WIRELESS TECHNOLOGIES FOR MANAGING GRAZING ANIMALS

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INTRODUCTION

Grazing is the cheapest method of feeding ruminants but it presents a management challenge for animals not under the eye of the farmer. The advent of low cost wireless technologies has made it possible to develop for cattle systems to monitor oestrus, lameness, lying behaviour, location and the time spent chewing. There have been many devices developed for research to measure location and chewing activity to aid in research in grazing but few of these are likely to have practical applications in the immediate future. Similarly devices to measure methane intra ruminally have been demonstrated but these are for research. This paper focuses on practical technologies for managing the dairy cow since it is the only class of stock that justifies heavy investment in individual animal mounted technology. Virtual fences are also discussed.

MATERIALS AND METHODS

Wireless is a powerful tool for transmitting data over long distances, however, there are limitations imposed by regulatory authorities and the power demands at different frequencies. Although wireless usually means radio at least one wireless collar system has used infra red but this has very low bandwidth and contamination of the transmitter and receiver can block the signal. The range of radio frequencies used by agricultural systems is limited to those within what are known as International Scientific and Marine (ISM) bands.

Table 1. Wireless frequencies available for livestock monitoring

Centre Frequency	Bandwidth	Range
Infra-Red	low	5 m
433.920 MHz	1.84 MHz	1000m
915.000 MHz	26 MHz	500 m
2.450 GHz	100 MHz	30 m

Thus within pasture lower frequency systems can be used to transmit data directly from the animal to a base station. However, long range radio transmission consumes power and as battery life is a key issue for practical reasons radio transmissions are normally made at low power and higher frequency when the cow comes into range of a base station at milking or feeding time. In a study conducted at SAC even grazing beef animals were found to be within range of an antenna mounted at a watering station for daily downloads of data (Kwong et al 2008). For hundreds of years the traditional method of monitoring the location and motion of a grazing animal was a bell on a collar. The switch to larger ranging herds led these to disappear, modern technology now requires a platform for mounting sensors and wireless transmitters as high as possible. The neck of the animal is by far the best place to mount electronics for the maximum range of the antenna although pedometers have been in use for many years with low level antennas. A description of the signal attenuation by a cow's body and poll of the antenna by Drysdale et al (2008) recommended that antennas be mounted at 4 m in height and preferably where the cow is standing with her head away from the antenna.

Oestrus Detection. Collars (and pedometers) have been used to detect oestrus for many years measuring the increase in activity above the base line of normal activity. The early versions used tilt switches based on a metal ball or mercury moving in a switch tube. When contact was made by the switch due to cow movements a counter was incremented, the number of counts would then either trigger a continuous radio transmission as in the Alpro or the number of counts would be transmitted when the cow neared the antenna. In recent years microchip accelerometers have displaced the old switch mechanisms and this opens new potential for monitoring cow health and behaviour. The amplitude of accelerations measured is used instead of the mechanical devices and software either on the collar or at the base station calculates an index. Cows move for many reasons and this can be filtered by software, for example the Heatime system based on the Voronin patent (2006) discards the data associated with feeding, as this improves the signal to noise ratio. In one implementation the eating activity is measured with an acoustic device.

Calving Detection. There is great potential for the tri-axial accelerometer data to be used for more than oestrus detection. Miedema (2009) demonstrated that the start of calving could be determined by measuring the frequency of moving from lying to standing and comparing this with the cow's baseline activity measured three weeks earlier. To detect an animal calving at pasture an extra radio transmission might be needed but for housed cattle this could be easily implemented in calving boxes within range of a single antenna.

Lameness Detection. A major problem for the dairy industry are the large numbers of animals lame at any one time. The cow collar provides an available device that can with a simple software upgrade measure mobility score. McCubbine and Mottram, (2013) have demonstrated a model that uses dynamic analysis of data collected as the cow walks under the radio antenna to determine the time to pass through a raceway and other features such as step frequency.

Lying Behaviour. Modern pedometers such as IceTag and Hobo can be used to assess lying time which is a key indicator of cow comfort. When the cow is standing or lying the angle of the leg can be analysed relative to the acceleration due to gravity and this can be used to measure lying behaviour. Mottram (2011) patented the measurement of lying and standing behaviour using a tri-axial collar based on measurement of the angle of the collar to the vertical at periods when the vertical amplitudes are low. As the cow cannot sit with her neck vertical the z-axis which normally measures turning behaviour contains a gravitational component so the collar measure whether the cow is lying on her left or right side.

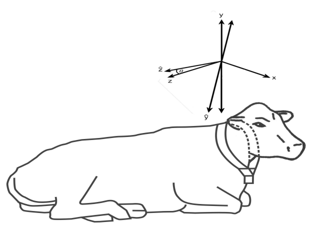

Figure 1: Forces acting on a cow's neck collar

Animal Location. Since the early 1990s the Global Position System created for the US military has become

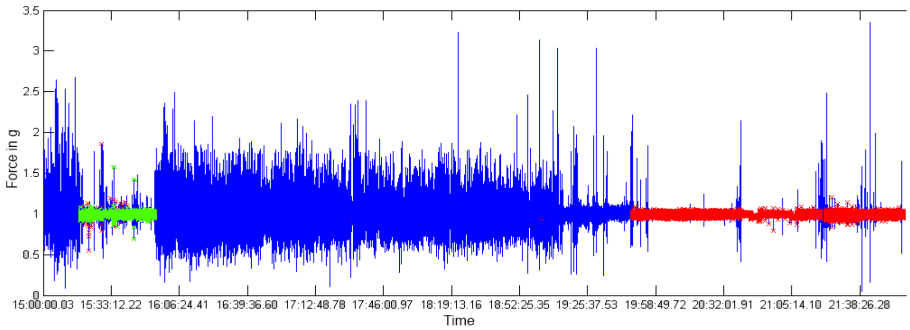

Figure 2: Forces analysed to show right side lying (green) and left side lying

very popular for identifying locations and many researchers have used GPS in collars for experiments to measure animal behaviour (the collars contain tilt information from which grazing is deduced) and location (Schlechte et al, 2004, Umstatter et al, 2008). However, the principal drawback of GPS is that is requires a lot of power and thus even with large battery packs operations are limited to days rather than years. However, technology and battery life is constantly improving and automatic location may become a routine built in element of collars in future when in could be used in conjunction with a virtual fence.

Rumen Status. Mottram et al (2008) reported the use of a wireless bolus to measure pH and temperature remotely. The study was to simulate the effect of moving steers from pasture to feedlots in Australia where this process can mean three days on a truck without feed. Developments have continued with the Kahne company of New Zealand advertising a system suitable for monitoring cows at pasture where the bolus measuring pH, temperature and pressure transmits data via a relay station to a base station where an alarm can be set for bloat or other conditions. Similarly the Well Cow, Smaxtec and eCow boluses are commercially available to measure rumen pH. These are principally used to detect low pH levels induced by heavy feeding of concentrates in continuously housed herds. However data from eCow boluses in grazing cows indicate pH values with a wider range of values (up to2.13 pH) around a mean of 6.5 whilst cows on a heavy cereal diet had a mean pH of 6.2 but with a range of only 1 pH. The temperature of the rumen is heavily influenced by drinking behaviour and it is easily possible to tell the number of drinks per day for the monitored animal by the T dipping to 35 C. At present boluses are fairly high cost devices and the sensors become inaccurate after 120 days so they are suitable for use in sentinel animals. The bolus records data in the reticulum which is approximately 0.26 pH units higher than the ventral sac measurements which are traditionally used to diagnose SARA.

Virtual Fences. The virtual fence is as yet a largely conceptual system for managing free ranging stock which has great appeal in reducing the cost and limitations of fences and was reviewed by Umstatter (2011). Physical fences are inflexible and labour intensive to move. The pasture is divided into sections defined in a virtual model. Because it is virtual it is easy to move. The areas of containment can be changed to adjust stocking density. The animals must either wear a device that signals to them when they are about to encroach into a prohibited zone or be so well trained that they recognise an aversive signal usually an audible cue to which the animal by training associates an electric shock. There have been some attempts to develop reinforcement behaviours. There is huge potential in the virtual fence concept in grazing management but no demonstrable systems currently other than for pet animal containment.

CONCLUSIONS

Three new technologies (low cost digital wireless, tri-axial accelerometers and global positioning) have been developed in the past 30 years which offer major potential for managing the grazing animal more precisely that in the past. Not only can we now learn what the animal has been doing but also where she has been doing it. Major problems remain in data interpretation and in developing systems with low maintenance requirements particularly in battery life.

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