Individual Consistency of Dairy Cows' Activity in Their Home Pen

R. Müller¹ and L. Schrader²

¹Institute of Animal Sciences,
Swiss Federal Institute of Technology ETH, Zurich, Switzerland

²Institute for Animal Welfare and Animal Husbandry,
Federal Agricultural Research Centre, Celle, Germany

ABSTRACT

The aim of this research was to investigate the long-term individual consistency of dairy cow activity in the home pen. Activity in a loose-housing barn was examined in 35 Holstein-Friesian dairy cows using an automatic monitoring system. Different amounts of activity could be distinguished by dynamic thresholds. Subsequently, the following categories of activities were calculated as mean daily values: number of high activity counts (N_{HA}), number of low activity bouts (N_{LB}), and mean duration of low activity bouts (D_{LB}). Category N_{HA} reflects locomotor behavior, and N_{LB} and D_{LB} reflect resting behavior. Recordings were repeated 4 times during a period of 2 lactations for 10 d each (total observation time: 40 d). Effects of parity, week of lactation, and environmental conditions (light intensity and ambient temperature) on activity were also assessed. Our results reveal a high degree of consistency in individual cow activity throughout 2 lactations. Repeatability (REP), calculated using covariance parameters, was high for all traits, although the REP of N_{HA} (REP = 0.62) was higher than the REP of N_{LB} (0.40) or D_{LB} (0.49). Parity, week of lactation, and environmental conditions had no significant effects on activity. In conclusion, our results indicate that activity of dairy cows in their home pen was highly consistent over time, and thus, could be considered as individual traits.

(**Key words:** dairy cow, activity, repeatability)

Abbreviation key: AMS = activity monitoring system; D_{LB} = mean duration of low activity bouts; N_{HA} = number of high activity counts; N_{LB} = number of low activity bouts; REP = repeatability.

INTRODUCTION

In traditional dairy farming, it was common for farmers to name their dairy cows. This suggests that the

farmers knew well the individuality of each of their cows (Schrader et al., 2000). Research on dairy cow reactivity toward challenging situations such as social separation (Kilgour, 1975; Hopster and Blokhuis, 1994) has confirmed that reactions toward acute challenges seem to be based on individual traits (R. Müller and L. Schrader, unpublished data, 2002). In contrast to experimental situations, little is known about the consistency of individual traits of dairy cows in their normal daily routine. Consistency of behaviors in their home pen has been shown in the side preference in a 2-sided milking parlor (Hopster et al., 1998), in home pen activity during 9 wk within one lactation (Schrader, 2002), or in feeding activity in early to peak lactation (DeVries et al., 2003b). Studies of the consistency of long-term behavior in the home pen, however, are still missing. Consideration of the consistency of individual behavior in the home pen is crucial for several reasons. In farm animals such as dairy cows, consistent behavior of individuals may be related to their ability to cope with husbandry conditions, and therefore, is germane to animal welfare concerns (Manteca and Deag, 1993). Substantial knowledge of behavioral consistencies may lead to better scheduling of daily management practices and help to improve the design of facilities for dairy cow management (Wagner-Storch and Palmer, 2003). Furthermore, knowledge of individual differences is important to help determine whether tests of treatment effects should be within or among cows in future research designs (Phillips, 2000).

On the other hand, many arguments suggest that consistent individual differences in home pen behavior are likely to be negligible. First, farm animals have undergone a long unidirectional selection, which may have led to diminished genetic variation (Jensen, 1995). Second, individual differences in activity may be overridden by more potent intrinsic and extrinsic factors, such as physiological state (week of lactation: Jans and Kessler, 1999), age (Gonzalez et al., 2003), management practices (feedstuff composition: Senn et al., 1995), and abiotic environment. Effects of abiotic environment include diurnal changes (Lefcourt and Schmidtman,

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Corresponding author: Roger Müller; e-mail: roger.mueller@inw.agrl.ethz.ch.

1989; Dürst et al., 1993; Overton et al., 2002; DeVries et al., 2003a), seasonal changes (light intensity: Dahl et al., 2000), or an interaction between them (Linane et al., 2001). Furthermore, dairy cows are gregarious animals, and behavior among herd members is highly synchronized. Synchronization can be stimulated by social facilitation (Rook and Huckle, 1995), management practices, such as external cues (Evans et al., 1991), and natural photoperiodic effects (Dahl et al., 2000).

Our aim was to investigate whether individual dairy cows display long-term consistency in their home pen activity and whether such individual differences are maintained throughout changes in parity, lactation, and abiotic environment. Subjects were kept under standardized husbandry conditions and activity was examined using an automatic monitoring system (Müller and Schrader, 2003) that enabled repeated continuous recording of activity throughout 10 d, each repeated 4 times during a period of 2 lactations.

MATERIALS AND METHODS

Animals and Housing Conditions

The study was conducted between May 2001 and May 2002 with 35 Swiss Holstein-Friesian dairy cows at the Research Center Chamau of the Swiss Federal Institute of Technology ETH. Three groups of 11 or 12 cows were maintained in a loose-housing barn (16.2×6.0 m) consisting of free stalls in a row and a slatted floor alleyway (16.2×3.3 m). Cows had ad libitum access to roughage, mineral feed, and water. Each pen was equipped with 12 individual feed bunks. Group attribution to the different pens was counterbalanced across repetitions. The cows were not on pasture during data collection, but were outside for short periods (approximately 30 min) after milking. Roughage was delivered at 0600, 1045, 1415, and 1700 h daily, and concentrate was feed from a transponder-controlled self-feeder according to milk yield. Cows were milked twice daily at 0430 and 1500 h.

The 3 groups were balanced for parity (number of cows in parity 1, 2, 3, 4, and 5 = 7, 8, 7, 11, and 2, respectively). However, to control for seasonal effect, the groups were not synchronized with respect to stage of lactation. The groups did not change during the experimental time and no new cows were introduced into the groups. All behavioral recordings were carried out between the 15th week of lactation (15 to 31 wk of lactation at starting point) and drying off to avoid effects of changing nutritional requirements. As a result of culling, the number of cows observed decreased from the first to the second lactation tested (repetitions 1 to 3: $n = 35$; repetition 4: $n = 15$).

Ambient temperature and light intensity in the home pen were recorded at 1-h intervals during the observation periods using StowAway data loggers (Onset Computer Corporation, Bourne, MA). Raw data were averaged over the 10-d observation periods. For further statistical analyses, ambient temperature and light intensity in the home pen were combined by principal component analysis. The calculated factor for environmental condition explained 98.1% of variance; factor loading for light intensity and ambient temperature were 0.84 and 0.54, respectively. Environmental data from the first recording period of group 3 were lost due to technical problems.

Home Pen Activity

The spontaneous behavior was recorded in the loose-housing barn applying the Actiwatch Activity Monitoring System (AMS; Cambridge Neurotechnology Ltd, Cambridgeshire, UK). The recording was repeated 4 times throughout 2 lactations with each group. Because of culling, group 3 became too small and repetition 4 was cancelled for this group. In the first lactation, there were 6-wk intervals between repetitions 1 to 2 and 2 to 3. The interval between repetitions 3 and 4 was 31 and 32 wk for groups 1 and 2, respectively. The recording system and method of analysis are described in detail elsewhere (Müller and Schrader, 2003). Briefly, the AMS is a compact ($27 \times 26 \times 9$ mm; 16 g) device that records the intensity and duration of the acceleration of a movement. The AMS devices were attached to the hind leg and selected in a random order each time to avoid possible differences among devices. Activity was recorded at 1-min intervals for 10 consecutive days. Subsequently, several levels of activities could be statistically differentiated by dynamic thresholds. By the use of these thresholds, possible differences between AMS devices in the measurement of the total amplitude of activity could be diminished (Müller and Schrader, 2003). All activity counts greater or less than the corresponding threshold were defined as high or low activity counts, respectively. The following categories of activities were calculated as mean daily values during the 10-d recording period: number of high activity counts (N_{HA}), number of low activity bouts (N_{LB}), and mean duration of low activity bouts (D_{LB}). Category N_{HA} corresponds to the total time of activity per day, and N_{LB} and D_{LB} refer to the number and duration of lying periods, respectively, as verified by video recordings (Müller and Schrader, 2003).

Statistical Analyses

We used linear mixed-effects models (Pinheiro and Bates, 2000) to estimate the fixed effects of repetition

Table 1. The *F*- and *P*-values of the repeated measurement of mean numbers of high activity counts (N_{HA}), mean numbers of low activity bouts (N_{LB}), and mean durations of low activity bouts (D_{LB}) estimated by the linear mixed-effects model for repetition, week of lactation, parity, and environmental conditions.

	N_{HA}		N_{LB}		D_{LB}	
	<i>F</i> -value	<i>P</i>	<i>F</i> -value	<i>P</i>	<i>F</i> -value	<i>P</i>
Repetition	3.0	0.038	10.2	<0.001	3.0	0.042
Week of lactation	0.6	NS	0.7	NS	0.0	NS
Parity	4.0	NS	0.2	NS	1.6	NS
Environmental conditions	2.7	NS	1.6	NS	1.9	NS

of the measures (as an ordered factor, linear, quadratic, and cubic effects were estimated; 3, 48 df), week of lactation (1, 48 df), parity (1, 13 df), and environmental condition (1, 48 df). The group and individual factors were added as random effects. Data were transformed logarithmically when the assumption of normality or of homogeneity of residuals was not fulfilled. These assumptions were checked graphically. For all calculations, type I sums of squares were used to test for the fixed effects. Calculations were conducted using R 1.8.1 (R Development Core Team: www.r-project.org, 2003). Repeatability (**REP**) was calculated using the covariance parameter estimated for cow identity (cov [cow]), parity (cov [par]), and residual (cov [error]): $REP = \text{cov}[\text{cow}] / (\text{cov}[\text{cow}] + \text{cov}[\text{par}] + \text{cov}[\text{error}])$. A repeatability of 1 means that repeated measurements of the same individual give identical estimates, and a repeatability of 0 would indicate that all variance is within individuals over successive measurements.

RESULTS

The repeatability calculated using the covariance parameters was high for all parameters. The repeatability of N_{HA} ($REP = 0.62$), however, was greater than that of low activity measures (REP of $N_{LB} = 0.40$ and REP of $D_{LB} = 0.49$).

Individual behavior in the home pen varied significantly over the 4 repetitions (Table 1). Significant linear, quadratic, and cubic effects indicate that N_{LB} was greater at the beginning of lactation than at the end, and increased again at the beginning of the next lactation (Figure 1). Although significant effects of repetition on N_{HA} and D_{LB} were detected (Table 1), these were not consistent across repetitions (Figure 1).

Week of lactation, parity, and environmental conditions (light intensity and ambient temperature) did not affect individual cow activity (Table 1). The temporal courses of these parameters were not consistent across repetitions.

DISCUSSION

Our results reveal a marked consistency of individual dairy cow home pen activity throughout 2 lactations.

In particular N_{HA} , which reflects the locomotor activity (Müller and Schrader, 2003), was highly stable within subjects, with 62% of the total variance explained by individual differences among subjects. Individual differences also explained a large amount of the variance in N_{LB} and D_{LB} , 40 and 49%, respectively. These findings confirm other reports of individual consistencies in activity throughout several weeks (Schrader, 2002; Fregonesi et al., 2004). In addition, we demonstrated that activity remained consistent throughout 2 lactations, which further supports the conclusion that individual differences in home pen activity are likely to be based on underlying personality traits, similar to individual differences in reactivity toward a challenging situation (R. Müller and L. Schrader, unpublished data, 2002). The large individual consistency in home pen behavior is especially noteworthy because it was evident in the face of advancing lactation, increased parity, and changing environmental conditions; all of which might be expected to be potent modifiers of behavior. Nevertheless, activity varied over time (Table 1). The N_{LB} decreased during the first lactation evaluated and increased in the following lactation. This temporal change may reflect a cyclic rhythm within lactation, but further research is required to verify this rhythm.

Several other factors that were considered in our study may affect dairy cows' home pen behaviors, as potentially or more so than individual cow traits. First, management practices, which we did not vary, can be an external cue that leads to synchronization of activity among herd members (Evans et al., 1991). For example, restricted feed availability increases synchronization of feeding behavior compared with ad libitum feeding (Rook and Huckle, 1995). Pushing feed back into feed bunks may have a similar effect (DeVries et al., 2003a). Because feed was available ad libitum, cows could eat anytime and synchronizing of feeding behavior was minimized. Second, because we analyzed mean values over 10-d periods, effects of unusual events and temporary fluctuations such as diurnal changes (Lefcourt and Schmidtman, 1989; Dürst et al., 1993; Overton et al., 2002; DeVries et al., 2003a) were reduced. Third, the potential effects of nutrient deficiencies on activity that

Figure 1. Box plots of mean numbers of high activity counts (N_{HA}), mean numbers of low activity bouts (N_{LB}), and mean durations of low activity bouts (D_{LB}) of dairy cows in their home pen during 4 repetitions of activity recording. The plots show the median (line within the box), 25th and 75th percentiles (box), 10th and 90th percentiles (whiskers), and outliers (dots).

occur early in lactation (Linnane et al., 2001) and of initiation of first parturition cows to the herd (Gonzalez et al., 2003) were avoided because our study began later in lactation. Fourth, subjects were not synchronized in season relative to their stage of lactation. Thus, activity was driven by current needs and individual traits rather than by responses to seasonal changes. Fifth, possible measurement differences among AMS devices may have increased the variance, which is included in the covariance parameter estimated for residual error (cov [error]). On this account, repeatabilities within cows likely would have been underestimated.

Understanding of consistent differences in individual activity may improve daily management routines and basic dairy research. Adapting routine activities may lead to improvements in facilities management (Wagner-Storch and Palmer, 2003). For example, it may be possible to use automatic activity monitoring systems to better detect cows in estrus or having lameness. In research, outliers based on conspicuous activity may be identified more efficiently, permitting better research designs that require fewer experimental units. In addition, a selective approach to the use of particular individuals as replicates is most reasonable (Phillips, 2000).

In conclusion, our results demonstrate that activity in the home pen is highly consistent within individual dairy cows. Furthermore, that repeatable activity was maintained throughout 2 lactations supports the idea that these consistencies are based on individual characteristic traits (Kilgour, 1975).

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