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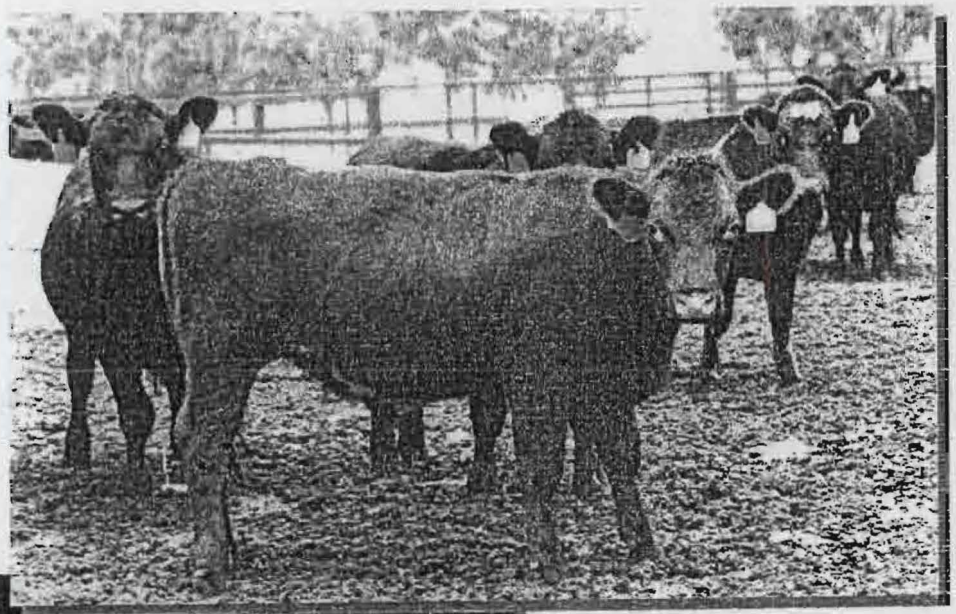
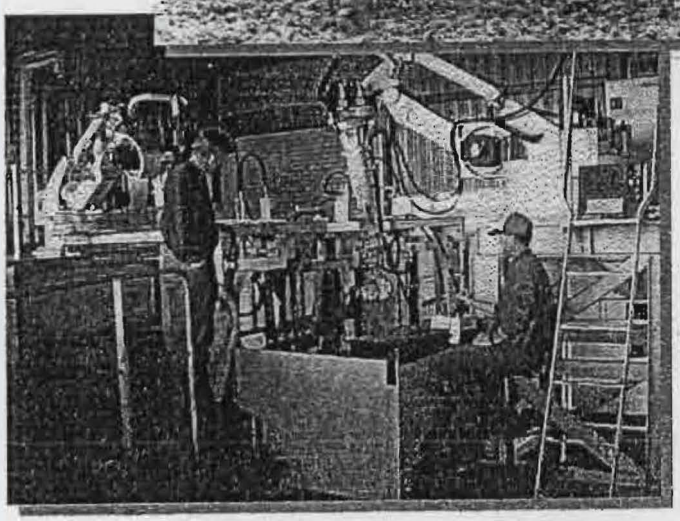
WELFARE ASSESSMENT OF CATTLE CLEANING TECHNIQUES





FINAL REPORT

DECEMBER 1998

NSW Agriculture

Beef Industry Centre
ARMIDALE

MEAT & LIVESTOCK
AUSTRALIA

Report to Meat & Livestock Australia Ltd

WELFARE ASSESSMENT OF CATTLE CLEANING TECHNIQUES

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December 1998

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PART 1 ABSTRACT

The Rockdale Dedag Machine did not elevate plasma cortisol or result in residual psychological stress beyond levels associated with other procedures involving similar handling of animals. However, cortisol levels associated with the Rockdale Dedag Machine, Shearing and Control groups were high compared to other cattle handling studies, indicating that the general handling procedure employed for these groups was relatively stressful, more so than the cleaning procedures themselves. Behavioural indices also support the notion that cattle handling procedures impacted more on animal welfare than did cleaning. At completion of the washing procedure, cortisol levels were lower than for the Rockdale Dedag Machine, Shearing and Control groups. Pre-shearing resulted in lower cortisol levels compared to animals which were not pre-shorn, although this result appeared confounded by residual effects of drafting animals immediately prior to commencement of welfare assessment. Residual psychological effects were indicated by a strong correlation ($r = 0.73$, $P < 0.001$) between cortisol levels on day 2 with those on day 1. This result was also indicative that any residual psychological stress was associated more with the overall cattle handling experience than with the cleaning treatments *per se*. It is concluded that the Rockdale Dedag Machine and shearing of cattle do not result in undue stress in cattle. Although the prolonged washing procedure appeared to be very benign by this method of study, a more detailed study over a longer period is recommended.

PART 2 EXECUTIVE SUMMARY

(i) Objectives

To conduct a welfare assessment of the Rockdale Dedag Machine (RDDM) relative to other beef industry cattle cleaning practices for support of the process and later defence of its use by industry if required, and to aid in interpretation of meat quality issues resulting from cattle cleaning techniques should they occur.

(ii) Brief methodology

One hundred and ten steers, 45 of which were pre-shorn, of similar Bos taurus genotype were studied. The cattle were part of the 200 steers (90 pre-shorn) in the overall cattle cleaning study coordinated by Agriculture Victoria. Approximately 9 weeks later, pre-shorn and unshorn animals underwent cleaning using either the RDDM, shearing or washing procedures. Control animals were managed in a similar manner to the RDDM and shearing procedures but were not cleaned. The day following cleaning the groups were handled using the same facilities as on the previous day, but without cleaning, to enable an assessment of residual psychological effects to be made. Stress resulting from the procedures was assessed using plasma cortisol concentration and various behavioural indices.

(iii) Main results and conclusions

The RDDM did not elevate plasma cortisol or result in residual psychological stress beyond levels associated with other procedures involving similar handling of animals. However, plasma cortisol levels associated with RDDM, shearing and control groups were high compared to other cattle handling studies, indicative that the general handling procedure employed for these groups was stressful and, in all likelihood, handling practices stressed the animals more than the cleaning procedures *per se*. Cortisol levels were far lower after the more chronic washing procedure than after the more acute RDDM, shearing and control procedures. Pre-shearing resulted in lower cortisol levels compared to animals which were not pre-shorn, although this result appears to have been confounded by residual effects of drafting just prior to the welfare assessment.

(iv) Recommendations

- The RDDM be considered as a viable option for cleaning cattle as it does not stress cattle beyond levels associated with usual husbandry practices.
- Handling practices associated with the RDDM be designed and conducted to minimise stress.
- A further investigation to assess the extent to which animals are stressed during washing procedures, and effects of washing in differing climatic conditions on cattle welfare be conducted.

PART 3 THE REPORT

(i) Background and industry context

Contamination of cattle with mud and excrement which forms balls on the hide known as dags can result in refusal by abattoir management to slaughter animals, in which case they must be cleaned. This may require transport back to the point of origin for cleaning and subsequent re-transport to the abattoir. It has been reported that cattle slaughtered with mud and excrement on their hides the risk of contamination of carcases during hide removal is increased, with consequent potential for hygiene problems.

A widely used industry practice to remove dags is to wash cattle using a soaking procedure and then a high pressure hose. This procedure may be only partially effective and is time consuming. It results in wet cattle, which may have adverse effects on cattle welfare and meat quality during winter when dags are more prevalent.

A machine known as the "Rockdale Dedag Machine" (RDDM) which can clean approximately 40 cattle per hour has been developed as an alternative to current practices. The machine utilises rotating cleaning drums and robotics to remove the dags and the process does not result in wetting of cattle. Other alternatives being considered by industry are shearing of the lower portion of cattle either well before and/or just prior to slaughter, and inclusion of a detergent in the current washing procedure to increase its effectiveness.

Meat & Livestock Australia Ltd funded this study to assess effectiveness of cleaning, animal welfare, meat quality, occupational health and safety, and costs associated with the RDDM in comparison with other industry practices. The study was coordinated by Agriculture Victoria. We were invited to conduct the animal welfare assessment.

(ii) **Objectives**

To conduct a welfare assessment of the RDDM relative to other beef industry cattle cleaning practices for support of the process and later defence of its use by industry if required, and to aid in interpretation of meat quality issues resulting from cattle cleaning techniques should they occur.

(iii) **Methodology**

One hundred and ten steers of similar Bos taurus genotype were studied. Of these, 45 were pre-shorn using the Parke Roto-Shear. The cattle were part of the 200 steers (90 pre-shorn) in the overall cattle cleaning study coordinated by Agriculture Victoria. Approximately 9 weeks later, Pre-shorn and unshorn animals underwent cleaning using either RDDM, shearing with the Parke Roto-Shear, or washing procedures. Control animals were managed in a similar manner to the RDDM and shearing procedures but were not cleaned. The following day the groups were again managed using the same handling facilities as on the previous day, but without cleaning, to enable an assessment of residual psychological effects to be made.

All cattle were Hereford or Hereford × Angus steers which were predominantly 2-tooth (mean ± SEM 2.4 ± 0.1). Average live weight (LW) at induction was 428 kg, and cattle had been on feed for 156 d when the welfare assessment was undertaken. At this time, LW was not recorded as planned because the cattle were too large to enter the race leading to the weighing crush. However, carcase weight averaged 402 kg suggesting the cattle were about 700 kg LW at the time of the welfare assessment (assuming a dressing percentage of 56-57 %). Based on these data, the cattle averaged a growth rate of about 1.75 kg/d from induction to slaughter.

Animals were drafted into treatment groups from about 0700 to 0930 h on the morning of cleaning (day 1), and remained in these groups until completion of behavioural assessment and sampling on the following day. Welfare assessment of the shearing commenced at 1020 h and of the RDDM at 1200 h. The Control animals were run

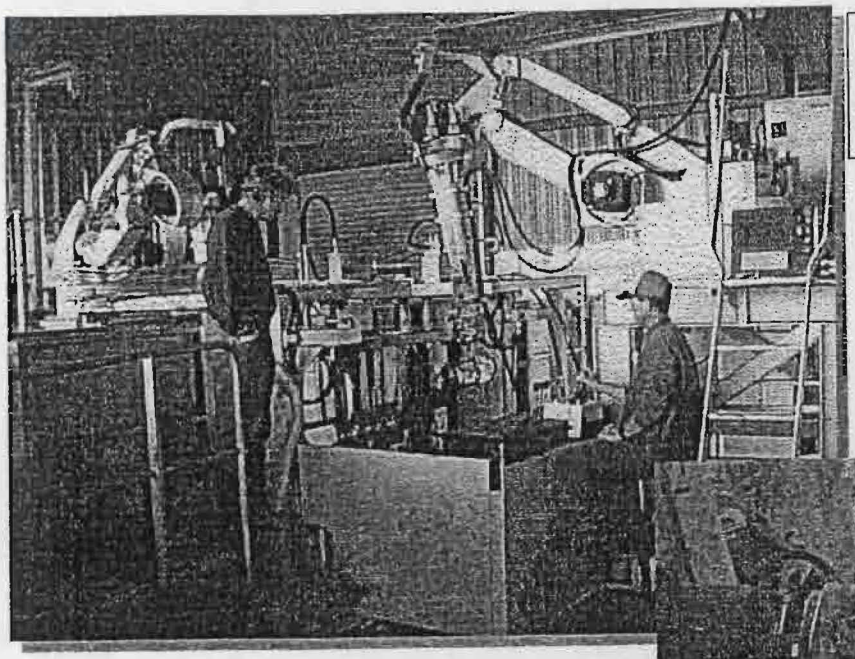
through the same race and were held in the same crush for the same approximate average period as the RDDM procedure (60 sec/animal). Welfare assessment of the Control animals commenced at 1530 h.

Timed, guided observations were made of animal behaviour in the race prior to the procedures and in the crush. Timed observations included duration in the crush and duration of the cleaning procedure. Behavioural observations included race and crush agitation scores (scale 1-5, see Table 1), entry and exit ease of movement scores (scale 1-3, see Table 1), and number of bellows. These behavioural assessments were based on those previously developed by Hearnshaw at al. (1979) and Grandin (1993; 1994) which are widely accepted.

Behavioural assessments were repeated for the Shearing, RDDM and Control groups on the following day at very similar times of day. Animals in the Control, RDDM and Shearing treatments were handled in the same general manner as for the previous day, although drafting was not repeated, and were held in the crush for 60 sec, about the same average length of time as on the previous day.

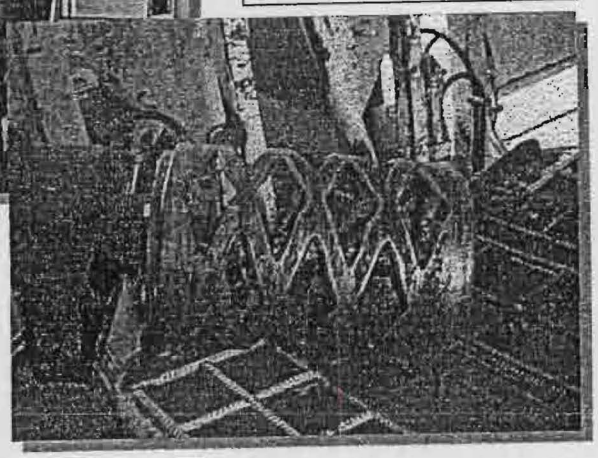
Following the Control, RDDM and Shearing procedures on both days, animals were moved to the sampling race in groups of approximately 10, and 5 mL of blood was collected from the tail vein into EDTA tubes as close as possible to 30 min after cessation of the procedure for each animal. The time of blood sampling was recorded.

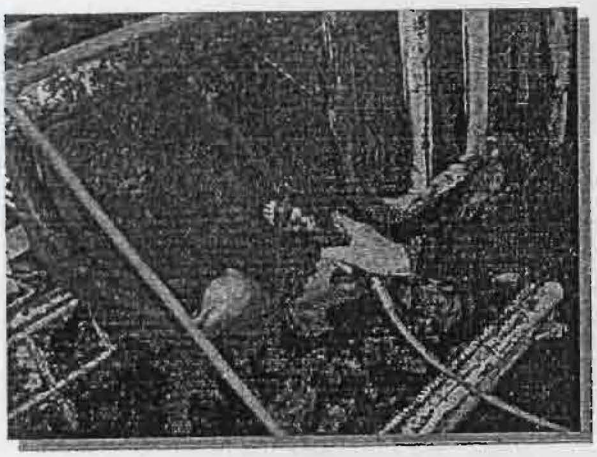
Washing was a more prolonged (4 h) multi-step procedure requiring 3 h soaking and 1 h hosing, hence it did not constitute the same type of acute stressor as the other treatments. The more chronic nature of the washing procedure, the concurrent conduct of the more acute procedures limiting our capacity to observe animals, and the need for the Washed animals to remain in their group throughout the procedure, necessitated the assessment protocol for these animals to be limited to blood collection and cortisol assay.



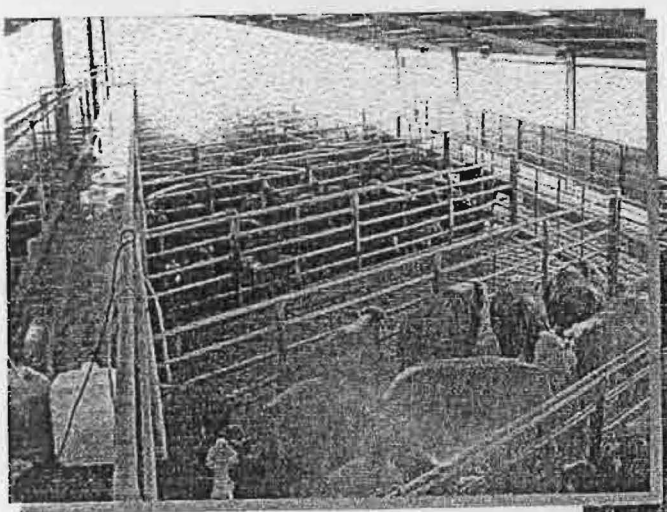
left: A general view of the Rockdale De-dag Machine (RDDM).

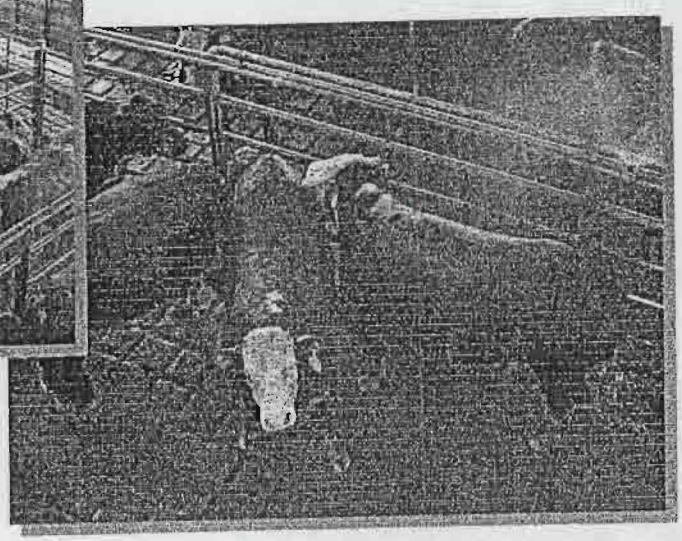
below: A closer view of the RDDM rotating drum.





left: The shearing treatment performed with the Parke Roto-Shear.





above and right: The washing treatment shown during the soaking phase.

For the Washing treatment, 10 animals (5 unshorn, 5 pre-shorn) were blood sampled in the same race as the RDDM, Shearing and Control groups, as close as possible to 30 min after completion of the procedure to provide Base-line values. On the day following washing, animals in the Washing treatment were run into the washing pen and held for 5 min, prior to blood sampling to assess residual psychological stress. The same animals sampled on the previous day were again sampled 30 min after leaving the washing area.

Blood was centrifuged after the completion of sampling from each treatment group and the plasma was stored frozen and transported to Armidale. Plasma cortisol concentration was measured by radioimmunoassay using Orion Diagnostica assay kits. The use of cortisol measurement as a key indicator of stress and welfare in cattle, particularly the effects of handling practices is widely accepted (Stephens and Toner, 1975; Broom and Johnson, 1993).

Data were analysed using a general linear model (SAS, 1996). Analyses of effects of plasma cortisol concentration included pre-treatment behavioural indices, length of time in the crush, duration of treatment, and time from treatment to blood collection as covariates. In all cases these were not significant ($P > 0.05$). Statistical significance for effects of treatments was accepted at $P < 0.05$.

(iv) **Results**

EFFECTS OF TREATMENTS ON DAY 1 (Tables 1 and 2)

Plasma cortisol

Plasma cortisol was highest in the Shorn and Control cattle and significantly lower lower in the RDDM and Washed cattle, respectively (Table 1). Shorn cattle which had undergone Pre-shearing had significantly lower plasma cortisol than their unshorn counterparts (Table 2).

Race bellows

No bellows were recorded in the race immediately prior to entry into the crush.

Race agitation

Race agitation score did not differ between Control, Shorn and RDDM cattle or due to pre-shearing treatment.

Entry ease of movement

Control animals were more agitated and moved faster during entry into the crush than RDDM or Shorn animals (Table 1). Shorn cattle tended to be more reluctant to enter the crush than RDDM cattle (Table 1). No effect of pre-shearing treatment was evident (Table 2).

Crush bellows

There was no difference in the incidence or number of bellows between the treatment groups. Four percent of animals bellowed while in the crush. Within the RDDM and Shorn treatments 5% of animals (2/40 for each treatment) bellowed.

Treatment/crush agitation

Shorn animals tended to be less agitated during treatment than Control or RDDM cattle (Table 1). The Pre-shorn Shear group was less agitated than the unshorn RDDM group and tended to be less agitated than the Pre-shorn RDDM group (Table 2).

Exit ease of movement

The shorn animals exhibited a more rapid exit from the crush than the RDDM cattle (Table 1). The Shorn group which did not undergo Pre-shearing had the fastest exit speed which was significantly greater than the corresponding RDDM cattle (Table 2).

Table 1. Plasma cortisol concentration and behavioural indices associated with cattle which underwent different cleaning regimens (day 1). Mean values in the same row without the same superscripts are significantly different ($P < 0.05$).

	Control	Shear	RDDM	Wash	Pooled standard error
Plasma cortisol (nmol/L)	300[a]	296[a]	230[b]	146[c]	16
Race agitation score[1]	2.05[a]	2.10[a]	2.15[a]	NA[3]	0.08
Entry ease of movement score[2]	1.95[a]	2.30[b*]	2.15[ab]	NA	0.14
Treatment/crush agitation score[1]	2.40[a]	2.05[b*]	2.35[a]	NA	0.13
Bellows during treatment	0.00[a]	0.30[a]	0.20[a]	NA	0.19
Exit ease of movement score[2]	2.20[ab]	2.05[a]	2.40[b]	NA	0.11

[*] Approaching significance ($P < 0.10$)

[1] Agitation score: 1 = calm (no movement), 2 = slightly restless, 3 = squirming, occasional shaking of crush, 4 = continuous, very vigorous movement and shaking of the crush, 5 = Rearing, twisting of the body and violent struggle

[2] Ease of movement score: 1 = fast (agitated), 2 = medium, 3 = slow (reluctance)

[3] Not applicable

Table 2. Plasma cortisol concentration and behavioural indices associated with pre-shorn and unshorn cattle which underwent different cleaning regimens (day 1). Mean values in the same row without the same superscripts are significantly different ($P < 0.05$).

	Shear		RDDM		Wash		Pooled standard error
	Pre-shorn	Unshorn	Pre-shorn	Unshorn	Pre-shorn	Unshorn	
Plasma cortisol (nmol/L)	237[a]	296[b]	217[a]	229[a]	166[c]	146[c]	17
Race agitation score[1]	2.10[a]	2.10[a]	2.05[a]	2.15[a]	NA[3]	NA	0.10
Entry ease of movement score[2]	2.30[a]	2.30[a]	2.10[a]	2.15[a]	NA	NA	0.13
Treatment/crush agitation score[1]	1.85[ab]	2.05[b*]	2.20[bc*]	2.35[c]	NA	NA	0.12
Bellows during treatment	0.00[a]	0.30[a]	0.05[a]	0.20[a]	NA	NA	0.16
Exit ease of movement score[2]	2.30[ab]	2.05[a]	2.20[ab]	2.40[b]	NA	NA	0.11

[*] Approaching significance ($P < 0.10$)

[1] Agitation score: 1 = calm (no movement), 2 = slightly restless, 3 = squirming, occasional shaking of crush, 4 = continuous, very vigorous movement and shaking of the crush, 5 = Rearing, twisting of the body and violent struggle

[2] Ease of movement score: 1 = fast (agitated), 2 = medium, 3 = slow (reluctance)

[3] Not applicable

EFFECTS OF TREATMENTS ON DAY 2 (Tables 3 and 4)

Plasma cortisol

Plasma cortisol was highest for the Control animals which had significantly higher levels than the Shorn, RDDM or Wash groups. The Shorn animals tended to have higher levels than the RDDM group. The Washed animals had significantly lower plasma cortisol than all other treatment groups.

Race bellows

There were no bellows in the race immediately prior to entry into the crush.

Race agitation

The Shorn group showed more agitation than the RDDM group in the race prior to entering the crush (Table 3).

Entry ease of movement

The Shorn group tended to move more rapidly into the crush than the Control group (Table 3). There was no effect of Pre-shearing.

Crush bellows

There was no difference in the incidence or number of bellows between the treatment groups. Two percent of all animals, which were in the RDDM group, bellowed while in the crush.

Crush agitation

Crush agitation tended to be greater in the Shear group (Table 3). The Shear group which was not Pre-shorn had a higher agitation score than the other groups. Similarly, the unshorn RDDM group was more agitated than the Pre-shorn RDDM group (Table 4).

Exit ease of movement

The RDDM cattle showed more reluctance to leave the crush than the Control animals and tended to show more reluctance than the Shorn animals (Table 3).

Table 3. Plasma cortisol concentration and behavioural indices associated with cattle which underwent different cleaning regimens (day 2). Mean values in the same row without the same superscripts are significantly different ($P < 0.05$).

	Control	Shear	RDDM	Wash	Pooled standard error
Plasma cortisol (nmol/L)	334^{a}	281^{b}	228^{cd*}	130^{e}	17
Race agitation score[1]	2.25^{ac}	2.30^{a}	2.05^{c}	NA[3]	0.09
Entry ease of movement score[2]	2.00^{a*}	1.65^{b*}	1.80^{ab}	NA	0.14
Crush agitation score[1]	2.40^{a}	2.70^{b*}	2.40^{a}	NA	0.12
Bellows during treatment	0.00^{a}	0.00^{a}	0.05^{a}	NA	0.03
Exit ease of movement score[2]	1.95^{a}	2.05^{a*}	2.30^{b}	NA	0.10

* Approaching significance ($P < 0.10$)

[1] Agitation score: 1 = calm (no movement), 2 = slightly restless, 3 = squirming, occasional shaking of crush, 4 = continuous, very vigorous movement and shaking of the crush, 5 = Rearing, twisting of the body and violent struggle

[2] Ease of movement score: 1 = fast (agitated), 2 = medium, 3 = slow (reluctance)

[3] Not applicable

Table 4. Plasma cortisol concentration and behavioural indices associated with pre-shorn and unshorn cattle which underwent different cleaning regimens (day 2). Mean values in the same row without the same superscripts are significantly different ($P < 0.05$).

	Shear		RDDM		Wash		Pooled standard error
	Pre-shorn	Unshorn	Pre-shorn	Unshorn	Pre-shorn	Unshorn	
Plasma cortisol (nmol/L)	226^{a}	281^{b}	182^{a}	228^{c*}	115^{d}	130^{d}	18
Race agitation score[1]	2.45^{a}	2.30^{ab*}	2.10^{bc}	2.05^{c}	NA[3]	NA	0.10
Entry ease of movement score[2]	1.80^{a}	1.65^{a}	1.85^{a}	1.80^{a}	NA	NA	0.13
Crush agitation score[1]	2.10^{a}	2.70^{b}	2.00^{a}	2.40^{cd*}	NA	NA	0.11
Bellows during treatment	0.00^{a}	0.00^{a}	0.75^{a}	0.05^{a}	NA	NA	0.38
Exit ease of movement score[2]	2.20^{ab}	2.05^{a}	2.15^{ab}	2.30^{bc*}	NA	NA	0.09

* Approaching significance ($P < 0.10$)

[1] Agitation score: 1 = calm (no movement), 2 = slightly restless, 3 = squirming, occasional shaking of crush, 4 = continuous, very vigorous movement and shaking of the crush, 5 = Rearing, twisting of the body and violent struggle

[2] Ease of movement score: 1 = fast (agitated), 2 = medium, 3 = slow (reluctance)

[3] Not applicable

COMPARISON OF DAY 1 AND DAY 2 AND OVERALL TREATMENT EFFECTS

Plasma cortisol

There was no difference between day 1 and day 2 in cortisol concentration (247 ± 8 cf 239 ± 10 nmol/L, respectively). There was a strong correlation ($r = 0.73$, $P < 0.001$) between the cortisol levels on days 1 and 2. There was clearly no interaction between day and treatment which indicates there was no residual effect of a particular cleaning treatment. Within the Shear and RDDM groups, cattle not Pre-shorn had higher plasma cortisol overall than those that had been shorn 9 weeks earlier (258 vs 215 nmol/L, pooled SE = 8.4 nmol/L).

Race agitation

Race agitation score did not differ due to day between treatment groups. There was a tendency towards a higher race agitation score on day 2 (2.23 vs 2.10, pooled SE = 0.05) when comparing effects of Pre-shearing treatment.

Entry ease of movement

Cattle were significantly more reluctant to move into the crush on day 1 (2.13 vs 1.82, pooled SE = 0.08).

Crush bellows

There was no difference in the incidence or number of bellows between days.

Crush Agitation

Cattle were more agitated while in the crush on day 2 (2.30 vs 2.11, pooled SE = 0.06). Animals which were not pre-shorn had a higher treatment/crush agitation score overall (2.38 vs 2.04, pooled SE = 0.06).

Exit ease of movement

There was no difference due to day in exit ease of movement score.

(v) Discussion

The results of this study suggest the Rockdale Dedag Machine does not result in animals being stressed beyond levels normally associated with holding animals in a crush. This conclusion is drawn from the findings that the RDDM did not result in elevated cortisol levels, adverse effects on cattle behaviour, or residual psychological effects specific to the RDDM.

The results also demonstrate the importance of handling and management to cattle welfare. This finding is emphasised by cortisol levels that were very high compared with other studies which assessed effects of handling on stress and welfare of cattle (Stephens and Toner, 1975; Grandin, 1993; Fell et al., 1997; Fell and Wilson, 1998). Fell et al. (1997) reported levels typically around 100 nmol/L during regular handling but reaching 250 nmol/L during feedlot induction procedures. This result could be due to various factors, most notably:

- Animals were drafted on the morning of the welfare assessment, not on the day prior as scheduled. Drafting was performed using a long open-sided race and not through the closed-sided induction race as planned, because of the delay in the conduct of the study resulting in cattle being too large for the race. Animals were observed exhibiting extremely agitated behaviour in the drafting race and in laneways following drafting. A number of animals were also observed crashing into the gate at the end of the laneway. These factors are likely to have contributed to the very high cortisol levels for the first group cleaned (Shear/not Pre-shorn).
- Animals were not fed on the morning of the welfare assessment.
- Different animal handlers moved cattle to the cleaning area. It was apparent that the handling methods employed by individuals varied widely, ranging from an easy non-forcing approach to an aggressive approach including the use of a stockwhip on the cattle. Abusive employee behaviour is recognised as one of the major contributors to stress in cattle (Grandin, 1998).
- Because of variable availability of stockmen, on both days Control animals were moved from their holding pen into the yard and raceway associated with the cleaning

(v) Discussion

The results of this study suggest the Rockdale Dedag Machine does not result in animals being stressed beyond levels normally associated with holding animals in a crush. This conclusion is drawn from the findings that the RDDM did not result in elevated cortisol levels, adverse effects on cattle behaviour, or residual psychological effects specific to the RDDM.

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- Animals were not fed on the morning of the welfare assessment.
- Different animal handlers moved cattle to the cleaning area. It was apparent that the handling methods employed by individuals varied widely, ranging from an easy non-forcing approach to an aggressive approach including the use of a stockwhip on the cattle. Abusive employee behaviour is recognised as one of the major contributors to stress in cattle (Grandin, 1998).
- Because of variable availability of stockmen, on both days Control animals were moved from their holding pen into the yard and raceway associated with the cleaning

facility by individuals on foot rather than on horseback. Again, depending upon the availability of stockmen, animals were moved to the bleeding area by stockmen on horseback or by individuals on foot.

- As a general observation, the cattle were more agitated during blood collection compared with other studies in which we have been involved. Collection of blood was performed in the same open race as used for drafting, rather than in the hospital area crush as planned. This allowed a high degree of movement by cattle during the blood collection procedure.

The high correlation between cortisol levels for individual cattle on day 1 and day 2, and lack of a significant effect of day on plasma cortisol level are also indicative that the handling procedures for the Shear, RDDM and Control groups were more stressful than the cleaning procedures. These findings also indicate residual psychological stress resulting from the animal handling procedures on day 1 when cleaning occurred. The results also demonstrate that the cortisol response to handling was a characteristic of the animal, more or less regardless of the cleaning treatment imposed.

The cattle in the study were relatively clean due to the delay in conduct of the study resulting in some loss of dags due to the commencement of coat shedding and relatively dry conditions. However, failure to observe any significant effect of duration of the cleaning procedures on plasma cortisol also provides evidence that the treatments were not overtly stressful. This finding is further emphasised by the lack of agitation of cattle during cleaning.

In comparison with the washing procedure, all animals that underwent handling through the cattle crush area had very high cortisol levels. Because the washing procedure was far more prolonged (4 h) and was a group procedure, some caution must be exercised in interpreting this finding. Our results simply measured plasma cortisol concentration 30 min after cessation of the procedure and do not provide detail of stress levels of individuals during the procedure. In particular, details of levels 30 min after

commencement of spray washing or high pressure hosing of individuals would shed more light on welfare of animals undergoing washing.

Despite the above mentioned limitations on welfare assessment of washing, the washed animals again had low cortisol levels on day 2 when they were returned to the washing area prior to blood sampling. This finding indicates that there was little residual psychological stress resultant from the washing process as a whole compared to the procedures associated with cleaning animals in the cattle crush. It would be of interest, however, to assess effects of washing during cold and/or windy conditions, particularly in Pre-shorn animals.

(vi) **Conclusions**

RDDM and Shearing do not elevate plasma cortisol, have adverse behavioural effects, or result in residual psychological stress beyond levels associated with other procedures involving similar handling of animals.

Plasma cortisol levels associated with RDDM, Shearing and Control groups were high compared to other cattle handling studies, indicating that the general handling procedures for these groups was relatively stressful.

The washing procedure resulted in lower cortisol levels 30 min after completion of the procedure compared with the RDDM, Shearing and Control groups. These levels were within the range more normally associated with cattle yarding procedures.

(vii) **Recommendations**

a. The Rockdale Dedag Machine be considered as a viable option for cleaning of cattle prior to slaughter provided that handling procedures associated with the process minimise stress in cattle.

b. A more thorough investigation of the washing treatment would be necessary to evaluate the procedure adequately from an animal welfare perspective, but there did not appear to be any problems with it in the current study.

(viii) **Success in achieving objectives**

This study provided information on stress and welfare associated with the Rockdale Dedag Machine in comparison with other industry cattle cleaning practices and, therefore, we achieved the objective of the study. Interpretation of the cortisol response to cleaning was confounded somewhat by results which appeared to be more influenced by the particular cattle handling practices used during the study.

(ix) **Impact on meat and livestock industry**

The Rockdale Dedag Machine has the potential to reduce contamination on hides of cattle due for slaughter. Inclusion of this process in feedlots and/or on-site at abattoirs has the potential to markedly reduce the number of rejections of cattle at abattoirs, provided cattle handling techniques associated with its use are designed to minimise stress.

(x) **Total funding and MLA contribution**

Meat & Livestock Australia Ltd provided funding totalling $8,025. In addition, NSW Agriculture provided financial support totalling approximately $10,000.

(xi) **Acknowledgments**

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