final report

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Open Innovation Invention Solution for Feedlot Dag Prevention and Management

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Executive summary

The value of Australia's cattle industry last year was almost $17 billion (Van Moort et al. 2018), making it the single largest contributor to the annual value of Australian agricultural production. To remain efficient and globally competitive, it is important that the industry's challenges and issues are addressed.

One of the issues faced by the industry is the presence of dags on feedlot cattle. Dags are the build-up of mud and manure on hides, which presents issues for various stakeholders in the value chain. This report summarises a broad exploration of this problem and the solution categories that exist to address and manage the impact from dags.

This study has taken a design-led approach to exploring and examining the impact of dag contamination on the Australian cattle industry and its stakeholders. The project explored this issue via stakeholder interviews specifically focused on the feedlot and processor sectors of the value chain. A mixed methods approach was employed to provide a balanced assessment of the dag issue through the desirable, feasible, and viable design thinking lenses. The purpose of the project was to better understand the basic requirements for designing and developing solutions to address the dag problem in the Australian cattle industry.

Information gained from stakeholder interviews and a meta scan of existing knowledge was used to analyse the value chain, to identify tangible and intangible exchanges between key stakeholders. A workshop was subsequently conducted to interpret and validate findings, to identify scenarios, and to focus on solution categories. Additional stakeholder interviews and a site visit were undertaken to validate the findings that support key solution categories.

These investigations identified that the dag problem originates almost exclusively at feedlots and that three key components dictate the severity of the problem: wet weather, geographical location, and cattle type. Stakeholders in southern Australia, who tend to operate in wetter areas and with long-haired cattle, are more affected than stakeholders in northern regions, who operate in drier areas and mainly with short-haired cattle.

Feedlots have little incentive to deal with the issue of dags. Where they do, it appears to be associated with vertically integrated supply arrangements, and typically involves sophisticated automatic washing facilities. This is more common in the north than in the south and is associated with business strategies seeking to exploit economies of scale.

The cost of dag removal is largely carried by processors and predominantly involves the allocation of extra personnel to remove dags and an increase in water usage. The interview process identified that microbiological contamination of beef products due to dags could have a significant financial and reputational impact on individual stakeholders and the entire Australian cattle industry.

The bottom line effect of dags on processors' revenues (around 0.05%) is approximately double that on feedlotters' revenues (around 0.025%), suggesting that the value of solving the issue is lower than had been expected and that the cost burden is mostly worn by processors. For feedlotters, treating daggy cattle effectively is not as crucial as for processors, given that they can choose a variety of selling alternatives (i.e. saleyards, live exporters, see Figure 4), each one with different cattle cleanliness standards.

The technology search, including a scan of registered intellectual property, demonstrated that dag removal technologies currently consist of either hand tools or automated water and roller-based cattle cleaning machinery. Further, dag prevention technologies are mostly focussed around shed design and construction, or

methods that automatically remove dag-forming materials from feedlots and holding pens. Prevention technologies are virtually non-existent and may require significant CAPEX and/or process modifications.

Based on stakeholder views, previous economic studies and our own value chain analysis, it is evident that the impact of the problem is currently subdued by drier conditions and not widespread. The value proposition for any intervention is additionally hampered by the separation of cause and impact between producers and processors. Despite these challenges the following solution areas were identified for solution sourcing:

Solution Area	Key Solution Criteria
Dag Prevention. Polymer coating application and formulations. Improved application and formulations of polymer coating applied to hides to prevent or limit dags and to prevent or limit dag contamination.	<$1 per treatment Eliminate need for dag removal Speed and ease of application
Efficient & Safe Dag Removal. Infrastructure, tools and methods to safely remove dags from cattle without causing animal stress or increasing risks to worker safety and contamination in processing.	<$10 per treatment Increased worker safety Reduced animal stress Reduced food contamination risk
Microbe Detection and Decontamination. The detection and (potentially) removal of microbes in the meat processing chain arising from sources including dags contamination.	Adhere food safety regulations Detect very low-level pathogens Not increase processing costs Not affect product quality

While promising solution criteria have been constructed from the analysis, there are a number of coalescing factors uncovered by the project that cast doubt on the viability of any solutions. The geographic extent of the problem, disconnection between the stakeholders originating the problem and those experiencing its impacts, and lower than expected financial impact on any of the participants has meant this project is recommended to be placed on hold until further notice.

The project has been extremely valuable in uncovering and developing the criteria under which solutions sourced through Xinova's Global Innovator Community would be most successful. Dry conditions are, thankfully, controlling the impact of dags currently while changed climatic conditions (wetter period) will see this issue re-emerge in the future.

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1 Background

A recent report by ACIL Allen Consulting (Van Moort et al. 2018), sponsored by MLA, estimated the total cost of dags to the industry to be between $10.55 and $16.02 per head depending on severity of the issue in any given season. This translates to $4 million to $10 million per year for the entire beef industry over a 5 month period in the year. This estimation is based on percentage of dag presence in the five integrated feedlot operators that took part in the study and an average cost of per head dag management in seven cost categories:

- Labour;
- Water;
- Effluent disposal;
- Energy;
- Infrastructure (CAPEX);
- Infrastructure (OPEX); and
- End product downgrades.

This is equivalent to 0.02-0.05% of the Australian beef and cattle industry value of production (Van Moort et al. 2018).

In our own estimation of dag management costs based on modelling feedlot and processor activities we were able to validate the cost to the entire industry ($4-10m) as per Van Moort et al. (2018). In addition, our analysis revealed a distribution of costs between northern and southern Australia for both feedlots and processors. Our figures show $10.72 per head, composed of $6.34 for processors and $4.38 for feedlots. The estimated cost of dag management in the north ($3.4m) is slightly lower than the south ($4m). Further explanation of these differences between regions and value chain participants is provided in the Value Chain Analysis section below.

Although the financial impact indicated by the ACIL Allen report appears to be low, the report highlights that 2016 (when the study was undertaken) was a year of drought and low dag presence. Available data on the impact of dag are limited and indicate huge variability in that impact between contributors across time and within business and market structures. Furthermore, the cost of dag is not borne equally, with costs varying considerably between businesses depending on their location, operation, supply chain relationships and season. The total financial impact of dag in the industry may therefore be significantly higher than what is outlined in the report.

Other beef-producing countries such as USA, Canada, UK, Argentina and Brazil also appear to suffer from feedlot dag issues. However, more research is required to understand the exact impact and management of dags. The issue is increasing due to consumption and environmental trends that require cattle to be grain feed at feedlots.

Recent events in the USA and Canada provide some indication of the seriousness of dags. In September 2018, Cargil and JBS in the USA had to recall more than 7 million pounds of ground beef due to salmonella and E. coli outbreaks that caused at least 75 illnesses and one death. Although a direct link to dag is uncertain, previous studies have found bacteria in ground beef that are indicators of fecal contamination (Jesse Hirsch, 2018). A Beef Quality Audit undertaken by Canada in 2016-17 provided indications of avoidable defects in Canadian slaughter cattle and identified opportunities to avoid these defects. One of the defects identified was dag and its relationship with food safety issues through contamination in processing plants. Compared to the previous

2010-11 audit, the 2016-17 audit found almost twice as many cattle with excessive dag (15% in 2010-11, 27% in 2016-17) (Reynold Bergen, 2018).

The audit also revealed that Canadian cattle farmers address the dag issue primarily by cleaning of feedlot pens and roller compacting soil, which help to avoid mud holes and dag. In addition, they use more bedding material such as wood chips. The USA disease outbreaks and the Canadian Audit support the view that the issue of dag in a global context is real and increasing due to environmental changes and a surge in beef consumption increasing the need for feedlot cattle.

From an Australian perspective, there is consensus that the dag problem varies geographically, with the southern region, particularly mid NSW, Victoria and Tasmania, more impacted than the north. Interviewees agreed that the main factors determining the accumulation of dags are:

- Weather: Dag season appears to be 2-3 months of the year, mainly during the autumn and winter periods. Long periods of rain in these seasons magnify the problem.
- Pen conditions: Feedlots with black soil also exacerbate the problem as these soil types are associated with poor drainage.
- Cattle type: The problem occurs mainly in cattle at feedlots and is significantly worse for long-haired breeds.

In general, small-scale producers have a greater reliance on saleyards, particularly in southern Australia (Figure 2) where saleyard auctions account for almost two-thirds of beef cattle sales. Online auctions are also popular in the southern region. In the northern region (Figure 1), a much higher proportion of cattle is sold over the hooks (OTH) and through paddock sales. Live exporters primarily source cattle through paddock sales, whereas major processors tend to purchase OTH, and major supermarkets predominantly use paddock sales and forward contracts.

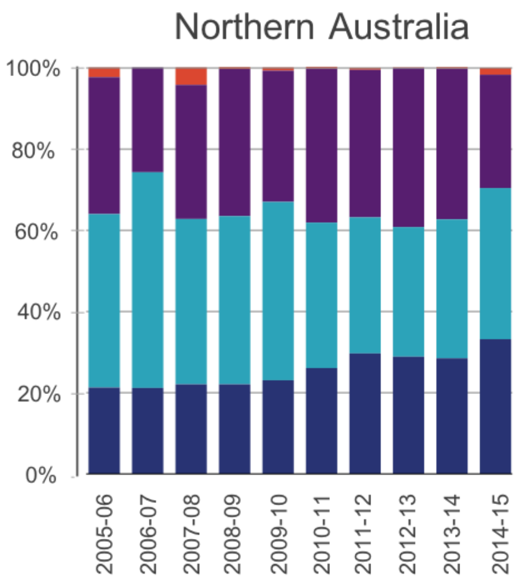


Figure 1. Method of selling cattle, northern Australia (Australian Competition and Consumer Commission, 2017))

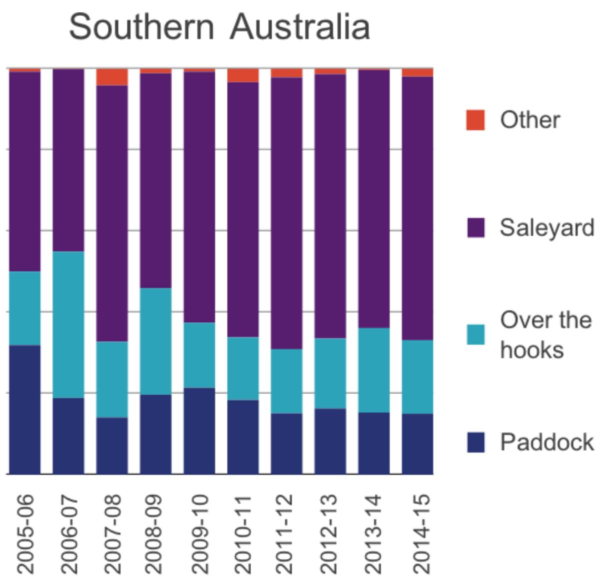


Figure 2. Method of selling cattle, southern Australia (Australian Competition and Consumer Commission, 2017)

2 Project objectives

The project scope included cattle feedlots and processors of the Australian cattle industry. Given the amount of work already done on the topic there was a requirement to underpin developments in the project process with detailed research and technology searches both

The objective of the project was to explore the cattle dag problem and propose solution areas that exist to address and manage the impact from dags.

3 Standards and Regulations

Australia's beef industry has a number of standards and regulations that apply to various parts of the value chain. Below is an overview of those that have a direct and indirect impact on the dags issue.

The Australian Animal Welfare Standards and Guidelines 2016 (Animal Health Australia, 2016) are the legal requirements that cattle producers and feedlots must follow to ensure animal welfare. These standards stress the importance of feedlot cleanliness and surface maintenance on a regular basis, to ensure pen surfaces can drain and dry freely.

The following are other mandatory requirements with which feedlots must comply:

- National Guidelines for Beef Cattle Feedlots in Australia (MLA, 2012a).
- National Beef Cattle Feedlot Environmental Code of Practice (MLA, 2012b).

These two regulations do not address animal cleanliness but emphasise the relevance of feedlot cleanliness.

Beef processing plants in Australia are governed by strict food safety standards. The national standard covering meat for human consumption in Australia is: AS 4696: 2007 Hygienic Production and Transportation of Meat and Meat Products for Human Consumption (CSIRO, 2007). Even though this standard does not address dags specifically, it does outline that ***"Animals presented for slaughter must be clean".***

In general, all food safety agencies work on a conservative philosophy that potential risk of food contamination should be addressed at the earliest opportunity in the supply chain.

Australian beef processors obtain domestic and export accreditation from AUS-MEAT to operate their facility; this accreditation is compulsory for processors wishing to export and, in some cases, a requirement if they wish to supply to supermarkets.

In addition, processing facilities exporting their products may also be audited by the overseas importers, food safety regulators or major domestic and international retailers concerned about food safety. This is done on a case by case basis and, as indicated by a few interviews, the specifics surrounding these additional food safety requirements are commercial in confidence.

4 Global Perspectives

Many countries suffer from issues related to feedlot dags. These issues are summarised below by country/region. Both extreme wet/hot (e.g. Indonesia) and extreme wet/snowy/cold (e.g. USA, Canada, UK, Europe) regions use sheds for protection and to decrease dags. Dags are a global problem.

Research indicates that cattle affected by dags eat less and are less able to deal with extremes in weather. Cattle confined to muddy pens and paddocks tend to eat less and use 20% more energy stepping in and out of mud. Dags are associated with increased stress in both cold climates where cattle are less able to insulate themselves and in hot climates where dags can cause heat stress (MLA Report B.LFT.0237).

Faecal contamination is considered the primary avenue for dissemination of pathogens on the farm (Mawdsley et al. 1995) and within meat processing establishments (Grau 1987; USDA 1996a, MLA report FLOT213, 2000.

4.1 Australia

Dags lead to increased heat stress (in northern regions, summer temperatures can exceed 45 degrees C) and cold stress (Alpine, northern highland and southern regions in winter can fall to -5 to -10 degrees C) for feedlot cattle. Regular bedding material changes and effective bedding material reduces this stress (multiple MLA reports).

4.2 New Zealand: MLA report B.FLT.0237, internet

High rainfall regions use out-wintering systems (OWPs: out-wintering paddocks). These are paddocks with woodchip pads on impermeable soils with drainage pipes installed to take manure to a storage pond or tank (various MLA reports).

4.3 USA and Canada: MLA report B.FLT.0237

Dags cause cold stress and heat loss (reduced live weight) in winter. High rainfall regions use out-wintering systems (OWPs) or corrals as for NZ or freely draining soils with no permeable lining (i.e. no woodchips).

Both covered feedlots and uncovered feedlots used with covered sheds are used more in areas with harsh winters, and corn stalk bedding is often used. Covered feedlots also use use sawdust and straw bedding material. Many US feedlots hold 1000 head or less.

Marbling percentage and dressing score is improved by reducing dags and properly maintaining pen bedding material; this also produces 6-7% better weight gain than daggy/muddy cattle. Some physical dag removal along cut lines is undertaken in processing plants.

4.4 UK, Ireland and Scotland: MLA report B.FLT.0237, internet

High rainfall regions use OWPs as in NZ and USA. Dags are referred to as 'dung cladding'. Tozan (2000) suggested enzyme solutions are effective to help soften dags (disputed by CSIRO work in an Australian context). Adhesion is between dung and hair alone; cellulase, xylanase and laccase are used to increase dung solubilisation (effective after 6-24 hours).

Washing and disinfection is utilised in Ireland to reduce faecal contamination in markets, thereby reducing the risk of disease spread among animals and of carcass contamination at slaughter. (https://irishvetjournal.biomedcentral.com/articles/10.1186/s13620-017-0081-1 Connor, 2017).

4.5 Europe: MLA report B.FLT.0237, internet

Countries that produce beef and use feedlots include Germany, France, Spain, Estonia, Italy, Poland, Czech Republic, Sweden and Austria. Cold climate countries use both enclosed sheds and uncovered areas, depending on winter severity and rainfall in warmer weather. Interventions focus on use of sheds and management of bedding material. Feedlot dags are recognised as an issue, to varying degrees, in all countries.

4.6 South America: MLA report B.FLT.0237, internet

Feedlot production is increasing in Argentina and Brazil (9.3 million tonnes of beef is produced annually in Brazil) (https://www.dandc.eu/en/article/cattle-industry-argentina-changing-rapidly-not-better, (https://www.dlg.org/fileadmin/downloads/member/news/beef_agribenchmark.pdf). Peru, Colombia, Uruguay and Mexico are also significant producers with some shedding used in hot and wet areas. Feedlots are mostly uncovered in Argentina and Brazil.

4.7 South Africa and Northern Africa: MLA report B.FLT.0237

In South Africa, 95% of beef comes from feedlots (Sth African Feedlot Association http://safeedlot.co.za/; https://www.drovers.com/article/behind-scenes-feedlot-south-africa). Feedlots are generally uncovered.

In northern Africa, Morocco, Algeria and Tunisia use mostly uncovered lots but some covered feedlots exist. Data on feedlot dags for northern African countries are difficult to obtain.

4.8 Live Export to Middle East: MLA B.FLT.0237

Bedding material absorbency quality is the most critical issue for live transport as it removes moisture from dung (MLA Report B.LFT.0237 and Banney et al. 2009). Cattle respond to the movement of boats in rough conditions by lying down, which leads to both injuries and increased occurrence of dags.

4.9 Indonesia:

Covered feedlots are commonly used due to high rainfall and exposure to strong sunlight.

5 Approach

The MDC/Xinova strategy provides the framework and agility, based on principles of design-led innovation, to navigate the ambiguity associated with complex multi-facetted problems.

Phase 2 of the methodology seeks to explore the problem to ensure subsequent phases are focused around how the problem can best be addressed by one or multiple solutions, at various points along the value chain (Figure 3).

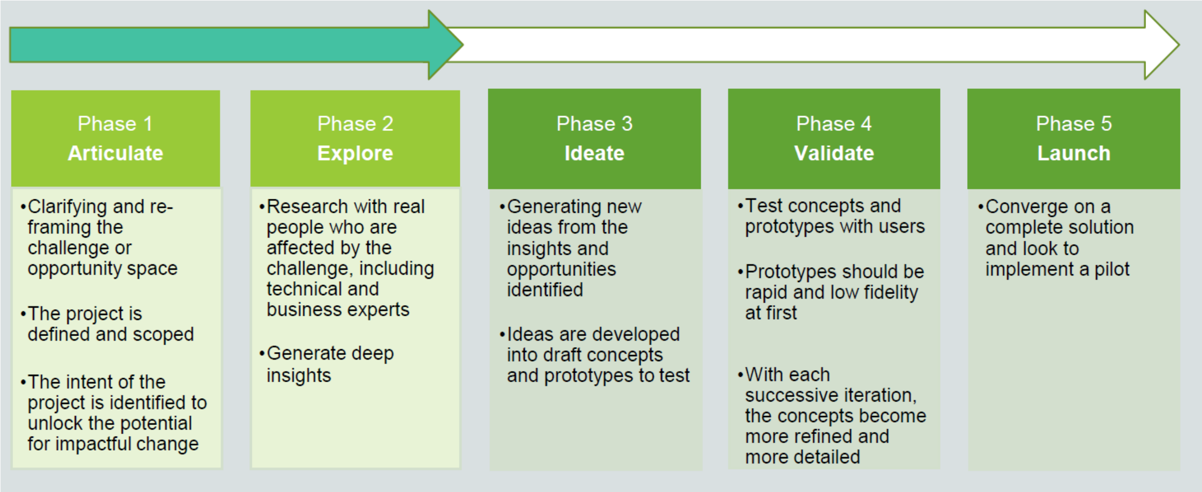


Figure 3. Current stage of the project

The exploration phase of this project involved a series of stakeholder interviews with producers, and staff at saleyards, feedlots, processing operations and regulatory bodies to explore the dag issue, with specific focus on the feedlot and meat processing sectors.

The process included a mixed methods approach bringing together both qualitative and quantitative methods for value chain analysis, technology search and assessments as well as semi-structured interviews. Together, this approach, provided a balanced assessment of the dags issue through the design thinking lenses of customer desirability, technology feasibility, and business model viability.

The high level process of Phase 2 included:

1. **An initial scan** to map and contextualise the existing knowledge base in relation to the dag problem.
2. **Semi-structured Interviews** with 24 stakeholders in the value chain, specifically focused on feedlots and processors.
3. **A value chain analysis** outlining tangible and intangible exchanges between key stakeholders. A network approach better captures behaviour of value chain participants and highlights potential opportunity areas.
4. **A synthesis workshop** with key Xinova and Asymmetric Innovation staff to help interpret and validate findings, identify scenarios and begin to narrow in on the key solution categories warranting further exploration.
5. **Additional stakeholder interviews** and a site visit to an integrated feedlot and processor operation to validate findings.
6. **Scan of existing technologies**. By searching technology databases and grey literature results were synthesised and categorised into a) dag prevention, treatment and removal, b) contamination detection and c) OH&S practises

The information and insights gained from these activities were used to create six personified scenarios that illustrate the potential impact from dags on different stakeholders in the value chain. These six scenarios varied in both the impact and likelihood of a negative outcome occurring as a result of dag contamination. The two highest ranked scenarios were then further developed and outlined in detail in three solution categories. These solution categories were designed to lay the foundations for the ideate phase and the development of impactful solutions.

6 Value Chain Analysis

This section presents insights from a value chain analysis for the cattle industry in relation to dags. Analysing the value network allows identification of which stakeholders are impacted by dags, as well as how the interactions between them drive behaviours toward the issue. To create these value network maps, stakeholder interviews were combined with market and technical insights. Together, the maps represent different parts of the Australian cattle value network.

There are three different levels of analysis:

a) A high level assessing cost-based impact of dags to the whole value chain (Figure 4)
b) An intermediate level assessing the effect of dags on the different types of exchanges between stakeholders (Figures 5 and 6); and
c) A detailed level assessing dag effects considering various types of stakeholders (Figures 7 and 8).

The three approaches revealed the following key observations:

Processors play a crucial role in ensuring the integrity of product quality and safety. **Large processors bear the burden** of risk of product quality and safety issues given their relationships with large supermarket chains. Large processors also have better capability than other value chain participants to treat dags. Processors may recoup the costs of dag removal from Feedlotters through a penalty.

Dag management costs are marginally greater in the south than in the north, which is surprising given the prevalence of the issues being much greater in the south. Processors spend more on dag management than Feedlots. The bottom line impact is greater (double) for Processors than for Feedlots.

Location is a strong indicator of occurrence of dags, sales pathways and treatment choices. In the north, dags are less prominent given short hair breeds, drier conditions and soil types. Untreated daggy cattle are less likely due to greater presence of large processors.

In the south, dags are more prominent given longer hair breeds, wetter conditions and soil types. Untreated daggy cattle more likely due to prevalence of small producers and small processors who are more likely to use Saleyards to intermediate trades and as such less likely to invest in infrastructure to treat the problem.

Feedlots have several 'elastic' selling alternatives available, which vary in dag tolerance.This allows flexibility to choose an alternative that has a higher dag tolerance.

7 High Level Value Network Map

The high-level value network map is illustrated in Figure 4, and supports the following insights listed below.

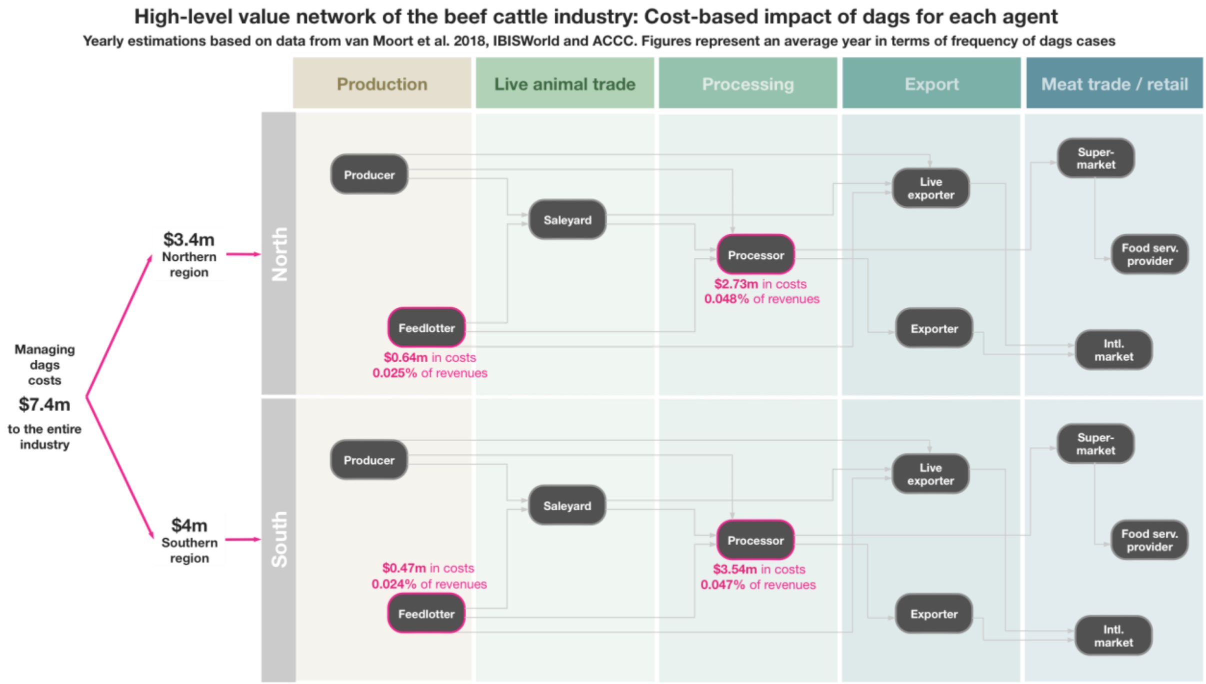


Figure 4. High-level value network of the beef cattle industry

- Although the financial costs of managing dags are greater in the south than in the north, the difference is moderate ($9.6m and $8.1m respectively). Considering that distinctions in cattle breeds and climate conditions makes the problem substantially more likely in the south, we should perhaps expect a larger difference. This indicates that spending aimed at solving the issue is not proportional to the size of the problem, suggesting that southern stakeholders (particularly feedlotters) are more efficient in dealing with the issue in some cases, and in other cases they are less motivated to fully solve the problem.
- For both southern and northern regions, processors spend more on managing dags than feedlot operators. The difference in expenditure seems logical considering the central role of processors in the value network (middle area in Figure 4). This emphasises the processor's crucial role of ensuring that the retail section of the value chain (and ultimately the end consumer) is not affected by the dag issue.
- In general terms, the costs of treating dags represent a marginal proportion of up to 0.1% of cattle industry revenues. This is a quantitative validation of the perception from the stakeholders gathered in the interviews, who have indicated that the scale and severity of the issue is low.
- The bottom line effect of dags on processors' revenues (between 0.047% and 0.048%) is approximately double that on feedlotters' revenues (between 0.024% and 0.025%), suggesting that the former put more effort into solving the issue than the latter. For feedlotters, treating daggy cattle effectively is not as crucial as for processors, given that they can choose a variety of selling alternatives (i.e. saleyards, live exporters, see Figure 4), each one with different cattle cleanliness standards.

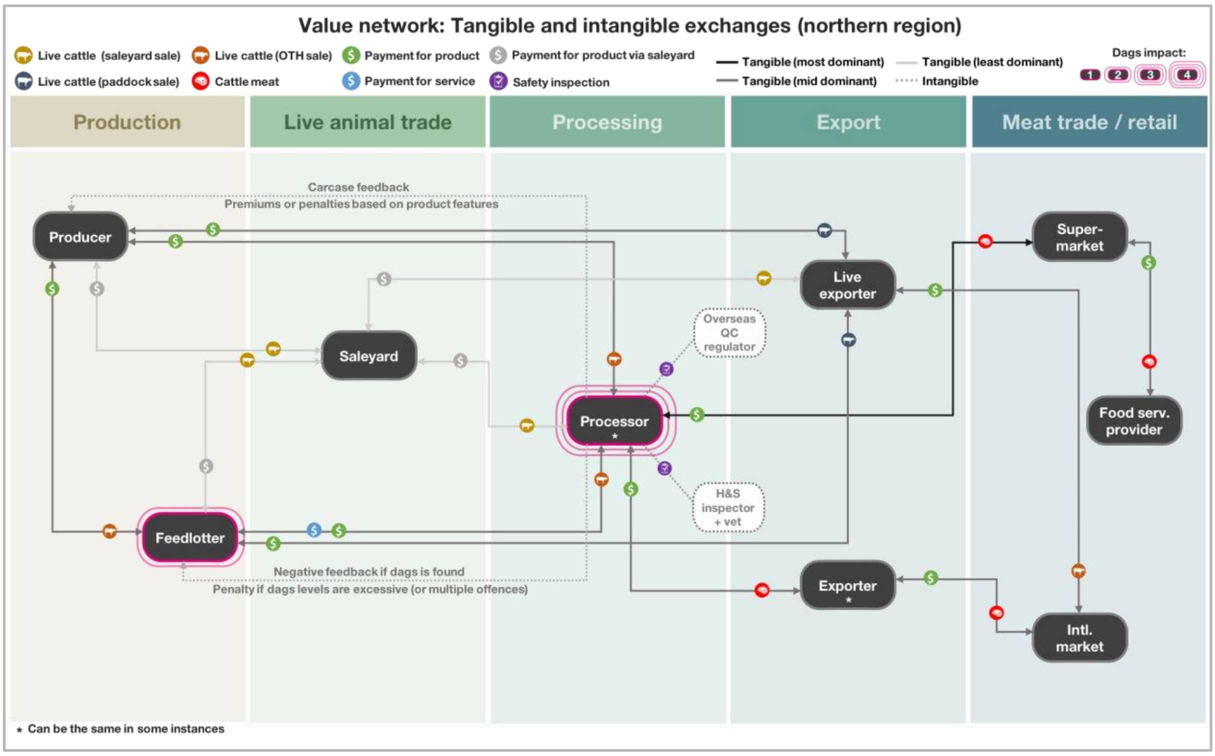


Figure 5. Value network: Tangible and intangible exchanges (northern region)

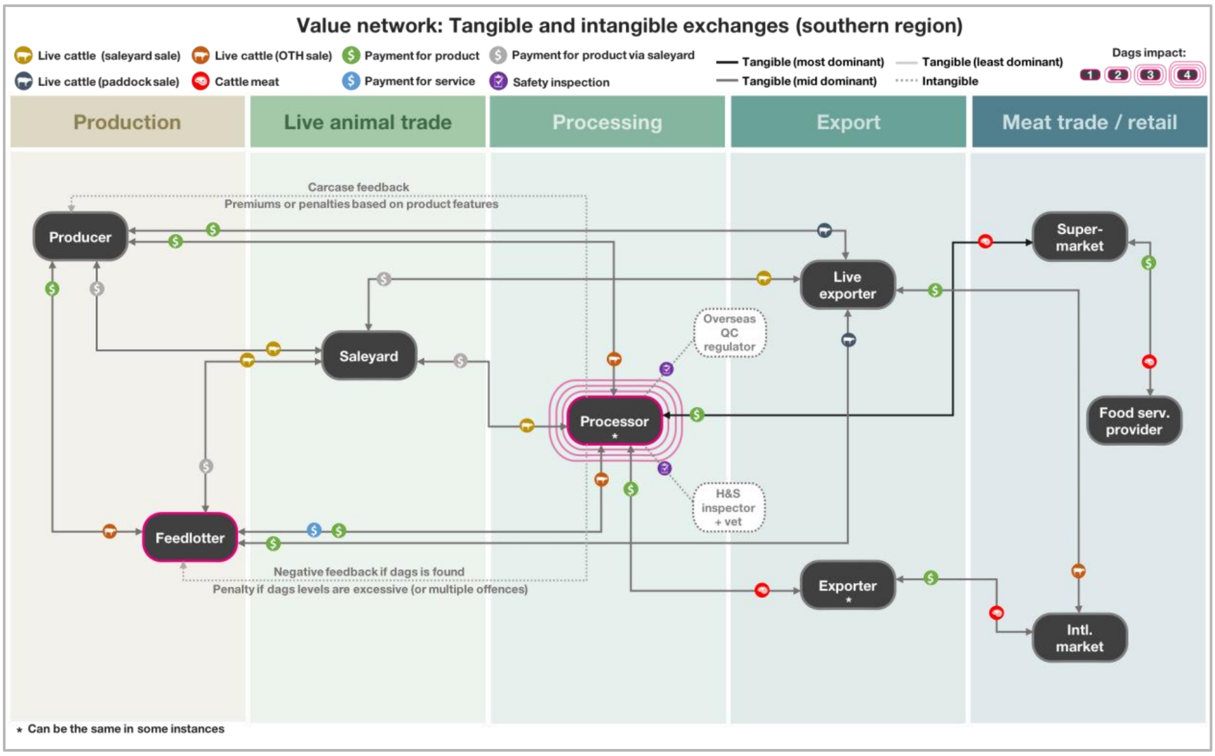


Figure 6. Value network: Tangible and intangible exchanges (southern region)

The value network maps showing exchanges between stakeholders are illustrated in Figure 5 (north) and Figure 6 (south). They illustrate the following insights:

General:

- Feedlotters are involved in direct sales, provision of cattle feed as a service, or a combination of both, as well as different customers (as indicated in Figures 1 and 2 from the Context section). Each channel and customer involve different dag tolerance levels, which need to be effectively managed by the feedlotter. This adds complexity to a feedlotter's operation as they need different procedures in place to treat dags accordingly, but it also gives them the option of choosing the best channel depending on the circumstances (e.g. if higher-than-expected levels of dags appear at a point in time, they may opt for channels more tolerant of dags in the short term).

- Processors acquire cattle from a combination of sources (i.e. multiple producers and feedlotters), that vary in their likelihood of providing cattle with dags. This variability is problematic for the processor as they need to have multiple dag identification procedures in place depending on the origin of the cattle. As a result, some processors prefer to avoid buying cattle in certain periods of the year from certain regions.
- When dags are found in cattle, the processor alerts the feedlotter. The processor may penalise the feedlotter when the level of dags is substantial and/or dags have been found multiple times in the past. Penalties range from $10 to $50 per head (sufficient to cover dag costs for processors, estimated between $6.34 and $9.34 per head by van Moort et al. 2018). Cases of processors penalising feedlotters are not frequent according to the interviews, which might be driven by some processors deciding to absorb the costs to protect their relationships with suppliers, and by some feedlotters trying other selling channels and/or different buyers to lower the risk of future penalties.

North vs South comparison:

- Compared to in the south, the northern Australian operators rely less on saleyards as a selling channel. Daggy cattle coming from saleyards (most likely in the south) restrict the ability to trace back the supplier, thereby amplifying the dag problem.
- In terms of costs associated with solving the dag issue, processors in the south incur higher costs in treating dags than those in the north. Given the greater flow of daggy cattle coming from southern feedlots, this difference in costs reflects the tendency for southern processors to source cattle from suppliers in their same region. Northern feedlotters spend more on treating dags than southern feedlotters. This behaviour is seemingly at odds with the fact than dags are more common in the south, suggesting that southern feedlotters are less motivated to treat dags. This is explained by the greater reliance southern feedlotters have on saleyards (see Research Overview section); cattle with excessive dags may be sold at saleyards rather than being treated accordingly, so they can be sold through direct selling channels.

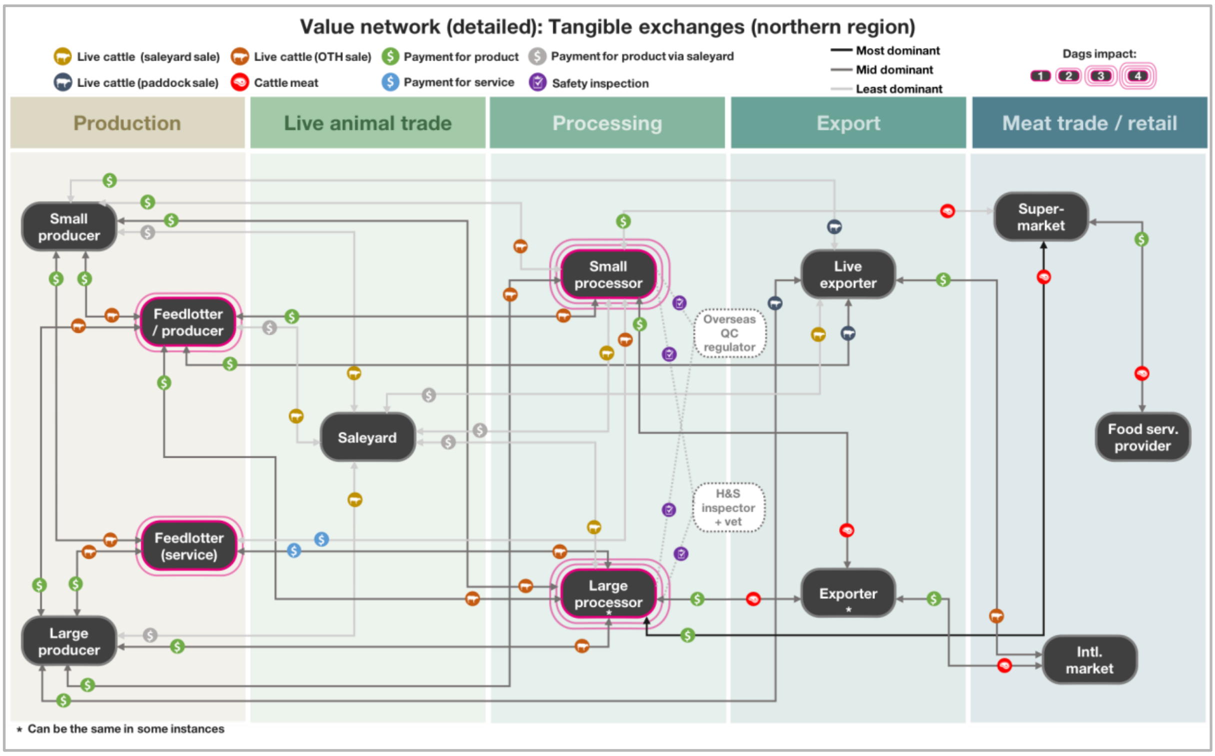


Figure 7. Detailed value network: Tangible exchanges (northern region)

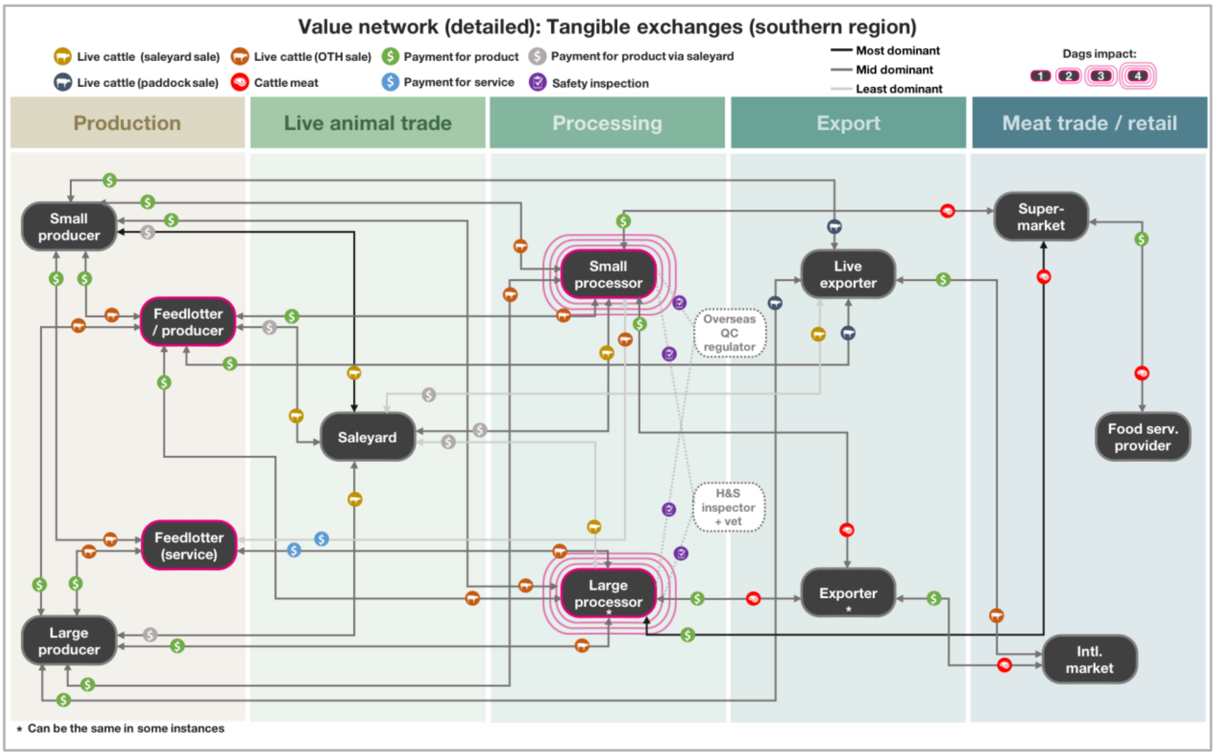


Figure 8. Detailed value network: Tangible exchanges (southern region)

Lastly, the detailed-level value network maps showing exchanges between stakeholders across different types are illustrated in Figure 7 (north) and Figure 8 (south). The maps support the following insights:

General:

- For cattle coming from feedlotters operating under a service business model, the dags issue is more likely to be controlled given the long-term and more direct nature of service agreements (i.e. more direct communication between supplier and customer).
- Large, rather than small, processors tend to be the ones sourcing meat to large supermarket chains. This puts them under pressure to maximise dag control to prevent product quality and safety issues. Large processors are also more likely to have the resources and equipment to effectively deal with the dag problem.

North vs. south comparison:

- In the north side of the value network, exchanges involving large processors are more dominant, given the presence of big processing companies in the north, whereas the exchanges between small and large processors in the south are more balanced. As large processors tend to have more resources to treat dags, untreated daggy cattle are more likely to be seen in the southern part of the value network.

Small producers and small processors in the south are more likely to use saleyards as a selling channel, as indicated in the Context section (Figures 1 and 2). As explained previously, the source of daggy cattle from saleyards is restricted by the limited supply from feedlots. However, daggy cattle at saleyards are less likely to be identified, thereby increasing the dag problem.

8 Stakeholder Perspectives on Dags

This section provides the main insights from the analyses of various stakeholders in the value chain, with respect to how the problem impacts them and how they manage it. A general profile of these stakeholders is presented below with the results of interviews, followed by observations and insights.

8.1 Producers

More than half of the total 123 000 agricultural properties in Australia are engaged in cattle production. The geographic distribution of these farms is concentrated in Queensland, New South Wales and Victoria (Figure 9), with Queensland having nearly half of the nation's beef cattle herd (Figure 10).

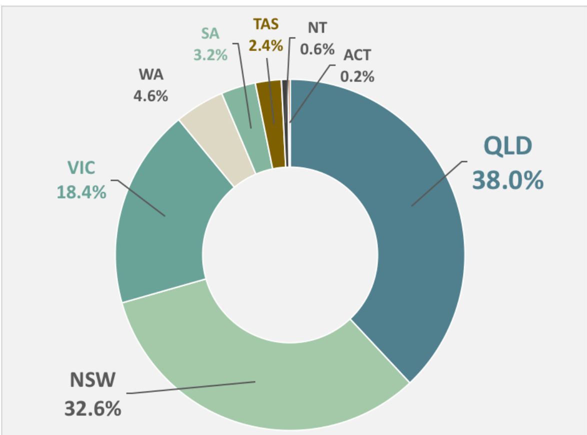


Figure 9. Cattle farms locations (Johnson, 2017)

Figure 10. Geographic distribution of cattle herd (Johnson, 2017)

Northern and southern regions of Australia are characterised by quite different environmental conditions relevant to cattle production.

The northern region is characterised by drier conditions, and because vegetation is sparse, larger areas of land are required to run herds. Northern producers favour *Bos indicus* breeds as these perform better than *Bos taurus* in the higher temperatures associated with the tropical climate; they also lose less condition when transported and possess greater tick resistance. However, beef from *Bos indicus* cattle is generally considered to be of lower eating quality. *Bos indicus* are distinguished from *Bos taurus* by the hump on their back and have a short, light-coloured coat.

The southern region is characterised by higher average rainfall, so less land is required to produce the pasture required for feed. Southern cattle farms are generally smaller in size as more consistent rainfall provides improved pastures and localised access to grain and fodder for supplementary feeding. *Bos taurus*, the preferred breed in the southern region, is derived from British and European stock. These animals have thicker coats and are generally better suited to colder climates than *Bos indicus*.

8.1.1 Insights

Initial interviews with industry stakeholders identified that dags are a very minor issue for producers as paddocks normally have plenty of ground cover. Therefore, no further interviews were conducted with producers; interviews were instead focussed on stakeholders representing other parts of the value chain.

8.2 Saleyards

Saleyards get most of their supply from producers. Dag issues are uncommon at saleyards because cattle are on paddocks with grass ground cover.

Saleyards encountered dags more frequently in the past but now find them only rarely. The reason is that the saleyards no longer receive much supply from feedlots due to the cost of listing and transport. Also, many feedlots now have forward contracts with processors and bypass saleyards.

8.3 Feedlots

There are around 400 accredited feedlots throughout Australia, most of them located in South East Queensland near cattle, grain supplies, water and processing facilities. Queensland is the largest producer of grain finished cattle, accounting for almost 56 per cent of turnoff in 2015 (Figure 11).

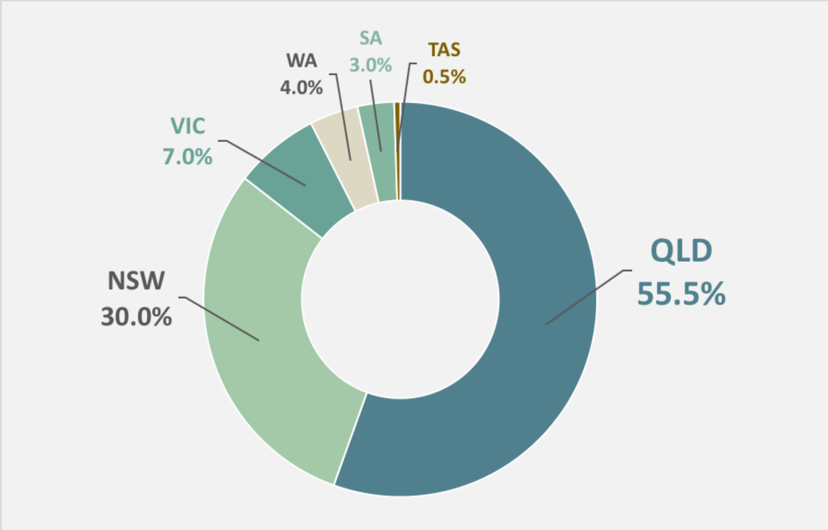


Figure 11. Cattle feedlot locations, 2017-18 (Johnson, 2018

Position	Business	No. of feedlots	One-time capacity	Turnoff 2014 (head)
1	JBS Australia, QLD, NSW	5	150,000	395,000 (estimate)
2	Teys Australia, QLD, NSW, VIC	3	67,000	220,000
3	Whyalla Beef, QLD	1	56,000	132,000
4	Mort & Co, QLD, NSW	3	52,000	178,000
5	Australian Agricultural Company, QLD	2	33,500	35,000
6	Rangers Valley Feedlot, NSW	1	33,250	43,000
7	Australian Country Choice, QLD	2	27,100	154,800
8	Stanbroke Feedlot, QLD	1	25,000	90,000 (estimate)
9	Myola Feedlot, NSW	1	20,000	60,000
10	Elders Killara Feedlot, NSW	1	20,000	55,000

Table 1. Top 10 Australian Feedlots – ranked by one-time operating capacity (Condon, 2015)

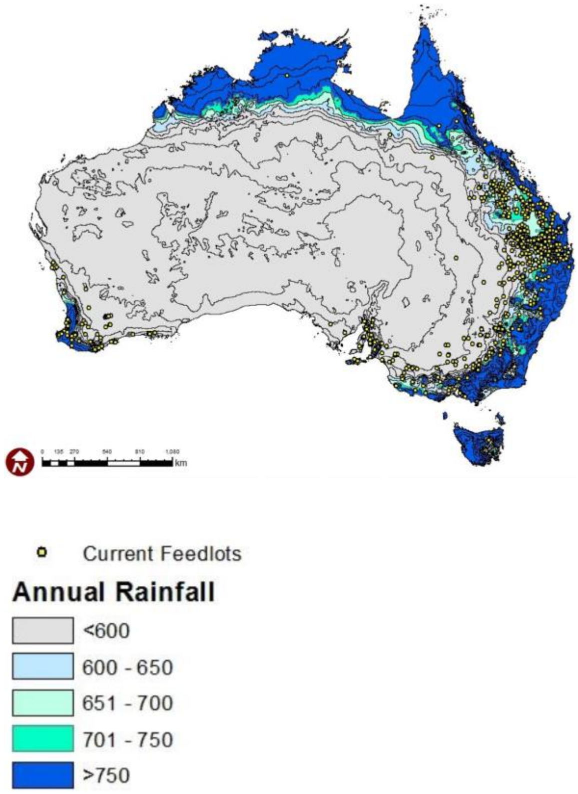
Several business models are used by feedlots. In one model, feedlots purchase cattle from farmers, then feed them on a grain-based diet until they reach market specifications and can be sold to processors. In another model, feedlots provide a fee for service operation, finishing cattle to market specifications, but have no ownership of the stock. A third model is a hybrid of the above, where feedlots are both a producer and provide fee for service finishing.

Cattle typically spend 50-120 days on the feedlot. Cattle for domestic markets are kept for 60-70 days whereas cattle that produce beef for exports markets will be there for 100 days or more (Johnson, 2018). Feedlotters producing cattle for high end products, like premium marbled and wagyu beef, keep cattle for considerably longer. Rangers Valley, as an example, keeps Angus for 270 days on average and Wagyu for 350 days (Rangers Valley, 2018).

Optimal rainfall levels make it easier for grass-fed cattle farmers to finish cattle on pasture, however this reduces the demand for feedlots. In contrast, reduced rainfall leads to pasture deterioration and increases the demand for feedlots and reduces the occurrence and impact of dags. Current drought conditions mean the impact of dags is not being felt as acutely as it will with the return of higher rainfall.

MLA and farm consultants (Watts et al. 2016) recommend that feedlots be located in areas with an annual rainfall of less than 750mm, since potential water pollution, odour problems and muddy conditions are generally more difficult to manage in wetter climates. They also identified a trend of feedlots being shifted to drier sites, with fewer environmental issues as a consequence (Watts, Keane and Ni Cheallaigh, 2012). Figure 12 shows the feedlot distribution and annual rainfall pattern in 2012.

Feedlots located in areas with summer dominant rainfall are also recommended by MLA and farm consultants (Watts et al. 2016) because these regions have high evaporation rates, making it easier to control mud. However, they also determined that this is not a limiting factor in the location of feedlots, and that other factors (e.g. grain supply) are more important (Watts, Keane and Ni Cheallaigh, 2012). Figure 13 shows the feedlot distribution and seasonal rainfall in 2012.



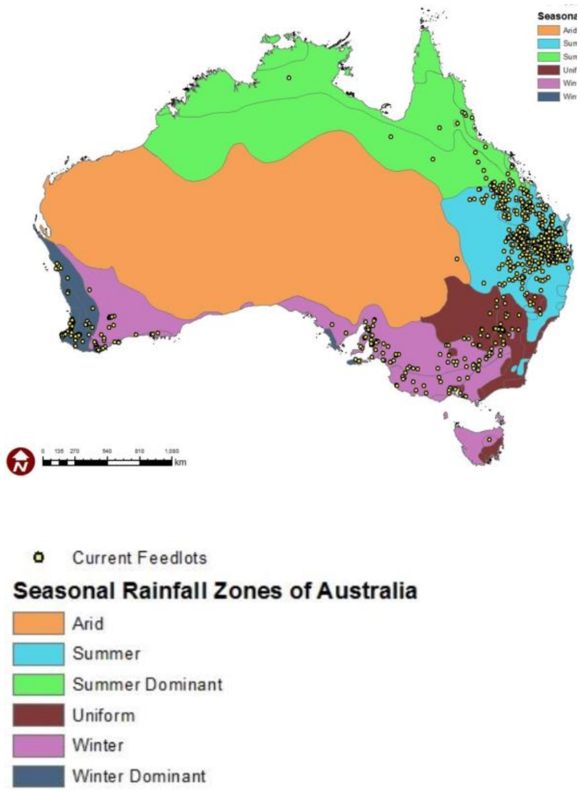


Figure 12. Feedlot distribution and mean annual rainfall in 2012 (Watts, Keane and Ni Cheallaigh, 2012)

Figure 13. Feedlot distribution and seasonal rainfall in 2012 (Watts, Keane and Ni Cheallaigh, 2012)

The following are key synthesised observations from interviews with feedlots and saleyards in different areas of Australia. The observations highlight how dags impact their operation and how feedlots manage the issue.

Feedlot and Saleyard observations	
Feedlots	• *In general, dags are not a significant problem.* • *They acknowledge that the dag issue, to a very large degree, originates at feedlots.* • *The problem of dags is mainly associated with long-haired cattle and wet weather conditions.* • *While some feedlots do wash cattle prior to departure, some also have special clean pens used to keep cattle dag-free prior to movement.* • *Larger feedlots reported that they are managing the dag issue by keeping pens clean and moving cattle to pens with sand or hay cover, or alternatively, mesh flooring. They move cattle to these pens a few weeks prior to departure for meat processing.*

	• *Smaller feedlots, such as Tasmania and Rangers Valley, who cater for high end products, have larger sheds where cattle can keep dry in wet weather, to limit dag formation. This also appears to have a positive impact on growth rate and decreases bedding costs, as bedding in shed complexes requires shorter replacement times than in external pens.* • *In large part, the problem is linked to poorly drained soil (older feedlots) which in wet weather and crowded spaces creates ideal boggy conditions for dag development. Newer feedlots appear to be designed and constructed with this issue in mind (geographical area, slope, improved drainage, etc).* • *Some feedlots reportedly clean cattle on site prior to departure. This appears to be associated with vertically integrated arrangements, such as co-ownership and co-location of feedlot and processor.* • *Soaking, washing and scrubbing is the most common method for cleaning dags. However, solutions such as a mechanical washer have also been tested but do not appear to be economically viable, and this may introduce other issues related to animal welfare.* • *Feedlots can be penalised if they supply dirty cattle to producers. One NSW feedlot reported that the "dag penalty from processors can be between $10 to $50 per cattle, which can be around 10 to 20% of our gross margin".*

8.3.1 Insights

Interviewees indicated that the occurrence of dags is strongly dependent on weather patterns, geographical location and the cattle type being held at feedlots. Dags appear to be more prevalent in southern regions compared to northern areas, where it tends to be wetter and long-haired cattle types are more common.

Feedlots vary significantly in how they operate and deal with the issue of dags. However, they generally do not have a strong focus on dags and leave the problem to be dealt with by processors. This is mainly a commercial rationale, as feedlots have little incentive to deal with the issue. Occasionally, processors issue supply penalties for daggy cattle, but this appears to be a rare occurrence (possibly due to buyer/supplier relationships and the need for processors to secure future cattle supply).

Some feedlots clean cattle and/or use bedding and clean pens prior to feedlot exit. This typically occurs where there are vertically integrated supply arrangements and contractual agreements, in an effort to manage the problem so it does not incur costs further down the supply chain.

Some large integrated operations, such as JBS's Beef City, have sophisticated, fully automatic washing facilities to ensure cattle are clean when entering the processing plant (see Box 1). The integrated nature of feedlot and processors, combined with scale economies, 24/7 operation and management of occupational health and safety risks to workers (who in the past washed daggy cattle by hand), make this large infrastructure investment viable.

Box 1: Beef City Cattle Washing

Cattle experience an Initial pre-soak at low pressure before they move to covered pens for a 90 second high pressure wash from nozzles set in concrete flooring. Pens keep animals in water streams and a high pressure upward-spraying wash is applied for 90 second bursts. The system can wash up to 12 cattle in a single pen or 60+ head in multiple pens at once, with alternating sprays for each pen. Recycled water is used and recirculated, with a separation/sieving plant (for mud, hair and gravel) incorporated into the design.

Cattle dags are effectively removed, even for long haired species (less common than short-haired cross breeds at Beef City). Cattle are moved to a feedlot after washing. Generally, it is 1 to 2 days between wash station and slaughter at the integrated processing plant.

Some feedlots that cater for high end products are building large sheds, where cattle can keep dry in wet weather. They claim this limits dag contamination, has a positive impact on cattle growth rates, and reduces costs because bedding requires less frequent replacement than in external pens. Although 'dags' is considered to be a key driver, increasing weight gain performance is probably a more important consideration, and also an industry wide challenge. A combination of high end products, small operational scale and favourable regional weather patterns appears to be an economically attractive model.

"Our $1 million investment in shedding infrastructure is to reduce dag loads, but it is also to increase improvements in weight gain performance and we anticipate a payback period of just three to five years"

Executive Manager from Tasmania Feedlot

8.4 Processors

Processors typically acquire their cattle from within 400 km of the processing plants. As Queensland accounts for the largest herd, they are also the largest processing state, contributing 47% of total slaughter (Figure 14).

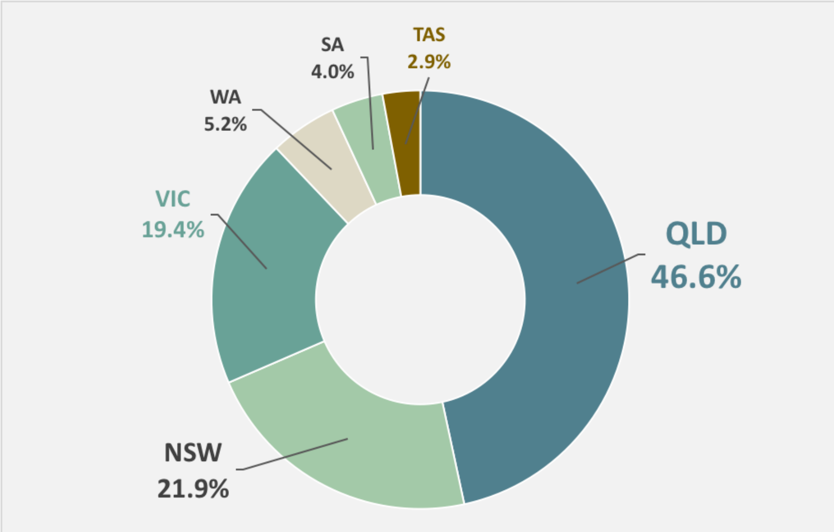


Figure 14. Cattle slaughter by state, 2017-18 (MLA, 2018c)

The Australian Competition and Consumer Commission (ACCC) indicates that Australia's five largest processors account for around 54% of total slaughter capacity. This includes two dominant firms, JBS Australia and Teys Australia, who operate multiple processing facilities across the eastern states, and three medium scale operators: NH Foods, Australian Country Choice and Northern Cooperative Meat. The remainder are small to medium niche producers.

Increasingly, the industry is using forward contracts and supply agreements that provide processors with some certainty of throughput to manage the risk of operating a high value asset for what is often a low margin product. For example, Teys' processing plant at Tamworth and Australian Country Choice's processing plant at Cannon Hill are dedicated to processing cattle for the major supermarket chains. In many cases, the cattle supplied to plants are grain fed at feedlots and are within a specific weight range at arrival, to ensure consistency of the final products.

All cattle need to be washed before slaughter to reduce hide contamination. Water is a significant expense for processing plants. The volume of water used to wash cattle will depend on the degree of dag accumulated on livestock, the cleanliness standard required at the processing plant, the number of cattle washed, the level of wastewater recycling implemented and seasonal conditions.

The following observations were obtained from interviews with processors in different areas of Australia about the impact dags have on their activities and the way they manage the issue.

Processor observations

- *Their view is that the dag problem originates entirely in feedlots and they would like to see that feedlots address the issue to make sure it does not enter the supply chain.*
- *For most processors, dags on cattle are not a significant issue, but one that is managed through established procedures and grading systems to prioritise dag treatment.*
- *Processors that deal with long-haired cattle reported that dags are a significant issue, particular during wet seasons as these breeds may require heavy manual labour to remove contamination.*
- *When feedlot and processing operations are integrated, there is better communication and prior warning for the processor when supplied cattle have significant dags.*
- *Although shaving along cut lines does occur overseas, it is avoided in Australia due to animal welfare issues.*
- *All processors use water soaking, low-pressure spraying and scrubbing as the main method for dag removal. Some have dedicated washing stations where cattle are washed automatically and scrubbed by washing personnel. Processor workers will only clean cattle along the cutting lines.*
- *Chemicals are not used due to health and safety issues related to meat contamination. However, it appears that some processors use chlorine dioxide as a bacterial control spray. This is used for cutting lines only. Also, some processors reported using chlorinated water for washing prior to slaughter to manage bacteria.*
- *In certain cases, processors financially penalise feedlots for supplying cattle with significant dags, though some reported this was an infrequent practice.*
- *Dealing with dags leads to an increase in costs of labour and water use. One processing operation reported they had 3 employees assigned full time 6 days a week to clean dags.*
- *Dag cleaning practices represent a safety risk for workers allocated to wash animals, despite protective equipment.*
- *Potential aerosol contamination of the processing environment due to dags is an issue as it can contaminate beef products. To reduce health risks, QA managers and on-site vets are employed to ensure cleanliness of all cattle pre-slaughter.*
- *Crucial negative impacts from dags are potential export bans, product rejection and loss of export licences and contracts, due to presence of contaminants such as E. coli.*

"We don't worry much about the cost of dealing with dags, we care about health risk which, if it comes, will have so much bigger an impact" ***Manager Processor NSW***	***"We do understand the implications of the detection of STEC (especially E. coli 0157 H7) which could lead to rejection of a whole container of product and ultimately could lose export contract(s)"*** ***Operations Manager Processor QLD***

> *"Daggy cattle will go through a wash pen where they're sprayed; if they need extra treatment they will be washed by hand by labourers. All wash personnel will be wearing safety masks and body protection"*
>
> *Operation Manager, Processor, VIC*

8.4.1 Insights

The observations from the stakeholder interviews and information from additional sources led to a number of insights with respect to the dag problem for processors. Firstly, although many processors acknowledged that dags present problems to their operations, in most cases, dags do not pose a significant and regular challenge. As the problem originates in the early stages of the supply chain, processors perceive the problem as a situation they cannot control, which is amplified by the variable nature of dags (i.e. they emerge in certain seasons, in certain areas, in certain cattle breeds).

Nevertheless, it is clear that southern processors acquiring long-haired cattle are more affected by the dag issue than processors in northern regions, who only deal with short-haired brahmans. This is possibly the reason why automated washing stations are more predominant in the north than in the south; the occurrence of wet weather and longer-haired cattle with dags adds a level of variability to the cleaning process that is difficult to automate, thereby requiring manual labour for effective dag removal.

Secondly, all processors reported additional costs for dag removal, related to two factors:

1. Allocation of extra personnel; and
2. Excessive use of water.

It remains difficult to predict (and plan) the amount of resources required to clean dags before they actually appear, and this affects production processes.

A crucial issue is the potential contamination of entire processing environments due to dags. As meat processor personnel will only clean cattle along cutting lines, left over dags on hides introduces a potential contamination risk to plants.

This could lead to high-risk scenarios where product quality and safety are compromised. Managing the risk of food contamination is a critical task for all producers, given the significant financial and reputational impact that the issue can have on the entire Australian cattle industry. The threat of losing export markets and licences is also linked to contamination issues.

Although chemicals are generally not employed due to health and safety concerns, some innovative processors are experimenting with application of chlorine dioxide across cutting lines for bacterial control, as well as using chlorinated water for washing prior to slaughter.

8.5 Live Exporters

Australian live cattle exports were valued at $1.2 billion in 2016-17, with 907,965 animals exported (MLA, 2017). The port of Darwin in the Northern Territory is the largest Australian exporter of live cattle - 39% of shipments in 2017-18 originated from this port (Figure 15). This is due to proximity of the region to large export markets in southeast Asia. Australia's largest market for live cattle exports is Indonesia, accounting for around 59% of shipments in 2016–17, and other major markets include Vietnam, China and Israel (Figure 16). Brahman is the cattle breed exported to Southeast Asia.

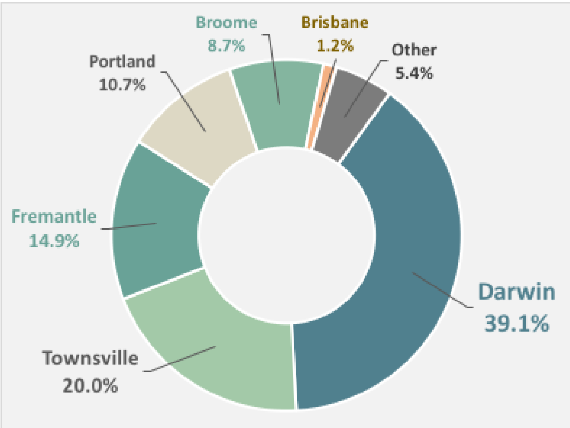


Figure 15. Cattle exports by port of origin (MLA, 2018d)

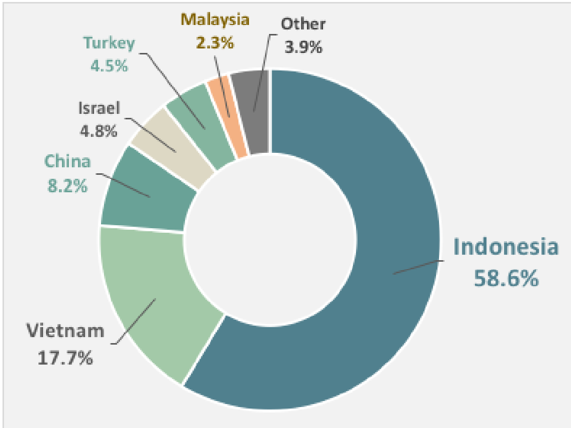


Figure 16. Australian live cattle export markets (DAWR, 2018a)

Below are key observations obtained from interviews with live cattle exporters. The statements illustrate how dags affect their operations and how they manage the problem.

Live exporter observations

- *Dags are considered a minor issue for the live cattle export industry as they are normally not considered to be an issue for import countries.*
- *As most breeds exported to Southeast Asian countries are short-haired tropical breeds or crosses, heavy dags are less of a problem and should be removed at the export port by washing.*
- *The cost of treating dags on board is mainly labour for washing.*
- *An indirect issue of dags is media exposure which can have a potentially large negative impact on the entire Australian cattle industry.*
- *The live cattle export industry is operating under strict regulations in Australia and also in relation to regulations for the importing countries.*
- *In relation to dags, the specific circumstances for washing are dictated by the country of entry.*
- *Most ports will not allow cattle washing while docked. Therefore, dealing with dags is done by soaking and washing onboard the ship when at sea using spray, water and some detergent.*

8.5.1 Insights

Live export cattle are mainly sourced from feedlots in northern Australia. As dags are less frequent in northern short-haired cattle breeds, it does not represent a significant issue for live exporters. Nevertheless, the severity of the issue depends on the market conditions and import standards in the receiving country.

The majority of Australian cattle are exported to Southeast Asian markets. Although Australia has strict export regulations, most of these markets have relatively lower standards regarding animal welfare, health and safety. Most of these countries process cattle almost immediately after offloading, to be sold at “wet” markets.

The most significant impact that dags can have on live cattle exports is via negative media exposure. Recent events in Israel (see Box 2) involving dirty cattle with dags were used by activist groups to argue against live animal imports. This event led to a wave of negative media exposure in Australia and overseas, raising issues for the cattle industry that affected not only exporters, but the entire value chain.

Despite the low likelihood of export cattle being affected by dags, there are some treatment procedures in place. Dags are usually managed onboard live export ships through removal by water washing and spraying, especially in cases where washing is not allowed at port of entry.

Box 2: Dirty Cattle in the Media

In June 2018, media showed video footage of filthy cattle being unloaded from an Australian live export ship at its destination in Israel.

The media claimed it was evidence of cattle mistreatment. The footage showed the cattle covered in dirt, excrement and wood shavings (dags). Israel Against Live Shipments claimed the cattle had been "mistreated" and called for an end to live animal imports. The Australian Government disputed the claims, saying an on-board experienced and independent veterinarian provided evidence that the 22 day voyage was positive in regard to the animals' health and welfare.

A significant occurrence of dags was evident in the footage and that was used to support the case against live cattle imports to Israel. In this case, the main reason for the build-up of dags was that Israeli laws for live import do not allow cattle washing two days prior to arrival in port. As the unloading from the ship took place over two days, significant occurrence of dags was visible on the cattle during offloading.

Source: ABC News, Puddy (2018).

9 Existing Approaches

The following points present an overview of the search for existing approaches and technologies. The section is divided into three specific groups:

a) dag prevention, treatment and removal
b) contaminant detection, and
c) OH&S technologies

9.1 Dag Prevention, Treatment and Removal

9.1.1 Washing systems

Several semi or fully automatic washing systems currently exist in the marketplace. The site visit to Beef City provided evidence that these systems work well and have helped to reduce dags significantly without causing animal stress (see Box 1). However, fully automatic washing systems come at a significant infrastructure cost and a certain scale is required to justify this level of investment.

9.1.2 Polymer coating applied to hides

- In previous iterations of this project, Xinova proposed three formulations of polymers (Siloxane, Surfactant and Stearate) in the prevention of dust, mud and faecal matter build up (dags) on cattle in a feedlot situation. These can be applied to the cattle by spraying. The trial was promising and pointed to areas that require further development:This:
    - Droplet size was not large enough and the coating dried slowly.
    - Formulations were viscous and sticky. These products attracted dust, dirt, loose hair, loose feed material and formation of plaques immediately post-treatment.
    - Further work needs to be done on formulation and method of application so as not to interrupt induction operations.
- A challenging factor for the studies was timing. The trial was conducted mid-winter when cattle have their winter coats, which they gradually lost over the next 2 months. Starting the study earlier in the year would have eliminated hair loss as a confounding factor.
- Other solutions included applying a compound with at least one hydrophobic component and at least two reactive functional components to the hair. Additionally, a binder was also applied. However, dags kept forming after the application of the compound. Therefore, this project was abandoned as it was not effective at dag prevention (See Appendix C)

9.1.3 Physical removal

- The Tailwell trimmer is designed for cleaning up long, wet and dag-filled tails in US dairy processing facilities. Trimming tails is usually required twice a year in dairy farms in Australia and the Taiwell trimmer is a popular tool among dairy farmers for this task. With this product, trimming takes only three or four seconds per tail and is easily accomplished during milking. It is designed to avoid risk of injury to man or cow. Pre-cutting of the tail switch is not necessary, even if it is very dirty.

- A hydraulic de-dag tool developed by CSIRO was used in a meat processing plant post slaughter. This tool was not effective, as while it reduced the severity of dags, this reduction was not sufficient.
- MLA conducted research to develop a robotic de-dagger system based upon a manual de-dagging tool installed and operating at John Dee, Warwick, for operation on the abdomen. The system was to include a carcass orientation and restraint device and a surface profiling sensor mechanism. The robotic project was terminated prior to completion. This is a complex tool that requires high investment. Therefore, it was found to be non-viable and the project was abandoned. The manual tool has been made available on a commercial basis via a New Zealand engineering company.
- MLA and AMPC conducted research to investigate the potential of CO2 blasting to provide a cost-effective solution to mid and large size processing plants for the removal of dags. The CO2 approach is still under development. It has proven to be technically viable without damaging the hide. One of the challenges is the cost of the CO2 and in operating a CO2 based system. Stage 3 of the project is under development. It aims to investigate the design of the CO2 system taking into account noise, waste removal and the safe use of CO2.

9.1.4 Use of shelters and sheds in feedlots

- Jusco Feedlot in Tasmania is recognised for its high average annual rainfall and low evaporation. Jusco invested in infrastructure that includes permanent shedding for 2000 cattle. This infrastructure offers dry conditions, which greatly reduce dag-load contamination, while also delivering improvements in weight gain performance in summer and winter.
- Another solution proposed by Xinova is a protective mesh cloth to cover cattle (similar to clothing for pets) during their stay in the feedlot. Proposed solutions included modifying the surface of the cloth to repel the constituents that make up dags and thereby protect the cattle.

9.1.5 Cow brushes

Cow brush systems are used in dairy milking plants in the USA and Europe to promote milk production. Similar brush systems could potentially prove useful for dag removal in the Australian cattle industry. However, cow brushes and their effect on dags is not yet proven (see Appendix A for more detailed information). Better understanding of how motivated cattle are to remove the dags themselves with a tool and the ability and feasibility of providing a tool for the cattle to access all areas where dags form.

9.1.6 Enzyme mixture for dag removal

A study examining the use of enzymes for dag removal has concluded that dag consistency and porosity are crucial factors in determining whether enzymes can improve dag treatment. Consequently, prior to future commercial releases of an enzyme solution, objective testing should be conducted on a wide range of dag types and compositions.

Other studies concluded that mixtures of cellulase, xylanase and laccase are more effective than individual enzyme treatments and that fast dung degradation should be based on opening up the structure with lignin and hemicellulose-degrading enzymes and breaking down the fibrous structure of cellulose.

A challenge which remains for this type of solution is the variability of Dag composition changes depending upon soil type, feed and potentially other factors. Further work may uncover a pathway to tailored mixtures. The viability of tailoring mixes for unique situations would need to be verified. (Cassell & Haritos, 2009; Navone & Speight, 2018; Slattery *et al,* 2005)

9.2 Contaminant Detection

- Hyperspectral imaging has been applied to food safety and quality assessment, particularly to contaminant detection. It has been tested to identify ingesta and faeces on poultry carcasses with 96.4% accuracy. However, there are two major barriers to its widespread adoption in the food industry: high purchasing costs and lengthy times for image acquisition, processing and classification.
- Other studies have researched the detection of faecal contamination in water systems:
    - Research on the numerical relationships between FRNA-bacteriophage genotypes, adenovirus 41, and human adenoviruses (HADV) in surface water systems to assess sewage contamination. This approach may have the potential for determining source contamination in water and, specifically, the presence of enteric viruses where clean and contaminated water have mixed.
    - Research to detect faecal contamination in tomatoes using Fluorescence Hyper-Spectral Imaging. The BRI image-processing method implemented in a study by Romaniello *et al* (2016) correctly classified 70% of contaminated areas, with no false-positives in all examined cases. Therefore, the developed methodology can be employed for a fast and

9.3 OH&S Technologies: Dag Removal

9.3.1 Physical harm minimisation

- Currently, in some feedlots and meat processing facilities, all staff who work close to live animals (to remove dags and wash cattle both pre- and post- slaughter) have to wear protective helmets with face-guards. If there is a high risk from kicks and cattle horns, additional body armour must be worn to prevent injury from livestock hooves, horns and tails.
- Educational material is available from the Australian Centre for Agricultural Health and Safety at the University of Sydney, which collaborates with the Australian government and other cattle industry organisations to assist cattle producers in improving the health and safety of workers handling cattle by identifying safety hazards and outlining options to control safety risks.

9.3.2 Other Associated Industries – humans handling Large Animals

Other educational materials are available to assist farmers in handling large animals:

- Temple Grandin, a US-based professor in animal science and an expert in handling large animals, has produced a publication to educate cattle farm staff in animal behaviour, in order to prevent injuries to both people and animals.
- The Canadian government has also made available educational material about large animal handling. This material helps farm workers to identify specific hazards and dangerous situations and provides guidance on how to mitigate these under the Occupational Health and Safety Act.

10 Inventions and IP scan

This section presents an overview of the information from the invention and IP scan.

An invention and IP scan was undertaken to gain an overview of the international invention and IP portfolio landscape. The scan revealed that the inventions and IP that can be utilised for dag prevention and treatment are predominantly concentrated in two main invention groups, cattle cleaning and cow sheds. In most cases, cattle cleaning involves some form of water spray / dispensing system, combined with animal cleaning machinery. The intent is to install this machinery into existing feedlot or processor infrastructure as cattle moves along races.

Cow sheds is a group that includes preventative technologies in the form of shed design and construction, bedding methods and materials and various forms of automatic cleaning of pens and cubicles to prevent dags forming from contact with soiled surface areas.

Most of the shed and cleaning technologies on the list will require significant infrastructure investment and may therefore not be well suited to Australian cattle farming, where properties are larger in size and number of cattle than many overseas farming setups and configurations.

A full overview of the invention and IP scan, including patent holders, is presented in Appendix B.

11 Scenarios

This section presents a number of scenarios that illustrate how dags may impact value chain stakeholders in different ways. The scenarios are based on an amalgamation of insights and information extracted from value chain and stakeholder interviews.

As the financial impact of dags on the industry is relatively low, the scenarios focus on other indirect issues related to dags, that could potentially have a significant impact on value chain stakeholders and also on the entire Australian beef industry.

The scenarios are personified narratives used to provide a more realistic view of the potential direct and indirect impact of dags on different stakeholders in the value chain. The data used is based on real interviews and analysis extracted from the previous sections.

11.1 Processor Treatment of Dags – Beef contamination issues

John is an operations manager at an export processor in southern NSW.

Lately, John has been concerned about how the processor deals with dag contamination on the cattle they receive from some feedlots. If not treated correctly, dags can have severe implications not only for John's meat processing business, but for the entire region and indeed, for the Australian beef industry.

John has seen several reports outlining the financial impact of dags. These reports show that the cost of dealing with dags is relatively low. They focus mainly on removal practices and techniques, which currently consist of automatic soaking, spraying, scrubbing and washing dag infested cattle with low pressure hoses (the same way John and his team are currently dealing with dags at their processing plant).

However, John is concerned that there is insufficient focus on the potential significant impact on food health and safety from microbiologically contaminated beef linked to poor treatment of dags. 50% of the cattle supplied to John's processing plant are long-haired cattle that require a lot of manual labour to remove dags.

John knows that if one of the "big six"* microbiological contaminants are found in their products it could have severe financial and social implications for their company and the entire region. These could include rejection of whole containers of products and the shut down or complete closure of export markets, which would lead to loss of employment in their community (the community already has a higher than average unemployment rate). In addition, there could also be severe human health issues, and in the worst case, fatalities associated with meat contamination linked to poor treatment of dags.

John is interested in all new and novel treatment methods and mitigation strategies. For example, he recently heard of a chlorine dioxide biological spray and is interested in similar mitigation strategies that may reduce the risk of introduction of pathogens in the slaughtering environment.

John is also a strong supporter of ongoing education in hygienic management techniques for all workers involved in the production process to keep microbiological contamination to an absolute minimum.

***"big six" strains being specific serotypes: STEC 026, 045, 0103, O111, O121 and O145, which in the US have been linked to a growing number of foodborne illnesses, prompting the U.S. Department of Agriculture (USDA) to add them to their test regimen.*

11.2 Occupational health and Safety – Human injury when removing dags

Jill Cook works as a health and safety inspector for the Department of Primary Industries in Queensland.

Jill has been concerned for the health and safety of both the animals and the workers at feedlots and at meat processors, who wash and scrub live cattle to remove dags.Jill is exploring initiatives that she believes will not only make animal handling safer, more humane and less stressful, but will also boost productivity. This is predominantly an issue where processing facilities are dealing with long hair cattle that require manual labour intervention to remove dags.

One initiative is stockyard design. Jill is investigating how to separate, wherever possible, livestock and people when cleaning cattle. She believes separation of the animal and the washer is best achieved by using automated washers. If that cannot be achieved, stockyards should alternatively have good escape routes for workers scrubbing the cattle, in case the animal behaves unpredictably or aggressively.

In general, Jill believes a well-designed stockyard with appropriate cleaning facilities will improve cattle handling operations, resulting in:

- reduction in worker injures
- less bruising of livestock
- less labour and more efficient handling of livestock
- reduced animal stress during the handling process

Although changes to stockyard design can be large investments, even small improvements to existing facilities can potentially make a significant difference for both animal welfare and the occupational health and safety of workers, as well as long term profitability.

11.3 Animal Stress – Stressful treatment of cattle

Anna is a manager at a feedlot in Queensland and she is concerned about the level of stress in cattle at feedlots. The implications of stress are that animals can lose weight, have an increased probability of getting sick and an increased risk of receiving low quality meat scores (high pH due to loss of glycogen) known as ‘dark cutters’. Dark meat may suffer price discounts ranging from 5-20% of the carcass weight and therefore it is a problem that can cost the industry millions of dollars.

Dag removal methods that include soaking, washing with a high pressure hose and mechanical systems are also stress factors.

Anna follows best practice guidelines that recommend cleaning heavily contaminated cattle in a mannerthat minimises stress, no less than seven days before dispatching to the processor. This includes avoiding the use of high pressure hoses on sensitive areas of the animal and minimising exposure to cold temperatures. To reduce climatic stress on animals, Anna’s feedlot incorporates shaded areas where cattle can escape from the heat of the sun and are protected from frosts and rain in colder weather.

Anna is generally interested in solutions that can minimise stress and is aware of a number of stressors including noisy environment, humans handling instruments, electric prodding, washing, dipping, brushing and shearing. She is very interested in solutions that minimise stress from any environmental factor. For example, Anna has found that other feedlots use software that calculates shade modelling, which could help her to optimise shaded areas at her feedlot.

11.4 Live Export – Negative media exposure

Julie is a live cattle exporter in Darwin. Producers in northern Australia account for the majority of live feeder/slaughter cattle exports as they are located in close proximity to major markets. Julie is part of the Australian live cattle supply chain to Indonesia that now supports over 12,000 direct jobs. Many of Julie's employees live in remote areas with little alternative of employment, including many indigenous Australians.

Julie understands that live cattle exports are highly dependent on international markets that affect prices for cattle, and hence producer returns. She is also aware of the challenges faced by the live cattle export industry, including its vulnerability to media exposure. If a case of dirty cattle is found and promulgated in the media it has the potential to hurt the Australian cattle industry as a whole.

Julie knows that dags are not a large issue for live cattle exporters and her company always complies with the Australian Standard for the Export of Livestock, as well as regulations of the importing government. However, recent news from Israel has started to concern her.

Israel has reported dirty cattle entering the country and that animals have been held in crowded pens, where they are stressed due to heat, rough seas and other conditions. Many animals are also getting sick and perishing during the journey. These are the main arguments from this country to support a bill to progressively reduce the importation of animals from Australia for slaughter.

Julie sees that this crisis would have a large economic impact on the Australian cattle industry and would lead to reputational damage of its image and the Australian brand. If Julie's clients in South-East Asia decide on a live export ban her company and other producers probably would have to ship cattle to southern processors, with no significant returns.

Among other animal welfare issues for cattle in transit, Julie is looking for options that minimise the risk of cattle being dirty at the port of entry and that fit within the regulations of the importing government at the same time.

11.5 Feedlot Dags Treatment – Poor treatment at dispatch

Jack owns a mid-scale feedlot in central NSW. Jack's feedlot is an independent business and not owned by a large processor. Feedlots typically source lightweight young cattle from producers and finish them to slaughter weight on grain for a period between 50-120 days, according to customer specifications (Australian Competition and Consumer Commission, 2017). Jack's main customer is a meat processor supplying beef to a major domestic supermarket chain. The feedlot is located in Australia's southern region, characterised by high rainfall in winter. As it is the winter season of a particularly wet year, the environmental conditions are ideal for dag formation in cattle.

Due to the associated costs, Jack's team is unable to effectively remove dags from their cattle. As the most common method for dag removal is soaking and washing, treatment of dags incurs considerable water-related expenses, as well as infrastructure and labour costs (Jack's washing facility is unable to recycle water, making water-related expenses even more significant). Unlike some feedlotters that wash cattle prior to dispatch, Jack omits this process. Jack sells cattle to the processor, approximately 20% of which are affected by dags. The processor detects the dags only after the cattle have been purchased.

As the degree of dags in Jack's cattle is significant and this is the second time he has supplied daggy cattle to the processor, the processor decides to financially penalise Jack. Dag penalties from processors can be $10-$50 per animal - around 10% to 20% gross margin. In addition, the processor charges Jack a fee for cleaning the daggy cattle. Adding to the financial impact is the non-monetary negative effects on Jack's feedlot when dags are left for the processor to action. If the incident is disclosed by the processor industry-wide, the brand image and reputation of Jack's feedlot will be affected, impacting future business opportunities. Even if the incident is not disclosed at first, if the processor has issues with health and safety assessments down the track, the reputation of both the processor and Jack's feedlot (as supplier) will also be affected.

Jack is interested in solutions to effectively remove dags from his cattle prior to dispatch that do not require considerable infrastructure investments and water-related expenses.

11.6 Feedlot Dags Preventative Treatment – Management of dags

Charlotte also owns a mid-scale feedlot in southern NSW that supplies mostly long-haired cattle which is very similar to Jack's business described immediately above. Charlotte's feedlot is an independent business and not owned by a large processor. She sources lightweight young cattle and finishes them on grain for between 50-120 days.

Charlotte's main customer is a meat processor that exports beef to an overseas market. Charlotte's feedlot has maintained a business relationship with this processor for over 20 years. Her feedlot is located in Australia's southern region, characterised by high rainfall in winter. As it is the winter season of a particularly wet year, the environmental conditions are ideal for dag formation in cattle.

Given the well-known health, safety and quality requirements of the customer, Charlotte has procedures in place to detect and treat daggy cattle effectively prior to dispatch. Charlotte then sells dag-free cattle to the processor. Every year, Charlotte's feedlot incurs costs in water, infrastructure and labour to treat dag-affected cattle through washing and soaking, but these are not preventative solutions. Many feedlotters use preventative methods including covered pens to divert precipitation (e.g. shedding, high roofs), bedding (applying wood chips or straw to pen surfaces) and proper drainage. However, these solutions require high capital outlays, as well as costs associated with yearly replacement of pen bases, involving removal of bedding material, manure and dags using tractors. For this reason and considering that dags only appear in a few periods throughout the year, Charlotte has decided not to implement these solutions.

As Charlotte is not passing the dags issue to the processor, the cost of managing it remains moves with the likelihood of occurrence and severity of impact on operations. For Charlotte, the cost of dags management is estimated to be $5.50 per head - in a year with average counts of dag cases (figure from MLA and Acil Allen Consulting). This erodes the profitability of Charlotte's feedlot in the long run. It also puts them in a risky situation in which they are forced to keep dags at bay due to fear of losing their long-term customers. In addition, there are benefits associated with preventative dag solutions that Charlotte's feedlot is missing. For instance, shedding is associated with increased cattle comfort and superior growth rates.

12 Opportunities

All scenarios were discussed by the study team and given a low, medium and high score on two dimensions - impact and likelihood.

Scenario	Impact	Likelihood
Processor Treatment of Dags – Contamination issues.	**High**	**Medium**
Occupational Health and Safety - Human injury related to dag treatment.	**High/Medium**	**Medium/Low**
Animal Stress – Stressful treatment of cattle (also leading to so-called “dark cutters” and poor eating quality).	**Medium/Low**	**Medium**
Live Export – Negative media exposure (and potential market access issues).	**Medium**	**Low**
Feedlot Dag Treatment – Poor treatment at dispatch.	**Low**	**High**
Feedlot Dag Preventative Treatment – Management of dags.	**Low**	**Medium**

The scores for each scenario were then plotted on a 3X3 matrix to identify the most impactful scenarios (Figure 17).

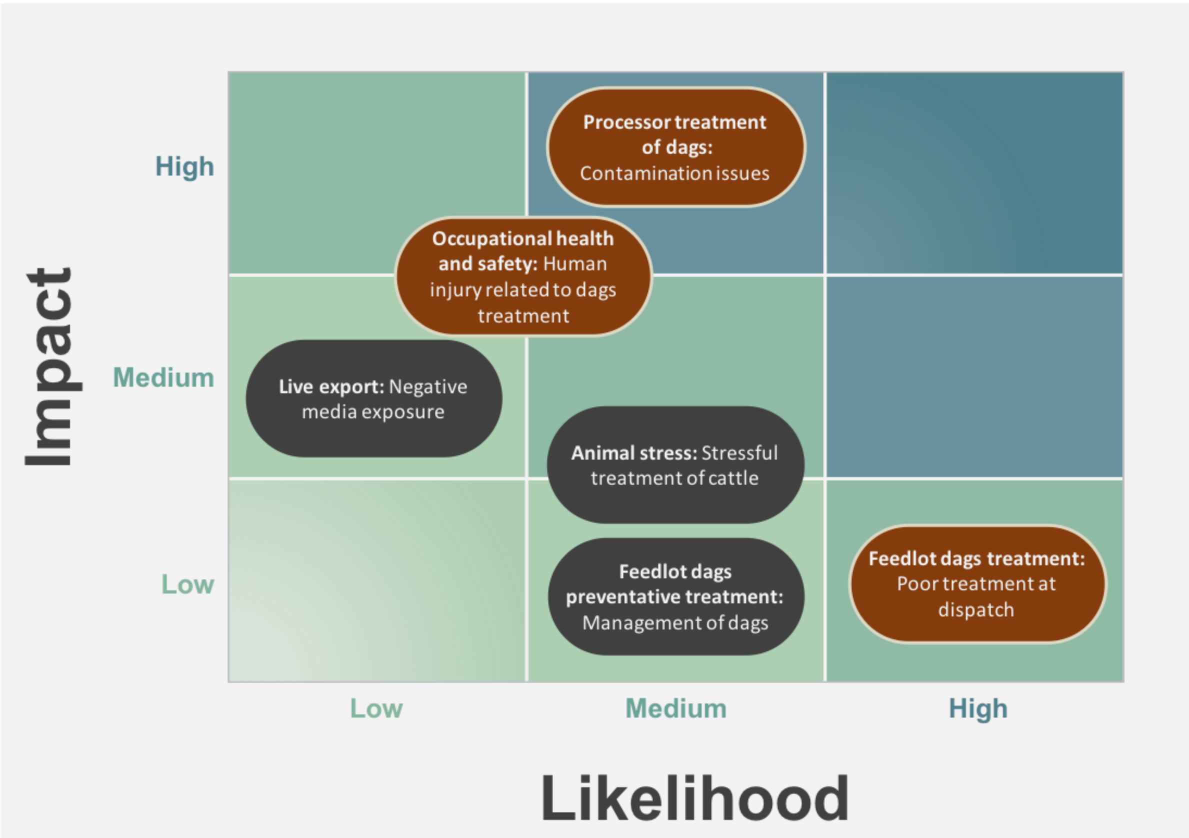


Figure 17. Scenario plot. Impact vs likelihood of occurrence

12.1 Improved Safety and Efficiency of Dag Removal

Australian regulations require that cattle are “cleaned” prior to slaughter. This cleaning process is, to a large degree, done by processors but there are benefits of dag removal for feedlots in terms of production efficiency, animal welfare and avoidance of penalties from processors.

Although current dag treatment practices vary between supply chain participants, it is normally done via semi-automated or manual soaking, washing and scrubbing. Light dags on short hair cattle are often dealt with effectively with conventional removal procedures with manual scrubbing to remove more severe dags. In a feedlot situation dag removal may be followed by cattle being put in clean pens with bedding before departure for processing.

There are a number of opportunities to improve dag removal systems, including:

a) **More efficient infrastructure**. Washing and manual treatment of dags requires considerable infrastructure investment as well as water and labour costs. In many cases, washing facilities are unable to recycle water, making water-related expenses even higher, and
b) **Improved worker safety.** Conventional practices require workers to be in close proximity to cattle when scrubbing (particularly for processors dealing with long-haired cattle). The process causes stress to the animal, which can impact on product quality as well as increase risk of injury from animals kicking and crushing workers. Protective equipment is used.

These factors strongly influence labour productivity and product quality.

In preparation for processing the cleaning process will only target cutting lines along the belly and sides, where the carcass will be penetrated by a cutting blade. This method will leave dags on hides in other areas and presents a pathogen contamination risk in the processing environment including foodborne illness in humans.

12.2 Prevention of Dag Accumulation on Animals

The origination of the issue of dags is with feedlots and so it makes logical sense that prevention within feedlots would be a pathway to minimising the costs of dag management to the industry. Current dag prevention methods include the use of sheds and bedding material to reduce the production of the materials that adhere to cattle and form the dags. However, adoption of these approaches has been insufficient. Cost of infrastructure and bedding material and the additional operational requirements may be causes.

An additional opportunity that holds some merit is the prevention of the adherence of materials that form dags to cattle hair. A physical barrier that prevents the dung and soil is an opportunity because:

a) A preventative measure may be cheaply applied at cattle induction without adding significant infrastructure costs to the feedlot which are otherwise prohibitive
b) Depending on the approach there may be additional productivity benefits which provide a return over and above the cost internally in the business
c) Feedlots would be able to stabilise and control the cost of dag management in their businesses particularly through the avoidance of penalties and fees charged by some processors

d) Feedlots that are able to guarantee dag free cattle may have greater flexibility in sales channels and development of higher value direct supply agreements with customers

12.3 Detection and Removal of Contamination

Research indicates that cattle with high faecal, mud or dirt contamination pose a significant threat of possible bacterial contamination on the resultant carcass (Bean and Griffin, 1990; Lambert et al., 1991; Ridell and Korkeala, 1993; Roberts, 1980). The assumption is that this threat can be minimised by presenting clean cattle to slaughter. While some work supports this, other studies indicate that the level of cleanliness of the presented animal bears little relationship to the microbial contamination of the subsequent carcass (Rowland et al., 1999; Sofos, 1999; Van Donkersgoed et al., 1997).

Based on these analyses, there are two solution categories for this, addressing dags within the processor treatment and testing scenario. One is to improve the treatment and removal of dags which will limit the carrying of dags into production facilities, thereby limiting the contamination risk. The second is to improve methods for detection of microbial contamination, so that the contamination risk for meat products is reduced to the lowest possible level.

13 Proposed Solutions

Given the differences in the operation of the value chain, climate and other factors between northern and southern regions it has necessarily focused solution generation in the south where the issue of dags is most present.

The opportunities identified for this project through value chain analysis, stakeholder interviews, technology search and synthesis are:

- improved safety and efficiency of dag removal
- prevention of dag accumulation on animals
- detection and removal of contamination

Solutions aimed at these opportunities must align the benefits to individual industry participants with the industry objective of reducing the impact of dags along the supply chain. Barriers to adoption as well as incentives need to be considered in the context of the strategic shifts that move the industry from the current state to the desired future state.

The following sections detail the solutions along with detailed criteria that will inform the solution sourcing phase (Phase 3).

13.1 Dag Prevention

Many feedlots already use some preventative methods that may include pens with better drainage, rain cover and bedding such as wood chips, straw or even nut shells, which also function as a scrubbing mechanism (see FSA Consulting, 2013, for trials involving different bedding materials). However, considering that dags only appear for a few periods during the year, some of the preventative solutions that require high capital outlays and operational costs are not economically viable for many feedlots, unless they are linked to significant increases in cattle growth rates.

Low cost polymer coating application methods and formulations are required solutions. Improved application and formulations (tailorable in terms of curing time, hardness, hydrophobicity) of polymer coating applied to hides to prevent or limit dags and to prevent or limit dag contamination. Automated spray application would be done when an animal is inducted onto a feedlot or goes into a crush ahead.

13.1.1 Design Information

Due to infrastructure and operational costs, as well as small profit margins, many feedlots are not able to effectively prevent or remove dags from their cattle. Not considering the commercial aspect of weight gain, it is important that both preventative and treatment solutions are cost effective down to the level of not exceeding AU$1 operational expenditure per application/head. (See Van Moort, J P. 2018, for a detailed overview of costs related to treatment of dags, and Appendix A and B for information related to automated washing systems and shed cleaning systems.)

Benefits from a solution should include:

- Would allow feedlots to avoid dag removal costs and penalties imposed by processors. Relevant particularly for southern feedlots interested in more direct relationships with processors.
- Would allow processors to better manage dag removal costs and contamination risks
- Would allow for combination with existing best practices for dag minimisation

13.1.2 Design Criteria

Solutions should adhere to the following design criteria:

a) Must not leave any residues that may be a potential contamination issue in the meat processing environment. Adhere to Australian food and safety regulations
b) Minimise animal stress and negative impact on animal welfare (see Grandin, 2016);
c) Adapt to the production processes already in place and should not require considerable changes in the order and/or nature of production activities. Minimise the physical demands placed on workers to remove dags (see MLA, 2009);
d) Automated in order to improve detection efficiency and decrease costs
e) Minimise the physical demands required of workers to remove dags
f) Not increase the cost of processing i.e. reducing chain speeds, increased labour costs due to additional trimmers
g) Not decrease product quality in any way
h) Works in long hair cattle
i) Mobile or portable infrastructure
j) Not exceed AUD$1 per treatment per head

13.2 Efficient and Safe Dag Removal

Solutions are required to remove dags while being much safer for workers and more effective in reducing food safety and contamination risks in processing plants. That may be a combination of infrastructure, tools and methods to safely remove dags from cattle. Semi or fully automatic systems that are effective in reducing dags without causing animal stress. Additionally,

13.2.1 Dag composition

The composition of cattle dags is complex and variable, depending on regional soil and feed. However, it is primarily composed of chaff, dung, soil and urine. Analysis of dung by Auer et al. (1999) showed it to be mainly composed of cellulose 30%, hemicellulose 28%, lignin 21%, protein 6% and ether soluble material (fats) 10%. Cellulose, the major polysaccharide of the cell walls of higher plants, is a crystalline linear polymer consisting of glucose subunits. Hemicellulose, associated with cellulose or bound to lignin, is composed of a mixture of 5-carbon and 6-carbon sugars such as xylans, glucans and mannans, forming branched chains (Tozan and Covington, 2002). Lignin is an amorphous, 3-dimensional aromatic polymer which forms a protective matrix around the cellulose fibres and is covalently bonded to hemicellulose.

13.2.2 Safety

According to national guidelines for health and safety in the meat industry, processors must ensure that their workers use proper personal protective equipment for their regular activities (Workcover Corporation SA, 2001). This includes fibre gloves woven with a cut resistant fibre, boots, hearing protection and eye protection. Further, practical guidelines for cattle handling are provided by the Australian Centre for Agricultural Health and Safety:
https://sydney.edu.au/medicine/aghealth/uploaded/fs_docs/guidance/Cattle_Handling_Safety.pdf

In addition, to reduce workplace hazards, regulators recommend designing the layout of stockyards in a way that separates, wherever possible, interactions between livestock and people. Factors to consider when designing stockyards include the ability to handle current and future workloads, ready access and escape points and yard capacity, among others (WorkSafe Queensland, 2018). Also, to comply with OH&S risk management measures, the design should also permit rapid implementation of first aid and initial treatment to minimise the impact of any injury (Australian Meat Industry Council, 2000).

In addition to becoming a hazard for operators, a stressed animal prior to slaughter is more likely to produce poor quality dark meat as the pH specification increases due to loss of glycogen (MLA, 2009).

Solutions could be considered in the following areas:

- Removing workers from the task of treating dags, employing non-manual methods such as automation.
- More efficient designs of stockyards so that workers can perform the task as far removed from the animal as possible, while ensuring quick exit and/or assistance should a problem arise.

- Solutions may involve the development of best practices for dag removal and education programs to disseminate such practices

13.2.3 Solution Criteria

Dag removal solutions may be semi or fully automatic washing systems. Beef City has produced evidence that these systems work well and help to reduce dags significantly without causing animal stress (see Box 1 and Appendix A for more details). However, fully automatic washing systems come at a significant infrastructure cost and scale economies are required to justify this level of investment. A design criterion is to create equally effective washing solutions at a significantly lower price point.

Solutions should adhere to the following design criteria:

a) Eliminate or reduce risk and severity of injuries to workers
b) Minimise the physical demands on workers removing dags
c) For personal protection, be easy to use & lightweight
d) Not leave any residues that may be a potential food safety issue.
e) Minimise animal stress, thereby minimising the likelihood of the animal becoming a threat to workers
f) Adapt to or align with the existing production process
g) Not significantly increase the processing cost, i.e. reducing production chain speeds, increased labour costs.
h) Create equally effective washing solutions at a significantly lower price point
i) Minimise excessive manipulation that may lead to bruising in cattle.
j) Minimise damage on animal hides
k) Not exceed AUD$10 per treatment per head

13.3 Microbe Detection and Decontamination

A more left field option for dealing with the impact of dags would be an attempt to increase confidence in dealing with the consequences of contamination through rapid detection and removal of food safety issues in the food processing environment. While this solution will not address the cause, it may enhance confidence in the control of risks arising from the presence of dags in the supply chain.

Solutions are required for the detection of microbial contamination need to adhere to Australian food and safety standards (see section above) and should be automated in order to improve detection efficiency and decrease costs. Appendix A provides more details around some automated systems.

13.3.1 Design Information

The detection and (potentially) removal of microbes in the meat processing chain arising from sources including dags contamination. Include technology and method for 100% sensing of microbes in meat processing chain. Additional process could include microbe removal with no impact on food safety or quality.

Under current testing regimes, Australian processors test for E. coli 0157:H7 and for all other STEC pathogens. It is a sampling swab of 750cm surface carcass square. The tests are highly sensitive and can detect a single organism. A statistical sampling plan is applied over 1 year, in which 0.2% presence of E. coli 0157 H7 and 0.1% of the other the 'big six' pathogens are the tolerated limits (Australian food safety standards: https://www.foodstandards.gov.au/code/proposals/Documents/P1014-MeatPPPS-AppR-SD2.pdf).

Solution benefits from should include:

- Would reduce consequence of dag management failure
- Would allow for current adequate practices in relation to dags to continue while allowing rapid notification of issues
- Would improve detection of breaches in contamination reduction practices

13.3.2 Solution Criteria

Solutions should adhere to the following design criteria:

a) Adhere to Australian food and safety standards
b) Detect extremely low levels of pathogens on carcass (i.e. a single organism in 750cm2)
c) Target and destroy pathogen bodies contaminating utensils
d) Not leave any residues that may be a potential contamination issue
e) Adapt to the production processes already in place and should not require considerable changes in the order and/or nature of production activities;
f) Not increase the cost of processing, i.e. reducing chain speeds, increased labour costs due to additional trimmers
g) Not decrease product quality or damage animal hides in any way
h) Minimise excessive worker manipulation that may lead to bruising of cattle.

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15 Appendices

15.1 Appendix 1 – Technology Search

15.1.1 Dag Prevention, Treatment and Removal

Search Terms: dag tag daglock dagginess matted faecal dung cladding mud soil manure contamination hides cross-contamination putative source hide cattle livestock bull cow tracking hair removal technology enzyme brush brushing tool de-dag spray wash system high pressure pre-soak polymer surfactant hide coating

Definition of Dags

A dag is a clotted mat of dirt, faeces and/or urine (often developing a hard, concrete-like consistency in hot, dry and sunny regions) that adheres to the hair on cattle (and the wool of sheep). Dags may be wet, dry, hard, soft, extensive or superficial, depending on:

- Feedlot bedding material (eg dirt, dark volcanic soil, straw, dust, woodchips, gravel or vegetable matter eg hay).
- Exposure of feedlot pens to rain, or dryness due to a local climate which generates dust.
- Type and composition of feed (eg amount of roughage, grain, grass or hay).
- Adequate feedlot drainage (poor drainage leads to wet, muddy feedlot pens).
- Management of bedding material, removal of manure and regular soil/pen surface replacement.
- Presence of weatherproof shelter/cover over feedlot (mostly used in southern regions of Australia and in countries of the northern hemisphere with cold climates).

Other terms used worldwide to describe dags include faecal (or fecal- US) hide contamination, tag (Canada[1]), dung (UK). The term also applies to sheep (dag, dag-lock, daggle-lock).

Presence of dags on cattle hides is a major problem to the feedlot and meat processing sectors globally due to concerns regarding:

- Welfare and health of animals; (stress produces poor quality carcasses and 'dark meat', and heavy dags contribute to stress levels).
- Increased costs associated with the cleaning and processing of daggy cattle (and reduced meat processor line speeds).
- Potential to compromise food safety through carcass contamination during processing, post-slaughter (1).

Dag Composition

- Dags are formed from dung, dirt, chaff and urine (1)

[1] http://www.omafra.gov.on.ca/english/livestock/beef/news/vbn0510a3.htm

- Dags are attached to, and form around the hair (2). There is no direct attachment of dung to the hide itself. The adhesion of the dung to the hair forms a very strong matrix. It is this matrix that needs to be broken in order to remove dags from the animal (3).
- 'Dags are comprised of faecal and soil particles that adhere to the hair in the coat of cattle, and usually develop during the winter period when pens remain wet following rainfall. Bos Taurus cattle, which traditionally have long hair coats during the winter period, are the most commonly affected, although other breeds can also be impacted. The dag is attached to the hair fibre and not to the epidermis of the skin, which makes it difficult to remove, but does provide the potential for non-invasive removal of the dags.' (4)
- 'The composition of cattle dags is complex and variable but primarily composed of chaff, dung, soil and urine. Analysis of dung by Auer et al (2) showed it to be mainly composed of cellulose 30%, hemicellulose 28%, lignin 21%, protein 6% and ether soluble material (fats) 10%. Cellulose, the major polysaccharide of the cell walls of higher plants, is a crystalline linear polymer consisting of glucose subunits. Hemicellulose, associated with cellulose or bound to lignin, is composed of a mixture of 5-carbon and 6-carbon sugars such as xylans, glucans and mannans forming branched chains (5). Lignin is an amorphous, 3-dimensional aromatic polymer which forms a protective matrix around the cellulose fibres and is covalently bonded to hemicellulose' (1).

Past work from Xinova/IDMC/Intellectual Ventures
Ideas for Dag Prevention (RFI – 140117)

- Sodium stearate coating applied to cattle directly: Sodium stearate is soluble in water. One can coat the hide by either spraying a solution of sodium stearate onto the animal or making livestock walk through a bath containing a sodium stearate solution. Either way, after drying the skin, hide and hair will be coated with stearate. The stearate surface is expected to be slippery and hydrophobic.
- Silicone coating applied directly onto hide: A variety of water soluble silicone additives, such as Silclean 3720, Dow Corning® 51, 52 additives, etc. are commercially available. These additives again can be applied to cattle by spraying or the bathing technique as described. After drying, the cattle will be coated with a thin silicone layer to discourage dag formation.
- Protective mesh clothing: Fabric meshes made from nylon and polyester of varying pore sizes (openings) are commercially available. This idea is to modify the surface of the mesh materials with either a stearate, silicone or fluoropolymer coating. The modified mesh will exhibit superhydrophobic and/or superoleophobic properties, depending on the surface modifier. The surface of the resulting mesh will repel water and oil and exhibit very low adhesion toward pollutants. We propose to use the modified fabric to cover cattle (like clothing for a pet) during their stay in the feedlot.
- Polymer coating applied to live cattle hides/hair (dag prevention attempt). Project trial work by Georgius Adams and Maggie Ng (Xinova, 2016):
- 'Methods and Compositions for Dag Mitigation' Georgius Adams September 2016

https://patents.justia.com/patent/20180077899

and

https://patents.justia.com/patent/20180078480

'Technologies are described for methods and compounds for mitigating dag development on hair. The method comprises applying a compound having at least one hydrophobic component and at least two reactive functional components to the hair and applying a binder to the hair. The applying of the compound and the binder to the hair enables a reaction with the hair and the formation of a matrix in situ with the hair. The matrix has at least one hydrophobic component extending from the hair and imparts its hydrophobicity to the hair to mitigate the dag.'

"**Evaluation of Several Coatings for the Prevention of Dag Formation on Cattle during the Feedlot Period": Invetus Pty Ltd Study**

Background:

This study sought to evaluate the effectiveness of three formulations in the prevention of dust, mud and faecal matter build-up (dags) on cattle in a feedlot environment.

Use of live animals for this work was necessary as the key outcome (prevention of dag formation over time) could not be adequately simulated in the laboratory.

Cattle were restrained in a cattle crush (stall). Hide treatments were applied through a pneumatic spray gun to the side, legs, belly and perineum of cattle, to the point where the hair coat was wet through with treatment solution.

Treatments were applied using an automotive spray gun, however problems with blockages of the nozzle lead to the application of a thicker coating of treatments to hides with a paint brush for adequate coverage.

The trial was conducted from September to December 2018 (Spring- Summer period). Temperatures over the trial period were relatively mild and rainfall was above average (200mm). Cattle were challenged with an extra 60mm of 'rain' applied via sprinklers to simulate a muddier, wetter feedlot environment.

Conclusions:

The study was concluded after 100 days due to the lack of any apparent favourable effects, and thus the trial was somewhat inconclusive. The applied products appeared to attract dust, dirt, loose hair and loose feed material with hair matting and, in some instances, formation of plaques of matted hair, dust and faecal material; these eventually were shed as cattle lost their winter coats late in the study.

Based on these field experiments on live animals, the study team ranked the performance of each treatment as follows:

1. 1.Hide Coating Product: 'Siloxane' (Siloxane or 'Silicone' based hydrophobic coating). The term silicone is a generic term referring to all materials made up of siloxane, including silicone in its fluid and solid forms. Siloxanes are organosilicon compounds exclusively derived by synthesis.

2. Hide Coating Product: 'Stearate' (Zinc stearate trioctylamine complex or 'metal stearates'). Pre- trials of metal stearates in the lab (using a sample of hide) were very successful, however in-field trials on live cattle indicated the stearate coating was less effective than Siloxane above.
3. Hide Coating Product: 'Surfactant' (Reactive surfactant based on solid epoxy resin). Consists of two conventional surfactant molecules chemically bonded together by a spacer molecule (also referred to as 'Gemini surfactants) and are generally superior in surface activity to conventional surfactants. The least successful coating system trialled.

Suggested Recommendations: Future Work:

As discussed, the trial was discontinued prematurely after an assessment considered that the applied methodology was not effective in preventing dag formation.

Laboratory pre-testing and evaluation of methods employed lead the study team to the conclusion that use of hide coatings may be still be effective if:

- Formulations were less viscous and more liquid (causing less blockage of spray applicators) and obviating the need to use a paint brush to enhance coating efficiency.
- Treatments were less 'sticky' and dried more rapidly after application- all 3 products appeared to attract dust and loose hair IMMEDIATELY post-treatment.
- Spray applicators were adjustable to allow larger volumes of treatments to be applied more rapidly.
- The study was repeated in mid-winter when cattle have full winter coats; (cattle lost these and attached dags over the spring-summer trial period by natural seasonal hair-shedding)

Existing Solutions and Proposed Dag Prevention Methods

Washing systems

Initial pre-soak, followed by high pressure jets from concrete floor of fixed wash station (eg Beef City, Toowoomba Qld system): 90 min. process

Figure 1: Cattle pre-soak, Beef City Toowoomba Qld   Figure 2: Cattle pressure wash, Beef City

UK Cattle Washing Study

Jarlath T. O'Connor 'Efficacy of washing and disinfection in cattle markets in Ireland' Irish Veterinary Journal February 2017

https://irishvetjournal.biomedcentral.com/articles/10.1186/s13620-017-0081-1

"Washing and disinfection at markets is utilised to reduce faecal contamination, thereby reducing the risk of contamination and disease spread among animals and carcasses at slaughter. The primary objective of this study was to assess the efficacy of standard washing and disinfection techniques at markets in Ireland in reducing bacterial contamination on internal structures…. Markets are a potential reservoir for microbial contamination with a resultant increased risk of disease, spread by cattle moving through markets into new herds, and carcass contamination for cattle moving directly to slaughter."

Polymer Coating Applied to Hide

IDMC/Xinova: Evaluation of three formulations for the prevention of dust, mud and faecal matter build up (dags) on cattle in a feedlot situation.

'Methods and Compositions for Dag Mitigation' Georgius Adams September 2016

https://patents.justia.com/patent/20180077899

and

https://patents.justia.com/patent/20180078480

'Another method of mitigating dags on hair comprises applying a compound having at least one hydrophobic component and at least two reactive functional components to the hair. A binder is also applied to the hair. The binder is selected from the group consisting of a curing agent, a catalyst, a hardener, a crosslinking agent, and combinations thereof. The applying of the compound and the binder to the hair enables a reaction with the hair and the formation of a matrix in situ with the hair, the matrix has at least one hydrophobic component extending from the hair and imparts its hydrophobicity to the hair to mitigate the dag.'

Physical Removal

Physical removal of dags from belly of cattle with serrated/metal tools (eg modified steel shovel blades). The system depicted below was employed at Beef City, Toowoomba but was discontinued due to physicality of process (most workers at the site are now female) and risk of injury to dag removal staff; (in the past male staff tasked with dag removal wore protective sports body armour, shin guards and helmets with face protection during dag removal operations).

Figures 3 & 4: Old physical dag removal area utilising metal tools and cattle locked in races, Beef City Toowomba Qld

Mechanically-based de-dagging
MLA Project: 'Research was done to develop and test a mechanical dag removal device that potentially offered an effective, economic, safe and reliable system for cleaning feedlot cattle carrying a heavy dag loading. The de-dagger technology was developed from a series of industry driven projects that were in response to a number of high cost problems associated with heavily dagged cattle. The manual de-dagger tool developed from these projects is still in operation at John Dee, Warwick, Qld (http://www.johndee.com.au). The eventual aim was to develop a robotic de-dagger system based upon the manual unit installed and operating at John Dee, Warwick, for operation on the abdomen. The system was to include a carcass orientation and restraint device, and a surface profiling sensor mechanism. The robotic project was terminated prior to being completed'. (7)

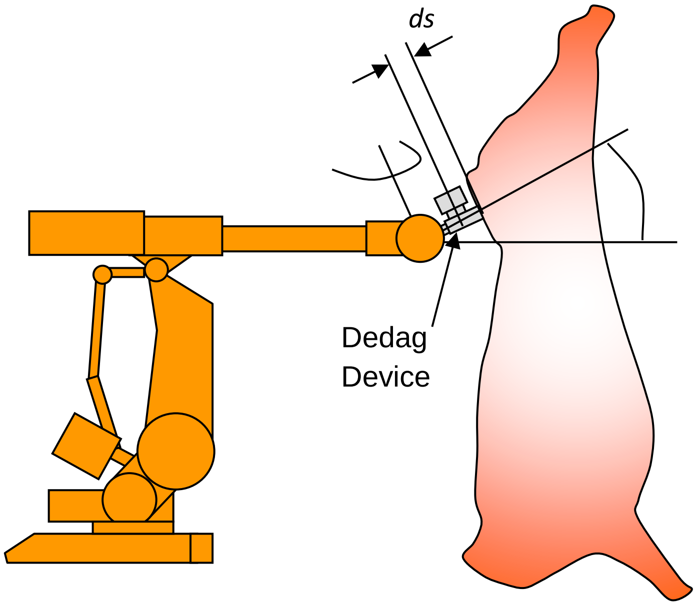


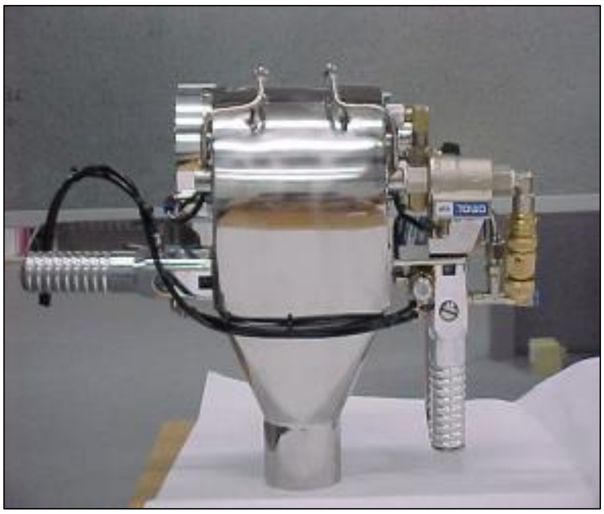
Figure 5: Proposed CSIRO post-slaughter cattle de-dagging robotic arm

CO2 based de-dagging

In 2009, a large processor requested that CO2 blasting be investigated as a potential to provide a cost effective solution to mid and large sized processing plants for the removal of dags. In 2010, Meat and Livestock Australia (MLA) and the Australian Meat Processing Corporation (AMPC) approved a project with Scott Technology Australia (Scott) to pursue this concept. The approved project (9) A.TEC.0081 was planned as Stage 1 of a possible three stage development program. (8)

https://www.mla.com.au/research-and-development/search-rd-reports/final-report-details/Productivity-Off-Farm/Mechanical-or-CO2-based-de-dagging/2731

Dedag Technology- CSIRO (7)



Figures 6 and 7: Hydraulic dedag tool (CSIRO) and (right) the tool being used in a meat processing plant post-slaughter

Tailwell Power Tail Trimmer (US)-

https://www.youtube.com/watch?v=kFIm30L5wWk

Figure 8: Tailwell Power Tail Trimmer, US

The Tailwell trimmer is designed for cleaning up long, wet and dag-filled tails in US dairy processing facilities.

Auto De-Dagger Study, John Dee, Warwick, Qld

The aim of this project was to develop a prototype automated de-dagging system based on the manual equipment, described on p. 5 of this report, operating at the processor John Dee in Warwick, Queensland. (8)

Manual work tasks carried out by the hand tool and an operator are as follows:

1. Orientate the carcass for dag removal.
2. Operate the hand tool to remove dag material along the belly opening cut line from the stick wound to the crutch area, avoiding the testes / udder protrusion.
3. Remove dag material where possible from the crutch area.
4. Remove dag material from the general belly region, at all times passing the dag cleaning rotor over and adjacent to the carcass opening cut lines to further clean this area.

The robotic Dedag system was designed to provide the following:

- Automatic carcass orientation and restraint during dag removal.
- Ability to apply the dag removal tool against the carcass surface with more appropriate, controlled force than is possible for a manual operator, to ensure the dag removal rotor can function in the most efficient manner.
- Movement of the tool at a constant speed and in a controlled manner so that the maximum area of the carcass hide is covered in the available process time.
- Possibility of increasing the rotor power and/or speed to achieve the most efficient waste removal setting for the tool.

Use of Shelters and Sheds in Feedlots

Jusco Feedlot in northern Tasmania uses covered sheds to reduce incidence of dags in this geographically temperate, wet region of Australia (30).

‘Infrastructure includes permanent shedding for 2000 cattle – easily the largest capacity among Australia’s small number of feedlots that use permanent shed structures, as opposed to shadecloth cover.’

‘Another factor setting the Tasmania feedlot apart is its high average annual rainfall – possibly the highest of any feedlot location in Australia, at more than 660mm- and low evaporation, which is the underlying reason for the original investment in shedding.’

https://www.beefcentral.com/features/top-25/lot-feeders/top-25-no-19-tasmania-feedlot/

Figure 9: Use of Shedding at Jusco Feedlot, Tasmania to Reduce Dags by Providing Rainproof Shelter for Livestock

Cow Brushes

Activated by animal, exploit natural grooming behaviour.

See References 32, 33, 34 and patent listings on p. 14 of this report for descriptions of various cow brush systems.

Cow brush systems are used in dairy milking plants, in the US and Europe; ‘The cows use the machine six times a day, on average.

Uses the cow's natural behaviour of rubbing its body up against the feeding tree and activating the device.

The HAPPYCOW has been built especially for group pens, where cows are free to move about’ (32)

See Videos: https://www.youtube.com/watch?v=eQzcsN1zdM4 and (pto)

https://www.nytimes.com/2018/08/08/science/cows-brush-grooming.html

'The DeLaval swinging cow brush is a self-grooming device employed by a number of dairy farmers. The device rotates on contact, with the bristles grooming the cow and stimulating blood circulation. The improved circulation has been linked to an increase in animal health- a study conducted by Cornell University in the US found that mastitis was 34% lower in the self-grooming cows.' (33)

Figure 10: DeLaval automated swinging cow brush

Figure 11: The 'HAPPYCOW' automated cow brushing system

Enzyme Mixture for Dag Removal

MLA Report: 'Assessment of an enzyme mixture for removal of dags from feedlot cattle'

https://www.mla.com.au/research-and-development/search-rd-reports/final-report-details/Productivity-On-Farm/Assessment-of-an-enzyme-mixture-for-removal-of-dags-from-feedlot-cattle/262

"We aimed to demonstrate proof of concept for the use of enzymes contained in a matrix applied to a small number of live feedlot animals using objective measures of dag removal. However, we were unable to demonstrate efficacy of soaking in enzyme solutions towards dry, hard dags even after extended soaking, or trialling a range of enzymes and concentrations. We identified matrices for delivering the enzymes to live cattle which were suitable for food animals, supported enzyme activity and trialled these against dags. The matrix with enzyme did not improve dag removal. We conclude that dag consistency and porosity are crucial factors in determining whether enzymes can improve dag removal, and prior to future commercial release of an enzyme solution for cattle treatment, objective testing should be conducted on a wide range of dag types and compositions."

Studies on the mechanism of enzymatic degradation of dung in the US (5)

'Dung cladding of hides presents several problems for processing, but typical soaking enzymes are ineffective for removing dung. This study evaluates the use of appropriate, targeting enzymes in soaking, to effect dung removal from hide. The major components of the composition of dung are lignocellulosic derivatives, cellulose, hemicellulose and lignin, which are the targets. The effects of individual enzymes and enzyme mixtures on dung removal were investigated and it was found that mixtures of cellulase, xylanase and laccase are more effective than individual enzyme treatments. The proposed mechanism for fast dung degradation is based on opening up the structure with lignin and hemicellulose degrading enzymes and breaking down the fibrous structure of cellulose.'

https://www.researchgate.net/publication/292916518_Studies_on_the_mechanism_of_enzymatic_degradation_of_dung

DSS for Dag Prediction and Management

There is potential for development of a computer or smartphone-based Decision Support System (DSS), using regional climate data (such as rainfall and wind forecasts), and other factors, (such as soil type, geographic location, feedlot layout, drainage, presence of shedding to protect cows, bedding material, and type and frequency of the changing of bedding material in pens), to provide a predictive management tool to allow feedlot managers to direct management practices and capital spend toward interventions aimed at decreasing dags.

May be an online tool, linked to a cloud database and used in conjunction with apps and/or Internet of Things (IoT) sensors to indicate high likelihood of dags if no interventions undertaken in a given season.

Figure 12: Example ecosystem of a Decision support System (DSS) for vineyard management

15.1.2 Contaminant Detection

- ‘Assessment of Microbiological Hazards Associated with the Four Main Meat Species’
  https://www.foodstandards.gov.au/code/proposals/Documents/P1014-MeatPPPS-AppR-SD2.pdf

  ‘This report identifies hazards (both identified and potential) that may be associated with meat from the four main meat species (cattle, sheep, goats and pigs), and lists pathogenic microorganisms that, if unmanaged, present or may potentially present a risk to public health… The report also reviews meat associated foodborne disease evidence in Australia.’

- ‘Hyperspectral imaging – an emerging process analytical tool for food quality and safety control’
  https://www.sciencedirect.com/science/article/abs/pii/S0924224407002026

  ‘Hyperspectral imaging (HSI) is an emerging platform technology that integrates conventional imaging and spectroscopy to attain both spatial and spectral information from an object. This paper provides an introduction to hyperspectral imaging: HSI equipment, image acquisition and processing are described; current limitations and likely future applications are discussed. In addition, recent advances in the application of HSI to food safety and quality assessment are reviewed, such as contaminant detection, defect identification, constituent analysis and quality evaluation.’

- ‘FRNA Bacteriophages as Viral Indicators of Faecal Contamination in Mexican Tropical Aquatic Systems’
  https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0170399

  ‘A particular challenge to water safety in populous intertropical regions is the lack of reliable faecal indicators to detect microbiological contamination of water, while the numerical relationships of specific viral indicators remain largely unexplored. The aim of this study was to investigate the numerical relationships of FRNA-bacteriophage genotypes, adenovirus 41, and human adenoviruses (HADV) in Mexican surface water systems to assess sewage contamination.’

- ‘Fluorescence Hyper-Spectral Imaging to Detect Faecal Contamination on Fresh Tomatoes’
  https://www.agroengineering.org/index.php/jae/article/view/491/536

'In this study a hyper-spectral fluorescence imaging system has been developed to evaluate the potential for detection of faecal contamination on red tomatoes. The results shown in this investigation are further manifestation that fluorescence imaging techniques are very sensitive tools and indicate that hyper-spectral fluorescence imaging systems can be used to detect faecal contamination on red tomatoes that is not visible to the human eye.'

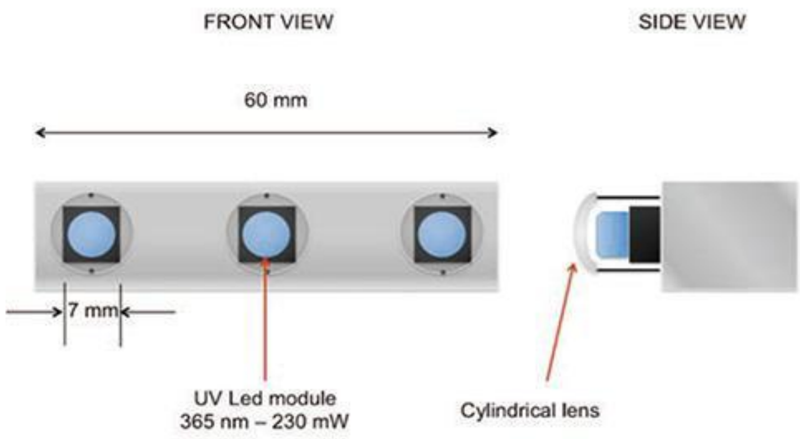


Figure13: UV-A Fluorescent Lamp Assembly for Hyper-Spectral Imaging

15.1.3 O H & S Technologies: Dag Removal

Physical Harm Minimisation

Figure 14: Use of helmets and faceguards immediately post-slaughter (Beef City, Toowoomba)

- Currently all workers in feedlots and meat processing facilities who are in close proximity to live animals, remove dags and wash cattle, (both pre- and post- slaughter), wear protective helmets with faceguards, and (where at high risk from kicks and cattle horns), additional sports body armour to prevent injury from livestock hooves, horns and tails.

- Australian Centre for Agricultural Health and Safety, University of Sydney 'Cattle Handling Safety: A Practical Guide' Revised December 2015
  https://sydney.edu.au/medicine/aghealth/uploaded/fs_docs/guidance/Cattle_Handling_Safety.pdf

  'The cattle industry is a key agricultural industry in Australia. However, those working in the industry are at risk of injury and illness associated with their work. This safety guide aims to assist cattle producers to improve the health and safety of workers handling cattle by identifying safety hazards and outlining options to control safety risks. It is not designed as a compulsory standard which you must meet. However, issues that are the subject of specific legislation are noted. Action to improve health and safety in the industry is not only a responsible step to take in terms of human health; it is a legislated responsibility under Work Health and Safety Acts and Regulations in each State. For all these reasons, it makes good business sense to manage safety and reduce the high cost of injury.'

Other Associated Industries- Humans Handling Large Animals

- Philadelphia, Hanley & Belfus 'Safe Handling of Large Animals (Cattle and Horses)' April-June 1999
  http://www.grandin.com/references/safe.html

  'The author has over 25 years of experience handling large animals. This chapter is based on both scientific literature and extensive practical experiences with cattle, bison, antelope, elk, and horse handling on ranches, feedlots, zoos, and slaughter plants throughout the United States, Canada, and other countries. The author has either observed or participated in animal handling in over 300 different places.

  An understanding of the behavior of large grazing animals helps prevent injuries to both people and animals. Grazing animals are a prey species, and fear motivates them to escape from perceived danger. When they become agitated during handling, it is usually due to fear. Fear based behavior is likely to be the main cause of accidents due to a horse kicking or a cow or steer becoming agitated in a chute.'

- 'Large Animal Handling: Occupational Health and Safety Guidelines for Farming Operations in Ontario, Canada'
  https://www.labour.gov.on.ca/english/hs/pubs/farming/gl_animal.php

  'The purpose of the guidelines is to help employers, supervisors and workers on farms recognize hazards and determine the ways they may best comply with their obligations under the Occupational Health and Safety Act (OHSA), and the relevant regulations. The guidelines provide general information to those in the workplace to help them identify specific hazards and dangerous situations. The guidelines may also provide the workplace parties with suggestions to consider in determining how to protect worker health and safety and to prevent injuries.'

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15.2 Appendix B – Invention and IP Scan

Animal Cleaning				
Publication Number	**Filing Date**	**Title**	**Abstract**	**Current Assignees**
US6966276B2	2003-11-07	Automated walk-thru cattle sprayer	A portable, towable livestock sprayer establishes a portal through which livestock move. A rigid, frame includes a removable tongue for connection to the draft vehicle. A pivoted, wheeled subframe hinged to the frame is switched between deployed or retracted orientations. The tongue fits to the subframe and functions as a leverage tool. With the sprayer properly positioned adjacent to a livestock gate, a shroud assembly is deployed. Photo-eyes determine the presence and direction of travel of animals being sprayed. A pump system controls solution. The shroud transforms between a stable, compact transportation orientation, and a deployed orientation conformed to the required dimensions. Separate, extensible shroud wings are folded together during transportation, or separately deployed on opposite sides of the sprayer to block escape routes. Each wing comprises an inner section adapted to be removably coupled to the frame, and an outer section slidably telescoped to the inner section enabling width adjustments.	DOLLAR D ALTON
EP0895715B1	1998-07-17	Cattle cleaning machine	The machine has a rotatable brush arrangement mounted on a holder and driven by a motor. The brush arrangement consists of a rotation symmetrical brush roller whose outer peripheral surface is concave in the longitudinal direction. The brush roller is in the form of a rotation hyperboloid and has stiffer brushes in the end region than in the middle region. It can have a number of axially sequential brush discs.	MAYER GEORG
US5630379A	1996-06-10	Electrically controlled spraying device for cleaning and treating animals	A low maintenance, electrically controlled automatic spray bath employs a spray system to wash animals and subsequently deliver treatment and prevention products at a continuous, consistent dosage rate. The automatic spray bath comprises at least one component. Each component comprises four rails defining an enclosure through which animals are walked in one direction, one after the other. Each rail of each component has a plurality of nozzles. When one component is employed the nozzles are divided into sets. Each set of nozzles sprays either a cleaning fluid or a treatment fluid. When more than one component is employed, the nozzles of each component spray either a cleaning fluid or a treatment fluid. The components are modular and portable. As animals are led between a set of nozzles, an electric eye beam is broken, causing a	SSI CORPORATION

			check valve to allow liquid to flow from a remote reservoir. Nozzles delivering the liquid are located and correctly pressurized to spray a particular part of an animal, for example, the hooves of a cow and not the udder. The rails of the automatic spray bath are mounted above the floor for continually flushing debris washed from the animal under the rails and out of the component enclosure. The nozzles have check valves to prevent the liquid from draining from the supply lines. The treatment solution is delivered to nozzles by a metering device which ensures that each animal is exposed to the correct dosage.	
US6029610A	1998-06-22	Washing animals	A method of washing animals prior to slaughter involves passing the animals one after another through a race having means to apply a pressurized spray of a cleaning fluid to the animal at least in those areas where incisions will be made. The animal exits from the race into a holding pen before passing to a wash station to wash off the cleaning fluid. The fluid is a high pH dilute detergent solution and is supplied under pressure to a solenoid operated valve and from there to spray bars and so that the spray continues so long as valve is open. The presence of the animal is detected by a flexible wand switch which turns on or off the solenoid operated valve.	KLENZION LIMITED
WO2005099447A1	2005-04-12	CATTLE-CLEANING DEVICE	The invention relates to a cattle-cleaning device comprising a driven brush assembly consisting of a vertical rotating brush and a rotating brush that lies above the latter, the shafts of said brushes being interconnected by means of gearing. The aim of the invention is to enable the almost complete cleaning of both larger and smaller animals. To achieve this, the end lying the furthest away from the drive of the shaft of the upper brush is mounted independently of the lower brush on a vertical plane on the approximately L-shaped limbs of a frame for said two brushes, said end being displaced upwards and downwards. At least the vertical limb is attached in a fixed manner. It is thus possible to increase the vertical extension of the stationary lower brush by a pivoting motion upwards of the independently displaceable upper brush, caused by the back of the animal.	SUEVIA HAIGES GMBH
EP1181862A2	2001-08-23	Cattle cleaning machine with a rotationally symmetric cylindrical brush	The electrically driven device is joined in an oblique position to the stand. When the animal walks slowly along the rotating device, the softer outer bristles give way slightly in order to match the contours of the animal's body and to work a large area, while the shorter inner bristles facilitate an optimal cleaning. The different grades of firmness and the slanted position of the drum ensure a thorough cleaning of the irregularly shaped bodies of the cattle.	HEITMANN BERNHARD

GB2063637B	1979-11-30	APPARATUS FOR SPRAYING SHEEP AND CATTLE	Apparatus for spraying animals which comprises a passageway through which an animal to be sprayed can pass, a spray means to which spray fluid is provided under pressure and means to collect spray fluid not deposited on the animal for recirculation, in which the spray means comprises a plurality of nozzles 32 deployed to direct spray fluid on an animal in the passageway, the nozzles each having a plurality of jets to provide an intense spray pattern.	BENTALL & CO LTD E H
CN202232498U	2011-09-13	High-efficiency cleaning device of cattle body	The utility model discloses a high-efficiency cleaning device of a cattle body, which aims at overcoming the defects of large labor intensity, small contact area between a brushing surface and the cattle body, low cleaning efficiency, poor effect, more water consumption and high cleaning cost and the like in the existing cleaning of the cattle body. The high-efficiency cleaning device comprises a brush body provided with the brushing surface and a main handle, wherein the main handle is provided with a water passing channel communicated with a water source; the brush body is provided with a water cavity communicated with the water passing channel; the water cavity is provided with a water outlet leading to the brushing surface; the other surface of the brush body, which is opposite to the brushing surface, is provided with an auxiliary handle; the main handle is provided with a switch for opening and closing the water source and controlling the water quantity; and the brushing surface is a concave-arc surface. The high-efficiency cleaning device is mainly used for cleaning cattle and sheep to be slaughtered and the like, and has the advantages of low labor intensity, high cleaning efficiency, good effect, water conservation and low scrubbing cost.	XINHUANG LAOCAI FOOD CO LTD
FR2563969A1	1984-05-11	Animal cleaning machine with liquid dispensing	This is an apparatus which is used for cleaning cattle, by brushing with brushes having hard synthetic bristles, and by depositing, during each passage, a veterinary product intended to avoid contamination between the animals and to combat parasites and various diseases. It comprises, in its articulated upper part, a reservoir which is also used as brush support. Small reservoirs made of flexible rubber, which are pierced at the end by a hole, are mounted under this reservoir and between the brushes. A small quantity of liquid is released at each passage and only during this passage of the animals under the brushes mounted on the reservoir. The invention may be used in agriculture for the treatment of animals but may optionally be used in other fields where animals must be brushed and treated, in particular in zoological parks.	DEFRANOUX BROSSERIE

AU2005201086 B2	2005-03-11	Animal Cleaning	The invention describes two methods of animal cleaning suitable for use in a meat processing industry and plants adapted to carry out the methods. The preferred method of animal cleaning comprises the steps of water washing at least selected areas of the exterior of an animal, allowing a substantial portion of the water on the exterior of the animal to drain, stunning, or exsanguination of, the animal, and the application of a vacuum cleaning process to at least selected areas of the exterior of the animal to remove a substantial part of any remaining water from the exterior of the animal in the selected areas. A second method describes the use of hot water and steam in conjunction with a vacuum cleaning process. Both methods can also incorporate wool or hair removal or trimming over at least selected areas of an animal.	CLEAN STOCK NZ LTD

Cowsheds

Publication Number	Filing Date	Title	Abstract	Current Assignees
EP0841003A1	1997-11-06	Scraper device for the removal of excrements	The livestock manure scraper consists of a drive (15) turning at least one roller (13) which acts directly on the surface being cleaned and guides (80) to ensure the scraper follows a set trajectory. it also has an implement (1) which has its centre of gravity situated close to the rollers' axis of rotation, i.e. within the radial dimension of the wheel. The width of the scraper assembly, measured parallel to its direction of travel is less than twice the diameter of the rollers, and its height is equal to the roller diameter. The guide has a blade on the underside which interacts with a groove in the surface of the area being cleaned.	SERMAP S A

US20040084064A1	2002-11-04	Apparatus and method for recovering, cleaning, and recycling animal bedding contaminated with manure and urine	A method, an apparatus, a plant, and business method are provided for recovering, cleaning, and recycling dirty crumb rubber bedding used in barns and stables which house animals such as horses and cows that produce manure. The dirty bedding includes bedding which is contaminated with animal manure and urine produced by the animals, and other waste materials such as straw, dirt, and sand. The method includes the steps of washing the dirty bedding on a pulse washer which washes and separates straw from the bedding, followed by washing on a vibratory washer which loosens and washes away any remaining solid particles clinging to the bedding. Dirty water in from the pulse washer is filtered and reused, while a filtered out a sludge primarily of manure is subsequently packaged for use as fertilizer. The recycling plant includes a pulse washer and vibratory washer fed with stockpiled dirty by an input conveyor. A water filtration device filters the dirty water, and an output conveyor move the cleaned bedding to a stockpile of cleaned bedding. The stockpiled cleaned bedding is packaged for re-use, the sludge of manure is packaged for use as fertilizer, and the other contaminates are filtered out as a sludge that is disposed of.	VERDEROSA, RALPH|BORRUTO, FORTUNATO

US5983833A	1997-10-28	Construction including a shed for animals	A shed for animals such as cows, having an overhead rail supported from the shed's roof which supports cleaning apparatus that is capable of being moved throughout the shed to remove manure and other debris from the floor. The cleaning apparatus includes a manure suction device, motor driven rotatable brushes and a connection to cleaning or disinfecting fluid. Containers for cleaning or disinfecting fluid and to receive manure are supported on a platform underlying the rail, the rotatable brushes and manure suction device being supported by articulated robotic arms which are controlled by piston and cylinder units to move transversely relative to the overhead rail and platform. Movement of the cleaning apparatus is guided by detectors and operatively associated controls so that the shed can be selectively cleaned. A suction device extends into the shed for removing manure into a container outside the shed as needed. A fodder pick-up device is also provided for moving fodder from a silo for distributing it into feed troughs in the shed. The pick-up device, which includes a gripping member, is also supported by a rail suspended from the shed's roof and can pick up fodder and other material at any place within the shed.	LELY PATENT NV
US3859962A	1973-08-03	SANITARY FLUSHABLE FLOOR FOR CATTLE CONFINEMENT FEEDLOTS	An improved feedlot floor and sub-floor construction for use in close confinement feeding of cattle and other farm animals. The floor includes a plurality of inclined solid plane floor surfaces sloping downward to floor slots connecting to sub-floor collector tubes or channels. Animal manure waste products flowing down the floor slopes, by action of gravity and animal movement, pass through the floor slot openings into sub-floor channels or tubes and are subsequently removed by gravity flow and hydraulic flushing action of water flowing therethrough. Floor sections adjacent to the feeding bunkers and watering troughs include relatively level step areas to provide secure footing for cattle while feeding or drinking and an increased angle of inclination of adjacent floor plane surfaces to induce cattle to move away from the feedbunk and watering trough areas when not feeding or drinking.	ERICKSON LENNART G

US20020133899A1	2001-01-24	Unmanned vehicle adapted to be used in a stable, such as a cowshed	An unmanned vehicle for cleaning and disinfecting the floor in a stable such as is used for dairy cattle. The vehicle is provided with a manure displacement device which has an extensible member capable of being moved to locations in the stable remote from the vehicle. The manure displacement device comprises a manure slide and is provided with a pressure setting mechanism to govern the force with which the manure displacement device is active on the stable floor. The manure displacement device may be extendible by a telescopic carrier or an articulated arm which is hingedly mounted to a housing of the vehicle. The vehicle also carries sensors to determine the presence and recent departure of animals in cubicles on the stable floor and for detecting undesired substances including manure on the stable floor.	LELY ENTERPRISES A.G., A SWISS LIMITED LIABILITY COMPANY
EP2183965A1	2009-11-02	Manure vehicle	An unmanned manure vehicle (5), which vehicle comprises drive means for driving the vehicle and orientation means for following a path on a floor (1) of a cattle shed, said manure vehicle being provided with a manure slide (6) for moving manure present on the floor to a desired location in the cattle shed, a special feature being the fact that the manure vehicle is provided with disinfecting and/or cleaning means (8) for disinfecting and/or cleaning the floor, which disinfecting and/or cleaning means are mounted on a side of the manure vehicle that faces the manure slide.	J O Z B V
US5477654A	1994-01-26	Grid floor for a cattle stable	The invention relates to a grid floor for a cattle stable. This floor comprises a grid formed by a number of mutually parallel supported beams with interspaces and a receiving surface arranged under the grid with a passage opening. The surface of the receiving surface is smooth and transporting means are arranged which are movable over the receiving surface and to the passage opening.	WEELINK| JOHANNES M. W.
WO2004068937A2	2004-02-09	FLOOR FOR ANIMALS, A SPACE FOR ANIMALS, AND A METHOD FOR REMOVING LIQUID	A floor for animals, wherein the floor (F) is provided with at least one passage (2) to discharge feces from the animals through the floor (F), wherein the floor (F) is designed to discharge liquid, which flows from a top side (T) of the floor (F) into a said passage (2), in an at least lateral direction (R) from the passage (2). The invention further relates to a	PRAKTIJKONDERZOEK VEEHOUDERIJ

			space for animals which is provided with such a floor.	
WO2014038930A1	2012-09-07	CATTLE FLOOR	Floor for animals such as cattle, comprising a base structure and a top layer, wherein the top layer is permeable to fluid portions of animal faeces and/or animal urine, but impermeable to solid parts of the animal faeces, wherein the base structure comprises voids for receiving said fluid portions and/or urine passing through the top layer, wherein the base structure comprises an array base elements forming a substantially continuous deck supporting the top layer, wherein the deck is arranged for passing said fluids into internal volumes of the base elements forming said voids, the internal volumes of at least a number of said base elements being in fluid communication with each other, preferably such that fluids received in said internal volumes can be removed from the base elements by flow through said internal volumes.	PERMAVOID LTD
EP1564664A2	2002-03-21	Method and arrangement for cleaning a deep litter house	The invention relates to a robot (7) for cleaning a deep litter house (1), the floor area of which consists of a thick layer of litter. To robot (7), a camera (8) is connected for detecting freshly produced droppings, which are subsequently are picked up and removed with the aid of a gripping means (10), together with an underlying layer of litter. Next, gripping means (10) is used for dropping fresh litter on the place where the droppings were picked up	PRAKTIJKONDERZOEK VEEHOUDERIJ

EP2042034A2	2008-09-26	Suspended car rail system, stall and method for feeding and cleaning	The system has suspended cars including a storage tank for accommodating feed and straw material, a delivery ejector for the feed and the straw material and a cleaning device. The cars are movable over a feed table (125) and livestock cubicles (112) which are arranged adjacent to each other. The cars are movable in a region of cattle prod devices (80, 180, 280, 380, 480) from 0.8 meters to 2.50 meters, particularly 2 meters, above a base. The cattle prod devices are designed as a manure scraper for cleaning gangways (30, 130, 230, 330, 430). Independent claims are also included for the following: (1) a method for supplying a feed table with feed, for cleaning the feed table and a livestock cubicle, and for supplying livestock cubicle with straw material (2) a cowshed comprising a control device.	HARTMANN GRUNDBESITZ GMBH & CO
US20040025461A1	2003-04-09	System for a free stall barn with a grooved floor, corresponding precast concrete slab and animal keeping method	The invention relates to a system for a free stall barn or the like for keeping animals, especially cattle, comprising a grooved floor configured as a concrete slab. Said grooved floor has a floor surface and said floor surface, between adjacent grooves, is provided with an elastic and anti-slip covering that reaches close to the grooves. The invention further relates to a precast concrete slab for assembling such a system wherein the precast concrete slab corresponds to the floor width and, in the longitudinal direction, is provided with adjusting elements for exactly aligning the slabs to be joined. The invention further relates to a method for keeping animals in the inventive system, according to which an organic or mineral binder is strewed across the floor of the free stall barn and the bound solid manure and liquid manure is separated when the barn is cleaned out.	REUVER HERMANNUS S.F.
EP2236024A1	2010-03-31	Manure scraper	A device for cleaning a stable for cattle, said device comprising a manure scraper (3) provided with at least one manure scraper blade (4) extending at least partially transversely to the longitudinal direction of the stable floor (1) for moving manure present on the floor to a desired location in the stable, and means (8) for moving the manure scrape forward across the stable floor, wherein the device further comprises a spraying device (5) for cleaning and/or disinfecting the floor.	J O Z B V

EP1557082A1	2004-01-24	Device and method for cleaning stables	The manure collecting duct is automatically cleaned by a pushing device moved by a rope and pulley mechanism (36) along the duct in predetermined intervals. The motion is controlled by a computer (71) receiving and processing signals transmitted by a distance- and a speed sensor (50, 60). When an animal enters the duct the pushing unit is automatically stopped. The difference between the resisting forces of the manure increasing over the length of the duct and the particular parameters of a cow or a bull can be detected by the system (70).	RUDOLF HOERMANN GMBH & CO KG
NL1003271C2	1996-06-05	Cattle stable floor construction	The cattle stable has a manure cellar (1) covered with panel type floor elements (3) forming the stable floor (4). The floor elements (3) are at the side supported by walls (5,7) of the manure cellar (1). The floor elements (3) have slots (9,9'') for urine discharge. Slots (9,9'') of two adjoining floor elements are in line. The walking surface (11) of the floor elements (3) is flat, which means the surface can be cleaned with manure disc (13) which has cams (14) to remove solid manure from the slots. The floor elements have wedge shaped sides (15,15;') which the slots (9,9') fit. This forms an opening through which urine can enter the cellar (1). Rising ammonia damp is retained in the cellar which reduces ammonia emission.	INST MILIEU & AGRITECH
GB2488823A	2011-03-10	Animal cubicle cleaning system with motorised movable belt floor	An animal cubicle cleaning system in the form of a movable belt 50 arranged to at least partially cover the floor of an animal cubicle [40, Figure 1], and a motor 60,70 for moving the belt as required. A scraper 130 and/or a water spray 120A,120B may be employed to clean the belt 50. The system may also include a sterilising and/or disinfecting device 110. The belt 50 may have a first end wound on to a first drum and a second end wound on to a second drum, or the belt may take the form of an endless conveyor belt held in a loop by two spaced drums (see Figure 5). A method of using the apparatus is also disclosed. The cleaning system may be used with multiple animal stalls [see Figure 1]. The invention is intended for use with animals, such as cows, which are housed inside buildings and require manure to be removed from their cubicles on a regular basis to avoid infection.	PLUESS DARREN

WO1993009304A1	1991-10-28	HANDLING SYSTEM FOR STABLE MANURE	The invention relates to a system in the cleaning of stables and cow-houses and comprises a plurality of wells installed in the floor. The present invention contemplates, among other things, collecting, transporting away and depositing of solid as well as liquid excrements from cows, horses and other animals. Thanks to the fact that the liquid excrements, i.e. urine, is immediately removed a drier and better environment for the cattle is created. According to the invention a plurality of drains (2) in the respective stables or cow-houses are interconnected by means of a tube or pipe system (3), which is connected to at least one collecting container (4), which is provided with means for creating a negative pressure in the container, so that material in the drains is sucked through the pipe system into the collecting container. Preferably there are provided in the respective drains two mutually concentric, vertical drain tubes (13, 14), whereby liquid, e.g. urine, flows down into the interspace (17) which is created between the two tubes, and subsequently is transported away. Each one of the drains is provided with a removable cover (19) which covers only the inner tube. Material from the outer tube as well as from the inner one may be transported away through one and the same tube system in that apertures through the wall of the inner tube are provided at the lower portion of the interspace between outer and inner tubes.	VOELKER PER

GB1509337A	1976-02-25	CATTLE SHED	1509337 Animal sheds NOLOS Ltd 25 Feb 1976 [25 Feb 1975] 07512/76 Heading AIM An animal shed has a solid floor area 24 and a slatted floor area 17 having a tank 23 thereunder for the reception of manure, honeycomb walls 28 separating the tank from tanks 23a into which liquid manure can drain through the walls 28. solid manure being retained in the tank 23. The liquid in tanks 23a may flow under gravity or be pumped into additional tanks for storage until required for use as fertilizer. Build-up of solid manure in tank 23 is slow, and it may be cleaned out when required after removing a concrete slab forming part of the outer wall of the shed. Various lay-outs of stalls are proposed; for example longitudinal rows of stalls may be provided on each side of a central passageway roofed with alternate asbestos and translucent panels 14; a single or double row of stalls could form an annular array with a feed silo and water tank provided in the central space and supplying to troughs 22; or two straight stall sections could be connected by semi-circular end arrays leaving an open rectangular centre to the shed. The shed may be formed by H frame support units 12 bridged by prestressed concrete beams 13 forming the roof of the pens, and the roof and solid floor areas may be insulated with foamed polystyrene. Hollow concrete beams may be used in the construction, and may form the slatted floor area, and these beams preferably have a core of foamed polystyrene.	NOLOS LTD
JP2006214179A	2005-02-03	BEDDING MATERIAL FOR JOGGING COURSE, CATTLE SHED, AND THE LIKE, PRODUCED BY USING CHARCOAL PRODUCING DEVICE, AND METHOD OF PRODUCING BEDDING MATERIAL	PROBLEM TO BE SOLVED: To provide a bedding material which is bedded on a road surface of a jogging course, a floor surface of a cattle shed, and the like, and particularly a bedding material which is bedded on the road surface of the jogging course, contributes to alleviation of a burden on the legs of the runner, and brings about a comfortable feel of running, or a bedding material which is bedded on the floor surface of the cattle shed, and contributes to easy mixture thereof with feces of cattle in the cattle shed, to thereby obtain manure of good quality, and to provide a method of producing the bedding material. <P>SOLUTION: According to the method of producing the bedding material, waste wood is crushed by a crusher to prepare coarse chips (1) for carbonization, having a size	JOMO RYOKUSAN KOGYO KK

			that can pass through an injection port of a spray nozzle of mortar or concrete, and the coarse chips are supplied to a drier (8) and a carbonizing boiler (12). When the coarse chips fall from a procedure front end in a traveling direction into the following step, the coarse chips (1) for carbonization are exposed to strong wind generated by a blower (6), so that fibrous fine chips (2) are separated from the coarse chips (1), whereby the separated fine chips are supplied to another step. <P>COPYRIGHT: (C)2006, JPO&NCIPI	
DE20309807U1	2003-06-25	Floor cleaning device for byre in particular suitable for slotted floor, comprising rubber flap electrically moved across soiled area	A rubber flap connected to a carrying plate and provided with angular mud removal elements is moved across the floor of the cattle compartment by an electric drive (2) attached to a horizontal bar carried by a vertical column and acting on a rope (6). The rope (6) is guided around a return pulley (5) at the outer end of the horizontal bar, facilitating a back and forth motion. The manure is pressed into the slots by the rubber flap.	FINK ALOIS
SE514334C2	2000-03-31	Grating for manure drain in cow shed, has grating bars guided by cavities in supports during backwards and forwards movement to remove manure on them	The horizontal supports (5-8) for the grating bars (3, 4) are provided with cavities corresponding to the bar cross-section and acting as guides for the bars, which are connected to a mechanism for moving them backwards and forwards in order to remove any manure on them.	TINGSVIK LARS
DE4320231C1	1993-06-18	Cleaning appts. for removal of manure from cattle stalls - has thrust force produced by gearwheel drive engaging in rails with holes to act as racks	The drive unit is operated by an electric motor or an IC engine, and its drive occurs by the rolling of a gearwheel on an engagement device along the cleaning path. The engagement drive is formed as a holed rail (4) which has a hole arrangement (4.2) matching the toothing of the gearwheel (2) and is spaced from the plane of the cleaning surface. Near to the running plane (4.1) of the holed rail (4) and arranged ahead of the gearwheel (2) in the running direction is a cleaning unit (11). On the opposite side of the holed rail (4) to the gearwheel (2) a holding device is so arranged that a secure engagement of the gearwheel (2) when it rolls is ensured. USE/ADVANTAGE - The cleaning appts. for removal of manure	WALKER ALFRED

			from cattle stalls has a secure drive and adequate traction.	
DE10257286A1	2002-12-07	Cattle stall floor has manure clearing system comprising water pipes embedded in floor with small outlets in its upper surface	The cattle stall floor (1) has a manure clearing system comprising water pipes (31) embedded in the floor with small outlets (33) in its upper surface. A sliding scraper (22) removes the manure. An Independent claim is included for a method for wetting a floor using the system.	REUVER HERMANNUS S F