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Research Paper

# Automatic herding reduces labour and increases milking frequency in robotic milking

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The motivation of cows to be milked is a key factor in the utilisation of milking robots. If a cow does not voluntarily attend a robot stall, fetching, that requires expensive labour, is required. This research suggests a new concept, herding all the cows to the milking robot using an automatic herding system (AHS). An AHS was built as a system of slow moving mobile fences controlled by an industrial controller. The AHS herds all the cows to the milking robot. The AHS was used in a commercial farm with two milking robots, and the experiment was conducted for three months. The dairy herd was divided into a reference group (43 cows) and an experimental group (38 cows). The AHS was used only with the experiment group. Milking frequency increased in the experimental group by 45.5% (1.89 milkings $d^{-1}$ vs. 2.75 milkings $d^{-1}$), while there was no major change in the milking frequency in the reference group 0.4% (2.38 milkings $d^{-1}$ vs. 2.39 milkings $d^{-1}$). Milk yield increased in the experiment group 15.7% (35.65 kg $d^{-1}$ vs. 41.25 kg $d^{-1}$). There was also no major change in the milk yield in reference group 4% (31 kg $d^{-1}$ vs. 29.76 kg $d^{-1}$). There was an 80% decrease in labour time for fetching the cows to the milking robot in the experimental group (5 h $day^{-1}$ vs. 1 h $day^{-1}$) while there was no change in labour for the reference group. The AHS was therefore associated with higher milking frequency, higher milk yield and labour reduction, hence economic benefits are expected for the system.



## 1. Introduction

Milking robots were developed in order to improve farmer daily routine by reducing labour use and improving cow welfare (Jacobs & Siegford, 2012; Kaihilahti, Suokannas, & Raussi, 2007; Pastell et al., 2006). However, the success of a milking robot is based on the cow's good will to be voluntarily milked. If a cow does not voluntarily attend a robot stall the consequences are economic losses due to: (1) the fetching work required – about 3 times per day, total of 7 h per 100 cows, (2) interference in the cow's routine, (3) loss of potential milk that

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**Nomenclature**

| | |
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| AHS | Automatic herding system |
| DIM | Days in milking |
| MPD | Milkings per day |
| OR | Occupation rate |
| PLC | Programmable logic controller |
| PMR | Partially mixed ration |
| VMS | Voluntary milking robot |

could have been produced from a higher milking frequency (Bar-Pelled et al., 1995; Hale, Capuco, & Erdman, 2003; Soberon, Ryan, Nydam, Galton, & Overton, 2011), (4) low efficiency of an economic investment due to the robot's idle time, especially at nights. Occupation Rate (OR) – defined as percentage of hours the robot is used per day (Castro, Pereira, Amiama, & Bueno, 2012). André, Berentsen, Engel, De Koning, and Lansink (2010) found that a herd of 62 cows with 64% OR can increase the milk revenue from 498 €/d to 529 €/d at 85% OR. The number of cows that have to be fetched is not consistent, and varies with cow, stage of lactation and farm design. During the first 14 d of lactation, 56–100% of the cows in a herd were found to require fetching at least once a day (Rousing, Badsberg, Klaas, Hindhede, & Sørensen, 2006). The number reduces in later stages of the lactation, but it still has been found to range between 6% and 45% of the herd (Rodenburg, 2002; Rodenburg & House, 2007; Rousing et al., 2006). In order to solve this problem, different types of methods have been proposed to attract the cows to the milking robot. Forced cow traffic is based on dividing the cowshed into three areas separated by one-way gates with lying, feeding, and milking areas. In these methods the cow hunger is utilised, forcing the cow to pass through the milking robot on its way to the feeding area (i.e., milk-first), or from the feeding area (i.e., feed-first) (Hermans, Ipema, Stefanowska, & Metz, 2003; Ketelaar-de Lauwere, Hendriks, Metz, & Schouten, 1998; Melin, Pettersson, Svennersten-Sjaunja, & Wiktorsson, 2007). One of the major side effects of these methods is a high number of non-milking related passages through the milking unit, caused by the short interval since the last milking. This problem can be solved by using a selection gate, which allows the cow to enter the milking robot only after sufficient time has passed since the last milking (Halachmi, 2009; Melin et al., 2007; Thune, Berggren, Gravås, & Wiktorsson, 2002). However, this solution increased waiting times for low ranking cows (Thune et al., 2002). Other methods try to attract the cows to the milking robot by using different attractions in the milking robot area. Using different levels of concentrate feed in the milking robot did not change the milking frequency (Bach, Iglesias, Calsamiglia, & Devant, 2007). Feeding with pellets rich with digestible neutral detergent fibre or with soy hulls also did not show any positive effect on the milking frequency. This method showed positive results only when there was at least 10% energy difference between the feeding bunks to the feeder in the milking robot (Halachmi, Shoshani, Solomon, Maltz, & Miron, 2006, 2009). Limiting water supply only to the milking area can decrease cow welfare and milk production (Spörndly & Wredle, 2005). Using cooling systems is only effective during the summer season and in hot climates and when the cooling system is located after the milking robot (Halachmi, 2004; Halachmi, vant' land, Ofir, Antler, & Maltz, 2010). Training cows to react to a positive reward, such as flavouring appetising substances, also did not show major effects on milking frequency (Migliorati, Speroni, Stelletta, & Pirlo, 2010) and did not change behaviour in some of the cows. Training the cows to react to acoustic signal, is effective, but also time consuming (12 sessions of 30–40 min) and it only partly affects the herd (80% was reported by Wredle, Munksgaard, & Spörndly, 2006). Using automatic feeders did not increase the milking frequency (Belle, André, & Pompe, 2012).

The methods mentioned above reduced the number of cows that have to be fetched, but none of them fully eliminated the requirement for fetching. Therefore, we propose a new concept. Instead of trying to attract the cows to voluntarily walk to the milking robot, we suggest all the cows are herded to the milking robot using an automatic herding system (AHS).

Several preliminary studies have used mobile robots for herd gathering. The herd gathering was performed using one robot that attempted to gather a herd, and moved it from a starting point, to a destination point (Thakkar & Wesley, 2005; Vaughan, Sumpter, Henderson, Frost, & Cameron, 2000). These studies have not reached practical applications due to several reasons: (1) expensive mobile robots, (2) limited traffickability in the farm, (3) limited velocity, and (4) limited sensing ability.

In our current proposed method, the herding is to be done by an automatic system of moving fences. Our hypothesis is that using an AHS can add 0.25 milkings $d^{-1}$ (MPD) for each cow. This method ensures that every cow is milked in a frequency that is set by the farmer. The objective of the research is to increase the number of successful milkings per cow, per day, without additional labour by using an AHS.

## 2. Materials and methods

An experiment was performed at a commercial farm in Tel Adashim, Israel, with 100 high-yielding Holstein-Friesian cows housed in an open cowshed (two identical yards of 30 m × 50 m without free stalls) and fed a partially mixed ration (PMR) that is commonly used in Israel (the PMR composition can be found in Halachmi et al., 2006). The cows received concentrate feed partly in the milking robot. The farm was equipped with two milking robots (VMS, DeLaval Voluntary Milking System, DeLaval International AB, Tumba, Sweden) that have been operating at the farm since 2007. The farm was divided into two groups: primiparous and second lactation cows (reference, n = 52–48 cows), multiparous cows (experiment, n = 50–47 cows). See Table 1 column "herd size". An AHS was installed in the multiparous cows' group. It comprised two mobile fences (as seen in Fig. 1). Each fence was made of two 12 m IPN 120 metal bars. The top bar was connected to the bottom bar with five 600 mm steel chains. Each fence was hung by two motorised hoists with trollies (HDGD-990C, Zhejiang Kaixun Mechanical and Electrical Co. Ltd, Zhejiang, China). Each trolley was hung on steel-beam