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# Non-compliance with Market Specifications in a Victorian Pasture-fed Beef Value Chain[1]

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**Abstract**

Pasture-fed beef is being increasingly demanded by global beef consumers. However, pasture-fed beef value chains are struggling to maintain continuity of supply and consistent quality of product year round. Pasture-based production systems are influenced extensively by environmental conditions, pasture species, grazing management and livestock management systems. This variability, compounded by variability in market outcomes, could have a significant impact on the long term viability and profitability of producers in the value chain. This study aimed to assess the level of non-compliance in one southern pasture-fed value chain, with the intention of using the results to focus further work on areas of production and supply most critical to sustaining the market. Nineteen months of carcass grading data over 2012 and 2013 from almost 63,000 cattle were evaluated to determine the levels of non-compliance with the relevant company specifications. Hot standard carcass weight, P8 fat depth and sex were the carcass attributes that were compared and analysed.

The 2012 data set comprised 3,905 heifers and 9,922 steers. Some 66% of the heifers and 62% of the steers did not meet the preferred company specifications for carcass weight and fat depth. For heifers, the cost of non-compliance was estimated to be $63 per carcass and for steers it was $47 per carcass. The 2013 data set comprised 19,099 heifers and 30,014 steers. A total of 78% of the heifers did not meet the highest value specification on the grid, with more than 50% of heifer carcasses being too light. Just on 60% of steer carcasses did not meet the 2013 weight and fat specifications with 39% of all the steers being overweight. The foregone value in non-compliance for heifers was estimated to be $84 per carcass and, for steers, $87 per carcass. Across the whole dataset, the weighted average cost of non-compliance was $78 per carcass.

***Key words***: non-compliance; market specifications; pasture-fed; beef; value chain.

[1] The authors acknowledge with thanks the data and assistance provided by the staff of the case study processing plant, and the very helpful comments by Peter McGilchrist and John Thompson on an earlier draft.

## Background

An emerging demand from export and domestic markets for pasture-fed or grass-fed beef has led to a number of processors and value chains focusing a portion of their business on this market. For a consumer demographic that places value on environmental, ethical and natural production of beef and can afford to purchase it (Morales et al., 2013, 2017), a market exists for the year round supply of this product in Australia and in some export markets. To enable processors to supply this market consistently, defined carcass weight and fat specifications with associated payment grids have been implemented for producers to target.

Little research has been done on weight and fat compliance in any Australian beef value chain. Slacksmith et al. (2009) analysed two grain-fed data sets and found that the costs of non-compliance to Australian beef market specifications were substantial. Over all of the 40,000 animals in these two datasets, the minimum total cost of non-compliance was approximately $1,628,000 or around $40/head.

McPhee and Walmsley (2014) conducted an analysis of non-compliance over two commercial data sets (n = 65,520 animals) of pasture-fed cattle supplied from specific processors. Over both data sets the results showed that 10-20% of carcasses were not compliant with hot standard carcass weight and/or fatness specifications.

Pasture-fed beef value chains are struggling to maintain continuity of supply and consistent quality of product year round. Producing cattle to meet specific pasture-fed specifications is by its nature more prone to variation and seasonal conditions, hence carrying more risk than grain feeding. This is difficult enough when targeting weight and fat windows, and becomes more difficult when other factors are considered. For example, dark cutting is particularly prevalent in southern Australian cattle coming off pasture during autumn and early winter (McGilchrist et al., 2014). Knee et al. (2004) have shown that this is due to levels of muscle glycogen. Pasture-based systems are influenced extensively by weather conditions, pasture species, grazing management and livestock management systems. This variability, compounded by variability in market outcomes, could have a significant impact on the long-term viability and profitability of producers in the value chain. However, there is limited information available explaining where the major non-compliance issues are in pasture-fed beef cattle systems.

An increase in compliance rates[2] improves the profitability of pasture-fed systems for the supplier through less price discounting, and for the processor in carcass breakdown and management through the plant and with marketing. Measuring current rates and types of non-compliance so as to indicate practices that would reduce non-compliance is therefore a worthwhile objective.

## Objectives

First, this study aimed to analyse the level of non-compliance with a high value southern pasture-fed Meat Standards Australia (MSA) grid between January 2012 and July 2013 (see Polkinghorne et al. (2008) for a technical discussion of the MSA beef grading scheme, and Griffith and Thompson (2012) for a discussion of the price impacts).

[2] From here on, compliance is defined on the basis of the type of grid presented in the Appendix; ie, based primarily on weight and fat ranges by gender, within the confines of acceptable age and body shape parameters. Other criteria, such as pH level and meat and fat colour, are not considered further.

Second, the study aimed to quantify the costs of non-compliance and to identify reasons for non-conforming cattle carcasses.

Third, the study aimed to assess where the potential benefits for both the supplier and the processor might lie through higher compliance rates.

## Methods

The project focus was on a case study pasture-fed specification from a major commercial processing plant in southern Australia. To meet the preferred specifications, steer or heifer carcasses must have been MSA graded and fall within a hot standard carcass weight (HSCW) of 280–340kg and a fat depth (P8 site) of 5-22mm. Interactions between these traits were also examined in relation to seasonal influences.

Individual company carcass data (>100,000 records) and Meat Standards Australia (MSA) grading data (>20,000 records) were provided in MS Excel files. The processor indicated that works data was extracted differently in each year, so each year was treated separately in the analysis. MSA grading only commenced at this plant during 2012, so another reason to keep the samples separate was to see if there was any learnings over time.

Data were compiled through MS Excel and MS Access for data analysis and graphing. Company data variables analysed include

- HSCW (kg)
- P8 fat depth (mm)
- Sex differences in HSCW specification non-compliance
- Sex differences in fat specification non-compliance
- Seasonal variability and sex difference non-compliance
- Effects of location of source stock and non-compliance[3].

Initially, from the two available data sets, consistent carcass data was obtained for 69,679 cattle between January 2012 and July 2013, and examined for non-compliance to company specifications. Data exceptions (missing, ungraded carcasses and outliers) were excluded from the analyses. The final data set comprised 62,940 cattle. Obviously, with MSA gradings being a relatively small share of the total number, the expected levels of non-compliance is high.

Fortnightly wholesale pricing schedules available to producers in 2012 and 2013 (see the Appendix for an example of a 2012 grid) were used to estimate carcass value and assess where changes to the procurement model would impact upon the marketing of pasture-fed brands.

### "Grass-fed" Company Specifications

When the company carcass specifications were met, no price discount was received by the supplier. For example, based on the MSA grid shown in the appendix for a particular fortnight in 2012, compliant steers would receive $3.30/kg and compliant heifers would receive $3.15/kg. Outside these specifications, price discounting was applied dependent upon the level of non-compliance to either carcass weight or fat depth or both.

[3] Analyses of compliance rates by individual producer and by local government area were undertaken but have been omitted from this paper to protect the anonymity of the case study processor.

If carcasses were 20kg too heavy or too light, thus 260-280kg or 340-360kg, a $0.10/kg discount applied. If carcasses were in the weight range 240-260kg, a further $0.05/kg discount was applied. A flat $0.10/kg discount was applied at 23-32mm P8 fat and carcass weight 240–360kg's. If the steer and heifer carcasses were graded with a different body shape, a further $0.15/kg discount was applied. So carcasses could still be graded MSA, but due to being under- or over-fat, or under or overweight, they could be discounted up to $0.40/kg.

Outside these immediate parameters, further discounting applied. Where carcasses did not meet MSA grade criteria, they were assessed against a non-MSA grid. For example, heifers that did not meet the MSA grid were assessed against a trade yearling heifer grid or a Jap heifer grid. Heifers that were very light could be discounted by up to $0.75/kg from the MSA compliant price; heifers that were older, very heavy and very fat could be discounted up to $1.20/kg from the MSA compliant price. The same sorts of discounts are evident for steers and for the 2013 data set.

**Cost Analysis**

***Calculating the cost of non-compliance***

The individual carcasses making up the raw data were re-categorised into whether they met the HSCW specification or not, whether they met the P8 fat specification or not, or whether they met both the HSCW and P8 specifications, or not. This gave a 9*9 matrix of categories (too light, acceptable weight range, too heavy; times too lean, acceptable P8 fat range, too fat). This was done separately for steers and heifers and separately for the 2012 dataset and the 2013 dataset.

Each carcass was then matched to the appropriate fortnight grid (such as shown in the appendix) and a c/kg discount was calculated where necessary. The total value of each carcass, and an estimate of the value of the lost income due to non-compliance, was then calculated. These individual carcass values were then summed or averaged as appropriate across all carcasses in the various categories. These calculations are shown in Tables 2 and 3 for 2012 and 2013 data respectively.

***BeefSpecs analysis***

The *BeefSpecs* decision support tool (http://beefspecs.agriculture.nsw.gov.au/) was used in an experiment to assess the benefits of reducing non-compliance by better estimating final weight and fat measures given starting weight and estimated growth rates. Following McKiernan (2011), it was arbitrarily assumed that the proportions of carcasses assessed as non-compliant in 2013 were reduced by half. That is, half of the heifers and steers that were too light and half that were too heavy moved into the acceptable weight range.

***Decision making by the processor***

A structured interview with the company's regional beef management contributed to analysis around different scenarios including decision making based on supply, how non-compliance is currently managed, what would change should compliance levels improve and how profits could be maximised if the costs of non-compliance were reduced. To gain a better understanding of the commercial imperatives, the following points were raised:

- Factors affecting plant efficiency and costs to the company from groups of cattle that are non-compliant compared to cattle that are compliant (including risk avoidance strategies),
- Brand structure and pricing,
- Plans for brand adoption and development,
- How the wholesale meat pricing schedule is affected or influenced by the current cattle supply grid.

The compliance data, in conjunction with the detailed interview responses, is being utilised in subsequent work to analyse the management strategies available to mitigate non-compliance and estimate the rate of adoption of on-farm strategies.

## 4. Results[4]

### Compliance data

The compliance data are summarised in Table 1.

**Table 1. Summary of non-compliance, steers and heifers, 2012 and 2013**

| **Heifers (F) & steers (M) outside weight specification <280kg &>340kg weight** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **F total** | **F <280** | **%** | **F >340** | **%** | **M total** | **M <280** | **%** | **M >340** | **%** |
| 2012 | 3905 | 1502 | 38.5 | 491 | 12.6 | 9922 | 842 | 8.5 | 3963 | 39.9 |
| 2013 | 19099 | 9650 | 50.5 | 2014 | 10.5 | 30014 | 3147 | 10.5 | 11558 | 38.5 |
| **Heifers (F) & steers (M) outside fat specification <5mm &>22mm fat** | | | | | | | | | | |
| **Year** | **F total** | **F <5mm** | **%** | **F >22mm** | **%** | **M total** | **M <5mm** | **%** | **M >22mm** | **%** |
| 2012 | 3905 | 206 | 5.3 | 820 | 21.0 | 9922 | 528 | 5.3 | 1971 | 19.8 |
| 2013 | 19099 | 2239 | 11.7 | 5177 | 27.1 | 30014 | 1603 | 5.3 | 4204 | 14.0 |
| **Heifers outside weight and fat <280 &>340 kg and <5mm and >22mm fat** | | | | | | | | | | |
| **Year** | **Total** | **<5<280** | | **%** | **<5>340** | **%** | **>22<280** | **%** | **>22>340** | **%** |
| 2012 | 3905 | 70 | | 1.8 | 21 | 0.5 | 285 | 7.3 | 110 | 2.8 |
| 2013 | 19099 | 1570 | | 7.9 | 9 | 0.0 | 1024 | 5.4 | 1513 | 7.9 |
| **Steers outside weight and fat <280 &>340 kg and <5mm and >22mm fat** | | | | | | | | | | |
| **Year** | **Total** | **<5<280** | | **%** | **<5>340** | **%** | **>22<280** | **%** | **>22>340** | **%** |
| 2012 | 9922 | 23 | | 0.1 | 230 | 2.3 | 161 | 1.6 | 728 | 7.3 |
| 2013 | 30014 | 623 | | 2.1 | 495 | 1.6 | 23 | 0.0 | 2218 | 7.4 |

***Combined steer and heifer data 2012 data set***

Figure 1 shows the range of HSCW and fat depth for steers and heifers in 2012. The preferred HSCW range (280-340kg) and P8 fat depth (5-22mm) is indicated between the vertical lines and horizontal lines respectively.

Between 1 January and 31 December 2012, 13,827 carcasses (9,922 steers and 3,905 heifers) were assessed against the MSA grass-fed grid. Some 51% of heifers and 48% of steers were outside the preferred weight specification, while 25% of both heifers and steers were outside the preferred fat specification. Almost 12% (n=1,628) of all steers and heifers were out of specification for both HSCW and P8 fat (that is, the upper left and upper right areas, and the lower left and lower right areas).

***Combined steer and heifer data 2013 data set***

[4] For interested readers, further detailed graphical analyses of weight and fat non-compliance by gender and by year are reported in Crawford et al. (2014).

Figure 2 shows the range of HSCW and fat depth for steers and heifers in 2013. The total number of carcasses was 49,113, made up of 30,014 steers and 19,099 heifers. Some 61% of heifers and 49% of steers were outside the preferred weight specification, while 39% of heifers and 19% of steers were outside the preferred fat specification. For steers and heifers, 15% (n=7,474) of carcasses did not meet the ideal specification for both HSCW and P8 fat. A greater portion of these were heifers (21% of all heifers) while only 11% of the steers were non-compliant to both weight and fat.

The aggregate steer and heifer carcass data across the two years showed broadly similar levels of non-compliance. Discounting for being overweight (>340kg HSCW) was the major reason for steer carcasses not meeting the preferred weight for both data sets. In contrast, a greater proportion of heifers over both years were underweight (<280kg HSCW). The data show heifers having higher numbers of carcasses out of specification for fat depth than steers and overall levels of non-compliance being greater in the heifer groups over both years.

***HSCW data***

The distribution of HSCW generally follows a normal distribution for both heifers and steers, for both years, although the distribution is to the right of the preferred specification for steers and to the left for heifers. An example is shown in Figure 3 for steers in 2012.

***P8 data***

The distribution of fat depth is definitely not normally distributed. As shown in Figures 1 and 2, there are definite bands of fat depth measurements at particular values. It appears these values are at multiples of 5mm; therefore 10mm, 15mm, 20mm, etc. Another view is provided in Figure 4 for steers in 2012 where there are obvious concentrations of values at those same 5mm intervals. This pattern is repeated in 2013 and is also evident in heifers (see the appendix). It is apparent that some P8 graders count in multiples of 5mm.

**Figure 1. HSCW and P8 fat depth, steers and heifer carcasses combined, 2012**

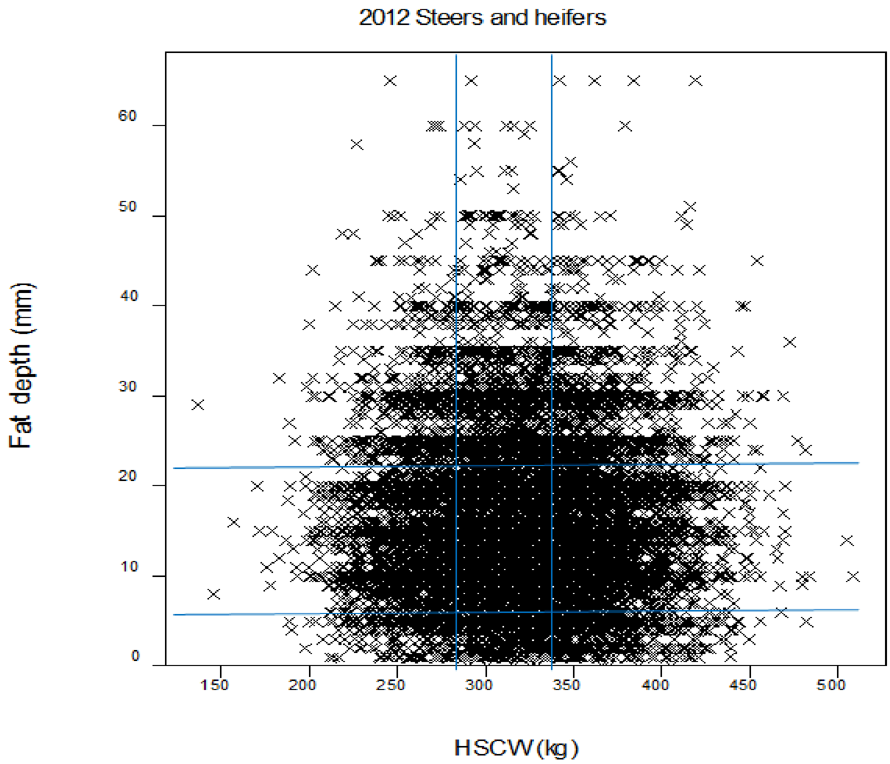


**Figure 2. HSCW and P8 fat depth, steer and heifer carcasses combined, 2013**

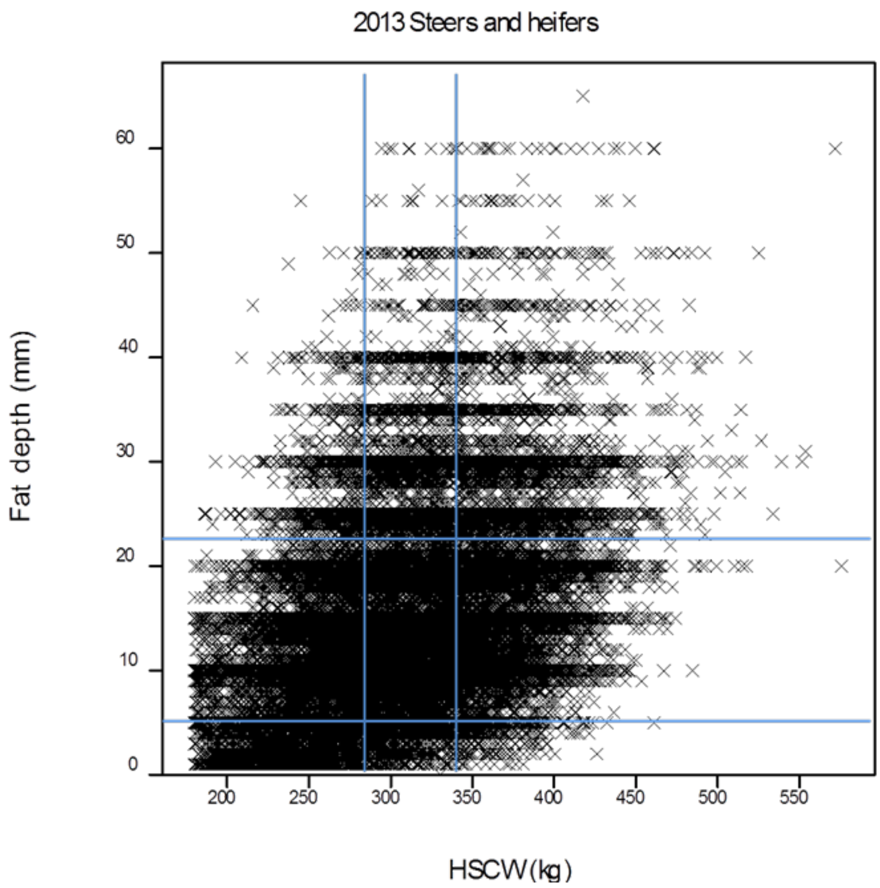



**Figure 3. HSCW and number of steers, 2012**

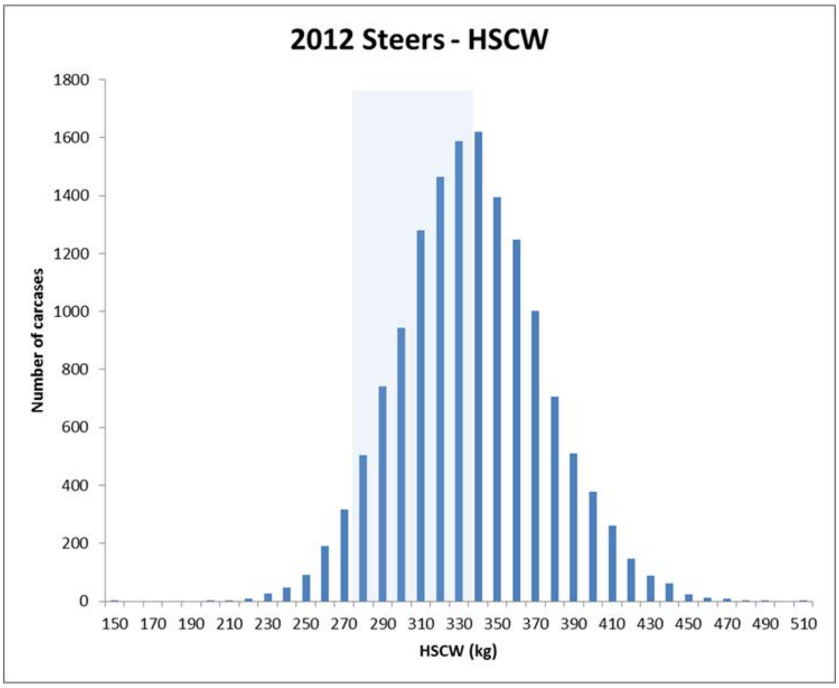
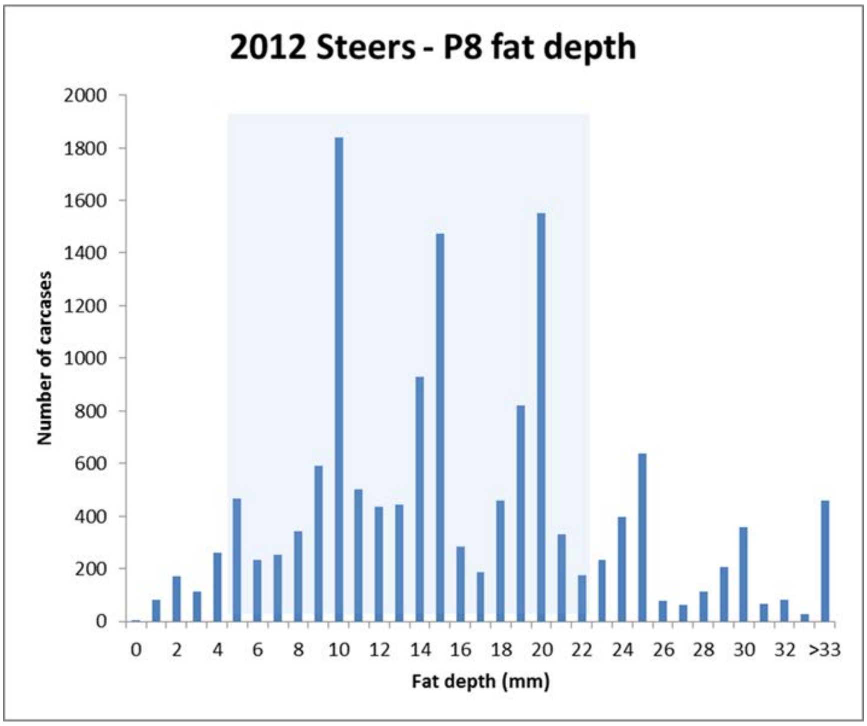


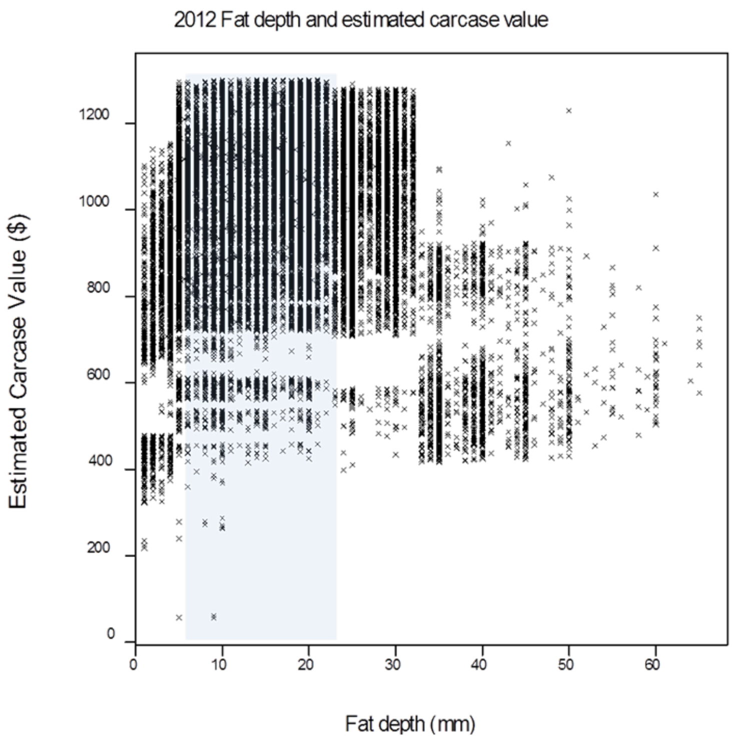
**Figure 4. P8 fat depth and number of steers, 2012**




### *Value data*

As an example of the financial impact of this non-compliance, Figure 5 shows fat depth distribution and estimated carcass value when applied to the company pasture-fed grid during 2012. The shaded area shows the preferred fat depth where no price discount applies. Overall carcass value decreased slightly in line with the first step down in price at 22mm, then more substantially at 32mm fat depth.

**Figure 5. P8 fat depth and estimated carcass value 2012**



***Seasonal non–compliance***

Figure 6 demonstrates the monthly percentage non-compliance for weight in heifer and steer carcasses (>340kg and <280kg) over the 2012 data collection period. The highest levels of non-compliance were amongst steers weighting >340kg and heifers weighting <280kg. The graph demonstrates a trend towards heavier steer carcasses as the year progressed with the exception of May. In November steer carcasses peaked at around 57% non-compliant in the >340kg range. Heifer carcasses <280kg were a consistent feature across the year. The reverse was demonstrated with steers <280kg. The month of May illustrates the highest percentage of steer carcasses <280kg and a corresponding lower percentatge of steers >340kg.

**Figure 6. Percentage steers (M) and heifers (F) outside HSCW specification, by month, 2012**

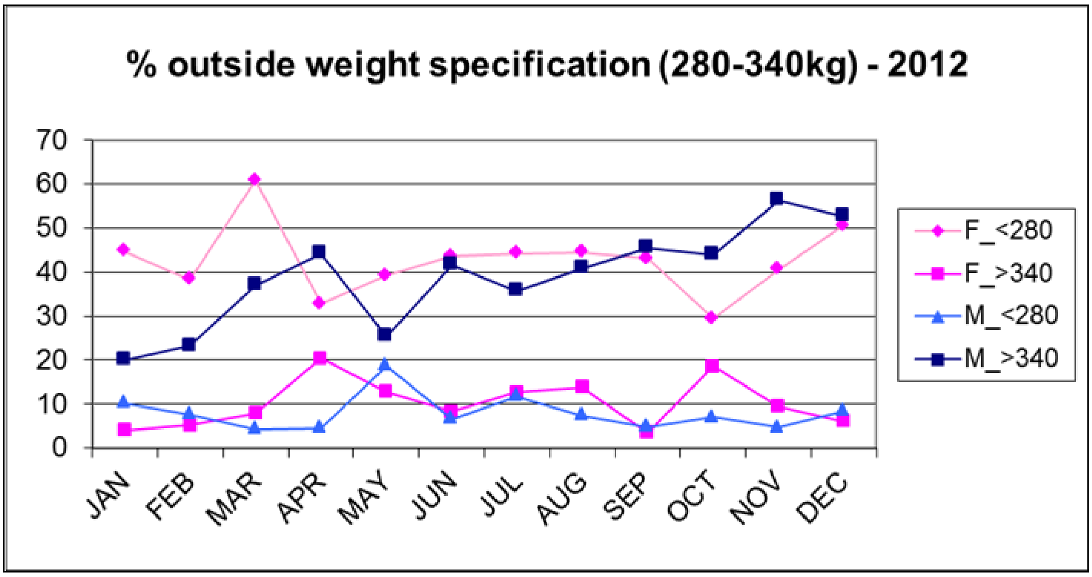



Figure 7 shows the percentage of steer and heifer carcasses falling outside specification each month for either having <5mm fat or >22mm fat. Heifer carcasses with more than 22mm fat provided the highest levels of non-compliance across the year. Thirty percent of heifer carcasses with >22mm fat were processed in March, with three more spikes, over 20%, in June, October and December. The other group with higher levels of non-compliance throughout the year were steer carcasses with >22 mm fat.

Figure 8 shows the monthly percentage of non-compliance to weight specification (<280 kg and >340kg) for heifer and steer carcasses over the 2013 data collection period. From January through to July heifers <280kg ranged from over 60% to just over 40% non-compliant. The number of steers in the lower weight range category <280kg stayed relatively stable between 10 and 20% across this time. Heavier steer carcasses in the >340kg out-of-specification group ranged from between 40 and 50% in the first three months to less than 30% in July.

Other than the heifers with <5mm fat, the percentage of non-compliance for heifers over fat or steers either over or under fat were within the 5-7% out-of-specification range across the seven months. As with the heifer carcasses shown in Figure 10 the heifers over this seven months were both underweight with regards to meeting specification as well as having <5mm fat.

**Figure 7. Percentage steers (M) and heifers (F) outside fat depth specification, by month, 2012**

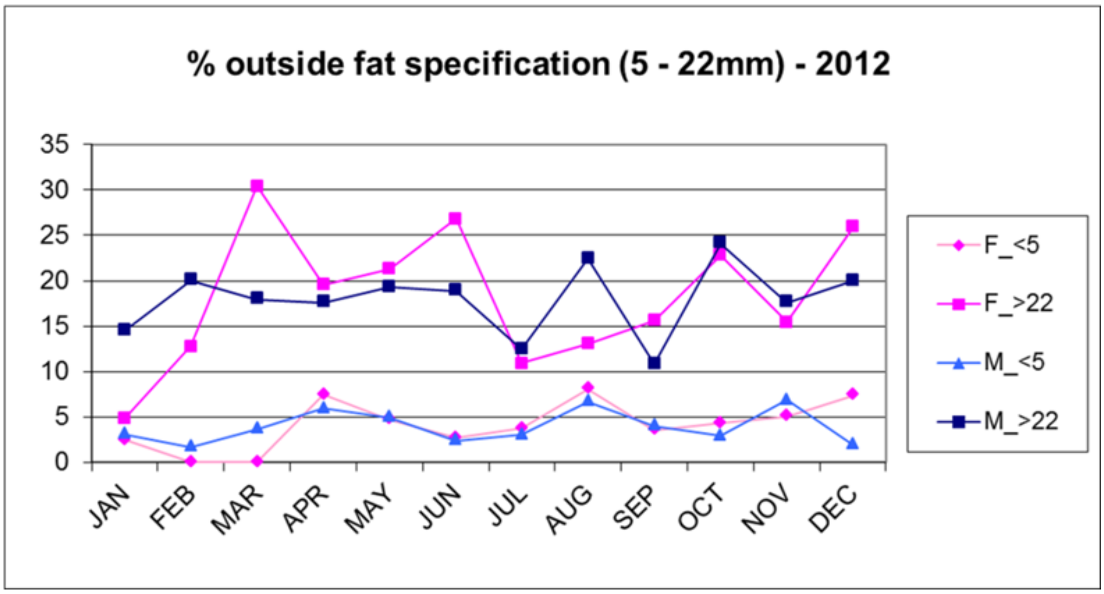



**Figure 8. Percentage steers (M) and heifers (F) outside HSCW specification, by month, 2013**

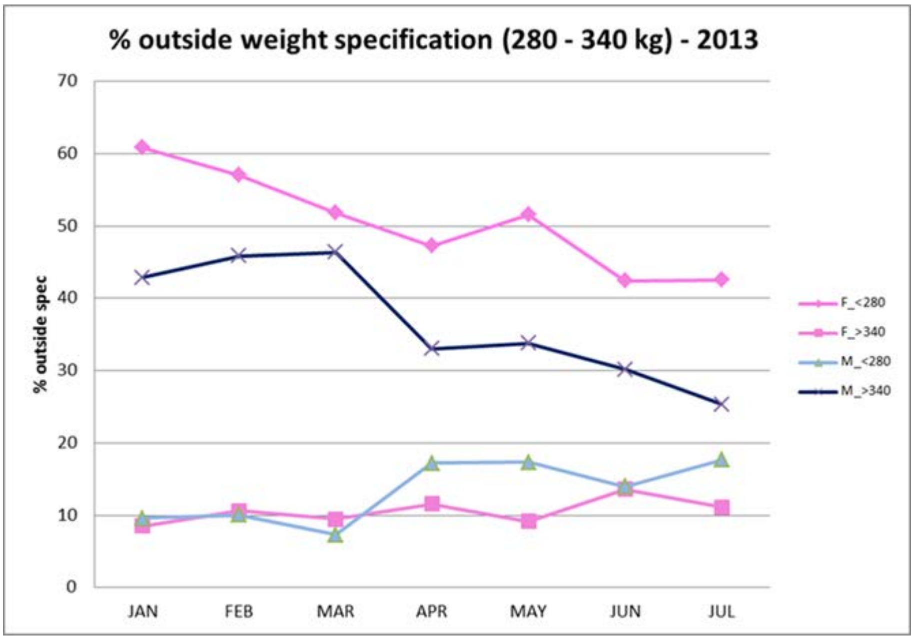



Figure 9 shows the percentage non-compliant to 5-22mm P8 fat depth specification for heifers and steers for 2013.

Figure 10 shows the percentage outside both weight and fat specifications for heifers and steers in 2013. Across the year steer carcasses showed consistently higher levels of compliance with specifications, whilst the heifers showed higher levels of non-compliance and variation throughout the year.

**Figure 9. Percentage steers (M) and heifers (F) outside fat depth specifications, by month, 2013**

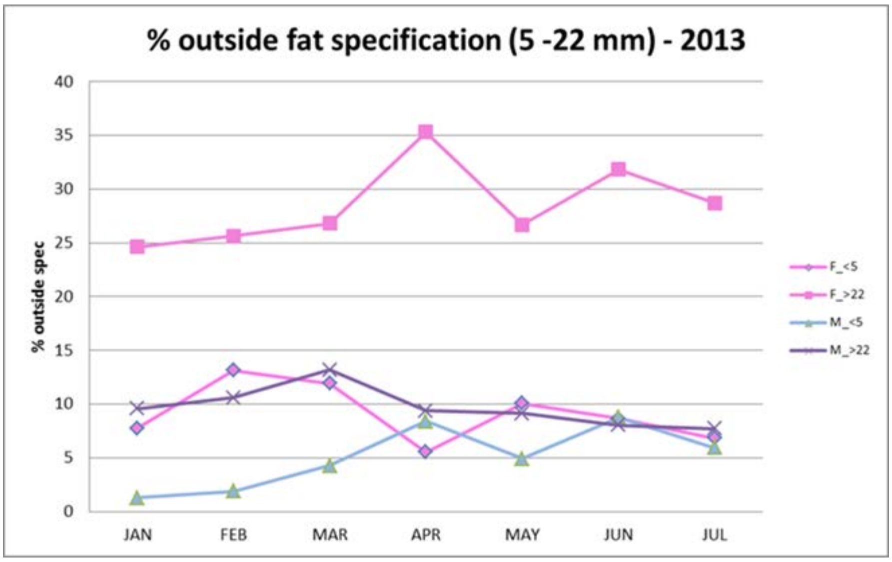
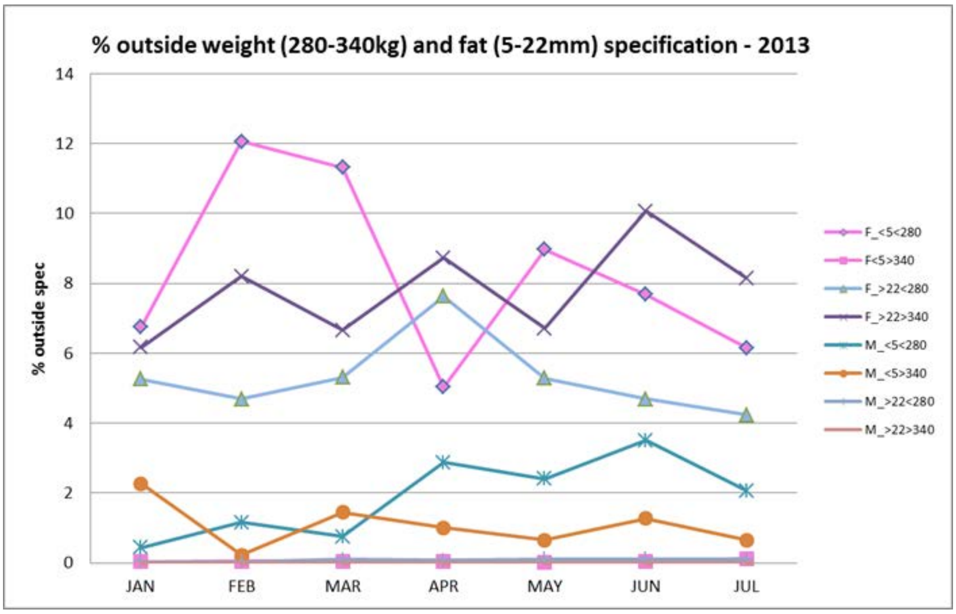



**Figure 10. Percentage steers (M) and heifers (F) outside both weight and fat specifications, by month, 2013**




Cull breeding heifers in February may have caused the spike in the supply of light heifers as well as poor seasonal conditions across the procurement area in autumn 2013. The poor autumn may also have contributed to a general turnoff of heifers, reducing breeding numbers within herds.

Analyses were also done to estimate non-compliance by individual producer and by geographical location, but these analyses were omitted from this paper to protect the anonymity of the case study processor and its clients.

**Cost of non-compliance**

***Cost of non-compliance, 2012***

Table 2 shows 3,905 heifers in this 2012 dataset derived from the grid. Only 1,342 (34%) met both the weight and fat specification for the 2012 grid. They had an average weight of 305 kg, an average P8 of 14 mm and an average value of $962.

The average discount for all of the light heifers was $0.27/kg and the average lost revenue per carcass was $67, but these values were significantly higher if the carcasses were also out of fat specification (up to $0.61/kg and up to $149 per carcass). Similarly, the average discount for all of the heavy heifers was $0.53/kg and the average lost revenue per carcass was $199, but these values were significantly higher if the carcasses were also out of fat specification (up to $0.78/kg and up to $288 per carcass). The discount for not meeting the P8 range only was quite minor at $0.09/kg for a carcass loss of just $28.

Putting these calculations together to calculate the total cost of non-compliance, it can be seen that this value is almost $250,000 across all of the 2,563 non-compliant heifers (Table 2). This is equivalent to $0.30/kg or close to $100 per carcass. Across all the heifers, the cost of the non-compliance is $63 per carcass. The total value of all of these heifers would have been some 7.4% higher if they had all met weight and fat specifications.

There were 9,922 steers in total in this 2012 dataset. Only 3,768 (38%) met both the weight and fat specification for the 2012 grid. They had an average weight of 314 kg, an average P8 of 14 mm and an average value of $1,037. Going through the same calculations as for the heifers, the total cost of non-compliance for the steers is over $470,000 across all of the 6,154 non-compliant steers (Table 2). This is equivalent to $0.16/kg or about $50 per carcass. Across all the steers, the cost of the non-compliance is $47 per carcass. The total value of all of these steers would have been some 4.6% higher if they had all met weight and fat specifications.

In aggregate for the 13,827 heifer and steer carcasses assessed in the 2012 data set, 8,717 or 63% were non-compliant to either HSCW, P8 fat, or both. The total cost of this non-compliance is over $716,000 across all of the non-compliant carcasses (Table 2). This is equivalent to $0.23/kg or about $75 per carcass. Across all the 2012 carcasses, compliant and non-compliant, the cost of the non-compliance is $51 per carcass. The total value of all of these cattle would have been some 5.3% higher if they had all met weight and fat specifications.

***Cost of Non-Compliance, 2013***

In Table 3, the number of carcasses is much higher than in Table 2, even though only a six month period is covered. The company made a concerted effort to increase pasture-fed throughput, and this resulted in a much more variable group of carcasses passing through the plant.

There were 19,099 heifers in the 2013 dataset, but only 4,135 of them (22%) met both the weight and fat specification for the 2013 grid: The total cost of non-compliance was almost $2.0 million across all of the 14,965 non-compliant heifers. This is equivalent to $0.46/kg or close to $150 per carcass. Across all the heifers, the cost of the non-compliance is $84 per carcass (Table 3). The total value of all of these heifers would have been some 11.5% higher if they had all met weight and fat specifications.

There were 30,014 steers in this dataset, but only 12,061 of them (40%) met both the weight and fat specification for the 2013 grid. The total cost of non-compliance for the steers is over $2.6 million across all of the 17,953 non-compliant steers. This is equivalent to $0.28/kg or about $92 per carcass. Across all the steers, the cost of the non-compliance is $87 per carcass (Table 3). The total value of all of these steers would have been some 7.8% higher if they had all met weight and fat specifications.

**Table 2. 2012 estimated non-compliance costs**

| Heifers | n | HCWT_avg (kg) | P8_avg (mm) | Discount_avg ($) | EstValue_avg ($) | EstLoss_avg ($) | EstValue_total ($) | EstLoss_total ($) | Loss/Value (%) |
|---|---|---|---|---|---|---|---|---|---|
| <280 | 1502 | 254.9 | 15.6 | 0.27 | 736 | 67 | 1098518 | 99962 | 9.1 |
| <280_<5 | 70 | 253 | 2.6 | 0.61 | 648 | 149 | 45328 | 10462 | 23.1 |
| <280_>22 | 265 | 258 | 28.4 | 0.42 | 702 | 108 | 179687 | 27702 | 15.4 |
| 280-340 | 1912 | 305.7 | 16.4 | 0.09 | 934 | 28 | 1769407 | 53045 | 3.0 |
| 280-340/5-22 | 1342 | 305.5 | 14.1 | 0 | 962 | 0 | 1292220 | 0 | 0.0 |
| >340 | 491 | 367.5 | 17 | 0.53 | 956 | 199 | 447442 | 93324 | 20.9 |
| >340_<5 | 21 | 364.5 | 2.7 | 0.75 | 875 | 273 | 19248 | 6015 | 31.3 |
| >340_>22 | 110 | 368 | 30 | 0.78 | 865 | 288 | 93392 | 31137 | 33.3 |
| **Total Heifers** | **3905** | **309.4** | **16.3** | **0.30** | **875** | **98** | **3315367** | **246331** | **7.4** |
| | | | | | | | | | |
| **Steers** | **n** | **HCWT_avg (kg)** | **P8_avg (mm)** | **Discount_avg ($)** | **EstValue_avg ($)** | **EstLoss_avg ($)** | **EstValue_total ($)** | **EstLoss_total ($)** | **Loss/Value (%)** |
| <280 | 842 | 262.8 | 16.4 | 0.19 | 818 | 49 | 688864 | 41389 | 6.0 |
| <280_<5 | 23 | 264.4 | 3 | 0.55 | 727 | 145 | 17453 | 3491 | 20.0 |
| <280_>22 | 161 | 262 | 28.3 | 0.37 | 767 | 98 | 123485 | 15726 | 12.7 |
| 280-340 | 5117 | 314.4 | 15.9 | 0.05 | 1021 | 17 | 5172789 | 85474 | 1.7 |
| 280-340/5-22 | 3768 | 314.3 | 14 | 0 | 1037 | 0 | 3910768 | 0 | 0.0 |
| >340 | 3963 | 369 | 15.9 | 0.23 | 1129 | 87 | 4451187 | 343617 | 7.7 |
| >340_<5 | 230 | 374.3 | 2.8 | 0.55 | 1017 | 204 | 218768 | 43754 | 20.0 |
| >340_>22 | 728 | 368.8 | 28.6 | 0.37 | 1077 | 139 | 778768 | 100289 | 12.9 |
| **Total Steers** | **9922** | **315.4** | **16.1** | **0.16** | **989** | **51** | **10312840** | **470480** | **4.6** |
| | | | | | | | | | |
| **Total All** | **13827** | **312.4** | **16.2** | **0.23** | **932** | **75** | **13628207** | **716811** | **5.3** |

**Table 3. 2013 estimated non-compliance costs**

| Heifers | n | HCWT_avg (kg) | P8_avg (mm) | Discount_avg ($) | EstValue_avg ($) | EstLoss_avg ($) | EstValue_total ($) | EstLoss_total ($) | Loss/Value (%) |
|---|---|---|---|---|---|---|---|---|---|
| <280 | 9650 | 245.7 | 12.6 | 0.45 | 770 | 102 | 7427640 | 988501 | 13.3 |
| <280_<5 | 1570 | 229.8 | 2.1 | 0.94 | 609 | 209 | 952512 | 328402 | 34.5 |
| <280_>22 | 1024 | 261.1 | 28 | 0.39 | 826 | 101 | 845520 | 103689 | 12.3 |
| 280-340 | 7435 | 305.3 | 20.9 | 0.17 | 1031 | 53 | 7637994 | 390031 | 0.5 |
| 280-340/5-22 | 4135 | 302.4 | 15.7 | 0 | 1013 | 0 | 4438519 | 0 | 0.0 |
| >340 | 2014 | 367.4 | 29.1 | 0.77 | 1013 | 290 | 2072404 | 593187 | 28.6 |
| >340_<5 | 9 | 353.8 | 2.8 | 0.17 | 1194 | 62 | 10746 | 559 | 5.2 |
| >340_>22 | 1513 | 369.8 | 33.5 | 0.91 | 969 | 344 | 1466247 | 519814 | 35.5 |
| **Total Heifers** | **19099** | **306.1** | **20.9** | **0.46** | **938** | **148** | **17138038** | **1971998** | **11.5** |
| | | | | | | | | | |
| **Steers** | **n** | **HCWT_avg (kg)** | **P8_avg (mm)** | **Discount_avg ($)** | **EstValue_avg ($)** | **EstLoss_avg ($)** | **EstValue_total ($)** | **EstLoss_total ($)** | **Loss/Value (%)** |
| <280 | 3947 | 261.3 | 8.9 | 0.35 | 866 | 89 | 3403216 | 352472 | 10.4 |
| <280_<5 | 623 | 253.9 | 2.9 | 0.78 | 729 | 198 | 453854 | 123392 | 27.2 |
| <280_>22 | 23 | 269.7 | 24.1 | 0.16 | 942 | 42 | 21673 | 968 | 4.5 |
| 280-340 | 14509 | 311.1 | 12.4 | 0.11 | 1102 | 33.3 | 15986081 | 482675 | 3.0 |
| 280-340/5-22 | 12061 | 311.1 | 12.9 | 0 | 1136 | 0 | 13698131 | 0 | 0.0 |
| >340 | 11558 | 375.1 | 16.4 | 0.39 | 1215 | 154 | 14041392 | 1781362 | 12.7 |
| >340_<5 | 495 | 384.1 | 2.8 | 0.85 | 1076 | 327 | 532399 | 161621 | 30.4 |
| >340_>22 | 2218 | 388.6 | 27.4 | 0.49 | 1221 | 198 | 2708071 | 438127 | 16.2 |
| **Total Steers** | **30014** | **315.8** | **12.6** | **0.28** | **1061** | **92** | **33430689** | **2616509** | **7.8** |
| | | | | | | | | | |
| **Total All** | **49113** | **311.0** | **16.7** | **0.37** | **999** | **120** | **50568727** | **4488507** | **9.1** |

**Processor views on compliance**

Interviews were held with representatives of both the livestock supply and beef marketing divisions of the company. The discussions revealed that the grid prices offered to producers for any two-week period were based on the following criteria:

(a) The overall level of beef prices in the market. The processor has a range of market outlets for the beef they supply, both domestically and in export markets. Some of these markets are based on relatively long-term contracts, others on medium- and short-term contracts, and some are opportunistic depending on circumstances at a particular time. The returns from these spot market sales can be quite variable. The grid prices offered do not reflect this short term variability, so the relationship between grid prices and prices in the spot markets is not close over a short time frame. However, the company expects that over a longer time frame the grid prices would generally reflect movements in the beef market.

(b) The premiums that consumers are willing to pay for quality. Prices for MSA-graded carcasses are higher than for non-graded carcasses. For example, in the 2012 grid shown in the appendix, the processor offered $3.15/kg for a heifer carcass of 300-320kg, 5-22mm fat, 0-2 teeth and conformation A-C that graded MSA. For the same carcass that did not grade MSA, the price offered was $3.00/kg. This premium reflects the premiums available in the market for retail cuts from MSA graded carcasses (Griffith and Thompson, 2012).

(c) The combination of carcass characteristics that lead to higher retail beef yield. The processor indicated that from experience and from the available research they offered higher prices for some types of carcasses (undefined, but presumably breed based) because they had an expectation that these carcasses would provide a higher saleable beef yield.

(d) Processing cost. Lightweight carcasses cost the same to process as heavier carcasses, so the cost/kg of lightweight carcasses coming off the chain was considerably higher and this cost could not be recouped in the market. A lower price had to be offered on the grid. Heavy carcasses, on the other hand, slowed down the chain and as well there were serious OH&S issues with slaughtering and processing staff. The processor indicated that they had done a lot of study of plant efficiency as it related to carcass size.

(e) Portion size. This was a major parameter. The processor indicated that the domestic food service sector had very precise requirements for the high value cuts. If the portion size was too large, they would not be bought for domestic use and would have to be discarded into trimmings and mince or sold onto export markets that like larger portion sizes. Discounts also had to be offered for large rumps.

## Cost of Non-Compliance Discussion

In these pasture-fed cattle data sets, the proportion of carcasses that are non-compliant with the processor specifications, and the cost of this non-compliance in terms of forgone revenue, is substantial and much higher than that found for grain-fed carcasses. For example, Slack-Smith et al. (2009) estimated that out-of-specification costs for weight and P8 fat in the short-fed market averaged $5.50 and $17.50/carcass respectively, but could be as high as $60 and $80/carcass, respectively. Here, in the pasture-fed market, average out-of-specification costs for weight and P8 fat ranged between $47 and $148/carcass across all carcasses, but could be as high as $344/carcass.

There are a couple of possible reasons for this disparity. First, it could be assumed that feedlotters have much better information on weights of their cattle and on prediction of appropriate turn-off times compared to grass-fed producers. Some grass-fed producers may not even have scales. Second, the types of operations are different. Many small scale grass-fed producers would see transport costs as being a large factor; hence, they send all cattle at once and absorb the weight/fat penalties as that is cheaper than paying multiple sets of transport costs.

The values calculated for average discount and average loss per carcass indicate the potential benefits from improved compliance, and the amount of money that could be invested rationally to improve compliance. For example, using the 2013 data set, more than half of the heifers offered to the processor were too light. This resulted in an average penalty of some $0.45/kg or about $100 per carcass. The producer could spend up to $0.45/kg, or up to $100 per head, on changing on-farm practices to ensure these heifers made the minimum weight threshhold. Such changes could include investing in new pasture varieties, purchasing supplementary feed, using different genetic material that had higher EBVs for growth, or applying decision support tools such as *BeefSpecs* that provide a better prediction of the outcomes from current practices.

Conversely, in the same data set, almost 40% of the steers were too heavy. This resulted in an average penalty of $0.39/kg or more than $150 per carcass. Using the same argument as for the heifers, the producer could spend up to this amount to ensure these steers did not exceed 340kg. However, closer examination of Table 2 shows that these average heavier (fat compliant) animals are worth some $113 above the average weight compliant (fat compliant) animals. Many producers would argue that having more weight on their animals makes them more money than meeting the specifications exactly. However, the data provided here proves otherwise: the discount for being too heavy well outweighs the value of the extra kilos. Knowing weights is important.

Further, just growing heavier steers is not a costless exercise. Larger, heavier animals require more feed. This suggests that a formal analysis of the benefits to producers from attempting to reduce the costs of non-compliance must be done in the context of the whole farm system, where the producer is bound by the constraint of total feed supply and has to make trade-offs between stocking rate and growth rate. That is the type of analysis reported in Graham et al. (2009) and related papers, where the software package *Beef-N-Omics* was used to match feed demand and feed supply in a Victorian pasture-fed production system. Carcass weight and faster growth were the main determinants of profitability in that analysis.

**An Improved Compliance Scenario**

One way to improve compliance is to use the *BeefSpecs* decision support tool to better estimate final weight and fat measures given starting weight and estimated growth rates. McKiernan (2011) undertook a number of simulation experiments with the package and concluded that it was not unreasonable to expect a 50% decline in non-compliance rates from using the tool once the producer was experienced in defining the input data. In the *Exit Report* for the Beef CRC, Griffith and Burrow (2015) estimated savings in the cost of non-compliance from using *BeefSpecs* as a net $10/head for pasture-fed cattle (based on the short-fed grain fed results of Slack-Smith et al. (2009) and assuming they might be similar for pasture-fed), and $35/head for feedlot cattle (based on McKiernan, 2011). However, given the non-compliance costs estimated above, between $47 and $148/carcass across all carcasses, a $10/head saving for pasture-fed cattle would seem to be a significant under-estimate.

In the following scenario, it was assumed that the producers supplying this processor during 2013 had access to, and were trained in the use of, the *BeefSpecs* decision support tool. Rather than assume a specific saving per carcass, it was assumed, following McKiernan (2011), that the proportions of carcasses assessed as HSCW non-compliant were reduced by half. That is, half of the heifers and steers that were too light moved up into the acceptable weight range, and half of the heifers and steers that were too heavy moved down into the acceptable weight range. Thus, in terms of the distributions of weight (illustrated above in Figure 3), the assumed distribution becomes more concentrated around the mean, with smaller tails on both sides. Almost 6,800 carcasses move from under-weight to acceptable weight, and about the same number move from over-weight to acceptable weight.

The proportions falling outside the acceptable fat range were kept the same as in the actual 2013 data. The same average discounts per kg and per carcass were also retained.

The results of this exercise are shown in Table 4. Losses from being under- or over-weight are essentially halved, but losses from being in the acceptable weight range are increased because there are almost 13,700 extra carcasses in this group and over 16% of them are discounted because they are out of specification for fat depth. However, the net result is a substantial reduction in the aggregate losses due to being out of specification. Comparing the data in Table 4 with that in Table 3, there is an estimated saving of almost $485,000 for the heifers and a saving of almost $810,000 for the steers, summing to $1.3 million. That is, a saving of 28% of the actual 2013 loss of $4.6 million calculated in Table 3, or on a per carcass basis, a reduction in losses from $93/head to $67/head, or by $26/head.

**Table 4. Improved Compliance Scenario, 2013 data**

| **Heifers** | **n** | **Average Discount ($/kg)** | **Average Estimated Loss ($/head)** | **Average Estimated Loss ($)** |
|---|---|---|---|---|
| <280 | 4825 | 0.45 | 102 | 492150 |
| <280_<5 | 785 | 0.94 | 209 | 164065 |
| <280_>22 | 512 | 0.39 | 101 | 51712 |
| 280-340 | 13267 | 0.17 | 53 | 703151 |
| 280-340/5-22 | 9967 | 0 | 0 | 0 |
| >340 | 1007 | 0.77 | 290 | 292030 |
| >340_<5 | 5 | 0.17 | 62 | 279 |
| >340_>22 | 757 | 0.91 | 344 | 260236 |
| **Total Heifers** | **19099** | | | **1487331** |
| | | | | |
| **Steers** | **n** | **Average Discount ($/kg)** | **Average Estimated Loss ($/head)** | **Average Estimated Loss ($)** |
| <280 | 1974 | 0.35 | 89 | 175642 |
| <280_<5 | 312 | 0.78 | 198 | 61677 |
| <280_>22 | 12 | 0.16 | 42 | 483 |
| 280-340 | 22262 | 0.11 | 33 | 741325 |
| 280-340/5-22 | 19814 | 0 | 0 | 0 |
| >340 | 5779 | 0.39 | 154 | 889966 |
| >340_<5 | 248 | 0.85 | 327 | 80933 |
| >340_>22 | 1109 | 0.49 | 198 | 219582 |
| **Total Steers** | **30015** | | | **1806932** |
| **Total All** | **49114** | | | **3294263** |

## Summary and Discussion

The analysis of carcass data from 19 months of supply to this case study pasture-fed value chain has shown substantial foregone value through carcasses not meeting processor weight and fat specifications. Across this whole dataset, between 51-61% of heifers and around 48% of steers were outside the preferred weight specification, while between 25-39% of heifers and between 19-25% of steers were outside the preferred fat specification. For heifers the cost of non-compliance was estimated to be between $63-$84 per carcass, and for steers it was between $47-$87 per carcass, with the weighted average being $78 per carcass. Across all of the animals in this data set, the cost of non-compliance summed to over $5.2 million.

Improved financial benefits could be gained by beef producers being better able to hit the highest value area on the processor grid. The use of the *BeefSpecs* decision support tool to simulate reduced losses across the 2013 data set demonstrated that more accurate attention to weight specification alone can improve carcass value and reduce foregone value. The estimated total saving from applying *BeefSpecs* to the 2013 data set was almost $1.3 million. This amount of money (approximately $26/head) could be profitably invested in making *BeefSpecs* more widely available to pasture-fed producers and in training them in its use.

Across both years heifer carcasses that did not meet minimum weight specifications made up the majority of the non-compliance. This could be attributed to a number of factors such as poor seasonal conditions resulting in producers turning off stock early. In contrast, non-compliant steer carcasses were heavier than the 340kg HSCW specification.

Further investigation is required to understand why carcasses do not meet specification. A number of reasons could be possible. Issues such as variation in seasonal conditions over the data collection period, livestock systems, producer attitude to meeting the sweet spot on the grid or price incentive and live cattle assessment skills all present potential reasons. Producers need to scrutinise their whole farm system including livestock genetics, pastures, calving time and markets so they can maximise their ability to meet target market specifications and reduce their level of non-compliance to ensure their losses are minimised.

For the processor, the benefits of higher compliance levels would potentially lie in higher efficiency of throughput at plant level, easier marketing of a known quantity of beef product that meets buyers' needs, and a lower opportunity cost of selling non-compliant product. The company grids used at the time of this project, however, did not reflect a significant premium for hitting the highest paying point in the grid. This may reflect the ability of the processor to access a number of different wholesale markets with different requirements cost effectively; or it could point to the imperative of filling the plant confirming that supply is all important. As a result, the company procurement model may reflect these issues in its buying behaviour. Over the course of the project the company has continued to modify the MSA grid to reflect southern Australian beef supply and market demand.

Another component in the value chain is that of the buyer for the processor and the demand made on him/her in meeting supply requests. There may be a 'bullwhip effect' where unforeseen spikes in demand or overestimations of demand result in the buyers having to fill orders in a relatively short time frame and this increasing the likelihood of buying non-complying livestock, and/or of increasing purchases from small scale producers who may not properly understand the need for uniform animals. The consequences of this exacerbate difficulties in the producer receiving clear market signals.

There are a number of possible avenues for follow-up research. First, profitable pasture-fed production systems require well attuned management in matching feed supply with demand and cattle production with the target market. There is significant further work to be completed right through the supply chain, from whole farm systems and livestock purchase through to the processor and marketing product and delivering clear market signals, in making improvements to compliance rates in pasture-fed systems. It is anticipated that an analysis of the type reported by Graham et al. (2009) could be undertaken as the options for on-farm changes in production and management practices become better defined. This would be especially relevant for examining in greater detail the on-farm implications of the simple *BeefSpecs* scenario reported above.

Second, it is apparent from the fat depth results reported here that some P8 graders count mainly in multiples of 5mm. There is a strong argument for more education and quality control in this aspect of carcass assessment.

Third, in this paper the authors did not report any analysis of individual producer data, but a comparison of compliance rates by producer location may point to potential problems in particular biophysical features, and an analysis of compliance rate by numbers sold may point to the impact of types of business models. For example, if farm size does moderate compliance, this may help processors learn that backgrounding/fattening facilities which aggregate many small scale lots are important.

Finally, the results have pointed to the critical importance of good estimates of carcass weight. Using some savings to buy cattle scales and reduce non-compliance is another good scenario worth investigating.

## References

BeefSpecs Decision Support Tool. Available at: http://beefspecs.agriculture.nsw.gov.au/

Crawford, M., Ferrier, G. and Griffith, G. (2014), *Benefit cost analysis of non-compliance within a Victorian pasture-fed beef supply chain*, Final Report to Meat and Livestock Australia on Project B.COM.0352, Victorian Department of Environment and Primary Industries, Hamilton, September.

Graham, J.G., Quinn, H., Davies, L. and Griffith, G. (2009), "Economic effects of alternate growth path, time of calving and breed type combinations across southern Australian beef cattle environments: grass finishing at the Victorian experimental site", *Australian Farm and Business Management Journal* 6(1), 17-26. Available at: http://www.csu.edu.au/faculty/science/saws/afbmnetwork/afbmjournal/volume6

Griffith, G.R. and Burrow, H.M. (2015), "The Cooperative Research Centre for Beef Genetic Technologies: using the Impact Tool to evaluate realized and anticipated benefits, 2005/06-2020/21", *Animal Production Science* 55, 133-144.

Griffith, G.R. and Thompson, J.M. (2012), "The aggregate economic benefits to the Australian beef industry from the adoption of Meat Standards Australia: updated to 2010/11", *Australasian Agribusiness Review* Volume 20, Paper 2, pp. 11-38. Available at: http://www.agrifood.info/review/2012/Griffith_Thompson.html

Knee, B.W., Cummins, L.J., Walker, P.J. and Warner, R. (2004), "Seasonal variation in muscle glycogen in beef steers", *Australian Journal of Experimental Agriculture* 44, 729–734. doi:10.1071/EA03044

McGilchrist, P. et al. (2014), "The incidence of dark cutting in southern Australian beef production systems fluctuates between months", *Animal Production Science* 54 (10), 1765-1769.

McKiernan, B. (2011), *Solutions to Feedback: Livestock Data Link*. Final Report to Meat and Livestock Australia, Project V.LDL.1004, NSW Department of Primary Industry, Armidale.

McPhee, M. and Walmsley B. (2014), *Assessment of compliance in grass-fed cattle and evaluation of increasing accuracy of BeefSpecs inputs,* Final Report to Meat and Livestock Australia, Project B.SBP.0108, NSW Department of Primary Industries – Agriculture NSW, Armidale.

Morales, L. E., Griffith, G., Wright, V., Fleming, E., Umberger, W. and Hoang, N. (2013), "Variables affecting the propensity to buy branded beef among groups of Australian beef buyers", *Meat Science* 94 (2), pp. 239-246. DOI information: 10.1016/j.meatsci.2013.02.005

Morales, L. E., Griffith, G., Fleming, E. and Mounter, S. (2017), "The role of animal welfare preferences in beef cuts differentiation in Australia", *Animal Production Science* (accepted).

Polkinghorne, R., Thompson, J.M., Watson, R., Gee, A. and Porter, M. (2008), "Evolution of the Meat Standards Australia (MSA) beef grading system", *Animal Production Science* 48 (11), 1351-135.

Slack-Smith, A., Griffith, G. and Thompson, J. (2009), "The cost of non-compliance to beef market specifications", *Australasian Agribusiness Review* 17(9): 178-190. Available at:
http://www.agrifood.info/review/2009/Slack-Smith_Griffith_Thompson.pdf

# Appendix

## Appendix 1: 2012 grass-fed grid for a particular fortnight

| Grade[5] | Fat | Teeth | Shape | Price | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MSA Grass Trade Yearling Steer** | | | | **440+** | **420+** | **360+** | **340+** | **320+** | **300+** | **280+** | **260+** | **240+** | **220+** | **200+** | **180+** | **160+** | **140+** | **120+** | **-120** |
| | 5-22 | 0-2 | A-C | | | | 3.20 | 3.30 | 3.30 | 3.30 | 3.20 | 3.15 | | | | | | | |
| | 23-32 | 0-2 | A-C | | | | 3.10 | 3.20 | 3.20 | 3.20 | 3.10 | 3.05 | | | | | | | |
| | 5-22 | 0-2 | A-D | | | | 3.05 | 3.15 | 3.15 | 3.15 | 3.05 | 3.00 | | | | | | | |
| | 23-32 | 0-2 | A-D | | | | 2.95 | 3.05 | 3.05 | 3.05 | 2.95 | 2.90 | | | | | | | |
| **MSA Grass Trade Yearling Heifer** | | | | **440+** | **420+** | **360+** | **340+** | **320+** | **300+** | **280+** | **260+** | **240+** | **220+** | **200+** | **180+** | **160+** | **140+** | **120+** | **-120** |
| | 5-22 | 0-2 | A-C | | | | 3.05 | 3.15 | 3.15 | 3.15 | 3.05 | 3.00 | | | | | | | |
| | 23-32 | 0-2 | A-C | | | | 2.95 | 3.05 | 3.05 | 3.05 | 2.95 | 2.90 | | | | | | | |
| | 5-22 | 0-2 | A-D | | | | 2.90 | 3.00 | 3.00 | 3.00 | 2.90 | 2.85 | | | | | | | |
| | 23-32 | 0-2 | A-D | | | | 2.85 | 2.95 | 2.95 | 2.95 | 2.85 | 2.80 | | | | | | | |
| **MSA Grass Ox** | | | | **440+** | **420+** | **360+** | **340+** | **320+** | **300+** | **280+** | **260+** | **240+** | **220+** | **200+** | **180+** | **160+** | **140+** | **120+** | **-120** |
| | 7-22 | 0-4 | A-C | | | | 3.10 | 3.15 | 3.15 | 3.15 | 3.10 | 3.05 | | | | | | | |
| | 23-32 | 0-4 | A-C | | | | 3.05 | 3.10 | 3.10 | 3.10 | 3.05 | 3.00 | | | | | | | |
| **MSA Grass-fed Jap Heifer** | | | | **440+** | **420+** | **360+** | **340+** | **320+** | **300+** | **280+** | **260+** | **240+** | **220+** | **200+** | **180+** | **160+** | **140+** | **120+** | **-120** |
| | 7-22 | 0-4 | A-C | | | | 2.90 | 2.95 | 2.95 | 2.95 | 2.90 | 2.85 | | | | | | | |
| | 23-32 | 0-4 | A-C | | | | 2.85 | 2.90 | 2.90 | 2.90 | 2.85 | 2.80 | | | | | | | |

[5] Specific grade codes have been removed to protect the anonymity of the case study processor.

| Grade | Fat | Teeth | Shape | Price | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Grass Trade Yearling Steer** | | | | **440+** | **420+** | **360+** | **340+** | **320+** | **300+** | **280+** | **260+** | **240+** | **220+** | **200+** | **180+** | **160+** | **140+** | **120+** | **-120** |
| | 5-22 | 0-2 | A-C | | | | 3.15 | 3.15 | 3.15 | 3.10 | 3.05 | 3.00 | 2.95 | 2.85 | 2.70 | | | | |
| | 23-32 | 0-2 | A-C | | | | 3.10 | 3.10 | 3.10 | 3.05 | 3.00 | 2.95 | 2.90 | 2.80 | 2.65 | | | | |
| | 5-22 | 0-2 | A-D | | | | 3.05 | 3.05 | 3.05 | 3.00 | 2.95 | 2.90 | 2.85 | 2.75 | 2.60 | | | | |
| | 23-32 | 0-2 | A-D | | | | 3.00 | 3.00 | 3.00 | 2.95 | 2.90 | 2.85 | 2.80 | 2.70 | 2.55 | | | | |
| **Ox** | | | | **440+** | **420+** | **360+** | **340+** | **320+** | **300+** | **280+** | **260+** | **240+** | **220+** | **200+** | **180+** | **160+** | **140+** | **120+** | **-120** |
| | 7-22 | 0-4 | A-C | 2.40 | 2.65 | 3.10 | 3.10 | 3.10 | 3.10 | 3.05 | 3.00 | 2.95 | 2.85 | 2.75 | 2.65 | | | | |
| | 23-32 | 0-4 | A-C | 2.30 | 2.65 | 3.10 | 3.10 | 3.10 | 3.10 | 3.05 | 3.00 | 2.95 | 2.85 | 2.75 | 2.65 | | | | |
| | 7-22 | 0-6 | A-C | 2.30 | 2.65 | 3.10 | 3.10 | 3.10 | 3.10 | 3.05 | 3.00 | 2.95 | | | | | | | |
| | 23-32 | 0-6 | A-C | 2.30 | 2.65 | 3.10 | 3.10 | 3.10 | 3.10 | 3.05 | 3.00 | 2.95 | | | | | | | |
| | 7-22 | 7-8 | A-C | 2.15 | 2.45 | 2.90 | 2.90 | 2.90 | 2.90 | | | | | | | | | | |
| | 23-32 | 7-8 | A-C | 2.15 | 2.40 | 2.85 | 2.85 | 2.85 | 2.85 | | | | | | | | | | |
| | 3-22 | 0-7 | A-D | 2.05 | 2.35 | 2.80 | 2.80 | 2.80 | 2.80 | 2.75 | 2.70 | 2.65 | 2.60 | 2.50 | 2.45 | 1.60 | 0.40 | 0.30 | 0.20 |
| | 23-32 | 0-7 | A-D | 2.05 | 2.30 | 2.75 | 2.75 | 2.75 | 2.75 | 2.70 | 2.65 | 2.60 | 2.55 | 2.45 | 2.40 | 1.55 | 0.40 | 0.30 | 0.20 |
| | 3-22 | 8 | A-D | 1.90 | 2.20 | 2.65 | 2.65 | 2.65 | 2.65 | 2.60 | 2.55 | 2.45 | 2.40 | 2.35 | 2.25 | 1.45 | 0.30 | 0.20 | 0.10 |
| | 23-32 | 8 | A-D | 1.85 | 2.15 | 2.60 | 2.60 | 2.60 | 2.60 | 2.55 | 2.50 | 2.40 | 2.35 | 2.30 | 2.20 | 1.40 | 0.30 | 0.20 | 0.10 |
| | 0-32 | 0-8 | A-E | 1.75 | 2.05 | 2.50 | 2.50 | 2.50 | 2.50 | 2.45 | 2.40 | 2.30 | 2.25 | 2.10 | 2.00 | 1.25 | 0.30 | 0.20 | 0.10 |
| | 33-42 | 0-8 | A-E | 1.60 | 1.90 | 2.35 | 2.35 | 2.35 | 2.35 | 2.30 | 2.25 | 2.15 | 2.10 | 2.00 | 1.90 | 1.10 | 0.30 | 0.20 | 0.10 |
| | 43+ | 0-8 | A-E | 1.45 | 1.75 | 2.20 | 2.20 | 2.20 | 2.20 | 2.15 | 2.10 | 2.00 | 1.95 | 1.80 | 1.70 | 0.90 | 0.30 | 0.20 | 0.10 |
| **Bull** | | | | **700+** | **650+** | **600+** | **500+** | **440+** | **340+** | **320+** | **300+** | **280+** | **260+** | **240+** | **220+** | **200+** | **180+** | **160+** | **-160** |
| | 0-32 | 0-8 | A-D | 1.25 | 1.85 | 2.05 | 2.20 | 2.50 | 2.50 | 2.50 | 2.40 | 2.35 | 2.30 | 2.25 | 2.05 | 1.95 | 1.80 | 1.50 | 0.35 |
| | 0-32 | 0-8 | A-E | 1.15 | 1.75 | 1.95 | 2.10 | 2.40 | 2.40 | 2.40 | 2.30 | 2.25 | 2.20 | 2.15 | 1.95 | 1.85 | 1.70 | 1.40 | 0.25 |

**Appendix 2: Distributions of fat depth estimates**

**Figure A1. P8 fat depth and number of heifer carcasses, 2012**

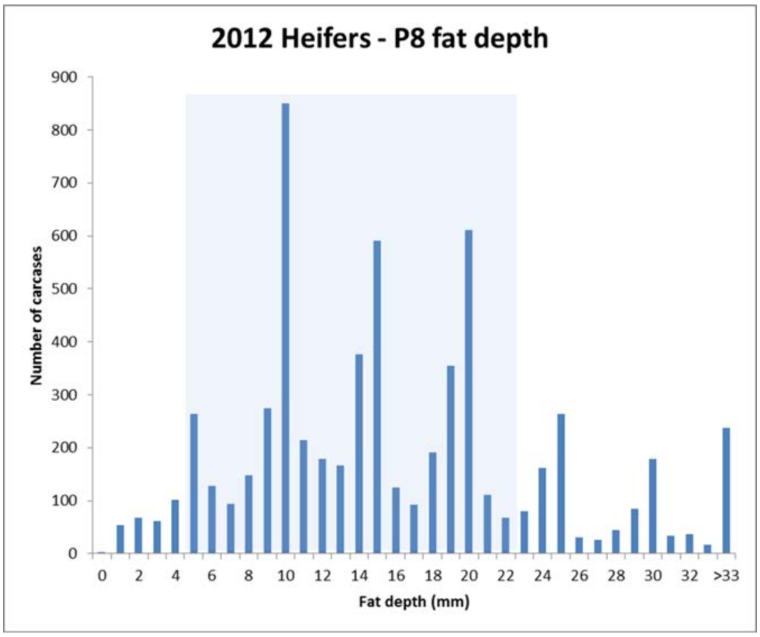



**Figure A2. P8 fat depth and number of steer carcasses, 2013**

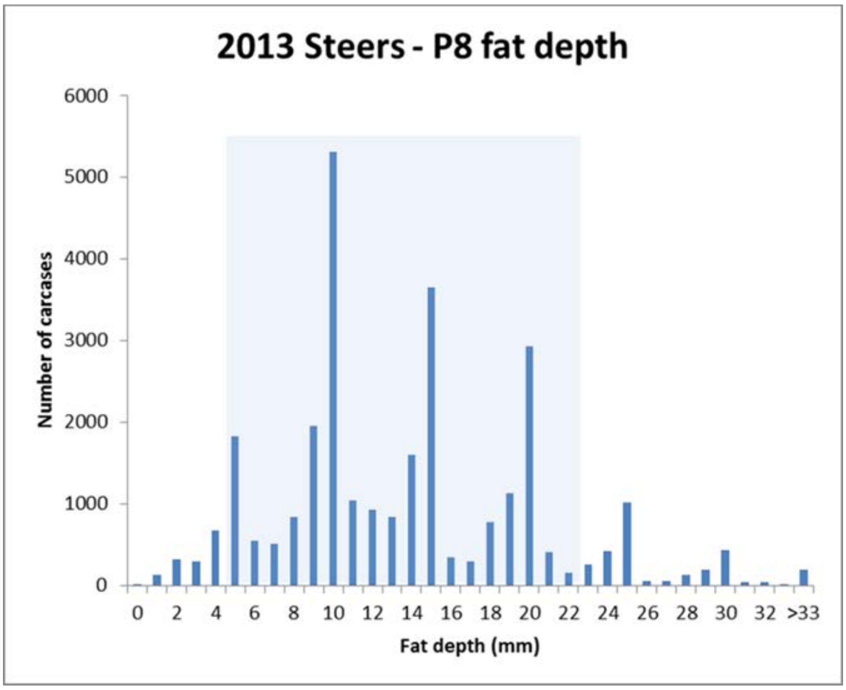


**Figure A3. P8 fat depth and number of heifer carcasses, 2013**