The incidence of liver abscessation in slaughtered beef bulls in the South Island of New Zealand

CG Trotter[1*] and SJ Gibbs[2]

[1]Centre for Dairy Excellence, 20 Wilson St, Geraldine 7930, South Canterbury, New Zealand; [2]Faculty of Agriculture and Life Sciences, Lincoln University, PO Box 85084, Canterbury, New Zealand.

**Corresponding author:* Email: Craig.Trotter@dairyexcellence.co.nz

Abstract

There has been anecdotal evidence of increasing liver abscessation on bull-beef farms across New Zealand from meat processors for more than a decade, but to date, no quantitative data has been published in the field. This study objective was to establish the incidence of liver abscessation in pasture- based beef bulls, the seasonality and breed differences, the impact on carcass weight, and to compare this with published data from feedlot cattle internationally. The study used a database of 137675 bulls slaughtered in the South Island between 2000-2005. The database included breed, farm location, carcass weight, liver abscess presence and abscess grading score (absent, mild, moderate, severe). The annual incidence of liver abscessation calculated was a mean of 9.5%. This recorded value is greater than other observed incidences from pasture-based systems and reduced compared with those observed in non-medicated feedlot systems internationally. There were significant variations in all measured parameters across years, and a clear and significant seasonal variation was observed. Incidence of liver abscessation peaked across November- December (11.3 and 11% respectively) and then declined as the slaughter season progressed. The typical NZ beef industry approach to rearing bulls for slaughter makes it likely that age at slaughter is a key influence on the seasonal incidence rate, with most cattle born in spring and slaughtered after 18 months, suggesting the late spring and summer peak in incidence is due to bulls older than two years. The percentages of abscesses graded were: severe (66.4%), moderate (12.8%), and mild (20.7%). Friesian and dairy cross-breed bulls had an incidence approximately twofold greater than that females beef breeds (10.3% and 4.7% respectively). There was a significant difference in the mean carcass weights of bulls graded, with those moderate with abscessation having a mean heavier carcass weight than those graded severe, minor and no abscess.

Keywords: Liver abscess; bull-beef systems; pasture-fed; bulls; Holstein-Friesian; rumen function; pH; *Fusobacterium necrophorum*; *Fusobacterium funduliforme*

Introduction

The issue of liver abscessation is a novel issue for producers and processors in the beef industry of New Zealand, which is overwhelmingly a pasture-based sector. From 1990 to 2000, inspectors were reporting an increase in liver abscessation at slaughter, a database was established to document the incidence of liver abscessation in the South Island of New Zealand. This database recorded the liver abscessation of bulls slaughtered during each month of the killing season from 2000 through to 2005. The typical New Zealand bull-beef slaughter cycle begins in September and is seasonally dependent on pasture production. During spring and summer, slaughter numbers rise with the increase in pasture production, with peak numbers slaughtered December-March. The aims of this research were to establish the annual and seasonal incidence of abscessation, the effect of breed, and the impact on carcass weights in bulls in the South Island of New Zealand.

Materials and methods

A database of a total of 137,675 bulls slaughtered from October 2000 to December 2005 was catalogued according to date of slaughter, breed of bull, carcass weight and farm of origin. Liver abscess severity was recorded as four grades based on the size and number of abscesses present upon the liver; severe (two or more abscesses greater than 4 cm in diameter), moderate, (one abscess greater than 4 cm in diameter), minor, (abscesses present under 4 cm in diameter and/or the presence of scar tissue) and no abscesses visible. Because of the wide range of breeds of bulls slaughtered, a further category was produced identifying each bull by purpose as beef or dairy type to simplify analysis, where dairy types were defined as having any dairy breed genotypes included. All animal inspections, liver abscess grading and data entry was performed by qualified New Zealand Food Safety Authority National Meat Inspectors.

All data that were entered was analysed using descriptive statistics with Genstat statistical software 12th edition (VSN International limited, Hemel, Hampstead, United Kingdom).

Statistical analysis was performed using a general linear model with year, month, abscess grade and breed as fixed model parameters with carcass weight and individual animal ID as variable parameters.

Results

Annual distribution of slaughter and liver abscess incidence

Over this trial period, the mean incidence of liver abscessation was 9.5% with a range of 8.4 to 10.4% between individual years (Table 1). Most liver abscesses were graded as being severe (63.4%; $P<0.001$); 13% were moderate and 21% minor.

Seasonal distribution of slaughter and liver abscess incidence

Liver abscessation incidence (Table 2) and the number of bulls slaughtered were considerably different among months. From September, there were an increasing number

Table 1 The annual incidence and recorded severity categories of liver abscesses (Severe: two or more abscesses greater than 4 cm in diameter, Moderate: abscesses greater than 4 cm in diameter and Minor: abscesses present under 4 cm in diameter and the presence of scar tissue) in bulls slaughtered between 2000 and 2005 in the South Island of New Zealand.

Year of slaughter	Severe (%)	Moderate (%)	Minor (%)	No abscess (%)	Number of bulls recorded
2000	3.90	2.45	3.79	89.9	9032
2001	5.80	1.17	1.82	91.2	19434
2002	5.98	0.90	1.53	91.6	18159
2003	7.27	1.29	1.80	89.6	29998
2004	6.52	1.20	1.78	90.5	30767
2005	6.42	1.04	2.13	90.4	30285
Mean/total	6.31[b]	1.22[a]	1.97[a]	90.50[c]	137675

Super script values represent differences (P<0.001) between grades of liver abscessation

Table 2 The incidence of liver abscessation in recorded severity categories of liver abscesses (Severe: two or more abscesses greater than 4 cm in diameter, Moderate: abscesses greater than 4 cm in diameter and Minor: abscesses present under 4 cm in diameter and the presence of scar tissue) as a percentage of total bulls slaughtered per month and the number of bulls slaughtered in each month from 2001-2005 in the South Island of New Zealand.

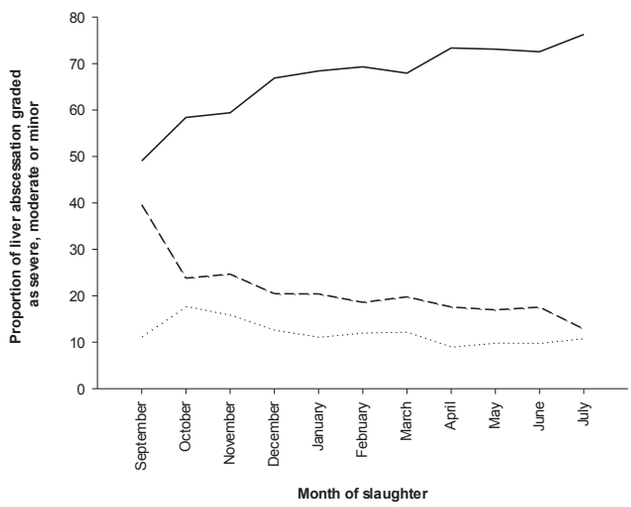
Month	Severe (%)	Moderate (%)	Minor (%)	No abscess (%)	Number of bulls slaughtered
September	3.89	0.90	3.14	92.1	668
October	5.55	1.69	2.26	90.5	10755
November	6.74	1.81	2.79	88.7	16447
December	7.39	1.40	2.25	89.0	14194
January	7.27	1.19	2.17	89.4	21944
February	5.96	1.04	1.60	91.4	19490
March	5.03	0.91	1.46	92.6	19652
April	6.82	0.84	1.63	90.7	11394
May	5.48	0.75	1.27	92.5	4560
June	5.77	0.79	1.39	92.0	7237
July	5.79	0.83	0.97	92.4	2055
August					
Mean/total	6.5[b]	1.19[a]	1.87[a]	90.5[c]	128643

Super script values represent differences (P<0.001) between grades of liver abscessation

of bulls slaughtered each month with a peak in January decreasing to July, and a smaller rise in April (9.3%). The greatest incidence of liver abscesses was in November (11.3%).

Those abscesses recorded as severe were consistently more numerous than those measured as moderate or minor (Table 2). Peak incidence for severe-graded abscesses occurred in December (7.39%) whereas for both moderate- and minor-graded abscesses, the peak occurred

Figure 1 The proportion of all liver abscessation incidence graded as Severe (solid line; two or more abscesses greater than 4 cm in diameter), Moderate (dashed line; one abscess greater than 4 cm in diameter) and Minor (dotted line; abscesses present under 4 cm in diameter and the presence of scar tissue) in the livers of bulls slaughtered in each month from 2001-2005 in the South Island of New Zealand.



in November (6.74 versus 1.81 and 2.79% respectively for each grade).

Severe abscessation incidence increased from September (49%) to July (76%), while that of moderate decreased (40-13% from September to July), and minor-graded lesions remained relatively stable (Figure 1).

The relationship between liver abscessation incidence and bull carcass weight

Table 3 shows that, in all categories of abscess severity, the mean bull carcass weight declined in the second half of the season; heaviest bulls for all grades were slaughtered in the summer months of November and December and then carcass weights gradually decreased till June. Bulls with moderate abscesses had a heavier mean carcass weight than those bulls with severe, minor and no abscesses respectively (P<0.05; 320 ± 1.1 versus 317 ± 0.5, 318 ± 0.8 and 317 ± 0.1 kg CW for moderate, severe, minor and no abscesses grades respectively).

Effect of breed on the incidence of liver abscessation

Friesian and Friesian-cross bulls represented 82.4% of all bulls slaughtered with the remaining consisting of Angus and Angus cross (4.6%), Hereford and Hereford cross (4.6%), Jersey and Jersey cross (3.0%) bulls slaughtered with other remaining breed composites accounting for less than 1%. The incidence of liver abscesses at slaughter varied widely between breeds and their associated composites, with the incidence of liver abscessation in pure Friesian bulls being recorded as 12.6%, Friesian crosses 7.3%, Jersey 2.3% and Jersey crosses 5.2%, Hereford bulls 5.2% and Hereford crosses 5.9%. Bulls were then categorised as beef or dairy-dominant breed type based from visual assessment. Dairy-type bulls had an incidence of liver abscessation more than twice that of beef-type bulls (10.3

Table 3 The mean carcass weight (kg ± SEM) of bulls with liver abscesses graded as Severe (two or more abscesses greater than 4 cm in diameter), Moderate (one abscesses greater than 4 cm in diameter) and Minor (abscesses present under 4 cm in diameter and the presence of scar tissue) in the livers of bulls slaughtered in each month from 2001-2005 in the South Island of New Zealand.

Year	Severe	Moderate	Minor	No abscess
		(kg ±SEM)		
September	334 ± 5.3	311 ± 10.5	332 ± 4.5	334 ± 1.3
October	325 ± 1.3	328 ± 2.3	327 ± 1.8	326 ± 0.4
November	326 ± 0.9	327 ± 2.0	328 ± 1.5	326 ± 0.3
December	326 ± 0.9	327 ± 2.1	326 ± 1.6	329 ± 0.3
January	326 ± 0.9	330 ± 2.4	325 ± 1.6	324 ± 0.3
February	323 ± 1.2	325 ± 3.2	325 ± 2.1	317 ±0.4
March	310 ± 1.3	312 ± 3.0	311 ± 2.7	306 ± 0.3
April	296 ± 1.2	302 ± 4.6	300 ± 2.4	297 ± 0.4
May	287 ± 2.0	292 ± 9.2	284 ± 4.6	296 ± 0.8
June	293 ± 1.8	294 ± 4.9	285 ± 3.8	296 ± 0.6
July	295 ± 3.8	315 ± 12.5	300 ± 10.2	303 ± 1.3
August				
Mean	317^{a} ± 0.5	320^{b} ± 1.1	318^{a} ± 0.8	317^{a} ± 0.1

Super script values represent differences (P<0.05) between grades of liver abscessation

Table 4 The total number of bulls slaughtered and mean incidence of liver abscessation throughout the production season for dairy and beef type bulls (all years from combined from 2001 to 2005) in the South Island of New Zealand.

Month	Beef type		Dairy type	
	Abscessed (%)	Number of cattle slaughtered	Abscessed (%)	Number of cattle slaughtered
August				
September	14.3	21	7.73	647
October	5.32	1411	10.0	12159
November	5.61	2050	12.0	17636
December	6.46	1456	11.4	15731
January	5.48	2664	11.3	19366
February	3.77	3424	9.62	16167
March	4.47	4053	8.17	15611
April	5.09	1906	10.1	9491
May	2.66	865	8.63	3695
June	3.42	1461	9.10	5782
July	5.54	379	8.08	1671
Mean/total	4.74^{a}	19960	10.3^{b}	108683

Super script values represent differences (P<0.001) between incidence of liver abscessation between beef and dairy type bulls respectively.

versus 4.71% respectively; P<0.001) and were a much higher proportion of the total bulls slaughtered (85.7%). This high incidence amongst dairy-type bulls was constant throughout all years (Table 4).

When these categories were divided into seasonal incidence, both types showed a very similar seasonal distribution of abscessation (Table 4). Abscessation incidence declined through the season after summer except for a small rise in April for both breed types.

Discussion

The annual incidence of liver abscesses (9.5%; Table 1) in bulls from the South Island of New Zealand between 2000 and 2005 is of concern to the bull-production industry. This is very high in comparison to reports of pastoral-production systems but is lower than that recorded internationally in the predominantly antibiotic-medicated, lot-fed beef industries with 12 to 32% of cattle having liver abscessation at slaughter (Brink et al. 1990).

Although the overall incidence is lower in the pasture-based bulls of this study compared with feedlot cattle, the incidence of severe abscessation is considerably greater than that recorded in the North American feedlot industry. That industry has previously reported data of A+ graded abscesses (one or more active abscesses > 2.5 cm in diameter and portions of the diaphragm may be adhered to the surface of the liver) accounting for between 33 and 53% of total abscessation recorded, lower than the severe graded abscessation reported here (66.3%: Table 2).

Dairy-type bulls and particularly Holstein-Friesians bulls were observed to have a higher incidence of liver abscessation in comparison to their beef cohorts or Jerseys (Table 4). This is in agreement with international literature which shows a two-fold greater incidence in Holstein-Friesian breed animals in comparison to Angus and Hereford breeds (Nagaraja et al. 1996; Nagaraja & Lechtenberg, 2007). The reported incidences in this study are very similar to that reported internationally with liver abscess incidence being 2.2 times greater in dairy versus beef category bulls, respectively (Table 4). There have been a number of explanations for this observation, but to date, there has been no definitive answer as to why Holstein-Friesian breeds have this apparent much greater incidence of liver abscess. Suggestions to date have been that because of their larger frame size, they remain on the feedlot for a longer period of time; 12% longer in some cases (Hicks et al. 1990) ensuring that they consume greater quantities of concentrate-type feed potentially making them more susceptible to ruminal acidosis and suffer from rumenitis-liver abscessation complex syndrome. The lower incidence in Friesian-cross bulls seen in this report (7.25%) in comparison to pure Friesian bulls (12.6%) does not support the traditional understanding as these crossbred bulls would take a longer period of time to reach target slaughter weights in the NZ system. The results of this study suggest that Friesian bulls have an inherent higher susceptibility to liver abscessation.

In general, as the season progressed, mean bull carcass weight declined. This may reflect a transition from bulls aged 26-30 months of age earlier in the season to slaughtering predominantly 18-22 month-old bulls from February onwards (Table 3). Spring-born bulls raised on an aggressive pasture-feeding system and slaughtered at 18-22 months would be predominantly slaughtered from

February-July, while bulls that do not reach slaughter target weights at 18-22 months as a result of being reared on a lower plane of nutrition are subsequently carried for a second winter and slaughtered during September to December, hence the heavier carcass weights in these months.

As shown in Table 2, there is a seasonal distribution in the incidence of liver abscessation with a peak in the incidence of liver abscesses occurring during the spring and early summer period. There may be a relationship with this seasonal increase in liver abscessation incidence and the intensification of feeding during this period when pasture quality and production is at its highest and when bull dry-matter intake and stocking rate are also at their highest to utilise the feed available. The peak in the incidence of liver abscessation and peak slaughter periods of these 26-30 month bulls would appear to coincide. One explanation for this is that the transition from a winter feeding regime, when bull feed intakes are relatively limited, through to the spring feeding period, provides favourable conditions for the growth of *F. necrophorum* in the rumen. International literature has shown that the transitional diet from a predominantly forage-hay to a grain diet increases the population of *F. necrophorum* in the rumen (Tan et al. 1994). This diet change can lead to abscessation of the liver through passive migration of *F. necrophorum* through the ruminal wall and into the portal circulatory system under these feedlot, high-concentrate fed situations (Tadepalli et al. 2009). While rumen pH shifts are often implicated in lot-fed diets, the diurnal pH flux in pasture fed cattle do not appear to be associated with rumen dysfunction nor detrimental animal performance. In both dairy and beef cattle, recent forage-based studies concluded that pasture-based rumen pH patterns are fundamentally dissimilar to those reported for TMR cattle and that pasture based cattle do not have syndromes of SARA rumen pathologies (Gibbs & Laporte- Uribe 2007; Saldias & Gibbs 2015; Prendergast & Gibbs 2015). Other NZ and international studies (Kolver 1998; de Veth & Kolver 2001; Taweel 2004; Williams et al. 2005) have similarly shown major diurnal rumen pH changes occurring in the rumen of forage fed cattle, without the typical dysfunction reported at similar thresholds in grain fed cattle. This suggests that in pasture-fed cattle, there are other more influential factors than pH damage of rumen epithelium in the incidence of liver abscessation.

There appears to be an association of bulls with heavier mean carcass weight having abscesses graded as moderate; Table 3 ($P<0.05$) with no statistical differences between other grades. Even though statistically significant, from a production perspective these differences are perhaps minimal with differences of 5 and 3 kg CW for the yearly and monthly analysis respectively. Of particular interest is that there were no differences observed in CW for bulls with severe versus no abscesses (318 ± 0.5 and 317 **±0.1** kg respectively). In comparison, data from international feedlots recorded A+ abscessed animals having CW 36 kg lighter than animals with livers graded as nil abscessation (274 versus 310 kg CW respectively; (Montgomery 1985). International literature also shows that cattle having abscesses graded as A+ have reduced performance and carcass dressing out percentage, (Brink et al. 1990) with the other grades of abscessation having no influential effect on animal performance or carcass characteristics.

The progressive nature of abscess maturation is of particular interest to this study in identifying any effect of plane of nutrition at any given point in time on abscess formation and development and how this is then related to animal performance and abscess severity at the time of slaughter. Even though peak abscessation occurs in November-December, there is an increase in the proportion of severe abscesses as the season progresses (Figure 1). There are two main factors which may be involved; first, this trend could be attributed to the higher proportion of 18-22 month bulls being slaughtered later in the season, as a higher feeding intensity is required for these younger bulls to reach target LW for slaughter in February-June. Alternatively, the incidence of severe abscessation may also be complicated by potential reduced animal LWG; particularly those animals with severe abscessation (a combination of 18-22 and 26-30 month of age bulls) may take a longer period of time to reach target LW for slaughter due to reduced LWG. This was not recorded in this study but this syndrome of reduced animal performance is supported internationally where animals on feedlots having A+ liver abscessation are on the feedlot for a longer period of time as well as reduced and downgraded carcass characteristics in comparison to animals with lower grades of abscessation (Brink et al. 1990; Nagaraja et al. 1996; Nagaraja & Lechtenberg 2007).

Conclusions

The prevalence of liver abscesses in a selection of bulls slaughtered in the South Island of New Zealand is 9.5%. This prevalence was strongly related to the primary source of bulls for the bull-beef industry, Holstein-Friesian breed sourced from dairy operations. There is a clear seasonality to the incidence of cases, with the highest rate occurring in the late spring and early summer period. The apparent seasonal increase in the proportion of severe abscesses may simply reflect the larger number of younger bulls reaching slaughter LW later in the season. The absence of any significant detrimental effect of liver abscessation on bull carcass weight may reflect the later slaughter of those severely affected bulls given the increased proportion of severe abscesses as the season progresses.

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