J. Dairy Sci. 100:1–15
https://doi.org/10.3168/jds.2016-12390

Only 7% of the variation in feed efficiency in veal calves can be predicted from variation in feeding motivation, digestion, metabolism, immunology, and behavioral traits in early life

M. S. Gilbert,*[1] J. J. G. C. van den Borne,*[2] C. G. van Reenen,† and W. J. J. Gerrits*
*Animal Nutrition Group, Wageningen University and Research, 6700 AH, Wageningen, the Netherlands
†Livestock Research, Wageningen University and Research, 6700 AH, Wageningen, the Netherlands

ABSTRACT

High interindividual variation in growth performance is commonly observed in veal calf production and appears to depend on milk replacer (MR) composition. Our first objective was to examine whether variation in growth performance in healthy veal calves can be predicted from early life characterization of these calves. Our second objective was to determine whether these predictions differ between calves that are fed a high- or low-lactose MR in later life. A total of 180 male Holstein-Friesian calves arrived at the facilities at 17 ± 3.4 d of age, and blood samples were collected before the first feeding. Subsequently, calves were characterized in the following 9 wk (period 1) using targeted challenges related to traits within each of 5 categories: feeding motivation, digestion, postabsorptive metabolism, behavior and stress, and immunology. In period 2 (wk 10–26), 130 calves were equally divided over 2 MR treatments: a control MR that contained lactose as the only carbohydrate source and a low-lactose MR in which 51% of the lactose was isocalorically replaced by glucose, fructose, and glycerol (2:1:2 ratio). Relations between early life characteristics and growth performance in later life were assessed in 117 clinically healthy calves. Average daily gain (ADG) in period 2 tended to be greater for control calves (1,292 ± 111 g/d) than for calves receiving the low-lactose MR (1,267 ± 103 g/d). Observations in period 1 were clustered per category using principal component analysis, and the resulting principal components were used to predict performance in period 2 using multiple regression procedures. Variation in observations in period 1 predicted 17% of variation in ADG in period 2. However, this was mainly related to variation in solid feed refusals. When ADG was adjusted to equal solid feed intake, only 7% of the variation in standardized ADG in period 2, in fact reflecting feed efficiency, could be explained by early life measurements. This indicates that >90% of the variation in feed efficiency in later life could not be explained by early life characterization of the calves. It is speculated that variation in health status explains a substantial portion of variation in feed efficiency in later life. Significant relations between fasting plasma glucose concentrations, fecal pH, drinking speed, and plasma natural antibodies in early life (i.e., not exposed to the lactose replacer) and feed efficiency in later life depended on MR composition. These measurements are therefore potential tools for screening calves in early life on their ability to cope with MR varying in lactose content.

Key words: veal calf, feed efficiency, growth performance, lactose, glycerol

INTRODUCTION

High interindividual variation in growth performance is commonly observed in veal calf production. For instance, the coefficient of variation (**CV**) in ADG in healthy calves fed equal levels of nutrient intake was 5.9% for calves aged 13 to 26 wk (Gilbert et al., 2015b), 12.3% for calves aged approximately 6.5 to 9.5 wk (Labussière et al., 2008), and 21.3% for calves aged 3 to 6 wk (Akinyele and Harshbarger, 1983). This interindividual variation occurs in the absence of clinical disease and at similar nutrient intake and therefore results mainly from variation in feed efficiency. Variation in feed efficiency can originate from variation in many biological processes. Assessing the ability of calves to respond to specific stimuli related to biological sources of variation might explain the variation in feed efficiency. We therefore designed targeted measurements related to feeding motivation, digestion, postabsorptive metabolism, behavior and stress, and immunology to characterize calves in early life kept under equal feeding

Received December 2, 2016.
Accepted July 3, 2017.
[1]Corresponding author: myrthe.gilbert@wur.nl
[2]Present address: Schippers Europe B.V., Rond Deel 12, 5531 AH Bladel, the Netherlands.

and husbandry conditions. If these early life measures show genetic variation and thus consistency over time and are related to feed efficiency, such an early life characterization could be predictive of later life feed efficiency in healthy calves. Indeed, in beef cattle divergently selected for residual feed intake (a measure for feed efficiency), variation in feeding patterns, feed digestion, protein turnover, tissue metabolism, heat production, activity, and stress contributed to variation in feed efficiency (Herd et al., 2004; Richardson and Herd, 2004; Herd and Arthur, 2009). These phenotypic measures explained most of the genetic variation in residual feed intake. Such relations between animal characteristics and feed efficiency suggest that these characteristics could be used as early life measures to predict later life feed efficiency in veal calves.

Veal calves are fed milk replacers (**MR**), which commonly contain 40 to 50% lactose. High and fluctuating dairy prices are a major economic incentive to replace lactose from MR with alternative energy sources. However, differences in growth rates between individual calves increased further when lactose was replaced from the MR. For instance, the CV in ADG increased from 5.9 to 8.4% when lactose was partially replaced with maltose, although ADG decreased (Gilbert et al., 2015b). This illustrates that variation in growth performance depends on MR composition and that not all calves are equally able to cope with lactose replacers (i.e., low-lactose MR). Digestive and metabolic processes may contribute to this increase in interindividual variation in growth performance when feeding low-lactose MR. For example, the CV in apparent ileal disappearance of DM increased from 5.0 to 6.9% when partly replacing lactose with maltose (Gilbert et al., 2015a), and the CV in urinary glucose excretion increased from 42 to 82% when partly replacing lactose with glucose, fructose, or glycerol (Gilbert et al., 2016). Predictions of feed efficiency of calves from traits measured in early life might therefore differ between calves fed a high- or low-lactose MR. Our objectives were (1) to examine whether variation in growth performance of healthy veal calves can be predicted from early life characterization of these calves and (2) to determine whether these predictions differ between calves that are fed a high- or low-lactose MR in later life.

MATERIALS AND METHODS

This experiment was conducted at the research facilities of the VanDrie Group (Scherpenzeel, the Netherlands) and was submitted to and approved by the Animal Care and Use Committee of Wageningen University (Wageningen, the Netherlands).

Experimental Design

The experiment consisted of 2 periods. Period 1 started when calves arrived at the experimental facilities, and measurements were performed from experimental wk 1 to 9 on individual calves to characterize each calf. In period 2, the feeding trial was conducted in which a control, lactose-based MR was compared with an MR in which 51% of the lactose was replaced with glucose, fructose, and glycerol. Period 2 lasted from experimental wk 10 to 28, and general performance was recorded.

Animals, Housing, and Feeding

Calves were housed on wooden slatted floors throughout the experiment. Light was provided by daylight, and artificial lights were on from 0600 to 1800 h. The stable was mechanically ventilated. The temperature and humidity averaged 19 ± 3.9°C and 77 ± 9.3% (mean ± SD), respectively.

Period 1. A total of 180 male Holstein-Friesian calves of Dutch origin arrived at the experimental facilities at 17 ± 3.4 d of age and 44 ± 2.6 kg of BW (mean ± SD). Calves were housed individually in a 1.2-m^2 pen so that all measurements could be performed individually.

The ingredient and nutrient composition of the experimental MR are shown in Table 1. Calves received MR with lactose as the only carbohydrate source. Solid feed comprised concentrates, rapeseed straw, and alfalfa and was supplied at a ratio of 70:15:15 on an estimated DM basis. Concentrates comprised oats, 250 g/kg; barley, 238 g/kg; corn, 201 g/kg; lupines, 155 g/kg; corn gluten meal, 111 g/kg; vitamin–mineral mix, 24 g/kg; and molasses, 20 g/kg. Analyzed CP content was 183 g/kg. The feeding levels for MR and solid feed were based on a practical feeding scheme and were equal between calves. Milk replacer allowance increased progressively from 400 to 1,200 g/d, and solid feed increased from 85 to 360 g/d. Solid feed was provided from 1 wk after arrival onward. The MR was mixed with warm water (66°C), and the concentration of reconstituted MR was 125 g/kg. Reconstituted MR was supplied at a temperature of approximately 42°C in 2 equal meals, at 0600 and 1600 h, and calves were allowed access for 15 min, after which refusals were quantified. Solid feed was provided to each calf individually directly after the morning MR meal. Solid feed refusals were removed and quantified before the morning meal. Water was available through water nipples continuously except for 2 h around MR feeding.

Period 2. Age and BW at the start of period 2 were 82 ± 3.5 d and 87 ± 4.1 kg (mean ± SD), respectively. Calves were housed in groups of 5 in a pen of 9 m^2. Each calf was assigned to 1 of 2 MR treatments: a con-