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Milk Cortisol Concentration in Automatic Milking Systems Compared with Auto-Tandem Milking Parlors

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ABSTRACT

Milk cortisol concentration was determined under routine management conditions on 4 farms with an auto-tandem milking parlor and 8 farms with 1 of 2 automatic milking systems (AMS). One of the AMS was a partially forced (AMSp) system, and the other was a free cow traffic (AMSf) system. Milk samples were collected for all the cows on a given farm (20 to 54 cows) for at least 1 d. Behavioral observations were made during the milking process for a subset of 16 to 20 cows per farm. Milk cortisol concentration was evaluated by milking system, time of day, behavior during milking, daily milk yield, and somatic cell count using linear mixed-effects models. Milk cortisol did not differ between systems (AMSp: 1.15 ± 0.07; AMSf: 1.02 ± 0.12; auto-tandem parlor: 1.01 ± 0.16 nmol/L). Cortisol concentrations were lower in evening than in morning milkings (1.01 ± 0.12 vs. 1.24 ± 0.13 nmol/L). The daily periodicity of cortisol concentration was characterized by an early morning peak and a late afternoon elevation in AMSp. A bimodal pattern was not evident in AMSf. Finally, milk cortisol decreased by a factor of 0.915 in milking parlors, by 0.998 in AMSp, and increased by a factor of 1.161 in AMSf for each unit of ln(somatic cell count/1,000). We conclude that milking cows in milking parlors or AMS does not result in relevant stress differences as measured by milk cortisol concentrations. The biological relevance of the difference regarding the daily periodicity of milk cortisol concentrations observed between the AMSp and AMSf needs further investigation.
Key words: dairy cow, milk cortisol, automatic milking system, auto-tandem parlor

INTRODUCTION

Only a few studies have addressed welfare issues of automatic milking systems (**AMS**) based on physiological measurements of stress, and their results are contradictory. Hopster et al. (2002) found lower epinephrine and norepinephrine reactions and a tendency for higher blood cortisol concentrations during the first phase of milking in an AMS with forced cow traffic compared with an auto-tandem parlor (**ATM**). They did not find a difference in the concentration of fecal cortisol metabolites, which might have indicated more general differences in the type or number of stressful situations that cows faced in AMS compared with ATM. In contrast, Wenzel et al. (2003), Hagen et al. (2004), and Abeni et al. (2005) reported higher cortisol concentrations in milk and blood for AMS with partially forced cow traffic in comparison with an ATM and a herringbone parlor, respectively, although all studies reported low absolute cortisol values.

Hopster et al. (2002) concluded that their measured physiological stress response to the milking procedure in an AMS was low and in the typical range for milking, whereas Wenzel et al. (2003) and Hagen et al. (2004) suspected some degree of stress on a farm with an AMS. However, they suggested that stressful social interactions in the waiting area in front of the milking parlor or evasion to less desirable times of day for milking by low-ranking cows were more likely related to the elevated levels of milk cortisol than the milking procedure in the AMS. All studies were limited in that only one type of AMS was investigated (Lely Astronaut), cow traffic did not follow the company's recommendation (promoting free cow traffic), only 1 herd was observed per milking system (1 group of dairy cows in the AMS and another group in the milking parlor), and all observations took place on only 1 experimental farm. Thus, it is difficult to assess how much the results were influenced by the specific farm and whether they can be generalized to other farms or even other types of AMS.

In the study presented, we compared 2 types of AMS (Lely Astronaut and DeLaval VMS) with ATM on 4 farms, each under practical conditions. We hypothesized that milk cortisol might be higher in the AMS independent of the specific cow traffic in comparison with the ATM and that this difference would be more pronounced for high-performance dairy cows, those with an impaired state of health, or those showing restless behavior during milking. Within the AMS, we ex-

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Table 1. Description of the farms and animals, sample sizes, and descriptive statistics on the measured variables for automatic milking systems with partially forced (AMSp) and free (AMSf) cow traffic and for auto-tandem milking parlors (ATM)

Item	AMSp	AMSf	ATM
Farms, n	4	4	4
Animal to feeding place ratio	≤1:1	≤1:1	≤1:1
Animal to lying cubicle ratio	≤1:1	≤1:1	≤1:1
Cubicles with bedding material	4	3	3
Cubicles with soft lying mat	0	1	0
Cubicles with both	0	0	1
Floor in the activity area			
Solid (concrete or mastic asphalt)	3	2	3
Partially or fully slatted concrete	1	1	1
Rubber coated (slatted or solid)	0	1	0
Type of feeding			
Grass and concentrate in feeder	2	1	1
Hay and concentrate in feeder	1	0	1
Silage and concentrate in feeder	1	1	2
Partial or TMR	0	2	0
Light at night	Off	Off	Off
No. of animals with samples	180	182	106
No. of animals sampled[1]	30 to 54	37 to 49	20 to 40
Average no. of lactations[1]	2.2 to 3.4	2.6 to 3.9	2.4 to 3.2
DIM[1]	142 to 195	140 to 169	97 to 168
Breed (no. of farms)			
Mainly Brown Swiss	0	3	2
Mainly Holstein-Friesian	2	0	1
Mainly Red Holstein	1	1	0
Brown Swiss/Red Holstein	1	0	0
Mainly Swiss Simmental	0	0	1
Data collection			
Average milking frequency[1]	2.3 to 2.5	2.2 to 2.7	2
Milk cortisol (no. of sampling days)[1]	2 to 4	2 to 4	1 to 2
Milk cortisol (no. of samples)[2]	2 to 4 (1 to 7)	3 to 4 (1 to 6)	2 to 4 (1 to 4)
Behavior (no. of observed milkings)[2]	3 to 8 (2 to 11)	5 to 9 (3 to 14)	5 to 6 (3 to 6)
Variable[3]			
Milk cortisol, nmol/L	1.15 ± 0.07	1.02 ± 0.12	1.01 ± 0.16
Mean daily milk yield, L	24 ± 2	22 ± 2	21 ± 2
SCC (×1,000)	219 ± 18	280 ± 13	113 ± 28
Stepping, no./min	1.64 ± 0.08	1.10 ± 0.08	1.23 ± 0.12
Foot-lifting, no./min	0.18 ± 0.05	0.13 ± 0.03	0.05 ± 0.02
Kicking, no./min	0.05 ± 0.03	0.00 ± 0.00	0.02 ± 0.01

[1]Range over farms.

[2]Range of median over farms (range over cows).

[3]A median (mean for daily milk yield) was calculated for each cow. The mean for each of the farms was then calculated. The values report the mean ± SE of these farm values.

pected the system with partially forced cow traffic to disrupt daily periodicity in milk cortisol compared with the system with free cow traffic because cow behavior is more restricted with forced traffic (Ketelaar-de Lauwere et al., 1998), possibly resulting in stressful situations for the cows.

MATERIALS AND METHODS

Experimental Design and Farms

The investigation included 12 farms (Table 1), 4 with conventional ATM [2 with products of DeLaval (Tumba, Sweden), and 2 with products of Westfalia (Westfalia-Surge GmbH, Oelde, Germany], and 8 farms with 1 of 2 AMS. The 2 AMS differed in that they were managed with free cow traffic (**AMSf**) or partially forced cow traffic (**AMSp**). Farms had used their respective milking system for at least 6 mo, and farms with an AMS had been recommended by the manufacturers. All dairy cows were habituated to the system at least for the current lactation. Data collection took place during 4 periods (November 2001, May to June 2002, October to November 2002, and January to February 2003). In each period, data on 1 farm per system were collected except for the fourth AMSf farm, which was investigated in the penultimate period.

As recommended by the manufacturers, cow traffic was partially forced in 1 type of AMS (AMSp: DeLaval VMS, DeLaval International AB) and free in the other (AMSf: Lely Astronaut, Lely Industries N.V., Maas-