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Review article

Milking frequency management in pasture-based automatic milking systems: A review

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ABSTRACT

The integration of automatic milking systems (**AMS**) with pasture-based dairy farming creates a new spectrum of challenges, different to those of indoor-based feeding systems. In order to formulate the correct research questions in areas that are likely to have the highest impact, there is a need to identify gaps within existing knowledge. Therefore, the objective of this review was to bring together, analyse and summarise relevant scientific literature from studies conducted in pasture-based AMS. The focus was placed on describing different animal, feed and management-related factors and their influence on milking interval (**MI**) and milking frequency (**MF**). The analysis of 21 studies in the literature in which AMS was combined with variable levels of grazing, indicated a wide data range in variables such as access time to pasture, distance to pasture, cows/milking unit, number of fetchings performed per day, minimum MI setting as well as MI, MF and milk yield achieved. Furthermore, the analysis showed that variability in MI and MF was present both between and within cows and farming systems. In general, pasture-based AMS cows appear to achieve lower MF than indoor-based feeding AMS cows with different access times to grazing, but there were no studies on the actual impact of different MI and MF on milk yield in pasture-based AMS cows. The lower MF of pasture-based AMS cows appeared to be associated with lower levels of cow traffic when AMS was combined with grazing, which highlights the need to test alternative management practices that could potentially increase cow traffic. Changes in frequency and location of feed incentives were identified as areas where further research is required. Overall, this review has identified key aspects of pasture-based AMS that should be taken into account to modify management strategies in these systems, with the aim of optimising MF and system utilisation.

Contents

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1. Introduction

The first AMS farms were established in Europe in the early 1990s in intensive indoor feeding barn systems and since then over 10,000 farms globally have adopted this technology (de Koning, 2011). A large proportion of installations operate in indoor feeding systems, some of them allowing their cows to graze during certain periods of the year (Ketelaar-de Lauwere et al., 1999b; Sporndly and Wredle, 2004; Sporndly et al., 2004). In these indoor feeding systems cows are housed and fed in barns for all or most of the year, and when in combination with AMS they are referred to as 'indoor-based AMS' throughout the manuscript. In 2001, AMS were introduced in grazing farms in Gippsland, Australia on a commercial farm (Greenall et al., 2004) and in Waikato, New Zealand as a research project (Jago et al., 2002, Jago and Woolford, 2002). In contrast to indoor feeding systems, in pasture-based systems cows are not housed in barns, instead they are kept outside and obtain over 50% of their annual requirements from grazed pastures or forages, and when in combination with AMS they are referred to as 'pasture-based AMS' throughout the manuscript. In 2006, an AMS research farm was commissioned within the FutureDairy Project in Australia (Davis, 2006; Garcia and Fulkerson, 2005; Garcia et al., 2007), which demonstrated that pasture-based AMS could still maintain high levels of pasture utilisation. Since the concept of successfully incorporating AMS into pasture-based farms has been proven, adoption in Australia and New Zealand has continuously increased (K. Kerrisk, The University of Sydney, Australia and J. Jago, DairyNZ, New Zealand, personal communication). The ongoing interest of pasture-based AMS internationally is evidenced by research programs at Michigan State University in the US (Utsumi, 2011) and the recently announced research programme at Teagasc, Moorepark in Ireland together with the EU project Autograssmilk (O'Brien, 2012).

The establishment of pasture-based AMS creates a new spectrum of challenges, as these systems aim to manage moderate to large herds (>200 milking cows), with considerable distances between paddocks and dairy facility, whilst maintaining production targets.

The main characteristic of AMS is that milking-related tasks are *automated*. A robotic arm cleans, attaches and sprays teats of each cow individually. Furthermore, the systems are described as *voluntary* because cows traffic unassisted throughout the farm system in search for feed, which acts as the main incentive to encourage them to traffic to the milking unit (Prescott et al., 1998). Cows are granted milking permission based on minimum milking intervals (**MMI**; set by the operator), which establish either a minimum time (h) or expected yield (in kg milk/milking event, which is related to milking intervals and secretion rate) that must elapse since the previous milking. Milking events are *distributed* throughout the day and night (there is no set defined milking session times) based on cow traffic, milking permission settings and system capacity. This allows the possibility for flexible milking frequency (**MF**, defined as the number of milking events/cow in any 24 h period) rather than the traditional twice-a-day milking regime, without the need for additional labour (Hogeveen et al., 2004). The actual MF achieved on-farm is directly related to the milking interval (**MI**, defined as the interval between consecutive milking events and measured in hours since the previous milking) and the spread of visits of cows to the dairy (which affects the cow queue at the dairy and thereby affects milking interval).

Therefore, MF has become a key performance indicator in AMS. In pasture-based AMS, target MF and total daily milk yield per cow, are usually lower than in indoor-based AMS (Garcia and Fulkerson, 2005). In addition, cows tend to have more cyclical routines with reduced visits to the dairy in early hours of the morning (approximately 0200–0600 h) (Davis et al., 2005). These two factors combined result in reduced daily average milk harvested per milking unit, with implications for the economic viability of pasture-based AMS.

System utilisation is defined as the amount of time each robotic arm or AMS unit operates per 24 h, or as a proportion of 24 h. Allowing spare time to perform system washes and technical maintenance usually means that robots are available to milk cows for around 21 h per day (Davis et al., 2005). This means that the highest achievable utilisation targets of AMS units are generally between 85%