European Innovation Partnership (EIP) Wales

Where have ewe moo-ved to? Trialling the use of tracking technology in extensive grazing systems

Final Report

Operational Group:

Ian Rickman (lead farmer)

Rob Williams

Hilary Kehoe

Gary Williams

Trevor Jones

Hugh Davies

PONT

Brecon Beacons National Park

Specialists:

Christian de Jong, Digitanimal

Carlos Callejero, Digitanimal

Innovation Broker:

Helen Ovens, ADAS

December 2022

Contents

Report compiler	Hannah Baldwin
Reviewer	Helen Ovens
Quality control	Jason Gittins

Project Description

This project was funded by the the European Innovation Partnership (EIP) Wales programme, the role of which is 'to pool expertise and resources by bringing groups of people from different practical and scientific backgrounds together to tackle specific challenges, and trial new approaches which will be of value to others in the agricultural or forestry industry.' EIP Wales, which is delivered by Menter a Busnes, has received funding through the Welsh Government Rural Communities - Rural Development Programme 2014-2020, which is funded by the European Agricultural Fund for Rural Development and the Welsh Government.

Individual projects are managed and supported by 'Innovation Brokers,' who are funded (separately and in addition to the EIP project budget) through Farming Connect. Project participants form an 'operational group' (OG), which includes a minimum of two farmers and one industry partner.

The lead farmer for this project was Ian Rickman, with active support from Rob Williams and it was facilitated by an approved 'Innovation Broker' Helen Ovens of ADAS.

Introduction

Grazing management, location of livestock and livestock theft are becoming increasingly problematic for farmers who graze livestock on extensive grassland areas. The project aimed to implement strategies to mitigate such problems, resulting in a more efficient system, improving livestock safety, reduce the time associated with gathering, and provide more detail on grazing habits, which may have both production and environmental management benefits.

Digitanimal provided livestock tracking technology (also referred to as 'tech' in this report) in the form of collars and communication antennae, to a group of six farmers in Wales, constituting four sheep farmers and two beef and sheep farmers. The technology enabled the farmers to know where their animals were in 'real time' and where grazed over specific historical periods of time. The project was to help the farmers assess the potential benefits, such as reduced gathering time and associated costs, a reduction in theft or the risk of theft, the ability to identify sick animals quicker and also to better understand and manage livestock grazing habits. This was the first project of its kind in Wales to use livestock tracking technology for extensive grazing systems, across a range of livestock farms, in both North and South Wales.

Project Aims

- Improve understanding of flock/herd movement and habitat management in an extensive grazing system.
- Trial the adoption of livestock tracking technology, looking to reduce farm labour costs, deal with potential livestock theft issues and improve access to animals for routine animal health interventions.
- Explore the benefits associated with dataset collection on grazing activity in conservation areas.
- Increase farmer understanding of the economic benefits and increased efficiency associated with using such technologies.

Experimental Design

Six farms participated in the project. The project used livestock tracking technology across two grazing seasons. Via a mobile app downloaded onto the farmers' smartphones/devices, they were able to access the following information:

- GPS location including latitude and longitude.
- Activity Flags – alerting the farmer of an increased degree of animal movement which can indicate theft.
- Behaviour Indicators include grazing, low intensity grazing and lying down.

Other benefits, implicit but not explored specifically in this project:

- Social Interactions – communication with other animals helping assess the mothering abilities of collared females. Assessing interactions between a parent and offspring by the level of contact/activity monitored by the collar.

Project Supplier

Digitanimal was founded in 2013 and provides a platform for locating and monitoring livestock animals, based on a long-lasting collar and algorithms which analyse the animals' behaviour to optimise farm profitability. As stated by Digitanimal, it offers:

'Efficient, innovative, and integrated solutions, Digitanimal contributes to the acceleration of the digital transformation and the development of useful products and services that will boost the productivity and environmental sustainability of farms while being adapted to each area's needs and individualities. Digitanimal provides collars that use Sigfox radiofrequency technology to a range of businesses across more than 50 countries. These businesses include universities, nature organisations, cooperatives, and over 6,000 farmers, 80% of whom are in Spain.'

For the project, this technology was backed up with technical support and information interpretation from Digitanimal, with regular Zoom meetings between supplier, the innovation broker and the farmer participants.

Project Participants

Each of the six farmers was a member of the operational group (OG) which tendered for the tracking technology supplier, following detailed discussions on what the farmers wanted to get from the project. The farmers were particularly interested in the real-time information aspect of the technology, for theft alert issues, and for when they need to locate and gather the animals for health treatments/management activities.

Assessing the value of the tech to assist with conservation grazing, although only one of several objectives (the primary ones being concerned with cost savings, theft mitigation and improving livestock welfare) was another important interest area for a couple of the participants. These farmers have grazing agreements with conservation bodies in both North and South Wales. As a result, Pori Natur A Threftadaeth (PONT), took an active interest in the project, and were part of the OG.

The Black Mountain

Four of the project's farmers are sheep producers in the Brecon Beacons and share summer grazing on the Black Mountain. Between June and October, they graze approximately 2,400 breeding ewes between them on the summer grazing. For these farmers, their main project goal was trial the tech to better locate sheep and reduce the risk of livestock theft on the extensive ground.

Theft is a major concern in extensive systems -one farmer cited the theft of 130 ewes in one incident, resulting in a loss of at least £13,000 to their business. In addition, faster location of sheep would make gathering easier across the common area, resulting in lower labour requirements and reduction in cost.

In addition, the ability to observe changes to environmental systems may assist graziers and landowners to have a more informed conversation about the benefits of sheep in high habitat value extensive systems, and any support payments associated with these landscapes.

Margam and Kenfig Reserve

A South Wales farmer involved in the project runs a 1,200-hectare lowland beef, sheep and arable unit in the Margam region, which includes grazing a 460-hectare sand dune area on the Kenfig Reserve. The farmer has extensive experience balancing conservation and production livestock systems, having worked with the Wildlife Trust at Kenfig for several years on conservation grazing with sheep and cattle. HIs goal was to trial collars on cattle, and better understand what would be useful for him longer term in helping him and the public understand where specific animals are so that any negative impacts (for e.g., dog worrying) can be minimised, which has been a recurrent issue in a multi-user setting.

Conservation grazing on Anglesey

The participating North Wales farmer runs a small beef and sheep enterprise, with a special focus on conversation grazing. Her conservation grazing company works with North Wales Wildlife Trust, Gwynedd Council, and Natural Resources Wales to maintain a variety of environments. One of these locations was a Local Nature Reserve, while the other two are SSSI locations. This farmer's motivation for participating in the project was to help locate livestock in difficult extensive grazing conditions (in terms of topography/vegetation), saving time and being able to respond more promptly to any issues arising from livestock location.

Several of the farmers in this project are members of PONT. PONT allows farmers from all over Wales to exchange their knowledge, experiences, and skills in the areas of conservation and grazing, and was a valuable member of the OG, particularly in the early stages of the project.

Methodology

Delivery and Deployment

Before the farmers received their equipment, Digitanimal carried out a mobile signal network study to identify a precise location to install antennae which guaranteed the system would function properly. Each farmer suggested possible locations for placing the antennae and the final locations were selected based on coverage and convenience.

For one farmer in particular, the installation of the antenna was a challenge due to the requirement for an energy source and a safe/stable fixing point. This is a key challenge associated with the use of tracking devices reliant on both energy and a phone or satellite signal. In his case, there were no electricity plug-in points for the antenna, so an 8-metre mast needed to be installed, powered by a solar panel.

Table 1 provides detail on the number of collars provided to each farmer and the percentage of their livestock to which collars were assigned. The number of collars available was limited by the EIP budget -it was agreed throughout the project that the more collars available to the project, the more valuable the trial would have been.

In addition to the collars, each farmer was sent at least one antenna which transferred all the information collected to the internet which could then be analysed using the Digitanimal app/by Digitanimal for the farmer.

It was important to ensure all farmers trialled the collars, as part of the project was to help them get used to using the technology itself, setting up the antenna, putting collars on sheep, using the app on their device and providing their own feedback to the group and Digitanimal about their experience.

Table 1: Number of collars assigned to each farmer.

Farmer ID	Allocated no of collars	Type of livestock	% of farmer's flock/herd wearing a collar
1 (IR)	20	Sheep	5%
2 (GW)	15	Sheep	2%
3 (HD)	29	Sheep	4%
4 (TJ)	30	Sheep	6%
5 (RW)	40	Cattle	40%
6 (HK)	5	Cattle	33%
Totals	**139**	**Project flock size**	**2,380**
		Project herd size	**115**

Project Duration

In both 2020 and 2021, six farmers tested the collars on three grazing environments across Wales during their primary grazing season, roughly February to May. These grazing environments were:

- Brecon Beacons National Park – a common on the Black Mountain
- Anglesey Fenlands, Anglesey
- Kenfig Dunes, Bridgend, Glamorgan

Monthly Reports

During the last year of the project, Digitanimal rolled out a new feature providing the farmers with a monthly report which could be compared with other Digitanimal users reports.

The information presented in the report included:

- Distance travelled by the animals and ranking with respect to other users.
- Level of activity and ranking with respect to other users.
- Detection of the animals with the highest and lowest statistics.
- Heat map of the livestock in the month.
- Application features – average app entries, number of notifications during a month and ranking positions.

Figure 1 below shows a sample report for one farm. This detail has a range of potential uses:

- Determination of land area utilised by livestock.
- Improved pasture management with consequent economic savings.
- Identification of productive and unproductive areas of the farm.
- Improved understanding of livestock behaviour.
- Improved livestock management with consequent economic savings.

Due to the short project timescale, the time needed for the farmers to get used to the technology, and disruption of aftercare support as a result of the COVID pandemic, the full potential of the platform was not taken advantage of by the participants. This report does however help show others the more in-depth potential of this technology for extensive grazing systems, over and above the original aims of the farmer members.

Figure 1: Monthly report example.

Theft Trial

Farmer members suspected that each business loses up to 10 young fit breeding ewes from their flock annually on the Black Mountain. At £100 a head, this not only causes a financial loss, but also the loss of a hefted breeding animal, which has to then replaced by another homebred hefted ewe.

Two of the project participants wanted to investigate whether the collars could contribute to reducing theft, primarily testing the value of a motion sensor on the collar and secondly the value of having real-time data on the location of sheep including ones that have moved unexpectedly, signalling a potential theft.

The collars were used as a deterrent, reducing the chances of sheep being stolen. It was known within the community that certain flocks had collars on them, and this itself was thought to act as a deterrent. As regards the sheep themselves, and the value of the collar on the animal, the principle was as follows. If an individual cut a collar off and left it in the field, an alert would be sent to the farmer to

inform them that an animal had not moved for a period of time. Stealing sheep also requires gathering them to load them up, which would also be flagged on the Digitanimal app. Farmers would then have evidence of the change in livestock behaviour regardless of whether thieves gather sheep and steal ones without collars or steal sheep with collars on and cut them off before taking them.

The real-time data provided on the location and movement patterns of the sheep should help the participants work more effectively with the police in reducing theft activities. In addition to this, the data could provide better detail such as the level of theft that was taking place and where such incidents occur for the investigation of theft incidents by the police authorities.

As it was, no sheep were stolen from the participating flocks during the project; the opinion being that the wider community knowledge of collars being on the sheep was an effective deterrent in its own right, aside from any movement anomalies being noted by the tech itself.

Farmer feedback and dataset results

Participants were asked to complete an end-of-trial evaluation to determine their experience of the collar trial and the challenges and benefits associated with it. Several other factors were gathered in the questionnaire, such as what the farmers had learnt, whether collar allocation was appropriate to get meaningful data, as well as gathering opinions on issues to be addressed in the future, if livestock tracking technology was to be adopted more widely by farmers in Wales.

Sheep and Cattle Location

The consensus was that the ability to locate cattle and sheep across different extensive environments was of significant benefit to the participants. It allowed them to gather information such as movement, distance travelled and grazing patterns on an individual level as well as gain a specific understanding of the general grazing habits of their livestock.

The real-time location meant that farmers knew where their animals were every half an hour as seen in Figure 2. Farmers received notifications when animals exceeded farm limits due to the ease of accessing the information via a mobile phone application or website, reducing stress on the farmer. The North Wales farmer lives half an hour from the Anglesey Fenlands, and by setting up virtual boundaries on the app, indicating where the boundaries are on the land, she was able to monitor and anticipate livestock movements which could result in damage/trespass/threat to the public, prior to that outcome becoming reality.

When flocks are gathered off the Black Mountain, typically, 20% of the sheep do not come down with the initial main flock. Approximately twice a week, farmer participants will have to spend circa three hours trying to locate and catch these outlier sheep. The tracking system helped reduce this resource requirement substantially, helping the gathering be much more efficient and less stressful for both farmer and the livestock.

Figure 2: Digitanimal's mobile tracking app -screenshots (two different locations).

Reducing farm labour costs

Three of the project participants were of the opinion that the technology had allowed them to make savings in labour costs when gathering animals. The collars helped to reduce labour time by knowing where the sheep were on the mountain for gathering. Furthermore, when checking on livestock on a daily or weekly basis, the tracking technology helped to locate the livestock in a large open area. This reduced the labour time for one of the project participants by one hour per week, however, they were unable to provide a financial figure for the cost saved.

For the other three project participants, they felt that the technology had not allowed them to make a saving in labour costs, due to the time associated with maintaining/working with the tech itself. Due to the fact that it could take up to a day to change the batteries in the collars and that the antenna and collars required regular maintenance, they believed the technology increased labour requirements. However, they believed that the tracking technology could save labour and costs in the future if the technology became more efficient.

Theft Trial

Digitanimal and one of the Black Mountain farmers undertook a dummy 'real time' theft trial, towards the end of the EIP project period, to try to assess the value of the tech in identifying an actual theft situation. The farmers had expressed some reservations about the accuracy of the collar signal, and this needed testing, as part of a theft trial.

Control scenario

The first test was carried out on the 18th of March 2022, whereby a collar was fitted to an animal in a vehicle at 1pm and then removed from the animal at 5pm. After the collar was removed it was then fitted back onto the ewe for a further 4 days of monitoring. The collar was not equipped with GPS

data, unlike the other project collards. Instead, it was equipped with a continuous accelerometer which saved the data on an SD card, and then the SD card was sent back to Digitanimal for analysis.

The point of this was to provide a 'control' dataset, for a comparison with a theft scenario (as outlined in 'theft scenario' below). In normal conditions, with the device correctly placed, the Z axis was above 10 (acceleration of gravity), when the animal was grazing the Z axis was between 10 and 0 and the X axis was between 10 and -10. Negative Z values imply anomaly or manipulation of the equipment. Based on this, it was determined that the device was manipulated on 18th March at around 3pm and 7pm as illustrated in Figure 3.

The data confirmed what the farmer knew from him controlling the location of the animal, that the device had not been removed from the animal, and that the collar was reading correctly, whether it was in a vehicle or grazing.

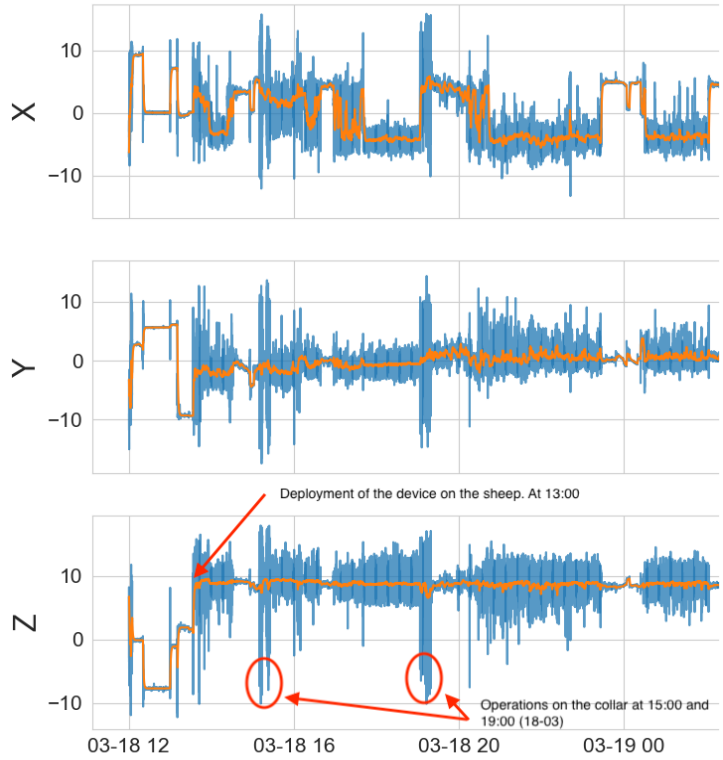

Figure 3: Acceleration signals for test 1.

Theft Scenario

The second test was carried out after 3pm on the 21st of March 2022. This involved one farmer visiting one of the project participant's farms and driving off with several collars on a quad bike. The farmer back at base waited to see how long it took for the app to send a notification of a sudden change i.e., replicating a sudden change in location of livestock, such as theft, or disturbance). The farmers were required to collaborate with Digitanimal to ensure the IT team understood why the changes in livestock behaviour had occurred. The graphs at Figure 4 show that an abrupt change in behaviour at around 16:00 was noted, however, as the devices did not leave the vicinity of the farm -i.e., the virtual farm boundary- no GPS alarm was generated in this instance.

Figure 4: An abrupt change in the behaviour pattern signalled in Test 2

Theft deterrent conclusions

It was discovered during this project that livestock tracking technology had a significant impact in reducing the risk of sheep theft. The collars and trackers, which are worn around the neck of the animal, operate as a deterrent to theft, resulting in fewer flock losses on the Black Mountain. Local farmers became more aware of and interested in different tracking technologies being employed on common grazing pastures throughout this project. One participant farmer believes the collars are making sheep theft more challenging since criminals must now consider which ewes are being tracked when gathering. The increasing value of this should be considered a benefit -with the increases in cattle and sheep prices and the rising cost of inputs the OG considers that the risk of livestock theft is rising.

Tackling Health Issues

Tracking the movement and location of sheep and cattle also helps to identify if an animal was behaving abnormally. For example, a lack of movement may indicate an urgent health issue. The farmer receives an alert if an individual animal has not been active for at least four hours, allowing them to locate the animal immediately and assess whether or not the animal requires treatment. It was possible to treat livestock in less time through fewer gatherings of livestock. Using livestock tracking technology allows animals to be treated more efficiently for fluke, worms, scab, etc. As a result, ongoing treatment costs are reduced, and treatment was more effective.

Whilst participating farmers did not carry out specific trials associated with this potential benefit, the time saving benefits associated with gathering had a positive impact on health management, due to the need to gather for routine health interventions, such as shearing/worming/fluke treatments/foot management.

Environmental Schemes

The potential for livestock tracking to help both environmental bodies and land managers/graziers manage land for environmental benefits is clear. With a commitment by government, conservation agencies and landowners to manage our habitats sustainably moving forward, any tools that are fit for purpose to assist in this are worthy of investigation. This was one of this project's objective.

The project fitted well with the policy objective of exploring ‘‘the role of technology to make farming businesses more efficient and profitable’.

This project helped demonstrate that livestock tracking can allow for improved control of ecosystem services, resulting in a better understanding of how to improve the ecosystem service offer associated with upland and fenland management, using technology.

Figure 5 and Figure 6 show the heat maps generated by Digitanimal from data collected from Kenfig Sand Dunes and the Black Mountain, indicating areas which are prioritised for grazing by the livestock over a particular period of time. The heat zones show where the animals are predominately grazing, and these visuals were available to the farmers via the Digitanimal platform, accessed via the app. This type of information could be used by farmers collaborating with conservation bodies to assess habitat management and work together to ensure grazing and vegetation management is sustainable for all concerned.

Figure 5: Kenfig Sand Dune heat map generated by Digitanimal.

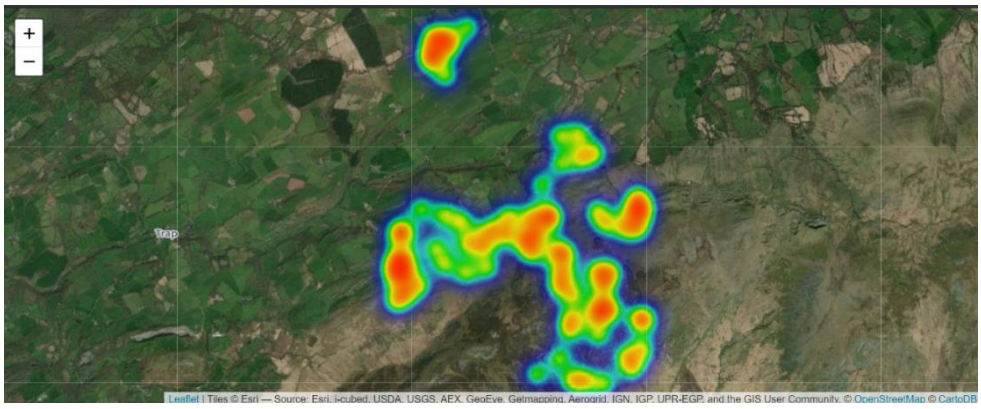

Figure 6: Black Mountain heat map generated by Digitanimal.

Challenges for Livestock Tracking -survey results

The Price of the Technology

The major challenge associated livestock tracking technology, as stated by the participants, was the cost of the equipment. Individual collars and antennas are not currently economically viable for a commercial flock or herd. Digitanimal’s price for an individual collar was over £120 and the associated antenna was over £500.

A collar at time of writing is more valuable than a breeding ewe, and therefore farmers would be hesitant to purchase tech if having to cover 100% of this cost of the tech. Only 17% of the six farmers

who took part in this project would buy the number of collars they felt would be useful to get more meaningful data for comprehensive flock management.

Other options were discussed with Digitanimal, and this included using a mix of functioning and dummy collars in their flow. All sheep farmers were interested in using dummy collars in their flocks to save money, still receive some location data and also help deter sheep theft.

Digitanimal stated that the barrier for farmers adopting livestock tracking technology without public-sector funded support was the challenges associated with the market value of sheep specifically (with cattle having higher value, therefore easier to justify the investment).

Wider industry issues emerging from survey discussions included a concern that sheep theft would move to other unmonitored common land livestock tracking equipment was used in only a few areas of Wales.

Many of the project participants felt that a grant to reduce the cost of the technology would encourage other farmers to adopt this technology, thus making it more accessible to commercial flocks and herds. One option would be an efficiency grant. Ear tags, neck collars, ankle transponders or boluses used for location tracking for management purposes were recommended as potential grant worthy items.

If grants cannot be obtained, participants felt it would be necessary to lower the price of the product on a commercial scale because the current price of the product does not equal the value of a breeding ewe.

Figure 7 shows participants' thoughts on the current value of the product - this example cost includes one collar and one antenna.

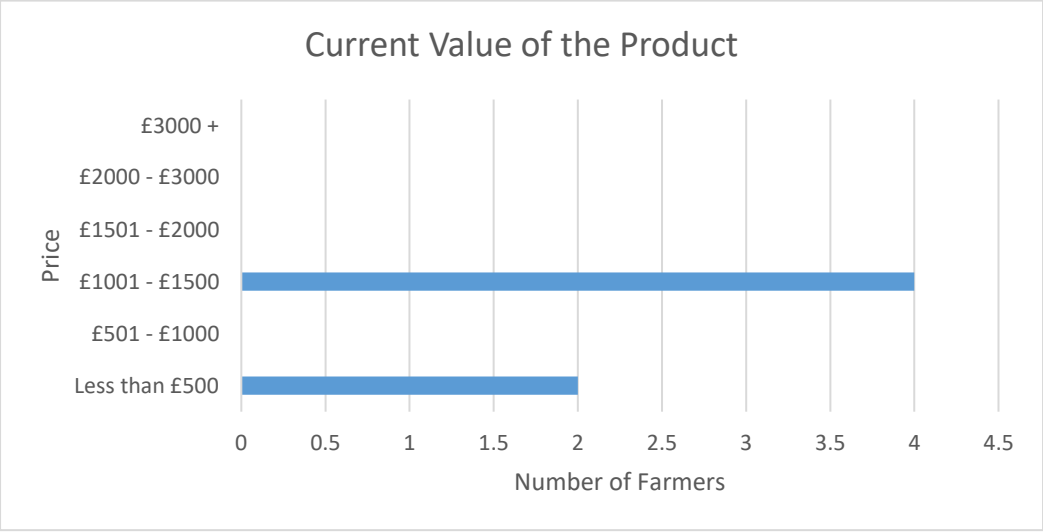

Figure 7: Participants thoughts on the current value of the livestock tracking technology.

Product accuracy

Another area of concern raised by one of the cattle farmer participants was that the tech trialled did not provide the level of accuracy needed for his system as regards location. The trackers used had an accuracy of within twenty metres, and this was a concern if using the tracker to determine proximity to a boundary of risk, such as a busy road, or where access to the public would become an issue. He was firm in the opinion that the location accuracy would need to be improved before the product becomes a worthwhile investment.

Design of Tracker/Collar

The user experience of the collars (Figure 8) was surveyed as part of the project. This in itself was a good learning experience for the farmers and the wider industry, as it became clear different designs suit certain farm species.

There were no real issues raised as regards collar design from the cattle farmers in the project, the comments around collar/weight/tracker positioning were primarily from the sheep producers in the group.

The weight of the collar allowed the tracker to sit on the side of the animal's neck, which was ideal for cattle but problematic for sheep. A weight was provided to assist in the positioning of the collar on the sheep. The accuracy of the data may have been somewhat compromised for some collars due to some participants not attaching the collar weight.

When asked what improvements the participants would like to see as regards livestock collars, the following feedback was provided:

- The value of extendable straps to help with the growth of wool on sheep all year round
- The addition of an antenna or light on the collar device to show that the product was on and working
- Improving the accuracy of the tracker
- Making the tracker easier to turn on and off

The collars were visible from a long distance due to their size and colour, leading to several external parties questioning participants about what information they were gathering. A more muted colour and a smaller tracking device would enable the product to be less visible to thieves.

Two farmers experienced issues with moisture entering the tracking boxes, causing them to rust and making it impossible for them to collect data throughout the year. Several farmers expressed concern about the size of the battery within the tracking device since changing them annually was a time-consuming and difficult task.

Notwithstanding the above comments, most farmer users rated the product as very high-quality, and were pleased with the aftercare support from Digitanimal across the project as regards adjusting/replacing collars, batteries, straps etc.

Figure 8: Digitanimal collars used on both cattle and sheep. The left photo also shows the weight available to attach to the collar to position the product better on sheep.

Challenges associated with technology use -generational issues

Farmer participants had not used this type of technology before -either at all, or to any great extent. Whilst tracking technology is not that novel in itself (used within the conservation sector to monitor animal/bird movements), the use of it with farm livestock is more novel, and its use with beef cattle and sheep is very much in its infancy.

Getting used to the tech, i.e., the collars, the antennae, setting up the interface on smart phones/devices, liaising with Digitanimal -all of this was new to the farmers. Feedback was gathered at the end of the project on this user experience, to help inform tech suppliers and other farming industry activity in this sector.

Having an understanding and interest in the use of data/tech/apps is critical to getting the most from livestock tracking. On the Black Mountain, the farmers were fortunate in having a younger member participating in the project who was happy to teach the other older/less tech savvy farmers how to use the smartphone app and assist with the setup.

Digitanimal unfortunately was unable to visit Wales during the project period to assist with the installation of the equipment and provide orientation time with the farmers due to the coronavirus outbreak. As a result, all of the farmers had to complete the setup by watching videos and interacting with one another either at home (face to face, or via Zoom). Some members required a higher level of contact with Digitanimal to understand how the technology worked and how to set it up. The group adapted well to virtual support and regular contact, and the project was able to continue with a good level of momentum, in difficult circumstances.

Despite there being frequent contact between the supplier and participants which allowed all issues to be resolved, Digitanimal would have preferred to visit each farm to ensure they were fully set up prior to the trial taking place, and also visit during the project to help see the collars in action and provide more face-to-face support to the project members.

Both the farmer and the tech supplier knowledge on the opportunities and challenges associated with farmers adopting tech to monitor their flock/herds. Ensuring technology is user-friendly on both smartphones, devices and computers is essential in order to help reduce the barriers to uptake. If the initial set up experience is challenging or negative for the user, this can result in the farmer disengaging and also presenting a negative experience to others, which in turn could have an impact on wider usage across the sector.

Transmission and accuracy

Testing the accuracy of the trackers was a key part of the project and involved adjustments and feedback between supplier and farmer members throughout the project.

Antenna location was key to getting a signal from the collars to farmer devices in the first place. Farmers had to adjust their antenna sites throughout the project to ensure that signal was received in all sections of grazing settings.

The Black Mountain farmers initially had trouble getting signals in the valleys and gullies across the mountain range during the first year of the project. However, by adding a second antenna, they were able to improve both transmission and accuracy of location detail. Digitanimal struggled to advise the farmers on the most appropriate positioning of antennae, which it would have been able to do if farm visits had been allowed (COVID stopped this happening).

Digitanimal trackers use the Sigfox communication system, which relies on a mobile phone signal, working off wireless networks -therefore access to a broadband signal was required for the antennae to work (not required for the collars).

Figure 9 shows the Sigfox coverage provided by the commercial operator in an example area of Wales including the Black Mountains with one antenna set up in the area. Sigfox builds wireless networks to connect low-power objects such as electricity meters and smartwatches, which need to be continuously on and emitting small amounts of data. Areas with coverage using one antenna are indicated here in blue, indicating not all areas had good Sigfox coverage. Figure 10 shows the increase in coverage (in red) once a second antenna was put up in the Black Mountain area, significantly improving transmission, therefore project data collection and accuracy.

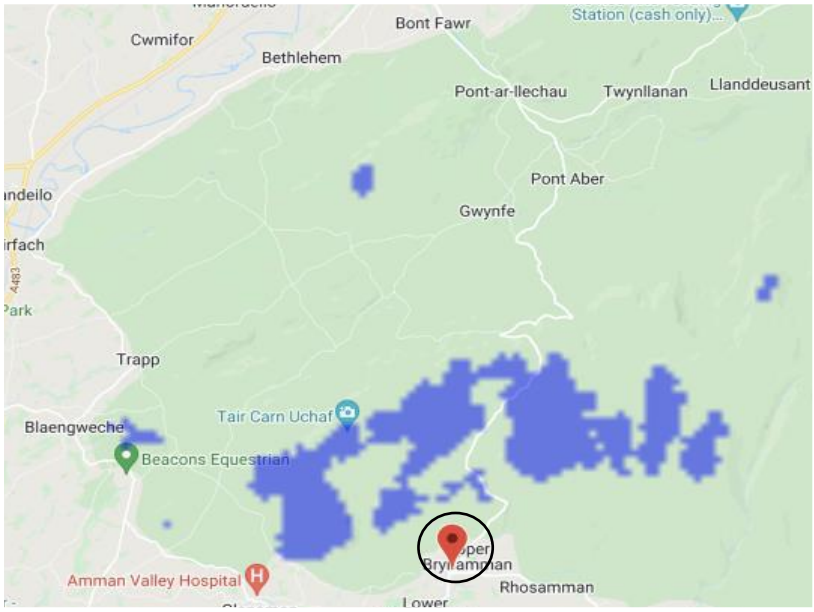

Figure 9: Sigfox coverage (blue) across an area of Wales including the Black Mountains. Antenna circled.

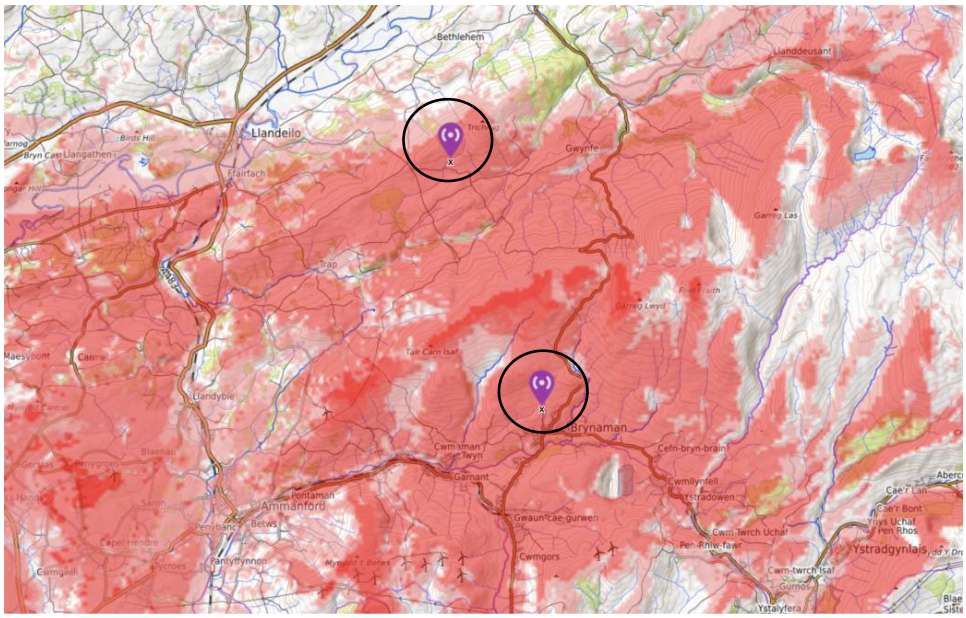

Figure 10: Showing the vast improvement in coverage (red) after the second antenna was deployed (antennae circled).

The accuracy of the tracker readings was rated as excellent by the majority of the project participants. They were able to monitor whether livestock was staying within the correct areas after establishing farm boundaries. Farmers were occasionally alerted to livestock crossing farm boundaries when they moved too close to fences due to the buffer radius set up as alerts to their phones.

Boundary accuracy proved a challenge during the project for one farmer, where the boundary was drawn on the other side of the road which was not part of their farm. However, Digitanimal instructed the farmer to redraw the boundaries, and once this had been completed, there were no further issues.

One farmer said they wouldn't recommend livestock tracking technology to farmers who use closed field boundaries since inaccurate readings meant the animals were being picked up in multiple fields.

Figure 11 depicts a mixed response from farmer participants when asked whether they would be likely to purchase the tracking system, based on their user experience and the quality of the data provided. The key determinant was whether or not accuracy could be enhanced in future versions of the existing product.

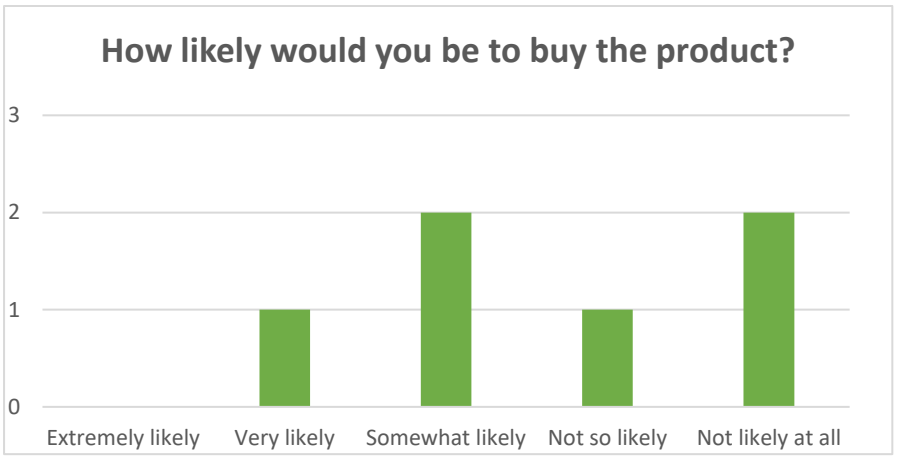

Figure 11: Participants' responses on how likely they are to purchase the livestock tracking technology.

Opportunities and challenges for the wider farming industry -participant reflections

Farmer participants agreed the following benefits arose from using tracking technology.

- Security and protection of livestock from theft and organised crime.
- Security and protection of livestock from injury or disease.
- Education of grazing behaviours that can be carried forward to protect and manage extensive environments.
- Contribution towards agri-environmental schemes.
- Improved farm efficiency.
- Improved farm productivity.

One aim of the project for some participants was to trial livestock tracking tech across a range of grazing systems and livestock and increase the awareness of this technology by common grazing associations, who would then be able to encourage farmers to adopt this technology. The common graziers who worked as a group in this project -the Black Mountain sheep farmers- felt they had benefited from working together as a group, to support each other as regards adopting the technology. The success of this was predicated by an established good working relationship, mutual respect and trust, and the sense of working towards a common goal.

Several participants in the project feel more awareness raising would be necessary on how tracking technology can benefit their business in both the short and long term to ensure it was more widely implemented. Most of the farmers were very engaged in the potential value.

One participant stated that this particular tracking product would be a good option for a cattle farmer, as the price of the technology becomes more financially viable for a business, given the typical value of the breeding cow.

During an interview with Digitanimal, staff confirmed that some of their UK-based customers have purchased the technology without public sector-funded support, however, the majority of these were cattle farmers who have a particular interest in livestock location due to grazing their cattle on common ground.

As regards application across the wider livestock sector species, the product supplier Digitanimal not only caters for ruminant livestock but also supplies tracking technology to businesses within the pig sector to enhance the traceability of pork products. This was currently being trialled alongside blockchain technology with the hope to become a unique selling point for many pork-producing businesses. The technology does not currently get used in the poultry industry due to cost of the technology versus the relative low value of an individual animal in that sector.

Future Developments

Livestock Tracking Technology

Both Digitanimal and the project participants were asked to provide ideas on how the technology could be improved in the future and how farmers can be encouraged to adopt this technology.

The project participants provided the following points:

- Making changes to the collars and tracking technology - less obvious/battery/colour/strap flexibility.
- Ensuring the product was not too big and was robust to withstand more extensive environments and climates.
- Use a master collar system or bolus, i.e., have a primary collar which talks the antennae and also to 'daughter' collars -the latter being cheaper and therefore more cost effective to roll out on a whole herd/flock basis.
- Looking at solar-powered tracking devices instead of using batteries.
- Identifying ewes and lamb pairing opportunities.
- Dummy collars on other sheep to reduce overall tech costs, but still deterring theft.
- Further developments as regards potential health management benefits – alerting specific behaviours to help with topics such as reducing the use of antibiotics, successful calvings and managing lameness in sheep.

The following areas of opportunity were identified by the tech supplier:

- Connectivity opportunities -providing better information platforms for future livestock farmer decision making.
- Heat detection in cattle.
- Ability to alert a farmer when an animal was calving.
- Implement the report onto the app, rather than being sent separately via email - the customer uses the app regularly.
- Educating the customer that the technology can do so much more than it currently does
- Training on the technology – for customers and businesses to raise awareness at events
- Reduced cost of the equipment.
- The government incentivises technology.

Digitanimal reflections on industry opportunities and developments

The following developments outline the improvements that the supplier was working on to enhance the overall quality of the tracking technology.

1) **Development of a satellite device/beacon, used for animal identification.**

This device can be read by an evolved version of the collar or by specific fixed readers. This device will allow the following functionalities depending on the way it was configured:

- Counting of animals and determination of grazing plots.
- Approximate location of a larger number of animals at a lower price.
- By installing the collar reader on the males and the beacons on the females, the system will allow extensive heat detection, shown in Figure 12.

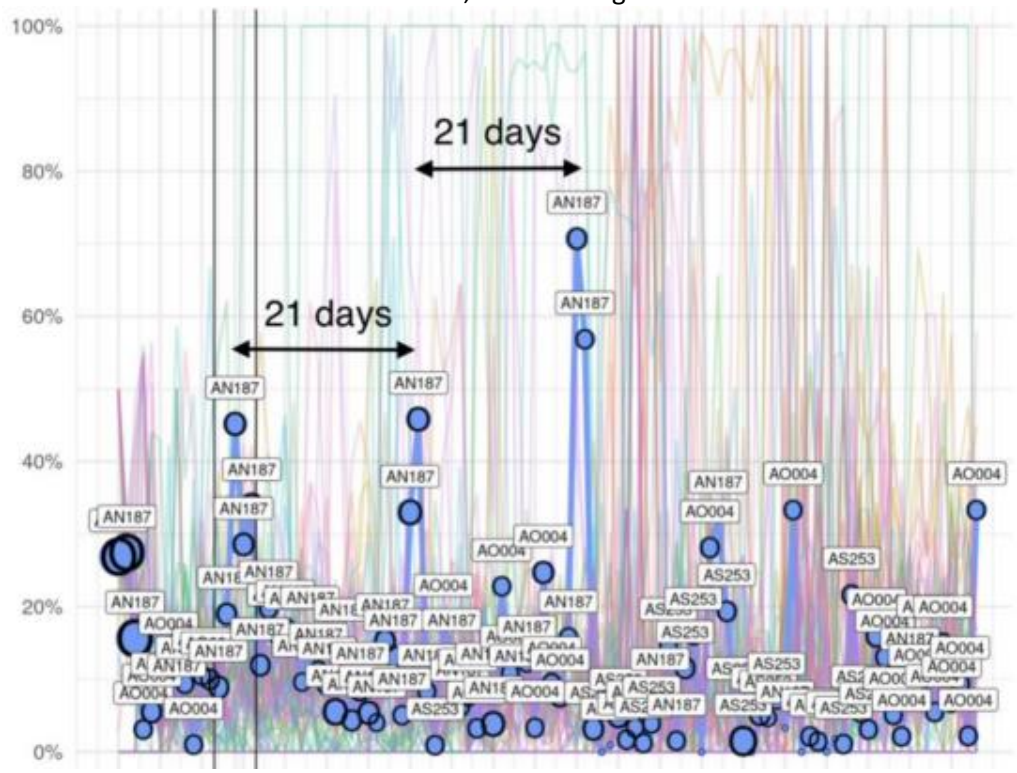

Figure 12: Example of a heat detection chart.

2) **Improving the intelligence of the collar by introducing new processing and memory capabilities.**

This would enable the better monitoring of the condition of the animals and determine more behavioural patterns and thus detect more anomalies to improve livestock productivity, shown in Figure 13.

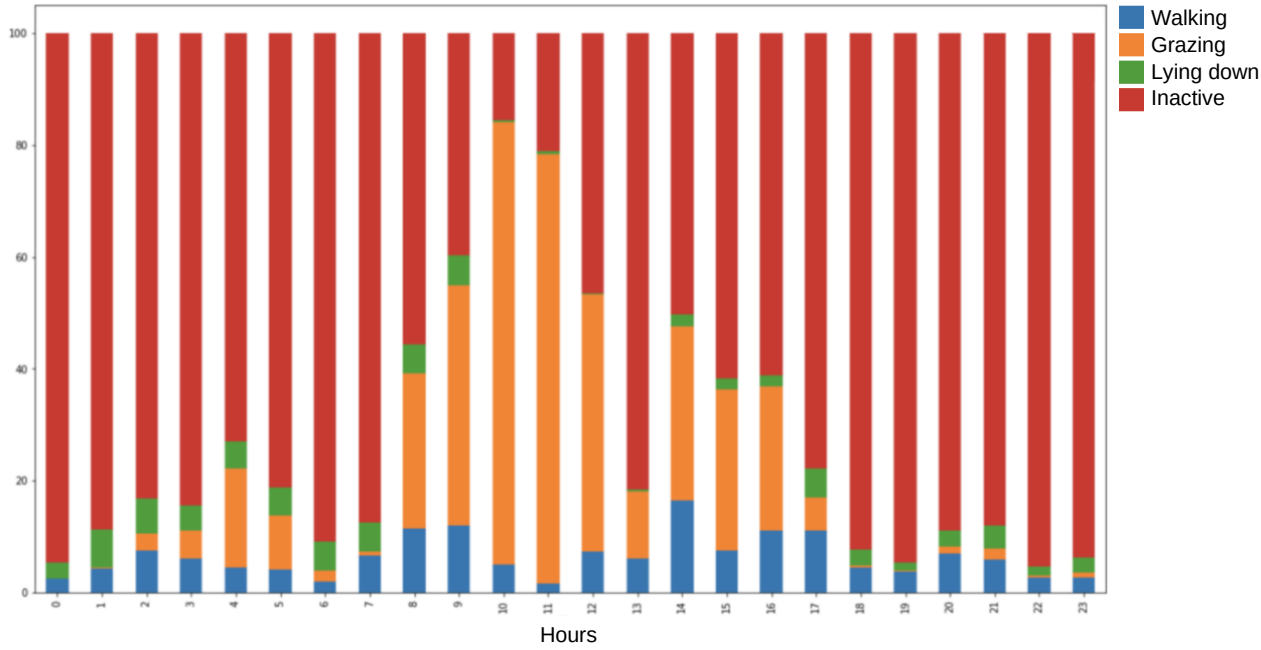

Figure 13: Behaviour pattern of a cow during a day in which different behaviours are distinguished.

3) **Land use analysis and combination with satellite imagery.**

This would allow the establishment of grazing calendars, helping save and optimise animal feeding costs.

4) **An intelligent scale for fattening control.**

This will allow the weight of the animals and their growth to be known at all times without causing health or welfare problems for the animals. Farmers can then detect health problems, minimise animal losses and minimise animal feed costs. The system was deployed in more than 20 feedlots systems (not in the UK) with more than 3 million weight data collected. Figure 14 illustrates this development.

Figure 14: Digitanimal weigh scales for cattle.

Conclusions

The project was a success as regards trialling livestock technology in an applied setting in Wales. This success was predicated on:

- a good working relationship between the farmers
- a sheep farmer lead who was willing to encourage and chivvy other farmer members
- support from a cattle farmer participant who was very interested in the tech and keen to keep the project going
- willingness to keep in touch as a group with both the facilitator and supplier, via virtual meetings
- the project concept coming from the farmers in the first place -i.e., all the farmers were very invested in the project aims from the outset.

The project aims were to investigate whether livestock tracking technology can improve farmers' understanding of the location of their livestock and their grazing habits as well as reduce the risk of livestock theft across large extensive grassland areas.

This aim was achieved, with the selected technology providing the location of livestock in real-time through a mobile app and showing where they had been grazing over a period of time under a range of conditions and different location. Not only did the real-time data allow participants to reduce the cost and time associated with gathering livestock but it also provided farmers with the opportunity to collaborate more effectively with each other and with other support agencies in minimising theft activities because of the real-time data on the position and movement patterns of the sheep. The technology also helped farmers to identify sick or injured animals which reduced the time and cost of treatment and loss in productivity as cases were identified more rapidly.

The cost of the equipment remains the biggest barrier to adoption, with reference to the sheep sector in particular, with farmers unable to justify the purchase because the current price of the product is prohibitive for the farmer. Participants concluded that either the price needed to be lowered or some external support would be required to encourage adoption.

Both the supplier of the technology and the project participants felt more training was needed to understand how the technology works and how to set it up to get the most use out of it. Despite this, Digitanimal and the organisation group worked extremely well together, communicating regularly, which allowed any issues that were raised to be dealt with.

Overall, the project has shown that this technology sits well in the livestock industry, providing benefits to both the farmer and the environment. Further work is needed to reduce the cost of the product, improve the connectivity, tracker accuracy, the overall user interface, robustness of the product and increase the level of information it can provide to a farmer. All this would help the industry not only see the theoretical value of the technology to a farmer but be more likely to trial and then adopt it for use across their livestock system.