final report

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Utilizing Innovative GPS IoT Technology to investigate multi-species grazing for improved pasture management and meat quality

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Executive summary

The beef industry represents the 3rd largest agricultural commodity in the Great Southern agricultural region of WA. Compared with most other subsets of the Australian beef industry, the South West is characterised by a large number of relatively small producers. This is evidenced by 29% of all beef cattle in the South West kept on properties with 200 or fewer head of cattle. With this backdrop, and with this region being fertile and having high-rainfall as well, there is enormous potential for livestock farmers in the region to realise much higher profits per hectare from innovative pasture and animal management practises. To this end, we have undertaken an Australia-first trial investigating the potential of multi-species grazing for this region using innovative GPS & Internet of Things (IoT) based tracking technology.

The two innovative key components of this trial are: 1) “animal tracking” technology i.e., long-range wireless GPS tracking collars and 2) management practice - “multi-species grazing.”

The aims of this work are to assess the opportunity for production benefits by co-grazing sheep and cattle. Secondarily, we aim to showcase the practical implementation of IoT technology on farm by using GPS tracking collars on cattle and sheep.

The project has successfully accomplished both those aims. We have obtained promising initial results from a small-scale co-grazing trial - one of the first ones to our knowledge on Australia soil whose results broadly validate scientific literature as well as trials in other countries, that co-grazing indeed has tremendous promise as a way to improve pasture utilization and hence yield per hectare.

We have also successfully setup an on-farm low-power wireless network - again, one of the first in this region, and demonstrated how individual animal tracking can be done using this setup in a reliable and cost-effective manner. We have successfully generated tremendous enthusiasm and interest among SCF members and the broader community in this region, to technology and innovation. We sincerely hope that this momentum continues and that our farmers are able to reap better harvests, better prices, markets and on-farm efficiencies for all the hard yards they put in every day, as a result.

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1 Background

The beef industry represents the 3rd largest agricultural commodity in the Great Southern agricultural region of WA. Compared with most other subsets of the Australian beef industry, the South West is characterised by a large number of relatively small producers. This is evidenced by 29% of all beef cattle in the South West kept on properties with 200 or fewer head of cattle. Comparatively, in South Australia only 11% of all beef cattle were kept on properties with 200 or fewer head. (Source: www.swdc.wa.gov.au/media/255573/south%20west%20transformative%20action%20plan.pdf).

With this backdrop, and with this region being fertile and having high-rainfall as well, there is enormous potential for livestock farmers in the region to realise much higher profits per hectare from innovative pasture and animal management practises. To this end, we propose here, an Australia-first trial investigating the potential of multi-species grazing for this region using innovative GPS & Internet of Things (IoT) based tracking technology.

The two innovative key components of this trial are: 1) “animal tracking” technology i.e., long-range wireless GPS tracking collars and 2) management practice - “multi-species grazing.” Both elements have long been touted for adoption in livestock farming citing their many benefits. Adoption of both of these, however, has been limited for a host of strikingly related reasons.

Graziers are expectedly reluctant to adopt new management practices without robust proof of their utility and potential. They expect a detailed assessment of both the potential benefits, as well as a rigorous elucidation of all the risks and additional cost/work involved before deciding to change the status quo.

Agricultural technology (Agtech) has also been touted as a major driver of increased productivity and profit on-farm. However, farmers, faced with routine working capital challenges, only want to adopt technologies with proven Return on Investment (ROI) with a clear use-case, both of which have preferably already been demonstrated on paddock beforehand.

This trial addresses both of these challenges by demonstrating the utility of latest agricultural technology like long-range wireless powered GPS tracking collars for livestock in evaluating the effectiveness of multi-species grazing and making data-driven decisions on farm using streaming IoT data.

Grazing a pasture with more than one species of animal offers several advantages. For one, a mix of different dietary preferences and grazing behaviours results in greater plant utilisation. (source: www.beefmagazine.com/mag/multi-species-grazing-goats-cattle-0801). This would also ultimately lead to higher sustainable stocking rates and increased production from every unit of land.

Cattle tend to be intermediate grazers. They graze grasses and legumes and bite with their mouth and tongue. Sheep graze closer to the ground than cattle. Sheep also eat forbs (brushy plants with a fleshy stem) and leaves better than cattle. Many weeds in a grass pasture are forbs. Cattle tend to graze grasses better than sheep. This will all lead to both more even grazing of the land as well as savings in the amount of time and money spent on chemical weed control.
(Source: www.progressiveforage.com/forage-types/grasses-and-grazing/multi-species-grazing-can-improve-utilization-of-pastures)

Due to many of the gastrointestinal parasites from sheep not surviving and reproducing in the gastro-intestinal tract of cattle and vice versa, mixed-species grazing will decrease gastrointestinal parasite loads and slow resistance of gastrointestinal parasites to conventional drenches.
(source: www.luresext.edu/?q=content%2Fco-and-multi-species-grazing)

This study uses long-range wireless LoRAWAN to measure the differences in spatial distribution of cattle and sheep over a 3 week period. LoRAWAN technology makes tracking individual head of cattle and sheep via GPS collars more affordable and attractive because it eliminates expensive data costs, and enables networking of land which is not covered with cellular networks.

2 Project objectives

This project aims to assess the opportunity for production benefits by co-grazing sheep and cattle. A secondary objective is to assess the practical implementation of IoT technology on farm by using GPS tracking collars on cattle and sheep. The project will act as a catalyst to gain producer interest in this and other new technology that can help to retain the Australian livestock industries' global competitiveness. Individual producers may also gain direct benefits including improved pasture utilisation, increased livestock productivity plus computer and data management skills. The experience of the trial host will be promoted as a case study for adoption of other farmers. Iotag will use the outcome of this research to continue to develop this technology. If GPS tracking of cattle and sheep appears to be beneficial on the various metrics previously mentioned, the longer-term aim for Iotag is to make the collar smaller and cheaper for producers to adopt and to increase the functionality of the product.

3 Methodology

MLA is committed to investing in top quality scientific research, performed by suitably qualified, experienced and registered researchers and organisations. In experiments that involve livestock, MLA acknowledges that such research needs to be done under the auspices of a recognised Animal Care and Ethics Committee (AEC). The responsibility for obtaining AEC approval lies with the researcher. MLA has in the past not specifically asked for evidence that such AEC approval had indeed been obtained.

3.1 Trial Establishment

3.1.1 Site identification & preparation

Stirlings to Coast Farmers (SCF) identified "Glenridge Park" as the most suitable trial site after receiving several responses from members interested in hosting this innovative trial. Glenridge Park run approximately 7,500 self-replacing Greenline composites ewes with an annual production of over 10,000 prime lambs. This is complemented by 850 commercial Sussex breeding cows and a 2700 hectare winter cropping program. The farm has a commercial focus with stud development aimed at maximising the productivity of the commercial operations. Fertility, early growth, carcase conformation and feed conversion are the main criteria used when selecting sires for beef and prime lamb production.

Being one of the foremost and innovative producers in this region, owned and run by the Slade Family, this operation was the best choice for a trial site. Mr. Andrew Slade, the Cropping and Feedlot Manager

at Glenridge Park volunteered to setup the host site and collaborate with SCF actively through the course of the trial period. Andrew is an enthusiastic advocate of Ag-technology on farm having recently completed a Nuffield Scholarship to study "digital agriculture". Andrew's topic was how different sources of farm data can be integrated into common management platforms to develop better decision support tools and facilitate the uptake of new agtech.

3.1.2 Trial Establishment - Hardware procurement

Fig.1 : LoRaWAN GPS Sensor Module + Cattle Collar

All the necessary "internet of things" hardware - a LoRaWAN Gateway (also called a "base station"), 60 GPS tracking sensors along with collars to attach them to the animals were procured via sub-contractors Iotag Pty Ltd. from suppliers in the US, Taiwan and Australia. Fig. 1 shows some example LoRaWAN GPS Sensor Modules as well as the custom-made canvas collar that is used to mount these modules to the necks of Cattle and Sheep. Collars are custom-made for each type of animal to allow easy mounting and dismounting as well as staying sturdy on the animal's neck throughout the duration of the trial.

3.1.3 Trial Establishment - LoRa Gateway Install & test

Fig 2: LoRa Gateway install - tag & test

After surveying the property, it was decided that the roof of the homestead, near the paddocks hosting the trial was the ideal location for the LoRaWAN base station. The base station needs to be close to the paddocks, to facilitate line-of-sight communication with the GPS collars on livestock and close to power and internet connectivity. The base station looks very much like an ADSL modem with GPS and LoRa antenna attached to it. When both antennae are mounted facing the sky, in a clear area, the base

station can receive signals from GPS collars up to 10 km away. Fig. 2 above shows the fully mounted base station infrastructure on the trial property just post tag & test.

3.1.4 Trial Establishment - Collar install on sheep & cattle

Fig 3: Collar Install on sheep & cattle

Fig. 3 shows the cattle participating in this trial, on the paddock just after the GPS collars were installed. Care was taken with the animal handling to maximize animal welfare whilst reducing stress as a confounding factor for the grazing data generated.

3.1.5 Trial Establishment - Iotag FarmView Software - tag & test

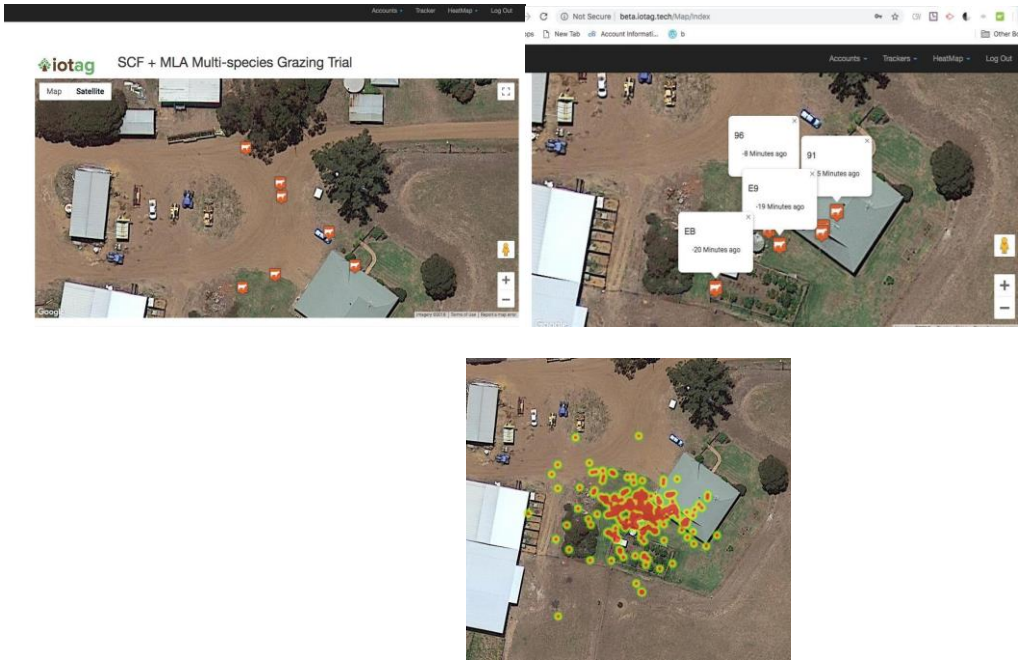


Figure 4: Iotag FarmView Software - snapshots.

Once all hardware infrastructure was live, testing & tagging of the Iotag FarmView platform was conducted. Iotag FarmView is a Software as a Service (SaaS) web platform developed by Iotag Pty. Ltd. Iotag's FarmView platform brings together streaming "internet of things" data from devices, like GPS tracking collars on cattle and sheep. The FarmView platform allows management and others to see in real-time, the location of the animals as well as view aggregated data over time such as "heat maps" as

shown in Figure 4 above. A user account was created for this trial on the FarmView platform and training was conducted to acquaint users on the property with the platform.

3.1.6 Trial Establishment - Workshop

On 27 September 2018, Iotag Co-Founder and Director Dr. Matthew Petersen presented at the annual Stirlings to Coast Farmers spring field day. This is the grower groups largest field day of the year with 120 farmers and agricultural stakeholders attending. Matthew outlined what Iotag and SCF are trying to achieve with the trial and demonstrated in real-time the locations of the cattle and sheep on the Slade's property. Matthew discussed the potential benefits of tracking collars to livestock producers as well as other IoT (Internet of things) devices producers are utilising in the eastern states currently. At the time of presenting, the collars had only been operating for a very short time, so there were no results to report to the group. Feedback for SCF members was very positive to the Iotag project as well as where agricultural technology is heading for livestock producers.

Fig. 5. Dr. Matthew Petersen (Co-Founder and Director, Iotag) presenting at the Stirlings to Coast Farmers Annual Spring Field Day on September 27th, 2018 at Kendenup, WA.

3.1.7 Trial Establishment - Workshop 2

Workshop two was scheduled to be presented at the SCF bi-annual Livestock Technology day in June 2019. SCF have decided to move the Livestock Field Day to the year 2020 due to conflicts with other grower group field days in 2019. As an alternative to the original plan, SCF will present trial data at a field day planned in the Frankland region in early February.

Dr. Petersen will present the data, if available, otherwise Andrew Slade (farmer host) and Nathan Dovey (SCF R & D Coordinator) will communicate the trial outcomes to SCF members.

3.2 Trial Design & Setup

Iotag GPS tracking collars were outfitted on a 8 cows and 24 sheep from a mob of 40 cows and 180 sheep respectively that were drafted to graze a 2 Hectare trial paddock at Glenridge Park outside Kendenup, WA. A Google Maps Satellite image of the said paddock is below.

Fig 6. - Trial Paddock at Glenridge Park

The trackers were set to record GPS location of each animal every 30 minutes and this data was collected for 3 weeks continuously from 3rd October - 24th October 2019.

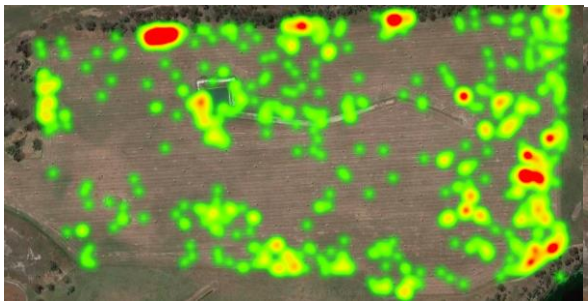
By co-grazing Cattle and Sheep together in one paddock and recording their grazing pattern, we intend to get an insight into the differences in grazing behaviour between the two animals and the potential impact of this on pasture utilization and hence productivity.

4. Results

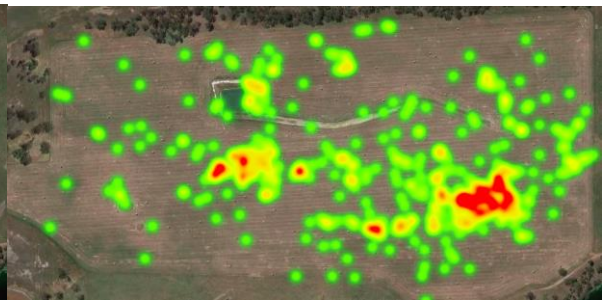
In the following sections we present several heat maps that were generated from the streaming GPS location data at 30 minute intervals. As the number of GPS points increase at a certain location, the colour becomes increasingly dense and changes green-yellow-red. Each map was broken into 1 week blocks, over the 3 week trial period. The final map is an aggregation of the 3 weeks.

4.1 Heat Maps

4.1.1 Trial Week 1 - 3rd -9th October 2019

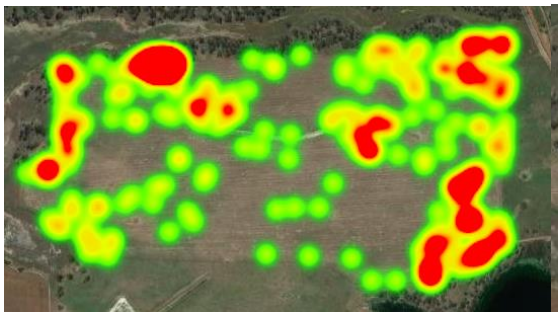


Cattle

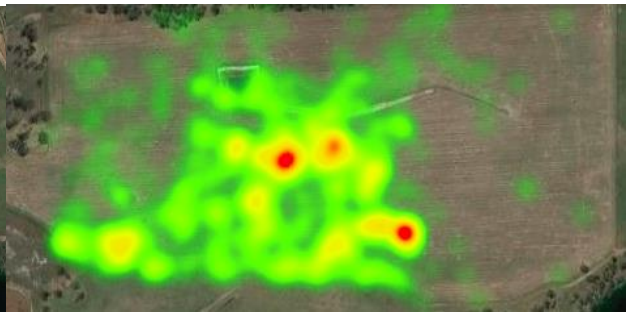


Sheep

4.1.2 Trial Week 2 - 10th -16th October 2019

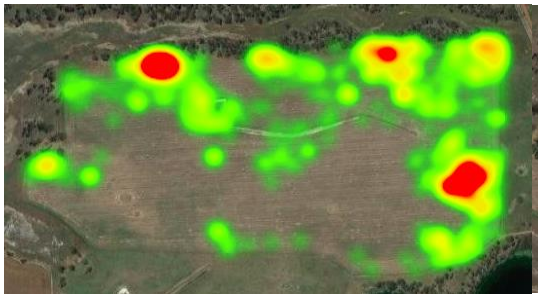


Cattle

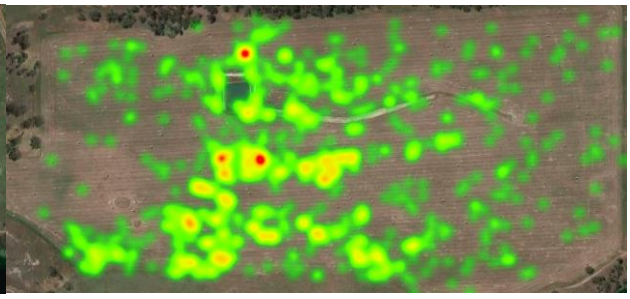


Sheep

4.1.3 Trial Week 3- 17th -23rd October 2019

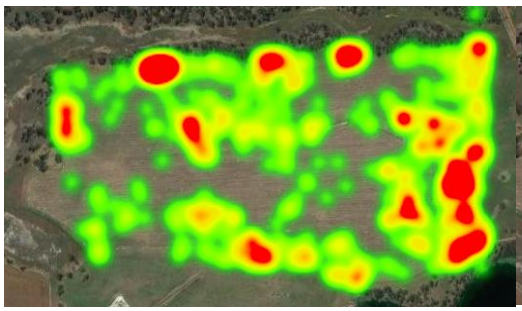


Cattle

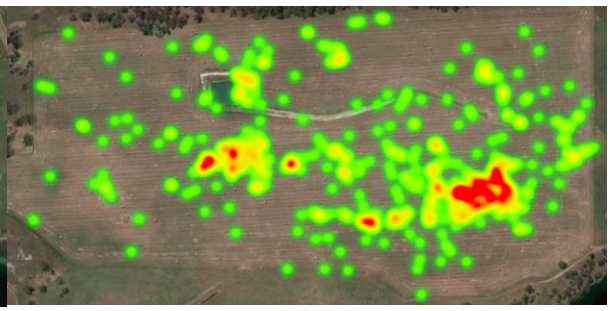


Sheep

4.1.4 OVERALL - 3rd Oct - 23rd Oct 2019

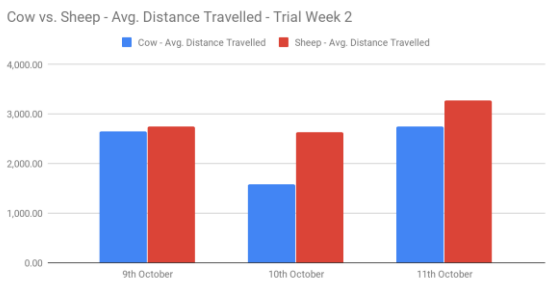


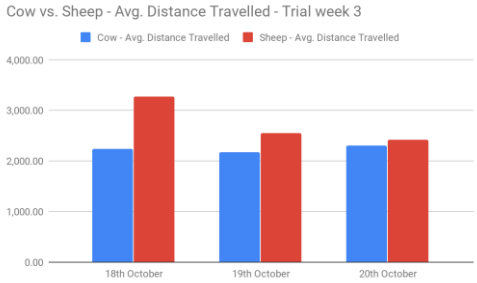
Cattle



Sheep

4.1.5 Daily Avg. Distance Travelled Comparison - Cattle vs. Sheep





5. Discussion

Over the duration of the trial period the spatial differences in cattle and sheep in the paddock were noticeably different (4.1). Cattle tended to occupy the perimeter of the paddock while sheep occupied the middle of the paddock. The reddest sections are where the animals are likely to be laying down, and still, 'resting and digesting'. After this period, they will be grazing, which creates a green colour as the animal is slowly moving while grazing.

The most compelling evidence of the difference in spatial distribution is figure 4.1.4 which shows the distribution of animals over the 3 week trial period. It is important to note, however, that given the trackers were collecting a GPS location every 30 minutes, this does not mean these areas that were most heavily grazed by the animals, but rather where they were spending the most time. Regardless, it is apparent there is a large difference in spatial distribution of cattle and sheep in the paddock over the trial period.

The distance walked was also consistently further in sheep rather than cattle. A common question graziers ask is the distance from a water point an animal is prepared to walk when grazing. Given the small size of this paddock, we were unable to obtain an upper limit.

A cross-section of findings from previous literature and trials in the US and such on this practise are as follows:

- "Grazing a pasture with more than one species of animal offers several advantages. For one, a mix of different dietary preferences and grazing behaviours results in greater plant utilization" (source:http://www.beefmagazine.com/mag/multi-species-grazing-goats-cattle-0801)

- "Cattle tend to be intermediate grazers. They graze grasses and legumes and bite with their mouth and tongue. Sheep graze closer to the ground than cattle. Sheep also eat forbs (brushy plants with a fleshy stem) and leaves better than cattle. Many weeds in a grass pasture are forbs. Cattle tend to graze grasses better than sheep. This will all lead to both more even grazing of the land as well as savings in the amount of time and money spent on de-weeding the land". (Source:https://www.progressiveforage.com/forage-types/grasses-and-grazing/multi-species-grazing-can-improve-utilization-of-pastures)

- Because gastrointestinal parasites from goats or sheep cannot survive in the stomach of cattle, and because gastrointestinal parasites from cattle cannot survive in the stomach of goats or sheep, mixed-species grazing will decrease gastrointestinal parasite loads and slow resistance of gastrointestinal parasites to conventional dewormers.
(source: http://www.luresext.edu/?q=content%2Fco-and-multi-species-grazing)

It has been our goal with this trial to demonstrate that these benefits can be realised in Australia, and that farmers can also measure and evaluate the pros and cons of this practise and other innovative practises like this, using the latest agricultural technology like GPS tracking collars on long-range wireless. From the heat maps and charts seen in the previous section, we are able to readily notice that sheep and cattle indeed graze different areas of the paddock and even in the same area, graze with different intensities owing to them being animals of different sizes and having different physical structures including teeth and digestive systems. This validates the promise of multi-species grazing to improve pasture utilization and hence increased production per unit of land.

6. Conclusions/recommendations

Multi-species Grazing holds promise as an innovative livestock management practice in view of benefits like increased pasture utilization, stocking rate and hence increased production from every unit of land. The results of this trial are in line with other research (Putfarken et al. 2008) which show cattle and sheep appear to be have complementary feeding preferences, which are beneficial on diverse pasture landscapes.

The scope of this trial was firstly to set up an IoT network on a commercial farm and get it operational. Secondly, we were collecting spatial information on sheep and cattle as they co-grazed for 3 weeks. To go on to work out the multiple factors that give us a much deeper understanding of the potential synergies when co-grazing sheep and cattle a much longer and detailed study should be commissioned. This would include an analysis of the vegetation types sheep and cattle preferentially eat, internal parasite monitoring including anthelmintic resistance surveys, management facilities which change grazing behaviours (water points, sheds, tree lines, fencing, salt licks) and the achievement of conservation goals including biodiversity.

This trial has demonstrated the potential to innovate farms using LoRaWAN networks i.e., GPS tracking livestock collars running on long-range wireless. We have demonstrated how to setup and run a long-range wireless network on a typical paddock in Western Australia. We have also demonstrated how to utilise this kind of technology to evaluate the benefits of a rather novel, but promising management practise like multi-species grazing.

We have also demonstrated, as detailed in the first sections of the previous chapter, how one is able to setup and utilize GPS tracking collars running on long-range wireless to cost effectively as well as accurately monitor paddock grazing patterns. Many kinds of sensors are currently available on the LoRa wireless stack like soil moisture probes, ultrasonic level sensors, pressure transducers, electric fence monitors, weather stations etc. By familiarizing farmers with this technology, as well as demonstrating a trial application like this one, on a regular paddock, we will hopefully be able to get more farmers realising the potential of using technology to simplify on-farm workflows and make data-driven improvements to their farming practises and realize better on-farm profits as a result.

7. Key Messages

7.1 Learnings from field-testing agtech on a WA farm

A lot has been learnt in these past few months collecting data for this trial using new innovative agricultural technology. A summary of our learning is explained below.

7.1.1 Local technical support is crucial to service agtech:

The hardware reached the trial farm on schedule, but a postal delay for the cattle collars from NSW to WA (to embed the sensor modules in) meant that we did not have the collars on the animals with internet connectivity until late September. Data collection commenced, but within a few weeks we lost internet connectivity through the base station. Since this time, we have been troubleshooting through different scenarios to why we have lost connectivity. This has been especially difficult to solve due to Iotag offices being interstate. Employing local technical support from Albany (85km from farm) has been more difficult than anticipated.

7.1.2 Agtech must specifically be designed for different kinds of farming systems and situations

Whilst we were working through the connectivity issues, the collars were still on the cattle and sheep in the paddock. We encountered another challenge where we saw a spate of GPS collars breaking off the animals, especially those on the cattle. We determined this was because the cattle were inadvertently brushing against concrete supplementary feed troughs that were either breaking or uncoupling the collars. We had never seen this before, or accounted for this, since our collars had only previously been used in free-range grazing situations. It has taught us that all agtech needs to be adjusted to local environments and situations. A simple change, such as supplementary feeding in the summer/autumn period, led to a failure in livestock collars durability. GPS collars for feedlots and other such environments in the future, need to be designed using more robust material to withstand grazing or rubbing on concrete feed bunks and such.

7.1.3 Agtech deployment can be a challenge with unforeseeable challenges to solve.

We have encountered a couple of challenges during this trial so far. After a heavy rainfall event, the base station lost internet connectivity, which was a surprise given all equipment is supposed to be weatherproof and waterproof. We ascertained that it was the 'power over Ethernet injector', a wire that goes into the base station being exposed to the elements, and since this component was not weather-proof, it failed. We ordered a replacement for this component, which delayed our schedule during the freight period and whilst we had difficulty finding professional support to install the new wire for the Slade's. We learnt that all details are important, and we had to ensure all equipment that wasn't meant to be exposed to the elements was either kept indoors or wrapped up in waterproof tape or such.

7.1.4 Watch out for Internet Provider settings

Whilst troubleshooting another time the base station lost connectivity for no apparent reason. Eventually we determined the Slade's had switched to a new internet provider and we learned that this ISP routinely blocked internet traffic on certain ports that were essential to a LoRaWAN base station's proper functioning. This was something unique to WA, because we never encountered this issue on previous trials of this same technology and equipment in QLD, NSW, VIC and New Zealand. Unblocking the requisite port traffic explicitly, fixed the problem.

7.2 Epilogue

Despite all of the challenges detailed in the previous section - the promising results obtained in a short period of time utilising all of this technology validates the basic premise of multi-species grazing and lays the groundwork for larger-scale and more rigorous trials to further evaluate and quantify all of the different benefits from this practise.

Agricultural technology holds a lot of promise for the ease and cost-effectiveness with which data of various kinds can be collected on farm - individual animal location, water trough and tank levels, soil moisture, satellite and drone-based imaging and the like. Trials such as this one serve to bring farmers closer to all of this technology - to take it from raw technology in the lab to one that's tailor-made to work on a typical paddock, in-service of the specific end-goals of the farming operation.

We have generated a fair bit of excitement and momentum for innovation - be it in farming practices or technology with members of the SCF farmer group, with sprightly start-up ventures that are putting brand-new technology and innovation to work at old problems through this work. We sincerely hope that this momentum continues and that our farmers are able to reap better harvests, better prices, markets and on-farm efficiencies for all the hard yards they put in every day, as a result.

8 .Bibliography

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