled. Instead, there are 2 or more subgroups within a population that were treated exactly the same, except for 1 or 2 risk factors that differ by circumstance (15).

If an individual cow was in a breeding group that contained *T. foetus*-positive bulls, she was 2.97 times more likely not to be pregnant than a cow in a breeding group in which all the bulls were *T. foetus*-negative. This is not surprising, as the clinical features of *T. foetus* infection in cows include early fetal death, abortion, and infertility (16,17).

Trichomonas status is the most significant predictor in this model, yet when it is controlled in the model, the nutritional factors still have significant odds ratios and coefficients. If a cow had an ADG greater than 0.36 kg/d on pasture, she was 2.16 times more likely to be pregnant than a cow with an ADG below 0.36 kg/d. This is in agreement with reports that cows gaining weight during the breeding season have higher pregnancy rates than those losing weight (2,4,6,7).

Although body condition score was confounded by herd of origin and was not included in the final pregnancy model, clearly there are tendencies that are biologically important in the overall picture. A cow with a body condition score of 2.5 or greater going onto pasture was 1.92 times more likely to become pregnant than a cow that had a body condition score of less than 2.5. This is in accordance with numerous reports that body condition score at calving or at the beginning of the breeding season is an important determinant of reproductive success (2–4,7,8). Body condition score, when coupled with changes in body weight, can be used to assess the reproductive potential of a cow (2).

There was considerable variation in the percentage of cows pregnant in each herd of origin, which did not appear to be associated with the number of cows in each herd. Therefore, it is most likely that some of that variation was due to the "herd effect" that was controlled for in the model.

Although being bred on the home farm may have reduced the risk of being exposed to a positive bull on the pasture, it was not significantly associated with pregnancy status, possibly because the "bred at home" variable was only determined by whether the patron exposed his cows to a bull, not that they were pregnant upon entry.

Body condition score entering pasture is herd-of-origin-specific, as it indicates how well the cows were fed and housed over winter. This may explain why this variable became less important once the data had been adjusted for clustering by herd of origin.

The ADG model only accounted for 15% of the variation seen in the ADG. This could be an area for further study. Weights were not offered to the ADG model, since they are the basis for determining ADG and would, therefore, add no information to the model. It is probable that body condition score entering pasture and body condition score leaving pasture entered the model, since they are indirect determinants of weight and, therefore, ADG. All systems of body condition scoring have been shown to determine some set change in body weight for each increment of score (4,6,7). Body condition score entering the pasture and body condition score leaving the pasture had a negative and positive association with ADG, respectively, in this study.

Height was a significant predictor of ADG and was used as an estimate of frame size. Cows with larger frame sizes require more energy for maintenance on pasture and may not receive adequate nutrition while on pasture. This was substantiated by the fact that height had a negative association with ADG.

Age was negatively associated with ADG, suggesting that older cows were less likely to gain weight while on pasture. Younger cows, particularly the 2-year-olds, are still growing and gaining significant amounts of bone and muscle mass. Older cows are also more likely to have worn teeth and other dental problems that may affect their intake and weight gain.

In conclusion, exposure to bulls infected with *T. foetus*, and ADG of cows during the grazing season, were important factors in affecting beef cow fertility. Shortening the breeding season should reduce the number of late-calving cows when trichomoniasis is present and enable better control through culling of nonpregnant cows. The ADG of the cows was affected by age, body condition score, and height.

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