Final report

Demonstration of the Te Pari automated cattle handler at a commercial feedlot

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Executive summary

The feedlot industry has been recognised as a sector that could greatly benefit from the implementation of automation to enhance efficiency and profitability. Automation of the processes performed at induction or entry of cattle into the feedlot has the potential to reduce labour costs, promote a safer operation, and decrease stress on cattle.

This project evaluated a cattle auto handler developed by Te Pari as part of MLA project B.FLT.1013. The auto handler features automated catch and restraint, automated delivery of chemicals and pharmaceuticals, automated weighing and software integration. Over a span of a year, 1,238 animals were inducted through the chute in 10 separate induction events, at a feedlot site located in Victoria.

Throughout the demonstration period, staff at the feedlot reported that the Automated Induction chute reduced the physical demands of personnel. Less eye/hand coordination was required compared to conventional manual feedlot induction chutes. In most cases, the need for human interactions with animals through the automated chute was reduced which improved observed animal behaviours. The addition of an automated back line dosing system has reduced the risk of exposure of staff to chemicals thereby improving operator safety. The dosing system which autonomously adjusted according to the weight of the animals helps prevent underdosing.

Automation allowed for the opportunity to re-allocate tasks amongst the feedlot staff. One staff member could operate both the machine and complete data entry on the feedlot computer software management system. This can lead onto a reduction of 1 or 2 labour units depending on tasks undertaken around the chute.

For this demonstration project, the Te Pari automated handler was placed within a commercial feedlot induction facility, adjacent to (but not altering) existing infrastructure. To enable cattle to be diverted from the existing lead up race, some modifications were required. Limited space meant that the lead up race to the auto-handler not ideal. The rate at which animals could be processed though the automated cattle handler was less than expected. This may have been due to the short lead in race to the auto-handler. Ensuring consistent cattle flow through the lead in race became the overriding factor in mitigating poor catching and over handling. Going forward, the race and forcing pen design needs to be considered when installing an automated chute.

Whilst animal throughput did not improve significantly as part of this demonstration, there were some advantages in the number of staff required to achieve feedlot cattle induction processes. Most of the evaluations involved only two staff. One loading the forcing pen and one attending to animal induction tasks as well as operating the chute. Although the total cycle time was extended, the benefit of less labour units reduced the overall cost of the process. Further work is needed to truly evaluate the efficacy and value of automatic subcutaneous injection and how the increase in technology is balanced against the value of trained staff. Automating subcutaneous injection has the potential to improve staff safety and labour efficiency.

Further research could include enhancements to feedlot software integration and standardisation of application across the industry. The value proposition of additional automation shows some benefit in the reduction of labour units. This must be balanced against the increased induction times that were seen over the trial. Ongoing improvements around task allocation will see a reduction in cycle time and a better overall result into the future.

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1. Background

Market research has shown that automation of tasks at induction or entry of cattle into feedlots is not widely used across the industry. The previous publication by MLA ‘B.FLT.1004 Feasibility of induction automation R&D’, identified areas for automation across the industry such as head and body restraint, automation of veterinary chemical and pharmaceutical application, as well as automated weighing and scanning, as priority targets to help increase productivity, reduce labour and improve animal wellbeing.

With these targets in mind, Te Pari was engaged to develop a prototype automated chute for evaluation in the feedlot environment. The MLA final report for project B.FLT.1013 described the development of an Automated cattle handler by Te Pari. The initial trials in New Zealand, at a grass-fed feedlot showed positive results in reducing inventory shrink, automated injection and automatic restraint compared with manual machines. As part of the current project, the automated handler, was shipped to Australia and installed at a commercial feedlot, and integrated with their existing software systems to evaluate induction efficiency improvements.

In today’s world of labour shortages, high quality operators of manual hydraulic chutes are not easy to find and can demand higher remuneration. Inexperienced or junior operators can struggle keep up with the demanding tasks of induction, leading to mistakes in data entry, processing and catching. This in turn leads to extended induction time, fatigue and can impact animal behaviour, causing elevated stress levels and risk of injuries to both humans and animals.

2. Objectives

1. Evaluate the performance of the automated features within the Te Pari Auto Induction Chute over twelve months in a commercial feedlot.
2. Study the animal welfare impacts.
3. Determine if there is any inventory shrink in drug use.
4. Evaluate tasks, labour requirements and study processing rates.
5. Evaluate maintenance and repair requirements.
6. Determine the value proposition for the Auto Induction Chute based on commercial feedlot results.

3. Methodology

The aim of the demonstration was to undertake a series of regular induction events with a minimum of 100 animal per event to understand the applicability of the technology in commercial feedlots. From June 2023 to July 2024, monthly induction events using the Te Pari Automated chute were conducted to evaluate the performance of the chute in relation to processing time, labour use efficiency, drug use efficiency, and animal welfare.

For the project, the automated cattle handler was positioned in a vacant pen beside the commercial feedlot's current induction infrastructure. This gave the system access to existing holding pens and laneways. Due to the space constraints, concessions were made around the size of the crowding pens and race design. The crowding pen held 8 to 10 animals, leading to a four head straight race sloping down towards the automated chute (Figure 1). There was no automated drafter attached to the facility. Cattle were pre-selected based on similar weight and class before entering the induction area to ensure consistent pen management for the feedlot once inducted.

The automated induction system is laid out in two units. The first being a separation zone positioned

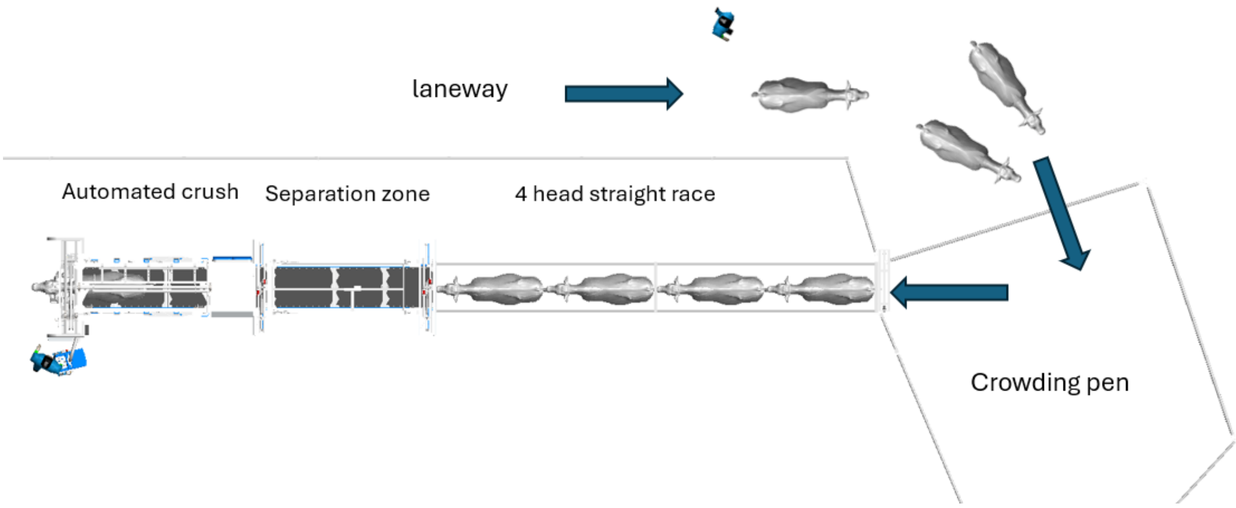

Figure 1: Automated chute, pen and race layout

between the automated chute and cattle race. The separation zone's function is to stabilise the cattle flow into the automated chute, to prevent cattle from rushing forward, and to not to allow more than one animal at a time from entering the chute. The separation zone's position also makes it easier for operators to handle animals before they enter the automated chute if two force themselves forward at once.

The second unit is the automated chute where induction tasks are applied. As animals travel through the chute, their position is monitored by software and scales, allowing for more accurate location monitoring and timing of automated features. The closing of the entry gate, anti-backing bar activation and the animal's correct positioning at catch is achieved by this function. Positional weighing also provides an additional safety feature of not allowing any automatic function while operators are inside the chute.

Operational training was supplied by Te Pari to the feedlot staff on the set up and use of the automated induction chute and machine guarding, and lockouts attached to satisfy company safety protocols.

For each induction event, the feedlot operator recorded date, weather conditions, start and end time, total number of head inducted, number of operators for induction, tasks performed during induction, startup procedure checklist, drug usage, and general comments and observations on the performance of the automated chute.

Otherwise, inductions were performed as per the feedlot's standard operating procedure, including animal health treatments, ear-tag application, tail-clipping, and data recording in management software.

3.1 Methodology to achieve objective 1: Automated feature evaluation.

- **Separation zone.** The entry gate from the race opens automatically. A sensor eye is used to close the gate once the animal has reached a point within the zone. The sensor position can be adjusted to reflect larger or smaller animals, and was adjusted during the trial. The operation of the separation zone was evaluated by veterinary observation, processing time, and feedlot operator observation.

- **Automated entry gates.** Two automated gates were used. One between the race and separation zone, as mentioned above, and one for entry into the automated chute. The chute gate closes at a pre-determined position dictated by software within the machine's controls. The operation of the gates at both the entry to the separation zone, and the entry to the automated chute were evaluated by veterinary observation, processing time, labour use, and feedlot operator observation.

- **Automated backing bars.** As above, activation of these bars is controlled by positional software within the machine's controls. Once a certain position is reached the bars automatically close behind the animal. The main function of is the backing bars is to prevent operators from being kicked if applying treatment or task to the rear of the animal. The bars also facilitate smooth release by preventing the animal from moving rearward. The operation of the backing bars was evaluated by veterinary observation, processing time, and feedlot operator observation.

- **Automated head catch and side squeeze.** These features act simultaneously to hold the animal securely in preparation for treatment. Prior to catch, the head bail opening gap can be adjusted by the operator depending on the size of cattle being inducted. The side squeeze open position can also be adjusted inwards to reduce the width prior to catch. The side squeeze feature is intended to help reduce the animals speed through the chute and allows the squeeze to activate faster. The operation of the head catch and side squeeze were evaluated by veterinary observation, number of mis-catches, processing time, labour use, and feedlot operator observation.

  Automated backline. The backlining operation is of an automated, or semi-automated nature. This was achieved using Te Pari products electronic dosing gun, linked by Wi-Fi to the weigh scale, thereby allowing the dose to be applied according to each animal's weight. This system reduces overdose/underdose resistance and waste drench. Application is achieved by the aid of a spray bar inside the chute that is activated, either automatically at the desired time within the animal hold cycle, or the pull of a trigger from the electronic drenching gun. This automation achieves two goals. 1) Prevents over or under dosing - the gun can only deliver the correct amount to the animal once. 2) Removes the proximity of chemical hazards to the operator, thereby creating a safer working environment. The automated backline was evaluated by measuring millilitres administered per head and comparing the results to a similar day using the feedlot's existing system. The existing system within the feedlot's manual chute also used the Te Pari electronic drench gun and backline dosing spray bar, however it used a fixed dose rather than a variable dose based on animal weight.

- **Semi-automated injection.** A custom auto injector was attached to the front of the head bail door. The injector was activated by a push button to supply one subcutaneous injectable into the desired dosing triangle on the neck. The dose was applied through the application of an electronic dosing gun linked to the onboard software. Use of the automated injector was ceased early in the project due to technical difficulties and was not evaluated.

- **Automated scan and weigh.** Two fixed RFID panels are attached at opposing sides of the chute to scan ear tags. Weighing is facilitated by four 3-tonne load cells, one positioned at each corner the automated chute. The automated scan and weigh features were evaluated by processing time, labour use, and operator observation of incidences manual RFID scanning was required.

- **Integration into feedlot software.** Onsite, the feedlot used Stockaid software to record animals' weight and NLIS tag at induction. The auto induction chute was interfaced into the software to deliver the above data. Integration with feedlot software was evaluated by feedback from the feedlot operator.

- **Ease of operation.** The trial examined whether automation of the controls improved the operator experience and reduce fatigue. Manual hydraulic chutes require the use of six or more levers to manage different functions, demanding intense concentration from the operator over prolonged periods. This level of focus can lead to fatigue, increasing the likelihood of mis-catches and raising concerns related to animal welfare. As a result, automation in this area has been recognized as a potential solution to reduce stress for both operators and animals. The operation of the Auto Induction Chute resembles that of a manual chute, enabling the operator to easily switch between systems without needing extensive technical training. When in automatic catch mode, the Auto Induction Chute can be manually overridden, providing the user with greater flexibility during operation. Ease of operation was evaluated by processing rate, veterinary observation, feedlot operator feedback, number of tasks required to be performed, and reporting of any safety incidents.

3.2 Method of objective 2: Study the animal welfare impacts

The project was approved by the University of Melbourne animal ethics committee before commencement (Approval number ID2023-25403-35879-4). During the demonstrations Animals were monitored by a veterinarian over 10 induction events to examine whether automation influenced animal behaviour and welfare.

For each induction, the behaviours in Table 1 were recorded if they occurred while the animal was inside the automated chute. Staff generated noise and background facility noise were both recorded on a scale of 1 to 5 for each induction to reflect the average noise/prevailing conditions during the observation period. The veterinarian also provided comments and observations on the environmental conditions, operation of the chute, and it's impacts on animal welfare.

Behaviour	**Definition**
Vocalisation	3 or more repeated bellows whilst restrained in the head bale
Abnormal release behaviour	Jumping or running out of the chute when released
Head mis-caught	Head not caught correctly by the head bale on the first attempt
Intervention inside the chute	Stockperson having to pat, tap, apply a tail jack or any other physical touch to the animal while inside the chute to encourage forward movement
Slip	A brief loss of footing on one foot
Repeat catch	Animal moved through
Handling aid used inside the chute	Use of flag or polypipe to tap animal while inside the chute to encourage forward movement
Adverse outcome	Three or more recordings against an animal while in the chute
Fall	Loss of footing on 2 or more feet causing the animal to become recumbent
Prodder	Use of electric prodder on animal while in the chute
Excess force used	3 or more repeated squeezes on body by chute in order to restrain
Repeat treatment	Re-application of vaccine, backliner, or other treatment as initial was unsuccessful or incomplete
Foot caught in head bail	Front foot caught in head bale
Animals drooling while caught	Excessive drooling with bubbling and saliva strings while restrained in chute
Difficult animals	Three or more of the above behaviours recorded.

Table 1: Veterinarian recorded behaviours while animals were inside the automated chute.

Observations recorded the reactions from animals due to handling, undue or excessive force, as well as behaviours associated with automated features. These observations were used to consider if the automated features and human interventions contributed to abnormal behaviour at entry, catch and at release during the induction cycle. Process rates and animal welfare observations were captured to provide supportive data for this report.

3.3 Methodology to achieve objective 3: Drug inventory shrink

Data was gathered from the onsite feedlot recording software to determine whether any excess drug usage has taken place while administering with the backline drench applicator. Backline dosing is a calculated ratio of the animal's weight and is set up within the Auto Induction Chute software. This dose calculation is achieved through the weigh scale and electronic dosing gun communicating to one another and adjusting the dose per animal. This achieves an accurate dose and eliminates overdosing (causing wasted drench) or underdosing (elevated parasite resistance). Doses were compared to those applied through the feedlot's standard fixed-dose system for inductions on the same or adjacent days.

3.4 Methodology to achieve objective 4: Evaluate labour requirements and processing rates.

Start and end times, number of staff, task allocation, and processing numbers were recorded to understand staff requirements per animal. These numbers were divided to study the processing rate per labour unit. Cattle for backgrounding were inducted using two staff. Full induction processing required three or four labour units. The processing rate is the overall time taken divided by the number of animals inducted. Results of this are shown in the following section.

3.5 Methodology to achieve objective 5: Maintenance and repair requirements.

Te Pari monitored the automated induction chute and all functions. Te Pari liaised with the operator staff as to issues and modification requests throughout the trial and supplied spare components on an as needed basis.

3.6 Methodology to achieve objective 6: Determine the value proposition for the automated chute based on commercial feedlot results

Evaluate whether the automated features at induction provide economic and commercial sense for the feedlot operator, and if the increased cost of the automation is offset by a reduction in labour units and/or induction time. Considerations were also made for other value propositions, such as improved operator safety.

4. Results

4.1 Results of Objective 1: Automated feature evaluation.

Over the course of the demonstration, Angus cattle varying in weight from 290 to 535kg were inducted through the chute. Data collected from the induction and veterinary templates, combined with qualitative observations and feedback were used to evaluate the automated features for the purposes of this demonstration trial.

Starting from the entry into the separation zone, the observation data revealed there were issues with cattle flowing into the into the automated induction chute. If cattle were hesitant or slow coming from the race, the entry gate closed earlier than desired, which in some instances could cause the animal's foot to be briefly held in the lower section of the gate. Conversely, some cattle tended to push forward, encouraged by the sloped race, crowding the entry to the separation zone. Subsequently, a second animal would frequently attempt to push past the first, causing its neck to be held in the closing gate. The software within the machine allowed the second animal to be automatically released to let the door to fully close. When this occurred, it led to hesitancy and agitation which contributed to 25% of the issues animals classed as difficult animals and added to overall the mis-catch total. Repositioning of the sensor improved some aspects of entry of cattle into the separation zone as the project progressed. A contributing factor to cattle rushing or hesitating was the inconsistent flow of cattle. When cattle flow was consistent the separation zone functioned as designed.

Once in the separation zone, entry and movement through the automated chute posed few problems in the context of the overall run. The anti-backing bars helped direct animals towards the head bail and improved the release time.

The automated catch functioned well in most instances. The initial opening gap distance is critical to ensure the animal was confident to move forward into the chute, and could be adjusted manually by the operator. Insufficient gap caused hesitancy at the head bail in some animals, whereas an oversized gap could allow the animal to position too far through the head bail, resulting in a miss catch and manual operator intervention. Data shows a recatch rate of 1.1% which equates to 14 animals out of 1238. Much of this can be attributed to either a manual variation in head bail gap or an excessive width causing the head bail close time to be insufficient to stop the animal correctly.

Automated injection, although successful in the previous trial in New Zealand, proved difficult to maintain the desired speed and strike rate in the Australian feedlot environment. Subsequently this operation was removed from the project and is still under evaluation. Development of the prototype in report B.FLT.1013 showed there is potential for automated injection to reduce the overall cycle time and improve safety of operators.

Following the automated injector removal from the project and feedback from the feedlot operators, neck extenders were added in favour of the chin-lift to provide sufficient room for operators to safely apply manual injection. Opening and closing of these were activated by the push of a button allowing constant stroke distance.

Feedback received from induction staff controlling the automated tasks such as entry gate control, side squeeze activation, anti-backing and catching, reported that the unit required less effort in operation. Staff reported that although maintained situational awareness was still necessary, overall, the pressure to control functions that required intensive eye to hand coordination was reduced.

Manual controls were only required to open the head bail gap farther to entice hesitant animals to move forward, or to intervene when more than one animal had entered the separation zone. Automation has the potential of also standardizing catch characteristics, allowing less than experienced operators the ability to keep up with the processing rate.

This shift in operations allowed for a redistribution of labour, enabling resources to be reallocated to other tasks. The existing manual chute requires many of the required tasks to be carried out by different operators due to the nature of the chute manual controls. On the Te Pari automated chute, the task of machine operation and system data input was combined into one operator. Automating the catch and dosing tasks allows more time to carry out tasks such as computer input, tag organisation and medicament refilling, while auto catching commences, thereby saving time, stress and eliminating mistakes. This is a major advantage in automating the catch system.

Backline dosing was made fully automatic or manually overridden by the main operator. This reduced the overall task time and increased operator safety by removing interaction with pour-on chemicals during application.

NLIS tag and weight data was automatically loaded into the feedlot software. Initial ear tag scanning proved problematic due to the increased amount of onsite frequency interference from large electrical sources. This added to overall cycle times in the first few inductions as tag data was manually entered. Additional shielding and repositioning of the reader panels on the chute improved read tag results in the later months of the project.

4.2 Results of objective 2: Study the animal welfare impacts.

A total 1238 cattle were monitored by the independent animal welfare veterinarian over 10 induction events.

Behavioural scoring, conducted by the veterinarian from the University of Melbourne, showed the impacts of automation on animal behaviour. Table 2 shows the number of recorded incidents per month. ‘Difficult’ animals were defined as having three or more adverse records.

Recoded instances	animal per run	Vocalization	Abnornmal release behaviour	Head miscaught	Intervention inside the crush	slip	Repeat catch	difficult animals	Handling Aid used insde crush	Adverse outcome	fall	Prodder	excess force used	Repeat treatment	Foot caught in headbail	Animals drooling whist caught
Jun-23	108	18	35	7	7	7	6	6	6	0	0	0	0	0	0	0
Aug-23	155	21	27	9	4	1	4	2	0	2	0	0	0	0	0	0
Sep-23	103	8	5	9	0	1	4	0	0	0	0	0	0	0	0	0
Oct-23	157	9	3	10	2	0	0	1	2	1	0	0	0	0	0	0
Dec-23	71	11	5	0	4	0	0	0	0	0	0	0	0	0	0	0
Mar-24	150	33	12	10	36	1	0	4	0	1	2	0	0	0	0	0
Apr-24	155	19	2	8	7	0	0	1	0	0	0	0	0	0	0	0
May-24	117	13	5	18	6	1	0	1	0	0	0	1	0	0	0	0
Jun-24	121	6	6	13	0	3	0	3	1	1	0	0	0	0	0	0
Jul-24	101	28	12	14	2	4	0	2	0	0	1	0	0	0	0	0
combined results	1238	166	112	98	68	18	14	20	9	5	3	1	0	0	0	0
% per total		13.41%	9.05%	7.92%	5.49%	1.45%	1.13%	1.62%	0.73%	0.40%	0.24%	0.08%	0.00%	0.00%	0.00%	0.00%

Table 2. Recorded incidence of selected animal behaviours.

Out of the total 1238 cattle, vocalisation was the largest recorded issue at 13.4%.

Interventions inside the chute, difficult animals and handling aids used, added to the 7.92% of mis-caught cattle. The repeat catch figure of 1.13% can be attributed to variations in the setup and operators becoming familiar with the automated system in the first months. As the project progressed there were no instances where a repeated catch was required.

In one instance during the induction events a prodder was used because an animal refused to leave the area in the rear of the automated chute and would not advance past the backing bars. A redesign to shorten the chute would mitigate against this reoccurring.

Based on observations throughout the project, the consultant veterinarian made the following statements;

Overall, the automated induction chute demonstrated positive impacts on animal welfare during its trial at the commercial feedlot in Victoria. Throughout the pilot, veterinary assessments made on cattle behaviour during induction did not identify any grievous animal welfare impacts. Positive outcomes have included noticeable reductions in stress and anxiety of cattle through reduced human handling. Human assistance is still required for effective animal flow, but the reduction in stock-people in close proximity to cattle allowed for self-regulation of animal flow by both the animals themselves and the machine. Issues surrounding increased vocalization at the point of capture were observed and recorded on every visit, however this was likely attributable to excessive handling or noise created in the lead up to entry, or incorrect mis catching of the animal.

Animals having three or more unwanted records whilst in the chute were recorded as an adverse outcome and were tracked throughout the project (marked in yellow Table 2 as 'difficult' animals). No serious injuries to cattle were detailed in the trial period. The records for these animals were further broken down into the categories below (Tables 3&4).

Month	Record A	Record B	Record 3	Record 4	possible cause
Jun-23	Vocalisation	Abnormal release	slip		Slip
	Miscaught	Handling aid used	Intervention inside		Handling aid used /intervention
	Intervention inside	Handling aid used	Abnormal release	Repeat catch	Handling aid used /intervention
	Intervention inside	Handling aid used	Vocalisation	Abnormal release	Handling aid used /intervention
	Intervention inside	Repeat catch	Handling aid used		Handling aid used /intervention
	Miscaught	Repeat catch	Intervention inside	Abnormal release	Stockperson intervention
Jul-23	No trial				
Aug-23	Miscaught	adverse outcome			Escaped the crush as not caught properly by head bale
	Miscaught	Intervention inside	adverse outcome		Escaped the crush as not caught properly by head bale
Sep-23	no issues recorded				
Oct-23	Miscaught	Intervention inside	Handling aid used		Handling aid used
Nov-23	No trial				
Dec-23	no issues recorded				
Jan-24	No trial				
Feb-24	No trial				
Mar-24	Intervention inside	Miscaught	Vocalisation	adverse outcome	Head of animal stuck in side crush bars at back entry – upset animal fro remainder of time in crush
	Miscaught	Intervention inside	Vocalisation		Stockperson intervention
	Intervention inside	Slip	Fall	adverse outcome	The slip and fall of the animal in the crush required stockperson intervention to get the animal up
	Miscaught	Fall	Intervention inside		Head miscaught at the front causing animal to fall and requiring stockperson intervention to get animal up
Apr-24	Miscaught	Intervention inside	Abnormal release		Stockperson intervention caused worry to animal
May-24	Miscaught	Intervention inside	Prodder used		Prodder use
Jun-24	Miscaught	Vocalisation	Abnormal release		Miscatching of the head (rear entry gate) upset animal as it entered
	Miscaught	Handling aid used	Vocalisation		Miscatching of the head (rear entry gate) upset animal as it entered
	Miscaught	Abnormal release	adverse outcome		Miscatching of the head at front caused a choking episode and animal fell out of crush upon release – animal recovered
Jul-24	Miscaught	Fall	Slip		Miscatching of the head (rear entry gate) upset animal as it entered
	Miscaught	Intervention inside	Vocalisation		Miscatching of the head (rear entry gate) upset animal as it entered

Table 3. Behaviours recorded for animals recording three or more adverse records during the project.

The animals with three or more adverse records were classed into 4 categories. Mis-catching at the entry to the automated system (25%), was a contributor to animal hesitation and has the potential to cause excessive handling (45%). Mis-catching at the rear and human intervention can be linked to the mis-catching the front (25%) and slips (5%).

Categories of animals exhibiting three or more adverse records	
Handling aid used /intervention	45%
Mis-catch at rear upsetting animal	25%
Mis-catch at front upsetting animal	25%
Slip	5%

Table.4 Animals exhibiting three or more adverse records percentage breakdown by recorded behaviours.

The biggest challenge during the evaluation was maintaining constant flow of cattle into the auto induction chute. Due to the available space at the feedlot, and a smaller than normal crowding pen, additional handling was sometimes required to move cattle, which had the potential to cause animal agitation or hesitancy entering the chute. Behavioural observations showed that 45% of the animals that displayed three or more adverse behaviours had additional handling or intervention. It was observed that the short straight sloping race allowed for crowding and mis-catches to occur at entry to the separation zone, accounting for 25% of the animals that displayed three or more adverse behaviours. Additional handling to move cattle, and inconsistent entry to the separation zone were cited as contributing factors in maintaining constant flow at the back entry gate from the yards. It is possible that unsettled animals entering the separation zone led to further problems in entering and exiting the auto induction crush, thereby slowing the induction process.

The veterinarian concluded that the Auto-handler does offer clear benefits in terms of efficiency and animal welfare, but further adjustments will be crucial to optimizing its performance in commercial feedlot settings.

4.3 Results of objective 3: Drug inventory shrink.

The automated backline drench applicator was tracked through the trial and compared to the backline doses applied on or around the same days on the existing manual induction chute. Both the manual and automated systems used the Te Pari electronic drench gun and backline dosing spray bar, however, the automated system's doses were linked to the weight of the animal, rather than the fixed dose of the manual chute. Both systems showed consistent dosing numbers across the range of induction events (Figure 2). The existing system at the feedlot was shown to be slightly under dosing by an average of 2.7% compared to dosing by weight as per the auto induction chute system.

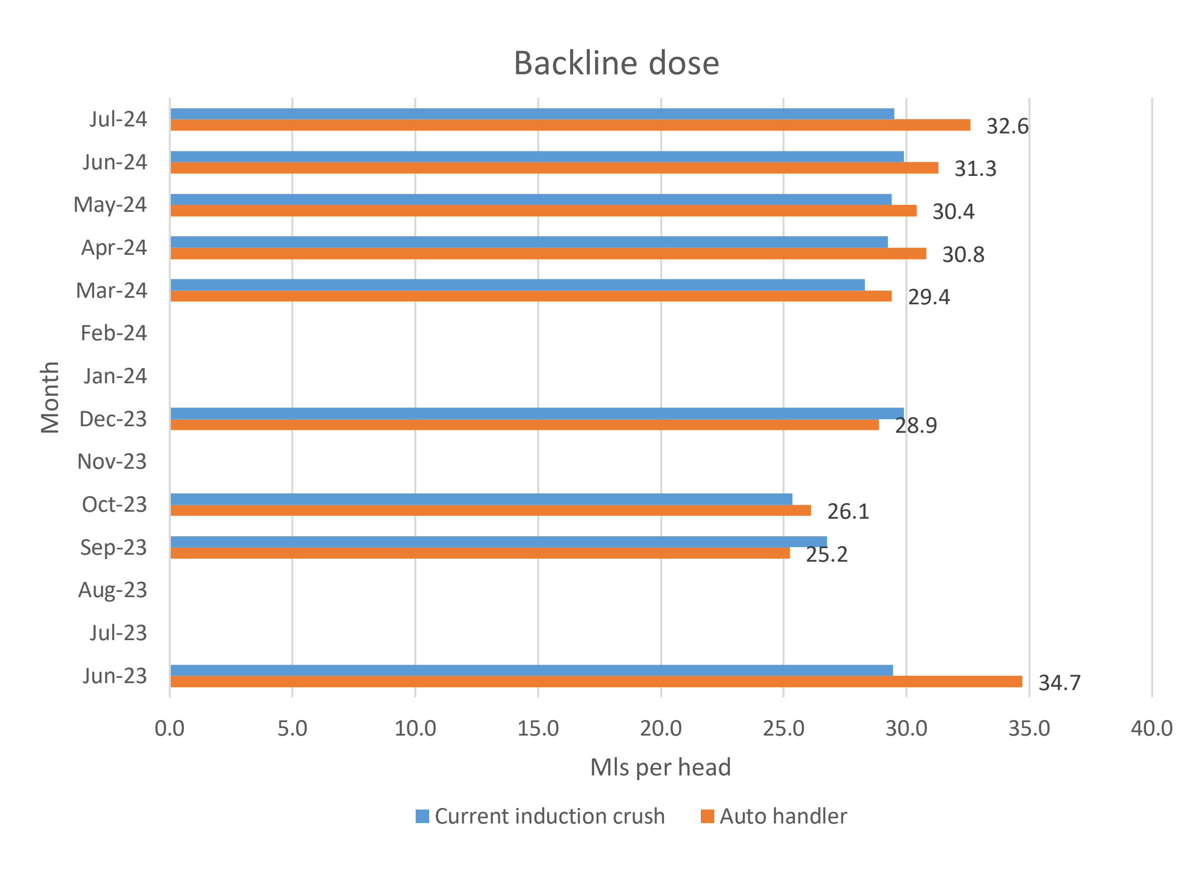

Figure 2: Backline dosing quantity (ml/head)

The data on volume of treatment applied on the scheduled induction days were cross referenced with tasks required and animals inducted (Table 5). Treatment 1 was administered by automated backline. The remaining treatments were manually administered. Treatment 2, 4 and 5 are injectables with treatment 4 being an oral probiotic. Combining the three injectable tasks into one using automation has the potential of reducing the time required for administering treatments by 50%. This is due to the reduced allocated time for operators to pick up multiple guns, inject and replace back on the table.

treatment	automated treatment 1		treatment 2		treatment 3		treatment 4		treatment 5		Induction type
month	COOPERS	mls per animal	BOVILIS MH + IBR	mls per animal	Tasvax 5 IN 1	mls per animal	Lactipro	mls per animal	BOVIMECTIN	mls per animal	
Jun-23	3750	34.7	296	2.7	n/a		n/a		n/a		BACKGROUND
Aug-23	n/a		296	1.9	n/a		n/a		n/a		BACKGROUND
Sep-23	1600	15.5	214	2.1	n/a		n/a		n/a		BACKGROUND
Oct-23	4100	26.1	299	1.9	712	4.5	n/a		n/a		BACKGROUND
Dec-23	2050	28.9	136	1.9	270	3.8	n/a		n/a		BACKGROUND
Mar-24	4417	29.4	293	2.0	n/a		160	1.1	1462	9.7	FULL INDUCTION
Apr-24	4770	30.8	322	2.1	624	4.0	n/a		1520	9.8	FULL INDUCTION
May-24	3562	30.4	228	1.9	470	4.0	470	4.0	1179	10.1	FULL INDUCTION
Jun-24	3793	31.3	239	2.0	471	3.9	n/a		1203	9.9	FULL INDUCTION
Jul-24	3292	32.6	199	2.0	400	4.0	n/a		1000	9.9	FULL INDUCTION

Table 5. Treatments applied for each induction. Total used for the induction and per animal doses. Treatment 1 was administered by automated backline, Treatments 2,3 & 5 were injected, and Treatment 4 was administered orally.

4.4 Results of objective 4: Evaluate tasks, labour requirements and processing rates.

Throughout the project, the Te Pari Auto induction chute was operated with four, three and two labour units at varying periods. This was dependant on tasks applied to the animal at induction. Note: backline application (Treatment 1) was automatically applied so is not included in the list of tasks (Table 6).

Task number	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9	Task 10
Treatment number				treatment 2	treatment 3	treatment 4	treatment 5			
Task	Control and input data	Dentition	Ear tag application LH	Bolvilis	Tasvax 5 -1	Lactipro	Bovimectin	Ear tag application RH	Tail clip	Push up.
Task description	Control automated chute, check data input	Mouth dentition for age classification	Application of ear tag to left ear	Injected administration	Injected administration	Oral administration	Injected administration	Application of ear tag to right ear	Clip end of tail	Move cattle into crowding pen and separation zone

Table 6. Manual tasks required per induction.

Cattle for backgrounding were inducted through June to December. These required fewer overall treatments and tasks, hence fewer operators are required. The full feedlot induction processes were applied from March until the end of the project.

Tasks details allocated per operator over each induction from Table 6 task list.						
Month	**Operator 1**	**Operator 2**	**Operator 3**	**Operator 4**	**Total manual tasks**	**Induction type**
Jun-23	1,2,4,5	10			5	Background
Aug-23	1,2,3,4	10			5	Background

Sep-23	1,2,3,5	10			5	Background
Oct-23	1,2,3,4,5	10			6	Background
Dec-23	1,2,3,4,5	10			6	Background
Mar-24	1,2,3,4,6,7	8	10		8	Full induction
Apr-24	1-7	8	9	10	10	Full induction
May-24	1-6	7,8	9	10	10	Full induction
Jun-24	1-8	10			9	Full induction
Jul-24	1-8	10			9	Full induction

Table 7. Task allocation per operator and number of operators for each induction.

Due to the setup of the auto induction crush, operator 1 completed most of the tasks (Table 7). This had the potential of not optimising the available time through induction and increasing the overall cycle length.

Pushing up cattle to the crowding pen is a task that requires operators move for comparatively short periods of time compared to other tasks. Revised yard design could prove beneficial in placing the push up operator closer to the chute, thereby reducing overall down time and the reallocating additional tasks.

The labour requirements were referenced against the number of animals per event and the tasks required to give an overall understanding to the processing rates (Table 8). These were compared against a targeted induction time. This time was derived from motion studies in and around the operation of the automated induction chute. Issues with RFID tag reading hindered the June and August 2023 inductions, with September through to December showing results marginally above the targeted time. The March through to April induction times proved disappointing, far exceeding the targeted induction time. The June and July 2024 inductions, using only two labour units, provided better results. Disappointingly none of the induction times achieved the desired targeted results. The predominant reason was due to inconsistent flow of cattle into the chute causing increased operator presence altering animal behaviour, more tasks being performed, task sharing not balanced allowing for excess idle time and/or external issues related to the operation of the chute.

Month	Total head per run	Overall cycle time (min)	Time per animal (sec)	Labour units	Target time per animal (sec)	Weather (°C)	Problems recorded by operator	Manual tasks	Compared to target time
Jun-23	108	120	66.7	2	28	Cold - 1	RFID scanner issues	5	x2.38
Aug-23	155	131	50.7	2	28	Sunny	RFID miss read x 4	5	x1.81
Sep-23	103	60	35.0	2	28	Sunny - 22	No reported issues	5	x1.25
Oct-23	157	97	37.1	2	35	Sunny - 30	No reported issues	6	x1.06
Dec-23	71	42	35.5	2	35	Sunny - 35	Test stopped early due to computer issues	6	x1.01
Mar-24	150	120	48.0	3	30	Sunny - 24	Full induction test through chute	8	x1.60
Apr-24	155	123	47.6	4	30	Sunny - 27	No reported issues	10	x1.59
May-24	117	110	56.4	4	30	Sunny - 15	Air problems and machine low on oil	10	x1.88
Jun-24	121	120	59.5	2	40	Sunny - 14	Flow issues cattle caught in back door	9	x1.49
Jul-24	101	91	54.1	2	40	Sunny - 15	Flow issues cattle caught in back door	9	x1.35
Total	1238								

Table 8. Total head, cycle time, labour units and tasks per induction event

Comparing processing rates with similar treatments and tasks, the best processing rate with four operators was in April at 47.6 seconds per animal for 9 tasks. The best proceeding rate with two operators for 9 tasks was in July 2024 at 54.1 seconds per animal (Table 8).

Optimally, the best combined labour time spent per animal came from using two operators, with an average of 1 minute 48 seconds per animal per operator. Three operators averaged 2 minutes 24 seconds and four operators averaged 3 minutes 10 seconds per animal per person (Table 9).

4.5 Results of objective 5: Maintenance and repair requirements.

Feedback from operator staff after six-months into the trial, showed that there was insufficient space or a gap to allow for proper manual injection technique and with some issues around vertical head movement of the animal. From this feedback, it was decided that the chin lift mechanism, injector tenting bars and automated injector would be removed and replaced with a hydraulic neck extender bar which offered safer access. These were developed and installed prior in January 2024 to allow the trail to continue. Problems with the pneumatic drench set up and chute function occurred during the May 2024 induction event. This was the result of low oil in the reservoir. Mechanically all other functions required no additional maintenance on top of the regular schedule.

4.6 Results of objective 5: Determine the value proposition for the automated chute based on commercial feedlot results.

The Automated Induction Chute is a significant investment over and above the traditional hydraulically operated chute. Current feedlot chute designs are based on a standardised heavy-duty chute. Additional features such as load cells, scale weigh systems and ear tag readers are incorporated depending on the client's needs.

The evaluated Automated Induction Chute came supplied with the above features with the addition to automated backline dosing. This gives the client a form of standardisation of process to improve throughput.

Recorded induction times exceeded the target assigned, reducing the value of the Automated Induction Chute. To improve cycle times, it is recommended that the yard and race setup be adjusted.

The project has shown that it is possible to decrease labour units required for induction. Saving on labour increases the value proposition in purchasing an automated chute.

Discounting the backgrounding inductions, similar treatment schedules for full induction were compared against the overall time spent. Two operators in July 2024 completed 9 tasks per induction at an overall cost of $0.96 per animal. In March 2024, three operators completed 8 tasks at the overall cost of $1.28. Four operators were required to do 10 tasks in April and May 2024. The additional task for those months was tail clipping, which added one additional labour unit. This additional labour unit discounted four operators for comparison. Therefore, two operators created the most efficient cost, per tasks required.

Month	Number of manual tasks	Labour cost per animal	2 Operators time in minutes	3 Operators time in minutes	4 Operators time in minutes	Induction type
Jun-23	5	$1.19	02:13			Background
Aug-23	5	$0.90	01:41			Background
Sep-23	5	$0.62	01:10			Background
Oct-23	6	$0.66	01:14			Background
Dec-23	6	$0.63	01:11			Background
Mar-24	8	$1.28		02:24		Full induction
Apr-24	10	$1.69			03:10	Full induction
May-24	10	$2.01			03:46	Full induction
Jun-24	9	$1.06	01:59			Full induction
Jul-24	9	$0.96	01:48			Full induction

Table 9. Number of manual tasks, labour cost per anima, and time taken per operator for each induction.

Table 10 shows an estimated value of an automated system compared with a standard hydraulic chute sourced from Silencer Hydraulic Chutes. This is to demonstrate the additional investment required when investing in an automated system.

Item	Silencer in AUD	Automatic handler in AUD
Chute	$48,000	included
EID ear tag reader	$4,000	included
Weigh scales and monitor	$5,400	included
Automated backline	N/A	included
Backline drench gun	120	N/A
Cost in AUD	$57,520	$82,850
Additional cost		$25,330

Table 10. Estimated Manual vs Automated chute cost comparison. (Silencer Hydraulic Chutes, n.d.)

Using Table 10 and adjusting for the additional automation, the payback is estimated below (Table 11). A reduction in labour units from three to two could result in a saving of $8,885.95 per annum, with a potential payback of 2.85 years over 50,000 per annum head of cattle.

Yearly head	50,000
Minutes per day to induct annual head. *Worked on a rate of 5 days per week over 50 weeks, with an average induction time of 0.8mins per head.	160
Cost per day for 2 @ $32 per hr	$169.26
Cost per day for 3 @ $32 per hr	$204.80
Saving per day	$35.54
Savings per year	$8,885.95
Payback in years	2.85

Table 11. Estimated payback on investment value if the automated chute saved one labour unit.

Caution needs to be applied as to overall value as many factors have an influence on the potential profit/loss.

5. Conclusion

This report has shown that automation can reduce the number of labour units required at feedlot induction. Automation can lead to calmer cattle and better flow through the chute, further improving the automated catch and throughput. Automating the backline drench to dose by weight further improves animal medication without under or overdosing. The drench is also safer for operators to administer.

By standardising the animal flow and catch characteristics through the chute, less experienced staff can handle the demands of induction. Despite these benefits, induction times did not reduce with the additional automation. This could be due to the available space constraining cattle flow, hesitant or rushing cattle, design features within the prototype machine that prevented flexibility in task sharing around the chute, and small delays at the start and end of the automated cycle that are not present with a manual chute.

Experienced operators, on manual chutes can alter the flow of cattle into the chute thereby improving throughput. This ability to adjust to varied conditions in real time can be seen as an advantage over the automated system. Automation relies on a non-variable flow through the system and when this is achieved the overall experience for operator and animal are improved.

Feedback from the feedlot has been predominantly positive, with reports that automated chute operation was less taxing on the operator. With the chute catching the animal, the operator may devote additional seconds to other tasks on the schedule.

With automation being in its infancy within the feedlot induction environment, additional features could prove beneficial in reducing the overall cycle time. Further automation provides the opportunity of improving the value proposition and reducing human and animal safety incidents.

5.1 Key findings

- The Automated Induction Chute showed a small positive value proposition.
- Reduction in labour units can offset the additional cost of the automated chute.
- The automated chute was reported as being less intensive and demanding to operate.
- Automated backline has the potential to improve safety by distancing the operator from drench.
- Cattle become calmer when less operators are in the proximity and when handling is minimised. Having calm cattle may improve consistent flow into the chute.
- Reallocation of tasks allows for a reduction in labour units.
- Throughout the project, the automated chute was reported as no harder to maintain than a standard chute.
- Automating catch has the potential to remove human error at catch phase of the cycle.
- Automating induction procedures may benefit animal welfare. Less agitated animals minimise the occurrence of incidence that can cause injury and stress.

- Manual head bail opening width settings need to be correct to promote proper catch.
- Overall cycle time has been negatively affected by factors included in the evaluation model.
- Induction facility design would benefit from the race and forcing pen being positioned closer to the exiting end of the chute to reduce time on distance push up tasks.

5.2 Benefits to industry

Benefits to the wider beef industry from automating induction procedures are as follows:

- Calmer cattle through induction are better (Buckley, 2021) from an animal welfare perspective, leading to less environmental induced stress.
- Skill shortages are reduced due to the less demanding operator interaction with the chute.
- A reduction in labour units allowing for increased profits.
- Drug and medication inventory can be optimised by standardising the delivery process.
- A reduction in workplace injuries as contact with cattle and medication is reduced.

6. Future research, recommendations and improvements

1. **Cattle Flow.** This is an important driver in maintaining the overall performance of the Automated Induction Chute. The onsite yards, due to site placement and space constraints were less than optimal in promoting good cattle flow. As the pen was small and lead up race short, it required more human handling per group. This could increase animal agitation resulting in a reduction in constant flow characteristics. Animal separation, pre induction into the chute, needs some work to ensure a better overall result and lower induction times.
2. **Limiting unnecessary shadowing and sunstrike.** These cause cattle disruption and hesitation. The position of the chute relative to the sun and shadowing can have adverse effects on cattle.
3. **Minimising all external noise.** Cattle behaviour improves with the elimination of unnecessary noise with regards to mechanical movements within the chute and opening and closing of gates.
4. **Lead up race and crowding pen design.** Future investment in automating the lead up race and forcing pen movement, without human interaction, will help in maintaining constant animal flow. Recent developments in AI have the potential to virtually eliminate human handling. The design of the race and force pen is altered to more of a U shape to reduce push up operator travel and down time. This will allow for more constructive use of available time so that it can be allocated to other induction tasks.
5. **Shorter chute zone.** The evaluated Automated Induction Chute initially had RFID readers towards the rear of the chute. Due to extensive on-site interference these were shifted farther forward. The current length potentially adds time to the overall induction cycle and can be difficult to facilitate movement of some animals through the chute. Ideally future trails are to use as short of an area as possible.
6. **Automated injection.** Trials in New Zealand showed potential in automated injection with strike rate at 75%. This focused on one injector. The Australian experience proved less than desirable, primarily due to the trialled operation not outperforming manual injection for speed of application and the increased number of onsite injections required. On going design reviews have indicated that multiple injectables and injection speed can be improved to

ensure accuracy is on par with manual techniques. A cautionary note as this technology needs to be balanced against operator technical training in servicing needle exchange and overall use and must achieve near perfect strike rate.

7. **Better computer integration into automated chute** This does pose ongoing challenges to ensure integration within the feedlot software. Standardization of this among multiple feedlots would go a long way to easing integration issues and problems going forward.

7. References

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