# Impact of a stair-stepped feeding regimen during gestation on production efficiencies in breeding horse operations

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We believe that a stair-step feeding regimen during gestation will improve feed and energetic efficiency during gestation and enhance lactation and reproductive performance in mares as well as increase early foal growth, development, and health/immune status. A preliminary experiment to test this hypothesis was initiated in January 2003 and should be complete by late summer 2004.

## Introduction

The horse industry is one of the brighter spots in animal agriculture in North Dakota. From 1992 to 1997 (the last year for which there is census data; http://www.nass.usda.gov/census/census97/volume1/nd-34/nd1_39.pdf), the number of farms with horses increased 15% (4,074 to 4,699) and the number of total horses increased 41% (24,914 to 35,103). The number of farms selling horses increased 18% (779 to 919), number of horses sold increased 24% (4,842 to 6,009) and the value of horses sold increased 32% ($3,609,000 to $4,770,000).

Despite this optimistic growth, then number of horses sold as a percentage of the number in inventory is not very high (approximately 18%) in comparison to other livestock species. Additionally, the value per animal sold increased only 6% from 1992 to 1997. Recognizing that the horse industry is not directly comparable to the other food- producing livestock industries in the state, it would appear that one viable opportunity for growth in the horse industry would be to increase the number of weaned horses available for sale as a percentage of horses in inventory.

Well managed horse breeding operations should be able to compare to the following benchmarks (Lewis, 1996):

- A foaling rate (percentage of live foals born) of 70 to 80% in mares bred or pasture exposed a stallion.
- Estrous cycles per conception of 1.43 or less.
- 45-d pregnancy rates of 88 to 97 %.
- Pregnancy loss percentage of 13% of mares conceived.

One opportunity for growth in the horse industry in North Dakota would be to increase the number of weaned horses available for sale as a percentage of horses in inventory. Profitability in horse breeding operations, like other enterprises based on reproducing females, is largely dependent upon the proportion of healthy, live offspring available for sale relative to the number of females exposed to breeding. Breeding horse operations in the United States have the lowest reproductive performance (live births per female exposed) of all domestic livestock species. Of the mares bred annually in the United States, only 55 to 60% produce a live foal. Survival rates of foals from birth to weaning may be only 68%. Increasing the percentage of mares that conceive and foal annually in defined seasons and increasing the survival rate of foals through weaning would greatly enhance the potential for profitability in horse breeding operations in North Dakota and throughout the United States.

Researchers at NDSU have developed stair-step compensatory growth feeding regimens that enhance growth and development and improve lifelong production and breeding performance in a number of animal species (e.g. beef and dairy heifers, gilts). The basic concept of this regimen is to reduce dietary energy levels [restriction phase] at times when animals are not as likely to put it to good use (e.g., early to mid-gestation). Dietary energy levels are then increased [realimentation phase] when the animal can make better use of it (e.g., late gestation). We hypothesize that a stair-step feeding regimen during gestation will improve feed and energetic efficiency during gestation and enhance lactation and reproductive performance in mares; as well as, increase early foal growth, development, and health/immune status.

If our hypothesis proves correct, this type of feeding regimen should maintain or reduce feed costs during gestation, increase the rebreeding performance of mares in defined breeding seasons, and increase the number and quality of foals weaned and available for sale. Specific objectives of this experiment are to determine if a stair-step feeding regimen during mid

and late gestation in mares will impact gestational feed efficiency; urinary excretion and serum concentrations of estrogen and cortisol; subsequent reproductive performance; milk production/composition; and early foal growth, development, and immune status.

**Brief literature review**

Profitability in horse breeding operations, like other enterprises based on reproducing females, is largely dependent upon the proportion of healthy, live offspring available for sale relative to the number of females exposed to breeding (Evans and Torbeck, 1982). Mares have been noted to have the lowest reproductive efficiency of all domestic farm animals (Lewis, 1996). The major cited reasons for this low reproductive performance are poor reproductive management, uterine infection, and irregular estrous cycles.

A gestational stair-step feeding regimen has been studied in a number of animal species. Early work in dairy cattle, rats and pigs demonstrated an increase in milk production when primiparous females were exposed to a regulated stair-stepped growth regimen during gestation. Work in beef cattle has been less consistent. A stair-step regimen in beef heifers has increased weaning weights in one study, but not affected milk production or weaning weights in other studies. Differences in consistency of response among beef cattle and other species is unknown at the moment. Other potential benefits of a stair-step regimen include enhance feed and energetic efficiency and improved breeding performance in beef heifers and transition health and immune function in dairy cattle. The effect of a stair-step regimen on mammary cancer is also currently being studied (Park et al., unpublished data). The effect of a gestational stair-step regimen in either primi- or multiparous mares has never been studied.

Weight maintenance, or possibly weight loss, is an integral part of the stair-step procedure. Low feed quality and/or a significant reduction in feed intake, particularly during periods of high energy requirements, may result in a hyperlipemia syndrome (Lewis, 1995). Hyperlipemia occurs because a severe negative energy balance can result in peripheral fat mobilization at a rate faster than it can be utilized by the body. This can lead to an accumulation of triglycerides in the serum and liver. Implementing the restricted growth phase during mid gestation in this study should avoid periods of high energy requirements and minimize the potential for development of hyperlipemia. Gentry et al. (2002) reported no complications resulting from the management of open mares to lose more than 130 pounds and 3 body condition scores in approximately 12 weeks.

Breeding quicky after foaling is essential if an annual foaling cycle is to be maintained. Gestation length averages 335 to 345 days (Frape, 1998). Increasing energy intake prior to breeding (e.g. flushing) is beneficial for thin mares and weight loss prior to breeding regardless of body condition reduces reproductive efficiency (Lewis, 1995). Conception rates were higher in thin mares gaining weight than in thin mares maintaining weight (Donoghue et al., 1990). A period of rapid growth and enhanced energy intake is the second or compensating phase of the stair-step regimen. Breeding performance following a stair-step regimen has improved pregnancy rates in beef heifers (Poland et al., 2000). Using a stair-step regimen during mid and late gestation may improve subsequent breeding performance in mares.

Adequate early growth rates are important particularly when foals are sold at or near weaning. Small, thin or unthrifty foals at weaning are discounted substantially (personal observation). However, excessive early growth rate can lead to developmental orthopedic disease (DOD) and structural abnormalities (Lewis, 1995). A gestational stair-stip regimen has been shown to moderately increase milk production in many species. A moderate enhancement in milk production and early foaling dates may improve growth rates to the point of reducing the incidence of small, thin or unhealthy foals at weaning without the concern of excessive growth rates.

**Materials and Methods**

*Gestational treatments*. Eighteen primi- and multiparous mares will be blocked by expected foaling date and randomly assigned to one of two gestational dietary regimen: control (CONT) or stair-step compensatory nutrition (SSCN). Gestation regimens will be initiated approximately 5 months (20 weeks) prior to expected foaling date. The CONT regimen will provide feed to mares that will meet or exceed the nutritional requirements (NRC, 1989) during mid and late gestation. Energetically, this amounts to providing 1.00, 1.11, 1.13, and 1.20 multiples of digestible energy (DE) for maintenance in months 7 to 8, 9, 10, and 11 of gestation, respectively. The SSCN regimen will split the gestation period into 2 phases and provide nutrients, with the exception of DE, in amounts similar to those delivered by CONT. Digestible energy will be provided in a stair-step fashion with the SSCN mares being delivered approximately 80% of DE provided to mares in CONT during phase 1 followed by approximately 120% of CONT DE during phase 2. The two phases of gestation will be approximately equal in length and consist of approximately 10 weeks per phase. During gestation, mares will be put in individual tie stalls in an unheated indoor facility each afternoon and provided their respective daily allotment of feed. Mares will be

released from tie stalls each evening. When not in tie stalls, mares will be kept in a large drylot adjacent to the indoor facility and provided free movement with unlimited access to a frost-free waterer. Mares will remain on their gestational treatments until foaling. Subsequently, all mares and foals will be similarly fed and managed as one group through approximately 90 days of lactation.

*Gestational data collection*. Mares will be weighed and assigned a body condition score every 14 days. Weights of daily feed deliveries and orts will be recorded. Weekly subsamples of feed ingredients and orts will be collected, composited over period (first or last 10 weeks of gestation), and subsampled for nutrient analysis. Periodic blood samples will be collected during phase 1 via juglular venipucture for determination of serum metabolites (e.g., triglycerides, estrogen and cortisol).

*Lactational data collection - mares*. Body weight and body condition score will be recorded every 14 days once all mares in an expected foaling group have foaled. Colostrial or milk samples will be collected at foaling and approximately on days 28, 56, and 84 postpartum. Colostrial and milk samples will be analyzed for fat, protein, solids-not-fat, and immunoglobulins (colostrial samples only). Milk production will be estimated using a weigh-suckle-weigh procedure on approximately days 28, 56, and 84. Other data recorded will include postpartum interval to resumption of estrus, breeding, conception (ultrasonographic estimates of fetal presence, age, and sex) and subsequent foaling.

Milk production will be estimated using a weigh-suckle-weigh procedure similar to that used in beef cattle experiments. Briefly, foals will be separated from mares for 4 hours. Foals and mares will be reunited for 20 minutes to allow mammary gland to be emptied. Foals and mares will then be reseparated for 8 - 12 hours. Following this second separation, mares and foals will be weighed, pairs will be reunited, allowed to nurse to appetite and then reweighed. Weight differences will be used as estimate of daily milk production.

*Lactational data collection - foals*. Body weight and skeletal dimensions (e.g., wither height, hip height, body length, forearm circumference, gaskin circumference, cannon bone circumference, girth) will be recorded at the same the frequency as body weight in mares. Blood samples will be drawn from foals at foaling and approximately on days 3, 7, 14, 28, 56, and 84 postpartum. Blood samples will be analyzed for selected metabolites (e.g., non-esterified fatty acids, glucose, (-glutamyltransferase, cortisol, immunoglobulins G and M, haptoglobin).

**Results and Discussion**

Experiment is currently underway and data collection complete by late summer 2003.

**Implication**

Our SSCN regimen, which enhances mammary development and lactation performance in cattle and rats, has never been tested in the horse. If our hypothesis proves correct, this type of feeding regimen should maintain or reduce feed costs during gestation, increase the rebreeding performance of mares in defined breeding seasons, and increase the number and quality of foals weaned and available for sale.