The Effect of Milk Allowance on Play Behaviour in Dairy Calves: A Preliminary Study

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Undergraduate Thesis Submitted to

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1.0 Introduction

Calf play is worthy of investigation for a multiplicity of reasons. As a promising representation of a positive affective state (Fraser and Duncan, 1998), play holds the potential to allow for scientific exploration of the effects of various causal factors (Fraser, 2009), such as reduced access to milk. Research suggests that mammalian play is a developmentally beneficial behaviour, in terms of motor-training, as well as in its ability to facilitate the building of social relationships (Spinka et al., 2001; Maestripieri and Ross, 2004). Therefore, understanding the conditions necessary for maximizing the occurrence of play can aid in animal management enhancement strategies, which will increase the calves' quality of life (Boissy et al., 2007). Additionally, an understanding of calf play as an indicator of good animal welfare can contribute to the development of progressive standards, policies and practices in the dairy industry (Fraser, 2009).

Ethograms of play include a myriad of observed behaviours that are believed to be representative of play in calves (Brownlee, 1954; Jensen and Kyhn, 2000). However, although play is an important application of ethology, scientists have struggled with finding consensus in defining and assessing play in calves in an objective manner (Allen and Bekoff, 1994); no repeatable measurement of play has been established to date. Thus, one of the objectives of this paper is to explore the repeatability of one measure of play, running time, in an effort to better understand play and to lay the foundations for further exploration of repeatable measures of it. For the purpose of this paper the term 'play' will refer to running time.

To date, detailed accounts of play behaviour in domestic calves is limited. There are likely many variables that affect the occurrence of play behavior, including the time of day and management practices, such as space provision and milk allowance. Preliminary research on play in dairy calves found that play decreases with age and is positively affected by increases in space allotment, as well as by group housing (Jensen and Kyhn, 2000). Other studies have established that milk allowance affects standing time (De Paula Vieira et al., 2008) and weight gain in calves (Jasper and Weary, 2002). Although a more definitive picture of standing behaviour is being developed, what is unclear is when calves are playing within this time or if there are peaks within their playing time and how it is distributed over the course of a day. Establishing patterns in play would allow future research to focus its play observations on peak times; furthermore, a greater composite picture will be formed by adding play behaviour to the repertoire of currently established calf behaviours. Thus, the second objective of this paper is to describe any noticeable patterns in play that take place throughout the day and to determine if age has an effect on play.

Motivational systems are believed to be responsible for causing animals to perform play behaviours, which are associated with a positive affective state, when the fitness benefit of doing so outweighs the costs (Duncan and Fraser, 1998). Research on calves fed 4 L (10% of body weight) of milk a day resulted in lower gains in weight and a decrease in resting time (De Paula Vieira et al., 2008). This suggests that calves fed a restricted amount of milk are experiencing hunger, an affective state that is considered to be negative. What has not been established though is how hunger due to milk restriction affects play behavior. The third objective of this paper was, thus, to compare the play responses of dairy calves provided restricted quantities of milk (15% of body weight) to those fed ad libitum from an automated feeding system.

It is apparent that physical and psychological benefits can be derived from play; however, there is limited information on play behaviour in dairy calves. It was thus the aim of the current project to describe play behavior in dairy calves. The specific aims of this study were to:

1) To assess the repeatability of measurements of running time (an indicator of play behaviour) between multiple observers

2) To describe any patterns in running behaviour throughout the day and to determine if age affects the running time of group housed calves

3) To assess the effect of milk allowance (ad libitum versus restricted) on the running time of group housed calves

2.0 Materials and Methods

2.1 Animals, housing and feeding

This experiment was conducted using 26 female Holstein dairy calves in the Westgen Calf Facility barn at the University of British Columbia's Dairy Research Centre, Agassiz, B.C., Canada. All calves were cared for, and all experimental procedures were undertaken in accordance with the requirements from the Canadian Council on Animal Care.

All animals were inspected once a day for signs of disease. Only healthy calves were used for this study.

Calves were housed in three pens, each consisting of 9 calves. All pens were constructed in the same manner, measuring 16 x 24 ft width by 24 feet in length with PVC panel (Canarm/BSM Agri, Ontario) siding and sawdust bedding covered an area of (15.5 ft by 15.5 ft) of the pen. Plastic grating at the front end of the pen allowed for drainage of manure and urine.

At the front of the pen, calves had access to two artificial nipples and were fed with whole milk via one automated DeLaval® CF 1000 CS Combi (Delaval, Tumba, Sweden) milk feeder. An Insentec water feeder and hay feeder (Insentec, Marknesse, Holland) and one

DeLaval® grain feeder CF 1000 CS Combi (DeLaval, Tumba, Sweden) provided calves with ad libitum access to water, hay and starter (Unifeed, Canada, 21.6% crude protein barley based calf starter).

KalbManager Version 1.1 and Win_Institut V02.18.24 software programs (Foerster-Technik, Engen, Germany) were connected to the grain and milk feeders and recorded the consumption of both with the aid of transponders, which were attached to each calf for individual recognition. The feeders were automatically washed with detergent twice daily and were manually calibrated once weekly. Milk was fed in 500 ml portions, except the first and last portions, which were 250 ml in volume. Ad libitum treatment calves had access to milk 24 h/d. Restricted treatment calves received a total quantity of 6 L of milk/d. The calf feeder recorded milk consumed per visit. Calf weights were recorded on a Western Scale Smart1 weigh scale (WesternScale, Port Coquitlam, Canada) each time they entered the milk feeder. Transponder and feeder data allowed for identification of each calf on the scale.

2.2 Pre-experimental period

Within 24 h after their birth, calves were separated from their dams. Within 12 h of birth, calves were bottle fed 4 L of colostrum with an average immunoglobulin quality of 55 g/L, according to standard operational practices and estimated using a colostrometer.

Calves were individually housed for the first 5 d of their lives in sawdust-bedded pens measuring 6.5 ft by 4 ft. During this time, calves were sedated and dehorned using caustic past; a transponder was attached to the left ear of each calf, along with personal numerical identification tags in both ears. Two litres of fresh, whole milk was provided twice a day by bottle attached to the door of each individual pen. Animals were assisted in learning how to obtain milk from an artificial nipple on a bottle.

2.3 Experimental period

Clinically healthy calves were moved into neonatal group housing at 6 d ± 1 d (mean ± SD). Calves were photographed upon entering group housing to facilitate individual identification during video playback. Upon entry into one of the three experimental group pens, calves were assigned to one of three treatments based on birth weight (42.8 kg ± 5.3, mean ± SD): 1) ad libitum-fed; 2) restricted-fed (6 L max. milk per day, approx. 15% body weight). Within the ad libitum treatment a subset were weaned at 5 weeks (early weaned, n=8) and a subset were weaned at 11 weeks (late weaned, n=9). Each pen contained all three treatments and was dynamic as calves entered the experimental pens based on their age.

2.4 Behavioural measures

One digital camera (Panasonic WV-BP 334; Osaka, Japan) was positioned above each pen to record groups of calves. Output collected from 0800 hrs to 2300 hrs was viewed using Genetec Omnicast software. Data were collected from 3 d in the first 5 wk of treatment for all three treatment groups, and up to 11 wk (2 d for every 2 wk) for calves on treatment 3. Calves were monitored for up to 84 days, after which time all calves were moved out of the experimental pen.

Running time was recorded between the hours of 0800 and 2300 based on a high correlation between this time period and a 24 h period (see Appendix A). Running time was recorded as durations with a start and end time when forward, rapid movement including trotting, galloping, cantering, and which may or may not have included instances of jumping and/or bucking with one or two legs, lasted 3 sec or longer. Bucking and jumping were not recorded on their own. Individual calf numbers were recorded for every running bout. Pauses less than 3 sec between running events were considered to be within the same running bout and contributed to the duration of play recorded. To estimate intra-observer reliability, observer 1 re-recorded running bout durations for each calf (n = 9) from 1 d selected at random, at least 5 d after the first data recording session. To estimate inter-observer reliability, observer 1 as well as two other trained observers (observer 2 and observer 3) recorded and re-recorded running bout data from 1 d selected at random (n = 9 calves).

2.5 Statistical Analysis

Correlation coefficients were calculated using the regression procedure (PROC REG) of SAS between a) first and second observations during 1 d to test intra-observer reliability for observer 1, and b) the mean hourly and daily running times for the 3 observers to test the inter-observer reliability.

Calves from the late-weaned ad libitum treatment (n = 9) were used to assess the effect of week of age on running time. Two days of data were collected and averaged from each of the following weekly periods for each calf: wk 3, wk 5, wk 7, wk 9 and wk 11. The PROC GLM procedure in SAS was used to determine differences in running behavior over these 5 weekly periods. Pen was included in the model as a classification variable. Week was considered a repeated measure and was included in the model as a quadratic effect. An autoregressive covariance structure was used based on best fit.

To determine the diurnal pattern of play, running time was first summarized per hour (between 0800 and 2300) and calf for 3 or 4 d within the first 5 wk of age. Hourly running times from calves from all three treatments (n = 26) were averaged and used to assess the diurnal pattern of running time in group housed calves.

To determine the effect of milk allowance on running time, calves from the ad libitum treatment (n = 18) were compared to calves on the restricted treatment (n = 8) within the between 2 and 5 wk of age. Data were collected 3 or 4 d per calf and were averaged to create one value for running time per calf. The PROC GLM procedure in SAS was used to determine the effect of treatment (ad libitum or restricted) on running time. Pen was included in the model as a classification variable.

3.0 Results

3.1 Reliability

High inter-observer reliability was found for running bouts (Table 1). Intra-observer reliability values reflected a reasonably consistent recording of running time in both times watched (Figure 1).

3.2 Age Effect

We found a significant effect of week on playing time, whereby calves played less as they became older (Figure 2; $F_{4, 28} = 2.87$, $P = 0.04$).

3.3 Diurnal Pattern

A diurnal pattern in play was found, with a peak in the morning between 0830 and 0930 and in the evening between 1800 and 1930 (Figure 3).

3.4 Treatment Effect

We found a trend for a treatment effect, whereby calves on ad libitum milk treatment played more than calves on restricted treatments (Figure 4; $F_{22} = 2.84$, $P = 0.11$).

4.0 Discussion

Mammalian play has been described as consisting of physical sequences involving dynamic and, at times, uncontrolled physical movements (Barber, 1991), which may emulate behaviours such as predation, flight, fight and copulation acts but which do not appear within their functional context (Aldis, 1975; Loizos, 1966 in Barber 1991). Performing these behavioural elements in non-emergency situations may be an evolutionary mechanism enabling animals to gain physical and emotional dexterity that will allow for quicker recovery in future situations that are disorienting, stressful, surprising or temporarily disabling (Spinka et al., 2001; Maestripieri and Ross, 2004). For example, play has been found to increase agility on slippery floors, facilitate animals' ability to rapidly recover from collisions with one another or other objects, and enable animals to maintain composure while running (Spinka et al., 2001; Rushen et al., 2008;). Moreover, play has been hypothesized to facilitate the enhancement of social skills in group-play situations (Rushen et al., 2008). The adaptive developmental benefits mammals gain from play are also believed to include the opportunity to exercise, thus increasing muscle, bone and cardiovascular conditions; activation of the sympathetic nervous system (Barber, 1991), general neuromuscular exercise (Muller-Schwarze, et al., 1982), as well as enhanced resistance to pathogens (Spinka et al., 2001).

Scientific study of play in mammals has long overlooked the potential for play to enhance the positive and complex emotional states of animals, although such a focus is beginning to emerge in animal welfare studies (Boissy et al., 2007; Balcombe, 2009). Play has been offered as an indicator of good animal welfare, specifically, as a manifestation of positive affect (Fraser and Duncan, 1998) because unfavorable environmental and physical conditions have proven to negatively affect its occurrence (Dudink et al., 2006). Weaning is a time associated with a negative affective state (De Paula Vieira et al., 2008); however, recent research has shown that by introducing a sound cue associated with enrichment increases the rate of play behaviour, perhaps as a result of an increase in a positive affective state (Dudink et al., 2006). These results draw attention to the cause of negative experiences for piglets (i.e., weaning), as well as to the positive affective state that is present when stress is diminished, and is manifested in increased play behavior.

Although play has been studied in mammals from deer fawns (Muller-Schwarze et al., 1982) to piglets (Blackshaw et al., 1997; Dudink, S. et al., 2006), as well as in dairy cattle (Brownlee, 1954; Jensen and Kyhn, 2000), no studies on calf play have assessed the reliability of specific components of play behaviours. In order to do so, these components must be measured by establishing objective, repeatable measures by which play can be assessed. Inter- and intra-observer reliability values within and between observers in this study, established for the first time that running time is a repeatable measure of play behaviour. It was not within the scope of this project to assess the repeatability of other potential forms of play behaviour such as head to head play and mounting behaviour; therefore, future research may focus on these behaviours and others that have been observed in calves (Jensen and Kyhn, 2000).

One of the aims of this study was to determine any patterns present in the running behavior of calves, as well as if play was affected by age. By establishing patterns and variables that might affect the occurrence of play behavior, future research in this area can focus its efforts on specific times of day and ages where peaks are present. We found peaks in play in the morning and evening. Although distinct peaks in running time were discovered it is not clear from the current study what causes these peaks. Future research should focus on physiological or management factors, such as changes in body temperature throughout the day or feeding times that might impact a diurnal pattern of running time. A significant effect of week on playing time was found, with calves playing less as they became older. This finding is consistent with Jensen and Kyhn's findings that locomotor play decrease over the weeks in dairy calves (2000); however, Jensen and Kyhn did not use a repeatable measure of play in her experiment where ours did.

This study sought to expand upon the current knowledge of how management practices affect calf behaviour, specifically, play behaviour. To date, management practices in dairy production systems have been shown to affect the occurrence of play behaviours in calves and their time spent standing, and calves' weight gains.

Previous research demonstrated that sufficient space allotment and group housing were necessary prerequisites for stimulating play behaviour (Jensen and Kyhn, 2000). Specifically, increases in space (up to 3 and 4 m^2 per calf) resulted in greater opportunities to play and subsequently greater incidents of play and showed improved quality of play behaviour in group housed calves (Jensen and Kyhn, 2000). Calves have been found to spend approximately 17 h/d lying down, including bouts of rest and sleep (Chua et al., 2002). The remainder of the day is spent standing, which includes time spent eating, grooming and playing. Research to date on milk allowance has established that calves alter their standing behavior based on the allotment of milk they are given, whereby calves given a restricted amount of milk (fed a total of 10% of body weight) stood for about 1 h longer than calves fed ad libitum. Moreover, providing calves with ad libitum nipple access to milk increased weight up to four times more compared to restricted fed calves (De Paula Vieira et al., 2008). Lower gains in weight, and a decrease in resting time suggests that calves fed a restricted amount of milk are experiencing hunger, a negative affective state.

Our results show that calves spend approximately 0.14% (117.7 sec/d) of their day playing, which comprises 0.5% of the time they spend standing (mean ± SD = 117.7 ± 58.3 sec/d based on 7 h/d of standing time; n=26 calves). It is understood that without adequate sleep and rest in growing animals, the regulation and secretion of many hormones essential for brain development, such as glucocorticoids, are negatively affected (Hanninen et al., 2007). These results add to the current body of knowledge on calf behaviours; however, whether these numbers represent maximum values of calf play is the subject of future inquiry. Although rhythms and durations of calf play in farm environments are likely affected by management and housing practices, there may be a limit to the amount of play that calves will perform, regardless of ad libitum access to milk in order for calves to fulfill necessary sleep requirements. Further investigation may explain what effect milk intake has on performance of play behaviour and whether calves can be motivated to play beyond the values we found by presenting them with novel stimuli, such as the addition of new bedding. Moreover, other behaviours such as head to head play and mounting may constitute attributes of play and future research that finds repeatable measures for these may be able to add to our understanding of how much time is spent in the day playing.

The physiological cost of performing play behaviour must be low in order for it occur. When the cost of performing play behaviour increases substantially (Fraser and Duncan, 1998), the occurrence of this behaviour, which offers long term fitness benefits, is expected to diminish

(Weary et al., 2008). For example, when White-tailed deer fawns milk allowance was reduced by 33% a proportional decrease of 35% in play behaviour was observed (Muller-Schwarze et al., 1982). After comparing the effect of milk allowance (ad libitum versus restricted) on the running time of group housed calves, we found that there was a trend for restricted fed calves to play less (days < 5 weeks). This trend may be indicative of a negative, prolonged state of hunger resulting in a curtailment of play bouts. More studies are needed to identify the significance of this trend, using more calves and a greater number of days before the milk reduction and weaning period. Moreover, analyzing treatment differences by breaking the pre-weaning time into smaller time periods may illuminate the differences more clearly, as age also plays a role in the occurrence of play.

5.0 Conclusions

The moral importance of understanding affective states in animals living in laboratories and intensive/factory farming situations cannot be diminished. Acknowledging that these creatures have the capacity to experience pleasure through expression of certain behaviours magnifies the moral weight of denying animals the chance to live enjoyable and fulfilling lives (Balcombe, 2009).

The results of this study suggest that running time is a repeatable measure of play behaviour is affected by time of day and that play decreases with age. Furthermore, we suspect that play is affected by milk allowance, specifically, that it takes place more often with ad libitum access to milk. It is hoped that this study will contribute its findings to the building of a consensus definition of play that will help to elucidate plays' importance in terms of affect. Furthermore, gaining a deeper understanding of the specific variables that influence how play is expressed will allow future research to focus on the long-term effects of play on social and physical development and to describe how play relates to learning and cognition (Bekoff and Allen, 1994).

Table 1. The inter-observer repeatability between observers 1, 2 and 3 for the running time of 9 calves summarized per hour for one 18 h period.

Observer Comparisons	**R^2**
1 vs 2	0.98
1 vs 3	0.97
2 vs 3	0.99

Figure 1. Intra-observer repeatability of observer 1 for running time (R^2 = 0.98, n = 9).

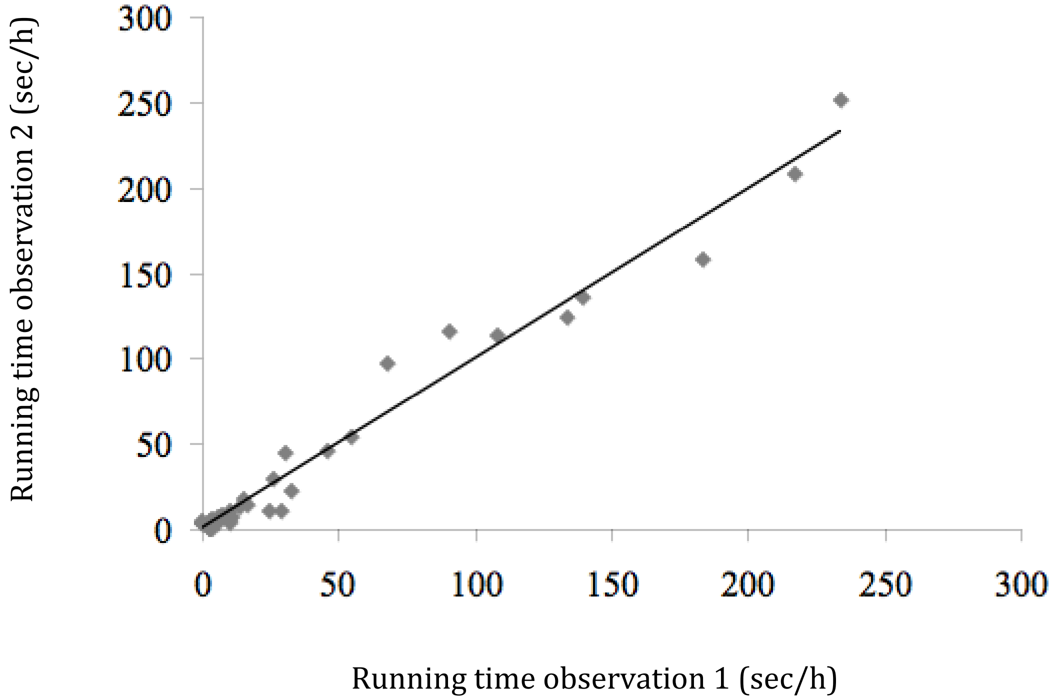


Figure 2. The effect of age (wk) on running time for calves on the RE84 treatment (n=9).

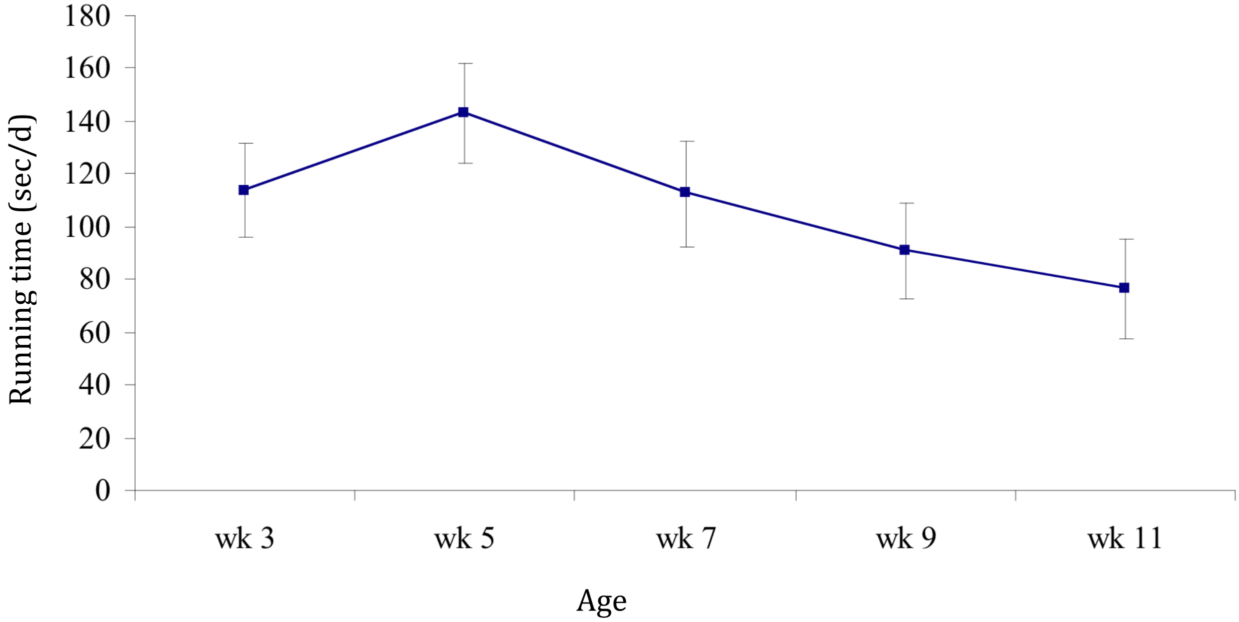


Figure 3. Diurnal pattern of running time in group housed calves (n=26) recorded over 3 d within the first 5 wk of age. Mean ± S.E.

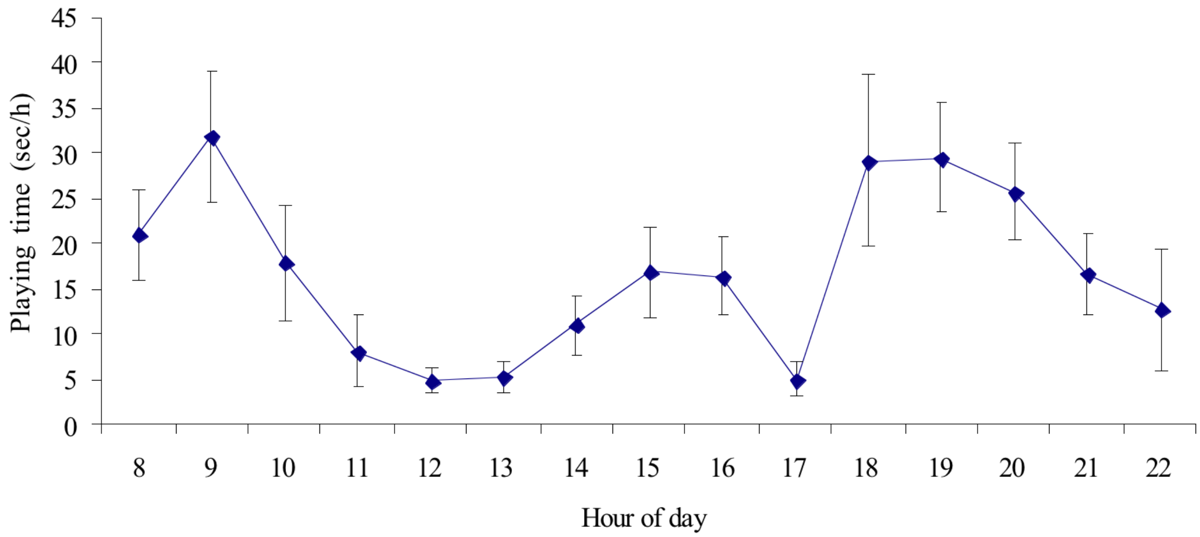
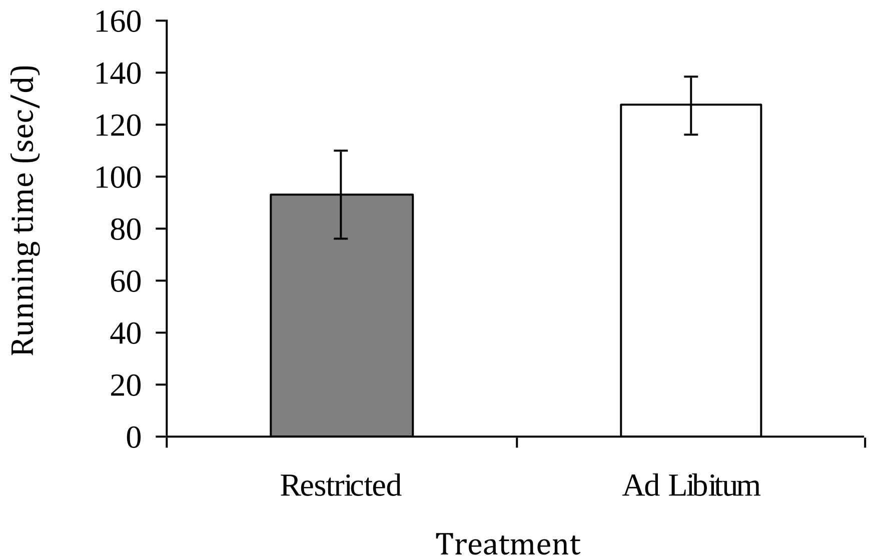
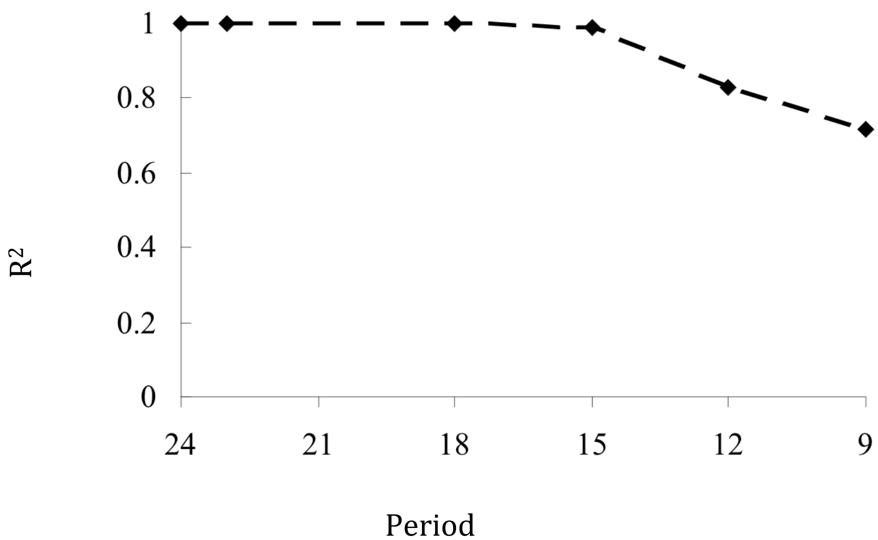


Figure 4. The effect of milk allowance (restricted, n = 9; Ad Libitum, n = 18) on the running time of group housed calves.



APPENDIX A: the relationship between periods of running time (21 h: 0200 to 2300; 18 h: 0500 to 2300; 15 h: 0800 to 2300; 12 h: 1100 to 2300; and 9 h: 1400 to 2300) versus 24 h of observation.



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