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Early Implementation and the Future of Individual Cow Monitoring Technology in the New Zealand Dairy Industry

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Executive Summary

The New Zealand dairy industry has a labour shortage from managers to farm assistants. This has pushed producers to look for automation options to reduce dependency on labour. Recent and ongoing improvements have produced large-scale, commercially viable individual cow monitoring technologies that can significantly reduce the workload on farms as well as increase animal performance and health measures. Suppliers of these technologies report a positive return on investment and a reduction in labour requirements. The industry has seen significant growth in the uptake and implementation of these technologies over the last 2-3 years. Implementation of emerging technologies is not always successful; challenges and limitations will exist in a commercial context that are not foreseen during the development or in early trials.

This report explores the intended application for these technologies and how this compares with current uptake and implementation at scale on commercial dairy farms. It explores areas of successful implementation and areas where obstacles have reduced performance or prevented the technology from being utilised as expected. Current and prospective users of the technology need to understand how different technologies in the market are likely to be implemented on their farms. This will help to make informed decisions around which technologies will achieve a more desirable outcome over the long term. This report will help suppliers and developers of individual cow monitoring technologies identify areas where their products are not being successfully implemented, and areas for further development to ensure the success of their technology in the New Zealand dairy industry.

A review of national and international literature was undertaken to confirm the accuracy and reliability of the technologies available to ensure they would improve or exceed the status quo of the current performance in the New Zealand dairy industry. The review examined the commercial viability of these products and looked to the future of the development and application of individual cow monitoring technologies. Qualitative, semi-structured interviews then took place with suppliers of the technologies, users, and non-users. Uptake, success and failure, and future development of the technology were examined.

Key Findings

- The technology is highly accurate and viable for a profitable outcome in a commercial large-scale context.
- All users interviewed agreed that the initial application has been successful and the return on investment has been neutral or positive.
- There is potential for greater return on investment from ongoing training and implementation of the full complement of features the technology has to offer.
- Challenges exist with the usability of the software and the sensitivity of health alerts specific to New Zealand's outdoor grazing systems.

Recommendations

Producers

- Develop a user-friendly interface as fast as possible, and regularly connect with users for improvements and future development.
- Reduce the sensitivity of health alerts and integrate on-farm weather conditions with health alerts to limit false positives from weather events.
- Ensure recruitment and the training of support staff can meet customer requirements as uptake increases. New support staff could double as sales staff to allow for early recruitment.
- Outsource and fund third parties for technical support. Farm consultants, vets, farm advisors, and other rural professionals could be used to help educate and review the data.
- Produce actionable reports/groups from the data to minimise the time and skill required for interpretation or lack thereof, and increase action taken on the farm.

Current and future consumers

- Prior to implementing any brand of individual cow monitoring technology, research the current and future access to after-sales support and technical specialists to ensure you will have ongoing support. Pay particular attention to your exposure to individual staff moving out of the role and limiting the technical support available.
- Be prepared to put the time and effort into learning and understanding the software as there is an interpretation of raw data required.
- Ensure the technology you implement is largely mainstream to ensure support from other users and increase the chances of new employees being familiar with the software.
- Work with vets and advisors to create protocols and policies to shift from clinical diagnosis to subclinical investigation and diagnosis before clinical illness impacts production and profitability.

The author certifies that there is no affiliations with or involvement in any organization or entity with any financial interest, or non-financial interest in the subject matter or materials discussed in this manuscript.

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1.0 Introduction

Innovations in technology have played an important part in the productive and economic gains in modern agriculture. General innovation starts with the discovery of new information about a resource, or how that resource can be better used (Chavas & Nauges, 2020). At the time of development, a new technology is an unknown, the full benefits are not known or understood ahead of time (Chavas & Nauges, 2020). Therefore, new technology is adopted based on perceived benefits by producers, benefits that are sensitive to current situation economic conditions and resource scarcity (Ruttan, 1977). The induced innovation hypothesis states that innovations are more likely to be implemented when they reduce current resource scarcity (Chavas & Nauges, 2020; Ruttan, 1977). In a New Zealand dairy industry context, scare resources include land, labour, and animals. If the pressure on resources can be reduced with the implementation of new technology, then producers can achieve and economic advantage within their production systems so long as the cost of the new technology is less than the value of the advantage gained. Individual cow monitoring technology has been recently implemented in the New Zealand dairy industry with the perceived benefits seeking to reduce the labour demand on farm, while improving animal performance and health factors. This technology is in the early adoptive phase of change and the technology, and its actual benefits, are being discovered on farm at the time of writing.

The NZ dairy sector utilises a large labour force and at the current time, a critical labour shortage exists, forcing an increased workload on existing staff (Groeneveld, 2021). The opportunity for automation is huge within the industry as there is a significant requirement for repetitive labour-intensive tasks such as the identification of cows for artificial insemination, animals with health issues, and shifting break fences and herds. The combination of a labour shortage and increased development of technology has resulted in attractive proposals from companies that can supply technology to ease the labour pressure on farms and improve animal and financial performance.

Individual cow monitoring technology comes mainly in the form of wearable devices that collect activity data of individual cows which are processed by algorithms to create meaningful insights into the status of that cow. Measurements include time spent active, inactive, ruminating, temperature, and location. Insights are determined from how long a cow spends in each state and reported to the farmer as reproductive activity and recommended insemination windows and varying degrees of animal health alerts.

This type of technology has been available in a global context in some form over the last 40 years, but only in the last 10 years it has become available in New Zealand in a large-scale commercial sense. Recently it has seen a rapid increase in implementation across the dairy industry. Allflex has seen the number of their collars on cows roughly double each year over the last three years. While the industry is still in an early adopter setting, it is rapidly advancing to being in a majority adopter phase.

Individual cow monitoring technology such as ear tags and collars are increasingly being used on New Zealand dairy farms to help monitor and manage animal

performance health and fertility. This report will focus on the current technologies with a high level of uptake in the New Zealand market.

- Cow monitoring collars – Allflex
- Cow monitoring ear tags – Cow Manager
- Cow monitoring and virtual fencing collars – Halter

With the development and implementation of new technology there often is a gap between the theoretical expected outcome and reality. This is especially true when the technology is implemented in a large-scale commercial context outside of the developer's control. The success of the technology relies on the usability and actionable outcomes derived from its implementation. Due to the recent implementation in New Zealand, it can be expected there will be varying degrees of success experienced by users relative to their ability to utilise and understand the software. The future success of the technology will be the ability for widespread implementation across users with varying degrees of technological capability, and therefore ease of use will be paramount.

This report examines the success of the implementation of individual cow monitoring technology in the eyes of the current users, as well as the suppliers to understand how the technology has been implemented relative to their expectations. It will determine if the technology has a place in the New Zealand dairy industry and what obstacles need to be navigated to ensure its success.

2.0 Aims and Objectives

This research project aims to understand:

1. Whether individual cow monitoring technology is successful in the New Zealand dairy industry.
2. Technological and commercial hurdles that require further development or support to improve the success of individual cow monitoring technology in the New Zealand dairy industry.

3.0 Methodology

A literature review identified the reliability and accuracy of the individual cow monitoring technology in a global and New Zealand context. It explored the performance improvements and reviewed the value it has within the New Zealand dairy industry, along with the hurdles faced by the technology in a global context. Qualitative semi-structured interviews were conducted with three groups of people relative to their relationship with this technology in New Zealand:

- Five dairy farm owners and managers who currently implement the technology within their businesses.
- Five dairy farmer-owners who have access to, but do not implement the technology within their businesses.
- Five suppliers and technical experts of individual cow monitoring technology.

A thematic analysis was carried out to present key collaborative and conflicting themes from the qualitative research. Qualitative research was undertaken as it allowed further discussion of core concepts behind the positions taken by individuals

and their relationships with cow monitoring technology. This allowed a greater understanding of the principles behind the success or failure of the implementation of cow monitoring technology than what could be gained from a quantitative dataset.

4.0 Literature review

The hurdles to materialise the potential of individual cow monitoring and management technology have been described as:

- Technological (precision, cost and ability to handle physiological data and models)
- Specific livestock applications (clear, and based upon sound biological principles)
- Marketing on a commercial scale (to win the confidence of farmers)
- Bioethics (public concern about using instruments on animals) (Maltz, 2020).

This review focuses on the technological and commercial hurdles. The specific livestock applications have been well-defined by the suppliers and users of the technology (Merck & Co, 2022). The public perception of bioethics is less of a commercial viability issue, and more of a public education hurdle, which has largely been quiet in the public domain to date.

4.1 Technology reliability and commercial viability

Individual cow sensor technology has been in development and commercial application through different forms for over 40 years by a raft of suppliers and research companies. The early 2000s saw a rapid increase in the number of wearable sensors available to dairy farmers worldwide, and these began to be offered and taken up within New Zealand.

For cow sensor technology to be successful in a commercial environment the accuracy of the data collected, and its interpretation must be comparable to or better than the current human ability. Overseas trials concur that the precision dairy monitoring technologies accurately monitored dairy cattle behaviour (Borchers et al., 2016; Werner et al., 2019) and that it is possible to show differences between disordered and healthy cows based on activity and rumination data recorded by individual cow sensors (Gusterer et al., 2020). Gusterer et al. (2020) went further to conclude that cows could spend three days with significantly higher lengths of time as "inactive" before being clinically diagnosed. This provides evidence that the sensor technology can alert users to subclinical issues before they become a clinical case, and the quality and interpretation of the data collected by individual cow sensor technology is the same, if not better, than human identification.

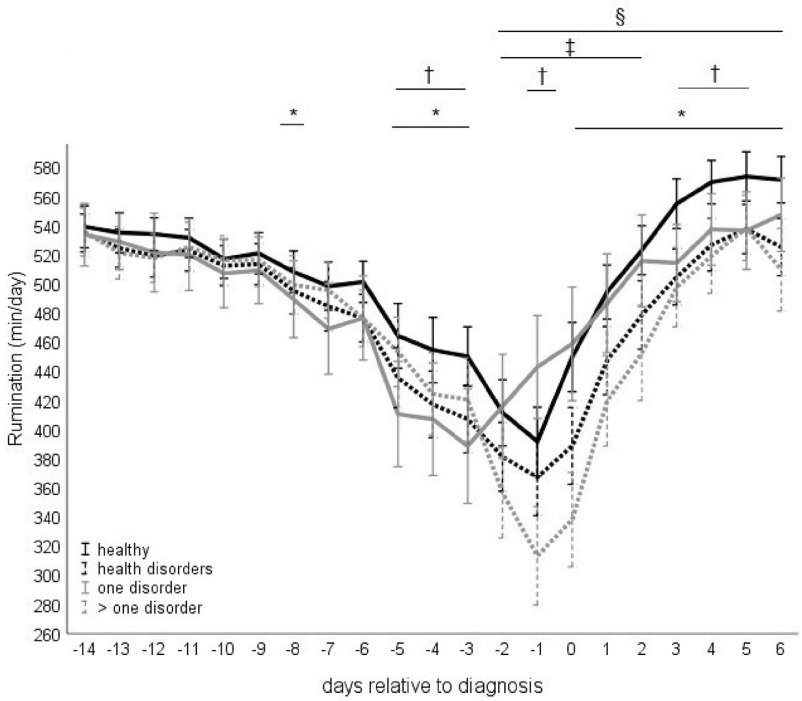

Figure 1: Daily "rumination" time patterns from -14 to 6 days relative to clinical diagnosis for cows in the non-diseased group (n ¼ 156) and cows diagnosed with health disorders (n ¼ 156) and for cows with disorders stratified by several disorders: one disorder (n ¼ 65) and >1 disorder (n ¼ 91). Within a day, pairwise comparisons that were statistically different (P < 0.05) are presented as follows: * healthy vs. health disorders; y healthy vs. one disorder; z healthy vs. > one disorder; x one disorder vs. > one disorder. (Gusterer et al., 2020)

NZ is unique in the global sense of its grazing method of feeding dairy cows (New Zealand Milk Products, 2022). The cow sensor technology has been developed in housed systems where feed is offered as a mixed ration and fed within these housed systems, rather than cows freely grazing pasture (Trebilcock, 2021). The justifiable concerns of how well cow sensor technology could transfer to a New Zealand grazing system with its relatively long walking distances have been met by both producers and recent research. In all the research papers reviewed, the relationship between observed and sensor-derived data had a high degree of agreement for identifying cow grazing activity in a New Zealand context (Dela Rue et al., 2020; Trebilcock, 2021; Werner et al., 2019).

	Date	Number of Head in Branch	Daily Rumination Average
1	31/10/2022	1287	526.5
2	30/10/2022	1287	565.7
3	29/10/2022	1288	495.2
4	28/10/2022	1289	473.3
5	27/10/2022	1289	520.1
6	26/10/2022	1288	519.6
7	25/10/2022	1288	520.0
8	24/10/2022	1288	582.5
9	23/10/2022	1181	522.7
10	22/10/2022	1181	531.1
11	21/10/2022	1181	521.0
12	20/10/2022	1182	552.1
13	19/10/2022	1182	493.2
14	18/10/2022	1182	531.2
15	17/10/2022	1182	530.6
16	16/10/2022	1184	522.7
17	15/10/2022	1196	453.8
18	14/10/2022	1196	472.2
19	13/10/2022	1151	466.7
20	12/10/2022	1151	505.5
21	11/10/2022	1151	472.9
22	10/10/2022	1151	505.8
23	9/10/2022	1150	554.5
			508.86

Figure 2: Allflex report on the daily herd rumination average, significant reductions are highlighted in light green.

The main sensor technology available in New Zealand is currently wearable collars and ear tag options. These sensors all largely collect the same motion activity data (Dela Rue et al., 2020; Saint-Dizier & Chastant-Maillard, 2012), while the Cow Manager ear tag sensor also collects the ear temperature of the animal (Trebilcock, 2021). This data is then applied to an algorithm that is adjusted for the New Zealand-based grazing system to determine activity type and its relationship to animal attributes such as health, nutrition, and fertility (Gusterer et al., 2020; Trebilcock, 2021). Thus, at the farm level, the farmer can get an accurate and continuous measurement of each individual cow and may then use those data for decision-making to optimize animal management and performance (Werner et al., 2019).

4.2 Commercial application and future potential

The uptake of individual cow monitoring technology has seen a rapid increase in the last three years within the New Zealand dairy industry. The industry can be described as being in the early adopter category for openness to change with less than 15% of farmers utilising some form of this technology, however from discussions with supplies of the technology the rate of uptake has recently been increasing exponentially.

Individual cow monitoring technology it is already being shown to combat animal health and fertility issues, along with reducing the labour requirements within the industry (Merck & Co, 2022). New Zealand has an estimated shortage of 4,000 to 6,000 workers on dairy farms (Groeneveld, 2021). Skilled and unskilled labour shortages are providing inroads for the uptake of cow monitoring technology, The non-GPS cow monitoring technology is being used as an insurance policy against poor-performing skilled labour in reproduction and animal health, while the GPS technology, Halter, is being used to reduce the reliance of unskilled labour shortages on the farm.

The application and interpretation of the data collected by individual cow monitoring devices have been so successful, that they are now used in farms all over the world (Maltz, 2020). All suppliers of individual cow monitoring technology

promote better reproductive performance from their application in New Zealand dairy systems, this supports the literature that farms with individual cow sensor technology had not only greater milk production, but shorter calving intervals (Lora et al., 2020). Crowe, Hostens, & Opsomer (2018) describe individual cow monitoring sensors as a time-saving technology able to identify the optimum time for artificial insemination. The traditional labour-intensive human identification of standing heats is becoming less effective, especially in high-performing cows, as the time spent displaying mounting activity is reducing. The literature agrees that the technology is identifying changes in cow activity and early oestrus activity as good as or better than human identification, which is critical to maintaining the 365-day calving interval for seasonal calving herds (Crowe et al., 2018).

Livestock Improvement Corporation Limited & DairyNZ Limited (2021) reported the mean 6-week in-calf rate for the 2020 to 21 season was 67.7%, surveyed across 4492 herds. The industry target is to aim above 78% (DairyNZ Ltd, 2022). The DairyNZ Reproductive Performance Tool dictates that a 1% increase in the 6-week in-calf rate is worth $4 per cow across the entire herd. A 10.3% increase in the 6-week in-calf rate across the entire dairy industry has the potential to be worth over $200 million, alternatively, $41.20 per cow. This is calculated at a $5.50 pay-out, at the time of writing the Fonterra farm gate milk price forecast for the 2022-23 season is $9.25 (Limited, 2022). Hugh Jackson (2021) has reported that the Alflex, Afimilk, and Cow Manager systems at $39 per cow per year on average in his cost comparison work in 2021, the cost of the technology could be paid for solely with an increase in 6-week in-calf rates to industry targets for the average performing farm (Jackson, 2021).

The future potential of individual cow monitoring technology is strong within the New Zealand dairy system as it can maintain high performance or improve poor performance while reducing the reliance on both skilled and unskilled labour requirements.

Obstacles to the commercial application of individual cow monitoring technology across the world that Bewley and Russell (2010) and van Empel *et al.* (2016) summarised, are still relevant to the New Zealand context. These include:

- Technologies promoted as user-friendly are not easy to use and costly.
- Technologies and concepts that are not fully developed and go to market without adequate training and instructions regarding how to translate the data into usable information, and what to do with this information.
- Technologies are developed without considering integration with other technologies.
- Information is provided with no clear plan of action (Bewley & Russell, 2020; Empel et al., 2016; Maltz, 2020).

Maltz (2020) summarised that for the future of individual cow monitoring technology to become a widespread practice, it must have clear instructions for use and application or, even better, it should be capable of automatic decision-making and execution (Maltz, 2020).

4.3 Conclusion

The reviewed literature was in agreeance that despite being a wide range of sensor types or where the sensors were located on the animal, the data collected are accurate in monitoring cow behaviour. The sensors and algorithms can also accurately identify the early onset of subclinical disorders before their human counterparts.

New Zealand trial data has concluded that despite the differences in New Zealand's pasture-based system, and the housed system that the cow sensor technologies were developed, the reliability of the information presented is the same or better than the status quo of applied human ability in a New Zealand context.

Uptake and application of individual cow monitoring technology is well underway on New Zealand dairy farms. The technology has a wide range of potential for increased performance and profitability in the dairy industry. Improvements to the industry target average 6-week in-calf rate could conservatively be worth $200 million, along with improvements in early animal health identification and treatment and reducing the reliance on skilled and unskilled labour in an industry with a labour shortage put the future of individual cow monitoring technology in a strong position in the industry.

Limitations to the uptake of individual cow monitoring technology in New Zealand and across the world have been identified in the literature. These have largely been identified around the presentation, interpretation and application of the data collected from the sensors, and integration with existing technologies.

5.0 Findings and discussion

The benefits to producers of individual cow monitoring technology are very attractive in the dairy industry as skilled labour becomes increasingly scarce and the costs of production continue to increase. Industry bodies such as Dairy NZ are making producers more aware to the significant costs of poor mating performance (DairyNZ, 2021), while suppliers and users of individual cow monitoring technology are advertising increasing mating performance with lower labour requirements (Merck & Co, 2022).

The results from the semi-structured qualitative interviews were categorised into topics of discussion for each group interviewed and the themes of those discussions summarised. Similarities and differences were compared between groups interviewed to analyse how well the current situation and future of individual cow monitoring technology is understood across the industry.

5.1 Dairy farmers and managers with individual cow monitoring technology

5.11 Return on Investment

The implementation of individual cow monitoring technology on all farms interviewed has been successful to some degree and all farmers agreed that they would make the same decision again knowing what they now know. All farmers interviewed have said that the technology has been a positive return on investment

or financially breakeven at worst while delivering other non-financial value. This gives confidence that the technology has enough benefits and return on investment to justify the cost and effort in implementing the system, and that with improvements from ongoing development and understanding of the technology and reports, the benefit will increase for farmers into the future.

The individual cow monitoring technology has been a recent implementation on all farms interviewed, early adopters of the technology have had three full seasons down to farms in their second season of use. This early stage of adoption means that there is still likely a lot of learning and understanding of the technologies full range of applications to be done by farmers, but also that development by producers of the technology is still underway. I expect as time goes by users will gain further insights into the application and usefulness of the technology, and we are currently not likely to fully understand all the data available to farmers.

5.12 Mating

With the implementation of cow monitoring technology, preparation for mating policy has changed from the application of tail paint and visual activity markers to auditing software and hardware. Cow information is reviewed to ensure that the sensors are allocated to the correct animals, sensors are working correctly, and that all animals are loaded into the system and are eligible for mating. Mating shifts from a labour-intensive, visual identification system, to one where no human heat detection is required. Farmers that have the individual cow monitoring technology agree that high mating performance could be maintained, and farms where performance was less than the industry target, could be improved with the technology.

> *"We have had a slight improvement in mating results, but I have been able to allocate more of my time to areas other than mating over the mating period." – Dairy farmer with individual cow monitoring technology.*

This is consistent with the literature where identifying cows in early oestrus is labour intensive and that the individual cow sensor technology is not only showing the correct day to inseminate a cow but also the correct time of day giving the farmers the option for multiple insemination times each day (Crowe et al., 2018). This gives confidence that the possibility of improving the NZ dairy herds' mating performance to industry targets with the implementation of individual cow monitoring technology. As discussed in the literature review this is potentially worth $200 million to the industry. It should also give confidence to farmers considering implementing the technology that the investment will largely be paid for by the improvement in mating results.

> *"In the first season of having the collars I had my best in-calf rate ever over 9 years on the farm, and the 6-week in-calf rate has continued to improve." – Dairy farmer with individual cow monitoring technology.*

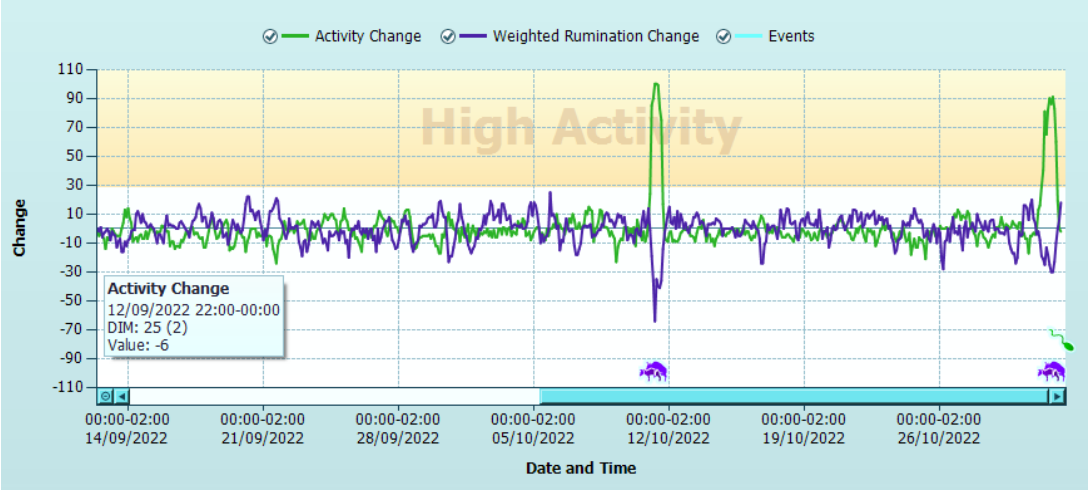

Figure 3: Allflex activity and rumination change chart for a postpartum milking cow. Periods of high activity and lowered rumination indicate heats where the cow is ready of artificial insemination.

Previously bulls have been used as insurance against human error in heat detection and to lighten the load for staff after the replacement heifers have been conceived, now all farms with individual cow monitoring technology artificially inseminate for the entire 10 to 12-week mating period. This provides several benefits to the dairy system, including but not limited to:

- It allows inseminating with higher value terminal sires, improving stock income in reducing the need for bobby calves, another major issue currently faced by the dairy industry.
- With more accurate AI times and scaling of heat intensity, the success of sexed semen will be greater, further increasing the ability for higher-value terminal sire use.
- Reduction in health and safety concerns with bulls on the property.
- Short gestation bulls can be used in the final weeks of mating to maintain a tight calving spread, this enables longer mating and a lower not-in-calf rate.
- Accurate insemination dates for the entire mating, along with the heat detection of the sensors eliminate the need for pregnancy scanning and expected calving dates should be very accurate, improving the management of cows close to calving.

5.13 Labour

The labour issue was raised by the farmers interviewed who have individual cow monitoring technology. Owner-operators and managers now spend less time in the dairy shed picking heats during mating, allowing this time to the reallocated in other areas. Farm owners who rely on staff for mating and the resulting success or failure agree that they are well insulated against the quality of the labour employed and will still achieve an excellent mating result regardless of manager ability. While ensuring the success of mating does not solve the issue of low-skilled labour requirements on the farm it does allow the highly skilled managers to reallocate their time during the mating period, partially reducing total farm labour requirements. It

will, however, allow farm owners to reduce the total wage spend as they could reduce the amount of highly skilled staff on the farm (second in charge, herd managers etc.) as their requirements are reduced, and have a single highly skilled manager and additional lower skilled staff.

Farms interviewed with GPS fencing technology have not focused on actively reducing staff numbers, but they have seen several labour benefits. Staff hours have been reduced, especially through the labour-intensive calving, as there are no breaks or fences to set up and shift, along with not needing to get cows in for milking. The need to urgently replace lower-skilled staff vacancies has been reduced with the implementation of Halter which is allowing farmers to recruit for longer and find better quality staff. The novelty and labour savings of Halter have made it attractive to both current and prospective employees as early starts to get the cows in 1-2 hours before milking in the morning is eliminated. This will help maintain good employees on the farm and will give farm owners a better pick of potential employees. However, it can be expected that as the uptake of the technology increases, the early adopter benefit will reduce in this regard. On farms with Halter, it will be necessary to have staff on hourly wages to realise the benefit of the reduced hours.

5.14 Challenges

Limitations and application of individual cow monitoring technology have not been around the accuracy of the sensors to detect changes in animal behaviour, but rather the interpretation and manipulation of the data generated. The consensus was a focus on difficulties of the ease of use of the software. It was hard for users to create and manipulate groups of cows to be able to view group parameters rather than individual cow parameters. This is largely due to how the software is developed and the initial application, Cow Manager, for example, was initially designed and applied for use in the Netherlands where herd sizes are far smaller and individual cow data is more appropriate.

> *"The input and creation of group data are hard, it's designed to be like MINDA, but it's not there." – Dairy farmer with individual cow monitoring technology.*

> *"I have cancelled our nutrition and health module; we are getting too many false positive health alerts and the usability of the phone app is only focused on the individual cow so you need to scroll through all the cows to get an idea of what's happening to a particular group." – Dairy farmer with individual cow monitoring technology.*

This may be a function of limited experience with the technology for the individual farmers, but the uptake and application of any technology needs to be user-friendly in a logical sense for it to be successfully utilised by its consumers.

Other areas of limited success have been described around the health alerts. False positive health alerts or sub-clinical health conditions where it is difficult to decern the issue with the animal have provided frustrations for dairy farmers with the individual cow monitoring technology. False positive alerts are commonplace during

weather events and calving, wet and cold weather will cause grazing cows to stand with their backs to the weather and subsequent activity and rumination to drop, these are key indicators for animals in distress and during these events, it is common for over 50% of the herd to produce a health alert. That is not practical or necessary to check every cow during these events however sheer number of alerts during these times will disguise the cows that have a clinical health issue. This issue is likely isolated to grazing animals as animals in a barn situation where the technology is developed will not have the same response to weather events. The interpretation of health alerts has its challenges as often a cow will show a drop in rumination and activity however there is no obvious issue with the animal at that point in time. There is the potential for development and integration with other technologies on the farm such as weather stations or cameras to moderate the reporting of health alerts in weather events. This would reduce the frustration of farmers and improve trust in the accuracy of alerts if the number of false positive alerts could be reduced.

> *"False positive alerts or alters where cows will self-cure lure you into a false sense of security. Due to the high number of cases that don't need treatment, you can miss clinical cases." – Dairy farmer with individual cow monitoring technology*

Dairy farmers have only been able to rely on clinical symptoms of disease or disorder. Individual cow monitoring technology is now identifying health alerts before these clinical symptoms appear. The general course of action has been to monitor these cows and identify the health issue when the animal presents a clinical condition. Just because the is no obvious health issue with the animals at the time of detection does not mean that she does not have a subclinical condition. This presents an opportunity for further training and on-farm testing to aid in the diagnosis of health conditions before they have a significant impact on the animal and performance and profitability of the farm.

5.15 Support

After-sales support had mixed reviews between different technologies. While all farmers interviewed agreed that the quality of the support for training to implement and understand the technology, as well as troubleshooting, was excellent, the availability of support staff was limited for the technologies that had wider uptake. It was concluded by farmers with Alflex and Cow Manager technologies that the support staff are excellent but spread very thin over a wide number of farms, an issue these farmers expect to increase as more farms implement the technology. Support staff are especially busy during times of high use such as leading up to mating, however despite the high workload, none of my interviews uncovered any critical failures.

The high demand from a few highly trained technical experts could produce issues with exposure if new experts are not trained fast enough or existing ones leave the role. A reduction in the quality or quantity of technical support would reduce the success of any implemented technology. Farmers have already started to create their own discussion groups to share ideas and issues to overcome challenges without the need for professional support.

Farmers with Halter have been impressed with their after-sales service and training, each farm has one after-sales representative who has three specialists behind them to troubleshoot and provide advice 24 hours a day. The high level of after-sales support with Halter can be expected to reduce, currently, the product is still being developed and feedback from farmers issues and possible improvements is being welcomed by the team to improve the success of the product. Ongoing farmer-to-farmer and third-party rural professional support in the face of limited technical support from the suppliers will be needed to increase the level of success users have with individual cow monitoring technology.

A potential major issue is a limited farmer-to-farmer, or professional support issue for technologies that are new to the market, or ones with lower uptake. If few farms are implementing a certain brand of technology, then experience of that particular brand will be scarce in the sector and exposure to a lack of training or technical support is high. It will also have the risk of the software being different to use for new staff coming to the farm and limited uptake and success if staff members change. Farmers must be diligent in their research into what brand of technology they implement to avoid exposure to limited future training, and the ability to operate the software by new staff.

5.2 Dairy farmers without individual cow monitoring technology

Education and awareness of the costs and benefits of individual cow monitoring technology have been a trend among farmers that have not implemented the technology. While farmers that do not currently employ cow monitoring technology are aware that the technology exists, they have not researched or been exposed to how that technology would suit their system, or how the technology works and would work within their system. Countering this issue will take careful marketing from producers and advice from trusted advisors and other rural professionals about the technology and its implementation in their dairy systems.

Other concerns around the uptake of technology have been the reliability of the product to fill its intended purpose. Failures and frustrations with other technology and the support provided to solve issues in the past have created doubt in new products and technology. These issues will solve themselves if the technology is successful in the coming years as success stories are shared and implementation becomes commonplace in the New Zealand dairy industry.

> *"We had ongoing issues with installing automatic cup removers years ago, they didn't work properly, and the tech guys couldn't figure out what was going wrong after coming to see it several times. It still doesn't work properly now." – Farmer without individual cow monitoring technology.*

Finally, the cost and cash flow of purchasing or leasing the technology is a deterrent for some farmers. The industry has only recently recovered from 2 very low pay-out years from 2014 to 2016 and only moderate pay-outs over the following 3 seasons to 2019 (Interest.co.nz, 2022). Only over the last few seasons have farms been able to pay good levels of debt incurred in the low pay-out seasons. The appetite to take on the additional costs associated with new technology within the businesses has been

low for some. As technology advances the cost point of basic functions like mating may reduce which will increase the ability for uptake in tighter financial situations. If the cost does not decrease, it can be expected that the return on investment will increase as costs and inflation increase in the sector the value of savings around mating, labour, animal health, and production will increase.

5.3 Producers and support staff for suppliers of individual cow monitoring technology

5.31 Data Collection and Processing

The producers were consistent with the literature review in what data are collected and how it is presented to the user. Measurements were effectively consistent between suppliers; however, Cow Manager takes additional ear temperature readings for support of health issues, and Halter has the additional GPS capability. All data is transferred to collection points around the farm where it is processed in the cloud before being sent to the app or computer program.

Both Cow Manager and Allflex programs are designed to be used on the computer and functionality is limited to some degree through any phone applications. However, Halter is designed exclusively to be used on the phone with no computer application available to consumers at this point. All suppliers are working to some degree on the user-friendliness of the software as they have identified that the success of the hardware is dependent on the ability of users to be able to use the software. The development of software upgrades varies, Cow Manager is very slow to make changes, this is largely due to the size of the New Zealand market and the different requirements a grazing system has compared to the original development for housed cows. This will limit both the success and future implementation of the technology in New Zealand, however, a lower price point and ease of installation may overcome this particular challenge.

> *"The algorithm for New Zealand had to be changed quite dramatically as it was showing a high number of false health alert cows due to the cows appearing sick, but rather they were hungry and waiting for a break fence to be shifted compared with housed cows having 24 h access to food." – Supplier of individual cow monitoring technology.*

Halter has a large focus on the development of the software and features with new features currently in production and regular interactions with farmers were suggestions and improvements are suggested and taken on by the producers. As this is being developed in the New Zealand context it is more likely to be suited to our grazing systems and likely be more user-friendly than its competitors in New Zealand. It is not likely to be as suited to a global position as the other technologies in a housed situation.

5.32 Investment and Education of Users

All suppliers have economic models to demonstrate the return on investment of their technology and all have positive outcomes for their consumers, this may be overinflated compared with what users are reporting but the models assume the product is being used to its fullest potential. Allflex has limited the use of these

economic models as a sales strategy as there are too many factors that affect the return on investment, they rely more on the success of early adopters to show the high level of benefit compared with the relative low cost of implementation. Producers agree that the more users can utilise the technology the higher the return on investment will be, and as such the future benefit would expect to be higher for users as understanding and implementation evolves.

The main reason for the investment into individual cow monitoring technology is the same for both Allflex and Cow Manager. Farmers are looking for consistent and automated heat detection, especially where there are only one or two people doing the heat detection as they are then able to have a sleep in over the 6 to 12-week mating period. Once the heat detection is accepted as a given, generally after one season, farmers are seeking further insights with the data provided and are focusing on the early detection of animal health and nutrition issues. This confirms that there is still a large amount of understanding and insights to be gained from the technology which will continue to improve the success and value from the implementation of individual cow monitoring technology.

There is a huge amount of information being collected and presented by individual cow monitoring technologies, but with that requires understanding to utilise the information. There are varying models between producers to educate their users and ensure product success, however rapid expansion and uptake of the technology has become an issue as support and training staff are being diluted over a larger number of users. This is an issue especially for the technologies available globally. Halter, in an early expansion stage, will need to ensure their support team can maintain a high level of service and success with its users if it wishes to avoid similar limitations experienced other suppliers. There will be a critical uptake threshold that all brands of individual cow monitoring technologies reach in the marketplace where the technology will be so commonplace, and expertise and experience will be high among farmers and third parties. In this situation, the need for training specialists will be reduced and the risk of exposure will be minimal.

6.0 Conclusion

Despite being in the early stages of uptake and implementation, all users interviewed have seen enough success with the implementation of the technology that they feel like they are making a financial return on their investment. However, interpretation of data is needed to get the most from the technology, so new users should be aware of the industry knowledge of each of the options available to ensure enough support will be available to fully utilise the technology on farm. Commitment to continued learning will be required to achieve the most from any of the technologies implemented, these are not a "set and forget" investment.

The major gains from the technologies have largely been in the mating context where highly skilled staff do not have the same daily pressure of identifying cycling cows for AI, and improvements in mating performance have been achieved without the use of natural bull mating. These improvements alone can largely fund the implementation of individual cow monitoring technologies.

While this success is promising, the industry is still struggling with many of the obstacles identified by Maltz (2020) which are limited user-friendliness of the software, training and learning limitations, and the cost of the technologies. An additional obstacle unique to New Zealand facing the uptake and full utilisation of individual cow monitoring technology is the issue with false positive health alerts. The best-case scenario is the alerts create a huge amount of work for staff to review cows that are not sick, worst-case scenario is the health alerts are being ignored or if the option is available, unsubscribed from, and sick cows are not being identified by the technology. This will severely limit the success and value it brings to the user.

7.0 Recommendations

7.1 Producers

- Develop a user-friendly interface as fast as possible, and regularly connect with users for improvements and future development.
- Reduce the sensitivity of health alerts and integrate on-farm weather conditions with health alerts to limit false positives from weather events.
- Ensure recruitment and the training of support staff can meet customer requirements as uptake increases. New support staff could double as sales staff to allow for early recruitment.
- Outsource and fund third parties for technical support. Farm consultants, vets, farm advisors, and other rural professionals could be used to help educate and review the data.
- Produce actionable reports/groups from the data to minimise the time and skill required for interpretation or lack thereof, and increase action taken on the farm.

7.2 Current and future consumers

- Prior to implementing any brand of individual cow monitoring technology, research the current and future access to after-sales support and technical specialists to ensure you will have ongoing support. Pay particular attention to your exposure to individual staff moving out of the role and limiting the technical support available.

- Be prepared to put the time and effort into learning and understanding the software as there is an interpretation of raw data required.
- Ensure the technology you implement is largely mainstream to ensure support from other users and increase the chances of new employees being familiar with the software.
- Work with vets and advisors to create protocols and policies to shift from clinical diagnosis to subclinical investigation and diagnosis before clinical illness impacts production and profitability.

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9.0 Appendices

9.1 Interview Questionnaire

Suppliers / Salespeople of Cow Monitoring Technology

- What measurements does the collars/tags record?
- How do the collars/tags get the data?
- How is the data presented to the consumer?
- What modules/add ons/packages are there available?
- What are the current known benefits to the consumer by using the technology?
- What is the return on investment for the technology?
- Is there a general focus that consumers are implementing the technology to achieve?
- Are there any existing applications that are not well used by consumers?
- How might consumers as a group improve their profitability from the technology beyond their current applications for it?
- What percentage of dairy herds in NZ have your technology?
- How stretched are you to support all your clients that have taken up the technology?
- How will you keep up with the demand for aftersales services and training if the technology uptake continues or increases?
- What development is intended to be released in the future?
- What research is being done that we can use with the current modules?
- Has the cow monitoring technology increased our understanding of animal performance?
- What unexpected benefits have there been with the implementation of the cow monitoring technology?
- Are there any publications of research or other material of cow monitoring technology that you could provide which would be of benefit to my understanding of cow monitoring technology and project report?

Farm owners/managers with cow monitoring technology

- How long have you had cow monitoring technology?
- What brand of cow monitoring technology do you have?
- What modules are you paying for?
- What modules do you use regularly use and how do you use them?
- What farm policies have you changed with the implementation of the cow monitoring technology?
- Are there any modules you have but don't use or understand well enough to use them?
- What limitations have you found in using the cow monitoring technology to its full potential?
- Are there any modules that are available that you are not using?
- Are you planning on subscribing in the future?
- What benefits have you seen with the cow monitoring technology?
- Do you have an idea of the return on investment that you have seen on farm?

- How have you found the after sales service for training and understanding the software and reports?
- How have you heard about development and research in the cow monitoring technology field?
- Are you implementing any different practices with new research being done with cow monitoring technology?
- What would you have done differently if you knew what you know now about cow monitoring technology?

Farm owners without cow monitoring technology

- Why have you not implemented cow monitoring technology on farm?
- Have you considered implementing any cow monitoring technology on farm?
- What would make you change your mind about implementing cow monitoring technology?
- Are you likely to implement cow monitoring technology in the future?
- Are there any gaps or problems in the products or services that you know of which is detracting from implementing cow monitoring technology?