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Effects of dietary fat on fertility of dairy cattle: A meta-analysis and meta-regression

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ABSTRACT

Evidence is increasing of positive effects of feeding fats during transition on fertility and the adaptation to lactation. This study used meta-analytic methods to explore the effects of including fats in the transition diet on the risk of pregnancy to service (proportion pregnant) and calving to pregnancy interval. Meta-analysis was used to integrate smaller studies and increase the statistical power over that of any single study and explore new hypotheses. We explored the effect of fats and diet composition on fertility using meta-regression methods. Relatively few highly controlled studies are available providing detailed descriptions of the diets used that examined interactions between fat nutrition and reproductive outcomes. Only 17 studies containing 26 comparisons were suitable for inclusion in statistical evaluations. Reproductive variables evaluated were risk of pregnancy (proportion pregnant), primarily to first service, and calving to pregnancy interval. Production variables examined were milk yield, milk composition, and body weight. The sources of heterogeneity in these studies were also explored. A 27% overall increase in pregnancy to service was observed (relative risk = 1.27; 95% confidence interval Knapp Hartung 1.09 to 1.45), and results were relatively consistent (I^2 = 19.9%). A strong indication of a reduction in calving to pregnancy interval was also identified, which was consistent across studies (I^2 = 0.0%), supporting a conclusion that, overall, the inclusion of fats does improve fertility. Further exploration of the factors contributing to proportion pregnant using bivariate meta-regression identified variables that reflected changes in diet composition or animal response resulting from inclusion of the fat interventions in the experimental diets fed. Increased fermentable neutral detergent fiber and soluble fiber intakes increased the proportion pregnant, whereas increased milk yield of the treatment group decreased this measure. Unexpectedly, the estimated energy costs of urea production also had a positive association with proportion pregnant. The limited number of suitable studies for the analysis highlights the need for more work to improve understanding of the critical nutritional factors affecting fertility. These factors include specific fatty acids in dietary interventions that contribute to increasing fertility of cows in dairy production systems.
Key words: dietary fat, fertility, conjugated linoleic acid

INTRODUCTION

Managing fertility of lactating dairy cattle is a challenge for dairy producers because poor fertility reduces productivity and profit. Declines in fertility have been noted and reflect associations with intensification of production and higher levels of milk production (Butler, 2000; Lucy, 2001; Lean et al., 2008; Thatcher et al., 2011). Studies are needed to identify which environmental factors, especially nutritional ones, may have a role in influencing the fertility of cattle.

The transition period, from approximately 3 wk before to 3 wk after calving, is characterized by changes in metabolism as dairy cattle respond to the metabolic challenges of late pregnancy and early lactation (Bell, 1995). Good management during the transition period, in particular nutritional strategies, can reduce the effects of this metabolic stress and improve production and reproduction (De Veth et al., 2009). DeGaris et al. (2010a,b) found that the risk of pregnancy increased by approximately 30% in cattle exposed to transition diets for 20 d compared with cattle not exposed.

Recent understandings of the role of fats in metabolism open new opportunities for improving production, health, and reproduction in cattle. Inclusion of fats in the diet during this transition period has improved reproductive performance (Thatcher et al., 2006; De Veth et al., 2009), improved energy balance (von Soosten et al., 2012), reduced the incidence of metabolic diseases, and allowed energy density to be maintained in diets without increasing the use of rapidly fermentable carbohydrates.

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The strength of meta-analytic methods is the ability to integrate smaller studies using effect-size metrics, enhance the statistical power over that of any single study, and provide the potential to explore new hypotheses (Lean et al., 2009). Further, the challenge in studies of nutrition and reproduction is that when a nutritional intervention is applied, something else in the diet necessarily changes (Lean et al., 2012). Therefore, the potential for confounding influences need to be considered in interpreting studies of nutrition and reproduction. Meta-regression methods allow this type of investigation. This study was designed to use meta-analytic and meta-regression methods to explore the effects of including fats in the diet during the transition period on measures of pregnancy, calving to pregnancy interval, and milk yield and components, and the factors that may explain sources of variation in these responses.

MATERIALS AND METHODS

Literature Search

A systematic review, across 3 databases (PubMed, Web of Science CABI, and Google Scholar) and references in papers, was used to identify studies exploring fat nutrition during transition and fertility that were published in English between 1970 and 2014 in a peer-reviewed journal, conference proceedings, or as an accepted thesis. Combinations of the following search terms were used: cow, cattle, dairy, fertility, pregnancy, reproduction, pregnancy, fat, CLA, conjugated linoleic acid, cottonseed, linoleic acid, linolenic acid, omega-6, omega-3, and energy.

Inclusion and Exclusion Criteria

Papers were deemed suitable for inclusion in the study if they were randomized controlled experiments using *Bos taurus* dairy cows in their first or later lactation during the dry/lactating period (i.e., primiparous nonlactating heifers were excluded). Studies evaluated the effect of feeding during the transition period, including the period 3 wk before and after calving, and included sufficient dietary details for the diet to be evaluated using CPM-Dairy (version 3.08; Cornell-Penn-Miner, http://cahpwww.vet.upenn.edu/doku.php/software:cpm:purchase) for cows that were fed as individuals or in appropriately replicated pens. Papers that had valid interventions, but did not provide adequate dietary detail, or animals were group fed and not replicated, were identified, but diets were not extracted. Measures of fertility were reported as (1) first service conception or pregnancy to a defined number of services (proportion pregnant); (2) calving to pregnancy interval; or both (1) and (2); and a measure of dispersion suitable to provide a standard deviation. Studies were also assessed for quality of study design including details of randomization, appropriate analysis, and elimination of bias or confounding. The number of cows in each treatment and control group and measures of variance or *P*-values for continuous variables that allowed an estimate of standard deviation to be derived must have been reported.

Data and Diet Extraction

Data extracted included authors, year, journal and type of publication, title of paper, feeding system, number of cows in treatment and control groups, parity, BW, and BCS for each group. Reproductive variables that were recorded were defined as proportion of cows pregnant to service [reported in the papers as first service pregnancy percentage or conception rate, pregnancy percentage (rate) to first 2 services, or pregnancy] and calving to pregnancy intervals (also reported as calving to conception interval or days open) for each treatment. Milk production (kg/cow per d), milk fat percentage and yield (kg/cow per d), and milk protein percentage and yield (kg/cow per d) were also recorded. Data were extracted and entered into a spreadsheet (Excel, Microsoft Corp., Redmond, WA). A summary of studies included is provided in Table 1.

To extract and model dietary information, data from accepted papers were entered into CPM-Dairy (version 3.08; Cornell-Penn-Miner, http://cahpwww.vet.upenn.edu/doku.php/software:cpm:purchase) following the standard operating procedure described in Rabiee et al. (2012). Ration ingredients and intake in the papers were entered into CPM-Dairy using ingredients selected from the feed bank (http://cahpwww.vet.upenn.edu/doku.php/software:cpm:fbk_use) and edited to the specifications described in the paper. This was combined with information on cows, housing, and environment from the paper to predict diet composition. If uncertainty was present with regard to the unit of interest or measures of dispersion reported in papers, authors were contacted to provide clarification of these measures.

Statistical Analysis

All statistical analyses were conducted using Stata (Intercooled Stata v.13, Statacorp, College Station, TX). The influence of fat nutrition during transition on production and reproductive performance was analyzed using meta-analysis. Trials were grouped by type of fat intervention [oilseeds, calcium salts of FA (**CSFA**), tal-