Economic Impact of Digital Dermatitis, Footrot and Bovine Respiratory Disease in Feedlot Cattle

J. A. Cortes, * S. Hendrick, † E. Janzen, *E. A. Pajor, * K. Orsel*

*University of Calgary, Faculty of Veterinary Medicine, Department of Production Animal Health, Calgary, Canada; †Coaldale Veterinary Clinic, Coaldale, Canada

Corresponding author: Julian Alberto Cortes, Email: julian.cortes@ucalgary.ca
**ABSTRACT**

Digital dermatitis has emerged in North American feedlots, although production and economic impacts are not fully understood. Objectives of this study were to: 1) estimate economic impact of a single case of digital dermatitis (DD), foot rot (FR) and bovine respiratory disease (BRD) in feedlot cattle; and 2) determine its impact on average daily gain (ADG). Feedlot cattle health and production records were available from 2 feedlots for a 3-year interval. The dataset consisted of 77,115 animal records, with 19.3% (14,900) diagnosed with a disease. Diseased animals were categorized in 5 groups: DD, FR, BRD, other diseases (OT) and 2 or more diseases (TM), with a treatment cumulative incidence of 6.0, 59.1, 10.7, 12.7 and 11.5%, respectively. Foot rot was the disease with the highest cumulative incidence in both heifers and steers (58.8 and 59.6%, respectively). Of all fall placed cattle diagnosed with any disease, 48.1% of cases were FR. Digital dermatitis affected the partial budget in 5 out of the 8 groups of cattle, with the highest impact of DD seen in grass yearling heifers (GYH) and grass yearling steers (GYS): $-98 and $-96 CAD, respectively relative to their healthier counterparts. Healthy cattle had a significantly higher ADG compared to DD cattle in 5 of 8 categories, ranging from 0.11 kg/d in winter placed heifers to 0.17 kg/d in fall placed steers.

In the economic analysis it was concluded that on an individual animal basis BRD was the most impactful of all analyzed diseases, where DD was second, marking the importance of controlling and mitigating this foot condition. Identifying differential effects of diseases on a partial budget analysis and ADG of the types of cattle stratified by sex, enables feedlot producers to focus control and mitigation strategies on specific groups.

**Key Words:** Beef cattle, Foot rot, BRD, economic impact, infectious disease, lameness.
List of Abbreviations:

- Symbol Definition
- CAD: Canadian dollars
- ADG: Average daily gain
- ANOVA: Analysis of variance
- AW: Arrival weight
- BRD: Bovine respiratory disease
- BY: Backgrounded yearling
- CI: Confidence interval
- d: day
- DD: Digital dermatitis
- DOF: Days on feed
- FPC: Fall-placed calf
- FR: Foot rot
- GY: Grass yearling
- HCW: Hot carcass weight
- HE: Healthy animal
- kg: kilogram
- n: Sample size
- OR: Odd ratio
- OT: Other diseases
- sd: standard deviation
- SEM: Standard error of the mean
- TM: Two or more diseases
- TW: Terminal weight
- WPC: Winter-placed calf

**INTRODUCTION**

Lameness, a clinical manifestation of an abnormal condition that affects locomotion (Van Nuffel et al., 2015), is the second most treated condition in feedlot cattle after bovine respiratory diseases (BRD) (Davis-Unger et al., 2018), with adverse effects on animal health, production and welfare. Foot lesions are responsible for 70-90% of lameness cases in both dairy (Solano et al., 2016) and beef cattle (Griffin et al., 1993; Schwartzkopf-Genswein et al., 2016), with infectious lesions like digital dermatitis (DD), foot rot (FR) and interdigital dermatitis having the highest prevalence (Brown et al., 2000; Refaai et al., 2013; Teixeira et al., 2010).

Digital dermatitis is a multifactorial polybacterial contagious foot disease, with microorganisms that belong to the species *Treponema* consistently isolated from DD lesions (Krull et al., 2014; Zinicola et al., 2015). It was first reported in Italy in 1974 (Cheli and Mortellaro, 1974) and subsequently in several countries around the world (Orsel et al., 2018), affecting both dairy (Solano et al., 2016) and beef cattle (Sullivan et al., 2013). In the former, it is usually present between heel bulbs of rear feet, where it can develop skin ulcers that cause discomfort or pain (Döpfer et al., 1997), although for beef cattle it’s manifestation is not as well characterized.

Foot rot, also called interdigital necrobacillosis, causes subcutaneous swelling that results in sudden lameness, where the main bacteria associated with this disease is *Fusobacterium necrophorum* (Whittier et al., 2009). Excess of moisture and unhygienic environments have been considered to be predisposing factors in dairy cattle for most infectious foot lesions (Hultgren & Bergsten, 2001; Solano et al., 2017), whereas for beef cattle this has not been fully elucidated.
Lameness accounts for 16% of all morbidity in feedlot cattle and up to 70% of revenue losses related to premature slaughter (salvaged) cattle, mainly due to chronic injury, treatment, decreased average daily gain (ADG) and increased days on feed (DOF) (Terrell et al., 2017). Estimated costs have been reported for other feet and leg conditions (Davis-Unger et al., 2017) albeit not for DD. Although DD is regarded as causing clinical lameness in heavy cattle that are nearly finished and ready for market, it is not clear how impactful it is (Plummer & Krull, 2017).

However, Kulow et al., (2017) reported significantly lower carcass weight in beef cattle with active M2 lesions relative to those without M2 lesions.

No studies to date have performed a partial budget analysis (= benefit - cost) of healthy cattle (HE; not diagnosed as sick) to diseased cattle with a single DD incident. To address this gap in knowledge and build on previous research, the objective was to estimate the economic and production impact of a single DD incident, specific to various cattle types and both sexes. To provide a frame of reference, cattle with a single incident of FR, BRD or other and multiple diseases were also included.

**MATERIALS AND METHODS**

This study used data from 2 finishing feedlots in southern Alberta with outdoor housing in pens, dirt floors and wind protection as is common in Western Canada. The dataset was not purposive collected, and it was provided by Coaldale Veterinary Clinic (CVC), Lethbridge, Alberta, Canada with feedlot workers recording data in a computer software program (Fusion, SSG Fusion). Diagnosis and treatment of diseases was performed according to protocols provided by CVC, in which a DD case was defined as a skin lesion between the heel bulbs that could be either active or chronic; a FR case as a symmetrical swelling of the foot with necrotic tissue between the toes and a foul odor; and a BRD case
was defined as a depressed animal with a difficulty to breathe, coughing, nasal discharge and fever once it was pulled.

Cattle in these feedlots were handled according to the code of practice for the care and handling of beef cattle (AAFC, 2018).

Data were available for a 3-year interval (2016 to 2018) where 34 different diseases were diagnosed. Stratification was done for cattle who had a single disease incident of DD, FR, or BRD. Besides, two new categories were created: one for cattle that had a single incidence of any other disease (OT), and another for cattle that were pulled for 2 or more diseases (TM), including any disease category mentioned previously.

Each individual in the dataset had: feedlot identification, type of cattle (fall-placed calves (FPC) placed between September 22 to December 20; winter-placed calves (WPC) placed between December 21 to March 19; grass-fed yearlings (GY, cattle placed on grass for the summer before going to a finishing feedlot) and backgrounded yearlings (BY, cattle placed in a feedlot with a moderate-energy diet before going to a finishing feedlot); cattle identification, arrival date, arrival weight (AW), DOF, date of slaughter, hot carcass weight (HCW), sex (steer or heifer), marbling, yield, premium/discount (relative to meat quality), processing cost and feed cost. Cattle that were treated had the following additional information: diagnosis, date of diagnosis and treatment, treatment costs. Days on feed at diagnosis was calculated using date of diagnosis minus date at arrival.

**Data Cleaning**

Identical copies of records were defined as duplicates and removed from the database. For missing values, treated cattle without production parameters or negative values were omitted ($n = 5,033$); similarly, for missing information on AW ($n = 301$), sex ($n = 200$) or type of cattle ($n = 99$). In addition, cattle with a weight at arrival $<136$ Kg and DOF $>500$ ($n$
were not included in the analysis, given their unlikely occurrence in the western Canadian feedlot setting, deeming them as a mistake in data entry as was suggested by Davis-Unger, et al (2018). This cleaning process resulted in exclusion of 13,686 animal records, resulting in \( n = 77,115 \) animal records for this study (Fig 1). One of the feedlots contributed 73\% of the resulting number of available records.

Therefore, the variable weight at slaughter (WS) was calculated by dividing HCW by 0.596 (Bartoň et al., 2006). The weight at arrival (WA) was then discounted from WS and the result divided by the DOF to create the continuous variable ADG (kg/d):

\[
ADG = \frac{WS - WA}{DOF}
\]

**Economic Parameters**

All economic results are reported in Canadian dollars ($CAD). For the partial budget analysis only those variable benefits and costs as affected by disease status were considered. We used the following formula [Eq. 1.]:

\[
\text{Partial budget} = \text{Benefit} - \text{Cost} \quad [1]
\]

The benefit per animal was calculated using the following formula [Eq. 2.]:

\[
\text{Benefit} = HCW \times (BPM + (MQ)) \quad [2]
\]

Where BPM stands for Base price of meat and MQ for meat quality, categorized as premium or discount. Since base price varies according to market volatility, the average was calculated for the 3-year interval (2016 - 2018) and used as a constant for all cattle in the database (= $5.65CAD / HCWkg). The premium or discount value was calculated individually, based on meat quality of each animal, determined on slaughter information on yield and grade, thereby affecting total revenue. (Bureš & Bartoň, 2018).
To calculate cost, the following formula was used [Eq. 3], with cost of calf at arrival not included due to a lack of data availability:

\[
Cost = Treatment + Processing + Feeding [3]
\]

All costs were obtained from the CVC dataset, where they are reported on an individual animal basis. Treatment costs differed based on protocol for the disease treated; processing cost varied according to the animal type, its weight and the number of times it was processed through the chute; and finally feeding cost. Since the economic analysis was done for a 3-year interval, the cost of the feeding ingredients changed during that interval, therefore influencing the total cost of the ration. Besides, the amount fed and DOF also influenced the total feeding cost. Therefore, costs included should reflect all events from arrival at the feedlot to departure to the abattoir and therefore indirectly reflects the risk type through inclusion of AW and DOF.

**Statistical Analyses**

Data were analyzed using STATA® 14.1 software (StataCorp LP, College Station, TX). Descriptive statistics were calculated for HE and each category of diseased cattle. Average, standard deviations and confidence intervals were generated for variables that were normally distributed. Cattle were stratified by type (FPC, WPC, GY, BY), sex (heifer, steer) and disease status (HE, DD, FR, BRD, OT or TM). Since observations were non-paired and data had a parametric distribution, an ANOVA was used to compare means within stratified groups, followed by Scheffe post-hoc test (i.e. HE fall-placed heifers vs DD fall-placed heifers). Correction for pen origin was not possible due to lack of information regarding resorting of cattle during the feeding cycle. Also, by stratifying for sex, data was adjusted for
feedlot as well, as the two feedlots analyzed had either steers or heifers, but not both. Values were considered significantly different if P<0.05.

RESULTS

**Cumulative Incidence of Foot Lesions and Other Diseases in the Study Population**

The dataset was composed of \( N = 77,115 \) cattle, with 21.8% of all heifers (9,167/42,009) and 16.3% of all steers (5,733/35,106) treated for any disease; consequently, 19.3% of cattle had any disease throughout the feeding cycle (14,900/77,115). Of the sick cattle, 6% were treated for DD (894/14,900), 59.1% for FR (8,804/14,900), 10.7% for BRD (1,590/14,900), 12.7% for OT (1,889/14,900) and 11.5% had TM diseases (1,723/14,900). Furthermore, in the TM category 2.1% were also treated for DD (37/1,723), 49.3% for FR (849/1,723), 38% for BRD (655/1,723) and 10.5% (182/1,723) were treated for two other diseases, as seen in Table 1.

Foot rot was the disease with the highest cumulative incidence in both heifers and steers (58.8 and 59.6%, respectively). Of total FPC diagnosed with any disease, 48.1% of cases were FR. From treated animals in category WPC, 62.2% were treated for FR. Of all cattle treated in the GY category, 60.7% were treated for FR, and for BY, 68.3% of total treated animals were diagnosed with FR.

Of cattle diagnosed as sick, BRD accounted for 10.6 and 10.8% of all cases in heifers and steers, respectively. For FPC, BRD accounted for 20% of all diseases diagnosed. In WPC, proportion of treated cattle diagnosed with BRD was 8.5%. Category GY had 7% of all disease diagnosis as BRD, whereas for the BY category, BRD was responsible of 3.5% of all diseases diagnosed. Furthermore, BRD is predominantly prevalent in calves relative to yearlings, as seen in Table 2.
Statistically significant differences were observed within types of cattle by sex, when comparing productive parameters of diseased cattle against healthy animals.

**Diseases and Average Daily Gain**

As shown in Table 3, some of the groups stratified by type and sex reported a statistically significant difference between ADG of healthy and DD affected cattle. Healthy cattle had a significantly higher ADG compared to DD cattle in 4 of 8 categories (FPS, WPS, WPH and GYS), with the difference ranging from 0.11 to 0.17 kg/d. Further descriptive data on the ADG of healthy vs. DD cattle can be seen in Table 4.

Healthy cattle had a significantly higher ADG compared to FR cattle in 2 of 8 categories, ranging from 0.05 kg/d in grass yearling heifers to 0.06 kg/d in backgrounded yearling heifers.

Healthy cattle had a significantly higher ADG compared to BRD cattle in 6 of 8 categories (FPH, FPS, WPH, WPS, GYH, BYH), with the difference ranging from 0.04 kg/d to 0.16 kg/d.

**Diseases and Partial budget analysis**

Healthy cattle had a significantly higher partial budget compared to DD cattle in 4 of 8 categories, ranging from $72 in winter placed heifers to $98 in grass yearling heifers.

Healthy cattle had a significantly higher partial budget compared to FR cattle in 2 of 8 categories, ranging from $3 in winter placed heifers to $30 in backgrounded yearling heifers.

Healthy cattle had a significantly higher partial budget compared to BRD cattle in 6 of 8 categories, ranging from $74 in fall placed heifers to $165 in backgrounded yearling steers.

Descriptive data on the partial budget analysis can be seen in Tables 5 and 6.
Furthermore, information on the DOF for the diverse categories are summarized in Table 7 and 8.

DISCUSSION

Our findings placed FR as the disease with the greatest treatment cumulative incidence (59%), followed by BRD (10.7%) and DD (6%). However, it is well known that BRD is the most prevalent health problem in North American feedlot cattle, ranging from 30 to 75% of total feedlot morbidity (Brooks et al., 2011; Griffin, 1997), with lameness being the second most prevalent condition (Schwartzkopf-Genswein et al., 2016). Recently a dataset analysis of 28 feedlots over a decade of data showed a BRD treatment cumulative incidence of 50.4%, whereas for FR it was 20.7% (Davis-Unger et al., 2019). The differences in the cumulative incidences reported could be attributed to multiple factors at cattle (weaning process, lack of immunity, type of animals entering the feedlot), and management practice (pooling of cattle from different sources, transportation, weather, recording optimization) (Taylor et al., 2010). However, a more detailed description on risk factors is hindered by the lack of data on calf processing, given that comparing solely weight at arrival would provide only a partial explanation. Another explanation might be pen-level treatment for diseases that are not taken into account in our data only included individual animal level treatments.

In the present study, a single case of DD negatively affected ADG and the partial budget, with the magnitude dependent on cattle type and sex. Few studies have examined production and economic impacts of a single case of DD relative to HE in feedlot cattle.
Economic Impacts of Infectious Diseases

Digital dermatitis affected the partial budget in 5 out of the 8 groups of cattle, with the highest impact of DD seen in GYH and GYS ($-98 and $-96 CAD, respectively relative to their healthier counterparts). Also, in the group FHC, those with DD had a significantly higher partial budget than HE, attributed to DD cattle having a longer DOF (+27) and a relatively higher TW, with negligible impact on the feed cost.

In addition, we found statistically significant difference in the partial budget between HE and FR in feedlot cattle in only two categories, where previous research reported no difference (Davis-Unger et al., 2018). This can be explained by the relative ease of FR field diagnosis; symmetrical swelling of the foot, and sudden and severe lameness, with rapid resolution expected if treatment is initiated soon after onset (Metre et al., 2005), thereby limiting its negative impact.

For BRD, in 6 of 8 groups, HE had a higher partial budget, placing BRD as the costliest of the 3 diseases, with DD being in second place and finally FR in third. This was partially supported by the literature, as BRD had the most impact of diseases that emerged in a feedlot (Cernicchiaro et al., 2013; Jim, 2009; Leach et al., 2013). In contrast, for DD, economic impact of a single case in feedlot cattle had not been reported. In dairy, it was estimated that a single case of DD or FR cost $US 128 (van Amstel & Shearer, 2006), attributed to additional value of milk and reproduction, relative to the beef system.

Nevertheless, it is important to acknowledge that the current ranking is based on an individual level comparison of diseased vs. healthy animals, and not necessarily at a population level. That is to say, BRD is the costliest of the 3 diseases relative to a healthy animal; however, in yearlings, where the cumulative incidence of BRD is lower than in calves, this may no longer be the costliest disease at a population level.
In addition, purchase price might have influenced cattle performance, as it reflects cattle quality, therefore being a limitation of the current study.

**ADG**

Healthy cattle had a significantly higher ADG compared to DD cattle in 5 of 8 categories (ranged from 0.11 kg/d in WPC heifers to 0.17 kg/d in FPC steers). It has been reported that sick cattle experience a decrease in feed intake and number of visits to the feed bunk, due to their decreased ability to compete with non-sick cows (Jensen & Proudfoot, 2017). However, impact of diseases on ADG varied by cattle type and sex, as reported in the current study.

It has also been reported that steers with active lesions (M2) gained 0.08 to 0.14 kg/d less than healthy cattle with no active lesions (Kulow et al., 2017). However, in our study we did not score M-stages therefore no comparison was performed at that level.

For cattle diagnosed with FR, it was documented by Tibbets et al., (2006) that a single FR incident caused 0.03 less kg/d relative to HE (1.27 vs 1.3 kg/d, respectively). The fact that several categories of animals with FR did not report a decrease in the productive parameters, can be explained by a quick diagnosis, treatment and healing, and in doing so decreasing its negative impacts.

Cattle diagnosed with BRD, had a significantly lesser ADG relative to HE in 6 of 8 categories, ranging from 0.04 kg/d in FPC steers to 0.16 kg/d in BY heifers. Those findings were in agreement with previous studies, where a reduction in the ADG of cattle affected by BRD was estimated to be between 0.07 (Schneider et al., 2009) to 0.09 kg/d (Griffin, 2014) less than healthy animals without BRD. Therefore, BRD is still an important economic driver of lost revenue and warrants further investigation for its control and mitigation.
A variation of the effect of the disease on the ADG was expected across different types of cattle, as it is influenced by sex and age, as evidenced with DD, FR and BRD. However, it is still unclear what is causing this decrease in the ADG, whether it is an increase in the energy expenditure for movement (Dijkman, 1997), access to the feed-bunk and/or decrease of the feed intake, and how this is affected by pen condition.

**Limitations**

Retrospective database analysis always has limitations and potential biases; this study is no exception. Despite a large number of animals included, the number of feedlots included limits the external validity. However, the inclusion of diseases like FR or BRD allows for a better understanding of the relative impact of DD in feedlot cattle as more data is available in literature on impact of these two disorders.

Although the feedlot crew was trained on case identification by the vet clinic, there is always the risk of misdiagnosis. For example, DD disease diagnosis is not easily done in the field, mainly due to a lack of clinical signs, where not all DD results in lameness and because of the area of the foot affected not always available for visual inspection. Furthermore, the chronic nature of this disease (Krull et al, 2016a) may allow it to go unnoticed for long intervals, causing an underestimation of its cumulative incidence and perhaps greater effects on production parameters, relative to acute diseases such as FR, as noted in this study. This might increase the risk of differential misclassification, causing an underestimation of the presence of DD and, eventually, its economic impact. With the disease emerging, routine checkups are advised, where the ideal method is a close-feet inspection that might imply lifting the legs.

Furthermore, although the current evaluation only included single case events for DD, FR and BRD purposively, recrudescence of those infectious diseases has been widely
described in domestic animals (Clifton & Green, 2016; O’Connor et al., 2013; Palmer & O’Connell, 2015), therefore there is the possibility of an underestimation of the production and economic impact. It is also worth noting how cases of DD, FR and BRD were present in the TM category, which contributes to a miscalculation and underestimation of the real impact of each disease, nonetheless representing how impactful they can be in a herd.

Also, the higher prevalence of FR relative to BRD differs from what is commonly reported, where BRD is placed as the most common disorder. However, a more detailed explanation of this phenomena is hindered by the lack of animal and environmental data in the early production and transitional stages of feedlot cattle.

In addition, dressing percentage has been documented to be influenced by genetic and non-genetic factors (diet, age, gut fill, sex, breed and within breed differences), therefore the estimation of the slaughter weight could be oversimplified by the lack of detailed data at the individual level.

The cost of the calf was not included, given that these data were not available for cattle in the database. This limits the evaluation of the influence of cattle quality (as reflected by purchase price) in the risk of getting diseases.

Since the ranking was done at an animal-level comparison of disease vs. healthy, population level evaluations may yield different results depending on the cumulative incidence.
**Conclusion**

DD is causing a decrease in the ADG of some categories of feedlot cattle, where no significant differences were observed between DD and the impact of BRD in the ADG of cattle in 7 out of the 8 categories.

This is the first report to investigate not only production but also economic impacts of a single case of DD in Canadian feedlot cattle. The differential economic impacts based on type of cattle and sex, allows for the creation of strategies focused on specific groups that are more predisposed resulting in largest economic impact. Further studies are needed to evaluate various strategies to deal with infectious diseases that cause lameness, by developing a cost-effectiveness analysis. This would provide producers with more management tools suited to a feedlot setting.

Identifying the most impactful conditions in feedlot cattle production systems could optimize mitigation and management strategies, prompting focus on specific subpopulations more susceptible to disease occurrence and ultimately, to understand dynamics of budget analysis. The creation and implementation of an early detection system for DD, suitable for a feedlot setting, is of paramount importance. This combined with group level interventions, e.g. improvement in pen condition and the use of footbaths, could help to mitigate and control this disease, allowing better outcomes from the economic, productive and welfare perspectives.
Conflict of Interest:

The authors declare no conflict of interest.
AAFC. (2018). Code Of Practice For The Care and Handling of Beef Cattle. Retrieved from https://www.nfacc.ca/codes-of-practice/beef-cattle

Bartoň, L., Řehák, D., Teslík, V., Bureš, D., & Zahrádková, R. (2006). Effect of breed on growth performance and carcass composition of Aberdeen Angus, Charolais, Hereford and Simmental bulls. *Czech Journal of Animal Science, 51*(2), 47–53.

Brooks, K. R., Raper, K. C., Ward, C. E., Holland, B. P., Krehbiel, C. R., & Step, D. L. (2011). Economic effects of bovine respiratory disease on feedlot cattle during backgrounding and finishing phases1. *Professional Animal Scientist, 27*(3), 195–203. https://doi.org/10.15232/S1080-7446(15)30474-5

Brown, C. C., Kilgo, P. D., & Jacobsen, K. L. (2000). Prevalence of papillomatous digital dermatitis among culled adult cattle in the southeastern United States. *American Journal of Veterinary Research, 61*(8), 928–930. https://doi.org/10.2460/ajvr.2000.61.928

Bureš, D., & Bartoň, L. (2018). Performance, carcass traits and meat quality of Aberdeen Angus, Gascon, Holstein and Fleckvieh finishing bulls. *Livestock Science, 214*(June), 231–237. https://doi.org/10.1016/j.livsci.2018.06.017

Cernicchiaro, N., White, B. J., Renter, D. G., & Babcock, A. H. (2013). Evaluation of economic and performance outcomes associated with the number of treatments after an initial diagnosis of bovine respiratory disease in commercial feeder cattle. *American Journal of Veterinary Research, 74*(2), 300–309. https://doi.org/10.2460/ajvr.74.2.300

Cheli, R. C. M. (1974). *La dermatite digitale del bovino*. 208–213. Piacenza, Milan, Italy.: Proc. 8th International conference on diseases of cattle.

Clifton, R., & Green, L. (2016). Pathogenesis of ovine foot rot disease: A complex picture. *Veterinary Record, 179*(9), 225–227. https://doi.org/10.1136/vr.i4554

Davis-Unger, Jessica; Pajor, E.A.; Schwartzkopf-Genswein, K.; Marti, S.; Dorin, C.; Spackman, E.; Orsel, K. (2018). Economic impacts of lameness in feedlot cattle 1. *Journal of Animal Science, (January)*, 467–479. https://doi.org/10.2527/tas2017.0052

Davis-Unger, J, Schwartzkopf-Genswein, K. S. G., Pajor, E. A., Hendrick, S., Marti, S., Dorin, C., & Orsel, K. (2019). Prevalence and lameness-associated risk factors in Alberta feedlot cattle. *Translational Animal Science, 3*(2), 595–606. https://doi.org/10.1093/tas/txz008

Dijkman, J. T., & Lawrence, P. R. (1997). The energy expenditure of cattle and buffaloes walking and working in different soil conditions. *Journal of Agricultural Science, 128*(1), 95–103. https://doi.org/10.1017/S0021859696003929

Döpfer, Koopmans, A., Meijer, F. A., Szakall, I., Schukken, Y. H., Klee, W., … ter Huurne, A. A. (1997). Histological and bacteriological evaluation of digital dermatitis in cattle, with special reference to spirochaetes and Campylobacter faecalis. *The Veterinary Record, 140*(24), 620–623. https://doi.org/10.1136/vr.140.24.620
Griffin, D. (1997). Economic impact associated with respiratory disease in beef cattle. *The Veterinary Clinics of North America. Food Animal Practice, 13*(3), 367–377. https://doi.org/10.1016/S0749-0720(15)30302-9

Griffin, Dee. (2014). The monster we don’t see: Subclinical BRD in beef cattle. *Animal Health Research Reviews, 15*(2), 138–141. https://doi.org/10.1017/S1466252314000255

Griffin, Dee, Perino, L., Hudson, D., Griffin, N.-L., Perino, D., & Hudson, L. (1993). *G93-1159 Feedlot Lameness Feedlot Lameness*. Retrieved from http://digitalcommons.unl.edu/extensionhist%5Cnhttp://digitalcommons.unl.edu/extensionhist/196

Hultgren, J., & Bergsten, C. (2001). Effects of a rubber-slatted flooring system on cleanliness and foot health in tied dairy cows. *Preventive Veterinary Medicine, 52*(1), 75–89. https://doi.org/10.1016/S0167-5877(01)00237-9

Jensen, M. B., & Proudfoot, K. L. (2017). Effect of group size and health status on behavior and feed intake of multiparous dairy cows in early lactation. *Journal of Dairy Science, 100*(12), 9759–9768. https://doi.org/10.3168/jds.2017-13035

Jim, K. (2009). Impact of bovine respiratory disease (BRD) from the perspective of the Canadian beef producer. *Animal Health Research Reviews / Conference of Research Workers in Animal Diseases, 10*(2), 109–110. https://doi.org/10.1017/S1466252309990119

John F, Whittier W, C. (2009). Foot Rot In Beef Cattle. *VirginiaTech*.

Krull, A. C., Shearer, J. K., Gorden, P. J., Cooper, V. L., Phillips, G. J., & Plummera, P. J. (2014). Deep sequencing analysis reveals temporal microbiota changes associated with development of bovine digital dermatitis. *Infection and Immunity, 82*(8), 3359–3373. https://doi.org/10.1128/IAI.02077-14

Krull, A. C., Shearer, J. K., Gorden, P. J., Scott, H. M., & Plummer, P. J. (2016). Digital dermatitis: Natural lesion progression and regression in Holstein dairy cattle over 3 years. *Journal of Dairy Science, 99*(5), 3718–3731. https://doi.org/10.3168/jds.2015-10535

Kulow, M., Merkatoris, P., Anklam, K. S., Rieman, J., Larson, C., Branie, M., & Döpfer, D. (2017). Evaluation of the prevalence of digital dermatitis and the effects on performance in beef feedlot cattle under organic trace mineral supplementation 1. (March), 3435–3444. https://doi.org/10.2527/jas2017.1512

Leach, R. J., Chitko-McKown, C. G., Bennett, G. L., Jones, S. A., Kachman, S. D., Keele, J. W., … Kuehn, L. A. (2013). The change in differing leukocyte populations during vaccination to bovine respiratory disease and their correlations with lung scores, health records, and average daily gain. *Journal of Animal Science, 91*(8), 3564–3573. https://doi.org/10.2527/jas.2012-5911
Metre, D. C. Van, Wenz, J. R., & Garry, F. B. (2005). Lameness in cattle: rules of thumb. *Annual Convention, American Association of Bovine Practitioners*, 40–43.

O’Connor, A. M., Coetzee, J. F., da Silva, N., & Wang, C. (2013). A mixed treatment comparison meta-analysis of antibiotic treatments for bovine respiratory disease. *Preventive Veterinary Medicine, 110*(2), 77–87. https://doi.org/10.1016/j.prevetmed.2012.11.025

Orsel, K., Plummer, P., Shearer, J., De Buck, J., Carter, S. D., Guatteo, R., & Barkema, H. W. (2018). Missing pieces of the puzzle to effectively control digital dermatitis. *Transboundary and Emerging Diseases, 65*(May 2017), 186–198. https://doi.org/10.1111/tbed.12729

Palmer, M. A., & O’Connell, N. E. (2015). Digital dermatitis in dairy cows: A review of risk factors and potential sources of between-animal variation in susceptibility. *Animals, 5*(3), 512–535. https://doi.org/10.3390/ani5030369

Plummer, P. J., & Krull, A. (2017). Clinical Perspectives of Digital Dermatitis in Dairy and Beef Cattle. *Veterinary Clinics of North America - Food Animal Practice, 33*(2), 165–181. https://doi.org/10.1016/j.cvfa.2017.02.002

Refaai, W., Van Aert, M., Abd El-Aal, A. M., Behery, A. E., & Opsomer, G. (2013). Infectious diseases causing lameness in cattle with a main emphasis on digital dermatitis (Mortellaro disease). *Livestock Science, 156*(1–3), 53–63. https://doi.org/10.1016/j.livsci.2013.06.004

Schneider, M. J., Tait, R. G., Busby, W. D., & Reecy, J. M. (2009). An evaluation of bovine respiratory disease complex in feedlot cattle: Impact on performance and carcass traits using treatment records and lung lesion scores. *Journal of Animal Science, 87*(5), 1821–1827. https://doi.org/10.2527/jas.2008-1283

Schwartzkopf-Genswein, K., Janzen, E., Orsel, K., Pajor, E. A., Jelinski, M., Dorin, C., … Millman, S. (2016). Feedlot Lameness. *Research & Technology Development for the Canadian Beef Industry, 39*, 112–115.

Solano, L., Barkema, H. W., Mason, S., Pajor, E. A., LeBlanc, S. J., & Orsel, K. (2016). Prevalence and distribution of foot lesions in dairy cattle in Alberta, Canada. *Journal of Dairy Science, 99*(8), 6828–6841. https://doi.org/10.3168/jds.2016-10941

Solano, L., Barkema, H. W., Pickel, C., & Orsel, K. (2017). Effectiveness of a standardized footbath protocol for prevention of digital dermatitis. *Journal of Dairy Science, 100*(2), 1295–1307. https://doi.org/10.3168/jds.2016-11464

Sullivan, L. E., Carter, S. D., Blowey, R., Duncan, J. S., Grove-White, D., & Evans, N. J. (2013). Digital dermatitis in beef cattle. *Veterinary Record, 173*(23), 582. https://doi.org/10.1136/vr.101802

Taylor, J., Fulton, R., Lehenbauer, T. W., Step, D. L., & Confer, A. W. (2010). The
epidemiology of bovine respiratory disease: What is the evidence for predisposing factors? Canadian Veterinary Journal, 51(10), 1095–1102. https://doi.org/10.1111/j.1751-0813.1996.tb10027.x

Teixeira, A. G. V., Machado, V. S., Caixeta, L. S., Pereira, R. V., & Bicalho, R. C. (2010). Efficacy of formalin, copper sulfate, and a commercial footbath product in the control of digital dermatitis. Journal of Dairy Science, 93(8), 3628–3634. https://doi.org/10.3168/jds.2010-3246

Terrell, S. P., Thomson, D. U., Reinhardt, C. D., Apley, M. D., Larson, C. K., & Stackhouse-Lawson, K. R. (2014). Perception of lameness management, education, and effects on animal welfare of feedlot cattle by consulting nutritionists, veterinarians, and feedlot managers. Bovine Practitioner, 48(1), 53–60.

Terrell, Shane P., Reinhardt, C. D., Larson, C. K., Vahl, C. I., & Thomson, D. U. (2017). Incidence of lameness and association of cause and severity of lameness on the outcome for cattle on six commercial beef feedlots. Journal of the American Veterinary Medical Association, 250(4), 437–445. https://doi.org/10.2460/javma.250.4.437

Tibbetts, G. K., Devin, T. M., Griffin, D., Keen, J. E., & Rupp, G. P. (2006). Effects of a Single Foot Rot Incident on Weight Performance of Feedlot Steers. The Professional Animal Scientist, 22(6), 450–453. https://doi.org/10.15232/S1080-7446(15)31145-1

van Amstel, S. R., & Shearer, J. (2006). Manual for Treatment and Control. https://doi.org/10.1002/9780470344576

Van Nuffel, A., Zwertiaegher, I., Pluym, L., Van Weyenberg, S., Thorup, V. M., Pastell, M., … Saeys, W. (2015). Lameness detection in dairy cows: Part 1. How to distinguish between non-lame and lame cows based on differences in locomotion or behavior. Animals, 5(3), 838–860. https://doi.org/10.3390/ani5030387

Zinicola, M., Lima, F., Lima, S., Machado, V., Gomez, M., Döpfer, D., … Bicalho, R. (2015). Altered microbiomes in bovine digital dermatitis lesions, and the gut as a pathogen reservoir. PLoS ONE, 10(3), 1–23. https://doi.org/10.1371/journal.pone.0120504
TABLES AND FIGURES

Figure 1 Diagram showing data filtering and cleaning of animal records.

1 WA = Weight at arrival
2 DOF = Days on feed
Table 1 Total number of cases (percentages) in each disease category, in data collected from 2 feedlots by type and sex (N=77,115 total animals and N=14,900 treated by any disease), for a 3-year interval.

| Disease | Type          | Calves | Yearlings |
|---------|---------------|--------|-----------|
|         | Fall Placed   | 120 (0.6) | 318 (1.6) |
|         | Winter Placed | 318 (1.6) | 318 (1.6) |
| DD      | Grass Fed     | 158 (0.7) | 298 (2.1) |
|         | Backgrounder  | 642 (1.5) | 252 (0.7) |
|         | Heifer        | 37 (0.5)  | 83 (0.6)  |
|         | Steer         | 79 (0.7)  | 79 (0.7)  |
|         | FPH           | 249 (1.9) | 249 (1.9) |
|         | FPS           | 69 (1)    | 69 (1)    |
| BRD     | Winter Placed | 1,364 (6.2) | 2,174 (15.6) |
|         | Grass Fed     | 5,387 (12.8) | 3,417 (9.7) |
|         | Backgrounder  | 1,073 (13.8) | 1,046 (8)  |
|         | Heifer        | 1,934 (14.5) | 1,213 (17.6) |
|         | Steer         | 760 (6.8)  | 604 (5.5)  |
|         | FPH           | 1,213 (17.6) | 604 (5.5)  |
|         | FPS           | 1,620 (16.7) | 604 (5.5)  |
| OT      | Winter Placed | 1,582 (4.3) | 2,174 (15.6) |
|         | Grass Fed     | 2,119 (10.2) | 2,119 (10.2) |
|         | Backgrounder  | 4,785 (12.8) | 4,785 (12.8) |
|         | Heifer        | 554 (13.1) | 554 (13.1) |
|         | Steer         | 1,213 (17.6) | 604 (5.5)  |
|         | FPH           | 1,213 (17.6) | 604 (5.5)  |
|         | FPS           | 1,620 (16.7) | 604 (5.5)  |

1. DD (Diarrhea), FR (Fever), BRD (Bacterial Respiratory Disease), OT (Other).
|        | TM    |       |       |       |       |       |       |       |       |       |       |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|        | 667 (3.2) | 563 (2.8) | 202 (0.9) | 291 (2.1) | 1,047 (2.5) | 676 (1.9) | 335 (4.3) | 332 (2.5) | 384 (2.9) | 179 (2.6) | 95 (0.8) |
| TM     |       |       |       |       |       |       |       |       |       |       | 107 (1) |
| Total  | 233 (2.4) | 58 (1.4) |       |       |       |       |       |       |       |       |       |
| treated| 4,409 (21.2) | 5,063 (25) | 2,246 (10.2) | 3,182 (22.8) | 9,167 (21.8) | 5,733 (16.3) | 2,184 (28) | 2,225 (17.1) | 3,294 (24.6) | 1,769 (25.7) | 1,303 (11.7) |
|        |       |       |       |       |       |       |       |       |       |       | 943 (8.6) |
|        |       |       |       |       |       |       |       |       |       |       | 2,386 (24.6) |
|        |       |       |       |       |       |       |       |       |       |       | 796 (18.9) |
| Total  | 796 (18.9) | 20,799 (100) | 20,269 (100) | 22,102 (100) | 13,945 (100) | 42,009 (100) | 35,106 (100) | 7,786 (100) | 13,013 (100) | 13,379 (100) | 6,890 (100) |
| animals|       |       |       |       |       |       |       |       |       |       | 11,132 (100) |
|        |       |       |       |       |       |       |       |       |       |       | 10,970 (100) |
|        |       |       |       |       |       |       |       |       |       |       | 9,712 (100) |
|        |       |       |       |       |       |       |       |       |       |       | 4,233 (10) |

1

1DD= Digital dermatitis, FR= Foot rot, BRD= Bovine respiratory disease, OT= Other, TM= Two or more diseases

2FPH/FPS=Fall-placed heifer/steer, WPH/WPS= Winter-placed heifer/steer, GYH/GYS= Grass fed yearling heifer/steer, BYH/BYS= Backgrounded yearling heifer/steer
Table 2  Average cumulative incidence (mean ± SD) in DD, FR and BRD, in data collected from 2 feedlots by type and sex (N=77,115 total animals and N=14,900 treated by any disease), for a 3-year interval.

| Disease | Cumulative Incidence | SD | CI |
|---------|----------------------|----|----|
| **Calves** | | | |
| DD      | 137                  | 30 | 102 | 171 |
| FR      | 1698                 | 600| 1019| 2377|
| BRD     | 438                  | 274| 128 | 749 |
| **Yearlings** | | | |
| DD      | 156                  | 38 | 113 | 198 |
| FR      | 1430                 | 395| 983 | 1877|
| BRD     | 89                   | 31 | 54  | 124 |

1DD= Digital dermatitis, FR= Foot rot, BRD= Bovine respiratory disease

2SD=Standard deviation

3CI=Confidence interval
Table 3 Average daily gain kg/d (ADG; mean ± SD) of cattle in each of the disease categories, by cattle type and sex.

| Disease   | Type x Sex | Calves | Yearlings |
|-----------|------------|--------|-----------|
|           | FPH        | FPS    | WPH       | WPS       | GYH     | GYS     | BYH     | BYS     |
| HE        | 1.35 ± 0.19<sup>a</sup> | 1.57 ± 0.2<sup>a</sup> | 1.5 ± 0.23<sup>a</sup> | 1.73 ± 0.24<sup>a</sup> | 1.56 ± 0.34<sup>a</sup> | 1.79 ± 0.31<sup>a</sup> | 1.49 ± 0.39<sup>a</sup> | 1.69 ± 0.33<sup>a</sup> |
| DD        | 1.34 ± 0.18<sup>h, c</sup> | 1.4 ± 0.17<sup>d</sup> | 1.39 ± 0.22<sup>h, c</sup> | 1.62 ± 0.23<sup>b</sup> | 1.47 ± 0.31<sup>h, b, c</sup> | 1.66 ± 0.33<sup>h, c</sup> | 1.43 ± 0.24<sup>a, b</sup> | 1.55 ± 0.24<sup>a, b</sup> |
| FR        | 1.35 ± 0.18<sup>a</sup> | 1.58 ± 0.18<sup>a</sup> | 1.49 ± 0.23<sup>a</sup> | 1.75 ± 0.22<sup>a</sup> | 1.51 ± 0.32<sup>b</sup> | 1.77 ± 0.31<sup>h, b</sup> | 1.43 ± 0.26<sup>b</sup> | 1.68 ± 0.27<sup>a</sup> |
| BRD       | 1.3 ± 0.19<sup>b</sup> | 1.53 ± 0.23<sup>b</sup> | 1.42 ± 0.27<sup>b</sup> | 1.64 ± 0.35<sup>b</sup> | 1.42 ± 0.37<sup>h, c, d</sup> | 1.64 ± 0.39<sup>h, b, c</sup> | 1.33 ± 0.42<sup>b, c</sup> | 1.53 ± 0.55<sup>a, b</sup> |
| OT        | 1.24 ± 0.21<sup>c</sup> | 1.51 ± 0.21<sup>h, c</sup> | 1.33 ± 0.34<sup>c</sup> | 1.55 ± 0.27<sup>b</sup> | 1.34 ± 0.4<sup>c, d</sup> | 1.71 ± 0.36<sup>h, b, c</sup> | 1.24 ± 0.3<sup>c</sup> | 1.45 ± 0.45<sup>b</sup> |
| TM        | 1.24 ± 0.21<sup>c</sup> | 1.46 ± 0.23<sup>c, d</sup> | 1.35 ± 0.26<sup>c</sup> | 1.59 ± 0.3<sup>b</sup> | 1.27 ± 0.4<sup>d</sup> | 1.62 ± 0.36<sup>c</sup> | 1.29 ± 0.27<sup>c</sup> | 1.43 ± 0.39<sup>b</sup> |
| Treated   | 1.31 ± 0.2 | 1.53 ± 0.2 | 1.44 ± 0.26 | 1.7 ± 0.26 | 1.45 ± 0.35 | 1.73 ± 0.33 | 1.39 ± 0.28 | 1.61 ± 0.34 |
| All       | 1.34 ± 0.2 | 1.57 ± 0.21 | 1.49 ± 0.24 | 1.73 ± 0.25 | 1.55 ± 0.35 | 1.78 ± 0.31 | 1.47 ± 0.36 | 1.68 ± 0.33 |

<sup>a-d</sup>Within a column, values without a common superscript differed (P<0.05).

<sup>1</sup>DD= Digital dermatitis, FR= Foot rot, BRD= Bovine respiratory disease, OT= Other, TM= Two or more diseases

<sup>2</sup>FPH/FPS= Fall-placed heifer/steer, WPH/WPS= Winter-placed heifer/steer, GYH/GYS= Grass yearling heifer/steer, BYH/BYS= Backgrounded yearling heifer/steer
Table 4 Average daily gain kg/d (mean and 95% CI) of healthy vs. DD cattle, by cattle type and sex.

| Type/Sex1 | Healthy |           |          |       |       |          |          |
|-----------|---------|-----------|----------|-------|-------|----------|----------|
|           | Mean (kg/d) | SE3       | 95% CI4  | Mean (kg/d) | SE     | 95% CI    |
| FPH       | 1.35    | 0.002     | 1.34     | 1.35  | 1.34  | 0.03     | 1.28     |
| FPS       | 1.57    | 0.001     | 1.57     | 1.58  | 1.40  | 0.02     | 1.36     |
| WPH       | 1.50    | 0.002     | 1.49     | 1.5   | 1.39  | 0.01     | 1.36     |
| WPS       | 1.73    | 0.003     | 1.73     | 1.74  | 1.61  | 0.03     | 1.56     |
| GYH       | 1.56    | 0.003     | 1.55     | 1.56  | 1.47  | 0.03     | 1.40     |
| GYS       | 1.78    | 0.003     | 1.78     | 1.79  | 1.66  | 0.04     | 1.59     |
| BYH       | 1.49    | 0.004     | 1.48     | 1.5   | 1.43  | 0.01     | 1.40     |
| BYS       | 1.69    | 0.005     | 1.68     | 1.7   | 1.55  | 0.05     | 1.44     |

1FPH/FPS=Fall-placed heifer/steer, WPH/WPS= Winter-placed heifer/steer, GYH/GYS= Grass fed yearling heifer/steer, BYH/BYS= Backgrounded yearling heifer/steer

2DD=Digital dermatitis

3SE=Standard error

4CI=Confidence interval
|                | FPH\(^1\) | FPS | WPH  | WPS  | GYH | GYS  | BYH | BYS |
|----------------|------------|-----|------|------|-----|------|-----|-----|
| He – DD\(^2\) | 131*       | -77.7 | -72.5 | 3.5  | -98.3 | -95.8 | 10.7 | -50.3 |
| He - FR        | -13.5      | 23.7  | -3.3  | 14.9 | 4.9  | -13.9 | -30.4 | -8.5 |
| He - BRD       | -73.9      | -19.5 | -99.2 | -129.8 | -148.4 | -67.2 | -142.8 | -165.4 |

\(^1\)FPH/FPS=Fall-placed heifer/steer, WPH/WPS= Winter-placed heifer/steer, GYH/GYS= Grass fed yearling heifer/steer, BYH/BYS= Backgrounded yearling heifer/steer.

\(^2\)DD=Digital dermatitis, FR=Foot rot, BRD=Bovine respiratory disease.

*Numbers in red are significantly different.
| Type/Sex¹ | Healthy Mean ($CAD) | SE² | 95% CI³ | DD² Mean ($CAD) | SE | 95% CI³ |
|-----------|---------------------|-----|---------|-----------------|----|---------|
| FPH       | 1509                | 3   | 1502    | 1514            | 1639| 41.3    |
| FPS       | 1656                | 2.3 | 1651    | 1660            | 1578| 25.5    |
| WPH       | 1660                | 2.3 | 1656    | 1665            | 1588| 12.6    |
| WPS       | 1837                | 3   | 1831    | 1843            | 1840| 21.6    |
| GYH       | 1800                | 2.5 | 1796    | 1805            | 1702| 25.4    |
| GYS       | 1878                | 2   | 1874    | 1881            | 1782| 25.5    |
| BYH       | 1750                | 2.4 | 1745    | 1755            | 1761| 11.7    |
| BYS       | 1938                | 3.4 | 1931    | 1944            | 1887| 51.7    |

¹FPH/FPS=Fall-placed heifer/steer, WPH/WPS= Winter-placed heifer/steer, GYH/GYS= Grass fed yearling heifer/steer, BYH/BYS= Backgrounded yearling heifer/steer

²DD=Digital dermatitis

³SE=Standard error

⁴CI=Confidence interval
Table 7 Days on feed (mean ± sd) of cattle in each of the disease categories, by cattle type and sex.

| Disease | Calves | | | | Yearlings | | | |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|
|         | FPH    | FPS    | WPH    | WPS    | GYH    | GYS    | BYH    | BYS    |
| HE      | 271 ± 50<sup>b</sup> | 265 ± 47<sup>d</sup> | 212 ± 50<sup>b</sup> | 207 ± 41<sup>b,c</sup> | 162 ± 29<sup>b,c</sup> | 164 ± 23<sup>b</sup> | 173 ± 19<sup>b</sup> | 155 ± 43<sup>b</sup> |
| DD      | 298 ± 47<sup>c</sup> | 292 ± 57<sup>c</sup> | 232 ± 36<sup>c</sup> | 210 ± 30<sup>b,c</sup> | 170 ± 16<sup>c</sup> | 160 ± 21<sup>a,b</sup> | 182 ± 12<sup>c</sup> | 150 ± 30<sup>c</sup> |
| FR      | 270 ± 41<sup>b</sup> | 252 ± 46<sup>b,c</sup> | 214 ± 44<sup>b</sup> | 192 ± 33<sup>b</sup> | 162 ± 19<sup>b,c</sup> | 157 ± 22<sup>a</sup> | 179 ± 19<sup>c</sup> | 160 ± 37<sup>c</sup> |
| BRD     | 268 ± 38<sup>a</sup> | 246 ± 35<sup>a,b</sup> | 235 ± 43<sup>c</sup> | 197 ± 38<sup>a,b</sup> | 153 ± 29<sup>a</sup> | 166 ± 20<sup>a,b</sup> | 169 ± 31<sup>b</sup> | 152 ± 45<sup>c</sup> |
| OT      | 258 ± 44<sup>a</sup> | 242 ± 44<sup>a</sup> | 196 ± 54<sup>a</sup> | 199 ± 54<sup>a,b</sup> | 150 ± 26<sup>a</sup> | 155 ± 23<sup>a</sup> | 158 ± 29<sup>a</sup> | 156 ± 48<sup>a</sup> |
| TM      | 262 ± 42<sup>a,b</sup> | 261 ± 46<sup>a,c,d</sup> | 229 ± 42<sup>c</sup> | 202 ± 41<sup>a,b</sup> | 155 ± 25<sup>a,b</sup> | 156 ± 24<sup>a</sup> | 177 ± 19<sup>b,c</sup> | 161 ± 34<sup>cd</sup> |
| Treated | 267 ± 42 | 252 ± 45 | 217 ± 46 | 195 ± 35 | 159 ± 23 | 157 ± 22 | 177 ± 21 | 159 ± 39 |
| All     | 270 ± 48 | 263 ± 47 | 213 ± 49 | 204 ± 40 | 162 ± 29 | 163 ± 23 | 174 ± 20 | 156 ± 42 |

<sup>a-d</sup> Within a column, values without a common superscript differed (P<0.05).

<sup>1</sup> DD= Digital dermatitis, FR= Foot rot, BRD= Bovine respiratory disease, OT= Other, TM= Two or more diseases

<sup>2</sup> FPH/FPS=Fall-placed heifer/steer, WPH/WPS= Winter-placed heifer/steer, GYH/GYS= Grass fed yearling heifer/steer, BYH/BYS= Backgrounded yearling heifer/steer
Table 8 Days on feed (DOF; mean and 95% CI) of healthy vs. DD cattle, by cattle type and sex.

| Type/Sex¹ | Healthy | DD² |   |   |   |   |   |   |   |   |   |
|-----------|---------|-----|---|---|---|---|---|---|---|---|---|
|           | Mean (d) | SE³ | 95% CI⁴ | mean | SE | 95% CI |   |   |   |   |   |
| FPH       | 271      | 1   | 269 | 272 | 298 | 8 | 283 | 314 |
| FPS       | 265      | 1   | 264 | 266 | 292 | 6 | 280 | 305 |
| WPH       | 212      | 1   | 211 | 213 | 232 | 2 | 228 | 237 |
| WPS       | 207      | 1   | 206 | 208 | 210 | 4 | 203 | 217 |
| GYH       | 162      | 1   | 162 | 163 | 170 | 2 | 167 | 174 |
| GYS       | 164      | 1   | 163 | 164 | 160 | 2 | 155 | 165 |
| BYH       | 173      | 1   | 173 | 174 | 182 | 1 | 181 | 184 |
| BYS       | 155      | 1   | 154 | 157 | 150 | 7 | 136 | 164 |

¹FPH/FPS=Fall-placed heifer/steer, WPH/WPS= Winter-placed heifer/steer, GYH/GYS= Grass fed yearling heifer/steer, BYH/BYS= Backgrounded yearling heifer/steer

²DD=Digital dermatitis

³SE=Standard error

⁴CI=Confidence interval
Animal records included production and treatment data of healthy and diseased animals. 
N = 90,801

Duplicate animal records were removed. 
N = 83,184

Animals with missing values were removed. 
N = 77,551

Animals with missing WA<136 kg and DOF>500 were removed. 
N = 77,115