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The future of surplus dairy calves – an animal welfare perspective

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An important obstacle toward sustainably produced animal-source food is the existence of so-called 'surplus animals', which are by-products of the production of dairy products and eggs, and 'unwanted' due to their perceived low value. Although this depends on the country, in Europe many surplus dairy calves are transported to veal farms to be raised for 6 months until slaughter. The aim of this article is to present ideas for alternative future systems for the dairy-veal chain, including an overview of current challenges and improvement strategies for calf welfare. This dairy-veal chain presents a number of potential concerns for calf welfare, including transportation of young animals, high risk of disease and barren housing. Many incremental changes have been suggested in past literature to lift the welfare of veal calves, including reducing transportation, transporting calves at an older age, better health screening, and pens with enrichment and bedding. The Netherlands is at the centre of the veal sector import-export flow in Europe and is one of the main veal producers in the world. The Dutch government has recently presented a report with three alternative 'scenarios' for the raising of these surplus dairy calves, which are expected to lead to improvements in animals welfare. The first scenario is a restriction on transport of <100km, leading to more local production of dairy-veal. The second scenario is a delay on the transportation of surplus calves from 2 weeks to 3 months of age, handing dairy farmers a much larger role in the raising of these calves. This delay would ensure that calves are more robust and less vulnerable to disease at the time that they are transported to the veal farm. The third scenario proposes an alternative system, where the veal sector is eradicated and surplus dairy calves are raised at the dairy farm of origin until slaughter. We, like others before us, question the impact of small incremental changes on calf welfare, arguing that improvements at one end could potentially lead to worsening of welfare at the other end, and prefer to focus on system changes, such as the use of dual-purpose cattle breeds. We do not however believe that system changes can be created and implemented with the sole input of animal welfare scientists. This work is hence just one piece of the puzzle towards the sustainable production of milk and meat, and more specifically the sustainable rearing of surplus calves.

KEYWORDS

dairy farming, surplus calves, animal welfare, Europe, system change

1 Introduction

The need for sustainably produced animal-source foods has reached a critical point. Since 1987, sustainability is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations Brundtland Commission, 1987). Incremental changes to current conventional farming systems are unlikely to result in sustainable food production, at least not at the speed that is now required to mitigate global warming, meet livelihood demands of farmers and meet animal welfare concerns of the public. Many conventional farming systems are designed to maximize one particular output at the expense of other co-occurring outputs, often referred to as 'by-products' or 'co-products' (Jayasundara et al., 2019). Looking at all farming outputs together and optimizing the farming system (possibly even the entire chain) according to all outputs is more likely to increase farm and food chain resilience, robustness, and overall sustainability in the long run. Resilience is defined as the capacity of a system to recover rapidly from challenges (Baggio et al., 2015), while robustness is defined as the capacity to maintain a given state in the face of challenge (Colditz and Hine, 2016). There is a need for the scientific community to move outside the box of conventional farming systems and introduce alternative and innovative systems that address as many aspects of sustainability as possible.

An important obstacle to the sustainability of animal-source food production is that of so-called 'surplus' animals. These are animals born for the production of milk and eggs, which are not required for the production of milk and eggs, either because they are male, or because they are not needed for dairy herd replacement. These animal are most often 'unwanted' due to their low economic value (Pahmeyer and Britz, 2020), which is a consequence of the high level of specialization of farms and high level of selective breeding for milk or egg production, leading to a decrease in meat production traits in the offspring (Muir et al., 2000; Albertí et al., 2008). As a consequence, these surplus animals may be killed at birth (Cave et al., 2005; Bruijnis et al., 2015; Renaud et al., 2017; Haskell, 2020) or may receive less optimal care (Klein-Jöbstl et al., 2014; Renaud et al., 2020) possibly leading to 'low quality' animals (Maher et al., 2021), resulting in ethical and animal welfare concerns, as well as an overall reduction in social sustainability of dairy and egg production.

Surplus calves in the dairy sector are male and female calves not needed for herd replacement. The term 'surplus calf' places a judgement on the animal as unwanted or low value. An alternative, more neutral term to refer to these calves is 'non-replacement calf' (Vicic et al., 2022). However, we choose to use the judgemental term 'surplus calf' throughout this paper to bring forward this flaw in our food production system. The fate of surplus calves depends on the country in which they are born. In Europe and North America, many of these calves are raised for veal (up to 8 months of age), young beef (up to 12 months of age), or dairy-beef (16-24 months of age) at dedicated fattening farms (European Commission et al., 2014; Pardon et al., 2014; Hessle et al., 2019; Agriculture and Horticulture Development Board (AHDB), 2020; Renaud and Pardon, 2022). In the UK, a small percentage of bull calves is euthanised at birth on the dairy farm of origin, but legislation is currently being put into place to abolish this practice (Agriculture and Horticulture Development Board (AHDB), 2020). In Australia and New Zealand, many surplus calves, referred to as bobby calves, are transported and slaughtered before 14 days of age (Cave et al., 2005; Thomas and Jordaan, 2013; Boulton et al., 2020). In several EU countries, veal is the main destination for surplus dairy calves. The Netherlands is one of the top producers of veal in the world with about 1.6 million calves fattened in 2020, including approximately 750,000 calves (2-5 weeks of age) imported from surrounding European countries (Berkhout et al., 2022). However, veal consumption in the Netherlands is low and about 90% of the veal is exported to France, Italy and Germany (European Commission et al., 2014).

Livestock production is dependent on public acceptance and the veal sector has had to apply big changes due to changed legislation in past decades to meet public demands – changes were applied rapidly and broadly facilitated by the integrated nature of the veal sector in Europe. These changes included group-housing and the provision of solid feed from 8 weeks onwards (EU Council, 1997). In Europe, veal consumption seems to be declining (Sans and de Fontguyon, 2009; European Commission et al., 2014), possibly due to the high price of the product or a decline in public image. Recently, the Dutch government called for alternative veal systems to be designed to further improve calf welfare following participatory engagement with scientists and stakeholders (specifically veal and dairy farmers), which led to the creation of a report describing three scenarios for the future of the Dutch veal industry (Dutch Ministry of Agriculture Nature and Food Quality, 2021). This report highlights the timely need for system changes to the dairy and veal sector if animal welfare is to be safeguarded. In addition, following public concerns surrounding the veal sector, the European Food Security Authority (EFSA) consulted with academic experts to devise a scientific opinion on the welfare of calves, with a particular interest in veal calf welfare (EFSA Panel on Animal Health Animal Welfare, 2023). The report defines particular aspects of calf welfare that are currently at risk of being comprised and proposes potential solutions, all of which are summarised in Figure 1.

The first aim of this short communication is to present a brief overview of the welfare challenges that are inherent to the conventional European veal system. The second aim is to present strategies to tackle these particular welfare challenges. The third aim is to describe Dutch initiatives. The fourth and final aim is to present our proposition of the future of surplus calves and specifically veal, keeping in mind that this is from the perspective of animal welfare and hence does not cover the full range of sustainability challenges faced by the dairy and veal sector. This short communication aims to contribute to future participatory research engaging stakeholders into designing future systems that take into account specific local contexts and in the possible design of living labs to test these innovative future system ideas.

2 Main welfare challenges identified in the conventional European veal system

Welfare challenges faced by surplus dairy calves destined for veal have been reviewed previously (Haskell, 2020; Renaud and Pardon, 2022) and have been addressed by EFSA (Figure 1).

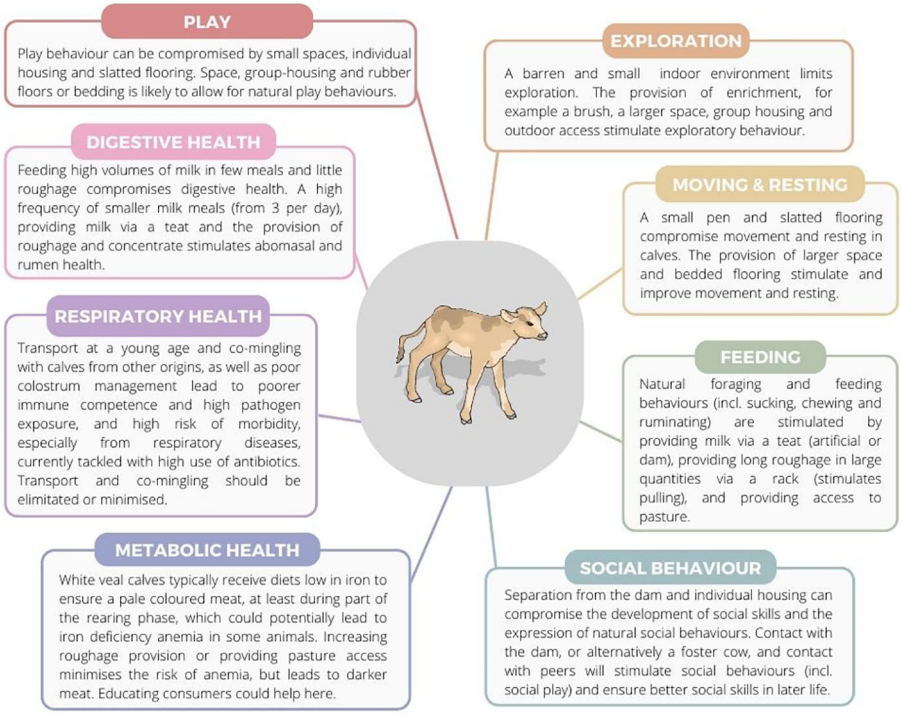

FIGURE 1
Areas of calf welfare that can be improved, with potential improvement strategies. Based on the EFSA report on calf welfare (EFSA Panel on Animal Health Animal Welfare, 2023).

2.1 At the dairy farm

In (mostly North American) surveys and observational studies, it was frequently recorded that the care provided to male calves, as opposed to female calves, was lower and of lesser priority. In particular, male calves were more likely to receive bacterial-contaminated colostrum (Fecteau et al., 2002), colostrum of lower quality and quantity and delayed colostrum feeding (Shivley et al., 2019; Renaud et al., 2020), as well as less feed (Klein-Jöbstl et al., 2014; Renaud et al., 2017) and were less likely to get navel dipping and vaccination (Renaud et al., 2017) compared with female calves. Vaccination includes vaccines for prevalent respiratory (e.g. Brscic et al., 2012) and intestinal pathogens which are given either to the dam combined with successful colostrum management or directly to the calf at the dairy farm (Renaud and Pardon, 2022). Consequently, some studies, but not all (Barry et al., 2019; Renaud et al., 2020), have identified a higher level of failure of transfer of passive immunity in male calves (Dubrovsky et al., 2019). Higher morbidity and mortality of male calves on dairy farms was also reported (Renaud et al., 2018c; Hyde et al., 2020) but this could be linked to a higher risk of dystocia (Mee, 2008; Mee et al., 2011) leading to lower vigour rather than sub-optimal care of male calves.

In addition, most dairy calves are separated from their dam soon after birth. This welfare challenge is not specific to surplus calves. However, this may have consequences for the resilience and health of the calf and hence contribute to the high incidence of respiratory disease observed at the veal farm. This early separation allows the dairy farmer to monitor the colostrum and milk intake, as well as the health of the calf, and prevents the calf from drinking saleable milk (Meagher et al., 2019). Other advantages are the prevention of the formation of a strong bond between mother and young and the reduction in pathogen exposure, although consequences for health linked to rearing calves with their dams are ambiguous (Beaver et al., 2019; Wenker, 2022). This early separation is condemned by part of the public (Ventura et al., 2013; Busch et al., 2017; Hötzel et al., 2017) because it does not allow for behaviours that the dam and calf are highly motivated to display, such as maternal care and sucking milk from the udder (De Passillé, 2001; Wenker et al., 2020). Calves have further been found to experience negative affective states in response to separation from the mother that are comparable to those experienced following hot-iron disbudding (Daros et al., 2014). Contact with the dam or peers leads to a more socially complex environment which has been linked to improved cognition (Costa et al., 2014; Gaillard et al., 2014; Meagher et al., 2015) and social skills (e.g. Santo et al., 2020; Webb et al., 2022). The latter may lead to more positive experiences in later life, which means that the impact of dam-rearing cannot be considered to be limited to the first weeks or months of life and may have important far reaching consequences for the entire life of the calf (Wagner et al., 2012). In a recent study, cow-calf contact for 2 or 4 weeks led to heavier (veal) calves with a slightly better immune system, but no particular subsequent advantage in clinical health could be identified (Webb et al., 2022), which is concurrent with the review by Beaver et al. (2019). Surprisingly, the weight advantage

from being reared by the dam, likely stemming from a higher milk intake, was lost by the time the veal calves were slaughtered at 6 months (Webb et al., 2022), but also in dairy calves at 6 months of age (Wenker et al., 2022b).

Another important concern for calf welfare (both dairy and surplus) is the limited space allowance and social isolation in the first weeks of life - including the individual housing at the dairy farm and that in the first few weeks at the veal farm, typically in so-called hutches and baby boxes respectively. Individual housing in young calves, depending on the duration, may impair social skills, coping abilities and cognitive performance, leading to an overall reduction in the ability to adapt to changing environments (Costa et al., 2016). Individual housing was moreover linked to a more negative affective state, defined here as emotions and moods (Bučková et al., 2019), and calves have been shown to be highly motivated to work for full access to a peer (Holm et al., 2002).

2.2 Transport

Surplus calves tend to be transported from the dairy farm at a young age - in Europe this is typically around 14 days of age (range 14 and 35 days: (Marcato et al., 2018; Nielsen et al., 2022), but in North America and Australia this can be within a few days of birth (Cave et al., 2005; Creutzinger et al., 2021). The period between 14 and 35 days of age in calves constitutes an 'immune gap' whereby passive immunity from the colostrum is decreasing and active immunity still needs to increase to compensate for this in terms of immune competence (Chase et al., 2008). This makes this period a time of high vulnerability to disease. The Netherlands is at the centre of the European calf exchange flows, as the principal importer of young calves (mainly from Germany and Poland) and exporter of veal (mainly to Italy, Germany and France, which are the top European consumers of veal) (European Commission et al., 2014). In Europe and North America, transport of young calves typically involves two separate transport events with an intermediate stop at an assembly centre or auction market, where calves are sorted and purchased based on weight and origin (Renaud and Pardon, 2022). Transportation leads to a number of welfare concerns including handling for (multiple) loadings and unloadings, being in a moving vehicle, mixing with unfamiliar peers, and feed and water deprivation (EFSA Panel on Animal Health Animal Welfare, 2022). The stress of transportation in conjunction with immune incompetence and commingling of calves from various origins are important factors in the morbidity and mortality rates in the first 3 weeks at the veal farm (Griebel et al., 2014; Marcato et al., 2018).

2.3 At the veal farm

Following a few weeks in baby boxes, veal calves are typically group-housed indoors with no outdoor or pasture access, on wooden-slatted floors, in ventilated barns with some daylight. The structure and material of these floors may hinder locomotion, including locomotory play, may cause discomfort during lying, include thermal discomfort, and may become slippery leading to injuries (e.g. Cozzi et al., 2009; Brscic et al., 2015). A Dutch report studying the impact of different materials for slatted floors on veal calf welfare found that calves prefer to lie on softer (rubber or soft plastic) floors versus harder (wood or concrete) floors and that softer floors lead to less 'thick/swollen knees' (Heeres et al., 2017). No other health or environmental differences could be identified in this study. In addition, veal calves are seldom provided any enrichment materials. Veal calves housed in large groups (50-70 calves) sometimes have access to a hanging ball, dry rubber teats and brushes. However, the typically barren pen combined with concentrated feed and no access to pasture likely impedes natural exploratory behaviours in calves, and may lead to boredom (Webb et al., 2017; EFSA Panel on Animal Health Animal Welfare, 2023).

Calves typically receive milk replacer in a trough or bucket twice a day and a solid feed mixture comprised of a high percentage of concentrates with chopped straw. In the past, the feeding regime applied on veal farms was linked to certain digestive health issues including the leaking of milk into the rumen (e.g. Labussière et al., 2014) and abomasal lesions (reviewed in Bus et al., 2019), as well as behavioural deviations supposedly linked to the thwarting of natural behaviours including sucking for milk and chewing, ruminating and grazing (e.g. Webb et al., 2015). In recent years in the Netherlands, however, the quantity of solid feed veal calves receive has much increased and the quantity of milk replacer decreased, possibly resulting in improved digestive health (Webb et al., 2013) and behaviour (Webb et al., 2012). Iron provision is traditionally low in veal systems to ensure the pale colour of veal preferred by consumers (Pardon et al., 2014).The requirement for blood haemoglobin in veal calves in the EU is a minimum of 4.5 mmol Hb/L on average (EC Directives 91/629/EC and 97/2/EC).

Reported morbidity and treatment rates range between 25 and 88% (Bähler et al., 2012; Pardon et al., 2012b; Scott et al., 2019; Goetz et al., 2021), while mortality rates range between 2.8 and 7.5% (Bähler et al., 2012; Pardon et al., 2012b; Pempek et al., 2017; Renaud et al., 2018b; Bokma et al., 2019; Scott et al., 2019; Goetz et al., 2021) throughout the fattening period of veal, which is typically 6 months. The high risk of morbidity and mortality on veal farms are tackled with metaphylactic and individual antimicrobial treatments (Pardon et al., 2012a; Bokma et al., 2019; Scott et al., 2019; SDa Autoriteit Diergeneesmiddelen, 2022). Although in the Netherlands antimicrobial use has decreased in veal production from 39.4 $DDDA_{NAT}$[1] in 2007 to 15.4 $DDDA_{NAT}$ in 2021, it is still considerably higher compared to dairy cattle (3.3 $DDDA_{NAT}$), broilers (6.3 $DDDA_{NAT}$) and pigs (7.6 $DDDA_{NAT}$) (SDa Autoriteit Diergeneesmiddelen, 2022). High antibiotic use leads to concerns for antimicrobial resistance and human health (World Health Organization, 2006).

1 DDDANAT : Defined Daily Dose Animal is the indicator for national use of antibiotics per livestock sector in the Netherlands (see for standard operating procedure: autoriteitdiergeneesmiddelen/userfiles/verage%20rapporten/sop-rekensystematiek-website-03032020-1.pdf)

3 Main strategies proposed to address these welfare challenges

3.1 At the dairy farm

The first aspect that can be tackled is the core issue of the low value of surplus calves. Their value can be increased if surplus calves can be sold at a higher price because their beef characteristics are improved. For example, dairy farmers could combine sexed semen and crossbreeding (with beef sires) to produce, on the one hand high performing replacement heifer calves and, on the other hand, beef-sire bull calves which fetch a higher price (Pahmeyer and Britz, 2020). Meat characteristics of crossbred dairy-beef calves are typically good (Muir et al., 2000; Albertí et al., 2008; Coleman et al., 2016). Sexed semen combined with crossbreeding with beef sires can increase dairy farm profitability despite the higher price and lower fertility success of sexed semen (Pahmeyer and Britz, 2020).

If the value of surplus calves is increased and farmers are financially rewarded for heavier and healthier calves, this may promote better neonatal care, including improvements in colostrum management and housing. Improving colostrum management, combined with vaccination (Wilson et al., 2020) and early detection of disease at both the dairy and veal farms, potentially via the use of sensor technology (e.g. automated milk dispensers or accelerometers) should reliably reduce morbidity and mortality, not just at the dairy farm but also at the veal farm. These measures are likely to combine into promoting more resilient and robust calves, leading to improved health and weight gain, leading to an economic benefit next to the obvious welfare benefits. One particular form of young calf care, dam-rearing, could lead to more resilient and robust calves by promoting faster weight gain (Meagher et al., 2019), and social skills (Wagner et al., 2012; Santo et al., 2020; Waiblinger et al., 2020). Dam rearing may also stimulate positive experiences in early life and later life through maternal care, natural behaviours such as sucking for milk from an udder and improved social skills. However, the separation from the dam can be stressful and gradual separation is advised, which may lead to the surplus calves having to stay for a longer period of time on the dairy farm (Eriksson et al., 2022; Wenker et al., 2022a). The importance of social contact in calves demonstrates the need for group housing in calves of all ages if welfare is to be elevated, with a preference for the dam in early weeks, as is recommended by EFSA (EFSA Panel on Animal Health Animal Welfare, 2023).

3.2 Transport

The negative impacts of transport on calf welfare could be mitigated by putting in place a 'fit for transport' decision tool, transporting older calves (>5 weeks) with a higher acquired immunity (Marcato et al., 2022a; Marcato et al., 2022b) as also recommended by the EFSA (EFSA Panel on Animal Health Animal Welfare, 2022), eliminating assembly points and reducing transport time by promoting local dairy-veal production (Creutzinger et al., 2021), improving the vehicles [e.g. conditioned versus open; Marcato et al. (2020)] and decreasing the number of farms they visit, to minimise stops and addition of calves to the vehicle (Damiaans et al., 2019). Watering and feeding calves prior to, during, and following transport would also mitigate the weight, hydration and health checks calves commonly experience during this transition between dairy and veal farms (Pempek et al., 2017; Renaud et al., 2018b; Marcato et al., 2020).

3.3 At the veal farm

The combination of a young age, immunity gap, transport stress and commingling leads to a high risk of morbidity at the veal farm, which is currently tackled using individual housing in the first few weeks after arrival, prophylactic (mostly oral) administration of antibiotics (and frequent veterinarian visits), and all-in-all-out systems with intense cleaning of the barn in between batches (Pardon et al., 2012a; Pardon et al., 2014; Marcato et al., 2018). Individual housing and antibiotic use, which challenge not only animal welfare but also human health and profitability, are only dealing with symptoms of a system that promotes the spread of diseases through various vectors. An additional action that has been proposed is the early detection of diseased or 'at risk' calves immediately after arrival at the veal farm, or through information exchange from the dairy to the veal farmer. A number of biomarkers or risk factors associated with an increase of morbidity, mortality or reduced average daily gain have been identified. For example, a low body weight (<50kg), swollen navel, severe dehydration, low cholesterol, low IgG, high cortisol, high acute phase protein, and high haptoglobin have been linked to increased morbidity or mortality in the first weeks at veal farm (Pardon et al., 2015; Winder et al., 2016; Renaud et al., 2018a; Renaud et al., 2018b; Marcato et al., 2022b). Identifying at-risk and diseased calves at arrival at the veal farm through routine weighing, health scoring and blood sampling in the first few days (Renaud and Pardon, 2022), could be used to group calves in terms of health status, thereby limiting the spread of pathogens between calves, and to provide at-risk calves with additional 'help' for example in the form of probiotics/prebiotics (Renaud and Pardon, 2022), vitamins, highly palatable feeds such as hay, and more comfortable pens, such as pens with straw bedding. The efficiency of blood testing at arrival at the veal farm, however, would be dependent on a rapid analysis of samples, the practicality of which is questionable. Compartmentalization at veal farm level from arrival to slaughter is another proposed strategy to mitigate poor health in veal calves (Damiaans et al., 2019). This could be done by health status or based on farm of origin. In addition to this, births on large dairy farms could be grouped to minimise the various origins of calves placed on one veal farm (Damiaans et al., 2019).

Next to health, important welfare considerations for veal calves include promoting natural exploratory, foraging and feeding behaviours, for example by providing enrichment such as a brush, long fibre roughages such as hay, and more frequent meals or longer access to feed (EFSA Panel on Animal Health Animal Welfare, 2023). Promoting natural social behaviours, locomotory play, moving and resting can be improved by providing soft floors

(Heeres et al., 2017) or optimised by providing straw bedded pens (EFSA Panel on Animal Health Animal Welfare, 2023) or access to pasture.

3.4 At the chain level

A key issue identified in the current dairy-veal chain, is the lack of information transfer, not only between dairy and veal farmers, but also between these farmers and the slaughterhouses (Damiaans et al., 2019; Haskell, 2020; Wilson et al., 2020). Benchmarking of the health of surplus calves, contractual agreements between buyers and sellers on the care of the calves, and feedback on the performance of the calves have all been mentioned as actions likely to benefit the overall level of animal welfare in the veal sector (Wilson et al., 2020).

Another action that has been frequently mentioned in this context is the education of both farmers and the general public. Education of the farmers, both dairy and veal, on calf (health) management and antibiotic use has been put forward as a strategy to tackle calf welfare and the high antibiotic use observed in the veal sector and subsequent antibiotic resistance (Wilson et al., 2020). Educating veterinarians also plays a crucial role because, with a few exceptions, only veterinarians are officially allowed to prescribe antibiotics to animals (Dutch Ministry of Economic Affairs, 2012). Other education topics could include calf thermoregulation (Roland et al., 2016). Citizen trust in both dairy and veal farming and products are critical and education can help manage this (Ritter et al., 2020; Bolton and von Keyserlingk, 2021). One study demonstrated that education about rosé veal in the UK increased the willingness to consume such products (Skelhorn et al., 2020). "Consumers are often seen as 'empowered political actors' who are armed with the ability to 'vote with their dollars'" (Ritter et al., 2022). Citizens in North America were positive towards rearing surplus dairy calves for meat because this gave them a purpose rather than being simple waste products, but were negative towards slaughter at a young age (<1 month) and separation from the dam at birth (Ventura et al., 2013; Hötzel et al., 2017; Ritter et al., 2022).

Creating a local or niche market for meat from surplus dairy calves and integrating the dairy and veal sectors are strategies that have also been frequently mentioned in the literature, not only in the context of animal welfare, but also of farm profitability and environmental (greenhouse gas (GHG) emissions) impact (Britt et al., 2018; Wilson et al., 2020). Due to the sharing of GHG emissions between milk and meat, and hence between dairy and veal, in the dairy-veal sector, the GHG emissions allocated to the meat products of surplus calves are relatively low, meaning these products could be marketed as 'climate friendly' and reach a niche market as a premium product (Murphy et al., 2017; Britt et al., 2018; Bolton and von Keyserlingk, 2021).

4 Initiatives in the Netherlands

In parallel to the EFSA initiative mentioned above, initiatives in the Netherlands are being developed by the Dutch Ministry of Agriculture, Nature and Food Quality (ANF) and the Dutch Society for the Protection of Animals (*De Dierenbescherming*). The Dutch Ministry of ANF commissioned a report on innovative rearing systems for surplus dairy calves. This report entitled '*scenariostudie kalverketen*' (scenario study in the calf chain) was made public on the 31st of January 2021 (Dutch Ministry of Agriculture Nature and Food Quality, 2021). The report describes three alternative scenarios aimed at improving calf welfare based on three main areas of focus: 1. Better collaboration within the chain for better transfer of knowledge between dairy and veal farmers; 2. Reduced transportation of calves; and 3. Minimizing contact between calves from different origins. For all three scenarios, the guidelines described would also automatically apply to calves being imported into the Netherlands.

The first scenario imposes a maximum transport distance of less than 100 km. This scenario hence proposes that dairy and veal produces should be close to each other and ensures a more local production. The current calf assembly centres would disappear in this scenario, rendering the transport direct and short between dairy and veal farms. Currently, assembly centres are in place to ensure that veal producers receive calves of similar body size, which makes the management of these calves as a group simpler for the veal farmer. In the case of direct transport between dairy and veal farm, this triage process would be eliminated and veal farmers would receive calves of various sizes throughout the year. This direct transport would also likely affect the 'all-in-all-out' procedure to minimise health issues. In this novel scenario veal farmers would need an alternative strategy to minimise health issues,: e.g. some sort of compartmentalisation, whereby calves are grouped on the veal farm by time of arrival and farm of origin. The second scenario proposes that calves remain on the dairy farm until weaning, i.e. until approximately 3 months of age, before being transported to a veal farm. As mentioned above, this ensures that the calf has a more developed acquired immunity and is heavier and stronger before leaving the farm of origin, meaning that the susceptibility to disease is much lower. The current dairy-veal system would remain rather similar with the exception that calves on the veal farm would no longer receive milk replacer and morbidity and mortality should be reduced, thereby reducing the need for antibiotics. Adequate care at the dairy farm would need to be ensured. The third scenario is the most radical and proposes that dairy farmers raise their own surplus calves until slaughter, effectively ending the Dutch veal sector. This scenario significantly shortens the veal chain, by eliminating the need for assembly centres and dedicated veal farms. Next to a full-time stay at the dairy farm, the calves would ideally: 1. Receive unlimited access to milk, which they would be able to suck from an udder or automated milk dispenser, to fulfil their sucking need, 2. Have double the amount of space per calf and a soft place to lie down; 3. Experience a maximum transport time of 4 hours to the slaughterhouse. Access to pasture and raising by the dam are mentioned as potentially being covered by this scenario on a voluntary basis by the dairy farmer. The Dutch ministry has further allocated 10 million euros to testing these scenarios in practice.

The Dutch Society for the Protection of Animals has also announced their intention to incorporate stricter requirements for dairy and veal calves into their three-star welfare labelling scheme called 'Better life' (BeterLeven) (personal communication Dierenbescherming). In particular, they aim for the immediate inclusion into their basic requirements (1 star) of: a teat for milk drinking, a high amount of solid feed from 2 weeks of age that surpasses the EU requirement and a minimum number of feeding spaces enabling each calf to access this feed without obstruction. Specially for veal calves, they additionally require transport from 4 weeks instead of 2 weeks of age and group-housing in straw-bedded pens from 4 weeks of age. In the future, they will also add pair-housing in the first 14 days and cow-calf contact in their three-star labelling scheme requirements.

5 Discussion - a possible future for surplus calves from an animal welfare perspective

In a system that inherently leads to negative impacts on calf welfare, 'small', incremental changes to this system are comparable to addressing the symptoms rather than the root cause of a disease. Improving welfare in the current veal system is limited because the current system requires early-life transportation and mixing of calves from different origins, which in itself leads to high levels of stress and high vulnerability to disease combined with high exposure to pathogens. In addition, the very structure of the veal sector may impair the ability of small incremental changes to have significant and long lasting impacts. If dam-rearing leads to higher weight gains and a slightly better immune system in the first weeks of life, these significant advantages may be lost at the veal farm because of the high stress levels caused by separation from the dam, transport, commingling, a new feeding management, a barren pen and so on (Webb et al., 2022). These advantages may, in addition to being lost, in fact cause increased stress and poorer welfare in the long term. If calves raised with their dam must be abruptly separated or are more fearful of humans, this may lead to an increase in negative experiences further down the line, leading to an overall decrease in animal welfare when the entire life of the animal is taken into account (Webb et al., 2022). Hence the nature of a particular production system may prevent the successful application of positive animal welfare changes. Another example of this is the need for individual housing at the veal farm for careful monitoring of individual calves and to limit the spread of diseases caused by a combination of (transport) stress, commingling, young age and an under-developed immune system. Removing this individual housing phase may have negative effects on the health of calves, but keeping it impairs their social development and likely negatively impacts their welfare in those first few weeks. Based on this, we carefully propose an alternative system for the rearing of surplus calves, as opposed to small incremental changes made to the current system, which is hopefully more likely to have significant positive effects on calf welfare. The aim of this perspective based on animal welfare alone is to start a discussion, where all stakeholders are included in participatory research to improve the sustainability of the dairy-veal system.

Combining all of the above information, we suggest that increasing the value of 'surplus' calves and making them an inherent part of the system and profitability of the dairy farm is a healthy first step. This could be achieved through the combination of sexed semen and crossbreeding, or alternatively, the use of dual-purpose cattle breeds, and a focus towards local, niche markets for animal-friendly milk and meat.

Briefly turning to the environmental impact of dairy and beef production, it appears at first glance that at the animal or farm level, specialisation of cattle breeds towards either milk or meat, results in a higher *emission efficiency* (kg of CO2-equivalence per kg of milk or beef), which suggests that high producing and highly specialised dairy and beef breeds result in a lower environmental impact. However, when considering dairy and beef production together, it has been demonstrated that meat from dairy breeds or dual-purpose breeds results in a lower environmental impact (e.g. global warming potential, eutrophication and land use) compared to specialised dairy production combined with specialised beef production (Zehetmeier et al., 2012; De Vries et al., 2015; Faverdin et al., 2022). In addition, maximising the value of all outputs on a farm, by valuing and selecting traits for both desirable milk and meat characteristics, increases a farm's resilience in the face of market fluctuation and challenges such as global warming (Zehetmeier et al., 2012; Vellinga and De Vries, 2018).

The next step is promoting positive experiences while minimising negative ones, which is the key to providing a good life to calves (Spruijt et al., 2001; Farm Animal Welfare Council, 2009; Green and Mellor, 2011; Webb et al., 2019). Promoting positive experiences is linked to providing access to preferred and valued environmental stimuli and events (Ahloy-Dallaire et al., 2018), which can be typically identified using so-called preference/choice and operant conditioning, or motivation, tests. Figure 2 presents stimuli that have been previously identified as preferred or valued in preference or operant conditioning tests. The preference and value for certain stimuli warrants further investigation, in particular the value assigned to having access to the dam or to pasture, and more detailed preference for various types of feeds and enrichment. Implementing such preferred and value resources in sometimes not straight forwards, as there may be associated trade-offs. For example, if calves stay with their own dam (or a foster cow) to promote weight gain and natural behaviours, until weaning, the stress of separating these bonded animals at a later stage needs to be carefully tackled. One possibility is step-wise, gradual weaning (e.g. Wenker et al., 2022a). If separation of the calves from their dam is not necessary for the profitability of the farm, then calves could even remain with their dam and be part of the herd until they are slaughtered for meat, at a nearby slaughterhouse.

Minimising negative experiences in calves is linked to improving health and minimising and optimising transport, which, as mentioned above, can be tackled by reducing transport

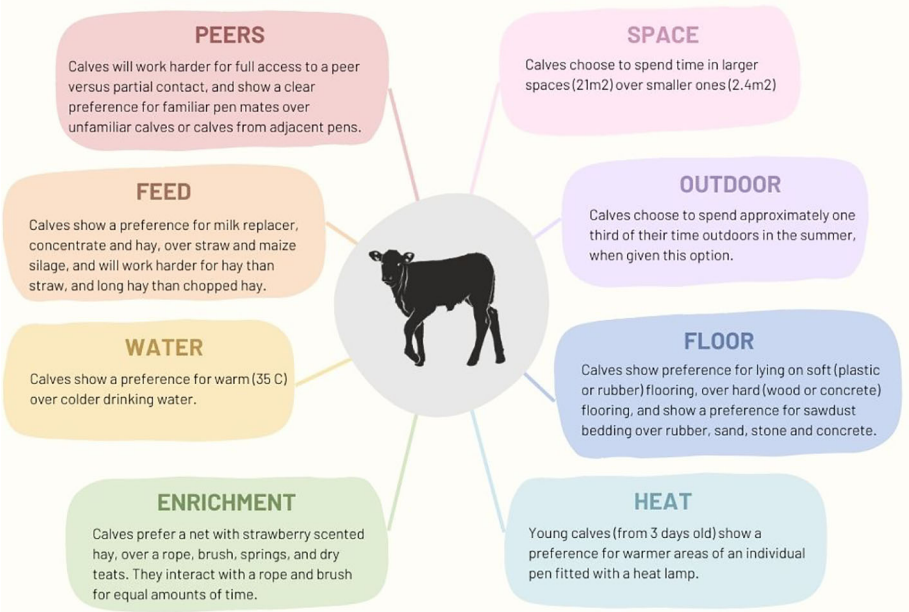

FIGURE 2
Stimuli that have been identified as preferred or valued by calves, using preference (choice) tests and operant conditioning (Holm et al., 2002; Færevik et al., 2006; Borderas et al., 2009; Duve and Jensen, 2011; Camiloti et al., 2012; Webb et al., 2014a; Webb et al., 2014b; Worth et al., 2015; Heeres et al., 2017; Zobel et al., 2017; Lindner et al., 2022; Whalin et al., 2022; Zhang et al., 2022a; Zhang et al., 2022b).

distances and time, eliminating assembly centres, transporting older, possibly weaned calves, compartmentalisation at the veal farm, and the use of sensor technology to detect and treat disease as rapidly and Individually as possible. A more radical system change, which would significantly minimise negative experiences linked to transport and health, would be to simply keep the surplus calves destined for meat on the dairy farm until slaughter, as proposed in the report of the Dutch Ministry mentioned above.

As briefly mentioned in the introduction, we do not pretend that we can propose a future dairy-veal/beef sector based only on the input of animal welfare science, and this was not the ambition of this work. These perspectives need to be combined with the expertise of scientists in other domains of farming system sustainability, including food system sustainability, and then discussed with the relevant stakeholders in a participatory approach. Ideally, this would be a two-way and repeated exchange between scientists and stakeholders, and fine-tuned to individual regions of the Netherlands and Europe. Finally scenarios should of course be put into place and tested, in e.g. living labs. This work is hence just one piece of the puzzle towards the sustainable production of milk and meat, and more specifically the sustainable rearing of surplus calves.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Author contributions

All authors contributed to brainstorming and editing. The first author took the lead in the preparation of the manuscript drafts. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Agriculture and Horticulture Development Board (AHDB) (2020). *Dairy beef production systems* (Coventry, UK: Kenilworth, UK).

Ahloy-Dallaire, J., Espinosa, J., and Mason, G. (2018). Play and optimal welfare: Does play indicate the presence of positive affective states? *Behav. Process.* 156, 3–15. doi: 10.1016/j.beproc.2017.11.011

Albertí, P., Panea, B., Sañudo, C., Olleta, J., Ripoll, G., Ertbjerg, P., et al. (2008). Live weight, body size and carcass characteristics of young bulls of fifteen European breeds. *Livest. Sci.* 114, 19–30. doi: 10.1016/j.livsci.2007.04.010

Baggio, J. A., Brown, K., and Hellebrandt, D. (2015). Boundary object or bridging concept? A citation network analysis of resilience. *Ecol. Soc.* 20 (2), 2. doi: 10.5751/ES-07484-200202

Bähler, C., Steiner, A., Luginbühl, A., Ewy, A., Posthaus, H., Strabel, D., et al. (2012). Risk factors for death and unwanted early slaughter in Swiss veal calves kept at a specific animal welfare standard. *Res. Vet. Sci.* 92, 162–168. doi: 10.1016/j.rvsc.2010.10.009

Barry, J., Bokkers, E. A. M., Berry, D. P., de Boer, I. J. M., McClure, J., and Kennedy, E. (2019). Associations between colostrum management, passive immunity, calf-related hygiene practices, and rates of mortality in preweaning dairy calves. *J. Dairy Sci.* 102, 10266–10276. doi: 10.3168/jds.2019-16815

Beaver, A., Meagher, R. K., von Keyserlingk, M. A. G., and Weary, D. M. (2019). Invited review: A systematic review of the effects of early separation on dairy cow and calf health. *J. Dairy Sci.* 102, 5784–5810. doi: 10.3168/jds.2018-15603

Berkhout, P., van der Meulen, H., Ramaekers, P., Verhoog, A., Berkhout, P., Bergevoet, R., et al. (2022). *Staat van Landbouw en Voedsel, editie 2022* (Wageningen, the Netherlands: Wageningen Economic Research), 128 p.

Bokma, J., Boone, R., Deprez, P., and Pardon, B. (2019). Risk factors for antimicrobial use in veal calves and the association with mortality. *J. Dairy Sci.* 102, 607–618. doi: 10.3168/jds.2018-15211

Bolton, S. E., and von Keyserlingk, M. A. G. (2021). The dispensable surplus dairy calf: Is this issue a "wicked problem" and where do we go from here? *Front. Vet. Sci.* 8, 660934. doi: 10.3389/fvets.2021.660934

Borderas, F. T., de Passillé, A. M. B., and Rushen, J. (2009). Temperature preferences and feed level of the newborn dairy calf. *Appl. Anim. Behav. Sci.* 120, 56–61. doi: 10.1016/j.applanim.2009.04.010

Boulton, A. C., Kells, N. J., Cogger, N., Johnson, C. B., O'Connor, C., Webster, J., et al. (2020). Risk factors for bobby calf mortality across the New Zealand dairy supply chain. *Prev. Vet. Med.* 174, 104836. doi: 10.1016/j.prevetmed.2019.104836

Britt, J., Cushman, R., Dechow, C., Dobson, H., Humblot, P., Hutjens, M., et al. (2018). Invited review: Learning from the future—A vision for dairy farms and cows in 2067. *J. Dairy Sci.* 101, 3722–3741. doi: 10.3168/jds.2017-14025

Brscic, M., Gottardo, F., Tessitore, E., Guzzo, L., Ricci, R., and Cozzi, G. (2015). Assessment of welfare of finishing beef cattle kept on different types of floor after short- or long-term housing. *Animal* 9, 1053–1058. doi: 10.1017/S1751731115000245

Brscic, M., Leruste, H., Heutinck, L. F. M., Bokkers, E. A. M., Wolthuis-Fillerup, M., Stockhofe, N., et al. (2012). Prevalence of respiratory disorders in veal calves and potential risk factors. *J. Dairy Sci.* 95, 2753–2764. doi: 10.3168/jds.2011-4699

Bruijnis, M., Blok, V., Stassen, E., and Gremmen, H. (2015). Moral "Lock-In" in responsible innovation: the ethical and social aspects of killing day-old chicks and its alternatives. *J. Agric. Environ. Ethics* 28, 939–960. doi: 10.1007/s10806-015-9566-7

Bučková, K., Špinka, M., and Hintze, S. (2019). Pair housing makes calves more optimistic. *Sci. Rep.* 9, 1–9. doi: 10.1038/s41598-019-56798-w

Bus, J. D., Stockhofe, N., and Webb, L. E. (2019). Invited review: Abomasal damage in veal calves. *J. Dairy Sci.* 102, 943–960. doi: 10.3168/jds.2018-15292

Busch, G., Weary, D. M., Spiller, A., and von Keyserlingk, M. A. G. (2017). American and German attitudes towards cow-calf separation on dairy farms. *PloS One* 12, e0174013. doi: 10.1371/journal.pone.0174013

Camiloti, T. V., Fregonesi, J. A., von Keyserlingk, M. A. G., and Weary, D. M. (2012). Effects of bedding quality on the lying behavior of dairy calves. *J. Dairy Sci.* 95, 3380–3383. doi: 10.3168/jds.2011-5187

Cave, J., Callinan, A., and Woonton, W. (2005). Mortalities in bobby calves associated with long distance transport. *Aust. Vet. J.* 83, 82–84. doi: 10.1111/j.1751-0813.2005.tb12203.x

Chase, C. C., Hurley, D. J., and Reber, A. J. (2008). Neonatal immune development in the calf and its impact on vaccine response. *Vet. Clin. North Am. Food Anim.* 24, 87–104. doi: 10.1016/j.cvfa.2007.11.001

Colditz, I. G., and Hine, B. C. (2016). Resilience in farm animals: biology, management, breeding and implications for animal welfare. *Anim. Prod. Sci.* 56, 1961–1983. doi: 10.1071/AN15297

Coleman, L. W., Hickson, R. E., Schreurs, N. M., Martin, N. P., Kenyon, P. R., Lopez-Villalobos, N., et al. (2016). Carcass characteristics and meat quality of Hereford sired steers born to beef-cross-dairy and Angus breeding cows. *Meat Sci.* 121, 403–408. doi: 10.1016/j.meatsci.2016.07.011

Costa, J. H. C., Daros, R. R., von Keyserlingk, M. A. G., and Weary, D. M. (2014). Complex social housing reduces food neophobia in dairy calves. *J. Dairy Sci.* 97, 7804–7810. doi: 10.3168/jds.2014-8392

Costa, J. H. C., von Keyserlingk, M. A. G., and Weary, D. M. (2016). Invited review: Effects of group housing of dairy calves on behavior, cognition, performance, and health. *J. Dairy Sci.* 99, 2453–2467. doi: 10.3168/jds.2015-10144

Cozzi, G., Brscic, M., and Gottardo, F. (2009). Main critical factors affecting the welfare of beef cattle and veal calves raised under intensive rearing systems in Italy: a review. *Ital. J. Anim. Sci.* 8, 67–80. doi: 10.4081/ijas.2009.s1.67

Creutzinger, K., Pempek, J., Habing, G., Proudfoot, K., Locke, S., Wilson, D., et al. (2021). Perspectives on the management of surplus dairy calves in the United States and Canada. *Front. Vet. Sci.* 8, 661453. doi: 10.3389/fvets.2021.661453

Damiaans, B., Renault, V., Sarrazin, S., Berge, A. C., Pardon, B., Ribbens, S., et al. (2019). Biosecurity practices in Belgian veal calf farming: Level of implementation, attitudes, strengths, weaknesses and constraints. *Prev. Vet. Med.* 172, 104768. doi: 10.1016/j.prevetmed.2019.104768

Daros, R. R., Costa, J. H. C., von Keyserlingk, M. A. G., Hötzel, M. J., and Weary, D. M. (2014). Separation from the dam causes negative judgement bias in dairy calves. *PloS One* 9, e98429. doi: 10.1371/journal.pone.0098429

De Passillé, A. M. (2001). Sucking motivation and related problems in calves. *Appl. Anim. Behav. Sci.* 72, 175–187. doi: 10.1016/S0168-1591(01)00108-3

De Vries, M.d., Van Middelaar, C., and De Boer, I. (2015). Comparing environmental impacts of beef production systems: A review of life cycle assessments. *Livest. Sci.* 178, 279–288. doi: 10.1016/j.livsci.2015.06.020

Dubrovsky, S. A., Van Eenennaam, A. L., Karle, B. M., Rossitto, P. V., Lehenbauer, T. W., and Aly, S. S. (2019). Bovine respiratory disease (BRD) cause-specific and overall mortality in preweaned calves on California dairies: The BRD 10K study. *J. Dairy Sci.* 102, 7320–7328. doi: 10.3168/jds.2018-15463

Dutch Ministry of Agriculture Nature and Food Quality (2021). *Scenariostudie Kalverketen - Scenario's voor een andere inrichting van de keten* (Netherlands: The Hague).

Dutch Ministry of Economic Affairs (2012). *Regeling diergeneesmiddelen*. Ed. E. Zaken (Netherlands: the Hague).

Duve, L. R., and Jensen, M. B. (2011). The level of social contact affects social behaviour in pre-weaned dairy calves. *Appl. Anim. Behav. Sci.* 135, 34–43. doi: 10.1016/j.applanim.2011.08.014

EFSA Panel on Animal Health Animal Welfare (2022). Welfare of cattle during transport. *EFSA J.* 20, e07442. 10.2903/j.efsa.2022.7442

EFSA Panel on Animal Health Animal Welfare (2023). Welfare of calves. *EFSA J.* 21, e07896. doi: 10.2903/j.efsa.2023.7896

Eriksson, H., Fall, N., Ivemeyer, S., Knierim, U., Simantke, C., Fuerst-Waltl, B., et al. (2022). Strategies for keeping dairy cows and calves together–a cross-sectional survey study. *Animal* 16, 100624. doi: 10.1016/j.animal.2022.100624

European Commission, Directorate-General for Agriculture and Rural Development, Romieu, V., Valli, C., Lardier, F, et al. (2014). *Evaluation of the market implications of veal and young cattle meat marketing standards*: Publications Office. doi: 10.2762/51824

EU Council (1997). *Directive 97/2/EC, Official Journal of the European Comminities* (Belgium: Bruxelles), 25/24.

Færevik, G., Jensen, M. B., and Bøe, K. E. (2006). Dairy calves social preferences and the significance of a companion animal during separation from the group. *Appl. Anim. Behav. Sci.* 99, 205–221. doi: 10.1016/j.applanim.2005.10.012

Farm Animal Welfare Council (2009). *Farm animal welfare in Great Britain: Past, present and future* (London, UK).

Faverdin, P., Guyomard, H., Puillet, L., and Forslund, A. (2022). Animal board invited review: Specialising and intensifying cattle production for better efficiency and less global warming: contrasting results for milk and meat co-production at different scales. *Animal* 16, 100431. doi: 10.1016/j.animal.2021.100431

Fecteau, G., Baillargeon, P., Higgins, R., Paré, J., and Fortin, M. (2002). Bacterial contamination of colostrum fed to newborn calves in Québec dairy herds. *Can. Vet. J.* 43, 523.

Gaillard, C., Meagher, R. K., von Keyserlingk, M. A. G., and Weary, D. M. (2014). Social housing improves dairy calves' performance in two cognitive tests. *PloS One* 9, e90205. doi: 10.1371/journal.pone.0090205

Goetz, H., Kelton, D., Costa, J., Winder, C., and Renaud, D. (2021). Identification of biomarkers measured upon arrival associated with morbidity, mortality, and average daily gain in grain-fed veal calves. *J. Dairy Sci.* 104, 874–885. doi: 10.3168/jds.2020-18729

Green, T. C., and Mellor, D. J. (2011). Extending ideas about animal welfare assessment to include 'quality of life' and related concepts. *N. Z. Vet. J.* 59, 263–271. doi: 10.1080/00480169.2011.610283

Griebel, P., Hill, K., and Stookey, J. (2014). How stress alters immune responses during respiratory infection. *Anim. Health Res. Rev.* 15, 161–165. doi: 10.1017/S1466252314000280

Haskell, M. J. (2020). What to do with surplus dairy calves? Welfare, economic and ethical considerations. *Landbauforschung* 70, 45–48. doi: 10.3220/LBF1593617173000

Heeres, J., Wolthuis-Fillerup, M., Bokma, S., Smits, D., Stockhofe-Zurwieden, N., Vermeij, I., et al. (2017). *Alternatieve vloeren voor vleeskalveren, Livestock Research Rapport 1056* (Wageningen, the Netherlands: Wageningen University & Research).

Hessle, A., Therkildsen, M., and Arvidsson-Segerkvist, K. (2019). Beef production systems with steers of dairy and dairy× beef breeds based on forage and semi-natural pastures. *Animals* 9, 1064. doi: 10.3390/ani9121064

Holm, L., Jensen, M. B., and Jeppesen, L. L. (2002). Calves' motivation for access to two different types of social contact measured by operant conditioning. *Appl. Anim. Behav. Sci.* 79, 175–194. doi: 10.1016/S0168-1591(02)00137-5

Hötzel, M. J., Cardoso, C. S., Roslindo, A., and von Keyserlingk, M. A. G. (2017). Citizens' views on the practices of zero-grazing and cow-calf separation in the dairy industry: Does providing information increase acceptability? *J. Dairy Sci.* 100, 4150–4160. doi: 10.3168/jds.2016-11933

Hyde, R. M., Green, M. J., Sherwin, V. E., Hudson, C., Gibbons, J., Forshaw, T., et al. (2020). Quantitative analysis of calf mortality in Great Britain. *J. Dairy Sci.* 103, 2615–2623. doi: 10.3168/jds.2019-17383

Jayasundara, S., Worden, D., Weersink, A., Wright, T., VanderZaag, A., Gordon, R., et al. (2019). Improving farm profitability also reduces the carbon footprint of milk production in intensive dairy production systems. *J. Clean. Prod.* 229, 1018–1028. doi: 10.1016/j.jclepro.2019.04.013

Klein-Jöbstl, D., Iwersen, M., and Drillich, M. (2014). Farm characteristics and calf management practices on dairy farms with and without diarrhea: A case-control study to investigate risk factors for calf diarrhea. *J. Dairy Sci.* 97, 5110–5119. doi: 10.3168/jds.2013-7695

Labussière, E., Berends, H., Gilbert, M. S., Van den Borne, J. J. G. C., and Gerrits, W. J. J. (2014). Estimation of milk leakage into the rumen of milk-fed calves through an indirect and repeatable method. *animal* 8, 1643–1652. doi: 10.1017/S1751731114001670

Lindner, E. E., Gingerich, K. N., Burke, K. C., Doyle, S. B., and Miller-Cushon, E. K. (2022). Effects of social housing on dairy calf social bonding. *Animals* 12, 821. doi: 10.3390/ani12070821

Maher, J. W., Clarke, A., Byrne, A. W., Doyle, R., Blake, M., Cromie, A., et al. (2021). Exploring the opinions of irish beef farmers regarding dairy beef integration. *Front. Vet. Sci.* 8, 660061. doi: 10.3389/fvets.2021.660061

Marcato, F., van den Brand, H., Kemp, B., Engel, B., Schnabel, S. K., Hoorweg, F. A., et al. (2022b). Effects of transport age and calf and maternal characteristics on health and performance of veal calves. *J. Dairy Sci.* 105, 1452–1468. doi: 10.3168/jds.2021-20637

Marcato, F., van den Brand, H., Kemp, B., Engel, B., Schnabel, S., Jansen, C., et al. (2022a). Calf and dam characteristics and calf transport age affect immunoglobulin titers and hematological parameters of veal calves. *J. Dairy Sci.* 105, 1432–1451. doi: 10.3168/jds.2021-20636

Marcato, F., van den Brand, H., Kemp, B., Engel, B., Wolthuis-Fillerup, M., and van Reenen, C. G. (2020). Effects of pretransport diet, transport duration, and type of vehicle on physiological status of young veal calves. *J. Dairy Sci.* 103, 3505–3520. doi: 10.3168/jds.2019-17445

Marcato, F., Van den Brand, H., Kemp, B., and Van Reenen, C. G. (2018). Evaluating potential biomarkers of health and performance in veal calves. *Front. Vet. Sci.* 5, 133. doi: 10.3389/fvets.2018.00133

Meagher, R. K., Beaver, A., Weary, D. M., and von Keyserlingk, M. A. G. (2019). Invited review: A systematic review of the effects of prolonged cow–calf contact on behavior, welfare, and productivity. *J. Dairy Sci.* 102, 5765–5783. doi: 10.3168/jds.2018-16021

Meagher, R. K., Daros, R. R., Costa, J. H. C., von Keyserlingk, M. A. G., Hötzel, M. J., and Weary, D. M. (2015). Effects of degree and timing of social housing on reversal learning and response to novel objects in dairy calves. *PloS One* 10, e0132828. doi: 10.1371/journal.pone.0132828

Mee, J. F. (2008). Prevalence and risk factors for dystocia in dairy cattle: A review. *Vet. J.* 176, 93–101. doi: 10.1016/j.tvjl.2007.12.032

Mee, J., Berry, D., and Cromie, A. (2011). Risk factors for calving assistance and dystocia in pasture-based Holstein–Friesian heifers and cows in Ireland. *Vet. J.* 187, 189–194. doi: 10.1016/j.tvjl.2009.11.018

Muir, P., Wallace, G., Dobbie, P., and Bown, M. (2000). A comparison of animal performance and carcass and meat quality characteristics in Hereford, Hereford× Friesian, and Friesian steers grazed together at pasture. *New Zeal. J. Agr. Res.* 43, 193–205. doi: 10.1080/00288233.2000.9513421

Murphy, B., Crosson, P., Kelly, A. K., and Prendiville, R. (2017). An economic and greenhouse gas emissions evaluation of pasture-based dairy calf-to-beef production systems. *Agric. Syst.* 154, 124–132. doi: 10.1016/j.agsy.2017.03.007

Nielsen, S. S., Alvarez, J., Bicout, D. J., Calistri, P., Canali, E., Drewe, J. A., et al. (2022). Welfare of cattle during transport. *EFSA J.* 20, e07442. doi: 10.2903/j.efsa.2022.7442

Pahmeyer, C., and Britz, W. (2020). Economic opportunities of using crossbreeding and sexing in Holstein dairy herds. *J. Dairy Sci.* 103, 8218–8230. doi: 10.3168/jds.2019-17354

Pardon, B., Alliët, J., Boone, R., Roelandt, S., Valgaeren, B., and Deprez, P. (2015). Prediction of respiratory disease and diarrhea in veal calves based on immunoglobulin levels and the serostatus for respiratory pathogens measured at arrival. *Prev. Vet. Med.* 120, 169–176. doi: 10.1016/j.prevetmed.2015.04.009

Pardon, B., Catry, B., Boone, R., Theys, H., De Bleecker, K., Dewulf, J., et al. (2014). Characteristics and challenges of the modern Belgian veal industry. *Vlaams Diergeneeskundig Tijdschrift* 83, 155–163. doi: 10.21825/vdt.v83i4.16641

Pardon, B., Catry, B., Dewulf, J., Persoons, D., Hostens, M., De Bleecker, K., et al. (2012a). Prospective study on quantitative and qualitative antimicrobial and anti-inflammatory drug use in white veal calves. *J. Antimicrob. Chemother.* 67, 1027–1038. doi: 10.1093/jac/dkr570

Pardon, B., De Bleecker, K., Hostens, M., Callens, J., Dewulf, J., and Deprez, P. (2012b). Longitudinal study on morbidity and mortality in white veal calves in Belgium. *BMC Vet. Res.* 8, 14. doi: 10.1186/1746-6148-8-26

Pempek, J., Trearchis, D., Masterson, M., Habing, G., and Proudfoot, K. (2017). Veal calf health on the day of arrival at growers in Ohio. *J. Anim. Sci.* 95, 3863–3872. doi: 10.2527/jas2017.1642

Renaud, D., Duffield, T., LeBlanc, S., Ferguson, S., Haley, D., and Kelton, D. (2018a). Risk factors associated with mortality at a milk-fed veal calf facility: A prospective cohort study. *J. Dairy Sci.* 101, 2659–2668. doi: 10.3168/jds.2017-13581

Renaud, D., Duffield, T., LeBlanc, S., Haley, D., and Kelton, D. (2017). Management practices for male calves on Canadian dairy farms. *J. Dairy Sci.* 100, 6862–6871. doi: 10.3168/jds.2017-12750

Renaud, D., Duffield, T., LeBlanc, S., Haley, D., and Kelton, D. (2018b). Clinical and metabolic indicators associated with early mortality at a milk-fed veal facility: A prospective case-control study. *J. Dairy Sci.* 101, 2669–2678. doi: 10.3168/jds.2017-14042

Renaud, D., Kelton, D., LeBlanc, S., Haley, D., and Duffield, T. (2018c). Calf management risk factors on dairy farms associated with male calf mortality on veal farms. *J. Dairy Sci.* 101, 1785–1794. doi: 10.3168/jds.2017-13578

Renaud, D., and Pardon, B. (2022). Preparing male dairy calves for the veal and dairy beef industry. *Vet. Clin. North Am. Food Anim.* 38, 77–92. doi: 10.1016/j.cvfa.2021.11.006

Renaud, D., Steele, M., Genore, R., Roche, S., and Winder, C. (2020). Passive immunity and colostrum management practices on Ontario dairy farms and auction facilities: A cross-sectional study. *J. Dairy Sci.* 103, 8369–8377. doi: 10.3168/jds.2020-18572

Ritter, C., Hötzel, M. J., and von Keyserlingk, M. A. G. (2022). Public attitudes toward different management scenarios for "surplus". *dairy calves. J. Dairy Sci.* 105, 5909–5925. doi: 10.3168/jds.2021-21425

Ritter, C., Mills, K. E., Weary, D. M., and von Keyserlingk, M. A. G. (2020). Perspectives of western Canadian dairy farmers on the future of farming. *J. Dairy Sci.* 103, 10273–10282. doi: 10.3168/jds.2020-18430

Roland, L., Drillich, M., Klein-Jöbstl, D., and Iwersen, M. (2016). Invited review: Influence of climatic conditions on the development, performance, and health of calves. *J. Dairy Sci.* 99, 2438–2452. doi: 10.3168/jds.2015-9901

Sans, P., and de Fontguyon, G. (2009). Veal calf industry economics. *Rev. Med. Vet.* 160, 420–424.

Santo, N. K., von Borstel, U. K., and Sirovnik, J. (2020). The influence of maternal contact on activity, emotionality and social competence in young dairy calves. *J. Dairy Res.* 87, 138–143. doi: 10.1017/S0022029920000527

Scott, K., Kelton, D., Duffield, T., and Renaud, D. (2019). Risk factors identified on arrival associated with morbidity and mortality at a grain-fed veal facility: A prospective, single-cohort study. *J. Dairy Sci.* 102, 9224–9235. doi: 10.3168/jds.2019-16829

SDa Autoriteit Diergeneesmiddelen (2022). *Het gebruik van antibiotica bij landbouwhuisdieren in 2021 - Trends, benchmarken bedrijven en dierenartsen* (Utrecht, Netherlands).

Shivley, C. B., Lombard, J. E., Urie, N. J., Weary, D. M., and von Keyserlingk, M. A. G. (2019). Management of preweaned bull calves on dairy operations in the United States. *J. Dairy Sci.* 102, 4489–4497. doi: 10.3168/jds.2018-15100

Skelhorn, E., Garcia-Ara, A., Nova, R., Kinston, H., and Wapenaar, W. (2020). Public opinion and perception of rosé veal in the UK. *Meat Sci.* 167, 108032. doi: 10.1016/j.meatsci.2019.108032

Spruijt, B. M., Van den Bos, R., and Pijlman, F. T. (2001). A concept of welfare based on reward evaluating mechanisms in the brain: anticipatory behaviour as an indicator for the state of reward systems. *Appl. Anim. Behav. Sci.* 72, 145–171. doi: 10.1016/S0168-1591(00)00204-5

Thomas, G., and Jordaan, P. (2013). Pre-slaughter mortality and post-slaughter wastage in bobby veal calves at a slaughter premises in New Zealand. *N. Z. Vet. J.* 61, 127–132. doi: 10.1080/00480169.2012.734374

United Nations Brundtland Commission (1987). *Report of the World Commission on Environment and Development: Our Common Future*. Ed. Nations U. (New York City, USA: United Nations).

Vellinga, T., and De Vries, M. (2018). Effectiveness of climate change mitigation options considering the amount of meat produced in dairy systems. *Agric. Syst.* 162, 136–144. doi: 10.1016/j.agsy.2018.01.026

Ventura, B. A., von Keyserlingk, M. A. G., Schuppli, C. A., and Weary, D. M. (2013). Views on contentious practices in dairy farming: The case of early cow-calf separation. *J. Dairy Sci.* 96, 6105–6116. doi: 10.3168/jds.2012-6040

Vicic, V., Saliba, A. J., Campbell, M. A., and Quinn, J. C. (2022). Barriers to utilizing non-replacement male calves in the Australian dairy industry: A qualitative study. *Front. Vet. Sci.* 8, 1671. doi: 10.3389/fvets.2021.800388

Wagner, K., Barth, K., Palme, R., Futschik, A., and Waiblinger, S. (2012). Integration into the dairy cow herd: Long-term effects of mother contact during the first twelve weeks of life. *Appl. Anim. Behav. Sci.* 141, 117–129. doi: 10.1016/j.applanim.2012.08.011

Waiblinger, S., Wagner, K., Hillmann, E., and Barth, K. (2020). Play and social behaviour of calves with or without access to their dam and other cows. *J. Dairy Res.* 87, 144–147. doi: 10.1017/S0022029920000540

Webb, L. E., Bokkers, E. A. M., Engel, B., Berends, H., Gerrits, W. J. J., and van Reenen, C. G. (2012). Behaviour and welfare of veal calves fed different amounts of solid feed supplemented to a milk replacer ration adjusted for similar growth. *Appl. Anim. Behav. Sci.* 136, 108–116. doi: 10.1016/j.applanim.2011.12.004

Webb, L. E., Bokkers, E. A. M., Heutinck, L. F. M., Engel, B., Buist, W. G., Rodenburg, T. B., et al. (2013). The effect of roughage type, amount and particle size on veal calf behavior and gastrointestinal health. *J. Dairy Sci.* 96, 7765–7776. doi: 10.3168/jds.2012-6135

Webb, L. E., Engel, B., Berends, H., van Reenen, C. G., Gerrits, W. J. J., de Boer, I. J. M., et al. (2014a). What do calves choose to eat and how do preferences affect behaviour? *Appl. Anim. Behav. Sci.* 161, 7–19. doi: 10.1016/j.applanim.2014.09.016

Webb, L. E., Engel, B., van Reenen, C. G., and Bokkers, E. A. M. (2017). Barren diets increase wakeful inactivity in calves. *Appl. Anim. Behav. Sci.* 197, 9–14. doi: 10.1016/j.applanim.2017.08.005

Webb, L. E., Jensen, M. B., Engel, B., van Reenen, C. G., Gerrits, W. J. J., de Boer, I. J. M., et al. (2014b). Chopped or long roughage: what do calves prefer? Using cross point analysis of double demand functions. *PloS One* 9, e88778. doi: 10.1371/journal.pone.0088778

Webb, L. E., Marcato, F., Bokkers, E. A. M., Verwer, C. M., Wolthuis-Fillerup, M., Hoorweg, F. A., et al. (2022). Impact of early dam contact on veal calf welfare. *Sci. Rep.* 12, 22144. doi: 10.1038/s41598-022-25804-z

Webb, L. E., van Reenen, C. G., Berends, H., Engel, B., de Boer, I. J. M., Gerrits, W. J. J., et al. (2015). The role of solid feed amount and composition and of milk replacer supply in veal calf welfare. *J. Dairy Sci.* 98, 5467–5481. doi: 10.3168/jds.2014-8547

Webb, L. E., Veenhoven, R., Harfeld, J. L., and Jensen, M. B. (2019). What is animal happiness? *Ann. N. Y. Acad. Sci.* 1438, 62. doi: 10.1111/nyas.13983

Wenker, M. L. (2022). *Welfare implications of prolonged cow-calf contact in dairy farming* PhD thesis (Wageningen, the Netherlands: Wageningen University). doi: 10.18174/564225

Wenker, M. L., Bokkers, E. A. M., Lecorps, B., von Keyserlingk, M. A. G., van Reenen, C. G., Verwer, C. M., et al. (2020). Effect of cow-calf contact on cow motivation to reunite with their calf. *Sci. Rep.* 10, 1–5. doi: 10.1038/s41598-020-70927-w

Wenker, M. L., van Reenen, C. G., Bokkers, E. A. M., McCrea, K., De Oliveira, D., Sørheim, K., et al. (2022a). Comparing gradual debonding strategies after prolonged cow-calf contact: Stress responses, performance, and health of dairy cow and calf. *Appl. Anim. Behav. Sci.* 253, 105694. doi: 10.1016/j.applanim.2022.105694

Wenker, M. L., Verwer, C. M., Bokkers, E. A. M., Te Beest, D. E., Gort, G., De Oliveira, D., et al. (2022b). Effect of type of cow-calf contact on health, blood parameters, and performance of dairy cows and calves. *Front. Vet. Sci.* 9, 855086. doi: 10.3389/fvets.2022.855086

Whalin, L., Weary, D. M., and von Keyserlingk, M. A. G. (2022). Preweaning dairy calves' preferences for outdoor access. *J. Dairy Sci.* 105, 2521–2530. doi: 10.3168/jds.2021-21064

Wilson, D. J., Canning, D., Giacomazzi, T., Keels, K., Lothrop, R., Renaud, D. L., et al. (2020). Hot topic: health and welfare challenges in the marketing of male dairy calves—Findings and consensus of an expert consultation. *J. Dairy Sci.* 103, 11628–11635. doi: 10.3168/jds.2020-18438

Winder, C. B., Kelton, D. F., and Duffield, T. F. (2016). Mortality risk factors for calves entering a multi-location white veal farm in Ontario, Canada. J. *Dairy Sci.* 99, 10174–10181. doi: 10.3168/jds.2016-11345

World Health Organization (2006). *Constitution of the World Health Organization - Basic Documents, 45th ed*.

Worth, G. M., Schütz, K. E., Stewart, M., Cave, V. M., Foster, M., and Sutherland, M. A. (2015). Dairy calves' preference for rearing substrate. *Appl. Anim. Behav. Sci.* 168, 1–9. doi: 10.1016/j.applanim.2015.04.003

Zehetmeier, M., Baudracco, J., Hoffmann, H., and Heißenhuber, A. (2012). Does increasing milk yield per cow reduce greenhouse gas emissions? *A system approach. Anim.* 6, 154–166. doi: 10.1017/S1751731111001467

Zhang, C., Juniper, D. T., McDonald, R., Parsons, S., and Meagher, R. K. (2022a). Holstein calves' preference for potential physical enrichment items on different presentation schedules. *J. Dairy Sci.* 105, 8316–8327. doi: 10.3168/jds.2021-21715

Zhang, Z., Wu, D., Li, X., Shao, K., Jia, H., and Xu, M. (2022b). Drinking water temperature preferred by Holstein calves under different temperature-humidity index conditions. *Livest. Sci.* 263, 105030. doi: 10.1016/j.livsci.2022.105030

Zobel, G., Neave, H. W., Henderson, H. V., and Webster, J. (2017). Calves use an automated brush and a hanging rope when pair-housed. *Animals* 7, 84. doi: 10.3390/ani7110084