BRIEF COMMUNICATION: An evaluation of the AGTECH360 Livestock Tracker for the automated recording of on-farm grazing events.

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Abstract

Many New Zealand farmers either do not record paddock grazing events or do not retain grazing data after making decisions about cow feeding and pasture management. This study, conducted at the Northland Agriculture Research Farm (NARF), aimed to determine whether GPS-enabled devices suitable for use on cattle could be used to automate the recording of grazing events on-farm. Accordingly, 12-13 cows within each of the three herds (herd size range 59-85 cows) were fitted with an AGTECH360 Livestock Tracker from 1 December 2021 to 31 March 2022. The GPS location data were then compared with manual grazing records. The grazed paddock was correctly identified on 80-92% of occasions, depending on the herd. These results indicate that it is feasible to automate the recording of on-farm grazing events by fitting a proportion of the herd with GPS-enabled devices.

Keywords: dairy farm systems; grazing records; global positioning systems (GPS); Internet of Things (IoT); low-power wide-area network (LPWAN); LoRa

Introduction

Grazed pasture is the primary resource that underpins dairy production and farm profitability in countries with temperate climates, such as New Zealand (Hanrahan et al. 2018; Neal & Roche 2019). In these climates, year-round pasture growth is achievable, albeit in a seasonal pattern, making pasture a low-cost, high-quality feed source if well managed. This can reduce reliance on purchased feeds with a higher cost and environmental footprint (Belflower 2010; Rotz et al. 2020). High on-farm pasture utilisation requires information on individual paddock performance and grazing records. However, while the recording of grazing events and pasture measurement are essential parts of pasture management, they are often neglected due to their time-consuming nature (Anderson & McNaughton 2018). While some farmers conduct regular farm walks and record pasture covers, this information is typically only used for short-term feeding and farm management decisions (i.e., where the cows will graze today) and not retained once these decisions have been completed (Stevens & Knowles 2011).

The recent expansion of the Internet of Things (IoT) has led to the development of new low-power wide-area networks (LPWAN), such as Long Range (LoRa) radio communication techniques (Augustin et al. 2016), which has led to an increase in the availability of Global Positioning System (GPS) devices suitable for use on cattle. Subsequently, there has been renewed interest in using GPS devices in the dairy sector. For example, they could be used to automate the recording of on-farm grazing events (Haultain 2014; Hofmann 2022; Hofmann et al. 2022). Alternatively, Woodward et al. (2019) incorporated GPS cow data and spectral data to estimate pasture mass. Our research evaluated the feasibility of automating the recording of paddocks grazed on-farm by fitting a proportion of the dairy herd with the AGTECH360 Livestock Tracker (AGTECH360 2020, Queensland, Australia).

Materials and methods

Device

The AGTECH360 Livestock Tracker is a reusable, lightweight (approximately 32 g), solar-powered ear tag measuring approximately 5.5 cm (wide) × 7 cm (high) with an estimated five-year lifespan (AGTECH360 2020; Meat and Livestock Australia 2019). The devices use a LoRa network to transfer data from the device to a base station and a cellular network to transfer data from the base station to the cloud and were configured to obtain a GPS position approximately hourly (24 daily positions) per the manufacturer's default setting. Previously, Hofmann (2022) conducted static testing of these devices at Scott Farm, Newstead, New Zealand (-37.769° S, 175.366° E) and reported a mean location error, which is the difference between an object's actual position and that estimated by a GPS position fix, of 5.4 m and a 95% Circular Error Probability (CEP) of 13.9 m. The CEP is a circular radius containing a stated percentile of points around an actual location (GPS device's proper location) (Morris & Conner 2017; Turner et al. 2000)

Research site

On-farm testing occurred at the Northland Agricultural Research Farm (NARF), Dargaville, New Zealand (-35.943° S, 173.841° E) between 1 December 2021 and 31 March 2022. This is an 82-hectare (effective) dairy farm. As part of the four-year Future Farm Systems Trial established on 1 June 2021 (Northland Dairy

Development Trust 2023), the farm is divided into three farmlets of approximately 27 hectares each, with paddock sizes ranging from 0.80 to 1.75 ha. Over the study period, the cows were milked twice daily. Herd sizes were 59 cows for the green farmlet, a low-stocked farmlet aimed at reducing greenhouse gas emissions, 83 for the blue farmlet, a farmlet testing alternative pasture species and 85 for the red farmlet, operating under a typical Northland farming system.

Data collection

Twelve cows from the green farmlet and 13 cows each from the red and blue farmlets (~14-22% of the milking herd) were randomly selected and fitted with an AGTECH360 Livestock Tracker. The Lincoln University Ethics Committee (AEC 2021-12) approved the application of devices. Throughout the trial period, the devices remained fitted to the same cows irrespective of whether they remained in the milking herd or were drafted out for treatment or other purposes. The LoRa base station was installed at the dairy for easy access. Essential information recorded by the devices included location (latitude and longitude), date and time of observation, and ambient air temperature. On most occasions, the milking herds were offered a proportion of a paddock with separate night and day paddocks. Daily grazing records (i.e., date, paddock number, percentage paddock allocated, and cow numbers) for each farmlet were recorded manually by NARF staff using a Microsoft Excel spreadsheet.

A digital map of the property (Figure 1) was produced in RStudio (version 4.2.1; R Core Team 2022) using the dplyr and sf packages in R (version 1.0.12; Pebesma 2018; Pebesma & Bivand 2023; R Core Team 2022). This made it possible to interpret the GPS data collected by the devices in terms of paddocks grazed over the trial period. The spatial join function st_join was used to identify which GPS points were recorded in which paddocks or in other farm areas, e.g., at the cowshed or on farm laneways. The GPS points were then grouped into periods corresponding to the grazing area for each farmlet, based on the farm milking times of 6 am and 3 pm (e.g., between 6 am and 3 pm, two grazing periods were applied: 6:00 to 10:30 am and 10:30 am to 3:00 pm). Multiple grazing periods were applied between milkings as, on occasions, several paddocks were grazed between milkings depending on the farmlet's needs, e.g., using a sacrifice paddock for the blue farmlet to protect the pastures on that farmlet from overgrazing. Additionally, the pm grazing was divided into two periods (3:00 pm to 00:00 am and 00:00 to 6:00 am) to ensure the GPS record date was correctly aligned with the manually recorded grazing dates. The paddock with the highest number of GPS observations in each grazing period was then selected as the most likely paddock grazed by the herd during each grazing period. Subsequently, the GPS grazing records were compared with the manual on-farm grazing records to identify which grazing areas the GPS devices correctly identified.

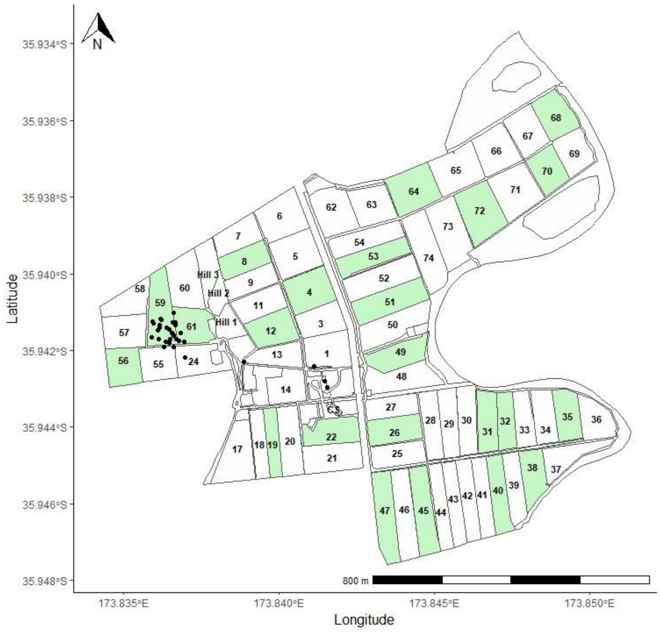

Figure 1 An Outline of the NARF and the GPS fixes recorded by 13 AGTECH360 Livestock Trackers on the green farmlet (shaded paddocks) for one grazing period (01 January 2022) between 6:00 and 10:30 am. Cows were allocated the first one-third of paddock 59 for this grazing period.

Results and discussion

The paddock grazed by the dairy herd was correctly identified on 79.6% of occasions for the blue farmlet, 91.3% for the red farmlet and 91.9% for the green farmlet over the four-month study period (Table 1).

There are several reasons why a 100% match rate between the GPS observations and the on-farm grazing records was not achieved. Firstly, GPS positions were sometimes either not reported, or the ear tags reported intermittently to the on-farm LoRa base station when grazing a particular farm area, possibly due to the positioning of the base station relative to these paddocks on-farm. Secondly, the blue farmlet cows spent time in sacrifice paddocks in February and March. However, these grazing events, which comprised 16.6% of the total grazings for this farmlet, were not included in the manual record; hence, the lower percentage of grazings correctly matched for this farmlet. If these grazing events are excluded from the GPS records, the result aligns with the remaining two farmlets. Thirdly, when solely selecting the paddock with the highest number of GPS observations during each grazing period, the incorrect paddock was identified in the GPS records for 3.8% of grazing events for the blue farmlet, 8.1% for the green farmlet, and 8.7% for the red farmlet which may be due to paddock shape or size or device accuracy. Finally, on occasions, there were equal numbers of GPS points in two or more paddocks within the same grazing period, occurring in < 1% of grazing periods for the blue farmlet and in 1.5% of grazing periods for the red and green farmlets.

Table 1 Key summary statistics from 1 December 2021 to 31 March 2022.

Farmlet	Herd Size	Number of Tags	Percentage of Herd Tagged	Number of Paddocks Grazed – NARF Records	Number of Paddocks Grazed – GPS Estimate	Percentage of Paddocks Grazed Correctly Assigned
Red	85	12	14.1	220	231	91.3
Green	59	13	22.0	221	234	91.9
Blue	83	13	15.7	236	289	79.6

In the four-month testing period (1 December 2021 to 31 March 2022), two tags or 5.3% of tags applied (one each from the green and blue farmlets) stopped reporting daily GPS positions, possibly due to tag failure or loss. Tag losses were not recorded. Across all farmlets, the devices reported an average of 19.6 positions per day throughout the trial period, close to their programmed rate of 24 daily positions.

One of the main factors that is likely to influence farmers' adoption of this technology is cost, with each AGTECH360 device costing around NZ$100 per tag in addition to the base-station cost of NZ$2000. Previous studies (Haultain 2014; Hofmann 2022; McGranahan et al. 2018) have suggested that a minimum of 1% of cows, or at least three cows per herd, should be fitted with GPS devices to record on-farm grazing events automatically. This number is lower than the current study, which used 12-13 devices per herd. The higher number of devices likely contributed to the high proportion of correctly identified paddocks in this study (79.6% or more). An earlier study by Hofmann et al. (2022) reported that in an on-farm study with 2.75% of the herd tagged with AGTECH360 devices, 52.5% of all recorded observations were within the correctly allocated paddock (i.e., the paddock the cows were grazing). To achieve high accuracy of grazing events, more than 1% of animals must be tagged based on the results of this study and previous studies (Haultain 2014; Hofmann 2022; Hofmann et al. 2022).

An important consideration when selecting GPS devices to identify the grazing area is the device's fix rate, which is how often a GPS position is recorded. A more frequent fix rate (i.e., every 30 minutes vs. once every hour) will improve the accuracy of identifying the grazing area (Swain et al. 2008; Turner et al. 2000). However, the fix rate cannot be selected in isolation. For example, a higher fix rate will increase the battery demand of the devices. Therefore, the end user will likely need to reach a compromise between several factors, including the fix rate, the number of devices required, and the error rate they are willing to accept.

Accurately recording paddock grazings provides valuable insights for management, including identifying which paddocks are growing best (e.g., grazed more often), and allows farmers to track rotation length or prepare a paddock shortlist to assess visually. Grazing data is also invaluable in feed planning and farm management decisions, such as pasture renewal and fertiliser usage. Automated grazing records could also be inputs to farm management software such as Pasture Coach or Minda Land and Feed (Hammond 2017).

These study results indicate that using GPS-enabled devices to automate the recording of on-farm grazing events is feasible, potentially leading to improvements in on-farm pasture management. However, further work is required before wide-scale use becomes possible. Research is currently underway investigating alternative GPS devices, including direct-to-satellite solar-powered ear tag options such as the Ceres Trace (Ceres Tag 2023) and GSatRancher (Global Satellite Engineering 2023), that may be able to overcome the coverage and set up constraints of a LoRa system.

Acknowledgements

Data for this study were collected as part of the New Zealand Bioeconomy in the Digital Age (NZBIDA) programme funded by AgResearch and New Zealand dairy farmers through DairyNZ Inc. and in-kind support from Fonterra Co-operative Group Limited. The authors wish to acknowledge the staff and management of the NARF for allowing this work to take place and for assisting with recording grazing events and tag application.

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