Venison Bruising Report:

Preliminary Investigation

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May 2018

Confidential Report for DEEResearch Limited

CLIENT REPORT FBP 78503

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Executive Summary

Deep-muscle bruising occurs in the back leg cuts of venison carcasses and results in product downgrades and significant losses over time. The bruising cannot be seen until the leg is fabricated into cuts, and the root cause(s) of bruising are presently unknown. Establishing and minimising the incidence of bruising is important potentially for improving animal welfare (if the bruising is occurring ante-mortem), for minimising yield losses due to trimming of bruised product and to minimise customer complaints due to cut deformation, or the failure to remove bruised product prior to packing.

In conjunction with Venison Packers Feilding (VPF), a protocol was developed to characterise the incidence of bruising and identify patterns of incidence. Between 15 November 2017 and 17 March 2018 a total of 395 bruised meat samples were saved along with carcass ID tags by VPF staff. AgResearch recorded the weight and ultimate pH of each sample. A total of 154 kg of bruised venison was saved, the weight of bruised meat per carcass where bruising was recorded varied from 20 g to 2.3 kg, with an average of 0.39 kg.

The results show that the ultimate pH of bruised leg meat is highly variable and covers the range of expected ultimate pH values for venison loin. 75/395 (19%) of the bruised samples had an ultimate pH of ≥5.80.There was no apparent correlation between the weight of bruised sample and the ultimate pH.

The sampling methodology was limited by the availability of VPF staff to routinely save bruised samples. The implications are that the incidence of bruising by supplier/slaughter day/mob observed in this sample set may be an artefact of the sampling occurrence rather than an accurate representation of the bruising present in carcasses from various suppliers/slaughter days/mobs. This also means that the true impact of bruising is likely to be greater than what was observed in the scope of this investigation.

Whilst providing an insight into bruising and the development of data collection protocols to characterise it, this study did not identify any causes of deep muscle bruising.

The following recommendations are made:

1. Compare current results against sex, carcass weight, fatness (or dressing weight), transportation and lairage conditions (additional data requires extraction from VPF databases).
2. Rates of bruising incidence should be determined systematically over time and reported against full plant statistics, including the total number of animals arriving from each supplier, number of animals in each mob and time of slaughter.
3. Further investigation of future carcasses from suppliers with higher incidences of bruising observed in this study may be worthwhile – Commission a monitoring programme to monitor bruising by supplier.
4. Rates of bruising incidence should be considered alongside the proportion of high pH animals for any given line/supplier.

Background

This particular form of bruising presents in the rear leg cuts, it results in product downgrades and significant losses over time. An example of deep muscle bruising is presented in Figure 1, further examples are provided in Appendix 5 (pages 25 and 26). The causative factors of deep-muscle bruising in venison are not well understood, but bruising in venison, like beef and lamb, is typically associated with handling, transportation, lairage and stunning prior to slaughter. Anecdotally, venison processors believe the cause to be prior to arrival at the processing plant, but exactly where or what may be leading to the bruising is presently unknown.

This preliminary investigation was commissioned by DEEResearch to identify common elements of carcasses presenting with bruising (see below).

Figure 1: A rear leg from a deer carcass opened up to reveal deep muscle bruising (red arrow) the femur can be seen in the top right of the image.

DEEResearch sub-project DMB 5.1: Incidences and causes of deep-muscle bruising in deer carcasses

Objectives: Identify sources of and potential solutions to unexplained haemorrhaging observed in venison leg cuts, by investigating the role of the deer production, transport and processing systems.

Milestone 13.1: Feedback from Mountain River and Venison Meat packers on batch provenance for bruising damage

Milestone 13.2: Research plan for investigating Deep Muscle Bruising (DMB) in-plant and at source completed

Milestone 13.3: Undertake and report on planned investigation into DMB

Sampling Methodology

In consultation with Simon Wishnowski from Venison Packers Feilding (VPF), an in-processing plant data capture protocol was developed to quantify bruising and to enable trace-back to farm of origin. The protocol can be found in the Appendix section of this report. Briefly, the carcass ID tag was retained with the bruised meat whenever it was found. The carcass tag and the bruised product were vacuum packaged and frozen for subsequent product weight and pH recording (Hanna 99163 pH meter with a FC232D combined pH/temperature probe (Hanna Instruments, Rhode Island, USA) against carcass ID by AgResearch undertaken on 03/04/2018 and 09/04/2018 at VPF. Tissue samples were collected using Allflex tissue sample units (TSU), to punch a small tissue sample for frozen storage. These tissue samples may have DNA extracted at a later date to assess relatedness using the Genomnz SNP platform. The TSU sample barcode was recorded against the carcass sample barcode.

On Day 1 of recording, 20 carcass tags had faded and were unable to be read by the barcode scanner. Thereafter on Day 1, manual recording was undertaken by writing down the last 7 digits of the barcode, but this meant the slaughter day within the month could not be confirmed. This error was avoided on the second sampling day and manual recording took into account the slaughter full date and slaughter sequence. The 20 observations with unconfirmed IDs were excluded from the data analysis.

1. Sample collection

It was envisaged that the collection and saving of samples would be undertaken routinely, however it was not possible for VPF to routinely collect samples every working day due to resource limitations. This sampling limitation means that the data collected may not accurately represent the population of deer processed by VPF. For example, some suppliers may be over- or under-represented, depending on whether they had deer being processed when the resources were available to collect bruised samples and ID tags. Nevertheless, the data collected provides some useful insights into deep-muscle bruising, but most likely underrepresents the magnitude of the bruising problem.

2. Scope of the report

This report considers only carcasses with observed bruising, slaughtered between 15 November 2017 and 14 March 2018. These samples were weighed and pH measured on 03 and 09 April 2018. Data processing has included a basic statistical analysis in an effort to discern the incidence of bruising in relation to the slaughter date, supplier and mob number.

Summary of Results

A summary of the bruised samples collected between 15 November 2017 and 17 March 2018 is presented in Table 1:

Table 1: Summary statistics for bruised venison.

Trait	n	Mean	Std	L. Quartile	U. Quartile	Min	Max
Weight of bruised product (kg)	395	0.39	0.26	0.34	0.53	0.02	2.30
Ultimate pH of bruised product	395	5.72	0.14	5.69	5.77	5.51	6.65

Normal ultimate pH for venison ranges from 5.5 to 5.7, with the occurrence of bruising in the time frame considered appearing with a typical skewed distribution with a mean of pH 5.72 (Figure 2). The results show that the ultimate pH of bruised meat is highly variable and covers the range of expected ultimate pH values for venison loin, but it is important to note that the bruised sample is derived from leg cuts. 75/395 (19%) of the bruised samples had an ultimate pH of ≥5.80.

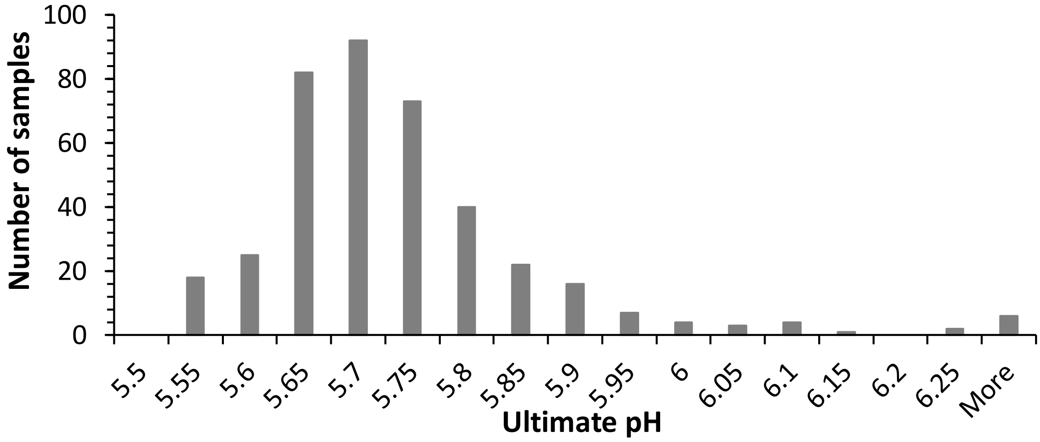

Figure 2: Distribution of ultimate pH of 395 bruised venison samples.

3. Relationship between bruising and pH

When the full dataset is considered, no apparent relationship can be observed between the weight of bruised meat and the ultimate pH of the meat (Figure 3).

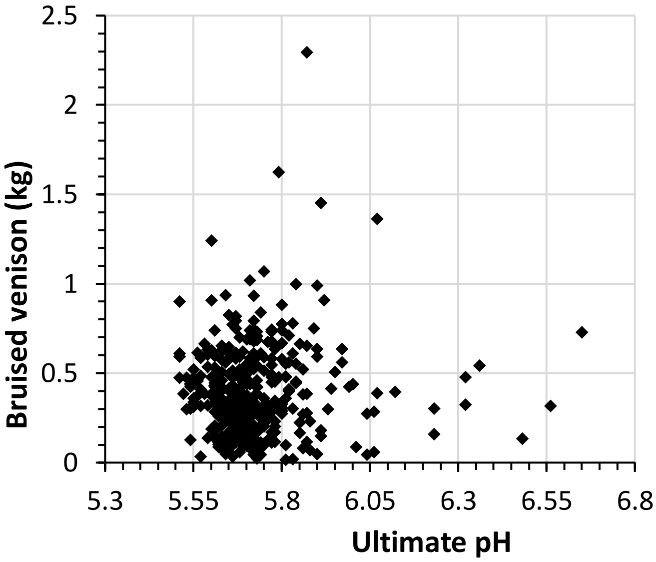

Figure 3: Scatter plot of bruised mass excised and ultimate pH of bruised venison samples.

4. Suppliers - bruising

The range, number and average weight of bruised meat varies by supplier. For suppliers where ≥10 carcasses were recorded the number of carcasses with presenting with bruising is presented in Figure 4. A summary of the mean weight of bruised meat per carcass is provided in Figure 5.

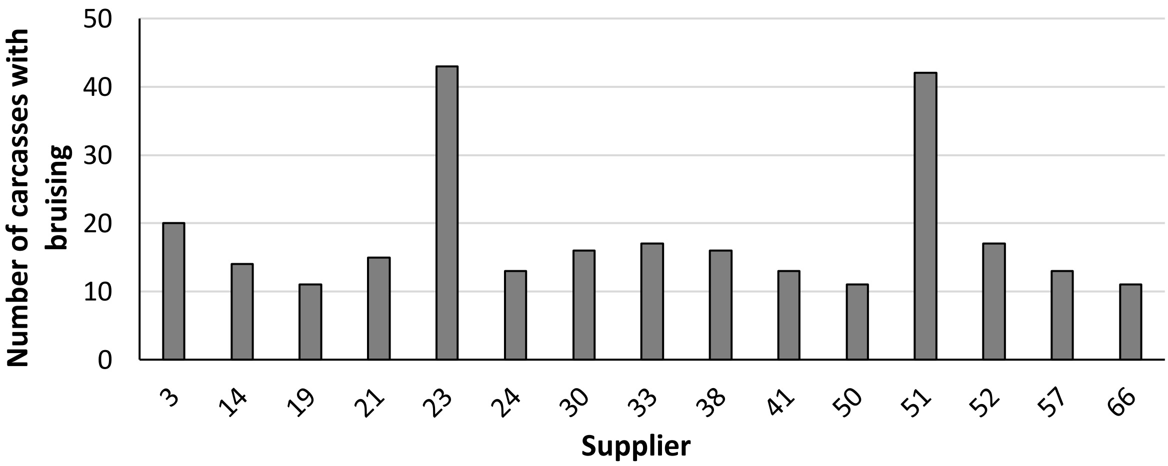

Figure 4: The incidences of bruised venison by supplier where the number of carcasses ≥10.

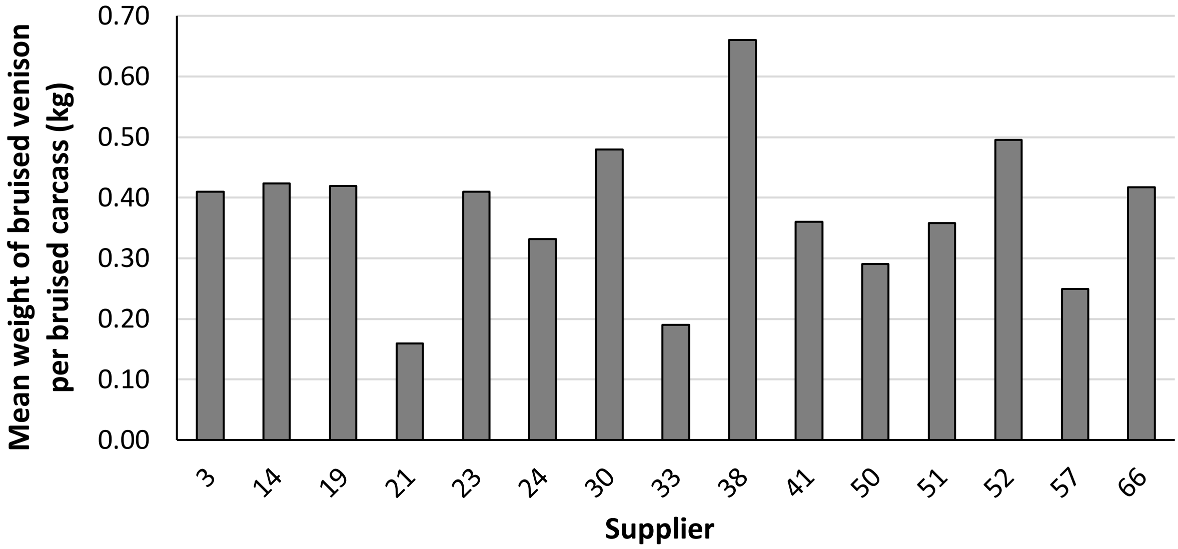

Figure 5: The average weight of bruised venison by supplier where the number of carcasses ≥10.

Figures 6 and 7 show the same information for the whole dataset. The frequency of bruising is highest for suppliers "*23*" and "*51*" (Figure 5). However, these suppliers may be over-represented in the data due to their providing a greater proportion of the total kills in the time frame considered, rather than due to specific animal characteristics or handling associated with the transportation of animals from these farms.

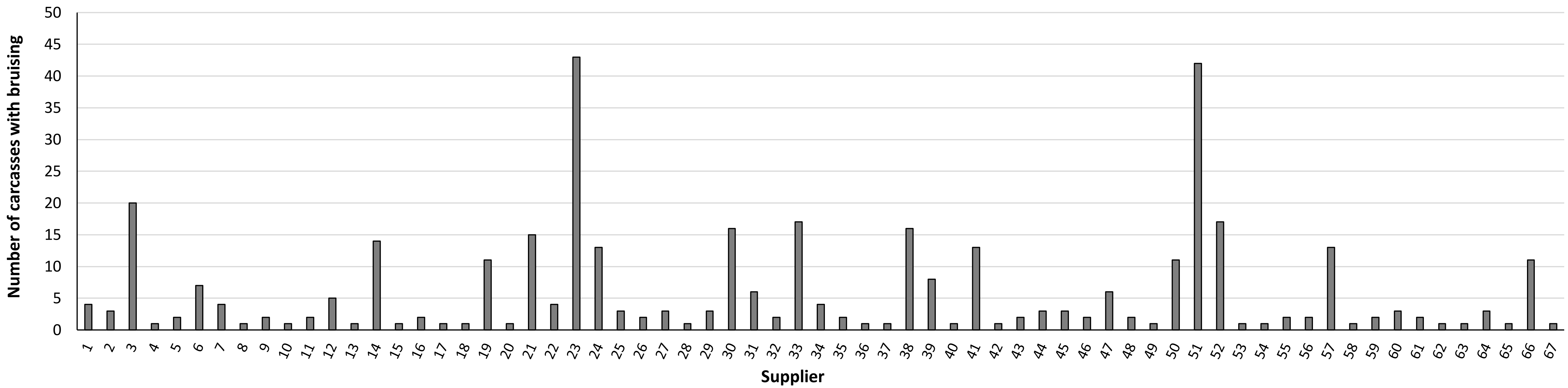

Figure 6: The incidence of bruising by supplier.

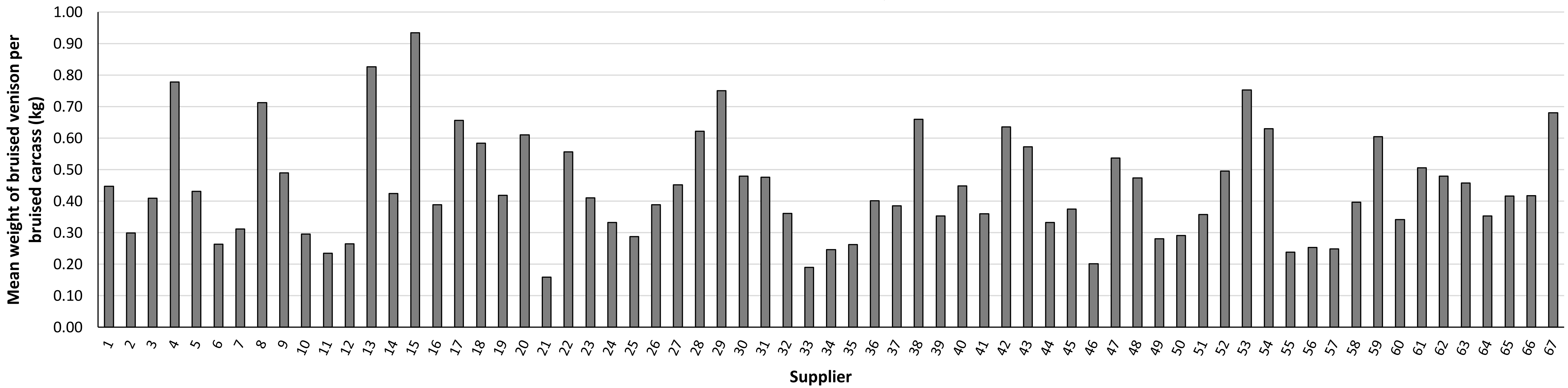

Figure 7: The average weight of bruised venison for all suppliers.

5. Suppliers – Ultimate pH of bruised venison

For suppliers who had greater than 10 animals sampled, the mean pH tends to be ~5.70 with some showing maximum pH values which would be considered outliers (Figure 8). The pH distributions for all suppliers are shown in Figure 9, the numbers of samples vary considerably and are shown in Figure 6 (above).

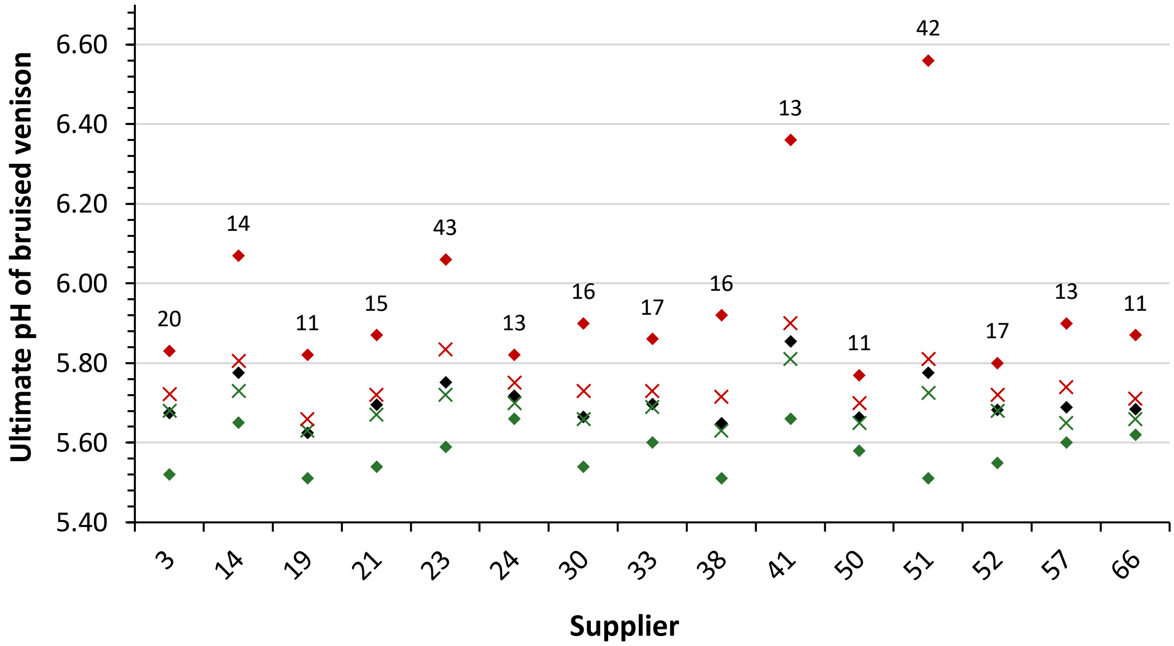

Figure 8: Observed ultimate pH ranges for suppliers with greater than 10 animals supplied. Maximum pH (◆), upper quartile pH (x), mean pH (◆), lower quartile pH (x) and minimum pH (◆). Numbers above each point indicate the number of samples obtained from the supplier to obtain the observed range.

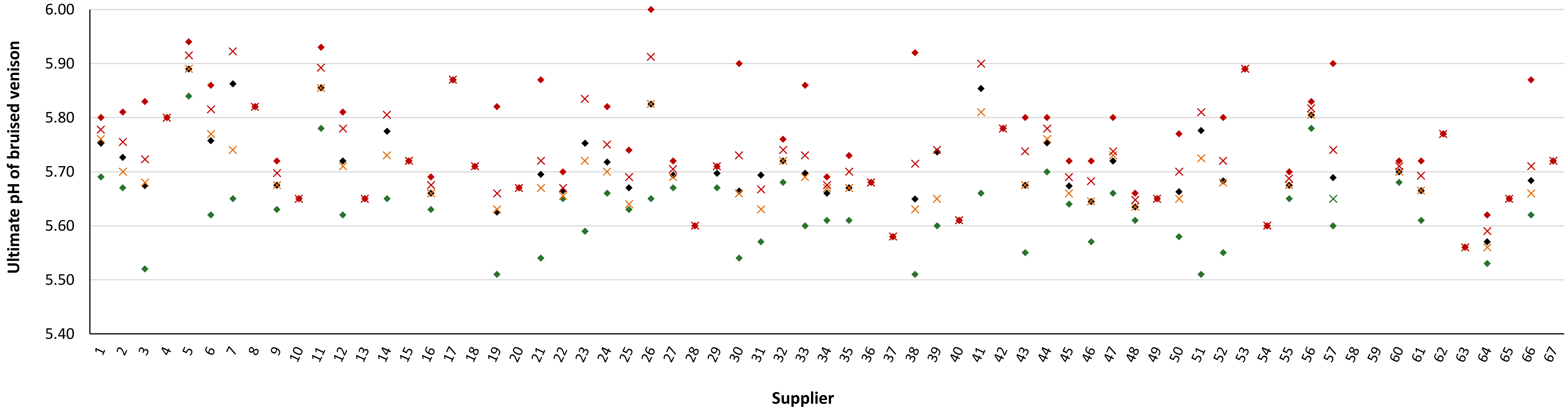

Figure 9: Observed ultimate pH ranges for each supplier, maximum pH (◆), upper quartile pH (x), mean pH (◆), lower quartile pH (x) and minimum pH (◆).

6. Slaughter dates

There is no apparent trend in the ultimate pH ranges or means observed with slaughter date (Figure 10). For any given slaughter date (where more than 10 animals were collected), the range and mean of pH is given (Figure 11). In addition, the number of samples with pH values above 5.85 appears to coincide with the total number of samples taken (Figure 12). However, due to limited data availability and without further understanding of the characteristics for all animals slaughtered on each date, it is unknown whether bruising rates coincide with the number of animals which could be considered stressed (inferred from high pH).

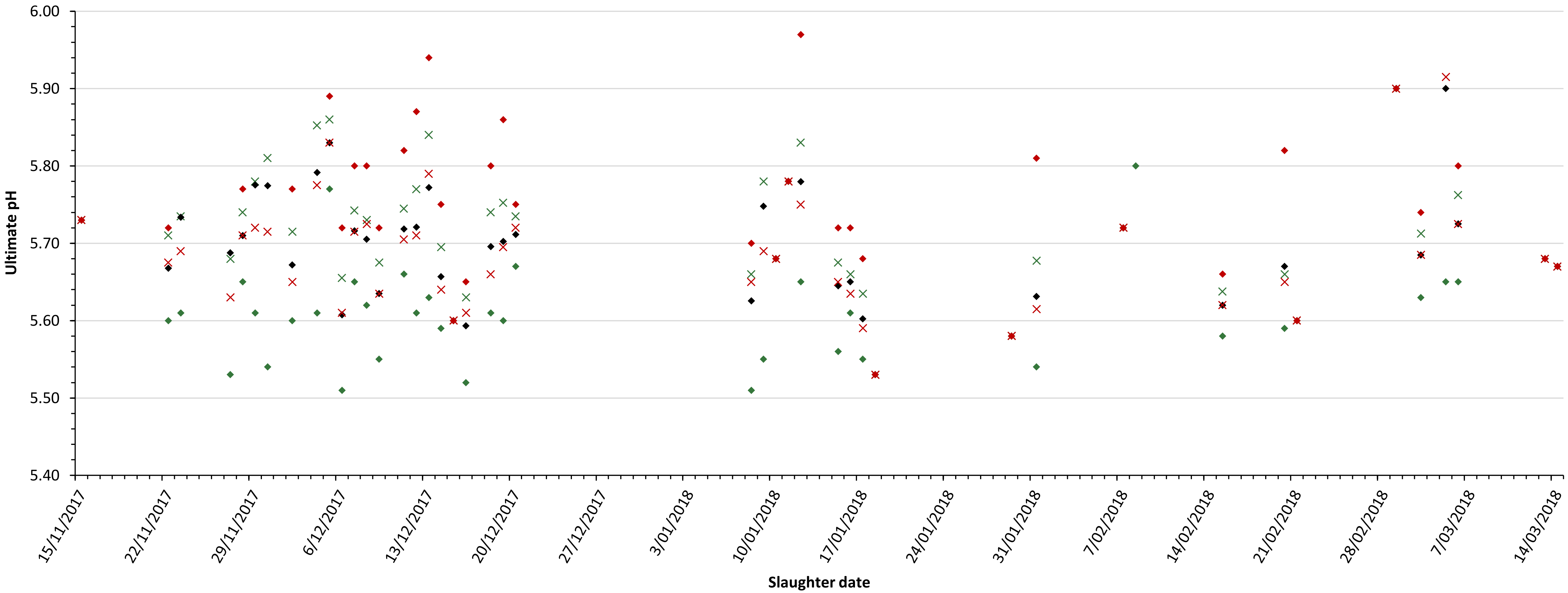

Figure 10: Observed pH ranges for samples collected for each slaughter date. Maximum pH (◆), upper quartile pH (x), mean pH (◆), lower quartile pH (x) and minimum pH (◆).

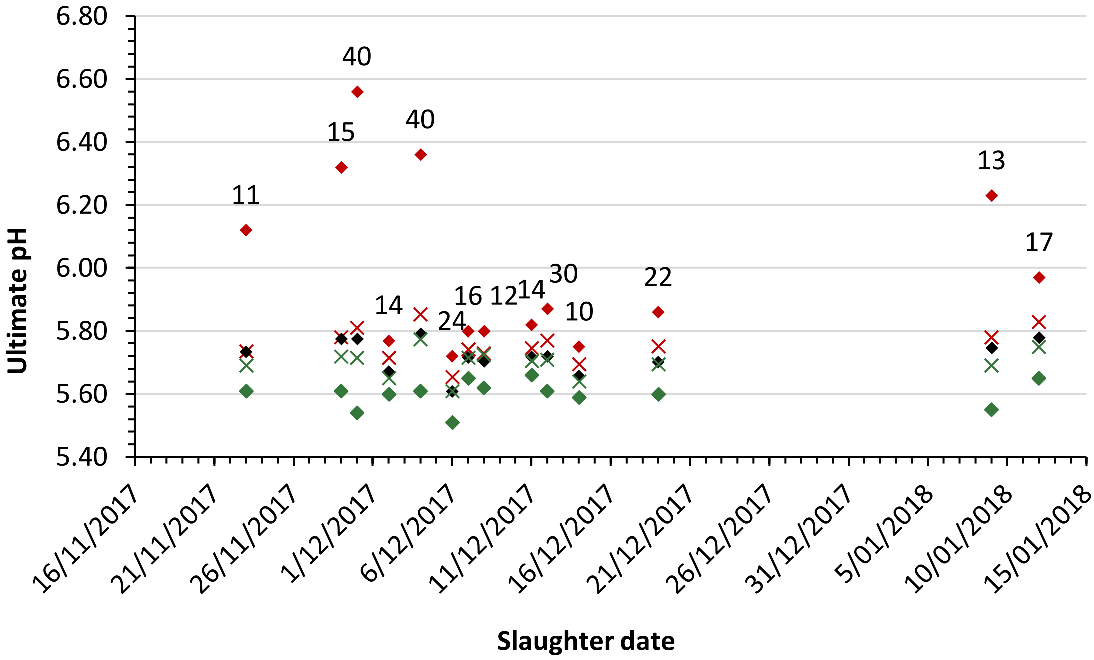

Figure 11: Observed pH ranges for slaughter dates with greater than 10 animals collected. Maximum pH (◆), upper quartile pH (x), mean pH (◆), lower quartile pH (x) and minimum pH (◆). Numbers above each point indicate the number of samples obtained from the supplier to obtain the observed range.

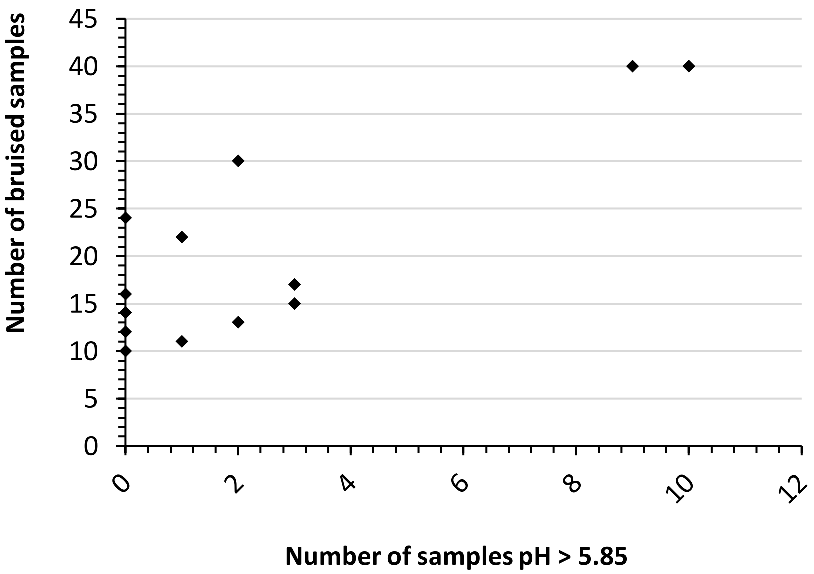

Figure 12: Frequency of bruising for each slaughter day with greater than 10 animals collected versus frequency of high pH (>5.85) occurrence.

7. Mob number

When the incidence of bruising is compared with mob number processed (Figure 13), there appears to be some level of periodicity, which becomes more apparent when bruising frequency is considered in the form of a histogram, with mobs binned in groups of five (Figure 14). This may be an artefact of the sampling method, where carcasses from similar mobs are easier to access in the chiller for sampling. However, pre-slaughter handling processes may be contributing to the observed frequency, such as putting through larger mobs at the start or end of shift, or time in lairage based on arrival at plant.

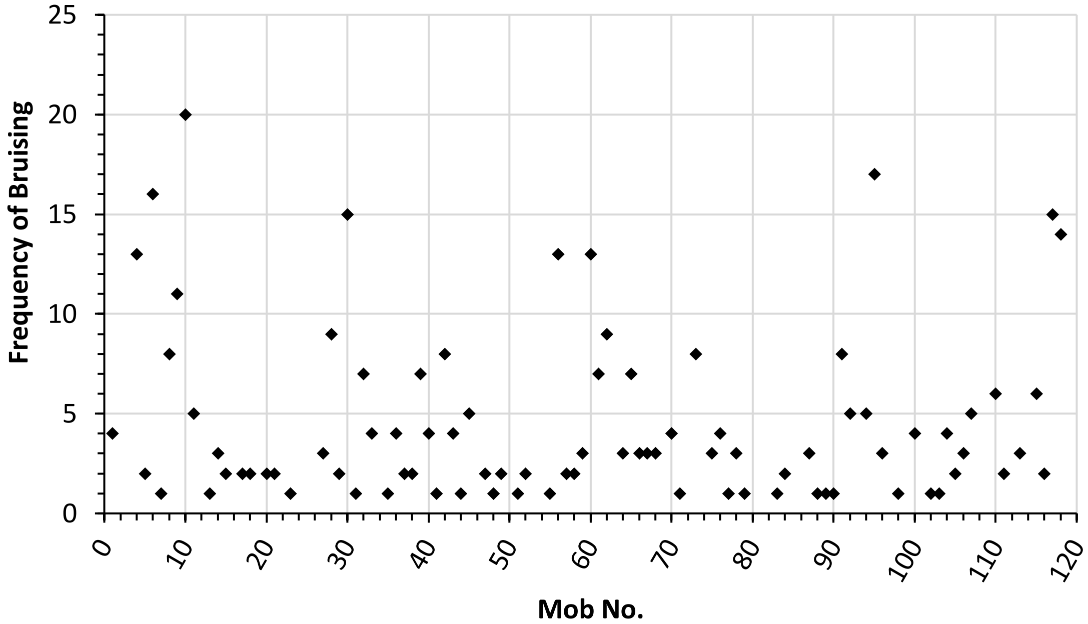

Figure 13: Incidence of bruising based on mob number processed.

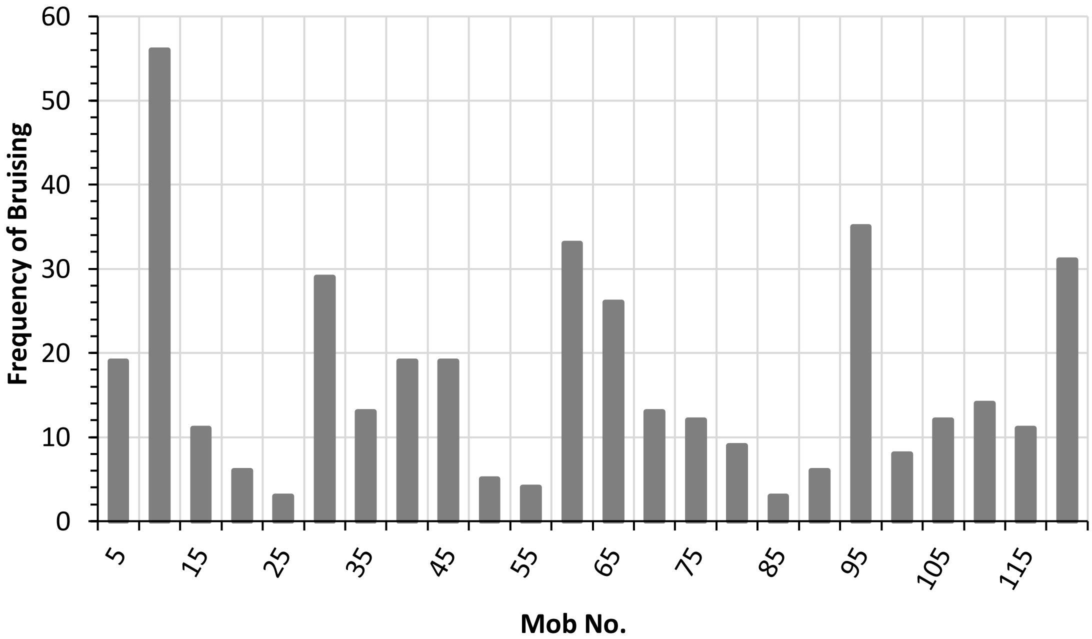

Figure 14: Histogram of incidence of bruising based on mob number processed, binned in groups of five.

Conclusion

Deep-muscle bruising in venison carcasses is complex and the causes are unknown. This study has identified that bruising incidence and impact in terms of average weight and pH of bruised meat varies by supplier, slaughter day and mob number, but because of the irregular sampling regime drawing strong conclusions on incidences by specific suppliers, slaughter dates and mob numbers may be misleading.

Recommendations

1. Compare current results against sex, carcass weight, fatness (or dressing weight), transportation and lairage conditions (additional data requires extraction from VPF databases).
2. Rates of bruising incidence should be determined systematically over time and reported against full plant statistics, including the total number of animals arriving from each supplier, number of animals in each mob and time of slaughter.
3. Further investigation of future carcasses from suppliers with higher incidences of bruising observed in this study may be worthwhile.– Commission a monitoring programme to monitor bruising by supplier.
4. Rates of bruising incidence should be considered alongside the proportion of high pH animals for any given line/supplier.

Appendix 1: Results Tabulated by Supplier

		Bruised meat weight (kg)						Ultimate pH					
Supplier	**N**	**Mean**	**Stdev**	**Min**	**Max**	**L. Quartile**	**U. Quartile**	**Mean**	**Stdev**	**Min**	**Max**	**L. Quartile**	**U. Quartile**
1	4	0.45	0.14	0.29	0.59	0.46	0.56	5.75	0.05	5.69	5.8	5.76	5.78
2	3	0.3	0.08	0.21	0.36	0.32	0.34	5.73	0.07	5.67	5.81	5.7	5.76
3	20	0.41	0.2	0.1	0.94	0.37	0.49	5.67	0.07	5.52	5.83	5.68	5.72
4	1	0.78		0.78	0.78	0.78	0.78	5.8		5.8	5.8	5.8	5.8
5	2	0.43	0.02	0.42	0.45	0.43	0.44	5.89	0.07	5.84	5.94	5.89	5.92
6	7	0.26	0.22	0.05	0.62	0.17	0.4	5.76	0.09	5.62	5.86	5.77	5.82
7	4	0.31	0.13	0.15	0.48	0.31	0.36	5.86	0.31	5.65	6.32	5.74	5.92
8	1	0.71		0.71	0.71	0.71	0.71	5.82		5.82	5.82	5.82	5.82
9	2	0.49	0.23	0.32	0.66	0.49	0.57	5.68	0.06	5.63	5.72	5.68	5.7
10	1	0.3		0.3	0.3	0.3	0.3	5.65		5.65	5.65	5.65	5.65
11	2	0.24	0.09	0.17	0.3	0.24	0.27	5.86	0.11	5.78	5.93	5.86	5.89
12	5	0.26	0.14	0.1	0.39	0.35	0.36	5.72	0.08	5.62	5.81	5.71	5.78
13	1	0.83		0.83	0.83	0.83	0.83	5.65		5.65	5.65	5.65	5.65
14	14	0.42	0.31	0.12	1.36	0.37	0.5	5.78	0.14	5.65	6.07	5.73	5.81
15	1	0.93		0.93	0.93	0.93	0.93	5.72		5.72	5.72	5.72	5.72
16	2	0.39	0.06	0.34	0.43	0.39	0.41	5.66	0.04	5.63	5.69	5.66	5.68
17	1	0.66		0.66	0.66	0.66	0.66	5.87		5.87	5.87	5.87	5.87
18	1	0.58		0.58	0.58	0.58	0.58	5.71		5.71	5.71	5.71	5.71
19	11	0.42	0.13	0.21	0.61	0.41	0.53	5.63	0.08	5.51	5.82	5.63	5.66
20	1	0.61		0.61	0.61	0.61	0.61	5.67		5.67	5.67	5.67	5.67
21	15	0.16	0.08	0.04	0.32	0.14	0.21	5.69	0.09	5.54	5.87	5.67	5.72
22	4	0.56	0.16	0.4	0.77	0.52	0.61	5.67	0.02	5.65	5.7	5.66	5.67
23	43	0.41	0.31	0.04	1.45	0.36	0.58	5.75	0.12	5.59	6.06	5.72	5.84
24	13	0.33	0.18	0.11	0.73	0.29	0.4	5.72	0.05	5.66	5.82	5.7	5.75
25	3	0.29	0.02	0.26	0.3	0.3	0.3	5.67	0.06	5.63	5.74	5.64	5.69

		Bruised meat weight (kg)						Ultimate pH					
Supplier	**N**	**Mean**	**Stdev**	**Min**	**Max**	**L. Quartile**	**U. Quartile**	**Mean**	**Stdev**	**Min**	**Max**	**L. Quartile**	**U. Quartile**
26	2	0.39	0.07	0.34	0.44	0.39	0.41	5.83	0.25	5.65	6	5.83	5.91
27	3	0.45	0.31	0.14	0.75	0.47	0.61	5.69	0.03	5.67	5.72	5.69	5.71
28	1	0.62		0.62	0.62	0.62	0.62	5.6		5.6	5.6	5.6	5.6
29	3	0.75	0.06	0.69	0.82	0.74	0.78	5.7	0.02	5.67	5.71	5.71	5.71
30	16	0.48	0.19	0.26	0.99	0.43	0.56	5.66	0.09	5.54	5.9	5.66	5.73
31	6	0.48	0.15	0.27	0.7	0.46	0.56	5.69	0.17	5.57	6.04	5.63	5.67
32	2	0.36	0.33	0.13	0.6	0.36	0.48	5.72	0.06	5.68	5.76	5.72	5.74
33	17	0.19	0.1	0.05	0.39	0.19	0.25	5.7	0.07	5.6	5.86	5.69	5.73
34	4	0.25	0.16	0.11	0.48	0.2	0.29	5.66	0.03	5.61	5.69	5.67	5.68
35	2	0.26	0.18	0.14	0.39	0.26	0.32	5.67	0.08	5.61	5.73	5.67	5.7
36	1	0.4		0.4	0.4	0.4	0.4	5.68		5.68	5.68	5.68	5.68
37	1	0.39		0.39	0.39	0.39	0.39	5.58		5.58	5.58	5.58	5.58
38	16	0.66	0.37	0.28	1.63	0.61	0.78	5.65	0.11	5.51	5.92	5.63	5.72
39	8	0.35	0.13	0.09	0.53	0.36	0.42	5.74	0.21	5.6	6.23	5.65	5.74
40	1	0.45		0.45	0.45	0.45	0.45	5.61		5.61	5.61	5.61	5.61
41	13	0.36	0.17	0.14	0.64	0.29	0.52	5.85	0.19	5.66	6.36	5.81	5.9
42	1	0.64		0.64	0.64	0.64	0.64	5.78		5.78	5.78	5.78	5.78
43	2	0.57	0.14	0.48	0.67	0.57	0.62	5.68	0.18	5.55	5.8	5.68	5.74
44	3	0.33	0.02	0.32	0.35	0.33	0.34	5.75	0.05	5.7	5.8	5.76	5.78
45	3	0.37	0.2	0.19	0.59	0.34	0.46	5.67	0.04	5.64	5.72	5.66	5.69
46	2	0.2	0.24	0.03	0.37	0.2	0.29	5.65	0.11	5.57	5.72	5.65	5.68
47	6	0.54	0.26	0.29	0.88	0.51	0.7	5.72	0.05	5.66	5.8	5.73	5.74
48	2	0.47	0.06	0.43	0.52	0.47	0.5	5.64	0.04	5.61	5.66	5.64	5.65
49	1	0.28		0.28	0.28	0.28	0.28	5.65		5.65	5.65	5.65	5.65
50	11	0.29	0.17	0.1	0.67	0.23	0.37	5.66	0.06	5.58	5.77	5.65	5.7
51	42	0.36	0.26	0.02	1.07	0.3	0.49	5.78	0.22	5.51	6.56	5.73	5.81
52	17	0.5	0.15	0.28	0.74	0.53	0.61	5.68	0.06	5.55	5.8	5.68	5.72
53	1	0.75		0.75	0.75	0.75	0.75	5.89		5.89	5.89	5.89	5.89

Supplier	N	Bruised meat weight (kg)						Ultimate pH					
		Mean	Stdev	Min	Max	L. Quartile	U. Quartile	Mean	Stdev	Min	Max	L. Quartile	U. Quartile
54	1	0.63		0.63	0.63	0.63	0.63	5.6		5.6	5.6	5.6	5.6
55	2	0.24	0.13	0.15	0.33	0.24	0.28	5.68	0.04	5.65	5.7	5.68	5.69
56	2	0.25	0.07	0.2	0.3	0.25	0.28	5.81	0.04	5.78	5.83	5.81	5.82
57	13	0.25	0.18	0.05	0.59	0.19	0.34	5.69	0.08	5.6	5.9	5.65	5.74
58	1	0.4		0.4	0.4	0.4	0.4	6.12		6.12	6.12	6.12	6.12
59	2	0.61	0.18	0.48	0.73	0.61	0.67	6.49	0.23	6.32	6.65	6.49	6.57
60	3	0.34	0.16	0.2	0.52	0.3	0.41	5.7	0.02	5.68	5.72	5.7	5.71
61	2	0.51	0.1	0.43	0.58	0.51	0.54	5.67	0.08	5.61	5.72	5.67	5.69
62	1	0.48		0.48	0.48	0.48	0.48	5.77		5.77	5.77	5.77	5.77
63	1	0.46		0.46	0.46	0.46	0.46	5.56		5.56	5.56	5.56	5.56
64	3	0.35	0.1	0.29	0.46	0.3	0.38	5.57	0.05	5.53	5.62	5.56	5.59
65	1	0.42		0.42	0.42	0.42	0.42	5.65		5.65	5.65	5.65	5.65
66	11	0.42	0.64	0.03	2.3	0.24	0.31	5.68	0.07	5.62	5.87	5.66	5.71
67	1	0.68		0.68	0.68	0.68	0.68	5.72		5.72	5.72	5.72	5.72

Appendix 2: Results Tabulated by Slaughter Date

		Bruised meat weight (kg)						Ultimate pH					
Slaughter date	N	Mean	Stdev	Min	Max	L. Quartile	U. Quartile	Mean	Stdev	Min	Max	L. Quartile	U. Quartile
15/11/2017	1	0.05		0.05	0.05	0.05	0.05	5.73		5.73	5.73	5.73	5.73
22/11/2017	8	0.48	0.16	0.18	0.63	0.52	0.61	5.67	0.05	5.60	5.72	5.68	5.71
23/11/2017	11	0.37	0.17	0.11	0.66	0.32	0.46	5.73	0.14	5.61	6.12	5.69	5.74
27/11/2017	9	0.61	0.30	0.27	1.24	0.51	0.70	5.69	0.17	5.53	6.04	5.63	5.68
28/11/2017	2	0.79	0.06	0.75	0.83	0.79	0.81	5.71	0.08	5.65	5.77	5.71	5.74
29/11/2017	15	0.36	0.23	0.13	1.02	0.33	0.41	5.78	0.19	5.61	6.32	5.72	5.78
30/11/2017	40	0.21	0.16	0.02	0.80	0.17	0.31	5.77	0.22	5.54	6.56	5.72	5.81
02/12/2017	14	0.22	0.15	0.05	0.58	0.17	0.33	5.67	0.05	5.60	5.77	5.65	5.72
04/12/2017	40	0.34	0.27	0.04	1.45	0.27	0.46	5.79	0.15	5.61	6.36	5.78	5.85
05/12/2017	2	0.62	0.19	0.48	0.75	0.62	0.68	5.83	0.08	5.77	5.89	5.83	5.86
06/12/2017	24	0.53	0.18	0.28	0.94	0.51	0.60	5.61	0.07	5.51	5.72	5.61	5.66
7/12/2017	16	0.58	0.21	0.20	0.84	0.64	0.74	5.72	0.04	5.65	5.80	5.72	5.74
8/12/2017	12	0.44	0.15	0.26	0.73	0.42	0.56	5.71	0.05	5.62	5.80	5.73	5.73
9/12/2017	4	0.47	0.11	0.33	0.58	0.48	0.54	5.64	0.07	5.55	5.72	5.64	5.68
11/12/2017	14	0.33	0.17	0.11	0.73	0.28	0.40	5.72	0.05	5.66	5.82	5.71	5.75
12/12/2017	30	0.37	0.44	0.02	2.30	0.26	0.45	5.72	0.08	5.61	5.87	5.71	5.77
13/12/2017	9	0.62	0.40	0.31	1.63	0.48	0.66	5.77	0.11	5.63	5.94	5.79	5.84
14/12/2017	10	0.24	0.15	0.09	0.48	0.18	0.37	5.66	0.05	5.59	5.75	5.64	5.70
15/12/2017	1	0.62		0.62	0.62	0.62	0.62	5.60		5.60	5.60	5.60	5.60
16/12/2017	3	0.34	0.05	0.30	0.39	0.33	0.36	5.59	0.07	5.52	5.65	5.61	5.63
18/12/2017	9	0.48	0.18	0.28	0.74	0.50	0.61	5.70	0.07	5.61	5.80	5.66	5.74
19/12/2017	22	0.21	0.11	0.05	0.39	0.19	0.27	5.70	0.07	5.60	5.86	5.70	5.75
20/12/2017	7	0.34	0.24	0.10	0.75	0.35	0.46	5.71	0.03	5.67	5.75	5.72	5.74
8/01/2018	9	0.50	0.15	0.27	0.77	0.50	0.60	5.63	0.06	5.51	5.70	5.65	5.66
9/01/2018	13	0.43	0.13	0.20	0.65	0.44	0.53	5.75	0.19	5.55	6.23	5.69	5.78
10/01/2018	1	0.30		0.30	0.30	0.30	0.30	5.68		5.68	5.68	5.68	5.68

		Bruised meat weight (kg)						Ultimate pH					
Slaughter date	**N**	**Mean**	**Stdev**	**Min**	**Max**	**L. Quartile**	**U. Quartile**	**Mean**	**Stdev**	**Min**	**Max**	**L. Quartile**	**U. Quartile**
11/01/2018	1	0.64		0.64	0.64	0.64	0.64	5.78		5.78	5.78	5.78	5.78
12/01/2018	17	0.51	0.19	0.15	0.88	0.50	0.64	5.78	0.10	5.65	5.97	5.75	5.83
15/01/2018	4	0.40	0.17	0.19	0.59	0.40	0.49	5.65	0.07	5.56	5.72	5.65	5.68
16/01/2018	4	0.54	0.29	0.26	0.93	0.48	0.66	5.65	0.05	5.61	5.72	5.64	5.66
17/01/2018	4	0.41	0.08	0.29	0.48	0.43	0.47	5.60	0.06	5.55	5.68	5.59	5.64
18/01/2018	1	0.30		0.30	0.30	0.30	0.30	5.53		5.53	5.53	5.53	5.53
29/01/2018	1	0.39		0.39	0.39	0.39	0.39	5.58		5.58	5.58	5.58	5.58
31/01/2018	8	0.34	0.07	0.21	0.44	0.34	0.38	5.63	0.10	5.54	5.81	5.62	5.68
7/02/2018	1	0.68		0.68	0.68	0.68	0.68	5.72		5.72	5.72	5.72	5.72
8/02/2018	3	0.63	0.13	0.48	0.73	0.67	0.70	6.26	0.43	5.80	6.65	6.32	6.49
15/02/2018	4	0.40	0.22	0.15	0.67	0.40	0.50	5.62	0.03	5.58	5.66	5.62	5.64
20/02/2018	5	0.35	0.13	0.21	0.54	0.33	0.41	5.67	0.09	5.59	5.82	5.65	5.66
21/02/2018	1	0.91		0.91	0.91	0.91	0.91	5.60		5.60	5.60	5.60	5.60
1/03/2018	1	0.99		0.99	0.99	0.99	0.99	5.90		5.90	5.90	5.90	5.90
3/03/2018	2	0.30	0.00	0.30	0.30	0.30	0.30	5.69	0.08	5.63	5.74	5.69	5.71
5/03/2018	6	0.57	0.42	0.17	1.36	0.49	0.59	5.90	0.16	5.65	6.07	5.92	6.04
6/03/2018	2	0.32	0.02	0.31	0.34	0.32	0.33	5.73	0.11	5.65	5.80	5.73	5.76
13/03/2018	1	0.52		0.52	0.52	0.52	0.52	5.68		5.68	5.68	5.68	5.68
14/03/2018	1	0.61		0.61	0.61	0.61	0.61	5.67		5.67	5.67	5.67	5.67

Appendix 3: Results Tabulated by Mob Number

		Bruised meat weight (kg)						Ultimate pH					
Mob Number	**N**	**Mean**	**Stdev**	**Min**	**Max**	**L. Quartile**	**U. Quartile**	**Mean**	**Stdev**	**Min**	**Max**	**L. Quartile**	**U. Quartile**
1	4	0.56	0.16	0.40	0.77	0.52	0.61	5.67	0.02	5.65	5.70	5.66	5.67
4	13	0.28	0.26	0.05	0.99	0.19	0.34	5.69	0.08	5.60	5.90	5.65	5.74
5	2	0.24	0.13	0.15	0.33	0.24	0.28	5.68	0.04	5.65	5.70	5.68	5.69
6	16	0.37	0.15	0.12	0.61	0.37	0.47	5.69	0.09	5.51	5.86	5.68	5.76
7	1	0.44		0.44	0.44	0.44	0.44	6.00		6.00	6.00	6.00	6.00
8	8	0.37	0.09	0.30	0.53	0.34	0.40	5.73	0.21	5.60	6.23	5.66	5.73
9	11	0.37	0.18	0.14	0.64	0.29	0.53	5.88	0.19	5.70	6.36	5.84	5.91
10	20	0.33	0.36	0.04	1.45	0.21	0.34	5.78	0.13	5.61	6.06	5.77	5.84
11	5	0.52	0.13	0.34	0.65	0.54	0.61	5.66	0.07	5.55	5.73	5.67	5.69
13	1	0.30		0.30	0.30	0.30	0.30	5.68		5.68	5.68	5.68	5.68
14	3	0.78	0.52	0.39	1.36	0.58	0.97	5.93	0.24	5.65	6.07	6.07	6.07
15	2	0.24	0.09	0.17	0.30	0.24	0.27	5.86	0.11	5.78	5.93	5.86	5.89
17	2	0.63	0.06	0.59	0.67	0.63	0.65	5.85	0.07	5.80	5.90	5.85	5.88
18	2	0.61	0.18	0.48	0.73	0.61	0.67	6.49	0.23	6.32	6.65	6.49	6.57
20	2	0.55	0.29	0.34	0.75	0.55	0.65	5.77	0.17	5.65	5.89	5.77	5.83
21	2	0.39	0.12	0.31	0.48	0.39	0.44	5.79	0.02	5.77	5.80	5.79	5.79
23	1	0.64		0.64	0.64	0.64	0.64	5.78		5.78	5.78	5.78	5.78
27	3	0.49	0.09	0.40	0.56	0.53	0.54	5.68	0.06	5.61	5.72	5.71	5.72
28	9	0.53	0.25	0.28	0.94	0.42	0.69	5.68	0.07	5.57	5.80	5.66	5.73
29	2	0.59	0.44	0.28	0.90	0.59	0.75	5.57	0.08	5.51	5.62	5.57	5.59
30	15	0.49	0.16	0.15	0.78	0.50	0.59	5.77	0.12	5.57	5.97	5.75	5.84
31	1	0.48		0.48	0.48	0.48	0.48	5.51		5.51	5.51	5.51	5.51
32	7	0.58	0.15	0.31	0.74	0.60	0.66	5.59	0.06	5.51	5.70	5.59	5.60
33	4	0.48	0.07	0.43	0.58	0.45	0.49	5.61	0.08	5.54	5.69	5.61	5.68
35	1	0.42		0.42	0.42	0.42	0.42	5.65		5.65	5.65	5.65	5.65
36	4	0.45	0.14	0.29	0.59	0.46	0.56	5.75	0.05	5.69	5.80	5.76	5.78
37	2	0.36	0.23	0.20	0.52	0.36	0.44	5.71	0.01	5.70	5.72	5.71	5.72
38	2	0.50	0.29	0.29	0.71	0.50	0.61	5.70	0.05	5.66	5.73	5.70	5.71

Mob Number	N	Bruised meat weight (kg)						Ultimate pH					
		Mean	Stdev	Min	Max	L. Quartile	U. Quartile	Mean	Stdev	Min	Max	L. Quartile	U. Quartile
39	7	0.60	0.24	0.19	0.84	0.68	0.77	5.70	0.05	5.64	5.77	5.72	5.73
40	4	0.69	0.13	0.52	0.82	0.72	0.76	5.69	0.02	5.67	5.71	5.70	5.71
41	1	0.46		0.46	0.46	0.46	0.46	5.56		5.56	5.56	5.56	5.56
42	8	0.47	0.16	0.26	0.73	0.44	0.58	5.68	0.05	5.62	5.73	5.69	5.73
43	4	0.40	0.25	0.05	0.60	0.47	0.56	5.68	0.06	5.61	5.73	5.69	5.72
44	1	0.93		0.93	0.93	0.93	0.93	5.72		5.72	5.72	5.72	5.72
45	5	0.37	0.14	0.26	0.61	0.33	0.35	5.71	0.07	5.64	5.80	5.70	5.76
47	2	0.43	0.13	0.33	0.52	0.43	0.47	5.61	0.08	5.55	5.66	5.61	5.63
48	1	0.40		0.40	0.40	0.40	0.40	5.68		5.68	5.68	5.68	5.68
49	2	0.51	0.10	0.43	0.58	0.51	0.54	5.67	0.08	5.61	5.72	5.67	5.69
51	1	0.48		0.48	0.48	0.48	0.48	5.55		5.55	5.55	5.55	5.55
52	2	0.38	0.12	0.29	0.46	0.38	0.42	5.59	0.04	5.56	5.62	5.59	5.61
55	1	0.28		0.28	0.28	0.28	0.28	5.73		5.73	5.73	5.73	5.73
56	13	0.33	0.18	0.11	0.73	0.29	0.40	5.72	0.05	5.66	5.82	5.70	5.75
57	2	0.75	0.05	0.71	0.78	0.75	0.76	5.81	0.01	5.80	5.82	5.81	5.82
58	2	0.22	0.11	0.15	0.30	0.22	0.26	5.60	0.09	5.53	5.66	5.60	5.63
59	3	0.54	0.12	0.43	0.67	0.52	0.59	5.62	0.04	5.58	5.66	5.61	5.64
60	13	0.43	0.59	0.03	2.30	0.28	0.34	5.67	0.07	5.60	5.87	5.64	5.70
61	7	0.32	0.20	0.08	0.62	0.35	0.45	5.74	0.10	5.61	5.86	5.77	5.82
62	9	0.26	0.32	0.02	1.07	0.21	0.28	5.74	0.05	5.67	5.83	5.74	5.76
64	3	0.44	0.24	0.18	0.66	0.48	0.57	5.78	0.10	5.68	5.87	5.79	5.83
65	7	0.47	0.11	0.31	0.62	0.45	0.54	5.73	0.12	5.62	5.94	5.71	5.78
66	3	0.52	0.19	0.31	0.68	0.58	0.63	5.70	0.07	5.63	5.76	5.71	5.74
67	3	0.87	0.67	0.36	1.63	0.63	1.13	5.71	0.08	5.63	5.79	5.70	5.75
68	3	0.30	0.18	0.09	0.40	0.40	0.40	5.80	0.28	5.63	6.12	5.64	5.88
70	4	0.37	0.14	0.21	0.54	0.37	0.44	5.68	0.10	5.59	5.82	5.65	5.70
71	1	0.28		0.28	0.28	0.28	0.28	5.65		5.65	5.65	5.65	5.65
73	8	0.23	0.15	0.09	0.48	0.18	0.31	5.66	0.06	5.59	5.75	5.65	5.71
75	3	0.63	0.29	0.32	0.91	0.66	0.78	5.65	0.06	5.60	5.72	5.63	5.68
76	4	0.25	0.16	0.11	0.48	0.20	0.29	5.66	0.03	5.61	5.69	5.67	5.68

Mob Number	N	Bruised meat weight (kg)						Ultimate pH					
		Mean	**Stdev**	**Min**	**Max**	**L. Quartile**	**U. Quartile**	**Mean**	**Stdev**	**Min**	**Max**	**L. Quartile**	**U. Quartile**
77	1	0.62		0.62	0.62	0.62	0.62	5.60		5.60	5.60	5.60	5.60
78	3	0.42	0.17	0.32	0.61	0.32	0.47	5.76	0.07	5.69	5.83	5.75	5.79
79	1	0.43		0.43	0.43	0.43	0.43	5.69		5.69	5.69	5.69	5.69
83	1	0.30		0.30	0.30	0.30	0.30	5.65		5.65	5.65	5.65	5.65
84	2	0.36	0.04	0.33	0.39	0.36	0.37	5.57	0.06	5.52	5.61	5.57	5.59
87	3	0.40	0.12	0.27	0.51	0.41	0.46	5.75	0.26	5.57	6.04	5.63	5.84
88	1	0.39		0.39	0.39	0.39	0.39	5.58		5.58	5.58	5.58	5.58
89	1	0.70		0.70	0.70	0.70	0.70	5.68		5.68	5.68	5.68	5.68
90	1	0.50		0.50	0.50	0.50	0.50	5.66		5.66	5.66	5.66	5.66
91	8	0.48	0.19	0.28	0.74	0.47	0.62	5.70	0.07	5.61	5.80	5.69	5.75
92	5	0.72	0.36	0.36	1.24	0.61	0.91	5.65	0.16	5.53	5.92	5.60	5.66
94	5	0.26	0.14	0.10	0.39	0.35	0.36	5.72	0.08	5.62	5.81	5.71	5.78
95	17	0.19	0.10	0.05	0.39	0.19	0.25	5.70	0.07	5.60	5.86	5.69	5.73
96	3	0.45	0.31	0.14	0.75	0.47	0.61	5.69	0.03	5.67	5.72	5.69	5.71
98	1	0.83		0.83	0.83	0.83	0.83	5.65		5.65	5.65	5.65	5.65
100	4	0.26	0.18	0.10	0.46	0.23	0.37	5.73	0.03	5.68	5.75	5.74	5.74
102	1	0.75		0.75	0.75	0.75	0.75	5.77		5.77	5.77	5.77	5.77
103	1	0.32		0.32	0.32	0.32	0.32	5.57		5.57	5.57	5.57	5.57
104	4	0.38	0.06	0.31	0.44	0.40	0.43	5.58	0.06	5.54	5.66	5.55	5.58
105	2	0.36	0.33	0.13	0.60	0.36	0.48	5.72	0.06	5.68	5.76	5.72	5.74
106	3	0.26	0.09	0.15	0.33	0.30	0.31	5.89	0.38	5.65	6.32	5.69	6.01
107	5	0.28	0.11	0.14	0.39	0.32	0.36	5.70	0.07	5.61	5.81	5.70	5.73
110	6	0.44	0.31	0.21	1.02	0.32	0.50	5.73	0.13	5.61	5.97	5.72	5.75
111	2	0.38	0.06	0.34	0.42	0.38	0.40	5.90	0.13	5.80	5.99	5.90	5.94
113	3	0.21	0.11	0.10	0.32	0.21	0.26	5.69	0.05	5.64	5.74	5.70	5.72
115	6	0.29	0.14	0.14	0.49	0.28	0.39	5.66	0.06	5.59	5.77	5.65	5.69
116	2	0.20	0.24	0.03	0.37	0.20	0.29	5.65	0.11	5.57	5.72	5.65	5.68
117	15	0.16	0.08	0.04	0.32	0.14	0.21	5.69	0.09	5.54	5.87	5.67	5.72
118	14	0.23	0.21	0.02	0.80	0.15	0.31	5.94	0.28	5.68	6.56	5.84	6.01

Appendix 4: Sampling protocol

Reducing the incidence of deep muscle bruising in venison (10 October 2017)

Cameron Craigie (AgResearch, Ruakura), Jamie Ward (AgResearch Invermay), Carolina Realini (AgResearch Grasslands) and Simon Wishnowski (Venison Packers Feilding)

Summary

Sporadic deep muscle bruising observed in venison topside and silverside cuts has significant detrimental impacts on meat yield, cut presentation and labour costs associated with additional trimming. The bruising is only observed upon breaking hind leg primals into sub-primal cuts, so there is no advance warning of an occurrence. The cause of the bruising is currently unknown.

The objective of this research is to establish causes of the bruising effects so the industry can reduce or eliminate the bruising.

Background

There are a number of possible causes of the deep muscle bruising. Based on our observations, we do not believe that it is a processing plant effect, however we currently cannot rule this possibility out. After observing the process and some incidences of bruising we agreed that a systematic approach was needed to establish if there were any patterns in the occurrence down to the carcass level.

Data needs to be collected to: a) quantify bruising impact on production over time, and b) allow us to map the occurrence of bruising against production factors (e.g. line of deer, gender, carcass weight, animal age, transport operator, time off feed and potentially genetic factors etc.). It is also possible that there are interactions among these factors resulting in multiple causes.

We recommend observations be made in more than one processing plant. Ideally, one North Island plant (Venison packers) and at least one South Island plant. The more information collected, the faster we can begin to hone in on risk factors.

Draft Protocol

1. Yardsman to note down temperament of mobs in lairage and note any major events such as a boxed mob that are likely to cause distress.
2. Carcass tag to remain with legs until bone-out, and retained if bruising present.
3. Retain any bruised meat with matched carcass tag, place in individual vac-pack bag (may wish to use different bags to signify left or right sides), If in different different muscles (topside/silverside) one bagged sample could be packed inside another for example if there was a double incidence (exact approach TBC with processing plant).
4. Vac-pack bags at end of run, freeze and stockpile samples.
5. Once a large enough batch of samples have been accumulated (e.g. 200+). Processing plant to advise AgResearch of sample numbers (Cameron Craigie and Jamie Ward).

6. AgResearch to arrange a day to come to the plant (samples to be thawed in advance) to undertake the following measurements:
    a. Weigh the bruised product in each bag and record against the carcass tag barcode
    b. Record pH of each sample (as long as bruising does not impair pH measurement)
    c. Use a DNA tissue sample unit (TSU) (AllFlex NZ) to save a sample for later genomic analysis
7. AgResearch to provide a spreadsheet of recorded observations back to processing plant for matching with plant records.
8. Processing plant to fill in the metadata for each carcass and return to AgResearch for analysis
9. AgResearch to analyse data to look for trends in occurrence of deep muscle bruising and report back to processing plant.
10. Monitor progress against objective (see below)

Monitoring Progress

Review progress after each batch of 200 samples have been analysed to see if we have enough information to identify causes of deep muscle bruising.

Consider the potential of a genetic basis for the bruising and whether DNA testing is a logical next step.

Appendix 5: Further examples of bruised venison product