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The effect of farmer and advisor perspectives about calf rearing practices on dairy farms in England: "There might be other priorities"

Ph.D. Thesis

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Abstract

Despite the vital importance of replacement heifer calves to farm performance and the future dairy herd, there is evidence of high morbidity and mortality. This research aimed to explore potential reasons for poor calf performance by exploring calf management on dairy farms through 40 in-depth face-to-face interviews with farmers, farm workers, designated calf rearers, veterinarians and other advisors including feed company representatives. Interviews were recorded and subsequently transcribed in preparation for thematic analysis. The main focal topics which emerged from the data were: colostrum management, preweaning calf nutrition, disease management, and the perceived value of calves, calf performance data and advice. All participants stressed the importance of colostrum being fed to calves, but the importance of feeding sufficient quantity of high quality colostrum quickly after birth (the 'Three 'Q's) appeared to be more widely recognised than hygiene practices and quantification of passive transfer of immunity and challenges with the practical implementation of advice and recommendations were evident. There were a large range of calf feeding practices used on participating farms, largely based on perceived calf performance, and the simplicity, efficiency and cost- or time-effectiveness of their feeding practices versus potential alternatives. Results also pointed to conflicting recommendations for calf feeding, which may contribute to the failure of farmers to feed calves sufficiently to align with their physiological needs and recommended growth targets, suggesting advisory efforts need to be improved. With regards to disease management, participants emphasised the role of good stockmanship and attention to detail for preventing, or limiting the negative effects of disease. Advisor and farmer participants believed that good husbandry could mitigate the problems associated with housing calves in suboptimal conditions, but in many cases calf feeding is assigned to a general farm worker rather than a designated calf rearer. Although industry have promoted youngstock management as key to farm economic efficiency, it appears that calves often have not been fully integrated into the whole dairy farm system, nor culturally as an integral part of the productive herd. These results indicate a culture shift is needed within the dairy industry and associated advisory services which could be aided by improved technical and support structures to foster action towards improved calf wellbeing. This thesis adds to the literature (e.g. Escobar & Buller 2014, Rose et al. 2018) which calls for social change approaches that address the wider context within which farming take place.

Declaration

I declare that this PhD thesis is the result of my own work and has not been previously submitted for a degree or any other qualification at this University or another institution.

Two chapters (4 and 5) have been published in peer-reviewed journals:

Ch 4. Palczynski LJ, Bleach ECL, Brennan ML and Robinson PA (2020) Giving calves 'the best start': Perceptions of colostrum management on dairy farms in England. *Animal Welfare* 29: 45–58.

Ch 5. Palczynski LJ, Bleach ECL, Brennan ML and Robinson PA (2020) Appropriate Dairy Calf Feeding from Birth to Weaning: "It's an Investment for the Future". *Animals* 10: 116.

Chapter 6 has been submitted for publication in peer-reviewed journal:

Ch 6. Palczynski LJ, Bleach ECL, Brennan ML and Robinson PA (unpublished) Stakeholder perceptions of disease management for dairy calves: "It is just little things that make such a big difference". *Animals*

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List of Abbreviations

AHDB - Agriculture and Horticulture Development Board

AFC - Age at first calving

BRD - Bovine Respiratory Disease

bTB - Bovine Tuberculosis

BVD - Bovine Viral Diarrhoea

CHAWG - Cattle Health and Welfare Group

CMR - Calf Milk Replacer

DEFRA - Department for Environment, Food & Rural Affairs

EU - European Union

FAWC - Farm Animal Welfare Committee

Ig - Immunoglobulin

ME - Metabolisable energy

NSAID - Nonsteroidal anti-inflammatory drug

RUMA - Responsible Use of Medicines in Agriculture

UK - United Kingdom

1. Introduction

The purpose of this thesis is to explore the beliefs and experiences of dairy farmers, calf rearers, and key advisors in England relating to calf management practices on dairy farms. In-depth qualitative interviews were used to gain insight into the individual experiences and perspectives from dairy farm managers, herd managers, calf rearers and advisors including youngstock veterinarians and industry representatives. Analysis of these findings explored the ways in which dairy calves, particularly replacement heifers, are reared.

Correct rearing of replacement heifers is of great financial importance to dairy enterprises, contributing to the efficiency and the future health, survivability and performance of the dairy herd (Boulton et al. 2017). Legislation sets out minimum requirements for calves (The Welfare of Farmed Animals (England) Regulations 2007 and EU Council Directive 2008/119/EC, outlined in the Code of Recommendations for the Welfare of Livestock (DEFRA 2003)) and industry efforts have promoted recommendations for best practice (e.g. *Calf to Calving Initiative* (AHDB Dairy 2021), *Keeping Britain's Youngstock Healthy* (MSD Animal Health 2018)). However, despite legislative requirements, plentiful guidance for calf rearers, and the recognised importance of calves to farm performance, much research indicates that sub-optimal calf performance occurs on dairy farms, resulting in high incidences of morbidity and mortality (Hultgren et al. 2008, Brickell et al. 2009, Johnson et al. 2017). This poses problems for the profitability of farms, as well as the health and welfare of calves. Most research that has been conducted to date has focused on *what* management practices are used on farms (e.g. Boulton et al. 2015, Wormsbecher et al. 2017, Robbers et al. 2021). This thesis contributes important insights into *why* different calf rearing practices might be performed on farms.

The application of social science approaches to applied animal health and welfare can yield useful insights into the priorities and rationale behind actions regarding animal husbandry practices on farms (Christley & Perkins 2010, Escobar & Buller 2014, Wauters & Rojo-Gimeno 2014). Farmers' behaviour is influenced by a complex range of interrelated factors from personal and farm-specific traits, to their social interactions and cultural contexts (Escobar & Buller 2014, Rose et al. 2018a). Farm advisors including veterinarians, feed merchants and pharmaceutical company representatives are often key information sources for farmers (Redfern et al. 2021), and their areas of expertise, communication techniques and advice offered may influence what farmers are aware of and encouraged to act upon (Kristensen & Enevoldsen 2008, Richens et al. 2016, Croyle et al. 2019). The overall aim of this doctoral research was to gain a holistic understanding of why recommended calf rearing practices are, or are not, used on dairy farms.

To investigate how human contexts, perspectives and experiences influenced calf rearing on dairy farms, 40 face-to-face, in-depth, semi-structured interviews were conducted between May 2016 and June 2017. Detailed information about this process is included in Chapter 3, and sections 4.2, 5.2, 6.2, and 7.2, with a short summary presented here. Participants included a range of both farmers and advisors, specifically; farm managers, herd managers, calf rearers, farm workers, veterinarians (including a pharmaceutical company advisor and government policy advisor), and feed company representatives. Interviews were conducted in batches according to geographical location, with participants from the South West of England, Midlands, and Yorkshire, and included a range of farming systems. The spread of participants strengthened the study by providing a range of farm sizes, contexts and experiences to inform theory generation. Thematic analysis was conducted in stages. First, interviews were audio recorded and transcribed in full, with consent. Interview transcripts were thematically coded and grouped into themes, with the main topics constructed relating to colostrum management, pre-weaning calf feeding, calf disease management, value of calves, calf performance monitoring, and advice about calf rearing. These themes are addressed in Chapters 4-7, with the overarching themes discussed in Chapter 8.

Colostrum is of vital importance to calves as it provides maternal immunoglobulins to confer protective immunity to calves (Blum 2003). Good colostrum management can be achieved by following recommendations commonly referred to as the 'Three 'Q's to ensure that calves receive sufficient 'Quantity' of good 'Quality' colostrum 'Quickly' after birth (Patel et al. 2014; AHDB Dairy 2018). Newer additional recommendations extend the number of 'Q's to five, including 'Quantification of passive transfer' and 'sQueaky cleanliness' of colostrum (Hart 2016). However, research commonly identifies high rates of failed passive transfer from colostrum (Beam et al. 2009, Macfarlane et al. 2015, Cuttance et al. 2017) and suboptimal colostrum management practices on farms (Kehoe et al. 2007, Vasseur et al. 2010a, Morrill et al. 2012), though the reasons for this are unclear. Chapter 4 aims to help to address this knowledge gap, discussing valuable insights into the challenges associated with colostrum feeding. Whilst colostrum management was considered important for calf rearing in the dairy industry, difficulties in achieving best practice were evident. Quantification of passive transfer and the importance of hygiene were areas which tended to be the most overlooked, suggesting the need to raise the profile of these additional 'Q's of colostrum management. Other challenges included; making time to feed colostrum to calves - particularly at night, harvesting sufficient quantities of good quality colostrum to store and feed to calves, and preventing transmission of Johne's disease to calves. Advisory efforts could also better focus on *how* to improve practices whilst considering the (perceived) challenges and constraints on individual farms.

Following the feeding of colostrum in the first days of life, calves' diets must support the development of their digestive function from the milk-fed pre-ruminant phase through the transition into a functional ruminant (Drackley 2008). The provision of nutrients must exceed calves' maintenance requirements (Drackley 2008) to sustain growth rates of approximately 0.75 kg/day to achieve adequate body weight and stature to calve for the first time at 24 months of age, in line with industry targets (Wathes et al. 2014). However, the underfeeding of calves is a common concern (Vasseur et al. 2010a, Lorenz et al. 2011c, Sumner & von Keyserlingk 2018), contributing to poor welfare (Thomas et al. 2001, Krachun et al. 2010, Rosenberger et al. 2017); these issues are explored in Chapter 5. Results indicated that the standard of calf feeding was less than ideal in the dairy industry. Although the importance of pre-weaning calf feeding was well recognised, there was a lack of consensus regarding what the 'best' calf feeding protocols were to meet calves' physiological and nutritional requirements. There was debate surrounding the cost-effectiveness of different feeding strategies and the trade-offs they bring regarding rumen development, gastrointestinal health, and growth rates pre- and post-weaning (Khan et al. 2011, Soberon et al. 2012, Heinrichs & Gelsinger 2017). This uncertainty in the academic research literature was compounded further by the feed industry vying to have the 'best' products available to serve any purpose the farmer wants - including some milk replacers which are marketed as being suitable for once-a-day milk feeding from 1-2 weeks of age which is contrary to legislative and calf physiological requirements (van der Burgt & Hepple 2013). This resulted in a range of feeding practices used on farms, with varying success in ensuring growth rates and calf health, suggesting that information and advisory efforts must be improved.

Contagious disease is the leading cause of mortality in calves under 6 months of age (Brickell et al. 2009, Johnson 2011) and surviving calfhood disease affects future performance and longevity of dairy cows (Heinrichs & Heinrichs 2011, Closs & Dechow 2017), conferring economic costs (Boulton et al. 2017, Bartram et al. 2017, Closs & Dechow 2017). Disease management is essential to prevent or mitigate the effects of calf illness (Nordlund & Halbach 2019, Johnson et al. 2021), but achieving high standards of disease control is ultimately dependent upon the persons responsible for planning and conducting preventative measures (Brennan & Christley 2012, Brennan et al. 2016). Chapter 6 explores the perceptions of farmers, farm workers, veterinarians, and farm advisors about the management of calfhood disease on dairy farms. The findings reveal that good stockmanship is believed to minimise the negative effects of suboptimal calf housing through good attention to detail, although further research is needed to better understand how different actors define attention to detail. It is recommended that efforts that promote disease management practices focus on the mindset, experiences and

priorities of the persons responsible for calf rearing and controlling farm finances, in addition to technical, practical solutions.

The perceived importance of calves, and related investments, depend on the assumptions and value judgements made by farmers (Moran 2009a), and dairy farmers have been shown previously to underestimate the cost of rearing replacement heifers, resulting in calves being considered a lower priority in management and investment decisions (Mohd Nor et al. 2015). A lack of calf performance data (Bach & Ahedo 2008) on dairy farms contributes to ambivalence about assessing routine calf management practices (Sumner et al. 2018a). Thus veterinary involvement often is not sought in the area of calf rearing (Hall & Wapenaar 2012, Pothmann et al. 2014). Chapter 7 explores the perceived value of youngstock and the role of calf performance monitoring and advice on dairy farms. The results indicate that calves often have not been fully integrated into the whole dairy farm system, nor culturally as an integral part of the productive herd, suggesting a culture shift is needed within the dairy industry and associated advisory services. Improved technical and support structures might help achieve greater focus on *how* to achieve rearing targets and increase the (perceived) usefulness of calf data.

Chapter 8 discusses the thesis' strengths and limitations, its key findings, and overall conclusions which were generated from the data. Experiences and beliefs about calf care on farms (section 8.1), were summarised in terms of the need to get the basics right, and the need to "make do" in suboptimal circumstances. Experiences relating to farmer information seeking and providing advice informed the recommendation to change the advisory approach to help address the knowledge-practice gap (section 8.2). This thesis adds to the literature (e.g. Escobar & Buller 2014, Rose et al. 2018) which calls for social change approaches that address the wider context within which farming take place.

2. Literature Review

2.1. The importance of rearing replacement dairy heifers

Rearing replacement dairy heifers is critical to farm economic efficiency (Boulton et al. 2017), contributing to the future profit and sustainability of farms, and the dairy industry as a whole (Boulton et al. 2015b). The annual cost of rearing replacement heifers is estimated to be the second-highest variable cost on dairy units after feed for the milking herd, accounting for approximately 20% of total production costs (DairyCo 2015). In a study involving 101 UK dairy farms, Boulton et al. (2017) showed that the mean cost to rear a replacement heifer to first calving was £1819, but this cost varied considerably according to different farm factors and management decisions regarding reproduction and grazing. In particular, age at first calving (AFC) accounted for 35% of the variation in the total cost of rearing; calving at 23 months reduced the average expenditure by 17.1% and costs increased progressively up to 25.2% more expensive for an AFC of greater than 30 months. Birth to weaning has been consistently shown to be the most expensive phase of heifer rearing (Gabler et al. 2000, Heinrichs et al. 2013, Boulton et al. 2015b) reflecting high costs of milk feed and labour for pre-weaned calves (Boulton et al. 2015b).

Dairy farms require a steady supply of herd replacements to maintain or grow their herd size and allow for culling of unhealthy or less productive animals to maintain a healthy, profitable herd (De Vries 2017). A farm's need for replacements is based on the number of heifers required each year to maintain or increase herd size; this number is influenced by culling/mortality rates and reproductive efficiency in replacements and the milking herd (Tozer & Heinrichs 2001). Average AFC is a key determining component of a farm's replacement policy and influences the amount of housing required to meet the requirement; for example, a 100 cow herd with a 20% culling rate requires 20 replacement heifers each year, if heifers calve at 24 months, facilities are needed to manage 40 heifers, if calving at 3 years, the farm must manage 60 heifers. Replacement heifer calves also contain the genetic potential for cumulative improvements to the health and productivity of the future dairy herd. If there are insufficient numbers of replacement heifers, farmers may lower their replacement rate by reducing culling within the milking herd, potentially retaining animals that do not meet their production, health or reproductive standards, or purchasing replacements (Tozer & Heinrichs 2001) which poses a biosecurity risk (Sibley 2010, Sayers et al. 2013).

The early stages of rearing are of vital importance to the future profitability of dairy breeding stock; high growth rates (recommended average gains of 0.7-0.8 kg/day (Wathes et al. 2014)) and reduced disease incidence improve the survival and productivity of the mature cow (Wathes et al. 2008, Bach 2011, Van De Stroet et al. 2016). An AFC of 24 months is recommended for both financial and physiological reasons (Boulton et al.

2017). However, heifers must achieve an adequate body size of 80-90% mature bodyweight before calving to avoid compromising their health and milk production potential (Bach & Ahedo 2008, Wathes et al. 2014), requiring increased milk feeding rates equivalent to 15-20% of bodyweight compared to traditionally fed allowances of 10% bodyweight (Khan et al. 2011). Whilst providing a higher plane of nutrition equivalent to 15-20% of bodyweight incurs higher daily feed costs, that increased expenditure is recouped when heifers calve at a younger age due to savings on labour, housing and overall feed costs (Tozer 2000, Boulton et al. 2015b) and the earlier onset of milk production.

The effect of calf rearing on whole-life health and performance of dairy cattle are thought to be due, at least in part, to epigenetic programming (Soberon et al. 2012). According to Berger et al. (2009), "an epigenetic trait is a stably heritable phenotype resulting from changes in a chromosome without alterations in the DNA sequence" which occur in response to changes in the environment. In the context of calf rearing, early-life nutrition and disease/health status influence gene expression such that the provision of an optimal rearing environment - maintaining calves in good health, and providing them with an appropriate diet - means that a heifer's full genetic potential is harnessed for optimal performance as an adult (Soberon et al. 2012, Bach 2016, Kesser et al. 2017).

To promote high growth rates, earlier AFC, and survival past the rearing cost repayment period, it is important to ensure good calf health and reduce risk of disease and mortality (Cooke & Wathes 2014, Wathes et al. 2014, Boulton et al. 2017). The Welfare of Farmed Animals (England) Regulations 2007 and EU Council Directive 2008/119/EC outline minimum requirements for calf rearing and stockpersons are expected to be aware of their responsibilities to farm animals, as outlined in the Code of Recommendations for the Welfare of Livestock (DEFRA 2003). Commercial industry companies and advisory organisations have also made consistent efforts to disseminate information to producers about the importance of rearing replacement heifers using a range of campaigns, for example the *Calf to Calving Initiative* (AHDB Dairy 2021), *Keeping Britain's Youngstock Healthy* (MSD Animal Health 2018), *LifeStart Programme* (Trouw Nutrition 2016), *Feed for Growth* (Volac 2015), *Colostrum is Gold* (AHDB 2021). These aim to educate producers about the importance of achieving first calving by 24 months, suggesting ways to improve calf growth, health, and survival to achieve rearing targets.

2.2. Recommended calf management practices

In addition to the economic importance of calf rearing outlined above, animal welfare is an important ethical consideration and the Five Freedoms are written into UK law - the Welfare of Farmed Animals (England) Regulations (2007) requires that the welfare needs of animals are met. However, more recent thinking is that focus should shift from merely

preventing harm to animals, but also provide them with positive experiences towards a life worth living, or a good life (Webster 2016, Mellor 2016a). To achieve the above-listed rearing targets and maintain good calf health and welfare, farmers should aspire to adhere to the "Five 'C's", critical control points for successful calf rearing: colostrum, calories, comfort, cleanliness, and consistency (McGuirk 2009). These areas will be discussed in more detail in later chapters, and a brief summary of each 'C' is provided below.

Colostrum contains components that influence the development of the gastrointestinal tract and the nutritional, metabolic and immune status of calves (Blum 2003). Maternal antibodies (mainly Immunoglobulin (Ig) G) are of particular importance as they cannot be transmitted in-utero, so the passive transfer of immunity to calves is dependent upon sufficient absorption of Ig from colostrum consumed shortly after birth (Godden 2008). There are recommended guidelines for colostrum management to promote successful passive transfer: the "Five 'Q's", referring to sufficient Quantity of high Quality colostrum Quickly after birth; it should be sQueaky clean and rates of passive transfer should be Quantified to assess the success (or failure) of passive transfer resulting from the colostrum management protocols being used on-farm (Godden 2008, Hart 2016). However, evidence from the research literature indicate high levels of failure of passive transfer (Beam et al. 2009, Macfarlane et al. 2015, Cuttance et al. 2017) and poor colostrum management practices (Kehoe et al. 2007, Vasseur et al. 2010a, Morrill et al. 2012) occur on farms.

Calories refers to the need to feed calves an appropriate diet which provides adequate nutrition to support maintenance functions (immunity, thermoregulation) and requirements for growth (Drackley 2008). Due to calves' transition from pre-ruminant to functional ruminant, calves up to 28 days of age require twice daily milk feeds (which equate to 20% of calf bodyweight (Khan et al. 2011)), with roughage, concentrates and drinking water available to support development of the rumen so that they can be successfully transitioned to a solid diet through weaning (Drackley 2008, van der Burgt & Hepple 2013). Calories are extremely important with regards to the thermal comfort of calves; milk-fed calves require additional energy to keep warm when temperatures drop below 10˚C (National Research Council 2001); if insufficient calories are fed to cover this deficit, resources will be diverted from growth, reducing daily gains and potentially impacting AFC (Wathes et al. 2014). Furthermore, malnutrition is associated with immunosuppression (Ollivett et al. 2012), so providing insufficient calories can leave calves more susceptible to infectious diseases. Research literature indicates that calf feeding practices on farms often do not adhere to recommended practices, and sometimes contravene legislative requirements (Vasseur et al. 2010a, Boulton et al. 2015b) and the underfeeding of calves

is a common concern (Vasseur et al. 2010a, Lorenz et al. 2011c, Sumner & von Keyserlingk 2018).

Comfort mainly concerns the housing of calves, ensuring their accommodation is dry, bright, soft, warm and well ventilated (Nordlund & Halbach 2019). Calves lie down for approximately 17 hours/day (Bonk et al. 2013, Calvo-Lorenzo et al. 2016) so should be provided with plenty of clean, dry bedding and shelter from draughts and wind (McGuirk 2009). Greater space allowances (Calvo-Lorenzo et al. 2016) in calf housing with adequate ventilation and drainage (Brown et al. 2021) may improve calf health and performance. Thermal comfort is important; below their critical temperature of 10˚C, calves expend energy to keep warm (National Research Council 2001). However, attempts to protect calves from wind and draughts in buildings designed for older livestock might result in the restriction of ventilation at the calf level, resulting in the accumulation of pathogenic bacteria in the pens which increases the prevalence of respiratory diseases in calves (Lago et al. 2006). Providing deep straw bedding material for calves to "nest", such that their legs are not visible when lying down (Lago et al. 2006, Nordlund & Halbach 2019), and calf jackets (Robertson 2020, Bell et al. 2021) can help calves to keep warm in sufficiently drained and ventilated calf microenvironments (Nordlund & Halbach 2019). Furthermore, Hyde et al. (2020) reported that environmental conditions had significant impact on calf mortality rates in the UK, and estimated that if optimal conditions could be maintained throughout the year by improving calf housing, overall annual calf mortality between 0-3 months of age could be reduced to <2%, equating to a saving of approximately £11.6 million per year.

Cleanliness is important to limit calves' exposure to disease-causing pathogens (McGuirk 2009). Biosecurity practices should be maintained to avoid transmission of disease from older to younger animals (Nordlund & Halbach 2019). Good hygiene practices are essential in colostrum management to avoid bacterial contamination which can interfere with the absorption of immunoglobulins from colostrum (Godden 2008). Sanitary calf housing and feeding equipment also contribute to good calf health (Khan et al. 2011, Curtis et al. 2016) and unhygienic practices contribute to increased rates of diarrhoea in calves (Appleby et al. 2001, Jasper & Weary 2002).

Consistency in calf management is important to limit the stress experienced by calves when they are required to adapt to change e.g. in feeding or housing (Mcguirk 2010) and can facilitate good calf husbandry (McGuirk 2009). Inconsistent milk feeding (i.e. variable volume, concentrations, temperature and/or meal times) negatively affects calf performance (Hill et al. 2009). Routine observation of calves enables stockpersons to take action if a calf is exhibiting a change in behaviour or appearance which might be indicative of disease (McGuirk 2008). Standardised scoring systems, like the one developed by

Mcguirk & Peek (2015) which attributes severity scores for calf rectal temperature, cough, nasal discharge, ocular discharge or ear position, can be used as a screening tool on farms to aid the early detection of respiratory disease (Mcguirk & Peek 2015). Early administration of treatments contributes to greater treatment success, reduced recurrence of illness, and the prevention of long-term damage (McGuirk 2008, Lorenz et al. 2011a).

2.3. Evidence of suboptimal calf rearing

Despite the genetic and economic importance of dairy replacement heifers and the provision of guidelines for successful calf rearing, international research evidence of high incidences of morbidity and mortality in dairy calves (Hultgren et al. 2008, Brickell & Wathes 2011, Windeyer et al. 2014) indicates that youngstock management is often suboptimal. In the UK, mortality rates have been shown to be twice as high for dairy calves compared to beef calves (6.00% and 2.86% respectively) in the first three months of life (Hyde et al. 2020). In a study involving 19 UK dairy farms, approximately 14% of potential replacement heifers failed to reach first lactation, though reasons for calf mortality were poorly recorded (Brickell & Wathes 2011). High morbidity and mortality rates in young animals are indicative of poor welfare (Mellor & Stafford 2004, Ortiz-Pelaez et al. 2008) and are likely to be linked to risky management of calving, colostrum and feeding practices which contribute to calf ill-health (Vasseur et al. 2010a, 2012). Mortality rates are higher for dairy-bred bull calves compared to heifer calves (7.37% compared to 4.96% respectively) (Hyde et al. 2020) and the management of male calves is often subpar compared to that of female dairy replacements (Renaud et al. 2017, 2018).

Infectious diseases, particularly diarrhoea and respiratory disease, have been shown to be common calfhood afflictions (Svensson et al. 2006, Hultgren et al. 2008). Awareness of these health concerns is not new - Waltner-Toews et al. (1986) reported that heifers treated for pneumonia during the first three months of life were more likely to die after 90 days of age than untreated calves, and heifers treated for scours were significantly less likely to calve before 30 months of age. However, calf illness is still prevalent in many modern systems. In a cohort study involving 492 heifer calves on 11 UK dairy farms, 48.2% of preweaned calves were diagnosed with diarrhoea and 45.9% with bovine respiratory disease, and some farms had rates of infectious disease greater than 70% (Johnson et al. 2017).

2.4. The human element of calf management

There are many risk factors which impact on animal health and welfare, both primary factors acting directly on the animals, and secondary factors which acknowledge the influence of humans on animal management and the control of primary risk factors (Whay 2007). Calf and heifer rearing requires significant cost investment, and mortality incurs a considerable economic toll, but these financial implications involve largely hidden costs

(Bach & Ahedo 2008). Farmers may not fully appreciate the importance and cost of calf rearing. Mohd Nor et al. (2015) reported that 32 of 37 Dutch dairy farmers surveyed underestimated the cost of rearing, particularly undervaluing the costs of housing and labour. Replacement stock can often be a secondary consideration, with the limited staff time available being concentrated on management of the milking herd which generate immediate income (Boulton et al. 2017); calf issues do not appear to be prioritised by farmers (Mee 2013). Recognition of the value of youngstock management relies upon value judgements made by farmers (Moran 2009b) which may be hindered by a lack of sufficient records, particularly regarding calves (Bach & Ahedo 2008). The Jonkos tool (Mohd Nor et al. 2015) or similar system to clarify the cost of rearing for farmers may help to shift their mindset to prioritise investments in calf management and facilities. However, farmers' decision making is not based on economic considerations, nor rational judgement alone; socio-psychological factors also influence farm practices (Ritter et al. 2017).

Social science methodologies are increasingly used to explore the human aspects of animal health and welfare (Wauters & Rojo-Gimeno 2014). Qualitative social science methodologies are useful tools in understanding topics which cannot be investigated quantitatively (Christley & Perkins 2010). It has been found that farmers' perceptions, priorities and emotional responses to lameness can affect the time taken to administer treatment (Horseman et al. 2014), suggesting a direct link between farmer values and animal welfare. Furthermore, internal differences concerning farmers' openness to external information and their interaction with the outside world may impact on the effectiveness of communication strategies (Jansen et al. 2010). Where producers perceive recommended practices to be irrelevant, or to have negative impacts on the animals, they are unlikely to adopt them, despite financial incentives (Dwane et al. 2013). In addition, the interest shown and quality of support given by veterinarians can influence the development of herd health plans as useful management tools (Burke & Roderick 2006), indicating that better understanding of farmers could lead to more effective advisory efforts.

Qualitative research about calf rearing has been conducted elsewhere, including in the Netherlands, Denmark, and Canada. Santman-Berends et al. (2014) identified Dutch farmers with structurally high calf mortality rates as those who: were partly, or not at all aware of high calf mortality; felt powerless and unable to solve the problem; or were aware there may be a problem but were reluctant to change their practices. Interviews with Danish farmers revealed that perceived self-efficacy and control over the problem, as well as time management which allowed 'flexible time' to deal with unexpected issues could prevent problems with calf mortality from developing into permanent crises (Vaarst & Sørensen 2009). In addition, access to calf benchmarking data challenged the notion

that calf rearing is a simple task which did not need to be discussed (Sumner et al. 2018a) and motivated farmers to make alterations to their calf feeding practices by providing objective, tangible assessment criteria and opportunities for peer-to-peer exchange (Sumner et al. 2018a, 2020).

In their review of the literature relating to farmer behaviour change, Rose et al. (2018) noted seven key factors that influence farmer behaviour: (i) personal factors including age, gender, experience, education, attitudes and beliefs; (ii) business factors such as farm size, cashflow, staff numbers, succession plans and profitability; (iii) family, peer and advisor networks; (iv) feeling in control of decisions and confidence in implementing practices; (v) incentives and rewards, referring to direct financial incentives to adopt a behaviour to compensate for the costs associated with change; (vi) market or compliance-based rewards - gaining higher prices or doing an activity that helps to satisfy compliance requirements; and (vii) information provision, education and clear communication. However, critics suggest that the majority of multidisciplinary research has been overly focused on personal factors and behaviour change at the level of individual farmers, and that more holistic investigations are needed to understand the wider circumstances, social interactions and cultural contexts within which farmers make decisions and take actions (Escobar & Buller 2014, Rose et al. 2018a).

Agricultural extension activities may also need to adapt in response to research about farmers' motivations and behaviour, as traditional "top-down" approaches used in knowledge transfer tend to assume that farmer decision making is rational and undervalue the farmers' knowledge, experience and personal factors (Ritter et al. 2017), and are often ineffective in motivating change (Rose et al. 2018a, van Dijk et al. 2019, Morgans et al. 2021). Veterinarians have been shown to misidentify the expectations and preferences of farmers in provision of herd health management programs (Kristensen & Enevoldsen 2008, Hall & Wapenaar 2012) and the veterinary profession generally lacks focus on and training in effective communication strategies (Bard et al. 2017, Croyle et al. 2019). Frustration at poor farmer uptake of advice might cause veterinarians to stop trying to influence farmers perceived as uncooperative (Richens et al. 2016, Redfern et al. 2021). Advisory efforts and animal welfare campaigns could benefit from a more holistic approach investigating policy, economics, societal pressures and technical feasibility at farm level (Rushton et al. 2007).

This PhD project aims to explore in-depth the reasons behind UK dairy producers' use of management practices and their perceptions of best practice, taking the wider social context into account in addition to farmers' personal values, beliefs and attitudes.

3. Methodology

The upcoming chapters in this thesis (Chapters 4-7) include detailed standalone methods sections which explain the recruitment of participants for, and data analysis conducted on, the 40 in-depth semi-structured face-to-face interviews which inform this thesis. To avoid unnecessary repetition, this methodology chapter will focus on the aspects not covered in detail in the following chapters.

3.1. Research Paradigm

As explained by Moon & Blackman (2014) in their guide to understanding social science research for natural scientists, qualitative research requires subjective interpretation of data, so it is important for the researcher to make explicit their research philosophy as a key influence on study design, data collection and analysis. Philosophical perspective is underpinned by the researcher's ontological and epistemological beliefs which influence how they derive meaning from their data (Flowers 2009).

Ontology refers to the researcher's belief about reality and the state of being. Realism holds that there is one objective reality. On the other hand, relativism holds that there are multiple realities constructed from, and dependent on, human experience (Moon & Blackman 2014).

Epistemology represents the researcher's belief about how reality can be known and observed (Moon & Blackman 2014). Objectivism assumes that meaning is derived from a physical entity and that an objective truth can be empirically verified. Constructionism believes that different individuals experience the same object or phenomenon in different ways, whereas subjectivism holds that knowledge is completely dependent upon how people perceive and understand reality (Moon & Blackman 2014).

Different combinations of ontology and epistemology form different theoretical perspectives. The two main groups of theoretical perspectives are: (post-) positivism, predominantly used in quantitative research - a single reality that can be objectively known and observed; and constructivism/Interpretivism, predominantly used in qualitative research - reality is based on human experience so knowledge of it must be constructed and interpreted.

3.1.1. Critical Realism

Critical realism is a research paradigm that assumes there is a real world which exists independently of our interactions with it. This realist ontology is paired with a constructivist epistemology which recognises that our knowledge of reality is imperfect and subjective; there will be many different interpretations and perspectives of this single objective reality (Easton 2010, Maxwell 2012). The world is seen to comprise of entities which contribute

to and cause events through their 'causal powers' (Easton 2010, Kempster & Parry 2011). Critical realists investigate the underlying causal processes of phenomena (Easton 2010). Since individual concepts and perspectives can affect outcomes, they are considered a real aspect of any reality (Fleetwood 2004, Maxwell 2012) and are worth investigating. Furthermore, the outcomes of causal powers are context-dependent (Kempster & Parry 2011). The world we live in is structured by our perceptions and experiences which are, to a large extent, expressed in language (Maxwell 2012).

In the context of this thesis, critical realism was chosen as a suitable research paradigm to explore human experiences relating to calf management on farms. This is on the basis that calf health and performance represents objective reality, but that the conduct and results of calf rearing are perceived relatively and these human experiences have real world consequences.

3.2. Research Method

There are a range of research methods that could be used to explore the perspectives, beliefs and experiences of dairy farmers, calf rearers and key advisors regarding calf management on English dairy farms and fulfil the aims of this thesis.

Quantitative research, predominantly using questionnaires, has been conducted with regards to calves, for example to investigate factors associated with high antimicrobial use (Holstege et al. 2018), mortality (Johnsen et al. 2021), and management practices (Vasseur et al. 2010a, Baxter-Smith & Simpson 2020). Using a questionnaire was not considered an appropriate research method for this thesis since statistical data cannot describe individual experiences, rather focusing on the quantification of self-reported practices (Rose et al. 2018a). Thus surveys are not well suited to understanding tacit knowledge (Christley & Perkins 2010), nor complex social relationships (Escobar & Buller 2014). Although questionnaires can be used as one element of a mixed methods approach which combines quantitative and qualitative approaches (Cameron 2009), it was felt that time and energy should be focused on qualitative methods which are more suited to answer the research question.

Ethnographic approaches like participant observation, would be a very useful methodology to understand links between participants' perspectives, actions, social processes and contexts (Clark & Emmel 2010, Helliwell et al. 2019). However, this practice is time consuming and costly compared to other methods, which would limit the number of participants considerably (Given 2006) and prevent this research from exploring a wide range of perspectives.

Focus groups, where a group of individuals are guided through discussion of their personal experiences of the research topic, are able to explore complex issues that are

comprised of multiple factors (Powell & Single 1996). This element of social interaction makes attitudes, feelings and beliefs more likely to be shared and elicit a range of views and emotional processes within a group context (Gibbs 1997). To my knowledge, focus groups have not been a common method to investigate issues around calf management, though previous studies have used them to explore dairy cattle veterinarian perceptions of calf welfare (Sumner & von Keyserlingk 2018), and farmer perceptions of a welfare scheme for beef calves (Dwane et al. 2013). Focus groups were initially intended to be included as part of this doctoral research, however, the challenging logistics of arranging multiple participants to meet together in one location meant that attempts to arrange focus groups were unsuccessful.

3.2.1. Semi-structured interviews

Face to face semi-structured interviews are well suited to gather rich, detailed data from participants who are asked questions designed to explore their personal experiences, attitudes, perceptions and beliefs related to a research topic. The structure of interviews come from their being based on a topic guide, but the form of the interview is more conversational and questions may be re-worded, re-ordered, or added to investigate topics introduced by the respondent (Tong et al. 2007). The language used by participants is considered essential to gain insight into their viewpoints and values (Newton 2010, Maxwell 2012). This method aims to understand the world from the interviewees' perspectives and explore subjective, tacit forms of knowledge (McIntosh & Morse 2015, DeJonckheere & Vaughn 2019). Thus, interviewing was chosen as an appropriate method for the current project to explore experiences relating to calf management on farms and in the wider dairy industry. Indeed, semi-structured interviews have been used previously to investigate attitudes and experiences relating to different calf rearing practices, systems and health/mortality outcomes (e.g. Vaarst & Sørensen 2009, Sumner et al. 2018, Vaarst et al. 2020).

However, it is important to note the limitations of semi-structured interviews. Firstly, the quality of the interviews are dependent on the skill (and experience) of the interviewer at producing a well developed topic guide, asking probing or follow-up questions, active listening, and building rapport with participants (DeJonckheere & Vaughn 2019). The validity of interviews can also be challenging to establish. The way in which the interviewer is perceived by interviewees may influence the information that they are willing to divulge, and participants might exhibit demand characteristics whereby what they say is affected by what they think is required (Newton 2010). There is also no guarantee that self-reported behaviours accurately reflect what happens in practice (Rose et al. 2018a). However, these problems can be mitigated; interviewing skills can be trained and learned, the purpose of the research should be made clear at the outset to reassure participants

that there are no right or wrong answers; and the interviewer should be mindful of how they portray themselves and build rapport with participants to encourage open, honest responses.

3.3. Analytic Approach

There are a range of analytic approaches that could be chosen to analyse the data generated from semi-structured interviews (Schmidt 2004). This thesis will use a primarily inductive approach in which the data content itself drives the developing analysis (Braun & Clarke 2006). Grounded theory (Glaser & Strauss 1967) was considered as a potential analytic approach for this work. Whereas phenomenological research is focused on the subjective experiences of individual actors to understand the research topic, grounded theory aims to generate theoretical statements about the social context and interactions of actors, to 'lift' data to a conceptual level, so grounded theory studies should not use interviews as their only source of data (Suddaby 2006). Furthermore, formalised theory development is often not achieved by research that claims to adopt a grounded theory approach, which may in part be due to its complexity and relative inaccessibility to novice researchers (Braun & Clarke 2006, Suddaby 2006).

3.3.1. Thematic Analysis

Braun & Clarke (2006) suggest that a more accessible method for novice researchers is thematic analysis as it does not require formalised theory generation and can be used within a range of theoretical frameworks, including critical realism. This method involves the identification of patterns (themes) to organise and describe a dataset in rich detail, enabling further interpretation of various aspects of the research topic. Themes are actively created by the researcher, chosen to identify a core concept that underpins observations from the data. Rich analysis can then move from simple description into the researcher's interpretation of the themes and the story they tell about the data and research topic (Clarke & Braun 2018). These characteristics of thematic analysis meant that it was selected as an appropriate method for this research project.

3.4. Data Collection and Analysis

Since I was responsible for data collection and analyses, it is important to reflect upon my potential influence on the interviews and results. Having graduated with a BSc (Hons) in Animal Behaviour and Welfare, I had heard from various researchers and veterinarians who were often frustrated by poor uptake of evidence-based recommendations for improving animal health and welfare. I was intrigued to understand more about the knowledge-practice gap and differing advisor/farmer perceptions, so I was attracted to the application of qualitative research methodologies to animal health and welfare issues. I do not come from a farming background, and had only limited knowledge of the dairy industry prior to embarking on this PhD studentship (my experience had been largely focused on

laying hens). This meant that I was able to be completely open-minded about the practices I saw on farms. I was not an expert, I was there to learn. However, my interview style would certainly have differed to that of a veterinarian or calf-focused researcher since I was limited in my ability to ask detailed probing questions. However, this was of little concern as the purpose of this research is to understand the perspectives and priorities of the participants, which should emerge from generic prompts.

In addition to establishing my theoretical framework and research/analytical methods, I also addressed my relative inexperience relating to the dairy industry in the first year of my PhD. I attended two practical calf rearing courses to gain understanding of basic calf physiology and the associated management practices alongside reading relevant scientific literature and industry recommendations as part of my literature review. These activities formed the basis of my data collection and analysis. This methodology chapter, together with sections 4.2, 5.2, 6.2, and 7.2 of this thesis, aims to provide insight into my practices in-line with recommendations for reporting qualitative research (Tong et al. 2007, Tracy 2010).

3.4.1. Design of the topic guide and informed consent

Two topic guides were designed, one for farmer participants and the other for advisors (Appendix I and II, respectively). For both guides, efforts were focused on creating open ended, neutral and clear questions, which could be supplemented by follow-up probes and prompts, (DeJonckheere & Vaughn 2019) to explore personal experiences related to calf management and opinions about calf rearing in the wider dairy industry. The farmer topic guide was designed to stimulate discussion about the farm's calf rearing practices from pre-natal management of the dam and the birth of the calf up to its first calving. Questions also aimed to investigate the perceived challenges, best practices and sources of information and advice. The advisor topic guide was focused on the participants' experiences of advising about calf management. These guides were not designed to provide rigid structure to the interviews, rather as a memory prompt for the topics to cover during a conversational interview style which covered the main areas of interest.

An information leaflet was created to provide participants with information about my background, the purpose of the research, and my contact details should they have any questions or wish to withdraw their consent for participation. Ethical considerations included the potentially sensitive nature of some topics of discussion, the participants revealing the use of illegal practices, or the researcher observing calves that were experiencing poor health and welfare. The research protocol was approved under project number 75-201511 by the Harper Adams University Research Ethics Committee on 13 January 2016.

3.4.2. Participant Selection

A convenience sample of participants was achieved through purposive and snowball sampling (Cohen et al. 2007). The first farmer interviewees were obtained by attending a farm walk hosted at Harper Adams University which had a calf focus; several attendees agreed to participate in the study. Other participants were existing contacts of the supervisory team, or Harper Network. I also attended trade events like UK Dairy Day in Telford where the feed representative agreed to take part, he then recommended his colleague who was responsible for managing the calf feeding products for the company. The majority of veterinarian participants were obtained by calling listed dairy practices and asking for interested veterinarians to take part. Some of these participating farmers, veterinarians and vet practices put me in contact with some of their contacts/clients who also agreed to speak to me.

This selection process achieved a range of participants (Tables 4.1, 5.1, 5.2). However, the voluntary nature of participation and purposive sampling meant that there was a bias towards individuals with a specific focus on calf rearing, particularly with regards to the advisors. This is not necessarily a weakness of the research, as it is important that interviewees have experiences and knowledge about the research topic to gain in-depth and detailed understanding of it (DeJonckheere & Vaughn 2019).

3.4.3. Conducting the interviews

The positionality of the interviewer was an important aspect to consider when conducting the interviews. I dressed appropriately and introduced myself as an inexperienced researcher curious to know more about the interviewee's experiences related to dairy calf management - the interviewee was the expert. Care was taken to present a friendly and non-judgemental attitude and maintain a conversational tone (DeJonckheere & Vaughn 2019).

As shown in Tables 4.1, 5.1, and 5.2, three interview formats were used: individual interviews in a seated setting, joint interviews with two to three participants interviewed together, or walking interviews during a tour of the farm and calf facilities. The participants were made aware when arranging the interview over the phone that they could invite others to participate if they wished, and that I would appreciate seeing the calf facilities if possible, but they were not required to inform me of their preferences ahead of time. Seated interviews with farmers were often due to poor weather, block calving systems meaning there were no/few calves to see, or the farmer simply didn't invite me to look around. Many walking interviews started, or ended, with a seated setting in the kitchen or farm office. All advisor interviews were conducted in an individual, sit down format, reflecting the solo nature of the advisory role and lack of farm facilities to tour.

At the beginning of this research, I was a novice interviewer, so after every interview I reflected upon my conduct, and I am conscious that my skills developed over the course of the project. The first seven interviews (with four farmers, two veterinarians, and one feed company representative) were considered pilot interviews in which the participants were specifically asked for their feedback on the questions asked and their experience of the interview. No significant changes were deemed necessary to the topic guide nor my interview style. In addition, data was collected and analysed using an iterative approach so that insights gained from previous interviews informed the ongoing interviews.

3.4.4. Transcription, Coding, and Development of Themes

I transcribed all interviews myself rather than using an external transcription service. Transcription was the first stage of analysis, allowing me to familiarise myself with the content of the interviews, and since data collection and analysis were conducted concurrently in an iterative approach, transcription provided an initial sense of the data which informed ongoing interviews.

Once the interviews were transcribed, I began coding, but due to my lack of previous experience, the process involved a large amount of trial and error to begin with. NVivo for Windows (Version 11.4.1.1064 Pro, QSR International Pty Ltd., Victoria, Australia) was very helpful in grouping extracts according to the descriptive, value and/or process code(s) (Miles et al. 2014) assigned to them. This initial coding informed ongoing interviews, and once data collection ceased, these codes informed the selection of the focal topics presented in the next chapters: colostrum management (Chapter 4), calf feeding and nutrition (Chapter 5), disease management (Chapter 6) and the perceived value of calves, data and advice (Chapter 7). These focal topics were then explored in more detail; relevant extracts were printed and individual excerpts cut out so that they could be physically arranged according to common topics, attitudes, beliefs, feelings, actions and consequences. Themes were then constructed by interpreting data to describe patterns and consider potential explanations. After these themes were chosen, key quotes were selected which were interpreted as being the best to describe the consensus between participants, demonstrate noticeably different views between participants, or that were considered particularly interesting in some way. There was a large time delay between data collection and establishment of the key themes so member checking was not conducted - experiences are time and context dependent so this validation technique might not reflect the lived experience of participants at the time of the initial interview (Birt et al. 2016)..

4. Giving calves "the best start": Perceptions of colostrum management on dairy farms in England

Once a calf is born, there are several factors which affect its health and welfare going forward. Perhaps the most important of these early-life practices is ensuring that calves consume colostrum for acquired immunity (Godden 2008). This chapter explores participants' perceptions about and understanding of colostrum management.

4.1. Introduction

The ingestion of colostrum is of great importance to bovine neonates as it provides nutritive and non-nutritive components that influence the development of the gastrointestinal tract and the nutritional, metabolic and immune status of calves (Blum 2003). Of particular importance are the high levels of immunoglobulin (mainly IgG) in colostrum (Godden 2008). Calves are born agammaglobulinemic so depend on the absorption of maternal colostral immunoglobulins through the wall of the small intestine in the first 24 hours of life (Weaver et al. 2000, Godden 2008). Failure of passive transfer from colostrum is diagnosed when calf serum levels of IgG or total protein are less than 10 g/L or 50 g/L, respectively (Patel et al. 2014). Failure of passive transfer increases calves' susceptibility to infectious disease and mortality (Wittum & Perino 1995, Raboisson et al. 2016), reduces growth rates (Robison et al. 1988), and has been linked to lower milk yield during their first lactation (DeNise et al. 1989). The total cost related to failure of passive transfer has been estimated as €60 per calf in European dairy systems, including costs related to mortality, morbidity and reduced average daily weight gain (Raboisson et al. 2016).

Current industry recommendations for colostrum management to promote successful passive transfer are based around principles commonly referred to as 'The Three 'Q's': 'Quantity', 'Quickly' and 'Quality' (Patel et al. 2014, AHDB Dairy 2018). Calves should consume a volume of colostrum equating to at least 10% of their bodyweight (3-4 L for a 30-40 kg calf) (Godden 2008). It is a legal requirement in England for calves to receive colostrum within six hours of birth (The Welfare of Farmed Animals (England) Regulations 2007 (as amended)); after six hours there is a progressive decline in the efficiency of immunoglobulin transfer across the gut epithelium until full gut closure at 24 hours of age (Godden 2008, Hart 2016). Calves should be artificially fed via nipple bottle or oesophageal tube due to concerns about the ability to attain sufficient immunoglobulin mass when suckling from the dam (McGuirk & Collins 2004, Patel et al. 2014). Immunoglobulin content of colostrum can be indirectly assessed using a colostrometer or Brix refractometer which measure specific gravity and total solids, respectively. Good quality colostrum contains over 50 g/L of immunoglobulin which equates to >22% (Brix) (Bartier et al. 2015). Samples with readings below 20 g/L or 22% (Brix) should be

discarded (AHDB Dairy 2018). Concentrations of immunoglobulin in colostrum have been shown to decline rapidly over time from calving (Moore et al. 2005) therefore colostrum should be harvested within six hours of parturition (Godden 2008). Pooling colostrum from multiple dams is not recommended; immunoglobulin content can be diluted (Weaver et al. 2000), and disease risk may be increased (Godden 2008).

Some extend recommendations from three to five 'Q's by including 'sQueaky clean' and 'Quantifying passive transfer' (Hart 2016). Bacterial contamination of colostrum interferes with absorption of immunoglobulins (Godden 2008) and total bacterial numbers and faecal coliform counts should not exceed 1 000 000 and 10 000 cfu/mL, respectively (McGuirk & Collins 2004). Colostrum should be collected hygienically and either fed or refrigerated within one hour of milking to impede rapid multiplication of microorganisms. Batch-pasteurisation of colostrum eliminates or at least significantly reduces pathogens, including *Mycobacterium avium* subspecies *paratuberculosis* which causes Johne's disease (paratuberculosis) in cattle (Godden 2008). Johne's disease can be spread from infected adult cattle to calves through ingestion of faecal matter or contaminated colostrum, and is a key reason to implement 'snatch calving' where calves are immediately removed from their dam and fed either colostrum from Johne's test-negative cows (Windsor & Whittington 2010) or colostrum replacement products (Godden 2008). Herd-based assessment of passive transfer, for example by monitoring serum total protein in healthy calves or zinc sulphate turbidity testing, can be used to evaluate colostrum management practices (McGuirk and Collins 2004; Hart 2016). Where high rates of failure of passive transfer are evident, colostrum protocols are more likely to be reviewed and improved (Atkinson et al. 2017, Sumner et al. 2018a).

It was first reported over 90 years ago that ingestion of colostrum confers protective immunity to newborn calves (Smith & Little 1922), yet problems achieving adequate passive transfer from colostrum remain evident at farm level. Failure of passive transfer was estimated to occur in 19.2% of dairy heifer calves in the US (Beam et al. 2009), and diagnosed in 26% of calves from 444 calvings across seven UK dairy farms (Macfarlane et al. 2015) and 33% of dairy calves in a study of 107 New Zealand dairy farms (Cuttance et al. 2017). Studies in various countries have demonstrated that colostrum management remains poor on many farms (Kehoe et al. 2007, Vasseur et al. 2010a, Morrill et al. 2012) suggesting that the scientific recommendations outlined above have failed to stimulate uptake of best practice by farmers. This could be because dissemination efforts have either failed to make farmers aware of recommended best practice, or have conveyed the information to farmers but did not motivate them to make improvements to their colostrum management. In either case, it is very important to understand why recommendations are not implemented on farms. Farmer attitudes, such as perceived control and ability to make

decisions and take action towards improving calf health, have been shown to influence husbandry practices related to calf mortality (Vaarst & Sørensen 2009, Santman-Berends et al. 2014). Where the alteration of management practices is considered unnecessary, impractical or unlikely to yield beneficial results, inaction is likely. On the other hand, positive beliefs about the potential for improvement, and the ease of implementation, are more likely to result in actions contributing to better calf management (Vaarst & Sørensen 2009, Santman-Berends et al. 2014).

Although farmers have a vital primary role, it is likely that both farmer and advisor perspectives and their interactions influence colostrum management on farms. For example, in response to benchmarking reports which included comparative passive transfer rates, many farmers consulted their veterinarian on how to make specific changes to improve their colostrum management (Atkinson et al. 2017). However, in general practice, data relating to calf health are under-recorded on dairy farms (Bach & Ahedo 2008), and farmers may believe that they have sufficient knowledge about calf rearing and the causes of problems on their farms, whereas veterinarians might consider those farmers' knowledge lacking, or inaccurate, in those areas, as was demonstrated in a Dutch study by Santman-Berends et al. (2014). In such cases, farmers are unlikely to consult their veterinarians about calf health or performance issues, but veterinarian-driven conversations explaining why certain practices could lead to problems and discussing possible improvements may convince farmers to take action (Santman-Berends et al. 2014). On the other hand, it is possible that neither the farmer nor veterinarian is focused on the calf rearing enterprise (Sumner and von Keyserlingk 2018), meaning colostrum management would be rarely discussed. Farmers may also receive input from other agricultural advisors with different areas of expertise and focus compared to veterinarians (Ellingsen et al. 2012), such as animal nutritionists and sales representatives from the pharmaceutical industry. Thus exploring the perceptions of a range of stakeholders with regards to management of colostrum on dairy farms will yield further useful insights. This chapter therefore investigates farmer and farm-advisor perceptions of colostrum management and administration to calves on dairy farms, to better understand why uptake of recommendations for best practice may or may not occur. Accepting the premise that if dairy calf health is generally suboptimal it may not be solely the fault of farmers, this chapter takes a wider perspective on the problem.

4.2. Materials and methods

Qualitative research methodologies from the social sciences are increasingly used to investigate animal health and welfare issues from the perspectives of both veterinarians and farmers (e.g. Brennan et al. 2016; Bourély et al. 2018; Robinson 2019) and several authors have advocated such interdisciplinary approaches (e.g. Whay 2007; Escobar and

Buller 2014). Qualitative methods are particularly useful to gain insight into choices made in relation to individual contexts, perspectives, emotions and priorities (Escobar and Buller 2014).The current study utilises a critical realist paradigm which combines realist ontology (there is a real world which exists independently of our interactions with it) with constructivist epistemology (knowledge of the world is imperfect and subjective, influenced by human perceptions and concepts, resulting in different yet equally valid experiences and interpretations of reality). This means that perceptions and physical entities are considered equally important in understanding phenomena (Maxwell 2012) such as colostrum management on dairy farms. Whereas quantitative research counts occurrences, (e.g. which practices occur in a representative sample of farmers), the aim of this qualitative study is to describe a range of experiences and beliefs held by farmers and farm advisors which may contribute to choices and actions made regarding colostrum protocols on farms.

It is important to note the potential influence of the first author who conducted the face-to-face interviews, transcriptions and data analyses. Well recognised within the social sciences, qualitative research requires a reflexivity which considers the potential influence of the researcher, those interviewed, and the context within which the interviews take place (Rose 1997). The researcher embarked on the project from a background in animal health and welfare, without in-depth knowledge of the dairy industry, and was interested to gain insight into human influences on animal husbandry. The participants were considered 'experts' in rearing dairy calves, while the researcher positioned herself as curious to learn about the industry and individual practices on farms.

4.2.1. Participants

Calf rearing and youngstock management practices on English dairy farms were investigated using 40 in-depth semi-structured interviews - 26 with dairy farmers and 14 with advisors (veterinarians (n = 11), feed (n = 2) and pharmaceutical company representatives (n = 1)) - conducted by the first author between May 2016 and June 2017. Advisors were included since they are often responsible for providing information to farmers, thus it was considered useful to compare their perceptions with those of farmers. Participants were recruited using purposive and snowball sampling (Cohen et al. 2007) which involved approaching relevant individuals at dairy events and conferences; email and phone call enquiries with existing contacts and veterinary practices; and asking interviewees to provide details of others who may be interested in participating in the study. This method provided access to a range of farmers; both males and females with different roles on farms (farm managers, herd managers, calf rearers and farm workers) and with various dairy herd sizes and calf rearing systems (Table 4.1).

Table 4.1 Interview participant details

Location	Interview code	Interviewee (role, gender, age estimate)	Calving pattern	Herd size
Southwest	F13 (Sit-down)	Farm manager, male, >50	Spring Block	600
	F14 (Joint)	Farm manager, male, >50 Calf rearer, male, 40-50	Autumn Block	420
	F15 (Joint)	Farm manager, male, 30-40 Calf rearer and farm worker, male, 30-40	All Year Round	120
	F16 (Joint)	Calf rearer, female, 30-40 Farm manager, male, 30-40	Spring Block	250
	F17 (Joint)	Farm manager, male, >50 Farm worker, male, 20-30 Farm worker, female, 20-30	Dairy Bull Calf Rearer (for beef)	N/A
	F18 (Sit-down)	Calf rearer, female, 20-30	All Year Round	180
	F19 (Sit-down)	Farm manager, male, 30-40	All Year Round	160
	F20 (Sit-down)	Farm manager, male, 30-40	Autumn Block	330
	F23 (Mobile)	Calf rearer and farm worker, male, 30-40	Autumn Block	250
	F24 (Sit-down)	Herd manager, male, 20-30	All Year Round	200
	F25 (Joint)	Farm manager, male, >50 Calf rearer, male, 20-30	All Year Round	350
	F26 (Joint)	Farm manager, male, >50 Calf rearer, female, >50	Autumn Block	500
	V5	Practice director and youngstock vet, male, 30-40		
	V6	Youngstock vet, male, 30-40		
	V7	Practice partner and farm vet, female, 40-50		
	V8	Practice partner and farm vet, male, >50		
	V11	Youngstock vet, female, 30-40		
	GA1 (V12)	Government advisor vet, female, 40-50		
Midlands	F1 (Mobile)	Calf rearer, female, 20-30	All Year Round	380
	F2 (Sit-down)	Calf rearer, female, 40-50	Autumn Block	350
	F3 (Sit-down)	Calf rearer and farm worker, male, 20-30	All Year Round	350
	F4 (Joint)	Farm manager, male, >50 Farm worker, female, 20-30 Son/trainee vet, male, 20-30	All Year Round	120
	F5 (Sit-down)	Farm manager, male, >50	Autumn and Spring Block	70
	F6 (Sit-down)	Calf rearer, female, 30-40	Spring Block	300
	F7 (Mobile)	Farm manager and calf rearer, male, 30-40	All Year Round	280
	V1	Specialist in cattle health vet, male, 30-40		
	V2	Youngstock vet, female, 20-30		
	V10	Out of practice vet/feed consultant, male, 40-50		
	N1	Feed company salesperson, male, 40-50		
	N2	Feed company calf specialist, female, 30-40		
	PR1	Pharmaceutical company advisor, female, 30-40		
Yorkshire	F8 (Joint)	Farm manager, male, 40-50 Farm wife, female, 40-50	Dairy Bull Calf Rearer (for beef)	N/A
	F9 (Mobile)	Farm manager, male, 40-50	All Year Round	250
	F10 (Mobile)	Farm manager, male, >50	Autumn Block	90
	F11 (Mobile)	Farm administrator, female, 30-40	All Year Round	400
	F12 (Joint)	Farm manager, male, 40-50 Herd manager, male, 20-30	Autumn Block	370
	F21 (Mobile)	Farm manager, male, 40-50	All Year Round	1200
	F22 (Mobile)	Herd manager, female, 20-30	All Year Round	130
	V3	Newly graduated farm vet starting a youngstock group, male, 20-30		
	V4	Farm vet, works on beef calf rearing unit, male, 30-40		

Advisors willing to be interviewed tended to be those with a specific interest in dairy youngstock and included both males and females with a range in years of experience. For logistical reasons, interviews were conducted in batches according to geographical location. Participants were sourced from areas of England densely populated with dairy farms (Southwest and Midlands) and from a north-eastern area where dairy farms were

less dense (Yorkshire). This sample diversity supported the aims of the study to examine how differing experiences affect perspectives and actions relating to calf management.

4.2.2. Interviews

The semi-structured interviews followed two separate topic guides, one for farmer interviews and the other for advisor interviews. These included questions about the background of the interviewee, their current role and their opinions on the most important aspects of calf rearing. The farmers were asked about their farm, calf rearing practices and facilities, as well as problems, desired improvements and useful sources of information. Advisors were asked questions relating to their input into the calf rearing enterprise of their clients' farms, and how they thought farmers interacted with information and advice. These guides were designed to include open-ended questions which ensured conversations remained relevant to calf rearing, yet allowed flexibility to explore issues of most importance to participants (Turner 2010) rather than being rigidly pre-determined by the interviewer. Advisors (n = 14) and some farmers (n = 9) were interviewed in an individual, sit-down format; other farmers participated in mobile interviews (n = 8) where questions were posed whilst on a walking tour of the farm (Holton & Riley 2014), or in joint interviews involving more than one interviewee (n = 20 (9 interviews)) (Riley 2014). These interview formats were decided by the participants according to their personal preferences.

Due to the broad nature of the topic guide, specific questions pertaining to colostrum management were not included, rather it was mentioned by participants in response to questions including: 'What are the most important things to get right in calf rearing?'; 'What do you think might not be done well on farms?' and 'How are calves managed from birth to weaning?'. Data collection and analysis were conducted concurrently in an iterative process whereby topics raised by participants could be incorporated into and explored further through ongoing interviews (Glaser & Strauss 1967) to gain further data richness (Bradley et al. 2007). The structure, prompts and areas of focus varied between interviews depending on what participants were most willing to talk about in detail, and which topics emerged from initial ongoing data analysis in order to further explore areas of interest, importance or contention. Seven pilot interviews were conducted (four with farmers, two veterinarians and one feed company representative) to ensure the interview guides were suitable. Since only minor refinements were made to the guides after these interviews, and responses were relevant and useful to the research project, the pilot interviews were included in the overall dataset. Data collection ceased when thematic saturation (the point at which the main ideas and variations relevant to the topic have been identified) had been achieved (Glaser & Strauss 1967).

Interviews were audio recorded with consent and subsequently manually transcribed in full using f4transkript transcription software (Version 6.2.5 Edu, Audiotranskription.de, Marburg, Germany).

4.2.3. Data analysis

NVivo 11 for Windows qualitative data analysis software (Version 11.4.1.1064 Pro, QSR International Pty Ltd, Victoria, Australia) was used to aid thematic coding of the interview transcripts which involved re-reading the data and grouping extracts to be interpreted into themes (Braun & Clarke 2006).

First and second coding principles (Miles et al. 2014) were used. Transcripts were initially coded in NVivo, assigning descriptive codes to arrange extracts into common topics, value codes to reflect personal factors such as attitudes, beliefs and feelings, and process coding to highlight actions and consequences (Miles et al. 2014). These initial codes informed ongoing interviews and provided a basis for focal topics - such as colostrum management. Second cycle coding was conducted to further examine specific extracts relating to colostrum management, constructing patterns, themes and potential explanations. This involved focused coding using NVivo 11 followed by physically arranging individual extracts into common themes and choosing quotes to include in this chapter. Quotes were chosen which clearly represented opinions and experiences of participants. Some quotes were modified to shorten or improve clarity: ellipses indicate omitted text and square brackets indicate author's additions or alterations to text.

4.2.4. Ethical approval

Approval was obtained from the Harper Adams University Research Ethics Committee for the collection and storage of interview data. Participants were provided with researcher contact details, project information, and made aware that they could withdraw from the study at any time. Written consent was obtained from participants for interviews to be audio recorded, transcribed and for these data files to be securely stored. Participants also agreed for anonymised interview excerpts to be used when reporting findings.

4.3. Results

Average interview length was 56 minutes (mean, range 26 - 90 minutes). Interview extracts regarding colostrum were arranged into two main sub-themes: management practices and obstacles to good colostrum management. These themes include viewpoints and experiences reflective of the sample diversity in this study.

4.3.1. Colostrum management practices

The way in which colostrum management was conducted on farms varied according to personal beliefs and knowledge regarding colostrum and recommended management practices. This theme focuses on the experiences of farmers in the context of their

differing farm settings, with some advisor perspectives on the impact of colostrum management to calf health and farmers' understanding of the subject.

All participants, regardless of occupation, recognised the importance of colostrum in calf rearing. Every farmer interviewed named colostrum as one of the most important factors in rearing healthy calves:

> "Colostrum is key, getting that into calves straight away, good quality stuff, and then you don't have the problems" (calf rearer, F6 (organic)).

Although farmers may not associate colostrum management with mortality, they often recognised potential impacts on growth and morbidity in calves:

> "If a calf hasn't had its colostrum it inevitably gets a case of some sort of scour, or a lack of motivation to drink. That certainly slows them down at the start. I think they can get through it, but it just doesn't give them the best start" (farm manager, F19).

Participants were familiar with 'The Three 'Q's' of colostrum management which refer to the need for high 'Quality colostrum of sufficient 'Quantity' to be fed to calves 'Quickly' after birth. Advisors used these terms when advising farmers, for example, a pharmaceutical company advisor (PR1) gave talks to farmer groups which included *"the 'Three 'Q's' of colostrum which I bang on about [mention] all the time"*. These recommendations were generally recognised and acknowledged by farmers, but were implemented to varying degrees, as outlined below.

Colostrum intake within the first 24 hours of a calf's life was a priority and efforts were made to provide calves with two to four litres of colostrum within six hours of birth. Many participants provided additional colostrum feeds, aiming to provide at least six litres of colostrum within six, 12 or 18 hours of birth:

> "We don't weigh the calves at all during the process, so the amount of colostrum that they get is always three litres at each feed. Trying to get the first one obviously within six hours and then the second one as soon after as possible, and then we can sometimes get a third in within the first 24 hours" (farm manager, F9).

Some participants perceived value in feeding colostrum or transition milk for several days after birth and believed this practice improved calf vigour:

> "People say to me, "Why do you carry on feeding colostrum for two, three days?" Alright, it's not being absorbed in the same way, but it is giving local protection, plus I think giving a smaller amount to those calves and it's higher energy density

in that colostrum. So that's why I like it and they seem to do really well" (calf rearer, F2).

Whereas farmers aimed to feed calves quickly after birth, using stored colostrum from Johne's-free cows which had been refrigerated or frozen, less focus was placed upon milking the dam as soon after parturition as possible. This appeared largely due to the practicalities of harvesting colostrum outside of routine milking times:

> "We try and milk them as soon as they've calved, usually though the parlour at milking ... but if one calves in the middle of the night, or in the late afternoon-evening, then we'll just milk her the following morning" (farm manager, F5).

The method of feeding colostrum to calves largely depended on the time available to staff and the perceived benefits of available options: leaving calves to suckle the dam, or hand feeding via artificial teat or oesophageal tube. Organic farmers in particular left the calf with the dam to suckle colostrum, but admitted calves often required assistance to consume sufficient colostrum:

> "I usually draw the teats out just to make sure because we dry them off with [teat sealant], and sometimes it's quite difficult for the calf to get out, so you think it's sucking but it's not" (calf rearer F6 (organic)).

> "[The calves are] left with the cow for 24 to 48 hours, but we make sure they've had enough colostrum. If necessary we will tube them ... Usually it's just a case of getting them to suck the colostrum off the cow and give it a bottle. If they're sucking well and they won't take any colostrum from a bottle then that's fine" (farm manager, F14 (organic)).

Veterinarian V8 recalled a farm with high calf mortality where calves were not artificially fed colostrum, and that may have contributed to severe failure of passive transfer:

> "I did zinc sulphate turbidity testing on calves ... a result of 20 [ZST Units] or more is deemed to indicate adequate colostrum, but the highest result I got on that farm was four. That was the highest one and they calved in individual calving boxes and left the calf with the cow for two days."

Stomach tubing was generally used for efficiency on larger or block calving units dealing with high numbers of newborn calves:

> "It's much quicker. You know that the colostrum goes where it wants to go and you know exactly how much they get" (calf rearer, F26).

Although artificial teat feeding (via nipple bottle or bucket) was considered a time-consuming practice, farmers often preferred to allow calves to suck; tube feeding was used as a last resort for calves that would not suckle. This seemed due to perceptions of improved calf health and easier training onto teated milk feeders, which could save time in the future:

> "We always try them on a bottle first, because obviously it's better for them to suck, but if they won't drink off the bottle for whatever reason then we will tube them" (calf rearer, F18).

> "I don't like tubing anything. [I used to but calves] just seemed to be getting ill. Then I tried getting them on the teat straight away, and then they transferred to the other teat feeders easier. So then your job's easier and you don't have to spend as much time with them" (calf rearer and farm worker, F3).

The desire for calf rearing systems to be welfare-friendly and foster a favourable public perception of farming also affected feeding method:

> Farm manager: "Some farmers now, it's part of the protocol to stomach tube every calf with stored or frozen colostrum. [We] don't do it, I don't agree with it. How can you justify to the general public that you've gotta stick a tube into them?"
> Calf rearer: "You saw this morning how easy those calves go on that bottle, there's no need to put a tube down their throat ... They resist it, they don't like it. There's nothing nice about it" (F16, married couple (organic)).

Whereas farmers were largely concerned with how calves were fed, advisors were more focused on the results of the practices used rather than method itself, per se. In accordance with general recommendations, advisors supported artificial feeding methods, with little preference between oesophageal tube or teat feeding. Their main focus was that calves were acquiring adequate passive transfer from colostrum:

> "I don't mind whether you've chosen to go nipple sucking off buckets ... or [tube] it. As long as you're getting the results and your calves are doing well then that's fine" (youngstock veterinarian, V11).

Advisors and some farmers appreciated the value of monitoring colostrum quality using a colostrometer or refractometer before storing or feeding to calves:

> "I used to just look at colostrum and go "Oh, that looks fine, feed that to the calf" and now that I've started measuring it ... the amount of colostrum I actually throw away because it's under [19% on the Brix scale] is amazing! I think we really have seen the benefits now" (calf rearer, F1).

Other farmers were less convinced of the need to quantify colostrum quality and would judge by eye, or use justifications including parity of the dam, breed or average milk components to support claims that colostrum quality was satisfactory:

> "You can just tell from how it looks, how it feels ... I thought the colostrometer measures the viscosity, how thick it is. So I just thought you would be able to tell that anyway ... Generally from the older cows you get the kind of frothy, thick colostrum ... from heifers it's very thin, and I guess it doesn't have all the antibodies" (calf rearer and farm worker, F3).

> "Our average butterfat, 12 months, is 4.5 and 3.4 protein - we're not white water. So I would say our colostrum is probably better than the average" (farm manager, F15).

Generally, collecting the colostrum from different cows together was considered beneficial by farmers to enhance the quality of poorer colostrum:

> "The good thing with us, all our colostrum from all our cows goes into that [container]. So it's all mixed up, so some of the cows that have got very high colostrum and say a heifer that hasn't got a lot, it compensates" (calf rearer and farm worker, F23 (organic)).

A veterinarian (V7) had a negative view of her clients' knowledge of colostrum quality and suggested that Johne's management was often conflated with colostrum protocols:

> "Most of our farmers don't take any notice of quality. Most of them are aware of their Johne's status, so aren't feeding Johne's colostrum, but that's probably as far as most of them are going".

Hygiene was considered an important factor in calf management overall, but was not often mentioned specifically in relation to colostrum by farmers, but was stressed by advisors. Several farmers mentioned other farms enacting negative practice where colostrum was left for several hours at ambient temperature in uncovered buckets. However, a common attitude amongst farmers was *"we don't have any Johne's problems, so we don't pasteurise [colostrum]"* (farm manager, F9), with apparent lack of recognition of the role of pasteurisation in reducing bacterial load in colostrum.

Many farmer interviewees stored colostrum on-farm, either by freezing or refrigerating; advisors did not comment on colostrum storage specifically. Farmers considered it important to ensure colostrum from Johne's-positive dams was not fed to replacement heifer calves, although some would risk infecting bull and beef calves:

> "We've got two piles in the freezer of clean colostrum and Johne's colostrum ... Obviously pasteurisation should kill Johne's, but we don't test that theory. We'll just

use the Johne's colostrum for the bulls and beef and save the best colostrum, which is clean, for the heifers" (calf rearer, F1).

Reluctance to use heifer colostrum due to its assumed poorer quality and discarding colostrum as part of Johne's disease control programmes sometimes led to insufficient colostrum being available for storage. Some participants lamented that whilst they monitored colostrum quality they sometimes had to make-do with poorer quality colostrum, or use powdered calf colostrum replacer as an alternative:

> "We don't save any colostrum from anything that's got Johne's and a lot of time heifers don't give sufficient, if any, colostrum. So if I started discarding colostrum that was of a lower quality in terms of antibodies, I wouldn't have enough to give all the calves" (calf rearer and farm manager, F7)

> "We actually use powdered colostrum. We have done a lot of tests on colostrum levels at a week old on calves that have just been fed the powdered stuff and we have found that the powdered stuff we use is pretty good. It's not as perfect as the mum's, but we've kind of proved that it works because there's lots out there that are [useless]" (calf rearer, F18).

4.3.2. Obstacles to good colostrum management

This theme explores the challenges farmers perceive regarding colostrum management, reasons behind a failure to follow recommendations, and the perceived role of advisors in supporting farmers to implement best practice and overcome difficulties.

Farmer participants appreciated that good colostrum management could improve passive transfer rates and health status of calves, but these views may not reflect the dairy sector overall. Advisors and some farmers expressed concern that colostrum management was not done well on many farms. Maintenance of traditional practices, age profile and educational attainment were suggested as possible issues:

> "Colostrum can be [neglected]. Farmers are getting better ... but you still go on farm and find farmers where they leave the calf with the cow and expect it to find [colostrum] itself. It worked years ago, and it worked well, but we face a whole different host of challenges these days than they did 20 or 30 years ago" (calf nutritionist, N2).

> "I'm surprised by the number of older farmers that don't know the value of colostrum ... I don't think it's through not being bothered, I think it's through genuine ignorance of not knowing the importance. I think education must've changed a lot between then and now because everybody my age [20-30 years] knows that [colostrum is] of extreme importance" (herd manager, F22).

Colostrum provision for bull and beef calves may also be less of a priority on dairy farms, as the focus is on rearing replacement heifers:

> "If they calve in the middle of the night, [my boss] tends to go on the theory if it's a heifer, he will feed it colostrum that night. If it's a bull calf or a beef, he'll leave it for me and I get in at six [o'clock]" (calf rearer, F18).

> "Testing colostrum, it's a double edged sword for the likes of us because the best stuff does go to the heifers" (bull calf rearer, F8).

Whilst all participating farmers considered colostrum provision to be important, some lacked the knowledge and confidence to alter their practices, or misinterpreted science-based advice, leading to uncertainty about the reasons behind recommended colostrum management:

> "It's just something I know I'm not very good at. I'd like to learn more about it to be honest with you. Taking a calf away from its mother when she's got colostrum there and ... giving it colostrum that you've pooled. I'd want to be confident that I was doing it right" (farm manager, F19).

> Calf rearer and farm worker: "Why do you ask [how quickly we refrigerate colostrum]?"
> Interviewer: "Bacteria will grow faster at room temperature than in the fridge" ...
> Calf rearer and farm worker: "You want some bacteria though, don't you?" (F12).

Others were aware of recommendations, but were disinclined to adhere to them. This may be due to personal preferences, complacency, or negative attitudes towards change and the effort required to implement advice:

> "There's always gonna be arguments for everything, isn't there, different ways, but [on the dam is] how [calves] were meant to be, so it's nice for them" (calf rearer and farm worker, F23 (organic)).

> "Any colostrum I have left [from freshly calved cows at morning milking] is in the bucket now, so anything that calves between now and milking tonight, I will feed that. Everybody says 'Oh, you shouldn't do that because it's not fresh enough, you should freeze it and then warm it'. Well yeah, you should do lots of things" (calf rearer, F14 (organic)).

The effectiveness of colostrum management could be hindered by physical limitations, for example the shortage of colostrum for storage mentioned previously. Further challenges included available time, labour and financial considerations. These barriers were commonly mentioned by advisors as reasons for poor colostrum management. There was

general consensus among all stakeholders that the work required to run a farm demanded time and labour which were in short supply, and this could impact on the speed of colostrum administration:

> "I think on dairy farms, one of the big issues is labour. You can't determine when a cow's gonna calve, and of course you want a calf to get colostrum within six or eight hours ... everyone's busy on dairy farms. There's just less and less labour, less and less good stock people on farms" (veterinarian, V10).

Farmers agreed that good colostrum management was time consuming. Most designated calf rearers seemed to cope well with the demands on their time, but those who were also responsible for additional farm work struggled to balance their tasks:

> "Colostrum is the hardest thing to do. You've got to be always prepared to take milk out of the freezer and then defrost it, but that's hard to do if I'm milking or something" (calf rearer and farm worker F3).

Calves born at night often were left unfed for longer, largely due to the lack of available staff, and this was often considered unfortunate but unavoidable. Often staff responsible for overnight checks for calvings would not include a designated calf rearer (who was likely to be more invested in the calves), and feeding colostrum at night was not prioritised as a standard practice:

> "[A cow] might calve at midnight. I don't get down there until eight o'clock the next morning ... They say it needs colostrum within six hours ... That's just how it is, you're not living on the site, it's just one of those things" (calf rearer, F14 (organic)).

> "If we've got a particularly weak [calf] that we think needs a bit of a perk up, we will feed it during the night ... If you get here and one's just calved and there's another one that needs looking at in half an hour's time ... we'll just [tube feed colostrum to] that calf while we've got five minutes" (farm manager, F13).

This suggests that 'available labour' is not purely a physical limitation, and personal attitudes and beliefs also play a role. Veterinarian V11 stressed the importance of motivating all relevant staff members to work as a team and take ownership of tasks, like colostrum management, which do not clearly fit into their remit:

> "A problem with some of these bigger [farms] is that the cows are somebody else's problem, and the calves are somebody else's, so colostrum falls in-between ... That can be particularly difficult when you're working with different groups of people and they quite like the fact that a big job falls between the gap, then it's nobody's fault".

Having clearly defined roles for each farm team was considered useful by farm manager F26:

> "The calf arrives in the calf shed having been through its colostrum policy. That isn't done by us, that's done by the dairy team."

Available finance was also partially reliant upon the perceived worth of an investment. Potential benefits gained must be considered worth the expenditure and be viewed as important compared to other demands for funds:

> "I don't get the vet to test [calves for passive transfer from colostrum]. May be a thought, I may ask him about it - depends how much he charges" (farm manager, F5).
>
> "We don't [pasteurise], which is something we probably should be thinking about doing. It's just the equipment [cost] ... it's something I'd love to do. It's just something else to add to my wish list" (herd manager, F24).

If farmers were able to see positive results of their actions or investments, they seemed pleased that the decision proved to be cost-effective. Some farmers had invested in a pasteuriser and considered it beneficial both in terms of making their job easier and improving calf health:

> "We used to put it in the bucket and nearly scorch the outside of the colostrum and the inside would still be frozen whereas now we use the actual pasteuriser which thaws it at the right temperature, all slowly done but within a quick way" (calf rearer, F1).
>
> "As soon as we've put [the pasteuriser] in, we're certainly getting a lot less scour in the calves, so that's been a good investment" (farm manager, F21).

This apparent need for changes to have tangible benefits may help to explain why advisors claimed that farmers would usually wait until a problem presented itself before implementing colostrum protocols. Some farmer participants confirmed that improvements were made in response to problems:

> "Often we put in protocols where they would deliver stomach tube, bottle, teat or bag to make sure the calf has had [colostrum], but that would usually follow a problem. If it's all working, why fix it?" (veterinarian, V8).
>
> "I've known us to have some real problems, and as soon as we got that colostrum sorted, that didn't half tick a lot of boxes" (farm manager, F21).

However, testing calf serum to monitor rates of passive transfer did not appear to be conducted by many participant farms. Only two farmers (F18, F24) reported routine testing of calves, and four (F4, F6, F20, F21) mentioned testing calves in response to problems. This lack of quantification could make it difficult to identify problems which need addressing, or assess the benefits of any alterations. Further incentives or checks for good colostrum management may be beneficial, with one farm manager (F20) suggesting an accreditation scheme for colostrum management in calves may better encourage best practice:

> "Guarantee that the calf has had the correct amount of colostrum and it gets a stamp on the passport. When it goes to market it shows up 'accredited', but it could be checked at any point, blood tested to see if it's had the right antibodies ... Adding value to the supply chain, isn't it? Should be part of farm assurance, really".

Advisors were frustrated at the lack of objective data to base recommendations on, but were sympathetic to the difficulties in enacting recommendations on-farm. Recognising that time and labour were limited, they stressed the need to ensure advice was easy to implement. Youngstock veterinarian V11 warned against over-simplification of advice and claimed that compromises could be made when following recommendations while still achieving good results:

> "To achieve [calves receiving four litres of colostrum within four hours of birth] on a small herd with limited labour is really tough ... It's not quite as simple as just that, which I think a lot of vets before have gone "Oh, just do this" and walked off ... It's always a balance, if you've got your timings right, and it's clean, and the other 'Q's are ticked, then you can get away with giving a bit less volume."

However, advisors may not seize opportunities to demonstrate recommended practices to farmers, as illustrated by this quote from a farm manager:

> "I fed some colostrum the other day when [the vet] was here and she said "Oh, that's nice and yellow, and looks nice and thick"" (farm manager, F15).

Furthermore, farmers may not recognise the root cause of problems, and rely upon the expertise of advisors. However, a calf nutritionist (N2) attributed blame to veterinarians overlooking the role of colostrum management in calf health problems:

> "It was bad when I started [on the farm] and that was scary because they had all these vets, and all their input on how to improve things and not one of them had looked at hygiene in the colostrum management. Not one. And these were vets from a top university."

Such oversights on colostrum management can prove costly and may contribute to high mortality rates and overuse of antimicrobials:

> "I took over the work on a 450 cow dairy and the first thing the farmer said is "You need to be aware that we've got a very difficult bug to treat on this farm, it really hammers our calves" ... He spent all his money on vaccines and everything that got sick had to be treated with antibiotics, and still a load of them died ... In the year after we [improved colostrum management], having lost 96 calves the year before, he lost six calves" (farm veterinarian, V8).

4.4. Discussion

As has been demonstrated in studies such as Robinson (2017) and Adam et al. (2017), it is important to understand the context within which farmers operate, and the various intrinsic and extrinsic influences that may affect their attitudes and behaviours in relation to livestock health. The themes explored in the current study demonstrate a heterogeneous group of both farmers and farm advisors whose individual perspectives, experiences and contexts impact their actions and recommendations relating to colostrum management. Appreciating this diversity is important for achieving a holistic understanding of calf health and welfare at farm level. Indeed, the opinions of farm advisors such as livestock nutritionists rarely feature in the animal health and welfare literature, and these important perspectives need to be included in future research studies.

Farmer and advisor interviewees agreed that colostrum intake is of great importance for calf rearing, and key to giving calves "the best start". Participants appreciated that good colostrum management could prevent problems in calves, but focused on the importance of antibodies in colostrum rather than other beneficial factors (e.g. hormones and growth factors (Blum & Hammon 2000)). Although all participants recognised the importance of colostrum and its role in calf health, it does not necessarily follow that farmers follow best practice or that advisors focus on or suggest improvements to colostrum management. Efforts to administer colostrum to bull and beef calves were likely to be lax; these animals are not destined to become dairy herd replacements (although beef heifer calves may join suckler herds) and may have low market value (Weigel & Barlass 2003). Even regarding potential replacement heifers, the general consensus between participants was that colostrum management in the overall dairy industry was better than it had been historically, but standards could be further improved. Recent recommendations include the five 'Q's of colostrum management (Hart 2016), but the majority of advice and scientific literature focuses on 'The Three 'Q's ' (Patel et al. 2014; AHDB Dairy 2018). No participants in the current study, including advisors, referred to five 'Q's, but knowledge of 'The Three 'Q's' was commonplace among farmers and advisors. However, some

interviewees mentioned less-informed farmers and several participants appeared to require clarity about the reasoning behind recommendations.

Even where recommendations were understood, achieving each 'Q' could be challenging. The recommendation to feed equivalent to 10% of a calf's bodyweight in colostrum is of limited use; calves are rarely weighed (Hart 2016) and farmers in this study more often quoted recommended values of 3-4 L. Farmers were aware that calves required at least one colostrum feed within six hours of birth, but achieving this could be difficult: some farms only harvested colostrum at routine milking times, which delayed its collection following calving, and time and labour limitations were apparent. This is consistent with previous findings where time pressures and prioritisation of the milking herd negatively impacted the speed of colostrum administration to newborn calves (Santman-Berends et al. 2014). In the present study, calf rearers with clearly defined roles, mainly pertaining to calf care, had more time designated to calves; they could focus on calf requirements and consider the benefits of good colostrum management. Staff having the time to carry out their tasks and respond to unforeseen problems is fundamental to good animal husbandry: time management, control and perceived self-efficacy have been found to influence the severity of calf mortality on farms (Vaarst & Sørensen 2009). However, staff structure, labour costs, calving pattern and calf numbers can make a designated calf rearer an unrealistic solution on many farms. In particular, night-time calvings often resulted in delayed colostrum administration; either night checks were conducted by staff who were not involved in calf rearing and focused on assisting calving, or not conducted at all. This highlights the importance of ensuring the entire farm team is motivated to engage with calves, and consider their management worth investing time and money into, as stressed by youngstock veterinarian V11. Indeed, Vasseur et al. (2010b) found that encouraging active participation in training and learning new methods was a good way to stimulate farmers to improve their colostrum management practices.

Farmers' attitudes, motivations and doubts are important considerations when offering guidance and can strengthen tailored advice (Santman-Berends et al. 2014). Farmers have been shown to perceive targeted advice, including explanations for recommended measures, as useful (Vasseur et al. 2010b) and whilst tailored approaches are more likely to prompt implementation (Vasseur et al. 2010b; Santman-Berends et al. 2014), they did not guarantee improvements to colostrum practices within six months (Vasseur et al. 2010b). This could suggest that some farmers are slow or reluctant to adapt existing practices (Santman-Berends et al. 2014), or that improved understanding alone is insufficient motivation to make or maintain changes. In the current study, feeding method was chosen according to perceived benefits or drawbacks rather than basing decisions on evidence-based recommendations. Decisions were based on ease, time, suitability for the

farm system, and sometimes veterinary advice. A herd's Johne's status often influenced feeding practices due to controls against infecting calves (Windsor & Whittington 2010). One farmer was concerned that he might enact snatch calving incorrectly, so continued to leave calves to suckle their dam. This reluctance to replace one suboptimal protocol with another is understandable. Doubts could be eased with improved encouragement, guidance in amending established systems or practices, and reassurance that alterations would have positive effects.

Several organic farmers in the current study believed leaving calves to suckle colostrum from their mother was natural and therefore beneficial. The concept of 'naturalness' is a key aspect of organic farming (Vetouli et al. 2012), and research indicates that cow-calf contact can encourage appropriate social behaviours of calves (Buchli et al. 2017). However, this practice increases the risk of failure of passive transfer (McGuirk & Collins 2004), so farm staff should feed colostrum to calves (Patel et al. 2014). There were also negative perceptions of recommended practices; for example, one farming couple had ethical objections over oesophageal tube-feeding of colostrum as standard practice, believing that public perception would be negative. When done correctly, stomach-tubing is generally considered a safe method (Besser et al. 1991, Kaske et al. 2005), and immunoglobulin transfer is comparable to teat feeding (Besser et al. 1991, Chigerwe et al. 2012). However, calves sometimes resist swallowing the tube and incorrect procedure could result in aspiration (Chigerwe et al. 2012), injuries to the pharynx and potentially fatal drenching pneumonia (Kaske et al. 2005). These findings indicate tube-feeding may be an unpleasant experience for calves, and warrant further investigation into its effects on calf welfare.

Advisors indicated most clients knew very little about their colostrum quality and claimed withholding colostrum from Johne's-positive dams was considered sufficient by some farmers. All farmer participants appreciated that colostrum quality related to its immunoglobulin content, but bacterial contamination was less of a concern. There was some evidence of misinterpretation or incomplete knowledge or understanding of scientific findings. For example, one farmer participant conflated the role of bacteria in acquired immunity with the cleanliness of colostrum, similar to farmers believing disease exposure to be a protective biosecurity measure (Frössling & Nöremark 2016, Brennan et al. 2016). Other farmer participants considered the benefits of pasteurisation to be limited to the prevention of Johne's disease. However, pasteurising colostrum has been shown to reduce its bacterial load and can reduce pathogen exposure to newborn calves (Elizondo-Salazar et al. 2010). This emphasises the importance of extending 'The Three 'Q's' to include hygiene as a specific recommendation.

Whilst participants who assessed colostrum quality using a colostrometer or Brix refractometer considered it a useful practice, one farmer used 19% (Brix) as a cut-off point which given that the recommendation is that colostrum should have a Brix reading of 22% or higher, could mean less than one third of poor quality samples are correctly identified (Bartier et al. 2015). Some farmers used poorer quality colostrum to alleviate colostrum shortages. Other farmers assumed it was an unnecessary bother; they believed immunoglobulin content of colostrum could be adequately judged according to its viscosity and colour. Safeguards were implemented e.g. withholding colostrum from primiparous dams, though this practice may be unnecessary and wasteful as heifer colostrum can be of high quality (Godden 2008) and seemed to contribute to colostrum shortages on some farms. Pooling colostrum from multiple dams was often considered beneficial but high-quality colostrum is actually diluted by larger volumes of low immunoglobulin content colostrum (Weaver et al. 2000). Colour measurement via spectrophotometry has indicated that colostrum with a more yellow and darker colour is likely to contain higher levels of immunoglobulin and constituents which contribute to the nutritive value of colostrum (Gross et al. 2014). However, it is unlikely that judging colostrum by eye provides reliable and accurate indication of quality compared to recommended implements. Though colostrometers have been criticised for their fragility and temperature dependency, Brix refractometers function independently of temperature and are user-friendly, requiring a very small amount of colostrum to sample (Bartier et al. 2015), but still add another step to the colostrum management routine. A lack of enthusiasm to quantify measures has been reported in other areas concerning cattle health and welfare, e.g. farmers in one study did not believe mobility scoring would improve their ability to identify cases of lameness (Horseman et al. 2014). This suggests farmers will monitor and implement recording practices only when *they* perceive some benefit or reward for doing so, regardless of best practice advice. This is somewhat paradoxical, as limited data can hinder the assessment of the risk or reward associated with management practices.

Some advisor interviewees claimed that farmers would usually improve their colostrum management only in response to a recognised health problem. Similar attitudes have been found in research concerning biosecurity and vaccination - farmers will often react to a problem rather than taking preventive action (Richens et al. 2016; Brennan et al. 2016). This tendency for reactivity as opposed to proactivity could relate to limited time and labour - why put effort into changing practices that are apparently functional? Sub-standard record keeping by farmers (Escobar 2015), particularly concerning calves (Bach & Ahedo 2008), prevents evidence-based, objective assessment of calf health and welfare issues before they present themselves as noticeable and concerning problems. Producers who participated in a benchmarking program for failure of passive transfer and average daily gain in milk-fed calves were motivated to alter management practices to improve calf

performance (Atkinson et al. 2017). However, very few of the participants interviewed in our study tested calves to monitor passive transfer and subsequent performance. For optimal evaluation of serum total protein or IgG concentrations, blood samples must be taken within the first week of a calf's life, and timing should be consistent to allow comparison (Villarroel et al. 2013). This may be difficult to achieve and cost of testing can deter farmers, but Brix refractometers, in addition to testing colostrum quality, can be used as an inexpensive estimate of calf serum immunoglobulin (Deelen et al. 2014). Achieving adequate transfer of immunity is the ultimate goal, regardless of which practices are used, so convincing farmers to adhere to the fifth 'Q' of colostrum management - quantification of passive transfer - is of great importance.

Lack of calf monitoring data may also partly explain why few participant farmers mentioned the economic significance of colostrum management, and why most downplayed the importance of colostrum administration in preventing calf mortality. One farmer suggested testing calves for adequate passive transfer as part of an accreditation scheme or farm assurance, but such approaches may not be highly motivating to farmers (Leach et al. 2010b). Farm advisors could potentially better highlight the avoidable cost of failure of passive transfer and aid decision-making using the method described by Raboisson et al. (2016). The ongoing benefits of good colostrum management could also be better promoted. For example, calves with adequate passive transfer require fewer antimicrobial treatments (Berge et al. 2009). In this vein, the Responsible Use of Medicines in Agriculture (RUMA) Alliance recently launched the '#ColostrumIsGold' campaign which promotes the role of colostrum management in reducing antibiotic usage on-farm (www.colostrumisgold.org).

The current study indicated that calf mortality and morbidity could be wrongly attributed to disease challenge rather than failure of passive transfer. Advisors could prompt farmers to re-evaluate their assessment of such problems but our findings suggest some veterinarians do not examine colostrum management when investigating calf issues. One farmer mentioned that his veterinarian did not challenge his tendency to assess colostrum quality by eye. This could be because some recommendations are not considered worthwhile to dispute if farmers are perceived as likely to continue using methods despite advice to the contrary. In such cases, providing visual assessment criteria to guide farmers' judgement might be beneficial, but this should be done alongside recommending best practice, possibly by demonstrating use of a colostrometer or Brix refractometer. Veterinarians are key advisors to farmers (Elliott et al. 2011, Garforth et al. 2013) so it is important that they provide a comprehensive and competent service which promotes science-based recommendations. It cannot be assumed that limited uptake of evidence-based advice is solely due to lack of engagement by farmers.

Interviews were a useful method to gain insight into participants' perspectives on colostrum management. Findings are indicative of what the wider dairy farmer population in England may believe or practice, but further research is needed to establish statistical representation. The first author was responsible for all interviews, transcription and coding which could introduce researcher bias and a tendency for invalid interpretations of participants' perspectives (Miles et al. 2014). To protect descriptive validity, verbatim transcriptions were made from audio recordings of the interviews and the selection and editing of presented quotes did not distort what was actually said. However, it was necessary to infer meaning from the words of participants who may distort or conceal their views, or recall experiences inaccurately (Maxwell 2012). To encourage honest, open discussion of calf rearing issues, interviews were conducted in a non-judgemental manner and participants chose their preferred interview format (seated, mobile or joint).

A range of participants were recruited. Farm managers, herd managers and calf rearers working on farms of varying sizes provided insight into the perspectives and priorities of those with different responsibilities and schedules. Advisors were knowledgeable about dairy youngstock and able to provide informative accounts of calf rearing based on their experiences. That fewer advisors participated in the project than farmers is not a concern since no statistical comparisons were made, but these interviews were valuable in triangulating the data obtained from the farmers, and also in exploring the wider context to colostrum management that we aimed for in the study. Due to farm-specific variations e.g. in calving pattern, herd size, staff structure and finances, the point of thematic saturation required a greater number of interviews for farmers than for advisors. All interview formats yielded useful insights into calf rearing but mobile and joint interviews were particularly informative. Mobile interviews enhanced farm-specific discussion since the researcher could view buildings, equipment and animals whilst participants reflected on their day-to-day practices (Holton & Riley 2014). Joint interviews allowed for co-narration which provided details and reflection on shared experiences which would have been unattainable by the interviewer alone (Riley 2014). Interviews specifically designed to investigate one particular aspect of calf rearing e.g. colostrum management would have allowed for more probing questions to generate more detailed data on that topic (Weller et al. 2018). However, the goal of the present research was to explore the broad topic of dairy calf rearing so the emergent theme of colostrum management could not have been pre-empted.

4.5. Animal welfare implications and conclusion

Our study demonstrates that 'The Three 'Q's' acted as useful reminders about the goals of colostrum management. It is possible that greater dissemination of 'The Five 'Q's', which include hygiene and monitoring of passive transfer as specific criteria, could further

increase awareness of those important aspects. Knowledge of the 'Q's of colostrum management did not guarantee implementation of recommended protocols. To motivate action to reduce failure of passive transfer rates in calves, advice should consider: physical challenges including Johne's management and time constraints; misconceptions, e.g. about the role of pathogens in acquired immunity; and farmers' perceptions, priorities and preferences. The welfare implications of oesophageal tube feeding may need further investigation if it is to be recommended as standard practice.

Quantification of passive transfer, when considered alongside health, growth and performance data, could help convince farmers that improved colostrum management merits the investment of more time, labour and finance. However, most farmers were reluctant to record and analyse data, so different motivational tactics to encourage long-term monitoring should be trialled. Advisors must not overlook the critical importance of colostrum management when investigating calf health issues, and should promote the use of evidence-based recommendations in the farm context when advising farmers on dairy calf health and welfare.

5. Appropriate Dairy Calf Feeding from Birth to Weaning: "It's an Investment for the Future"

Calf nutrition is a key aspect of calf health and welfare. Appropriate calf feeding provides the essential building blocks for calf maintenance and growth requirements and leaves calves satiated, as is required by the five welfare provisions/aims paradigm (Mellor 2016b) contributing to a life worth living for animals (Mellor 2016a). This chapter explores participants' perceptions and experiences regarding dairy calf feeding.

5.1. Introduction

Dairy calves must be fed appropriately to meet their nutritional needs for optimal growth and development. Diet must also support and reflect the development of calves' digestive function from the liquid-fed pre-ruminant phase through the transition into a functional ruminant (Drackley 2008). There are also financial implications since milk feeding accounts for 40% of total rearing costs from birth to weaning, the most expensive phase of rearing replacement dairy heifers (Boulton et al. 2015b, 2017). Calf growth rates at least partly determine their age at first calving (AFC), with heifers calving at 23–24 months being more cost-efficient than later calving animals (Boulton et al. 2017). The recommended target AFC of 24 months achieves optimal economic efficiency resulting from increased lifetime fertility, survival and milk production compared to later calving heifers (Cooke et al. 2013, Wathes et al. 2014, Eastham et al. 2018).

A typical Holstein-type heifer must maintain a growth rate of about 750 g/day from birth to achieve adequate body weight and stature to calve at 24 months (Wathes et al. 2014). The optimal protein to energy ratio for growth in pre-weaned calves has been estimated to be approximately 11.5 g of crude protein per MJ of metabolisable energy (ME) (Hill et al. 2013). Approximately 325 g/day whole milk solids (2.5 L/day) or 380 g/day calf milk replacer (CMR) (3 L/day), which contain about 22.5 MJ ME/kg and 19.5 MJ ME/kg respectively, provide sufficient ME to meet the maintenance requirements of a 45 kg calf under thermoneutral conditions with surplus nutrients supporting growth (Drackley 2008).

Traditional feeding practices provide daily milk allowances of approximately 10% of calf bodyweight, primarily to increase solid-feed intakes to facilitate rumen development for earlier weaning. These restricted feeding practices limit the growth potential of calves (Bleach et al. 2005) and are likely to provide insufficient energy in temperatures below 15 °C (National Research Council 2001). When calves are malnourished, particularly in cases of insufficient energy intakes, their immunity is impaired and they are more susceptible to disease (e.g. Godden et al. 2005, Ollivett et al. 2012, Gerbert et al. 2018). The effect of feeding higher planes of nutrition, above maintenance requirements, on the immunocompetence of calves is less clear cut as intensive milk feeding does not appear

to affect the health and immune status of calves in a consistent manner (Hengst et al. 2012, Gerbert et al. 2018).

However, calves will voluntarily consume over 9 L/day of milk (Bleach et al. 2005, Rosenberger et al. 2017), indicating that larger milk meals are required to satiate calves and improve their welfare. Indeed, restricted milk feeding causes calves to experience persistent hunger, as indicated by higher numbers of unrewarded visits to milk feeders (De Paula Vieira et al. 2008, Rosenberger et al. 2017), more frequent and higher pitched vocalisations (Thomas et al. 2001) and reduced play behaviour (Krachun et al. 2010). More recent recommendations suggest daily milk or CMR feeds should equate to 20% of calf bodyweight to support calf growth and health (Khan et al. 2011) and a common target is to have doubled the birth weight of calves by the time of weaning at 8 weeks of age (Soberon et al. 2012). Increasing the amount of milk or CMR fed per day supports higher growth rates, with the weight advantage persisting post-weaning (Khan et al. 2007, Silper et al. 2014), and is linked to developmental effects which positively affect future milk yield (Soberon & Van Amburgh 2013).

Despite these recommendations, once-a-day milk feeding is sometimes used on farms to reduce labour requirements whilst achieving adequate gains in calf bodyweight (Galton & Brakel 1976, Kiezebrink et al. 2015). In England, The Welfare of Farmed Animals (England) Regulations 2007 and European Union (EU) Directive 2008/119/EC on the minimum standards for the protection of calves require calves to be fed at least twice-a-day up to six months of age. European legislation also requires that all calves over two weeks of age must be provided with sufficient fresh drinking water to satisfy their needs and have access to water at all times in hot weather or if they are ill. The national legislation in England requires that all calves are provided with sufficient fresh drinking water each day from birth. Once-a-day milk feeding in the first month of life may contribute to abomasal disorders (abomasitis and/or bloat) in calves (van der Burgt & Hepple 2013) and is illegal since the limited intakes of solid feed during early life do not constitute a meal. Twice daily milk feeding is necessary to meet calves' nutritional requirements prior to 28 days of age (van der Burgt & Hepple 2013, Farm Animal Welfare Committee (FAWC) 2015).

Water is a key nutrient and plays a critical role in calf growth and rumen development (Drackley 2008) and calves should be provided free access to clean drinking water from birth. Although calves obtain the majority of their water intake through consumption of milk or CMR (Thomas et al. 2007), this water from feed goes directly to the abomasum. Drinking water enters and supports the development of the rumen (Govil et al. 2017) and encourages greater intakes of starter concentrates (Kertz et al. 1984), milk consumption and growth performance (Wickramasinghe et al. 2019).

Despite the research outlined above evidencing the benefits of feeding calves greater milk allowances and offering drinking water from birth, many farms feed a restricted milk diet, and some do not provide access to water prior to weaning (Vasseur et al. 2010a, Boulton et al. 2015b). Restricted calf feeding has been highlighted as an area of concern in the scientific literature (Vasseur et al. 2010a, Lorenz et al. 2011c, Sumner & von Keyserlingk 2018), suggesting that legislation and current industry advisory efforts may have failed to assert best practice on farms. Very few studies have explored the rationale behind the calf feeding systems adopted by farmers. The present study used qualitative interviews to explore the practices, experiences and perspectives of participant dairy farmers and advisors. Such social science approaches are advocated by a growing proportion of the animal health and welfare research community e.g. (Kauppinen et al. 2010, Escobar & Buller 2014, Ruston et al. 2016, Brennan et al. 2016, Robinson 2017). The objectives of this chapter were to explore the nuanced reasoning behind the different pre-weaning calf feeding protocols used on English dairy farms to provide greater holistic understanding of the wider context which might influence on-farm decisions.

5.2. Materials and Methods

This study employed a critical realist paradigm which asserts that subjective experiences of phenomena and objective facts are equally important in understanding a topic within its wider context (Maxwell 2012). This epistemology enabled the exploration of different perspectives regarding dairy calf management, providing a more holistic understanding of pre-weaning calf feeding.

5.2.1. Data Collection

Calf management on English dairy farms was investigated through 40 in-depth semi-structured interviews (26 with farmers, 14 with advisors) conducted between May 2016 and June 2017. All interviews were conducted by the first author, a doctoral student who sought to investigate human influences on calf health and welfare regarding rearing practices from birth to first calving. Presented here are findings relating to calf feeding following the provision of colostrum, which has been addressed in a Chapter 1 (Palczynski et al. 2020a).

Purposive and snowball sampling (Cohen et al. 2007) was used to recruit participants from existing contacts, veterinary practices, dairy events and conferences, and individuals suggested by interviewees. This method yielded farmers who managed a range of dairy herd sizes and production systems (Table 5.1) and advisors who tended to have a specific interest in dairy youngstock (Table 5.2). Interviews were grouped according to geographical location with participants from areas of England with high densities of dairy farms (Southwest and Midlands) and from a north-easterly area with less dairy focus in Yorkshire.

Interviewees included 37 dairy farmers (farm managers (n = 17), farm workers (n = 9), calf rearers (n = 8) and herd managers (n = 3)) and 14 advisors (veterinarians (n = 11), feed (n = 2) and a veterinary pharmaceutical company representative (n = 1)). One of three interview formats were used according to participants' preferences: all advisors and nine farmers were interviewed individually in a seated setting; 20 farmers participated in nine joint interviews where two to three participants were interviewed together; and eight farmers were interviewed whilst walking around the farm.

Table 5.1. Farmer participant demographics.

Interview Code, Style	Interviewee details: Job, Gender, Age Estimate	Farm details: Calving Pattern, Herd Size, Farm System	Location within UK
F1, Mobile	Calf rearer, f, 20–30	AYR, 380, conventional	Midlands
F2, Sit-down	Calf rearer, f, 40–50	AB, 350, conventional	Midlands
F3, Sit-down	Farm hand/calf rearer, m, 20–30	AYR, 350, conventional	Midlands
F4, Joint	Farm manager, m, >50 Farm hand, f, 20–30 Son/trainee vet, m, 20–30	AYR, 120, conventional	Midlands
F5, Sit-down	Farm manager, m, >50	AB/SB, 70, conventional	Midlands
F6, Sit-down	Calf rearer, f, 30–40	SB, 300, organic	Midlands
F7, Mobile	Farm manager/calf rearer, m, 30–40	AYR, 280, conventional	Midlands
F8, Joint	Farm manager, m, 40–50 Farm wife, f, 40–50	Dairy bull calf rearer, batches of 20 calves	Yorkshire
F9, Mobile	Farm manager, m, 40–50	AYR, 250, conventional	Yorkshire
F10, Mobile	Farm manager, m, >50	AB, 90, conventional	Yorkshire
F11, Mobile	Farm administrator, f, 30–40	AYR, 400, conventional	Yorkshire
F12, Joint	Farm manager, m, 40–50 Herd manager, m, 20-30	AB, 370, conventional	Yorkshire
F13, Sit-down	Farm manager, m, >50	SB, 600, conventional	Southwest
F14, Joint	Farm manager, m, >50 Calf rearer, m, 40–50	AB, 420, organic	Southwest
F15, Joint	Farm manager, m, 30–40 Calf rearer, m, 30–40	AYR, 120, conventional	Southwest
F16, Joint	Calf rearer, f, 30–40 Farm manager, m, 30–40	SB, 250, organic	Southwest
F17, Joint	Farm manager, m, >50 Farm hand, m, 20–30 Farm hand, f, 20–30	Dairybull/beef calf rearer, 1400 calf places	Southwest
F18, Sit-down	Calf rearer, f, 20–30	AYR, 180, conventional	Southwest
F19, Sit-down	Farm manager, m, 30–40	AYR, 160, conventional	Southwest
F20, Sit-down	Farm manager, m, 30–40	AB, 330, conventional	Southwest
F21, Mobile	Farm manager, m, 40–50	AYR, 1200, conventional	Yorkshire
F22, Mobile	Herd manager, f, 20–30	AYR, 130, conventional	Yorkshire
F23, Mobile	Farm hand/calf rearer, m, 30–40	AB, 250, organic	Southwest
F24, Sit-down	Herd manager, m, 20–30	AYR, 200, conventional	Southwest
F25, Joint	Farm manager, m, >50 Calf rearer, m, 20–30	AYR, 350, organic	Southwest
F26, Joint	Farm manager, m, >50 Calf rearer, f, >50	AB, 500, conventional	Southwest

Abbreviations: male (m), female (f), all-year-round calving pattern (AYR), autumn block calving pattern (AB), and spring block calving pattern (SB).

Table 5.2. Advisor participant demographics.

Interview Code, Style	Interviwee Details: Job, Gender, Age Estimate	Location within UK
N1, Sit-down	Feed company salesperson, m, 40–50	Midlands
N2, Sit-down	Feed company calf specialist, f, 30–40	Midlands
DR1, Sit-down	Pharmaceutical company veterinary advisor, f, 30–40	Midlands
GA1, Sit-down	Government veterinary advisor, f, 40–50	Southwest

V1, Sit-down	Veterinary specialist in cattle health, m, 30–40	Midlands
V2, Sit-down	Youngstock veterinarian, f, 20–30	Midlands
V3, Sit-down	Veterinarian starting a youngstock discussion group, m, 20–30	Yorkshire
V4, Sit-down	Farm veterinarian, works on beef calf rearing unit, m, 20–30	Yorkshire
V5, Sit-down	Practice director and youngstock veterinarian, m, 30–40	Southwest
V6, Sit-down	Youngstock veterinarian, m, 30–40	Southwest
V7, Sit-down	Practice partner and farm veterinarian, f, 40–50	Southwest
V8, Sit-down	Practice partner and farm veterinarian, m, >50	Southwest
V10, Sit-down	Out of practice veterinarian, now feed consultant, m, 40–50	Midlands
V11, Sit-down	Youngstock veterinarian, f, 30–40	Southwest

Abbreviations: male (m), female (f).

Two separate interview topic guides were used, one for farmer interviews, the other for advisor interviews. These guides included open-ended questions which ensured interviews remained relevant to calf rearing whilst allowing flexibility to explore areas of most importance to participants (Turner 2010) rather than being predefined by the researchers. Farmers were asked questions about the practices used on their farm and their opinions about how calves are reared elsewhere, whereas advisors were asked about their main areas of concern regarding calf rearing and their role in providing information and advice. Seven pilot interviews were conducted, four with farmers (F1, F2, F3, F4) and three with advisors (V1, V2, N1) to ensure topic guides were suitable. Responses were useful to the research project and only minor refinements were made to the topic guides so the pilot interviews were included in the overall dataset.

Data collection and analysis overlapped in an iterative approach so that topics raised in earlier interviews could be further examined with later interviewees (Miles et al. 2014). Interviews were audio recorded with consent and subsequently manually transcribed in full using f4transkript software (Version 6.2.5 Edu, audiotranskription.de, Marburg, Germany). Data collection ceased when it was judged that thematic saturation was established (Miles et al. 2014), i.e., the main concepts and range of opinions relevant to calf rearing had been identified, and no new themes were emerging.

5.2.2. Data Analysis

Transcripts were analysed using thematic coding which involved reading and re-reading the data and grouping extracts into common themes [44]. Transcripts were coded in NVivo 11 for Windows (Version 11.4.1.1064 Pro, QSR International Pty Ltd., Victoria, Australia). In first cycle coding excerpts were arranged according to topic, personal values, and processes (Miles et al. 2014) to inform ongoing interviews and indicate focal subjects including calf feeding. Coding was repeated to explore the topic of calf feeding in-depth and relevant interview extracts were chosen to represent the perceptions of participants relevant to the themes and explanations being constructed.

5.2.3. Ethical Approval

Prior to participation in the study, all participants gave their informed consent—specifically for interviews to be conducted, audio recorded, transcribed, securely stored and for anonymised interview excerpts to be used when reporting findings. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Harper Adams University Research Ethics Committee on 13 January 2016 under project number 75-201511.

5.3. Results

Average (mean) interview length was 56 min (range 26–90 min). Most results within the theme of calf feeding pertained to liquid feeds, with some reference to the provision of water and solid feeds in preparation for weaning.

5.3.1. Milk Feeding: Amount Fed

Participating farmers fed their calves 4–8 L milk per day (10 fed whole milk, 16 fed CMR) (Table 5.3) and the mixing rates, brands and composition of CMR varied. Few farmers could recollect basic details of their CMR, including the protein and fat content. Most farmers provided the weight of CMR fed, since *"water is just the carriage to get [nutrients from CMR] into the calves"* (F8 male, farm manager); the total CMR provided ranged from 500 g–996 g per day, though some farmers referred only to the volume of CMR fed. The majority of milk was fed in two daily feeds unless calves had access to an automatic feeder throughout the day. One organic farm fed cold whole milk ad libitum to calves after the first week. Two farms fed once-a-day milk to calves from 1 to 2 weeks of age and F7 used a particularly concentrated 3 L feed once a day with a mixing rate of 300 g/L, believing that increasing the feeding rate in this manner had improved calf health:

> "Prior to the feeding regime we're on now I generally tended to restrict milk to 4 L of milk a day, 750 g of milk solids over two feeds, and I would get a lot more enteric disease. I'd get a lot more of all calf health issues" (F7, male farm manager).

Table 5.3. Information given by farmer participants regarding heifer calf milk feeding during interviews

Farm	Colostrum	Milk Feeding			
		Type	**Amount per Day**	**Feeding Method**	**Temperature**
F1	1 feed of 4 L	CMR	2.8 L twice daily	Teat bottles filled from mixer	40 °C set on equipment
F2	2–3 days: 4 L first feed then 2.5 L twice daily	CMR (26% CP)	3.5 L twice daily (2.5 L twice daily first week)	Multi-teat bucket feeder filled from mixer	40 °C set on equipment
F3	4 days: 2 L twice daily	CMR	3 L twice daily (166 g/L) (2 L over 2 weeks)	Multi-teat bucket feeder	Warm (not measured)
F4	3–4 days: 3 L first feed, then amount not stated	Waste WM	Not stated	Multi-teat bucket feeder	Warm (not measured)
F5	4 days: amount not stated	CMR (26% CP)	400 g milk solids twice daily	Multi-teat bucket feeder	Warm (not measured)
F6 [2]	3–4 days: 3–5 L first feed, left with dam for 24 h then 3–4 L twice daily	WM (Johne's-free only)	3–4 L twice daily	Via teat	Warm, straight from parlour
F7	"As much colostrum as I can get it to drink"	CMR (26% CP, 20% oil, skim-based)	3 L once daily (300 g/L) (3 L twice daily 150 g/L until day 7–14)	Teat bottles filled from mixer	Not stated
F8 [1]	Calves not on farm at this point	CMR (whey-based)	Total amount not stated, 150 g/L	Automated feeders with teat	Warm, set on feeder
F9	2–3 feeds of 3 L	WM, soon CMR again [3]	Not stated	Multi-teat bucket feeder	Warm, straight from parlour
F10	2 feeds of 3–4 L	CMR (skim-based)	3.5 L twice daily (125 g/L)	Not stated	Warm (measured on thermometer)
F11	1 feed of 3 L	CMR (skim-based)	6 L over the day (150 g/L)	Automated feeders with teat	Warm, set on feeder
F12	2 feeds, amount not stated	WM [3]	Not stated	Multi-teat bucket feeder	Warm, straight from parlour
F13	1 feed of 2 L	Pasteurised waste WM [3]	Not stated	Multi-teat trailer feeder	40 °C from pasteuriser
F14 [2]	One feed then left with dam for 24–48 h	Pasteurised WM	3 L twice daily	Multi-teat bucket feeder	Warm from pasteuriser
F15	One feed of 2–4 L then left with dam for 3–4 days.	CMR	2.5 L twice daily (100 g/L) (2 L twice daily, 125 g/L until day 9)	Multi-teat bucket feeder	38–40 °C
F16 [2]	Left with dam for 24 h	WM	*Ad libitum* (3 L twice daily first week)	Multi-teat buckets, barrels or trailer feeder according to group size	Warm for first week, then cold

F17 [1]	Calves not on farm at this point	WM	3L once daily (125 g/L) from arrival date (14 days of age)	Trough (no teats) filled from mixer	Not stated
F18	6 L within six hours of birth	CMR	Not stated	Teat bottle for first couple of weeks then bucket (no teat)	Not stated
F19	Left with dam for 24–48 h. Two 3 L feeds if necessary	CMR	3 L twice daily (150 g/L)	Not stated	38–40 °C measured using thermometer by interviewee, but not others
F20	2 feeds of 2.5–3L	CMR (50% skim)	Not stated, but decrease to once daily feeds at 3 weeks	Multi-teat bucket feeder	35 °C
F21	1 feed of 4 L	CMR	6 L over the day (150 g/L (increased from 4.5 L first couple of weeks)	Bucket fed for 10 days then automated feeders with teat	Warm, set on equipment
F22	Left with dam for 3 days. Will feed if necessary	WM	2 L twice daily	Bottle fed for first few days then bucket fed	Warm (not measured)
F23 [2]	Left with dam for a week	Waste WM	3 L twice daily	Multi-teat bucket feeder	Warm from parlour
F24	1 feed of 2.5–3 L within six hours	CMR	3 L twice daily (166 g/L) (increased from 2 L first week)	Multi-teat bucket feeder	Not stated
F25 [2]	2 feeds of 2–3 L within 24 h	Waste WM	2 L until 3–4 weeks, then 2.5 L twice daily	Multi-teat bucket feeder	Warm
F26	2–3 feds within 24 h, amount not stated	CMR	Up to 7 L over the day (137 g/L)	Automated feeders with teat	Warm, set on feeder

Abbreviations: calf milk replacer (CMR), whole milk (WM), crude protein (CP). [1] Rears dairy bull or beef cross calves. [2] Organic. [3] Price driven decision. Any details not included in the table mean those aspects were not covered during the interview.

Most farmers appreciated that a higher rate of nutrition could contribute to improved calf health and recognised the high feed conversion efficiency for calf growth and potential impacts on future performance. However, several participants believed that on some farms calves were not prioritised as the focus was centred on the milking herd, and advisor participants were concerned that underfeeding of calves was commonplace:

> "The amount of people that feed once a day cold milk to calves despite the fact it's illegal is still quite high" (V2, female youngstock vet).

> "I think these calves are starved [...] The number of people that feed two litres twice a day—which is not even maintenance growth rates, especially considering the [cold] weather." (V3, male youngstock vet).

Farmers seemed less concerned by legislation and calf growth requirements, focusing instead on what suited their management routine and whether calves *"looked well"* (F22, female herd manager). Reasons for restricted feeding included maintenance of traditional practices, following instructions on CMR packaging, and attempts to save money. Calf feeding protocols were usually only changed in response to problems:

> "[On the packaging] 250 g was what was recommended, so that's what [the calves] got, but they weren't really doing well on it. You think "it's disease", or "it's the [starter] feed" [...] it was actually the lack of a decent amount of milk [...] You can't hide behind saying "I'll save a bit of money on milk powder" [...] it's an investment for the future" (F5, male farm manager).

That CMR guidelines on commercial product packaging did not provide sufficient nutrition to meet recommended growth targets, e.g., to double the birth weight by weaning, was raised by a veterinarian-turned-feed-consultant (V10):

> "Current recommendations often to a farmer are only about 750 g of milk powder a day [...] Even if they're being as efficient as they possibly could, you're only gonna get 750 g a day of growth [...] and that's before you factor in any cold or draughty conditions."

Furthermore, one farmer (F15) admitted finding instructions to be unclear and fed the same milk solids as a more dilute milk solution when attempting to increase the amount fed to calves (Table 5.3):

> "Generally it's just water I've been adding [...] because reading the instructions on the bag, it doesn't actually say if you're supposed to give more powder."

5.3.2. Milk Feeding: Type of Milk Fed

The majority of participant farmers (16/26) fed CMR while all participating organic farmers (n = 5) and five conventional farmers fed whole milk (Table 5.3). Three participants stated that they fed calves unpasteurised non-saleable milk, two fed pasteurised whole milk and five did not specify. Three participants had started feeding whole milk to reduce feed costs during the 2014 downturn in milk prices:

> "I did fall out with my powder milk supplier because the price didn't come down when milk price came crashing down [...] so I put a pasteuriser in. It was expensive [...] but the calves are so much better on whole milk than they are on powdered milk" (F13, male farm manager).

Some farmers were very positive about the information and support provided by their feed company representative, and most were willing to invest in *"a feed that's right"* (F17, male farm hand)—CMR, which was cost-effective rather than the cheapest available. However, what constitutes a 'good' CMR was not specified, though some referred to the protein and oil content of their milk powder. Other farmers were distrustful of salespeople and one youngstock veterinarian questioned both farmers' knowledge of feed components and the ethics of feed companies:

> "If you look at milk powders, some of them, particularly when money was getting very tight, their vitamin E levels suddenly crashed. I think that's a bit naughty of them [the feed companies] because a lot of farmers won't really know what's in their milk powder" (V11, female youngstock vet).

Several participants, particularly organic farmers, perceived feeding whole milk to be more natural and suggested that it resulted in better calf performance, having been *"designed"* (F13, male farm manager) for calf feeding. Feeding whole milk was also considered beneficial in terms of consistency in feeding if more than one person was responsible for feeding calves. Dairy-bred bull and beef-cross calves were either fed the same as dairy replacement heifer calves for ease of management in dual dairy-beef systems or considered to be low-priority *"milk thieves"* (F10, male farm manager) which would be quickly removed from the farm. In these cases, dairy-bred bull calves received poorer-quality feeds, largely due to a poor market value for those calves:

> "I'm rearing a calf, and it's margin with me [...] If they put another £20 worth of milk powder into that calf and get that heifer in-calf three months quicker that's cheap, but for me it's £20 directly off" (F8, male farm manager, rears dairy bull calves).

Although feeding waste milk may be standard practice for replacement calves on some farms, unpasteurised non-saleable milk was more commonly fed to bull or beef-cross calves on dairy enterprises.

> "The bull calves and any beef calves, they get [...] antibiotic milk, [...] high cell count milk, anything really because they're not going to be around for long enough to pick up anything serious" (F5, male farm manager).

These non-saleable milk feeds often included milk from cows treated with antimicrobials, an area of concern acknowledged by this farm manager:

> "If you're feeding milk from cows which have been treated with [antibiotics], you're feeding that antibiotic to those calves. So what problems are you creating? What resistance do you create?" (F19, male farm manager).

5.3.3. Milk Feeding: Preparation and Feeding Method

In addition to what was fed to calves, many farmers emphasised the importance of how milk was prepared and delivered to calves. Farmers using automatic machine feeders believed calves benefited from being able to feed throughout the day:

> "If you're bottle feeding a calf twice a day, when you feed it it's always starving and it guzzles it really fast. You don't get that when they're on machine because they're doing it in a more natural way, as if they were on a cow" (F8, female calf rearer).

Automated feeders could also help to ensure consistency of milk feeding, a fundamental principle according to farmer participants. They could also provide farmers with flexible time as they could check the calves when it was convenient rather than being tied to a specific feeding time.

> "If you're really busy, you don't have to tend the machines, two or three hours either way, it's really flexible [...] The milk's always there at the right temperature, it's well mixed, should be [hygienic] if they've kept the machines clean" (F21, male farm manager).

However, the cost of machine-feeders prevented many farms from installing them.

Several participants stressed the need for staff to have the time and equipment available to make calf feeding easy and simple to facilitate proper feeding. However, mixing CMR involves several variables, including water temperature, mixing rates and timings, and if the person responsible for calf feeding does not use measuring implements or if several people feed the calves, consistency may suffer and affect calf performance.

> "I use a thermometer and I mix at 40 ˚C and I feed at about 38 ˚C. Dad uses his finger and I couldn't tell you what [temperature] he feeds at [...] Then

concentration, I've given him a scoop that's pretty failsafe, but when I was doing it myself I did get better results" (F19, male farm manager).

Teat feeding was considered beneficial by most farmers. Some had made the change from bucket feeding and were impressed with the results, or acted on external information:

"One journal said that teat feeding over bucket feeding actually helps them grow a little quicker [...] I'm not sure if it does, but I tried doing it anyway" (F3, male farm hand and calf rearer).

"[I visited a farm with stunning calves, the farmer] said whatever you do, do not feed a calf on a bucket. It gulps it down, it gets into the wrong stomach. He said, when a calf suckles, it produces saliva, you can see it around its mouth, that aids digestion." (F8, male farm manager).

However, one farm veterinarian indicated that the feeding position resulting from the angle of teats on bar feeders may contribute to respiratory disease:

"I think calves on a bar feeder get a certain degree of aspiration pneumonia from the teats being horizontal [...] I can't understand why no one's invented a calf bucket that's got like a corner cut off and the teat coming out on the 45˚ angle so that it forces them into a neck down, head up position which is more natural" (V4, male farm vet).

Hygiene of the feeding equipment was considered important by both farmer and advisor participants to foster good calf health.

"[Calves] are babies. You have to keep your bottles clean, disinfect everything in-between feeding each calf on a bottle [...] even if they're healthy calves, I always disinfect the teat" (F18, female calf rearer).

However, cleaning may not be done to a high standard on farms and may not be recognised as a problem by farmers:

"[I recommended increasing] everyone's milk that they were feeding, and everyone would say "oh no, if I do that they scour!" [...] I think it was just general hygiene of the milk preparation and the buckets. So when they cleaned that, adding more milk wasn't the problem " (V11, female youngstock vet).

Advisors tended to attribute lack of hygiene to farm facilities and poor availability of hot water. Reasons given by farmers for a lack of hygiene in calf feeding included lack of perceived efficacy in disease control and a perception that sanitation hinders the acquisition of immunity:

"Some people say you should disinfect between [feeding groups of calves], but I never have done. If one lot gets [an infection], they usually all get it anyway" (F14, male calf rearer).

"Everything should be washed and sterilised with hot water after every calf's fed. With that you're not giving the calf the chance to build up any immunity" (F16, male farm manager).

5.3.4. Solid Feed, Weaning and Water

A range of weaning methods were implemented by farmers, although the majority were weaning calves at around 7–8 weeks (Table 5.4). Some based weaning decisions on age alone whilst others considered calf weight or starter intakes. There was generally a negative view of early weaning practices:

"It seems to me there's this race to wean the calves as quickly as you can. "We wean all calves at six weeks old." It's unnatural. [...] You're gonna grow better animals by just feeding them milk for longer." (F16, male farm manager).

Farmers fed calves different starter feeds and forage, and used different methods for gradual weaning. Some decreased the volume or concentration of milk fed, others decreased the number of daily milk feeds. One farm veterinarian (V4) admitted being unsure of the 'best' weaning technique:

"Weaning, I don't think there's a right answer with that. I certainly haven't found it yet [...] How you reduce the milk? Some people will do it by going from two times a day to once a day. Some people will continue twice a day, feeding smaller amounts. Some people will continue twice a day, feeding the same amount but a lower concentration and I don't know what the right answer is to be honest with you."

Table5.4. Information given by farmer participants regarding weaning practices during interviews.

Farm	Water	Solid Feed	Weaning Process	Calf Weight Recording
F1	From birth	Rearing pellets from birth	Gradual when calf weighs 80 kg and consume 1 kg starter	Weekly from birth using weigh-crate. Aim for 0.8–0.9 kg/d growth
F2	From birth	Corn and straw from birth	Decrease to one daily milk feed at 7–8 weeks. Weaned when consuming 2 kg starter	At turn-out (6–7 months). Plan to improve weigh system
F3	From birth	Rearing pellets from birth	Group housed at 6 weeks to begin weaning by decreasing volume or concentration of milk	No. Lacks time. Mental record of intakes and growth
F4	Not stated	Straw and concentrates from a week old	Gradual decrease in milk concentration between 6–10 weeks depending on availability of milk and intakes of concentrates	No. Judge by end product (target AFC 24 months)
F5	Not stated	Corn	Decrease to one daily milk feed at 6 weeks, weaned at 8 weeks depending on availability of milk and intakes of concentrates	No. Judge by end product (target AFC 24 months)
F6 [2]	Not stated	Rearing nuts, oats, straw from birth	Gradual decrease in volume of milk at each feed. Weaned at 12 weeks (organic standard)	At movements between accommodation and vaccinations. Aim for 0.8 kg/d growth.
F7	From birth	Rearing pellets (18% CP) from birth	Decrease volume of milk according to intakes of dry starter feed not based on age. Weaned when consuming 2 kg starter for one week	Used to. Established regime that achieved desired growth rates. Aim for >850 g liveweight gain by calving (target AFC 24 months)
F8 [1]	Not stated	Rearing pellets, home mix (barley, distillers grains, soya, rape meal and minerals), straw	Automated feeders programmed to decrease volume of milk allowance	No. Intends to start
F9	From birth	Rearing pellets from birth and straw from three weeks	Weaned at 8–10 weeks, later if calf is small	No. Labour intensive. Plan to incorporate automated weigh system
F10	From birth	Rearing pellets and straw from birth	Weaned over the course of a week at 7–8 weeks when calf weighs 80–85 kg	Girth measurements at birth and before weaning at 7 weeks. Aim to double birth weight by weaning
F11	Not stated	Concentrates, home mix	Automated feeders programmed to reduce milk allowance by 0.2 L/d day 40–65	Girth measurement at birth. Weigh scale output manually recorded periodically. Aim to double birth weight by weaning.
F12	Not stated	Minimal concentrates, grass	Weaned at about 12 weeks when calf weighs 100 kg	Weighed when approaching weaning and about a month after weaning. Compare annual average values.
F13	Not stated	Minimal concentrates, barley, grass	"we probably keep them on milk a little bit longer than we need to"	No. New employee to take groups of calves over local weighbridge
F14 [2]	First week	Rearing pellets	Decrease milk from 7–12 weeks	Monthly weights taken to calculate growth rate

F15	First week	Rearing pellets, barley straw or hay	Decrease to one daily milk feed at 6–7 weeks for one week	Not stated (Target AFC > 24 months)
F16 [2]	Four weeks	Straw, grass, no concentrates	Decrease to one daily milk feed of decreasing volume to wean at 12 weeks	Not stated
F17 [1]	From arrival	Concentrates, straw	Start weaning when calf weighs about 80 kg	Weighed on arrival and departure over local weighbridge
F18	From birth	Rearing nuts, barley straw	Decrease to one daily milk feed at 6–7 weeks for one week before weaning at 7–8 weeks, depending how calf is doing	No. Intends to start
F19	From birth	Concentrates and straw first week	Weaned at 12 weeks	Girth measurements taken throughout rearing period
F20	From birth	Rearing pellets, chopped wheat straw	Weaned at 8–9 weeks	No. Wants a simple, easy system to use
F21	Not stated	Rearing pellets, straw	Automated feeders programmed to reduce milk allowance by 0.6 L/d day 49–59	Periodically. Would like vet-tech service to reduce labour cost
F22	Four weeks	Rearing nuts, hay	Not stated	No. Does not seem feasible or small farms
F23 [2]	Three weeks	Rearing pellets, straw	Weaned at 12 weeks	No. Would like to start but can judge by eye
F24	Not stated	Concentrates	Weaned at 8–10 weeks	No. Intends to start
F25 [2]	Not stated	Rearing pellets	Decrease to one daily milk feed from 10–12 weeks	Regular use of weigh-crate
F26	From birth	Concentrates, straw	Weaned at 7–9 weeks. Automated feeders programmed to decrease volume of milk allowance.	Not stated

Abbreviations: age at first calving (AFC), crude protein (CP). [1] Rears dairy bull or beef cross calves. [2] Organic. Since no quantitative survey of farm practices was conducted, some details were not included in the interviews - this does not necessarily indicate that calves were not provided with components e.g., straw, water. Straw is stated where it is provided as a feed substrate rather than as bedding.

Participants were aware that calves should be consuming solid feed and forage to aid rumen development, and milk feeding practices sometimes needed to be altered to facilitate intakes of dry starter.

> "We do struggle to get roughage in them [...] We've had the odd post-mortem done on calves which have been poor and we've had poor rumen development so it's something we're trying to improve on" (F9, male farm manager).

> "We tried a kilogram [of CMR] a day, but we found that although the calves looked great at weaning time, they didn't wean as well. I don't think they had room to eat as many pellets. This way [875 g/day], they eat more pellets and it's a more seamless weaning" (F10, male farm manager).

Problems encountered at weaning time included pot-bellied calves, growth checks and diarrhoea. Some farmers had changed their practices and improved weaning, whereas others struggled to prevent problems, despite trying several alterations in a trial-and-error approach:

> "I used to wean everything at six weeks. We'd go once a day milk at five weeks and they'd be weaned at six. But now we do twice a day feeding until six weeks and then once a day for another two weeks, monitoring how much corn they're eating. By eight weeks old they're taking a lot of corn, and then we wean them. That's made quite a difference to the calves in that they used to be pot bellied and horrible after weaning, but they're not now" (F5, male farm manager).

> "[The calves] do get very loose [at weaning] and that's mostly when the coccidiosis kicks in [...] I know you shouldn't do everything all at once. They're trying to be weaned, they're changing the ration, they're introduced onto silage—that's when they get loose. I've tried not giving them silage, I've tried keeping them on pellets, I've tried putting them on rearing nuts [sooner] and they still get loose, so it doesn't really seem to make a lot of difference" (F14 male calf rearer).

Water affects calf consumption of concentrates, plays an important role in rumen development and its provision is required under UK and EU law. However, many advisors were frustrated that calves on many farms did not have access to fresh water.

> "You can walk around quite a lot of dairy farms in the UK that the calves don't have access to water. The fact that it's illegal let alone detrimental to growth rates..." (V2, female youngstock vet).

> "[Farmers will] complain to you "oh, they're not eating much dry starter feed, your feed's rubbish"—you're not really gonna want to eat dry crackers without a drink of water, are you? They don't realise that [calves] need fresh water for rumen

development. Their milk feeds twice a day—it doesn't constitute free water. It doesn't go to the rumen for rumen development—it goes to the abomasum." (N2, female feed company calf specialist).

Some farmers who did not provide water to young calves believed that calves would reject their milk feed after gorging on water, particularly if both were provided in buckets rather than milk via a teat. Others did not realise that calves required access to free water in addition to their liquid feeds.

> "One thing is that they don't fill up on water, so when you feed them they're hungry enough to drink the milk. They shouldn't really need it. It's like a newborn baby, you don't give them water. Apart from warm milk, they don't need anything else" (F16, female calf rearer).

> "Milk when you feed it is a fixed dry matter content and fixed fat and protein content, so you haven't got the element of a thirst-quenching feed for the baby calf" (GA1, female government veterinary advisor).

If calves seem to be doing well, often practices are not altered and farm staff may not have control over management decisions.

> "This is a source of contest between me and the bosses because I think they should have water all the time, but they only feed water when they get to about a month old [...] that's how they've always done it, and the calves look really well so I can't really tell them to do otherwise" (F22, female herd manager).

5.4. Discussion

Our results indicate that a wide variety of calf feeding regimes, primarily to rear replacement heifers, are used on English dairy farms. Whilst participant farmers reported providing concentrates and forage to calves, discussion in our interviews was focused on liquid feeding, particularly CMR. Farmers' actions concerning calf feeding practices were largely determined by their attitudes regarding the ease of management and wellbeing of calves. Some farmers made proactive changes seeking to achieve optimal calf performance, with several noting the benefits of feeding programmes which promote accelerated growth. Most participants maintained the status quo, continuing historic practices, including limiting liquid feed allowances and only making alterations in response to perceived problems with calf health or growth rates. However, farmers may struggle to accurately assess calf performance due to a lack of calf monitoring data (Bach & Ahedo 2008), possibly resulting in failure to identify problems. Calf feeding is also often regarded as a simple, childhood task that does not require discussion or deliberation, particularly if calves are perceived to be performing well (Sumner et al. 2018a).

In the present study, advisors, particularly veterinarians, were concerned about widespread underfeeding of dairy calves. Sumner & von Keyserlingk (2018) found that Canadian dairy cattle veterinarians were also concerned about calf hunger and malnutrition, suggesting that underfeeding calves is potentially a global problem in the dairy industry in developed countries. This may, at least in part, be due to the long-established industry standard for restricted milk feeding which has only relatively recently been challenged to favour greater milk allowances for improved calf performance (Khan et al. 2007, 2011, Soberon & Van Amburgh 2013, Silper et al. 2014) and better welfare standards (Bleach et al. 2005, Rosenberger et al. 2017). However, it has also recently been argued that increasing intakes of solid feed during the pre-weaning period alongside appropriate liquid feeding (as opposed to accelerated liquid feeding programmes) offers a more cost-effective route to achieving greater growth rates whilst also supporting rumen development and future lactation performance (Heinrichs & Gelsinger 2017). This lack of consensus in the research literature is reflected by the range of milk allowances provided by participant farmers. Farmers were providing approximately 5–6 L/day of liquid feed to calves on average, with most feeding above the historically-favoured daily rate of 4 L/day. However, the traditional practice of restricted milk feeding persists on many farms (Vasseur et al. 2010a, Boulton et al. 2015b), including a minority of those participating in this study. Several farmers had increased the milk allowance for calves and perceived the change positively, largely pertaining to improved calf health. This indicates that their previous milk ration did not provide calves with sufficient nutrition, impairing their immune function (Hengst et al. 2012, Gerbert et al. 2018), and increasing liquid feed allowances covered this nutritional deficit.

Contrary to the legislative requirements, once-a-day milk feeding for young calves was used on two farms in this study. One farm was a rearing unit for dairy bull calves seeking the most time- and cost-effective feeding method for their calves. The other farmer provided the recommended daily milk solids to replacement heifer calves in one highly concentrated feed (30% CMR solution) and observed improved calf health as a result. However, these perceived health benefits are again likely due to the provision of increased nutrition compared to the previous restricted feeding programme rather than the provision of a single, concentrated daily feed. Calves can digest large milk meals of up to 6.8 L (13.2% of bodyweight) without evidence of abdominal discomfort or milk entering the rumen (Ellingsen et al. 2016). However, large, infrequent milk meals can cause negative metabolic changes including impaired insulin sensitivity which may negatively affect animals long-term (Bach et al. 2013). Despite the legal requirement to provide two liquid meals per day to calves under 28 days of age, some CMR products have been marketed as being suitable for once-a-day feeding (van der Burgt & Hepple 2013), thereby encouraging it as an acceptable protocol on farms.

The ethics or technical competency of some animal feed companies was questioned by some of the participants in this study. In particular, concerns were raised that recommended feeding rates from manufacturers of CMR may not facilitate optimal growth efficiency. Calves fed high rates of CMR can achieve growth rates of 1 kg/day (Bleach et al. 2005), but a recent study showed that normal pre-weaning feeding practices on commercial farms resulted in 70% of calves failing to achieve the recommended growth rate of 0.7 kg/day, and 20% of those calves grew at less than 0.5 kg/day (Johnson et al. 2018). That study did not report how the participating farms established their feeding protocols, but it is likely that current industry standards which may not be based on the optimal physiological requirements of calves (Johnson et al. 2018) contribute to the consistent failure to meet the recommended AFC of 24 months (Hanks & Kossaibati 2019). It is imperative that recommended feeding rates are sufficient to meet calf nutritional requirements and support growth rates which are compatible with industry targets, and that product packaging is updated to reflect these recommendations.

The current study also raises concerns about the clarity of the instructions provided on CMR product packaging, as written instructions for mixing CMR with water to obtain the correct concentration for calf feeding were misunderstood by at least one farmer in the present study. Farmers respect the advice given by trusted feed company representatives who are familiar with their farm and the farms of others (Croyle et al. 2019) so in-person advice which can account for farm-specific rearing targets may be the best way to facilitate optimal feeding protocols on farms. Regardless, written instructions for preparing liquid feeds to pre-weaned calves should be easy to follow in order to support farmers who do not accept in-person advice, and to act as a reference or reminder when mixing CMR at calf feeding.

Few participant farmers accurately measured the temperature of the liquid mix or the amount of CMR included in the feed provided to calves. A consistent liquid diet is important for calf performance; inconsistent provision of milk solids hinders growth, starter intake and feed efficiency (Hill et al. 2009). Whilst most farmers appreciated the need for consistency in calf feeding systems, it could be difficult to achieve in practice, largely affected by the values and priorities held by the person responsible for calf feeding, but also the time, equipment and facilities available. Despite the importance of stockmanship (Tucker et al. 2005), most studies have focused on the feeding systems employed by farms, rather than the individuals employing them (e.g. Boulton et al. 2015, Medrano-Galarza et al. 2017). This study indicated that designated calf rearers tended to be most diligent regarding calf feeding, prioritising attention to detail including measuring the variables affecting CMR feeding consistency. On farms where calf feeding was carried out by persons with other responsibilities on the farm, feeding processes were more variable,

possibly stemming from a lack of time dedicated to calves and a sense of diminished responsibility compared to designated calf rearers. Automated milk feeders were useful calf management aids for the farms that had them, and can improve welfare due to calf socialisation and constant access to feed which is consistently mixed and at an appropriate pre-set temperature. However, machine feeders have high upfront capital costs, require suitable accommodation for grouping calves, and may contribute to increased disease incidence due to the hygiene challenges presented by calves sharing a single teat (Curtis et al. 2016).

Good hygiene regarding food preparation was prioritised to varying degrees on farms; some diligently disinfected equipment between feeding each calf or pen, others did not. This was sometimes due to pessimistic perceptions that hygiene was ineffectual in disease control, but management problems including uncleanliness have been shown to contribute to increased rates of diarrhoea (Appleby et al. 2001, Jasper & Weary 2002). Others believed sterilisation hindered the acquisition of immunity, similar to misunderstandings previously reported in areas of colostrum management (Palczynski et al. 2020a, Chapter 4) and biosecurity (Brennan et al. 2016). Indifference or negative attitudes towards ensuring good hygiene are problematic since sanitary feeding equipment and accommodation are critical to maintaining good calf health (Khan et al. 2011, Curtis et al. 2016). Furthermore, such attitudes may compound the restricted feeding of calves, as indicated in the literature (Khan et al. 2011) and by a youngstock veterinarian in the present study, who revealed that farmers often associated increased milk allowances with increased incidences of diarrhoea in calves, but cases of calf scour were more likely to stem from poor hygiene.

In addition to the contribution of poorly sanitised feeding equipment to calf ill-health, one veterinarian in the current study believed the angle of artificial teats on bar feeders could cause aspiration pneumonia in calves. The authors are not aware of research investigating this issue, since aspiration pneumonia is more commonly associated with incorrect oesophageal feeding (Poulsen & McGuirk 2009, Gorden & Plummer 2010) but if proven, calf feeders may need to be adapted and their design improved to encourage correct feeding position and reduce the risk of aspiration. Artificial teat feeding is recommended to allow expression of natural sucking behaviour and aid digestion (Jasper & Weary 2002) through activation of the oesophageal groove reflex which bypasses the rumen for milk to enter the abomasum. Farmer participants appreciated this, referencing milk entering 'the wrong stomach' in the absence of a teat and saliva.

Feeding unpasteurised whole milk, or non-saleable milk, can also contribute to pathogenic risk (Drackley 2008). Of the nine participating farmers feeding whole milk to calves, only two stated that they pasteurised whole milk before feeding it to calves, one of whom was

using waste milk, and a further two participants fed unpasteurised non-saleable milk. The practice of feeding milk from cows treated with antimicrobials is also a key area of concern in relation to antibiotic resistance (Ricci et al. 2017) as antibiotic residues cannot be decreased through pasteurisation. Also, feeding milk containing antimicrobial residues causes microbial imbalance in the gut microbiome of pre-weaned calves (Malmuthuge & Guan 2017). These issues appear to be most common in relation to bull or beef-cross calves from dairy enterprises due to the cost of feeding CMR or saleable milk, but some farms also fed their dairy heifers non-saleable milk as standard practice. This could be because the up-front cost of installing a pasteuriser is considered prohibitive or the benefits of pasteurisation and the risks of feeding non-saleable milk are not well understood by farmers, suggesting a need for proactive advice from veterinarians.

The information interviewees provided regarding their CMR lacked detail. Whilst farmers would refer to the need to use a 'good' feed, they did not provide a definition. This suggests that farmers require further guidance on calf nutrition, and it is likely that they relied heavily upon the information provided by their feed merchant or product packaging. The current study relied only on interviewee accounts which limited our ability to precisely assess what was fed to calves. However, detailed analyses of feed packaging or written records were beyond the scope of the study. The interviews did provide a useful overview of calf feeding and highlighted a potential disconnect between current recommendations and information provided on CMR packaging as outlined above. The interviews also showed that participants were most focused on liquid feeding of calves, with limited discussion of concentrate and forage feeding for milk-fed calves beyond ensuring adequate intakes of dry feed prior to weaning. Young calves are most at risk of diarrhoea and mortality (Windeyer et al. 2014), and there are arguably more variables and effort involved in providing milk or CMR to calves (temperature, consistency, timing, feeding method, hygiene) compared to providing calf starter and roughage. Participants said very little about the post-weaning feeding of calves, attitudes which are reflected in the lack of coverage of the post-weaned period to approximately 4–5 months of age in the research literature (Kertz et al. 2017).

Participants' main focus regarding dry feed for calves was ensuring adequate intakes to prepare calves for weaning. All producers in this study used some form of gradual weaning, and none weaned earlier than six weeks of age. Farmers mainly based weaning decisions on calf age, with some also considering calf bodyweight or starter intake, recognising that calves should be consuming over 1 kg/day of dry calf starter before weaning to indicate sufficient rumen development and prevent growth checks (Drackley 2008). These practices should support gastrointestinal growth and development in dairy calves (Schäff et al. 2018). However, not all farmers provided calves with access to water

from birth, which may negatively affect rumen development, restricting pre-weaning feed-efficiency and impeding growth both pre- and post-weaning (Wickramasinghe et al. 2019). This could be related to the poorly described water requirement for calves and few published research articles which include calf water intakes (Kertz et al. 2017).

Furthermore, the range of weaning practices used on farms indicates that there is a lack of consistent guidance regarding the best way to wean calves, or if there is, it is not being consistently implemented at farm level. Research has largely focused on the positive effects of gradual weaning based on concentrate intakes (Roth et al. 2009) and the effect of pre-weaning milk or CMR allowances on the weaning and post-weaning period (Quigley et al. 2018). However, participants were unsure of the best weaning methods, largely pondering whether transition should be done by diluting milk feeds, reducing the number of feeds, or reducing the quantity fed at each meal. Even a veterinarian who would be expected to have a good understanding of the developing bovine digestive physiology was unsure which weaning method was most effective. This suggests the industry requires further evidence-based recommendations for practical methods to wean calves, particularly *how* to reduce milk provision to best transition calves onto solely solid feed. Several participant farmers also reported that calf health status and growth rates were most problematic at weaning time, suggesting their calves did not have sufficiently-developed rumens when transitioned from milk to solid feed, or that forage intakes are insufficient to mitigate ruminal acidosis (Laarman & Oba 2011) and support the establishment of diverse rumen bacteria (Kim et al. 2016). Our results indicate a need for further research to establish a consensus on optimal weaning techniques so that farmers can be more effectively advised.

In summary, there is considerable variation in the calf feeding practices used on UK dairy farms, possibly reflecting the current lack of consensus in the scientific literature regarding the most cost-effective feeding protocols to promote growth and future performance. Although now outdated, restricted milk feeding was the predominant recommendation for decades, and advice must be consistent and have evident benefits at the farm level to shift mindsets away from restricted milk feeding. Some CMR feed manufacturers may need to review their feeding recommendations in order to better ensure calves' nutritional needs are met. More consistent advice, for example, about the importance of drinking water and hygiene practices regarding milk feeding, have also not stimulated all farmers to implement best practice. In these cases, it is possible that more effective calf performance monitoring and peer-to-peer learning may help to show farmers that their methods may not be as efficient as they could be, thus motivating them to make improvements (Sumner et al. 2018a).

Farmers would also likely benefit from more input from their advisors to counter the variation and confusion about what to feed calves and how to do it. However, it appears that the area of calf nutrition is somewhat of a grey area in terms of advice. Veterinarians may not be focused on the calf rearing of their dairy farm clients (Sumner & von Keyserlingk 2018) and are often not asked by the farmers about calf feeding. It might seem more appropriate to seek advice from trusted animal nutritionists or feed merchants (Ellingsen et al. 2012), though some participants in this study indicated they would be distrustful of receiving a sales pitch rather than honest information about the best way to feed their calves. Collaboration between veterinarians and the feed industry could help to improve the consistency of recommendations for ensuring suitable calf nutrition. Working together, veterinarians, feed merchants and nutritionists could offer farmers high-quality, bespoke advice about the most cost-effective nutrition and feeding systems that would provide for the health and wellbeing of calves on individual farms.

5.5. Conclusions

Feeding practices on dairy farms tended to be based on perceived calf performance, and the simplicity, efficiency and cost- or time-effectiveness of their feeding practices versus potential alternatives. However, farmers cannot be expected to implement best practice if the recommendations for standard feeding provide insufficient nutrition and guidance regarding weaning protocols. The advice available to farmers on the subject of practical calf feeding needs to be improved and communicated by advisors. In particular, the animal feed industry should make a more concerted effort to ensure guidelines are compatible with the physiological needs of calves, facilitate weaning and support growth targets to achieve earlier AFC.

6. Stakeholder perceptions of disease management for dairy calves: "It is just little things that make such a big difference"

According to the epidemiological triad of causation (Pfeiffer 2009), disease management must seek to control interactions between calves, pathogens and the environment. This chapter explores participants' perceptions surrounding infectious disease in calves - its occurrence, prevention and treatment - with particular focus on the effects of calf accommodation and stockmanship and the importance of attention to detail.

6.1. Introduction

Calf morbidity and mortality rates are often high in dairy herds, raising animal welfare concerns and negatively affecting farm economic efficiency (Boulton et al. 2017, Closs & Dechow 2017). Contagious disease, particularly bovine respiratory disease (BRD) and diarrhoea (commonly referred to as pneumonia and scour, respectively), is the leading cause of mortality in calves under 6 months of age (Brickell et al. 2009, Johnson 2011), with some farms experiencing disease incidences of over 70% (Johnson et al. 2017, Baxter-Smith & Simpson 2020). Costs relating to health and disease amount to an estimated 4.1% of overall rearing costs from birth to first calving, and represent 9.6% of costs in the preweaning period, with the mean cost of heifer mortality calculated at approximately $198 (£140) per surviving heifer (Boulton et al. 2017). Furthermore, calfhood disease negatively impacts first lactation performance (Heinrichs & Heinrichs 2011) and heifers treated for pneumonia as calves have shorter longevity than their cohorts (Closs & Dechow 2017). The total lifetime cost of respiratory disease has been estimated as $1089 (£772) for dairy heifers (Bartram et al. 2017).

Accurate data regarding calf disease incidence is lacking, in part because of poor recording on farms (Brickell & Wathes 2011, Johnson 2011), but also because of difficulties regarding the diagnosis of disease (Johnson 2011). There are multiple causal pathogens for BRD and diarrhoea, including viruses, protozoa and bacteria, as well as non-infectious causes such as those relating to feeding management. *Cryptosporidium parvum,* coronavirus and rotavirus are the most common pathogens causing enteric disease in calves (Gulliksen et al. 2009, Johnson 2011, Baxter-Smith & Simpson 2020), and BRD is caused by corona- and para-influenza viruses, *Pasteurella spp*. and *Mycoplasma spp.*, amongst others, but it is comparatively more challenging to determine the causal agent for respiratory disease than for diarrhoea (Johnson 2011). Additionally, Bovine Viral Diarrhoea (BVD) is a costly disease (Stott et al. 2012) which negatively affects the productivity and immune function of affected animals (Evans et al. 2019), making calves susceptible to secondary infections from enteric and respiratory pathogens (Peterhans et al. 2003). BVDFree England (2020) is a voluntary scheme which aims to eradicate BVD from all cattle in England by 2022, primarily using diagnostic testing

(Reardon et al. 2018, Evans et al. 2019) - either an antibody blood test on a sample of unvaccinated youngstock at 9-18 months of age, or conducting 'tag and test' or blood samples on all calves born to detect BVD antigen or antibodies to the virus (BVDFree England 2020).

Antibiotic use in calves (Johnson et al., 2017) is an important consideration for antimicrobial stewardship, but treatments can be hidden in farm usage metrics, largely due to the smaller liveweight of calves compared to adults (CHAWG 2020). Standard treatment for diarrhoea should consist of oral rehydration therapy, continuation of milk feeding, and antimicrobial treatments only when appropriate (Constable 2009, Lorenz et al. 2011b). The administration of nonsteroidal anti-inflammatory drugs (NSAIDs) also relieve symptoms, improving weight gain and feed intakes (Philipp et al. 2003, Todd et al. 2010, Laven 2020). Treatment for pneumonia generally involves appropriate antibiotic treatment and NSAIDs (Lorenz et al. 2011a), although antibiotics may not be necessary in all cases (Mahendran et al. 2017, Laven 2020). Disease prevention is critical to reduce disease incidence, antibiotic use, and the need for interventions (Lorenz et al. 2011c) and their associated costs, as well as to maintain calves in good health to achieve target growth performance and more positive welfare. Furthermore, antibiotic usage is perceived to be greatest during the calf rearing period of cattle production systems, so maintaining calves in good health will contribute to antibiotic reduction targets aimed at combating antimicrobial resistance (RUMA, 2020).

The epidemiological triad describes how infectious disease is dependent upon interactions between the host (calf), agent (pathogens), and the environment (Pfeiffer 2009). Therefore, disease control measures must include supporting calves' immune systems through good colostrum management, suitable nutrition, and vaccination, whilst also controlling pathogen load and challenge in the environment through good hygiene practices and biosecurity measures (Johnson et al. 2021) alongside adequate ventilation and drainage within calf housing (Gorden & Plummer 2010, Lorenz et al. 2011a, Nordlund & Halbach 2019). Management of groups of calves is also key, though the effects of individual compared to group housing on calf health are unclear due to conflicting findings in the literature (Lorenz et al. 2011a, Costa et al. 2016, Curtis et al. 2016), although group housing is considered better for growth and welfare (Costa et al. 2016). Maintaining appropriate stocking rates and avoiding shared air spaces with older animals are also important to prevent spread of disease (Nordlund & Halbach 2019). However, farms might struggle to achieve this as space restrictions or layout of existing farm buildings might limit their ability to accommodate calves appropriately. Additional pressures occur when farms are rearing more calves to increase herd size or are unable to offload surplus calves

(Haskell 2020), particularly during bovine tuberculosis (bTB) breakdowns during which movement and sales restrictions apply to animals from afflicted herds (Butler et al. 2010).

Achieving high standards for disease control is ultimately dependent on the persons responsible for planning and conducting measures - the farmers and stockpersons, and their veterinarians and other advisors (Brennan & Christley 2012, Brennan et al. 2016, Sumner et al. 2018b). Individual values and priorities affect decision making (Hansen & Greve 2014, Hansson & Lagerkvist 2016), as does awareness of a problem and willingness to change practices alongside perceived control over the situation and ability to make improvements (Vaarst & Sørensen 2009, Santman-Berends et al. 2014). Time, labour, and financial constraints can also pose barriers to making improvements to protect animal health and welfare on farm (Leach et al. 2010b, Palczynski et al. 2020a, Chapter 4). In addition, inconsistent information and advice can impinge on effective decisions and actions at the farm level, such as those relating to milk feeding of calves (Palczynski et al. 2020b, Chapter 5). It is therefore important to understand the personal and practical factors contributing to disease management. This chapter focuses on the perception of farmers, farm workers, veterinarians, and farm advisors on the management of calfhood disease on dairy farms in England.

6.2. Materials and Methods

The research presented here used a critical realist paradigm, meaning that subjective experiences and beliefs are as valid as objective facts to understand phenomena (Maxwell 2012). In-depth, semi-structured interviews followed by thematic analysis of the interview data were used to achieve a holistic understanding of calf management on English dairy farms including colostrum management (Palczynski et al. 2020a, Chapter 4), calf feeding (Palczynski et al. 2020b, Chapter 5), and the perceived value of youngstock, advice and calf performance monitoring which will be presented in Chapter 7. This chapter examines findings particularly related to disease management in dairy calves derived from the wider research study.

The research was conducted and presented in line with COREQ criteria for reporting qualitative research (Tong et al. 2007). Data collection and analysis was conducted by the first author, a female doctoral student with an interest in human influences on animal care and with initially a basic knowledge of the dairy industry and disease processes. The researcher did not have a prior relationship with the participants; some contacts were recommended by the co-authors acting as the supervisory team but contact between the student and interviewee was limited to one interview (average interview length was 56 minutes, range 26 - 90 minutes). Participants were considered the 'expert' and were asked to confer their knowledge to the curious researcher through the interview discussions.

6.2.1. Data collection - interviews and participants

Forty face-to-face interviews (26 with farmers, 14 with advisors) were conducted between May 2016 and June 2017. Three interview formats were used: individual interviews in a seated setting (n = 23), joint interviews where two to three participants (n = 20) were interviewed together (n = 9), or walking interviews during a tour of the farm and calf facilities (n = 8). Questions in the interviews were based on a topic guide and were deliberately broad, looking to obtain a general overview of participants' experiences related to calf rearing on dairy farms and to allow them to lead the discussion in the direction of their choice and on issues which mattered to them. Interviews were audio-recorded and assigned a representative code: a letter referring to the type of participant (farmer, F; veterinarian V; feed consultant, N; pharmaceutical company representative, DR; veterinary government advisor, GA) and numbered in chronological order for each grouping (F1, F2, F3, etc.).

Participants were recruited using purposive and snowball sampling (Cohen et al. 2007), starting with existing networks and contact with veterinary practices, individuals attending dairy events and conferences, and persons suggested by interviewees. This recruitment method resulted in a variety of dairy production systems and herd sizes being represented. Three geographical areas in England were covered: the Southwest and Midlands (high densities of dairy farms) and Northeast (less dairy focus). Interviewees included 37 dairy farmers (farm managers (n=17), farm workers (n=9), calf rearers (n=8), and herd managers (n=3)) and 14 advisors (veterinarians (n=11), feed (n=2) and a veterinary pharmaceutical company representative (n=1)). This variation satisfied the need for rich, detailed data from a range of contexts, in line with quality criteria for qualitative research (Turner 2010).

6.2.2. Data analysis - Thematic Analysis

Data collection and analysis were conducted in an iterative approach until it was judged that no new themes were emerging, indicating thematic saturation (Miles et al. 2014).

Audio recordings of the interviews were manually transcribed using f4transkript software (Version 6.2.5 Edu, audiotranskription.de, Marburg, Germany). Interview transcripts were thematically coded in NVivo for Windows (Version 11.4.1.1064 Pro, QSR International Pty Ltd., Victoria, Australia) to group common extracts into themes (Braun & Clarke 2006). Coding was conducted by the first author. First, content coding was used to group extracts according to topic (Miles et al. 2014) i.e. management practices, processes and personal values. This helped to inform ongoing interviews and indicate focal topics for further analysis. Once data collection was completed, coding was repeated for in-depth exploration of extracts relating to each focal topic.

Extracts were chosen to represent the perceptions of participants which informed the construction of themes and explanations by the first author. The extracts most relevant to calf disease and its management tended to be in response to questions like *"What are the main problems you experience regarding calves?"*; *"What is important for successful calf rearing?"*; and *"Which changes would you like to make, if any, to your calf management or facilities?"*. Additional probing questions were asked to gain further insight into the participant's initial response. Quotes from participants are presented within quotation marks; ellipses indicate omission of text; and square brackets indicate clarifications from the authors.

6.2.3. Ethical approval

All participants gave their informed consent for interviews to be conducted, audio recorded, transcribed, securely stored, and for anonymised interview excerpts to be published. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved under project number 75-201511 by the Harper Adams University Research Ethics Committee on 13 January 2016.

6.3. Results

6.3.1. Disease occurrence and treatments

Pneumonia, diarrhoea and mortality

Farmers and veterinarians considered BRD and diarrhoea (scour) to be the main threats to calf health. However, on individual farms, it was generally perceived that one was more problematic or common than the other (Table 6.1). Most farmer participants perceived pneumonia to be a bigger problem than scour for their calves (Table 6.1), based on their recollection of issues rather than treatment records, but some veterinarians disagreed with this farmer perception, as demonstrated by the following contrasting opinions of a farm manager and a veterinarian:

> "Scours we don't get so much of a problem with. We could count the number of cases on one hand that we get like in 6 months, or even a year" (F9, male farm manager).
>
> "I would say scour is by far the most common, but a lot of farmers don't perceive it as a problem. They'll know the ones that die because of it, but they'll often massively underestimate how much of a problem it is" (V11, female youngstock veterinarian).

Advisors were concerned that farmers often failed to record calf data to accurately assess morbidity and mortality rates:

> "The change in the Red Tractor standards [assurance scheme] that came in 3 - 4 years ago, when it's one of the requirements to actually track your calf mortality and I think a lot of people maybe didn't even know that. I think it's quite scary" (DR1, female pharmaceutical company veterinary advisor).

Aside from a few calf rearers (F2, husband and wife F26) who announced their mortality figure from the previous year to be zero, and a dairy bull calf rearer who stated their mortality rate was 2-3% (F17), farmers in this study generally relied on memory to assess calf mortality, and tended to perceive low numbers of calf deaths:

> "Mortality rate's really, really low. Might have about one a month or something, I don't even know that it would be that. I think we were below double figures last year and the year before" (F11, female farm administrator, herd size approximately 400, all year round calving).

The long-term significance of calfhood illness on adult performance was mentioned by several farmers. Some joked that they were unsure why they nursed some very poorly calves back to health, but seemed proud that they had. Others felt it was often better to cull calves which would not recover sufficiently to perform well as adults; on a couple of farms, there was evidence that calfhood pneumonia had resulted in long-term lung damage that negatively affected performance and welfare in later life:

> "You could persevere with some - we put them to sleep. They're just gonna be poor doers and I don't think it's worth wasting several thousand pounds on rearing them when they're just probably gonna give us poor lactations and just be problems ... I'd rather get rid of them after a few weeks" (F24, male farm manager).

> "There's a few cows ... they've had pneumonia as calves and it's just coming out now, maybe second lactation and it really, really hurt them" (F22, female herd manager).

Understanding of disease processes and treatments

Farmer participants demonstrated a basic understanding of disease processes. Pneumonia problems were mainly attributed to poorly-ventilated, overstocked buildings and winter weather. Little consideration was given to the causal pathogens for pneumonia (aside from some mentioning *Mycoplasma bovis* issues); farmers tended to refer to the infectious causes of diarrhoea, particularly coccidiosis, Cryptosporidiosis and Rotavirus (Table 6.1). Scour outbreaks were perceived to be linked to calf management: hygiene, stressful periods, mixing of groups, colostrum management, milk feeding and weaning. Participants also referred to nutritional scour which they considered resulted from

increasing calf milk replacer feeding rate (particularly in accelerated feeding programmes when increasing to >900 g milk powder/day), or when seasonal grass quality changed the profile of whole milk being fed. Preventive measures to protect calves against pneumonia and scour included a range of practices such as: colostrum management, providing adequate nutrition, vaccinations, good hygiene practices and group management, and improvements to calf accommodation (Table 6.1). Some participants blanket treated calves with Halocur® (halofuginone lactate, MSD Animal Health UK Ltd.) to prevent diarrhoea caused by *Cryptosporidium parvum* (Table 6.1).

However, preventive measures did not negate the need for disease treatments. The key treatment used for diarrhoea was oral rehydration therapy (Table 6.2), because *"the dehydration will kill them more than anything else*" (F6, female calf rearer). Pneumonia was usually treated with antibiotics, and although only one participant mentioned *"how painful pneumonia is. So that brings a huge compromise to animal welfare"* (V4, male farm veterinarian), several farmers appreciated the benefits of analgesic treatments (Table 6.2) to improve calf wellbeing and recovery:

> "What we've found works best [is] the Metacam [meloxicam, Boehringer Ingelheim Animal Health UK Ltd] anti-inflammatory painkiller. Just gets the calf up on its feet. You get it up, you get it eating, you get it drinking again ... feeling better in itself, regardless [of] whether the infection's gone, you've got a lot more chance of him coming right" (F17, male farm worker on calf rearing unit).

Antimicrobial Stewardship

Both veterinarian and farmer participants were cognisant of antimicrobial resistance and expressed concern regarding the use of blanket prophylactic antibiotic treatments being *"accepted as normal"* (V4, male farm veterinarian) on farms. Indeed, some participants shared their experiences of engaging with farmers for whom prophylactic antibiotic use was a routine management protocol for their calves:

> "I do the computer work for another farm down the road and they just feed their calves blanket antibiotics in their milk because they have lots of problems with them and ... that's the easiest, quickest fix" (F2, female calf rearer).

> "A very big calf rearer ... he said ... "I buy 2000 calves a year and we don't worry about BVD ... because we feed antibiotic milk powder for five days when they arrive on farm" ... We cannot be doing that as an industry, that is not acceptable practice ... that kind of stuff really frustrates me" (DR1, female pharmaceutical company veterinary advisor).

Concerns were not limited to certain individuals. One veterinarian (V4) criticised the inattention to antibiotic usage stemming from treatments against *Mycoplasma bovis* within the dairy industry:

> "Mycoplasma bovis in the national dairy herd is a huge, huge problem. No one talks about it ... It's probably the single biggest cause of antibiotic usage in dairy replacements" (V4, male farm veterinarian).

Antimicrobial stewardship appeared suboptimal when it came to treating ill calves. Apparently some perceived antibiotics as the most effective solution for calf health problems, regardless of causal pathogen, as reported by this veterinarian:

> "Particularly the older generation, "Why do I want to give them electrolytes when I could give them a pill that works?" And you're going ... "There's no reason to give antibiotics to something with Rotavirus". It's really difficult. Sometimes you just have to let them carry on giving the pills, provided they do the other things that you want them to do as well ... [they think] it's only the pills that have worked and nothing else" (V7, female farm veterinarian).

Indeed, some farmer participants treated scouring calves with antibiotics, even when the cause of diarrhoea was not believed to be bacterial (Table 6.2). There were mixed feelings about the need to take faecal samples to diagnose the cause; treatment decisions were often based on previous diagnoses in efforts to intervene quickly:

> "If we get any scouring calves, we'll take a [faecal] sample and give it to the vets and they'll test for what's actually wrong with it, and then we'll be injecting them with the right drug ... the medicines are expensive, so we don't want to be injecting them and not utilising the medicine and we don't want to use more antibiotics than we need to" (F1, female calf rearer).

> "Nine times out of ten you know it's gonna be [coccidiosis] so I just dose [the calf] anyway and they seem to clear up. Trouble is that ... you take [faecal] samples to the vets and [they say] "Oh yeah, but it's at a very low level, just see how it goes on" ... It goes on, then a week later it's got even worse and you think "Well, I could've treated that a week ago and it wouldn't have been knocked back"" (F14, male calf rearer).

The importance of early treatment interventions

It was widely accepted among participants that early treatment for calf illness led to higher survival rates and treatment success:

> "With a calf, you have to be on it. They're babies. If they're not very well, the next day they're nearly dying" (F18, female calf rearer).
>
> "If you [detect illnesses] quickly then [calves] respond much better to treatment than if you leave them until they're really sick" (F2, female calf rearer).

An experienced designated calf rearer whose time and priorities were focused on calves was generally considered to allow for higher-quality calf husbandry and earlier detection of behavioural signs of illness in calves:

> "Say a calf looks a little bit sick, maybe it's got its ear down, or you just know them, they just look a little bit off colour. Someone else would walk in the shed and say "What are you worried about? That calf looks fine!" But you know it's not. Take its temperature" (F18, female calf rearer).
>
> "There's a couple of farms I can think of, where if the stockman who rears the calves goes away for the weekend and the farmer rears the calves, there'll be two or three dead calves come Monday because he's not fed them right, or he's not spotted the signs early enough" (V3, male youngstock veterinarian).

Technology was reported as a tool to facilitate the detection of early signs of disease. Farmers using automated milk feeders used notifications of slow drinking or lower feed consumption by calves as an early indicator of calf illness. Some farmers were also considering investing in TempVerified Calf Tags (FeverTags®, https://fevertags.com), which flash in response to sustained high temperature:

> "I've looked at these tags that flash a light at you if [the calf is] hot ... I might do a trial on that, do a couple of pens and you're not allowed to treat them for antibiotic unless you see there's a temperature for pneumonia. That could cut our antibiotic usage ... They're quite expensive ... I wouldn't do it unless it saves us money" (F20, male farm manager).

Vaccines

Aside from one farmer who resented that he had to vaccinate against Rotavirus after buying an infected calf (F10, male farm manager), most conversation about vaccination was focused on pneumonia. Vaccinating calves against pneumonia was believed to help mitigate the impact of subpar calf accommodation, but a veterinarian was frustrated by the reluctance of farmers to vaccinate against pneumonia despite rearing calves in poor environmental conditions:

> "There's a couple of people who have horrible pneumonia problems and the shed's not designed for [calves] and they're overstocked and they've mixed different age

groups - so they're doing everything wrong and yet they still won't vaccinate and it's just madness" (V8, male farm veterinarian).

Economic considerations contributed to the absence of calf vaccination on some farms:

> "We haven't recovered properly from the [milk] price slump yet, and so to start a new vaccination policy and everything like that, I just don't think it would be looked upon well" (F22, female herd manager).

Several participants were vaccinating calves against pneumonia (Table 6.1) but the perceived effectiveness of pneumonia vaccines was mixed:

> "Some years, we were treating virtually all the youngstock [for pneumonia], whereas now we get one, two. So [the vaccine has] made a great difference" (F15, male calf rearer and farm worker).

> "It's very frustrating because we've started vaccinating everything for pneumonia but yet we still have to treat a lot of [calves] with pneumonia" (F24, male farm manager).

One farmer (F9) took blood samples to assess the effectiveness of their pneumonia vaccination programme:

> "We regularly take blood samples of calves that contract pneumonia, even though they've been vaccinated, to try to identify the strains and make sure that it's being covered by the vaccine, or if it wasn't administered correctly, or if the vaccine simply didn't work" (F9, male farm manager).

One veterinarian questioned whether pneumonia vaccines would be necessary if calf facilities and early life management were adequate:

> "We've got any number of vaccines available, and yet they still don't cover all the infectious causes of pneumonia. And we keep getting hammered by drug companies that we don't sell enough pneumonia vaccine! Well actually, if we got the colostrum right, and we got the feeding right, and we got the environment right, we wouldn't need any" (V8, male farm veterinarian).

However, despite a keen focus on colostrum management and recent investment in a new youngstock unit designed with the help of their veterinarian to promote good calf health, this farmer still had to treat calves for cases of pneumonia:

> "Part of the expectation of the new calf unit was that we would not need to vaccinate any more ... We did have an element of pneumonia in the new calf unit last year, which was disappointing" (F26, male farm manager).

Table 6.1. Participants' main health problems in their calves, and prevention methods mentioned in the interview

Farm	Problems, past and present	Main problem(s)	Vaccines	Other prevention methods
F1	Cryptosporidiosis, scour, pneumonia (adults with lung damage)	No major issues	Against pneumonia, product not specified.	- Halocur® [1] oral treatment first three days - Treat navel - Attention to detail
F2	*Mycoplasma*, pneumonia, scour	No major issues	Against pneumonia: - Bovilis® Ringvac [1] - Rispoval® RS+PI3 Intranasal [2] (stopped last year - no issues)	- BVD tag and test - Treat navel - Attention to detail - Cleanliness
F3	Pneumonia, scour	Pneumonia (overstocking)	Against pneumonia: - Bovilis® Bovipast RSP [1] - Intranasal (not specified) Against scour: - Bovilis® Rotavac® Corona [1] (cows at drying off)	- Treat navel
F4	Cryptosporidiosis, Coccidiosis, pneumonia	Scour	Against BVD and leptospirosis, products not specified.	- Treat navel - Cleanliness
F5	Pneumonia, pot bellied calves	Pneumonia	Against pneumonia: - Currently Rispoval® 4 but planning to change to RS+PI3 Intranasal [2] and vaccinate cattle against BVD - Against IBR, product not specified.	- Once vaccine protocol changes, will do BVD tag and test
F6	Coccidiosis	No major issues	Against pneumonia/BVD: - Rispoval® 4 [2] Against lungworm: - Bovilis® Huskvac [1] Against black leg and leptospirosis. Products not specified.	- Treat navel - Attention to detail - Clean boots before entering calf space
F7	Navel-ill, Joint-ill, respiratory disease	No major issues	Against pneumonia/BVD: - Rispoval® 4 [2]	- BVDFree accredited - Monitoring faecal samples for Coccidiosis - Treat navel
F8	Pneumonia, Cryptosporidiosis, scour	Pneumonia	Against pneumonia: - Rispoval® RS+PI3 Intranasal [2]	- Calves treated with 4 ml Selectan® [3] (Florfenicol-based injectable antimicrobial against pathogens causing BRD) on arrival
F9	Pneumonia, Cryptosporidiosis, Coccidiosis	Pneumonia	Against pneumonia: - Rispoval® RS+PI3 Intranasal [2]	- BVD tag and test (heifers only, bull calf buyer sees no merit in it) - Good hygiene - Fans for increased ventilation

F10	Rotavirus	No major issues	Against scour: - Rotavirus, product not specified.	- Free of BVD
F11	Pneumonia, scour	No major issues	Not covered.	- Free of BVD (but considering stopping tag and test due to cost). - Attention to detail
F12	Pneumonia, Rotavirus, Salmonella	No major issues	Against scour: - Rotavirus, product not specified.	- Cleanliness - Treat navel
F13	Pneumonia, scour	Pneumonia	Against pneumonia: - IBR - BVD - Against leptospirosis Products not specified.	- Keep bedding clean and dry - Improved ventilation - Outdoor rearing - Starting BVD tag and test
F14	Pneumonia, *Mycoplasma*, Infectious Bovine Rhinotracheitis (IBR), coccidiosis, leptospirosis,	Pneumonia	Against pneumonia: - Rispoval® RS+PI3 Intranasal [2] - Against IBR, product not specified. Against lungworm: - Bovilis® Huskvac [1]	- Low levels of BVD according to bulk milk tests, will start blood testing heifers as part of BVDFree England scheme. - Fans for improved ventilation - Vecoxan® [4] (Diclazuril-based endoparasiticide oral drench against coccidiosis) in final milk feed prior to weaning
F15	Pneumonia, Coccidiosis	Pneumonia	Against pneumonia: - Rispoval® RS+PI3 Intranasal [2]	- Low levels of BVD according to bulk milk tests, "testing really poorly calves [for] BVD, and we always keep coming negative on that"
F16	Minor nutritional scour	No major issues	Not covered.	Not covered.
F17	Pneumonia, coccidiosis	Pneumonia	Against pneumonia: - Bovilis® Bovipast RSP [1]	- Deccox® [2] (Decoquinate-based endoparasitiide against cocidiosis) at a low level in concentrate for 4 weeks upon arrival.
F18	Pneumonia, rotavirus, cryptosporidiosis, coccidiosis, salmonella	No major issues	Not covered.	- BVD tag and test, no positive results so far - Good hygiene - Attention to detail
F19	Pneumonia, cryptosporidiosis, nutritional scour	No major issues	Not covered.	- Free of BVD - Vecoxan® [4] in milk when case(s) of coccidiosis occur.
F20	Pneumonia, cryptosporidiosis	Pneumonia	None. May start vaccinating to reduce antibiotic treatments for pneumonia	- Free of BVD -"more airy sheds"
F21	Pneumonia, coccidiosis, rotavirus	No major issues	Against pneumonia: - (unspecified Rispoval® [2]) Against scour: - Rotavirus - Against ringworm Products not specified.	- BVD tag and test, no positive results for past 3 years - Powdered antibiotic (product not specified. To help reduce scour related to cryptosporidia and coccidiosis) - Hygiene - Improved calf housing

F22	Pneumonia, general ill-thrift, nutritional scour	Pneumonia	Against BVD and leptospirosis, products not specified. Stopped pneumonia vaccine due to price pressures.	Not covered.
F23	Pneumonia, swollen navel, diptheria	No major issues	Against pneumonia, product(s) not specified.	- Fans for improved ventilation
F24	Pneumonia, scours	Pneumonia	Against pneumonia, product(s) not specified.	- Improved ventilation
F25	Scour, pneumonia	No major issues	Not covered.	- Halocur® [1] oral treatment in first milk feed. - Attention to detail
F26	Pneumonia, Coccidiosis, Cryptosporidiosis, Rotavirus	No major issues, pneumonia	None. Stopped pneumonia vaccine due to new calf housing.	- Good hygiene - New, purpose-built calf housing - Attention to detail

Note: The contents of this tables are not exhaustive, other practices may not have been mentioned in the conversation.

[1] MSD Animal Health UK Ltd.

[2] Zoetis UK Ltd.

[3] HIPRA UK & Ireland Ltd.

[4] Elanco UK Animal Health Ltd.

[5] Norbrook Laboratories Ltd.

[6] Boehringer Ingelheim Animal Health UK Ltd.

Table 6.2. Participants' main treatment protocols referred to during interviews.

Warning sign/Illness	Treatment protocols	Farm(s)
Slow drinking calves	- Thermometer: check for fever then select appropriate treatment.	F1, F19, F24
Calves 'not quite right' (behaviour, early symptoms)	- Thermometer: check for fever then select appropriate treatment.	F2
Pyrexia	- Treat with Metacam® [6] and oxytetracycline antibiotics (product not specified).	F24
Calf Scour	- Separate scouring calf from group	F6, F25
	- Add oral rehydration sachet to milk fed little and often	F6, F25
	- Oral rehydration (route of administration not specified)	F26
	- Oral rehydration therapy and antibiotics (product not specified).	F23, F25
	- Treat scour with electrolytes and in cases of coccidiosis, provide Norodine® [5] (antibiotic).	F19
	- Treat cases of cryptosporidiosis with Halocur® [1]	F20
(Early) calf pneumonia symptoms (breathing, coughing, high temperature)	- Treat with antibiotics (product not specified).	F20
	- Oral rehydration therapy and antibiotics (product not specified).	F23
	- Inject with long acting antibiotic and anti-inflammatory.	F2
	- Metacam® [6] anti-inflammatory, antibiotics if necessary (product not specified, treatment protocols based on vet advice).	F26
	- Alamycin®[5] (long acting antibiotic containing Oxytetracycline Dihydrate) or Draxxin® [2] (Tulathromycin-based antibiotic) and Metacam® [6] (Mexoxicam-based NSAID)	F11, F22
	- Resflor® [1] (Contains Florfeniol and Flunixin to provide antibiotic, anti-inflammatory and anti-pyrexic in one dose)	F7
	- Treat cases of pneumonia with Zactran® [6] (Gamithromycin-based antibiotic) and pain relief from Metacam® [6]	F13
	- Treat cases of pneumonia with Metacam® [6] (pain relief) and Nuflor®[1] (Florfenicol-based antibiotic) to treat the infection.	F17
	- First case give 5ml Resflor® [1], repeat case give Draxxin® [2] and Metacam® [6], if treatment fails again, Alamycin® [5]	F25

Note: The contents of this tables are not exhaustive, other practices may not have been mentioned in the conversation.

[1] MSD Animal Health UK Ltd. [2] Zoetis UK Ltd.

[5] Norbrook Laboratories Ltd. [6] Boehringer Ingelheim Animal Health UK Ltd.

6.3.2. Management of calf environment

Calf group management

Farmer participants housed calves in a variety of group sizes in outdoor hutches, indoor pens, or a combination (Table 6.3). This variation was largely dependent on the space available to rear calves and the labour-intensiveness of different systems. Individual hutches were considered particularly demanding, but worth the extra labour for improved calf health:

> "I'm highly satisfied with all disease levels. Diseases are pretty low in their hutches" (F7, male calf rearer and farm manager).

Calves were often individually housed at first, then grouped once they were confidently drinking milk, or after weaning (Table 6.3), but the way in which calves were grouped was also somewhat dependent on the priorities and time management of the responsible stockperson(s):

> "I wanted to make sure everything went through a single hutch and then went on to group hutches ... you end up cleaning out a group hutch, put some calves in, then you have to clean out [the single hutches] as well. Before I came, they didn't really bother doing that. They just cleaned out the group hutch and then just put the new [calves] in there instead" (F3, male calf rearer and farm worker).

While the social interaction of group housing could be beneficial for calves, it was also thought to result in some being bullied away from feeding by other calves and led to variable growth rates within the same group:

> "I do like putting them into the big hutches and seeing them run around and seeing them mix and interact, but it is just interesting that we've had real variance in growth rates from the group hutches [prior to weaning compared to individually housed calves in a trial]" (F1, female calf rearer).

Grouping calves was also perceived to influence disease incidence, although it was suggested that disease transmission could be mitigated by appropriate management:

> "A lot of the guys will pen individually and feed individually and I think that massively reduces scours, but then probably increases pneumonia further along" (V4, male farm veterinarian).
>
> "It's important to keep them in very small groups of a similar age, and don't mix them" (F10, male farm manager).
>
> "Instead of trying to limit it to number, limit it to age range. If we think of how the diseases spread, it's normally a ten day to two-week cycle. So if you open a pen

and only fill it for two weeks and then shut that pen, independent of whether it's got three calves in it or ten calves, which is really the maximum I like to go with, then that'll stop your disease spread" (V11, female youngstock veterinarian).

Some farmers noted the apparent ease of disease transmission between calves and from older animals, and so were mindful of internal farm biosecurity. Several farms kept heifer calves and beef calves separate to avoid cross-contamination, and a few considered the equipment being used for both the milking herd and the youngstock:

> "One thing that we are quite careful with is that we use the loader that hasn't been in all the muck where all the Johne's is. A lot of farms, they'll do everything for Johne's, but then they'll just drive in and scrape up with the tractor that scraped up all the cow muck" (F1, female calf rearer).

> "We do go from adult cows to young calves. We don't go in the pens with the calves without washing our wellies [boots]" (F9, male farm manager).

However, several farmers struggled to maintain sufficient space for all their calves:

> "Overstocking is probably the biggest issue ... we had so many I had to double up all the single hutches" (F3, male calf rearer and farm worker).

This was sometimes due to farms being under movement restriction due to bTB, resulting in limited outlets for the sale of their calves and high stocking densities on farm. This often compromised hygiene and grouping/housing protocols, and in some cases resulted in calves sharing airspaces with older cattle:

> "One of the sheds that we were moving calves into had older cattle in, because we were a bit tight for space. The vet said "Older cattle are resistant to a lot of the pneumonias, but of course they're still breathing out the virus, so then if you're putting youngstock in with older ones, then you're at high risk of passing on". So we've tried to break that link [by putting up some new sheds as calf housing]" (F5, male farm manager).

Table 6.3. Participants' calf housing, group management and hygiene practices mentioned during interviews.

Farm	Farm details: Calving Pattern, Herd Size, Farm System	Accommodation	Group size(s)	Cleaning practices	Jackets worn by calves
F1	AYR, 380, conventional	Hutches	Individual until after weaning, then groups of 5	Fresh bedding every 3 days, pressure washed, steam cleaned and disinfected (using Kilcox® disinfectant - effective against coccidiosis and cryptosporidiosis) between calves	Yes, up to 3 weeks
F2	AB, 350, conventional	Pens, new calf buildings	6 at first, 12 when drinking milk well, 20 pre-weaning	Fresh bedding daily, mucked out as required according to atmosphere, disinfected and rested between blocks	Yes, below 10˚C
F3	AYR, 350, conventional	Hutches	Individual, paired when drinking milk well, 6 pre-weaning	Not covered	Yes, for first week
F4	AYR, 120, conventional	Hutches, overflow buildings (old)	Groups of 5	Regularly cleaned, especially the hutches because otherwise ventilation is restricted	Some, for poorly calves
F5	AB/SB, 70, conventional	Pens, recent calf sheds (cheap to build)	Individual, groups of 3-4 when drinking well, bigger groups post-weaning	Not covered	No, would consider
F6	SB, 300, organic	Hutches	Individual for 2-3 days then groups of 12	Plenty of fresh straw. Mucked out and disinfected between batches	Some
F7	AYR, 280, conventional	Hutches	Individual until pre-weaning groups of 4	Fresh bedding every other day	No
F8	Dairy bull calf rearer, batches of 20 calves	Pens	Groups of 20 on automated feeder	Mucked out at group movements	Some, trial with one batch
F9	AYR, 250, conventional	Hutches, then pens	Individual hutches, grouped in pens at 2-3 weeks	Cleaned and disinfected (using Bi-OO-Cyst® disinfectant, effective against endoparasites including coccidiosis) between calves	Yes, until moved inside
F10	AB, 90, conventional	Pens	Groups of 4-5	Regularly cleaned out with fresh bedding, power wash and disinfect after every calf	Yes, up to 4 weeks
F11	AYR, 400, conventional	Pens	Grouped at 5-6 days old, automated feeder	Not covered	Yes, up to 3 weeks
F12	AB, 370, conventional	Pens, then outdoors	Groups of 10 until 6 weeks when combined into group of 40	Disinfected and rested between blocks	No, would consider
F13	SB, 600, conventional	Pens, then outdoors	Pairs until drinking well, then groups of 15-20, then 35	Pressure wash, quicklime, open doors in summer, let it dry and rested between blocks	No
F14	AB, 420, organic	Pens	Individual until 10-14 days old, then groups of 8	Mucked out and disinfected when calves move. Pressure washed and disinfected between blocks	One, for ill calves
F15	AYR, 120, conventional	Pens	Groups	Pressure washed	Not covered

F16	SB, 250, organic	Pens followed by outdoor paddock	Groups	Mucked out when calves move outside, accommodation rested between calf groups	Not covered
F17	Dairy bull/beef calf rearer, 1400 calf places	Pens	Groups	Mucked out, pressure washed, disinfected, rested for about 1 week between batches	No
F18	AYR, 180, conventional	Pens	Individual then groups of 5 at 6-7 weeks for weaning	Disinfect for coccidiosis	Yes
F19	AYR, 160, conventional	Pens	Not covered	Fresh bedding often, cleaned out, sprayed with peracetic acid, left to dry, rested 1 day between calves	Not covered
F20	AB, 330, conventional	Pens	Groups of 4-6, depending on feeder	Steam cleaned and disinfected between every group	Some, for ill calves
F21	AYR, 1200, conventional	Pens	Individual until 10 days	Steam cleaned and disinfected	Yes
F22	AYR, 130, conventional	Pens	Individual until eating enough	Mucked out once a month, never disinfected	No
F23	AB, 250, organic	Pens	Groups of 5, post-weaning groups of 30	Fresh bedding 2-3 times per week, pressure washed, steam cleaned, disinfected	Has some, rarely used
F24	AYR, 200, conventional	Pens	Individual first week then moved into groups	Mucked out at group move	Not covered
F25	AYR, 350, organic	Hutches, pens in buildings	Groups of 5	Hutches disinfected after every batch of calves. Buildings infrequently disinfected	Trialled for first 4 weeks
F26	AB, 500, conventional	Hutches	Groups of 15	Fresh bedding daily, steam cleaned, open and aired/rested between blocks	Not covered

Table content is not exhaustive. Other practices may not have been covered during the interview.

Hutches were located outdoors, pens were inside a building.

Thermal comfort and hygiene within calf accommodation

Several farmers aimed to create a microclimate for calves to provide them with thermal comfort. Some farmers considered modifications within the accommodation itself to help keep calves warm, but actions were influenced by the perceived severity of seasonal weather:

> "We did think about putting a cover over the back, like they do with pigs, with some straw on top to keep them warm. The vet suggested it, actually. We might do it, but it hasn't been too bad this year, we've had a reasonably kind winter" (F20, male farm manager).

Standard use of calf jackets during the winter was more common in all-year-round calving systems rather than block calving systems (Table 6.3), due to the number of calves requiring jackets at the same time in block systems. Some farmers kept a small number of calf jackets to aid the recovery of ill calves:

> "We'll put a calf jacket on anything that has had the scours, really, and just looks generally not very thrifty" (F20, male farm manager).

However, use of calf jackets was dependent upon the stockperson's knowledge of how to make best use of them. One farmer (F9, male farm manager) used two different brands of calf jackets, noting that the sizes available from one brand were too large to benefit small calves. Another farmer was unsure of the calf jacket protocol to follow if they are not standard attire for all calves:

> "I don't know when you would take a calf jacket off. Some people say once it goes on, it stays on until you've weaned them ... But if you put a jacket on like for a week, and then take it off, does a calf go back [lose condition] then? I don't know." F14, male calf manager.

Although bedding plays a key role in thermal comfort for calves, farmers seemed to focus on the aesthetic and disease prevention associated with providing calves with plenty of clean, dry bedding:

> "I don't want the calves to ever look dirty ... If they look dirty, I'm a day late with the straw going in ... I get moaned at by dad because he thinks I use too much straw, but it saves me [using] antibiotics" (F19, male farm manager).

Adding fresh bedding on top of soiled material was acknowledged by some to *"breed more bugs"* (F14, male calf rearer), but was a common practice. Stockpersons might

postpone cleaning the calf pens, especially where calf buildings did not allow for easy hygiene management:

> "I've had a lot of coccidiosis in that one particular pen, but you can't just go and clean that one pen out ... you have to clean the whole shed out. Well, then you sort of think "It can wait another week". Things like that don't get done as quick as what they should because it's quite a job to push everything out, take all the pens down, then clean out, then put it all back up again" (F14, male calf rearer).

Participants noted that pathogen load could be further reduced if calf housing could be disinfected and left empty for a time, but this option was limited by the space available to house calves on farms:

> "We don't have enough space, so we can't have [the pens] resting. It's a day's rest. They're cleaned out, they're sprayed with peracetic acid, washed down with it and then left ‘til they dry, but it's not that long. A nice drying day like today helps. A wet, drizzly day and they don't really ever dry out" (F19, male farm manager).

In block calving systems it was possible to rest calf accommodation between calving blocks, although disease burden did build up over the course of the calving season:

> "Leaving a shed clean, dry and empty for a few months massively reduces the pathogen challenge ... You see a lot less disease, especially at the start of the block. It might build up towards the end of the block, but compared to these guys who are constantly housed, it definitely helps" (V3, male youngstock veterinarian).

Investing in calf accommodation

Many farms had limited space for calf rearing and often utilised existing multi-purpose farm-buildings to house calves with inappropriate airflow and drainage, partly because the milking herd and parlour were commonly prioritised for investment:

> "Access to clean out the shed is very difficult ... And the floors, they should be on more of an angle ... but they're reasonably flat, so drainage into all the drains isn't particularly great. It's not the best calf shed, really, considering we've got this nice dairy" (F24, male herd manager).

> "Most buildings in the UK are old buildings that you use for calves. You'll spend money on your buildings for your cows, but you won't spend it on the calves. Calves go in some poorly ventilated, or cold, damp area" (V2, female youngstock veterinarian).

Often, the person working with the calves was not in control of the farm's finances, so they had little choice but to work within the limitations of the calf facilities available to them.

Farm developments were in competition for space, function and expense, so even if calf rearers were consulted their input was restricted to a choice between what they perceive to be suboptimal options for calf accommodation:

> "It all comes down to money at the end of the day, so, it's a shed here empty, so we use it and you've gotta make the most of it and just get on with it ... We've got a couple of those Igloo things [group hutches], I hate them ... I've never seen so many ill calves ... [The farm manager] said we could put a concrete slab there and use those Igloos and I said "Nah - I'd rather use this [shed that's not ideal]"" (F23, male farm worker and calf rearer).

In many cases farmers appreciated an advisor's ability to recommend practical, realistic upgrades to existing accommodation to improve calf health:

> "Some vets have this similar sort of mindset: in an ideal world you could do [with] a new space, well it's not an ideal world, so what are we gonna do? Some don't have that, they come out with theory ... we all read the same books, but how do we get different results [on our farm]?" (F25, male farm manager).

All participant farmers who had invested in purpose-built calf accommodation perceived significant improvements in calf health. However, in many cases, erection of new calf housing was considered prohibitively expensive. The decision to invest in new calf housing was largely dependent on the farm's willingness, or ability, to finance the development:

> "Eventually we came to the conclusion that we had to spend some money, this [the new calf accommodation] was desperately needed [to improve calf health]" (F26, male farm manager).

> "The farmer may know that the shed he rears the calves in is just awful ... but he also knows he hasn't got X-thousand pounds to put up a new one ... He'd need to be very convinced that if he goes out and borrows X amount to put up a calf house that there is gonna be a return that will pay for his borrowings, and that can be a challenge" (V10, formerly practising veterinarian, now feed consultant).

Even where the farmer and veterinarian were discussing improvements to calf accommodation, financial constraints could halt progress. The same suboptimal accommodation would be used, calves would continue to require pharmaceutical treatments and stagnation contributed to despondency, for both the farmer and veterinarian, at not being able to progress with preventive calf health measures:

> "Sometimes you turn up to what feel like slightly helpless situations, where they're going, "I know this shed is awful ... I can't deal with it now [because of financial

pressures]." ... It can reach a brick wall where people are much happier to go "Well it's broken, we'll just use the drugs", than really start investing their time and energy in patching together that shed" (V6, male youngstock veterinarian).

Designing replacement calf accommodation

Advisors stressed the importance of building accommodation with a focus on calf health, recommending veterinary involvement at the designing stage of the development, which many farmers had not done:

> "I have seen plenty of big, shiny units ... that don't necessarily perform as well as they were hoped by the person who designed them ... People get advice from different sources and often the animal health side of things only actually comes in once you've got animals in the shed and maybe they're not performing" (DR1, female pharmaceutical company veterinary advisor).

> "If they could involve the vet more in building planning ... I think we could save them thousands and thousands of pounds, but it's often one of the last people that a farmer will consider to speak to is their vet when they're putting up a new shed ... Shed design is probably not something they think that we know an awful lot about" (V4, male farm veterinarian).

Relying on building contractors was reported to be problematic since they are unlikely to be familiar with the scientific basis for the design features of a calf shed. It was considered important that the farmer, potentially with support from their veterinarian, was confident in the rationale behind building design elements to ensure the accommodation was built according to specifications likely to optimise calf health:

> "[A farm client] building this new shed ... that had a 1 in 20 slope ... When they were building it, he called me out because the builders were going "We will do it, not a problem, but [1 in 20 is a very steep incline] on your head - are you sure?" ... If we commit the cardinal sin that has led to these sheds in the past of looking at it and go "Phwar, bit steep, maybe a little less?" then ... it'll still be £30,000, it just won't work as well as it might" (V6, male youngstock veterinarian).

However, calf health was not always a priority for farmers when building calf accommodation. One dairy bull calf rearing enterprise (F17) prioritised having buildings which were multipurpose to allow adaptability in function in response to volatile market fluctuations:

> "The whole sheds are designed with multipurpose in mind. As time's gone on, they've become more angled towards calves, but if things changed tomorrow and

the money dropped out of calves, it'd probably take us a week to convert this shed into a pig shed" (F17, male farm worker on calf rearing unit).

Another farmer had used their own initiative to design and build affordable calf accommodation, replacing their previous set-up of 12 calf hutches which did not allow them enough calf rearing capacity. His innovative design was popular with other farmers, likely due to his focus on cost-effectiveness and ease of management:

> "Cost £7,000 [$9,876] to build, that's everything, metalwork, concrete panels. We can fit 42 calves in here ... A lot of farmers would need to [get input from the veterinarian]. I went online and looked it up, it's all on the internet ... We wanted to make physical barriers so then we could ... take this pen out, steam clean it, and that pen can still be there! ... I know of two farmers that have copied it since we've done it" (F20, male farm manager).

6.3.3. The role of stockmanship and perceived control

Attention to detail in calf rearing was stated by every participant to be the most important aspect for successful calf rearing, particularly with regards to disease management, and was dependent on the skill, time and interests of the stockperson, as well as the facilities available to them:

> "It is just little things that make such a big difference to calf rearing ... if you've got a problem, deal with it straight away, and if you can move them to a fresh place, a fresh, clean place, that makes a huge difference" (F2, female calf rearer).

Stockmanship was commonly perceived to determine how well calves could perform in any building:

> "I've walked into some sheds that I have thought "[Swears], this is an awful place to see calves", and actually, when you look at the calves, they are growing really well - you can't put a value on good husbandry" (DR1, female pharmaceutical company veterinary advisor).

> "You could have the most amazing shed in the world, but if you don't have attention to detail of like the stupid little things ... you're never gonna get it right" (F18, female calf rearer).

This emphasizes the importance of human influences on calf husbandry and health in the context of the epidemiological triad of interactions between host, pathogen and environment, as modelled in Figure 6.1.

Perceived control over disease processes

Farmer participants endeavoured to prevent calf disease from occurring on their farms. Once disease issues are established, it becomes a difficult cycle to escape:

> "If you've got unhealthy calves, it doesn't matter what you do, you're on a backwards spiral all the time. They're not very well, then they don't drink [milk], so then they don't gain weight, and because they're not getting that adequate nutrition, you get more health issues" (F2, female calf rearer).

Despite investing in preventive measures, health problems - especially pneumonia - often persisted on farms. This could leave farmers disillusioned and wondering what more they could do to address the issue:

> "We get pneumonia every single month of the year - even in the middle of summer ... We vaccinate for it [pneumonia], we're looking out for it all the time, we never lose any with it, but we do jab [inject] a lot of calves for pneumonia. There's no sort of pattern to it ... they're bedded up well, but we still get it" (F8, male farm manager of dairy bull calf rearing unit).

Furthermore, weather conditions were thought to contribute to pneumonia because *"It doesn't matter how good your ventilation is ... you're still pumping cold, damp air into a building"* (F13, male farm manager) and difficulties in determining what specific aspects of calf management needed attention to improve the situation also appeared to contribute to a perceived lack of control over disease incidence:

> "Dad had two [calves] the other day that didn't do very well. I don't know what happened there, they looked like calves that missed their colostrum." F19, male farm manager.

One farmer implied that experiencing a small number of calf deaths was inevitable *"It's rare that you get one die, I mean, you always get the odd one"* (F14, male calf rearer). However, another farmer believed *"mortality's usually a result of bad management"* (F20, male farm manager). This perception might partially relate to the disease profiles of individual farms; F20 was accredited as BVD-free, whereas F14 had a low level of BVD within their herd. The immunosuppression caused by BVD could make it difficult to successfully rear calves:

> "I think it's a waste of time rearing heifer calves if you have got BVD ... We don't have BVD so we've not got that sort of threat on them being pushed towards them getting pneumonia and scours and all that business" (F10, male farm manager).
>
> "You see some farms where they keep their calves in appalling conditions and never have any problems because ... there's no BVD" (V8, male veterinarian).

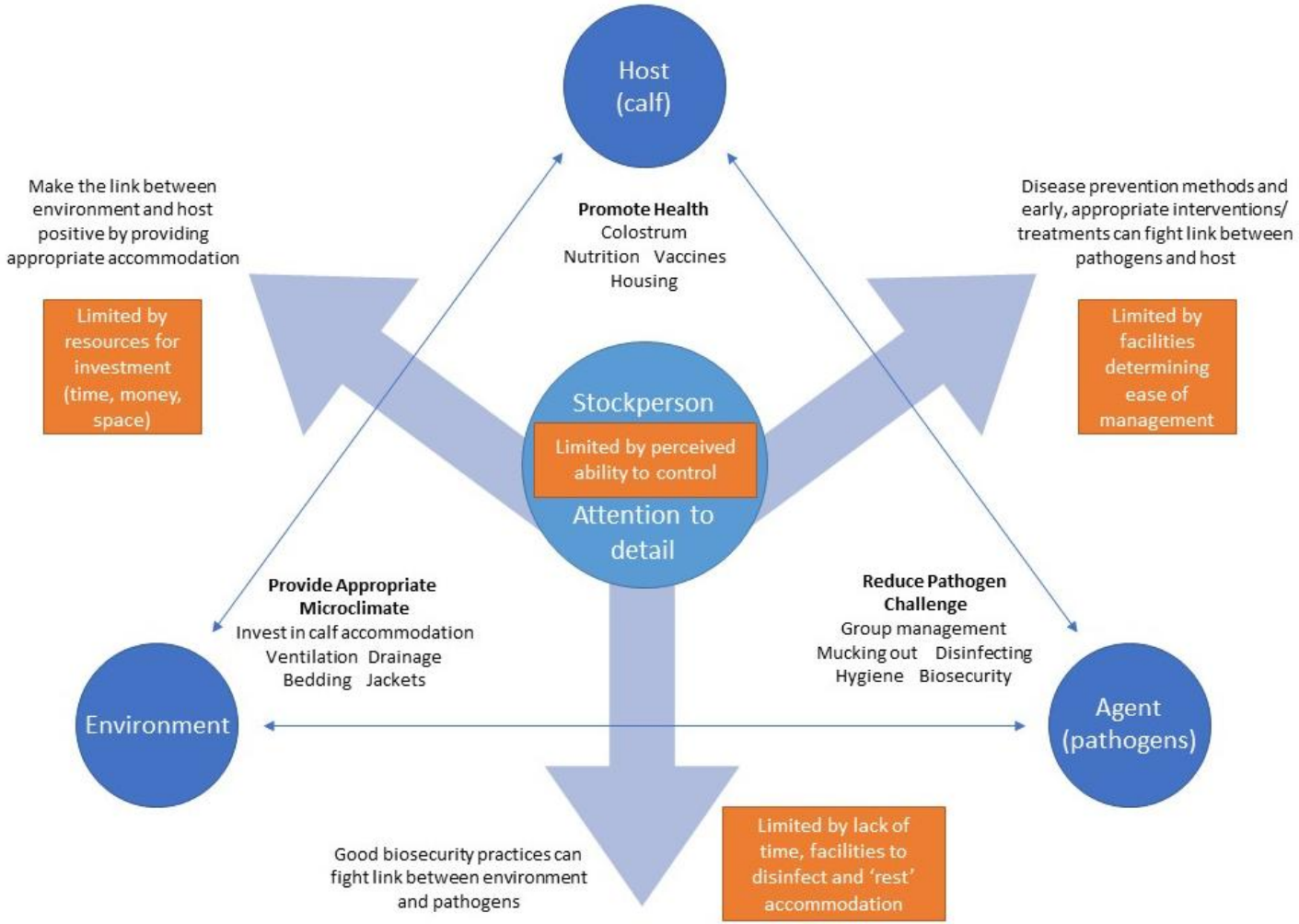

Figure 6.1. Schematic demonstrating the human dimension of the epidemiological triad.

6.4. Discussion

The research findings presented in this chapter once again highlight the essential human dimension of disease management in calves (Burton et al. 2012). Interviewees alluded to interactions between each of the three components of the epidemiological triad (Pfeiffer 2009) in relation to calfhood diseases but control measures were dependent upon the person(s) responsible for conducting them. Stockmanship was believed to help mitigate the effects of suboptimal calf accommodation; excellent facilities could support - but not replace - good calf husbandry and attention to detail. Participants often indicated that a designated calf rearer whose focus and priorities were centred on calf rearing was beneficial. Their interest and aptitude for calf care enabled them to notice and deal with problems promptly, preventing them from developing into permanent crises (Vaarst & Sørensen 2009) and fostered enjoyment of the work, a key value held by dairy farmers (Hansen & Greve 2014). These findings are presented in Figure 6.1. However, causal factors for disease were often difficult to pinpoint so it could be challenging to decide which specific curative actions to take, especially where calves are immunocompromised due to BVD (Peterhans et al. 2003). In the present study, the efficacy of calf rearing was further challenged by limited resources including time and finance. This could contribute to a perceived lack of control and inability to improve the health of calves, resulting in inaction (Santman-Berends et al. 2014). Whilst it is important for research to consider the practices and facilities which can promote good calf health - and there has been much research in this area (Johnson 2011, Torsein et al. 2011, Vasseur et al. 2012) - the individuals responsible for providing calf care must not be overlooked (Sumner et al. 2018a, 2020, Holstege et al. 2018). Farmer-led participatory approaches can empower farmers to make changes and regain control (Morgans et al. 2019, 2021) suggesting that these approaches could be hugely beneficial in achieving the continuous improvement of rearing practices for better calf health and welfare.

Farmer participants in the present study tended to perceive low levels of calf mortality. Calf mortality on UK farms has been reported previously as 4.5% (Johnson et al., 2017) and as high as 48% (Baxter-Smith & Simpson 2020), which could suggest that participants in this study may have downplayed or underestimated their calf mortality rates. Santman-Berends et al., (2014) found that on farms experiencing high calf mortality farmers were often unaware of the issue. On the other hand, previous research has shown a range in mortality rates of 0-30% across farms, suggesting good husbandry can mitigate the effects of disease (Johnson 2011). Due to the nature of sampling for this study, participants may have had a keen interest and focus on calf rearing; it is therefore possible that participating farmers actually achieved the low levels of calf mortality which they perceived. Some believed that it was more cost-effective to cull calves experiencing ongoing illness; culling might not be perceived as mortality per se, rather serving an

economic purpose (Overton & Dhuyvetter 2020). However, euthanasia decisions are complex and multifaceted, and more support in the form of training and guidelines is warranted (Walker et al. 2019, Wagner et al. 2020). The perceived cost-benefit of treating versus culling calves may also be linked to the stockperson's ability to identify initial signs of disease and administer early treatment, a key contributor to preventing treatment failure (McGuirk 2008, Lorenz et al. 2011a), recurrence of illness, and long-term damage (McGuirk 2008). Early disease detection and intervention could be aided by technology, suggesting that there is appetite for technological management aids for dairy calves, in line with precision farming approaches being developed for disease detection in adult cattle (Klerkx et al. 2019, van Erp-van der Kooij 2020).

In agreement with existing literature (reviewed by Johnson et al. 2011), calfhood pneumonia and diarrhoea were considered the most problematic and/or common calf health issues encountered in the present study. Farmer participants tended to perceive pneumonia to be the most problematic, but advisors indicated that scour was a key problem which was often underestimated by farmers. Participating farms may well have experienced higher incidences of pneumonia compared to enteritis, but it has been previously noted that diagnoses by farmers are often inaccurate and underestimated (Johnson 2011, Vasseur et al. 2012) and records might lack detail (McGuirk 2008), affecting their perception of the main problems on their farm (Bach & Ahedo 2008, Vasseur et al. 2012). Whereas UK farmers are legally obligated to record pharmaceutical treatments of livestock (The Veterinary Medicines Regulations 2013), including antibiotics and NSAIDs (the main treatments associated with BRD (Lorenz et al. 2011a)), there is no mandate to monitor the use of oral rehydration therapy (the primary treatment for calf scour (Constable 2009, Lorenz et al. 2011b)). Furthermore, some farmers participating in the present study were aware that calfhood pneumonia could negatively impact animals' long-term health, welfare and longevity (Closs & Dechow 2017), whereas the long-term effects of diarrhoea in calfhood, which have been shown in previous research (Shaw et al. 2020), were not mentioned. This may contribute to the visibility of disease occurrences and the perceived importance of respiratory disease relative to gastrointestinal illness alluded to by interviewees. In addition, farmers might perceive scour as less problematic because they consider it comparatively easy to control through improved hygiene management (Lorenz et al. 2011b) whereas pneumonia prevention was considered to require investment in building infrastructure and was more affected by the weather and climatic conditions (Lorenz et al. 2011a).

In the present study, more of the farmers interviewed vaccinated calves against pneumonia compared to enteritis, but several questioned the efficacy of pneumonia vaccines; similar findings were reported in a recent UK survey about youngstock rearing

and disease (Baxter-Smith & Simpson 2020). Vaccine efficacy might be impinged by improper storage (Williams & Paixão 2018) or administration (Cresswell et al. 2013) but the complex nature of BRD and its environmental interactions leaves the (cost-) effectiveness of vaccination arguably uncertain (Lorenz et al. 2011a). The causal pathogens for pneumonia are more difficult to diagnose (Johnson 2011) so farmers more frequently referred to the potential causes of diarrhoea, usually relying on historic diagnoses rather than testing faecal samples from every scouring calf, seemingly concerned that the time taken to obtain results would delay treatment. On-farm diagnostics like the Rainbow™ Calf Scour test (Bio-X Diagnostics, Belgium) can detect four of the main causal pathogens (Rotavirus, Coronavirus, '*E. coli*' F5 (K99), and *Cryptosporidium parvum*) in calf stool within ten minutes and could be incorporated into standard treatment protocols to ensure appropriate treatments are given. However, some participating farmers, despite attributing the diarrhoea to cryptosporidiosis or coccidiosis, reported treating cases of scour with antibiotics; Baxter-Smith and Simpson (2020) found that 27% of surveyed farmers used antibiotics to treat diarrhoea. Routine treatment of calf diarrhoea with antibiotics has been shown to have minimal or negative effects so is not recommended (Johnson 2011) unless calves are systemically ill (Constable 2004, Lorenz et al. 2011b). However, antibiotics were previously recommended as standard treatment (Stoltenow & Vincent 2003); changing these established, habitual practices is challenging (Morgans et al. 2019). Improving protocols around vaccinations and antibiotic treatments in calves is an essential part of antimicrobial stewardship, but it is necessary to consider farmer opinions and mindset as well as technical issues (Holstege et al. 2018) and the approach of the veterinarian can influence behaviour change in farmers (Bard et al. 2019).

Participants identified calf housing as a key influencing factor for calf health (Nordlund & Halbach 2019). Individually housing calves, especially in outdoor hutches, was generally considered beneficial for calf health, particularly in the first days-weeks of life, but these systems are labour intensive compared to group housing (Krawczel 2016) and health risks associated with group housing calves can be mitigated by appropriate management alongside good stockmanship (Costa et al. 2016). However, many farms used pre-existing, multi-purpose buildings to accommodate calves, requiring stockpersons to manage within an environment with inadequate airflow and drainage which can predispose calves to contracting pneumonia (Chamberlain 2015). Poor building design, lack of space, and all-year-round calving affected the ease, and therefore frequency, of conducting basic hygiene practices like mucking out and disinfecting pens and prevented the implementation of an all-in-all-out system (Maunsell & Donovan 2008), exposing calves to greater risk of disease. There are clear links between the effectiveness of calf housing and stockmanship in ensuring calf health, thus personal preferences of the

stockperson(s) are important considerations to ensure they feel able to work effectively within a given system.

Similar to previous findings (Baxter-Smith & Simpson 2020), farmers in this study often identified housing, stocking density, facilities and ventilation as areas for desired improvement. Since design features can allow for easier management within an optimal calf environment to foster good calf health (Nordlund & Halbach 2019), participants who had installed purpose-built calf accommodation perceived it to be a worthwhile investment. However, in many cases, replacement accommodation was highlighted as necessary but prohibitively expensive, or not cost-effective (Garforth et al. 2013), so farmers continued 'making do' with suboptimal facilities, sometimes making alterations to improve existing calf buildings, usually to improve ventilation. These relatively minor changes were generally considered easier and less costly to implement, but were also less effective than a complete overhaul of calf accommodation. Thus lack of funds preventing structural improvements could lead to disillusionment (Santman-Berends et al. 2014), frustration and an over-reliance on antimicrobials. If consulted, veterinarians were often expected to offer practical, realistic recommendations that were possible to achieve within farm constraints of space, labour and financial considerations, but farmers indicated that some veterinarians were more able to put theory into practice than others. Veterinarians were concerned that they were not often consulted about building design, previous findings indicate farmers do not perceive veterinarians as important consultants on this topic (Pothmann et al. 2014); large investments in purpose-built calf accommodation may not be as effective as they could be at promoting good health in calves. It is also possible that the cost of replacing suboptimal calf accommodation need not be as great as some participants perceived; one farmer was able to research, design and build affordable calf accommodation with a focus on functionality, suggesting that by clever sourcing of materials, lower-cost housing solutions may be possible in the mainstream. Farmer-led approaches harness the interests and motivations of farmers and have proved effective in developing practical innovations relating to a range of topics (Innovative Farmers 2021, Morgans et al. 2021) so could potentially be used to create more cost-effective building solutions for calf housing.

It should be emphasised that the primary focus of this chapter was not to quantify which infectious diseases calves suffered from, and how frequently, nor specific treatment protocols. Rather the methodology aimed to uncover and reflect upon the most pressing concerns and priorities of the participants to gain an understanding of the wider context and issues surrounding disease management in dairy calf enterprises. Similar approaches have been used to investigate, for example, perspectives regarding calf management before and after benchmarking reports (Sumner et al. 2018a), calf mortality rates

(Santman-Berends et al. 2014), and calf welfare in organic systems (Vetouli et al. 2012). It should also be noted that participant views on the related subjects of colostrum management and feeding, which also impact on calf husbandry and health, are not covered in this chapter as they have previously been published elsewhere (Palczynski et al. 2020a, 2020b, Chapters 4 and 5).

The essential role of good stockmanship and attention to detail in maintaining calves in good health, as represented in Figure 6.1, must not be underestimated. Research surveys tend to focus on the prevalence of calf management practices relative to an area of interest e.g. use of automated milk feeders (Medrano-Galarza et al. 2017), or their associations with mortality and morbidity (Vasseur et al. 2010b, 2012) but the diligence with which stockpersons carry out these activities i.e. the level of attention to detail, remains unclear. Furthermore, the concept of 'attention to detail' is applied broadly across all areas of farm performance, planning and day-to-day management (Wilson et al. 2012) and is not well-defined. From farmers' perspective, attention to detail appears to mean doing the small things well (Delves 2013), like noticing and responding to early signs of illness, and maintaining good hygiene practices (Palczynski et al. 2020b, Chapter 5). Others have defined attention to detail as knowing the value of specific activities and managing time accordingly, resulting in the aggregation of marginal gains (AHDB 2018). It is recommended that goals should be SMART (specific, measurable, actionable, relevant and time-bound) (Mee 2007) so the concept of attention to detail should be applied to a specific context or activity. To the authors' knowledge, the concept of attention to detail as it relates to animal management has not been explored in depth - it remains a vague term despite its apparent importance. It is likely that what constitutes attention to detail is interpreted differently according to individual interests and the requirements of different roles. For example, some, like calf rearers, might prioritise calf-based observations which allow for immediate, specific actions as part of day-to-day management (Palczynski et al. 2020a, 2020b, Chapters 4 and 5), others, like advisors and farm managers might seek details which offer broader, long-term insights, for example to aid farm health planning or business decisions (Wilson et al. 2012). To navigate these different priorities relating to calf rearing, and more specifically disease management in calves, facilitation could be a useful tool as it can help actors to navigate difficult, multifactorial issues (Morgans et al. 2019) and investing in trained facilitators can aid decision making and guide farm actors through a process of change leading to continuous improvement (Vaarst et al. 2011, Rose et al. 2018a, Morgans et al. 2019).

6.5. Conclusion

Calf pneumonia and diarrhoea were the main problems experienced by participants, but it was believed that the severity of calf health issues could be minimised by paying close

attention to detail with respect to calves and their environment. On some farms, suboptimal calf facilities and reluctance to invest in protective measures impeded actions to protect calf health and could limit the success of attempted mitigation strategies, leaving stockpersons and advisors feeling helpless to change the situation. However, the results presented in this chapter indicate that good husbandry and stockmanship could compensate for poor infrastructure by promoting health and immunity in calves, improving the microclimate around calves, and reducing pathogen challenge in the environment. Achieving improved calf health and welfare on farms is therefore dependent upon fostering perceived control and self-efficacy in farmers and stockpersons. This could be achieved by using supportive knowledge exchange practices including farmer-led participatory approaches and facilitation. Further research is needed to better understand what ‘attention to detail’ means to different actors within specific contexts. It is essential that efforts to promote disease management practices not only focus on technical solutions, but also the mindset, experiences and priorities of the persons responsible for calf rearing and control of farm finances.

7. Calf management as "the key for everything"? Perceived value of youngstock and the role of calf performance monitoring and advice on dairy farms

Understanding beliefs, motivations and barriers for taking action to improve calf health and welfare on farms is an essential element of this thesis. Research indicates the importance of rearing replacement heifer calves in terms of both farm financial performance (Boulton et al. 2017) and future milking herd (De Vries 2017). However, at farm level, the costs and potential gains associated with calf rearing are largely hidden due to a lack of data monitoring (Bach & Ahedo 2008), impacting farmers' ability to make informed decisions (Moran 2009a) and willingness to invest in calf management and facilities (Mohd Nor et al. 2015). The perceived importance of calves and associated problems also affect advice-seeking behaviours (Sumner et al. 2018a). This chapter explores participants' perceptions of the importance of calves and calf management compared to the milking herd and the role of personal values held by stockpersons. It also seeks to understand the motivations and barriers to monitor calf and heifer performance and the quality of, and engagement with, available information and advice.

7.1. Introduction

Rearing of replacement heifers is of great importance to the economic efficiency of dairy enterprises (Boulton et al. 2017). The annual cost of rearing replacement heifers is estimated to account for approximately 20% of total production costs, and is the second-highest variable cost on dairy units after feed for the milking herd (DairyCo 2015). Boulton et al., (2017) calculated the average cost to rear a replacement heifer to first calving to be £1819 ($2506), ranging from £1073 to £3070 ($1479 - $4230) depending on farm factors including average age at first calving, calving pattern, rearing system and other management decisions. In addition to the financial implications of calf rearing, heifers represent the continuation and genetic merit of the future milking herd (De Vries 2017). In the UK, the replacement rate has been increasing since the 1990s (Evans et al. 2006), with figures indicating an increase from 23% to 28% between 2007 and 2020 respectively (AHDB 2020a), reflecting increased demand for replacement heifers to replace cull cows and/or increase herd size. The value of dairy bull calves poses some problems, as low market values have meant they have been considered a waste by-product of the dairy industry, although the industry has committed to eliminating the practice of euthanizing healthy calves by 2023 by changing breeding practices to modify the supply chain (AHDB 2020b).

Calfhood performance influences the future productivity of heifers; growth rates of 0.75 kg/day (Cooke & Wathes 2014, Van De Stroet et al. 2016) and good health are associated with improved longevity and lifetime milk production (Waltner-Toews et al. 1986, Wathes

et al. 2008, Bach 2011). This is in part due to achieving an earlier age at first calving (AFC) (Cooke et al. 2013, Cooke & Wathes 2014). Heifers that calve for the first time at 23-24 months are less expensive to rear and provide an earlier return on investment than later calving animals (Boulton et al. 2017). Recent industry efforts have aimed to highlight the importance of calves achieving a target AFC of 24 months, for example as shown by the AHDB Calf to Calving initiative (AHDB Dairy 2021). Despite these efforts, average AFC in the UK has remained at 27 months since 2015 (Hanks & Kossaibati 2020). There is also evidence of high rates of morbidity and mortality in dairy calves (Johnson et al. 2017, Baxter-Smith & Simpson 2020) which are often underestimated by producers (Vasseur et al. 2012).

Dairy enterprises are comprised of many components which compete for limited resources, especially time and labour (Kristensen & Enevoldsen 2008). The costs associated with rearing replacement heifers are largely hidden and return on investment is delayed until heifers enter the milking herd (Boulton et al. 2017). Whereas data on the milking herd is generally routinely gathered, there is comparatively little information about calf performance available on farms (Bach & Ahedo 2008). Limited information at the farm level about calf performance and associated losses and (potential) gains means that the perceived importance of calves depends on the assumptions and value judgements made by the farmer (Moran 2009a). Indeed, dairy farmers tended to underestimate the cost of rearing replacement heifers, which can mean calves are prioritised less in management and investment decisions (Mohd Nor et al. 2015).

Lack of data relating to calf performance also contributes to ambivalence about assessing and managing calves and questioning routine practices (Sumner et al. 2018a). A UK-based questionnaire showed that approximately 50% of veterinarians, compared to 15% of farmers, reported that calf mortality was a recurring topic during herd health visits (Hall & Wapenaar 2012). Farmers might not seek advice regarding their calf rearing practices, nor perceive a need to do so. Calf management is not typically discussed by farmers, unless a specific calf-related problem is identified, in part because calf rearing is perceived as straightforward (Sumner et al. 2018a). Indeed, findings from an online survey of Austrian farmers revealed only one third of respondents considered the veterinarian to play an important role regarding calf management (Pothmann et al. 2014).

Even when advice is sought and received, recommendations are not necessarily implemented on farms (Kristensen & Jakobsen 2011). Further, it has been suggested that veterinarians fail to identify farmers' goals and priorities (Kristensen & Enevoldsen 2008, Derks et al. 2013), focusing primarily on production whereas some farmers value animal welfare and herd health planning more for reasons of subjective wellbeing such as pride and job satisfaction (Kristensen & Enevoldsen 2008). As reviewed by Kristensen and

Jakobsen (2011), farmers' motivations might relate to their identity (Burton 2004), perception of risk, and perceived need and ability to improve a problem (Vaarst & Sørensen 2009). Farmers are also influenced by their social networks (Heffernan et al. 2008, Azbel-Jackson et al. 2018).

Replacement heifers play a vital role in farm economic efficiency (Boulton et al. 2017) but are not always perceived as doing so. Calves might be considered in terms of their instrumental usefulness (serving a financial and/or functional role) and intrinsic value framed within personal and societal values and beliefs (Hill 1993). Decisions regarding their rearing are likely to be complex and nuanced, influenced by a variety of personal and contextual factors (Hansen & Greve 2014). For instance, the anticipated benefit in having access to calf data has been linked to personal values, the perceived intrinsic value of calves, and the instrumental value of calves as a productive member of the future milking herd (Sumner et al. 2018a). The objectives of this chapter were to explore the ways in which the perceived value of calves and their performance impact on the ways in which calves are managed on-farm. It also considers the role of advisory services and wider industry in the framing of calves as an integral part of the dairy herd.

7.2. Materials and Methods

As part of a wider research study which used in-depth, semi structured interviews and thematic analysis to seek a holistic understanding of calf management on English dairy farms, this chapter examines findings related to the perceived value of dairy calves, collection of calf performance data, and availability calf-oriented information and advice. Results relating to colostrum management (Palczynski et al. 2020a, Chapter 4), calf feeding (Palczynski et al. 2020b, Chapter 5), and disease management (Chapter 6) have been presented elsewhere. This research used a critical realist paradigm, meaning that subjective experiences and beliefs have real-world consequences and should be considered alongside objective facts to understand phenomena (Maxwell 2012).

COREQ criteria for reporting qualitative research (Tong et al. 2007) were consulted. Data collection and analysis was conducted by the first author, a female doctoral student with an interest in human attitudes and behaviour relating to animal husbandry and with initially a basic knowledge of the dairy industry; now working within agricultural knowledge exchange. Participants were asked to confer their expert knowledge to the curious researcher through the interview discussions.

7.2.1. Data collection - participants and interviews

Participants were recruited using purposive and snowball sampling (Cohen et al. 2007), starting with existing networks and contact with veterinary practices, individuals attending dairy events and conferences, and persons suggested by interviewees. The first author

did not have a relationship with the participants prior to arranging and conducting the interview. A range of dairy production systems and herd sizes were represented and participants worked in one of three geographical areas in England: the Southwest and Midlands (high densities of dairy farms) and Northeast (less dairy focus).

In total, 40 face-to-face interviews (26 with farmers, 14 with advisors) were conducted between May 2016 and June 2017; average interview length was 56 minutes, range 26 - 90 minutes. Three interview formats were used, based on the preference of the participant: individual interviews in a seated setting (n = 23), joint interviews (n = 9) where two to three participants (n = 20) were interviewed together, or walking interviews during a tour of the farm and calf facilities (n = 8). Interviewees included 37 dairy farmers (farm managers (n=17), farm workers (n=9), calf rearers (n=8), and herd managers (n=3)) and 14 advisors (veterinarians (n=10), a veterinary government advisor (n=1), feed (n=2) and veterinary pharmaceutical company (n=1) representatives). This variation satisfied the need for rich, detailed data from a range of contexts, in line with quality criteria for qualitative research (Turner 2010).

Questions in the interviews were based on a topic guide and were deliberately broad, looking to obtain a general overview of participants' experiences related to calf rearing on dairy farms and to allow them to lead the discussion to focus on areas of most interest or importance as perceived by the participant. Additional probing questions were sometimes asked to gain further insight into the participant's initial response. Interviews were audio-recorded and assigned a representative code: a letter referring to the type of participant (farmer, F; veterinarian V; feed consultant, N; pharmaceutical company representative, DR; veterinary government advisor, GA) and numbered in chronological order for each grouping (F1, F2, F3, etc.).

7.2.2. Data analysis - Thematic Analysis

Data collection and analysis were conducted in an iterative approach until it was judged that no new themes were emerging, indicating thematic saturation (Miles et al. 2014). Analysis was grounded in the data, and no preconceived framework was used to group extracts into themes.

Audio recordings of the interviews were manually transcribed using f4transkript software (Version 6.2.5 Edu, audiotranskription.de, Marburg, Germany). Interview transcripts were thematically coded in NVivo for Windows (Version 11.4.1.1064 Pro, QSR International Pty Ltd., Victoria, Australia) to group common extracts into themes (Braun & Clarke 2006). First, content coding was used to group extracts according to topic (Miles et al. 2014) i.e. management practices, processes and personal values. This helped to inform ongoing interviews and indicate focal topics for further analysis. Once data collection was

completed, coding was repeated for in-depth exploration of extracts relating to each focal topic.

Extracts were chosen to represent the perceptions of participants which informed the construction of themes and explanations by the first author. Quotes from participants are presented within quotation marks; ellipses indicate omission of text; and square brackets indicate clarifications from the authors. The extracts most relevant to perceived importance/value of calves tended to be in response to questions like *"tell me about your farm"*, *"talk me through your calf management", "do you like working with calves?"* and *"how do you think calves are treated on other farms?".* Quotes about information and advice in relation to rearing calves generally stemmed from questions to farmers asking *"where would you get information about calf rearing?"* and about the role of their veterinarians with regards to calves. Advisor responses were often replying to questions about the client-advisor relationship, their involvement in calf rearing on their dairy clients' farms, and whether advice was implemented. Comments about calf performance and how it was monitored were usually in response to questions directly asking about calf records, including health and growth data.

Analysis of these extracts resulted in six overall themes: perceived importance of calf management on dairy farms, the role of calf rearers, monitoring calf and heifer performance, farmer engagement with information and advice about rearing calves, quality of communication and advice about calf rearing, and veterinary involvement in calf rearing.

7.2.3. Ethical approval

All participants gave their informed consent for interviews to be conducted, audio recorded, transcribed, securely stored, and for anonymised interview excerpts to be published. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved under project number 75-201511 by the Harper Adams University Research Ethics Committee on 13 January 2016.

7.3. Results

7.3.1. Perceived importance of calf management

Perceived value of calves and calf management relative to the milking herd

Participating farmers valued their calves for a variety of reasons. Firstly, there were several use values attributed to calves. It was well recognised among farmer participants that heifer calves are "the future of your herd, so they are really important" (F2, female calf rearer). Calf management was also seen to affect the overall efficiency of the farm:

> "I just started to find it was the key for everything ... If you get your youngstock right, you get them calving at the right age ... you need less building space, so that brings in all the building design. You've got less nitrogen to manage so that brings in the slurry and soils management. It just comes back as such a key thing" (DR1, female pharmaceutical company veterinary advisor).

Rearing sufficient replacement heifers also reduced the need to buy-in adult animals, which could protect the herd's disease status:

> "I don't like buying cows in. I don't like it at all. I don't like that lack of biosecurity" (F19, male farm manager).

Replacement heifer calves were especially valued where large numbers were required to increase herd size or recoup cow losses from the milking herd, particularly as a result of bovine Tuberculosis (bTB):

> "We have lost a lot of animals to bTB ... [it's] an additional burden to try and cater for the losses, and some years, 150 is barely sufficient replacements" (F26, male farm manager of 500-head dairy herd).

However, it was commonly acknowledged that calf rearing had historically not been a key focus in the dairy industry and that calves were still marginalised on many farms. Generally it was perceived that *"calves get to be second citizens quite often ... most people are focussing on their dairy cows"* (V7, female farm veterinarian). Some advisors believed that most farms could stand to further improve processes and management related to milk production, so it was considered unsurprising that calves were overshadowed:

> "The best attention's gonna be given to getting the milk out of the cows because the milk's the bit you sell - and they [farmers] can't even do that very well" (V8, male farm veterinarian).

Even on high-profile, award winning dairy farms, advisors witnessed that the youngstock facilities were often under-invested in:

> "A lot of these really top units, they're going for the Gold Cup [award for excellence and efficiency in the British dairy industry] and they're winning herds everywhere, and you go and look round the calf units and it's as if you're going back in time into the '60s" (V11, female youngstock veterinarian).

The ability to finance improvements to youngstock management and facilities might be limited when balanced against the expense of managing and maintaining the milking herd

and parlour, particularly during a downturn in milk prices, when farmers may struggle to invest in infrastructure and staff:

> "I think the hunger for capital for the dairy herd is so colossal and so immediate, it soaks up all the good all the time. Profitability has been so low, and under so much pressure for quite an extended period of time, that there is never anything spare to apply to the youngstock and they are the poor relations on a good many farms, I suspect" (F26, male farm manager).

> "If milk price was 35 pence a litre, I'd have someone else working with me, and then I would have a lot more time to spend making sure that my calf rearing protocols were as I wanted, in sheds that I wanted, because I'd be able to afford them ... the biggest limiting factor to animal welfare, I believe, is purely down to the constant pressure on price" (F19, male farm manager).

Added to this, the financial significance of youngstock rearing may not be recognised by farmers, in part due to a lack of calf performance monitoring:

> "[We] record everything that we're doing. I didn't *really* know exactly what it cost us to rear a heifer. Now I do ... The worst guys are spending £3000 [$4146.75] per heifer on heifer rearing and probably calving them at three years old, and not making money until they're in about their third, fourth, or fifth lactation and they don't realise ... They moan and say they're not making any money out of milk" (F10, male farm manager).

This was likely due to the comparative invisibility of rearing costs and delayed return on investment for youngstock compared to the productivity of the milking herd:

> "When you're worried month on month how much money you're gonna bring in ... you want to make sure that there's milk in the tank that's gonna pay your wage and pay your bills for the month" (F1, female calf rearer).

> "It's never as urgent, I don't think. So the [somatic] cell count goes too high, and the milk company start paying you less, you want that fixed tomorrow. If your calves aren't growing as fast as they could, you can wait before you fix that. I guess that's always going to be a bit of a barrier" (V1, male veterinary specialist in cattle health).

Dairy bull calves

Whereas replacement heifer calves are inherently valuable to the future of dairy farms, the value of dairy-bred bull calves was considered highly market-dependent. Bull calves received less attention compared to heifer calves on some participating farms, but where

there was good return on investment for healthy bull calves, their standard of care was likely to increase:

> "They're babies, they all need the same care and attention. I am able to sell my bull calves at £100 a piece at the moment, which I think is pretty good for Friesian bulls, and that's only because they're reared well and they're fit and healthy" (F6, female calf rearer).

> "Doing a guaranteed buy-back regime for the dairy-cross calves and for the male dairy calves ... if they're 50 kilograms by two weeks. By heck, suddenly there were all these farmers feeding ad lib milk replacer to their calves to get them up to the right weight" (GA1, government veterinary advisor).

However, many farmers struggled to find an outlet for their unwanted dairy bull calves due to their low market value, particularly those farmers under restriction for bTB or running Jersey or Jersey-cross herds:

> "We have moved entirely to sexed semen. That's also to improve upon the dreadful problems of disposing of black and white bull calves, which are virtually valueless in a TB-afflicted herd, there's so few outlets for them" (F26a, male farm manager).

Farmer participants acknowledged the practice of euthanizing male dairy calves as a necessary business decision on some farms, but interviewees preferred to avoid the practice:

> "[The Jersey farm down the road], they tried every single avenue they could think of. They tried giving calves away, they tried rearing them themselves, they tried bull calves, they tried castrated calves ... nothing would make a profit off Jerseys, and so they carried on shooting them" (F22, female herd manager).

> "We don't receive a lot of money for our bull calves, and it's more labour, feed, time we invest in them, but I'd rather just spend a little bit more and get them slaughtered than shoot them ... I just wouldn't want to shoot a newborn calf, really ... you give them as good a life as you can for a few weeks and then they go, I think that's a better way of doing things, than shooting them" (F24, male herd manager).

7.3.2. The role of calf rearers and influence of calf rearers

There was a lot of pride involved in calf rearing. Participant calf rearers enjoyed working with calves, and were satisfied knowing they were contributing to the future of the dairy herd:

"I like them [the calves] to look good and I like them to be healthy. That's kind of what drives me. And I love them when they're looking perfect, so the minute they don't look perfect, I'm like 'why?'" (F18, female calf rearer).

"I love it [working with calves] because look at what I've helped produce [dairy cows]!" (F15, male calf rearer).

For optimal calf management, most participants believed there was great benefit to *"having a designated person, somebody responsible*" (F2, female calf rearer) for calves, so they were invested and had time to do a good job:

"If it's your sole job and you've got a passion for it, then you're gonna do it well" (F4, farmer's son and trainee vet).

"If you've got plenty of staff, then no one's overstretched for time. They haven't gotta do this, this, this *and* this - they've just gotta do the calves ... It's calm, it's simple, it's just your job" (F19, male farm manager).

There were mixed opinions about the need for previous experience of calf rearing:

"The girl I've got [rearing calves] ... she'd come from completely outside farming. No preconceived ideas. Which is good" (F20, male farm manager).

"If you get a good person, that's key, who is committed to the job. Whether they've done calves before or not, I don't think that matters as much because you can train them. It's that willingness to learn and want to try new things, and that attention to detail" (V11, female youngstock veterinarian).

"The more experience the better ... It's alright someone having passion, but if they don't know what they're doing, if no one is there to tell them, teach them how to do it, then they're a sitting duck" (F4, female farm worker).

Several participants suggested that females were better calf rearers than men, though others (especially young females) claimed gender was irrelevant. It was agreed that there were common qualities a person needed to be a good calf rearer, regardless of gender. These included keen observational skills and attention to detail to allow them to prioritise good hygiene and notice early signs of illness and other potential problems for quick intervention. Patience and perseverance were also considered necessary, particularly when training calves to drink from milk feeders. A passionate person who cared about calves and their importance to the dairy enterprise, who had adequate time allowed for calf rearing was considered a recipe for success.

Unfortunately, it was not always possible to employ someone to only rear calves. There was insufficient work to warrant a full-time position focused on calves on some farms and

often there was limited budget available to cover staff costs. This meant that calf feeding was just another job to get done, which might exacerbate the marginalisation of calves on farms.

> "To find someone that will just come down for an hour or two hours every day, it's really quite hard" (F16, female calf rearer).

> "Here, there's only three of us, so the general farm worker, he does all the scraping [of manure] and odd jobs, and he feeds the calves. So when you add that to a long day, and you feed them twice a day, you can miss things" (F24, male herd manager).

For farms where several people were responsible for calves, calf rearing protocols were considered necessary, but it was noted that *"they're not worth the paper they're written on unless they're followed"* (F21, male farm manager). Successful calf rearing with multiple responsible persons was considered to be *"completely dependent on communication"* (F9, male farm manager) between different staff members. Notes and records could help, so long as everyone wrote legibly and checked the information. This teamwork was dependent upon individual values to ensure everyone played their part and shared information.

The role of personal values: disbudding calves as an example

Disbudding calves was a practice which clearly demonstrated a range in personal values regarding calves and calf management. Most participants empathised that the head wound resulting from disbudding would hurt in the time following the initial procedure, so provided analgesia in addition to local anaesthetic:

> "If it saves them two or three days of pain, it's probably an investment in their growth rate ... and it's just the right thing to do" (F21, male farm manager).

However, following a change in staff responsibilities (thereby changing personal values), one farm had reverted to following minimum legal standards (as per The Protection of Animals (Anaesthetics) Act 1954, as amended), disbudding using local anaesthetic without pain relief:

> "I used to use Metacam for post-pain relief, but I don't do the dehorning anymore, so they just use Adrenacaine ... it *must* make them feel poorly having these wounds on their head. That's why I used to use the long acting one, but the general advice is just [local anaesthetic] so..." (F22, female herd manager).

Another farmer sedated his calves for disbudding to reduce the stress experienced by the calves and the handlers. He believed eliminating the need to restrain calves conferred better welfare and would be perceived more positively by the public:

> "How do you justify that to the general public? With two strong men holding down a calf and ... I know you're *supposed* to use local anaesthetic, and we always did because it's cheap. I know plenty of farmers that don't. They say "that'll take too long because you've gotta catch them, inject them, leave them ten minutes and then come back and catch them again" ... The only way to justify to the public, method of doing it, in my opinion is to sedate them. And [provide] pain relief as well" (F16, male farm manager).

Several farmers opted to use their veterinary practice's technician service to save time and labour and ensure disbudding was *"done properly"* (F21, male farm manager). Breeding polled cattle is another option to improve welfare by avoiding the need for disbudding, but was only mentioned by two farmers (F20, male farm manager; F22, female herd manager).

7.3.3. Monitoring calf and heifer performance

Achieving calf and heifer rearing targets

Participants believed that the importance of calf management was gradually becoming increasingly recognised by dairy farmers and the wider industry. Although some farmers indicated that they *"don't often come across calf ones [events]"* (F22, female herd manager) in regions less focused on dairy, more generally it was thought that calves and calf rearing facilities were more likely to be featured at on-farm events than they were previously, which could both reflect and contribute to increased interest in calf rearing:

> "When I used to go out on farm walks, you didn't often get to see the calves, and I used to wonder why. But now I think people are getting much better at it [calf rearing], and realising that if you treat them right to start with, then they can save you a fortune" (F6, female calf rearer).

This might in part be due to industry efforts to highlight the financial significance of calf rearing and meeting recommended rearing targets. All participants were aware of the recommendation to achieve an AFC of 24 months, though when asked, most were not meeting that target. Several farmers opined that information and advice lacked focus on practical ways to achieve rearing targets and justify investments:

> "I don't know if we've had enough focus on what we can do to improve calf rearing. It's more just we're hearing the implications of it, which is the start of the process

because until farmers realise that there is financial implications of poor calf rearing then you don't try to improve" (F9, male farm manager).

Failure to achieve an average AFC of 24 months was partially related to calf growth rates, since participants stressed the importance of heifers being large and mature enough to be served and enter the milking herd:

> "If you have a heifer that's [calved at] three years old, they're not usually any good. Two and a half seem to be alright [AFC 30 months], two [AFC 24 months], I think they're probably not [developed enough] - because we're on a forage based system, they need to be a certain amount of size" (F15, male farm manager of an all year round calving herd).

Delayed first calvings could also be attributed to service period management of youngstock, particularly where heifers were housed away from the main farm, or at pasture:

> "You want to make the most of the grazing season, but then on the other hand you want them in to serve them ... The first ones [born] do tend to get a little bit over [15 months at serving]" (F10, male farm manager).
>
> "It's just having the organisation to actually get them to somewhere where they can be with a bull, or be served" (F3, male calf rearer and farm worker).

Failure to account for the heifer rearing period was not limited to farmers; many veterinary services also focus only on the first months of life:

> "What some of the other vets are offering, it basically stops at weaning because then [the heifers are] out this time of year whereas that's when a lot of the truly unrecognised problems go on ... [Farmers] won't do any grazing management for youngstock ... then they go "Oh, these aren't big enough to bull now"" (V11, female youngstock veterinarian).

Monitoring calf health data

Although farmer participants indicated the most common calf ailments on their farms, they did not report disease incidences or mortality rates, suggesting a lack of formal records and review of calf data. On some farms, basic information relating to calf health (colostrum feeding and incidences of diarrhoea and pneumonia) was recorded, usually written on whiteboards or a book, to communicate between staff members about day-to-day calf management. However, transferring treatment practices to long-term records could be problematic:

> "It's alright having a book, but with the best will in the world, you're doing another job across there, then you're doing something else, think "Ah, I haven't wrote it [calf treatment] in the book" and you've forgotten it, unless you write it on your hand or a scrap of paper or something. Even if you've got a diary you've gotta transfer it" (F8, male farm manager of dairy bull calf rearing unit).

Despite farm assurance regulations which require the reporting of calf illness and treatment data, veterinarians believed many farmers used guesswork rather than records to report on calf health, particularly since herd health assessments were more focused on the milking herd:

> "Herd health plans, my experience wouldn't be great of them ... They don't focus mainly on calves ... They ask you to fill in the number of cases of scour and pneumonia, well, most people are making numbers up and don't really know" (V3, male youngstock veterinarian).

Some armers were enthusiastic about digital technologies - cloud-based systems for easy single-entry recording of calf treatment data which could fulfil both management and paperwork requirements:

> "I want a system where I've got auto ID on the calves ... So, my phone: zap - she's had [treatment]. Done. Up to a database ... cloud based ... that the vet can get hold of" (F20, male farm manager).

> "You can put absolutely everything on [the app], it's on everybody's phone ... you can print reports" (F8, farmer's wife on dairy bull calf rearing unit).

However, some advisors might overlook digital solutions as a way to make record-keeping easier for farmers:

> "Technology does make things easier. You tend to think "Oh, keep it simple, keep it just on a paper-based thing", but actually we all carry our phone around in our pocket *all* the time" (V5, male youngstock veterinarian).

Monitoring calf growth performance

The perceived importance of calf growth performance monitoring varied amongst farmers. Some farmers weighed/measured calves at regular intervals from birth, others at key milestones like birth, weaning and/or turnout and a few collected group averages by running calves in a trailer over a local weighbridge. Most farmer participants were not recording calf growth data. Although many of them intended to start by reviewing staff responsibilities or investing in (automated) handling systems for weighing calves, in several cases a lack of motivation, or ability, to collect calf weights was apparent:

> "Too much hassle. Calves are forgotten about as it is on 90% of dairy farms I've come across. So let alone an extra job [growth rate monitoring] that doesn't really give you much out of it when you can judge by eye" (F22, female herd manager).
>
> "I would like to [monitor growth rates] ... It's a time aspect really, because I have to milk as well, so that's already seven hours milking and then the calves can take up to four hours a day" (F3, male calf rearer and farm hand).

Several participants would judge performance retrospectively based on meeting or missing targets:

> "Growth rate doesn't really matter. It's getting that heifer to first calve down to 24 months" (F5, male farm manager).

This suggests that for some, a problem would need to be perceived before weighing calves was considered beneficial enough to warrant the extra time and effort involved in collecting the data:

> "If they're not growing to the size of what you want them to be when you're going to serve them, and they're not calving down at an appropriate age ... that's when you'd have to start getting into the nitty-gritty [growth monitoring]" (F4, female farm worker).

This is somewhat paradoxical since data monitoring could help to identify problems and allow timely interventions to be made; this was considered valuable information by those who were monitoring calf growth rates:

> "It does help to know that you are doing the right thing and you can pick out any that aren't growing and then you can do something about it if you need to" (F6, female calf rearer).

The reluctance to monitor calf growth performance appeared primarily due to the time and labour required for manual weighing of calves. Although advisors often proposed girth measurements as an accessible method for monitoring calf growth due to their low up-front cost, farmers tended to perceive them negatively. The tapes were thought to be ineffective for very small or large calves, difficult to use, and inaccurate:

> "The weigh-band actually starts at 40 kilos, which for some [calves] is too [large], which suggests that they're probably 35 to 40 [kilograms] ... it's a bit hit and miss" (F11, female farm administrator).
>
> "Weigh bands ... you have to bend round them ... you stop at a certain size because you physically can't get round her very well" (F12, male herd manager).

> "It's time consuming and I don't think the data would be certain enough ... The weigh tapes ... give you a good idea ... but they're a little bit subjective and time consuming" (F9, male farm manager).

Several participants indicated a need to develop ways to make "the monitoring of youngstock easier on a far more modest farm" (V6, male farm veterinarian), more in-line with the passive data collection available for dairy cattle through milk recording. Farmers were enthusiastic about automated systems for weighing calves. However, there could be some issues when combining different technologies from different manufacturers:

> "Unfortunately those collars [for the automated milk feeders] interfere with this weigh [scale from] a different manufacturer. So we thought it would auto-weigh everything but the signals are interfering with each other so this isn't auto-weighing which is a big disappointment" (F11, female farm administrator).

Making use of calf data

Collecting calf data and benchmarking could be effective motivational tools for responsible staff to assess their work performance:

> "[A calf rearer on a farm with zero mortality was] set up with a bonus system as to how many calves he got through the system at the end of the calving season. He was just so massively driven. He was putting the effort into monitoring and measuring everything because then he could show to his boss "look what a good job I've done, I deserve my bonus this year"" (DR1, female pharmaceutical company veterinary advisor).

> "You're sat in a group with everyone else who is hitting [growth targets of] 0.8 [kg/day] and you don't want to be the person not hitting it" (F1, female calf rearer).

However, one farmer noted the difficulty in identifying marginal gains and best practices from calf performance data:

> "We measure it, we monitor it ... it would be lovely to see all these patterns that you guys [researchers] talk about - "if you do this you'll get extra milk here" and so on ... You probably have to be doing things a whole lot worse. If we were terrible and we did some things, then we would see the benefit of it but because we do most things pretty well, it's very difficult to detect the effect of one thing so it's a little bit frustrating" (F11, female farm administrator).

Advisors appreciated that it could be difficult to record data, particularly related to calf growth, but considered poor records to limit their ability to provide effective, objective advice about youngstock:

> "You can nearly double how long it takes to do a job by recording what you're doing, and labour on a farm [costs money] so you have to make a really significant impact to justify that expense. From a veterinary point of view, it is very hard to do anything without data" (V4, male farm veterinarian).

Whereas advisors often indicated that some data was better than no data relating to calf health and growth performance, several farmers appeared to believe that data collection was only worth doing well, since even sub-optimal records would require time and effort to collect and would offer limited, or potentially misleading, information:

> "Compromises will have to be made ... a farmer just doing weaning weights, he might not do birth weights, but at least it gives him something ... taking a picture of a group [of calves] every time I visit and look back over a few months" (V11, female youngstock veterinarian).

> "You need a proper set-up [to weigh calves]. You need it to be easy, otherwise no one's going to do it regularly, and there's no point in doing it irregularly" (F22, female herd manager).

One option to take the onus of calf data monitoring away from farm staff was to include it as part of a youngstock veterinary technician service. Assuming farmers were motivated to invest in calf monitoring, the service could provide regular weighing of calves to monitor growth rates and analyse treatment data provided by farm staff:

> "We as the vets collect the data [growth data and calf illness tallies recorded by farm staff], keep recorded data, and then present it back at regular periods. That's how I think works best ... If you leave it for them to gather the data, they won't gather it well enough, or regularly enough and you won't get it back to interpret it" (V3, male youngstock veterinarian).

However, subscription to a youngstock service did not guarantee that farmers would supply the information required by the veterinary practice for analysis:

> "Most of the guys that have signed up to our youngstock service, they are *paying* for this service and for us to analyse the data, are not recording that data. And it's immensely frustrating for us, because even the people that I think have actually really engaged ... still half of them are not recording" (V5, male youngstock veterinarian).

One farmer believed there was a need for a centralised database to record treatment data to improve transparency in the sector:

> "As an industry, we're not honest enough ... There should be a national database and we could have all the veterinary records for these animals on [it]. Wouldn't that

be brilliant? So when you buy an animal, you get a history ... The whole industry would benefit" (F20, male farm manager).

7.3.4. Farmer engagement with information and advice about rearing calves

Most participant farmers were quite open to seeking advice. Some enjoyed independent learning, often reading articles in journals and farming magazines whereas others claimed they did not have much time to read information, so tended to prefer short summary text and discussion of ideas with other farmers and advisors (including nutritionists, suppliers, veterinarians). The motivations for seeking information varied. Some were keen to gain new knowledge so they could rear calves to the best of their abilities, others would do little research unless seeking to address a perceived problem.

It was commonly assumed that younger, progressive farmers were most driven to learn and implement best practice compared to farmers of an older generation. Reluctance to seek or follow advice regarding calves was perceived to reflect individuals' aversion to change and the general marginalisation of calves on dairy farms:

> "Any sane person would hope to improve what they're doing, wouldn't they? It's just the older generation that might not want to - set in their ways" (F22, female herd manager).

> "[A lot of farmers] ... they've not been brought up in a mindset to think about youngstock" (V2, female youngstock veterinarian).

Farmers tended to appreciate engaging with other farmers and advisors - particularly those with hands-on experience of rearing calves - to obtain fresh perspectives from beyond their farm. Discussion groups and farm walks were particularly popular among farmers as an opportunity to observe and talk about alternative calf rearing systems:

> "All of us need some exposure off the farm. Either you physically remove yourself from the farm ... or you bring the exposure to you. They [the youngstock veterinarian and nutritionist] bring it to us because they see it practiced on many other farms" (F26, male farm manager).

> "Discussion groups are quite good, and farm walks. It's always good to look round other people's [farms to see] how they're doing it. A lot of farmers are quite honest ... they'll tell you what problems they've had to start with and how they've addressed that, which is quite reassuring and good to learn from" (F4, male farm manager).

However, one farmer believed that some individuals were unwilling to share their knowledge with their peers for fear of losing their competitive advantage:

> "Farmers need to be more transparent ... they don't wanna tell their neighbours because they wanna make sure they're doing a bit better than their neighbours ... But actually, if we all shared all this information, and it was really clear, and we could all calve our [heifers] at 24 months, we'd all be doing better" (F19, male farm manager).

The lack of time and labour on farms could mean that farmers *"perceive that they don't have time to come to courses, talks"* (V7, female farm veterinarian). However, *"a lot of farmers go to meetings regardless of if they've work to do or not because they like that sort of thing"* (F4, male farm manager). The time commitment of attending events or groups was influenced by how far farmers had to travel to attend them. In areas less densely populated with dairy farms, local activities were less common. It was also important that advice efforts were high quality and engaging for farmers, since if they were perceived badly, farmers were hesitant to participate in future:

> "My experience of [agricultural knowledge provider] hasn't been very good so I don't interact with them much ... I guess once you get put off, you don't necessarily go straight back to it" (F9, male farm manager).

There appeared to be a somewhat positive bias in peer-to-peer exchange since farmers preferred to share aspects that they were proud of and learn from *"the best"* (F10, male farm manager). However, this could mean that some farmers would feel their calf facilities were not comparable, and would not be inspired to make changes:

> "When you go on farm [for a calf event], you go to a youngstock unit, you don't go to a farm that's just got a few calves that are stuck in a shed ... I think it's almost beyond their ability to see how they could possibly do that, so then they don't ... The people that see the calves a chore, it's difficult to get them to engage, and if they do come and engage, and you actually put them off because you've shown them something beyond their reach, that doesn't help" (V7, female farm veterinarian).

Furthermore, farmers who experienced problems could be too embarrassed to discuss them with their close contacts and advisors:

> "There's lots of farmers, they know that they do it wrong and they don't do it to the best of their ability and you have got the odd one which is like "Oh no, you can't come and see it" because they know that it's not gonna be up to your standards" (N2, female feed company representative).

> "They wouldn't tell their friends [about their disasters] because that's too on their doorstep, but they come to our discussion group ... we can just laugh ... it lightens

the mood and people really appreciate being able to talk about it, get it off their chest ... We all respect each other. It may not be the best advice, but it's an outlet" (F5, male farm manager).

7.3.5. Quality of communication and advice about calf rearing

One advisor questioned whether former farmers teaching at agricultural colleges might perpetuate the persistence of traditional calf rearing practices whilst neglecting more recent evidence-based recommendations:

> "It's usually former farmers delivering practical elements of calf rearing ... within an agricultural college environment ... you're trying to teach practical calf rearing, and you say "let's bring a scientist in and tell you about this", and the person running the calf rearing unit goes "I know what I'm doing, why do you wanna bring some expert in?"" (GA1, female government veterinary advisor).

Several advisors believed that the persisting problems with calves and calf rearing were related to inadequate communication:

> "I don't think there is that much need for more research in *how* to get it [calf management] right ... We know what works, and we have lots of different options in what works. How do we get that more widely adopted and help people find the information?" (DR1, female pharmaceutical company veterinary advisor).

> "We get the message across ... to the same percentage of people every time. You almost need an outreach type programme to be able to get that information to farmers that don't go to [trade shows], that don't go to benchmarking groups, that don't have the vet [routinely]. It's very difficult to get information to those guys" (V2, female youngstock veterinarian).

However, efforts to communicate the basic principles of calf management to more farmers tended to result in the repetition of information in various sources (trade magazines and online) which could be frustrating for farmers who were motivated to do their own research about calf rearing:

> "They are quite similar every time, they're the same sort of articles. You don't get much new information" (F1, female calf rearer).

Advisors were often concerned by the potential confusion caused by inconsistent messages from different sources and advisors:

> "Agricultural consultants ... When their specialist area is, say, banking and finance and because they are there as that farm's consultant, they make some glib comment about animal health that can be very undermining of the vet who is the

specialist on animal health on that farm" (DR1, female pharmaceutical company veterinary advisor).

Conversely, farmers did not appear to consider mixed messages to be a problem. Farmers preferred *"impartial advice"* (F2, female calf rearer) without commercial influence, but felt able to factor in commercial biases in their assessment of information:

> "Occasionally the [events] that are put on [are sponsored] by the drug companies ... they're good, they can be quite informative, but there's always a little lean to use their product or whatever, but then as long as you know that it's okay" (F26, female calf rearer).

The role of trusted advisors

Farmers trusted their advisors, particularly their farm veterinarian, to validate information. This appeared to be largely due to their perception that their veterinarians were aware of the latest research and industry developments and could contextualise information for a specific farm:

> "One doesn't believe farming press stuff too much unless it's backed by a vet telling you about that report, or somebody emphasising it" (F4, male farm manager).

> "If there's something cheaper that'll do just as good a job, you want to be using that, don't you? That's where you rely on the vet to keep you informed of the latest trends and practices" (F8, male farm manager of dairy bull calf rearing unit).

> "The vet knows your farm, your system, your people, what you're good at. Having something generalised [a written information resource] would be good, but it just wouldn't fit everybody" (F24, male herd manager).

Indeed, most veterinarians felt it was their responsibility as farm advisors to ensure their knowledge was current, and offer tailored advice for individual farms:

> "The good, forward-thinking farmers will be as up to date, if not more, than me. So if you want to work with them, if you want any sort of credibility you need to be at least as up to date as they are" (V1, male veterinary specialist in cattle health).

> "The role of vets and other consultants, other members of industry, is to try and help farmers to make the best decisions for *their* individual farm" (V5, male youngstock veterinarian).

> "You've gotta do it as a team. There's no point in saying "I think you should do this" if it's just not practical or feasible on that farm" (V2, female youngstock veterinarian).

However, some veterinarians might lack current knowledge about calf rearing. They might be disinterested in youngstock, or struggle to find the time to focus their research and training on calf rearing as opposed to other topics:

> "There are some really good vets out there which are really keen on the youngstock side of things and really help their farmers. There are still some vets out there that don't really understand the whole area of calf rearing ... they don't always know enough about the preventative methods" (N2, female feed company representative).

> "It's difficult for mixed practice vets ... if you've only got limited hours to do your CPD [continuing professional development] and space in your brain to do reading" (DR1, female pharmaceutical company veterinary advisor).

Another participant raised concerns about a lack of awareness of calf-specific legislation among some practicing veterinarians:

> "Private vets ... don't actually know some of the laws ... Top of the range veterinary advisors communicating inaccurate stuff, as well as illegal stuff" (GA1 , female government advisor).

7.3.6. Veterinary involvement in calf rearing

Despite their veterinarian being a trusted advisor, the way in which farm clients engaged with the veterinarian varied:

> "[Some] clients ... see us as part of the team ... get us involved in on-farm meetings with nutritionists and other farm consultants whereas other clients would never think of doing that. That's maybe partly down to them not wanting to, but maybe partly down to us not allowing them to recognise that we can have that role" (V5, male youngstock veterinarian).

Most farmers did not consult the veterinarian about their calf management practices. Several calf rearers believed that they were able to rear calves effectively and deal with basic problems themselves, only consulting the veterinarian in the case of novel symptoms or chronic problems:

> "If I see something weird with a calf that I've never seen before then I would usually ask the vet, but I've found just asking the vet for advice on rearing calves then they'll just say the same things that I know anyway so I've never really bothered asking much about that. It's only if I feel it is a more veterinary kind of thing" (F3, male calf rearer and farm hand).

Lack of information about calf illness might also contribute to a lack of veterinary involvement in calf rearing on dairy farms:

> "If you're not recording any disease incidences, you're not picking up on them and you can't effectively try and make change ... If [dad] doesn't perceive there to be a problem then why would he want to call the vet out unnecessarily and pay for the vet's time?" (F4, farmer's son and trainee veterinarian).

Veterinarians perceived many farmers to be entrenched in the attitude that the only need for veterinary involvement in calf rearing was in response to problems, rather than developing preventive strategies and investing in calf performance:

> "Can the vet help with calf rearing? Not until they're ill. Not as much preventative advice given as I would like to" (V7, female farm veterinarian).

> "Nothing wrong with the calves, so it doesn't need a vet. Well there's nothing wrong with a cow producing 8,000 litres, other than you want it to produce 10,000, and you involve us in that" (V6, male youngstock veterinarian).

The variation in the way in which farm clients consulted the veterinarian about calf rearing was reflected in the services and payment plans offered by veterinary practices. Most routine herd health visits were focused on the milking herd:

> "The vet comes [for the weekly routine fertility visit to the adult cattle] ... if she's not coming, we don't get her to check [a problem with the calves], but if she is then "oh, these calves are a bit dank [unwell], come and have a look"" (F19, male farm manager).

This suggests that farmers avoided consulting their veterinarian about calves when it incurred additional fees. Although some clinics offered a separate youngstock service, farmers had to pay to subscribe to it. Other veterinary practices included calves as part of their preventive herd health approach. Farmers appeared to be most receptive to an inclusive package, where the focus on calves was driven by an enthusiastic veterinarian:

> "We're reasonably proactive in our youngstock management so if they didn't ask us [about their calves], we'd ask them ... It's all part of a routine dairy herd health visit" (V8, male farm veterinarian).

> "We have a very proactive vet ... We [have a] routine farm visit every fortnight, so that will incorporate looking at calf health. So yeah, so we definitely use him as a learning source" (F9, male farm manager).

However because different members of staff are often responsible for different areas of the farm, including youngstock as part of routine herd health visits could be challenging:

"The person that you're discussing things with may not be aware of the problems, or their perception of the importance is slightly altered to the person who looks after the calves" (V6, male youngstock veterinarian).

Uptake of advice

It was well accepted that *"advice is better value if you act on it"* (V1, male veterinary specialist in cattle health), however, implementation of advice on farms could be challenging when working within farm limitations in terms of time, labour and finance:

"It's not rocket science what they're proposing. Keep them clean and warm and dry and feed them properly and they'll grow. But how do you do that when there just isn't the time and there isn't the money?" (V8, male farm veterinarian).

"Calves would be one of many issues on the farm and the advice I give might involve cost, either financial costs or labour costs, and that cost is in competition with other costs because [farmers] can't do everything" (V1, male veterinary specialist in cattle health).

It could also be that calf care and uptake of advice was affected by the farmer's personal and mental wellbeing:

"Sometimes it's hard to take advice, especially if you've been doing something for a long time in a way and someone says "oh, that's wrong". One, it depends how it's presented, but also their mindset. If things are down .... and the world just seems to be all against you, then someone telling you "you ought to be doing this instead" isn't gonna encourage people to change. It's gonna just ... feel like it's a criticism" (F5, male farm manager).

"Sometimes all they want is a friend, they want someone to call in every two or three weeks when they're passing and say hello and have a cup of tea ... Part of the time you're an animal doctor, part of the time you're a psycho-analyst" (V8, male farm veterinarian).

The quality of the relationship between veterinarians and their clients was believed to be a critical component in motivating uptake of advice:

"Individual advice is so important because you need to understand what motivates your clients and I think as a profession, vets tend to assume it's money, and often it isn't ... You need to understand what a farmer's hoping for to be able to advise" (V1, male veterinary specialist in cattle health).

"If a different vet came ... I've built up a relationship with this vet, and so he'd have to prove himself, or she, before I would really take his advice over my current one" (F22, female herd manager).

However, the quality of advice might depend on the advisor's perception of the client's level of engagement and interest in calves, as well as their ability and willingness to invest in alterations:

> "We always tailor our advice to each farm ... which might be wrong because that means maybe some people don't always get gold standard advice. Or, maybe I tell them that this is gold standard, this is probably what you can do" (V7, female farm veterinarian).

Veterinarians might also struggle to remain motivated to advise clients who repeatedly fail to implement recommendations, which could affect a veterinarian's willingness to engage with clients they perceived as uncooperative:

> "The vets feel they have such a relationship with their clients ... or they've created enough of a stereotype that they start speaking for them ... and saying "Oh, they'll never be up for this, we won't bother"" (V6, male youngstock veterinarian).

> "I think sometimes it can be more effort, this may be the wrong attitude, but I think almost more effort than it's worth. Trying really hard somewhere ... and then never getting anywhere. Whereas if you invested that time in people that *were* willing to change, you could have a lot more impact and it's much more rewarding for everybody" (V1, male veterinary specialist in cattle health).

7.4. Discussion

The interview findings presented in this chapter reflect the complexity of factors affecting calf care on dairy farms, as presented in Figure 7.1. Interviewees in the current study attributed both use and non-use values to calves which relate to farm performance and personal drivers, respectively (McInerney 2004). Key use values identified by participants were that replacement heifer calves will become the future milking herd, and rearing costs contribute to overall farm financial efficiency (Boulton et al. 2017). In addition, having sufficient replacements can protect the disease status of farms by limiting the need to purchase cattle (Sayers et al. 2013). Although not mentioned specifically by participants, genetic improvement is another important aspect of replacement heifers entering the future milking herd (De Vries 2017). Similar to findings from Canadian research which indicated that economic and logistical aspects of marketing bull dairy calves affect their standard of care (Renaud et al. 2017), market value of bull calves was a key consideration for several farmers in this study. This issue is recognised in the industry - the Dairy Cattle Welfare Strategy for Great Britain aims to eliminate the practice of euthanasia of healthy calves by 2023 through adaptations to the market supply chain (AHDB 2020b). These use values were complemented by non-use values, as well as intrinsic and extrinsic motivators: personal ethics and priorities, motivations like job satisfaction and pride, and concern about the public's perception of calf management practices. Ethical obligations,

pride and personal responsibility of care have been highlighted as key motivators to maintain good animal welfare in previous research (Leach et al. 2010a, Croyle et al. 2019).

7.4.1. Challenges in prioritising calf care

Due to the nature of recruitment of participants for this research, interviewees were likely to have an interest in calf rearing and place high value on dairy calves. However, even some of these individuals struggled to invest in their calf management, largely due to competing demands for finite resources (time, labour and finance) which limited the options available to farm managers to make desired changes (Sutherland et al. 2012). Participants also conveyed concerns about the persistence of historic attitudes which resulted in calves being undervalued on many farms. Marginalisation of calves on farms often meant that limited investment was made in calf infrastructure, staff, and monitoring of calf performance. On average, replacement heifers that calve at 23-24 months repay the cost of rearing during their second lactation, though farms that exceed the recommended AFC can take up to six lactations to reach the breakeven point; there is a high risk that those heifers exit the herd before making a profit for the farm (Boulton et al. 2017). Due to a lack of long-term data monitoring, financial losses and potential gains from replacement heifer calves within the overall farm system are likely underappreciated, ultimately negatively impacting future milking herd productivity and exacerbating the farm's financial situation (Figure 7.1). In addition, a lack of objective data frustrated advisors and hindered effective preventive veterinary medicine approaches.

Burton et al. (2021) identified three components for producing good practice: i) innate characteristics, ii) skills learnt through practice, and iii) knowledge gained through practice or training - these individual qualities are moderated by the tools and facilities available. In the case of calves, participants in the current study indicated that calf rearers required specific attributes and good attention to detail, which requires sufficient time to perform their duties - but calf feeding was often one of several responsibilities assigned to a general farm worker.

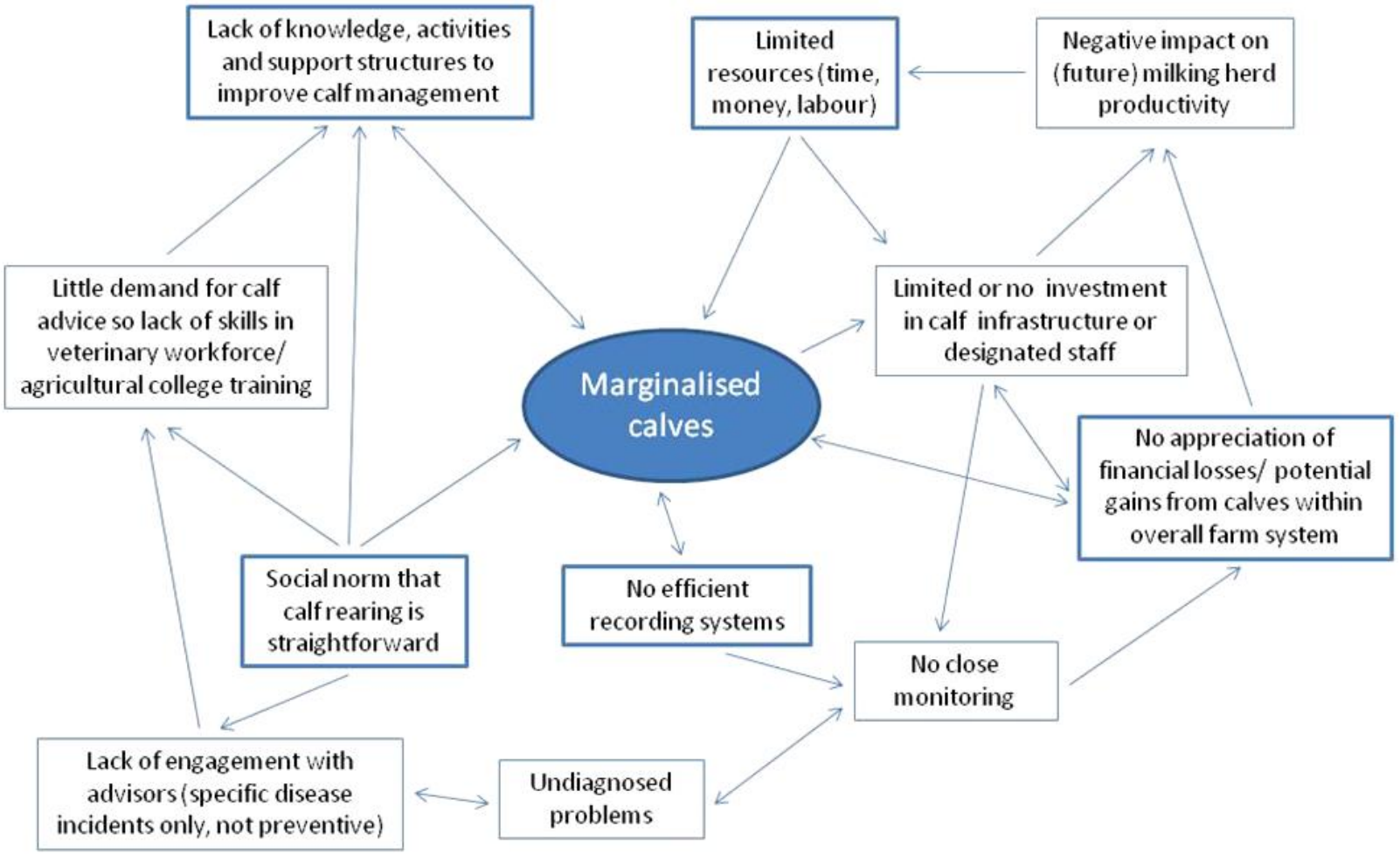

Figure 7.1 Schematic demonstrating the effect of marginalisation of replacement heifer calves

Limited resources, unrecognised potential of calves, lack of data monitoring, social norms and scarcity of support structures are key areas for improvement.

Dairy farmers who identified a need for reduced antimicrobial use in calves often included improved staffing - in terms of both quality of labour and the time available to them - as a corrective action (Morgans et al. 2021). Key limitations include the often under-invested calf infrastructure and limitations in the training, advice and technologies available, as depicted in Figure 7.1. The habitus that calf rearing is straightforward (Sumner et al. 2018a) might contribute to the perception that calf-oriented events and services are unnecessary. This lack of demand affects the prevalence of relevant skills in the veterinary workforce and agricultural college training, ultimately resulting in a dearth of knowledge and support structures to improve calf management, which feeds back into the cultural marginalisation of dairy calves. Participants were hopeful that attitudes were shifting in the industry to focus more on the importance of calf management. Indeed, the financial implications of calf rearing (Boulton et al. 2017) have been publicised (AHDB Dairy 2021) and calf care and youngstock survival has been identified as a key priority for the dairy industry (AHDB 2020b). However, it is difficult to shift traditional norms (despite evidence supporting the need for change), depending on the strength of attachment to old ideas and practices, availability of the required technology and skills, and the extent to which the change is considered an improvement (Burton et al. 2021).

7.4.2. Recognition of calf potential and data monitoring

The perceived value of calves appears to be reflected in the amount of performance monitoring and advice sought regarding youngstock. Where farmers appreciated the impact of health and growth rate on calves' future performance in the milking herd, they were more likely to be monitoring calf health and growth data. Designated calf rearers were most likely to have the time and inclination to monitor calf performance and valued the ability to objectively assess calf management practices and determine the need to invest time and money for improvements (Sherwin et al. 2016) proactively rather than retroactively observing a problem when rearing targets were not met. Some farmers valued the option of having a veterinary technician perform certain husbandry practices (e.g. disbudding) and data monitoring (e.g. weighing calves to record growth rates) and there is now a formal qualification for this role in the UK (Institute for Apprenticeships and Technical Education 2021). There appeared to be less focus on reviewing long-term data to assess the effects of calfhood experiences on future performance (Bach & Ahedo 2008, Johnson et al. 2017, Baxter-Smith & Simpson 2020). This meant that on some farms the consequences of poor calf performance are hidden and overshadowed by the immediate and clearly visible penalties resulting from reduced milk supply and/or quality.

Often, participant farmers used information about calf feeding, disease incidents and treatments mainly to aid communication and cohesion between staff carrying out calf protocols; i.e. record keeping that directly influenced their animal care practices rather

than perceived as satisfying external regulatory demands (Escobar 2015, Escobar & Demeritt 2016). The ease with which calf data could be collected, recorded and monitored was a key concern, an area which could be aided by well-designed and integrated precision livestock technology applications (Rose et al. 2018b). Since the time of the interviews in this study, the offering of digital technologies has expanded; for example Breedr (2021) offers a free app to track growth rates and treatments in cattle (including calves) and Smartbell (2021) are currently trialling a sensor-based calf health monitoring and management system to allow 24/7 monitoring of calves to provide actionable insights to farmers. However, the availability of technologies does not guarantee their uptake, and user-centred design is an important consideration for developers to help ensure decision support systems are fit-for-purpose and (perceived as) cost-effective (Rose et al. 2018b).

7.4.3. Engagement with information and advice

Aside from data monitoring, contact from individuals external to the farm can also help to challenge the farmer's normative frame of reference, or "barn blindness" (Jansen et al. 2009, Croyle et al. 2019). Leaving the farm to attend peer-to-peer learning opportunities like discussion groups and farm walks were popular avenues to gain insight from beyond the farmgate, though the frequency of events was largely dependent on dairy density in the locale, and calves might not feature as a focal topic. The COVID 19 pandemic has propelled the use of webinars and 'blended' events which are available both in-person and digitally online, with providers indicating that they wish to continue using so geographical location of events may pose less of a barrier now than in the past (Kindred et al. 2021). Advisors - particularly those with hands-on experience as calf rearers, or a keen interest in calves - were valued as another source of information. However, most farmers did not routinely discuss calf management with their veterinarian, partly to avoid incurring additional costs if not part of a routine herd health visit, and partly because it was not perceived as part of the veterinarian's role. Some farmers did not consider expert advice to be necessary, reflecting social norms that calf rearing is straightforward and requires little deliberation and discussion; similar attitudes were reported from Canadian farmers (Sumner et al. 2018a). Veterinary involvement regarding calves generally followed a reactive treatment model in response to disease issues, even when a preventive herd health strategy was applied to the adult herd.

Participating farmers' attitudes towards seeking and implementing advice appeared to sit on a spectrum between proactive individuals who want to keep up-to-date with research to do their job to the best of their ability and individuals who lack the time and/or interest in learning so take a more reactive approach, focusing their efforts on addressing perceived problems. This is consistent with the 'types' of farmers previously described by Jansen et al. (2010). Similar to previous research, veterinarians also grouped farmers according to

their perceived engagement with the veterinarian and uptake of advice (Richens et al. 2016, Bard et al. 2019). Veterinarians in this study admitted that these perceptions affected the quality of advice given to clients, echoing previous findings that farmers who showed poor levels of engagement and willingness to change had almost been given up on (Richens et al. 2016, Redfern et al. 2021). Veterinarians also reported that they would tailor advice to be more attainable for the client, but their assumptions about what is or is not attainable may well be incorrect as veterinarians have been shown to misidentify the expectations and preferences of farmers in provision of herd health management programs (Kristensen & Enevoldsen 2008, Hall & Wapenaar 2012). Furthermore, the quality of advice likely depends upon the advisor's interest and motivation to remain up-to-date with the latest research and recommendations regarding calves. In this study, a government advisor indicated that some veterinarians are not aware of basic legislative requirements pertaining to calves, which suggests that not every veterinarian is suited to offering preventive calf health advice, or that more calf-specific training is required. In a previous study, veterinarians who believed that they did not have sufficient knowledge and expertise were less confident to be proactive on farms (Bellet et al. 2015).

Farmers might assume that a trusted advisor, particularly their veterinarian, would identify and inform them of animal care issues on their farm and that if they say nothing, that there is no need for improvement (Croyle et al. 2019). Several veterinary practices in this study did not include calves as part of a comprehensive herd health package. Some practices offered a standalone calf service involving data recording, benchmarking and discussion group with other registered clients, but farmers had to be motivated enough to subscribe and pay for this additional service. This means that an individual - farmer or advisor - must have calf-centric interests; without a driven individual, calves will likely continue to be overlooked, perpetuating the culture of marginalisation of dairy calves.

7.4.4. The need for knowledge exchange and support structures

Several participants in the present study indicated perceived shortcomings in the efforts to communicate and educate farmers about calf rearing. Advisors were concerned about the reach and effectiveness of messaging in encouraging uptake of recommendations. Some farmers, particularly those who were engaged and proactive calf rearers were frustrated by repeated messaging and struggled to gain new insights. Several farmers felt that advice efforts have focused only on highlighting the importance of calf rearing and meeting rearing targets (Palczynski et al. 2020b, Chapter 5), with limited information on *how* to achieve those targets. Furthermore, farmers were keen to gain practical insights that would work within their specific farm context. Veterinarians and other advisors can provide tailored advice, but it is essential that their approaches involve teamwork and a trusting relationship. However, there has been a lack of focus on this "relationship-centred

care" in the veterinary profession, with little structured training in effective communication (Bard et al. 2017, Croyle et al. 2019). Farmers appeared to be more inclined to learn from other farmers, which supports research advocating peer-to-peer learning and participatory approaches, e.g. using the stable schools (or farmer action group) approach (Vaarst et al. 2007, Morgans et al. 2021) and benchmarking (Sumner et al. 2018a, 2020). These approaches have been shown to be highly effective in empowering farmers to make changes whilst considering a holistic view of their whole farm system (Morgans et al. 2021).

7.5. Conclusion

Although industry have promoted youngstock management as key to farm economic efficiency, it appears that calves often have not been fully integrated into the whole dairy farm system, nor culturally as an integral part of the productive herd. These results indicate a culture shift is needed within the dairy industry and associated advisory services. There is a need to make the use value of calves more visible at farm level through greater technical and support structures being in place to provide longitudinal insights of the impact of calf rearing practices within the whole farm system. The current findings indicate the need for greater focus on *how* to achieve rearing targets by provision of technical and support structures to foster action towards improved calf wellbeing and for the status of calves to be raised in line with their vital importance for the future dairy herd.

8. General Discussion and Conclusions

The purpose of this thesis, as outlined in Chapters 1 and 2, was to gain insight into the perspectives, beliefs and experiences of dairy farmers, calf rearers and key advisors to explore how they relate to calf health and welfare on English dairy farms. The results presented in Chapters 4-7 provide a more holistic understanding of calf management as it relates to the whole dairy farm system and wider industry. Chapter 4 highlighted the importance of the practical nature of advice and (perceived) ease of implementation of management practices related to colostrum management; these factors were also critical for other aspects of calf rearing (Chapters 5-7). Chapter 5 indicated that calf nutrition and feeding is a particularly divisive area, with a lack of consensus in the research literature and competing commercial interests contributing to variations in calf feeding practices across farms, and in many cases the provision of inadequate calf nutrition. Chapter 6 underlined the importance of attention to detail and the key role of stockpersons in providing quality calf care that reduces incidences of disease and mortality, even where calf accommodation was suboptimal. Chapter 7 explored potential reasons for the marginalisation of calves in the dairy industry, and called for both technical and social support structures focused on improving calf management and wellbeing. This chapter presents the discussion of the results as a whole to identify areas for further research and adaptations to the services offered by advisors with the potential to increase positive calf-oriented attitudes and behaviours on farms and in the wider dairy industry.

8.1. Experiences and beliefs about calf care on farms

The focus of this thesis, based on the interviews that informed it, was on calf rearing from birth to weaning. The focal topics presented in Chapters 4-7 were not pre-determined. The interviews allowed participants the opportunity to comment on their experiences of dry cow and calving management through to the post-weaning period during which heifers are served, calved and enter the milking herd. The topics explored in this thesis were based on the aspects most readily discussed, and therefore most likely to be perceived as important, by participants (Turner 2010, Miles et al. 2014).

Dry cow transition management and calving were considered important, but more relevant to the health, welfare and productivity of the dams rather than the calves. Problems during this period are common and complex, requiring further investigation of the social factors at play (Redfern et al. 2021), but were not considered relevant to the current work. Cow-calf separation within 24 hours was perceived to be less stressful than allowing prolonged contact; research indicates early separation reduces the acute stress response in both cows and calves, but is less beneficial to calves in terms of behavioural development, socialisation and growth (Meagher et al. 2019). Colostrum, calf feeding and pre-weaning management was discussed in great detail (Chapter 4-7). Post-weaning heifer

management was not discussed in detail during interviews. Previous research reported heifer mortality rates of 6.9% between 1 month of age and first serving (Brickell et al. 2009) and emphasised the importance of efficient management involving appropriate nutrition and preventive health measures throughout the heifer rearing period to reduce the risk of calving difficulties and achieve an earlier AFC (Boulton et al. 2015a, 2015c). Furthermore, the introduction of freshly calved heifers to the milking herd can be stressful, influenced by the socialisation they experience as calves (Wagner et al. 2012). Further exploration of how farmers manage the later stages of heifer rearing is warranted. Finally, participants' breeding decisions tended to be focused on promoting calving ease (Zaborski et al. 2009) and the use of sexed semen to limit the number of bull calves produced (Balzani et al. 2021). Two farmers mentioned breeding polled (naturally hornless) animals; the number and genetic merit of polled bulls available for artificial insemination has increased (Windig et al. 2015) but breeding for polledness might not be a priority selection criterion (Kling-Eveillard et al. 2015). Farmers also identified animals to avoid breeding from due to disease eradication efforts (e.g. against Johne's disease and BVD) but breeding specifically for improved health traits (Pritchard et al. 2013, Berry 2015) was not mentioned.

Another area which this thesis has not previously focused on is the role of gender in calf rearing. Several male participants referred to women making better calf rearers, believing that they were more likely to have a nurturing nature involving the personal values and attributes previously described as important for good calf husbandry (patience, attention to detail, etc.). Indeed, research has indicated that females are more empathetic towards the pain experienced by animals (Wikman et al. 2013). Traditionally, calf rearing was the responsibility of the mother, wife, and/or daughter on family farms (Shortall 2006). Despite their capabilities, women's work might be marginalised and largely invisible on farms (Alston et al. 2017). It is possible that this contributes to the historic (and in many cases persisting) marginalisation of calves on dairy farms discussed in Chapter 7.

8.1.1. The need to get the basics right

Throughout the interviews (preceding chapters), participants indicated that calf rearing is not "rocket science" - the need for colostrum, calories, comfort, cleanliness and consistency (The 5 C's (McGuirk 2009)) appeared to be widely known amongst participants. In broad terms, the key areas identified by interviewees as contributing to the rearing of healthy, well-growing calves included practices which promote calf immunity, reduce pathogen challenge in the calf's environment (Johnson et al. 2021), and provide early, appropriate intervention in response to calf illness (McGuirk 2008). Calf rearers in particular emphasised that calves are "babies" that require good care and attention, but comparing the needs of calves to those of human babies could lead to misconceptions, for

example that milk-fed calves do not require access to drinking water (Chapter 5) when water is vital for rumen development and a smooth weaning transition (Drackley 2008, Govil et al. 2017). Furthermore, the perceived simplicity of calf rearing (Sumner et al. 2018a) appeared to contribute to the underestimation of the time and skill required to rear calves effectively on participating farms where calf feeding was assigned to a general farm worker.

Stockmanship was considered another fundamental aspect of calf rearing on farms, both in terms of personal attributes and the time afforded to staff for calf management (as described in Chapters 6 and 7). Attention to detail was repeatedly mentioned by farmer participants in this study, and previously by Welsh farmers (Atkinson 2015), as being key for successful calf rearing. Thus participants tended to believe that having a designated calf rearer was beneficial; this has been shown to be correlated with better calf health on farms (Atkinson 2015). Furthermore, personal beliefs, ethics, priorities and motivations (Kristensen & Enevoldsen 2008, Kristensen & Jakobsen 2011) affect the way in which calf rearing practices are conducted. Positive handling results in more positive calf mood and friendliness (Ellingsen et al. 2014) and can make painful procedures like disbudding less stressful to both calves and stockpersons (Charlton & Bleach 2007). Furthermore, the human-animal relationship is a key component of positive welfare (Mellor 2016a, Adamczyk 2018). Several calf rearers were from non-farming backgrounds and described learning on the job and asking lots of questions of advisors and other calf rearers, potentially indicating a lack of skills development training for calf rearers. Training could encourage thinking about SMART goals (Mee 2007) to pinpoint which details require attention and assess whether specific protocols achieve their intended purpose, and help ensure calves are provided with opportunities to have positive experiences, in line with 'a life worth living', or 'a good life' (Mellor 2016a).

8.1.2. The need to "make do" in suboptimal circumstances

Somewhat in contrast to the perceived need for good attention to detail, participants often referred to 'making do' within challenging farm circumstances, e.g. a lack of time, funds and labour, insufficient space, or improper accommodation for calves. Participants from farms where calf infrastructure and designated staff had been invested in noted improvements to the health and appearance of calves as a result, thus perceived the investment positively. However, participants indicated that other farmers might take a more reactive, short-term approach to problems, for example treating BRD with antimicrobials rather than investing in calf accommodation with suitable drainage and ventilation (Chapter 6). This need to 'make do' meant that stockmanship was especially important as fastidious calf care can help to mitigate environmental disease risk factors (McGuirk 2008, Lorenz et al. 2011a).

Another reason for the need to 'make do' with the existing farm features was the (perceived) financial capital available to make investments. In response to volatile economic conditions, dairy farms might alter various production activities and management practices to diversify in response to crisis e.g. reducing hired labour. Investments in infrastructure, which are usually realised through loans, can cause further financial stress (Ragkos et al. 2015). In addition, the visibility and immediacy of costs and/or benefits associated with the productive milking herd mean that associated investments are a greater priority than those related to calf management (Mohd Nor et al. 2015), especially if those responsible for investment decisions are not directly involved in the calf rearing. Furthermore, uncertainty has been shown to influence farmers' investment decisions, using Real Options Theory helped to assess the rationality of decisions (Tubetov et al. 2012, Rutten et al. 2018). To my knowledge no studies have been conducted to understand investment decisions specifically related to youngstock management, but it would be useful to gain further understanding of the tradeoffs farmers are willing - or forced - to make.

Life cycle changes including retirement and succession on future planning in terms of farm development and financial management (Parry et al. 2005). Farm investments and expansion are more likely to occur at an earlier stage in farmers' lives or accompany succession, whereas 'making do' is more likely associated with retirement or uncertain succession (Ingram et al. 2013). Two farmer participants in this present research discussed not having a clear succession plan, indicating that they wanted to farm to the best of their ability until retirement, so minor changes and investments might be considered but large investments, e.g. new buildings, were unlikely due to the length of time that would be needed to repay those costs. This again reflects the role of personal values, as well as the way in which uncertainty and future planning influences the time, attention and investment allocated to calves. According to Sutherland et al. (2012), succession is an opportunity for change (e.g. a heightened focus on youngstock) due to an influx of new skills, ideas and priorities through the successor, especially if they have been educated and/or worked away from the farm for a period of time. However, the new owner might continue the existing farming trajectory and practices (e.g. marginalisation of calves), particularly if they are compatible with their aspirations and have been trained in the farming styles of their predecessor. Young people are increasingly being deterred from taking on their parents' farm where the business is not believed to be financially viable and it is perceived as difficult to make a good living from farming (Parry et al. 2005). This increases the intensity of pressures related to workload and succession (Parry et al. 2005), so farmers might decide to let or sell their farm or rely on paid, non-family labour in structuring their retirement (Riley 2016).

8.2. The knowledge-practice gap

Poor incorporation of applied science and advisory recommendations into farm practice represents a significant science-practice gap (Rose et al. 2018a, van Dijk et al. 2019). Policy outlining minimum legal requirements for calf rearing (DEFRA 2003) also do not guarantee compliance. For example, in Chapter 7, participants indicated that they knew some farmers did not use a local anaesthetic when disbudding calves, apparently perceiving practical, time-related concerns with regards to calf handling; these aspects were also raised as concerns in previous research with Irish beef farmers (Dwane et al. 2013). On the other hand, most participating farmers provided NSAIDs in addition to local anaesthesia, a practice which confers benefits to calf welfare (Herskin & Nielsen 2018). There are multiple influences on behaviour e.g. personal factors; business factors; family, peer and advisor networks; perceived control; incentives and penalties; and the provision of information and education (Rose et al. 2018a). Traditional top-down dissemination of scientific knowledge to farmers has proven ineffective at achieving behavioural change (Rose et al. 2018a, van Dijk et al. 2019). It is difficult to shift traditional norms, even when there is evidence supporting the need for change (Burton et al. 2021). This applies not only to farmers' (failed) adoption of legal requirements and recommended improvements to their calf rearing practices and/or infrastructure, but also to advisory approaches.

8.2.1. Experiences relating to farmer information seeking and advice

As found in previous research (Richens et al. 2016, Redfern et al. 2021), several advisor participants in this study described their frustration at the perceived ineffectiveness of their efforts when farmers failed to implement advice, which often resulted in disengagement with farmers they perceived as uncooperative. As in previous studies, farmer participants seemed content with their calf performance and management practices (in a state of path dependency, (Sutherland et al. 2012)); most reported that they would rarely speak to advisors about their calf rearing protocols, and would only ask for veterinary involvement in response to disease occurrences in calves (a trigger event (Sutherland et al. 2012)). That said, a number of the farmers interviewed were very positive about the passion, expertise and experience of their advisors, particularly if they were considered adept at providing recommendations that were practical within their specific farm context. Some advisor participants recognised the need to work as a team with clients to identify improvements that were perceived as more feasible for farmers to achieve in practice within their specific farm context, a skill that required them to have good technical knowledge and enthusiasm to encourage improvements to calf management on dairy farms. Collaborative, two-way knowledge exchange approaches are increasingly recognised as having potential to bridge the science-practice gap (Rose et al. 2018a, van Dijk et al. 2019), as are peer-to-peer learning opportunities (Henriksen et al. 2015, Morgans et al. 2021).

Many calf rearer participants were motivated to expand their knowledge and further improve their practices through participation in calf discussion groups (often run by their veterinary practice), attendance at on-farm events, and through reading relevant materials. However, these individuals sometimes felt that they struggled to gain new knowledge about calf rearing. This could indicate a failure of knowledge providers to identify areas of interest, or knowledge gaps, for example, a previous focus group study revealed that although disbudding animals worried farmers due to the infliction of pain and difficulties in carrying out the procedure, opportunities to discuss disbudding with other farmers and advisors were limited (Kling-Eveillard et al. 2015). Calf rearer participants in this study also felt that information about calf rearing published in the farming press was repetitive, a technique which can increase the memorability, salience and acceptance of knowledge claims (Rust et al. 2021). The actual and perceived content and relevance of the farming press as it relates to calf rearing practices has not been studied. However, this perceived repetition might again reflect the apparent simplicity of calf rearing; Rose et al. (2018a) recommend that written information contain farmer testimonies explaining the practices they use on their farms, thus it is likely that articles will focus on the overarching fundamentals e.g. colostrum management, housing, feeding, and attention to detail, whereas calf rearer participants seemed more interested in learning about 'little things' with the potential to benefit their calves.

8.2.2. Changing the advisory approach

Farmer and advisor participants appeared to have different priorities regarding calf management advice. Farmers expressed an interest in practical advice with a focus on how to make recommendations work within their specific farm context and assessed the success of any changes by their experience e.g. of easier management and improved appearance or health of calves. The advisors interviewed appeared to focus on why farmers should make a change and the anticipated animal health outcomes, which could be evaluated using calf performance data. A mismatch between the perceived burden and relative value of paperwork associated with regulatory record keeping between farmers and advisors/regulators has been previously reported (Escobar 2015, Escobar & Demeritt 2016). Reviewing longitudinal data to assess the effects of calfhood experiences on (future) farm performance was an uncommon practice amongst farmers but could provide useful insights (Bach & Ahedo 2008, Johnson et al. 2017, Baxter-Smith & Simpson 2020). Technology including decision support systems for herd health management could play a role in reducing the effort required for data monitoring, whilst increasing the (perceived) utility for farmers' day-to-day practices (Escobar 2015, Escobar & Demeritt 2016, Rose et al. 2018b). For example, incorporating calf health and performance data into feedback on overall farm performance could increase the visibility of the influences of calf rearing on cow health, survival and production (Brickell & Wathes 2011, Wathes et al. 2014, Boulton

et al. 2017) at farm level. This information would also have the potential for benchmarking against other farms, which has been shown to motivate positive changes to calf rearing practices on farms (Sumner et al. 2018a, 2020).

In addition, a number of advisor participants in the present study suggested that research should shift its focus towards how communication and advisory efforts can better encourage behavioural change for improved calf health and wellbeing on farms, rather than aiming to develop new technical knowledge. Recent research has called for increased and improved communication training for veterinarians (Bard et al. 2017, Croyle et al. 2019). Furthermore, as explained in the review by Rose et al. (2018a), there is a need to shift the focus away from individual behaviour change models towards a social change approach involving participatory engagement. Face-to face meetings with a trusted and trained facilitator to manage group dynamics and the relationships between different actors (Rose et al. 2018a, van Dijk et al. 2019, Morgans et al. 2021), e.g. farmers, researchers, policymakers, can be effective in promoting the co-creation of research, farming practices and policies which incorporate and value the knowledge and experiences of farmers (Rose et al. 2018a, van Dijk et al. 2019). Vasseur et al. (2010) asked dairy farmers to be actively involved in the development and validation of an advisory tool to help improve calf and heifer management practices, and reported that the participants perceived this tool as useful, and had implemented many of the recommendations six months later. By including farmers at an early stage, strategies are much more likely to be designed in ways that are compatible with existing workflows and systems, making their adoption more accessible at the farm level (Rose et al. 2018a).

8.3. Thesis strengths and limitations

The holistic, semi-structured interview approach used in this thesis differs from the majority of research literature about calves in which the research focus is predetermined by the researchers in questionnaire based studies (e.g. Hötzel et al. 2014, Medrano-Galarza et al. 2017, Phipps et al. 2018), and investigations of a particular aspect of calf rearing (e.g. Curtis et al. 2016, Robbers et al. 2021). Furthermore, previous research has largely focused on behavioural change models and the management practices conducted by farmers (Rose et al. 2018a). The approach used for this thesis was able to explore the participants' experiences of calf rearing, as well as the potential influence of wider external factors. However, the methodology used for this thesis has several limitations.

Firstly, the interviews relied upon self-reported accounts which might not be reflective of what is actually happening on farms, and previous research has noted discrepancies between farmers' intentions and their behaviours (Viira et al. 2014). Participant observation would have been more suited to observe calf rearing practices and the provision of advice. Furthermore, although Chapter 7 discusses the perception of calf

data, the farm records were not analysed as it was assumed that the information provided would be inconsistent across farms, and in many cases incomplete (Bach & Ahedo 2008). This assumption may not have been accurate, and since it is recommended that precision livestock technologies are developed to incorporate a greater focus on heifer rearing, a study focused on what data is collected on farms and how it is used could be very useful.

Generally, the participant selection was good and provided a range of perspectives which informed the interpretations and highlighted some interesting issues. However, the two feed company representatives both worked for the same company; one who was a general feed salesman, the other a youngstock nutrition specialist with a background in calf rearing, although one veterinary participant had left practice and worked at a feed company. Including these actors provided valuable insights, but since problems around recommended calf feeding protocols was a key finding from Chapter 5, further research focused on calf rearing should include representatives from a wider range of companies, and who have different roles and responsibilities. In addition, the voluntary nature of participation meant that there was a bias towards individuals with a specific focus on calf rearing. This might not be a limitation as these individuals likely have more to say on the topic and results were able to flag up problematic issues which, if they affect these more engaged farmers and advisors, are likely to reflect issues experienced by other advisors and farmers.

For the most part, this research meets the criteria for quality qualitative research described by Tracy (2010). This study is meaningfully coherent in that semi-structured interviews and thematic analysis were appropriate methods to use within a critical realist paradigm to achieve the stated aim to explore issues related to dairy calf management on English dairy farms and interconnect findings with the research literature. I was sincere and transparent about my background and the methods used, including ethical considerations, particularly in Chapter 3. The topic was worthy and the results and discussions presented in this thesis represent resonant and significant contributions to knowledge, flagging up potential issues with current calf rearing advice and practices (e.g. the tendency to oversimplify colostrum management and the practical challenges associated with it), suggesting areas for further research and exploration (e.g. the concept of attention to detail in disease management), and highlighting potential problems to address (e.g. the need for greater scrutiny of CMR products and associated feeding recommendations). However, this research is limited in terms of rich vigour and credibility. No alternative methods were used to triangulate data, participant validation was not conducted, and only one person was responsible for conducting and analysing the interview data, thus increasing the potential for researcher bias and limiting the validity of results (Birt et al. 2016). That said, a sufficient number and range of interviewees, ad

verbatim transcription of interviews for analysis, and use of quotes from multiple and varied voices to evidence the points raised in this thesis all contribute to the rigor and credibility of qualitative research (Tracy 2010).

8.4. Overall Conclusions

This thesis successfully explored its participants' perspectives, beliefs and experiences relating to calf management on English dairy farms. The broad scope of the interviews allowed a range of topics relating to replacement heifer rearing to be covered, and based on the interpretation of this data, the topics of colostrum management (Chapter 4), calf feeding and nutrition (Chapter 5), disease management (Chapter 6), and perceived value of calves, advice and data monitoring (Chapter 7) were selected for in-depth analyses. This thesis, informed by its participants, explored the experiences, attitudes and beliefs regarding calf rearing, including the potential influence of wider contextual and social factors, with a particular focus on the quality of advisory services and advisors. Based on the results of this research, it is recommended that policy, industry and advisory efforts to promote the importance of youngstock are improved to encourage farmers to act based on up-to-date and accurate information. It is likely that social change approaches will be needed to successfully transition from a culture of marginalisation of dairy calves to one where youngstock are prioritised as an integral part of a productive dairy herd.

9. References

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10. Appendices

Appendix I: Interview Topic Guide for Farmers

Participant and Farm Information checklist ['office' use]

Interview type:	Interview ID:	
Role on Farm:	Age (estimate):	Gender:
Calving Pattern:	Farm type e.g. family, organic:	
Ownership status:	bTB status:	
Land:	Number of cows:	Breed:

Mixed enterprise?

Active use of herd health plan?

Record keeping?

GENERAL FARM QUESTIONS

Tell me about your farm.

(System, number of cows, breed, land, just dairy? See above checklist)

What's your background, how did you get into farming?

(Experience and training, farm succession status)

Talk me through your current practices (ask for opinions on the practices used):

Dry cow management and calving protocols.

(Nutrition? Housing – group/individual, cleaning? Monitoring cows due to calve? Time in calving pen? Availability of assistance if necessary?)

Newborn calves.

(Removing from dam, weak calf syndrome, treating navel, housing – individual or group)

What happens to your bull calves and freemartins?

(Castration (anaesthetic)? Market/export to EU (transport)? Culling/shot at birth?)

Colostrum management?

(Milking the dam/preparation of stored colostrum? Feeding practice – method, timeframe, amount, how many feeds/number of days? Storage, pooling? Quality testing? Dam vaccinations?)

Milk-feeding protocols?

(Whole milk/CMR type? Amount: volume, density/concentration? Frequency? System? Warm or cold? Consistent routine? Gradual changes over time? Why did you choose these practices?)

Where do you house the calves?

(What is the building like, near older animals? Bedding type/frequency of fresh added? How often do you muck out and disinfect pens (cleaning protocol)? Individual or group housing? Mixing groups/All in, all out? Movements, to where? Transport? At which ages?)

How and when do you prepare for weaning?

(Based on age, weight, concentrate intake? Provision of water, concentrates, straw, from what age?)

What else happens in terms of general management up until weaning?

(Illness/disease management e.g. vaccination, treatments? Disbudding/dehorning (age, anaesthetic/anti- inflamatories)? Regular checks? Hot/cold-weather protocols? Biosecurity, isolate new calves etc.)

How do you manage your weaned calves until serving and calving?

Do you have a herd health plan? What do you think about it?

(Actively used? Useful? Keep other records? Benchmarking? Buy in cows/calves? Key Performance Indicators?)

Do you have calf rearing targets?

(Why, useful? What are they? How did you come up with them? Are you meeting them, how do you monitor that? Useful? Records for culling rate, calving rate, stillbirth rate, average first lactation yield and average total herd 305-day yield?)

CALF REARING QUESTIONS

Talk me through a general day, what are your main, most important activities?

(Time management and important tasks. Time spent with calves, yearlings, dry cows, milking herd. Order of priority? Focus on youngstock or milking herd? Why?

How much would you say a female calf was worth?

(Monetary value, investment and potential loss, future genetics/milk yield)

What makes a good replacement heifer, what can you do to achieve these traits?

What are the main problems you have with your calves?

(Appropriate housing, illness, mortality. How important are these issues (in comparison to milking herd issues). In terms of illness and mortality is there a level that

you tolerate/expect? Standard treatments? When would you become concerned and call the vet out?)

Have you tried to solve these issues? How? Has it been successful?

What sorts of things influence the effectiveness of your calf rearing?

(Structural issues related to buildings/planning restrictions, staffing/training/communication issues, commitment, cost in time/money, available support. Decisions made but not done properly?)

What do you think are the most important things to do for your calves?

(Important for current H&W or future profitability? Life stage, environment, colostrum/immunity, hygiene, nutrition, housing, monitoring etc.)

Do you like working with calves?

(Perception of role (cf. milking herd), feelings about healthy vs unhealthy calves, meeting targets, what makes for good job satisfaction?)

Who do you think make the best calf rearers? What qualities do they need?

(Male/female, patience, empathy, routine, consistency)

Have you considered making any changes to your youngstock management?

(Recent changes, ability to and reason for taking action, are they working? Changes you would like to make,why? Performance, financial, job satisfaction, perceived obligation. What holds you back?)

What would you consider before making changes?

(Likely efficacy, time/financial investment, time/cost effectiveness, ease of implementation/incorporation into a routine. Is there anything that would facilitate change?)

If someone came to you for advice on calf rearing, what would you tell them?

Do you think there are the problems with calf rearing nationally?

(What are they? Who should be doing something about it: industry, government, retailers, individual farms? What do you think could be done to help the situation?)

Do you think the public are aware of the issues that can arise when rearing youngstock?

ADVICE AND COMMUNICATION QUESTIONS

Are you a member of any groups, do you have any subscriptions?

(Farming groups, AHDB, RABDF, publications – idea of contacts, circle of influence)

Have you, or would you, seek advice/information about rearing practices? From where?

(When/why – in response to a problem or more proactively? Publications, people – other farmers, vets, etc. Does it depend on the nature of the issue where information is sourced?)

Is good advice easy to come by, or do you find it difficult?

(Bias, ulterior motives, system-specific. Look at assumptions about different groups/wider society. Code of Recommendations, aware of it, useful or not? Valuable/trusted sources? More sceptical of some sources? Consistent advice or mixed messages?)

How do you like to receive information?

(Mode of communication – written, group presentations, one-on-one. Find events useful? e.g. farm walks, conferences, courses, trade fairs. Pick and choose from a list or find it difficult to bring together different recommendations?)

Is there anything that you would value but is unavailable to you?

What do you think about the advisors available to you? What do you think their motivations are? What do you think they think about you? (vet, nutritionists, drug reps, dairy advisor etc)

There has been quite a big push by the industry to educate about healthy youngstock and rearing targets. Are you aware of any campaigns and recommendations? [opportunity for examples]

(Do you think the information is good? Relevant to your farm? Communicated well? Would you make use of the information and put it into practice on your own farm? Is there more useful information which could be offered, or more effective means of getting it out to farmers? How to encourage implementation?)

What do you think are the main difficulties in implementing advice? Do you ever come across an idea and think it seems useful but not do anything about it? Do you think anything would motivate you to actually implement it?

(Availability/communication of advice, application to own farm, attitude/commitment, available resources)

What do you think about participatory/collaborative research, where farmers work with other stakeholders from the industry, government, vets, researchers etc. to identify problems and work on solutions? Would you get involved in this type of project? Do you think farmers in general would get involved?

(Aid understanding of different perspectives/priorities, more relevant, useful information generated? Greater sense of control?)

Appendix II: Interview Topic Guide for Advisors

Participant Information checklist ['office' use]

Interview type: Interview ID:

Advisory role: Age (estimate): Gender:

Advisor Interview Topic Guide

GENERAL QUESTIONS

Tell me about your work.

What's your background, how did you get into [insert role here]?

(Experience and training)

Talk me through the contact you have with your dairy clients (specifically to do with calf rearing)?

(How much? When? For what purpose i.e. preventive/proactive or treatment - early or late onset of issue? Mode of communication i.e. phone, farmer meetings, on-farm, advice leaflets.)

What are the most common things you get called for?

What services do you offer with regards to calf rearing? What do you think of them? Are they received well?

How much do you charge for your services? Do you feel confident that you're providing value for money?

Do you like working with clients? Do you feel confident about advising farmers?

(Personal knowledge/ability. Expected response from farmers. How well do you think you communicate information to farmers?)

What do you think motivates your clients? What do you think about them? What do you think they think about you?

Do you feel your clients trust you and value your opinions and advice? Does this translate to implementation?

Is there anything you particularly like or that frustrates you when dealing with clients?

What do you think are the most important aspects of calf rearing?

(Colostrum, nutrition etc. Dry cow, calving, neonatal, weaning etc.)

What would your most important recommendations be? What would you check for?

What do you think are the most common problems/oversights in calf rearing?

(Housing, hygiene etc. Staffing and management?)

How useful do you think herd health plans are? Calf rearing targets, Key Performance Indicators? Are they used?

(Do farmers perceive them as useful?)

What do you think of record keeping by farmers? Is there a difference in perspectives about their importance?

Why do you think advice receives varying levels of uptake? What do you think are the most important factors determining implementation of advice?

(What helps/hinders adoption?)

How responsible do you feel for calf health and welfare?

(Perception of advisory role to clients)

Do you collaborate with others in an advisory role? What do you think about others in an advisory role?

(Why? With whom? To offer consistent advice, to enhance own learning?)

Do you keep up to date with research?

(Why? Personal knowledge, to disseminate to farmers? Would you produce information handouts if anything seems particularly useful?)

How much would you say a female calf was worth?

(Monetary value and future profitability, genetic potential etc.)

Who do you think make the best calf rearers, what qualities do they need?

What do you think farmers value/prioritise? How would you 'sell' advice to them?

(Would you adapt your approach according to each individual client - personality type, goals etc.?)

Do you think there is a problem with calf rearing nationally? What do you think can be done?