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Environmental impacts of cow-calf beef systems with contrasted grassland management and animal production strategies in the Massif Central, France

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ABSTRACT

To meet the increasing market demand for store male calves sold in summer, cow-calf beef cattle producers from the Charolais area, France, can opt for various strategies including changing the calving period. The objective of our study was to analyze and compare the impacts on greenhouse gas emissions (GHG), energy consumption and land use of two grassland-based cow-calf beef systems in relation to their contrasted grassland management and animal production strategies. Based on repeated measurements over 2 years, we carried out a Life-Cycle Analysis on two systems designed on an experimental farm. The Aut-system was based on autumn-calvings that required budgeting for a sufficient quantity and quality of grass fodder stocks harvested to cover the high feed demands of winter-lactating cows. The Spr-system was based on spring-calvings so that the peak needs of the herd and the breeding cows coincided with peak pasture grazing period. Management of male calves relied on a more intensive use of concentrate in the Aut-system. This study showed that at identical beef live weight produced, the Spr-system required 18% more on-farm utilized agricultural area, excreted 14% more nitrogen and released 12% more enteric methane, but used 22% less mineral nitrogen fertilizer, 34% less fuel, 89% less off-farm fodder purchases, 73% less concentrate purchases and 5% less bedding straw purchases. Livestock emissions per animal were close between the two systems and accounted for 75% of gross GHG emissions. As the Aut-system had a higher animal productivity, it was able to dilute this impact at identical live weight produced (4% higher gross GHG emissions in the Spr-system). This higher productivity also enabled the Aut-system to use less land (13% higher land use in the Spr-system) but relied on greater use of inputs (31% lower energy consumption in the Spr-system). As the Aut-system involved a lower surface area to produce beef, it reduced the potential of carbon storage by grassland to offset gross GHG emissions. This is the reason why the Spr-system led to 9% lower net GHG emissions. This mixed bag of results raises the question of the relative weight lent to each environmental impact and of the complementarities between strategies in grassland-based systems at region-wide scale.

1. Introduction

In the Charolais area, a pastureland region of specialized beef cattle farming in the French Massif Central, the downstream value chain wants to push its offer of store male calves in the off-season (June–July) so as to better gear livestock supply to market demand. To meet this raising commercial objective, cow-calf producers can pick from a variety of grassland management and animal production strategies including changing the calving period which was traditionally in spring. In a global context where livestock farming has been under fire as a driver of negative impacts on climate change, energy consumption and land use (Milne, 2005; Steinfeld et al., 2006), there is a need to understand the impacts of these new breeding strategies.

In the last decade, a large number of studies have been carried out to assess the environmental impacts of different farming systems (Bockstaller et al., 1997; Van der Werf and Petit, 2002; Halberg et al., 2005) including beef livestock systems (Casey and Holden, 2006; Beauchemin et al., 2011). These studies have implemented a number of methods including Life-Cycle Analysis (LCA) which is a holistic method to evaluate the use of resources and emission of pollutants during the entire life cycle of a product (Lee et al., 1995; De Vries and De Boer, 2010; Place and Mitloehner, 2012). These analyses have aimed to compare the impacts of different systems according to types of production, scales and breeding practices. For example, they have investigated

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different steer finishing strategies (Pelletier et al., 2010), suckler vs suckler-to-finish systems (Eady et al., 2011), specialized vs mixed-livestock systems featuring different combinations of animals produced (male/female, age and finishing schemes) (Veysset et al., 2010), grassland vs non-grassland systems (Pelletier et al., 2010; Ridoutt et al., 2011). The LCAs performed have mainly been based on farm-modeling data rather than field data (Veysset et al., 2014).

The objective of our research was to analyze and compare the impacts on greenhouse gas emissions (GHG), energy consumption and land use of two grassland-based cow-calf beef systems in relation to their contrasted grassland management and animal production strategies. These two systems were studied on an experimental farm of the Charolais area over two years. They were designed to sell store male calves in June in line with the market demand but with distinct strategies coherent with their calving period: either spring or autumn. As collecting good-quality well-documented data is a key pillar of LCA-method reliability (Lee et al., 1995), we carried out a LCA based on repeated measurements.

2. Materials and methods

LCA offers a transparent method for assessing the environmental impacts tied to the life cycle of a product. Such approach requires to define precisely the boundaries of the studied system and to quantify the emissions of pollutants and the use of resources along the production cycle of one functional unit, which is the main function of the production system expressed in quantitative terms (De Vries and De Boer, 2010; Veysset et al., 2014). For convenience, the different factors causing the emissions of pollutants and the use of resources will be grouped in the following text under the generic term of "sources of environmental impacts" (SEI).

2.1. Characteristics of autumn and spring calving systems

This experimental animal trial was performed in full compliance with all governing French ethics and welfare legislation. Two Charolais beef cow-calf systems were set up in 2010 on the Jalogny experimental farm (N 46°25′ 6.251″ E 4° 37′ 49.511″) and tracked over two production campaigns: 2011 and 2012. Each 12-month-long production campaign started in late March with a rotational grazing period (lasting about 8 months) followed by a period overwintering indoors in deep bedded freestalls until the following spring. The two systems were grassland-based systems that aimed to use a modest level of feed supplements to produce store male calves which could be sold in June, in line with the market demand. To achieve this goal, each system was managed under its own grassland management and animal production strategies. Animal production strategy embraced the choice of the calving period and the feeding strategy (Fig. 1).

The autumn-calving system ('Aut') was based on calvings from August to October that required budgeting for a sufficient quantity and quality of fodder stocks harvested to cover the high feed demands of winter-lactating cows. The nutritionally-rich winter rations were based on a large share of early-mown pasture as silage (60% of winter rations) mixed with hay (40% of winter rations).

Male calf management was relatively intensive (1.2 kg DM of concentrate/calf per day) in an effort to get them to the target weight of 350 kg ready for sale directly post-weaning at 8–10 months.

The spring-calving system ('Spr') was based on calvings from late-February to April so that the peak needs of the herd and the breeding cows coincided with peak pasture production. Winter-season rations were hay-based (65% of winter rations) but also included grass baled silage (35% of winter rations). After weaning in November at 8–10 months of age, male calves were overwintered indoors then turned back out to pasture, after which they were sold at age 14–16 months at a target live weight of 450 kg. The more extensive management of male calves was less reliant on concentrate inputs than the Aut-system (0.5 kg DM of concentrate/calf per day). In both systems, winter rations of cows and heifers were complemented with small amounts of concentrate.

Cow-calf systems are the primary source of impact for beef production (Beauchemin et al., 2010; Nguyen et al., 2012) and a lot of cattle breeders of the Charolais area only produce store animals which are sold and finished in Italy. This is the reason why we did not include the finishing phase of animals in our trial. The two systems had a similar number of calvings (Table 1) at just over 50 a year (the light difference

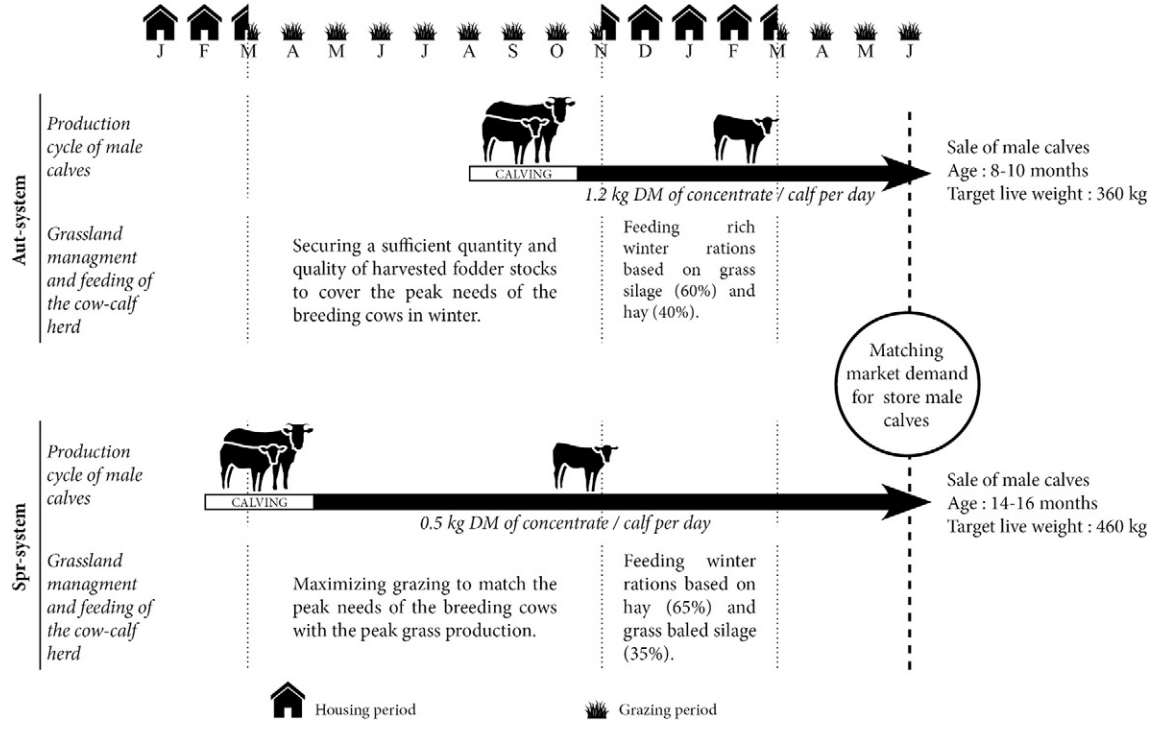

Fig. 1. Grassland management and animal production strategies of the two systems.