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Prepared by: Symbio Alliance

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Management of *s. aureus* in Australian red meat industry (A.MFS.0087) & Enterococci on beef and sheep carcases (A.MFS.0112)

Stage 2

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Contents

1 Introduction

The finding of coagulase positive staphylococci (*S. aureus*)1 levels of concern was identified in the first national baseline study (Vanderlinde, Shay and Murray, 1998) and confirmed in the second baseline study (Phillips *et al*., 2001a, b). Investigations were undertaken (Desmarchelier *et al*., 1999; Vanderlinde *et al*., 1999) which identified contamination as human, rather than bovine origin and Orr (1998) undertook preliminary experiments which suggested that use of gloves on the slaughter floor and in the boning room might reduce levels of *S. aureus*.

The third national baseline study of carcases and trim (Phillips *et al*. 2006a, b) plus the first national retail study of ground beef and diced lamb (Anon, 2005) indicated substantial levels of *S. aureus*, both in terms of prevalence and of concentration. While some processing operations produced meat with low prevalence and concentration, at others the reverse was obtained.

In early 2006 a project *"Practical approaches to reducing S. aureus contamination in the Australian red meat industry"* was begun. In Stage 1, processes were investigated at ten beef abattoirs and nine sheep abattoirs in five states. A major finding was that, in the period since sampling was undertaken for the third baseline study, a number of plants had implemented the use of gloves on the slaughter floor or/and in the boning room.

Accordingly, in Stage 2 of the project:

1. Chilled carcases were sampled for *S. aureus*.
2. Hands of operators freeing the pelt of lamb carcases (punching) were assessed for presence of *S. aureus*.
3. The "punched" area of carcases was sampled immediately after the punching operation.
4. The hindquarters of lambs were sampled immediately after final inspection.
5. Hands of operators were rinsed and the rinsate analysed for *S. aureus*.

The results of the above investigations are presented in this report.

2 Methodology

2.1 Design of the study

Samples were collected between October-November, 2006 at six abattoirs sampled in three mainland Australian States.

2.2 Sampling

2.2.1 Sampling of beef and sheep carcases

Selection of carcases and subsequent sampling was performed by a team of trained technicians. Individual carcases were selected for sampling using a systematic-random approach. Briefly, of the total lot of carcases accessible to the technician's one was sampled at regular intervals until the required number of carcases was attained. Separate polyurethane

1 Throughout this report *S. aureus* refers to coagulase positive staphylococci.

sponges (Whirlpak speci-sponge, NASCO, USA) moistened with buffered peptone water (25ml) were used to sample each site of the selected carcase, a composite sample being taken by sponging a 100cm^2 area at each of the butt, flank and brisket regions of beef, and a 25cm² area at each of the mid-loin, flank and brisket of sheep as detailed in the Mega Reg methodology.

2.2.2 Sampling of “punched” areas of sheep

Using a Whirlpak sponge moistened as described above, each side of the freshly-exposed carcase was sponged from immediately below the hindquarters to the brisket, using one side of the sponge for each half of the carcase. It was estimated that a total area of 3000cm² was sampled.

2.2.3 Sampling of the hindquarters of sheep

Using a Whirlpak sponge moistened as described above, the entire hindquarters were sponged with one sponge to a level just below the tail. It was estimated that a total area of 1500cm² was sampled.

2.2.4 Direct plate sampling of the hands of operators

Operators were requested to place their fingertips, the entire hand or/and the back of the hand onto the surface of a Petri dish (14.5 cm diameter) containing Baird Parker Agar (BPA).

2.2.5 Rinse sampling of the hands of operators

Operators were requested to remove gloves and place their hand into a sterile plastic bag containing Sterile Butterfields solution (25ml). The hand was then massaged by a technician from the outside of the bag in an attempt to release microflora from the hands.

2.3 Transport of samples to the laboratory

All samples were packed in insulated containers with chiller packs for transportation to a National Association of Testing Authorities (NATA) accredited laboratory for testing. Upon arrival at the laboratory, samples were held at 2-4°C until examination. To standardise time between sample collection and analysis, samples were analysed at least 18h after collection. In all cases this was on the day of arrival at the laboratory.

2.4 Determination of total viable counts (TVC), coliforms/e. coli, enterococcus and *S. aureus*

Carcase sponge bags, already containing buffered peptone water (25ml) were squeezed by hand 10 times. For all samples, serial dilutions were prepared in 0.1% peptone water using 1ml aliquots. For TVC, duplicate Petrifilm plates (3M, Sydney, Australia) were prepared according to method AOAC 990.12 and incubated at 35oC/48h at which time the colonies were counted and the count/cm² recorded. For calculating TVC/cm² of gloved and ungloved hands a nominal area of 500cm² was used.

Generic *E. coli* were estimated by placing 1ml aliquots of both the initial solution and appropriate dilutions onto duplicate *E. coli* Petrifilm (3M, Sydney, Australia) and incubating at 35oC for 48h. Colonies were counted as per the manufacturer’s instructions and AOAC method 991.14. Enterococci were estimated by placing 0.5ml aliquots of both the initial solution and appropriate dilutions onto duplicate m-Enteroccoccus spread plates and incubating at 37oC for 48h. Confirmation was carried out as per AS4276.8.

S. aureus were determined using Australian Standard method AS1766.2.4 where 0.5ml aliquots were spread onto dried plates of Baird Parker agar (Merck, Melbourne, Australia) and incubated at 37°C for 48h. Colonies with typical morphology (grey-black, shiny, convex colony with a

narrow entire margin surrounded by a zone of clearing) were picked off the plate for coagulase testing using BHI broth and then rabbit blood plasma.

3 Results

3.1 *S. Aureus on beef and sheep carcases*

In Table 1 are presented summary data for prevalence and concentration of *S. aureus* on chilled carcases at five plants. Enterococci data are provided in Annex 1. At Plants A and B latex gloves had been introduced between sampling carried out for Baseline 3 and for the present survey and were worn by all operators; *S. aureus* was not detected on any of the 25 samples from each plant, compared with over 50% prevalence prior to their introduction.

Table 1: Prevalence and concentration of S. aureus on chilled carcases at selected plants

	Baseline 3			Present survey		
Plant	n	Prevalence (concentration*)	HI**	n	Prevalence (concentration*)	HI**
Beef						
A	41	58.5 (9.4)	550	25	0	0
B	31	51.6 (11.6)	599	25	0	0
Sheep						
C	71	17.0 (80)	474	25	80 (10)	800
D	30	63.3 (32)	2217	25	32 (17)	544
E	30	43.0 (20)	650	25	20 (7)	140

*Antilog of mean log count/cm^2

**Hygiene Index (HI) is the product of prevalence and antilog of the mean log count/cm^2

At Plants D and E wearing of latex gloves had become optional. At Plant E almost all slaughter-floor operators were wearing gloves during the present survey, with the scales operator and chiller personnel being the sole operators with ungloved hands. At Plant D uptake of glove-use had been less complete with a large proportion of operators post-hide removal using bare hands. Thus increased glove use at these plants is associated with a reduction in prevalence and concentration of *S. aureus*.

At Plant C gloves are worn by all slaughter floor operators except for those involved in freeing the pelt by manual punching and by staff at final inspection; the HI was much higher in the present survey than in Baseline 3 and further investigation was undertaken to estimate contamination incurred at punching and final inspection (sections 3.2 & 3.3).

3.2 *S. Aureus on freshly exposed surfaces after punching and final inspection*

The entire punched area on the carcase was sponged immediately after the fleece had been released by operators at the pelt pulling station. The *S. aureus* count was determined using an estimated area of 3000cm² per carcase; a total of 15 carcases were sampled. The counts are presented in Table 2 from which it can be seen that *S. aureus* was isolated from all carcases with

a mean log 0.45/cm² or 2.8 cfu/cm² (antilog of mean log count). Enterococci data are provided in Annex 1.

Table 2: *S. aureus* counts on freshly-exposed flanks of sheep carcases

Sample	Log cfu/cm^2
1	0.26
2	0.54
3	0.51
4	0.20
5	0.78
6	0.77
7	0.68
8	0.32
9	0.45
10	0.82
11	-0.27
12	0.38
13	-0.08
14	1.00
15	0.34
Mean	0.45

At Plant C it was noted that hindquarters were inspected by two operators, neither of whom wore gloves. Inspection involved significant handling of the rump and hindlegs as operators turned and held the body during inspection. Accordingly, carcases were transferred to the retain rail as required for sponging of the entire hindquarter to a level just below the tail. Ten carcases were sampled and it is estimated an area around 1500cm² was sponged on each hindquarter. The counts are presented in Table 3 from which it can be seen that *S. aureus* was isolated from all 10 hindquarters with a mean log of 0.17/cm² or 1.5 cfu/cm² (antilog of mean log count). Enterococci data are provided in Annex 1.

It should be noted that at final operations (post pelt removal) at Plant C the anus is ringed, the anal canal tied and removed and the abdominal and thoracic viscera are removed by operators all of whom wear latex gloves. Normal practice for these operators is unlikely to spread contamination from flanks and briskets to the hindquarters and it is believed that this was achieved at final inspection either directly from the hands of the inspectors or via cross contamination from the flanks and briskets.

Table 3: *S. aureus* counts on freshly-exposed hindlegs of sheep carcases

Sample	Log cfu/cm^2
1	0.60
2	0.60
3	-0.89
4	0.95
5	-0.48
6	0.80
7	0.37
8	-0.48
9	-0.60
10	0.83
Mean	0.17

3.3 Prevalence and numbers of *S. aureus* on the hands of punching operators

Plates of Baird Parker Agar (BPA) were prepared using large (14.5cm^2) Petri dishes which allowed contact with the entire hand (fingers and palm). Four operators who were undertaking punching placed the front of each hand and the back of each hand on a BPA plate. For each operator four plates were used (2 hands x front x back of hand). The data (Table 4) indicate that each operator carried *S. aureus* on both surfaces of both hands.

Table 4: *S. aureus* counts from the front and back of the hands of operators at the punching station

Operator	Surface	Count/plate	Log count/plate
1	Front	2100	3.32
	Front	920	2.96
2	Front	360	2.56
	Front	1100	3.04
3	Front	28	1.45
	Front	3600	3.56
4	Front	1300	3.11
	Front	3200	3.51
		Mean	2.94
1	Back	800	2.90
	Back	2200	3.34
2	Back	2100	3.32
	Back	1200	3.08
3	Back	8000	3.90
	Back	8000	3.90
4	Back	2800	3.45
	Back	1200	3.08
		Mean	3.37

3.4 *S. Aureus on the hands of boning room operators*

It was noted that, in common with slaughter floor personnel, the use of gloves was becoming more prevalent in boning rooms where staff typically wore a latex glove covered by a chain mail glove or wore a cut proof glove.

At Plant A operators were requested to place their fingers on a BPA plate before and after removing their cutproof gloves; *S. aureus* was not recovered from any of the 25 gloved or bare hands of operators. None of these operators wore a latex glove over or beneath their cut proof glove. While the former finding was perhaps unsurprising since *S. aureus* was not detected from any of 25 carcases sampled at Plant A, the non detection from the fingertips of 25 bare hands was considered unusual.

In an attempt to improve isolation of *S. aureus* it was decided to massage hands in sterile Butterfields solution and plate onto BPA. Accordingly, at Plant F hands were massaged before and after removal of gloves (an outer glove of cutproof material over an inner latex glove). In Tables 5 and 6 are presented TVC, *E. coli* and *S. aureus* counts on gloved hands and bare hands, respectively.

Table 5: Bacterial counts on rinsates from gloved hands at Plant F

	Count/cm^2 gloved area			
Sample	TVC	Log TVC	*E. coli*	S. aureus
1	12	1.1	0.002	nd
2	0.5	-0.3	nd	nd
3	0.6	-0.2	nd	nd
4	4	0.6	nd	nd
5	1.8	0.3	nd	nd
6	0.85	-0.1	nd	nd
7	9.5	1.0	nd	nd
8	1.85	0.3	nd	nd
9	20	1.3	nd	nd
10	12	1.1	nd	nd
11	1.75	0.2	nd	nd
12	0.7	-0.2	nd	nd
13	0.9	0.0	nd	nd
14	0.5	-0.3	nd	nd
15	11	1.0	nd	nd
16	1.9	0.3	nd	nd
17	1.5	0.2	0.002	nd
18	2.6	0.4	nd	nd
19	8	0.9	nd	nd
20	1.8	0.3	0.03	nd
21	0.5	-0.3	nd	nd
22	0.5	-0.3	nd	nd
23	110	2.0	nd	nd
24	2.4	0.4	0.03	nd
25	20	1.3	nd	nd
Means		0.4		

Gloved hands (Table 5) had a mean log count of 0.4/ cm² (antilog 2.5/ cm2) ranging up to log 2.0 cm2 (antilog 110/cm²), levels which mirror the range of counts expected from carcase surfaces

and freshly-cut meat surfaces, particularly when it is noted that 35°C incubation was undertaken which is likely to underestimate the total count due to non-detection of psychrotrophs.

E. coli were detected on 4/25 samples but at extremely low concentration. *S. aureus* was not detected which is not unsurprising since all slaughter floor operators at Plant F wear latex gloves beneath either cut proof or chain mail gloves.

Ungloved hands (Table 6) had a mean log count of 0.7/ cm² (antilog 5/ cm²) ranging up to log 1.9 cm² (antilog 86/cm²), *E. coli* and *S.aureus* were not detected on any of the 25 hands sampled and, while the former finding is not unexpected, the failure to isolate *S. aureus* from the bare hands of 25 operators is.

Table 6: Bacterial counts on rinsates from bare hands at Plant F

	Count/cm^2 ungloved hand			
Sample	TVC	Log TVC	*E. coli*	*S. aureus*
1	2.4	0.4	nd	nd
2	22	1.3	nd	nd
3	13	1.1	nd	nd
4	13	1.1	nd	nd
5	86	1.9	nd	nd
6	2.4	0.4	nd	nd
7	60	1.8	nd	nd
8	1.7	0.2	nd	nd
9	2.4	0.4	nd	nd
10	28	1.4	nd	nd
11	0.6	-0.2	nd	nd
12	1.35	0.1	nd	nd
13	10	1.0	nd	nd
14	1.3	0.1	nd	nd
15	32	1.5	nd	nd
16	28	1.4	nd	nd
17	0.5	-0.3	nd	nd
18	0.5	-0.3	nd	nd
19	8	0.9	nd	nd
20	1.8	0.3	nd	nd
21	9	1.0	nd	nd
22	1.6	0.2	nd	nd
23	9.5	1.0	nd	nd
24	0.5	-0.3	nd	nd
25	5	0.7	nd	nd
Means		0.7		

The non-detection of *S. aureus* from the hands of any of 50 operators from Plants A and F, either by direct contact with BPA or by massaging into a rinsate was considered surprising.

Accordingly the rinse-plate technique was evaluated using a person who normally carries *S. aureus* in ears, nose and fingers. Fingertips were pressed onto BPA plates and the hand was massaged in Butterfields solution, after which aliquots (0.5ml) were pipetted onto BPA plates. From each BPA plate, three colonies of appearance typical of *S. aureus* were transferred to BHI broth and then rabbit plasma for coagulase testing. The results, presented in Table 7, indicate that *S. aureus* was present on hands before and after rinsing when fingertips were placed on BPA and in 5/6 aliquots (0.5ml) of hand rinsate.

Table 7: Presence of *S. aureus* in rinsate (0.5ml) from the hands of a carrier

Area sampled	Coagulase positive "typical" colonies
Fingertips before rinsing	3/3
Fingertips after rinsing	2/3
Rinsate (0.5ml)	2/3
Rinsate (0.5ml)	2/3
Rinsate (0.5ml)	2/3
Rinsate (0.5ml)	1/3
Rinsate (0.5ml)	0/3
Rinsate (0.5ml)	1/3

Given the foregoing it is believed that both direct plating from fingertips and plating of a 0.5ml aliquot of hand rinsate on BPA should lead to isolation of *S. aureus* should they be present on the hands of operators.

4 Discussion

In baseline studies since 1993-94, *S. aureus* has been shown to have a relatively high prevalence on both beef and sheep carcases. For example, in 1993-94, 27.5% of beef carcases carried the organism as did 17.5% of frozen, boneless beef samples. In Table 8 is presented a profile of *S. aureus* levels in 2004 on chilled carcases and in frozen boneless meat and chilled minced beef and diced lamb at retail.

Table 8. Prevalence and concentration of *S. aureus* on chilled beef and sheep carcases and in frozen boneless beef and sheep meat, minced beef and diced lamb

	Beef			Sheep		
	Carcase	Boneless	Minced	Carcase	Boneless	Diced
Prevalence (%)	28.7[a]	20.3[b]	28.1[b]	23.4[c]	32.7[b]	22.5[b]
Mean $\log_{10}$ cfu/cm^2 or/g	0.34	0.80	2.18	0.93	1.14	2.34
Standard deviation	0.70	0.32	0.95	0.65	0.65	0.86
90th percentile	1.36	1.00	3.74	1.85	2.16	3.63
95th percentile	1.56	1.74	4.23	2.14	2.51	4.02
99th percentile	2.40	2.24	4.63	2.52	3.10	4.48
Maximum	2.96	2.32	4.63	2.63	3.38	4.48

[a] Limit of detection 0.08 cfu/cm^2
[b] Limit of detection 10 cfu/g
[c] Limit of detection 3.3 cfu/cm^2

The summary of *S. aureus* levels from carcase to final products (Table 8) serves to illustrate concerns at significant (1-2 log) increases in retail products, with 5-10% of product trending towards level of concern. That *S. aureus* is perceived as a poor competitor against the spoilage microflora, coupled with its inability to multiply at temperatures colder than 10°C, points towards either temperature abuse and/or excessive contact with the hands of food operators in the retail sector.

Orr (1998) presented preliminary evidence that the use of gloves both on the slaughter floor and in the boning room might reduce prevalence and concentration of *S. aureus* and the present project has the objective of investigating the veracity of this finding. Coincidentally, in the period

between completion of the third baseline survey (2004) and the present study it was learned that a number of plants had implemented use of gloves. The primary purpose is that of operator safety, with latex gloves being used on slaughter floors and cut proof gloves in boning rooms, sometimes being worn over a latex glove. At some plants glove use has become mandatory while at others at the discretion of the individual operator.

The effect of glove use is well illustrated at Plants A and B where mandatory glove use has reduced prevalence of *S. aureus* from over 50% in baseline 3 to zero in the present study. At plants D and E, glove use is discretionary and prevalence, while halved since baseline 3, is still significant due to operators at post-pelt removal stages not using gloves.

At Plant C all operators on the inverted dressing chain wear latex gloves except for the 4 or 5 operators engaged in freeing the pelt for subsequent mechanical removal by “punching” with their fist along each flank of the sheep. At the same plant two operators at final inspection also used bare hands and made significant contact with hindquarters and flanks.

The effect of the punching operation was assessed by sponge-sampling the entire punched area immediately after the pelt had been pulled free; all carcases were positive for *S. aureus*. Both hands of each of the four operators at punching were found to be positive for *S. aureus*, with a mean count around 103 cfu from both the front and the back of the hand. It should be emphasized that the four operators involved in punching fleeces at the time of sampling were diligent in washing their hands and arms to the elbow with soap and water between each body. It was also noted that they bore numerous small nicks and abrasions on their hands, possibly due to contact with grass seeds protruding through the fleece and it is stated that *S. aureus* is especially prevalent in wounds, especially if these are kept moist.

In similar manner, the hindquarters of bodies were sponge-sampled immediately after final inspection with *S. aureus* being isolated from each of the 10 bodies tested; it was not possible to sample the hands of either operator involved in final inspection.

It seems clear that even a small number of operators may cause widespread contamination of carcases. In Table 9 it can be seen that, with six operators undertaking punching and final inspection with their bare hands, *S. aureus* was recovered from 5/25 (80%) of carcases. The mean log TVC was 2.08/cm2 which is almost identical with that established for Plant C in Baseline 3. The mean log for S. aureus was 0.83/cm2 and, on some carcases e.g. 10, 19 and 22, S. aureus formed >20% of the total microflora.

It should be noted that unit operations at Plant C have been designed primarily to minimize contamination of faecal pathogens and, with 2/25 carcases positive for *E. coli*, the prevalence at Plant C was much lower than the national average of 33% established in Baseline 3.

Observations show that manual punching and pull back of the fleece minimize roll-back and, therefore, contamination of the freshly-exposed carcase. Unfortunately manual punching can also lead to contamination with *S. aureus*, particularly when the knuckles and back of the hand of operators suffer small nicks which occur when “seedy” sheep are punched.

Table 9: TVC, *S. aureus* and *E. coli* counts on chilled sheep carcases at Plant C

Sample	Log TVC/cm^2	*E. coli*/cm^2	Log *S. aureus*/cm^2
1	2.11	nd	1.1
2	2.18	nd	0.7
3	1.9	nd	0.43
4	1.57	nd	nd
5	1.36	nd	0.43
6	1.67	nd	nd
7	0.85	nd	nd
8	2.18	nd	1.18
9	2.9	nd	1.82
10	1.57	nd	0.88
11	2.0	nd	1.04
12	2.54	nd	1.7
13	2.36	nd	1.25
14	1.85	nd	0.7
15	1.94	nd	0.52
16	3.76	10	1.4
17	1.48	nd	0.43
18	1.0	nd	nd
19	1.9	nd	1.3
20	2.28	3.33	0.43
21	2.49	nd	0.22
22	3.3	nd	2.76
23	1.99	nd	nd
24	2.3	nd	1
25	2.48	nd	1.36
Mean	2.08		0.83

This poses the question: can manual punching be done without contaminating with *S. aureus*? An informal survey of QA Managers of plants in south-eastern Australia revealed that manual punching is common, especially for lambs. However, at least one plant mandates the use of a cut resistant glove, covered by a latex glove for operators involved in punching; this improves OH&S and reduces contamination with *S. aureus*.

Given the increased use of gloves on slaughter floors and in boning rooms, the hands of operators were sampled, a total of 50 operators at two plants (A and F) participating. At Plant A, 25 operators in the boning room removed their gloves and pressed their fingertips onto BPA plates; no *S. aureus* were isolated. In view of the results obtained at Plant C, where all four punching operators had large numbers of *S. aureus* on their hands, the finding (0/25 positive for *S. aureus*) at Plant A was considered surprising.
Accordingly, an alternative method was undertaken, that of hand rinsing followed by plating on BPA. The technique was trialed using a colleague known to be a carrier of *S. aureus* in his nose, ears and hands. In the trial, summarized in Table 7, *S. aureus* were recovered from 5/6 aliquots (0.5mL) of rinsate. At Plant F, 25 operators in the boning room removed their outer cut proof or chain mail gloves and their inner latex gloves and their hands were massaged to release bacteria. *S. aureus* were not recovered from any of the 25 operators' hands. The finding that *S. aureus* could not be recovered from the hands of 50 meat processing operators was considered surprising since *S. aureus* appears to be a commensal in the bodies of a significant number of healthy humans. For example, Stewart (2003) reports 10-40% of healthy individuals are nasal carriers. Sumner *et al*. (1982) isolated *S. aureus* from the hands of 137/262 (52%) prawn

processing operators in Sri Lanka and, in Australia, Eu (1984) isolated *S. aureus* from 27/55 (49%) of operators in a food establishment.

Of further interest was the concentration of the total microflora on the hands of operators at Plant F. From Table 6 it can be seen that the mean log count/cm2 of hand surface was 0.7 (antilog 5 cfu/cm2). This is much lower than the levels recorded on the hands of meat workers by Bell (1997), Bell and Hathaway (1996) and Gill and McGinnis (2002). In all three studies the microflora were removed from the hand by massaging into a rinsate, as in the present study. In the studies on beef and sheep slaughter floors no gloves were worn, while in the boning room most operators wore polyester-cotton gloves.

Table 10: TVCs on the hands of meat workers

	Mean log TVC/cm^2 hand	
Beef slaughter floor	3.73	Bell (1997)
Sheep slaughter floor	4.16	Bell & Hathaway (1996)
Beef boning room	3.69	Gill & McGinnis (2002)

We can not account for either the non-detection of *S. aureus* from the hands of 75 operators and neither can we explain the low recovery of total microflora from the hand. While it is entirely speculative to suggest that the native microflora of the hand may be affected by the use of latex gloves, we can think of no other alternative.

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6 ANNEX 1 – A.MFS.0112 – Enterococci on beef and sheep carcases

Table 1: Enterococci (cfu/cm2) on chilled carcases at selected plants

	Beef Carcases		Sheep Carcases		
Sample	Plant A	Plant B	Plant C	Plant D	Plant E
1	nd	nd	nd	nd	0.00
2	nd	nd	nd	0.43	nd
3	nd	nd	nd	0.00	nd
4	nd	nd	nd	nd	nd
5	nd	nd	nd	-0.17	nd
6	nd	nd	nd	nd	0.30
7	nd	nd	nd	-0.17	0.00
8	nd	nd	nd	0.88	0.85
9	nd	nd	nd	nd	-0.17
10	nd	nd	nd	nd	nd
11	nd	nd	nd	nd	0.30
12	nd	nd	nd	0.43	-0.17
13	nd	nd	nd	-0.17	nd
14	nd	nd	3	-0.17	nd
15	nd	nd	3	0.70	nd
16	nd	nd	7	nd	nd
17	nd	nd	nd	nd	nd
18	nd	nd	nd	nd	nd
19	nd	nd	3	0.48	nd
20	nd	nd	nd	nd	nd
21	nd	nd	nd	nd	nd
22	nd	3	nd	-0.17	nd
23	nd	nd	3	nd	nd
24	nd	nd	nd	nd	-0.17
25	nd	nd	nd	-0.17	-0.17
Prevalence (%)	0	4.0	20.0	48.0	36.0
Mean log cfu/cm^2		0.48	0.58	0.16	0.08

Table 2: Enterococci (cfu/cm^2) on warm sheep carcases at Plant C

Sample	'Punched' area - Flank	Hindquarters
1	-0.04	-0.77
2	0.22	0.00
3	nd	nd
4	nd	nd
5	nd	nd
6	nd	-0.08
7	nd	nd
8	-1.10	1.02
9	nd	nd
10	-0.77	-0.17
11	-0.24	
12	nd	
13	-0.48	
14	nd	
15	nd	
Prevalence (%)	40.0	50.0
Mean log cfu/cm^2	-0.40	0

- Area 'punched' on carcase estimated at 1,500 cm^2
- Area sampled on carcase hindquarters estimated at 3,000 cm^2